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*Original Paper*

# Population Density and Structure of Marula (*Sclerocarya Birrea)* in Gonarezhou National Park and Adjacent Areas, Southeast Zimbabwe

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***Abstract***

*This study assessed the population density and structure of marula (*Sclerocarya birrea*) in the Gonarezhou National Park (GNP) and adjacent areas, southeast Zimbabwe. Data were collected from 15 belt transects using a stratified random sampling technique (with study sites located in the northwestern Gonarezhou National Park, adjacent communal and resettlement areas) in November 2014. The study results showed that marula tree and shrub densities were highest in the Gonarezhou National Park compared to the communal and resettlement areas. The diameter size class generally showed a reverse J shape in all the land use categories implying that there was a high regeneration and low recruitment into mature marula trees. Anthropogenic uses and herbivory may likely have influenced the density and population structure of marula in the study area. Thus, continuous monitoring and adaptive management is essential in ensuring that marula species is not locally extirpated in areas of high use or damage.*

***Keywords***

*density, population, recruitment, savanna, structure*

## 1. Introduction

The marula tree *(Sclerocarya birrea)* is an iconic wild growing deciduous dioecious leafy tree species indigenous to Africa (Nerd & Mizrahi, 1993). It belongs to the genus *Sclerocarya*, species *birrea* and falls under the *Anacardiacea* family (Moganedi et al., 2007). There are three subspecies that are known to exist and these are *Sclerocarya b. caffra*, *Sclerocarya b. birrea* and *Sclerocarya b. multifoliata* (Holtzhausen et al., 1989). *Sclerocarya b. birrea* subspecies *caffra* is the most widespread and most researched in southern and southwestern African parts of the continent (Ojewole et al., 2010; Seloana et al., 2017; Nndwammbi et al., 2018; Sinthumule & Mzamani, 2019). *S. birrea caffra* is a keystone African savanna tree species with high ecological, commercial and cultural value (Helm et al., 2011; Murye & Pelser, 2018). It is an abundant fruit bearing tree which plays a significant role in the lives of both humans and animals in southern African ecosystems (Hall & O'brien, 2002; Gouwakinnou et al., 2011; Mocheki et al., 2018; Sinthumule & Mzamani, 2019).

In countries where it is found, the marula species has long formed an integral part of rural communities' livelihoods, culture and spirituality (Wynberg et al., 2003). It is known to support the lives of rural families as they harvest its timber and non-timber products (Wynberg & Laird, 2007; Gouwakinnou et al., 2011; Murye & Pelser, 2018). The marula species is used to generate income, medicine and for nutrition (Thiong'o et al., 2000; Shackleton & Shackleton, 2005). Apart from sustaining rural livelihoods, the marula species also acts as forage for browsing wild animals such as elephant (*Loxodonta africana*) and impala (*Aepyceros melampus*) (Gadd, 2002) and domestic animals which are potentially important seed dispersers (Gallaher & Kruger, 2012).

In protected areas such as Gonarezhou National Park (GNP), southeast Zimbabwe, large herbivores and fires have a significant negative impact on vegetation structure and composition thereby threatening local extirpation of some plant species (O'Connor et al., 2007). Marula is one of the heavily utilized tree species facing pressure from elephants and humans in savanna ecosystems (Helm & Witkowski, 2013). Gadd (2002) asserts that the marula species has poor regeneration and recruitment ability which is mainly attributed to overutilization. With the increasing human and large herbivore populations in southeast lowveld of Zimbabwe, the survival of the marula species is a cause of concern mostly due to overutilization. Elsewhere, in South Africa, the marula species is regarded as a keystone species, hence, this contributes towards its conservation (Shackleton et al., 2007). To date, little is known about the population density and structure of the marula species in the south eastern lowveld of Zimbabwe. Therefore, the present study provides a baseline assessment of the marula species in GNP and adjacent areas. The objective of this study was to assess the population density and structure of marula (*Sclerocarya birrea*) in the northwestern GNP and adjacent areas.

## 2. Methods

### *2.1 Study Area*

This study was conducted in the northwestern part of GNP and its immediate surrounding communities, i.e., Chibwedziva Communal Area and Chizvirizvi Resettlement Area (Figure 1). The GNP is approximately 5 000 $km^2$ in extent whereas Chibwedziva Communal Area and Chizvirizvi Resettlement Area are 350 $km^2$ and 250 $km^2$ in extent respectively (Gandiwa et al., 2013). The study area experiences two contrasting seasons, a dry and wet season. It receives an average annual rainfall of approximately 466 mm (Gandiwa & Kativu, 2009). The study area is endowed with diverse flora and fauna. The dominant vegetation types are *Colophospermum mopane* shrubland or woodland, wooded and bushed grassland, dry deciduous woodland and riverine woodland (Martini et al., 2016). There is a wide variety of large herbivores in the study area and these include hippopotamus (*Hippopotamus amphibious*), African buffalo (*Syncerus caffer*), African elephant, giraffe (*Giraffa camelopardalis*), waterbuck (*Kobus ellipsiprymnus*), Burchell's zebra (*Equus quagga*), kudu (*Tragelaphus strepsiceros*) and wildebeest (*Connochaetes taurinus*) (Gandiwa et al., 2013).

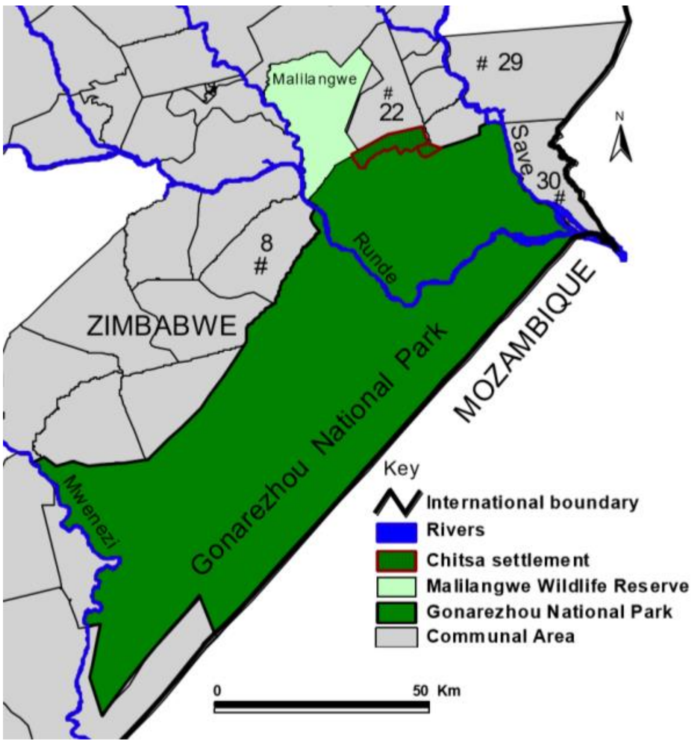


**Figure 1. Location of the Study Area in Southeastern Zimbabwe**

*Notes*. #8 represents Chibwedziva Communal Area and #22 Represents Chizvirizvi Resettlement Area. *Source*: Gandiwa (2011).

*2.2 Data Collection*

A random stratified sampling design was used with the study area being divided into three strata, i.e., northwestern GNP, Chibwedziva Communal Area and Chizvirizvi Resettlement Area. A total of 15 belt transects were sampled, i.e., five belt transects per stratum. The location of belt transects were randomly selected in a geographic information system environment. A fixed transect width of 100 m was used for all transects with the length being variable and determined by having 15 marula trees within the transect (Walker, 1976). Field sampling was conducted in November 2014 when most marula trees and fruits could easily be identified.

In each transect, the following variables on each marula plant were recorded: height, girth, and tree status (dead or alive). Marula plant height was measured by placing a six metre calibrated pole against the plant and for plants with heights greater than six metre, a visual estimation was conducted. Girth was measured using a flexible tape measure at breast height (1.3 m above the ground) whereas tree status, i.e., dead or alive was determined visually following Gandiwa and Kativu (2009). The stage class were categorised as: (i) trees, i.e., woody plants ≥3 m in height; (ii) shrubs, i.e., woody plants 1.5 m to <3 m in height, and (iii) saplings, i.e., woody plants <1.5 m in height (Muchayi et al., 2017). Saplings were counted in two (2) plots measuring 20 m × 30 m within each of the sampled belt transect.

*2.3 Data Analysis*

All recorded marula plant species study variables in each belt transect were summarised following Gandiwa and Kativu (2009). A non-parametric test, the Kruskal-Wallis *H* analysis of variance (ANOVA) test was used to test for significant differences in marula plants population density and structure across the three study strata. Moreover, multiple comparisons *post-hoc* tests were carried out to determine any significant variations within the measured variables across the different land use categories. Statistical tests were conducted using the Statistical Package for Social Sciences (SPSS) version 20 for Windows (SPSS, Chicago, IL).

## 3. Result

A total of 310 marula plants were recorded within the 15 belt transects in the three study strata. Trees constituted 76% ($n$ = 235), shrubs 7% ($n$ = 21) and saplings 17% ($n$ = 54). Three dead marula trees were recorded in GNP, one (1) in Chibwedziva Communal Area and three in Chizvirizvi Resettlement Area. Tree height, tree density and shrub density were highest in GNP whereas sapling density was highest in Chibwedziva Communal Area compared to the other land use categories (Table 1). In contrast, no significant differences were recorded in shrub height across the study strata.

**Table 1. Kruskal-Wallis *H* ANOVA Test Results for the Marula Attributes Across the Land Use Categories Expressed as Median and Range in Backets**

| Attribute | GNP | CCA | CRA | $H$ (2, N=235) | $P$-value |
|---|---|---|---|---|---|
| Tree height (m) | 8.3 (9.7)[a] | 8.2 (7.9)[a] | 7.2 (9)[b] | 16.07 | 0.001 |
| Shrub height (m) | 0.3 (2.5) | 0.1 (2.3) | 0.07 (2) | 9.79 | 0.080 |
| Tree density ($ha^{-1}$) | 8.9 (25.5)[a] | 7.4 (17.2)[b] | 5.0 (11.2)[c] | 6.33 | 0.042 |
| Shrub density ($ha^{-1}$) | 1.7 (5.4)[a] | 0.4 (2.1)[b] | 0.02 (0.8)[c] | 51.47 | <0.001 |
| Sapling density ($ha^{-1}$) | 1.2 (4.1)[a] | 63.5 (316.7)[b] | 0.1 (0.4)[c] | 64.96 | <0.001 |

*Notes*. Different superscripts within the same row indicate significant differences ($P$ < 0.05); GNP - Gonarezhou National Park; CCA - Chibwedziva Communal Area and CRA - Chizvirizvi Resettlement

Area.

A higher proportion of the marula plants were in the diameter size class of < 0.20 m to 0.60 m across the three study strata. However, a sharp decline in abundance was recorded for the marula plants in diameter size class of > 0.61 and above across the three study strata thus depicting a near reverse *J* shape in terms of marula recruitment in the study area (Figure 2).

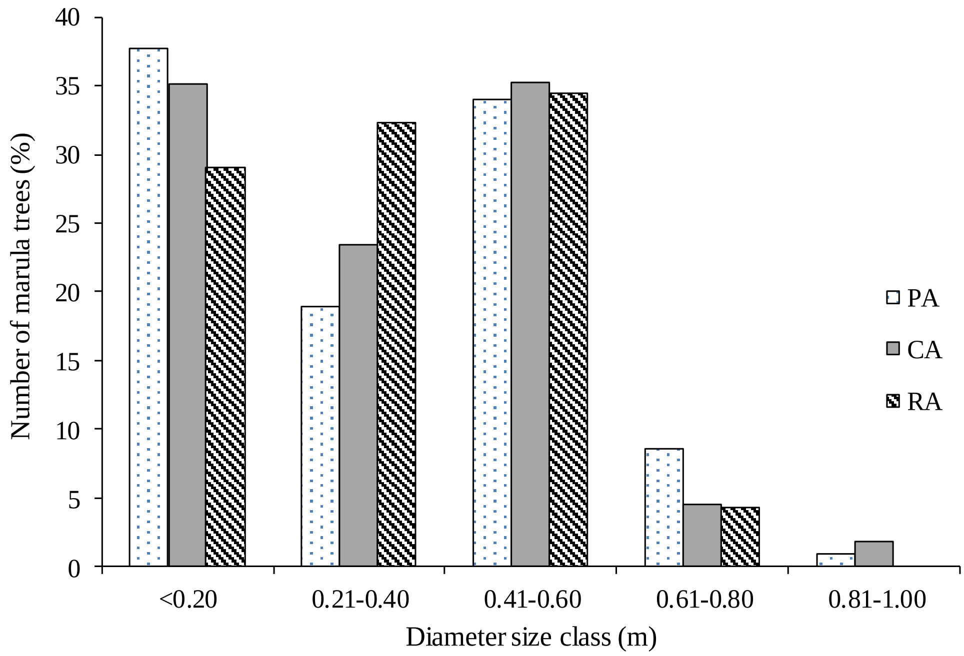


**Figure 2. Diameter Size Class Distribution of Marula Plants across the Three Land Uses in the Northwestern GNP and Adjacent Areas, Southeast Zimbabwe**

*Notes*. PA (protected area) - Gonarezhou National Park, CA - Chibwedziva Communal Area and RA - Chizvirizvi Resettlement Area.

## 4. Discussion

The present study results showed that tree, shrub, sapling densities, and tree height significantly differed across the three land use categories (or the three study sites) in the southeast Zimbabwe. Only shrub height did not significantly vary across the three study sites. The generally higher marula tree, shrub, sapling densities and tree height within the GNP compared to the adjacent areas suggest lower levels of utilisation on the marula species within the protected area than in the adjacent communal and resettlement areas. Higher human activity through agriculture and livestock browsing on vegetation in the communal and resettlement areas adjacent to GNP could likely have a negative impact on marula plant population density and structure growth than inside the northwestern part of GNP. The present study results corroborates those of Zisadza-Gandiwa et al. (2013) whose study on vegetation structure and composition in the same study area showed high tree densities of woody plants species within the GNP compared to the communal and resettlement areas.

The study belt transects within the GNP were located towards the periphery of the park, a zone of high human-wildlife interaction, characterised by low residency of wild animals resulting in the low impact on marula plants. Moreover, the high density of the marula shrubs within the GNP suggests high elephant and fire impact on marula species since studies indicate that elephants prefer browsing young plants (O'Connor et al., 2007; Seloana et al., 2017). Elsewhere, Shackleton (1998) and Nndwammbi et al. (2018) reported that human utilization of woody plant resources had an effect on structural attributes of woody vegetation in South Africa. Field observations during the data collection, showed a considerable number of the marula plants that were cut in the communal and resettlement areas probably due to harvesting of the tree products which in turn impacts negatively on the structure of the marula species.

In contrast, sapling density was higher in Chibwedziva Communal Area than the GNP with the Chizvirizvi Resettlement Area having the lowest sapling density. The lower sapling density within the GNP suggests that other forms of disturbance may be affecting the species, e.g., herbivory from wild animal species such as impala, the influence of veld fires (Tafangenyasha, 1997; Gandiwa & Kativu, 2009), and past droughts (Gandiwa, 2014). Field observation in the communal and resettlement areas showed that local people left marula saplings in their fields for them to grow and recruit into higher tree levels. This is likely due to the benefits local people derive from the marula trees and the increasing conservation awareness through programs such as the communal areas management programme for indigenous resources on the importance of the tree species to the local communities and also for wildlife conservation. Thus, it can be deduced that human settlements act as refuge for the marula species. This is mainly due to people sustainably utilizing as well as domesticating the tree. Gouwakinnou et al. (2011) also reported that local people in the communal areas do conserve the tree species contributing to its healthy population in Benin.

Results on the size class distribution indicated high marula plant regeneration but low recruitment into older trees, thus the near *J* shaped recruitment pattern. The diameter size classes showed that marula plants in class <0.20 m followed by those in class 0.41 m–0.60 m were more dominant than other classes. This indicates that there is high recruitment of the species across the study area. However, diameter size class 0.61 m–0.80 m and 0.81 m–1 m were the least dominant classes. These present study findings are similar to Jacobs and Biggs (2002), Shackleton et al. (2003), and Ngorima (2006) whose findings in other savanna semi-arid areas showed dominance of marula plants in the lower diameter size classes.

In conclusion, the present study results showed some significant variation in the population density and structure of marula plants across the varying land-use categories in the southeast Zimbabwe. Varying levels of human and animal (domestic and wild) utilisation and veld fires among other disturbance factors are likely playing an important role in influencing the marula species populations and structure in the study area. Hence, it is essential to enhance the conservation of the marula species beyond the strict protected area boundaries through robust adaptive management systems characterized by continuous field monitoring and conservation education in the communal and resettlement areas.

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