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Ecological Structure of Pre-Forest Fallow Lands Following Shifting Cultivation in the Congo Basin

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Abstract

This study analyzes the floristic diversity and autoecological traits of pre-forest fallows resulting from slash-and-burn shifting agriculture (AIB) in the Local Community Forest Concessions of the Mbali River (CFCL-RM), in the Congo Basin. Inventories recorded 2578 individuals, identifying 170 species, 126 genera, and 59 families. Diversity (Shannon ~4.0) and evenness (>0.96) indices reveal structured communities. The flora is predominantly Guineo-Congolian (47%) and dominated by phanerophytes (97%), particularly mesophylls (75%). The predominant dispersal trait is zoochory (sarcochores: 68%), highlighting the vital role of frugivorous fauna. The mean Pioneer Index (45%) indicates an intermediate successional stage. The analysis shows a clear successional dynamic: canopy opening promotes understory regeneration, followed by progressive canopy closure and self-thinning in older fallows. Significant differences were observed between the Nkala site (forest block, more disturbed) and Embirrima (forest-savanna mosaic). The study concludes that these fallows are dynamic and resilient ecosystems, essential for biodiversity and landscape connectivity. Their sustainable management must integrate maintaining long fallow periods and conserving key animal dispersers.

Keywords

Secondary Forest, Fallow, Succession, Autoecology, Dispersal, Congo Basin, Shifting Cultivation, Resilience

1. Introduction

Forest areas are currently heavily degraded and still face increasing anthropogenic pressures (Lubini, 2022). Indeed, since the dawn of time, humans have made numerous modifications to their environment to meet their needs (Klanderud et al., 2010). Mainly, it is the tropical forests that are currently under the most pressure (Aryal et al., 2024; Beni et al., 2024; Lubini, 2016; Mukul, 2016). With the increase in population in tropical areas (Suharti, 2020; Ye, 2024), research has shown that a high percentage of primary forests have disappeared, giving way to anthropogenic secondary forests (Grantham et al., 2020; Lubini, 2022; Mukul, 2016). Of all the existing anthropogenic activities, the one recognized as the main one significantly altering the structure and composition of primary forests is Shifting Cultivation (SC) (Bezerra et al., 2024; Defourny & Delhage, 2009; Klanderud et al., 2010). also known as slash-and-burn agriculture or swidden agriculture (Deere et al., 2020; Edwards et al., 2017), it is the most predominant traditional agricultural practice in forested rural areas (Mukul et al., 2020).

Historically, slash-and-burn agriculture was a relatively sustainable practice when population densities were low and fallow periods were long enough (several decades) to allow for near-complete forest regeneration (Edwards et al., 2017; Kalaba, 2012; Kembelo et al., 2023). However, the rapid increase in population in the Congo Basin over the past few decades has led to an intensification of this practice, a drastic reduction in fallow periods (2 to 3 years), and an increase in cleared areas (Haurez et al., 2017; Loubelo, 2012; Loubota Panzou et al., 2024).

This intensification has led to a gradual transformation of forest landscapes (Bangirinama et al., 2011), where primary forests are increasingly being replaced by a complex mosaic of secondary forests (SF) at different stages of regeneration (Belesi, 2009; Kimvwela et al., 2025; Lubalega, 2016; Lubini, 2022). These secondary forests, although often considered degraded ecosystems (Bandy, 2000), are in reality dynamic and essential components of the landscape (Lubini, 2016), playing a crucial role in biodiversity conservation and the maintenance of ecological functions (Douglas Sheil, 2019; Mukul et al., 2016). It is therefore important to conduct studies aimed at understanding the dynamics and resilience capacity of these post-AIB secondary forests for better management planning balanced between conservation and the well-being of local populations. Thus, the autecological and floristic analysis of secondary forests remains a fundamental approach to understanding their regeneration dynamics as well as their ecological value (Edwards et al., 2017; Fournier et al., 2001; Rabiou et al., 2017).

Autoecological analysis, which delves into the core of individual relationships between a given species and its environment, allows for surpassing mere description to achieve a mechanistic understanding of plant succession (Gourlet-Fleury et al., 2013; Rabiou et al., 2017). Ultimately, the integration of synecological and autecological perspectives offers a richer and more nuanced understanding of the complexity of secondary forests in the Congo Basin (Lisingo, 2016; Nshimba, 2005). It allows for a shift from mere description to an analysis of ecological processes, thus providing solid scientific foundations for more informed and effective conservation and management interventions in this region crucial for global biodiversity (Belesi, 2009; Lisingo, 2016).

Thus, this study aims primarily to comprehensively analyze the floristic diversity and the autoecological characteristics of fallows of different ages after AIB in the Congo Basin, specifically in the Forest Concessions of the Local Communities of the Mbali River (CFCL-RM). By adopting this dual approach, the research aims to provide a detailed understanding of the regeneration processes and the factors that influence them, with direct implications for the conservation and sustainable management of natural resources.

2. Materials and Methods

2.1. Study Site

This study was conducted in the community forests of Nkala and Embirrima, located in the Guineo-Congolian zone in the southwest of the Mai Ndombe province (Beni et al., 2024), Bolobo territory, and which are part of the six community forests grouped under the label of the "Community Forest Concessions of the Mbali River" (CFCL-RM) (Narat et al., 2013). The choice of the Nkala and Embirrima forests is explained in that they are the oldest to have been ceded for the conservation of the Bonobo habitat. These two forests have substrates on hydromorphic soils, periodically flooded, and firm lands (Omasombo Tshonda et al., 2019; Omasombo et al., 2022).

The fauna is diverse with a dominance of bonobos (Pan paniscus) as the main disperser and a strong presence of birds and other species (Beni et al., 2024; Onishi et al., 2020). The local Téké population living there are practicing slash-and-burn agriculture and are highly dependent on the forest for subsistence farming. Households in our area clear only half a hectare per year on average and rarely more than one hectare (De Weerdt, 2019).

2.2. Methods

2.2.1. Field Data Collection

"Pre-forest fallow" is defined in this study as a post-agricultural site that has been abandoned after slash-and-burn cultivation and is undergoing natural secondary succession toward a forest state. Only fallows ≥ 10 years since abandonment were included, ensuring that the initial herbaceous and early shrub phases had been surpassed. Fallow age for each plot was determined through semi-structured interviews with local land chiefs and the farmers who last cultivated the plot, who provided the year of final clearing and cropping. The number of years since abandonment was calculated from that date, and plots were subsequently assigned to six age classes (10 - 19, 20 - 29, 30 - 39, 40 - 49, 50 - 59, and ≥ 60 years). Within each fallow land, we established a 0.25 ha plot, following established clearing practices (Kalaba, 2012; Lisingo, 2016; Mkanda et al., 2014). Each plot was established from the center outwards to minimize the risk of introducing bias as shown in

Figure 1. A total of 20 square plots in fallows ≥ 10 years since abandonment were established across two sites: 10 plots in Nkala and 10 in Embirrima.

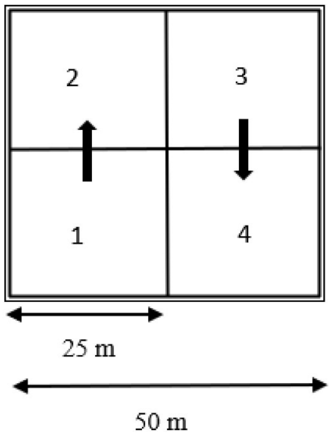


Figure 1. Data collection plot.

Once the plot was established, the next step was to take the geographic coordinates from the center. We identified all species of trees, shrubs, seedlings, herbs, and lianas, and measured the heights of the trees and shrubs, as well as the DBH (Depth of Water) of species ≥ 10 cm. The plants were classified into strata according to Belesi (2009).

2.2.2. Species Identification

Species identification was made possible using several identification keys and botanical indicators. The samples were compared at the botany laboratory of the Department of Biology and at the Laboratory of Systemic Biodiversity, Conservation, and Endogenous Knowledge of the Department of Environmental Sciences and Management at the University of Kinshasa. We also used several illustrative and descriptive documents on tropical species worldwide, primarily in Central Africa, available both online and in print.

Canopy opening was estimated visually as the percentage of canopy cover per 50 × 50 m plot. Understory density was quantified as the combined cover percentage or stem count of all vegetation in the shrub (1 - 5 m) and herbaceous (≤1 m) strata, also recorded per plot. Pearson correlation coefficient (r) was calculated to assess the relationship between canopy opening (%) and understory density (%). The test was performed using R software (version 3.3.1).

2.3. Data Analysis

2.3.1. Autoecological Characteristics

The various intrinsic characteristics of the species were determined by observation according to the approach proposed by Braun-Blanquet (1951), Raunkiaer (1934), and Troupin (1971); and subsequently adopted by Le Joly et al. (1982), Lubini (1982), Belesi (2009), Boyemba (2019), and Kimvwela et al. (2025). The elements considered were diaspore type (TD), biological type (TB), leaf type (TF), phytogeographic distribution (DP), and phytosociological status (TP). The species form was also taken into account.

2.3.2. Degree of Fallow Disturbance

We determined the degree of fallow disturbance using the Hawthorne (1996) formula, as employed by Boyemba et al. (2019). By assessing the relative importance of pioneer species compared to all species inventoried at this site, the "Pioneer" index was calculated using the following formula:

$$PI = [(pi + np)/N] \times 100$$

where pi is the number of individuals of pioneer species, np the number of individuals of non-pioneer but sun-loving species, and N the total number of individuals of all inventoried species. *PI* ranges from 0 (absence of pioneer species and therefore of disturbance) to 100 (all species are pioneers; the forest is completely disturbed and degraded). This Pioneer Index is a good indicator of the degree of disturbance or degradation of the forest.

2.4. Statistical Analyzes

Diversity and similarity indices such as the Shannon, Pielou, Simpson, Jaccard, and Sorensen indices were used to analyze the biodiversity between the two vegetations of the CFCL-RM. The Shannon-Weaver index (H') allows for measuring diversity by taking into account both species richness (number of species) and evenness (distribution of abundances among species).

A high value indicates a diverse and balanced community (many species, none very dominant). A decrease may indicate environmental stress. Much more sensitive to the presence of rare species than the Simpson index, it is the most commonly used in community ecology. It allows for solid comparisons between different sites or periods.

$$H' = -\sum_{i=1}^{S} p_i \ln(p_i)$$

Interpretation: 0 - 1 = low, 1 - 3 = medium, >3 = high.

Pielou's evenness (*J'*) measures the uniformity of abundance distribution among the species present. It is the ratio between observed diversity (*H'*) and the maximum possible diversity (*H'*max = ln(S)). It complements the Shannon index by addressing whether diversity is low due to a lack of species or very strong dominance. A value close to 1 indicates that all species have the same abundance. Close to 0, one or a few species dominate. It is key to interpreting changes: A decrease in H' with a stable *J'* indicates a loss of species. A decrease in *H'* with a drop in *J'* indicates an increase in dominance.

$$J' = \frac{H'}{\ln(S)}$$

Simpson (D): measures the probability that two individuals randomly drawn from the community belong to the same species. The original index (D) is a measure of dominance. 1 − D or 1/D is often used as a measure of diversity. It emphasizes dominant species: It is more sensitive to changes in the abundance of common species. It is useful for assessing resistance to invasions. A high dominance (high D) can sometimes indicate a less resilient community.

$$D=\sum_{i=1}^{S} p_i^2$$

Sørensen (Sø) and Jaccard (J) measure the compositional similarity between two communities (beta diversity). They are based on the presence/absence of species. These two indices prioritize conservation by identifying sites that harbor unique communities (low similarity) and thus complementary for a network of reserves. However, while Sorensen gives more weight to common species than to unique ones, Jaccard treats them equally. Sø is generally preferred in ecology. In our work, we used both formulas.

$$\text{Sorensen}\quad C_S=\frac{2a}{2a+b+c}$$

$$\text{Jaccard}\quad C_J=\frac{a}{a+b+c}$$

3. Results

3.1. Floral Diversity and Richness of the Florule

The inventories conducted in the forest fallows of Nkala and Embirrima on dry land in the CFCL-RM reported 2,578 individuals belonging to 170 species, 126 genera, and 59 families (APGIII). The most representative family's number 5, including the Fabaceae group with 12% (Mimosoideae 3%; Faboideae 4% and Caesalpinioideae 5%), followed by Annonaceae and Apocynaceae with 8% each, then Euphorbiaceae with 7%, and finally Rubiaceae with 5%.

The other families are poorly represented. The vegetation of Nkala (135) presents a higher number of taxa than that of Embirrima (114) as shown in Table 1. Thus, the two sites are not significantly different with p-Value (0.227) > 0.005.

Table 1. Spatial variation of different biodiversity indices of pre-forest fallows.

Indices	CFCL-RM sampled sites	
	Nkala	Embirrima
Taxa_S	135	114
Individus	1405	1173
Simpson_1-D	0.95933733	0.95987943
Shannon_H	4.02627466	3.87804349
Equitabilité_J	1.03822318	0.96318404
Jaccard	0.32608696	
Sorensen	0.49180328	

The Simpson_1-D index indicates that both sites have high species diversity (values close to 1, meaning low dominance). Contrary to the original statement, the Shannon index is slightly higher in Nkala ($H' = 4.03$) than in Embirrima ($H' = 3.88$), suggesting marginally greater diversity in Nkala, while Simpson values are nearly identical (0.9593 and 0.9599), confirming that overall diversity is comparable between the two sites. The evenness index J' (corrected) is approximately 0.82 for both sites, indicating a balanced distribution of species abundances. The Jaccard and Sørensen similarity indices (0.33 and 0.49, respectively) show moderate floristic similarity between Nkala and Embirrima.

3.2. Autecological Characteristics of the Flora

The biological traits considered in this study concern the geographical distribution of species, the types of diaspores, the biological types, and the leaf types.

3.2.1. Phytogeographic Spectrum

The proportions of the geographical distribution of the collected species (Figure 2) highlight the predominance of Guineo-Congolian species (GC) (47.0%). They are followed by the species of the Lower Guineo-Congolian (20%), and finally the Afro-Tropical (14%). Practically no endemic species have been identified in the fallow land flora.

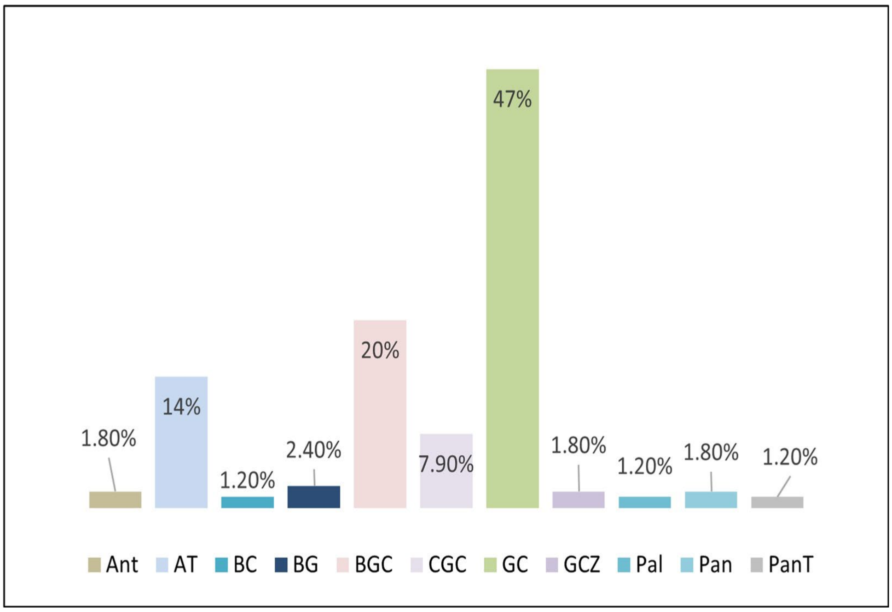


Figure 2. Phytogeographic spectrum of fallow land.

3.2.2. Diaspore Types

A detailed examination of diaspore types (Figure 3) shows a large predominance of species with fleshy diaspores (Sarcochores: 68%) in our study. These are diaspores from shrubs, trees, and overstory vegetation. Ballochorous species (19%) are the second most common, followed by Pterochorous species (6.4%).

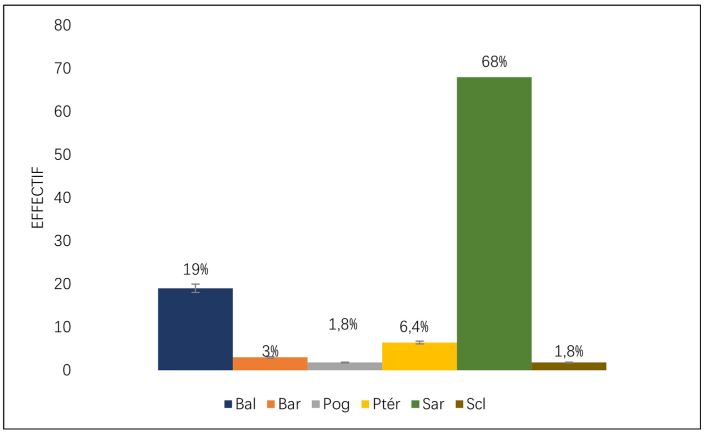


Figure 3. Spectrum of diaspore types in the fallow flora.

3.2.3. Biological Types

The biological types (**Figure 4**) most represented in the flora of the studied fallows are the Mesophanerophytes (MsPh) with 74%, followed by the Lianous Phanerophytes (Lph) with 23% and the Megaphanerophytes (MgPh) with 23%. Phanerophytes are dominant in the pre-forest fallows of the CFCL-RM, however, a chamaephyte tendency is very weakly observed.

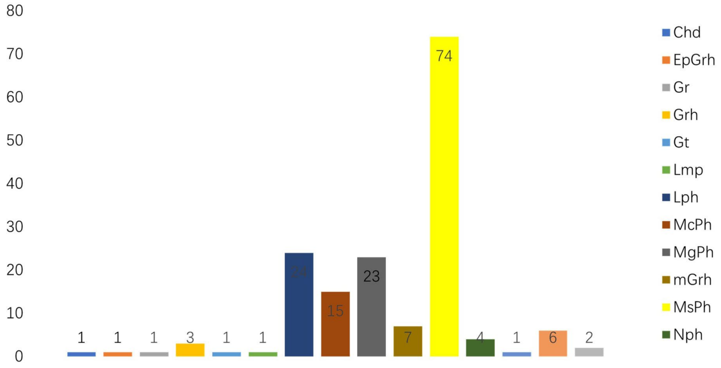


Figure 4. Biological spectrum of fallow lands in CFCL-RM.

3.2.4. Leaf Types

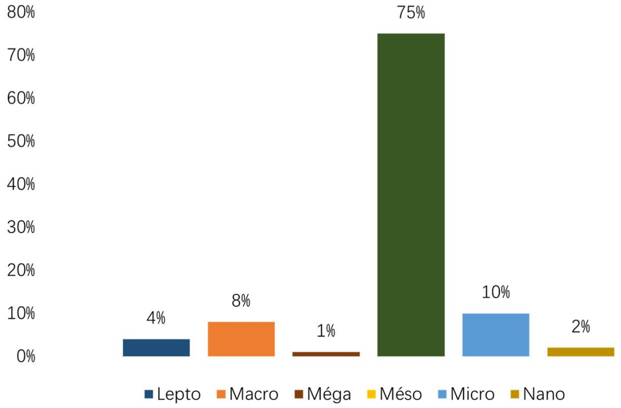
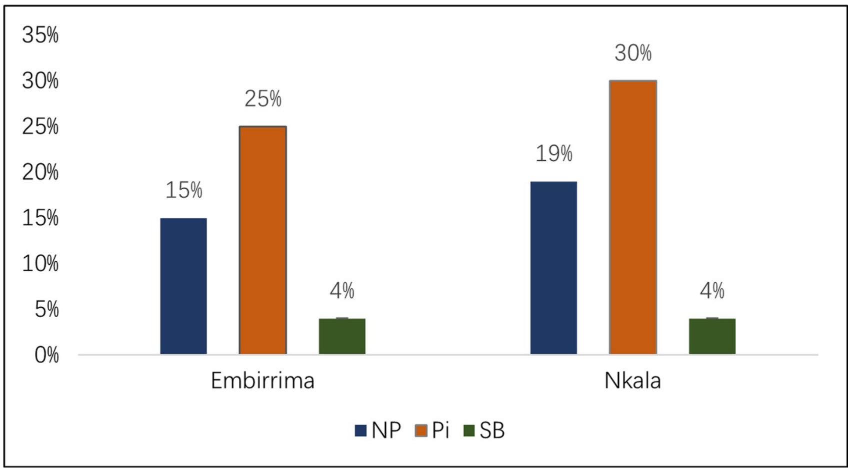


Figure 5. Analysis of the leaf spectrum of the CFCL-RM fallows.

Analysis of leaf size types (**Figure 5**) indicates a dominance of mesophyll species (75%). Microphyll species (10%) are the second most common. The other categories are poorly represented. Mesophyll species are largely dominant in the different fallow areas.

3.3. Comparison of the Temperament Spectra of the Two Sites

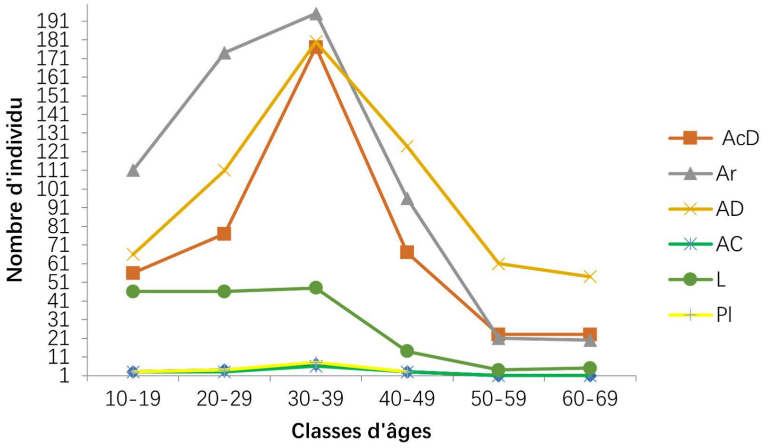
The Pioneer Index (PI), which gives us an image of the degradation state of the two sites (**Figure 6**), is generally low overall with an average PI of ± 45%. This value indicates that, overall, the forest stands are slightly disturbed. Individually considered, Nkala is the most disturbed site with a PI of 55% and 45% for Embirrima.



NP = non-pioneer species; Pi = pioneer species; SB = shade-tolerant species.

Figure 6. Raw spectra of temperament and pioneer index by site.

3.4. Morphological Variation by Age Classes



AcD: Co-Dominant Trees; Ar: Shrubs; AD: Dominant Trees; AC: Canopy Trees, L: Vines; Pl: Seedlings.

Figure 7. Variation in the number of individuals based on morphologies by age class in the pre-forest fallows of the CFCL-RM.

Plant morphology variation by age showed a decreasing curve in the number of trees between 30 years and 60 years as shown in **Figure 7**. Dominant trees (DT) are much more represented in increasingly older fallows with more than 50 trees between 10 years and 60 years. We observe a decline in canopy trees (CT) and seedlings (S) with age.

3.5. Ecological Relationship between Canopy Opening and Understory Density

The correlation between canopy opening and understory density was strong and statistically significant ($r = 0.82$, $p < 0.001$, $n = 20$), confirming that understory density increases with greater canopy openness as shown in **Figure 8**. The highest understory density occurred in the 30 - 39 year fallow class, where canopy opening peaked.

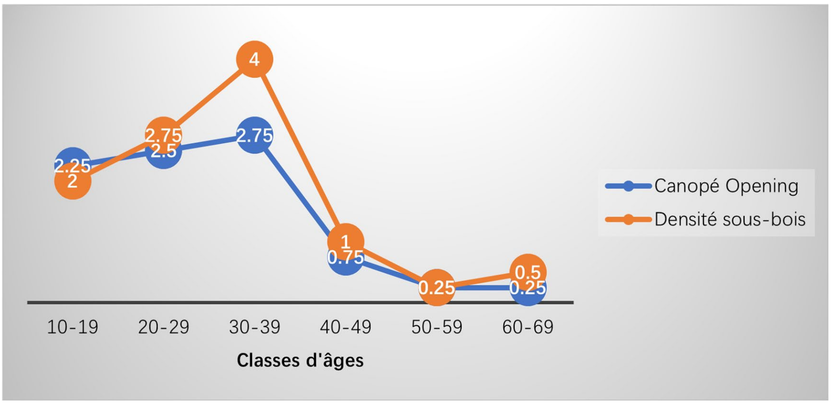


Figure 8. Variation of the undergrowth depending on the canopy opening in the fallows of the CFCL-RM.

4. Discussion

4.1. Diversity and Floristic Richness of the Flora

The floristic inventory revealed a notable diversity in the pre-forest fallows of the CFCL-RM, with 170 species distributed across 59 families. This richness, although lesser than that of the neighboring primary forests (Beni et al., 2024), is significant for post-agricultural regeneration ecosystems. The superiority of the number of taxa at Nkala (135) compared to Embirrima (114) could be explained by the nature of the landscape: Nkala constitutes a continuous forest block, potentially more favorable for the accumulation of species than the forest-savanna mosaic of Embirrima, where ecotones and different historical disturbances can filter certain species (Narat et al., 2015). The Shannon diversity indices ($H' \approx 4.0$ and 3.9) and Simpson ($1 - D > 0.95$) indicate structured and diverse communities, typical of African secondary forests in the process of reconstitution (Lubini, 2016; Gourlet-Fleury et al., 2013). The evenness values ($J' \approx 0.82$ for both sites) suggest a relatively balanced distribution of abundances among species, indicating intra- and interspecific competition not yet dominated by a few taxa, characteristic of an intermediate stage of succession.

4.2. Autoecological Characteristics of the Florule

4.2.1. Phytogeographic Spectrum

The strong predominance of species from the Guineo-Congolian domain (47%) and the Lower Guineo-Congolian sector (20%) confirms the biogeographical affiliation of the flora studied in the heart of the Congo basin. The almost total absence of strict endemics reflects the secondary and still young nature of these fallows, where the flora is mainly composed of species with a wide distribution and good dispersal capacity, typical of post-disturbance stages (Fournier et al., 2001). The presence of Afro-tropical elements (14%) indicates the influence of savanna corridors or more open environments, particularly in Embirrima.

4.2.2. Types of Diaspores

The overwhelming dominance of sarcochores (fleshy diaspores, 68%) is a major result. It highlights the crucial role of zoochory, and particularly frugivory, in the recruitment and regeneration of these fallows. This predominance is consistent with the presence of a dispersal fauna, particularly bonobos (Pan paniscus) identified as key players in the landscape (Beni et al., 2024; Onishi et al., 2020). In fact, Based on the combination of diaspore syndromes and prior studies on bonobo ecology in the same landscape, a plausible inference can be made that bonobos actively shape forest regeneration, even though direct dispersal observations were not conducted in this study.

The inventoried flora shows a clear predominance of sarcochores (fleshy diaspores), a dispersal syndrome directly associated with frugivorous animals. This structural trait alone confirms that zoochory is the dominant regeneration mechanism. Prior research in the Mbali landscape (Onishi et al., 2020; Narat et al., 2015; Beni et al., 2024) has documented bonobos (*Pan paniscus*) as the largest and most abundant frugivores, with diets composed largely of the same tree species that dominate these fallows. Moreover, the spatial continuity of the forest block and the cultural prohibitions against bonobo hunting in the study area further support their role as effective, unhindered dispersers.

Therefore, while this study did not directly measure seed ingestion, gut passage, or dispersal distances, the convergence of functional trait analysis (sarcochore dominance) and existing ecological knowledge (bonobo frugivory and habitat use) provides strong confirmatory evidence that bonobos are key agents in the successional dynamics and forest evolution of the CFCL-RM. Their frugivory likely drives the recruitment of many late-successional species, linking faunal conservation directly to forest recovery and carbon sequestration.

The low representation of pterochorous plants (6%) suggests that anemochory plays a secondary role in the colonization of these environments, perhaps due to the closed structure that young fallows quickly develop.

4.2.3. Biological Types

The community is largely dominated by phanerophytes, a category that includes nearly 97% of the species, with a clear predominance of Mesophanerophytes

(74%). This spectrum is characteristic of a forest formation undergoing vertical structuring. The high proportion of liana phanerophytes (23%) is a classic indicator of recent disturbance and the exploitation of available light in the early stages of succession (Lisingo, 2016). The scarcity of chamaephytes and therophytes confirms that the environment has surpassed the initial stage of pioneer herbaceous plants to evolve into a structured woody population.

4.2.4. Leaf Types

The clear dominance of mesophylls (75%) is a functional trait adapted to moderate light conditions and high atmospheric humidity under a closed forest canopy. This result indicates that, despite their post-cultural origin, the studied fallows have recreated an internal forest microclimate that favors this type of foliage, to the detriment of microphylls (10%) which are more suited to conditions of greater water or light stress (Belesi, 2009).

4.3. Comparison of the Temperament Spectra of the Two Sites

The average Pioneer Index (PI) of 45% confirms that the stands are in an advanced phase of succession, far from a pure pioneer stage. The difference between Nkala (PI = 55%) and Embirrima (PI = 45%) is significant. The Nkala site, although a forest block, has a slightly younger or more frequently disturbed stand (probably due to local human activities such as collection), favoring a higher proportion of heliophilous species. Embirrima, despite its mosaic landscape, harbors slightly more mature or less disturbed stands, with a higher proportion of shade-tolerant species. This nuance highlights that the history of use and the configuration of the landscape finely influence the successional trajectory.

4.4. Morphological Variation by Age Class

The morphological analysis reveals an expected but instructive demographic dynamic. The decreasing curve of the total number of individuals with age, associated with the increasing proportion of dominant trees (AD), illustrates the process of self-thinning and competition for light. The scarcity of seedlings (Pl) and canopy trees (AC) in the oldest classes suggests that regeneration under closed canopy is becoming limiting. This indicates a possible bottleneck for the recruitment of shade-loving species in the absence of gap-creating disturbances, a key natural process for maintaining long-term diversity (Gourlet-Fleury et al., 2013; Kimvwela et al., 2025).

4.5. Ecological Relationship between Canopy Opening and Understory Density

The strong positive correlation observed between canopy opening and understory density is a cornerstone of tropical forest ecology, clearly confirmed in our context. The peak in understory density in the 30 - 39 year age class likely corresponds to a phase where the canopy of fast-growing pioneer species begins to open (through senescence or competition), allowing for a strong surge in sun-loving regeneration and liana growth. Subsequently, the progressive closure of the canopy by longer-lived, broad-crown species leads to understory thinning, as observed in older fallows. This "wave" dynamic is characteristic of secondary succession and underscores the importance of gap cycles for forest renewal and stratification (Edwards et al., 2017; Lisingo, 2016).

4.6. Conclusion of Discussion

Overall, this study demonstrates that post-AIB fallows in CFCL-RM, beyond 10 years, are dynamic and complex ecosystems engaged in an active process of forest regeneration. The flora is already dominated by traits of mature forest (Guineo-Congolian phytogeography, dominance of mesophyll sarcochores), but the demographic structure and temperament indices reveal that they are still in an intermediate phase of succession. Comparison between sites shows that the successional trajectory is modulated by the landscape context and the intensity of residual disturbances. The strong dependence on zoochory highlights the critical interdependence between forest regeneration and the conservation of frugivorous fauna, particularly bonobos. These secondary forests therefore play an irreplaceable role as a biodiversity reservoir and ecological corridor in a human-modified landscape, fully justifying their integration into conservation and land-use planning strategies (Mukul et al., 2016; Douglas Sheil, 2019).

5. Conclusion

This study demonstrates that post-AIB pre-forest fallows in the Congo Basin, represented by the CFCL-RM sites, are dynamic and resilient ecosystems engaged in active secondary succession. Despite their anthropogenic origin, these secondary forests develop, within one to a few decades, remarkable floristic diversity (170 species) and a complex structure dominated by ecological traits of mature forest: a predominance of Guineo-Congolian species, phanerophytes, and mesophylls. The regeneration process is primarily driven by zoochory, as evidenced by the overwhelming dominance of sarcochores (68%), highlighting the critical symbiotic link between forest regeneration and the conservation of frugivorous fauna, particularly bonobos.

The successional trajectory follows an expected dynamic, marked by self-thinning, the progressive closing of the canopy, and the transition from pioneer species to more shade-tolerant species. However, our analysis reveals that this dynamic is modulated by the local landscape context, with significant differences in floristic composition, successional stage, and disturbance indicators between a forest block (Nkala) and a forest-savanna mosaic (Embirrima). These fallow areas are therefore not simply "degraded forests," but rather ecosystems in their own right, playing a crucial role as biodiversity refuges, ecological corridors, and providers of ecosystem services in an increasingly fragmented landscape.

For sustainable management, it is imperative to: 1) maintain sufficiently long fallow periods (beyond 30 years) to allow for the establishment of more mature species; 2) protect key disseminators such as bonobos; and 3) integrate these mosaics of secondary forest into land-use plans and networks of protected areas. This research thus provides a solid scientific basis for conservation policies that recognize the value and potential of secondary forest landscapes in the Congo Basin.

Conflicts of Interest

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

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