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Full Length Research Paper

Habitat characteristics and threat factors of the rare and endangered *Prunus africana* (Hook. f.) Kalkman in Nyanga National Park, Zimbabwe

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One of the three known remnant populations of the rare *Prunus africana* is found in Nyanga National Park. The objective of this study was to use adaptive cluster sampling and a rapid ecological assessment to collect information on the abundance, regeneration, habitat characteristics and threat factors of *P. africana* which is important in the conservation of the species. A total of 89 *P. africana* trees in 12 clusters were found mainly in sub-montane forests, between 1716 to 1888 m.a.s.l. The major threats were invasive spp. and wild fires. All invaded clusters recorded no seedlings while 3 of the 5 non-invaded clusters recorded a total of 64 seedlings.

Key words: Threat factors, habitat characteristics, species association, regeneration, *Prunus africana*, invasive species, Nyanga National Park.

INTRODUCTION

Over the past decades, *Prunus africana* (Hook.f.) Kalkman populations have been declining due to commercial harvesting of its bark which contains active ingredients known to treat prostate gland hypertrophy and benign prostatic hyperplasia (Cunningham and Mbenkum, 1993). Raw bark, macerated bark, or bark extracts were shipped to Europe and occasionally to the United States, where it was eventually sold in herbal formulations under its synonym *Pygeum africanum*. Because of this growing international demand, *P. africana* was included in Appendix II of the Convention of International Trade in Endangered Species (CITES) as an endangered species in 1995 (Stewart, 2003). The species is geographically widespread but restricted to Afromontane forest habitats (Stewart, 2003) of the African continent.

In Zimbabwe, it is rare and restricted to small forest patches in the Eastern Highlands (Betti, 2008). This study presents revised information on the abundance of the species which was previously reported in the National Museums Botanical database to be less than 10 in the park. Furthermore, the study sought to provide information on *P. africana* habitat characteristics, associated species, threat factors and regeneration in Nyanga National Park where one of the three known remnant populations of the rare species is found.

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MATERIALS AND METHODS

This study was carried out in the Nyanga National Park (32° 45´E, 18° 17´S) in 2010. The park covers an area of 471 km^2 and is located in the Eastern Highlands of Zimbabwe. It is wetter than the surrounding areas due to higher, variable rainfall ranging from 741 to 2,997 mm; characteristic low cloud cover, early morning mist and heavy dew. Mean annual precipitation is 1200 mm. Annual mean temperatures range from a minimum of 9 to 12°C to a maximum of 25 to 28°C. The weather is very hot and extensive wild fires occur in the high-elevation grasslands from August to November when the grasses are dry. The vegetation is mainly sub-montane and montane grassland. Some parts of the National Park have a typical rain forest of the moist tropics consisting of five strata: The upper canopy (more than 20 m height), the medium canopy (between 8 and 20 m height), the lower layer (between 2 and 8 m height) the sapling layer (1 to 2 m height) and the ground layer characterized by seedlings; litter which in some places is as thick as 20 cm and several herbal species. The geology is mainly the Precambrian Umkondo system, which consists of flat-lying shales, quartzites and intrusive dolerites. The soils are highly leached paraferallitic. The drainage pattern is characterised by deeply cut valleys.

Adaptive cluster sampling involving first, the identification of *P. africana* reference trees as a starting point was used. The identify-cation of reference trees was aided by local knowledgeable people. Once these reference trees were located, cluster sampling followed whereby all the *P. africana* trees in the neighbourhood were con-sidered to constitute a cluster. The cluster was closed when there were no more *P. africana* neighbours within a distance of 500 m from the last tree. A total of 12 clusters were found and assessed. Adaptive sampling was based on the assumption that every identified *P. africana* tree unit *i* in population *U* had a well defined neighbourhood composed of one or more other units. The set of all the distinct units thus tested constituted a cluster *c* (*i*) for *i* including *i* itself.

Adaptive cluster sampling was used because the density of rare and clustered populations is difficult to estimate precisely using conventional sampling designs but requires cluster sampling especially in this case where cluster membership was not known prior to sampling (Brown, 2003; Talvitie et al., 2006; Goldberg et al., 2007; Sullivan et al., 2008).

All *P. africana* trees, that is, those greater than 2 m in height; saplings 50.1 to 150 cm height; saplings 20.1 to 50 cm height; seedlings 5.1 to 20 cm height and seedlings < 5 cm in each cluster were recorded, their geo-location taken using a handheld Garmin GPS, aspect taken through observation and a topographical map. Botanical specimens of associated tree species were identified in the field and those that could not were collected, pressed and later identified by botanists at Bindura University of Science Education. Information on threats was collected by assessing each cluster for invasive alien species and fire scars on trees. Invasive species densities were collected from 2 randomly allocated plots each measuring 20 × 50 m (1000 m^2) (Stohlgren et al., 1995) within each cluster. Invader species' litter thicknesses were measured using a tape measure.

Data were analysed through regression analysis and't' test using SPSS Version 15 (2006). Mapping of the distribution of invasive alien species (*Acacia meansii* and *Pinus patula*) together with the location of *P. africana* clusters was done through ArcView GIS (Applegate, 2002).

RESULTS AND DISCUSSION

Distribution of *P. africana* along identified gradients in Nyanga NP

A total of 89 mature *P. africana* trees were recorded in13 clusters (Table 1). This is by far more than the number in the National Museums Botanical database (unpublished) which is less than 7 for the whole park. Adaptive cluster sampling involving the identification of reference trees through knowledgeable local inhabitants made this survey more efficient than methods previously used by the National Museum. Regression analysis showed a relationship (R = 0.596; P = 0.09; F = 8.804) between the distribution of *P. africana* and altitude.

The minimum and maximum altitudes recorded for *P. africana* occurrences in Nyanga National Park were 1716 and 1888 m.a.s.l, respectively. This is similar to findings by Vivian and Faure cited in Betti (2008). However, Tchouto (1996) and Betti (2008) also recorded *P. africana* trees in low altitudes of 600 to 900 m.a.s.l in Cameroun. For every 1.8 trees away from wet areas, 1 is along wetter areas like rivers, streams and valleys. Regression analysis showed a weak and non-significant relationship (R = 0.225; P = 0.668; F = 0.214) between the distribution of *P. africana* and aspect although the species occur more on the north to west facing slopes than on south to east facing as indicated by 38 trees on north facing, 21 on west facing, and 9 on north-west facing slopes and only 11 on east facing, 6 on south facing and 1 on south-west slopes. The remaining (3) were on north-east facing slopes.

Most of the clusters (1 to 7 and 10 to 12) are in sub-montane forests whilst a few are in miombo woodlands (clusters 8 and 9). Betti (2008) reported *P. africana* to occur in montane and sub-montane forests of Africa. The occurrence of *P. africana* in sub-montane forests and miombo patches supports the fact that the species is a light-demanding and secondary-forest species (Stewart, 2003). Species associated with *P. africana* included *Albizia adeanthifolia, Albizia antunesiana, Albizia schimperana, Allophylus chaunostachys, Alsophila capensis,* Cyathea dregei, *Bossqueia phoberos, Brachystegia spiciformis, Bridelia micrantha, Cathium gueinzii, Calophyllum pauciflorum, Celtis africana, Chrysophyllum gorungosum, Cirsium viridifolium, Coffea ligustroides, C. zanguebariae, Croton sylvaticus, Ensente ventricosum, Dovyalis lucida,* Dovyalis macrocalyx*, Erythrina abyssinica,* Erythrina *lysistemon, Ficus ingens, Macaranga* spp.*, Maytenus* spp.*, Newtonia buchananii, Ochna* spp.*, Protea* spp.*, Rauvolfia caffra, Rhus* spp.*, Rubus rigidus, Rothmania* spp.*, Strychnos* spp.*, Syzigium cordatum, Syzigium guineense, Trichilia dregeana, Vernonia* spp. and *Vitex* spp..

Threats to *P. africana* regeneration in Nyanga NP

Although Nyanga National Park is a protected area and hence not directly threatened by humans, field observations showed invasive alien species and wild fires to be the major threat factors to *P. africana* in the Park (Figures 1 and 2). Peculiar to Nyanga National Park is the threat posed by *F. ingens* whose slender stems grow around and envelop *P. africana* stems (Figure 2c), threatening the trees' survival through strangling. The strangled *P. africana* tree dies and is replaced by *F. ingens*. This is a serious threat considering that *P. africana* is rare and already threatened in Zimbabwe.

The problem of invasive alien species threatening habitats is not new and is reported here in relation to its threat on *P. africana* in Zimbabwe. In Nyanga National Park, the most serious invasive alien species are *A. mearnsii* and *P. patula* which are spreading from the

Table 1. *P. africana* clusters, geo-location, altitude, aspect and abundance in Nyanga National Park as of 2010.

Cluster number	Geo-location	Elevation (m.a.s.l)	I/U	Tree location, forest type, invader species and aspect	Cluster Size (Number of *P. africana* trees)
1	$18^{o}17'04''.6$; $32^{o}44'25''.9$	1793-1823	I	All trees located in or near pits. Sub-montane forests. Invaded by *A. mearnsii* and *P. patula*. Cluster is N (11) facing	11
2	$18^{o}16'58''.6$; $32^{o}44'10''.2$	1771-1799	I	All trees located in or near pits. Sub-montane forests. Invaded by *A. mearnsii*. Cluster is N (2)/NW (3)/W (3)/S (6) facing	14
3	$18^{o}17'02''.4$; $32^{o}44'67''.8$	1809-1817	I	All of the trees located along a stream. Sub-montane forests. Invaded by *A. mearnsii* and *P. patula*. Cluster E (1)/N (3) facing	4
4	$18^{o}17'34''.3$; $32^{o}44'08''.0$	1821-1837	I	All trees located in pits. Sub-montane forests. Invaded by *P. patula* and *A. mearnsii*. Cluster N (1)/NW (2) facing	3
5	$18^{o}17'52''.2$; $32^{o}43'40''.8$	1778-1818	I	Trees located along a stream. Sub-montane forests. Invaded by *A. mearnsii*. Cluster N (10)/W (3)/SW (1) facing	14
6	$18^{o}17'42''.9$; $32^{o}43'84''.3$	1784-1795	I	Trees located in a compound near a hotel. Sub-montane forests. Invaded by *A. mearnsii* and *P. patula*. Cluster NW (2)/E (2) facing	4
7	$18^{o}17'43''.9$; $32^{o}45'10''.2$	1859	U	Trees at the foot of a mountain. Sub-montane forests. Cluster NW (2) facing	2
8	$18^{o}16'52''.1$; $32^{o}43'02''.8$	1716-1737	U	All of the trees located in a gulley. Cluster located in miombo woodlands. Cluster E (8) facing	8
9	$18^{o}16'51''.1$; $32^{o}42'26''.5$	1716-1717	U	All trees located along a stream. Cluster located in miombo woodlands. Cluster N (1)/W (2) facing	3
10	$18^{o}18'07''.5$; $32^{o}43'33''.4$	1745-1805	U	All of the trees were located along a stream. Sub-montane forests. Cluster N (1)/W (10) facing	11

Table 1. Contd.

11	18°17′55″.7; 32°43′20″.1	1761-1782	I	Trees located in a gulley. Cluster located in sub-montane forests/ grassland. Invaded by *A. mearnsii* and *P. patula*. Cluster W (3) facing	3
12	18°18′07″.4; 32°43′09″.5	1738-1755	U	Trees located in or near pits. Cluster located in sub-montane forests. Cluster N (9)/NE (3) facing	12
Total					89

I, invaded; U, un-invaded; the number in brackets show the number of *P. africana* trees.

neighbouring forest plantations into the park (Figure 1).

Acacia mearnsii and *P. patula* spread mainly through seed. Mammals like *Papio urcinus* (Katsvanga et al., 2009) and birds feed on pine and acacia seed which they disperse into the Park. Furthermore, *A. mearnsii* seed dormancy is broken by fires which occur almost every year in the Park. This promotes invasion by this species. Due to the fast growth and high regeneration rates of *A. mearnsii* and *P. patula*, these species are gradually replacing indigenous species including *P. africana*. Invasive species can change the structure of local plant communities through competition and modification of fire regimes (Higgins et al., 1999; DiTomaso, 2000). Some deplete soil water faster and at greater soil depths, others utilize increased levels of soil nutrients faster than native species and thus reduce their growth rates (Brooks, 2000). Densely packed stands of invasive annual plants may reduce the germination rates of native plants (Inouye, 1991) and this is especially so for *P. africana* considering that it is shade intolerant (Stewart, 2003). This can significantly reduce native seedling biomass (Brooks, 2000) as indicated by the low regeneration of *P. africana* recorded in this study.

The densities of *A. mearnsii* were highly variable giving an average of 1100 stems/ha (815 sd) compared (P = 0.175) to *P. patula* which recorded 25 stems/ha (21.2 sd). The effect of invasive species on *P. africana* regeneration is apparent by comparing clusters 1 to 6 and 11 that were invaded with non-invaded clusters 7 to 10 and 12. Neither saplings nor seedlings were recorded in all the 7 invaded clusters. A total of 64, 2 and 16 saplings/seedlings were recorded under mature *P. africana* trees in non-invaded clusters 8, 10 and 12, respectively. Cluster 8 recorded a total of 12 seedlings < 5 cm height; 42 seedlings in the 5.1 to 20 cm height category; 3 saplings in the 20.1 to 50 cm height category and 7 saplings in the 50.1 to 150 cm category. The 2 seedlings recorded in in cluster 10 were < 5 cm in height. Cluster 12 had 14 saplings in the 20 to 50 cm height category and only 2 in the < 5 cm height category. Poor regeneration in invaded clusters could be attributed to the shading effect of invasive alien species or leaf litter thickness which was averaged at 5.89 cm (2.09 sd) for the invaded plots which was significantly higher (P = 0.46) than that of un-invaded plots which was 3.00 cm (2.23 sd) (Figures 2d to f). The thick litter makes it difficult for the small *P. africana* seed (length: 8.1 mm, width: 6.1 mm, height: 5.5 mm, mass: 0.15 g according to Farwig et al. (2007) to get access to conditions necessary for them to germinate and for the seedling to establish successfully. According to Betti (2008), poor esta-blishment conditions for the seedlings were the main cause of *P. africana* population decline in Cameroun. The study showed that there are more *P. africana*

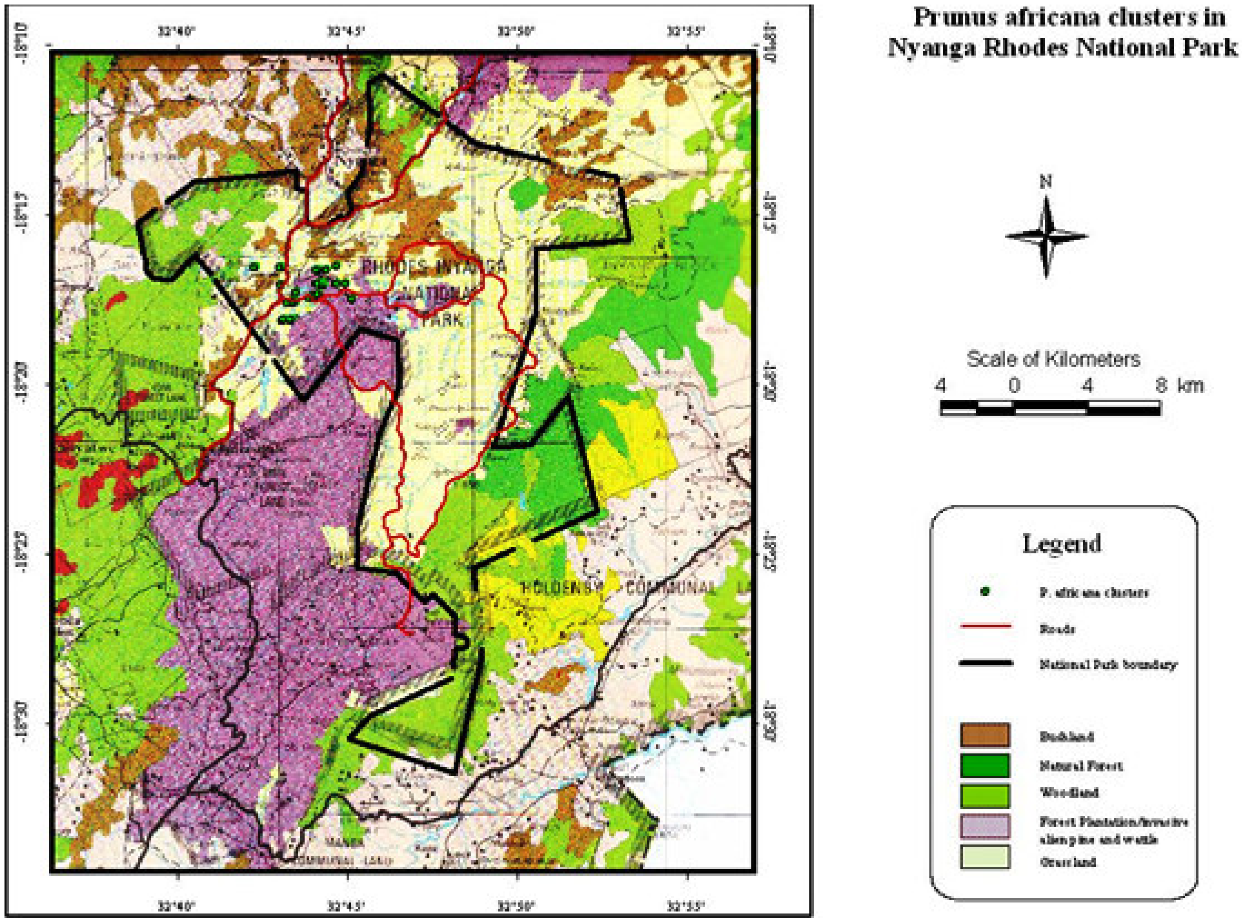

Figure 1. Map showing invasion into the National Park by *A. mearnsii* and *P. patula* (purple shade) as well as the distribution of *P. africana* clusters and vegetation types.

trees than previously recorded in the park. *P. africana* occurs mainly in sub-montane forests and to a lesser extent in miombo. The species is under threat from invasive alien species, *A. mearnsii* and *P. patula* which are invading its habitat and could be affecting regeneration through shading and excessive leaf litter production.

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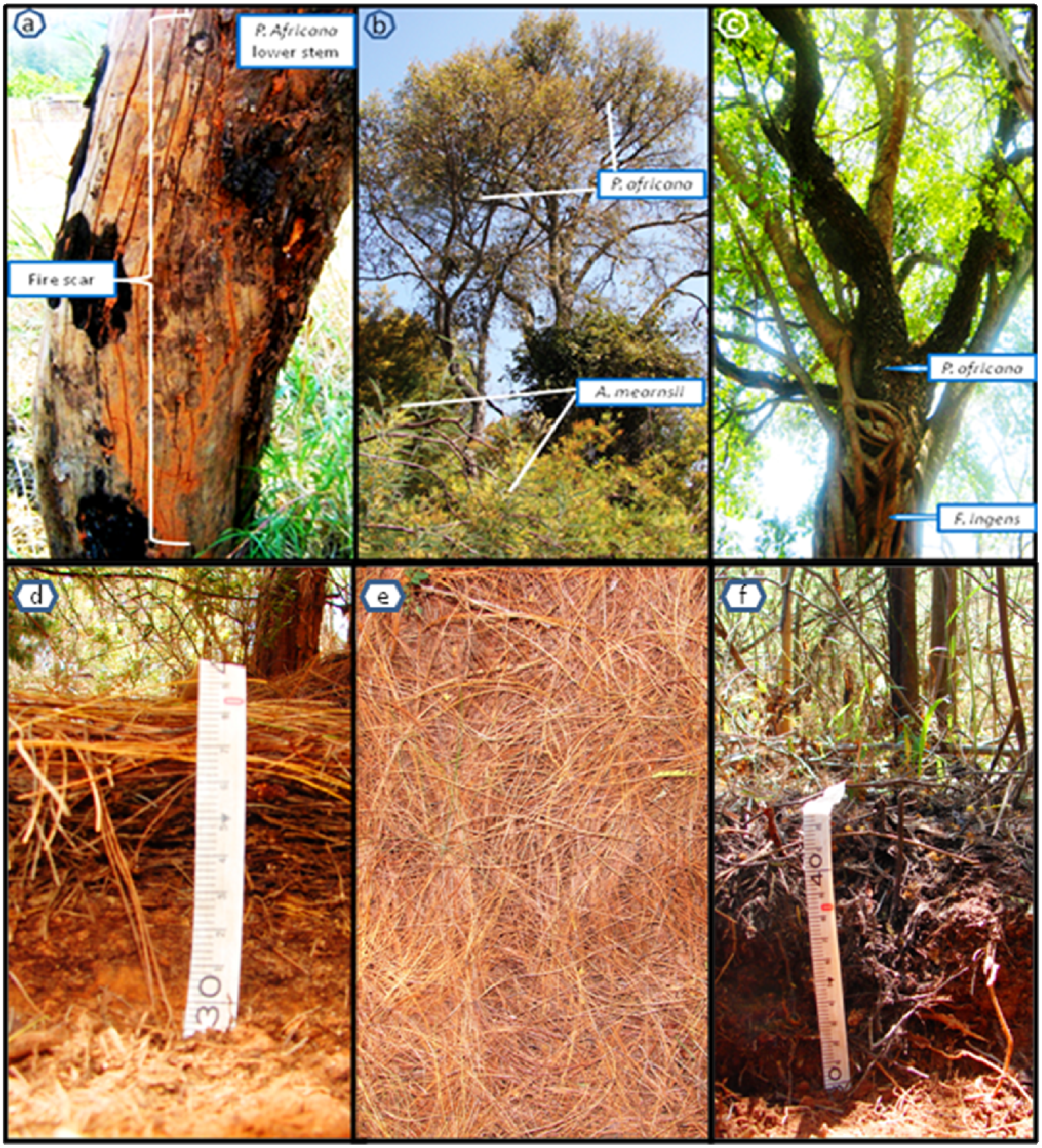

Figure 2. *P. africana* threats in Nyanga National Park (a) fire scar, (b) invasive alien species (*A. mearnsii*), (c) the strangling process of *P. africana* by *F. ingens*, (d), *P. patula* litter thickness, (e) *P. patula* litter on surface, (f) *A. mearnsii* litter thickness.

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