# Population structure and regeneration status of Sclerocarya birrea (A. Rich.) Hochst. under different land use types in Burkina Faso, West Africa

**Satassa Hien**
satsonhien@gmail.com

University Norbert Zongo (UNZ)

**Lassina Traoré**
University Norbert Zongo (UNZ)

**Yaya Maiga**
Nazi Boni University

**Aziz Abdoul Kaboré**
University Norbert Zongo (UNZ)

**Kuilpoko Marie Laure Guissou**
University Norbert Zongo (UNZ)

**Anne Mette Lykke**
Aarhus University

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## Abstract

*Sclerocarya birrea* is a keystone species in the diet, traditions, and culture of local communities in West Africa. This study assessed the impact of land use type on the woody's diversity, regeneration pattern and population structure of *Sclerocarya birrea* stands to implement a strong management scheme. Data were collected from 150 plots across field, fallow, and forest in Burkina Faso. Regeneration was recorded as seedling, suckers and coppices in diameter height classes. Hill diversity indices were used to determine the effect of land use in stands diversity. Weibull theoretical model was applied to analyze size classes distribution. Land use significantly influenced *Sclerocarya birrea* stands diversity and structure, with the lowest diversity recorded in field. The largest and tallest individuals were recorded in field while fallow and forest had the maximum tree density. Seedling is the most common regeneration type, especially with higher density in flied. However, diameter size classes distribution revealed unstable structure population in field while fallow and forest were more stable. This study highlights the need to improve juvenile management and promote low-cost nursery techniques for *Sclerocarya birrea*. Famer's should support seedlings protection in agroforestry systems for better sustainable use and long-term preservation of the species.

## Introduction

In West African savannas, anthropogenic activities, land use and climate change have led to a decline of many indigenous tree species (Zoungrana et al. 2023; Lykke et al. 2025). For example, defoliation, debarking and full fruit harvesting of non-timber forest products (NTFPs) reduced populations of several multipurpose tree species (Nacoulma et al. 2011; Long et al. 2021). Since most people in this region rely on land for agriculture, wood, and non-timber forest products, these negative trends seriously affect ecosystems and their associated goods and services (Houehanou et al. 2013; Guissou et al. 2015; Sanou et al. 2019). Furthermore, this situation induced a regressive dynamic of stand composition and low regeneration often with no juvenile individuals (Abdourhamane et al. 2017; Zon et al. 2022; Ouédraogo et al. 2025). As a result, biodiversity and ecosystem functions in savannas are increasingly at risk (Aleza et al. 2015; Zerbo et al. 2018; Li et al. 2025). Given the benefits of multipurpose species, like *Sclerocarya birrea*, it is important to prevent their decline to enhance environmental functions and support local livelihoods.

*Sclerocarya birrea* plays a key role in the diet, traditions, and culture of local communities in West Africa. *S. birrea* fruit pulp contains four times vitamin c than lemon and mango (Glew et al. 2004). It also has strong potential in both local and international markets (Gouwakinnou et al. 2011; Lykke et al. 2021; Leakey et al. 2021). In rural areas, Women and children exploit fruit pulp and seeds. Its fruits are eaten fresh or fermented into beverages, while the kernels are consumed raw or used for oil (Bationo/Kando et al. 2016; Moussa et al. 2022; Chauke et al. 2025). *S. birrea* is well-adapted to semi-arid savanna conditions, and is often retained in agroforestry systems for its ecological services and as a source of income, particularly for smallholder farmers (Emanuel et al. 2005; Leakey 2017; Sinthumule and Mashau 2019).

Despite its apparent preservation in agroforestry systems, populations of *S. birrea* are experiencing a gradual decline (Jacobs and Biggs 2001; Shackleton 2002). Natural regeneration of the species is comprised by inappropriate farming practices, overexploitation, livestock damage to young plants, and limited human support for regeneration(Agbogan et al. 2015; Helm et al. 2011). *S. birrea* density varies by land use. In Benin, 27 trees/ha vs 3 trees/ha were recorded in protected areas and agroforestry systems, respectively (Gouwakinnou et al. 2009). A similar pattern was observed, with 25 trees/ha in protected areas and 6 trees/ha in cultivated fields in Niger (Abdourhamane et al. 2017). Farmers tend to favor species of direct use, thus shaping the floristic composition of fallows and farmlands. Moreover, shortened fallow periods further compromising the natural regeneration of *S. birrea* populations (Zermeño-Hernández et al. 2016). *S. birrea* is fast-growing with high seed germination potential (Hien et al. 2024). Given that this species is not currently domesticated in West Africa, regeneration relies predominantly on natural processes which still poorly documented (Bognounou et al. 2009; Helm et al. 2011).

The distribution of diameter size classes is a key indicator of regeneration potential and vegetation dynamics (Glèlè-Kakaï et al. 2016; Lykke et al. 2025). The population structures, abundance patterns, and spatial distribution are essential indicators for the sustainable management of woody resources. These characteristics are habitat-dependent and must be assessed across land-use types to inform conservation strategies (Jurisch et al. 2012; Munyebvu et al. 2018; Hounwanou et al. 2025). In particular, A better understanding of these ecological patterns is necessary to guide effective resource management, ensure long-term sustainability and use of *S. birrea*. Therefore, it is important to assess the ecological impact of land use type on the woody's diversity, regeneration pattern and population structure of *S. birrea* stands to implement a strong management scheme.

This study aims to (1) assess the influence of land use types on the diversity and the composition of woody species associated with *S. birrea* stands, (2) analyze the effect of land use type on the density of adult, seedling, sapling and coppices, and (3) to assess regeneration potential via size class distribution of *S. birrea* across land use types.

## Materials and Methods

# Study area

The study was carried out at four sites in classified forest, field and fallow along a phytogeographic level in Burkina Faso. The sites were Wayen (11°55'08"N and 3°43'33"W), Tiogo (12°10'36"N and 2°41'29"W), Bondoukuy (11°55'08"N and 3°43'33"W) and Boromo (11°44'47"N and 2°55'54"W) (Fig. 1). The vegetation in the classified forests is characterized by various savanna types including shrub savannas, tree savannas, woodlands, dry forests, and gallery forests (Traore et al. 2020). Fallow and field were dominated by agroforestry parks. Wayen and Tiogo sites are located in the North Sudanian sector with annual rainfall varies from 600 to 700 mm, and 40–70 rainy days per year. Soils are mostly lithosols. Bondoukuy and Boromo are located in the South Sudanian sector. Annual rainfall ranges from 800 to 900 mm, with 70 to 90 rainy days per year. Soils are mainly ferralsols (Bognounou et al. 2009). Subsistence agriculture, livestock and exploitation of NTFPs are the main livelihood activities in all sites. A wide variety of annual crops are cultivated: cotton, maize, sorghum, groundnut, cowpea and millet. These are often associated with multipurpose species trees like *Vitellaria paradoxa*, *Parkia biglobosa*, and *Sclerocarya birrea* (Cissé et al. 2019).

## Description of study species

*Sclerocarya birrea*, a dioecious tree in the Anacardiaceae family, is found in West Africa, northern Cameroon, Sudan, Tanzania, and northern Kenya (Hall et al. 2002). Female trees bear yellow drupes, 3–4 cm in diameter and 15–25 g in weight (Shackleton et al. 2003). The leaves are borne in clusters at the apex of stout branchlets, and are alternate and compound, 8–38 cm long imparipinnate, bearing 3–18 pairs of opposite or subopposite leaflets (Arbonnier 2009). The flowers are small, shortly pediculate, whitish purple to red. The fruits are obovoid fleshy and juicy drupes, 23.5 cm in diameter, green becoming yellow at maturity with a weight of 18–35 g (Diallo et al. 2006). The species thrives with 500 to 1600 mm of annual rainfall over different soil types (Gouwakinnou et al. 2009). It occurs across a range of vegetation types, principally mixed deciduous woodland, wooded grassland and through the open dry savannas of northern Tropical Africa and the Sahelian region (Nyoka et al. 2015). In Burkina Faso, it occurs in Sudanian zone, sometimes forming monospecific stands (Tingueri et al. 2021).

## Sampling design and data collection

Three land use types were considered regarding the different anthropogenic pressures: field, fallow and classified forest (Fig. 2). In this study, classified forests are legally designated areas of natural savanna or forest established by public authorities to limit human disturbances and protect resources, ecosystem functions, and services (Fig. 2c). The classified forests of Tiogo and Wayen were sampled in the North Sudanian sector, while the classified forests of Bale and Tuy were sampled in the South Sudanian sector. However, except the classified forest of Tiogo, which operates under participatory management with local communities, the other forests were fully controlled by the States services (Kagambega et al. 2019). All these classified forests are designated by IUCN Category IV of protected areas (IUCN 2012). Despite their status, illegal logging and NTFPs harvesting occur in these forests (Traore et al. 2020). Fields are currently active croplands under intensive cultivation (Fig. 2a). Fallows refers to previously cultivated lands left uncultivated for over five years to restore vegetation and soil fertility (Fig. 2b).

Data were collected during the rainy season (July to October 2023). In each site, the fields were visited with the owner's permission to identify accessible populations of *S. birrea* for measurements and understand their management. A total of 150 plots were selected using a stratified random sampling method across the three land-use types. In fields and fallows, 120 square plots (50 × 50 m) were established, while 30 rectangular plots (50 × 20 m) were set up in classified forest. Plot sizes followed the savannas vegetation surveys guidelines (Thiombiano et al. 2016). Sampling was based on the presence at least four trees of *S. birrea* individuals, with a minimum distance of 100 m maintained between plots within each land use type (Aleza et al. 2015). In each plot, all woody species were recorded to assess diversity and composition. Species that could not be identified *in situ*, were sampled for later determination using the catalogue of vascular plants of Burkina Faso (Thiombiano et al. 2012), and names were checked with World Plant Names Index (https://wfoplantlist.org/plant-list). Tree height and diameter at breast height (DBH ≥ 5 cm) were measured for all woody species.

To assess *S. birrea* regeneration, five subplots of 5 x 5 m were placed at each plot's four corners and center. In each sub-plot, seedlings, suckers and coppices was recorded and classified following previous studies (Aleza et al. 2015; Kabré et al. 2020; Ouédraogo et al. 2025). Seedlings grow from germination of seed (Fig. 3a), suckers from lateral roots (Fig. 3b) and coppices are juvenile plant from cut or burned tree stumps (Fig. 3c).

# Statistical analysis

**Influence of land use on the diversity and composition of woody species associated with S. birrea stands**

The composition, abundance, and taxonomic diversity of woody species associated with *S. birrea* were analyzed across land use types. Stand diversity was assessed using Hill's framework (Hill 1973) with the *BiodiversityR* package (Kindt 2022), by calculating four indices:

N0 = S; with S the number of species in a plot;

N1 = $e^{H'}$; with H' Shannon's index;

N2 = 1/D, D = is the Simpson's diversity index;

Evenness (E) = H'/ln(S).

One-way analysis of variance (ANOVA) was used to assess the effect of land use on diversity indices (N0, N1, N2, and Evenness). When significant, Tukey's HSD test identified pairwise differences between land use types. Species composition across land-use types was assessed using ANOSIM and visualized with NMDS based on species abundance and dominance data. The ecological importance of woody species co-occurring with *S. birrea* was evaluated using the Importance Value Index (IVI), which ranges from 0 to 300 (Mueller-Dombois and Ellenberg 1974). The IVI was calculated by summing three components:

Relative Frequency = frequency of a species/sum of all frequencies × 100;

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

Relative Dominance = total basal area of a species/basal area of all species × 100

Importance Value Index = Relative density + Relative dominance + Relative frequency.

For each land use type, the 20 species with the highest IVI were selected to illustrate patterns in dominant woody species composition.

**Effect of land use on the density of adult, seedling, suckers and coppices of S. birrea**

Structural parameters of *S. birrea* included basal area (G), density (N), mean diameter ($D_g$), and Lorey's mean height (HL) were assessed. $G = \frac{\pi}{40000\ S} \sum_{i=1}^{n} di^2;$ $di$ the DBH of i-th tree (Philip, 2002). N= n/S, with n the average number of individuals per plot and S as the area expressed in hectares. HL expressed: $HL = \frac{\sum_{i=1}^{k} gihi}{\sum_{i=1}^{k} gi}$ ; expresses the height of the individuals adjusted by the basal area. The natural regeneration was calculated $Nr = \frac{\sum_{l=1}^{k} N_l \bar{N}_{rl}}{n}$; with $\bar{N}_{rl} = \left(\frac{1}{n_l}\right) \sum_{i=1}^{n_l} y_{li};$ $Nr$ is the mean density of S. birrea regeneration within land use, n the total number of sampling, $N_l$ is the mean density of adults *S. birrea*, $y_{li}$, the regeneration density withon $i^{th}$ plot of the stand (Bonou et al. 2009). ANOVA was used to compare structural parameters among land use types.

**Size class distribution of S. birrea across land use**

Diameter and height class distributions based on Condit et al. (1998) were used to interpret the status of *S. birrea* populations according to land use types. DBH data were computed and assembled in ten diameter classes of regular interval whereas five height classes were established for regeneration stratum. To assess population structure, the 3-parameter Weibull theoretical distribution model was applied due to its flexibility and simplicity (Glèlè Kakaï et al. 2016). The density function f(x) was define below: $f(x) = \frac{c}{b}\left(\frac{x-a}{b}\right)^{c-1} \exp\left[-\left(\frac{x-a}{b}\right)^{c}\right]$ ; where, a is the location parameter, b is the scale parameter, c is the shape parameter, x is the diameter. The Weibull distribution can take several forms depending on the value of the shape parameter. Value of $c < 1$ generally indicate populations with high regeneration potential (reverse J-shaped distribution), whereas values of *c* near or greater than 1 (flatter, unimodal, or left skewed distributions) indicate populations with a lower regeneration potential. Many factors, however, affect the *c* value and it, must be interpreted with caution, but generally the higher the *c*, the higher the tendency for population decline and vulnerability to extirpation (Lykke et al. 2025). A log-linear analysis was performed to test the adequacy of the observed structure to the Weibull distribution. The hypothesis of adequacy between both distributions is accepted if the probability value of the test is higher than 0.05. All statistical analyses were performed in R (R Core Team, 2022).

# Results

**Influence of land use type on diversity and composition of woody species associated with S. birrea stands**

A total of 99 woody species belonging to 66 genera and 28 families were recorded across the four study sites (Appendix A). The represented families were Fabaceae (29%), Combretaceae (15%), Malvaceae (7%), Rubiaceae (6%), and Anacardiaceae (5%). Forest areas had the highest species richness with 84 species, followed by fallow areas with 80 species, and fields with 58 species (Fig. 4).

Hill's diversity indices revealed significant differences among land-use types for N0, N1, and N2, but not for evenness (Table 1).

Table 1
Diversity indices of *S. birrea* stand according to and land use

| **Parameters** | **Field** | **Fallow** | **Forest** | **Fisher statistic** | **Pr(> F)** |
|---|---|---|---|---|---|
| N0 (Richness) | 18.1 ± 4.96c | 24.1 ± 11.3b | 27.6 ± 7.76a | 4.63 | 0.0122 ** |
| N1 ($Exp.^{H}$) | 11.0 ± 3.23b | 14.3 ± 7.53a | 15.0 ± 4.31a | 2.10 | 0.0135** |
| N2 (1/D) | 1.10 ± 0.06b | 1.18 ± 0.08a | 1.90 ± 0.04a | 2.56 | 0.038* |
| Evenness (E) | 0.80 ± 0.05a | 0.81 ± 0.07a | 0.821 ± 0.04a | 0.67 | $0.516^{ns}$ |

Legend: a, b, c = Tukey-HPT: levels with different letters are significantly different, *** P < 0.001, ** P < 0.01, * P < 0.05; ns = non-significant; F = Statistic of Fisher.

NMDS ordination showed a forest-fallow-field gradient (Fig. 5). *Sclerocarya birrea* had an IVI in fields (146.0), fallows (127.3), and forest (123.4) (Table 2). Other dominant species included *Combretum micranthum*, *Combretum glutinosum*, and *Guiera senegalensis*, especially in forest and fallow. *Senegalia gourmaensis* was mainly found in forest, while *Vitellaria paradoxa* dominated field and fallow but was less common in forest.

Table 2
Variation in *S. birrea* stands composition according to land use types

| Species | Importance value Index | | |
|---|---|---|---|
| | Fallow | Field | Forest |
| *Balanites aegytiaca* | 74.0 | 71.5 | 81.7 |
| *Combretum adenogonium* | 56.0 | 14.2 | 55.7 |
| *Combretum glutinosum* | 76.8 | 74.9 | 66.1 |
| *Combretum micranthum* | 104.3 | 44.7 | 110.5 |
| *Combretum nigricans* | 60.6 | 72.8 | 76.8 |
| *Dichrostachys cinera* | 34.6 | 42.2 | 49.1 |
| *Entada africana* | 34.1 | 34.3 | 68.5 |
| *Feretia apodanthera* | 49.1 | 13.7 | 66.3 |
| *Gardenia ternifolia* | 20.5 | - | 55.2 |
| *Grewia bicolor* | 48.8 | 7.1 | 55.9 |
| *Grewia flavescens* | 13.5 | 37.2 | 62.7 |
| *Grewia mollis* | 78.6 | 27.9 | 70.4 |
| *Guiera senegalensis* | 87.2 | 51.8 | 61.6 |
| *Lannea acida* | 76.4 | 47.6 | 68.5 |
| *Lannea microcarpa* | 76.9 | 78.4 | 54.8 |
| *Sclerocarya birrea* | 127.3 | 146.0 | 123.4 |
| *Senegalia gourmaensis* | - | - | 56.1 |
| *Senegalia macrostachya* | 78.1 | 51.0 | 95.7 |
| *Vitellaria paradoxa* | 6.2 | 56.8 | 48.9 |

**Structural parameters of S. birrea among land use types**

Adult tree density was twice as high in forest compared to fallow and quadrupled as high compared to field (Table 3). Conversely, field had the highest basal area, mean diameter and Lorey's mean height compared to fallow and forest. Furthermore, G, Dg and HL did not differ significantly between forest and fallow (Fig. 6). In terms of natural regeneration, seedling was higher abundant in field compared to fallow and forest, whereas sucker and coppices densities showed no significant variation (Table 3).

Table 3
Natural regeneration of *S. birrea* in different land use type.

| Regeneration | Field | Fallows | Forest | F | Pr(> F) |
|---|---|---|---|---|---|
| Seedlings | 311.7 ± 42.9 | 40.3 ± 75.5 | 88.6 ± 89.6 | 3.146 | 0.0459 * |
| Suckers | 1.3 ± 12.9 | 13.6 ± 58.6 | 4.6 ± 22.4 | 1.461 | $0.235^{ns}$ |
| Coppices | 7.3 ± 51.1 | 2.6 ± 33.0 | 5.3 ± 37.0 | 0.583 | $0.559^{ns}$ |
| * Significantly different values Confidence intervalle 95%, ns = non-significant, F = Fischer statistic | | | | | |

**Size classes distribution and population structure of S. birrea across land use types**

DBH size classes distribution showed a bell-shaped curve in fields indicating low regeneration potential, with low abundance of individuals in the smallest diameter size, and a high individual ranging from 25 to 40 cm (Fig. 7a). In contrast, fallows and forests showed reverse J-shaped distributions, characteristic of stable populations, though dominated by intermediate diameters (10–25 cm), reflecting moderate but insufficient regeneration. Slope and $r^2$ values confirm the absence of small individuals in fields and a steady population trend in fallows and forests (Table 4). Regarding the height classes structure, seedlings were dominant across all land use types, especially in fields followed by forests (Fig. 7b). Coppices and suckers were rare and uneven, with suckers slightly more frequent in fallows.

Table 4
Linear regression models illustrating the demographic trend of the *S. birrea* by land use type

| Land use type | Equations | $r^2$ | p-value |
|---|---|---|---|
| Field | Y = 0.3683x + 1.9609 | 0.24 | 0.15 |
| Fallow | Y = -1.0548x + 0.2405 | 0.96 | 0.031 |
| Forest | Y = -0.3929x + 4.2792 | 0.77 | 0.002 |

# Discussion

This study assessed the ecological impact of land use type on the woody's diversity, regeneration pattern and population structure of *S. birrea* stands. Results indicated that land use type affect composition and diversity of *S. birrea* across land use. Higher abundance of adults in the protected areas than in field and fallow where the biggest individuals were found. Higher abundance of seedling was recorded in field than both fallow and forest, whereas suckers and coppices showed similar densities across all land use. There was a marked difference in the population structure of the species according to land use.

**Influence of land use on diversity and composition of woody species associated with S. birrea stands**

The woody species associated with *S. birrea* show high diversity, with 99 species recorded across study sites, representing about 19% of Burkina Faso's vascular flora (Thiombiano et al. 2012). This richness aligns with previous studies in similar savanna zones (Balima et al. 2020; Taonda et al. 2024). Dominant families include Fabaceae, Combretaceae, Malvaceae, and Anacardiaceae, all typical of dry tropical savannas (Zerbo et al. 2023, 2024). These families are adapted to harsh climates and frequent disturbances. *S. birrea* tends to associate with stress-tolerant species, contributing to system resilience. Hill diversity indices confirm its coexistence with ecologically compatible taxa (Pennington et al. 2018). The species' broad ecological tolerance supports its persistence in degraded or managed areas. Land use strongly influences species composition. Forests and fallows had higher IVI and diversity values than fields, suggesting better ecological conditions and lower disturbance levels. NMDS ordination revealed a forest-fallow-field gradient in species composition indicating that field showed low richness and altered population structures due to intensive land use. Farmers select trees based on utility, often preserving *Vitellaria paradoxa* and removing less useful species (Djossa et al. 2008; Aleza et al. 2015). Key species like *Combretum micranthum*, *Guiera senegalensis*, and *Vitellaria paradoxa* co-occur with *S. birrea*, indicating ecological compatibility and reflecting field management. *Senegalia gourmaensis* was restricted to forests, while *V. paradoxa* dominated field and fallow. Forest and fallow harbored more native species and lower human impact, supporting functional ecosystems. Despite illegal logging, protected areas remain among the most diverse savannas in West Africa (Traoré et al. 2020; Zon et al. 2022). Across land uses, Fabaceae and Combretaceae remained dominant, showing adaptation to disturbance. These findings highlight the need to integrate biodiversity conservation into land-use planning, particularly in agricultural landscapes.

**Structural parameters of S. birrea among land use types**

The study revealed a significant difference in tree density among land use types, for both adults and juveniles, with a higher abundance in forest, followed by fallow, and tend to be critically reduced in field. Similar patterns were observed in Benin, where adult density dropped ninefold from protected areas to agroforestry systems due to human activities (Gouwakinnou et al. 2009). Despite this trend, our study recorded higher densities of *S. birrea* than several previous studies (Shackleton et al. 2003; Nghitoolwa et al. 2003; Agbogan et al. 2015; Abdourahmane et al. 2017). For instance, Shackleton et al. (2003) reported 4.2 stems/ha in fields and 13.4 stems/ha in protected areas in South Africa, while Nghitoolwa et al. (2003) found only 1.5 stems/ha in Namibian farms. Agbogan et al. (2015) noted variable densities across topographies: 39 stems/ha on low plateaus, 2 on plains, 9 on foothills, and 3 on hills. Larger individuals in fields may result from lower interspecific competition and disturbance. Positive community attitudes towards *S. birrea* management, as seen in South Africa (Sinthumule and Mzamani 2019), also prevail in Burkina Faso, explaining the higher abundance of the species. This appreciation is linked to its socio-economic importance and market value, enhancing rural livelihoods. *S. birrea* pulp is mostly use by children and women who pick up mature fallen fruits for processing to local juice and seed extraction for pit (Moussa et al. 2002). Seedling, coppices and suckers occur as patterns of natural regeneration of the *S. birrea* across land use. Similar observation was reported for *Senegalia macrostachya* and *Saba senegalensis* across the same land use types (Kabre et al. 2020; Ouedraogo et al. 2025). These results prove that *S. birrea* has a good natural regeneration potential that can be promoted for sustainable management and conservation of the species in agroforestry systems. However, higher seedling abundance in field compared to fallow and forest, result from farming practices that bury fallen fruits, enhancing seed germination, as previously observed by Gouwakinnou et al. (2009). In contrast, higher abundance of coppices suggesting that *S. birrea* individuals are facing anthropogenic threat, and good management challenges in field and fallow due to tree cutting. This required specific attention by raising famer's awareness to integrate natural assisted regeneration practices of the species, such it is done for most multipurpose species like *Tamarindus indica*, *Vitellaria paradoxa* and *Parkia biglobosa* (Fandohan et al. 2010; Byakagaba et al. 2011; Lokonon et al. 2022). In contrast, the densities of suckers and coppices did not show significant variation among land-use types, suggesting that vegetative regeneration is less influenced by land use and more dependent on micro-site conditions or the physiological state of individual trees. These patterns indicate that while agricultural fields may favor sexual regeneration through seeds, vegetative regeneration remains stable across landscapes, underlining the resilience of *S. birrea* and the need for land-use sensitive conservation strategies. Furthermore, *S. birrea* is found in all climatic zones in Burkina Faso and can be promoted as an agroforestry species to improve yield and diversify production systems.

**Size classes distribution and population structure of S. birrea across land use types**

The bell-shaped DBH distribution in field, characterized by a scarcity of small-diameter individuals and dominance of larger size classes trees, suggests a senescing population with limited regeneration. This may result from a selective preservation of mature trees and total fruit harvesting by farmers causing poor regeneration conditions. According to Nightoolwa et al. (2003), farmers likely preserved trees with ≤ 40 cm Dbh in fields for fruit yield. Agricultural land clearing, grazing and/or harvesting of fodder, medicinal products providence, and absence of protection measures led to the unstable structure. In contrast, the reverse J-shaped curves observed in fallow and forest indicate of more stable populations, although the dominance of intermediate diameter classes (10–25 cm) points to regeneration constraints, possibly due to competition, grazing, or fire. The presence of trees in 5 to 10 cm class is influenced by age of the fallow (at a mean of 7 years), and to the good monitoring of the forest concerned in this study. This supports the assertion that protected areas are more effective in conserving woody species (Houehanou et al. 2013) and highlights the role of fallows in restoring soil fertility and biodiversity (Kaboré et al. 2012). Height class analysis showed an overall predominance of seedlings, particularly in field, which may reflect favorable germination conditions, although seedling survival and growth into larger classes appear limited. Similar result was reported by Abdourhamane et al. (2017) for the same species. According the above authors, *S. birrea* has bulk germination in field during cultivating period, but famers destroyed most of seedlings which limited the recruitment in juvenile stage in field. Coppices and suckers were rare and unevenly distributed across land uses, indicating that vegetative regeneration plays a minor role in *S. birrea* population renewal. It is therefore important to develop simple and effective techniques to enhance seed germination, making it easier to produce vigorous seedlings in nurseries. These seedlings can then be used for reforestation efforts, supporting the integration of *S. birrea* into agroforestry systems and the restoration of degraded lands.

# Conclusion

This study showed that land use type influences both regeneration and population structure of *S. birrea*. The population structure is well conserved in fallow and forest, but unstable in fields. The absence of good management practices, such as seedling protection, compromises long-term resource availability. Fields under cultivation showed low tree densities and larger individuals in diameter, height, and basal area. This reflects the species' importance for local people. However, *S. birrea* faces over-exploitation and poor management. Nursery production could help farmers interested in planting. Natural-assisted regeneration is also needed to conserve saplings in fields. Plantations are recommended for both protected and degraded areas to enhance ecosystem functions and services for *S. birrea*.

# Declarations


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**Credit authorship contribution:**

**Satassa Hien**: Writing- original draft, Visualization, Software, Methodology, Investigation, Formal analysis, Data curation and Conceptualization. **Lassina Traore**: Writing- Original draft, Validation, Software, Methodology, Data curation, Conceptualization, Review and editing draft. **Abdoul Aziz Kabore**: Writing- original draft, Validation, Software, Methodology, Data curation, Conceptualization and draft editing, **Yaya Maiga**: Vizualization, **Anne Mette Lykke**: Visualization, Methodology, Formal analysis and conceptualization. Formal analysis, Data curation, Writing-review and editing, **Kuilpoko Marie Laure Guissou**: Writing review and editing, Visualization, Validation, Supervision, Funding acquisition, Supervision and Project administration.


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**Competing interests**

This article is an original research and the authors declare that they have known competing financial interest or personal relationships that could have appeared to influence this work.

**Data availability**

Data will be made available on request.

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# Figures

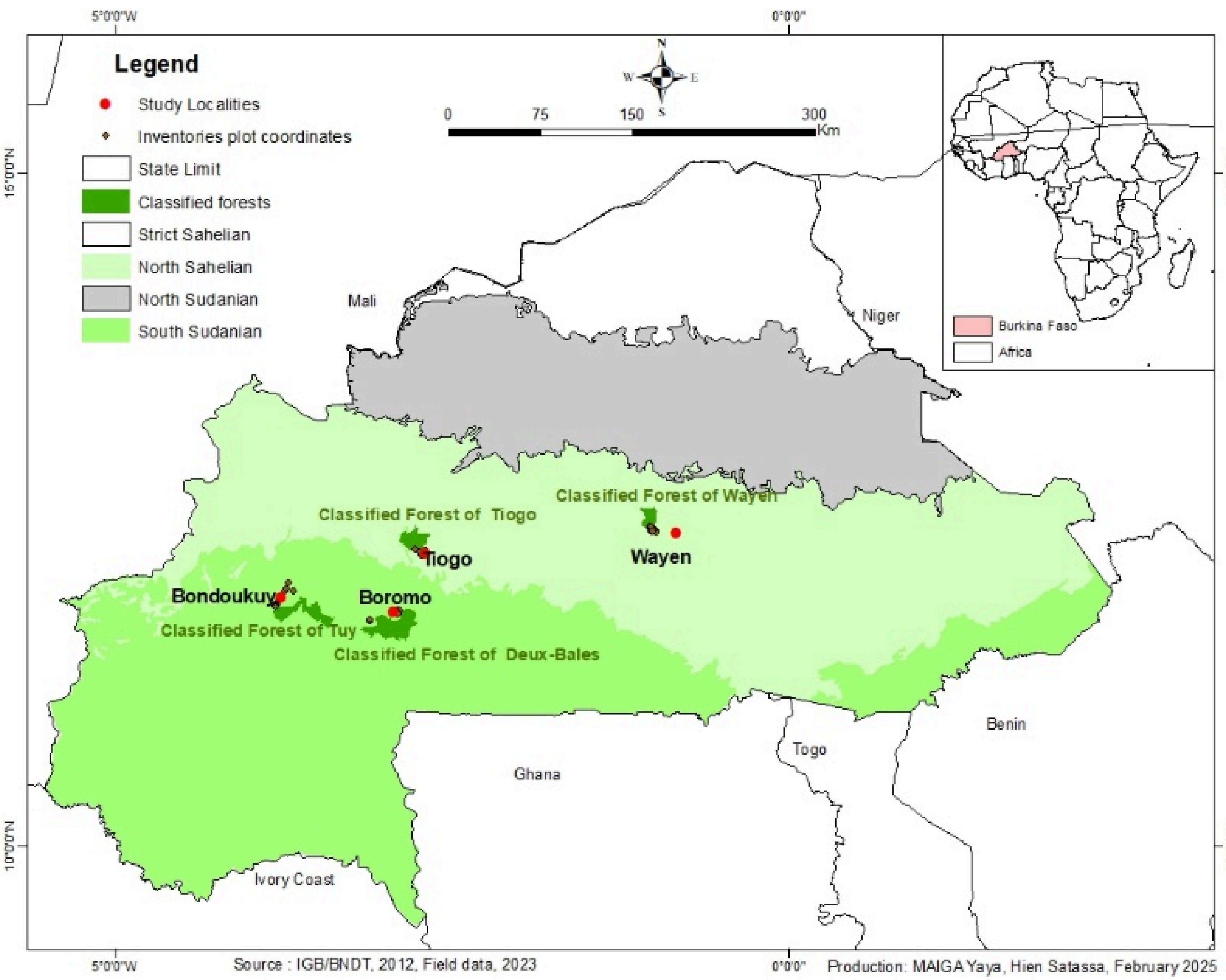



**Figure 1**

Location of study sites.


**Figure 2**

Land use type: (a) field showing Zea mays associated with S. birrea and V. paradoxa trees, (b) fallow showing S.birrea stands in Bondoukuy, (c) Tiogo classified forest, Burkina Faso.

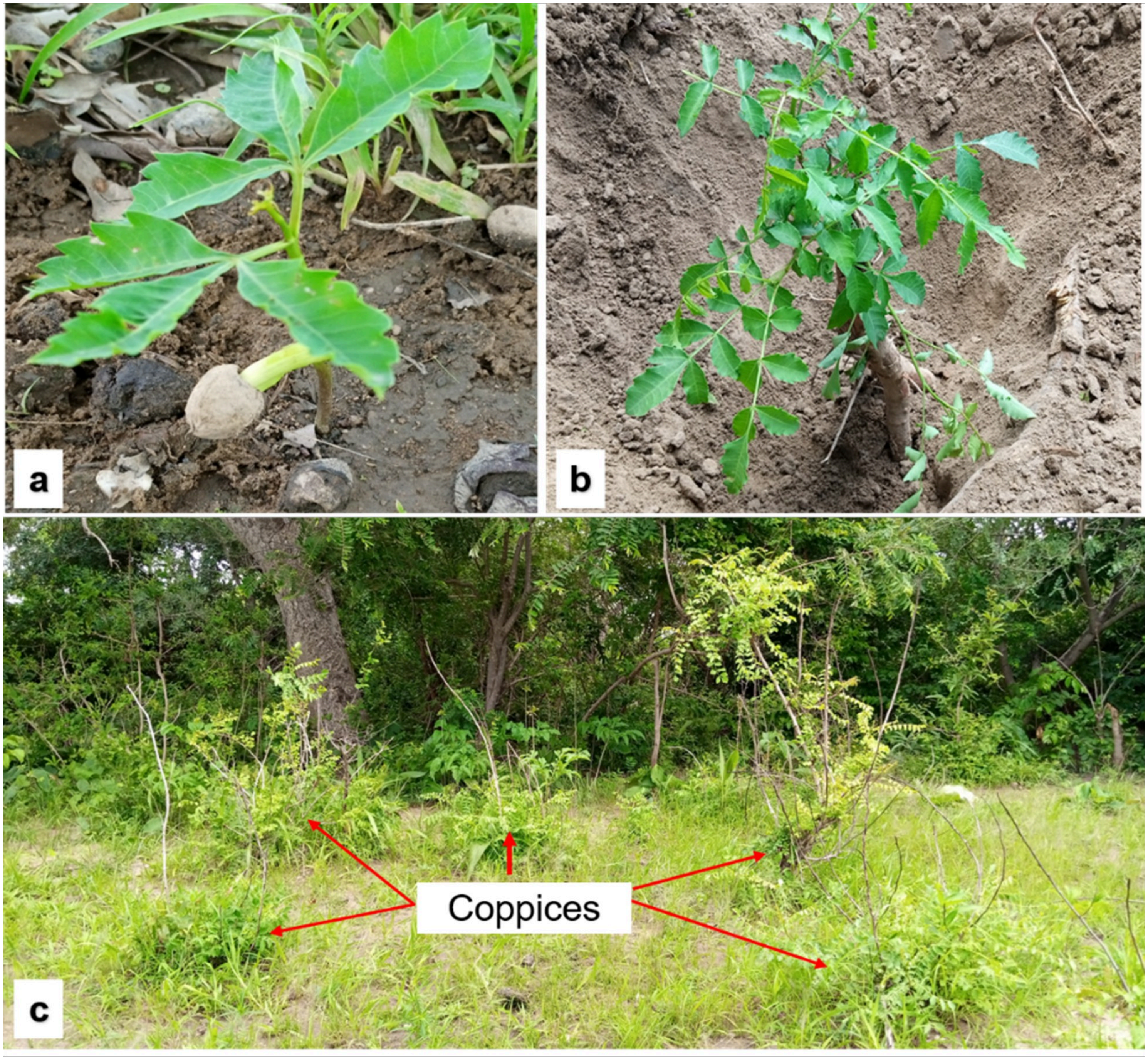



**Figure 3**

Regeneration patterns of S. birrea: seedling(a), suckering(b) coppices (c, d) under the different land use

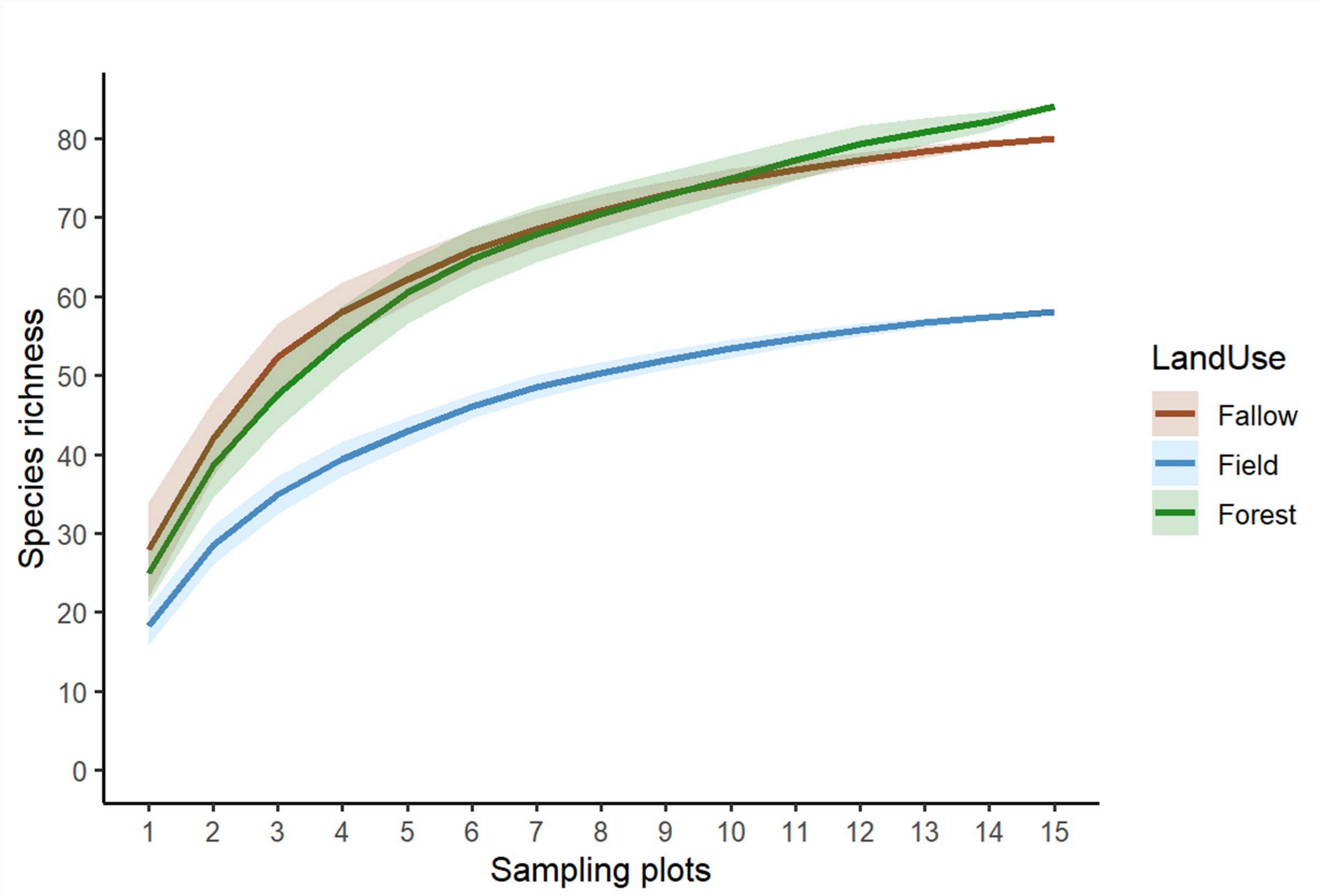



**Figure 4**

Species richness of S. birrea stands among land use types.

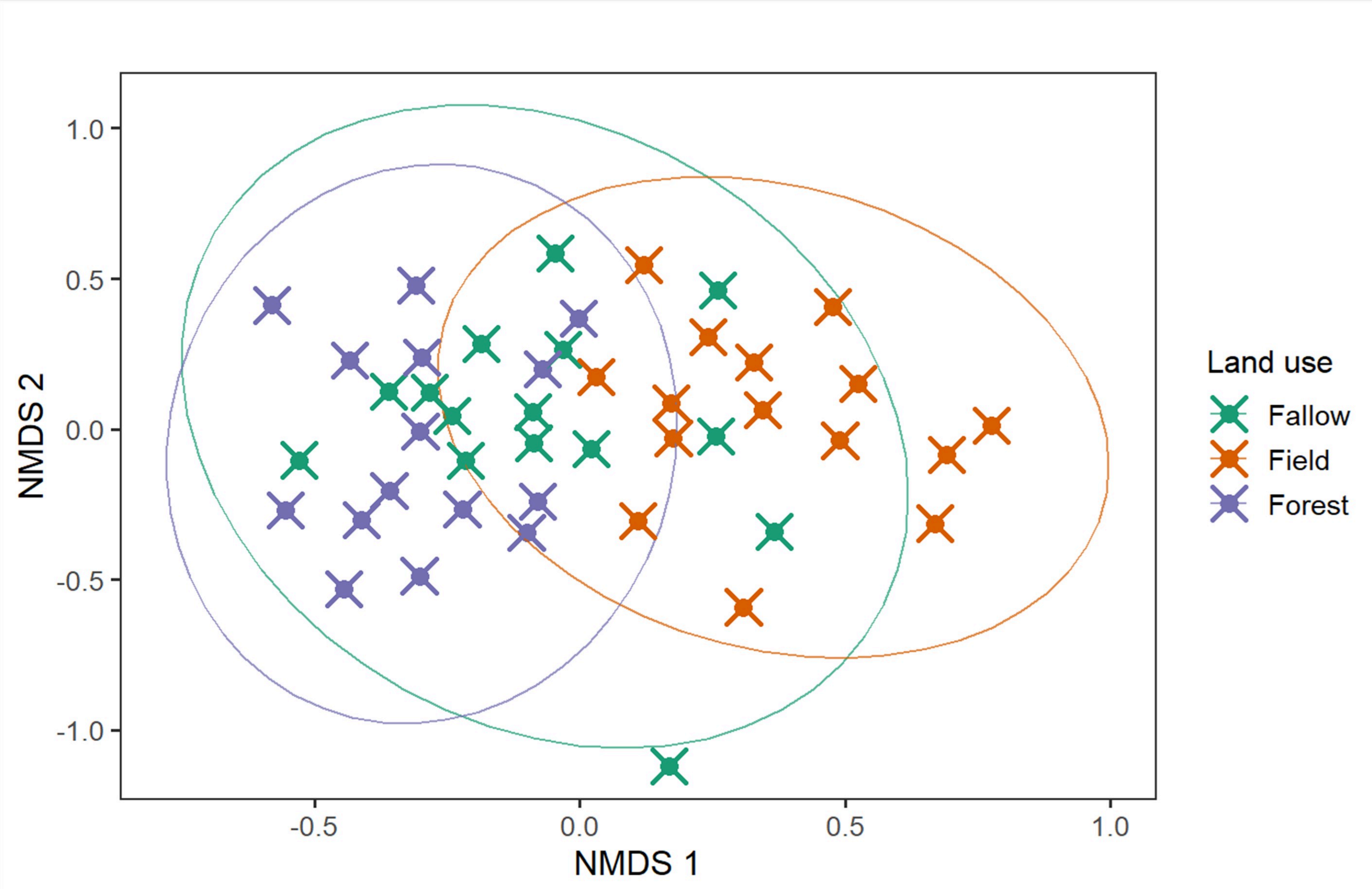
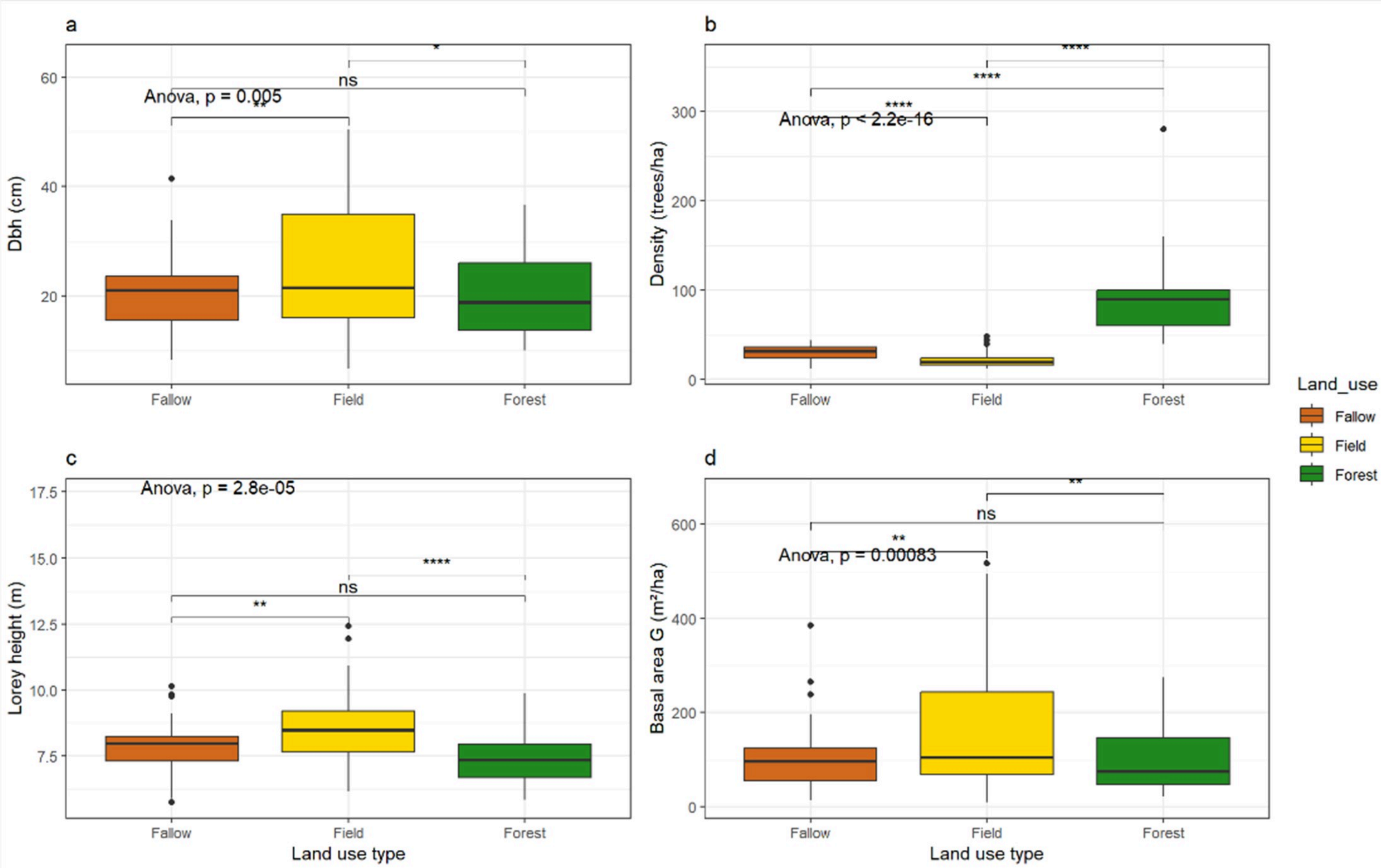



**Figure 5**

Similarity and co-occurrence of S. birrea stands according to land use types




## Figure 6

Difference of S. birrea structural parameters between land use types.

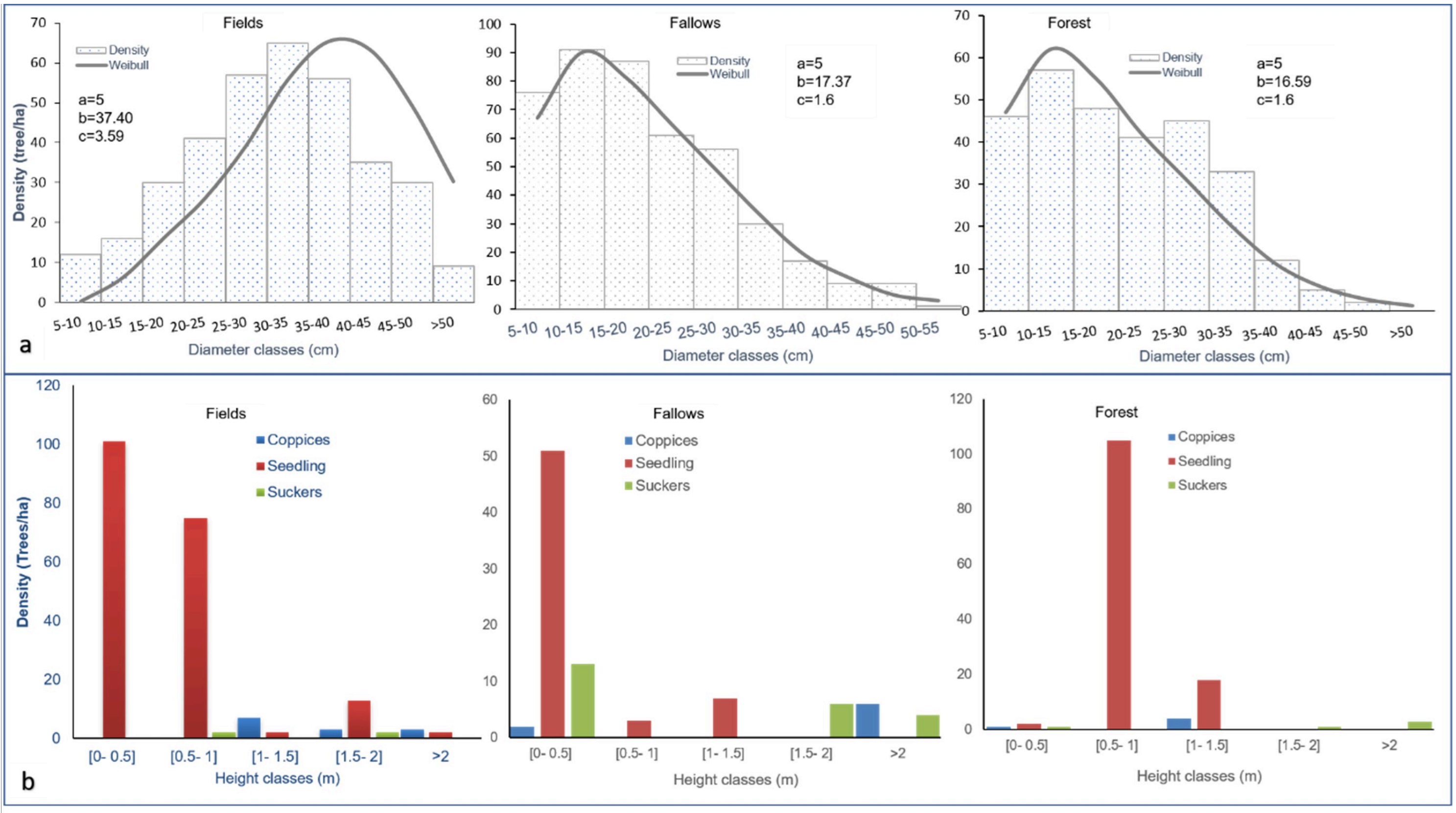



**Figure 7**

Size classes structure of S. birrea in each land use type with Weibull distribution added (black line)

# Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- AppendixListofwoodyspeciesacrosslandusetypesinthestudysites.docx