academicJournals

Vol. 6(12), pp. 869-875, December 2014
DOI: 10.5897/IJBC2014.0750
Article Number: 2A2D04549023
ISSN 2141-243X

http://www.academicjournals.org/IJB

International Journal of Biodiversity and Conservation

Full Length Research Paper

Population structure and regeneration status of *Prunus africana* (Hook.f.) Kalkm. after selective and clear felling in Kibale National Park, Uganda

Arthur A. Owiny* and Geoffrey M. Malinga

Department of Biology, University of Eastern Finland, P. O. Box 111, FI-80101 Joensuu, Finland.

Received 31 July, 2014; Accepted 7 November, 2014

Prunus africana **is a globally threatened indigenous medicinal tree species, and food for many primates. Its population has declined in Sub-Saharan Africa due to unsustainable harvest and poor protection. In this study, we determined the population density, population structure and regeneration status of *P. africana* in the former clear felled, selectively logged and primary forests of Kibale National Park, and assessed the effects of dense cover of *Acanthus pubescens* on its regeneration. Trees were measured from 180 randomly established plots. The densities of *P. africana* seedlings and saplings differed significantly among the three forests while that of poles and mature trees did not. The density of seedlings was significantly higher in the selectively logged than in primary forests. The density of saplings was higher in clear felled than in selectively logged forests. Tree density was not negatively affected by *A. pubescens* cover. Clear felled areas had a more stable population structure with better regeneration, while selectively logged and primary forests had unstable population structures with poor recruitment potential. Our results show that *P. africana* regenerates more in intensively disturbed forest areas than less disturbed or primary forests, highlighting the importance of regenerating forests in the conservation of *P. africana*.**

Key words: *Acanthus pubescens,* density, disturbance, population dynamics, regeneration, restoration, size class distributions, succession, tropical forest.

INTRODUCTION

African cherry (*Prunus africana* (Hook.f.) Kalkm.) is a globally vulnerable tropical tree species (IUCN, 2013), included as Appendix II by CITES in 1995 (Cunningham et al., 1997), and by FAO panel of Experts on Forest Genetic Resources as a species with maximum action priority in Africa (Navarro-Cerrillo et al., 2008). The population of mature sized trees has declined in many Sub-Saharan African forests due to subsistence and large

*Corresponding author. E-mail: owinyiarthur@yahoo.com. Tel: +256788557572.

Abbreviations: CITES, Convention on International Trade on Endangered Species; **FAO,** Food and Agriculture Organization; **IUCN,** International Union for the Conservation of Nature; **RAC,** regenerating age classes; **SCD,** size class distribution.

scale bark harvests for medicinal trade (Stewart, 2009; Jimu, 2011; Jimu et al., 2012). In Cameroon, Stewart (2009) showed that the number of surviving trees reduced in all size classes as a result of past harvesting. In Kibale National Park (KNP), a mean density of only 0.4 trees per ha has been reported (Chapman and Chapman, 1997). Moreover, *P. africana* is a highly preferred food source for many primates and frugivorous birds (Chapman and Chapman, 2002; Fashing, 2004).

Despite its threatened status, few tropical studies have examined its density, population structure, size class distributions and regeneration status as recommended by CITES, (2006) (but see, Fashing, 2004; Eilu and Obua, 2005; Kasenene, 2007a). Knowledge of tree population structure and density is important for understanding the status of regeneration of the species (Tesfaye et al., 2010). Kasenene (2007a) found significantly higher densities of *P. africana* saplings and poles in logged than in the unlogged coniferous forest of KNP.

Furthermore, the reproduction process of *P. africana* is not well documented. According to Farwig et al. (2006) and Berens et al. (2013), many seeds fall under the tree crown after heavy fruiting and are likely dispersed by frugivorous birds and monkeys. Despite massive seed production, its recruitment into the reproductive size classes is limited (Hall et al., 2000). The regeneration of *P. africana* is generally very low or sporadic (Stewart, 2003), reproducing best in large gaps and forest margins (Njunge, 1996; Ndam, 1996), probably due to lower predation rates at gaps and forest margins.

Tree regeneration processes, like seedling establishment, spatial distribution and population structure, might also be influenced by past disturbances, logging methods, colonizing vegetation, gap sizes, canopy cover, seed reproduction and dispersal (Vieira and Scariot, 2006; Bognounou et al., 2010). These factors can determine seedling recruitment, which is a critical part in tree development, because they can determine the rates of regeneration, growth forms and composition of mature populations. For example, in Kibale forest, the opportunistic woody herb, *Acanthus pubescens* Engl. (Acanthaceae) can colonize and dominate large canopy gaps created by logging. The resulting dense herb cover might interfere with the tree seedling establishment, growth and survival (Chapman et al., 1999; Paul et al., 2004; Lawes and Chapman, 2006), due to changes in light and nutrient availability (Duclos et al., 2013).

In this paper, we assessed the population and regeneration status of *P. africana* in the former clear felled coniferous plantation, selectively logged and primary forests. The specific objectives were to: 1) determine the population densities of seedlings, saplings, poles and mature individuals of *P. africana* in the clear felled, selectively logged and primary forests; 2) assess the size-class distributions and regeneration status of *P. africana* in the different forest areas; and 3) determine the effects of dense cover of *A. pubescens* on the regeneration of *P. africana*. We predicted that the recruitment rate of *P. africana* would be higher in the former clear felled and selectively logged areas than in the primary forest areas (Fashing, 2004). We expected to find higher densities (individual/ha) within the former clear felled and selectively logged than in the primary forest areas. We also anticipated that the densities of *P. africana* would negatively correlate with the cover of *A. pubescens* (Chapman and Chapman, 2004).

MATERIALS AND METHODS

Study area

This study was conducted in the Kanyawara compartments of Kibale National Park (KNP), located 20 km south-east of Fort Portal, western Uganda (0'13'-0"41' N and 30"19'-30'32' E). The park covers approximately 795 km^2. Rainfall is highly variable, but generally bimodal with peaks between March–May and September–November (Struhsaker, 1997). Mean annual rainfall at Kanyawara averages 1547 mm year^{-1} and annual means for daily minimum and maximum temperatures are 14.9 and 20.2°C (1990–2001), respectively (Chapman et al., 2005).

The study sites were located in four regenerating aged forests of the former clear felled coniferous plantation, hereafter referred to as 'clear felled areas', RAC9, RAC11, RAC14, RAC19, name indicating the approximate years since clear felled (Table 1, Nyafwono et al., 2014; Malinga et al., in press); three natural forest compartments selectively logged at varied intensities between 1967 and 1969 (K13, K14 and K15); and two primary forest compartments (K30 and K31). Compartment K13 was heavily logged (50% basal area reduction) during 1968-69 and treated with aboricide, Finopal (2:1 mixture of 2,4-D and 2, 4, 5-T). K15 was heavily logged from 1968 to 1969 (40% basal area reduction), whereas K14 was lightly selectively harvested in 1969 with basal area reduction of 25-27%. The primary forest compartment K30 had only two to three trees per hectare felled by pit sawyers in 1970 with minimal impact, while K31 was not harvested (Struhsaker, 1997). Logging activities resulted into large canopy gaps and forest tracts at various levels of disturbances and degradation (Kasenene, 2007b).

Study species

P. africana (Hook. f.), also known as African cherry, belongs to the subfamily Prunoideae in the Rosaceae family and genus *Prunus*. It is an evergreen canopy tree species that can grow between 25 to 30 m in height (Hall et al., 2000). It is distributed primarily in montane and middle-elevation forests of Sub-Saharan Africa (Hall et al., 2000, Stewart, 2009). The leaves are simple, alternately arranged, and elliptic to oblong or slightly ovate. The flowers are small, creamy white, androgynous, wind pollinated and are distributed in axillary racemes of 3.5-8 cm long (Lovett et al., 2006). The fruit is a red or red-brown ellipsoid drupe, 0.7 cm long and 1.1 cm in diameter (Hall et al., 2000; Lovett et al., 2006), and is dispersed by birds and monkeys (Fashing, 2004).

Study design and tree measurement

The Kanyawara forest area in KNP was classified and mapped a priori into nine differently aged successional forests by inspection of Landsat images (Malinga et al., in press). In each of the nine aged

Table 1. Mean density (individuals ha^{-1}) of *P. africana* in different size classes among the different forests areas.

Variable	Mean density (individuals ha^{-1})			Kruskal-Wallis test		
	Clear felled	Selectively logged	Primary forest	χ^2	df	*P*
Seedlings	11.25 ± 4.36	16.67 ± 5.40	0	6.53	2	0.04
Saplings	7.50 ± 3.99	0	0	9.05	2	0.01
Poles	3.44 ± 1.52	0.42 ± 0.41	0.63 ± 0.63	4.41	2	0.13
Mature trees	2.81 ± 1.37	6.25 ± 2.65	0.31 ± 0.31	2.46	2	0.29

successional forest, the location of 20 sampling plots was randomly established using a relative grid system, based on the actual sizes of RACs (RAC9-RAC19), and others (K13, K14, K15, K30 and K31) approximately on the same sized areas as RACs. At each GPS location, study plots were established with sides oriented to north (40 m) and east (20 m) direction. If the plot extended into foot trails or inaccessible points such as steep slopes, it was re-oriented perpendicular from that direction.

In each plot, we counted the number of individuals and measured for either stem diameter (saplings, poles and mature trees) or diameter above the root collar for seedlings (Kent and Coker, 1992). The species was identified by a trained botanist at the Makerere University Biological Field Station (MUBFS) Mr. Richard Sabiti, and voucher specimens have been deposited at MUBFS. The diameter of saplings, poles and mature trees were measured at the 1.3 m height, that is, diameter at breast height (DBH). Tree diameters of mature trees (diameter class > 20 cm), poles (diameter class 10–20 cm), saplings (diameter class 5–10 cm) and seedlings (diameter class 0–5 cm) were measured in nested plots of 40 × 20, 20 × 20, 20 × 10 and 10 × 10 m, respectively. At each plot, we visually estimated the percentage cover of *Acanthus pubescens* as follows: 0, <1% = 1, <10% = 10, <20% = 20, <30% = 30, etc. Because of low tree observations, in each aged successional forest, plots were regrouped into three forest areas based on previous history of disturbance, namely; clear felled (RAC9, RAC11, RAC14 and RAC19, logged between 9 to 19 years ago (80 plots)); selectively logged (K13, K14 and K15, logged 42-43 years ago (60 plots)); and primary forests (K30 and K31 (40 plots)), respectively.

Data analysis

For each of the three forest areas, we assessed the densities (individuals ha^{-1}) of *P. africana* in each size class (seedlings, saplings, poles and mature trees). A non-parametric Kruskal-Wallis test was used to compare *P. africana* densities in each size class among forests, since the data were not normally distributed. Whenever differences were significant, Mann-Whitney *U* test as a pair wise comparison was used. All analyses were conducted with IBM SPSS Statistics, Version 19.

To examine the population structure (distribution of individuals in the different size classes) and regeneration patterns of *P. africana*, in each of the three forests, tree counts were converted into densities (individuals ha^{-1}) (Venter and Witkowski, 2010). Population structure and regeneration status of *P. africana* was analyzed by computing the slope of regression of size class distribution (SCD) as proposed by Condit et al. (1998) and Lykke (1998). Tree diameters were categorized into thirteen size classes: [0.1 to 5], [5.1 to 10.0], [10.1 to 15.0], [15.1 to 20.0], [20.1 to 25.0], [25.1 to 30.0], [30.1 to 35.0], [35.1 to 40.0], [40.1 to 45.0], [45.1 to 50.0], [50.1 to 55.0], [55.1 to 60.0] and [> 60.0 cm]. The linear regression slope of SCD was calculated with the size-class distribution midpoint (d_i) as the independent variable and the number of individuals (N_i) in each size class as the dependent variable. In order to obtain straight line plots (Obiri et al., 2002), N_i was transformed by $\ln(N_i + 1)$ because some size classes were without individuals. The regression was calculated between d_i and $\ln(N_i + 1)$ (Lykke, 1998; Obiri et al., 2002; Venter and Witkowski, 2010). SCD slopes of regressions were used as indicators of recruitment and population structure (Obiri et al., 2002; Mwavu and Witkowski, 2009; Tabuti, 2007; Venter and Witkowski, 2010). Negative slopes indicate good recruitment, with proportionally more individuals in smaller than in larger size-classes. A flat distribution with a slope of zero indicate approximately equal numbers of individuals in smaller and larger size-classes, while positive slopes indicate unstable or poor recruitment with more trees found in larger than in smaller size classes (Obiri et al., 2002). The steepness of the slope was further used to describe the recruitment trends in the different forest areas. Steep negative slopes indicate better recruitment than shallow slopes (Lykke, 1998; Mwavu and Witkowski, 2009).

To test for the associations between *A. pubescens* cover at each study plot, and its influence on *P. africana* tree density, spearman rank correlation was calculated. We used Kruskal-Wallis test to compare the distribution of *A. pubescens* cover between the clear felled, selectively logged and primary forests, since the data was not normally distributed.

RESULTS AND DISCUSSION

Population densities of *P. africana* in the different forest areas

We recorded significant differences in the densities of *P. africana* seedlings and saplings across the three forest areas (Table 1). The densities of poles and mature trees did not differ significantly across the three forest areas (Table 1). According to the pairwise tests, seedling densities differed, and were significantly higher in the selectively logged than in the primary forests (Mann-Whitney *U* test, z = -2.552, *P* = 0.011, Figure 1). Sapling density also differed, and were significantly higher in the clear felled than in the selectively logged forests (z = -2.342, *P* = 0.019), but no significant difference was found for sapling density between selectively logged and primary forests (*P* = 1.00, Figure 1). The high density of *P. africana* seedlings and saplings recorded in the selectively logged or clear felled areas in comparison with the primary forests support several previous studies indicating that *P. africana* can regenerate well in the more disturbed or forest gaps than in less disturbed forests (Kiama and Kiyrapi, 2001; Ndam, 1996; Fashing, 2004). This suggests that the tree is a light demanding secondary forest species.

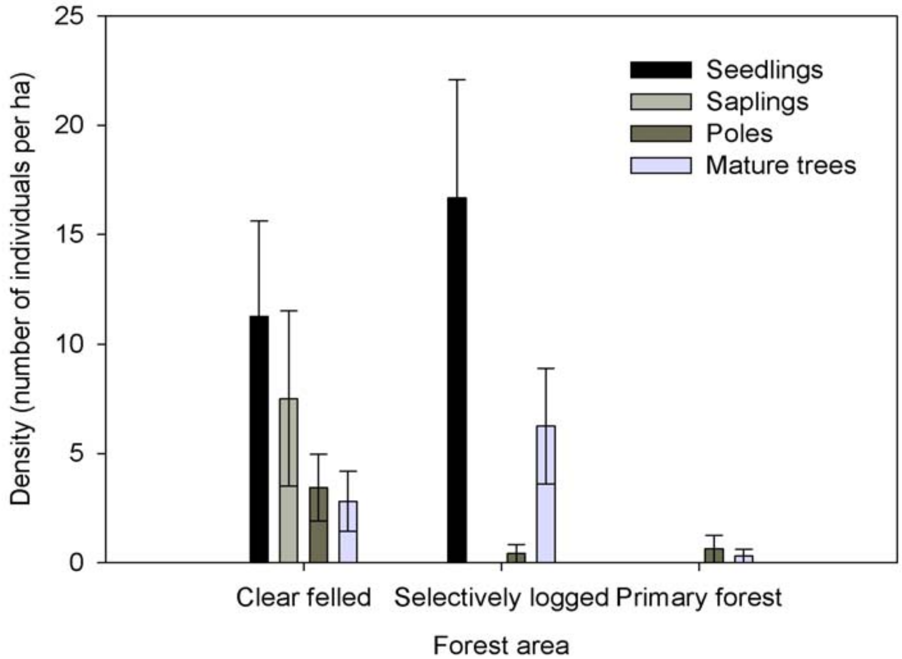

Figure 1. Population density (individuals ha^{-1}) of *P. africana* in the clear felled, selectively logged and primary forest areas in KNP.

Population structure and recruitment in different forests

Our results indicated that *P. africana* population structure in clear felled areas had a significant negative SCD slope (Slope = -2.176, r^2 = 0.77, P < 0.001, Figure 2) and an inverse *J*-shaped size class distribution, with a considerably smooth decline in the number of individuals from smaller to larger size classes (Figure 2). Such a trend is an indication of a healthy and stable population that are naturally replacing themselves through good recruitment (Condit et al., 1998; Mwima and McNeilage, 2003; Muoghalu, 2006; Tabuti, 2007). In contrast, the population structures of *P. africana* in the selectively logged and primary forests had positive slopes (Figure 2) which is indicative of an unstable population with a poor recruitment potential, that is, there are more individuals in the larger than in the smaller size classes. Such recruitment bottlenecks can weaken the population structure which might lead to local extinction of species (Obiri, et al., 2002; Tabuti and Magula, 2007; Gwali et al., 2009). The higher rates of recruitment of *P. africana* in clear felled areas might partly be due to higher rates of seed dispersal or seed banks in clear felled as compared to the selectively logged or primary forests (Farwig et al., 2006; Tesfaye et al., 2010). Previous studies have shown that *P. africana* trees in disturbed areas are visited more by dispersal agents, e.g., birds and monkeys than those in the primary forest (Chapman and Chapman, 2004; Farwig et al., 2006). The poor regeneration recorded in the primary or selectively logged forests could be attributed to insufficient light penetrating the forest floor (Fashing, 2004; Jimu et al., 2012).

Influence of *A. pubescens* cover on the regeneration of *P. africana*

At plot level, the cover of *A. pubescens* differed significantly between the clear felled, selectively logged and primary forests (Kruskal-Wallis test, χ^2 = 12.75, df = 2, *P* = 0.002). Despite significant variations between forests, the cover of *A. pubescens* was positively associated with density of *P. africana* (Spearman correlations; rho = 0.21, *P* = 0.004) suggesting that, the increase in *A. pubescens* cover might not affect regeneration of *P. africana* as we expected. In KNP, dense *A. pubescens* cover occurs in logged sites and canopy gaps. This herb cover limits forest regeneration by slowing down tree seedling establishment, growth and survival by altering the light and nutrients availability to tree seedlings (Lawes and Chapman, 2006; Duclos et al., 2013). The high tolerance of *P. africana* to *A. pubescens* cover might be a result of its ability to grow relatively fast or establish in shade (Kiama and Kiyrapi, 2001; Meunier et al., 2010). Our result suggest that *P. africana* might be an ideal species for forest restoration activities in logged areas dominated by extensive *A. pubescens* cover like in KNP.

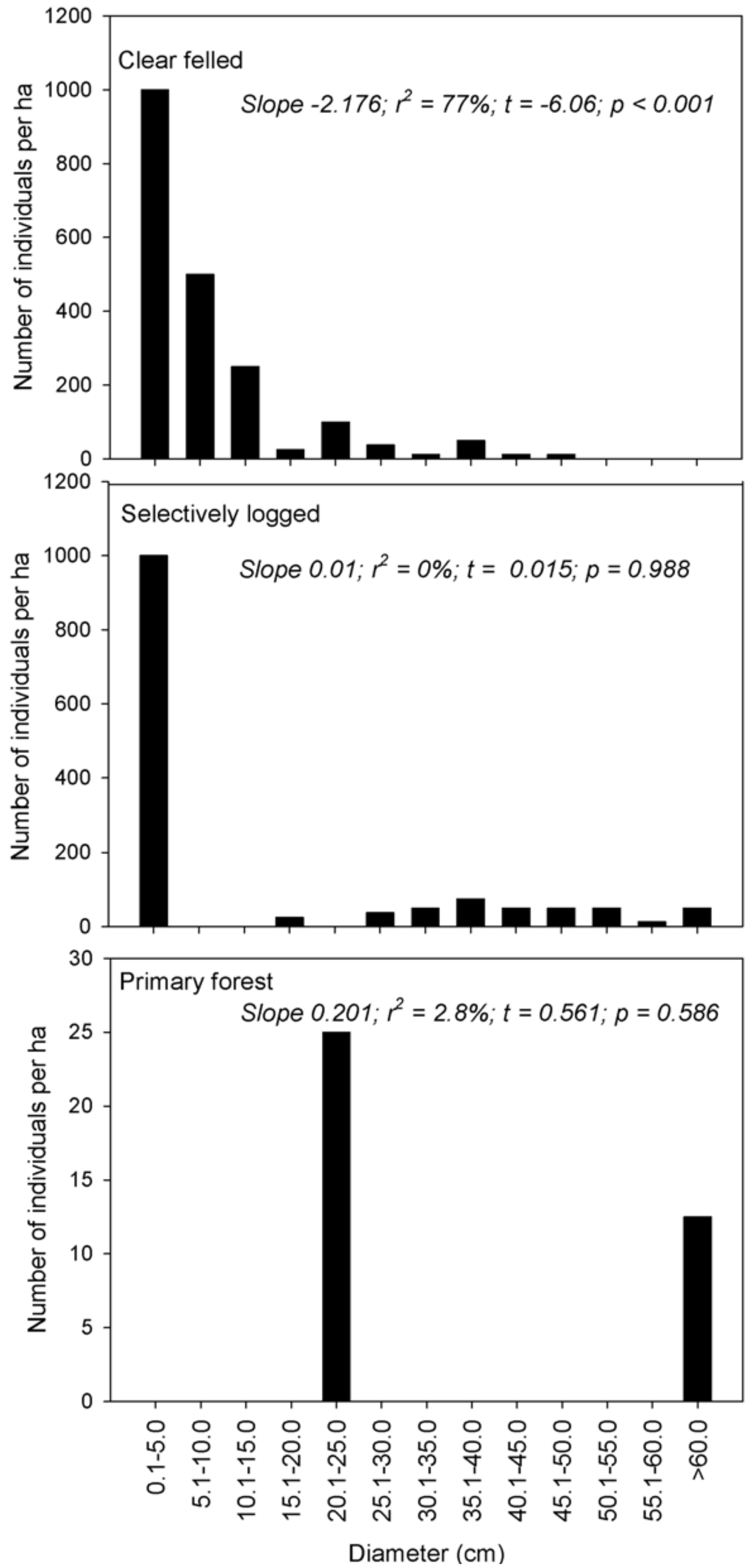

Figure 2. Size class distribution plots of *P. africana* in the clear felled, selectively logged and primary forest areas of KNP. The y-axis represents the individuals (ha^{-1}) while the x-axis is tree diameter size class in 5 cm intervals from 0.1 to 60 cm.

Conclusion

In this study, we showed that clear felled and selectively logged areas support proportionally higher densities of *P. africana* seedlings and saplings than primary forests suggesting that it is a light demanding species. Additionally, our results show that *A. pubescens* cover does not negatively affect the regeneration of *P. africana* in KNP. Clear felled areas had a stable population structure, with good recruitment potential, whereas that in the selectively logged and primary forests was unstable and had poor regeneration. This indicates that *P. africana* requires relatively heavy disturbances in order for it to regenerate, high-lighting the importance of the studied regenerating forests in the conservation of the tree species.

Conflict of Interests

The authors declare that there is no conflict of interest.

ACKNOWLEDGEMENTS

The study was funded by the Finnish Academy of Science, (SA no: 138899 to Roininen Heikki) under the Tropical forest Biodiversity recovery project. Permission to conduct this study was granted by the Uganda Wildlife Authority and the Uganda National Council of Science and Technology. We thank R. Sabiiti for his help with field work.

REFERENCES

Berens DG, Griebeler EM, Braun C, Chituyi BB, Nathan R, Böhning-Gaese K (2013). Changes of effective gene dispersal distances by pollen and seeds across successive life stages in a tropical tree. Oikos 122:1616-1625.

Bognounou F, Tigabu M, Savadogo P, Thiombiano A, Boussim IJ, Oden PC, Guinko S (2010). Regeneration of five *Combretaceae* species along a latitudinal gradient in Sahelo-Sudanian zone of Burkina Faso. Ann. For. Sci. 67:306.

Chapman CA, Chapman LJ (1997). Forest regeneration in logged and unlogged forests of Kibale National Park, Uganda. Biotropica 29:396-412.

Chapman CA, Chapman LJ (2002). Foraging challenges of red colobus monkeys: influence of nutrients and secondary compounds. Comp. Biochem. Physiol. A 133:861-875.

Chapman CA, Chapman LJ (2004). Unfavorable successional pathways and the conservation value of logged tropical forest. Biodivers. Conserv.13:2089-2105.

Chapman CA, Chapman LJ, Kaufman L, Zanne AE (1999). Potential causes of arrested succession in Kibale National Park, Uganda: growth and mortality of seedlings. Afr. J. Ecol. 37:81-92.

Chapman CA, Chapman LJ, Struhsaker TT, Zanne AE, Clark CJ, Poulsen JR (2005). A long-term evaluation of fruiting phenology: importance of climate change. J. Trop. Ecol. 21:31-45.

Condit R, Sukumar R, Hubbell SP, Foster RB (1998). Prediction of population trends from size distributions: a direct test in a tropical tree community. Amer. Nat. 152:495-509.

Convention on International Trade in Endangered Species of wild fauna and flora (CITES) (2006). Evaluation of the harvest of *Prunus africana* bark on the Bioko Island (Equatorial Guinea): guidelines for a management plan. *Review of significant trade in specimens of Appendix-II species. Sixteenth meeting of the Plants Committee*, Peru. PC16 Doc. 10.2.1, pp. 13.

Cunningham M, Cunningham AB, Schippmann U (1997). Trade in *Prunus africana* and the Implementation of CITES. German Federal Agency for Nature Conservation, Bonn.

Duclos V, Boudreau S, Chapman CA (2013). Shrub cover influence on seedling growth and survival following logging of a tropical forest. Biotropica 45:419-426.

Eilu G, Obua J (2005). Tree condition and natural regeneration in disturbed sites of Bwindi Impenetrable Forest National Park, southwestern Uganda. Trop. Ecol. 46:99-111.

Farwig N, Böhning-gaese K, Bleher B (2006). Enhanced seed dispersal of *Prunus africana* in fragmented and disturbed forests? Oecologia 147:238-252.

Fashing PJ (2004). Mortality trends in the African cherry (*Prunus africana)* and the implications for colobus monkeys (*Colobus guereza*) in Kakamega Forest, Kenya. Biolo. Conserv. 120:449-459.

Gwali S, Okullo P, Hafashimana D, Byabashaija DM (2009). Diversity and composition of trees and shrubs in Kasagala forest: a semiarid savannah woodland in central Uganda. Afr. J. Ecol. 48:111-118.

Hall JB, O'Brien EM, Sinclair FL (2000). *Prunus africana*: a monograph. School of Agricultural and Forest Sciences Publication Number 18, University of Wales, Bangor. pp.104.

IUCN (2013). IUCN Red List of Threatened Species. Version 2013.1. http:// www.iucnredlist.org.

Jimu L (2011). Threats and conservation strategies for the African cherry (*Prunus africana*) in its natural range-A review. J. Ecol. Nat. Environ. 3:118-130.

Jimu L, Ngoroyemoto N, Mujuru L (2012). Structural diversity and regeneration of the endangered *Prunus africana* (Rosaceae) in Zimbabwe. Afr. J. Ecol. 51:102-110.

Kasenene JM (2007a). Impact of exotic plantations and harvesting methods on the regeneration of indigenous tree species in Kibale forest, Uganda. Afr. J. Ecol. 45 (Suppl. 1):41-47.

Kasenene JM (2007b). Post logging structural changes and regeneration of *Olea welwitschii* (Knobl) Gilg and Schellemb in the Kibale National Park, Uganda. Afr. J. Ecol. 45 (Suppl. 3):109-115.

Kent M, Coker P (1992). Vegetation Description and Analysis, a practical approach, Belhaven Press, London, UK.

Kiama D, Kiyiapi J (2001). Shade tolerance and regeneration of some tree species of a tropical rain forest in Western Kenya. Plant Ecol. 156:183-191.

Lawes MJ, Chapman CA (2006). Does the herb *Acanthus pubescens* and/ or elephants suppress tree regeneration in disturbed Afrotropical forest? For. Ecol. Manage. 221:278-284.

Lovett JC, Ruffo CK, Gereau RE, Taplin JRD (2006). Field Guide to the Moist Forest Trees of Tanzania, The Society for Environmental Exploration, UK and the University of Dar es Salaam, Tanzania.

Lykke AM (1998). Assessment of species composition change in savanna vegetation by means of woody plants' size class distributions and local information. Biodivers. Conserv. 7:1261-1275.

Malinga GM, Valtonen A, Nyeko P, Roininen H (2014). High resilience of galling insect communities to selective and clear-cut logging in a tropical rainforest. Int. J. Trop. Insect Sci. (in press).

Meunier Q, Lemmens R, Morin A (2010). *Alternatives to exotic species in Uganda: Growth and cultivation of 85 indigenous trees.* GraphiConsult (U) Ltd, Kampala, Uganda. pp. 152.

Muoghalu JI (2006). Tree species population dynamics in a secondary forest at Ile-Ife, Nigeria after a ground fire. Afr. J. Ecol. 45:62-71.

Mwavu EN, Witkowski ETF (2009). Population structure and regeneration of multiple-use tree species in a semi-deciduous African tropical rainforest: implications for primate conservation. For. Ecol. Manage. 258:840-849.

Mwima PM, McNeilage A (2003). Natural regeneration and ecological recovery in Bwindi Impenetrable National Park, Uganda. Afr. J. Ecol. 41:93-98.

Navarro-Cerrillo RM, Clemente M, Padrón E, Hernandez-Bermejo E, Garcia-Ferrer A, Kasimis N (2008). Forest structure in harvested sites of Afromontane forest of *Prunus africana* (Hook.f.) Kalkm. in Bioko (Equatorial Guinea). Afr. J. Ecol. 46:620-630.

Ndam N (1996). Recruitment patterns of *Prunus africana* (Hook f.) Kalkman on Mount Cameroon: a case study at Mapanja. In: *A Strategy for the Conservation of Prunus africana on Mount Cameroon*. Technical Papers and Workshop Proceedings.

Njunge JT (1996). Species composition and regeneration at South Nandi forest, Kenya. PhD thesis, University of Wales, Bangor. pp. 216.

Nyafwono M, Valtonen A, Nyeko P, Roininen H (2014). Butterfly community composition across a successional gradient in a human-disturbed Afro-tropical rainforest. Biotropica 46:210-218.

Obiri J, Lawes M, Mukolwe M (2002). The dynamics and sustainable use of high value tree species of the coastal Pondoland forests of the Eastern Cape Province, South Africa. For. Ecol. Manage. 166:131-148.

Paul JR, Randle AM, Chapman CA, Chapman LJ (2004). Arrested succession in logging gaps: is tree seedling growth and survival limiting? Afr. J. Ecol. 42:245-251.

Stewart KM (2003). The African cherry (*Prunus africana*): Can lessons be learned from an over-exploited medicinal tree? J. Ethnopharmacol. 89:3-13.

Stewart KM (2009). Effects of bark harvest and other human activity on populations of the African cherry (*Prunus africana*) on Mount Oku, Cameroon. For. Ecol. Manage. 258:1121-1128.

Struhsaker TT (1997). Ecology of an African Rain Forest: Logging in Kibale and the Conflict between Conservation and Exploitation, University Press of Florida, Gainesville, FL.

Tabuti JRS (2007). The uses, local perceptions and ecological status of 16 woody species of Gadumire Sub-county, Uganda. Biodivers. Conserv. 16:1901-1915.

Tabuti JRS, Mugula BB (2007). The ethnobotany and ecological status of *Albizia coriaria* Welw. ex Oliv. in Budondo Sub-county, eastern Uganda. Afr. J. Ecol. 45:126-129.

Tesfaye G, Teketay D, Fetene M, Beck E (2010). Regeneration of seven indigenous tree species in a dry Afromontane forest, southern Ethiopia. Flora 205:135-143.

Venter SM, Witkowski ETF (2010). Baobab (*Adansonia digitata* L.) density, size–class distribution and population trends between four land–use types in northern Venda, South Africa. For. Ecol. Manage. 259:294-300.

Vieira DLM, Scariot A (2006). Principle of natural regeneration of tropical dry forests restoration. Restor. Ecol. 14:11-20.