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POPULATION STRUCTURE OF *PELTOPHORUM AFRICANUM* SOND. IN BOLLA-TAU, MPUMALANGA PROVINCE, SOUTH AFRICA

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Abstract

Population structure of plants assists in identifying the health of plants species within a particular habitat. The aim of this study was to determine the population structure of *Peltophorum africanum* in Bolla-Tau village. Twenty-six 100m x 10m line transects were established within *Peltophorum africanum* Sond. Population. The height of the plants, stem circumference, healthiness of crown and information on whether the plant species was being harvested or not, were recorded. A total of 256 individuals were recorded from the study. The results showed that the population structure of *P. africanum* was bell-shaped and the Logarithmic analysis along with generalized log analysis depict that there is significant correlation between the plant height and stem circumference. Resprout of *P. africanum* individuals were only 18% and 82% of the individuals were harvested. The study observed that 43.8% of individuals had traces of crown damage as compared to healthy crown (35.9%).

Key words: Line transects, Bell-shaped, Resprout.

Introduction

Population structure reveals the ecological characteristic of plant species along with their regeneration patterns (Cunningham, 2001; Bharali *et al*., 2012; Sarkar & Devi, 2014; Tzeng *et al.*, 2018). The structure is determined by assessing the number of plants species in size classes. Population structure of plant species can be bell-shaped whereby plant species found will have a greater number of sapling with few seedlings and adults (Cousins *et al.*, 2014; Kflay & Kitessa, 2014; Aine-omucunguzi *et al.*, 2015; Bayen *et al.*, 2015; Nasrullah *et al.*, 2015; Lisao *et al.*, 2018). Other population shows a reverse J-shape where there will be few seedlings and saplings (Sarkar & Devi, 2014; Mekonen *et al.*, 2015). An inverse J-shaped population reveals a great number of seedlings as compared to saplings and adults (Cousins *et al.*, 2014; Kflay & Kitessa, 2014).

Peltophorum africanum Sond. is a semi-deciduous tree with a dense spreading crown, well established on well-drained, less fertile sandy soils' bushveld (Fisher, 2013). Its distribution ranges from south of the Democratic Republic of Congo, Mozambique, Namibia and South Africa (Venter & Venter, 2012; van Wyk *et al*., 2014). *P. africanum* is the only species under the *Peltophorum* genus within southern Africa (Bizimenyera *et al.*, 2005). It is classified in the Fabaceae family in the sub-family Caesalpinoideae and characterized with bipinnate leaves, multi-stems with no spines with a height reaching up to 15m (Barbosa *et al.*, 2014).

In South Africa, the utilization of *P. africanum* has been well documented as medicine in veterinary, antimicrobial and ethnobotanical studies but limited information is documented on aspects of population status. It is known to treat different ailments, such as menorrhagia, tooth ache, wounds, stomach ache, infertility body pains dysmenorrhea, diarrhea, sexually-transmitted infections, dysentery, tuberculosis, coughs and sore throat (Fernandes *et al*., 2008; Maroyi, 2011; De Wet *et al*., 2012; Venter & Venter, 2012; Semenya *et al*., 2013; Motlhanka & Nthoiwa, 2013; Naidoo *et al.*, 2013; van Wyk *et al*., 2014; Masevhe *et al*., 2015; Chinsembu *et al*., 2015; Rankoana, 2016; Chinsembu, 2016; Tshikalange *et al*., 2016; Urso *et al*., 2016). Antimicrobial activities have been documented by Samie *et al*. (2005); Theo *et al*., (2009); Naidoo *et al*., (2013) and Tshikalange *et al*., (2016). Bark and roots of *P. africanum* have several antioxidant compounds (Bizimenyera *et al.*, 2005). The *in-vitro* activity from crude extracts of *P. africanum* justifies its utilization in traditional medicine (Okeleye *et al.*, 2010).

Population structure of plants assists in identifying the health of plants species within a vegetation community. Population monitoring is therefore important in making sure that the community is kept intact and viable. In Botswana, *Peltophorum africanum* population is characterized by stable population structure with high density of individuals (seedlings) (Teketay *et al.*, 2016). In Kwazulu-Natal, South Africa, the size structure had remained the same between 1992 and 2000, where elephants were responsible for the damage of the species (Wiseman *et al*., 2004). In a another study done in South Africa the plant species was reported as being affected by bark harvesting from human activities (Tshisikhawe *et al.*, 2012). The species sometimes show an aggregated distribution pattern (Käller, 2003). It is a significant plant species used for fuelwood in numerous villages around South Africa (Madubansi & Shackleton, 2007; Dovie *et al.*, 2008; Rasethe *et al.*, 2013) and as a fodder tree (Mongalo, 2013; Mugabe *et al.*, 2017).

The Mapulana people utilize *P. africanum* for fuelwood and as medicine for treating bad luck, kidney diseases, stomach cleansing, sprinkling traditional medicine, stomach pains, blood-related diseases and making of traditional cooking stirrer. *P. africanum* was observed to be declining from 1991 to 2002 at a rate of 5% or more in some villages around the Bushbuckridge Municipality; the degree of fuelwood harvesting, within the villages, was observed to be moderate (Madubansi & Shackleton, 2007). The aim of this study was to determine the population structure of *Peltophorum africanum* in Bolla-Tau village in the Bushbuckridge area.

Materials and Methods

Study area: The study was conducted in Bolla-Tau (Buffelshoek) village situated at 24.63'27° S 31.13'09° E (Fig. 1). The village is 16 km from Acornhoek town within the Bushbuckridge Municipality in the Ehlanzeni District, Mpumalanga Province. The vegetation type of the area is classified as Mapulaneng Scrap forest which is moist and subtropical. Fabaceae, Asteraceae, and Rubiaceae are dominant families and the genera are dominantly represented by *Rhoicissus*, *Ficus* and *Syzygium* to mention a few (Lötter *et al.*, 2014).

Experimental design, protocol and analysis: *Peltophorum africanum* was among the most utilized plant species by the Mapulana. The species was reported to be utilized for fuelwood, medicine, as well as making of traditional cooking stirrers. In traditional medicine, the species has been reported in treatment of kidney diseases, stomach pains, as well as blood-related diseases. It was also reported to address problems of bad luck. The high rate of utilization citation by participants from Bolla-Tau made *P. africanum* a candidate for the investigation of its population status. Twenty-six line transects of 100 m x 10 m were constructed within the *Peltophorum africanum* population.

The sampling of ecological data focused on the height of plants, stem circumference, healthiness of crown and evidence of harvesting on all *P. africanum* individuals within the demarcated transects. Plant height gives a visible image of population structure for individuals (Cousins *et al.*, 2014). Stem circumference provides growth pattern of plant species (Sop *et al.*, 2011; Aine-omucunguzi *et al*., 2015). Crown-health status indicates the health of the species (Morin *et al.*, 2012). The most significant impact of harvesting is the local extinction of species, therefore studying the impacts can assist in determining the possibility of species survival if harvesting is reduced (Tshisikhawe & Van Rooyen, 2013).

Stem circumference were categorized into several size classes. Seedlings were categorized in 0-10 cm, saplings in 10.1 to 20 cm size class, juveniles in 20.1 to 30 cm size class while adults were categorized in the 30.1 to 40 cm size class. Cousins *et al.*, (2014) as well as Kflay & Kitessa (2014) claim that the classification of plants into seedlings, saplings, juveniles, and adults assists in determining the plant species regeneration status' changes over time.

The crown healthiness sliding-scale estimates used in this study were from 0 to 5 where 0 = no crown, 1 = severe crown damage, 2 = moderate crown damage, 3 = light crown damage, 4 = traces of crown damage, 5 = healthy crown (Sadiki *et al.*, 2018). Data were analyzed using IBM Statistical Product and Service solutions (SPSS) statistics version 25 and Microsoft Excel 2013 version.

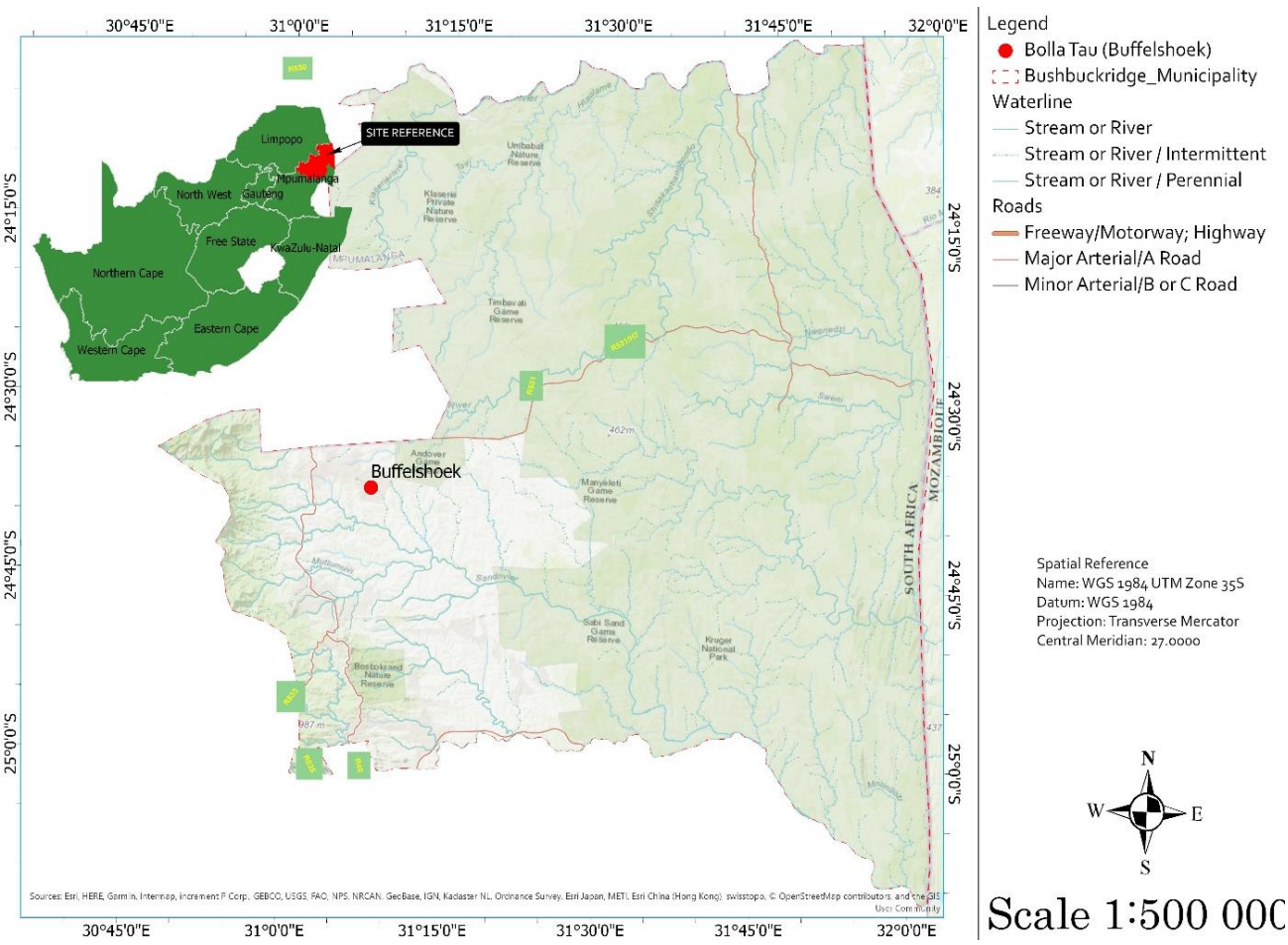

Fig. 1. A map showing Buffelshoek (Bolla-Tau).

Results and Discussions

Population structure and regeneration strategy: A total of 256 individuals were recorded from the study on a total sampled area of 26 000 m^2 (i.e. 100 m x 10 m x 26). This translate to a density of 9.85 individuals per hectare obtained from total number of individuals recorded per total area sampled. Understanding the density of species in communal areas is important because unsustainable harvesting of plants affects the density most in undisturbed areas (Lalfakawma *et al.*, 2009). It was noted that in areas accessible to the public, the density tends to be low (Phama *et al.*, 2014). Anthropogenic activities in communal areas can drive a vegetation into patchiness or narrow distribution of plant species (Worku *et al.*, 2012; Nasrullah *et al.*, 2015). A study by Sadiki *et al*., (2018) on *Pterocarpus angolensis* population in a protected area revealed a density of 9.62 individuals, per hectare.

The distribution of sampled *Peltophorum africanum* individuals as per stem circumference size classes depicted poor regeneration strategies, whereby the size class of 10.1 - 20 cm had a high number of saplings as compared to seedlings and adult tree classes. The regeneration of the species was through stem re-sprouting. Similar findings were observed by Neke *et al*., (2006) where *P. africanum* stem circumference sizes of 10–20 cm were highly harvested and re-sprouted from stems. This was due to the fact that re-sprouting was influenced by the height position of cutting of the stems (Neke *et al.*, 2006); wherein the taller the stump, the more re-sprouts from the cut stem.

The population structure of *Peltophorum africanum* observed in this study is bell-shaped curve; meaning that the number of individuals with stem circumferences in the middle classes is higher as compared to both low and high stem-size classes (Fig. 2). Similar results were recorded by Cousins *et al.*, (2014); Kflay & Kitessa, (2014) who also observed high numbers of individuals in the middle classes compared to the number of individuals in both low and high stem-size classes. A bell-shape curve shows a hampered regeneration because of external factors (Worku *et al.*, 2012). The decrease of adult trees and lack of regeneration showed a decline in the population of plant species (Bayen *et al.*, 2015). Regeneration strategy of plants showing a bell-shape is unstable and under threat because there is few or low numbers of plant species regenerating, therefore, the limitation in germination of seedlings from seeds may be due to vegetation types and harvesting techniques (Aine-omucunguzi *et al*., 2015).

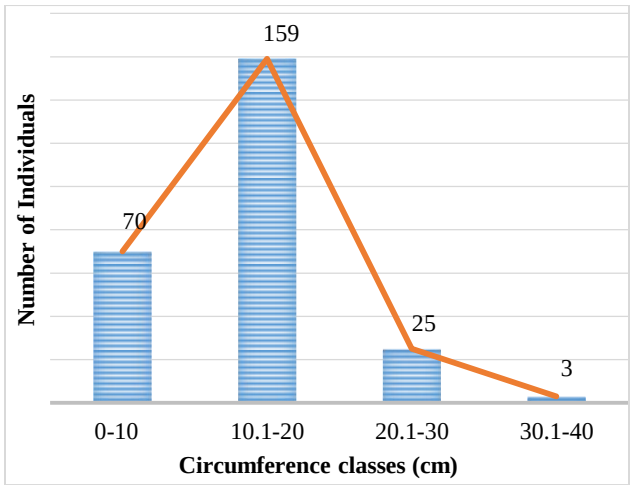

Fig. 2. Stem circumference distribution of *Peltophorum africanum* population at Bolla-Tau village.

P. africanum is severely harvested for use as fuelwood in the village. Evidence of bark harvesting was not noticed in the area. The observed stem removal for fuelwood purposes were regenerating as shown in Fig. 3.

Height of plants in a population signifies the growth pattern and survival strategies of plant species. The seedlings become threatened due to unsustainable harvesting of plant species. A larger number of saplings in height classes signifies that the individuals were able to survive the disturbances (Sop *et al.*, 2011). Fig. 4 depicts that numerous individuals were in size class 1.7 - 2.4 with the others in lower classes. The number of seedlings and adults were significantly the same with high amounts of saplings and juveniles; implying that the plants are harvested during their adult phase. Tshisikhawe *et al*., (2012) stated that other criteria should be taken into consideration in order to classify a species as being at risk.

Fig. 3. Regeneration of *Peltophorum africanum* cut stem at Bolla-Tau village.

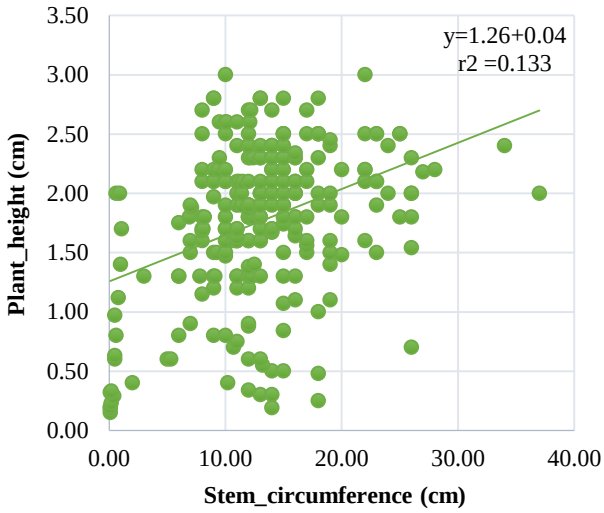

Fig. 4. Plant height distribution of *P. africanum* population at Bolla-Tau village.

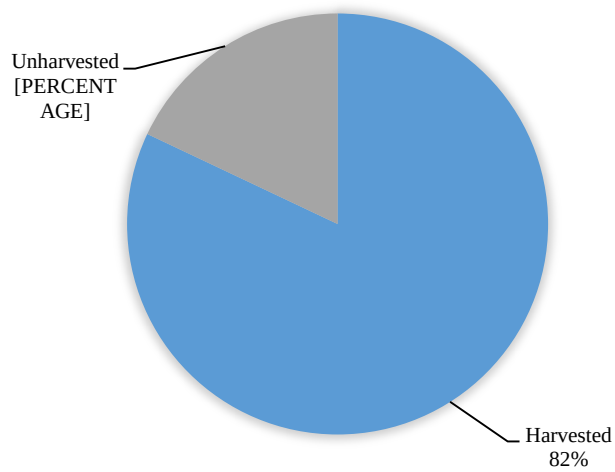

Fig. 5. Percentage distribution of harvested against unharvested individuals of *Peltophorum africanum* population sampled at Bolla-Tau village.

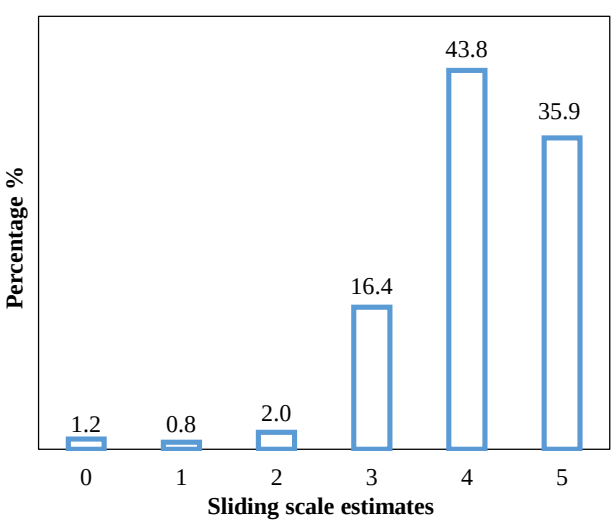

Fig. 6. Crown healthiness of *P. africanum* population at Bolla-Tau village.

Logarithmic analysis, along with generalized log analysis depicts that there is significant relation between the plant height and stem circumference, indicating that the higher the stem circumference, the higher the plants height y = 1.26+0.04, r2 = 0.133 (p<0.01) (Fig. 4). Similar results were observed by Tshisikhawe & Van Rooyen (2013) where stem circumference correlates with plant height. Both the stem circumference and height of *P. africanum* showed a bell-shaped structure. The majority of individuals were found in circumference class 10-19 (cm), with 0-09 (cm) and 30-39 (cm) being the lowest as compared to the other classes.

Harvesting impact: The majority (82%) of *P. africanum* individuals in Bolla-Tau were re-sprouts with only 18% of the individuals being recorded as unharvested (Fig. 5). The overall results showed poor reproduction strategies where there is high number of juveniles, few seedlings, saplings and adult trees. The ability of *P. africanum* to resprout from severe harvesting is due to it being multi-stemmed, occurs in variety of habitats and shows slow growth. Stump size affects the resprouting ability, location of resprout which occurs vigorously when the plant species are small (Cunningham, 2001; Neke *et al*., 2006).

Unsustainable harvesting for fuelwood does not only affect the survival of plant species but also the reproduction strategies and growth, thereby affecting the population dynamics and structure (Ticktin, 2004; Amahowe *et al*., 2017). The parts of plant harvested, the intensity, frequency and quantity of harvesting of plant species, all affect the population structure; extinction normally occurs due to severity of harvesting certain species (Cunningham, 2001). A study done by Neke *et al*., (2006) observed that *P. africanum* was severely harvested, especially stems larger than a centimeter. Severe harvesting of *P. africanum* can be from the possibility of the species' local abundance but, it is not dependent on its spatial distribution (de Oliveira *et al.*, 2007).

Shackleton *et al.*, (2005) observed that the removal of mature stems resulted in a decrease of tree density after a period of 10 years, therefore, the population structure of highly preferred plant species were observed to lack large mature stems, rather a large number of small stems were noted (Higgins *et al.*, 1999; Kaschula *et al.*, 2005). As a result, it can be concluded that unsustainable harvesting for fuelwood may cause the extinction of such plant species.

Crown health status: The study observed that most of the individuals sampled had traces of crown damage (43.8%) when compared to individuals with healthy crowns (35.9%) (Fig. 6). The fact that individuals that were either dead or in severe damaged states were few, is a good sign of a population that is not badly affected by harvesting.

Morin *et al.*, (2012) explains that crown healthiness predicts the survival and health of plant species. An improved growth is shown by healthy crown while minimal growth is shown by damaged crowns. Ugarković *et al.*, (2012) in a study done in Croatia recorded extensive crown defoliation on damaged trees.

Conclusion

The study revealed that population structure of *Peltophorum africanum* was bell-shaped that results in an unstable population. The ability of the plant to resprout after harvesting is seen as a clear recruitment strategy. The severe harvesting of the species in Bolla-tau if not monitored could lead to plant's disappearance from the village. The crown health status of most individuals showed traces of crown damage, while others had healthy crowns.

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