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STRUCTURE AND COMPOSITION OF WOODY VEGETATION IN TWO IMPORTANT BIRD AREAS IN SOUTHERN ZIMBABWE

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ABSTRACT

This study assessed the status of woody vegetation structure and composition in two Important Bird Areas (IBA) i.e. Manjinji Pan and Save-Runde Junction located in southeastern Zimbabwe. The objectives of this study were to: (i) determine the woody vegetation structure and composition of the study areas and (ii) find out any differences and similarities in woody vegetation between the two IBAs. Data about woody vegetation were collected from 40 randomly placed sample plots from both study areas. Tree density was higher in Manjinji Pan IBA (406.67 ± 16.86 trees ha^{-1}) than Save-Runde Junction IBA (275.83 ± 17.62 trees ha^{-1}). In contrast, Save-Runde Junction IBA had higher numbers of stems per plant (2.88 ± 0.22), species richness (59) and diversity (H' = 3.28) than Manjinji Pan IBA: numbers of stems per plant (2.16 ± 0.12), species richness (43) and diversity (H' = 2.90). No significant differences were recorded in woody plant height, shrub and dead plant densities. The findings suggest that several factors including fires, herbivory and human activities could be influencing the woody vegetation in the two IBAs. However, further research is suggested to better understand the drivers of woody vegetation variation in IBAs occurring in savanna ecosystems. It is recommended that species richness and diversity of woody plants should be maintained and invasive plant species controlled for the conservation of endemic and migratory avifauna.

Key words: Important Bird Areas, savanna, woody vegetation, fire, herbivory, species richness, diversity.

INTRODUCTION

The Important Bird Areas (IBAs) programme of BirdLife International is a worldwide initiative aimed at identifying, documenting, and protecting a network of sites critical for the long-term viability of naturally occurring bird populations across the geographical range of those bird species for which a site-based approach is appropriate (Bennun and Fishpool, 2000). The IBA programme in Africa, which commenced in 1993, has identified over 1,200 IBAs across the continent (Buchanan *et al.*, 2009). IBAs are places of international significance for the conservation of birds at the global, regional or sub-regional level (Bennun and Fishpool, 2000). IBAs are selected according to an internationally agreed criteria based upon the presence of globally threatened species, species of restricted range, biome-restricted species assemblages and concentrations of numbers (Mwangi *et al.*, 2010).

Despite their biodiversity value, many IBAs are threatened by habitat degradation and a high proportion of IBAs still lack legal protection (Buchanan *et al.*, 2009). Vegetation changes in savanna landscapes can affect both ecosystem productivity and conservation value (Sharp and Bowman, 2004) of IBAs. Savannas are ecosystems with a continuous herbaceous layer and a discontinuous woody stratum (Scholes and Archer, 1997). Factors influencing woody vegetation in savannas include fires, herbivory, rainfall, soil nutrients, soil type and human activities (Frost *et al.*, 1986; Higgins *et al.*, 1999; Sankaran *et al.*, 2005).

Earlier studies have reported that bird species composition, habitat selection and foraging efficiency are influenced by habitat integrity, woody vegetation structure and composition (Berg, 2002; Rais *et al.*, 2010; Joshi *et al.*, 2012). For instance, an increase in avian diversity has been associated with increased vegetation structural diversity (MacArthur and MacArthur, 1961; Hudson and Bouwman, 2007). Woody plants are important for a diversity of bird species as they provide food, cover, sites for nesting, roosting, perching, and observation posts for raptorial birds (Dean *et al.*, 1999; Ffolliott *et al*., 2011). Moreover, plants that produce fruit consumed by birds have been reported as being particularly important since they may attract a high number of bird species with the bird species also assisting in seed dispersal (Luck and Daily, 2003). Therefore, understanding the structure and composition of woody plants in IBAs is valuable for avian conservation. This study assessed the status of woody vegetation structure and composition in two IBAs occurring in southeastern

Zimbabwe. Specifically, the objectives of this study were to: (i) determine the woody vegetation structure and composition of the two IBAs and (ii) establish whether there were differences and similarities in woody vegetation between these two IBAs.

MATERIALS AND METHODS

Study Area and Sites: In this study we focussed on two IBAs from a total of 20 IBAs in Zimbabwe (Childes and Mundy, 2001). These two IBAs are located in the savanna ecosystems of southeastern Zimbabwe, namely Limpopo–Mwenezi flood-plain and pans (i.e. Manjinji Pan), and Save-Runde Junction (Fig. 1). Manjinji Pan is a sanctuary under the Parks and Wildlife Act (1975) of Zimbabwe and an old oxbow lake along the Mwenezi River with a spatial extent of ~300 ha and an elevation of ~300 m above sea level. Manjinji Pan lies at 22° 07′ S 31° 24′ E and is located in Malipati communal land surrounded by thick woodland, dominated by fever-trees (*Acacia xanthophloea*) (Childes and Mundy, 2001). Both study sites occur in a region characterised with a short dry winter season (May–July), hot dry summer season (August–October) and a hot wet summer season (November–April). Mean annual rainfall for Manjinji Pan is ~490 mm. Common livestock in the Manjinji Pan include domestic cattle (*Bos taurus*) and goats (*Capra hircus*) whereas Nile Crocodiles (*Crocodylus niloticus*) are the common wildlife species with rare occurrences of African Elephants (*Loxodonta africana*).

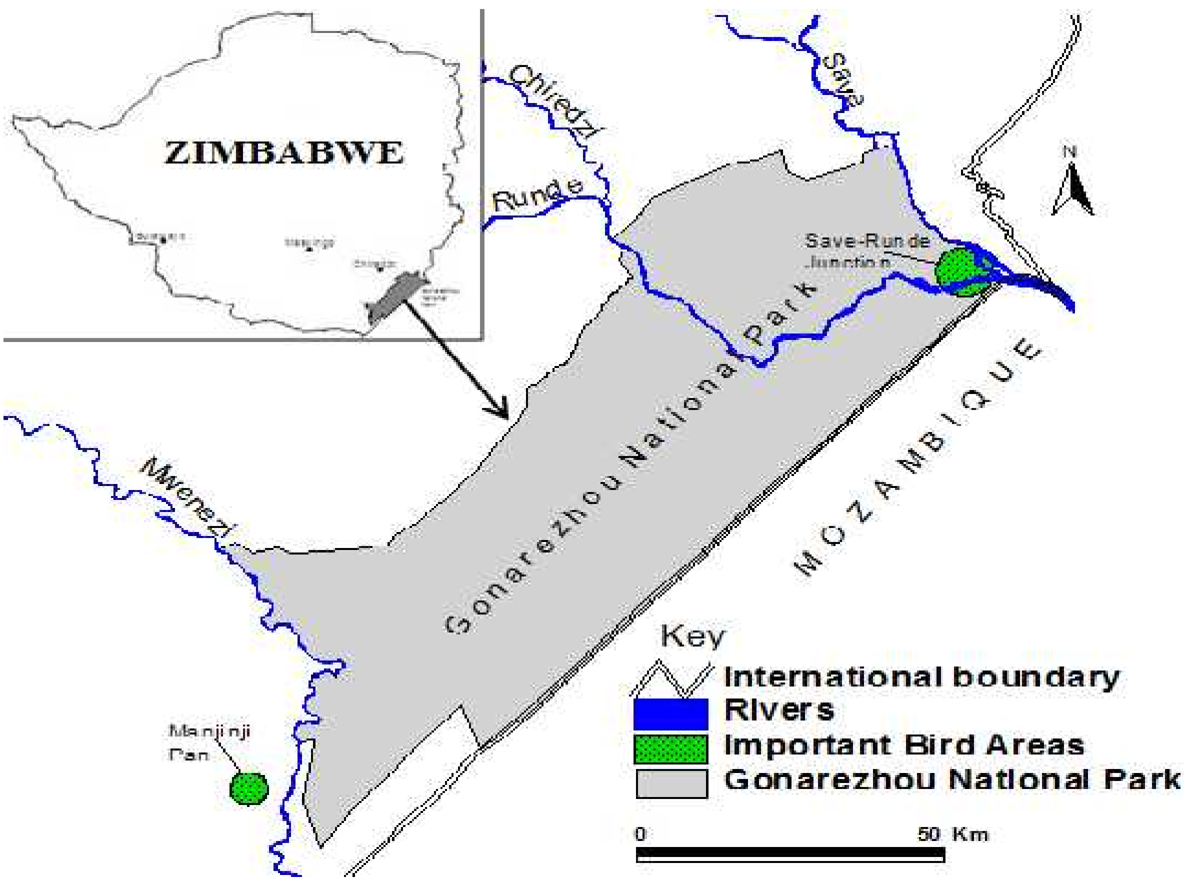

Fig. 1. Location map of study sites i.e. Manjinji Pan and Save-Runde Junction in southeastern Zimbabwe.

The Save-Runde Junction IBA lies at the confluence of Runde and Save Rivers (21° 19' S 32° 26' E) in northern Gonarezhou National Park with only a small portion of the IBA extending into the adjacent Mahenye communal land with a spatial extent of ~1,000 ha and an elevation of between 180 and 300 m. This IBA consists of Tambohata Pan which is surrounded by *Acacia* trees and Machaniwa Pan which is surrounded by baobabs (*Adansonia digitata*) (Childes and Mundy, 2001). Major wildlife species in the Save-Runde Junction IBA include African Elephant (*Loxodonta africana*), Buffalo (*Syncerus caffer*), Giraffe (*Giraffa camelopardalis*) and plains Zebra (*Equus quagga*) (Gandiwa, 2012). Mean annual rainfall in the northern Gonarezhou National Park is 466 mm. Bird species of special conservation concern and their associated categories of threat (IUCN, 2012) in the two IBAs are listed in Table 1.

Table 1. Key bird species and their status in Manjinji Pan and Save-Runde Junction IBAs in southeastern Zimbabwe

Common name	Scientific name	Manjinji Pan IBA	Save-Runde Junction IBA	Status (IUCN Categories of Threat)
Blue-throated Sunbird	*Anthreptes reichenowi*	X		NT
Southern Banded Snake Eagle	*Circaetus fasciolatus*		X	NT
Cape Vulture	*Gyps coprotheres*	X	X	V
Corncrake	*Crex crex*		X^M	LC
Lesser Kestrel	*Falco naumanni*		X^M	LC
Southern Brown-throated Weaver	*Ploceus xanthopterus*		X	LC
Brown-headed Parrot	*Poicephalus cryptoxanthus*	X	X	LC
Lemon-breasted Canary	*Serinus citrinipectus*	X	X	LC
Four-colored Bush shrike	*Telophorus quadricolor*		X	LC
Lesser Black-winged Lapwing	*Vanellus lugubris*		X	LC
Barred Long-tailed Cuckoo	*Cercococcyx montanus*		?	LC
Black-bellied Glossy-starling	*Lamprotornis corruscus*		?	LC
Lesser Seed cracker	*Pyrenestes minor*		?	LC
Livingstone's Turaco	*Tauraco livingstonii*		?	LC

Source: (Childes and Mundy, 2001; IUCN, 2012).
X = known to occur; ? = possibly occur; NT = Near Threatened, V = Vulnerable, LC = Least Concern, M = Migratory. Migratory species are indicated

Data Collection: Floristic composition and structure of woody vegetation was measured in 20 randomly placed sample plots, of 20 × 30 m, in each IBA. Measurements were taken in May 2011 when species were more easily identifiable. A stratified random design using random numbers based on topographical map grid intercepts was used for plot selection. The following woody vegetation variables was recorded or measured in each of the 40 sample plots: species, height, whether the woody plant was alive or dead and number of stems per plant.

Woody plant height was measured using a calibrated 8 m pole. Heights of woody plants greater than 8 m were visually estimated. Only the height of the tallest stem was measured for multi-stemmed plants. Woody plants were divided into shrubs and trees. Shrubs were defined as woody plants with a stem diameter less than 6 cm and 1–3 m in height whereas trees were defined as woody plants with a stem diameter of 6 cm or more and higher than 3 m (Ben-Shahar, 1998). Number of stems per plant was manually counted for each multi-stemmed plant. Dead plants were defined as plants without living leaves, with dry and cracking trunk, bark and stem.

Data Analysis

Woody Vegetation Structure: Descriptive statistics were used to summarise measured woody vegetation data. Data were first tested for normality using the Shapiro-Wilk test (Shapiro and Wilk, 1965) and only tree density data was found to be normal. Consequently, data for woody plant height, number of stems per plant, shrub density and dead plant density were $\log_{10}(x+1)$ transformed. Independent samples two-tailed *t*-tests were used to analyse woody vegetation structure variables data of 40 sample plots from Manjinji Pan and Save-Runde Junction IBAs using SPSS version 19 (SPSS Inc., Chicago, Illinois). The woody vegetation structure variables were used as the test variables whereas the IBAs were used as the grouping variables.

Woody Vegetation Composition: Woody plant species diversity for the two IBAs was calculated using the Shannon-Weiner Index (H') (Ludwig and Reynolds, 1988). The Jaccard index of community similarity (Ludwig and Reynolds, 1988) was used to determine the extent of woody species composition between the two IBAs. In order to better understand the relationships between the two IBAs, woody species abundance data from 40 sample plots were subjected to a hierarchical, agglomerative cluster analysis (McGarigal *et al.*, 2000) using the Ward's method with relative Euclidean distance in STASTICA version 6 for Windows (StatSoft, 2001). Clusters were described and interpreted in terms of species associations.

RESULTS

Woody Vegetation Structure: A total of 1,409 trees and shrubs were recorded in 40 sample plots. Manjinji Pan IBA (406.67 ± 16.86 trees ha^{-1}) had a significantly higher tree density than Save-Runde Junction IBA (275.83 ± 17.62 trees ha^{-1}) (t = 5.36, df = 38, P<0.0001; Table 2). In contrast, Save Runde Junction IBA (2.88 ± 0.22) had a significantly higher number of stems per plant than Manjinji Pan IBA (2.16 ± 0.22) (t = –2.89, df = 38, P<

0.001). No significant differences were recorded in woody plant height, shrub and dead plant densities between Manjinji Pan and Save-Runde Junction IBAs (Table 2).

Table 2. Differences and similarities in woody vegetation structure between Manjinji Pan and Save-Runde Junction IBAs in southeastern Zimbabwe (mean ± standard errors).

Woody vegetation variable	Important Bird Area		*t*-value	*P*
	Manjinji Pan	Save-Runde Junction		
Height (m)	6.01 ± 0.46	5.03 ± 0.59	1.89	$0.067^{n.s.}$
Tree density (trees ha^{-1})	406.67 ± 16.86	275.83 ± 17.62	5.36	0.000^{***}
Shrub density (plants ha^{-1})	220.00 ± 23.34	269.17 ± 35.46	–0.90	$0.376^{n.s.}$
Dead plant density (plants ha^{-1})	16.67 ± 3.42	20.00 ± 6.35	0.38	$0.705^{n.s.}$
Number of stems per plant	2.16 ± 0.12	2.88 ± 0.22	–2.89	0.006^{**}

Statistical significance (*P*-value): n.s. = not significant ($P > 0.05$), * = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.0001$. (df = 38)

Woody Vegetation Composition: A total of 73 woody plant species were recorded from 40 sample plots out of which 29 species were common in both Manjinji Pan and Save-Runde Junction IBAs. Save-Runde Junction IBA had higher species richness (59) than Manjinji Pan IBA (43). Similarly, Save-Runde Junction IBA had a higher woody plant species diversity (H' = 3.28) than Manjinji Pan IBA (H' = 2.90). Of the 29 common woody plant species, the most abundant species were *Dichrostachys cineria*, *Acacia tortilis*, *Philenoptera violacea*, *Thilachium africanum*, *Flueggea virosa*, *Ehretia amoena*, *Croton megalobotrys*, *Tabernaemontana elegans* and *Capparis tomentosa*. Furthermore, the Jaccard index of community similarity showed a 39.73% similarity between the two IBAs.

Three sub-clusters were identified from the hierarchical cluster analysis dendrogram (Fig. 2). First, sub-cluster A consisted of four sample plots from Save-Runde Junction IBA and comprised of the following dominant species: *Colophospermum mopane*, *Maerua parvifolia* and *Thilachium africanum*. Second, sub-cluster B consisted of 14 sample plots from Save-Runde Junction IBA and comprised of the following dominant species: *Acacia tortilis, Adansonia digitata*, *Capparis tomentosa, Combretum imberbe*, *Combretum mossambicense*, *Dichrostachys cineria*, *Kigelia africana, Maclura africana*, *Philenoptera violacea*, *Tabernaemontana elegans* and *Thilachium africanum*. Third, sub-cluster C consisted of 22 sample plots, with 20 sample plots from Manjinji Pan IBA and two sample plots from Save-Runde Junction IBA. Sub-cluster C comprised of the following common woody plant species: *Acacia robusta*, *Acacia schweinfurthii*, *Acacia tortilis*, *Acacia xanthophloea*, *Albizia harveyi*, *Berchemia discolor*, *Capparis tomentosa*, *Croton megalobotrys, Dichrostachys cineria*, *Ehretia amoena*, *Flueggea virosa*, *Grewia inaequilatera*, *Grewia flavescens*, *Grewia sulcata*, *Philenoptera violacea* and *Phyllanthus reticulatus*.

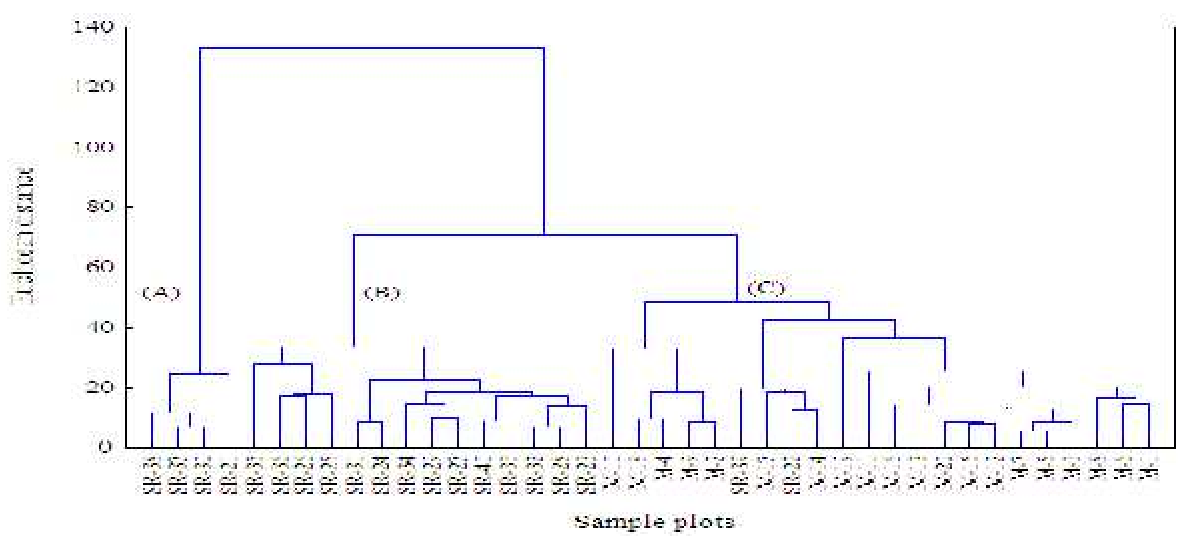

Fig. 2. Dendrogram from hierarchical, agglomerative cluster analysis of Manjinji Pan and Save-Runde Junction IBAs woody species abundance data collected in May 2011. Sample plot labels at the bottom of the dendrogram denotes: M–Manjinji Pan and SR–Save-Runde Junction IBAs. A, B and C represents the sub-clusters.

DISCUSSION

Results showed differences and similarities in woody vegetation structure and composition between Manjinji Pan and Save-Runde Junction IBAs. Tree density and number of stems per plant differed whereas plant height, density of shrubs and dead plants were similar in both study areas (Table 2). Tree densities and number of stems per plant could have differed due to interaction of fires and herbivory effects leading to a lower tree density and an associated high number of stems per plant primarily from resprouting in Save-Runde Junction IBA than in Manjinji Pan IBA. Intensive browsing by mostly large herbivores such as elephants and repeated fires are known to open up woodlands through breaking and killing of mature trees (Skarpe *et al.*, 2004; O'Connor *et al.*, 2007; Guldemond and Van Aarde, 2008). Previous studies on vegetation structure and composition across various woodland types in Gonarezhou National Park have also attributed the lowering of tree density and high numbers of stem per plant to herbivory and fires (Tafangenyasha, 1997; Gandiwa *et al.*, 2011; Mpofu *et al.*, 2012). Higher tree density and lower numbers of stems per plant in Manjinji Pan IBA could be attributed to lower negative impact of browsing by goats and low fire occurrences in adjacent communal land due to low fuel load resulting from heavy grazing by livestock.

Secondly, human activities could also be influencing the density of trees in the study sites, particularly in Manjinji Pan IBA. Human removal of mature woody plants for domestic use is likely to promote increased resprouting leading to high tree density and number of stems per plant. It has been suggested that woody vegetation in Save-Runde Junction IBA were also negatively affected by past human settlements before the establishment of the park and also with the tsetse fly (*Glossina* spp.) eradication activities (Tafangenyasha, 1997; Gandiwa and Kativu, 2009). In Manjinji Pan IBA, it was evident from tree stumps that some trees were being harvested by the local people, hence affecting woodland structure. Rural households in southern Africa mostly depend on fuel wood, and this affects woody vegetation structure and associated biodiversity (Du Plessis, 1995).

Woody plant height, densities of shrubs and dead plants in two study areas were found almost similar (Table 2). This could be attributed to relatively high woody community similarity (39.73%) recorded in this study. Similarly, the hierarchical cluster analysis dendrogram (Fig. 2) revealed similarities in woody plant species within each site, likely contributing to the recorded similarities in attributes of woody vegetation structure. Furthermore, it is likely that other factors such as droughts and rainfall (micro-climate conditions) are uniformly affecting the study sites as they occur in the same climatic region. It was reported that the severe drought in 1991–92 affected the southeast lowland in Zimbabwe leading to massive die-offs of mature trees across the ecosystem (Tafangenyasha, 1998).

Fully protected areas such as national parks are often assumed to be the best way to conserve biodiversity (Banda *et al.*, 2006; Gaston *et al.*, 2008). Interestingly, the present study results also revealed that Save-Runde Junction IBA which occurs inside a protected area had a higher species richness (59) and species diversity (H' = 3.28) compared to Manjinji Pan IBA which had a species richness of 43 and a species diversity of 2.90. Similarly, Save-Runde Junction IBA had a higher number of bird species of special concern than Manjinji Pan IBA (Table 1). The lower woody plant species richness and diversity in Manjinji Pan IBA could be attributed to its relatively smaller area and isolation as compared to Save-Runde IBA (Fig. 1) and to the likely loss of woody plant species within the IBA. Loss of woody species in Manjinji Pan IBA could have resulted from targeted extraction of certain plant species for construction or firewood. Human influence has undoubtedly influenced the woody vegetation structure and composition of several terrestrial ecosystems (Luoga *et al.*, 2002; Gaugris and Van Rooyen, 2010). The present study results are consistent with those of Higgins *et al*. (1999) who also recorded lower species richness in woody communities occurring in communal land as compared to protected private game reserves in South African semi-arid savanna. In Save-Runde Junction IBA, the higher species richness and species diversity of woody plants could be a result of low current woody species extraction due to strict law enforcement inside Gonarezhou National Park (Gandiwa *et al*., 2013).

In Manjinji Pan IBA, threats to the area are likely to come from overgrazing, trampling by cattle, browsing by goats (Childes and Mundy, 2001), spread of invasive species such as *Lantana camara* (also recorded in this study), water abstraction for irrigation projects and extraction of wood products. In Save-Runde Junction IBA, major threats to the woody vegetation come from high densities of large herbivores, fires and to some extent from illegal harvesting of poles for construction.

Variation in woody vegetation among two study areas is likely to influence bird species composition and distributions as reported in other studies conducted in tropical savanna ecosystems (Monadjem, 2005; Tassicker *et al.*, 2006; Sirami and Monadjem, 2012). It has been reported that while some bird species are generalists, many species have narrower ecological niches (Bergen *et al.*, 2007), and hence influenced by slight changes in the woody vegetation. For example, increases in woodland bird assemblages have been associated with an increase in woody vegetation density (Skowno and Bond, 2003; Kutt and Martin, 2010).

Large trees are also of considerable importance in the savannas as they attract birds by providing perch, nest and roost sites (Dean *et al.*, 1999). In this study several important woody plant species consisting of large trees were recorded in the study sites such as *Adansonia digitata*, *Philenoptera violacea*, *Combretum imberbe*, *Kirkia africana* and *Acacia xanthophloea*. Furthermore, changes in woody vegetation structure and composition may also influence dynamics at the herbaceous layer, thereby influencing avifauna which utilises this layer. For instance, in many ecosystems, increases in woody plant abundance are accompanied by decreases in herbaceous production and shifts in species composition (Archer, 1990).

Based on the present study findings, it is recommended that there is need to strengthen law enforcement particularly in Manjinji Pan IBA for conservation of woody plant species richness and diversity for reducing further loss of woody species. There is also need to control the spread of invasive woody plant species, such as *Lantana camara*, in both the IBAs. Furthermore, identifying scales at which birds respond strongly to changes in habitats (Cunningham and Johnson, 2006) and which woody vegetation structure variables induces changes to bird assemblages (Bergen *et al.*, 2007) would be valuable to avifauna conservation in savanna ecosystems. Finally, it is important to develop long-term monitoring programmes for woody vegetation in IBAs to allow for long-term conservation of endemic and migratory birds.

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