Population Structure and Exploitation of Three Commercial Tree Species in Nguru ya Ndege Forest Reserve, Morogoro – Tanzania

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Abstract

Forests in tropical environments are unstable and hardly maintain fixed climax species composition over long periods. They are victims of modifications by variety of factors including human influences that result in long lasting disturbances. Having observed this, we investigated the population structure and rate of exploitation for three commercial tree species namely, Dalbergia melanoxylon, Pterocarpus angolensis and Afzelia quanzensis in Nguru ya Ndege Forest Reserve. Objectives were to determine the density, DBH distribution and the harvesting rate. We employed simple random procedure to select sampling points, where a map of the reserve was used to divide the study area into 100 equal grids. Fifty grids were then picked randomly, and within these grids, 20 by 20 m quadrats were established for counting stumps and trees with DBH ≥ 4 cm. In addition, saplings with DBH of ≤ 4 cm were counted inside 5 by 5 m quadrats placed within the 20 by 20 m quadrats. Results showed that, the density of P. angolensis was 19 stems/ha, A. quanzensis 8 stems/ha and D. melanoxylon 3.1 stems/ha. DBH graphs showed characteristic inversed J shapes for P. angolensis and A. quanzensis, but broken pattern for D. melanoxylon. Harvesting rates (stumps/ha) was 4.5 for A. quanzensis, 4.0 for P. angolensis and 1 for D. melanoxylon. We concluded that, all target species were found facing harvesting pressure, with the population structure of D. melanoxylon being disturbed. We recommended that harvest of trees in the reserve should be controlled.

Keywords: Density, DBH distribution, Illegal harvest, Tropics

Introduction

Forests in the tropical environments are unstable ecosystems and hardly maintain fixed climax species composition over long periods. They are victims of modifications by a variety of factors including human influences, and generally this result in long lasting disturbances. Factors that lead to forest habitat modifications include activities such as tree cutting and selective removal of timber trees (Blockhus *et al;* 1992). Harvesting of trees from a natural forest however, affects the forest biodiversity through reducing species diversity and altering the structure (Heywood and Watson, 1995). On the other hand, selective harvesting contributes significantly to loss of individual tree species (Tisdell, 1991; Shepherd, 1992). As a consequence, the disappearance of individual tree species has negative implications to the ecosystem in general because other organisms depending on such a vanished tree face setbacks due to loss of their host (Johns, 1992). Hence, putting selective harvesting pressure on individual tree species, threatens many species. Therefore, assessment of the conservation status of the world's tree species is necessary (WCMC, 2000). As this can help in setting priority on species conservation, which in turn can benefit other organisms of the concerned ecosystems.

However, in order to identify a plant species for protection priority, it is desirable to have baseline information on its density, stem size and reproduction status (Tuxill and Nabhan, 2001). This is because the classification of plants in classes based on their stem diameters, showing size-class distribution tells us about plant population structure that indicates the chances of plants in one size class to survive into next size class. This classification is used to establish plant population dynamics especially for trees, and therefore the status of the population (Cunningham, 2001). For example, studies that endeavor on measuring numbers of individuals from different size classes of tree species can generate baseline data necessary for understanding how population structure of the concerned trees change over time (Martin, 1995). The information generated from this kind of studies also can indicate the species future population structure and predict their fate (Harper, 1994). Cunningham (2001) argues that, 'information on how a plant population is regenerating provides a valuable data for resource management purpose and is widely used in planning for sustainable management of uneven-aged, mixed species forest'.

Nevertheless, in comparing and prioritizing species for management, it is imperative to think about the magnitude of threats that the species is facing (Tuxill and Nabhan, 2001). For example, a commercial value placed on a certain tree species usually leads it to a disadvantage, as the species faces selective removal from the ecosystem to offer services such as timber, charcoal, fuel wood, ornamental or handicraft. For instance, Omeja *et al;* (2004) found that, intense use and

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concentration on a few most favored drum making tree species in central Uganda resulted in their over-exploitation with negative ecological effects. Furthermore, in Kenya, some tree species commonly used for woodcarvings were reported to have been depleted close to extinction and can only be found in areas distant from markets selling craft products (Obunga, 1995). In the case of Tanzania, species such as *Pterocarpus angolensis*, *Afzelia quanzensis* and *Dalbergia melanoxylon,* are commercially over-exploited, also faces threats from forest degradation due to forest fires, and grazing. To prevent further decline, the Tanzanian government gave them the status of protected trees, i.e. they cannot be cut without government permission, even if they are on agricultural lands (Munyanziza and Wiersum, 1999).

Mostly, while unsustainable exploitations of woody products continue to challenge us, our understanding on the distribution and population sizes for plants in different parts of the world is inconclusive and most of them are under pressure due to harvesting or natural deleterious events (Briggs and Walters, 1997). For example, whilst Tanzania possesses a range of forests, most of them remain insufficiently protected and seriously threatened (Stuart *et al;* 1990). Nguru ya Ndege Forest Reserve for instance faces annual bush fires, and illegal tree harvest, that put pressure on the reserve's biodiversity (CELP, 2003). Taking this situation into account, we asked a question as how could the population structure in Nguru ya Ndege Forest Reserve look like for the three commercial tree species namely, *D. melanoxylon, P. angolensis* and *A. quanzensis*. We also asked as how the rate of exploitation could be for the same three tree species. We then investigated the population density, harvesting rate and DBH class distribution to determine their structure and rate of their exploitation in the aforementioned reserve.

Study area

The study was carried out in Nguru ya Ndege Forest Reserve, that covers an area of 36.14 km^2, found between 6^0 41' - 6^0 44' S, and 37^0 35' - 37^0 37' E in Morogoro Region, Tanzania (Lovett *et al;* 1995; CELP, 2003). The reserve receives an estimated rainfall of 850 mm/year in the woodlands, and 1500-1800 mm/year in the forested part, and experience dry season from June to November. The temperature ranges from a maximum of 25°C in December to a minimum of 20°C in July (CELP, 2003). The area is composed of the woodlands as the main vegetation type, covering about 60% of the reserve's area (Lovett *et al;* 1995; CELP, 2003) Figure 1.

Material and Methods

Simple random sampling procedure was employed in selecting quadrats for data collection. A map of the reserve was used to divide the study area into 100 equal grids. The grids were then assigned numbers from one to 100, and the same numbers were written on pieces of papers and mixed thoroughly in a box container. After that, fifty pieces of papers with grid numbers were randomly picked from the box without being replaced while ensuring the shaking of the box at each removal. A map of the reserve was then revisited and the geographical coordinates of the selected grids were noted. Later on, the grids were located in the field by using a GPS unit (Williams, 1991). Then, within each grid, a 20 by 20 m quadrant was established while making sure it is at the centre of the grid. Stems and stumps of target tree species were then indentified and counted within each quadrant. For stumps, only those fresh harvested were identified and counted with the help of an experienced local assistant. Criteria to identify species from the stumps were wood and bark characteristics (Luoga *et al;* 2002). Once the stems and stumps had been identified and counted, the diameter at breast height (DBH) of trees with diameters of ≥ 4 cm were measured (Cunningham, 2001 In addition, one 5 by 5 m quadrant was established within each 20 by 20 m quadrant for counting saplings with DBH of ≤ 4 cm (Kent and Coker, 1992). The data was entered in Microsoft Excel to create data files and sorted to generate DBH class distributions, as well as stem and stump densities. Furthermore, DBH were categorized into 10 classes:- Class 1: DBH 0-4.9 cm, Class 2: DBH 5.0-9.9 cm, Class 3: DBH 10.0-14.9 cm, Class 4: DBH 15.0-19.9 cm, Class 5: DBH 20.0-24.9 cm, Class 6: DBH 25.0-29.9 cm, Class 7: DBH 30.0-34.9 cm, Class 8: DBH 35.0-39.9 cm, Class 9: DBH 40.0-44.9 cm, and Class 10: DBH ≥ 45 cm (Cunningham, 2001; Omeja *et al;* 2004).

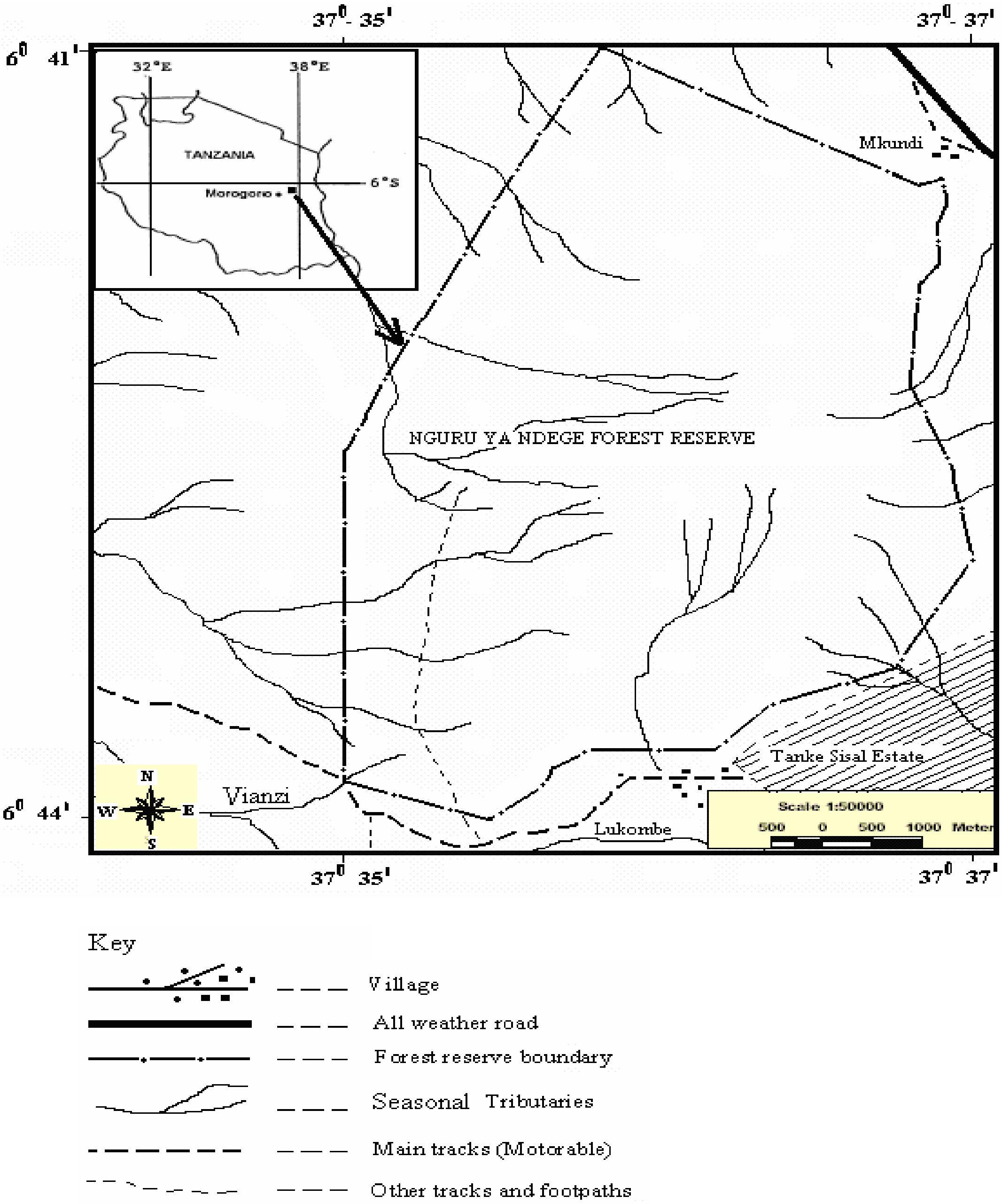

Fig 1: Location of study area

The densities obtained from this classification were used to plot graphs in order to assess the DBH class size distributions, and thus the population structure of the target tree species. The population density of trees with DBH of ≥ 4 cm, and that of the stumps were calculated as number of individual plants/ha and number of stumps/ha, respectively (Mueller-Dombois and Hellenberg, 1974; Kershaw, 1979; Kent and Coker, 1992). Kruskal-Wallis test was used to decipher the difference in density between the three species. The Kruskal-Wallis with Dunn's post-hoc test was performed using GraphPad InStat version 3.00 for Windows 95 (InStat, 2008).

Results

The tree mean density for individuals with stem of DBH ≥ 4 cm were 19 stems/ha for *P. angolensis*, 8 stems/ha for *A. quanzensis* and 3.1 stems/ha for *D. melanoxylon* (figure 2). There was significant difference in the mean stem density for the three species, Kruskal-Wallis 8.839, P = 0.0120. The *post-hoc* test with Dunn's multiple comparisons showed this difference being between *P. angolensis* and *D. melanoxylon*, (Table 1). The DBH class distribution graphs showed characteristic inversed J shapes for *P. angolensis* and *A. quanzensis* although that of *P. angolensis* seemed interrupted. However, for *D. melanoxylon* the DBH class size distribution graph showed a broken pattern, (figure 3). The harvesting rate calculated as number of stumps/ha was 4.5 for *A. Quanzensis*, 4.0 for *P. angolensis* and 1.0 for *D. melanoxylon,* (figure 4). There was no significant difference in the harvesting rate of the three tree species in the reserve, Kruskal-Wallis 3.170, P = 0.2049.

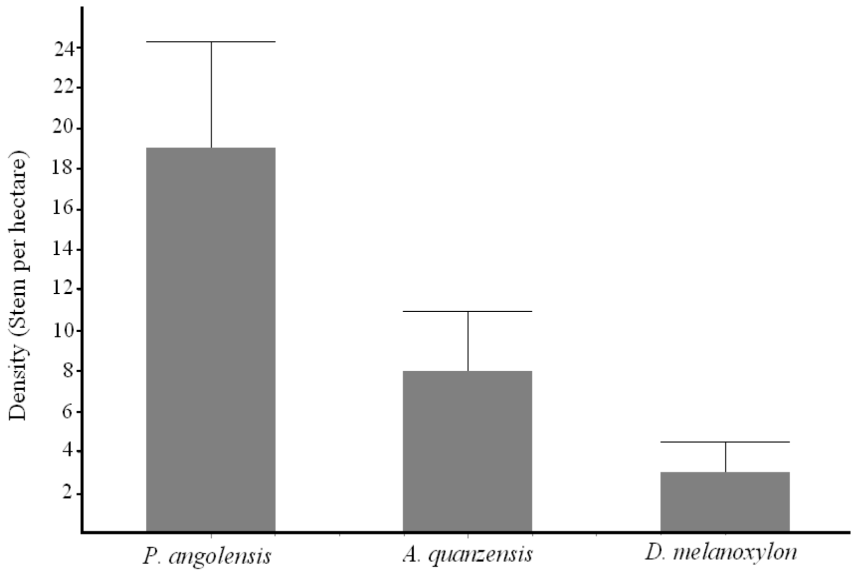

Fig 2: Stem density for the three tree species recorded in the reserve-Mean and Standard Error

Table 1: Dunn's multiple comparisons test on stem density of the three tree species in the reserve

Comparison	Mean Rank Difference	P value
P. angolensis vs. A. quanzensis	10.880	ns P>0.05
P. angolensis vs. D. melanoxylon	17.080	* P<0.05
A. quanzensis vs. D. melanoxylon	6.200	ns P>0.05

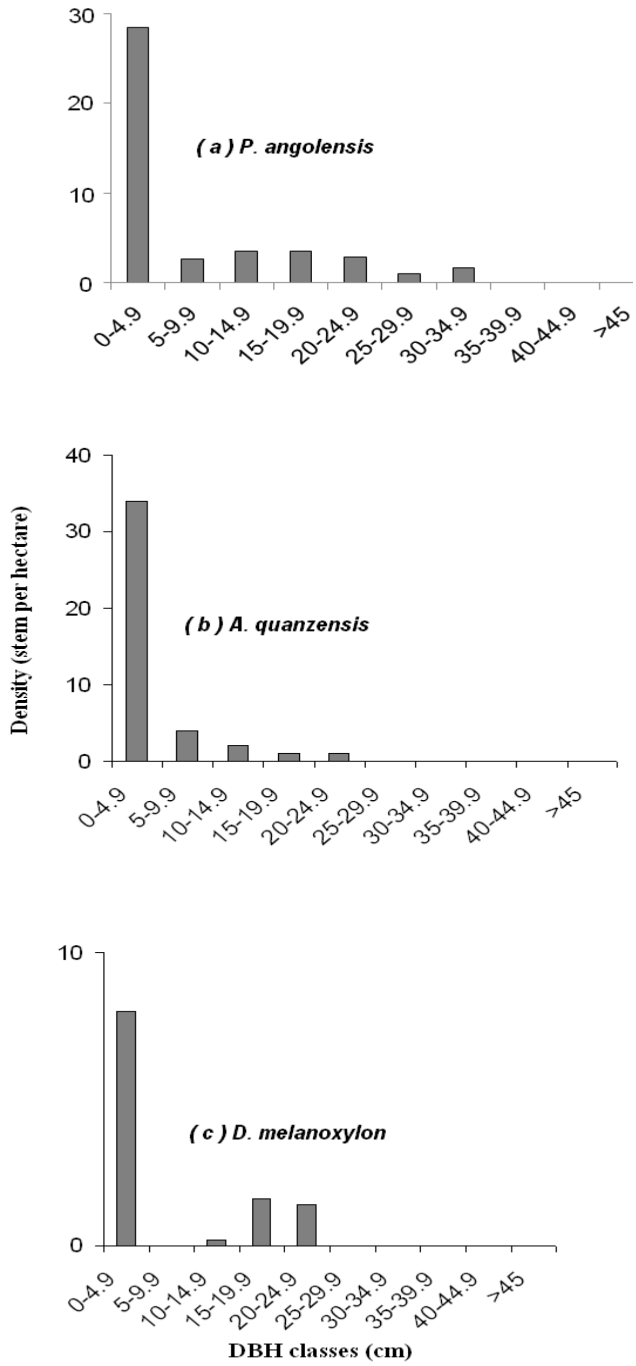

Fig. 3: DBH class size distribution of target tree species

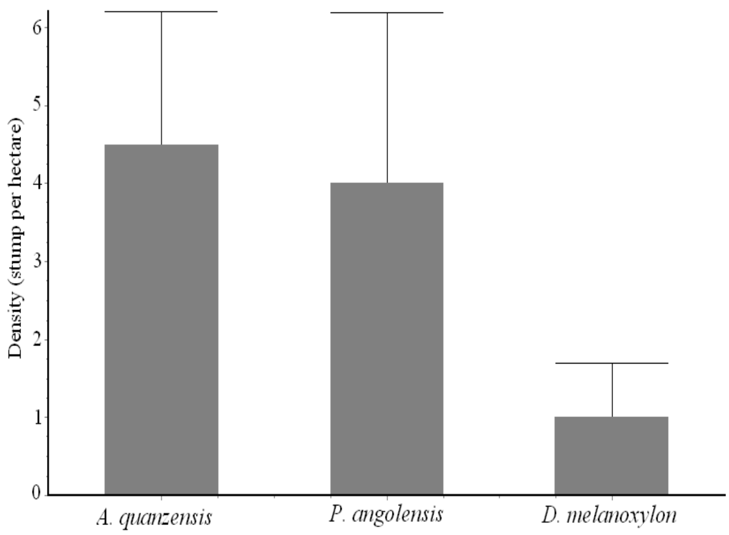

Fig.4 : Stump density for the three target species-Mean and Standard Error

Discussion

The density of 19 stems/ha for *P. angolensis* recorded under our study was higher compared to densities reported in other studies, for example Schwartz *et al*; (2002), reported 3.67 stems/ha, in western Tanzania while Mudekwe, (2007) reported 13 stems/ha. However, the interrupted pattern revealed in an inversed J shaped DBH graph for this species in our findings indicated selective harvesting especially within the higher diameter classes ranging from 20 to 29.9 cm. Mushove, (1996) also worked on *P. angolensis* in three sites in Zimbabwe, where in two sites, the inversed J shaped distribution curves were reported, but in the third study site a gap was noted in the DBH classes from 2.6 - 15.0 cm. This trend was also observed in our findings where a lag was noticed at 5-9.9 cm DBH class. Since there was no evidence of harvesting young individuals of this species from our study area, the lag can be attributed to fungal diseases that usually attack regenerating shoots of saplings of this species (Vermeulen, 1990), or it could be due to repeating heavy fires. However, despite the abnormality in the DBH classes of *P. angolensis* observed in our findings, the harvesting rate of 4.0 stumps/ha was fairly lower compared to 7.7 stumps/ha recorded by Schwartz *et al*; (2002). Nevertheless, this small rate of removal does not necessarily suggest lack of preference on harvesting the species; rather it may be due to unavailability of suitable trees for harvest as majority of individuals recorded were those of crooked trunks, which are not favoured by harvesters.

For *A. quanzensis*, a density of 8 stems/ha was also somehow above the density of 6 stem/ha reported by Mudekwe (2007). But the inversed J shape in the DBH graph observed in our findings was contrary to Mudekwe (2007), who reported interrupted DBH distribution and the graph depicted a bell shape. Ball (2004) also observed the bell shape but individuals extended to upper DBH classes reaching the maximum of 94 cm. On the other hand, even though there was no significant difference in the harvesting rate of the three target tree species from our study area, the harvesting rate of 4.5 stumps/ha for *A. quanzensis* indicated preference of the species by harvesters. Since our study recorded only small sized individuals, this is the supporting evidence on the selective exploitation of this species from the reserve. Harvesting of small sized individuals of *A. quanzensis* has also been reported elsewhere by Ahrends (2005). Therefore it can generally be asserted that this species is highly preferred by harvesters compared to others.

Moreover, the density of 3.1 stems/ha for *D. melanoxylon* that was recorded under our study was lower than what Ball (2004) and Opulukwa *et al;* (2002) found in southern Tanzania, where they reported 8.5 stems/ha and 20 stems/ha, respectively. It is therefore important to note that, the low density of *D. melanoxylon* recorded under our study, and the gaps revealed in the DBH class distribution suggests the overexploitation of this species especially in the past years. This harvest slowed down the regeneration potential of the species. Elders at Mkundi, a village close to Nguru ya Ndege Forest Reserve, claimed that in the past years there were enough stock of *D.*

melanoxylon in the reserve, and that the tree started declining in mid 1970s. This supposition seems to be relevant bearing in mind that Platt and Evison, (1994) also argue that *D. melanoxylon* usually faces heavy harvesting pressure in places that are easily accessible and closer to major tourist markets for handicrafts, such as Dar es Salaam. Therefore, the proximity of Nguru ya Ndege Forest Reserve to Dar es Salaam City where the handicraft industry is well established might have contributed to the over-harvesting of this species in the past years. However, the current low rate of harvest for this species of 1 stumps/ha recorded under our study, is due to its unavailability.

Conclusion

The study concluded that, all three tree species in the study area were found being selectively harvested. This has a management implication; because if selective harvest continues, it can lead to local extinction of the said species which might be accompanied with negative ecological effects. However, the population structures for both *A. quanzensis* and *P. angolensis* were not heavily disturbed and thus have a good potential to recover in the future if the anthropologic factors of disturbance will be kept minimum or eliminated. On the other hand, the population structure of *D. melanoxylon* had been adversely disturbed due to over-exploitation especially in the past years and there may be no possibility of recovery in the near future.

It is recommended that regular patrols by the authority responsible with the management of the reserve to stop illegal harvest of both timber and non-timber products. It is also recommended stringent measures against those found involved in illegal trade on logs for both protected and non-protected tree species. The authority should also engage in controlling frequent bush fires to allow for tree regeneration in the reserve. We also recommended restocking of the three tree species in the reserve by abiding to the national tree planting policy.

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