Chapter

Contextualizing the Factors Affecting Species Diversity and Composition in the African Savanna

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Abstract

Recently, sustainable forest management has been the top priority for many international forest conservation organizations, governing authorities, and interest groups. Forest conversion to farmland for fuel wood removal, charcoal production, and woodland grazing is the principal mechanism of forest degradation, habitat change, and loss of biodiversity. Despite the increasing acknowledgment of conservation values of savanna, our understanding of the factors affecting species diversity and composition for the African savanna remains limited. This chapter provides a systematic review of the factors affecting species diversity and composition in an African savanna. However, in order to reduce this inadequacy, a careful examination of the existing literature was conducted. After a thorough review, it was revealed that species diversity and composition in savanna are significantly shaped by grazing, fire, and resource availability, that is, rainfall and soil nutrients, as well as anthropogenic activities. Understanding the diversity and composition of tree species is vital since they provide resources and habitats for several other species. Botanical assessments, such as floristic composition, species diversity, and structural analysis studies, are significant for providing accurate information on species richness, which is valuable for sustainable forest management and helps to understand forest ecology and ecosystem functions.

Keywords: floristic composition, drivers, species richness, species diversity, savanna ecosystem

1. Introduction

Africa houses the largest area of savanna, covering about 65% of the continent [1]. However, the natural savanna ecosystems in Africa are undergoing a serious transformation, which is due to the conversion of land parcels into wide-ranging livestock production foraging arenas, slash and burn for the production of crops, and creation of municipal cities [2–4]. Despite these changes having enormous impacts on the capability of the ecological system to exchange and store carbon [4, 5] as well as on species diversity and composition, the factors affecting the species diversity and composition are still poorly understood. Furthermore, poor grazing management, linked with livestock overstocking, results in extreme treading, which has a detrimental impact on the vegetation [6–8]. This also leads to an increase in the bulk density of the soil and reduces its water permeation [8, 9]. Hence, it results in alterations in the composition of the plant species, reducing the rates of photosynthetic activities in the leaf and reducing the storage of the carbon stock in the ecosystem [7, 10].

On the contrary, the aboveground biomass may be stimulated by light grazing via increased cultivation of grasses [8, 11, 12]. Indeed, increased germination of young shoots from the cultivators leads to a better and improved generation of fresh energetically photosynthesizing green vegetation. This ultimately, when combined with reduced accrual of dead biomass, leads to an improvement in the penetration of light into the canopy and intensifies the uptake of carbon dioxide and storage of carbon by the grasslands [10, 12].

Moreover, degradation of habitats, excessive utilization, harmful non-native species, contamination, and alteration in the climate have affected and still impact the biosphere's ecological systems [13, 14]. Sixty percent (60%) of the globe's ecosystems are estimated by Refs. [15, 16] to be utilized in an unsustainable way. Seventy-five percent (75%) of the stocks of fish resources are being used excessively, which may lead to their depletion. Moreover, about 13 million hectares of tropical forest ecosystems are cleared annually [15, 16], significantly affecting the biotic diversity and composition, especially in African savannas.

The rate at which the loss of biological diversity proceeds if continues, we may face a mass extinction [13]. The decline in biological diversity represents a planet's irreversible loss. It poses a serious menace to the life support system of humanity, and some authors describe it as the amenities that are delivered by natural systems representing the entirety from the food we consume to the air we breathe (e.g., [17–19]). This chapter, therefore, contextualizes the factors affecting species diversity and composition in an African savanna. Understanding these factors will provide policymakers with a strong basis for planning and managing the forest ecosystems in an African savanna.

1.1 Concepts of species diversity and composition & ecosystem functioning

The term "biodiversity" was first used in its long version (biological diversity) by Ref, [20] and is most commonly used to describe the number of species. It came into effect in the mid-1980s, prefigured by a convention in 1986, followed by the book called biodiversity [21]. These proceedings, in most cases, are construed as the inauguration of the story of biodiversity.

Faith [22] defines biodiversity as a variation in living things, from genetically modified characters to species and, ultimately, ecological systems. The term "biodiversity" energized some essential concepts formulated over the preceding decade. Moreover, the concept of the variation in living things itself has current value since it avails the chance for humanity to benefit. The International Union for the Conservation of Nature [23], summed up these initial concepts about diversity as affording both "insurance" as well as "investment" benefits. The convention on biological diversity (CBD) and intergovernmental platform on biodiversity and ecosystem services (IPBES) echoed the focus on biodiversity. The IPBES conceptual framework describes nature's contribution to humanity [24], which encompassed maintaining future generations' choices availed by biotic diversity as variety. This significance of diversity in living things supplements the recognized worthiness of singular species and solidifies the concept that biotic diversity may denote a singular assemblage of species (or other units) and the quantity of disparity as a property of that assemblage.

The other prominent concept with regard to species diversity, composition, and ecosystem functioning is that modern energy and water have a direct influence on the richness of plant species. This is due to the fact that they control the primary productivity of an ecosystem, which helps in the formation of the food chain and drives other indirect effects (i.e., primary productivity hypothesis) and also by the degree to which an organism can tolerate one or more environmental factors that control the distribution of species (i.e., physiological tolerance hypothesis) [25–28].

Therefore, the theory of the connection of water and energy dynamics postulates that there is an impact of the environment on the distribution of abiotic resources (e.g., water, temperature, and ultraviolet-B (UV-B)) among various species and that this is what principally controls regional biological diversity patterns [29]. Its basic view is that water and energy control the extensive species diversity patterns [30, 31].

Global climate variations could also impact the allocation of species, composition of communities, and structure of an ecosystem [32–34]. Global climate change is not anymore a debatable matter, though various scientists may disagree on the precise forecasts from several models [35], and coming up with viable solutions to the connections between vegetation and climate dynamics is an exceptionally precarious issue of current research [36, 37]. Ref. [38] predicts a rise in the average temperature of between 0.3 and 4.5°C by the end of the twenty-first century, with the Arctic having experienced speedy warming over the current decades.

1.2 The distribution of the African savannas

Worldwide, savanna is the second largest biome, covering about 33 million km^2 or nearly 20% of the earth's land surface [39–41]. Africa inhabits the largest savanna, which occupies about half of the continent with approximately 15.1 million km^2 [42]. Besides, Ref. [1] note Africa to encompass undoubtedly the largest area of savanna, covering 65% of the African content. Tropical savannas are found in the move between the deserts and the tropical rainforests, where there is limited rainfall to support the forest.

Savanna ecosystems predominantly are comprised of a combination of open grasslands, closed coppices with closed thickets consisting of trees and shrubs, which have broad leaves and woodlands that have dispersed trees [43]. This according to Ref. [44] can have implications on human livelihood globally in an even to any alteration to the ecosystem.

The western central rainforest is surrounded by tropical savannas. To the north and south, it is surrounded by deserts. For African savannas, systematic numerical classifications based on climate and physiognomy have been used. The bioclimatic categorization separates four physiognomies of savanna (**Table 1**) [46] cited in [45]).

Despite it being challenging to describe the confines of the African savanna accurately, Okigbo (1985) estimates that it occupies over 12 million km^2 and covers approximately 60% of tropical Africa. It encompasses all or parts of closely all the 45 countries of tropical Africa (**Figure 1**).

Bioclimatic zone	Equivalent ecological region		Annual rainfall average (mm)	Growing season length (days)
	West Africa	**Eastern and southern Africa**		
Arid savanna	Southern Sahelian	Acacia woodland	300–600	60–90
Subarid savanna	Sudanian	Southern miombo woodland	600–900	90–140
Subhumid savanna	Northern Guinean	Northern miombo woodland	900–1200	140–190
Humid savanna	Southern Guinean	Derived savanna	1200–1500	190–230

Note: adapted from Ref. [45].

Table 1.
Bioclimatic zones of the African savanna.

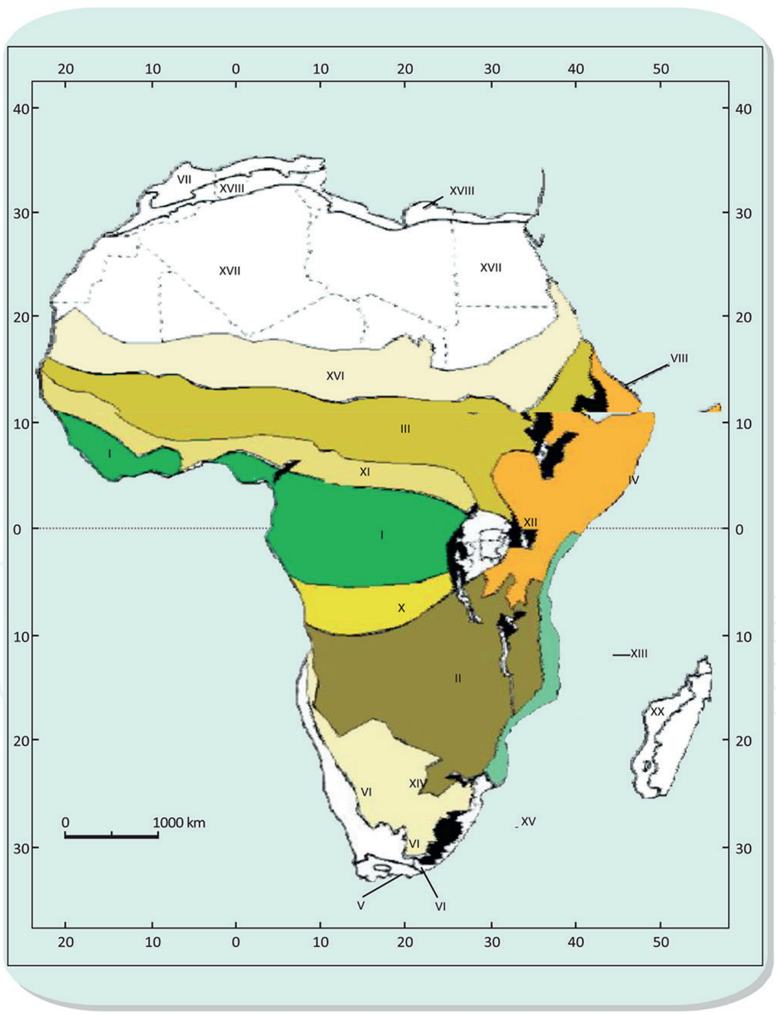

Figure 1.
The distribution of African savannas (in color) around the Congo Basin with tropical moist forests, in dark green. (adapted from White, 1983; Geldenhuys and Golding, 2008). The symbols indicate the following vegetation units (phytochoria): I = Guineo-Congolian regional centre of endemism (RCE); II = Zambezian RCE; III = Sudanian RCE; IV = Somalia-Masai RCE; X = Guinea-Congolia/Zambezian regional transition zone (RTZ); XIO = Guinea-Congolia/Sudanian RTZ; XII = Lake Victoria regional mosaic (RM); XIII = Zanzivar-Inhambane RM; XIV = Kalahari-highveld transtion zone; XVI = Sahel RTZ (adapted from Geldenhuys & Golding, 2008).

1.2.1 Arid savanna zone

The arid savanna zone includes a large portion of central Mali, northern Burkina Faso, southern Niger, northeast Nigeria, Chad, Sudan, and Ethiopia. It also includes a large portion of northern Senegal from Dakar to south of the Senegal river. This region reaches southern Ethiopia, central Tanzania, and Somalia via a thin strip that passes into Kenya. Along with eastern Zambia and southwest Angola, it is also common in southern Mozambique, Zimbabwe, and eastern and northern Botswana. The predominant plant species in this region include *Acacia* spp., including *Acacia* Senegal (gum Arabic), *Acacia vaddiana*, *Leptadenia pyrotechnica*, *Salvadora* spp., *Grewia* spp., and *Acacia seyal* in low places susceptible to flooding, as well as Sahelian grasses, such *Aristida* and *Chloris* spp.

This zone is characterized by low rainfall (300–600 mm/year), a brief rainy season (2–3 months), and frequent droughts. The leguminous Faidherbia albida trees, which shed their leaves in the wet season and manure the soil to provide feed for cattle in the dry season, have historically been preserved by the Serer people of Senegal.

Additionally, significant in eastern Africa are *Commiphora* species. Nearly every tree in the Sahel seems to have a purpose, whether it is for fruit (*Balanites aegyptiiaca*, *Phoenix dactylifera*), fodder (Acacia spp.), or both (Okigbo, 1986). During the protracted dry season, when grazing is scarce, a large number of trees and bushes are severely pruned for food and subsistence.

Dune sands are common in this area, especially in West Africa, and it has historically been subject to wind erosion to a large extent. However, other soils with marginally higher productivity are also present. Although there is little or inconsistent rainfall, this region is crucial for agriculture. A sizeable portion of it is cultivated in West Africa, where pearl millet is mostly grown along with big herds of domestic cattle. As a result, the long rainy season in the northern half of the zone fits the early mature types, known as Souna in Senegal (Bilquez, 1975).

1.2.2 Subarid savanna zone

From Dakar, the subarid savanna zone extends through the majority of northern Nigeria, central Chad, southern Burkina Faso, central Mali, and southern Burkina Faso. In Sudan, it broadens to encompass a sizable portion of the central rain lands as well as a few blue Nile irrigation projects. The region includes a significant portion of the Rift Valley in the south of Addis Ababa in Ethiopia, the Karamoja district in northeastern Uganda, a small portion of the Rift Valley in Kenya to the east of Nairobi, and a portion of central Tanzania. This region also includes the majority of western Zimbabwe, southern Zambia, and southern Angola.

Although alfisols are the most common upland soils in this region, there is significant regional diversity, including dune sands in some regions of West Africa, vertisols around lake Chad and in Ethiopia, Somalia, and Sudan, and oxisols and entisols in southern Africa. F. albida and Hyphaene thebiaca are indicator species, and mixed combretaceous and acacia tree savanna make up the majority of the vegetation in this zone. These species are protected and used as browse, together with Parkia spp. Mango trees are grown in areas with shallow groundwater. Cenchrus ciliaris, Cenchrus biflorus, Eragrostis tremula, and Pennisetum pedicillatum are examples of grasses (Okigbo, 1986).

With significant populations concentrated throughout most of both western and eastern Africa, this region is crucial for agriculture. An essential component of Africa's primary belt for producing cereals is the subarid savanna region.

1.2.3 Subhumid savanna zone

Another significant agricultural region in the African savanna is the subhumid zone, which has the greatest potential for the production of annual crops, particularly cereals.

It stretches from southern Senegal, Gambia, and Guineas through southern Mali and Burkina Faso, northern Cote d'Ivore, Ghana, Togo, Benin, central Nigeria, Chad, and the Central African Republic, before entering southern Sudan, the majority of Uganda, and western Kenya.

There are also significant portions of Tanzania, Mozambique, northern Zambia, southern Zaire, and Angola.

The soils in a large portion of this zone are classified as alfisols, despite the fact that the soil associations in this zone are complex and there are numerous diverse catenary sequences, similar to the subarid zone. However, there are sizable areas of ultisols in Guinea and Uganda and oxisols in Angola, the Central African Republic, and Zaire. Isoberlinia spp., Burkea Africana, and Afzekia Africana are prevalent in West Africa, while in the miombo woodlands, Brachystegia spp. and Julbernardia spp. define the natural vegetation in this zone. Parkia clappertoniana and Butyrospermum spp., sometimes known as the shea butter but, which is a popular source of fat and oil, are protected species. Milicia (previously Chlorophora) excels and Entandrophragma spp. are examples of timber trees. Andropogon gayanus, Hyparrhenia spp., and Pennisetum spp. are examples of tall grasses (Okigbo, 1986).

1.2.4 Humid savanna zone

The humid savanna zone, which begins in West Africa, includes Guinea Bissau, most of Guinea, a portion of southern Mali, Cote d'Ivoire, Ghana, Togo, Benin, a sizable portion of central Nigeria, Cameroon, the majority of the Central African Republic, a small portion of southwest Sudan, the majority of Uganda, the Kenyan highlands, the majority of Rwanda, Burundi, a portion of western and southeastern Tanzania. Although the soils of this region are diverse, a significant portion of the West African coast, as well as Burundi, Rwanda, Uganda, and some areas of Zaire, are classified as utisols. Other large areas are classified as alfsols in much of Benin, Cote d'Ivoire, Ghana, Nigeria, Tanzania, and Togo, and oxisols in Cameroon, Central African Republic, and Zaire.

The majority of the zone's natural climax vegetation would be light forest, with some open woodland in the drier regions and on the less fertile soils, but due to human activity, the majority of the forest has been transformed into derived savanna. This is a transition zone between savanna and forest, and between a unimodal rainfall distribution in roughly 190–200 days in the savanna part and a bimodal distribution in two rainy seasons, each lasting 2–4 months and adding up to 210–230 days in the area derived from the forest.

Some areas of the zone, especially those with light or shallow soils, can occasionally make it difficult to plant annual crops because, even if it is sometimes possible to grow two crops per year, there may not be enough rain in season to result in an ideal crop. The humid savanna is well adapted to a variety of crops, both annual and perennial because it is a transition zone between unimodal and bimodal rainfall distribution, as well as between savanna and forest.

2. Floristic composition in the African savanna

2.1 Factors driving the structure of the African savanna vegetation

The vegetation structure is coined as a three-dimensional distribution of plant biomass. The structure typically denotes perpendicular distribution despite having a flat configuration. More significantly, the species composition and fluctuations in temporal scales can be used to characterize the vegetation structure. According to Ref. [47] factors, including geologic substrate, terrain, human activity, fire, and large herbivores, particularly elephants, all influence the woody vegetative structure of savanna ecosystems.

Plant species' adaptations to the environment include both biotic and abiotic elements, resulting in the structure of the vegetation [48]. The vegetation structure studies mainly concentrate on density, canopy cover, and standing crops of various species [49]. Resource managers use the measurements derived from these factors to understand better how vegetation responds to different management approaches [49].

Several researchers (e.g., [50–52]) have investigated how woody canopy cover varies throughout African savannas in response to environmental conditions. Given that tropical savannas span roughly one-eighth of the land surface [53] and play a significant role in the global carbon cycle [54], it is critical to know how these differences in crown widths and tree densities are formed.

Vegetation structure and the composition of plant species play a trivial role in animal habitat suitability. This is due to the fact that the sensitivity of diverse animal species depends on the quantity of vegetation and bare patches in the landscape, making the condition of spatial heterogeneity a valuable indicator of the suitability of animal habitat [55]. Grass plains, tree savannas, woods, and thickets can all be distinguished by their vegetative structure. Besides, according to Ref. [56], structural vegetation differences exist within a particular habitat, like between short-grass and tall-grass plains.

Variations in the structure of savanna vegetation can be undergone seasonally due to the deciduous nature of woody plants. This may happen when the tall grasses are burnt so as to transform the area to a short-grass area or due to the impact of animals which may defoliate or trample on the vegetation [57–61]. Savanna trees are reported to have both positive and negative competition on the individual tree scale and, therefore, influence the growing grasses beneath their canopies in relation to grasses in inter-canopy areas. Hence, plant species composition in sub-canopy areas can be impacted by large trees, thereby modifying the vegetation structure of the nearby environment [62, 63].

However, this has a positive impact: rich soil nutrients and grass leave in sub-canopy areas, an increase in the availability of soil water due to the hydraulic lift, a reduction in evapotranspiration, and an increase in the productivity of grass [62]. Furthermore, animals are supplied with shade, shelter from the elements, and huge woody plants to browse. Large woody plants also provide higher sub-habitats, a higher yield of highly palatable grass species, and many more rewards [63–65].

Holdo [44] denotes key determinant variables of vegetation structure, such as fire, browsing, and grazers. These were pointed out by Ref. [44] to determine the vegetation structure across rainfall and fertility gradient. Elephants were identified as keystone browsing species. Although the current elephant population does not control the woody vegetation on its own, [44] postulate that the population density has an impact on the tree-size class distribution of woody vegetation because an increase in population density causes a shift in tree size distribution from mature to small height classes, as well as a shift in woodland to grasslands. Refs. [44, 66, 67] identified fire to have a detrimental impact on the type and structure of woody vegetation. It was also noted that grazers affect the woody vegetation by regulating the quantity of fuel suitable for fire and enhancing competition between grasses and woody plants, especially in the regeneration of nutrients and water. Besides, browsers were identified by Ref. [43] to have the greatest influence on woody species regeneration. Using *Euclea divinorum* seedlings, it was discovered that fire reduces seedling survival by 50% and browsers reduce it by 70%, with elephants having no effect.

2.2 Diversity and richness in an African savanna

African savanna ecosystems have experienced severe variations in their vegetative composition, diversity, and species richness due to the influence of human land use and changes in climate conditions. According to Ref. [68], there is a challenge in comprehending the factors affecting the variations in spatial patterns of composition, diversity, and structure of woody species.

2.3 Factors influencing species diversity and composition

Savanna ecosystems play a trivial role in the entirety of the biosphere's activities. Trees and grasses are two divergent life forms characterizing savanna ecosystems. The structure and purpose of savanna are said by Ref. [69] to be influenced by the availability of resources, such as rainfall and nutrients. This is also stated to be affected by natural and anthropogenic disturbances, such as fire and herbivory.

The supply of water is detected by rainfall through the quantity that is then consequently accessible by plants and is subjected to the drainage aspects and storage, which comprises topography, vegetation cover and losses, soil texture, and compaction as a result of evaporation and evapotranspiration. There is a high variation of rainfall in the spatial and temporal scales in the savanna ecosystem. This is exacerbated by aridity, with many places experiencing regular droughts, which according to Ref. [70], can be a chief influencer of the variations in the composition of the vegetation. Recruitment and growth of trees are preferred to grasses in years of high rainfall compared to the times experiencing droughts where growth and recruitment of trees are limited [69].

Species diversity and composition are also affected by soil nutrients. Mainly, there are limited nutrients in the soil since soils in most tropical savannas are obtained from old weathered acid crystalline igneous rock leading to leaching sandy soils with low fertility and CEC. Specifically, low nitrogen and phosphorous availability limit numerous savanna ecological systems [71]. In addition, the water in the soil also hinders the plants from accessing the nutrients because mineralization of nutrients, transport, and root uptake are all factors of soil water content.

Fire has conventionally been utilized as an instrument for managing and conserving savanna ecosystems. This is mainly because there is an exposure of the woody meristems within the flame zone (< 5 m) to the fire damage compared to the grass meristems. Besides, according to Ref. [53], grass meristems can recuperate more efficiently in the short term. Hence, the frequency of fires overpowers the recruitment of mature woody plants. It is noted that there can be interactive impacts on the savanna ecosystem structure by fire and grazing where the high grass biomass buildup is permitted by low grazing, which can impact the biomass and population of the tree by fueling intense fires. Ref. [53] denotes that woody plants are kept within the flame zone by heavy browsing; hence a combination of tree-grass is strongly affected by a strong grazer-browser fire relationship.

Fire has since time immemorial been a significant feature of the ecology in African savanna ecosystems. Fire, according to Refs. [39, 72, 73], has been used both as a selective and regulatory agent, as well as a destructive force. For instance, 25 to 50% of an area has been reported to be subjected to burning on an annual basis. Furthermore, the entire African zone has been estimated to undergo burning for about 2.5 years due to anthropogenic activities [74, 75].

Fire is noted to be vital for a lot of farmers in Africa and it is said to be a cheap hunting tool for clearing vegetation that is not wanted, maintenance of grasslands, and removal of dry vegetation and crop residues to promote the productivity of agricultural produces and permit better visibility [76, 77]. Most fires occur at the beginning of the dry spell when herbaceous biomass has dried out. Refs. [73, 78] reports fire to be known for shaping the savanna ecosystem. As a result, all savanna vegetation communities virtually display fire dependence or tolerance [79, 80].

Plant species respond differently to fire. Some are totally resilient, while the aboveground biomass of other plants may be damaged but can shoot from below-ground structures after the fire, and still, other plant species rely on the seed to recover [78]. The frequency of fire consumes the accumulated production of grass and litter in most tropical savannas, and this favors the predominant grassland vegetation to develop and be maintained by decreasing the natural regeneration of trees and shrubs [81].

Fire can also inspire growth in the flowering of plants and, consequently, the production of seeds among shrubs and herbaceous species [82]. Fire is depended upon for the germination of seeds of a variety of plant species in that it provides one or more physical cues, such as light and temperature as well as chemical cues, including smoke, gases, and nutrients [83–85].

Fire suppression on a temporal basis is regarded as being induced by human disturbance [86]. This is because some woody and herbaceous species, which are generally resilient in burnt areas, often become feeble in protected areas. Lack of fire occurrence may disturb their productiveness either by sustaining a dense layer of standing dead material that hinders young suckers or by keeping alive buds on old axes and thereby wearying the plant [87].

Savanna structure and composition are also stated by Ref. [88] to be impacted by the physical effects of defoliation and selective feeding. The viability of some woody plant populations may be compromised due to the excessive pressure emanating from heavy browsing, such as the elephant. This may result in community fluctuations coupled with species diversity and structural diversity loss. Besides, herbivory plays a trivial role in the cycling of nutrients, dispersal of seeds, and creation of microsites and space, thereby improving and increasing the recruitment of shrubs [88].

Plant species diversity in African savanna is determined by some factors, including competitive exclusion, disturbance processes, and environmental heterogeneity [89–91]. The diversity in species is decreased by competitive exclusion since it is considered as strong competitors first overpower lesser competitors and later cause them to become extinct locally. Moreover, environmental heterogeneity can stimulate species diversity by promoting spatial niche apportioning and heterogeneity in plant community composition across environmental slopes [89]. Disturbances can diminish the diversity of plant species by eradicating disturbance-sensitive species. This can also be done by increasing the diversity of species by opening up growing space and resources for utilization by the colonizing species, maintaining species richness by retarding or averting competitive exclusion, and modifying spatial heterogeneity in the composition of the plant community [91].

The competition was backed by Ref. [92] to influence the savanna ecosystem's vegetation types and structure. Their study exhibited that areas receiving less rainfall are dominated by grasslands, whereas those receiving rainfall of more than 650 mm annually are mostly composed of woodlands except for areas where moisture is transformed by a landscape factor, such as topography.

Sharam et al. & Pellew [43, 67] additionally view vegetative structure in the savanna ecosystem as being affected by demographic factors. Ref. [67] in his study of African savannas, postulates factors, such as elephants, giraffes, and fire, directly impact the type of structure of the woodland. He further states tree height affects woody vegetation structure. He sees trees surpassing 6 m as ecologically mature because they escape the influence of fire due to the fact that the fire threshold is 3 m and also browsing by giraffes, whose threshold is approximately 5.75 m. According to Ref. [67], fires influence the regeneration of trees, whereas elephants lead to mortality in trees of all size classes of regeneration (< 1 m), recruitment (1–5.75 m), and mature phases (> 5.75 m).

3. Species diversity, composition, and ecosystem functioning

Loss in biotic diversity is occurring so that we may experience mass extinction if the trend continues, which may affect the functioning of the ecosystem and ultimately affect the diversity of species and composition [13]. The decline of biological diversity not only represent irrevocable damage to the globe but also poses a menace to what offers support to the lives of human beings owing to the fact that services that nature affords signify everything from the food we eat to the air we breathe [17–19].

4. Impact of anthropogenic activities on the species diversity, composition, and ecosystem functioning

For more than two million years, the structure of the African savanna ecosystems has been affected by anthropogenic activities [93]. Human beings impact the structure of savanna ecosystems directly by cultivating and cutting woody species. They also indirectly impact the structure because of their ability to alter fire and herbivore numbers and distribution through hunting and livestock management [79].

4.1 Anthropogenic activities and species diversity

Human activities have time in memorial influenced the diversity of species in African savannas. Refs. [94, 95] reported that the annual burning of savannas tends to increase species richness. On the other hand, Ref. [96] reported a negative correlation between fire frequencies and woody plant species richness where it was stated that high frequencies of fire reduce woody plant species devoid of producing substantial upsurges in species richness of grass and forb. Fires have been said to alter and restrain tree crown cover and diversity by sporadically killing the tree crown canopy. Fires also restrict the sapling growth into the crown cover canopy and eradicate the regeneration of the tree species, which are intolerant to fire but tolerant to shade [96].

The dominance of the woody plant growing on savannas with finer textured soils may be decreased due to fires which may ultimately reduce the species' richness. The occurrence of fires may harm the woody plants and reduce their cover of the woody plants. It may also reduce the frequencies of woody species, thereby declining the species diversity [97–99]. On the other hand, low fire frequencies have been reported to maximize the understory woody species richness because high fire frequencies damage the seedlings and saplings, which are species sensitive to fire. This inhibits seedlings and saplings' growth into tree crown cover, harming overstory trees over time and limiting the species mix of overstory trees to extremely fire-resistant oaks [96]. The savanna ecosystem houses huge heterogeneous communities because the plant composition communities differ across fine-scale environmental slopes connected to the variability in tree canopy cover throughout space [53, 100].

4.2 Anthropogenic activities and species composition and ecosystem functioning

Ceballos et al. & Steffen et al. [101, 102] denoted that anthropogenic activities have rapidly exacerbated the rate of loss in global biological diversity in the past. Loss of habitat has been the principal driver of this decline globally and is reported to be accountable for almost 67% of the terrestrial land surface, having passed a suggested "safe limit" of the extinction of local species [103].

These declines in biological diversity adversely affect the local functioning and services of an ecosystem and pose a major threat to mankind [12]. On the other hand, biodiversity in flora and fauna has a positive relationship with the productivity of plants as well as soil health [104, 105], thereby enhancing the sequestration ability of atmospheric carbon [104]. Besides, mitigation of alarming carbon dioxide levels may be decelerated due to the loss of diversity which may undermine the progress on limiting climate change. On the other hand, increased crop production and resilience to distress are connected to higher species diversity in agricultural lands [106]. Conservation of biodiversity is thus key to safeguarding the availability of food in light of rising demand and fluctuating environmental conditions.

The structure and functioning of the savanna ecosystem are also affected by the selective removal of trees in several ways. Mostly, the selective removal of trees forms gaps in the crown canopy may lead to increased diversity and abundance because the competition for water and nutrients, as well as increased availability of light, may be reduced [79]. Loss in biological diversity has also been reported by Ref. [18] to reduce the efficiency by which ecological communities capture biologically essential resources, produce biomass, decompose and recycle biologically essential nutrients. Advances have also been made in under-studied areas, such as soils and exhibiting, for instance, that cycling of nitrogen and diversity of plants can be reduced due to the reduced soil biodiversity [107–109].

4.3 Land use change and species diversity and composition

In the past 20 years, the emergence of change in land science has sought to understand the dynamics of anthropogenic activities on the earth through the changes in land use and land cover [110]. Conversion of land to agriculture is reported by Refs. [111, 112] to be a key driver of universal biological loss, with implications for the functioning of an ecosystem, thereby disrupting species diversity and composition. According to Ref. [113], the human population is much higher across the savannas, implying that the more anthropogenic activities, the more pressure on savanna degradation, cover loss, a continued downward trend in species diversity, and composition. Ref. [114] adds that globally land-use change is the principal influence of biological diversity loss.

Taubert et al. [115] note that agricultural expansion and its impact on the loss and disintegration of native habitats causes a reduction in the habitat areas. This also leads to increased predation, a decline in population, extinctions in species, and alterations in species compositions [112, 116]. Nevertheless, these effects change according to the species characteristics and the spatial structure of the habitat. The effects also change according to the surrounding human-modified landscape (matrix) [117]. However, land-use change in African savannas poses a threat to the tenacity of biotic diversity through wildlife grazing loss and dispersal area to agriculture, as well as enlarged disturbance of wildlife around human inhabitation [118].

5. Implications for management of the African woodland savannas

Understanding the diversity and composition of tree species is vital since they provide resources and habitats for a number of other species. Assessments in botanical studies, such as floristic composition, species diversity, and structural analysis studies, are significant for providing accurate information on the species richness, which is valuable for sustainable forest management and helps to understand forest ecology and functioning of the ecosystem. Understanding the long-term response of biological diversity as a result of land use and cover change is vital if species extinctions and decline in biotic diversity were to be minimized. This can be enhanced by implementation of sound and timely conservation and restoration efforts by international forest conservation organizations, governing authorities, interest groups, etc. The knowledge provided in this chapter is expected to be beneficial for planning purposes and management intended for the conservation of biotic diversity and the sustenance of local livelihoods.

6. Conclusion

The evidence presented in this chapter shows how anthropogenic activities, such as forest conversion to woodland for fuel wood removal, charcoal production, woodland grazing, herbivory, habitat degradation, overexploitation, invasive alien species, pollution and climate change, exploitation through illegal and legal logging, and set forest fires, have impacted on the African savanna's species diversity and composition. The chapter also noted that the availability of resources, that is, rainfall and soil nutrients, is a significant factor in species diversity and composition. The chapter also highlights the influence of selective feeding and the physical effects of defoliation, competitive exclusion, and environmental heterogeneity as other significant factors affecting species diversity and composition in an African savanna. This has clearly degraded most parcels of African savanna and has disturbed the species' habitat, thereby significantly exacerbating its decline.

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