

State of *Prunus africana* Regeneration within the Cloud Forest of Mt Cameroon

Godlove Ambe Neba^{1*}, Remyeh Gracious Kifon¹, Mana Djbrilla¹, Neculina Anyinkeng¹, George Bindeh Chuyong¹, Jean Lagerde Betti²

¹Department of Plant Science, University of Buea, Buea, Cameroon

²Higher Institute of Agriculture, Wood, Water and Environment, University of Bertoua, Bertoua, Cameroon

Email: *negoda70@yahoo.com

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Abstract

Mount Cameroon (4100 m) is a vital biodiversity hotspot featuring *Prunus africana*, an Afromontane forest species, with bark extracts that treat benign prostatic hyperplasia. While Cameroon is a major exporter of prunus bark, unsustainable harvesting, exacerbated by illegal exploitation, has caused significant population declines, resulting in strict CITES regulations and temporary European Union import bans to force better management practices. However, little is known about the natural regeneration of the species on Mt Cameroon after the 2011/2012 bark exploitation under CITES regulation. The current study was designed to evaluate the natural regeneration of *P. africana* within the cloud forest of Mt Cameroon from the seedling stage. Two 1 ha permanent forest plots, setup between 1800 and 2100 m asl and divided into sixteen 25 × 25 m subplots made for easy assessment. Adult and juvenile census of *P. africana* trees in the plots (DBH ≥ 10 cm) was done, heights estimated across all subplots, while seedlings and saplings were censused using 5 × 25 m units over the entire plot. Collar diameter was measured for seedlings and small saplings, while the dbh of bigger saplings was measured. Plot one recorded 49 *P. africana* (5 adults, 8 juveniles and 36 seedlings + saplings), while plot two counted 124 individuals (19 adults, 61 juveniles and 44 seedlings + saplings) for corresponding regeneration indices of 0.47 and 0.69. While all subplots in plot 2 had at least 1 prunus plant (range 1 - 20), only 12 out of 16 subplots had a prunus plant (range 0 - 7) in plot 1. The basal areas and stand volumes were 0.78 m², 2.7 m³ and 5.7 m², 14.3 m³ for plots 1 and two respectively. These results emphasize the need for rigorous implementation of sustainable exploitation of *Prunus africana* on Mt Cameroon and a possible review of the fallow period.

Keywords

Prunus africana, Cloud Forest, Regeneration, Mount Cameroon

1. Introduction

Mount Cameroon (4100 m asl), the only active volcano in West Africa, is a crucial Pleistocene refuge that played a significant role in preserving biodiversity during the arid, cold glacial periods of the Pleistocene epoch, consequently a biodiversity hotspot and a centre of endemism [1]-[4]. The region boasts 49 strictly endemic and 50 near-endemic plant species. It features diverse habitats including lowland evergreen rainforest, submontane forest, montane forest and grasslands. Among the submontane and montane plant diversity is *Prunus africana* [5]-[7].

Prunus africana (Hook.f.) Kalman, also known as the African cherry or Pygeum, is an evergreen canopy tree (30 - 40 m tall), native to the montane regions of sub-Saharan Africa and stretching from West Africa (Nigeria) through Central and East Africa to South Africa, including the islands of Madagascar, Bioko, São-Tomé, and Grand Comore [8]-[10]. It is a light demanding secondary-forest or open forest species [11]. Significant populations are found in Cameroon, Madagascar, and various highland regions of Kenya and Uganda [12] [13].

It is globally renowned for its medicinal bark (“canda stick”), which is primarily used to manage Benign Prostatic Hyperplasia BPH, reducing inflammation and improving urine flow [14] [15]. In traditional medicine, bark decoctions treat stomach pain, kidney disease, gonorrhoea, chest infections, respiratory diseases and fever. Anti-bacterial activity against *Staphylococcus aureus*, anti-inflammation, anti-malaria and wound healing effects of bark and leaf decoctions have been demonstrated [16]-[18]. Away from medicine, the hard, deep red wood of prunus is a source of timber and tools [19]. Ecologically, it plays a role in soil improvement, carbon sequestration and apiculture [20] [21].

The demand for *Prunus africana* is high and growing globally, driven primarily by the pharmaceutical industry for treating benign prostatic hyperplasia (BPH) in the USA and Europe, particularly France, Italy, Germany and Belgium. In the late 1990s, the international market for *P. africana* bark extract was estimated to be worth approximately US\$220 million annually [20]. The high demand for *Prunus africana* bark has caused severe ecological, social, and economic consequences [8] [22] [23].

Ecologically, the massive demand has led to unsustainable, “irrational” harvesting, including cutting down entire trees or completely stripping bark, causing the species to become very scarce in many natural habitats [24]. Also, destructive harvesting techniques have led to increased mortality rates for *P. africana* that are 50 to 100 times higher than natural, hindering tree recovery and making natural regeneration difficult [25]-[27]. As a result, the species has been listed as Vulnerable on the IUCN Red List and in CITES APPENDIX II, necessitating trade regulation [28] [29]. The socioeconomic consequences of trade regulation include conflicts, illegal trade, exploitation of local harvesters by economic operators, economic vulnerability and market regulation [30].

Cameroon has one of the world’s largest reservoirs of this species, naturally found in six of Cameroon’s ten regions, with the most significant populations con-

centrated in the mountainous highlands [31] [32]. Cameroon is also the world's largest exporter of *Prunus africana* bark, holding 38% - 48% of the global market [33]. South West Region is home to the largest single population in Cameroon, primarily on the slopes of Mount Cameroon. The North West and Adamaoua Regions also host significant populations in the Kilum-Ijim, Tchabal Mbabo and Tchabal Gang Daba mountain ranges respectively [34].

Prunus africana exploitation on Mt. Cameroon is a major, yet threatened, economic activity for local communities supplying bark for global prostate medicine [35] [36]. Decades of unsustainable harvesting necessitated strict CITES regulations and a temporary EU export ban in 2007, shifting focus toward sustainable management, community-based harvesting, and domestication to reduce pressure on wild stocks [35] [37]. The EU ban on Cameroon-produced *Prunus* in 2007 was lifted only after improved, inventory-backed, sustainable management systems were implemented. While illegal, small-scale, or localized exploitation may have continued, the last official, large-scale sustainably managed harvests were initiated around 2010/2011 by organizations like the Mount Cameroon Prunus Management Organisation (MOCAP).

Since then, there has been no other official bark extraction in the Mt Cameroon. This is not because of lack of market but most likely due to the insecurity that came with armed crises that rocked the North West and South West Regions since 2016. This lack of activity within the *Prunus* sector for about 15 years has brought frustration and desperation to actors in the sector such as farmers, community forest managers and the community-based organisation MOCAP. On the other hand, long periods of inactivity like this can also be an opportunity for ecosystem recovery.

Studies on *Prunus africana* in Cameroon and elsewhere have heavily focused on inventorying, monitoring, and managing the species due to its high value in treating benign prostatic hyperplasia (BPH) and its status as a threatened species. Using the "Adaptive Clusters Sampling (ACS)" method, [38] assessed 1.11% of the 22, 881.085 ha total *Prunus* range of Mt. Cameroon for Stocks of *Prunus africana* stems in the forest between 2010 and 2011. This study recorded a total stem count of 79 660 *Prunus* tree, with 51.52% of harvestable dbh (≥ 30 cm). According to the same authors, *Prunus* densities were 1.5 times higher in the National Park than in the forest around it, with mean densities of 3.43 stems/ha. This was before the last managed commercial bark exploitation. [39], in an evaluation of *Prunus* abundance along elevational gradients on Mt. Cameroon enumerated 177 trees within 450,000 m² for an average density of 3.9 stems/ha and maximum of 6.2 stems/ha, which they said varied with altitude and that over 70% of these trees were healthy.

Elsewhere in Cameroon, inventories carried out on wild *Prunus* by [40] recorded 1552 trees on 330 hectares of forests, with about 10% dead and 3.84 trees/ha generally with an average of 0.5 trees/ha of harvestable size. Another study by [41] in the Tchabal Mbabo montane forest, Adamawa region, counted (358) stems of

P. africana on a surface area of 57.5 ha, which gave a density of 6.23 stems/ha.

All the above studies focused on trees of 10 cm dbh and above, leaving a gap in knowledge of the species at sizes below 10 cm. Therefore, little is known about the natural population structure of this species and potential regeneration in the wild, understandably so because the Afromontane habitat is naturally difficult to access and further compounded by huge resources (time and money) needed for field studies down to seedling stage.

This study was thus designed to assess the regeneration of *P. africana* within the cloud forest of the Etinde community forest of Mt Cameroon, in permanent plots that will in the future also provide information on the dynamics of the species in this prunus block.

2. Materials and Methods

2.1. Site Description

The study was carried out in the Etinde community forest on mount Cameroon, covering about 48.6 km², a buffer zone around the Mount Cameroon National Park. Mount Cameroon is found in the South West Region of Cameroon along the Gulf of Guinea between latitude 3°57' to 4°28'N and longitude 8°58' to 9°24'E and is the only active volcano along this line [42]. The altitude ranges from sea level to 4100 m above sea level with its main peak situated at 4°13'N and 9°10'E, the highest point in West and Central Africa [1] [43].

The area has two distinct seasons, the wet season (mid-March to October), with the wettest months being July to September and dry seasons from November to mid-March [34]. Precipitation is abundant, ranging from above 10000 mm/year on the west coast to a little above 2000 mm/year on the leeward side of the mountain. Rainfall decreases with altitude with the lower flanks of the montane being warm and very wet while the peak is dry, windy and freezing cold [44]. Humidity is generally high, usually above 85% all year round. Temperature varies from an average of 25.5°C to 35°C depending on location and season of the year, naturally decreasing by about 1°C per 100 m altitude [39] [45] [46].

The young volcanic soils of Mount Cameroon support a unique relatively unbroken sequence of natural vegetation from lowland evergreen forest almost at sea level, sub montane forest, montane forest, montane grassland to sub-alpine prairies near its summit [44]. It is known for its exceptional plant diversity and high number of endemic species with over 2300 species of plants in more than 800 genera and 210 families, with 49 strictly endemic and 50 near endemic plant species found in the area. The exceptional plant species diversity of Mount Cameroon is a result of the wide range of physical and climatic factors [47]. This vegetation plays host to many endemics, rare and threatened wildlife species such and birds, reptiles, primates, forest elephants etc. [48]. The diversity of plant and animal species have earned the region an internationally recognized status as a biodiversity “hot spot” in Cameroon.

This work was carried out on two 1 hectare plots located in the montane forest

zone at an altitude of about 2100 m and 1800 m above sea level for plot 1 and plot 2 respectively. This altitude bracket is listed as the zone of abundance of *P. africana* on Mt Cameroon [39] [49]. Within this area of high prunus density, accessibility and safety guided the specific location of plots, given that this part of the mountain is steep and riddled with dangerous gullies.

The forest here is often covered with very low to ground level clouds, hence the name cloud forest. A key characteristic of cloud forests is that the trees are always heavily covered with abundant lichens, mosses and lianas. Plot 1 was located very close to the grassland (50 m) while plot 2 was located deep within the forest.

2.2. Methods

Two 100 m × 100 m (10,000 m²) plots were demarcated at an average altitude of 2026 m and 1858 m above sea level for plot 1 and 2 respectively, using a 100 m linear tape. The tape was accompanied by a line tied to poles at the four ends of the plot ensuring possibility of tracing back to starting point. To confirm the plot layout as a square, the internal angles were measured, and adjusted to have a right-angles (90°), thereby ensuring the plots geometric configuration conforms to a square shape. Coordinates of the four corners of the plots were registered with the help of a GPS.

The plots were each divided in to quadrants of 25 m × 25 m, resulting to 16 sub plots each labelled 1A - 1D, 2A - 2D, 3A - 3D and 4A - 4D for line 1, 2, 3 and 4 respectively, delimited with plastic corner post, with ribbons tied on them. The altitude differences between plot 1 and 2 was 168 m. Subplots 1A - 1D of plot 1 was on the average 80 m from the forest edge (grassland) while 4A - 4D were deep in to the forest. The field design was in accordance with that of [50].

All trees in each plot with DBH ≥ 10 cm were tagged, measured using a diameter tape. Due to the high density of mosses and lichens on the barks of trees in the cloud forest, *P. africana* trees were identified using leaf morphology and confirmed with a bark slash. These permanent plots were designed for long term dynamic studies for plant species of Mt Cameroon.

Adult and juvenile census of all *P. africana* trees in the plot with diameter at breast height (DBH) ≥ 10 cm was done across all subplots and the trees tags noted. DBH of all tagged trees was measured using a diameter tape at breast height (1.3 m) from the ground. Lianas were shifted and mosses removed around the point of measurement before measuring the diameter. For DBH measurement on slope, the point of measurement was on the uphill side of the tree and for leaning trees, they were measured along the lower side of the tree parallel to the stem axis. For trees with malformation or bumps at 1.3 m from the ground, diameter was measured above 1.3 m. For trees that developed multiple stems before breast height, all the stems with DBH ≥ 10 cm were tagged separately, measured and recorded, while indicating that all the stems belonged to the same tree. Signs of debarking and recovery were noted by physical observation. Number of dead *P. africana* trees were also noted alongside the possible causes of death.

Smaller *P. africana* stems and seedlings were censused by dividing each subplot into strips of 5 × 25 m for greater efficiency in the search. Two field workers then moved up and down each strip searching for seedling and saplings of the species of interest until a subplot was completed before moving to the next. Each encountered seedling or sapling was measured for height using a linear tape and collar diameter using an electronic vernier calliper and diameter tape for bigger saplings. This procedure continued until all 16 subplots (comprising 60 stripes) were completed for each plot. Seedlings were considered to be less than 1 cm diameter and less than 5 m tall. Prunus plants that were not seedlings and less than 10 cm DBH were considered saplings and the measured for DBH and height. Juveniles were those ≥ 10 cm DBH but also <20 cm. Adults were the *P. africana* plants with DBH ≥ 20 cm, while those with DBH ≥ 30 cm were considered harvestable.

2.3. Data Analysis

The collected data was entered into Microsoft excel, and summarized using tables, charts and summary statistics.

$$D = \frac{N}{A} \quad (1)$$

where D is tree density (treeha⁻¹), N is total number of tree population for each plot and A is the size of the study area in hectare [51].

$$\text{Frequency} = \frac{\text{count of Species of interest}}{\text{number of plots sampled}} \quad (2)$$

Basal Area Estimation

For the estimation of tree Basal Area (m²), Diameter at breast height (D) in meter recorded for each tree was used. The following formula was used to estimate Basal Area [52].

$$\text{Basal Area} = \frac{\pi D^2}{4} \quad (3)$$

Stand volume was estimated using the formular

$$\text{Basal Area} \times \text{height} (H) = \frac{\pi D^2}{4} H \quad (4)$$

$$\text{Dominance} = \frac{\text{Total basal area of species}}{\text{total area sampled}} \quad (5)$$

Regeneration index was assessed using the regeneration index formula proposed by [23].

$$\begin{aligned} &\text{Regeneration index} \\ &= \frac{(\text{Number of seedlings} + \text{saplings} + \text{juveniles}) - \text{Number of adults}}{\text{Total number of the species encounter}} \quad (6) \end{aligned}$$

3. Results

In plot 1, a total of 49 *Prunus africana* plants were censused, composed of 7 seed-

lings, 29 saplings, 8 juveniles and 5 adults. Three of the five adults were within the harvestable dbh limit of ≥ 30 cm (Figure 1).

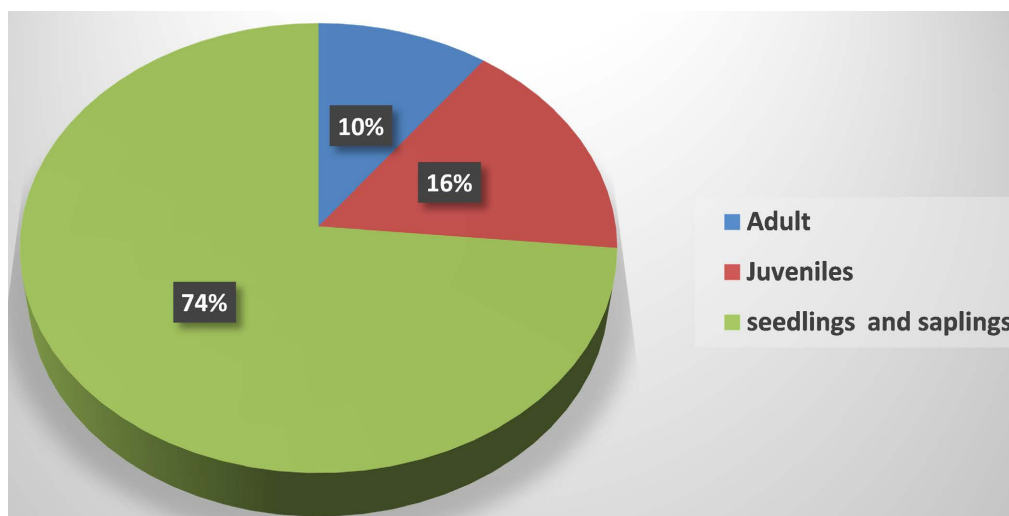


Figure 1. Percentage of adults, juveniles, seedlings and saplings of *P. africana* in plot 1 within the cloud forest of Mount Cameroon.

The linear dimensions of seedlings and saplings encountered in this plot ranged from 0.13 - 0.90 cm collar diameter and height of 0.5 - 2.4 m. Sapling DHB ranged from 1.29 - 7.5 cm while their heights ranged from 3.3 m - 7.4 m. The mean DBH of juveniles was 14.8 cm while their mean height was 16.6 m. Adult prunus trees had mean height of 35.9 m and mean DBH of 37.7 cm. Harvestable tree DBH mean was 46.4 and their mean height was 35.9 m.

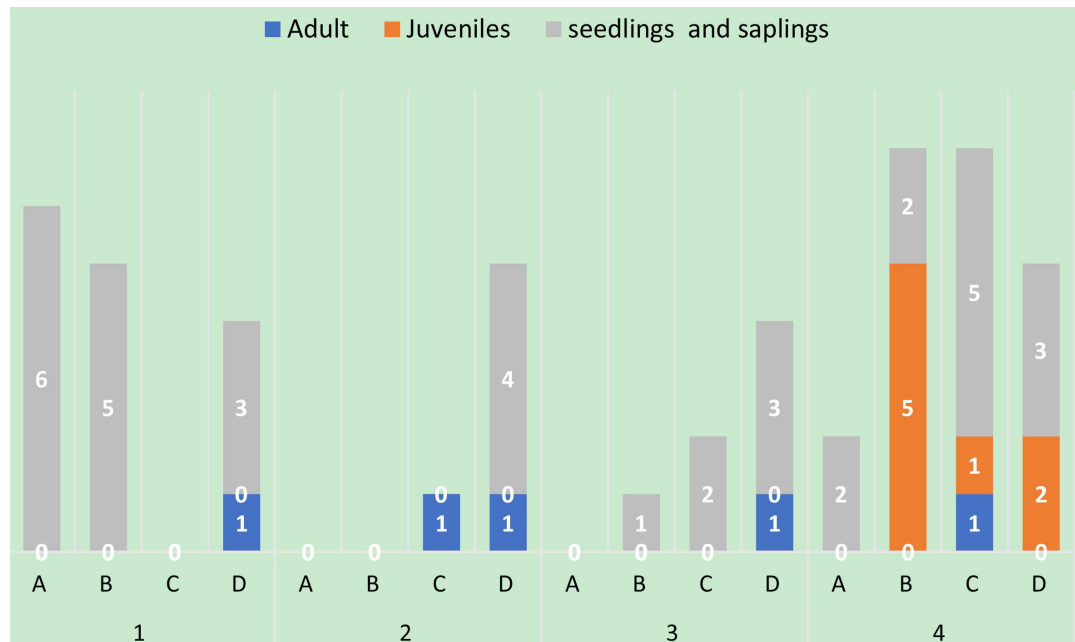
The total basal area of prunus trees with DBH ≥ 10 cm was found to be 0.78 m², with contributions of 0.14 m² from juveniles and 0.64 m² from adult trees. Three harvestable prunus trees (dbh ≥ 30 cm) contributed over 69% of the total basal area (Table 1).

Table 1. Means and ranges dbh, height, basal area and stand volume of *P. africana* stems in plot 1 within the cloud forest of Mt Cameroon.

Variable	DBH (cm)		Height (m)		Basal Area (m ²)	Stand Volume (m ³)
	Mean	Range	Mean	Range		
Juvenile	14.8	11.0 - 19.5	16.6	15.0 - 27.5	0.14	0.24
Adult	37.7	22.2 - 57.0	35.9	27.7 - 33.1	0.64	2.3
Harvestable	46.4	31.7 - 57.0	35.9	28.0 - 42	0.54	2.1
Total					0.78	2.7

The distribution of *P. africana* on plot 1 (1 ha) was such that 12 out of 16 subplots had at least one prunus tree at one of the selected stages of growth, with only 4 subplots void of any prunus. Five subplots had adults, three had juveniles while

11 sub plots had seedlings and saplings. Only one sub plot had all size classes and five sub plots recorded two categories (**Figure 2**).



The numbers 1, 2, 3 and 4 represent strips (25 × 100 m), into which the 1 ha plot was divided, while A, B, C and D represent further division of these strips to give the plots of 25 × 25 m plots.

Figure 2. Distribution of adults, juveniles, saplings and seedlings of *P. africana* on the surface of plot 1 within the cloud forest of Mt Cameroon.

The regeneration index for plot 1 was 0.47 when seedlings and saplings were used in one group.

Three dead prunus trees were encountered in plot 1, one of which was a large tree (dbh > 82 cm) with clear signs of failed bark regeneration due to abusive exploitation and pruned branches, over 20 meters tall, that died a few years ago with little or no decomposition. The pruned branches were still on the forest floor at an advanced state of decomposition with only the hard red core remaining. Two others, medium size trees at an advanced state of decomposition were cut down as indicated on the more resistant stumps.

The search for *P. africana* in plot 2 recorded a total of 124 individuals, made up of 44 seedlings and saplings, 61 juveniles and 19 adults (**Figure 3**). Of the 19 adults encountered, 12 were of harvestable size, with DBH ≥ 30 cm.

Mean growth parameters of individuals encountered showed that, the mean height of juveniles was 16.7 m with a range of 6 to 30 m, while the dbh for the same category ranged from 10.0 - 19.8 cm with a mean of 13.6 cm. Adults measured 42.4 cm mean dbh (range 20.9 - 124.0 cm) and an average height of 24.7 m. Harvestable individuals averagely measured 26.7 m in height and 53 cm DBH.

The juveniles in this plot had a basal area of 0.92 m²/ha and a stand volume of

1.6 m³/ha, while the adults had a basal area of 4.8 m²/ha and a stand volume of 12.6 m³/ha (Table 2). The exploitable adults in this plot contributed most of the basal of adults (4.4 m²) and stand volume (11.9 m³).

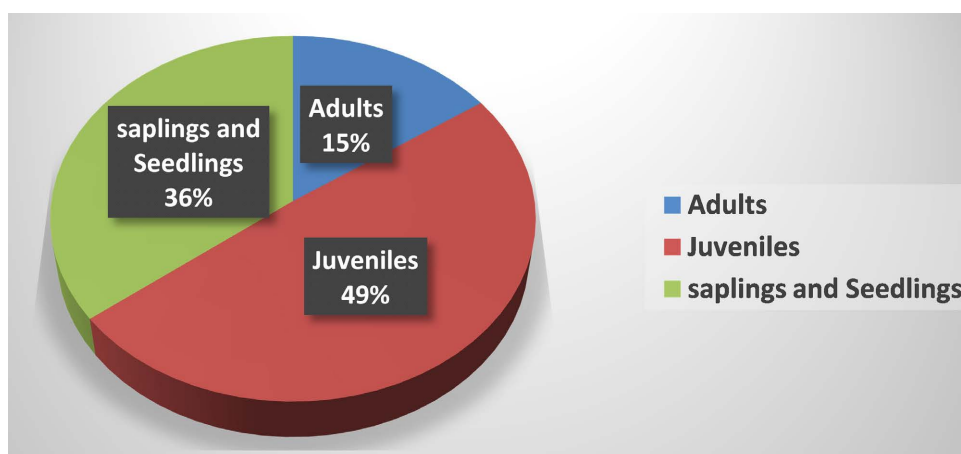


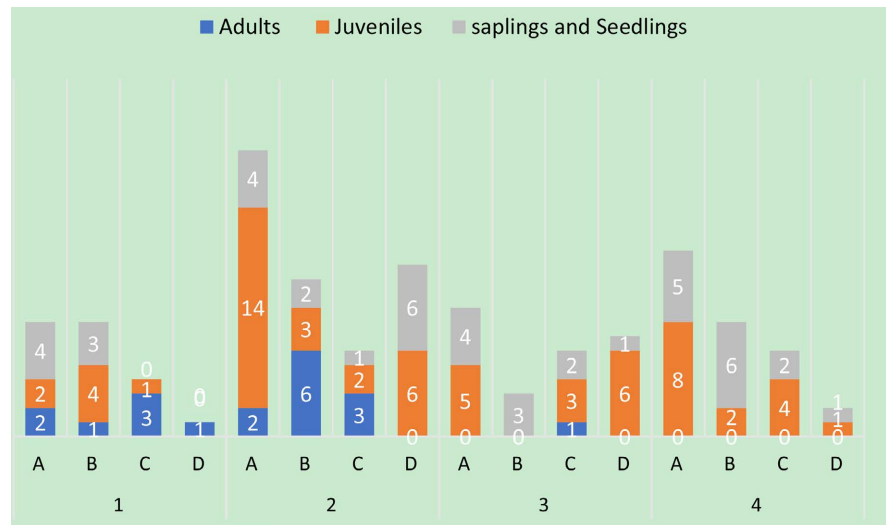
Figure 3. Percentage of adults, juveniles, seedlings and saplings of *P. africana* in plot 2 within the cloud forest of Mount Cameroon.

Table 2. Means and ranges dbh, height, basal area and stand volume of *P. africana* stems in plot 2 within the cloud forest of Mt Cameroon.

Variable	dbh (cm)		Height (m)		Basal Area (m ²)	Stand Volume (m ³)
	Mean	Range	Mean	Range		
Juvenile	13.6	10.0 - 19.8	16.7	06.0 - 30.0	0.92	1.6
Adult	42.4	20.9 - 124.8	24.7	22.0 - 48.0	4.8	12.6
Harvestable	53.0	30.3 - 124.8	26.7	20.0 - 48	4.4	11.9
Total					5.7	14.2

In this plot, seven trees showed signs of previous bark removal, all recovering, among which was one old, very big prunus (124.8 cm dbh) with visible signs of multiple debarking around the entire stem up to some branches, at different stages of recovery.

The distribution of *P. africana* in plot two (Figure 4) is such that all 16 sub plots had at least one prunus plant, with a mean of a little less than 8 prunus per sub plot and a range of between 1 and 20. While sub plot 1D had only one individual, an adult, sub plot 2A had the highest number of individuals composed of two adults, 14 juveniles and 4 seedlings/saplings. While Adult prunus trees were concentrated in sub plots 1A - 1D (9 individuals) and subplot 2 A, 2B and 2C (11 individuals), sub plot 3 and 4A - D had a high concentration of juveniles (28 individuals) and seedlings/saplings (24 individuals), with only one adult at 3C. The observed distribution in which regeneration seems to occur away from the parent cluster confirms its light demanding nature.



The numbers 1, 2, 3 and 4 represent strips (25 × 100 m), into which the 1 ha plot was divided, while A, B, C and D represent further division of these strips to give the plots of 25 × 25 m plots.

Figure 4. Distribution of adults, juveniles, saplings and seedlings of *P. africana* on the surface of a 1 ha plot 2 within the cloud forest of Mt Cameroon.

The regeneration index for this plot was calculated to be 0.69.

4. Discussion

Regeneration studies are important for assessing a forest's long-term health, resilience, and sustainability. Such studies provide essential data on how seedlings and saplings are establishing and growing to replace older adult populations. This is particularly critical for endangered medicinal plants subjected to high exploitation, as they provide the scientific foundation to prevent extinction while ensuring a sustainable supply of pharmaceutical raw materials like *Prunus africana* [32]. The key importance of regeneration studies lies in the development of sustainable harvesting models, mitigating destructive harvesting and ex situ conservation, ensuring genetic diversity [53] [54].

Natural regeneration of *Prunus africana* in undisturbed forests often shows a stable population structure (reverse J-curve), with numerous seedlings present but limited recruitment into the sapling stage, often due to high seedling mortality in shaded environments. [55], studied the population structure of *Prunus africana* in South Nandi Afromontane Forest, Kenya and found that the diameter size class distribution took the shape of a reverse “J” curve, indicating stable populations that naturally replace themselves, particularly in areas with good recruitment. [56] in their paper on the variation in regeneration density and population structure of *Prunus africana* across human disturbance gradient in South West Mau Forest reported that the relatively undisturbed site of the forest had a stable population structure that followed a reverse-J curve.

In the current study, seedling numbers were smaller than sapling numbers in

both plots and in plot 2, juveniles were way higher than seedlings and saplings put together. This scenario can't produce the reverse J curve. Adults, as expected were smaller in numbers than all the other size classes in both plots. The cloud forest of Mt Cameroon where this work was done is very difficult terrain, on steep slopes, far from habitation, with limited human activities that impact the vegetation. Apart from poaching, prunus bark collection is the only vegetation related activity of this part of the mountain. It is therefore safe to suggest that previous unsustainable bark extraction is responsible for the distortion of the *Prunus africana* population structure in this forest [57]. [8], noted the unbalanced distribution (a variation of the J) while working on the sustainability of cherry (*Prunus africana*) bark harvesting in Cameroon. This study recorded dead prunus trees that were still standing or cut down while others were debranched, an indication of irresponsible, unprofessional and unsustainable bark collection in the past, resulting in reduce adult population for seed production. These results emphasize the need for rigorous implementation of sustainable bark collection to ensure normal regeneration. Apart from four very big trees encountered in plot 2 that might have been too big to be cut down by machetes during the last bark exploitation, the mean dbh of adult of *P. africana* was 37.7 cm and 30 cm respectively for plot 1 and 2, an indication that the few harvestable trees are recent recruits into the ≥ 30 cm class within the over 15 years fallow period.

The number of individual *P. africana* encountered in this study is the highest ever recorded in Cameroon. This could be accounted for by the sampling intensity (in permanent plot) and the small size of the area in this study together with the fact that it falls within the reported altitude of *P. africana* abundance on Mt. Cameroon [20]. [38] reported 3.43 stems/ha, [20], 3.9 stems/ha on Mt Cameroon. Elsewhere in Cameroon, [40] counted maximum of 6.2 stems/ha in the North West Region while [41] reported a density of 6.23 stems/ha in the Tchabal Mbabo montane forest, Adamawa region. For the same size class (≥ 10 cm dbh) as the studies above the current research recorded 13 and 80 individuals for plots 1 and 2 respectively, with mean of 43.5 individuals/ha. While 43.5 individuals/ha may look exceedingly high compared to observations from the other *Prunus* blocks in Cameroon, it is not the highest ever recorded for the species. [55], working in South Nandi Afromontane Forest, Kenya recorded mean density of 51 trees/ha with dbh ≥ 10 cm.

The spatial distribution of the species within the plots was such that most of the young survived away from the adults, in line with [11], suggesting that while *P. africana* can regenerate naturally, it often favours light gaps, meaning mature undisturbed forests may exhibit lower regeneration rates than lightly disturbed areas.

In regeneration studies, permanent plots are essential for tracking the long-term survival and transition of young plants into mature stands [58]. Unlike one-time surveys, they allow researchers to follow the specific fate of individual seedlings and saplings over decades, providing data that is otherwise "unknowable". The key roles of permanent plots include tracking survival and mortality, monitoring successional stages, growth and yield modelling, understanding disturb-

ance impacts, validating remote sensing as they provide the “ground truth” needed to calibrate large-scale remote sensing models.

[41], in a study of potential and measures for sustaining *Prunus africana* in Tchal Mbabo forest (Adamaoua, Cameroon) stressed that future sustainable management must “take into account the dynamic elements” of the species, which are best captured through the ongoing monitoring provided by permanent plot systems. This is particularly important for protected area such as Mt Cameroon National Park and the community forests around it. Scientifically, permanent forest plots act as “miniature labs” to observe how regeneration patterns shift in response to changing temperatures and rainfall, help distinguish between natural “fluctuations” (seasonal noise) and actual “trends” (long-term decline or recovery) and help set scientifically sound harvesting limits by showing how fast a species can actually replace itself through recruitment. While providing baseline data at the beginning, long-term data from these plots can justify the legal protection of critical habitats [59].

In a highly heterogenous environment like Mt Cameroon, using many small permanent plots to study the regeneration of *Prunus africana* offers significant advantages over a single large plot, particularly in addressing the high spatial variability and clustered distribution of this endangered, shade-tolerant species. Smaller, distributed plots enhance statistical power and improve the accuracy of regeneration data compared to a single, large one. They also better capture of spatial heterogeneity, high statistical power and precision, ability to detect fine-scale patterns, risk spreading and long-term monitoring [60]. If one area is destroyed by a tree fall or human disturbance, the entire study is not lost, as in the case of a single large plot.

5. Conclusion

The regeneration of *P. africana* within the cloud forest of Mt Cameroon is, on average, good as the stem count recorded was considerably higher than for all the other studies carried out in this site and elsewhere. However, the population structure didn't yield the reverse J due to anthropogenic factors. It is thus recommended here that longer periods between commercial bark collection and strict implementation of the management guidelines will allow for recovery and sustainability of both the economic activity and the species. Also, setting up more of such plots in all the prunus blocks of Mt Cameroon, both in and out of the National Park, will help in tracking the long-term survival and transition of young plants into mature stands and also follow up the fate of harvested plants and more.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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