COMPARATIVE STUDY OF THE NATURAL REGENERATION OF 30 FOREST SPECIES UNDER MANAGEMENT IN THE SHORT PLOT N° 11 OF THE MANAGEMENT UNIT

MADERACRE FORESTRY

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IÑAPARI- MADRE DE DIOS

I. INTRODUCTION

One of the fundamental bases of sustainable management of tropical forests is the maintenance of natural regeneration. This form of management requires that the harvested timber species regenerate naturally to maintain their populations and ensure the future productivity of the forest (Bawa & Seidler cited by Leigue, 2011). The use of timber species has several consequences for natural regeneration, some with opposite effects. On the one hand, the damage and mortality of individuals, the considerable reduction in fruit production, and the increase in the availability of light in the residual forest (Dickinson et al., 2000; Jackson et al., 2002; Van Rheenen et al., 2004). On the other hand, it has been found that logging and other anthropogenic activities, they could influence the spatial distribution of forest species (Rivas et al, 2005); it can even significantly alter the abundance and modify the spatial distribution of the natural regeneration of the harvested and remaining species.

It is important for the elaboration of forest management plans to consider natural regeneration, in such a way that data must be collected from each stand and from the total area. Information on the area, characteristics of the forest, exploitation technique, regeneration and growth of commercial species, protection measures for non-commercial species, river and stream sources, and defining an annual exploitation schedule are of the utmost importance. The expression "natural regeneration" refers to the treatments that are applied to the original forest, with the purpose of producing wood without any additional cultivation. The basis of this system is the natural regeneration process taking into account its dynamics before exploitation or other human intervention.

In this sense, the company MADERACRE SAC has been carrying out various studies that seek to generate the necessary knowledge for the conservation and maintenance over time of the exploited species, one of these is the evaluation of the natural regeneration of the exploited areas, in this sense in This report reports and analyzes the results of the evaluation of the natural regeneration of 30 forest species in the Cutting Plot No. 11 of the forest management unit (UMF) of the company MADERACRE SAC.

II. GOALS

2.1. General objective

- **Evaluate the natural regeneration of timber-yielding forest species before and after the logging of Plot of Cutting No. 11 of the UMF of MADERACRE SAC.**

2.2. Specific goal

- **Determine the Importance Value Index (IVI) of the natural regeneration of timber forest species.**
- **Analyze the population equilibrium curve of the natural regeneration of timber forest species.**
- **Analyze the natural regeneration of timber forest species according to sociological position, liana infestation, crown shape and exposure.**
- **Carry out a comparative analysis of natural regeneration before use and its behavior after 9 years of its execution.**

III. BACKGROUND

MADERACRE SACis one of the largest forest management companies in Peru and holds international certifications that accredit the responsible management of its FMU, which considers the implementation of measures to care for and safeguard forests, however, it is necessary to carry out studies to know the health of the ecosystems intervened during the implementation of the forest management plan, in this sense knowing the state of natural regeneration of timber forest species is of vital importance. To the date, MADERACRE SAC has carried out the following studies:

- **Chambi, P. 2011. Natural Regeneration of Timber Species of Two Annual Cut Plots under Forest Management in the Timber Concession MADERACRE SAC Madre de Dios, Peru: MADERACRE.**
- **Zapana, F. 2017. Natural Regeneration of 21 Timber Species in the plot of Cut 12 under Forest Management in the timber concession MADERACRE SAC Madre de Dios, Peru: MADERACRE.**
- **Ñaña, L. 2018. Natural Regeneration of 19 Timber Species in the plot of Cut 13 under Forest Management in the timber concession MADERACRE SAC Madre de Dios, Peru: MADERACRE.**
- **Ñaña, L. 2019. Natural Regeneration of 25 Timber Species in the plot of Cut 14 under Forest Management in the timber concession MADERACRE SAC Madre de Dios, Peru: MADERACRE.**
- **Ñaña, L. 2020. Study of the natural regeneration of 23 timber species in the Plot of Cut 15 under Forest Management in the Consolidado Maderera Río Acre SAC, Madre de Dios.**

3.1. Characterization of the use in the study area

3.1.1. Year of execution of the use

Harvesting in PC 11 (2566.05 ha) was carried out during 2012, specifically during the dry season from May to October. The pre-use natural regeneration evaluation was carried out during the month of August 2011 (one year before its intervention) and the post-use evaluation in November 2021, that is, after 9 years of its use. intervention.

3.1.2. Silvicultural information on harvested species

The forest species selected for harvesting, their minimum cutting diameters (DMC), harvest intensity (IC), basal area (AB) and volume established in the current general forest management plan, as well as harvesting figures are presented. next:

Table 1.Harvested species, DMC, IC, AB Y Volume according to management plan and Report of execution of PC 11 of the UMF of MADERACRE SAC.

Species	Scientific name	DMC (cm)	CI FAQ (%)	CI Executed (%)	No. of trees felled	AB $(m)_2$	Volume $(m)_3$
ana caspi	*Apuleia leiocarpa*	75	100	57.78	104	64,231	514,745
huayo sugar	*Hymenaea oblongifolia*	75	100	77.18	115	112,019	943,645
Mahogany	*Swietenia macrophylla*	90	100	76.47	14	11,347	94,332
Cedar	*cedrela odorata*	70	100	50.00	19	10,524	81,457
slack	*Myroxylon balsamum*	60	90	58.12	68	30,158	245,272
ishpingo	*Amburana cearensis*	70	100	56.94	160	94,852	744,944
Manchinga	*brosimum alicastrum*	75	100	0.50	3	4,403	33,747
Pumaquiro*	*Aspidosperma macrocarpon*	60	fifty	32.08	17	11,370	88,320
quinilla	*Manilkara bidentata*	70	100	52.17	60	41,265	353,283
shihuahuaco	*Dipteryx micrantha*	75	100	85.42	451	802.34	5468.572
tahuari	*Handroanthus capitatus*	60	100	21.57	22	11,757	93,186
yacushapana	*Terminalia oblonga*	65	100	17.07	35	18,626	146,858
Total					1068	1212.89	8808.361
Total per ha					0.416	0.47	3,433

Source: General Forest Management Plan (2019 update); Report on the execution of the Annual Operative Plan PCA N°: 11 /ZAFRA: 2012-2013.
* Data from the PGMF version 2006.

The Cutting Index (CI) defines the proportion of usable individuals of a certain species that can be harvested in an area unit (PC) as part of the silvicultural system in implementation defined in the PGMF.

The values of the IC executed during the use of the year 2012 for the species felled in PC 11 were below what is established in the PGMF in force to date, ensuring the permanence in the forest of a greater number of remaining commercial individuals that together with seed trees ensure a sufficient source of genetic material for

ensure the natural regeneration of each species, as well as the fulfillment of its ecological functions.

3.1.3. Affectation of the Basal Area of the forest

Below is the calculation of the average AB of the FMU calculated based on the results of 8 evaluations in 6 permanent monitoring plots (PPM) within the FMU. This information will be used to calculate the direct impact of the felling carried out in the year 2012 in PC11 on the total basal area of the forest.

Table 2.Basal Area (m_2/ha) at the level of stems and stubs of PPMs of the CMRA.

ppm	Evaluation year			AB Overall Average $(m)_2$/ha)
	FY 2021 $(m)_2$/ha)	FY 2018 $(m)_2$/ha)	FY 2014 $(m)_2$/ha)	
008	-	14.90	-	14.90
009	-	-	20.29	20.29
010	-	-	31.80	31.80
011	24.88	25.26	-	25.07
012	18.36	19.11	-	18.74
Total average				22.16

Source: PPM 007, 008, 009, 010, 011, 012 database.

The values of the basal area of the PPMs shown in Table 2 represent all the individuals at the level of saplings and stems, whose final average value is 22.16 m2/ ha; These plots are located in low hill type forests near the study PC within the CMRA, and have not been disturbed by forestry operations of any magnitude. For its part, the basal area used (withdrawal of PC 11) in 2012 was 0.47 m2/ha, representing the 2.12% decrease or affectation on the basal area of the forest represented by the previously mentioned average.

3.1.4. Area Degraded by Management Operations

The environmental monitoring calculations for the determination of degraded areas had not yet been applied in 2012, which is key information to know the dimension of the opening of clearings in the forest, which is why, based on the studies of degradation carried out by MADERACRE SAC during the years 2017 to 2021, under the same terms of forest use, it has been obtained on average that 117.46 m3exploiters degrade 1 ha of forest as a result of all the activities that forest exploitation contemplates (logging, dragging, roads, patios and camps); from which it is estimated that the impact on the forest in terms of area generated in 2012 as a result of the use of 8808,361 m3of wood, generated the degradation of 73.69 ha of forest representing 2.87% of the PC 11 area and 0.03% of the total area of the FMU in that specific year. This indicator allows us to know the level of impact of the logging operation on the forest and, in turn, to infer that the impact on the ecosystem's resilience capacity is negligible in the face of the structural changes that it suffers as a result of logging.

In order to have a visual idea of the level of affectation of the forest cover and its regeneration capacity, the comparison of the satellite images corresponding to PC 11 of the UMF of MADERACRE SAC in the years 2011, 2012 and 2016 was made:

Year (-1): Figure 1 dates from the month of August 2011, where it shows the pre-harvest stage of the PC in which the roads for access to the area have been built.

Year (0): Figure 2 dates from the month of September 2012, showing the level of intervention within the polygon. The degradation corresponds to the implementation of operations within the framework of the management plan (logging, roads, vials, storage yards and camps). Note that the forest outside the PC has not been affected except for access roads to that area.

Year (4): Figure 3 dates from August 2016, where it can be seen how the forest cover in PC 11 is recovering satisfactorily after four years of logging. The degraded areas have almost completely disappeared due to the natural regeneration of the forest, which is part of the resilient power that characterizes it, even on the main roads where the width of the road and clearing on the sides adds up to an average of 13 m, in addition to These are places where trucks used to transport logs from the storage yards to the sawmill, which subjected the soil to constant loads.

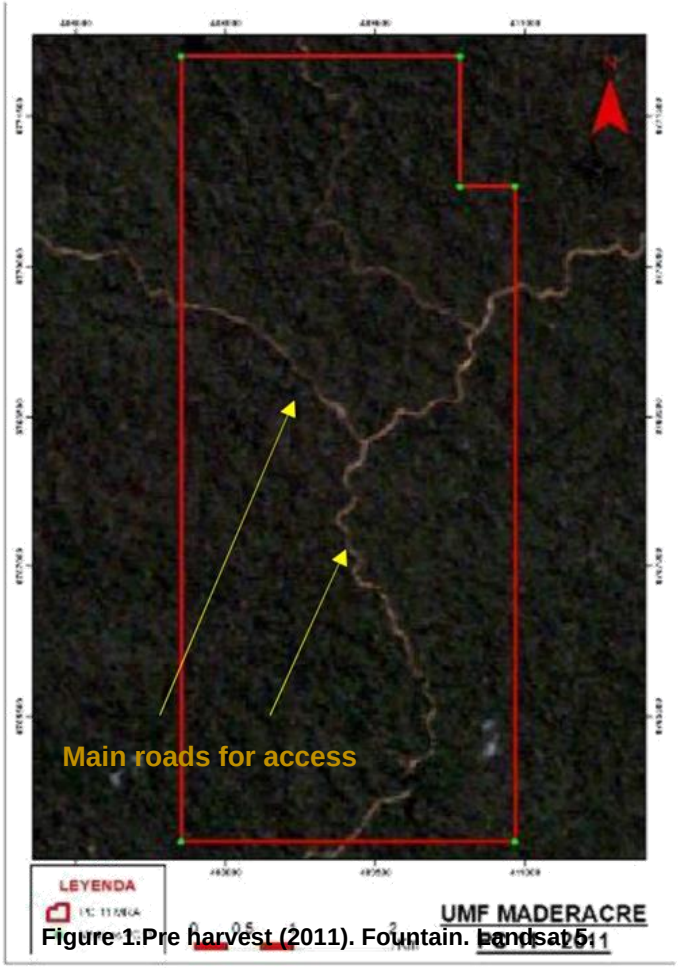


Figure 1.Pre harvest (2011). Fountain. Landsat 5.

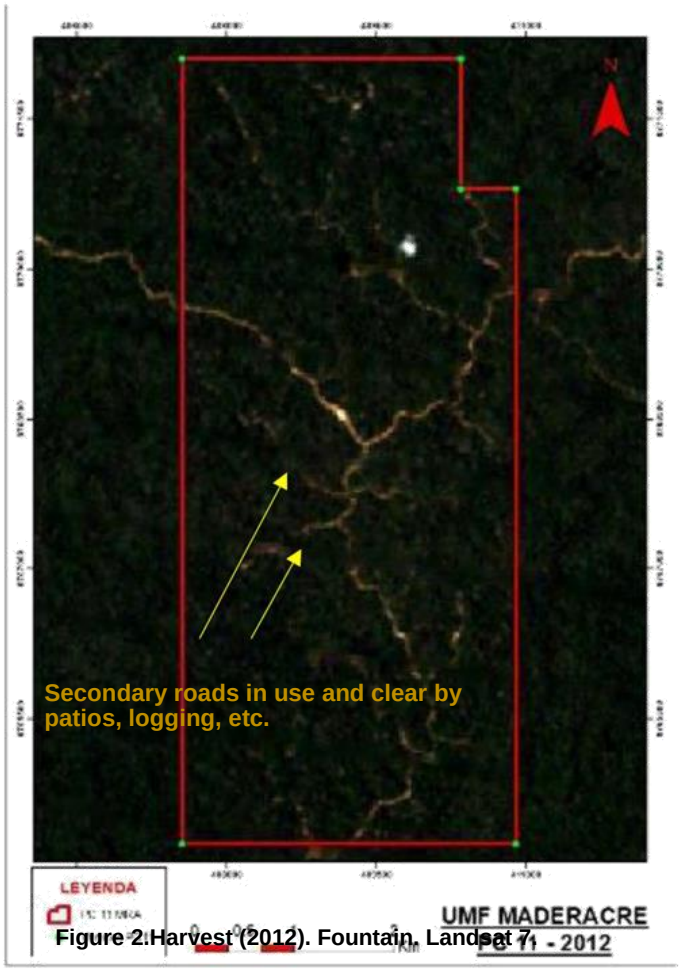
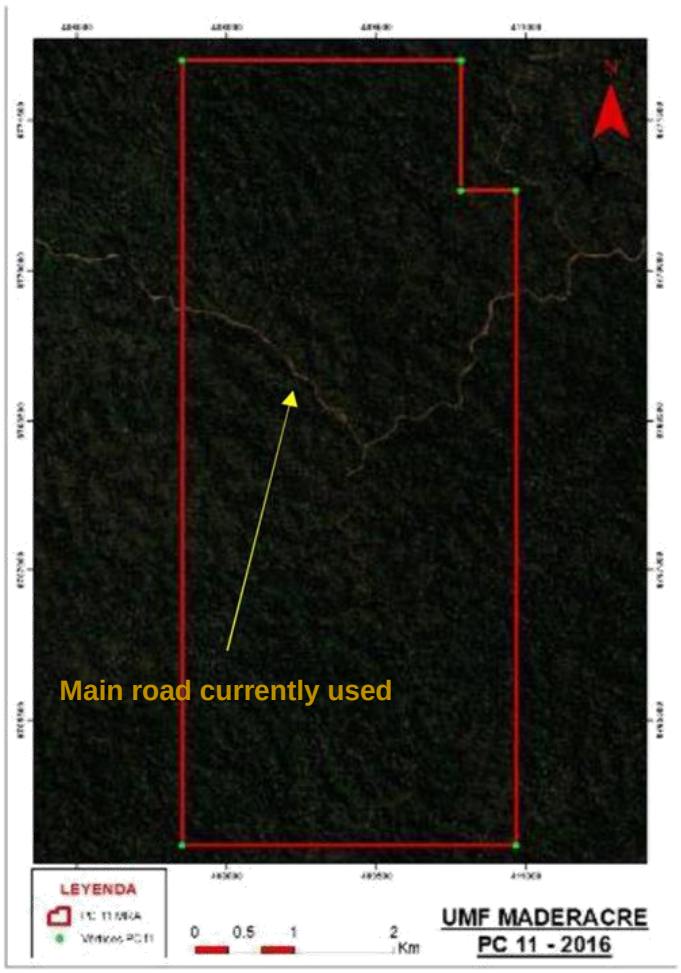


Figure 2.Harvest (2012). Fountain. Landsat 7



IV. METHODOLOGY

4.1. Definition of the study area

The natural regeneration evaluation area is established in the 2016 MADERACRE SAC Concession General Forest Management Plan, corresponding to PC No. 11 with an extension area of 2566.05 ha, located in the District of Iñapari, Province Tahuamanu, Madre de Dios Region.

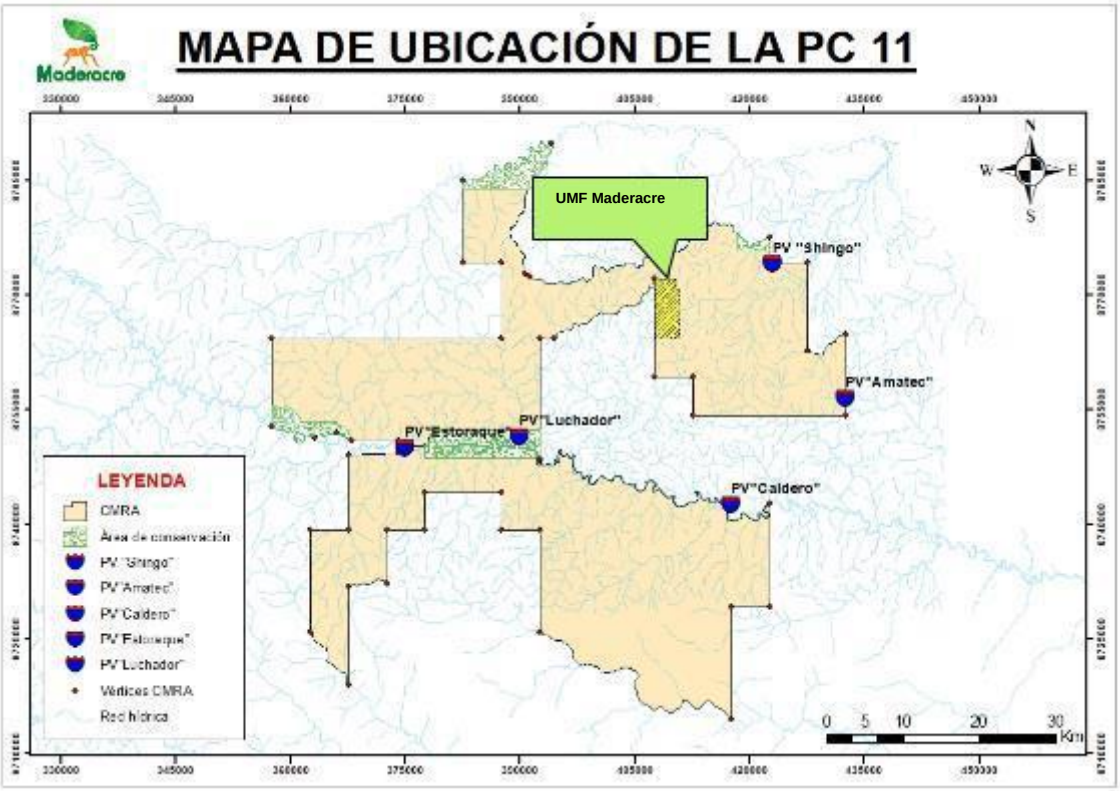


Figure 4.Location of PC 11 of the UMF of MADERACRE SAC.

The UTM coordinates of the vertices of the PC are the following:

Table 3.UTM coordinates of the vertices of PC 11 of the UMF of MADERACRE SAC.

No.	UTM coordinates	
	This	North
1	407548	8772111
2	410352	8772109
3	410352	8770808
4	410903	8770808
5	410903	8764249
6	407548	8764249

4.2. plot sampling

The methodology considers that each of the plots should contain a certain number of strips that will be installed systematically dispersed in the area of use.

Using the Dauber (1995) methodology, the number of sampling units was determined depending on the stratum to be inventoried, thus Table 4 allows knowing the sampling intensity to be applied to obtain the sampled area, being that in the case of the PC 11 of the UMF of MADERACRE SAC, whose area is 2566.05 ha, corresponds to a minimum intensity of approximately 1.1%, which would be equivalent to 29 sampling units or evaluation transects.

Table 4.Minimum intensities and other sampling parameters depending on the surface population according to Dauber (1995).

total area of forest strata (ha)	Minimum intensity (%)	sampled area (ha)
100	8	8
500	2	10
1000	1.5	fifteen
2000	1.2	25
2566.05	1.1	29
5000	0.8	40
10000	0.5	fifty
15000	0.35	fifty
20000	0.28	55
25000	0.24	60
30000	0.22	65
50000	0.2	100
100000	0.15	150
200000	0.1	200

Source: Dauber (1995))

4.3. Distribution of plots and sub plots

Considering that the area to be evaluated is relatively large and with limited access, and since it is the same type of forest (low hill), it was decided to establish the 29 sampling units in blocks distributed randomly over the PC area, but considering the ease of access for its location on the ground (proximity to forest roads).

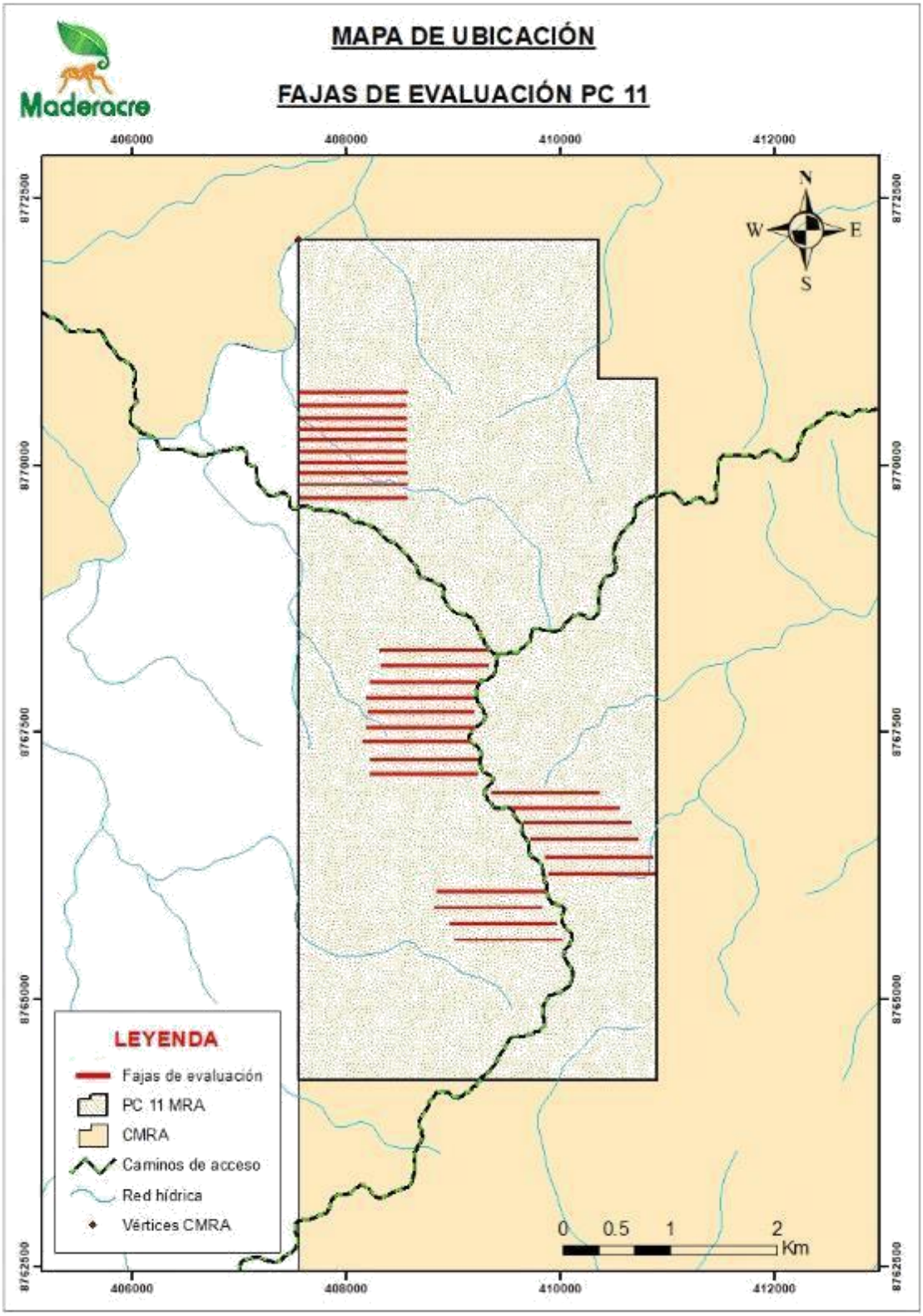


Figure 5.Location of the 29 strips of natural regeneration in PC 11.

4.4. Survey of natural regeneration and mature trees

For this evaluation, the "Methodological Guide for the Pre and Post Evaluation of Natural Regeneration" was used, developed by MADERACRE SAC based on the methodology used by the BOLFOR project in Bolivia.

The registration of individuals was carried out zigzagging along the transect (1000m). Where all the naturally regenerating individuals were evaluated at different widths from the central axis of the evaluation strip:

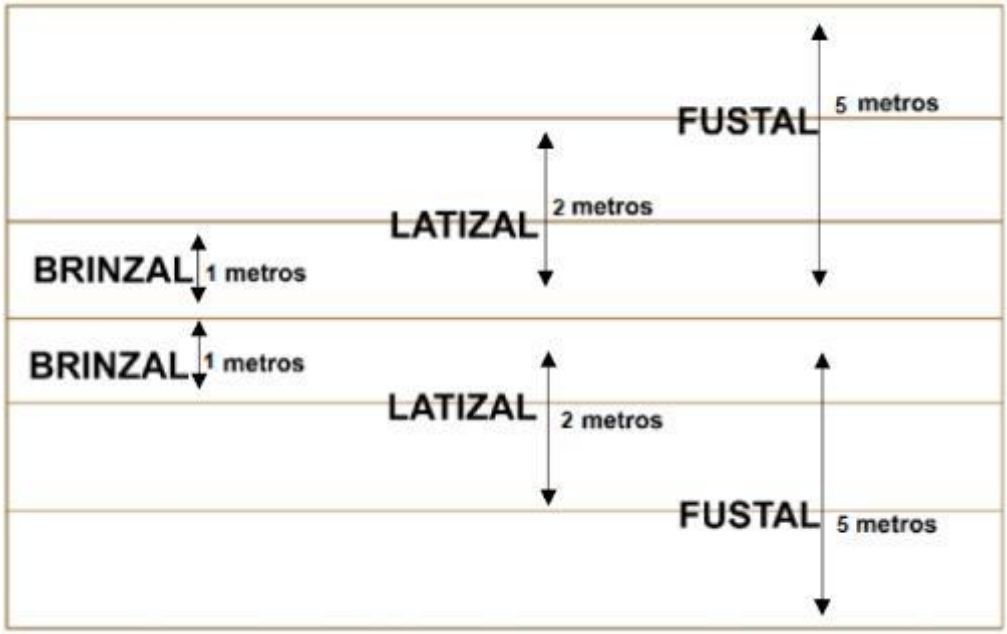


Figure 6.Belt model for the evaluation of natural regeneration in PC 11.

Table 5 describes the characterization of the size classes established for field evaluations.

Table 5.Characterization of the size classes for their identification in the field.

size classes	Belt width (m)	Height (m)	DAP (cm)
seedling	2	< 1.3	-
latizal	4	> 1.3	< 10
fustal	10	> 1.3	> 10

4.5. Identification of forest species

The preliminary identification of the naturally regenerating individuals was carried out in the field with specialized literature for botanical identification (Gentry, 1993; Vásquez & Rojas 2004; Killeen et al. 1993), a tool that was used to strengthen the empirical knowledge of the planters.

4.6. diameter measurement

The CAP (Circumference at Chest Height) was measured at a height of 1.3m, as long as at that height there were no physical inconveniences specific to the individual, due to deformations or the presence of tree stem fins. In several cases, 30 cm was added above this modification of the base of the stem to measure the CAP. On the other hand, the DAP was measured by projecting the measurement from the center of the stem. For the individuals of the latizal strata, the vernier tool was used, which allowed a more precise measurement.

4.7. height measurement

To determine the heights of the trees, the ocular estimation mechanism was used. Prior to the execution of the field work, "tuning" practices were carried out, and to reduce the error, trained personnel with many years of experience in the field were used.

For the estimation of the height of the stem, it began from the base of the stem to the first bifurcation or important ramification that defines the beginning of the crown.

4.8. Measurement of ecological variables.

4.8.1. cup exhibition

Crown exposure was measured qualitatively, using the system developed by Dawkins (1958) cited by Hutchinson (1993b):

- **Emergent: The top of the crown fully exposed to vertical light and free from lateral competition, at least in a 90° inverted cone with the vertex at the point of the base of the crown.**
- **full top lighting: The top of the crown is fully exposed to vertical light, but is adjacent to other crowns of equal or larger size within the 90° cone.**
- **some overhead lighting: The top of the crown is exposed to vertical light, or partially shaded by other crowns.**
- **some side light: The upper part of the crown entirely shaded from vertical light, but exposed to some direct lateral light due to a clearing or edge of the upper canopy.**
- **absence of light: The upper part of the crown entirely shaded from both vertical and lateral light.**

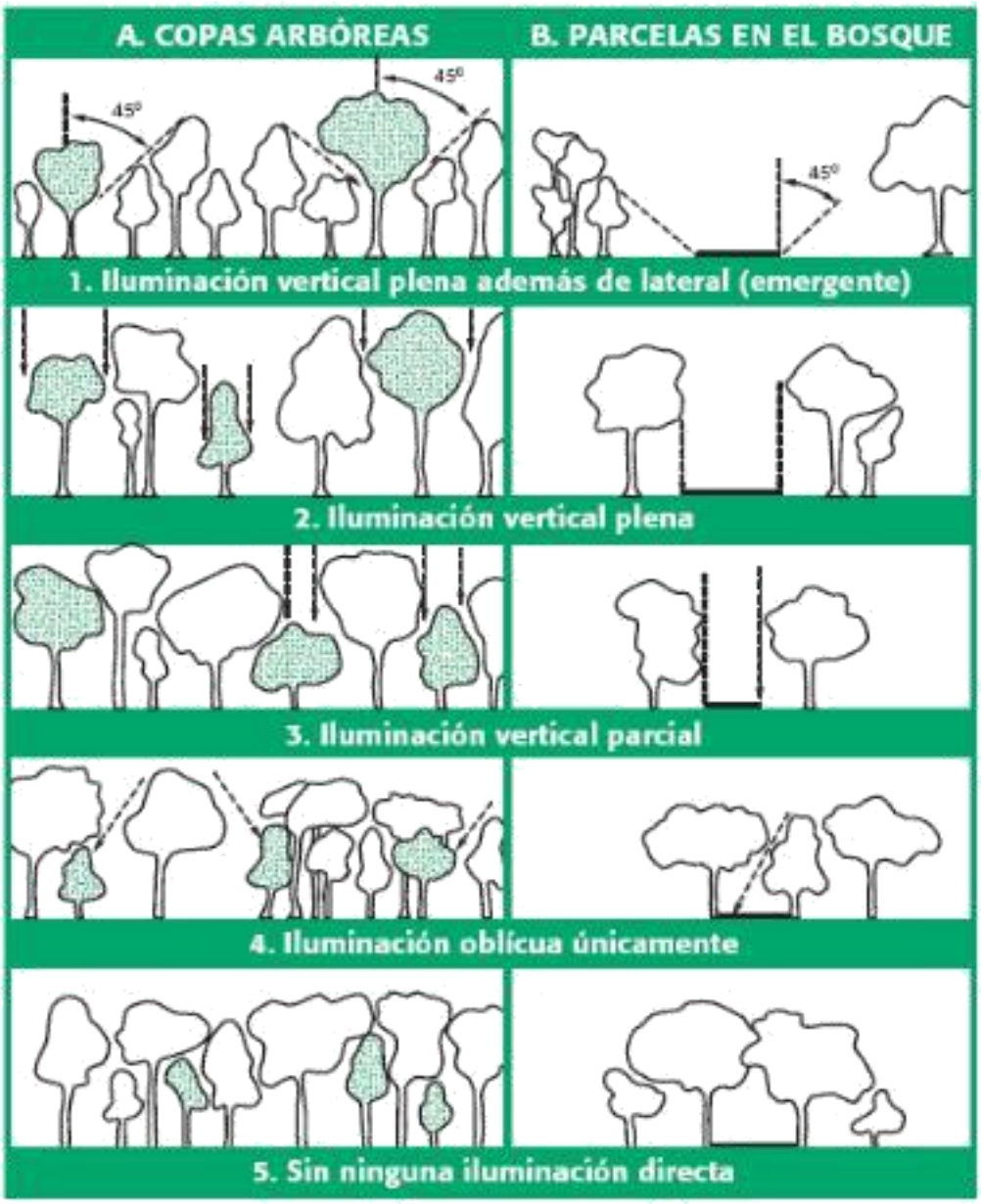


Figure 7.Crown exposure according to Dawkins (1958) cited by Hutchinson (1993b).

4.8.2. cup shape

The crown plays an essential role in the capture of solar energy and the growth of trees, as well as in the production of seeds, and therefore, in the natural regeneration of forest species, which is why its shape is relevant in the effectiveness of these functions.

The classification of this variable is based on the Dawkins five-point system. Synnott (1990) proposes this modified system giving the definitions of cup shape that are given below and that must be interpreted and applied according to the characteristics of each species and the state of development of each tree. To facilitate the interpretation of this variable, in the present study the summarized classification made by Pinelo will be used as reference, and which is presented in Figure 8:

Forma de la copa	Nº de código
Copa vigorosa, círculo completo ó irregular (1 y 2)	1
Medio círculo (3)	2
Menos de medio círculo (categorías 4 y 5)	3
Solo rebrotes o sin copa (categorías 6 y 7)	4

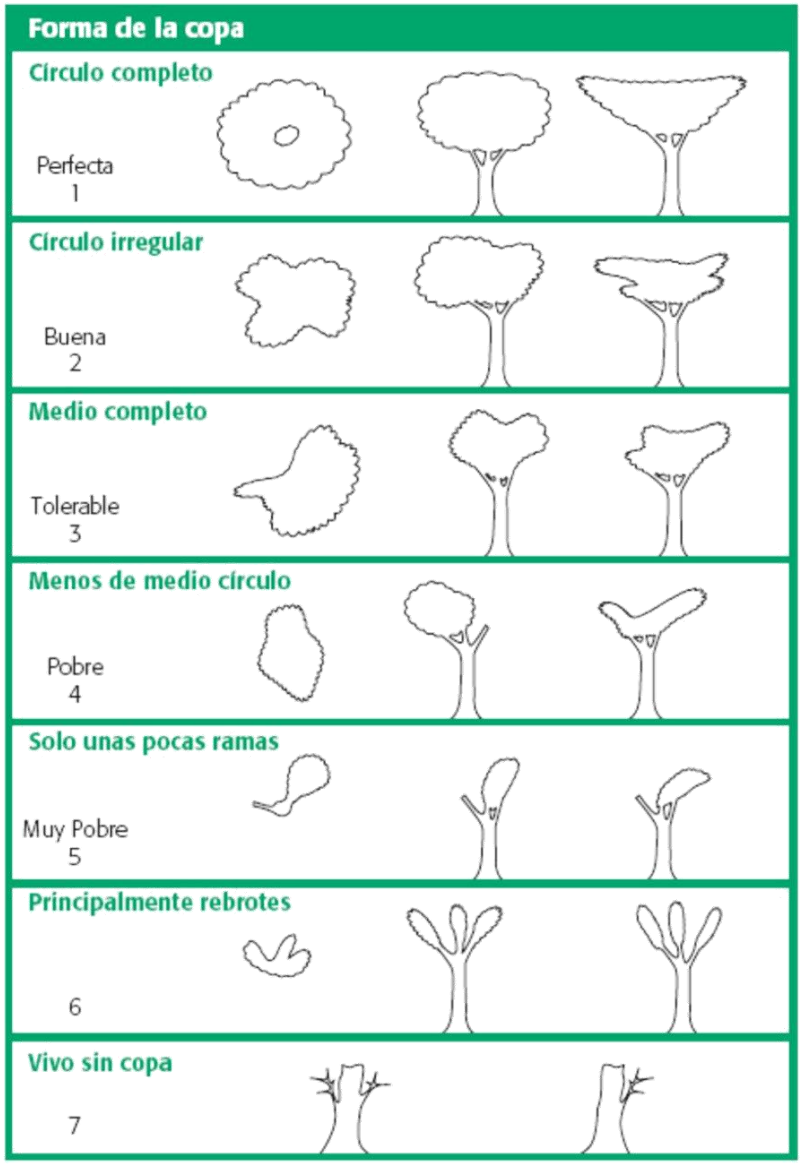


Figure 8.cup shapeFountain:Pinelo (2000); adapted from Synnott (1991).

4.8.3. Liana infestation

The infestation by lianas decreases the quality of the wood and limits the growth of the trees, due to the strangulation of the stem, the weight they represent or the light competition (Putz, 1991) cited by Evans (2003). The lianas join the tops of the trees together, so that the trees cut down during harvesting can drag other trees during their fall. In addition, this network of lianas is a danger to workers. The cutting of these minimizes the damage to the surrounding trees and reduces the risks of accidents during the

use (Pérez-Salicrup, 2001) cited by Evans (2003). The coding to use for the measurement of this variable is presented in Table 6.

Table 6.Codes to qualify the presence of lianas.

Presence of lianas	No. of code
No lianas, not visible on stem and crown	1
Presents in stem	2
Present in stem and crown, but do not affect growth with the tree	3
Present in stem and crown almost covered, they compete with the tree or affect its growth	4

4.9. sociological position

For the division of forest height, the inverse relationship of the rule known as 20/30/50 (Serrada, 1997 cited by Araujo et al., 2008) was applied, which divides the sub-strata into: Low stratum (≤ 6m), E. Medium (6-10m) and E. High (≥ 10m). That is, according to the ordinates and abscissas (Cartesian or orthogonal system), the first 50% of individuals according to their height (ordinate) are located on the lower floor, which determine the height of the stratum, in the same way it is applied for the other following floors (30% and 20%).

4.10. Information processing and analysis

Variables such as: DBH, total height, population density, abundance of all trees, shape and crown exposure were analyzed, which allowed us to know the composition and population structure of the natural regeneration of timber species from the Consolidado MADERACRE (CMRA) forest.

- **Analysis of the floristic composition and structure of the plots**

  Based on the experiences of Mori & Boom (1987), Campbell (1989) and Galindo et al. (2003), the analysis was carried out with conventional formulas.

$$\text{Basal area} = (\pi \, DAP^2) / 4$$

- **Relative density of the species or family**

$$DR = (\text{No. of trees of species A} / \text{No. of total trees}) \times 100$$

- **Relative dominance of the species or family**

$$DoR = (\text{Basal area of species A} / \text{Basal area of total trees}) \times 100$$

- **Relative frequency of the species or family**

RF = (Frequency of species A/ Number of total strips evaluated) x 100

- **Importance Value Index (IVI) of species A**

IVI_{fus}= DR + DoR + FR
$IVI_{The\ t}$= DR + DoR + FR
IVI_{Bri}= DR + FR

- **Vertical and Horizontal distribution**

The histograms of the distribution of individuals in diameter and altimetric classes were made based on the experiences of Pitman et al. (1999 and 2001), who grouped all the individuals in intervals of 5 m height and 10 cm DAP.

v. RESULTS

5.1. Taxa identification

In the 29 strips (transects) evaluated in PC 11 in the years 2011 and 2021, 30 species registered at the vernacular name level were considered, being considered by the company MADERACRE SAC as species of high current and potential timber value, and included as part of the General Forest Management Plan.

Below is the list of species defined for identification.

Table 7.Identification of taxa in PC 11.

No.	Common name	Scientific name
1	ana caspi	*Apuleia leiocarpa*
2	huayo sugar	*Hymenaea oblongifolia*
3	hookah	*Allantoma decandra*
4	Mahogany	*Swietenia macrophylla*
5	capirona	*Calycophyllum spruceanum*
6	Catahua	*Hura crackles*
7	catuaba	*qualea paraensis*
8	Cedar	*cedrela odorata*
9	Copaiba	*Reticulated Copaifera*
10	slack	*Myroxylon balsamum*
eleven	Huayruro	*Ormosia schumkei*
12	Huimba	*ceiba lupuna*
13	ishpingo	*Amburana cearensis*
14	Itauba	*Mezilaurus itauba*
fifteen	lupuna	*kapok pentandra*
16	Manchinga	*brosimum alicastrum*
17	Mashoned	*Clarisia racemosa*
18	Mass	*schweilera*sp.
19	hey	*ficus insipida*
twenty	stick cane	*Astronium graveolens*
twenty-one	pumaquiro	*Aspidosperma macrocarpon*
22	quillobordón	*Aspidosperma parvifolium*
23	quinilla	*Manilkara bidentata*
24	white quinilla	*Micropholis egensis*
25	requisition	*guarea*sp.
26	shihuahuaco	*Dipteryx micrantha*
27	tahuari	*Handroanthus capitatus*
28	yacushapana	*Terminalia oblonga*
29	son-in-law	*Acacia*sp.
30	Sapodilla	*Matisia*spp.

5.2. Abundance and population density

The results obtained when comparing the evaluation of the year 2021 compared to 2011, have registered the species*Astronium graveolens*("stick cane"),*Myroxylon balsamum*("storax"), *Terminalia oblonga*("yacushapana"),*Dipteryx micrantha*("shihuahuaco") and*Mezilaurus itauba* ("itauba") as the ones with the highest degree of increase of individuals per hectare in all size classes (sapling, latizal and fustal), likewise the species*Matisia*spp. ("sapodilla"), *schweilera*sp. ("mass"),*Ormosia schunkei*("huayruro"),*Swietenia macrophylla*("mahogany") and *Handroanthus capitatus*("tahuarí") as those with the highest mortality.

Table 8.Annual rate of increase of the species evaluated in PC 11 (N° individuals/ha).

No.	Species		Evaluation 2021			Evaluation 2011			Increase (No./ha)	Percentage (%)
	Common name	Scientific name	Ab.	Density (No./ha)	Density relative (%)	Ab.	Density (No./ha)	Density relative (%)		
1	stick cane	*Astronium graveolens*	626	99.97	15.79	138	16.17	5.73	83.79	518
2	slack	*Myroxylon balsamum*	660	106.33	16.8	305	45.88	16.26	60.45	132
3	yacushapana	*Terminalia oblonga*	352	59.29	9.37	137	9.24	3.27	50.05	542
4	shihuahuaco	*Dipteryx micrantha*	295	48.76	7.7	109	14	4.96	34.76	248
5	Itauba	*Mezilaurus itauba*	180	29.31	4.63	22	0.81	0.29	28.50	3517
6	capirona	*Calycophyllum spruceanum*	147	22.28	3.52	14	1.05	0.37	21.22	2018
7	requisition	*guarea*sp.	355	56	8.85	287	37	13.11	7:00 p.m.	51
8	Mashoned	*Clarisia racemosa*	360	58.76	9.28	336	41.84	14.83	16.91	40
9	quillobordón	*Aspidosperma parvifolium*	228	28.71	4.54	189	17.98	6.37	10.72	60
10	Cedar	*cedrela odorata*	78	12.22	1.93	54	2.83	1	9.40	332
eleven	son-in-law	*Acacia*sp.	54	8.81	1.39	14	0.91	0.32	7.90	864
12	ishpingo	*Amburana cearensis*	53	7.66	1.21	19	0.76	0.27	6.90	909
13	Manchinga	*brosimum alicastrum*	353	56.95	9	375	52.43	18.58	4.52	9
14	ana caspi	*Apuleia leiocarpa*	44	6.28	0.99	twenty-one	1.86	0.66	4.41	237
fifteen	quinilla	*Manilkara bidentata*	49	6.72	1.06	40	3.95	1.4	2.78	70
16	Copaiba	*Reticulated Copaifera*	54	7.1	1.12	37	4.53	1.61	2.57	57
17	white quinilla	*Micropholis egensis*	23	2.91	0.46	14	0.93	0.33	1.98	213
18	catuaba	*qualea paraensis*	12	1.34	0.21	25	0.97	0.34	0.38	39
19	lupuna	*kapok pentandra*	7	0.48	0.08	4	0.19	0.07	0.29	155
twenty	huayo sugar	*Hymenaea oblongifolia*	25	3.83	0.6	31	3.9	1.38	-0.07	- 2
twenty-one	Huimba	*ceiba lupuna*	16	1.33	0.21	28	1.47	0.52	-0.14	-9
22	hookah	*Allantoma decandra*	1	0.03	0.01	6	0.21	0.07	-0.17	-83
23	pumaquiro	*Aspidosperma macrocarpon*	0	0	0	7	0.4	0.14	- 0.40	- 100
24	Catahua	*Hura crackles*	26	1.38	0.22	37	1.83	0.65	-0.45	-25
25	hey	*ficus insipida*	3	0.16	0.02	13	1.1	0.39	-0.95	-86
26	tahuari	*Handroanthus capitatus*	43	3.6	0.57	76	4.67	1.66	-1.07	- 23
27	Mahogany	*Swietenia macrophylla*	0	0	0	13	1.6	0.57	- 1.60	- 100
28	Huayruro	*Ormosia schunkei*	5	0.52	0.08	twenty-one	2.31	0.82	- 1.79	-78
29	Mass	*Eschweilera sp.*	5	0.22	0.04	60	2.95	1.04	- 2.72	-92
30	Sapodilla	*Matisia*spp.	23	1.97	0.31	146	8.41	2.98	- 6.45	-77
Total			4077	632.91	100	2578	282.19	100	350.72	
Standard deviation									20.87	

The results shown in Table 8 allow us to deduce that the opening of clearings as a result of forest exploitation activities (tree felling, construction of roads, drag roads and storage yards) have favored, in general terms, the natural regeneration of the timber forest species whose increase is 350.72 ±20.87 (proportional increase of 56.20%) per ha for an evaluation period of 9 years, extrapolating this last value to the study area (PC11: 2566.05 ha) for the re-evaluation period, the forest would have recovered with 899,965 individuals; carrying out the same analysis for the species with the highest degree of use, which in this case is the species *Dipteryx micrantha* ("shihuahuaco"), for a 20-year rotation cycle, 198,213 individuals of the species would be incorporated into the forest dynamics, thus ensuring its recovery over time, provided that harvesting practices are maintained or improved. of reduced impact and the silvicultural variables defined in the PGMF. These results are part of what was established by Rivas (2005) where he mentions that forest exploitation and other anthropogenic activities could influence the spatial distribution of forest species; it can even significantly alter the abundance and modify the spatial distribution of the natural regeneration of the harvested and remaining species.

Table 9.Comparative historical analysis of abundance in natural regeneration studies post exploitation in the CMRA.

Chambi (2011)		Zapana (2016)		Nana (2018)		Nana (2019)		Nana (2020)		Carcheri (2021)	
PC 08		pcs 12		PC 13		PC 14		PC 15		PC 11	
Species	RA (%)	Species	RA (%)	Species	RA (%)	Species	RA (%)	Species	RA (%)	Species	RA (%)
Manchinga	16.89	slack	22.40	slack	27.10	slack	17.86	slack	19.96	slack	16.19
pashaco	13.94	Manchinga	17.10	macaw c.	11.65	Manchinga	9.57	Mashoned	14.97	stick cane	15.35
slack	13.67	quillobordón	12.50	stick cane	10.85	capirona	8.98	shihuahuaco	11.39	Mashoned	8.83
Moena	11.01	stick cane	11.10	quillobordón	9.57	Mashoned	8.46	Manchinga	10.54	requisition	8.71
requisition	5.88	Mashoned	9.40	Manchinga	9.48	stick cane	7.50	macaw c.	8.92	Manchinga	8.66
stick cane	5.81	shihuahuaco	5.10	Mashoned	7.75	macaw c.	6.97	stick cane	7.26	yacushapana	8.63
Sapodilla	5.31	huayo sugar	4.40	capirona	6.59	shihuahuaco	5.12	Itauba	4.35	shihuahuaco	7.24
Mashoned	3.80	tahuari	3.80	shihuahuaco	3.56	Itauba	4.87	capirona	3.93	quillobordón	5.59
quillobordón	2.88	Cedar	3.00	yacushapana	2.72	huayo sugar	4.87	quinilla	3.55	Itauba	4.42
yacushapana	2.76	yacushapana	2.40	ishpingo	2.61	ishpingo	4.23	ana caspi	3.13	capirona	3.61

Note: The time elapsed between the use and the evaluation of the natural regeneration are the following:

- **2 years: PC 08, 12, 13, 14 and 15**
- **9 years: PC 11**

In Table 9, the species with the greatest presence in the studies of natural regeneration is the *Myroxylon balsamum*("storaque"), appearing as the most abundant in almost all evaluations. Another important species per year evaluated is the manchinga, present in all the studies of the historical analysis. Also, the species *Astronium graveolens*("stick cane") and *Clarisia racemosa*(" mashonaste") are frequent in a considerable proportion. Lastly, the species *Dipteryx micrantha*(" shihuahuaco") is present in the top 10 in 5 of the 6 evaluations, this represents a good indicator of the behavior of the species in the face of the opening of clearings, since it shows a propitious development to ensure the continuity of its populations in the low forest driving.

5.2.1. Abundance and density of forest species by size category

As is understood, the number of seedlings determines the future abundance of mature trees, therefore, the initial phase of the growth of the forest mass is a critical stage that must be considered when trying to use a forest species economically (B. Mostacedo and TS Federicksen (Eds), 2001).

It is important to study the abundance of species in PC 11 according to their size category (sapling, sapling, and stem), since this phytosociological criterion will allow establishing the main adaptive measures that the forest structure poses in natural regeneration.

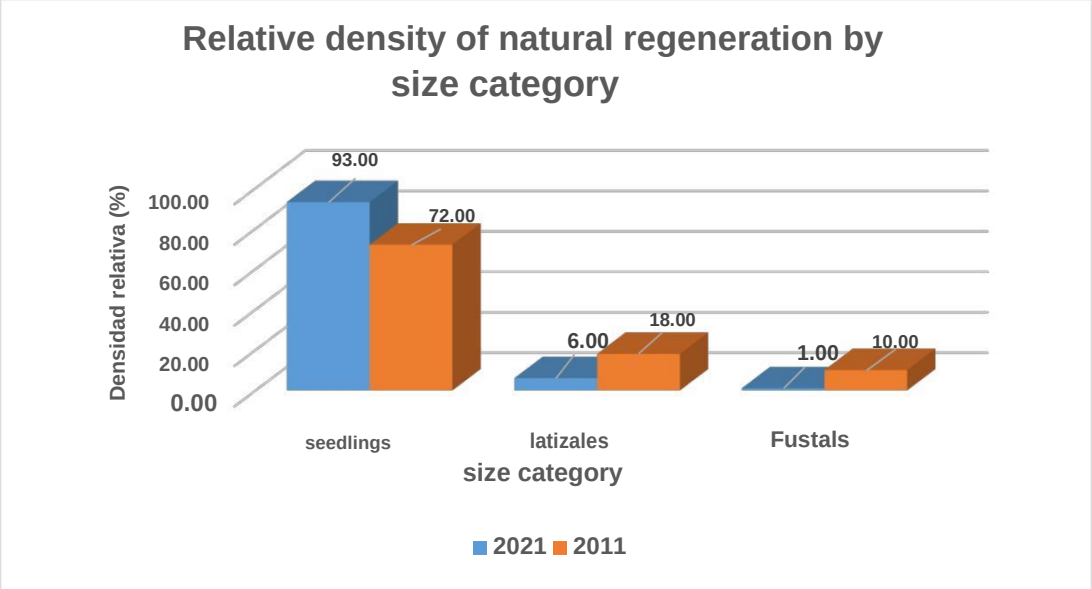


Figure 9.General distribution of the relative density of natural regeneration according to the size category in PC11.

Figure 9 illustrates how after 9 years of forest intervention (2021), the population of timber species is predominantly younger compared to the population before logging (2011). It can be seen how the relative density of seedlings for the year 2021 compared to 2011 is remarkably higher with 21 percentage points above, this is attributed to the fact that forest management operations such as logging, drag roads, roads and storage yards generated an increase in forest dynamics due to the opening of clearings that allowed more light to enter and reduced the basal area, freeing up space in the carrying capacity of the forest, thus promoting greater germination and growth of timber species.

Establishing the density of the species according to their size category will allow us to know those with the best possibilities of development and thus move to the upper strata. The density record of the species evaluated by class is presented below:

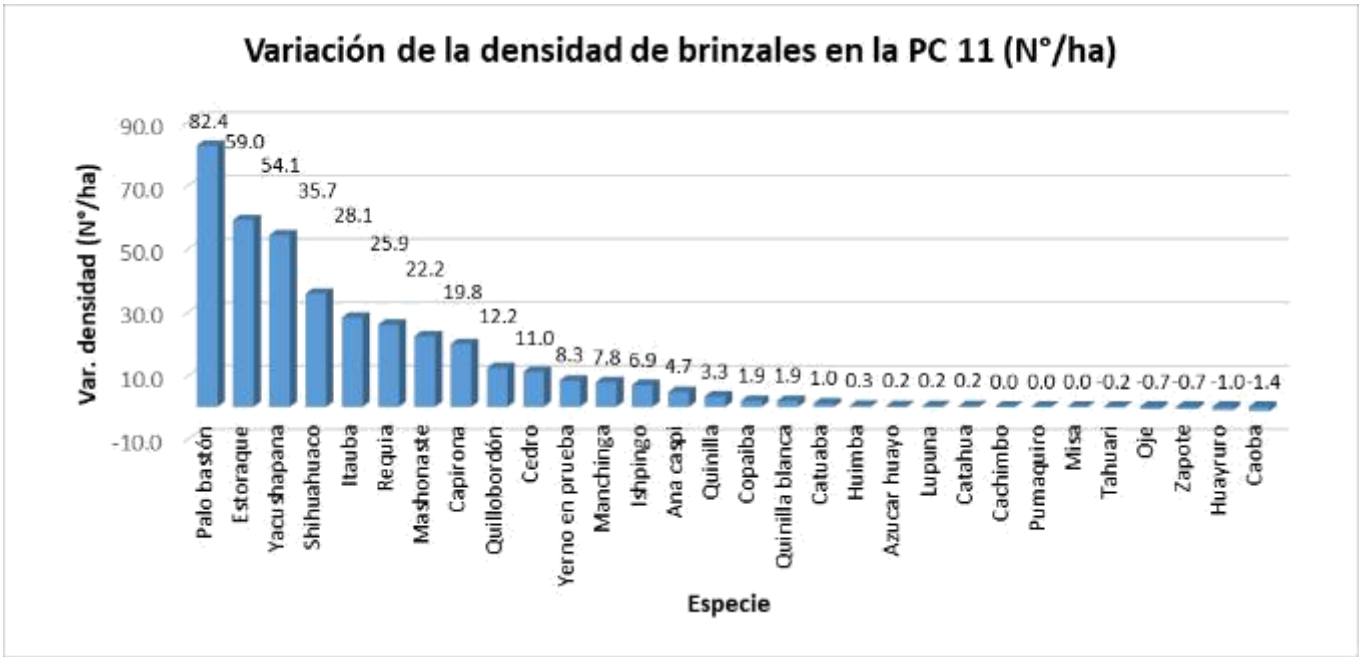


Figure 10.Variation in the density of seedlings according to species in PC11 between the years 2011 and 2021.

Figure 10 shows that in PC 11 the species with the greatest variation in density by recruitment in the seedling stage is the*Astronium graveolens*("palo bastón") with 82.41 individuals/ha, followed by the*Myroxylon balsamum*("storaque") with 58.97 ind/ha, *Terminalia oblonga*("yacushapana") with 54.14 ind/ha,*Dipteryx micrantha*("shihuahuaco") with 35.69 ind/ha and*Mezilaurus itauba*("itauba") with 28.10 ind/ha. It should be noted that the species*Dipteryx micrantha*("shihuahuaco") appears among the most abundant, showing a high regenerative capacity after harvesting. Likewise, it is observed that the species with less variation in abundance in this stage of seedlings are the*kapok pentandra* ("lupuna") with 0.17 ind/ha,*Hura crackles*("catahua") with 0.17 ind/ha,*Allantoma decandra*(" cachimbo") with 0 ind/ha,*Aspidosperma macrocarpon*("pumaquiro") with 0 ind/ha and *schweilera*sp ("mass") with 0 ind/ha, this is mainly due to the particularity of each species, quantity and seed dissemination capacity, flowering stage, seedling germination percentage, etc. Finally, the species that have had a negative variation due to mortality were the*Swietenia macrophylla*("mahogany") with 1.38 ind/ha,*Ormosia schumkei* ("huayruro") with 1.03 ind/ha,*Matisia*spp.("sapote") with 0.69 ind/ha,*ficus insipida*("oje") with 0.69 ind/ha and*Handroanthus capitatus*("tahuari") with 0.17 ind/ha.

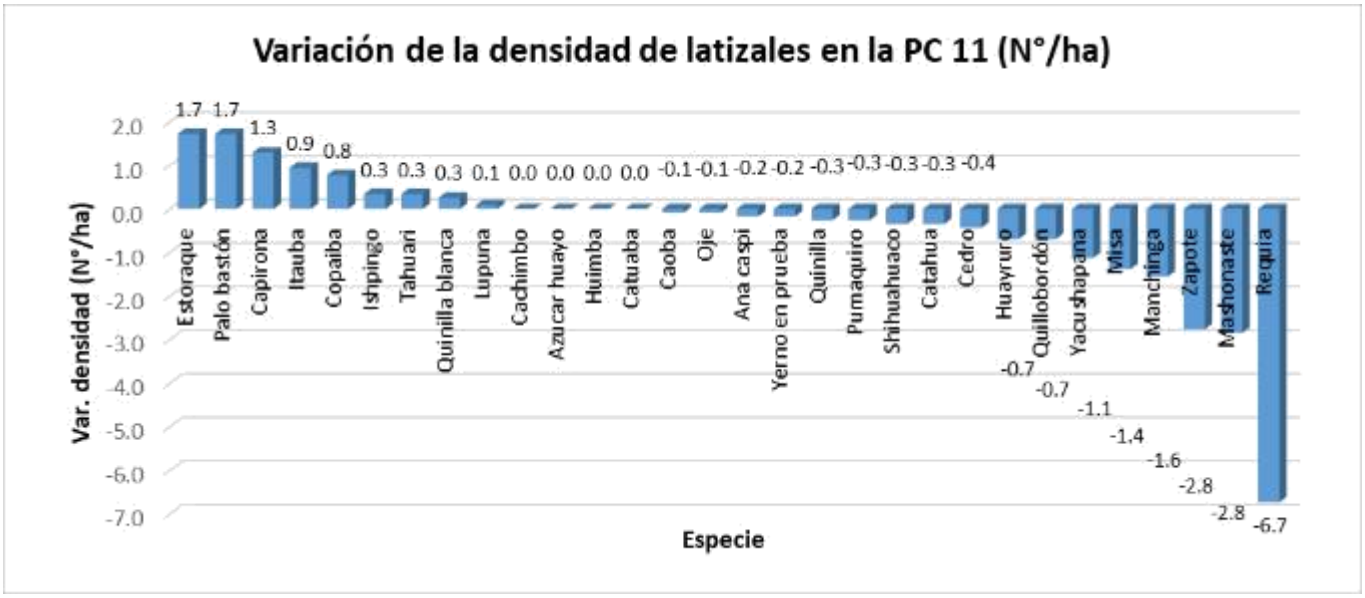


Figure 11.Variation of the density of latizales according to species in PC11 between the years 2011 and 2021.

Figure 11 shows that in PC 11 the species with the greatest variation in density by recruitment in the latizales stage is the*Myroxylon balsamum*("storaque") with 1.72 ind/ha, followed by the *Astronium graveolens*("palo bastón") with 1.72 ind/ha,*Calycophyllum spruceanum*("capirona") with 1.29 ind/ha,*Mezilaurus itauba*("itauba") with 0.95 ind/ha and *Reticulated Copaifera*(" copaiba") with 0.78 ind/ha. Likewise, it is observed that the species with less variation in abundance in this stage of latizales are*kapok pentandra*("lupuna") with 0.09 ind/ha,*qualea paraensis*("catuaba") with 0 ind/ha,*ceiba lupuna*("huimba") with 0 ind/ha, *Hymenaea oblongifolia*("azúcar huayo") con 0 ind/ha y *Allantoma decandra* ("cachimbo") con 0 ind/ha, esto se debe principalmente a la particularidad con las que cuenta cada especie. Finalmente, entre las especies que han tenido una variación negativa por mortandad destacan la *Guarea* sp ("requia") con 6.72 ind/ha, *Clarisia racemosa* ("mashonaste") con 2.84 ind/ha, *Matisia* spp. (" zapote") con 2.76 ind/ha, *Brosimum alicastrum* ("manchinga") con 1.55 ind/ha y *Eschweilera* sp. ("misa") con 1.38 ind/ha.

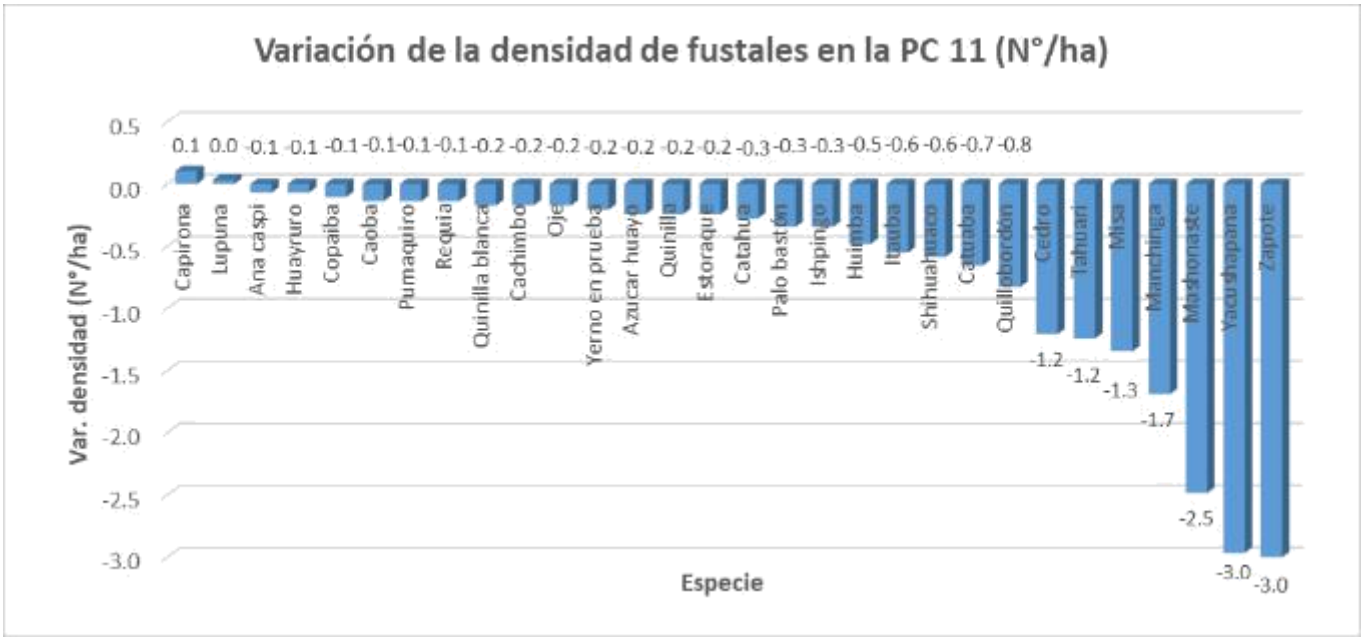


Figura 12. Variación de la densidad de fustales según especie en la PC11 entre los años 2011 y 2021.

La Figura 12 muestra que en la PC 11 las únicas especies con una mínima variación positiva en la etapa de fustales son la *Calycophyllum spruceanum* (“capirona”) y la *Ceiba pentandra* (“lupuna”) with 0.10 ind/ha and 0.03 ind/ha respectively. Likewise, the species that have had the greatest negative variation due to mortality were mainly the*Matisia*spp. (“zapote”) with 3 ind/ha,*Terminalia oblonga*("yacushapana”) with 2.97 ind/ha,*Clarisia racemosa* (“mashonaste”) with 2.48 ind/ha,*brosimum alicastrum*("manchinga”) with 1.69 ind/ha and *schweilera*sp.("mass”) with 1.34 ind/ha. It is important to consider that the species that has had to decrease in the greatest proportion the density of stems as a result of the release for use is the*Dipteryx micrantha*("shihuahuaco") -0.59 ind/ha, which has the highest volume of harvest in the 2012-2013 harvest, the species with a medium proportion of extraction are the*Hymenaea oblongifolia*("sugar huayo") -0.24 ind/ha,*Amburana cearensis* (“ishpingo”) -0.34 ind/ha,*Apuleia leiocarpa (“*ana caspi”) -0.07 ind/ha,*Manilkara bidentata* (“quinilla”) -0.24 ind/ha,*Myroxylon balsamum*("storax") -0.24 ind/ha and*Terminalia oblonga* (“yacushapana”) -2.97 ind/ha, and finally those with the lowest proportion are*Swietenia macrophylla* ("mahogany"),*Handroanthus capitatus*("tahuari"),*Aspidosperma macrocarpon* ("pumaquiro"), *cedrela odorata*("cedar") and*brosimum alicastrum*("manchinga”) with less than 100 m³ of volume felled. However, this does not mean an imbalance due to a greater or lesser volume harvested by each species, since sustainable forest management of the forest is based on silvicultural variables such as the minimum cutting diameter (DMC) and harvest intensity (IC), the latter makes it possible to define the proportion of usable individuals that can be harvested in a given area (PC). The values of the CI executed for the harvested species are below the CI projected in the PGMF, which allows the permanence of a greater number of remaining trees in the forest that add to the role of seed trees so that they fulfill their ecological functions, ensuring future harvests based on natural regeneration.

5.3. Importance Value Index (IVI)

5.3.1. IVI Fustales

The IVI was segregated for each of the size classes in order to study their behavior over the years individually.

Table 10.Summary of the values of the Importance Value Index for Futals in the years 2011 and 2021 on PC 11.

Species		IVI 2021 (%)	IVI 2011 (%)
Common name	Scientific name		
Catahua	*Hura crackles*	12.03	5.04
quillobordón	*Aspidosperma parvifolium*	9.87	5.00
Manchinga	*brosimum alicastrum*	8.98	9.68
stick cane	*Astronium graveolens*	8.71	3.86
Mashoned	*Clarisia racemosa*	7.85	9.47
tahuari	*Handroanthus capitatus*	5.55	5.19
capirona	*Calycophyllum spruceanum*	5.53	1.49
shihuahuaco	*Dipteryx micrantha*	4.89	6.59
slack	*Myroxylon balsamum*	4.57	3.06
Copaiba	*Reticulated Copaifera*	3.29	1.53
quinilla	*Manilkara bidentata*	2.85	1.34
requisition	*guarea*sp	2.73	1.40
lupuna	*kapok pentandra*	2.66	1.51
Huimba	*ceiba lupuna*	2.65	2.65
ishpingo	*Amburana cearensis*	2.60	2.71
ana caspi	*Apuleia leiocarpa*	2.60	1.43
Itauba	*Mezilaurus itauba*	2.41	2.62
catuaba	*qualea paraensis*	1.56	2.85
Mass	*schweiler*asp.	1.50	4.67
son-in-law	*Acacia*sp	1.40	1.17
hey	*ficus insipida*	0.98	1.70
yacushapana	*Terminalia oblonga*	0.96	7.93
white quinilla	*Micropholis egensis*	0.89	1.02
Cedar	*cedrela odorata*	0.80	3.75
hookah	*Allantoma decandra*	0.80	1.25
Sapodilla	*Matisia*spp.	0.69	8.27
huayo sugar	*Hymenaea oblongifolia*	0.65	1.54
Mahogany	*Swietenia macrophylla*	0.00	0.53
Huayruro	*Ormosia schumkei*	0.00	0.23
pumaquiro	*Aspidosperma macrocarpon*	0.00	0.50
Total		100.00	100.00

Table 10 shows that the species with the greatest ecological weight for the year 2021 are the *Hura crackles*("catahua") with 12.03%,*Aspidosperma parvifolium*("quillobordón") with 9.87%, *brosimum alicastrum*("manchinga") with 8.98%,*Astronium graveolens*("stick stick") with 8.71% and*Clarisia racemosa*("mashonaste") with 7.85%. The percentage of dominance that the species presents*Hura crackles*("catahua") in the horizontal structure of the forest lies mainly in the fact that phenotypically the species has diameters above the average and has not been considered in the use until before the evaluation.

The upper diameter classes contain the greatest amount of basal area in the horizontal structure of the forest, which is why after harvesting we observed a significant change in the IVI in stems of the species that have been harvested; he*Dipteryx micrantha* ("shihuahuaco") is a clear example of what has been mentioned as it is identified as the one with the largest volume cut (5,468.572 m3)1reducing the value of the IVI from 6.59% to 4.89%, however despite the decrease it is placed in 8th place out of 30 species analyzed for the study, demonstrating an important participation in the diameter categories below the DMC defined by the company for this species, as well as an adequate resilience capacity to anthropic intervention. Parallel to this, and making a valid comparison with the species *Hymenaea oblongifolia*("azúcar huayo"), this is in the 27th place of the 30 species evaluated, being this the second species with the highest volume felled for the same year (943,645 m3), but with a postharvest behavior very different from that of*Dipteryx micrantha*("shihuahuaco").

It is important to note that forest harvesting has caused important changes in the class of stems within the variations of the IVI values in all species, since the results of the post-harvesting evaluation have shown considerable changes in the basal area of the harvested ones, modifying the percentage values in each one.

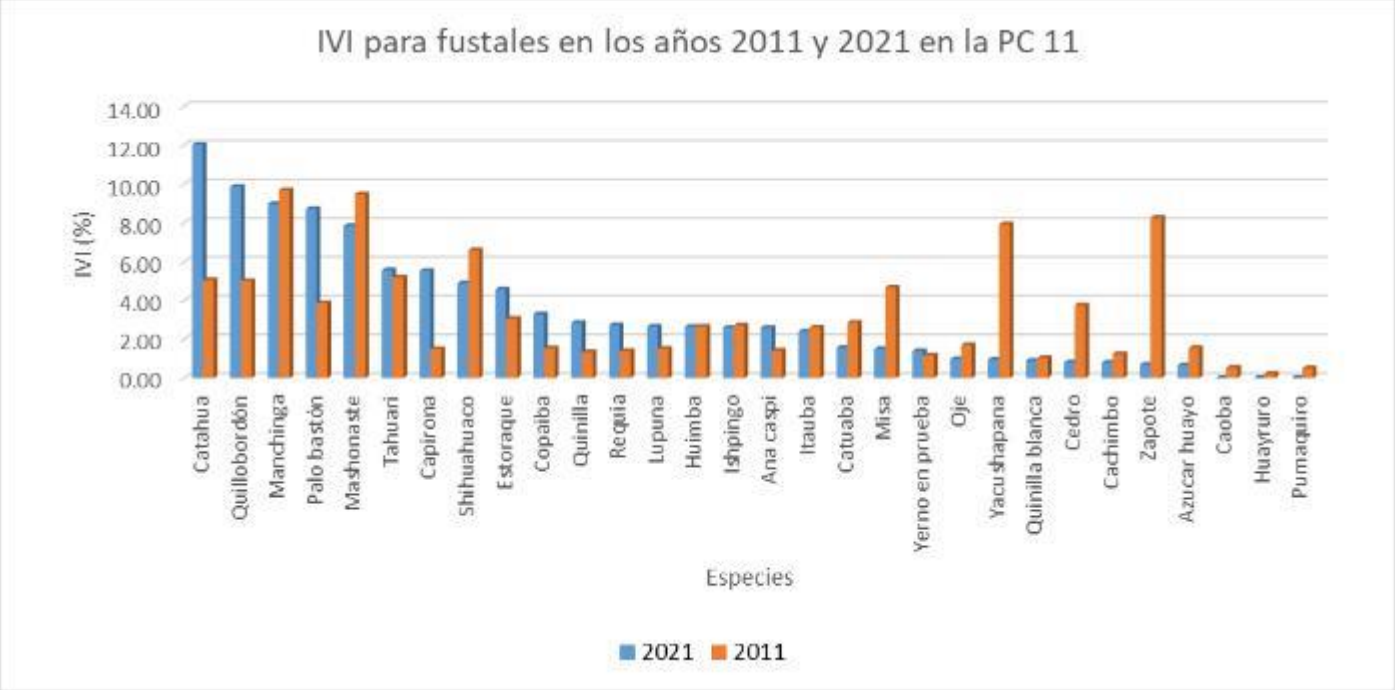


Figure 13.Importance Value Index for fustals in the years 2011 and 2021 in PC 11.

1Report on the execution of the POA for timber forest concessions PCA N°: 11/ZAFRA: 2012-2013

Figure 13 shows the trend of the dynamic behavior of the forest at the stem level in PC 11, reflecting the timber potential for the next felling cycles with emphasis on species not regularly exploited such as*Hura crackles*("catahua") and *Aspidosperma parvifolium* ("quillobordón") where the values of its IVIs are within the first two places, thus also highlighting species such as*Astronium graveolens*("stick cane"),*Calycophyllum spruceanum*("capirona") and*Reticulated Copaifera*("copaiba"), making special mention of the case of*Calycophyllum spruceanum*("capirona"), whose population of stems has been the most benefited after 9 years of exploitation. There is also an important participation in the IVI of other species that are already part of the portfolio of species subject to annual harvesting and that show a significant level of permanence or recovery in the latizales category, as is the case of*Dipteryx micrantha* ("shihuahuaco") where, despite having been one of the species with the highest harvest intensity, its IVI value after 9 years of use is among the first 8 places of importance, which indicates that it maintains healthy postharvest populations under the silvicultural standards implemented in MADERACRE SAC. There is also the case of species that, despite having been exploited, their stem populations have benefited from the new ecological conditions of the intervened forest, to increase their value of importance, in the case of*Apuleia leiocarpa*("ana caspi"),*Myroxylon balsamum*("storax"),*Manilkara bidentata*(" quinilla") and*Handroanthus capitatus*("tahuari").

In general terms, it can be considered that the best positioning of the stems of the species *Hura crackles*("catahua"),*Aspidosperma parvifolium*("quillobordón"),*Astronium graveolens* ("stick cane"),*Handroanthus capitatus*("tahuari"),*Calycophyllum spruceanum* ("capirona"), *Myroxylon balsamum*("storax"),*Reticulated Copaifera*("copaiba"),*Manilkara bidentata*(" quinilla"),*guarea*sp. ("request"),*kapok pentandra*("lupuna"),*Apuleia leiocarpa* ("ana caspi") and*Acacia*sp. ("son-in-law on trial") has been due to the liberation of the basal area of the ecosystem by the extraction of individuals of the exploited species, which means that the percentage values have a greater weight in the mentioned species; the species *Handroanthus capitatus*("tahuari"),*Myroxylon balsamum*("storax"),*Manilkara bidentata* ("quinilla") and*Apuleia leiocarpa*("ana caspi"), despite having been part of the exploited species, have had an improvement in their percentage values in the IVI, this does not necessarily mean that the values of Abundance, Frequency and Dominance increased, but that these results are influenced by the important number of individuals and volumes of the species*Dipteryx micrantha*("shihuahuaco") removed from the forest after harvesting and it is its decrease in the initial IVI that has allowed to improve the ecological position of other species (harvested or not).

Given this situation, it is important to determine, at the level of the management plan, the silvicultural variables such as the Minimum Cutting Diameter (DMC) and the Harvest Intensity (IC) appropriate for each species, this with the purpose of leaving enough trees per below the DMC seed producers that together with the trees selected as seed (20% of individuals above the DMC), ensure the productive and ecological sustainability of the forest.

5.3.2. IVI Latizales

Table 11.Summary of the values of the Importance Value Index for latizales in the years 2011 and 2021 on PC 11.

Species		IVI 2021 (%)	IVI - 2011 latizales low (%)	IVI – 2011 tall latizales (%)
Common name	Scientific name			
quillobordón	*Aspidosperma parvifolium*	16.78	10.31	17.15
stick cane	*Astronium graveolens*	11.92	6.52	5.82
slack	*Myroxylon balsamum*	10.85	11.98	3.14
Sapodilla	*Matisia*spp.	7.27	5.81	13.28
requisition	*guarea*sp.	6.62	23.42	4.66
tahuari	*Handroanthus capitatus*	4.84	3.85	1.37
Manchinga	*brosimum alicastrum*	4.73	5.79	7.03
Copaiba	*Reticulated Copaifera*	3.37	2.47	0.52
Huimba	*ceiba lupuna*	3.08	0.00	3.48
capirona	*Calycophyllum spruceanum*	3.01	0.41	0.83
shihuahuaco	*Dipteryx micrantha*	2.97	3.46	1.20
white quinilla	*Micropholis egensis*	2.91	1.23	1.37
quinilla	*Manilkara bidentata*	2.69	2.06	3.66
Mashoned	*Clarisia racemosa*	2.55	6.49	9.57
yacushapana	*Terminalia oblonga*	2.52	3.17	7.15
Itauba	*Mezilaurus itauba*	2.46	0.00	0.42
Cedar	*cedrela odorata*	2.36	2.35	4.05
ishpingo	*Amburana cearensis*	1.82	0.41	0.46
Catahua	*Hura crackles*	1.71	1.64	1.99
huayo sugar	*Hymenaea oblongifolia*	1.13	1.64	0.00
Huayruro	*Ormosia schumkei*	1.09	1.23	3.40
ana caspi	*Apuleia leiocarpa*	1.03	1.64	0.96
catuaba	*qualea paraensis*	0.88	0.00	0.87
lupuna	*kapok pentandra*	0.49	0.41	0.00
hey	*ficus insipida*	0.49	0.82	0.00
son-in-law	*Acacia*sp.	0.23	0.41	0.93
Mass	*schweiler*asp.	0.23	2.06	5.44
hookah	*Allantoma decandra*	0.00	0.00	0.00
Mahogany	*Swietenia macrophylla*	0.00	0.00	0.43
pumaquiro	*Aspidosperma macrocarpon*	0.00	0.41	0.82
Total		100.00	100.00	100.00

Table 11 shows that the species with the greatest ecological weight for the year 2021 in the latizales category are*Aspidosperma parvifolium*("quillobordón") with 16.78%,*Astronium graveolens* ("stick stick") with 11.92%,*Myroxylon balsamum*("storax") with 10.85%,*Matisia* spp. ("zapote") with 7.27% and*guarea*sp. ("requia") with 6.62%. The IVI of the species *Aspidosperma parvifolium*("quillobordón") is positioned in first place because it is driven by high abundance and its wide distribution in most strips.

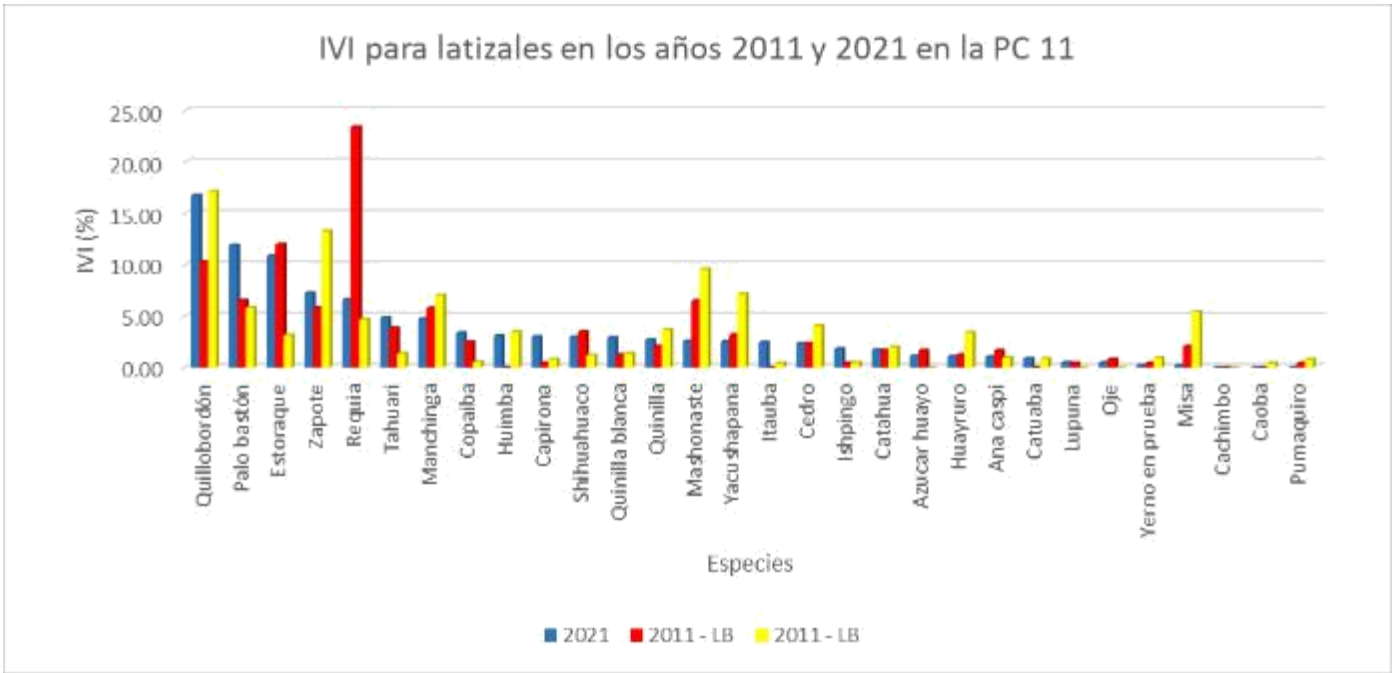


Figure 14.Importance Value Index for latizales in the years 2011 and 2021 in PC 11.

Figure 14 shows the trend of the dynamic behavior of the forest at the level of latizales in PC 11, reflecting the development of some species compared to the forest exploitation carried out in 2012, where it denotes that species such as*Aspidosperma parvifolium* (“quillobordón”) and*Astronium graveolens*("stick stick”) are within the first two places and have developed better in the face of the opening of clearings generated. It is important to note that the species*Myroxylon balsamum*("storaque") has had substantial improvements in its IVI value, since, for the study carried out by the company in 2011, it showed a second position in low latizales and thirteenth in high latizales, compared to current studies of a third position in general terms in the latizal stratum, shows that it has had a good development in the face of the opening of clearings generated by the exploitation activities. A similar case occurred with the species *Aspidosperma parvifolium*(" quillobordón") that for previous studies showed a third position in low latizales and first in high latizales, compared to the current study we see a notable improvement, since it is consolidated in the first position.

5.3.3. IVI Brinzales

Table 12.Summary of the values of the Importance Value Index for seedlings in the years 2011 and 2021 on PC 11.

Species		IVI 2021 (%)	IVI 2011 (%)
Common name	Scientific name		
slack	*Myroxylon balsamum*	12.19	15.71
stick cane	*Astronium graveolens*	11.59	7.24
yacushapana	*Terminalia oblonga*	8.49	3.31
Manchinga	*brosimum alicastrum*	8.36	17.23
Mashoned	*Clarisia racemosa*	8.18	14.08
shihuahuaco	*Dipteryx micrantha*	7.72	7.39
requisition	*guarea*sp.	7.06	11.01
Itauba	*Mezilaurus itauba*	5.69	0.00
quillobordón	*Aspidosperma parvifolium*	4.84	5.70
capirona	*Calycophyllum spruceanum*	3.51	0.71
Cedar	*cedrela odorata*	3.36	0.24
ishpingo	*Amburana cearensis*	2.99	0.00
Copaiba	*Reticulated Copaifera*	2.88	3.03
quinilla	*Manilkara bidentata*	2.62	2.50
ana caspi	*Apuleia leiocarpa*	2.38	1.42
son-in-law	*Acacia*sp.	2.00	0.28
huayo sugar	*Hymenaea oblongifolia*	1.94	2.75
white quinilla	*Micropholis egensis*	1.44	0.24
tahuari	*Handroanthus capitatus*	1.27	2.17
Huimba	*ceiba lupuna*	0.42	0.24
catuaba	*qualea paraensis*	0.34	0.00
Catahua	*Hura crackles*	0.28	0.24
Sapodilla	*Matisia*spp.	0.14	0.99
Huayruro	*Ormosia schumkei*	0.14	1.66
lupuna	*kapok pentandra*	0.14	0.00
hey	*ficus insipida*	0.00	0.75
Mass	*schweilera*sp.	0.00	0.00
hookah	*Allantoma decandra*	0.00	0.00
Mahogany	*Swietenia macrophylla*	0.00	1.12
pumaquiro	*Aspidosperma macrocarpon*	0.00	0.00
Total		100.00	100.00

Table 12 shows that the species with the greatest ecological weight for the 2021 study are *Myroxylon balsamum*("storax") with 12.19%,*Astronium graveolens*("stick stick") with 11.59%,*Terminalia oblonga*("yacushapana") with 8.49%,*brosimum alicastrum*("manchinga") with 8.36% and*Clarisia racemosa*("mashonaste") with 8.18%. The first two species that occupy the first places show a high percentage of abundance compared to the results of the study carried out in 2011 where the species were in the second and sixth

place, respectively, this shows that the response to the opening of clearings caused by logging operations has been favorable. It is worth noting the case of the species*Dipteryx micrantha*("shihuahuaco"), ranking 6th in the seedling category, which has risen one position in the table, increasing its IVI due to the increase in abundance and the degree of dispersion for this category, being an important achievement for a species that in its higher categories of diameter reach outstanding dimensions that end up influencing the result of the general IVI of the species, so the result for the category of seedlings is more significant considering that in this there is no presence of large trees that can influence the Dominance variable of this IVI. For its part, the important ecological weight of this category in the species*Dipteryx micrantha*("shihuahuaco") is indicative of the adequate process of population recovery that it has been experiencing after its use within the framework of the forest management plan, and it can be inferred that forest management under the conditions defined by MADERACRE SAC generates a more favorable scenario for the sustainability of the species compared to a forest without intervention.

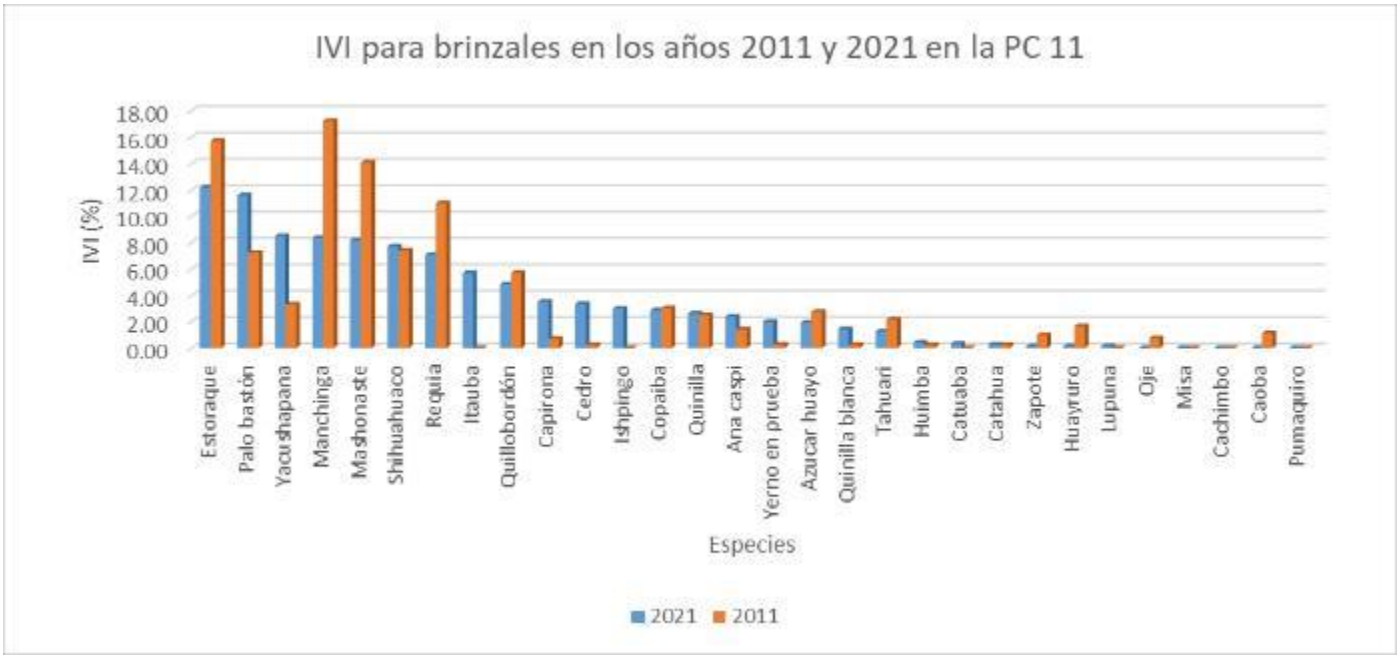


Figure 15.Importance Value Index for seedlings in PC 11.

Figure 15 shows the trend of the dynamic behavior of the forest for the category of seedlings in PC 11, reflecting the development of some species compared to the forest exploitation carried out in 2012, where it denotes that the species*Myroxylon balsamum*("storax"), despite the reduction in the percentage value compared to 2011, it is positioned as the most important species at the seedling level, followed by the *Astronium graveolens*("stick cane"),*Terminalia oblonga*("yacushapana"),*brosimum alicastrum*("manchinga") and*Clarisia racemosa*(" mashonaste"), which have been the most favored due to the opening of clearings and the dynamics that this has generated. It is important to indicate that the species*Hura crackles*(" catahua"), despite having the highest IVI in the fustal class, it is one of the lowest in the sapling class, this allows us to infer that it does not have a good growth and development stimulus when faced with the opening of gaps by the activities of use.

5.4. Population equilibrium curve

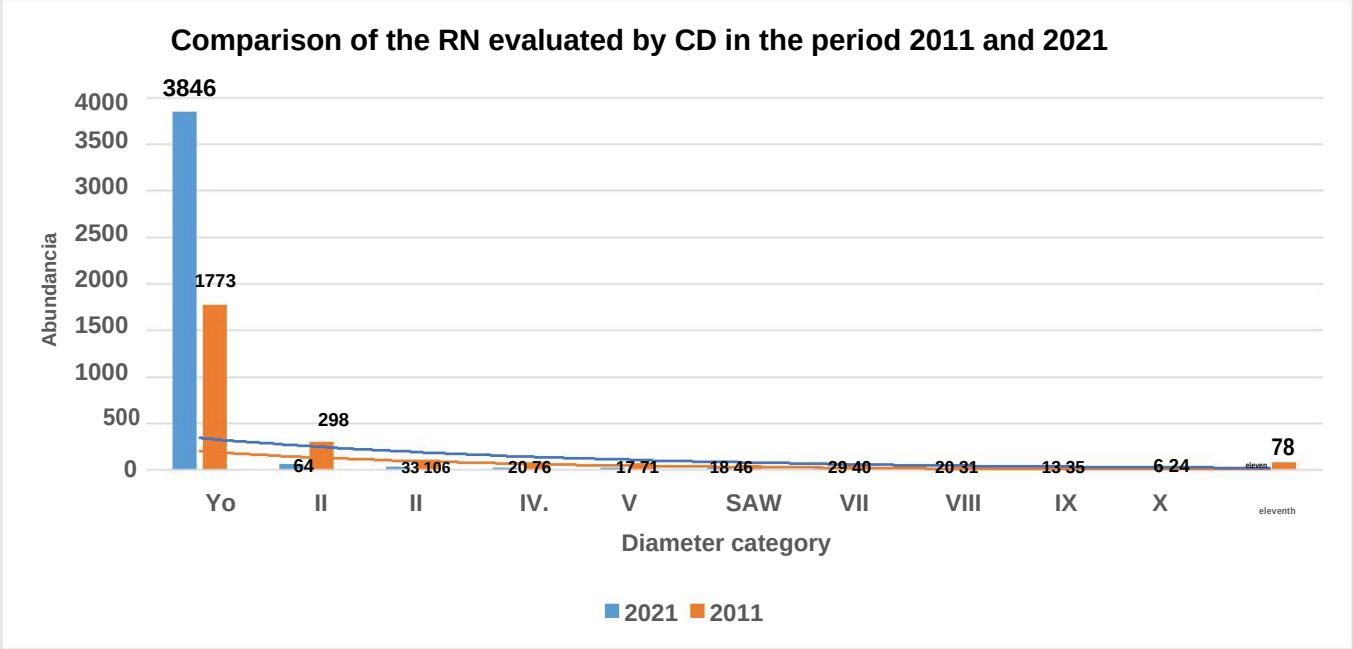
5.4.1. Diameter Classification (CD)

In the following section, the analysis of the distribution of diameter classes for the different tree species will be discussed, evaluating their ecological and conservation status; in particular, it allows detecting the lack and/or richness of regeneration (Ajbilou et al. 2003).

Table 13.Classification by diameter class of the forest species evaluated in PC 11.

Classification by diameter class																												
Evaluation year	2021	2011	2021	2011	2021	2011	2021	2011	2021	2011	2021	2011	2021	2011	2021	2011	2021	2011	2021	2011	2021	2011	2021	2011	2021	2011	2021	2011
size class	seedlings		latizales										Fustals														Total	
Category	IB		IL		II		II		IV.		V		SAW		VII		VIII		IX		X		eleventh					
Species	< 10				10-19.9		20-29.9		30-39.9		40-49.9		50-59.9		60-69.9		70-79.9		80-89.9		90-99.9		> 100					
ana caspi	33	6	4	6	3	2		1	1		1	2	2			1				2		1			13	fifteen
huayo sugar	twenty	19	4	4		2												1	1	1		2		2	twenty	12
hookah													1		1			1		1	1	1		1	1	6		
Mahogany		8		1				2		1										1					8	5		
capirona	118	3	18	3		1	3		1	1		1			1		3	2	1		1		1	3	14	eleven		
Catahua	2	1	4	8	1	2	2		1		1	2		3	3	4	4	3	3	1	2	3	3	10	twenty-one	36		
catuaba	6		2	2	3	7		1		1		4		2	1	1		3		1				3	4	25		
Cedar	65	1	eleven	16	1	17		8		6		1	1	1		2		1						1	3	53		
Copaiba	32	twenty-one	16	7	1	1	1					2					1	1	1	3	2			2	27	16		
slack	580	238	69	49	1	5	3	2		1	3	5	3		1			1		1				3	249	67		
Huayruro	1	7	4	12		2																			7	14		
Huimba	3	1	7	7	2	4		4	1	2		1		1	3			2		4		1		1	7	27		
ishpingo	40	1	6	2		5	5	2		5	1	1		1	1	1						1		1	8	19		
Itauba	162		13	1	1	9		4	1			1	1	2			2			2		1		2	5	22		
lupuna	1		2	1	2																		2	3	4	4		
Manchinga	319	274	fifteen	33	5	fifteen	1	4		2	1	5	1	6	2	5	4	5	4	7		3	1	fifteen	293	100		
Mashoned	333	204	8	41	2	40	4	10	2	3	1	7	3	6	5	9	1	4	1	4		3		3	223	130		
Mass			1	17	1	eleven	2	16		5		2		1		3	1	1		1		1		2	4	60		
hey		4	1	2		2					1				1							1		4	6	9		
stick cane	548	70	54	3. 4	8	10	2	8	3	5	4	4	2	1	4			2		1			1	3	94	68		
pumaquiro				3		2				1				1											0	7		
quillobordón	123	52	75	83	16	36	4	5	5	1	2	3	1	4	1	2		1		1			1		82	136		
quinilla	32	13	12	fifteen		7		1	1			2	1	2			1		1				1		18	27		
white quinilla	12	1	9	6	1	2		1		1					1	1						1		1	3	13		
requisition	300	150	46	124	4	8	2	2	2	1	1	1						1							159	137		
shihuahuaco	277	69	10	14		2	2	3		2		1			2	1	2	1	1			4	1	12	77	40		
tahuari	9	10	17	13	9	30	2	6	2	6		6	2	2	2	1								2	27	66		
yacushapana	337	23	13	26	1	32		18		17		5		7		5	1			1				2	25	113		
son-in-law	fifty	2	1	3		1		1		2	1	1	1	2	1	1						1			5	12		
Sapodilla	1	5	twenty	52	2	43		7		13		14		3		2		1		3				2	7	140		
Total	3404	1183	442	585	64	298	33	106	twenty	76	17	71	18	46	29	40	twenty	31	13	35	6	24	eleven	78	1414	1390		

Table 13 shows the distribution of diameter classes in the evaluation periods 2011 and 2021, which will be analyzed by means of bar graphs that are presented below.



I: <10 (cm); II: 10-19.9 (cm); III: 20-29.9 (cm); IV: 30-39.9 (cm); V: 40-49.9 (cm); LV: 50-59.9 (cm); VII: 60-69.9 (cm); VIII: 70-79.9 (cm); IX: 80-89.9 (cm); X: 90-99.9 (cm); XI: > 100 (cm)

Figure 16.Diameter classes of natural regeneration of the forest species evaluated in the years 2011 and 2021 in PC11.

In general, the individuals evaluated in both years represent a trend of the curve in the typical inverted J shape. The CD "I" of the year 2021 shows a considerable recruitment of individuals in its evaluation compared to 2011, noting that the opening of clearings as a result of forest exploitation activities favors the establishment and development of individuals of the smaller diameter classes. , especially that of saplings, ensuring the abundance of successors for the upper DCs in a greater proportion than in a forest without intervention.

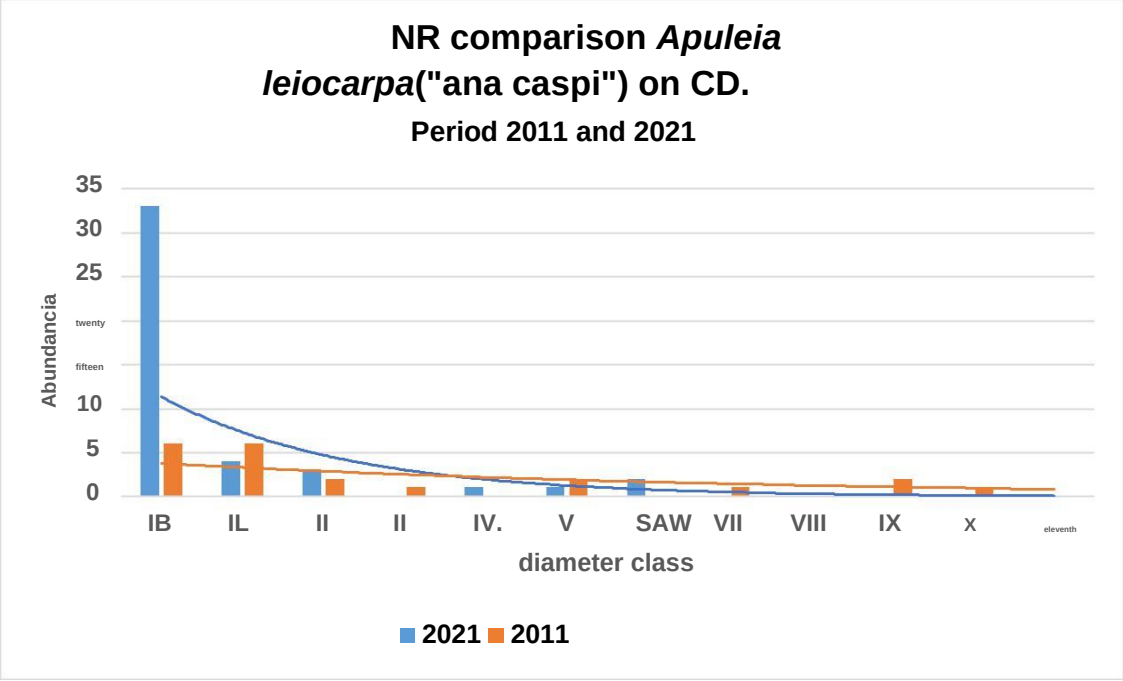
fact that could be being used more efficiently by another group of species not considered in this evaluation; In addition to this, it is mentioned in the studies carried out by Licona (2007) in PPMs post logging in Amazonian forests in the Department of Pando (Bolivia) that the average natural mortality rate in stems for a treatment under silvicultural standards, similar to the one applied the company MADERACRE SAC, increases from 1.28% in 2004 to 2.84% in 2005, indicating that the lower diameter classes are the most affected (CD 5-10 cm slats with greater affectation), and decreases as it advances towards the classes superiors becoming similar in the latter.

behavior similar to that mentioned. The explanation supported by the author was that the increase in the rate may be due to forest use that caused the opening of the canopy and the entry of light, favoring the species that require it, but not the species that do not need it, which that could cause the death of individuals of these.

Lastly, it is necessary to mention that from CD "VIII" onwards, and according to the DMC established by the company, the extraction of individuals selected for harvesting has caused a decrease in abundance, compared to non-disturbed forests where The generation of gaps due to the natural fall of trees are infrequent events that generate relatively small tree mortality values, as is the case of the studies carried out in Cocha Cashu, with an average mortality rate of 1.6 % (Romo, 2005), and the Amazon forest of Pando (Bolivia) within the BOLFOR Project 1.71% (Licona, 2007).

Figure 16 shows that the trend of the inverted J curve for the year 2021 is much more exponential compared to that of 2011, representing greater forest dynamics, with more abundant lower CDs and on which a better process would be based. of development of the population of commercial species in the direction of stages of growth and productivity in the coming years as the start of a new felling cycle approaches. This allows us to infer that the scenario of a forest under management with appropriate silvicultural parameters would present better conditions for the development of this group of species in comparison with undisturbed forests.

I. Analysis by species:*Apuleia leiocarpa*("ana caspi")



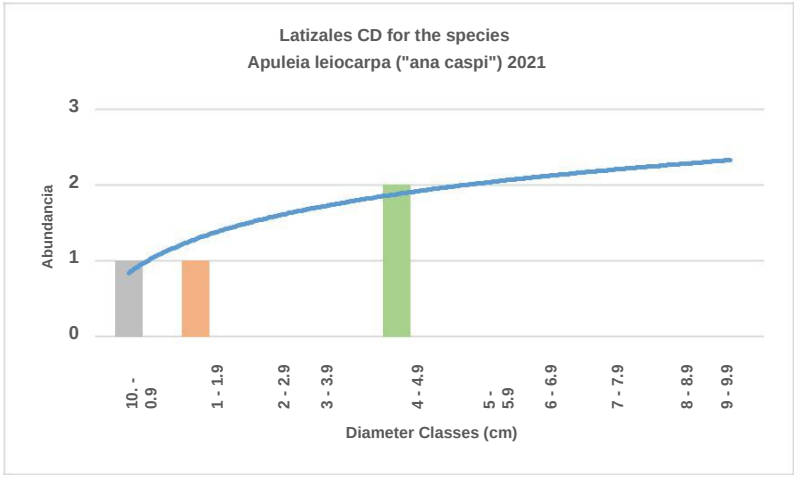
IB: Seedlings; IL: Latizales; II: 10-19.9 (cm); III: 20-29.9 (cm); IV: 30-39.9 (cm); V: 40-49.9 (cm); LV: 50-59.9 (cm); VII: 60-69.9 (cm); VIII: 70-79.9 (cm); IX: 80-89.9 (cm); X: 90-99.9 (cm); XI: > 100 (cm)

Figure 17.Diameter classes of natural regeneration of*Apuleia leiocarpa*("ana caspi") in the years 2011 and 2021 in PC11 for the evaluated area.

Figure 17 shows a significant increase in individuals of the species*Apuleia leiocarpa* (“ana caspi”) in the CD “IB” (RN increase rate in seedlings: 450 %,) this indicator allows to know the degree of response that the species possesses in front of the activities of forest exploitation. In the CD "IL" the decrease of individuals from 2011 to 2021 is observed, however, the opening of clearings as a result of forest exploitation has generated a greater income of light, accelerating the growth dynamics mainly of intermediate and suppressed individuals of the tree layer as a result of the new ecological conditions fostered by the use, which allows species such as the*Apuleia leiocarpa*("ana caspi”) generates better probabilities of obtaining individuals established towards the category of stems compared to those found under canopy in primary forests without intervention. In general, it is observed that in some CD there is an increase in individuals typical of a better development due to recruitment of the species in the face of the opening of gaps, which is significantly conspicuous in the seedlings. Reviewing the curve we can distinguish the exponential increase in the abundance of individuals in the early stages of the natural regeneration of the species for the year 2021, which denotes the important contribution of exploitation to induce a high increase in the natural regeneration of the species. , basic for the recovery of its postharvest population. The upper diameter classes do not have large individuals, since part of this group of the population was exploited within the framework of the area management plan (DMC: 0.70 m). The harvest intensity (CI) for the species during the harvest carried out in 2012 was 57.78%, a value considerably lower than that established in the PGMF (100%), remaining a greater number of individuals in the forest that will provide genetic material for natural regeneration, in addition to the contribution to the formation of a random dispersed network of seed trees and remnants that are below the DMC throughout the harvested PC.

Species	DAP at 9 years post harvest in 11.6 ha (Latizales) (cm)	Growth annual diameter (cm)	Estimated time for DAP Goal (70 cm) (years)
Apuleia leiocarpa("ana caspi")	0.50	0.67	103.73
	1.20	0.67	102.69
	4.00	0.67	98.51
	4.00	0.67	98.51

Concept	Total
Number of individuals in latizales evaluated in PC 11 (11.6 ha)	4
N° individuals standing on latizales applying % Mortality* (11.6 ha)	3.64
No. of individuals standing on stems that reached the DAP Target applying % Mortality** (11.6 ha)	3.53
No. of individuals recruited to poles (10,000 ha)	3,041
Projected average volume for 105 years with target DAP 70 cm (m_3/ 10,000 ha)	15,213.4
Projected volume in 105 years (m_3/ind.)	5,003



* Mortality rate in latizales Forest UNAS Tingo María Huánuco (Baldomero, 2011). Low L.: 8.9%; L. tall: 7.39%

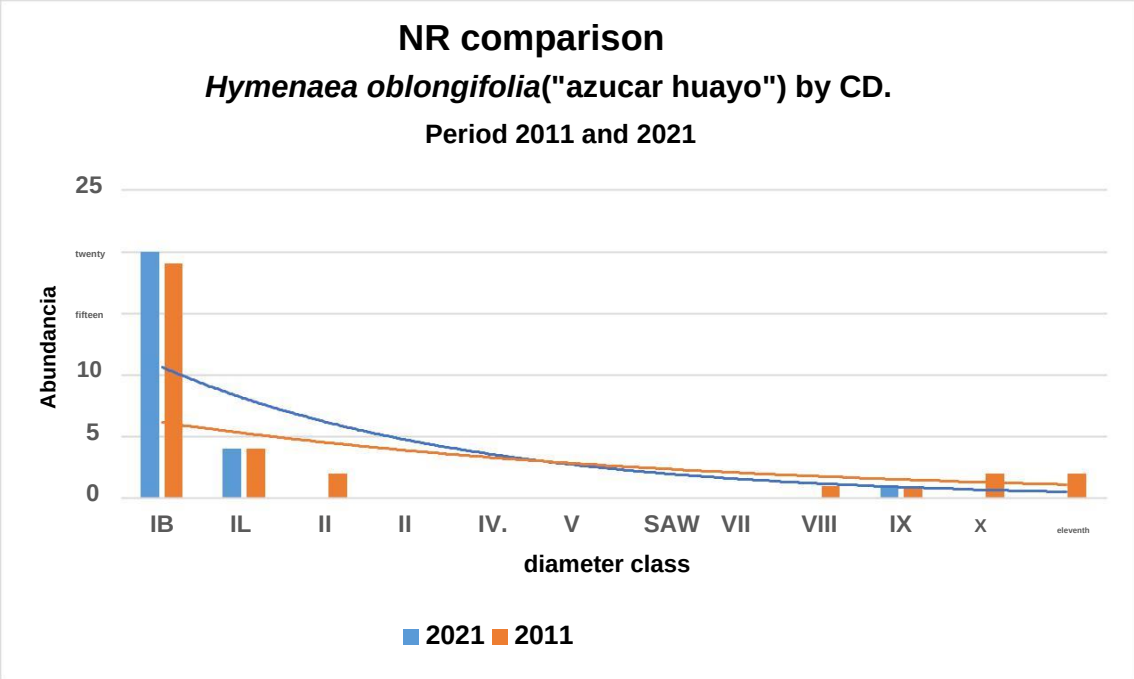
* * Mortality rate for stems Bosque UNAS Tingo María Huánuco (Baldomero, 2011). Fustals: 3.2%

Figure 18.Projection of the Cutting Cycle at the level of latizales with reference to the volume and number of individuals for the use of the species*Apuleia leiocarpa*("ana caspi").

Figure 18 shows the timber potential of the species*Apuleia leiocarpa*("ana caspi") by projecting growth for an approximate target time of 105 years (target DBH 70 cm at a diametric growth rate of 0.67 cm/year) taking individuals at the latizal level as a starting point, obtaining as a final result a projected volume of 15,213.4 m_3(1,521 m_3/ha) and a population of 3,041 individuals (0.304 ind/ha) established for an extension of 10,000 ha, which corresponds to the area of a type PC in the MADERACRE FMU. It is important to point out that the mortality rates for the classes of saplings and stems used in this report are the result of studies for the structure of tropical forests, but not specific to the species; however, the highest mortality values have been used. high levels found for the purpose of making conservative calculations and projections; the results are almost 5 times higher than the volume and number of individuals registered in the PC 11 UMF MADERACRE with 0.392 m_3/ha and 0.077 ind/ha, respectively. Based on what has been described, the supply of wood of the species for future forest use is guaranteed; however, it should be taken into consideration that the results described are preliminary, and it is necessary to carry out complementary studies that generate information on the rates of

mortality, recruitment, and growth for the species under forest conditions at the UMF MADERACRE.

b. Analysis by species:*Hymenaea oblongifolia*("huayo sugar")



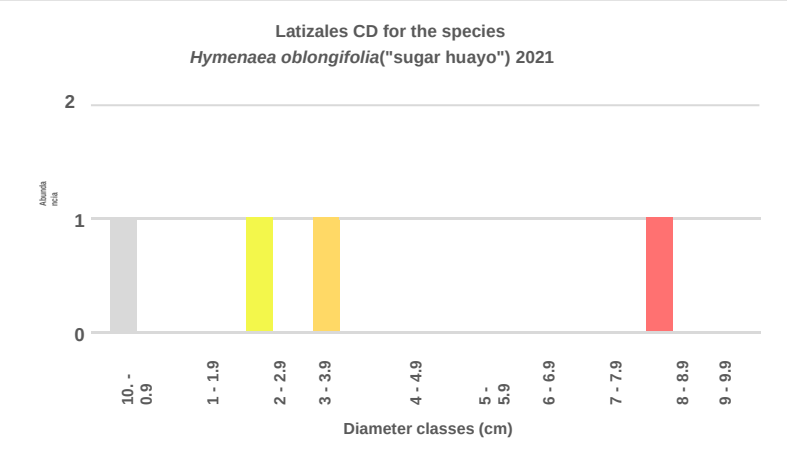
IB: Seedlings; IL: Latizales; II: 10-19.9 (cm); III: 20-29.9 (cm); IV: 30-39.9 (cm); V: 40-49.9 (cm); LV: 50-59.9 (cm); VII: 60-69.9 (cm); VIII: 70-79.9 (cm); IX: 80-89.9 (cm); X: 90-99.9 (cm); XI: > 100 (cm)

Figure 19.Diameter classes of natural regeneration of*Hymenaea oblongifolia*("sugar huayo") in the years 2011 and 2021 in PC11 for the evaluated area.

Figure 19 shows that the CD "IB" of the species*Hymenaea oblongifolia*("azúcar huayo") does not have a significant variation after harvesting (RN increase rate in seedlings: 5.26%), therefore it can be deduced that the opening of clearings as a result of forest harvesting activities has not led to a relevant increase in the seedling class. In the same way, in the CD "IL" there is no evidence of a variation of individuals from the year 2011 to 2021, however, a greater income of light has been generated, which accelerates the growth dynamics mainly of intermediate and intermediate individuals. suppressed from the tree layer, this could positively influence species such as the*Hymenaea oblongifolia*("azucar huayo"), generating better probabilities of obtaining individuals established towards the category of stems compared to those found under the canopy in primary forests without intervention. The upper diameter classes do not have large individuals, since part of this group of the population was exploited within the framework of the area management plan (DMC: 0.80 m). The harvest intensity for the species during the exploitation carried out in 2012 was 77.18%, a value considerably lower than that established in the PGMF (100%), remaining a greater number of individuals in the forest that will provide genetic material for natural regeneration. , in addition to the contribution to the formation of a random dispersed network of seed trees and remnants that are below the DMC throughout the harvested PC. Due to the characteristics of the regeneration of the species, its monitoring should continue in order to better understand its population dynamics over time and optimize the silviculture of the species.

Species	DAP at 9 years post harvest in 11.6 ha (Latizales) (cm)	Growth annual diameter (cm)	Estimated time for DAP Goal (75 cm) (years)
Hymenaea oblongifolia ("sugar huayo")	0.90	0.64	115.78
	2.00	0.64	114.06
	3.90	0.64	111.09
	8.50	0.64	103.91

Concept	Total
Number of individuals in latizales evaluated in PC 11 (11.6 ha)	4
N° individuals standing on latizales applying % Mortality* (11.6 ha)	3.67
No. of individuals standing on stems that reached the DAP Target applying % Mortality** (11.6 ha)	3.55
No. of individuals recruited to poles (10,000 ha)	3,063
Projected average volume for 116 years with target DAP 75 cm (m_3/ 10,000 ha)	19,347.9
Projected volume in 116 years (m_3/ind.)	6,318



* Mortality rate in latizales Forest UNAS Tingo María Huánuco (Baldomero, 2011). Low L.: 8.9%; L. tall: 7.39%

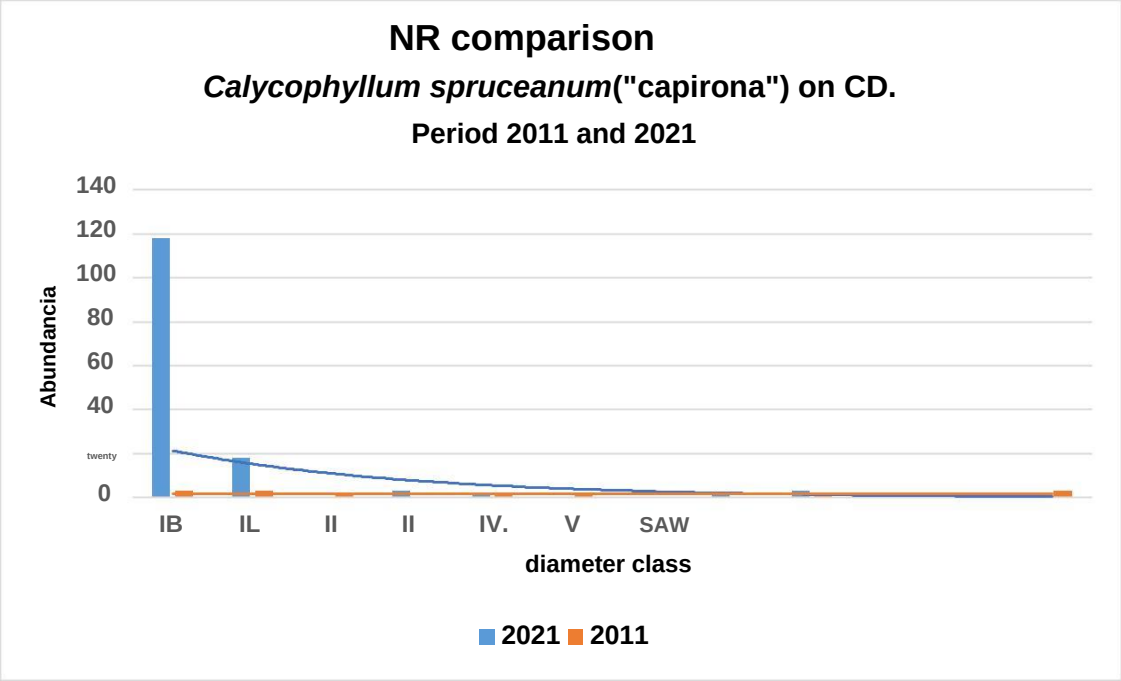
* * Mortality rate for stems Bosque UNAS Tingo María Huánuco (Baldomero, 2011). Fustals: 3.2%

Figure 20.Projection of the Cutting Cycle at the level of latizales with reference to the volume and number of individuals for the use of the species*Hymenaea oblongifolia*("sugar huayo").

Figure 20 shows the timber potential of the species*Hymenaea oblongifolia*("azucar huayo") by projecting growth for an approximate target time of 116 years (target DBH 75 cm at a diameter growth rate of 0.64 cm/year) taking individuals at the latizal level as a starting point, obtaining as a final result a projected volume of 19,347.9 m_3(1,934 m_3/ha) and a population of 3,063 individuals (0.306 ind./ha) established for an extension of 10,000 ha, which corresponds to the area of a typical PC in the MADERACRE FMU. It is important to point out that the mortality rates for the latizales and stems size classes used in this report are the result of studies for the structure of tropical forests, but not specific to the species; however, the highest mortality values have been cited. high to obtain conservative figures for projection calculations; Despite this, these are almost 4 times higher than the volume and 5 times the number of individuals registered in the PC 11 UMF MADERACRE with 0.528 m_3/ha and 0.064 ind./ha, respectively. Based on what has been described, the supply of wood for future forest use is guaranteed; however, it must be taken into account that the results are preliminary and it is necessary to generate

information on mortality rates, recruitment and growth of the species in the conditions of the forest under management in MADERACRE.

C. Analysis by species:*Calycophyllum spruceanum*("capirona")



IB: Seedlings; IL: Latizales; II: 10-19.9 (cm); III: 20-29.9 (cm); IV: 30-39.9 (cm); V: 40-49.9 (cm); LV: 50-59.9 (cm); VII: 60-69.9 (cm); VIII: 70-79.9 (cm); IX: 80-89.9 (cm); X: 90-99.9 (cm); XI: > 100 (cm)

Figure 21.Diameter classes of natural regeneration of*Calycophyllum spruceanum* (“capirona”) in the years 2011 and 2021 in PC11 for the evaluated area.

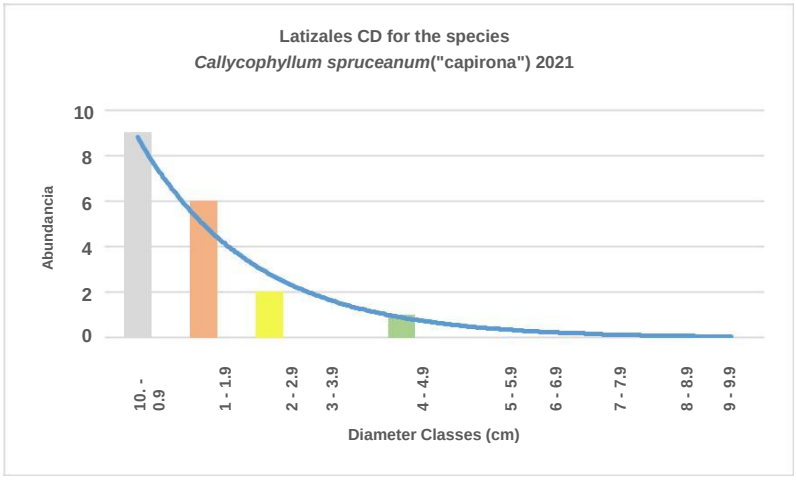
Figure 21 shows a considerable recruitment of individuals of the species*Calycophyllum spruceanum*("capirona") in the CD "IB" (RN increase rate in seedlings: 3833 %) this indicator allows to know the positive exponential response that the species has in front of the gaps generated by forest exploitation. Parallel to this, in CD "IL" the increase of individuals from 2011 to 2021 is also observed, which favors a logical succession of the development of the species, as a positive response to the new forest conditions after logging. In general, no significant difference is observed in the following CDs, this is due to the fact that the impact of the use in increasing the dynamics of the forest in these first 9 years would be influencing the initial stage of the natural regeneration of the species, it is also worth noting the ability of the species that, Despite appearing with a very small number of adult individuals in the forest without intervention, it manages to have an exponential reaction in the dispersal and establishment of new natural regeneration when the carrying capacity of the ecosystem is released. To this is added its rapid level of diametric growth, having reached a rate of 0.67 cm/year for mature trees in the range of [35.00 - 75.00 cm][2]which makes it a promising species for management since it could occupy a greater space of the basal area of the forest in the

[2]Technical report N°004-2022-CCR-Diametric growth rate of timber species in the MADERACRE SAC forestry concession.

future rotations. Special attention should be paid to the monitoring of this species in order to better understand its population dynamics after harvesting operations.

Species	DAP at 9 years post harvest in 11.6 ha (Latizales) (cm)	No. ind.	Growth diametral annual (cm)	Estimated time for DAP Goal (65 cm) (years)
Calycophyllum spruceanum ("capirona")	< 1	9	0.67	96.34
	< 2	6	0.67	94.96
	2	1	0.67	94.03
	2.9	1	0.67	92.69
	4	1	0.67	91.04

Concept	Total
Number of individuals in latizales evaluated in PC 11 (11.6 ha)	18
N° individuals standing on latizales applying % Mortality* (11.6 ha)	16.40
No. of individuals standing on stems that reached the DAP Target applying % Mortality** (11.6 ha)	15.87
No. of individuals recruited to poles (10,000 ha)	13,684
Projected average volume for 97 years with target DAP 65 cm (m3/10,000 ha)	56,078.0
Projected volume in 97 years (m3/ind.)	4,098



* Mortality rate in latizales Forest UNAS Tingo María Huánuco (Baldomero, 2011). Low L.: 8.9%; L. tall: 7.39%

* * Mortality rate for stems Bosque UNAS Tingo María Huánuco (Baldomero, 2011). Fustals: 3.2%

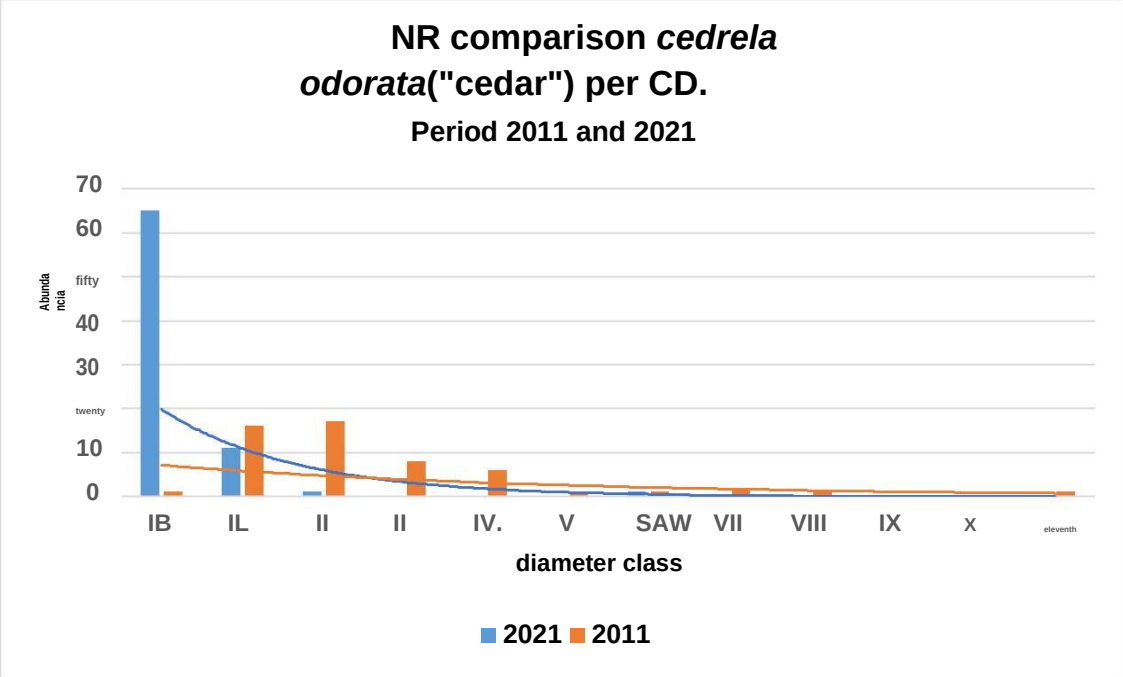
Figure 22. Projection of the Cutting Cycle at the level of latizales with reference to the volume and number of individuals for the use of the species*Calycophyllum spruceanum*("capirona").

Figure 22 shows the timber potential of the species*Calycophyllum spruceanum* ("capirona") by projecting growth for an approximate target time of 97 years (target DBH 65 cm at a diametric growth rate of 0.67 cm/year) taking individuals at the latizal level as a starting point, obtaining the final result a projected volume of 56,078.0 m3 (5,607 m3/ha) and a population of 13,684 individuals (1,368 ind/ha) established for an extension of 10,000 ha that corresponds to a typical CP in the MFU of MADERACRE. It is important to note that the mortality rates for the sapling and stem size classes used in this report are the result of studies for the structure

from tropical forests, but not typical of the species, however, the highest values have been quoted to carry out conservative projection calculations; Despite this, these are almost 13 times higher than the volume and number of individuals registered in the PC 11 UMF MADERACRE with 0.457 m3/ha and 0.105 ind/ha, respectively. Based on what has been described, the supply of wood for future forest use would be guaranteed; However, these results are preliminary and there is a need to generate information on mortality rates, recruitment and growth of the species under the conditions of the forest managed in MADERACRE.

The upper CDs present a low or null number of individuals, which denotes the low presence of the species in a forest without intervention, since the effect of harvesting 9 years after its execution would still not be visible on the saplings and stems (classes larger diameter). However, the exponential increase in the number of seedlings and the liberation of space in the carrying capacity of the ecosystem due to the decrease in the basal area, would be generating better conditions for the future establishment of a greater number of individuals in the larger DCs, increasing the ecological weight of this species in the FMU of MADERACRE SAC as a consequence of the exploitation carried out in the felling plots.

d. Analysis by species:*cedrela odorata*("cedar")



IB: Seedlings; IL: Latizales; II: 10-19.9 (cm); III: 20-29.9 (cm); IV: 30-39.9 (cm); V: 40-49.9 (cm); LV: 50-59.9 (cm); VII: 60-69.9 (cm); VIII: 70-79.9 (cm); IX: 80-89.9 (cm); X: 90-99.9 (cm); XI: > 100 (cm)

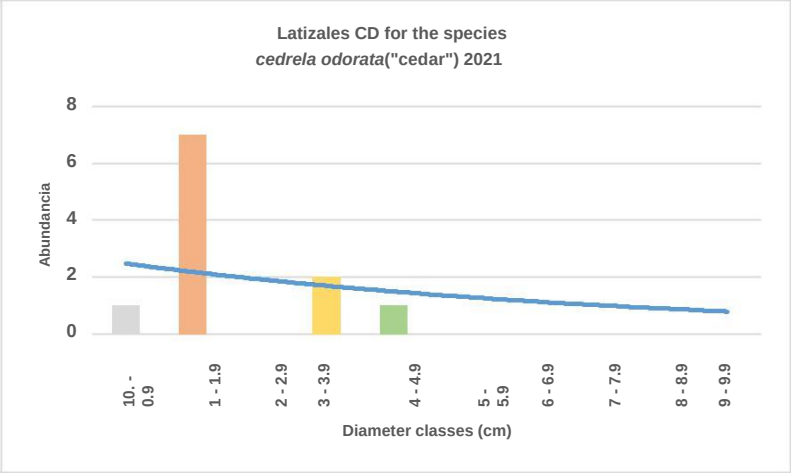
Figure 23.Diameter classes of natural regeneration of*cedrela odorata*("cedar") in the years 2011 and 2021 in PC11 for the evaluated area.

Figure 23 shows a considerable recruitment of individuals of the species*cedrela odorata* ("cedro") in CD "IB" (increase rate of NR in seedlings: 6400 %), this indicator allows knowing the degree of significant response that the species has to the gaps left by logging. In the CD "IL" the decrease of individuals from 2011 to 2021 is observed, however, the opening of clearings as a result of forest exploitation generates a

greater entry of light into the understory and thus accelerates the growth dynamics in the place, consequently, it is estimated that this will allow species such as the*cedrela odorata*(" cedar") generate higher probability indices of obtaining individuals established towards the category of stems compared to those found under the canopy in primary forests without intervention. In the remaining diameter classes there is a considerable reduction in the abundance of individuals that could be occurring due to borer attacks or another condition generated by the change in forest dynamics; however, the post-harvesting exponential increase in the abundance of the early stages of regeneration could ensure an increase in the ecological weight of the species in the coming years. It is necessary to continue with the studies to know the evolution of the natural regeneration of the species. The upper diameter classes do not have large individuals, since part of this group of the population was used within the framework of the management plan of the area (DMC: 0.70 m). The harvest intensity for the species during the exploitation carried out in 2012 was: 50%, a value considerably lower than that established in the PGMF (100%), remaining a greater number of individuals in the forest that will provide the genetic material for regeneration natural, in addition to the contribution to the formation of a random dispersed network of seed trees and remnants that are below the DMC throughout the harvested PC.

Species	DAP at 9 years post harvest in 11.6 ha (Latizales) (cm)	Growth annual diameter (cm)	Estimated time for DAP Goal (70 cm) (years)
cedrela odorata("cedar")	0.3	1.12	62.23
	1	1.12	61.61
	1	1.12	61.61
	1	1.12	61.61
	1.1	1.12	61.52
	1.20	1.12	61.43
	1.50	1.12	61.16
	1.90	1.12	60.80
	3.00	1.12	59.82
	3.00	1.12	59.82
	4.60	1.12	58.39

Concept	Total
Number of individuals in latizales evaluated in PC 11 (11.6 ha)	eleven
N° individuals standing on latizales applying % Mortality* (11.6 ha)	10.02
No. of individuals standing on stems that reached the DAP Target applying % Mortality** (11.6 ha)	9.70
No. of individuals recruited to poles (10,000 ha)	8,362



Projected average volume for 63 years with target DAP 70 cm (m3/10,000 ha)	**39,745.0**
Projected volume in 63 years (m3/ind.)	**4,753**

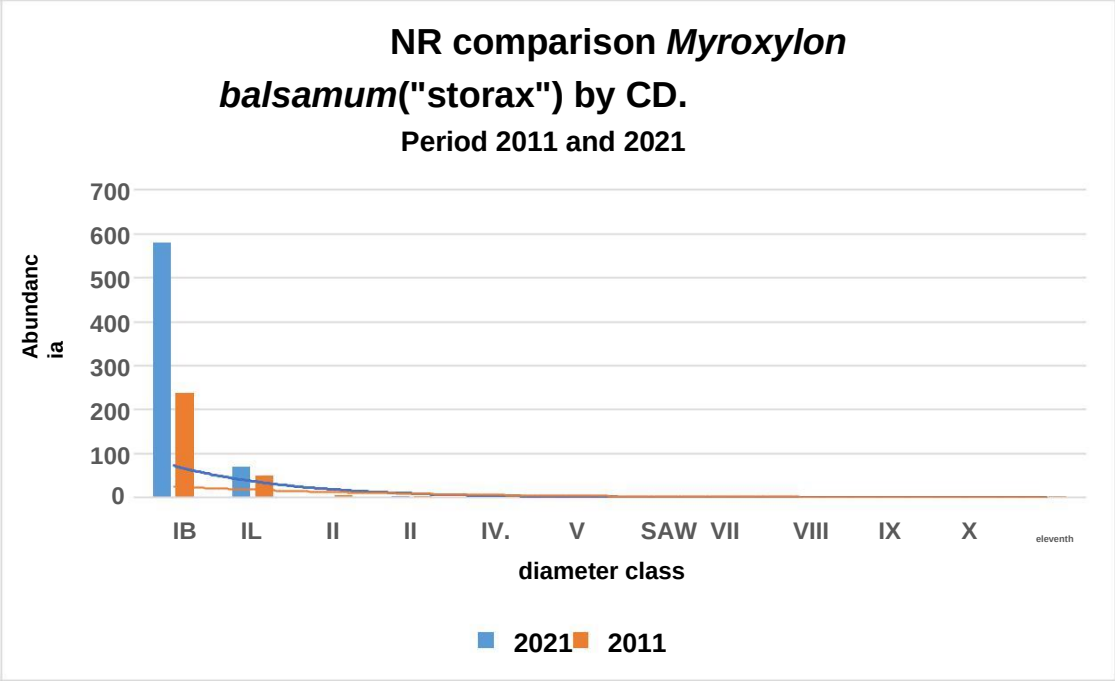
* **Mortality rate in latizales Forest UNAS Tingo María Huánuco (Baldomero, 2011). Low L.: 8.9%; L. tall: 7.39%**
* ***Mortality rate for stems Bosque UNAS Tingo María Huánuco (Baldomero, 2011). Fustals: 3.2%**

Figure 24.Projection of the Cutting Cycle at the level of latizales with reference to the volume and number of individuals for the use of the species*cedrela odorata*("cedar").

Figure 25 shows the timber potential of the species*cedrela odorata*("cedar") by projecting growth for an approximate target time of 63 years (target DBH 70 cm at a diametric growth rate of 1.12 cm/year) taking individuals at the latizal level as a starting point, obtaining as a final result a volume projected 39,745.0 m_3(3,974 m_3/ha) and a population of 8,362 individuals (0.836 ind/ha) established for an extension of 10,000 ha, which corresponds to the area of a type PC in the FMU of MADERACRE. It is important to note that the mortality rates for the latizales and stems size classes used in this report are the result of studies for the structure of tropical forests, but not specific to the species, however conservative values have been quoted and used for projection calculations; Despite this, these are almost 46 times higher than the volume and number of individuals registered in the PC 11 UMF MADERACRE with 0.087 m_3/ha and 0.018 ind/ha, respectively. Based on what has been described, the future supply of wood for forest use is guaranteed; however, it must be taken into account that the results are preliminary and there is a need to generate information on mortality rates, recruitment and growth of the species under the conditions of the forest under management.

The upper diameters of the category of Latizales present a low or null number of individuals, which allows us to interpret that recruitment to the category of poles is not immediately assured in the coming years. However, the high number of individuals in the lower classes as a result of the intervention of the forest could constitute a solid base to increase the ecological weight of this species in the coming years. Special attention should be paid to monitoring this species in order to better understand its population dynamics over time.

AND. Analysis by species:*Myroxylon balsamum*("storax")



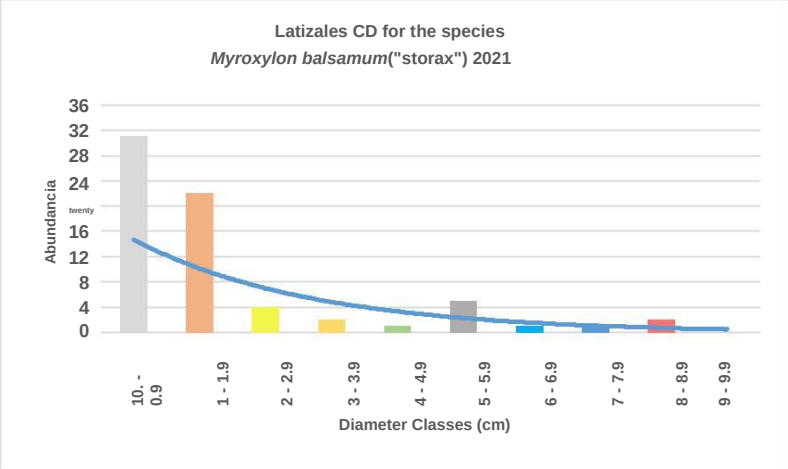
IB: Seedlings; IL: Latizales; II: 10-19.9 (cm); III: 20-29.9 (cm); IV: 30-39.9 (cm); V: 40-49.9 (cm); LV: 50-59.9 (cm); VII: 60-69.9 (cm); VIII: 70-79.9 (cm); IX: 80-89.9 (cm); X: 90-99.9 (cm); XI: > 100 (cm)

Figure 25.Diameter classes of natural regeneration of*Myroxylon balsamum*("storax") in the years 2011 and 2021 in PC11 for the evaluated area.

Figure 25 shows a considerable recruitment of individuals of the species*Myroxylon balsamum*("storax") in CD "IB" (RN increase rate in saplings: 144 %), this indicator allows knowing the degree of response that the species has to the changes generated in the forest by logging. Parallel to this, in the CD "IL" the increase of individuals from 2011 to 2021 is observed, which favors a logical succession of the development of the species as a positive response of the intermediate and suppressed individuals of the arboreal stratum as a result of the greater ingress of light and release of the carrying capacity of the ecosystem caused by forest exploitation, it is estimated that this will be translated into better probabilities of obtaining individuals established towards the category of stems for*Myroxylon balsamum*in the medium term. In general, no significant difference is observed in the remaining DC, which allows us to deduce that from the good results obtained in DC "I" and the release of the carrying capacity of the ecosystem, the recruitment in the DC of latizales and older could increase, making it opportune to continue with the evaluations over time to validate this hypothesis. The upper diameter classes do not have large individuals, since part of this group of the population was exploited within the framework of the area management plan (DMC:
0.60 m). The harvest intensity for the species during the exploitation carried out in 2012 was: 58.12%, a value considerably lower than that established in the PGMF (90%),

Species	DAP at 9 years post harvest in 11.6 ha (Latizales) (cm)	No. ind.	Growth diametral annual (cm)	Estimated time for DAP Goal (60 cm) (years)
Myroxylon balsamum("storax")	< 1	31	0.54	110.30
	< 2	22	0.54	108.57
	<3	4	0.54	106.72
	< 4	2	0.54	105.09
	< 5	1	0.54	103.70
	< 6	5	0.54	101.85
	6.3	1	0.54	99.44
	7	1	0.54	98.15
	8.5	1	0.54	95.37
	8.5	1	0.54	95.37

Concept	Total
Number of individuals in latizales evaluated in PC 11 (11.6 ha)	69
N° individuals standing on latizales applying % Mortality* (11.6 ha)	63.09
No. of individuals standing on stems that reached the DAP Target applying % Mortality** (11.6 ha)	61.07
No. of individuals recruited to poles (10,000 ha)	52,650
Average volume projected for 111 years with DBH target 60 cm (m3/10,000 ha)	193,524.2
Projected volume in 111 years (m3/ind.)	3,676



* Mortality rate in latizales Forest UNAS Tingo María Huánuco (Baldomero, 2011). Low L.: 8.9%; L. tall: 7.39%

* * Mortality rate for stems Bosque UNAS Tingo María Huánuco (Baldomero, 2011). Fustals: 3.2%

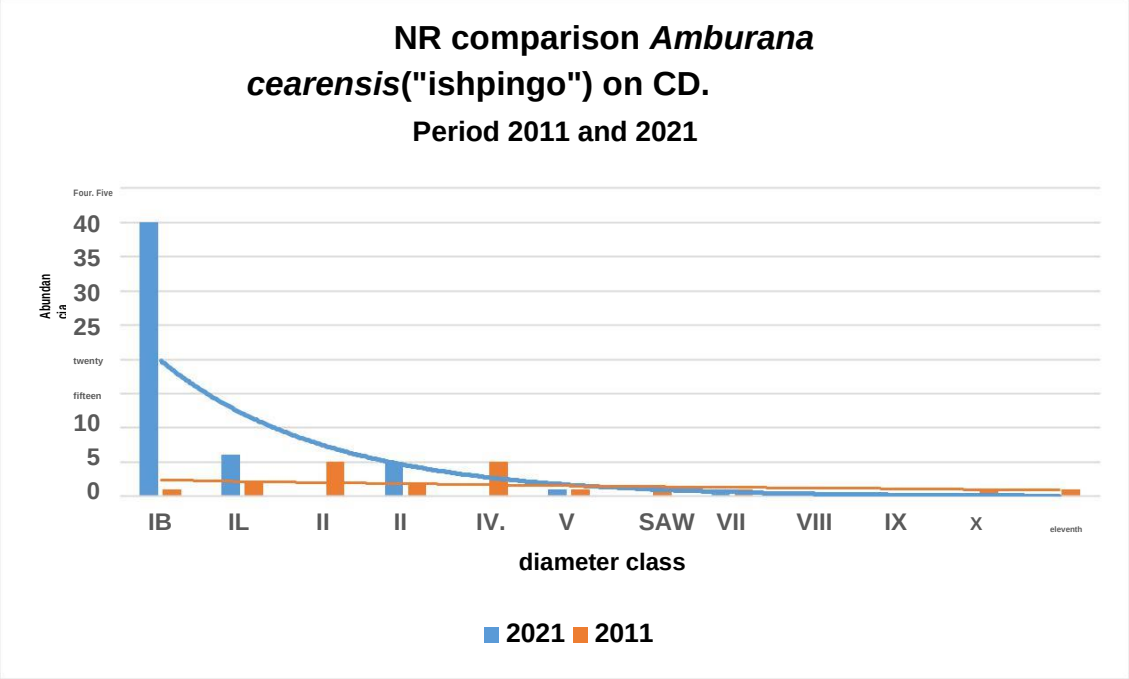
Figure 26.Projection of the Cutting Cycle at the level of latizales with reference to the volume and number of individuals for the use of the species*Myroxylon balsamum*("storax").

Figure 26 shows the timber potential of the species*Myroxylon balsamum*("storaque") by projecting growth for an approximate target time of 111 years (target DBH 60 cm at a diametric growth rate of 0.54 cm/year) taking individuals at the latizal level as a starting point, obtaining as a final result a volume projected 193,524.2 m_3(19,352 m_3/ ha) and a population of 52,650 individuals (5,265 ind/ha) established for an extension of 10,000 ha, which corresponds to the average area for a typical CP in the FMU MADERACRE. It is important to note that the mortality rates for the size classes

saplings and stems used in this report are the result of studies for the structure of tropical forests, but not typical of the species, however high mortality values have been cited to obtain conservative projection calculations; Despite this, these are almost 19 times higher than the volume and 25 times the number of individuals registered in the PC 15 CONSOLIDATED MADERACRE with 1,038 m3/ha and 0.218 ind/ha, respectively. Based on what has been described, the supply of wood for future forest use is guaranteed; however, it must be taken into account that the results are preliminary, since they need to be reviewed once information on mortality rates, recruitment and growth of the species in the MADERACRE FMU is available.

Analyzing the category of Latizales, a high number of individuals is observed in the first CDs that then decreases towards the upper ones, revealing that there is a logical succession of inverted "J" type growth where there should be a greater abundance in the CDs. lower to ensure the continuity of the species in the face of natural processes and/or disturbances that generate mortality. The higher DCs present a low number of individuals, but in greater abundance compared to the other species in this study, which allows us to deduce that recruitments to the category of poles are ensured in a timely manner in the coming years in order to optimize the growth and productive development of the species.

F. Analysis by species:*Amburana cearensis*("ishpingo")



IB: Seedlings; IL: Latizales; II: 10-19.9 (cm); III: 20-29.9 (cm); IV: 30-39.9 (cm); V: 40-49.9 (cm); LV: 50-59.9 (cm); VII: 60-69.9 (cm); VIII: 70-79.9 (cm); IX: 80-89.9 (cm); X: 90-99.9 (cm); XI: > 100 (cm)

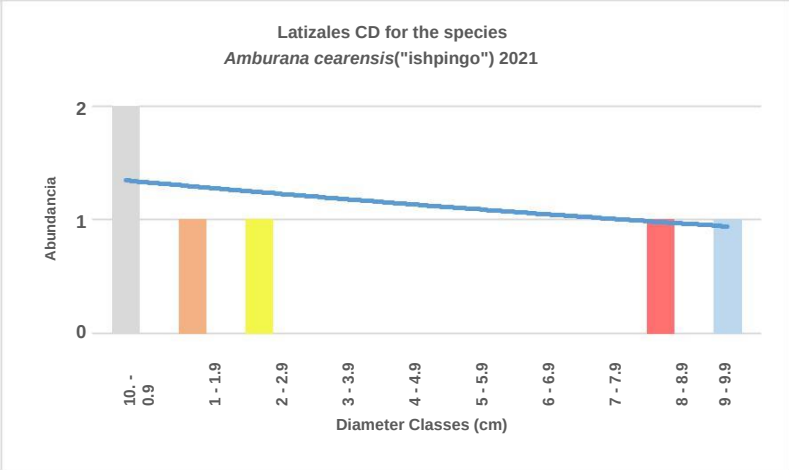
Figure 27.Diameter classes of natural regeneration of*Amburana cearensis*("ishpingo") in the years 2011 and 2021 in PC11 for the evaluated area.

Figure 27 shows how the changes generated in the forest from its selective use have generated an exponential increase in the recruitment capacity of the species. *Amburana cearensis*("ishpingo") in the CD "IB" (Index of increase of the RN in

Seedlings: 4000 %), a more marked inverted J-type curve can be seen, which allows us to infer that in the coming years recruitment could increase in the larger CDs, even beyond what is seen on the date of the 2021 evaluation, when in which the CD "IL" already experienced a significant increase compared to the evaluation of the year 2011 (forest not intervened), it is considered that this logical trend of the development of the species as a positive response to the greater entry of light and release of the carrying capacity of the ecosystem generated from forest exploitation will be maintained over the years towards the category of poles. On the other hand, The upper CDs do not have large individuals due to the characteristics of the species' architecture and the use that has extracted the largest individuals from the forest (DMC: 0.70 m). The harvest intensity for the species during the exploitation carried out in 2012 was: 56.94%, a value considerably lower than that established in the PGMF (100%), remaining a greater number of individuals in the forest that will contribute the genetic material for regeneration. natural, in addition to the contribution to the formation of a random dispersed network of seed trees, and remnants that are below the DMC throughout the harvested PC.

Species	DAP at 9 years post harvest in 11.6 ha (Latizales) (cm)	Growth annual diameter (cm)	Estimated time for DAP Goal (70 cm) (years)
Amburana cearensis("ishpingo")	0.3	0.57	122.28
	0.6	0.57	121.75
	1	0.57	121.05
	23	0.57	118.77
	8	0.57	108.77
	9	0.57	107.02

Concept	Total
Number of individuals in latizales evaluated in PC 11 (11.6 ha)	6
N° individuals standing on latizales applying % Mortality* (11.6 ha)	5.52
No. of individuals standing on stems that reached the DAP Target applying % Mortality** (11.6 ha)	5.34
No. of individuals recruited to poles (10,000 ha)	4,605
Projected average volume for 125 years with target DAP 70 cm (m_3/ 10,000 ha)	23,037.2
Projected volume in 125 years (m_3/ind.)	5,003



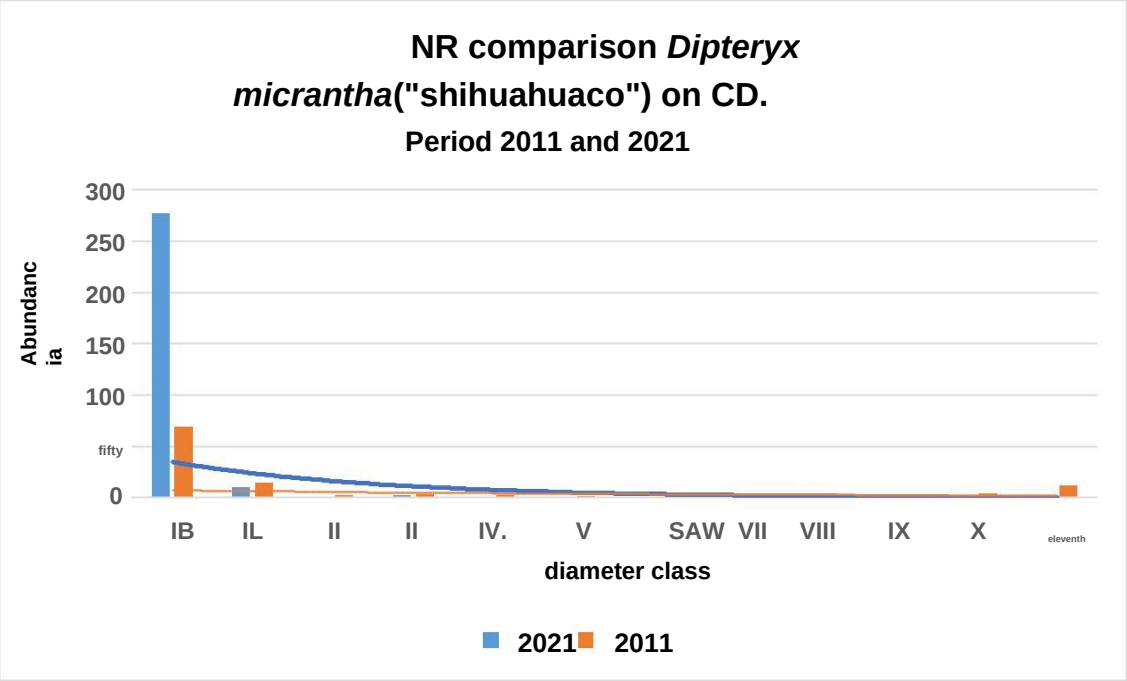
* Mortality rate in latizales Forest UNAS Tingo María Huánuco (Baldomero, 2011). Low L.: 8.9%; L. tall: 7.39%

* * Mortality rate for stems Bosque UNAS Tingo María Huánuco (Baldomero, 2011). Fustals: 3.2%

Figure 28.Projection of the Cutting Cycle at the level of latizales with reference to the volume and number of individuals for the use of the species*Amburana cearensis*("ishpingo").

Figure 28 shows the timber potential of the species*Amburana cearensis*("ishpingo") by projecting growth for an approximate target time of 125 years (target DBH 70 cm at a diametric growth rate of 0.57 cm/year) taking individuals at the latizal level as a starting point, obtaining as a final result a volume projected 23,037.2 m_3(2,303 m_3/ha) and a population of 4,605 individuals (0.460 ind/ha) established for an extension of 10,000 ha, which corresponds to the area of a typical CP of the MADERACRE FMU. It is important to point out that the mortality rates for the latizales and stems size classes used in this report are the result of studies for the structure of tropical forests, more not typical of the species, however, conservative values have been used to perform projection calculations; Despite this, these are almost 4 times higher than the volume and number of individuals registered in the PC 11 of the UMF MADERACRE with 0.638 m_3/ha and 0.121 ind/ha, respectively. Based on what has been described, the supply of wood for future forest use is guaranteed; however, it must be taken into account that the results are preliminary, so it is necessary to generate information on mortality, recruitment and growth rates specific to the species and under the conditions of the forest under management.

g. Analysis by species:*Dipteryx micrantha*("shihuahuaco")



IB: Seedlings; IL: Latizales; II: 10-19.9 (cm); III: 20-29.9 (cm); IV: 30-39.9 (cm); V: 40-49.9 (cm); LV: 50-59.9 (cm); VII: 60-69.9 (cm); VIII: 70-79.9 (cm); IX: 80-89.9 (cm); X: 90-99.9 (cm); XI: > 100 (cm)

Figure 29.Diameter classes of natural regeneration of*Dipteryx micrantha*("shihuahuaco") in the years 2011 and 2021 in PC11 for the evaluated area.

For the case of the species*Dipteryx micrantha*("shihuahuaco"), Figure 29 shows how after 9 years of carrying out the exploitation (year 2021 curve), this has generated favorable conditions in the ecosystem to considerably increase the recruitment capacity of the species in the diameter class "IB" (seedlings), reaching an index of

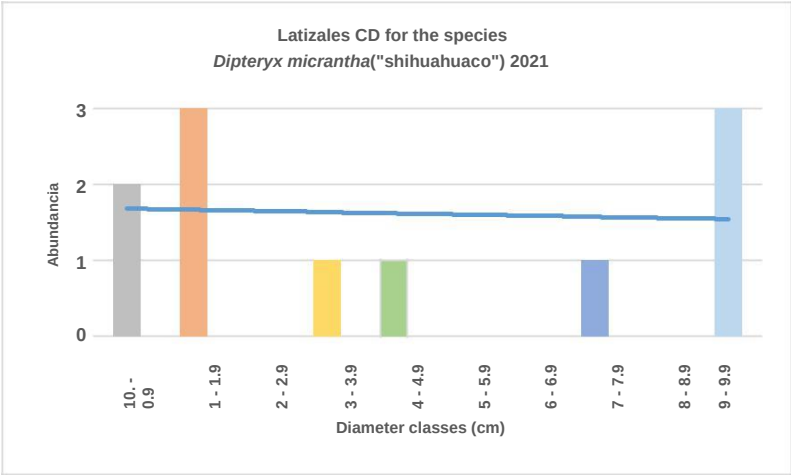
increase in RN: 301 % compared to the situation experienced by the species in an untouched forest, that is, before the selective logging of reduced impact carried out by MADERACRE SAC in 2012, this indicator allows knowing the positive response that the

species possesses in the face of changes in the forest brought about by logging. In the case of Los Latizales (IL) the decrease of individuals from 2011 to 2021 is observed in a proportion of 28.57% and in general, there is no significant positive change in the values of the subsequent CD (fustals), which which demonstrates that the impact of logging by increasing the dynamics of the forest in these first 9 years would have a greater influence on the initial stage of the natural regeneration of the species, especially when considering that seedlings and saplings in general prioritize their growth in height first rather than in diameter. It is considered that the greater presence of seedlings in this first stage, the greater entry of light due to the generation of gaps and the consequent release of the carrying capacity of the ecosystem would be generating favorable conditions to increase the number of individuals recruited in the future in the classes of latizales and fustales. The creation of gaps in the forest through logging favors environmental conditions that could improve the recruitment conditions of the species. The greater income of light due to the generation of gaps and the consequent release of the carrying capacity of the ecosystem would be generating propitious conditions to increase the number of individuals recruited in the future in the classes of saplings and stems. The creation of gaps in the forest through logging favors environmental conditions that could improve the recruitment conditions of the species. The greater income of light due to the generation of gaps and the consequent release of the carrying capacity of the ecosystem would be generating propitious conditions to increase the number of individuals recruited in the future in the classes of saplings and stems. The creation of gaps in the forest through logging favors environmental conditions that could improve the recruitment conditions of the species.*Dipteryx micrantha* ("shihuahuaco") from the residual seedlings to the upper classes (Putzel et al., 2011), which allows generating an available and manageable stock for future rotations.

It is also worth noting the capacity of the species, which despite having experienced a decrease in large trees due to logging, manages to have a significant positive reaction in the dispersal and establishment of new natural regeneration, which would be confirming the suitability of the silvicultural variables. defined for its management in the Management Plan (PGMF: DMC=75cm, IC=100% and 20% of Seedbeds) and the general state of conservation of the ecosystem in the FMU of MADERACRE SAC that has allowed maintaining healthy populations of wildlife responsible for the pollination and dispersal of the genetic material of the species, as is the case of the populations of bats, macaws, añujes, among others (evidenced from periodic assessments of wildlife).These factors would be causing an increase in early natural regeneration above the values for the species in comparison with the undisturbed forest, improving the conditions for maintaining a healthy population in the MADERACRE FMU.

Species	DAP at 9 years post harvest in 11.6 ha (Latizales) (cm)	Growth annual diameter (cm)	Estimated time for DAP Goal (75 cm) (years)
Dipteryx micrantha("shihuahuaco")	0.5	0.65	114.62
	0.9	0.65	114.00
	1.3	0.65	113.38
	1.3	0.65	113.38
	1.3	0.65	113.38
	3.70	0.65	109.69
	4.00	0.65	109.23
	7.20	0.65	104.31
	9.00	0.65	101.54
	9.00	0.65	101.54
	9.87	0.65	100.20

Concept	Total
Number of individuals in latizales evaluated in PC 11 (11.6 ha)	eleven
N° individuals standing on latizales applying % Mortality* (11.6 ha)	10.13
No. of individuals standing on stems that reached the DAP Target applying % Mortality** (11.6 ha)	9.80
No. of individuals recruited to poles (10,000 ha)	8,449
Projected average volume for 115 years with target DAP 75 cm (m_3/ 10,000 ha)	48,525.4
Projected volume in 115 years (m_3/ind.)	5,743



* Mortality rate in latizales Forest UNAS Tingo María Huánuco (Baldomero, 2011). Low L.: 8.9%; L. tall: 7.39%

* * Mortality rate for stems Bosque UNAS Tingo María Huánuco (Baldomero, 2011). Fustals: 3.2%

Figure 30.Projection of the Cutting Cycle at the level of latizales with reference to the volume and number of individuals for the use of the species*Dipteryx micrantha*("shihuahuaco").

Figure 30 shows the timber potential of the species*Dipteryx micrantha*("shihuahuaco") by projecting growth for an approximate target time of 115 years (target DBH 75 cm at a diametric growth rate of 0.65 cm/year) taking individuals at the latizal level as a starting point, obtaining as a final result a volume projected 48,525.4 m_3(4,852 m_3/ha) and a population of 8,449 individuals (0.844 ind/ha) established for an extension of 10,000 ha, which corresponds to the area for a typical PC in the MADERACRE FMU. It is important to point out that the mortality rates for the latizales and stems size classes used in this report are the result of studies for the structure of tropical forests, rather than specific to the species; however, high mortality values have been cited since From this, carry out conservative projection calculations for the species; Despite this, these are almost 4 times higher than the volume and number of individuals registered in PC 11 of the FMU of MADERACRE CONSOLIDATED with 3,469 m_3/ha and 0.453 ind/ha, respectively. Based on what has been described, the supply of wood for future forest use is guaranteed; however, it must be taken into account that the results are preliminary, since it is necessary to generate information on the mortality, recruitment and growth rates of the species under the conditions of the forest under management in MADERACRE.

In general, for the class of Latizales, the presence of individuals with a grouping slightly oriented and close to the class of seedlings is observed, although it is not so marked in comparison with other species, it denotes a logical tendency typical of a population curve of the tropical forests. The reduced number of individuals in the latizales class allows us to deduce that the time elapsed since the harvest (9 years) would be insufficient to influence the abundance of this category and in the subsequent ones, this is validated when considering the diametric growth rate reached by the species, which according to the evaluations carried out in

MADERACRE SAC is in the order of 0.65 cm/year3for mature trees of a range of diameters from[50.00 – 120.00 cm](may be greater in more juvenile stages of the species), which determines that after 9 years of the exploitation, a newly installed seedling should exceed 6 cm in diameter at the date of this evaluation, passing the medium stage of the latizal category.

On the other hand, it is observed that 3 individuals of the sample that represent 27% of the population of latizales are close to passing to the category of fustal, the same one that presents a much lower theoretical mortality, so it could be considered that this A significant number of latizales would be close to guaranteeing their permanence in the forest, advancing towards the larger CDs, ensuring the survival of the species and with it the fulfillment of its ecological roles and future harvests within the framework of the management plan.

The analysis shows the importance of continuing to monitor the dynamics of natural regeneration and the evolution of the population of the species in managed forests.

[3]Technical report N°004-2022-CCR-Diametric growth rate of timber species in the MADERACRE SAC forestry concession.

5.4.2. altimetric classification

In the following section, the analysis of the distribution of altimetric classes for the different tree species will be discussed, evaluating their ecological and conservation status; in particular, it allows detecting the lack and/or richness of regeneration (Ajbilou et al. 2003).

Table 14.Altimetric classification of the forest species evaluated in the felling plot 11 in the years 2011 and 2021.

Classification by altimetric class																
Evaluation year	2021	2011	2021	2011	2021	2011	2021	2011	2021	2011	2021	2011	2021	2011	2021	2011
Species	< 5 (m)		5 - 9.9 (m)		10 - 14. 9 (m)		15 - 19.9 (m)		20 - 24.9 (m)		25 - 29.9 (m)		> 30 (m)		Total	
ana caspi	37	8	2	4		1			2	5	2	1	1	2	44	twenty-one
huayo sugar	23	23	1					2		1	1	1		4	25	31
hookah												3	1	3	1	6
Mahogany		8		1		1		2				1			0	13
capirona	136	4		2			5		1	1	4	7	1		147	14
Catahua	4	5	4	6	2		5		7	7	4	17		2	26	37
catuaba	7		1	3	3	4		6		1	1	8		3	12	25
Cedar	74	8	3	12		17		4	1	7		6			78	54
Copaiba	46	27	3	2			1				1	6	3	2	54	37
slack	643	281	7	5		6	1	1	5	4	2	7	2	1	660	305
Huayruro	5	eleven		8		2									5	twenty-one
Huimba	6	3	6	7	2	6		2		2	2	7		1	16	28
ishpingo	44	1	2	3	1	2	4	4	1		1	9			53	19
Itauba	173		2	1	2	1		7	1	7	1	4	1	2	180	22
lupuna	3	1	2									1	2	2	7	4
Manchinga	329	292	eleven	24		10	1	3	1	eleven	7	17	4	18	353	375
Mashoned	336	221	6	27	3	22	2	twenty	7	eleven	5	27	1	8	360	336
Mass	1	6		13	2	8		19		6	1	7	1	1	5	60
hey		6	1	2	1				1			4		1	3	13
stick cane	583	90	22	16	5	6	2	4	3	8	8	12	3	2	626	138
pumaquiro		2		1		2				1		1			0	7
quillobordón	173	92	35	46	7	30	7	8	5	5		8	1		228	189
quinilla	41	19	4	eleven		4	1	4	2	1		1	1		49	40
white quinilla	17	4	5	3		2		1	1	1		1		2	23	14
requisition	342	262	5	fifteen	3	7	5	3							355	287
shihuahuaco	283	81	5	3				1	1	4	1	14	5	6	295	109
tahuari	17	18	16	9	2	23	2	eleven	4	9	2	6			43	76
yacushapana	349	36	1	17	1	twenty		twenty-one	1	28		fifteen			352	137
son-in-law	51	3		2		1			1	1	1	6	1	1	54	14
Sapodilla	8	26	14	46	1	39		10		19		6			23	146
Total	3731	1538	158	289	35	214	36	133	Four. Five	140	44	203	28	61	4077	2578

Table 14 shows the distribution of altimetric classes in the evaluation periods 2011 and 2021, which will be analyzed by means of a bar graph that is presented below.

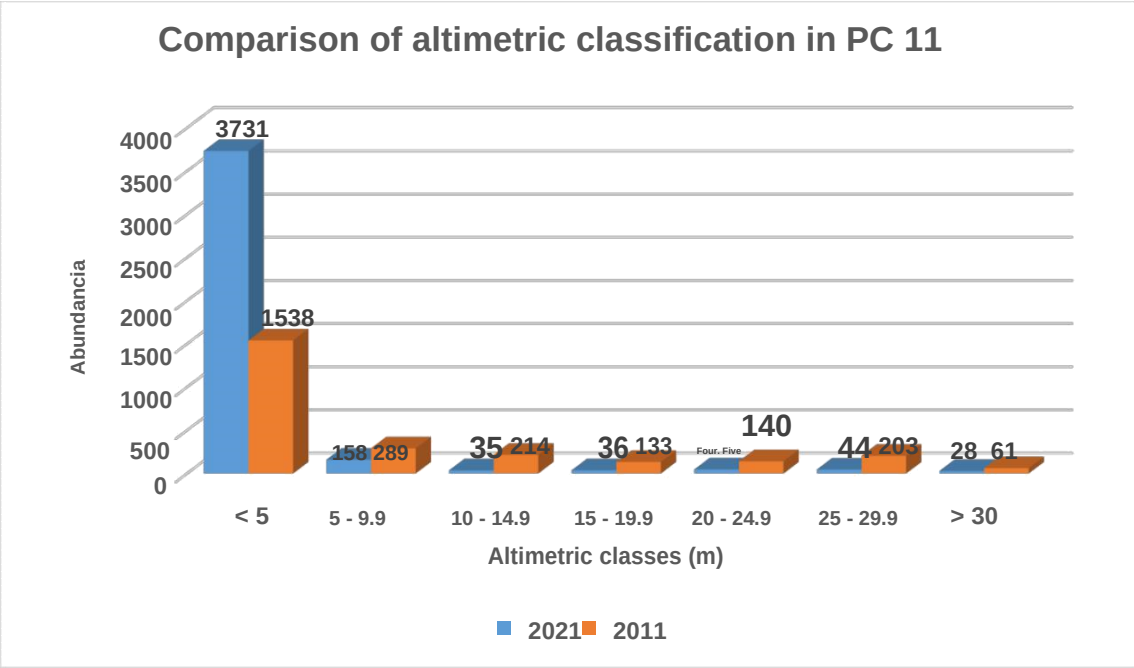


Figure 31.Altimetric classification of the forest species evaluated in PC 11 in the years 2011 and 2021.

Figure 31 shows the distribution of altimetric classes of the evaluated individuals projecting an inverted "J" shape typical of tropical forests where, for a given number of dominant individuals, there is a much higher proportion of smaller growing individuals. Comparing the results obtained in both years of evaluation, it is observed that the first altimetric class less than 5m high shows a considerably higher abundance in the year 2021 (9 years post-harvesting), a priority fact for the tree species present in the plot. of cutting ensure their survival in the continuous competition of ecological development, which indicates that the felling of the dominant trees gave rise to the establishment of a greater number of juvenile individuals, evidencing the use as a highly effective silvicultural treatment to increase the dynamics of the forest, promoting the processes of natural regeneration, allowing the establishment not only of pioneer species but also of the species that have been harvested. It is observed that in 2021 the individuals present from CA "II" onwards suffer a decrease in their abundance, which could be generated by the felling of commercial trees and the consequent activities of forest use.

5.5. cup exhibition

The importance of the exposure of the crown lies in the innate need of the trees to receive an amount of light necessary for their photosynthetic processes, this need is not only specific in adult individuals, but rather individuals in the seedling stage, latizal and fustal require such exposure to be able to overcome the environmental and socio-ecological barriers present in the forest.

Table 15.Classification of crown exposure for stems of forest species evaluated in cutting plot 11 in the years 2011 and 2021.

Cup Exposure Classification										
year evaluated	2021	2011	2021	2011	2021	2011	2021	2011	2021	2011
Species	1		2		3		4		5	
ana caspi	3	4	2	2			1		1	
huayo sugar		5	1	1						
hookah	1	5						1		
Mahogany		1								
capirona	6	1	5	5						
Catahua	4	19	10	6	4	1	1		1	
catuaba	1	9		3		2	1		2	
Cedar		2	1	3		1	1			
Copaiba	3	6	2	2			1			
slack	3	5	6	5	1				1	
Huimba	2	7	1	2	1	1			2	
ishpingo		6	4	4			3			
Itauba		5	2	3	1		1		1	
lupuna	2	3					1		1	
Manchinga	eleven	32	2	12		2	3		3	
Mashoned	5	23	8	13	1		3		2	
Mass	1	4	1	5	1	2			1	
hey	1	4		1	1					
stick cane	8	8	8	2	1	1	4		3	
pumaquiro		1								
quillobordón	6	6	4	4	3	1	9		8	
quinilla	3	1	1	1		2	1			
white quinilla	1	3							1	
requisition			3	1	1		4	1	1	
shihuahuaco	4	10	3	9	1		1			
tahuari	3	6	4	3		2	5		5	
yacushapana		9	1	eleven			1			
son-in-law	3	4		1						
Sapodilla		10		8		7	2			
Total	71	199	69	107	16	22	43	2	33	0
Total (%/year evaluated)	31	60.3	30	32.4	6.9	6.7	19	0.6	14	0

*** 1 “Emerging”; 2 “Full upper illumination”; 3 "Some higher illumination"; 4 “Some Side Light”; 5 “Absence of light”**

Table 15 shows a considerable variation of individuals in each of the categories of the years studied as a result of forest exploitation activities and the consequent entry of a greater light intensity in the different horizontal strata.

forest. in kind*Dipteryx micrantha*("shihuahuaco"), individuals have been identified in the categories "Emerging" and "Full upper illumination" in fewer numbers in 2021 vs. 2011, this decrease is mainly due to the logging of the species. However, in the latest study, the presence of individuals in the categories "Some upper lighting" and "Some lateral light" has been identified where there were no records previously; this would be occurring due to the growth of individuals of the species that were previously found. in lower stages, and thanks to the opening of clearings as a result of forest exploitation activities, they have allowed breaking the state of dormancy.

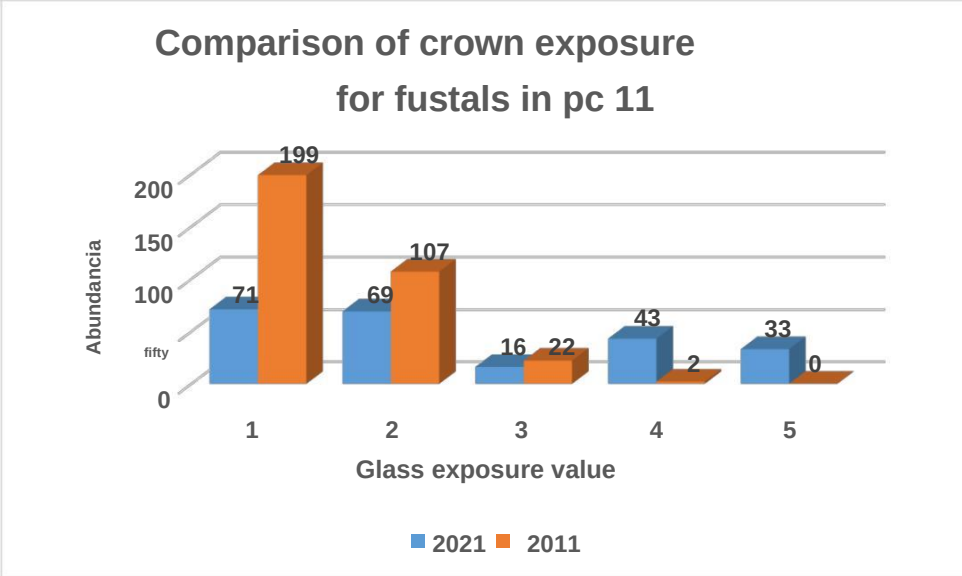


Figure 32.Classification of crown exposure for stems of forest species evaluated in PC 11 in the years 2011 and 2021.

Figure 32 shows a drastic reduction of individuals present in the type 1 and 2 classification, since forest harvesting activities focus on the extraction of commonly dominant harvestable trees that belong to the first classes. Class 3 has not suffered great variations, so it remains in balance. Classes 4 and 5 have positioned themselves considerably, increasing their values as a result of the opening of clearings, inducing the growth of individuals in the lower strata that remained dormant, thus complementing what Gunter (2003) mentions where dense forests need large disturbances to the development of natural regeneration, however, Camacho and Finegan (1997) mention that we can consider that the effect of the silvicultural treatment by opening clearings as a result of forestry activities, is due to the decrease in competition for soil resources, rather than for solar illumination; In other words, the positive effect of silvicultural treatment could also be attributed to the decrease in interspecific competition and the release of the carrying capacity of the ecosystem.

5.6. sociological position

The sociological position establishes the stratum to which the registered individual belongs, this indicator contemplates 3 categories, the lower stratum is characterized mainly by individuals belonging to the category of seedlings and some small saplings that have altitudes of less than 6 meters; the middle stratum is characterized by species with crowns that have a certain intensity of light but that do not come to protrude from the understory, presenting altitudes between 6 to 10 meters of altitude, in this category the latizales and some small stems are classified; and finally, the upper stratum is characterized by

contain most of the mature individuals that receive a large amount of light intensity during the day and are the most developed and dominant in the area.

Table 16.Classification of the sociological position of the forest species evaluated in the cutting plot 11 in the years 2011 and 2021.

sociological position						
year evaluated	2021	2011	2021	2011	2021	2011
Species	< 6m		6 - 10m		> 10m	
ana caspi	38	9	1	3	5	9
huayo sugar	23	23	1		1	8
hookah					1	6
Mahogany		8		1		4
capirona	136	6			eleven	8
Catahua	5	8	3	3	18	26
catuaba	7		3	4	2	twenty-one
Cedar	76	12	1	14	1	28
Copaiba	47	28	2	1	5	8
slack	644	282	6	7	10	16
Huayruro	5	12		8		1
Huimba	6	5	7	7	3	16
ishpingo	Four. Five	1	1	4	7	14
Itauba	173		3	1	4	twenty-one
lupuna	3	1	2		2	3
Manchinga	329	296	eleven	25	13	54
Mashoned	337	226	6	26	17	84
Mass	1	7		fifteen	4	38
hey		6	1	2	2	5
stick cane	593	93	14	16	19	29
pumaquiro		3		1		3
quillobordón	181	108	28	41	19	40
quinilla	43	22	2	12	4	6
white quinilla	twenty-one	5	1	2	1	7
requisition	343	269	4	12	8	6
shihuahuaco	284	83	4	1	7	25
tahuari	twenty-one	19	13	fifteen	9	42
yacushapana	349	39	2	24	1	74
son-in-law	51	4		1	3	9
Sapodilla	fifteen	40	7	48	1	58
Total	3776	1615	123	294	178	669
Total (%/year evaluated)	92.62	62.65	3.02	11.40	4.37	25.95

* (> 10m): High stratum; (6 – 10): Middle stratum; (< 6m): Low stratum.

After the disturbance carried out in the forest as a result of logging activities, Table 16 shows a considerable variation of individuals in each of the categories of the years studied. the species*Dipteryx micrantha* ("shihuahuaco") has a greater number of individuals in the "low stratum" in 2021 compared to those identified in 2011, this is consistent with the high degree of recruitment of seedling-type size class individuals. In the middle stratum we can also observe a slight increase in individuals for the year 2021. The aforementioned results are possible because the opening of gaps and the greater entry of light intensity have allowed breaking the latency state and giving way to the growth of the species. Finally, the high stratum decreases due to the extraction of the dominant individuals.

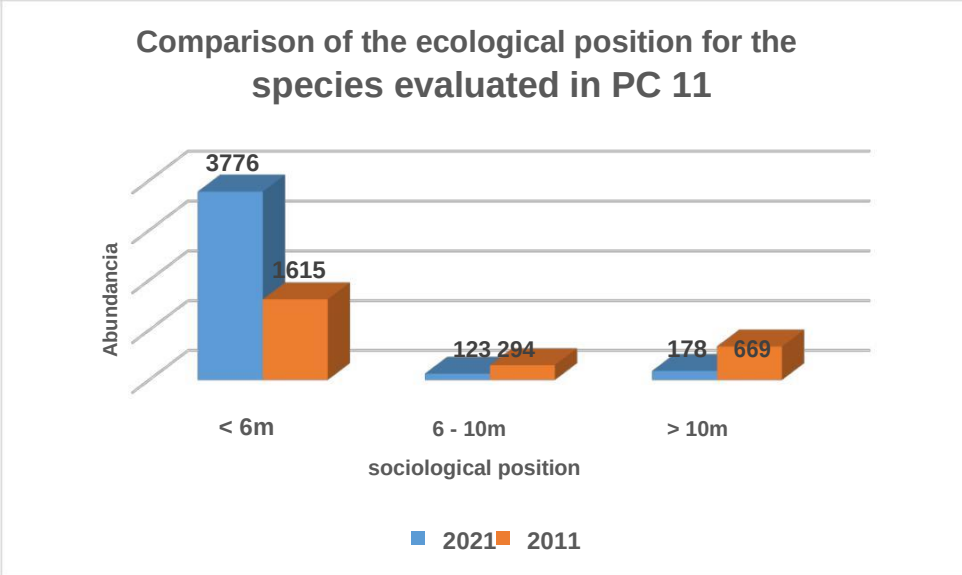


Figure 33.Classification of the sociological position of the forest species evaluated in the PC 11 in the years 2011 and 2021.

Figure 33 shows a drastic reduction of individuals present in the > 10m tall category, since forest harvesting activities focus on usable trees that normally belong to the dominant stratum. The 6 – 10 m tall category has been reduced by half due to the damage caused to individuals in the lower strata due to disturbances in the forest. The <6m height category has considerably increased its values as a result of the opening of clearings, inducing a higher degree of recruitment of the different forest species.

5.7. liana infestation

The evaluation of the infestation of lianas is a very important variable in usable species, since their growth habit allows them to compete effectively with trees for light, water and nutrients, since they do not allocate large resources to the thickening of stems and roots. but due to its elongation, it can explore larger volumes of land and airspace (Putz, 2004), affecting both young and adult individuals.

Table 17.Classification of liana infestation for stems of forest species evaluated in cutting plot 11 in the years 2011 and 2021.

liana infestation								
year evaluated	2021	2011	2021	2011	2021	2011	2021	2011
Species	1 (%)		2 (%)		3 (%)		4 (%)	
ana caspi	100.00	77.78	0.00	11.11	0.00	11.11	0.00	0.00
huayo sugar	100.00	75.00	0.00	12.50	0.00	12.50	0.00	0.00
hookah	0.00	16.67	0.00	50.00	100.00	33.33	0.00	0.00
Mahogany	0.00	50.00	0.00	25.00	0.00	25.00	0.00	0.00
capirona	63.64	75.00	27.27	12.50	9.09	12.50	0.00	0.00
Catahua	50.00	28.57	25.00	28.57	25.00	42.86	0.00	0.00
catuaba	100.00	91.30	0.00	4.35	0.00	4.35	0.00	0.00
Cedar	100.00	74.29	0.00	14.29	0.00	11.43	0.00	0.00
Copaiba	83.33	100.00	16.67	0.00	0.00	0.00	0.00	0.00
slack	90.91	82.35	9.09	5.88	0.00	11.76	0.00	0.00
Huayruro	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
Huimba	100.00	85.00	0.00	10.00	0.00	5.00	0.00	0.00
ishpingo	100.00	87.50	0.00	12.50	0.00	0.00	0.00	0.00
Itauba	40.00	80.95	60.00	9.52	0.00	9.52	0.00	0.00
lupuna	75.00	33.33	25.00	33.33	0.00	33.33	0.00	0.00
Manchinga	63.16	44.12	31.58	33.82	5.26	22.06	0.00	0.00
Mashoned	73.68	81.11	15.79	15.56	10.53	3.33	0.00	0.00
Mass	100.00	72.09	0.00	20.93	0.00	6.98	0.00	0.00
hey	0.00	100.00	100.00	0.00	0.00	0.00	0.00	0.00
stick cane	91.67	91.18	8.33	8.82	0.00	0.00	0.00	0.00
pumaquiro	0.00	50.00	0.00	50.00	0.00	0.00	0.00	0.00
quillobordón	80.00	77.78	20.00	11.11	0.00	11.11	0.00	0.00
quinilla	60.00	66.67	40.00	25.00	0.00	8.33	0.00	0.00
white quinilla	50.00	71.43	50.00	28.57	0.00	0.00	0.00	0.00
requisition	77.78	92.31	11.11	7.69	0.00	0.00	11.11	0.00
shihuahuaco	100.00	80.77	0.00	3.85	0.00	15.38	0.00	0.00
tahuari	82.35	78.85	17.65	9.62	0.00	11.54	0.00	0.00
yacushapana	50.00	80.68	50.00	4.55	0.00	14.77	0.00	0.00
son-in-law	100.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
Sapodilla	100.00	90.91	0.00	5.68	0.00	3.41	0.00	0.00

* 1: No lianas; 2: On stem; 3: In stem and partial crown; 4: In stem and full crown.

Table 17 shows the percentage presence of the degree of infestation of the evaluated species and their post-harvesting behavior. It is important to emphasize that all individuals of*Dipteryx micrantha*("shihuahuaco") evaluated in 2021 have been found free of lianas, compared to the pre-harvesting study where 3.85% of lianas were found in category "2" and 15.38% in category "3", this indicates that the activities Post harvesting have not allowed a totally positive response of the growth of lianas against the increase in light intensity generated for the species. On the other hand, it is known from the results of the forest census carried out in the different PCs of the CMRA that the Manchinga species has a high degree of presence of lianas, they are even usually very invasive due to the affinity they have, however the result of the final study shows the opposite where category "1" has increased its values by almost 20% and category "3" has reduced them by more than 15%, this is undoubtedly relevant data to take into account, since the competition for light, reproduction and soil nutrients is favored for the individuals of this species; In addition, for the trees currently used, lianas can increase the affectation of the shape or architecture of the stem of their host tree, since they prevent the cambial activity of the trees that carry them, producing a strangulation that decreases both the growth and the commercial value of the wood (Acevedo-Rodríguez & Woodbury, 1985).

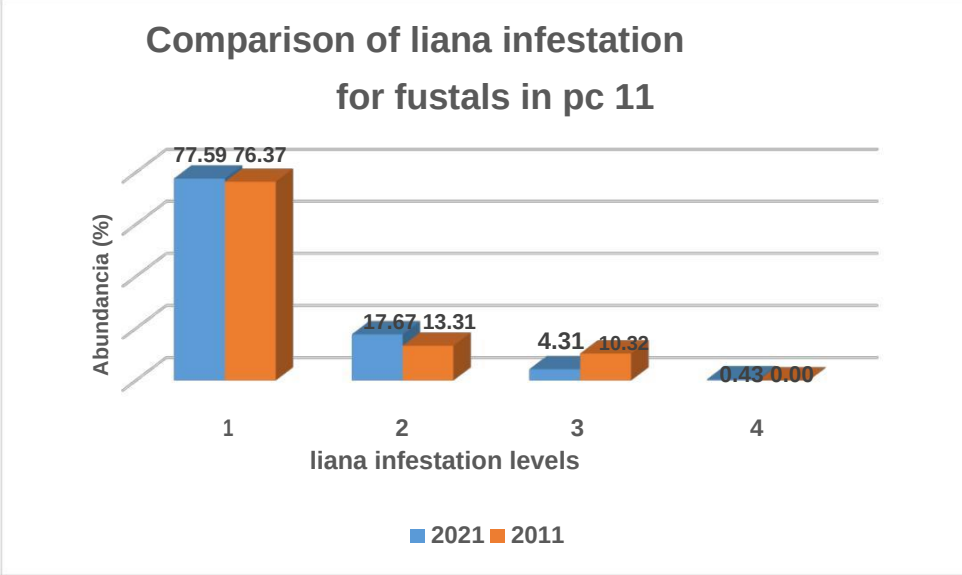


Figure 34.Classification of liana infestation for stems of forest species evaluated in PC 11 in the years 2011 and 2021.

In general, the levels of infestation by lianas have not been of very harmful degrees, as shown in Figure 34, where it can be seen that at level "4" the values are almost zero, this being the most harmful for individuals. If we analyze level "3" we can see that in the evaluation of the year 2021 the percentage values of liana infestation have been reduced by more than half, this is considerable data since the lianas of the category in question are found in the stem and part of the treetop, being somewhat invasive towards the trees. Category "2" has increased its values in the current study, however, the lianas at this level only affect the part of the stem of the tree, not being a direct threat to the host individuals. Finally,

Table 18.Classification of liana infestation for stems in forest species evaluated by diameter class in PC 11 in the years 2011 and 2021.

Year of assessment	Infestation of lianas	Diameter classes (CD)									
		Yo	II	II	IV.	V	SAW	VII	VIII	IX	X
2021	1	90.63	93.94	80.00	76.47	72.22	65.52	45.00	61.54	66.67	72.73
2011		66.67	86.10	90.29	83.12	72.73	64.58	62.50	65.63	60.61	49.46
2021	2	7.81	3.03	20.00	23.53	27.78	24.14	40.00	30.77	16.67	18.18
2011		33.33	7.80	5.83	11.69	15.58	16.67	17.50	21.88	18.18	29.03
2021	3	0.00	3.03	0.00	0.00	0.00	10.34	15.00	7.69	16.67	9.09
2011		0.00	6.10	3.88	5.19	11.69	18.75	20.00	12.50	21.21	21.51
2021	4	1.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2011		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

*** L: 10-19.9 cm; II: 20-29.9 cm; III: 30-39.9 cm; IV: 40-49.9 cm; V: 50-59.9 cm; LV: 60-69.9 cm; VII: 70-79.9 cm; VIII: 80-89.9 cm; IX: 90-99.9 cm; X: >100cm**

The classification of the infestation of lianas by diameter class shows indicators that allow to know the behavior of these against the hosts in juvenile and adult stages. It can be observed in Table 18 that the CD "I" and "II" of the infestation level "1" the values for the year 2021 have increased compared to the year 2011, as well as the decrease of the level "2" of infestation in the The same CDs, the results of the study are relevant, since in these DCs the highest concentration of individuals is evident, and due to their small dimensions they are the most affected by the exceptionally rapid development of the lianas; The liana seedlings are tied to the young trees, and since they grow faster than these, they soon cause shade and deformations, which leads to the fact that in places with high densities of lianas, tree plant succession is interrupted for periods of up to 13 years (Schnitzer et al., 2000). The resulting percentage values from category "III" to "VIII" have decreased their values at the liana infestation level "1", these DC have individuals with sufficient dimensions to support the weight of the lianas that develop on them. Finally, the DC "IX" and "X" have dimensions large enough to be affected by the lianas in the crown and stem, however, it can be observed that the percentage values have improved at all levels of infestation. these CD have individuals with sufficient dimensions to support the weight of the lianas that develop on them. Finally, the DC "IX" and "X" have dimensions large enough to be affected by the lianas in the crown and stem, however, it can be observed that the percentage values have improved at all levels of infestation. these CD have individuals with sufficient dimensions to support the weight of the lianas that develop on them. Finally, the DC "IX" and "X" have dimensions large enough to be affected by the lianas in the crown and stem, however, it can be observed that the percentage values have improved at all levels of infestation.

5.8. cup shape

The type of crown of a species is vital in the process of development and competition in tropical forests, so depending on the shape of the crown of an individual, it is where more or less light intensity is captured, it also determines the amount of processed matter processed in the photosynthetic stage, as well as the production of fruits and seeds necessary to guarantee natural regeneration.

In PC 11, the crown types of the registered individuals were evaluated, this will allow forecasting a future structure of the upper strata of the forest.

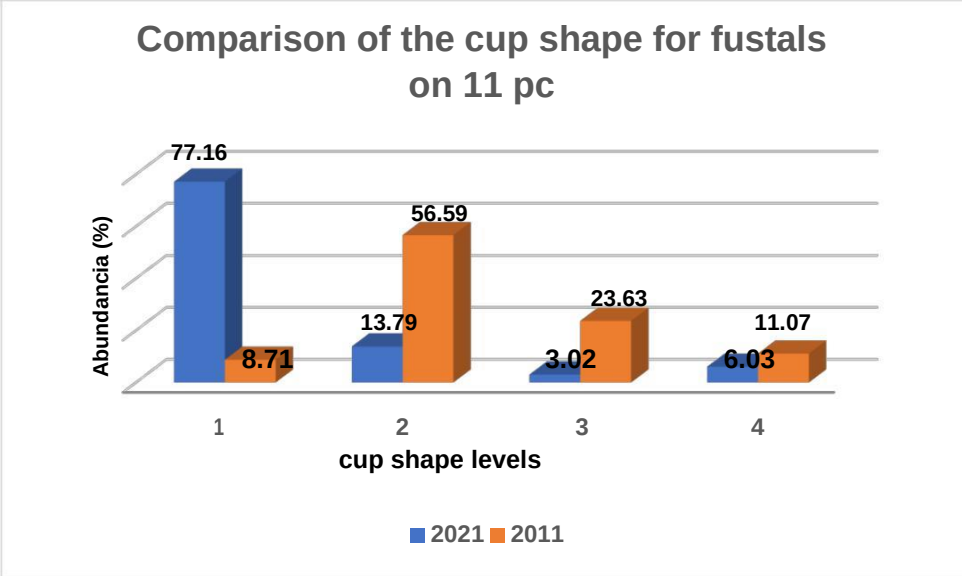
Table 19.Classification of the shape of the crown for stems of forest species evaluated in cutting plot 11 in the years 2011 and 2021.

cup shape								
year evaluated	2021	2011	2021	2011	2021	2011	2021	2011
Species	1 (%)		2 (%)		3 (%)		4 (%)	
ana caspi	71.43	11.11	0.00	33.33	0.00	33.33	28.57	22.22
huayo sugar	100.00	37.50	0.00	50.00	0.00	0.00	0.00	12.50
hookah	100.00	16.67	0.00	66.67	0.00	0.00	0.00	16.67
Mahogany	0.00	25.00	0.00	0.00	0.00	50.00	0.00	25.00
capirona	90.91	0.00	9.09	100.00	0.00	0.00	0.00	0.00
Catahua	25.00	3.57	65.00	39.29	10.00	39.29	0.00	17.86
catuaba	50.00	34.78	50.00	56.52	0.00	8.70	0.00	0.00
Cedar	50.00	0.00	0.00	40.00	0.00	45.71	50.00	14.29
Copaiba	83.33	44.44	16.67	44.44	0.00	11.11	0.00	0.00
slack	90.91	11.76	9.09	70.59	0.00	17.65	0.00	0.00
Huayruro	0.00	0.00	0.00	50.00	0.00	50.00	0.00	0.00
Huimba	50.00	0.00	33.33	5.00	0.00	25.00	16.67	70.00
ishpingo	100.00	0.00	0.00	37.50	0.00	18.75	0.00	43.75
Itauba	60.00	4.76	40.00	66.67	0.00	28.57	0.00	0.00
lupuna	75.00	0.00	0.00	33.33	0.00	33.33	25.00	33.33
Manchinga	89.47	17.65	5.26	52.94	5.26	23.53	0.00	5.88
Mashoned	84.21	4.44	15.79	82.22	0.00	13.33	0.00	0.00
Mass	100.00	11.63	0.00	67.44	0.00	18.60	0.00	2.33
hey	100.00	42.86	0.00	28.57	0.00	14.29	0.00	14.29
stick cane	83.33	8.82	0.00	52.94	8.33	35.29	8.33	2.94
pumaquiro	0.00	0.00	0.00	50.00	0.00	50.00	0.00	0.00
quillobordón	73.33	0.00	16.67	81.48	6.67	14.81	3.33	3.70
quinilla	100.00	16.67	0.00	75.00	0.00	8.33	0.00	0.00
white quinilla	50.00	14.29	0.00	85.71	0.00	0.00	50.00	0.00
requisition	77.78	15.38	11.11	84.62	0.00	0.00	11.11	0.00
shihuahuaco	100.00	26.92	0.00	61.54	0.00	7.69	0.00	3.85
tahuari	76.47	0.00	0.00	48.08	0.00	50.00	23.53	1.92
yacushapana	100.00	4.55	0.00	67.05	0.00	27.27	0.00	1.14
son-in-law	100.00	33.33	0.00	55.56	0.00	11.11	0.00	0.00
Sapodilla	100.00	2.27	0.00	26.14	0.00	26.14	0.00	45.45
Total	77.16	8.71	13.79	56.59	3.02	23.63	6.03	11.07

*1: Full or irregular circle; 2: half circle; 3: Less than half a circle or few branches; 4: Only sprouts or without crown.

Table 19 shows the percentage values of the different degrees of development of the crown shape of the evaluated species and their post-harvesting behavior. One of the most important species to analyze is the*Dipteryx micrantha* ("shihuahuaco") for its high utilization rate and for being currently the most valued for industrial development, where it can be seen that the shape of the crown for the species has a 100% crown with a complete or irregular circle, capturing a high light intensity for the photosynthetic development of their individuals, accelerating their growth and development, and

possibly impacting positively on the production of fruits, which in turn allows the production of the necessary genetic material to increase the number of saplings necessary to cover the load capacity released with the use. Other species valued as *Apuleia leiocarpa* ("ana caspi"),*Myroxylon balsamum*("storax") and*Hymenaea oblongifolia* (“azúcar huayo”) have also shown improvement in the formation of their crowns, which leads to deduce that the opening of clearings after logging has allowed the development of these species, being important to complement that when a tree is released from the shade that affected it, typical of individuals from an intervened forest, it must adapt to the new conditions, and this is done by increasing the size of the crown (Polyfarming, 2022).



*1: Full or irregular circle; 2: half circle; 3: Less than half a circle or few branches; 4: Only sprouts or without crown.

Figure 35.Classification of the crown shape for stems of the evaluated forest species on PC 11 in the years 2011 and 2021.

The shape of the crown is the external characteristic of the tree that provides more information about its vitality, growth capacity, response to release and maturity of the tree. With this premise we observe Figure 35 where a favorable percentage abundance is shown for the formation of a level "1" crown for the year 2021 compared to 2011, whose values have increased considerably caused by the opening of clearings after logging, highlighting that the size of the crown is related to the health, vigor and growth in diameter of the tree, favoring the species in its development. A large and well-lit crown also has better conditions to produce fruit, ensuring the future natural regeneration of the forest. The results obtained are complemented by the statement of Polyfarming (2022) where he mentions that the cup gives a lot of information about how it has lived, its vitality, and what its most likely development will be in the future. Finally, it is important to emphasize what the author mentions, when the tree has already completed its growth in height (which occurs at an early stage of its age), we say that the crown, and therefore the tree, is already formed, and it is very difficult to modify its growth conditions; Compared to the current study, we can previously emphasize the high abundance of individuals in the lower CDs, and added to the high percentage value of crown shape in category "1", it follows that the species have a greater potential for growth and development in time. vitality, and what will be its most likely development in the future. Finally, it is important to emphasize what the author mentions, when the tree has already completed its growth in height (which occurs at an early stage of its age), we say that the crown, and therefore the tree, is already formed, and it is very difficult to modify its growth conditions; Compared to the current study, we can previously emphasize the high abundance of individuals in the lower CDs, and added to the high percentage value of crown shape in category "1", it follows that the species have a greater potential for growth and development in time. vitality, and what will be its most likely development in the future. Finally, it is important to emphasize what the author mentions, when the tree has already completed its growth in height (which occurs at an early stage of its age), we say that the crown, and therefore the tree, is already formed, and

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VI. CONCLUSIONS

- **A total of 29 strips were evaluated in PC 11 belonging to the UMF of MADERACRE SAC in the years 2011 (pre-harvest) and 2021 (post-harvest), recording information for 30 forest species (mahogany and pumaquiro not registered in the last evaluation). , being 2012 the year of the execution of forest exploitation operations.**
- **The increases in abundance of the individuals with the highest recruitment of the total size categories belong to the species*Astronium graveolens*("palo bastón") with 83.79 ind/ha,*Myroxylon balsamum*("storax") with 60.45 ind/ha, *Terminalia oblonga*("yacushapana") with 50.05 ind/ha,*Dipteryx micrantha*(" shihuahuaco") with 34.76 ind/ha and*Mezilaurus itauba*("itauba") with 28.5 ind/ ha, values corresponding to 9 years after the forest was intervened, demonstrating that the opening of clearings as a result of forestry operations has favored, in general terms, the natural regeneration of timber forest species that Currently they are managed in the MFU of MADERACRE SAC, and they represent the individuals that will not only ensure future harvests but also the maintenance of the ecological roles of these species in the forest.**
- **The individuals of the saplings stage of the year 2021 compared to 2011 were more abundant in their record and with greater variability in their population density whose value corresponds to 187.74%, this is how the*Astronium graveolens*("palo bastón") with 82.41 ind/ha, followed by the*Myroxylon balsamum*("storaque") with 58.97 ind/ha, *Terminalia oblonga*("yacushapana") with 54.14 ind/ha,*Dipteryx micrantha*(" shihuahuaco") with 35.69 ind/ha and*Mezilaurus itauba*("itauba") with 28.10 ind/ha are the species with the highest degree of recruitment in their early natural regeneration, the result of a greater dynamic of the forest fostered by the use that allowed a greater entry of light and caused a reduction of the basal area, freeing up space in the carrying capacity of the ecosystem, thus generating better conditions for these species compared to an undisturbed forest. The results of the Importance Value Index (IVI) for this class show that the species with the greatest ecological weight are the*Myroxylon balsamum*("storax") with 12.19%,*Astronium graveolens*("stick stick") with 11.59%, *Terminalia oblonga*("yacushapana") with 8.49%,*brosimum alicastrum*("manchinga") with 8.36% and*Clarisia racemosa*("mashonaste") with 8.18%, the first two show a high percentage of abundance, raising the value of their IVI, denoting that forest harvesting operations have benefited the development of seedlings compared to their condition in the untouched forest (year 2011). .**

- **For its part, the early natural regeneration (saplings) of the species*Dipteryx micrantha*("shihuahuaco"), which is the one that occupies the largest volume harvested with 5468,572 m3equivalent to 451 trees from the forests in the UMF of MADERACRE SAC, it has positioned after 9 years of its intervention, well above the evaluation prior to harvesting, increasing its abundance by 301%, this indicator allows knowing the answer positive that the species has in the face of changes in the forest caused by logging, being in this sense the selective logging of reduced impact an important silvicultural treatment that improves the conditions of the forest for the maintenance of a healthy population of the species even in better conditions compared to a forest without intervention.**

- **In the latizales class, the majority of species have suffered a reduction in their abundance, probably due to natural factors not yet defined or due to damage caused by forest exploitation activities, however, species such as*Myroxylon balsamum*("storax") and*Astronium graveolens*("stick stick") with 1.72 ind/ha show recruitment for this category. In the same way, the IVI of this class shows the species with the greatest ecological weight, such as the*Aspidosperma parvifolium*("quillobordón") with 16.78%,*Astronium graveolens*("stick stick") with 11.92%,*Myroxylon balsamum*("storax") with 10.85%,*Matisia*spp. ("zapote") with 7.27% and*guarea*sp. ("requia") 6.62%, the first places have developed in a better way in the face of a greater income of light intensity, as well as the *Myroxylon balsamum*("estoraque"), which ranks third despite having lower values in the previous study of tall latizales.**
- **Parallel to this, the usable volumes of the species of interest were projected applying mortality and recruitment rates from studies carried out in tropical forests, using as a starting point the size class of the latizal type and the rates of diametric growth resulting from the studies developed. in the MADERACRE FMU, where it has been possible to define times for the development of new timber stocks (DMC Target by species), the latter being, in all cases, higher than the volume figures of the harvests of the first rotation. This is how, for example, the species*Dipteryx micrantha*("shihuahuaco") could reach a volume of 4,852 m3/ha at a DBH Target of 75 cm in a total approximate time of 115 years for the youngest individuals of this class. However, the information should be considered referential, since the results obtained are preliminary values due to the fact that the mortality rates used are not specific to the species studied; therefore, the need to develop studies of mortality rates, recruitment and growth of species considered of commercial interest.**
- **Similarly, and driven by the use of large trees of species defined in the POA corresponding to the 2012-2013 harvest, the stem class is negatively affected in its population density in almost all species, however, despite that him*Dipteryx micrantha*("shihuahuaco") has been the one with the highest volume harvested in 2012, it has not suffered a significant reduction (-0.59 ind/ha). The IVI for this class has had a variation in the position of the species where the*Hura crackles*(" catahua"),*Aspidosperma parvifolium* ("quillobordón"),*Astronium graveolens*(" stick cane"),*Calycophyllum spruceanum* ("capirona") and*Reticulated Copaifera*(" copaiba") are positioned in the first places reflecting the timber potential for the next cutting cycles with emphasis on the species not exploited in 2012, however the species*Dipteryx micrantha* ("shihuahuaco") ranks eighth out of 30 species analyzed, demonstrating positive dynamism in its establishment in the forest under the silvicultural standards implemented by MADERACRE SAC, a similar case occurs with the species *Apuleia leiocarpa*("ana caspi"),*Myroxylon balsamum*("storax"),*Manilkara bidentata*("quinilla") and*Handroanthus capitatus* ("tahuarí") whose population of fustales benefited from the new ecological conditions of the intervened forest.**
- **The distribution of the diameter classes for both years of evaluation represents a trend of the curve in the typical inverted J shape, however the evaluation of the year 2021 shows a considerable increase in the diameter class "I" growing exponentially in the values of the curve as a consequence of forest exploitation activities that favored the development of individuals of the classes**

smaller diameters, especially that of seedlings with 187.74% more compared to the year 2011, ensuring the abundance of successors for the superior CDs. the species*Myroxylon balsamum*("storaque") is a clear example of the balance in which the forest is after the logging intervention with an abundance of seedlings and a succession curve of individuals in the stem class that will allow the development of the species over time and how future stock of individuals for forest use. the species*Dipteryx micrantha*("shihuahuaco") has a similar condition, with a large number of individuals, but with a smaller number of latizales and fustales, the latter favored by the considerable forest use that the species had, however, despite the reduction in the number of trees , the species achieves an exponential reaction in the dispersion and establishment of natural regeneration, this under ideal silvicultural standards applied in MADERACRE SAC.

- **The upper CDs have experienced a decrease in their abundance, firstly due to the harvest of individuals, the affectation of remaining trees by the operations, and thirdly due to the lack of light for some species caused by the opening of clearings, this It is diminished in the advance towards the superior CD since they are already established individuals and accustomed to the greater light capture since they would be occupying the dominant stage in the canopy, for which their degree of disturbance is much lower compared to individuals of lower CDs. In addition, it is possible that the time elapsed between both evaluations is not sufficient to influence the abundance of species in latizales and in the following subcategories. However, it is considered that the greater presence of seedlings in this first stage, the greater entry of light due to the generation of gaps and the consequent release of the carrying capacity of the ecosystem would be generating favorable conditions to increase the number of individuals recruited to future in the classes of latizales and fustales.**
- **All of the above and the results obtained do not imply an imbalance in the forest, since the silvicultural system being implemented is based on minimum cutting diameters (DMC) and harvest intensities (IC) calculated for each species with information generated from the characterization of the forest in the same FMU, having respected these parameters in the execution of forest exploitation, being the percentages harvested lower than those defined in the PGMF, which allowed the permanence of a greater number of remaining trees in the forest, and added to the seedbeds, they fulfill ecological functions typical of the species that allowed showing favorable results 9 years after their intervention, as well as ensuring future harvests based on natural regeneration.**
- **The altimetric classification (CA) less than 5m in the evaluation of the year 2021 was the most abundant (3731 ind.<>2021 vs 538 ind.<>2011, which represents an increase of 593.49%) due to the high number of registered seedlings being demonstrated that the felling of trees is highly effective as a silvicultural treatment allowing the establishment and development of timber species.**
- **The ecological aspects have shown favorable results: crown exposure in categories 4 and 5 "some lateral light" and "absence of light", respectively, have shown a considerable increase in individuals as a result of the opening of the canopy that facilitates entry. of a greater quantity of light, with it the breaking of the dormancy of dormant species that begin their stage of development and the search for light for their growth; the lower stratum (< 6m) of the sociological position possesses**

records above double in the evaluation of the year 2021 compared to that of 2011 due to the increase in the number of individuals in the seedling category, however a decrease is obtained in the upper strata as a result of the activities of forest exploitation of direct and indirect way;

- **Regarding the crown shape, category 1 "complete or irregular circle" shows favorable results in the development of the remaining individuals after harvesting, since the percentage of them increased from 8.71% in 2011 to 77.16% in 2021, which demonstrates the increase of individuals with a well-illuminated crown, which consequently will have a greater potential for growth, as well as better conditions for the production of fruits and seeds, improving the conditions for the natural regeneration processes of the forest.**
- **The greater income of light has partially positively impacted the degree of liana infestation of the host individuals, this is how grade 1 "without lianas" and grade 2 "lianas in stem and partial crown" have better values compared to of the year 2011, favoring trees with less competition for light and nutrients, strangulation of the stem that decreases the quality of the wood and invasion in the crown that does not allow its optimal development. Parallel to this, there is a lower invasion of lianas in the lower CD "I" and "II" where there is the highest concentration of individuals with a high degree of vulnerability, thus favoring the growth of trees in optimal conditions.**

VII. RECOMMENDATIONS

- **Outline the evaluation periods for natural regeneration in PC 11 in the areas already evaluated to obtain a control of ecological succession of the species of interest, with which it will be possible to analyze their growth behavior in the face of forestry intervention in 2012, and their arrival at the next cutting cycle in 2032.**
- **For a substantial improvement of data in saplings and stems, it is recommended, in other evaluations, to increase the sampling intensity that allows obtaining more data on the species at all levels and a better analysis of the ecological succession over time to understand it in greater detail. the behavior of the forest in front of an intervention.**
- **Systematize a better distribution of the evaluation ranges that allow statistically optimal results to be obtained for analysis.**
- **Emplear personal de alto conocimiento y experiencia en especies maderables y de interés para la empresa con lo cual se obtendrán resultados mucho precisos y con ello decisiones silviculturales mejor desarrolladas.**

VIII. ANEXOS

Anexo 1: Fajas de evaluación de la PC 11 UMF MADERACRE SAC

Número de transecto	Extremos del transecto	Este	Norte	PCA
31	Inicio	407552	8769690	11
31	Final	408555	8769686	11
32	Inicio	408560	8769830	11
32	Final	407550	8769833	11
33	Inicio	407551	8769930	11
33	Final	408560	8769931	11
34	Inicio	408555	8770030	11
34	Final	407555	8770028	11
35	Inicio	407560	8770130	11
35	Final	408570	8770140	11
36	Inicio	408560	8770240	11
36	Final	407545	8770242	11
37	Inicio	407546	8770340	11
37	Final	408550	8770348	11
38	Inicio	408550	8770440	11
38	Final	407550	8770440	11
39	Inicio	407555	8770560	11
39	Final	408555	8770560	11
40	Inicio	408550	8770652	11
40	Final	407560	8770681	11
51	Inicio	409350	8766930	11
51	Final	410385	8766935	11
52	Inicio	410550	8766800	11
52	Final	409550	8766790	11
55	Inicio	410896	8766280	11
55	Final	409895	8766270	11
56	Inicio	409880	8766150	11
56	Final	410890	8766180	11
57	Inicio	409850	8765990	11
57	Final	408850	8765986	11
58	Inicio	408820	8765860	11
58	Final	409830	8765870	11
60	Inicio	410002	8765633	11
60	Final	409002	8765633	11
59	Inicio	409950	8765730	11
59	Final	408950	8765730	11
54	Inicio	409715	8766538	11
54	Final	410715	8766538	11
53	Inicio	409658	8766655	11
53	Final	410650	8766655	11

Número de transecto	Extremos del transecto	Este	Norte	PCA
49	Inicio	409239	8767245	11
49	Final	408230	8767245	11
50	Inicio	409230	8767110	11
50	Final	408230	8767110	11
45	Inicio	409175	8767406	11
45	Final	408175	8767406	11
43	Inicio	409197	8767546	11
43	Final	408190	8767546	11
41	Inicio	409220	8767692	11
41	Final	408190	8767692	11
39	Inicio	409200	8767832	11
39	Final	408200	8767832	11
37	Inicio	409222	8767975	11
37	Final	408222	8767975	11
35	Inicio	409320	8768130	11
35	Final	408320	8768130	11
33	Inicio	407554	8768905	11
33	Final	408554	8768926	11

Anexo 2: Fotografías de los trabajos de campo

Figura 36. Identificación y medición de altura en la categoría brinzales.

Figura 37. Identificación y medición de altura en la categoría latizales.

Figura 38. Identificación y medición de altura en la categoría brinzales.

Figura 39. Medición de diámetro en la categoría latizales.

Figura 40. Brigada de evaluación de regeneración natural.

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