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Original Research Article

Stand Dynamics of Non-Wood Forest Product Species in the Kuinima Classified Forest (KCF) in the Houet Province (Burkina Faso)

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Abstract

The vegetation cover of forest ecosystems in sub-Saharan Africa is currently deteriorating. Species that provide non-wood forest products such as *Vitellaria paradoxa*, *Parkia biglobosa* and *Adansonia digitata* are not spared. The aim of this study is to contribute to the valorization and conservation of these species. To achieve this, a forest inventory of the main species was conducted in the Kuinima classified forest. A systematic inventory was carried out using circular plots with a radius of 20 cm. The data obtained was complemented by a structural study of these formations, based on the circumference measured at 1m 30 from the ground. ANOVA analysis of variance revealed a significant difference between densities. The results show that *Vitellaria paradoxa* has the highest average density (47.714±65.165 individuals/ha), followed by *Parkia biglobosa* (5.626±2.29 individuals/ha). In terms of health condition, *Vitellaria paradoxa* is the most attacked by Loranthaceae (41.93%). Regarding the stand structure, all three species show an abundance of juvenile trees (c ≤20 cm). Moreover, with the low mortality rates observed, the dynamics is evolutionary for all three species. In order to preserve the wood potential of this forest, capacity building, technical and awareness-raising actions could be undertaken. These results constitute data that should be taken into account in programs for the conservation of NWFP species in general, and for the control of Loranthaceae that parasitize *Vitellaria paradoxa* in particular.

Keywords: Kuinima Classified Forest, Loranthaceae, Dynamics, Non Wood Forest Products.

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INTRODUCTION

In Sub-Saharan Africa, edible woody species are highly valued by local populations. These species contribute to the diversification of livelihoods in addition to agriculture. Their role in combating food insecurity is irrefutable, particularly in rural areas (Kouyaté AM *et al.*, 2016). Forests provide livelihoods for nearly 60 million people in Africa (De Wasseige C *et al.*, 2014). It is permitted for the populations to collect animals and plant products other than wood, which are classified as Non-Wood Forest Products (NWFPs) in protected areas (Kouakou AM *et al.*, 2017). They constitute a source of survival food during lean periods, particularly in years of drought, and a supplementary food source during periods of abundant rainfall in the Sahel (Hill D *et al.*, 2007). They play a pivotal role in maintaining health, combating food insecurity and making a substantial contribution to economic development at the household level (Kouyaté AM *et al.*, 2016).

In Burkina Faso, the inventory indicates that 70% of the national territory, or approximately 19,048,352 ha, contains a wide variety of NWFPs. Such products are defined as "any goods of biological origin other than wood and fauna, excluding insects, that are derived from forests, other wooded land and trees outside forests. Included in this classification are both spontaneous and domesticated plants as well as those intended for reforestation". These include leaves, flowers, fruit, bark, roots, non-lignified stems, sap, gum, resins, fungi, honey and insects (MECV, 2010). In order to promote the NWFPs, the government has established a NWFP promotion agency (APFNL). Among the species that provide NWFPs, *Vitellaria paradoxa* C.F

Gaertn, *Parkia biglobosa* (Jacq.) R. Br. and *Adansonia digitata* L. are notable for their supply of edible fruits and seeds, edible leaves and bark which are utilized for various purposes.

Vitellaria paradoxa (shea) and *Parkia biglobosa* (néré) are the most significant NWFP species in Burkina Faso. These two species contribute to the satisfaction of household needs in a variety of ways, including as a source of food, as a source of income through the marketing of products derived from these species, and as a source of pharmacopoeia and other ecosystem services (Coulibaly-Lingani P, 2023). It is unfortunate that these species, along with the country's overall plant cover, are subjected to persistent degradation.

The shea sector is encountering challenges in maintaining and increasing production due to the decreasing frequency of trees in the field (Kaboré SA et *al.*, 2012). Over the years, environmental changes have been observed in the ecosystems, posing serious threats to the populations of forest species such as *Vitellaria paradoxa* and *Parkia biglobosa* (Coulibaly-Lingani P, 2023). The heavy reliance of local populations on NWFPs exerts increased pressure on species, contributing to their decline and the disappearance of the habitats of species that provide these NWFPs (Wadt LHO *et al.*, 2005). In response to the decline or diminition of NWFP species, numerous studies have been conducted in Burkina Faso that address different aspects of species with high socioeconomic value (Thiombiano DNE *et al*, 2012; Ouédraogo I *et al.*, 2014; Nacoulma BIM *et al.*, 2016; Bondé L *et al.*, 2019). In the existing literature, there is a paucity of studies that simultaneously address the dynamics and vitality of these three NWFP species. Therefore, the present study was initiated to shed light on the topic. The objective is to contribute to the development and conservation of these species.

MATERIAL AND METHODS

Study Site

The Kuinima classified forest which is the site of this study, is located in the province of Houet, with Bobo-Dioulasso as its capital (Burkina Faso). It is located between 11°03 and 11°7 north latitude and 04°19 and 04°36 west longitude (Figure 1). According to the classification order of November 20, 1935, it covered an area of 4,000 ha. Today, it covers an area of only 2150 ha, after part of it was declassified on May 31, 1947.

As stated by Thiombiano A *et al.*, (2010), the climate of the area is of the South Sudanian type, with an alternating rainy season (May to October) and a dry season (November to April). The former is characterised by the harmattan, while the latter is dominated by the monsoon. The rainfall data series from 2008 to 2017 from the Farako-Ba station indicate that the annual rainfall varies between 744.6 mm and 2262.5 mm, with an annual average of 1315.96 mm.

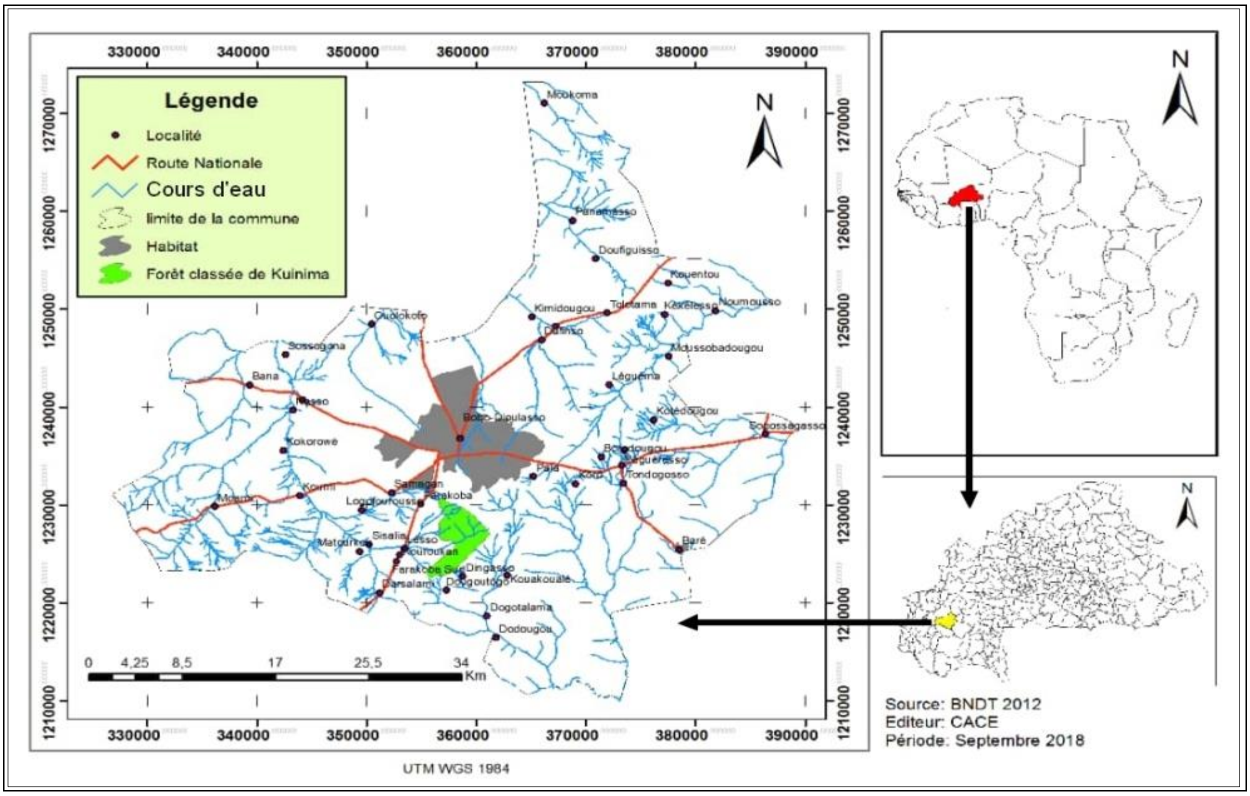

Figure 1: Location of the Kuinima classified forest

Inventory Type and Sampling Rate

The systematic sampling technique was selected. This type of sampling is a common methodology utilized in national forest inventories. The principal benefit is that it is more convenient to implement in the field, as the sample is distributed uniformly across the entire area (FSA, 2016).

Circular plots of 20 m radius (1256.63 m^2) were marked following transect lines. Circular plots are the easiest to establish in the field (Zoungrana, 2008).

The sampling rate (or sampling intensity, or sample rate, or fraction surveyed) is defined as the ratio of sample size to population size. It measures the sampling effort, the proportion of the population from which conclusions have been drawn (FSA, 2016). Considering a finite population of N units of equal size s and a sample with a number n of these units (each of size S), the sampling rate f is:

$f = n / N$

In this instance, the following method was employed:

Total number of plots = 2150 / 0.1256 = 17117.8343 plots

n= 80 N = 17117.8343 => f = (80/ 17117.8343) × 100 = 0.46%

Based on the sampling rate :

- Total area : 2150 ha,
- Sample unit area : plot of 1256.63 m^2,
- Plot type : circular,
- Equidistance between transect lines : 300 m,
- Equidistance between the centers of plots : 300 m,
- Number of plots : 80.

Data Collected

Dendrometric parameters:

The parameter that was measured was the circumference of all individuals of the three species encountered in the plot. The circumference was taken at breast height, equivalent to 1.30 m above the ground. An individual was considered juvenile if its circumference was less than or equal to 10 cm (diameter ≤ 3 cm), and was considered adult if it measured beyond that value, in accordance with the work of Sawadogo I (2006).

Plants Vitality:

Any woody plant exhibiting a completely desiccated shoot system, whether in an upright or lying-down position, is considered to be dead. This value was employed in the calculation of the mortality rate.

Cuts:

All methods of removal of aerial parts are considered to be forms of cutting, including pruning, lopping, and topping. This parameter is used to evaluate the exploitation rate.

The exploitation and mortality rates were defined as the ratio of cut or dead plants to the total number of individuals of the species. *Parasitized individuals (by Loranthaceae):* the number of plants of each species attacked by Loranthaceae was counted.

Data Processing

The surveys permitted the calculation of the density, mortality rate, and dynamics rate, as well as the determination of the stand structure.

- Density (N/ha) represents the number of individuals considered in the inventory per unit of area expressed in hectares.

The area of the plot = 20m × 20m × π = 1256.637 m^2 = 0.1256637 ha

So the total area inventoried = 0.1256637 ha × 80 = 10.05304 ha

- Stand structure: this refers to the distribution of trees by diameter or circumference class.
- Mortality rate (M): this is the count of dead plants per observation plot, expressed as a percentage of the total number of individuals in the plot. This permitted the assessment of the dynamics of the three species in the Kuinima Classified Forest (KCF).

Dynamic rate (D): The dynamics is considered as the difference between the regeneration rate and the mortality rate. It is expressed as follows:

D (%) = R-M where

D = dynamic rate; R = regeneration rate ; M = mortality rate.

Statistical Analysis

The data were entered into EXCEL spreadsheets and the statistical analyses were performed using XLSTAT software. The analysis of variance (ANOVA) was used to determine the difference between the average densities of the three species at the 5% significance level.

RESULTS

Health Status or Vitality of the Three Species

The health condition varies between species (Table 1). It can be observed that 49% of the trees of the *Vitellaria paradoxa* C.F. Gaertn species exhibit no visible defects, in comparison to 89% of the *Parkia biglobosa* (Jacq.) R. Br. species and 100% of the *Adansonia digitata* L. species. Conversely, 41.93% of *Vitellaria paradoxa* C.F. Gaertn and 2% of *Parkia biglobosa* (Jacq.) R. Br. are affected by Loranthaceae.

Table 1: Vitality of the three species in the KCF

	Especies		
	Vitellaria paradoxa	***Adansonia digitata***	***Parkia biglobosa***
With no visible defect	49%	100%	89%
Parasitized	42%	0%	2%
standind dead or dying	3%	0%	4%
cut or burnt	6%	0%	5%

Density and Condition of Regeneration

Table 2 shows the average density per hectare of the three species. The analysis of variance shows a significant difference between these averages (P= 0.04). *Vitellaria paradoxa* C.F. Gaertn. Is the most abundant species with an average density of about 48 plants/hectare, followed by *Parkia biglobosa* (Jacq.) R. Br. (about 7 plants/hectare). *Adansonia digitata* L. is only 0.54 plants/hectare.

Table 2: Average density per hectare of the three main NWFP species by category

Categories	Species					
	Vitellaria paradoxa	***Parkia biglobosa***	***Adansonia digitata***	**F**	**P**	**F critical value**
Regeneration	11.979±7.389	1.051±0.52	0.497±0.334			
Tree	35.735±57.896	4.575±1.770	0.049±0.099	3.475	0.043	3.315
Total	47.714±65.165	5.626±2.29	0.546±0.433			

The results confirm an average density difference between the three species. An exception can be observed in the case of *Vitellaria paradoxa* C.F. Gaertn, where the maximum value (121.85 plants/ha) is far from the average.

Stand Structure of the Three Species

The results on the stand structure, represented by the distribution of individuals by circumference class measured at breast height, i.e (1 m 30) from the ground, are shown in Figure 4. The analysis of this figure reveals a concentration of *Vitellaria paradoxa* individuals in the first and second class, with a slightly higher number in the second class. In these classes, there are 843 and 1225 individuals of this species.

Similarly, individuals of *Parkia biglobosa* are abundant in the first two classes with nearly equal number (64 and 70 individuals). It should be noted, however, that this species has a record circumference of over 40 cm, with 49 individuals.

The entire *Adansonia digitata* species is found in the smallest class with 35 individuals. All in all, 87.28% of the individuals from all three species combined have a circumference of less than 20 cm.

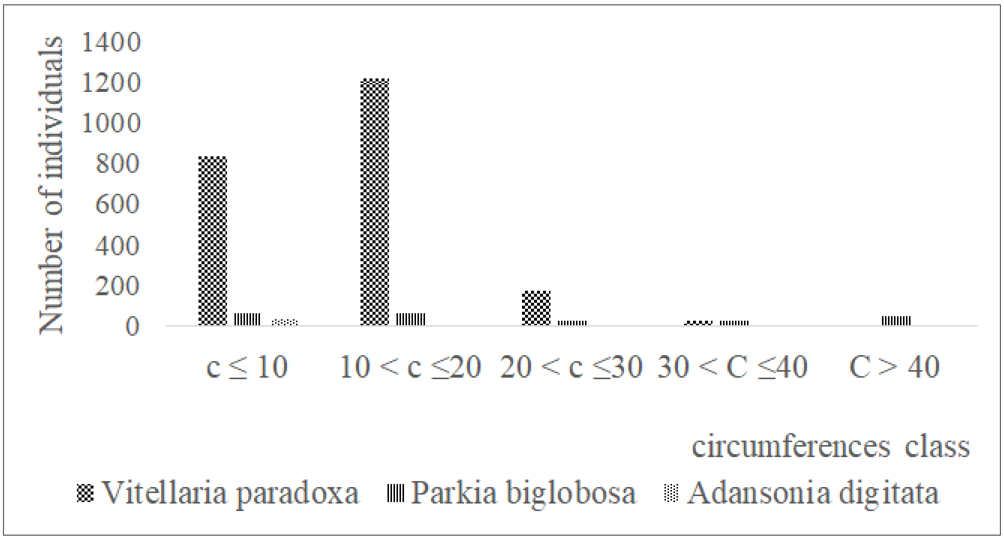

Figure 2: Horizontal stand structure of the three species

Stand Dynamics of the Three Species

The stand dynamics of the three species is evolutionary (Table 3). Indeed, it is much higher for *Adansonia digitata* L. (94.59%), followed by *Vitellaria paradoxa* C.F. Gaertn (36.11%) and finally, *Parkia biglobosa* (Jacq.) R. Br. (25.01%).

Table 3: Stand dynamics of the three species

Characteristics	Species		
	Vitellaria paradoxa	*Parkia biglobosa*	*Adansonia digitata*
C (%)	2,80	3,60	0,00
M (%)	0,86	0,80	0,00
R (%)	36,97	25,81	94,59
D (%)	36,11	25,01	94,59

C= cutting rate; M= mortaity rate; R= regeneration rate; D= dynamic rate

DISCUSSION

The results of the health assessment indicate that 48.83% of *Vitellaria paradoxa*, 89.2% of *Parkia biglobosa* and 100% of *Adansonia digitata* individuals are free of visible defects. This may be attributed to the uses that the nearby populations make of these species. Yaméogo JT *et al.,* (2020) found that 59.87% of individuals in this forest showed no visible defects. However, their study was comprehensive, including all species encountered. They assert that the health condition of agroforestry parks is influenced by anthropogenic pressures.

The *Vitellaria paradoxa* species is by far the most attacked by Loranthaceae (41.93%). The abundance of this species could explain this result. In terms of density, this species ranks first with an average of 47.71 plants/ha. Tafokou RBJ *et al.,* (2010) show that dispersing and pollinating birds are the main vectors as they pass through host trees. Indeed, in the case of high species diversity, these birds can deposit part of the Loranthaceae seeds on other hosts, including hosts that are resistant to Loranthaceae. The infestation rate remains significantly lower than the 87% obtained by Ahamidé IDY *et al.,* (2017) in northern Benin.

From the perspective of the stand structure of the three species, 36.72% of individuals are in the first class (c ≤ 10 cm) compared to 50.56% in the second class (10 cm < c ≤20 cm) all three species combined. These results are consistent with those of Yaméogo JT *et al.,* (2020) in their study on agroforestry parks in the classified forests of Dindéresso and Kuinima. These authors found an L-shaped structure with a prevalence of individuals with diameters of [5-15], cm. They state that the shape of the diameter-class distribution histogram of individuals in the stands could indicate that these stands are in a phase of regeneration. Furthermore, Glèlè KR and Lykke AM (2016) demonstrate in their study that stands with a horizontal L-shaped structure are stable and capable of renewing themselves through natural regeneration.

In terms of regeneration, *Vitellaria paradoxa* has a higher average rate compared to the other two species (11.979 plants/ha). In fact, people deliberately preserve this species in agricultural plots because of its socio-economic benefits. Yaméogo JT *et al.,* (2020) observed the abundance of *Vitellaria paradoxa* in regeneration (18 individuals/ha). However, seedlings are often vulnerable to degradation factors. For example, Kambiré HW *et al.,* (2015) found in their study in the Sudanian zone of Burkina Faso that the main degradation factors are fire, drought, and grazing, etc.

The dynamics of all three species is evolutionary. The low mortality rates may explain this result. *Adansonia digitata* has the highest rate (94.59%). As this species is less abundant in the forest, the few plants planted by local populations are well taken care of. However, previous studies (Tankoano B *et al.*, 2016; Tiamiyu K *et al.*, 2023) observed a decline in vegetation cover respectively in the classified forest of Tiogo (Burkina Faso) and in the community forests of the Centre-Ouest region (Burkina Faso). This discrepancy may be due to the utilization of satellite imagery in these studies and to the fact that their analyses cover several years.

CONCLUSION

This study was conducted with the aim of contributing to the development and conservation of the three major NWFP species: *Vitellaria paradoxa*, *Parkia biglobosa* and *Adansonia digitata*. The inventory permitted the evaluation of their density and regeneration and the estimation of their health condition. The analysis of the structures reveals a prevalence of juvenile individuals with circumferences at breast height of ≤20 cm. However, all three species exhibit poor regeneration, with regeneration rates below 100%. Among the three species, *Vitellaria paradoxa* is the most prevalent in the Kuinima classified forest. In terms of health condition, this species is also the most affected by Loranthaceae parasitism. Understanding the structure and health condition of these species is an important aspect in their development, especially in light of overexploitation and in the design of pest control strategies. The implementation of Assisted Natural Regeneration (ANR) may prove an efficient means of reinforcing the dynamics of these species.

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