Establishment of the population structure and abundance of P. *africana* in Western Mau Forest.

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Abstract: *Prunus africana* (Hook. f) Kalkman, 1965 (formerly *Pygeum africanum* Hook.f) is a geographically widespread tree restricted to highland forest of main land Africa and outlying islands. The species is commercially important for its bark, which is used in the treatment of prostate gland disorders. It also produces high quality timber used locally for building poles and furniture as well as fuel wood. The high demand for the bark has led to notable destruction of the species in natural forests, leading to concerns on the long term sustainability of harvesting and the conservation of the species. In this study, information on *P. africana* was obtained mainly from literature survey while population data was obtained by sampling methods. The study was conducted in Western Mau forest (E35^{0}27.05' and E35^{0}39.42') which is found in the South Rift region, Kericho county. Transects were laid across four blocks in Western Mau forest and diameter at breast height (dbh) of mature trees measured along with their total heights. Saplings were counted and recorded in subplots and seedlings counted in micro plots. Densities of seedlings, saplings and mature *P. africana* trees were examined across the Western blocks of Mau forest. The data generated was analyzed and presented using both descriptive and inferential statistics. Data on height and dbh were summarized as mean ± SE and variations tested using one way ANOVA. Histograms, tables and graphs showed that there were differences in the densities of seedlings, saplings and trees across the forest blocks. Inferential statistics however only revealed significant variation in the density of saplings ($p<0.05$). The seedling numbers exceeded saplings and trees, suggesting potential for regeneration and population increase even though the population is not increasing. It was recommended that an awareness creation be organized regularly for all stakeholders on sustainable de-barking and logging be greatly regulated to save this tree of great value to mankind. The local community and more so those who rely on the tree for herbal medicine should be encouraged to grow the tree in their botanical gardens to reduce the pressure on wild trees thereby enhancing its conservation.

Key words: Population, Structure, Abundance, *P-africanas*

INTRODUCTION

Prunus africana is an African tree and exhibits different structure and distribution pattern between different African countries. Until the late 1960s, the tree was known only for its timber, as fuel and as a traditional medicine (Stewart, 2001). Cameroon has the longest history of bark harvest, and most studies of the harvest are from here, particularly from Mount Cameroon. The dire state of the remaining populations of *P. africana* in Cameroon appears to be due to complex and inter-related social and economic factors. For example, until the late 1980s, hundreds of square kilometers surrounding Mount Oku in the North West province were completely forested. Today only10, 000 ha of montane forest remain. The same case applies for Madagascar.

In South Africa, *P. africana* has a limited distribution and small harvest occurs in the Eastern and Transkei Mist-belt forest located in the eastern montane regions generally between the cities of Umtata and Peitermaritzburg. The tree can be described as scarce if not extinct in Rwanda which is corroborated by lack of harvest from the country.

In Kenya *P. africana* is exported as dried bark, chipped bark and timber. Harvest began in 1995 with the export peaking at 500 tons of bark in 1998 and about 300 tons were shipped in 2000. Only one exporter (Jonathan Leakey) has been involved in the *P. africana* trade in Kenya and he ships dried or chipped bark to France. Cultivation trials have been conducted, but large scale plantations are not yet in production (Kuijper, 2011). Mature trees are also exploited for their timber. Following harvest of mature trees for local and export timber products, Farwig *et al*. (2007) examined the Kakamega forest in Western Kenya and found few saplings and young trees, suggesting poor recruitments resulting from the removal of mature trees, poor germination or herbivory on seedlings.

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MATERIALS AND METHODS

Study Area

The research was carried out in selected sub blocks within Western Mau Forest block which is the fifth largest block of Mau Complex in the South Rift region of the Rift Valley Province of Kenya (Figure 1). It is located in Kericho County at an altitude of between 2000 and 2600 m above sea level; and between latitude 0^0 10’ 46’’S to 0^0 17’ 42” S and longitude of 35^0 27’ 05’’ E to 35^0 39’ 42” E. It is managed by Kenya Forest Service and covers about 22,712 hectares of indigenous forest. The study blocks were Sorget, Masaita, Kedowa, and Kerisoi.

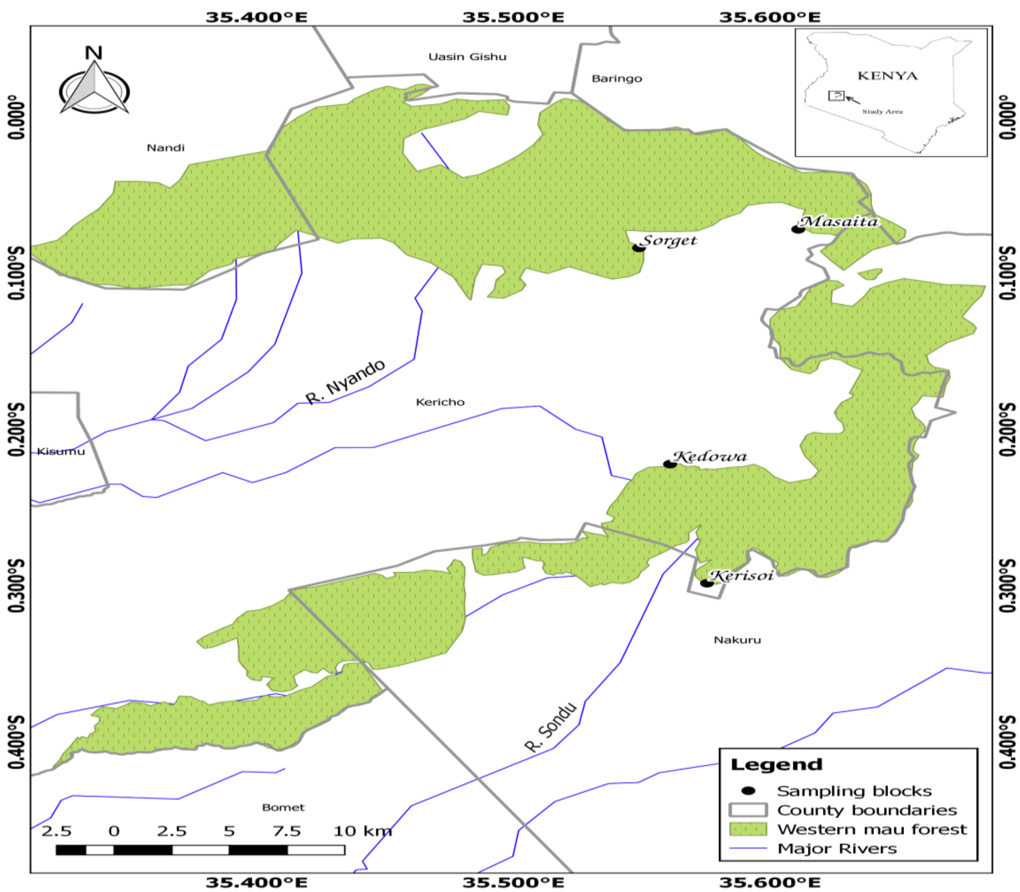

Figure 1: Map of Western Mau Forest and Locations of the Study Blocks.

Sampling and sampling procedure

Stratified sampling was used to lay a total of six transects and six quadrats in each of the forest blocks. Distances between 0 and 500m were drawn between the successive transects and quadrats marked. In each of the 50x50m square quadrats, corners were marked using GPS coordinates for geo-referencing. Two quadrats were placed at the beginning, two at the middle and the remaining two at the end of the marked transect per sampling block.

Data Collection and analysis

From each block, respondents were also interviewed using structured questionnaires to determine their uses of the target tree and their perceptions on the factors affecting the tree. The respondents were selected objectively to represent the various groups in terms of age and economic status. Key informants such as herbalists and provincial administrators were also interviewed with separate set of questions. Photograph taking was also part of the ways of collecting data. This helped in capturing salient information about the study.

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All the data generated were entered in excel spreadsheet for the purpose of storage and management. Qualitative data were converted into quantitative form and represented in form of proportions. The influences of human activities was tested using chi-square statistics at 95% confidence levels.

RESULTS

From the study, 305 *P. africana* were identified and recorded from all the blocks within Western Mau forest. This translates to an average of approximately 13 plants in a 50m × 20m quadrat translating to approximately 130 pieces per ha. On a spatial scale, Masaita block had the highest number of *P. africana* plant (185 pieces per ha) representing 36.4% while Kerisoi had 57 pieces per ha which was the least (11.8%) where as Kedowa and Sorget were second and third in total abundance respectively (Fig. 4.1).

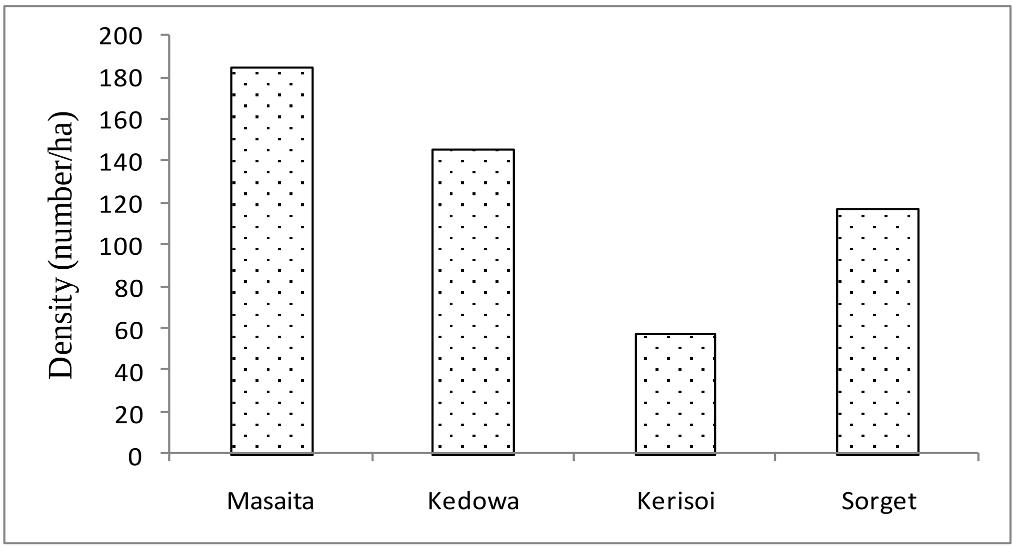

Figure 2: Population density of *Prunus africana* per block within western Mau forest during the study period.

Kruskal-wallis test revealed significant variation in total abundance between the blocks ($p = 0.041$) though Mann Whitney u test grouped together Masaita and Kedowa but separated kerisoi and Sorget from the two blocks.

Population structure of *P. africana.*

Three age categories of *P. africana* namely seedlings, saplings, and trees were observed and recorded in varying proportions. The forest was generally dominated by seedlings accounting for 39.0% of the total population recorded followed by saplings (36%) while the mature trees (25%) were the lowest in proportion (Fig. 4.2).

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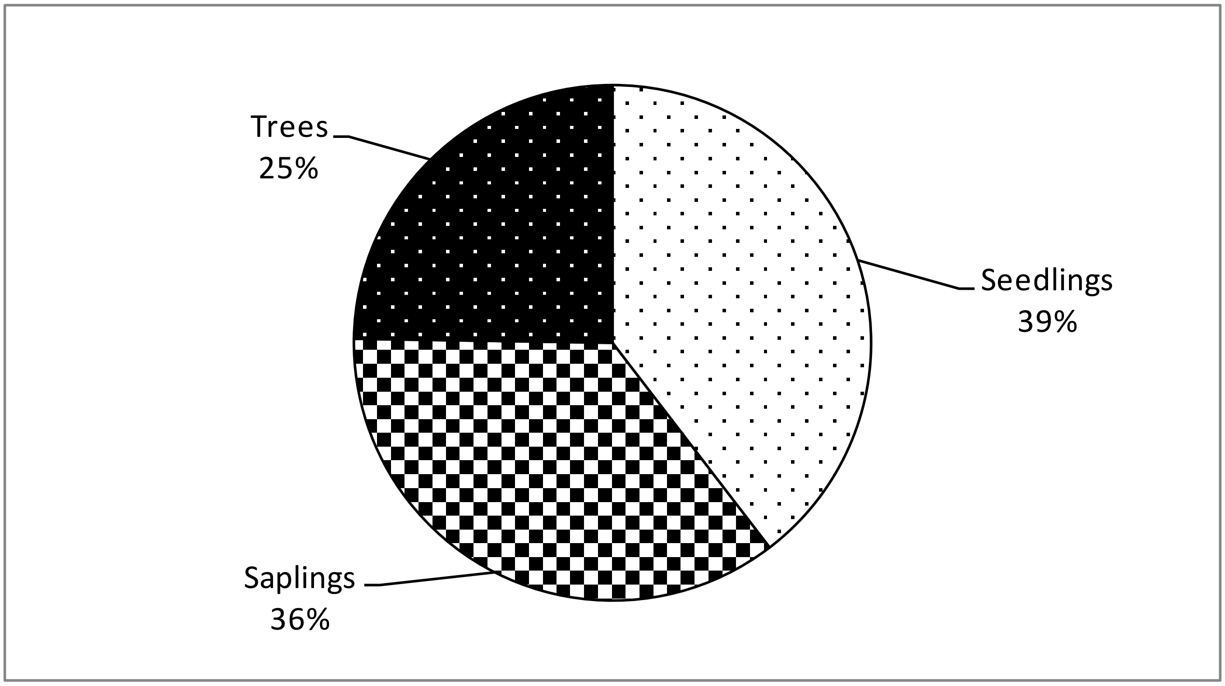

Figure 3: Proportions of trees, saplings, and seedlings of *Prunus africana* within western Mau forest during the study period.

On examining the various age categories per site, the populations of *P. africana* in Kedowa and Kerisoi were dominated by saplings followed by seedlings and finally trees (Fig. 4.3). Masaita had an almost equal proportion of saplings and seedlings while trees were the least in proportion. Sorget had seedlings being the most dominant whereas saplings were the least in proportion.

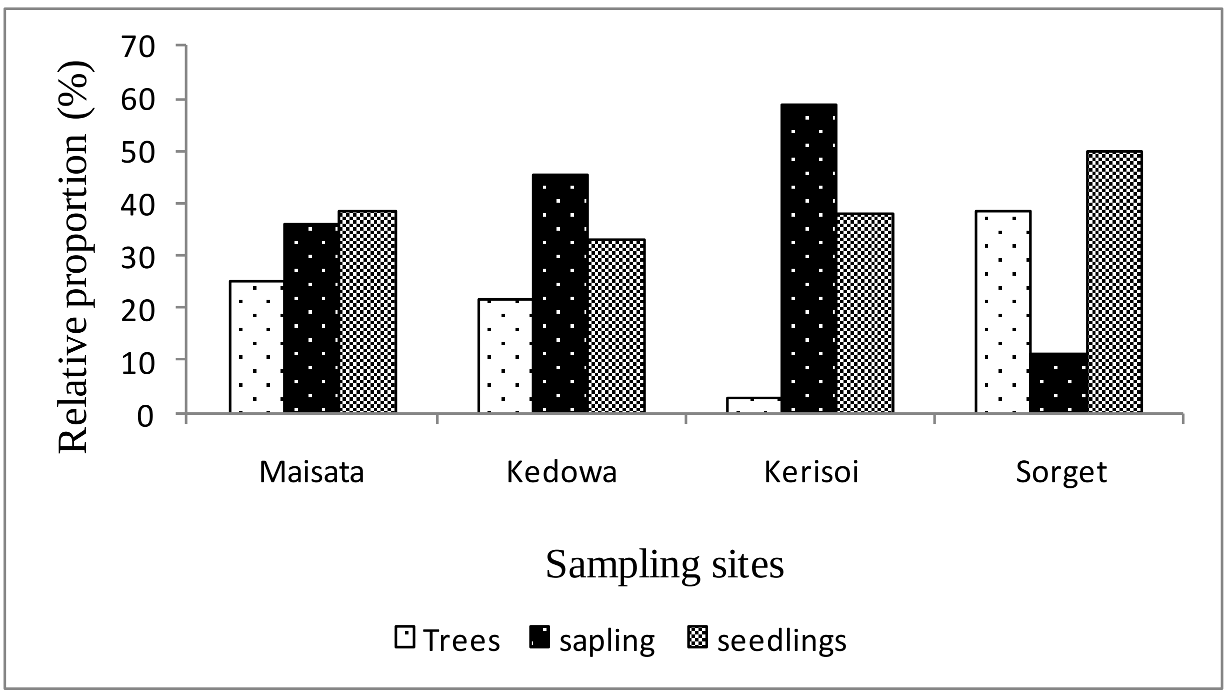

Figure 4: Proportions of trees, saplings, and seedlings of *Prunus africana* at the various sites within western Mau forest.

The highest density of seedlings was found in Masaita with an average density of 72 seedlings per hectare followed by Sorget with 58 seedlings per hectare while Kerisoi block had the lowest density (Table 4.1). A log transformed one way ANOVA revealed that there

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was no significant variation in the number of seedlings between the blocks (p > 0.05). Turkey test further grouped Masaita, Kedowa, and Sorget blocks in one sub set and separated Kerisoi from them, an indication that Kerisoi block variedly significantly from the other three blocks in terms of seedling abundance. Just like for seedlings, a higher density of saplings were recorded in Masaita though this was followed by Kedowa block and not Sorget which was the least dense. One way ANOVA revealed significant difference in number of saplings recorded between the blocks (p <0.05). Turkey test grouped the blocks in three sub sets, putting Masaita and Kedowa together in one sub set where as Kerisoi and Sorget were in different sub sets as shown in Table 4.1 below. The trees exhibited an almost similar trend as that of seedlings with highest densities at Masaita and Sorget and the lowest at Kerisoi block. One way ANOVA revealed that there was no significant variation in the number of trees between the blocks (p > 0.05) but Turkey test separated Kerisoi from the rest.

Table 1: Mean density of *Prunus africana* per ha at different blocks within the Western Mau Forest (different superscript letters horizontally show significant variation).

Plant type	Study sites				Statistics	
	Masaita	Kedowa	Kerisoi	Sorget	F value	p value
Seedlings	72^{c}	48^{bc}	22^{b}	58^{c}	1.51	0.284
Saplings	67^{c}	65^{c}	33^{b}	13^{a}	5.09	0.029*
Trees	47^{c}	32^{c}	2^{a}	45^{c}	3.93	0.054

Height and Diameter at Breast Height

Majority of the trees from Western Mau forest were of height between 20m and 40m representing 75.7% of all the trees measured while only 10.0% were of a height above 40m. The remaining 14.3% had heights below 20m. Figure 4.4 overleaf shows the distribution of trees within Western Mau forest in terms of height. Majority of the tall trees of height above 40m were recorded in Kedowa representing 25.0% of the trees within the block and 57.1% of all the trees above 40m within Western Mau forest.

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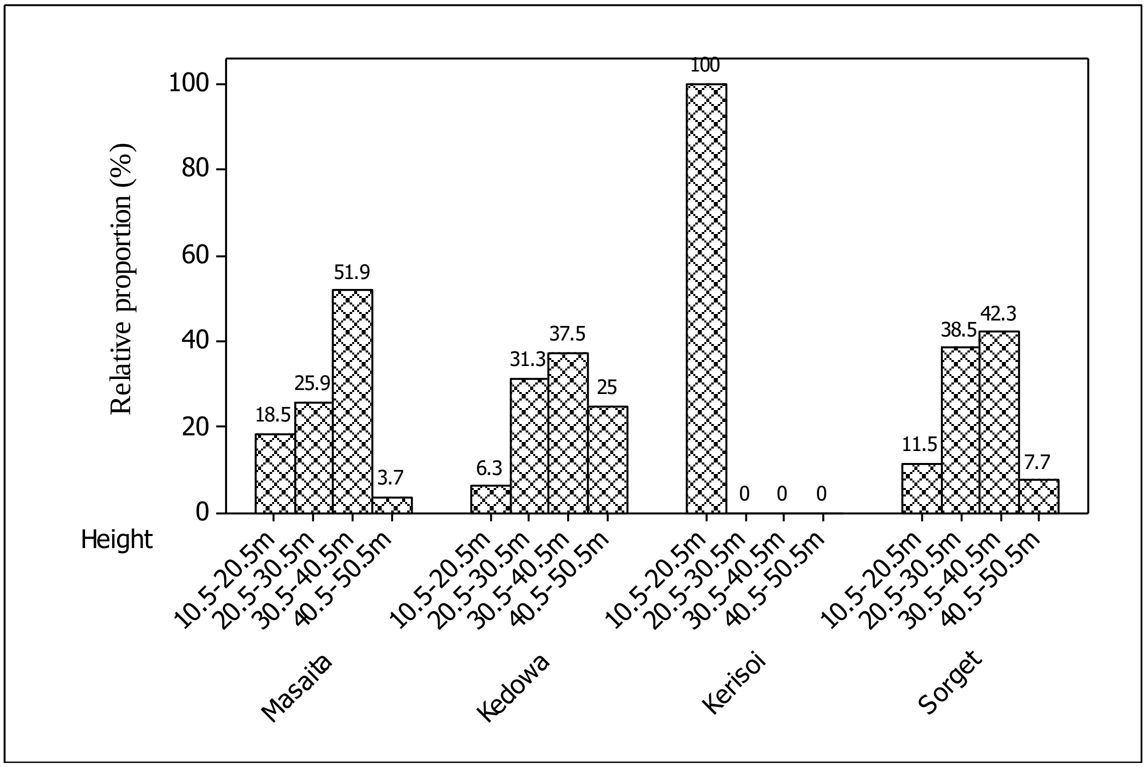

Figure 5: Distribution of trees based on height within Western Mau forest.

The tallest tree sampled measured 50.1m and was found in Sorget block where as the shortest was recorded in Masaita block and measured 10m. On average, Kedowa block recorded the highest mean height (33.63 ± 1.89m) while Kerisoi had the lowest average tree height (19.40 ± 0.98) as shown in figure 4.5 overleaf. One way ANOVA revealed significant variation between the blocks (p = 0.048) but Turkey test grouped together Masaita, Kedowa, and Sorget, only leaving out Kerisoi as the possible reason for the significant variation.

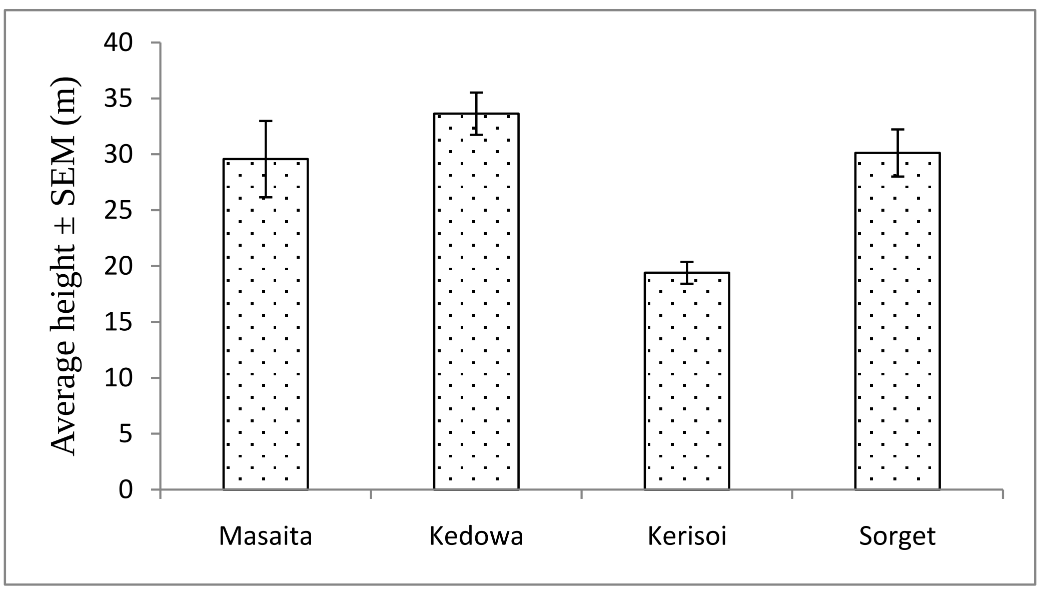

Figure 6: Spatial variation in average tree height within Western Mau forest.

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Most of the trees sampled within the forest had a DBH ranging between 40cm and 50cm (28.17%) while trees with a DBH ranging between 10 and 20cm accounted for only 1.41% (Fig. 4.6). The first and second largest trees in terms of DBH were recorded in Masaita (123 cm and 120cm) while the third came from Kedowa and Masaita block (114cm). .

Masaita block recorded the largest mean DBH (48.49 ± 2.17 cm) followed by Sorget block (42.65 ± 4.15 cm) where as Kerisoi recorded the smallest with only 15.4 ± 1.09cm (Fig. 4.7). Just like with the height, inferential statistics revealed significant variation between the blocks (p = 0.017) but post hoc test only separated Kerisoi block from the other three.

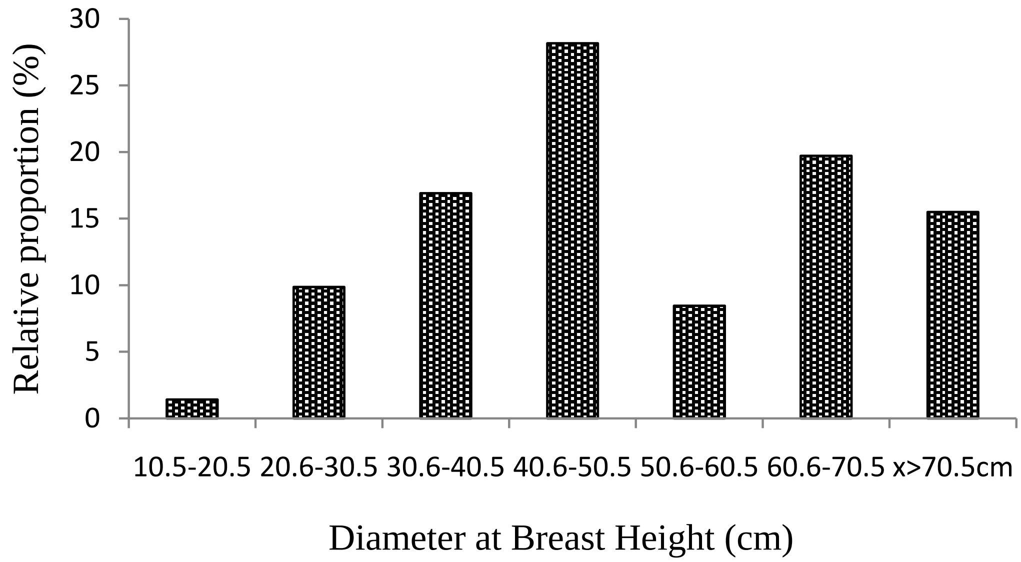

Figure 7: Distribution of trees based on DBH within Western Mau forest.

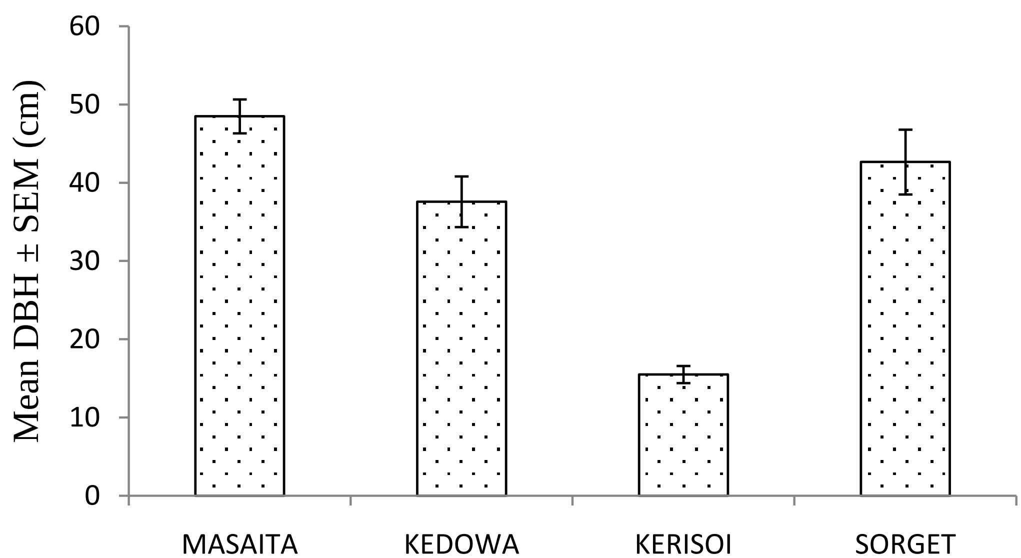

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Figure 8: Spatial variation in average tree DBH within Western Mau forest.

DISCUSSION

The high number of *P. africana* plants in Masaita block and low numbers in Kerisoi were probably due to variation in the intensity of human activities such as charcoal burning and logging within the blocks. Previous studies have shown strong negative correlation between logging incidences and sizes of trees (Bolognesi *et al*., 2015). The absence of bigger trees in Kerisoi as opposed to Kedowa and Masaita blocks can therefore be attributed to charcoal burning and logging.

The presence of more seedlings and saplings in the forest indicates that Prunus is regenerating while the bigger trees are constantly being felled. Research has shown high preference of bigger trees for logging and charcoal burning purposes (Hansen *et al*., 2013). It can therefore be deduced that the low population of *Prunus* tree in Kerisoi was as a result of human logging. Sedano *et al* (2016) reported that charcoal burning is one of the major causes of forest degradation and reduced population density. Previous studies have shown that charcoal burning not only leads to deforestation from logging but also causes death of other trees around the kiln (Hansen *et al*., 2013; Rembold *et al*., 2013; Bolognesi *et al*., 2015). A strong negative correlation has been shown to exist between the intensity of charcoal burning kilns and tree population in the surrounding area (Sedano *et al*., 2016). The result of this study therefore corroborates these earlier conclusions.

In a normal functioning forest system, it is expected that the seedlings will be highest in proportion followed by saplings then finally mature trees (Nowak and Crane, 2002), a situation that was only observed in Masaita block. Deviation from this trend is a clear sign of disturbance. Population of mature trees are usually influenced by logging where as that of saplings are influenced by herbivory and to a small extent disease infestation (Nowak *et al*., 2004).

Sorget block which had the highest frequency of animal grazing recorded the lowest proportion of saplings relative to other two groups i.e. mature trees and seedlings. Low number of saplings and seedlings in an area can be attributed to poor germination and low post germination survival as a result of several factors both natural and anthropogenic (Kuijper, 2011; Clasen *et al*., 2015; Apollonio *et al*., 2017). These include damage due to foot path creation, herbivory both insect and animal, diseases, and smothering during charcoal burning (Apollonio *et al*., 2017). Since there were more seedlings, the small number of saplings can thus not be as a result of poor germination but poor post germination survival probably due to herbivory and presence of several foot paths in Sorget block.

From the study it was evident that majority of *P. africana* trees from Western Mau forest were of the height between 20m and 40m. This height concurred with the one found by Navarro-Cerrillo *et al*., (2008); Stewart, (2003) of 30m to over 40m. This is an indication that the tree height within the country has generally not changed much. The diameter at breast height largely ranged between 40 and 50 cm though previous studies in Kenya have recorded DBH of over 1m (Hitimana, 2000; Betti, 2008; Orwa *et al*., 2009).

Tree size such as height and girth is influenced generally by age and conditions of growth such as soil type, disturbance, and rainfall pattern among others (Mligo *et al*., 2009). Being that all the blocks experienced relatively similar weather pattern, soil characteristics and rainfall pattern were probably similar. The variation in height can thus be attributed to age of tree, human disturbance, or both. The presence of several stamps in an area is an indication that bigger trees are being harvested for timber and charcoal leaving behind only small ones that cannot serve the purpose. Hansen *et al.* (2013) recorded a negative correlation between number of bigger trees and logging incidences consequently attributing the low number of bigger trees to logging. The result of this study corroborates their finding.

CONCLUSION AND RECOMMENDATIONS

Human factors were the primary cause of the spatial variation in P. africana abundance and population structure in the Western Mau forest. This study suggests that the distribution, abundance, and population structure of trees within the forest were significantly impacted by practices like logging, debarking, and animal grazing. The three most prevalent activities in the study area were logging, animal grazing, and de-barking.
According to community opinion and comparison with other earlier studies conducted both inside and outside of Kenya, the population density of P. africana is significantly declining in the Western Mau forest. This is a sign that the tree's conservation status is declining or that it is in danger, and if nothing is done to control the ever-increasing human pressure on the tree, the situation could get worse. Based on these study findings, the following are recommended,

i. Since this activity is unlikely to stop, a thorough and inclusive training on sustainable *P. africana* de-barking should be planned and executed.
ii. To prevent the tree from going extinct, all forms of logging and the burning of charcoal inside and outside of the forest should be strictly prohibited.

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iii. To maintain continuity, it is best to discourage animal grazing during the post-seeding phase in order to permit seedling growth and transition to adult trees. Trees follow a set cycle and are likely to seed and produce seedlings at a specific time of year.
iv. It is recommended that *P. africana* trees be planted both in-situ and ex-situ.
v. The community should be encouraged to collect seedlings of *P. africana* from the forest in order to plant them in their farms.

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