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Asseessing deadwood availability in yankari game reserve, bauchi state, Nigeria

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Abstract
This study assessed the abundance and mean volume of coarse woody debris (CWD), comprising fallen logs, stumps, and snags, across six woodland types within the Yankari Game Reserve, Nigeria. Data were collected on frequency and estimated volumes (m³/ha) of each component at specific georeferenced locations. Results indicated marked variation in CWD distribution among sites. The highest total volume of CWD was recorded in Annogeissus woodland (110.24 m³/ha), driven primarily by the abundance of large fallen logs, while Detarium woodland also showed relatively high accumulation (58.16 m³/ha). In contrast, the Gaji River Complex exhibited the lowest CWD volume (32.44 m³/ha), despite recording the highest frequency of fallen logs. Stumps and snags generally contributed negligibly to overall volume across sites, with values ranging between 0.06 and 0.17 m³/ha. These findings highlight spatial heterogeneity in CWD distribution, suggesting differences in woodland structure, disturbance regimes, and decomposition dynamics. Such variations have ecological implications for carbon storage, nutrient cycling, and habitat availability within the reserve's woodland ecosystems.

Keywords: Coarse woody debris (cwd), fallen logs, stumps, snags, and woodland ecosystems

Introduction

Deadwood plays critical roles in woodland ecosystems by influencing biological, physical, and chemical processes (Harmon *et al*., 1986) [6]. It serves as a long-term reservoir of nutrients and carbon, with carbon being gradually released during decomposition, thereby acting as a significant store of energy (Stevens, 1997 [18]; Karjalainen *et al*., 2002 [8]; Fred *et al*., 2003) [3]. Ecologically, deadwood provides substrates for fungi and invertebrates, while cavities formed through decay serve as nesting or shelter sites for many vertebrates. In addition, decaying logs create favorable microsites for seed germination and bryophyte growth by reducing competition from ground flora. Fallen logs can also alter microhabitats by shading, crushing vegetation, or forming bare soil patches, while on slopes they may slow soil and water movement. Nutrient enrichment often occurs beneath or around deadwood, enhancing soil fertility and influencing vegetation composition (Falinski, 1986) [2]. The formation of deadwood is largely linked to natural tree mortality processes, such as fire, wind, snow breakage, drought, competition, insect infestations, and pathogen attacks (Kuuluvan, 1994).

Woody detritus encompasses both above- and below-ground woody material (Harmon & Sexton, 1996) [7]. Below-ground components include decayed roots and buried wood found within mineral soils or forest floors, while above-ground fractions are classified as coarse or fine detritus. Coarse woody debris (CWD) has been variously defined, with Harmon and Sexton (1996) [7] identifying it as woody pieces greater than 10 cm in diameter and 1.5 m in length, whereas Harmon *et al*. (1986) [6] consider material exceeding 2.5 cm in diameter. CWD includes snags, logs, chunks from disintegrating wood, large branches, and coarse roots. Further classifications distinguish standing deadwood (snags) and fallen logs (Harmon & Sexton, 1996) [7]. According to the Forest Biota Protocol (Travaglini & Chirici, 2006) [19], deadwood components also include downed trees, lying deadwood, and stumps. Snags are generally regarded as vertical remnants resulting from natural processes, while stumps are short vertical remains from cutting (Harmon & Sexton, 1996) [7]. Travaglini *et al*. (2007) [20] further specify that snags must reach a minimum height of 1.3 m. Ultimately, deadwood originates from either natural mortality, caused by senescence, competition, or disturbances such as windthrow, or from human-driven structural treatments (Rondeux & Sanchez, 2009) [17].Thus the aim of the research is to Quantify the availability of deadwood in Yankari Game and to provide recommendations for the incorporating deadwood management into the reserve conservation strategy

Study Area

The Yankari Game Reserve, located in Bauchi State, Nigeria, was established as the Bauchi Native Authority Forest Reserve in 1957 and opened to the public in 1962. Its management has alternated between state and federal authorities, but it is currently overseen by the Bauchi State Government. Although the surrounding areas are inhabited by farmers and herders, there have been no permanent settlements within the reserve for over a century, though traces of earlier habitation exist (North Eastern State Nigeria, 1973). Geographically, the reserve lies in the southern Sudan Savanna, characterized by rolling hills between 200 and 400 m above sea level. The vegetation is dominated by Combretaceae trees and shrubs, with notable species such as *Afzelia*, *Anogeissus*, and *Detarium* (Geerling, 1976) [4]. Along the Gaji River, riparian and swamp forests form distinct patches of humid vegetation (Green & Amanche, 1987) [5].

The climate is marked by annual rainfall of 900–1,000 mm between May and September, with temperatures ranging from 18°C to 38°C during the wet season. The dry season brings harmattan winds that lower night temperatures to around 12°C, while March and April are the hottest months, with daytime temperatures exceeding 40°C (Geerling, 1973 [4]; Green & Amanche, 1987) [5]. Soils are generally deep,

sandy loams derived from the Kerri-Kerri formation and are nutrient-poor (Green & Amanche, 1987) [5]. The Gaji River and its tributaries provide essential water for wildlife, particularly in the dry season. The reserve also harbors over 350 bird species, including residents, Palearctic migrants, and intra-African migrants, making it an important site for biodiversity and ecotourism (Green & Amanche, 1987) [5].

Materials

The materials used for the study are Rope, Measuring tape, Handheld GPS

Study Procedure

Line-intersect sampling (Warren and Olsen, 1964 [21], Kirby *et al.,* 1998) [10] was used to record the volume and length of fallen dead wood. At each site a number of equal length transects (covering a total distance 50m = t) was laid out from random start points and in random directions. The number (N) of fallen dead stems attaining minimum of five cm diameter and intersecting the line was counted, and their diameter (d) in cm where they intersected the line was measured and species identified. Also, snags was recorded in the research from a plot running 2m either side of the transect line. The diameter at breast height (DBH) was measured for trees more than 5cm DBH. For stumps the diameter at the level where the tree was cut or where the stem was broken off was measured (Travaglini *et al.,* 2007) [20]

The length (L) and volume (V) of fallen deadwood, stumps and snags was estimated using the formulae,

$L = N*p*10^4/2*t$ (m/ha), and $V = {}^{p}/_{4}\ d^2 \times L$

- Kirby *et al..,* 1998 [10]

Where, t = distance

N = number of fallen logs

d = diameter

L = length

p = 3.142

The selection of sites was done to satisfy and provide for reasonable inventory of deadwood in the woodland types in the reserve. The research was conducted in the following coordinates to each woodland of the reserve.

- **Mixed woodland (Afzelia/combretacious species):** Is characterized by the dominance of *Afzelia* and *combretaceus* shrubs and trees. N09°59'07.7s E010°20'10.5s
- **Afzelia woodland:** Is characterized by the dominance of *Afzelia* species.N09°51'46.3s E010°24'05.6s
- **Combretum woodland:** Is characterized by the dominance of *combretaceus* shrubs and tree N09°45'42.2s E010°30'27.8s
- **Detarium microcarpum:** Is characterized by the dominance of *detarium* species. N09°59'44.7s E010°34'25.4s
- **Gaji River Complex:** Is characterized by the vegetation typical of the forest ecosystem and consists of evergreen swamp and riparian forest (Green and Amanche, 1987) [5]. N09°46'38.2s E010°32'11.2s
- **Annogeissus woodland:** Is characterized by the dominance of *Annogeissus* species N09°53'19.5s E010°22'38.8s

Results and Discussion

1. Amount and Variability of Coarse Woody Debris

Coarse woody debris (Fallen logs, stumps and snags) were assessed in six different zones of Yankari game reserve. Table 1 shows abundance and total volume of fallen logs, stumps and snags. The values obtained of mean volume of fallen logs ranged from 32.3-110m^3/h, snags ranged from 0.08-017m^3/h. and of stumps ranged from 0.06-0.11m^3/h. the frequencies of fallen logs ranged from 29-44, of snags from 21-26 and of stumps ranged from 10-14

From statistical analysis (ANOVA) the results reveal that:

1. For the sites, the F computed value (1.0041) is less than the F critical value (3.3258) using 0.05 level of significance. Therefore, the null hypothesis is not rejected and concludes that the mean volume of the dead wood is the same for all the sites.
2. While the treatment result reveals that the F computed value (25.0074) is greater than the F critical value (7.56) using 0.01 level of significance. This means that the null hypothesis is rejected and concludes that there is very high significance difference ($P<0.01$) in the treatment of means in terms of mean volume of fallen log, stumps and snags.

Table 1: Abundance and Mean Volume of Fallen Logs, Stumps and Snags in the Site

Site	Fallen Logs		Stumps		Snags		Total
	Freq.	Vol. m^3/h	Freq.	Vol. m^3/h	Freq.	Vol. m^3/h	Vol. m^3/h CWD
Mixed woodland N 09°59'07.7s E 010°20'10.5s	31	35.71	13	0.11	24	0.17	35.99
Afzelia woodland N 09°51'46.3s E 010°24'06.6s	38	42.8	13	0.08	22	0.13	43.01
Combretum woodland N 09°45'42.2s E 010°30'27.8s	36	53.5	14	0.08	26	0.09	53.67
Detarium woodland N09° 59' 44.7s E010°34'25.4s	33	58.0	10	0.06	25	0.10	58.16
Gaji River Complex N 09°46'38.2s E 010°32'11.2s	44	32.3	10	0.06	21	0.08	32.44
Annogeissus woodland N 09°53'19.5s E 010°22'38.8s	29	110	11	0.08	21	0.16	110.24

Key: CWD = Coarse Woody Debris, **Freq**.= Frequency, **Vol.** = Volume

Discussion

Coarse woody debris assessed in this study showed availability of deadwood in the reserve and the distribution of coarse woody debris varied from site to site as shown in Table 2,3 and 4 and this may be attributed to storms, drought and diseases which kill many trees, generating a pulse of large deadwood. This agreed with the findings of Muller and Liu (1991) [13] which states that within natural forest the distribution of deadwood is usually patchy. The plants species of fallen logs, snags and stumps contribute significant amount of dead woody material to the ecosystem in the reserve.

The total/mean volume of coarse woody debris for mixed woodland was 35.99m^3/h, for *Afzelia* woodland was 43.01m^3/h, for *combretum* woodland was 53.67m^3/h, for *Detarium* woodland was 58.16m^3/h, for Gaji river complex was 32.44m^3/h and for *Annogeissus* woodland was 110.24m^3/h. Comparisons of these figures with other published data in tropical region are not available, However, some estimates are available for the amounts of fallen deadwood from the North American and European old-growth broad-leaved deciduous woodland in temperate zone. *Fagus-Betula* woodland contain 82m^3/h, Harmon *et al* (1986) [6]., *Acer-Fagus* woodland 139 m^3/h, (McGgee *et al.,* (1999), *Quercus-Fagus* woodland 66.3m^3/h, Muller *et al.,* 1991 [13], Quercus-mixed woodland 46 m^3/h (Macmilan, 1981), Tilio-Carpenetum woodland 75 m^3/h, Kirby *et al.,* (1991) [9], *Populus Euphratia* woodland 73.7m^3/h (Narjamal Sarbay, 2010) [14].

Also, the results of the study of mean volume of fallen logs in Yankari Game Reserve showed that mixed woodland have 35.71 m^3 /h, *Afzelia* woodland have 42.8m^3 /h, *Combretum* woodland have 53.5 m^3 /h, *Detarium* woodland have 58.0 m^3 /h, Gaji River Complex have 32.3 m^3 /h and *Annogeissus* woodland have 110 m^3 /h and are similar to the provisional bench mark of deadwood in woodland system which stated that 20m^3/h – 40m ^{3}/h have medium level of deadwood (Kirby *et al.,* 1998) [10] and greater than 40 m^3/h of fallen logs have high level of dead wood (Kirby *et al.,* 1998) [10]

In this study fallen logs were abundant along Gaji river complex. It is assumed that the seasonal flood has the importance of deadwood in the reserve, because flooding brings much deadwood to sites. Snags and stumps were abundant in *combretum* woodland and this may be attributed to low-level of protection and is at the periphery of the reserve, communities living at Yankari margins depend on some of the plant resources for firewood, food, fodder for animals and raw materials to traditional herbalists. So, they encroach into the reserve and cut these plants. Mohammed (2011).

Conclusion

Deadwood has been recognized as a habitat of great importance for many species of forest ecosystems; it is considered to be a key element of biodiversity in forests. Deadwood is associated with relict, rare and protected species and therefore, it is regarded as a key feature for the preservation of many threatened species (Ranius *et al.,* 2003) [16]. A higher amount of deadwood in forests increase the number and the density of species and hence species richness, because higher deadwood amount means greater surface and area in forests and hence its higher availability for potential users.

The study found that there is much availability of fallen logs stumps and snags and this is attributed to no intense fuelwood, fodder for animals, and raw materials to traditional herbalists' collection from the nearby settlers and protection it received from the government.

Recommendations

1. Yankari Game Reserve should be conserved to meet the ecological needs of the present and future in maintaining the biodiversity of the reserve, because deadwood make an important contribution to the conservation value of the reserve.
2. An attention should be given to patrolling the Reserve, intensifying efforts at patrol will help to ward off illegal collection of deadwoods for fuelwood by the nearby settlers.
3. There is need for additional studies on below ground deadwood, deadwood on living trees, fine woody debris and the decay stage of deadwood.

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