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Floristic diversity, structure, and anthropogenic disturbances in Goulourgou-Wina Forest, Cameroon

DANGRA ALPHONSE[1,♥], FROUMSIA MOKSIA[1], TAFFO JUNIOR BAUDOIN WOUOKOUE[1], HAÏWA GILBERT[2], DJIBRILLA MANA[3]

[1]Department of Biology, Faculty of Science, University of Maroua. Kongola-Djoulgouf-Kodek Campus, P.O. Box: 814 Maroua, Cameroon. Tel.: +237-696204672, Fax.: +237-679378202, ♥email: alphonsedangra@gmail.com
[2]National Advanced School of Engineering, Maroua University. P.O. Box: 58 Maroua, Cameroon
[3]Department of Plant Science, Faculty of Science, University of Buea. P.O. Box: 63 Buea, Cameroon

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Abstract. *Alphonse D, Moksia F, Wouokoue1 TJB, Gilbert H, Mana D. 2025. Floristic diversity, structure, and anthropogenic disturbances in Goulourgou-Wina Forest, Cameroon. Asian J For 9: 284-298.* The Sudano-Sahelian zone harbors important woody plant diversity that contributes to ecological regulation but is increasingly threatened by anthropogenic disturbances. This study assessed floristic composition, structural characteristics, regeneration capacity, and human impacts in the Goulourgou-Wina Forest, Far North Cameroon. Floristic inventories were conducted in 15 transects (1,000×20 m) during May-June 2022, where all woody individuals with a circumference ≥10 cm were recorded. Regeneration was evaluated in 300 plots (10×10 m), while evidence of cutting, debarking, and bushfires was documented. In total, 78 species belonging to 54 genera and 24 families were identified, with Fabaceae as the richest family (27 species). *Guiera senegalensis* exhibited the highest importance value index (25.02%). The overall density reached 295.87 individuals/ha with a basal area of 52.94 m²/ha. Diversity was moderate (Shannon Diversity Index = 3.38), and the diameter and height distributions displayed an L shape, indicating dominance of small stems and active regeneration. Seedling and stump shoot regeneration rates were 16.96% and 23.41%, respectively, while mortality reached 16.09%. Bushfires (8.39%) were the most frequent disturbance, followed by systematic logging (6.75%), partial logging (3.93%), and bark stripping (1.84%). These results demonstrate that, despite moderate diversity and regeneration potential, intensive anthropogenic activities remain major drivers of forest degradation. Sustainable management measures, including community involvement and conservation planning, are urgently required to maintain the ecological and socio-economic functions of the Goulourgou-Wina Forest.

Keywords: Floristic diversity, Goulourgou-Wina, *Guiera senegalensis*, regeneration, structure

INTRODUCTION

Cameroon, as part of the Congo Basin, is recognized as one of the most biologically diverse regions in Africa. With an estimated flora of more than 7,800 vascular plant species, including over 7,500 indigenous and naturalized taxa and about 350 exotics, the country ranks fourth on the continent in terms of plant biodiversity, after the Democratic Republic of Congo, Tanzania, and Madagascar (Onana 2011, 2015). This richness reflects the wide ecological gradient across the nation, ranging from humid equatorial forests to dry savannahs and Sahelian steppes. Such diversity provides ecological stability and ecosystem services, yet it is increasingly vulnerable to human-driven pressures that threaten the long-term integrity of forest ecosystems in the region.

In the Sudano-Sahelian zone of Cameroon, woody vegetation plays a crucial role in maintaining ecological balance and supporting local livelihoods. The vegetation of this region, largely composed of savannahs interspersed with forest remnants, is particularly sensitive to both climatic variability and anthropogenic activities. High population density, combined with subsistence agriculture, livestock rearing, and widespread reliance on fuelwood, exerts tremendous pressure on forest resources (Koffi et al. 2018). Over time, these activities have led to degradation of plant cover, soil impoverishment, and accelerated desertification. The Goulourgou-Wina Forest, located in the Far North Region of Cameroon, exemplifies this situation, as it represents one of the last remaining wooded ecosystems under intense human use.

The ecological significance of the Goulourgou-Wina Forest extends beyond its biodiversity. Like other forests of the Sudano-Sahelian belt, it provides multiple ecosystem goods and services, including carbon sequestration, climate regulation, soil fertility enhancement, and the provision of non-timber forest products. These functions are indispensable for rural communities that depend directly on forest resources for food, medicine, energy, and income (FAO 2024). However, unsustainable exploitation has increased in recent decades, with widespread wood harvesting, bushfires, grazing, and land conversion contributing to a decline in forest resilience. Such disturbances not only reduce floristic richness but also affect structural patterns, natural regeneration, and species dominance, ultimately threatening the ecological integrity of the entire landscape (Yao and N'Guessan 2006).

Several studies in the Sudano-Sahelian region have documented the floristic composition and ecological characteristics of savannah and forest ecosystems (Sani et al. 2018; Africa et al. 2020; Konsala et al. 2020; Moctar et al. 2024; Wouokoue et al. 2024). These works consistently highlight the vulnerability of vegetation to human activities, but significant gaps remain concerning site-specific dynamics. For example, while floristic inventories have been carried out in Moutourwa, Laf, and Masgaya forests, relatively little is known about the floristic diversity and regeneration capacity of the Goulourgou-Wina Forest. Considering the rapid population growth and rising demand for agricultural land and wood-based resources in the region, updated ecological assessments are critical to guide conservation and sustainable management strategies.

Woody plant diversity is a key indicator of ecosystem health in semi-arid and Sahelian zones. Patterns of species richness, density, basal area, and Importance Value Index (IVI) provide insights into both ecological stability and the impacts of external disturbances (Gilbert et al. 2016). In addition, the ability of species to regenerate, either through seedlings or stump sprouts, reflects their capacity to maintain population dynamics under pressure. Disturbances such as cutting, grazing, fire, and debarking influence these parameters by altering recruitment, mortality, and structural composition of woody stands. Evaluating these aspects at local scales is therefore indispensable to detect early signals of degradation and to recommend appropriate conservation measures (Diguera et al. 2024).

The Goulourgou-Wina Forest, situated in the Wina Sub-division of the Mayo-Danay Division, is particularly vulnerable to these disturbances. Its geographic position in a transition zone between the Sahelian savannah and wooded formations makes it ecologically fragile and highly responsive to anthropogenic stressors. Local communities rely heavily on their resources for energy, timber, fodder, and other daily needs. As a result, species composition and forest structure are being altered, with dominant species such as *Guiera senegalensis* J.F.Gmel., *Prosopis africana* (Guill. Et Perr.) Taub and *Balanites aegyptiaca* (L.) Delile. becoming increasingly overexploited. The persistence of uncontrolled bushfires further exacerbates degradation, threatening regeneration potential and accelerating biodiversity loss. Despite these challenges, comprehensive assessments of floristic diversity, structural dynamics, and disturbance regimes in this forest remain scarce.

The present study was conducted to fill this knowledge gap by providing an updated ecological evaluation of the Goulourgou-Wina Forest. Specifically, it aimed to (i) determine the floristic composition and species richness, (ii) analyze structural patterns of woody vegetation, (iii) assess regeneration capacity through seedlings and stump sprouts, and (iv) quantify the extent of anthropogenic disturbances such as logging, debarking, and bushfires. The outcomes are expected to support strategies for sustainable management and conservation of forest resources in the Sudano-Sahelian zone of Cameroon.

MATERIALS AND METHODS

Study area

The study has been carried out in the Goulourgou-Wina Forest massif located in the Wina Sub-division, Mayo-Danay Division, Far North Region, Cameroon, in between latitudes 10°6'0"- 10°0'0" North and longitude 15°4'12"-15°'12" East (Figure 1). The climate is a Sudano-Sahelian type, with an average annual temperature of 30°C and an average annual rainfall of 800 mm/year. The vegetation consists of trees, shrubs, and grassy savannahs. The main economic activities are farming, livestock rearing, and trade.

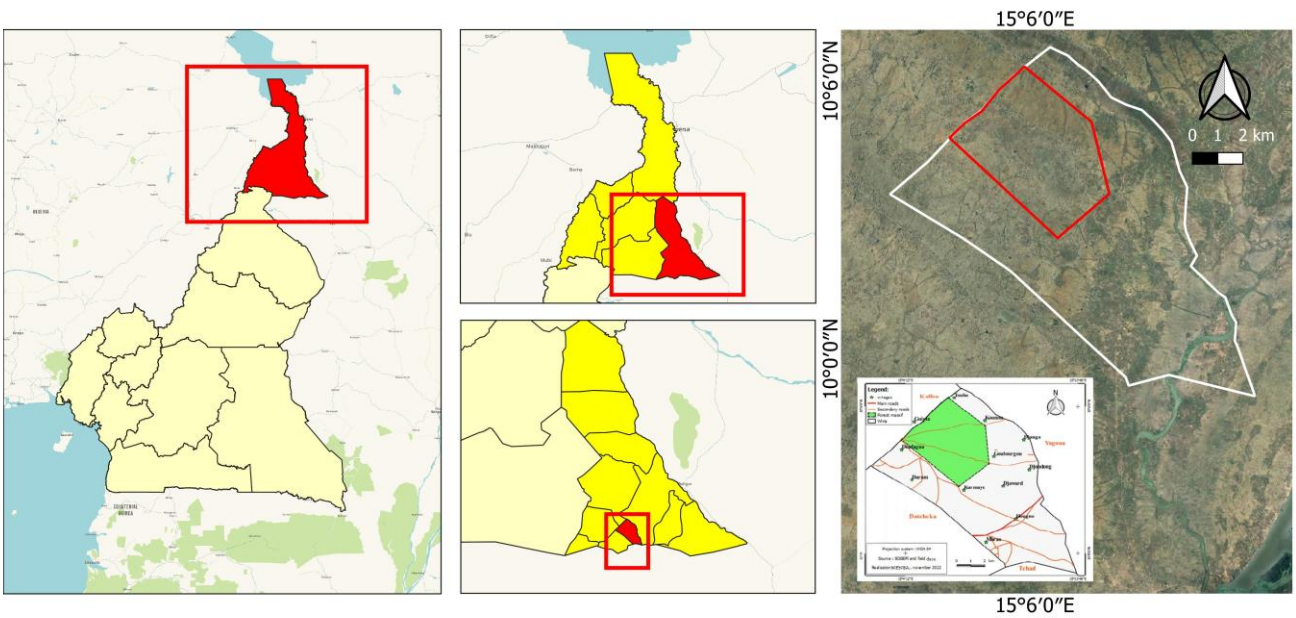

Figure 1. Map showing the location of the study site in the Wina Sub-division, Mayo-Danay division, Far North Region, Cameroon

Data collection

The floristic inventory of woody species has been conducted within transects of rectangular transects of 1000 m length and 20 m width, which were randomly arranged in various orientations along the four cardinal points. The different orientations were determined using a Sunto compass. A total of 15 transects of 2 ha were randomly distributed in the study area, covering a cumulative area of 30 ha. The renewal potential of woody species (seedlings and stump sprouts) has been evaluated within 300 plots (20 plots of 10×10 m along each transect). In these plots, all seedlings less than 1 m tall are identified and counted. The distance between two transects was at least 200 m. The transects are carried out at the beginning of the rainy season (May and June 2022). Along a path line, members of the inventory team sweep on both sides of the transect, counting, measuring, and observing the individuals of the woody species. The circumference of adult individuals (circumference ≥10 cm) at the base of the trunk, i.e., 60 cm above the ground or knee level, was measured using a tape measure and the height using a graduated rod. The botanical identification of the collected taxa was made using the standard floras, including trees, shrubs, and lianas of West Africa (Arbonnier 2019). For unidentified species, samples were collected, pressed, dried, and identified in the national herbarium of Cameroon. Seedlings and stump shoots regeneration was carried out within 300 plots of 10×10 m (20 plots for each transect of 1000×20 m). The young individuals with a circumference <10 cm at the base of the trunk, i.e., 60 cm, were considered for regeneration. The following anthropogenic activities were assessed visually within each transect: the number of individuals showing systematically cut, partially cut, dead, debarking, and traces of bushfire were encountered.

Data analysis

The analysis of flora characteristics was based on the total number of woody species, including the collection of vascular plant specimens in the studied area.

Density: Number of individuals per hectare

Basal area: $S = \pi (Di^2/4)$ in (m²/ha),

Relative dominance = (total basal area for a species/total basal area of all species) × 100.

Relative density = (number of individuals of a species/total number of individuals) × 100.

Relative frequency = (Number of plots where species appear/total number of plots) × 100.

Relative diversity = (number of a species in a family/total number of species) × 100.

The Importance Value Index (IVI), which is obtained by: IVI = Relative Dominance + Relative Frequency + Relative Density;

The Family Importance Value Index (FIVI), which is given by: FIVI = Relative Dominance + Relative Density + Relative Diversity.

The Shannon–Weaver diversity index was calculated as follows: $H = -\sum [(ni/N) \log_2(ni/N)]$

Where: ni is the number of species i, and N is the total number of all species. Diversity is low when $H < 3$, medium for $3 \leq H < 4$, and then high when $H \geq 4$ (Legendre 1984).

Equitability Pielou Index (E) was determined using the formula: $E = H/\log_2(R)$, where H is Shannon-Weaver's diversity index and R is species richness.

The impact of human activities is assessed by calculating the rates of systematic cutting (TCS), partial cutting (TCP), debarking (TE), and bush fires (TF).

TCS = (Ni Cs/N) *100

TCP = (Ni Cp/N) *100

TE = (Ni E/N) *100

TF = (Ni F/N) *100

Where: Ni Cs: The number of stumps; Ni Cp: The number of individuals showing all traces of partial cutting; Ni E: The number of debarked individuals; Ni F: The number of individuals showing all traces of fire; and N: The total number of standing individuals.

The inventory data were seized checked in an exhaustive way and were treated under a Microsoft Excel sheet and XLSTAT software version 2016, which allowed the realization of the histograms. QGIS software was used to produce the study area map.

RESULTS AND DISCUSSION

Floristic composition

In total, 78 species belonging to 54 genera and 24 families (APG IV) were recorded in the Goulourgou-Wina Forest. The value of the Shannon Diversity Index was 3.38, and the Pielou evenness was 0.43. Tables 1-6 and Figure 2 summarized the information on the top ten species and twelve families with highest characteristics values. Detailed information on all the 78 species and 24 families are found in Tables S1-S3.

The total density in the massif was 295.87 individuals/ha. The densest species was *G. senegalensis* with 58.87 individuals/ha and a basal area of 1.71 m²/ha, followed by *P. africana* (density of 11.55 individuals/ha and a basal area of 12.79 m²/ha, and *Combretum collinum* Fresen. (12.20 individuals/ha and 1.60 m²/ha), *B. aegyptiaca* (10.93 individuals /ha and 2.04 m²/ha), *Terminalia leiocarpa* (DC.) Guill. & Perr. (11.30 individuals/ha and 4.46 m²/ha), *Sclerocarya birrea* (A.Rich.) Hochst. (8.77 individuals/ha and 8.21 m²/ha) and *Combretum molle* R.Br. ex G.Don (8.10 individuals/ha and 1.00 m²/ha) (Table 1). The species with the lowest densities and basal areas were *Vitellaria paradoxa* C.F.Gaertn., *Gardenia ternifolia* Schumach. & Thonn., *Cassia sieberiana* DC., *Vachellia hockii* De Wild Seigler & Ebinger, *Vitex madiensis* Oliv., *Crossopteryx febrifuga* (Afzel. ex G.Don) Benth, *Vachellia gerrardii* Benth P.J.H.Hurter, *Grewia barteri* Burret, *Gardenia erubescens* Stapf & Hutch. and *Ficus thonningii* Blume.

Guiera senegalensis (19.83%), *P. africana* (5.04%), and *C. collinum* (4.12%) were the most relevant dense species (Table 2). The most frequent species were *Sterculia setigera* Delile (8.65%), followed by *P. africana* (7.75%) and *S. birrea* (6.00%). *Prosopis africana* (11.74%), *S. birrea* (6.84%), and *S. setigera* (6.70%) were the most dominant species. The species with the highest Important Value Indices were *G. senegalensis* (25.02%), followed by *P. africana* (24.53%), *S. setigera* (17.97%), *S. birrea* (14.86%), *T. leiocarpa* (11.15%), *B. aegyptiaca* (8.99%), *Vachellia sieberiana* (DC.) Kyal. & Boatwr. (8.69%), *C. collinum* (8.52%), *C. molle* (7.37%), and *Combretum adenogonium* Steud. ex A.Rich. (5.64%). The species with the lowest IVI values were *C. sieberiana* (0.51%), *Albizia chevalieri* (Harms) (0.49%), *Gymnosporia senegalensis* (Lam.) Loes) (0.47%), and *V. gerrardii* (0.44%) and *G. barteri* (0.26%).

Among 24 families encountered, the Fabaceae was the richest family (27 species), followed by Combretaceae (10 species) and Capparaceae (5 species) (Figure 2). The twelve richest families had 66 species, which represent 79.48% of the total species. Twelve families (Bignoniaceae, Burseraceae, Cannabaceae, Celastraceae, Cochlospermaceae, Loganiaceae, Meliaceae, Myrtaceae, Polygalaceae, Sapotaceae, Ximeniaceae, and Zygophyllaceae) were represented by a single species.

The relative densest families were Fabaceae (42.21%), Combretaceae (14.71%), and Anacardiaceae (5.33%). The most dominant families were Combretaceae (23.59%), Fabaceae (17.48%), and Malvaceae (13.38%). The highest relative diversity was recorded in families Fabaceae (16.49%), Combretaceae (13.94%), and Anacardiaceae (7.36%) (Table 3). The families with the highest important value were Fabaceae (76.18%), Combretaceae (52.24%), Anacardiaceae (25.56%), Malvaceae (19.06%), Moraceae (17.70%), Capparaceae (10.48%), Zygophyllaceae (7.87%), Annonaceae (7.11%), Rubiaceae (5.23%), and Rhamnaceae (4.33%). The following families had the lowest important values: Cannabaceae (1.02%), Celastraceae (0.90%), and Cochlospermaceae (0.60%).

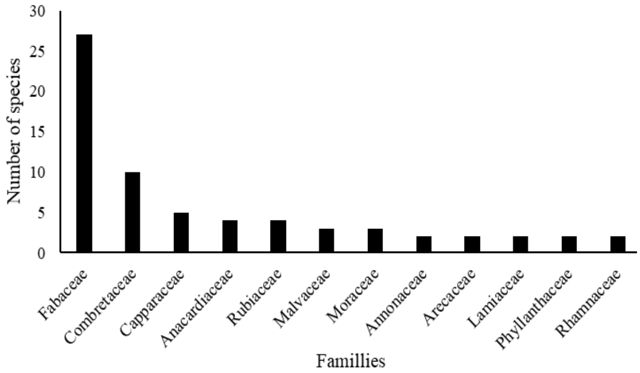

Figure 2. Specific family richness

Table 1. Species with high density and basal area

Species	Density (individuals/ha)	Basal area (m²/ha)
Guiera senegalensis J.F.Gmel.	58.87	1.71
Prosopis africana (Guill. Et Perr.) Taub	11.55	12.79
Combretum collinum Fresen.	12.20	1.60
Balanites aegyptiaca (L.) Delile.	10.93	2.04
Terminalia leiocarpa (DC.) Guill. & Perr.	11.30	4.46
Sclerocarya birrea (A.Rich.) Hochst.	8.77	8.21
Combretum molle R.Br. ex G.Don	8.10	1.00
Sterculia setigera Delile	7.40	9.28
Vachellia sieberiana (DC.) Kyal. & Boatwr.	7.23	4.14
Combretum adenogonium Steud. ex A.Rich.	6.50	1.21

Table 2. Ecological importance of species

Species	RD (%)	RF (%)	RDo (%)	IVI
Guiera senegalensis J.F.Gmel.	19.83	2.58	2.61	25.02
Prosopis africana (Guill. Et Perr.) Taub	5.04	7.75	11.74	24.53
Sterculia setigera Delile	2.62	8.65	6.70	17.97
Sclerocarya birrea (A.Rich.) Hochst.	2.98	6.00	6.84	15.82
Terminalia leiocarpa (DC.) Guill. & Perr.	3.35	3.19	4.61	11.15
Balanites aegyptiaca (L.) Delile.	3.59	2.51	2.89	8.99
Vachellia sieberiana (DC.) Kyal. & Boatwr.	2.27	2.62	3.80	8.69
Combretum collinum Fresen.	4.12	2.69	1.71	8.52
Combretum molle R.Br. ex G.Don	2.90	2.18	2.29	7.37
Combretum adenogonium Steud. ex A.Rich.	1.93	1.95	1.76	5.64

Note: RD: Relative density, RF: Relative frequency, RDo: Relative dominance, IVI: Importance Value Index

Structural patterns

The distribution of individuals in diameter classes showed an 'L' shape structure. The high number of individuals was concentrated in the lower diameter classes 3-6 cm followed by 6-9 cm and 9-12 cm (Figure 3), which had a smaller diameter. The individuals with diameter classes ≥30 cm were least represented. Trees with large diameters were observed in species *Ficus platyphylla* Delile., *S. setigera*, *P. africana, S. birrea, T. leiocarpa, Ficus ingens* (Miq.) Miq., *Terminalia macroptera* Guill. & Perr., *Bombax costatum* Pellegr. & Vuillet.

The height structure of the individual's analysis showed an "L" shape. The distribution of individuals in height classes showed that the classes 1-4 m were the most represented with 54.43% of the total number of individuals, followed by the classes 4-7 m and 7-10 m (Figure 4). The individuals with height classes ≥16 m were least represented.

Regeneration

The mean regeneration rate by seedlings was 16.96%. The species with higher seedling regeneration capacity in the forest were *G. senegalensis* (3.61%), *T. leiocarpus* (1.08%), *C. adenogonium* (0.88 %), *B. aegyptiaca* (0.78%), *Combretum glutinosum* Perr. ex DC (0.76%), *C. molle* (0.54%), and *C. collinum* (0.53%) (Tables 4 and S2). The species *V. madiensis, V. paradoxa*, and *Pterocarpus lucens* Lepr. ex Guill. & Perr., hadn't seen regeneration.

An overall regeneration rate of stump sprouting of 23.41% was recorded. The best regeneration potential by stump sprouting was recorded in the species *G. senegalensis* (4.21%), *B. aegyptiaca* (2.47%), *T. leiocarpa* (1.97%), *S. birrea* (1.15%), *C. molle* (0.82%), *S. setigera* (0.81%), *C. collinum* (0.80%), *C. adenogonium* (0.71%), *P. africana* (0.65%), *Ziziphus mauritiana* Lam. (0.60%), *Vachellia seyal* (Del.) P.J.H.Hurter (0.54%), and *Piliostigma thonningii* (Schumach.) Mine-Redh. (0.53%) (Tables 4 and S2). Species with the lowest regeneration rates were *G. erubescens* (0.06%), *Hymenocardia acida* Tul (0.05%), *Terminalia avicennioides* Guill. & Perr. (0.05%), *C. febrifuga* (0.04%), *Celtis toka* (Forssk.) Hepper & J.R.I.Wood (0.03%), and *Tamarindus indica* L. (0.03%).

The global mortality rate was 16.09% in the Goulourgou-Wina Forest. Species with high mortality rate were: *G. senegalensis* (4.38%), *P. africana* (2.25%), *C. glutinosum* (0.73%), and *C. collinum* (0.60%), *Senegalia ataxacantha* DC. (0.45%), *Dichrostachys cinerea* (L.) Wight & Arn (0.52%), *S. setigera* (0.48%), *Piliostigma reticulatum* (DC.) Hochst. (0.38%), *B. aegyptiaca* (0.30%) (Tables 4 and S2). The species with the lowest mortality rate were *F. platyphylla* (0.01), and *F. thonningii* (0.01%).

Table 3. Ecological importance of families

Families	Relative density (%)	Relative dominance (%)	Relative diversity (%)	FIVI
Fabaceae	42.21	17.48	16.49	76.18
Combretaceae	14.71	23.59	13.94	52.24
Anacardiaceae	5.33	12.87	7.36	25.56
Malvaceae	1.27	13.38	4.41	19.06
Moraceae	2.63	13.23	1.84	17.70
Capparaceae	2.83	1.02	6.63	10.48
Zygophyllaceae	3.61	2.42	1.84	7.87
Annonaceae	2.83	0.60	3.68	7.11
Rubiaceae	2.10	0.74	2.39	5.23
Rhamnaceae	1.12	1.37	1.84	4.33

Note: FIVI: Family Importance Value Index

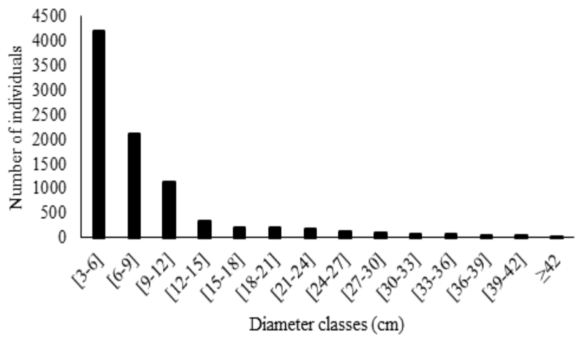

Figure 3. Diametric distribution of woody species

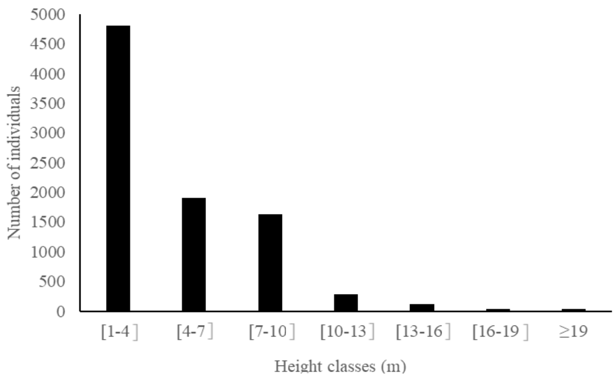

Figure 4. Distribution of individuals by height class in the collection units

Disturbance effects

The intensity of cutting by systematic removal of individuals showed an overall rate of 6.75%. The species with higher intensity of systematic cutting were *G. senegalensis* (1.26%), *P. africana* (0.42%), *C. collinum* (0.36%), *T. leiocarpa* (0.33%), *B. aegyptiaca* (0.31%), and *S. birrea* (0.27%) (Tables 5 and S3). The species with the lowest rate of systematic cutting in Goulourgou-Wina Forest, *G. erubescens*, *Lannea velutina* A.Rich., *Securidaca longepedunculata* Fresen., *T. avicennioides,* and *T. macroptera* had 0.01% each (Tables 5 and S3).

The intensity of partial cutting showed an overall rate of 3.93% of the total individuals. The species with the highest partial cutting were: *Vachellia seyal* (0.54%), *P. africana* (0.25%), *Stereospermum kunthianum* Cham. (0.23%), *T. leiocarpa* (0.19%) and *Z. mauritiana* (0.17%) (Tables 5 and S3). The species *V. madiensis*, *V. hockii, Capparis sepiaria* L., *C. sieberiana, Eucalyptus camaldulensis* Dehnh and *V. gerrardii* with 0.01% each showed the lowest rate of partial cutting in Goulourgou-Wina Forest (Tables 5 and S3).

The bushfires in the Goulourgou-Wina Forest were uncontrolled, and all species were affected. The global rate of bushfires on individuals was 8.39%. The species with a high rate of bushfire were *G. senegalensis* (2.15%), *P. africana* (1.07%), *T. leiocarpa* (0.39%), *B. aegyptiaca* (0.35%), and *S. ataxacantha* (0.34%) (Tables 5 and S3). The species with the lowest rate of bushfire in Goulourgou-Wina Forest were *L. schimperi* (0.01%), *V. seyal* (0.01%), *B. costatum* (0.01%), *Z. mauritiana* (0.01%), and *Flueggea virosa* Roxb. ex Willd. Voigt (0.01%) (Tables 5 and S3).

The debarking of species in the forest showed a rate of 1.84%. The highest debarking species were *A. senegalensis* (0.39%), *P. lucens* (0.22%), *P. reticulatum* (0.22%), *V. seyal* (0.19%), *S. birrea* (0.16%), and *B. costatum* (0.10%) (Table 6). The species with the lowest rate of debarking in Goulourgou-Wina Forest were *T. indica* (0.01%), *C. molle* (0.01%), *H. acida* (0.01%), *X. americana* (0.01%), *V. hockii* (0.01%), and *C. sieberiana* (0.01%).

The effects of these disturbances were confirmed by land use maps of the study area between the years 1980 and 2022 (Figure 5). In 1980, land use was dominated by grassy savannah, followed by shrub and wooded savannah. In 2022, land use is marked by the dominance of burns and fields. The state of degradation of plant resources is very significant, and this is the direct consequence of anthropogenic activities (logging, agriculture, overgrazing, bushfires, and debarking) in the Gouloùrgou-Wina Forest.

Table 4. Species with high seedling rate in the Goulourgou-Wina Forest, Cameroon

Species	Regeneration rate by seedling (%)	Regeneration rate by stump sprouting (%)	Mortality rate (%)
Guiera senegalensis J.F.Gmel.	3.61	4.21	4.38
Terminalia leiocarpa (DC.) Guill. & Perr.	1.08	1.97	0.14
Combretum adenogonium Steud. ex A.Rich.	0.88	0.71	0.14
Balanites aegyptiaca (L.) Delile.	0.78	2.47	0.30
Combretum molle R.Br. ex G.Don	0.54	0.82	0.12
Combretum collinum Fresen.	0.53	0.80	0.60
Vachellia seyal (Delile) P.J.H.Hurter	0.48	0.54	0.07
Piliostigma thonningii (Schumach.) Mine-Redh.	0.38	0.53	0.07
Ziziphus mauritiana Lam.	0.34	0.60	0.02
Annona senegalensis Pers.	0.31	0.24	0.01
Sclerocarya birrea (A.Rich.) Hochst.	0.31	1.15	0.01
Vachellia sieberiana (DC.) Kyal. & Boatwr.	0.24	0.32	0.01

Table 5. Systematic cutting, partial cutting, and bushfire rate

Species	Systematic cutting rate (%)	Partial cutting rate (%)	Rate of bushfires (%)
Guiera senegalensis J.F.Gmel.	1.26	0	2.15
Prosopis africana (Guill. Et Perr.) Taub	0.42	0.25	1.07
Combretum collinum Fresen.	0.36	0.11	0.01
Terminalia leiocarpa (DC.) Guill. & Perr.	0.33	0.19	0.39
Balanites aegyptiaca (L.) Delile.	0.31	0.05	0.35
Sclerocarya birrea (A.Rich.) Hochst.	0.27	0.14	0.03
Stereospermum kunthianum Cham.	0.18	0.23	0.09
Bombax costatum Pellegr. & Vuillet	0.15	0.10	0.01
Combretum adenogonium Steud. ex A.Rich.	0.14	0.11	0.07
Dichrostachys cinerea (L.) Wight & Arn	0.09	0.02	0.03
Ziziphus mauritiana Lam.	0.03	0.17	0.01
Senegalia ataxacantha DC.	0.01	0.01	0.34

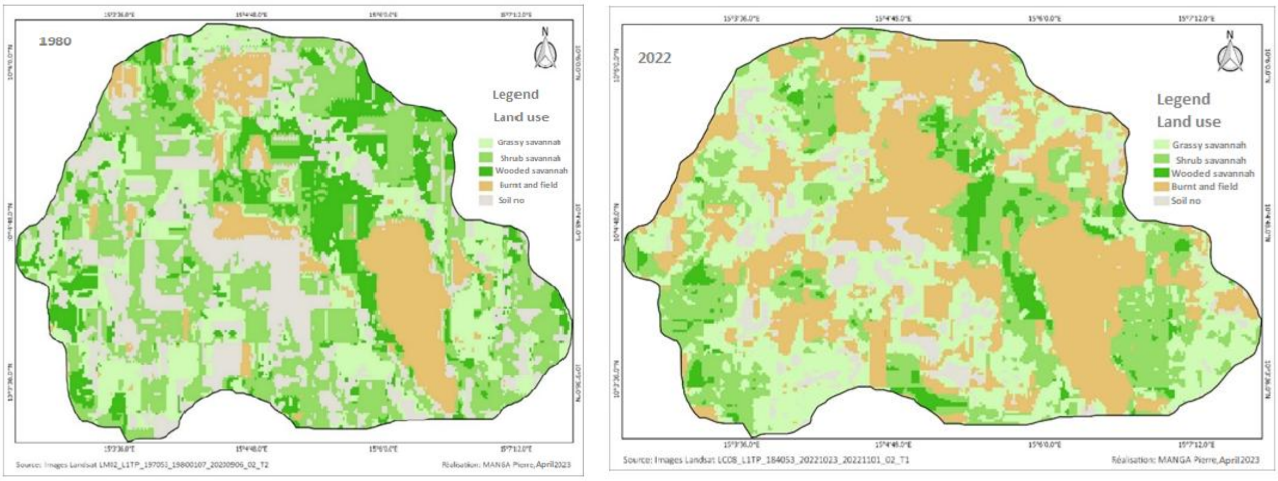

Figure 5. Mapping of land use in the Goulourgou-Wina Forest, Cameroon, in 1980 and 2022

Table 6. Debarking of species

Species	Debarking rate (%)
Annona senegalensis Pers.	0.39
Pterocarpus lucens Lepr. ex Guill. & Perr.	0.22
Piliostigma reticulatum (DC.) Hochst.	0.22
Vachellia seyal (Delile) P.J.H.Hurter	0.19
Sclerocarya birrea (A.Rich.) Hochst.	0.16
Bombax costatum Pellegr. & Vuillet	0.10
Ficus platyphylla Delile.	0.06
Lannea schimperi (Hochst. ex A.Rich.) Engl.	0.06
Grewia barteri Burret	0.06
Vachellia nilotica (L.) P.J.H.Hurter & Mabb.	0.05
Piliostigma thonningii (Schumach.) Mine-Redh.	0.05

Discussion

Floristic richness and diversity

The floristic survey revealed 78 woody species from 53 genera and 24 families in the Goulourgou-Wina Forest, indicating substantial richness within the Sudano-Sahelian ecological zone. This level of diversity is slightly higher than that reported in Moutourwa forest (Gilbert et al. 2016) and markedly exceeds the figures from Pette and Diamaré woodlands (Diguera et al. 2024; Wouokoue et al. 2024). Such variation reflects differences in disturbance intensity across sites, particularly in relation to wood harvesting, grazing, and bushfires. The Shannon Diversity Index (H' = 3.38) falls within the moderate range, which suggests that the forest still maintains a relatively stable community structure despite ongoing human pressures. This finding is comparable to the Laf-forest reserve, where moderate diversity was also observed under similar ecological conditions (Konsala et al. 2020).

Evenness, however, was relatively low, highlighting the ecological dominance of a few species such as *G. senegalensis*, *P. africana*, and *B. aegyptiaca*. The prevalence of these species indicates strong adaptation to disturbance but also raises concerns about the declining representation of less competitive taxa. Families such as Fabaceae and Combretaceae contributed most to overall richness and dominance, consistent with patterns observed elsewhere in northern Cameroon and neighboring Chad (Nangndi et al. 2021; Konsala et al. 2022). The ecological success of Fabaceae, a globally widespread family, can be attributed to traits such as efficient nitrogen fixation and resilience to environmental stress (Craven 2009).

While the dominance of adaptable species enhances short-term stability, it may also reduce functional diversity and long-term resilience. Rare species with low IVI are particularly vulnerable to local extinction if anthropogenic pressures persist. These findings emphasize the need for targeted conservation of underrepresented taxa through assisted natural regeneration, domestication, or enrichment planting. Protecting this component of floristic diversity is critical not only for maintaining ecological balance but also for safeguarding the ecosystem services that local communities depend upon.

Structure and regeneration

The structural profile of woody species in the Goulourgou-Wina Forest displayed an "L-shaped" distribution, characterized by a predominance of small-diameter and short-statured individuals. This pattern is typical of disturbed Sudano-Sahelian woodlands, where selective removal of mature trees alters stand composition while younger cohorts continue to dominate (Africa et al. 2020). Comparisons with protected areas such as Moutourwa and Kalfou (Moksia 2012; Nnanga et al. 2022) highlight the contrast, as those forests retain larger diameter classes due to stronger protection measures. The lack of large trees in Goulourgou-Wina suggests sustained extraction pressure, particularly for fuelwood and construction timber, and signals a gradual loss of ecological complexity.

Despite these pressures, regeneration was evident through both seedlings and stump sprouts, indicating that many species still retain the capacity for renewal. Nevertheless, regeneration rates were lower than those reported in Pette (Diguera et al. 2024) and Otikéran National Park (Chase et al. 2020), reflecting the combined effects of grazing, bushfires, and seed predation. Such constraints compromise the ability of young individuals to reach maturity, raising concerns about the forest's long-term sustainability. Seed viability, dormancy, and dispersal strategies also play critical roles in regeneration outcomes (Condit et al. 2000).

From an ecological standpoint, the observed regeneration provides cautious optimism but should not be interpreted as sufficient for ensuring population stability. The persistence of strong anthropogenic pressures may eventually overwhelm natural recruitment. To enhance forest resilience, management interventions such as assisted natural regeneration, protection of regeneration sites from grazing, and enrichment planting of vulnerable species are necessary. These actions would not only reinforce natural processes but also help secure the ecological services on which local communities rely.

Anthropogenic pressures

Human activities represent the most significant drivers of structural change and biodiversity loss in the Goulourgou-Wina Forest. Logging, both systematic and selective, continues to remove valuable timber species, reflecting rural communities' reliance on forest resources for energy and livelihoods (Moksia et al. 2019). Although cutting rates were lower than in some comparable sites (Diguera et al. 2024), the cumulative effect of ongoing extraction gradually reduces forest resilience. Bark stripping, while less frequent, weakens individuals and makes them more vulnerable to secondary stressors such as pathogens.

Bushfires emerged as the most pervasive disturbance, affecting nearly all woody species. Fire-tolerant taxa such as *V. paradoxa* and *Entada africana* Guill. & Perr. display adaptive traits, including thick bark and resprouting ability (Wouokoue et al. 2020). However, late-season fires can be particularly destructive, increasing mortality among seedlings and reducing recruitment (Poilecot et al. 2006; Biaou et al. 2023). Repeated cycles of fire and grazing lead to structural simplification, loss of sensitive species, and reduced capacity of the ecosystem to provide carbon storage, soil stabilization, and biodiversity conservation.

The ecological implications of these pressures are profound. Continued disturbance risks shifting the forest towards a more degraded savannah-like state, with lower diversity and diminished ecosystem functions. Addressing these challenges requires more than ecological interventions; it demands strong community involvement in conservation. Fire management committees, participatory monitoring of resource use, and the promotion of sustainable harvesting practices are potential strategies to mitigate degradation. By engaging local stakeholders, conservation efforts can become more culturally acceptable and socially sustainable, thereby reducing pressures while supporting rural livelihoods.

In conclusion, the Goulourgou-Wina Forest hosts 78 woody species across 54 genera and 24 families, confirming its importance as a biodiversity reservoir in the Sudano-Sahelian zone. Moderate diversity values and the dominance of Fabaceae and Combretaceae indicate a resilient but increasingly simplified community structure. The prevalence of small-diameter individuals reflects ongoing regeneration, though limited recruitment and removal of large trees raise concerns about long-term stability. Anthropogenic disturbances, particularly uncontrolled bushfires and logging, remain the main drivers of degradation. While several species exhibit adaptive traits, continued exploitation threatens biodiversity, ecosystem services, and forest resilience. Sustainable management strategies are therefore essential. Priority measures should include assisted regeneration, enrichment planting, and conservation of low-IVI species. Active participation of local communities through fire management, sustainable harvesting, and participatory monitoring will be critical. Strengthening these approaches offers a pathway to maintaining both ecological integrity and rural livelihoods in the region.

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Table S1. Species density, basal area and IVI

Species	Density (individuals/ha)	Basal area (m²/ha)	IVI (%)
Albizia chevalieri Harms	0.70	0.03	0.49
Amblygonocarpus andongensis (Welw. ex Oliv.) Exell & Torre	1.83	0.02	1.34
Annona senegalensis Pers.	5.30	0.01	3.87
Azadirachta indica A.Juss	3.07	0.08	2.51
Balanites aegyptiaca (L.) Delile.	10.93	2.04	8.99
Bauhinia rufescens Lam.	0.73	0.03	0.60
Bobgunnia madagascariensis (Desv.) J.H. Kirkbr. & Wiersema	1.73	0.11	1.88
Bombax costatum Pellegr. & Vuillet	3.67	0.18	4.61
Borassus aethiopum Mart.	0.80	0.18	1.21
Boscia senegalensis (Pers.) Lam. ex Poir	0.47	0.04	1.31
Cadaba farinosa Forssk	2.53	0.05	2.26
Capparis fascicularis DC	0.47	0.17	1.31
Capparis sepiaria L.	2.87	0.02	2.38
Cassia sieberiana DC.	0.47	0	0.51
Celtis toka (Forssk.) Hepper & J.R.I.Wood	1.00	0.30	4.11
Cochlospermum tinctorium Perr. ex A.Rich.	0.87	0.02	1.19
Combretum aculeatum Vent.	2.47	0.01	1.30
Combretum adenogonium Steud. ex A.Rich.	6.50	1.21	5.64
Combretum collinum Fresen.	12.20	1.60	8.52
Combretum glutinosum Perr. ex DC	11.47	0.38	7.87
Combretum micranthum G.Don	6.60	0.06	4.22
Combretum molle R.Br. ex G.Don	8.10	1.00	7.37
Commiphora pedunculata (Kotschy & Peyr.) Engl	1.07	0.03	1.52
Crateva adansonii DC	2.37	0.08	2.65
Crossopteryx febrifuga (Afzel. ex G.Don) Benth	0.93	0	0.73
Daniellia oliveri (Rolfe) Hutch. & Dalziel	1.80	0.30	1.63
Detarium microcarpum Guill. & Perr.	2.53	0.17	3.10
Dichrostachys cinerea (L.) Wight & Arn	6.27	0.07	4.33
Eucalyptus camaldulensis Dehnh	0.60	0.05	0.84
Faidherbia albida (Delile) A.Chev.	1.93	0.14	1.32
Feretia apodanthera Delile	4.10	-	3.01
Ficus ingens (Miq.) Miq.	0.87	0.21	3.55
Ficus platyphylla Delile.	2.40	-	9.59
Ficus sycomorus L	1.97	0.17	7.03
Ficus thonningii Blume	0.10	0	0.43
Flueggea virosa (Roxb. ex Willd.) Voigt	2.67	-	2.49
Gardenia aqualla Stapf & Hutch	1.57	-	1.44
Gardenia erubescens Stapf & Hutch.	0.20	0	0.46
Gardenia ternifolia Schumach. & Thonn	0.47	0	0.57
Grewia barteri Burret	0.20	0	0.26
Guiera senegalensis J.F.Gmel.	58.87	1.71	25.02
Gymnosporia senegalensis (Lam.) Loes)	0.93	-	0.47
Hexalobus monopetalus (A.Rich.) Engl. & Diels	2.67	0.07	2.90
Hymenocardia acida Tul	0.93	-	1.31
Hyphaene thebaica (L.) Mart	1.40	0.24	1.93
Lannea fruticosa (Hochst. ex A.Rich.) Engl.	3.03	0.19	3.11
Lannea schimperi (Hochst. ex A.Rich.) Engl	2.53	0.34	3.47
Lannea velutina A.Rich.	0.90	0.04	0.74
Parkia biglobosa (Jacq.) R.Br. ex G.Don	0.53	0.09	0.91
Philenoptera laxiflora (Guill. & Perr.) Roberty	0.47	0.04	1.19
Piliostigma reticulatum (DC.) Hochst.	6.57	0.08	5.02
Piliostigma thonningii (Schumach.) Milne-Redh.	3.63	0.07	3.23
Prosopis africana (Guill. & Perr.) Taub	11.55	12.79	24.53
Pterocarpus lucens Lepr. ex Guill. & Perr.	3.87	0.38	4.81
Sclerocarya birrea (A.Rich.) Hochst.	8.77	8.21	14.86
Securidaca longepedunculata Fresen.	0.77	0.06	1.24
Senegalia ataxacantha DC.	4.00	0.06	2.62
Senegalia senegal (L.) Britton	0.73	0.10	0.76
Senna singueana (Delile) Lock	1.67	0.04	1.99
Sterculia setigera Delile	7.40	9.28	17.97
Stereospermum kunthianum Cham.	2.57	0.05	3.56
Strychnos spinosa Lam.	2.13	0.10	2.34
Tamarindus indica L.	2.67	0.47	5.34

Terminalia avicennioides Guill. & Perr.	2.00	0.05	1.57
Terminalia laxiflora Engl. & Diels	2.33	0.02	1.79
Terminalia leiocarpa (DC.) Guill. & Perr.	11.30	4.46	11.15
Terminalia macroptera Guill. & Perr.	2.37	0.08	5.44
Vachellia gerrardii Benth P.J.H.Hurter	0.23	0	0.44
Vachellia hockii De Wild Seigler & Ebinger	0.43	0	0.95
Vachellia nilotica (L.) P.J.H.Hurter & Mabb.	0.97	0.04	1.21
Vachellia seyal (Delile) P.J.H.Hurter	6.40	0.41	5.33
Vachellia sieberiana (DC.) Kyal. & Boatwr.	7.23	4.14	8.69
Vitellaria paradoxa C.F.Gaertn.	0.47	0	1.42
Vitex doniana Sweet	1.53	0.15	2.52
Vitex madiensis Oliv.	0.40	0	0.60
Ximenia americana L.	6.07	0.19	4.89
Ziziphus mauritiana Lam	5.10	0.22	4.65
Ziziphus mucronata Willd.	1.27	0.01	1.43
Total	295.87	52.94	299.84

Note: -: Absent

Table S2. Species seedling rate, stump sprouting rate and Mortality rate in the Goulourgou-Wina Forest

Species	Regeneration rate by seedling (%)	Regeneration rate by stump sprouting (%)	Mortality rate (%)
Albizia chevalieri Harms	0.03	0.05	0.07
Amblygonocarpus andongensis (Welw. ex Oliv.) Exell & Torre	0.11	0.11	0.15
Annona senegalensis Pers.	0.31	0.24	0.01
Azadirachta indica A.Juss	0.22	0.41	0.18
Balanites aegyptiaca (L.) Delile.	0.78	2.47	0.30
Bauhinia rufescens Lam.	0.11	0.09	0.06
Bobgunnia madagascariensis (Desv.) J.H. Kirkbr. & Wiersema	0.07	0.15	0.08
Bombax costatum Pellegr. & Vuillet	0.09	0.19	0.22
Borassus aethiopum Mart.	0.13	-	-
Boscia senegalensis (Pers.) Lam. ex Poir	0.02	0.05	0.07
Cadaba farinosa Forssk	0.09	0.19	0.17
Capparis fascicularis DC	0.02	0.05	0.03
Capparis sepiaria L.	0.12	0.13	0.18
Cassia sieberiana DC.	0.01	0.02	0.01
Celtis toka (Forssk.) Hepper & J.R.I.Wood	0.03	0.15	0.02
Cochlospermum tinctorium Perr. ex A.Rich.	0.14	-	-
Combretum aculeatum Vent.	0.08	0.13	0.08
Combretum adenogonium Steud. ex A.Rich.	0.88	0.71	0.14
Combretum collinum Fresen.	0.53	0.80	0.60
Combretum glutinosum Perr. ex DC	0.76	0.90	0.73
Combretum micranthum G.Don	0.23	0.02	0.23
Combretum molle R.Br. ex G.Don	0.54	0.82	0.12
Commiphora pedunculata (Kotschy & Peyr.) Engl	0.02	0.04	0.05
Crateva adansonii DC	0.10	0.09	0.08
Crossopteryx febrifuga (Afzel. ex G.Don) Benth	0.04	0	0.01
Daniellia oliveri (Rolfe) Hutch. & Dalziel	0.29	-	-
Detarium microcarpum Guill. & Perr.	0.12	0.25	0.16
Dichrostachys cinerea (L.) Wight & Arn	0.19	0.20	0.52
Eucalyptus camaldulensis Dehnh	0.11	-	-
Faidherbia albida (Delile) A.Chev.	0.03	0.06	0.02
Feretia apodanthera Delile	0.37	0.38	0.38
Ficus ingens (Miq.) Miq.	0.11	0.05	0.03
Ficus platyphylla Delile.	0.02	0.19	0.01
Ficus sycomorus L	0.34	0.26	0.03
Ficus thonningii Blume	0.18	-	0.01
Flueggea virosa (Roxb. ex Willd.) Voigt	0.38	0.37	0.52
Gardenia aqualla Stapf & Hutch	0.02	0.07	0.04
Gardenia erubescens Stapf & Hutch.	0.06	0.02	0.02
Gardenia ternifolia Schumach. & Thonn	0.11	-	-
Grewia barteri Burret	0.10	-	-
Guiera senegalensis J.F.Gmel.	3.61	4.21	4.38
Gymnosporia senegalensis (Lam.) Loes)	0.05	0.03	0.04
Hexalobus monopetalus (A.Rich.) Engl. & Diels	0.10	0.18	0.14
Hymenocardia acida Tul	0.05	0.02	0.02
Hyphaene thebaica (L.) Mart	0.06	-	0.08
Lannea fruticosa (Hochst. ex A.Rich.) Engl.	0.13	0.19	0.18
Lannea schimperi (Hochst. ex A.Rich.) Engl.	0.12	0.23	0.19
Lannea velutina A.Rich.	0.13	-	-
Parkia biglobosa (Jacq.) R.Br. ex G.Don	0.08	-	-
Philenoptera laxiflora (Guill. & Perr.) Roberty	0.05	0.06	0.08
Piliostigma reticulatum (DC.) Hochst.	0.26	0.37	0.38
Piliostigma thonningii (Schumach.) Milne-Redh.	0.38	0.53	0.07
Prosopis africana (Guill. & Perr.) Taub	0.03	0.65	2.25
Pterocarpus lucens Lepr. ex Guill. & Perr.	0.08	0.15	0.17
Sclerocarya birrea (A.Rich.) Hochst.	0.31	1.15	0.01
Securidaca longepedunculata Fresen.	0.03	0.02	0.10
Senegalia ataxacantha DC.	0.20	0.21	0.45
Senegalia senegal (L.) Britton	0.03	0.05	0.07
Senna singueana (Delile) Lock	0.13	0.18	0.13
Sterculia setigera Delile	0.10	0.81	0.48
Stereospermum kunthianum Cham.	0.07	0.18	0.14
Strychnos spinosa Lam.	0.06	0.07	0.09
Tamarindus indica L.	0.03	0.10	0.02

Terminalia avicennioides Guill. & Perr.	0.05	0.06	0.05
Terminalia laxiflora Engl. & Diels	0.11	0.14	0.12
Terminalia leiocarpa (DC.) Guill. & Perr.	1.08	1.97	0.14
Terminalia macroptera Guill. & Perr.	0.11	-	0.13
Vachellia gerrardii Benth P.J.H.Hurter	0.01	0.02	-
Vachellia hockii De Wild Seigler & Ebinger	0.15	0.06	0.05
Vachellia nilotica (L.) P.J.H.Hurter & Mabb.	0.04	0.10	0.07
Vachellia seyal (Delile) P.J.H.Hurter	0.48	0.54	0.07
Vachellia sieberiana (DC.) Kyal. & Boatwr.	0.24	0.32	0.01
Vitellaria paradoxa C.F.Gaertn.	0.03	0.14	0.11
Vitex doniana Sweet	0.07	0.08	0.06
Vitex madiensis Oliv.	0.07	0.05	0.07
Ximenia americana L.	0.15	0.21	0.30
Ziziphus mauritiana Lam	0.34	0.60	0.02
Ziziphus mucronata Willd.	0.05	0.07	0.09

Note: -: Absent

Table S3. Systematic cutting, partial cutting, and bushfire rate

Species	Systematic cutting rate (%)	Partial cutting rate (%)	Bushfire rate (%)
Albizia chevalieri Harms	0.03	0.01	0.02
Amblygonocarpus andongensis (Welw. ex Oliv.) Exell & Torre	0.02	0.05	0.04
Annona senegalensis Pers.	0.10	0.02	0.01
Azadirachta indica A.Juss	0.04	0.01	0.08
Balanites aegyptiaca (L.) Delile.	0.31	0.05	0.35
Bauhinia rufescens Lam.	0.08	0.01	0.02
Bobgunnia madagascariensis (Desv.) J.H. Kirkbr. & Wiersema	0.08	0.01	0.03
Bombax costatum Pellegr. & Vuillet	0.15	0.10	0.01
Borassus aethiopum Mart.	0.09	0.02	0.04
Boscia senegalensis (Pers.) Lam. ex Poir	0.08	0.01	0.06
Cadaba farinosa Forssk	0.01	0.01	0.06
Capparis fascicularis DC	0.02	0.01	0.05
Capparis sepiaria L.	0.02	0.01	0.03
Cassia sieberiana DC.	0.01	0.01	0.01
Celtis toka (Forssk.) Hepper & J.R.I.Wood	0.03	0.03	0.03
Cochlospermum tinctorium Perr. ex A.Rich.	0.02	0.05	0.05
Combretum aculeatum Vent.	0.17	0.02	0.03
Combretum adenogonium Steud. ex A.Rich.	0.14	0.11	0.07
Combretum collinum Fresen.	0.36	0.11	0.01
Combretum glutinosum Perr. ex DC	0.01	0.06	0.08
Combretum micranthum G.Don	0.01	0.01	0.05
Combretum molle R.Br. ex G.Don	0.01	0.05	0.03
Commiphora pedunculata (Kotschy & Peyr.) Engl	0.06	0.03	0.08
Crateva adansonii DC	0.05	0.03	0.02
Crossopteryx febrifuga (Afzel. ex G.Don) Benth	0.08	0.01	0.05
Daniellia oliveri (Rolfe) Hutch. & Dalziel	0.09	0.08	0.03
Detarium microcarpum Guill. & Perr.	0.01	0.02	0.05
Dichrostachys cinerea (L.) Wight & Arn	0.09	0.02	0.03
Eucalyptus camaldulensis Dehnh	0.01	0.01	0.04
Faidherbia albida (Delile) A.Chev.	0.06	0.01	0.02
Feretia apodanthera Delile	0.05	0.01	0.38
Ficus ingens (Miq.) Miq.	0.06	0.01	0.03
Ficus platyphylla Delile.	0.05	0.01	0.01
Ficus sycomorus L	0.07	0.05	0.03
Ficus thonningii Blume	0.07	0.06	0.01
Flueggea virosa (Roxb. ex Willd.) Voigt	0.05	0.01	0.01
Gardenia aqualla Stapf & Hutch	0.01	0.03	0.04
Gardenia erubescens Stapf & Hutch.	0.01	0.06	0.06
Gardenia ternifolia Schumach. & Thonn	0	0	0.06
Grewia barteri Burret	0.06	0	0.08
Guiera senegalensis J.F.Gmel.	1.26	0	2.15
Gymnosporia senegalensis (Lam.) Loes)	0.06	0	0.07
Hexalobus monopetalus (A.Rich.) Engl. & Diels	0.06	0.06	0.06
Hymenocardia acida Tul	0.07	0.06	0.08
Hyphaene thebaica (L.) Mart	0.01	0.05	0.08
Lannea fruticosa (Hochst. ex A.Rich.) Engl.	0.06	0.01	0.18
Lannea schimperi (Hochst. ex A.Rich.) Engl.	0.12	0.01	0.01
Lannea velutina A.Rich.	0.01	0.06	0.06
Parkia biglobosa (Jacq.) R.Br. ex G.Don	0.01	0.03	0.05
Philenoptera laxiflora (Guill. & Perr.) Roberty	0.07	0.05	0.07
Piliostigma reticulatum (DC.) Hochst.	0.08	0.06	0.08
Piliostigma thonningii (Schumach.) Milne-Redh.	0.09	0.07	0.09
Prosopis africana (Guill. & Perr.) Taub	0.42	0.25	1.07
Pterocarpus lucens Lepr. ex Guill. & Perr.	0	0.05	0.06
Sclerocarya birrea (A.Rich.) Hochst.	0.27	0.14	0.03
Securidaca longepedunculata Fresen.	0.01	0.05	0.08
Senegalia ataxacantha DC.	0.01	0.01	0.34
Senegalia senegal (L.) Britton	0.04	0.08	0.02
Senna singueana (Delile) Lock	0.05	0.05	0.05
Sterculia setigera Delile	0.07	0.01	0.09
Stereospermum kunthianum Cham.	0.18	0.23	0.09
Strychnos spinosa Lam.	0.06	0	0.08
Tamarindus indica L.	0.08	0.06	0.07

Terminalia avicennioides Guill. & Perr.	0.01	0.08	0.08
Terminalia laxiflora Engl. & Diels	0.04	0.08	0.08
Terminalia leiocarpa (DC.) Guill. & Perr.	0.33	0.19	0.39
Terminalia macroptera Guill. & Perr.	0.01	0.05	0.08
Vachellia gerrardii Benth P.J.H.Hurter	0.06	0.01	0.06
Vachellia hockii De Wild Seigler & Ebinger	0.05	0.01	0.06
Vachellia nilotica (L.) P.J.H.Hurter & Mabb.	0.03	0.01	0.05
Vachellia seyal (Delile) P.J.H.Hurter	0.18	0.54	0.01
Vachellia sieberiana (DC.) Kyal. & Boatwr.	0.08	0.01	0.01
Vitellaria paradoxa C.F.Gaertn.	0.02	0.05	0.09
Vitex doniana Sweet	0.02	0.03	0.08
Vitex madiensis Oliv.	0.02	0.01	0.09
Ximenia americana L.	0.01	0.04	0.08
Ziziphus mauritiana Lam	0.03	0.17	0.01
Ziziphus mucronata Willd.	0.10	0.04	0.07
Total	6.75	3.93	8.39

Note: -: Absent