INVENTORY OF *Dalbergia melanoxylon* (MPINGO) IN THE SOUTHERN PART OF TANZANIA: THE CASE OF NACHINGWEA

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ABSTRACT The study was designed to assess the current status of *Dalbergia melanoxylon* (Mpingo) in Tanzania. A total of 44 sample plots (3.08 ha) were laid on public land. *D. melanoxylon* contributes about 4% of all total stems out of 103 tree species identified and most of them found in clusters. Out of all visited plots 36.4% had *D. melanoxylon*. Parameters determined include height, stems per hectare, basal area per hectare, volume per hectare and diameter class of trees. The number of stems, basal area and volume per hectare was found to be 20, 1.2m^2 and 8.6m^3 respectively. The stems were distributed in five diameter classes.

Based on the importance of *D. melanoxylon* for the economy of Tanzania, it is recommended that national inventory for the species should be carried out in order to know the existing stock and to prescribe sustainable harvesting regimes. Licensing for logging *D. melanoxylon* should be based on estimates of the yield and not on the existing demand.

Key Words: *Dalbergia melanoxylon*; Inventory; Diameter at breast height (DBH); Sampling intensity; Sampling design; Regeneration and Ecosystem.

INTRODUCTION

I. Background Information

D. melanoxylon is a small, heavily branched tree typically 4.5 to 7.5 m tall but occasionally reaching a height of 15 m. It takes about 70-100 years to mature (CMP, 1999). The bole is fluted with high narrow ribs separated by deep indentations. In comparison with the heartwood, the sapwood is less dense. The density of *D. melanoxylon* can be as high as 1.3 gcm^{-3}, i.e. it sinks in water, compared with 0.76 gcm^{-3} for the sapwood (Malimbwi *et al.*, 1998). The sapwood is significantly less resistant to termite and fungal damage (Bryce, 1967). In comparison, the heartwood is resistant to biotic (Nshubemuki, 1993) and abiotic agents of decay. The stem is often crooked. Bole length occasionally reaches up to 3.6 m, but normally ranges from 1.2 to 1.8 m.

Average diameter at breast height (DBH) at maturity is less than 38 cm, although trees of more than 60 cm (DBH) can be found. The bark is gray to grayish-brown, papery, fairly smooth and flanking in long narrow strips. Logs are almost invariably defective and the wastage in conversion to top-grade dimension stock is considerable. End checks appear in the log soon after felling and develop rapidly into star shakes unless end coatings are applied immediately (Bryce, 1967). The dry wood is difficult to saw and plane; it blunts saws and cutters rapidly, and cannot be nailed or screwed without drilling (Moore & Hall, 1987). It is however the finest of all turnery timbers, cutting most exactly and finishing to a brilliantly polished lustrous surface, dry and cold to the touch.

Germans started large-scale logging of *D. melanoxylon* in the early 20th century. The practice continued even under British rule, and after the Second World War, higher levels of demand led to an increase in sawmill capacity. Export of logs from Tanzania was banned in 1993 in order to conserve the species and increase its value through semi or full processing (Moore & Hall, 1987).

II. Abundance of *D. melanoxylon* in Tanzania

Although it was recorded as plentiful in Tanzania in the 1930's (Grant, 1934), most sources indicate that the species is now scattered in occurrence. In 1960's it was recorded as being rare due to intensive exploitation. Places which are under heaviest harvesting pressure are those which are easily accessible, close to the major tourist markets for Makonde art and those near sawmills in Dar es Salaam, Lindi and Mtwara regions (Irene & Steve, 1994). Tree population continued to decrease due to over-exploitation and inadequate control of fires (Read, 1993).

Dubai Blackwood Enterprise Sawmill, is located in Nachingwea where it extracts and processes *D. melanoxylon* for export to United Kingdom and Japan. Harvesting has been conducted in the district at least since 1945, with a large increase in volumes extracted after 1980. The demand has increased but the problem was supply. Due to this factor, now it is very hard to find harvestable wood.

Due to lack of funds, there is no large-scale inventory carried out for *D. melanoxylon* in Tanzania. Therefore, the exact stock in the country is not known. Small patches of forests in Kilwa and Mikumi National Park have been inventoried.

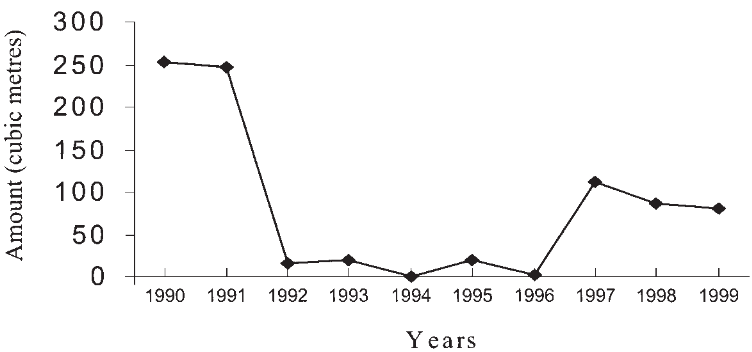

Fig. 1. Harvesting Trends for the Last Ten Years.
Source: District Forest Office (DFO), Nachingwea district, Lindi region (1999)

Prescribing a sustainable harvesting regime for the species requires adequate information on the distribution, stand volume and growth rates of the resource. This is one of the factors hindering sustainable management of *D. melanoxylon*.

It was against this background that an inventory was carried out in southern Tanzania where it still believed the species is plentiful.

MATERIALS AND METHODS

I. Sampling Design and Sampling Intensity

Systematic sampling was adopted. Under this design the first sampling unit was randomly selected on the ground, thereafter, plots were spaced at uniform intervals. The reason for the selection of this design was based on the fact that, there was no great variation in the forest vegetation. Malimbwi (1997) reports that since all parts of the population are represented in the sample, the precision of the parameters estimated is usually high.

A total of 44 sample plots were laid along pre-determined transects covering the community forests on public land of four villages under study. The plots were located at almost three to six kilometers away from the villages because the land near the villages was under cultivation. At Mtua village with an approximate of 2000 hectares of the community forest under public land, 14 sample plots were taken at the interval of one kilometer from each plot and one kilometer from each transect. Kipara and Nalengwe with an approximated area of 2,500 hectares were considered as a single unit of forest because they are sharing public land, and therefore, 20 plots were taken at the interval of one kilometer from each plot and one kilometer from each transects. Similarly, the same intervals from one plot to another and from transect to transect were taken from Mkonjela village with an area of approximate 1000 hectares on public land. Sampling intensity of 0.5 to 0.7% was used. This is in accordance to recommendation by Synott (1979) for the case of tropical inventories. Sampling intensity of 0.5 to 0.7% is recommended for use with plot a size of 0.07 hectares.

Table 1 indicates the number of plots and the total hectare surveyed from each village. However, the sample plots taken at all villages exceeded 0.7%, implying that the sampling intensity exceeded the minimum recommended range.

Table 1. Sample Plots Obtained from Each Forest Cover.

Village names	Estimated size of the forest (ha)	Total area of sample plots (ha)	Number of sampled plots
Mtua	2000	0.98	14
Kipara and Nalengwe	2500	1.4	20
Mkonjela	1000	0.7	10
Total	5500	3.08	44

II. Plot Shape, Size and Measurements

The shapes of the sample plots were circular with radius of 15 m. In each plot, all trees with DBH $\geq$ 4 cm were measured. Measurements for DBH were taken to the nearest 0.1 cm and those for total height to the nearest 0.1 m. Diameter of fluted trees was recorded as the average of two measurements taken at right angles. The reason for the selection of that particular diameter is that, trees have great potential to grow to maturity compared to the smallest ones (below $\leq$ 4 cm). The height of all *D. melanoxylon* trees were measured while only the largest, medium and the smallest tree of other species were taken. Due to multiple stems and flutings, standard mensurational techniques were strictly followed to minimize measurement errors. For example, for a tree forking below 1.3 m from the ground, each stem was treated as an individual tree. However, data were collected during dry season such that most of the small trees with DBH $\leq$ 4 cm were dead hence, the collection of data for regeneration potential became of less importance. Local botanists were recruited to identify all other tree species counted, for later translation into botanical names.

III. Data Analysis

Parameters obtained included height, stems/ha, basal area/ha, volume/ha and diameter classes of trees.

IV. Diameter Classes

The standing stock of the forest cover was distributed in five classes. The classification was done species by species per hectare basis. The five diameter classes were as follows:

Class 1 composed of trees with DBH 0-10
Class 2 composed of trees with DBH 10.1-20
Class 3 composed of trees with DBH 20.1-30
Class 4 composed of trees with DBH 30.1-40
Class 5 composed of trees with DBH >40

V. Height

In each plot, all *D. melanoxylon* was measured for height while for other species only the smallest, medium and the largest trees were measured for height. The following models were tested for height-diameter relationship:

i. $h=aD^b$ ··································(1)
ii. $h=a+bD^2$ ······························(2)
iii. $h=a+bD+cD^2$ ························(3)

Where: h=height in (m)
D=diameter at breast height (DBH) in (cm)
a=intercept.
b, c=regression coefficients

Table 2. Equations Showing the Relationship between Diameter and Height.

No.	Model	Equation	R^2	S.E.
1	$h=aD^b$	$h=0.7749D^{0.3132}$	0.911	1.05
2	$h=a+bD^2$	$h=11.8566+0.1685D^2$	0.907	0.86
3	$h=a+bD+cD^2$	$h=10.4197+0.25022D+0.00095D^2$	0.926*	0.77

R^2=Coefficient of determination; S.E.=Standard Error; * Selected R^2
a, b, c=as defined in equation 1, 2 and 3.

The summary of the height-diameter relationship is shown in the Table 2. An equation with the highest coefficient of determination (R^2) and low standard error was selected.

The height-diameter equation was developed for the purpose of height prediction for miombo woodland species. Volume calculation for miombo was carried out using the formula by Malimbwi *et al.* (1994). The formula of volume calculation for *D. melanoxylon* does not require height-diameter equation for height prediction.

VI. Number of Stems per Hectare

The number of stems per hectare was calculated as follows;

$$N=n/A \cdots\cdots(4)$$

Where, N=number of stems/ha
n=Total number of trees in each DBH class
A=Total area of sampled plots (ha)

VII. Basal Area

Basal area of a tree was calculated by the following formula:

$$g_i=\pi \times D^2/4 \cdots\cdots(5)$$

While the basal area per hectare (BAH) was calculated as follows;

$$G=\sum g^i/A \cdots\cdots(6)$$

Where: G=basal area per hectare (m^2/ha)
g^i=basal area of tree (m^2), n=number of plots surveyed
D=diameter at breast height (DBH)
A=Total area of sampled plots (ha)
π=3.14

VII. Volume

The total *D. melanoxylon* volume was calculated using the following formula provided by Malimbwi *et al.* (in press):

$$V_{TOB}=0.00023D^{2.231}$$

Where, $_{TOB}$=Total Volume Overback
D=diameter at breast height (DBH)

RESULTS AND DISCUSSION

I. Number of Stems per Hectare

The average number of *D. melanoxylon* stems was found to be 20 stems/ha. In most cases the stems are found in clusters. Among these, five stems were in diameter Class 1, five stems in diameter Class 2, four stems in diameter Class 3, four stems in diameter Class 4, and two stems in diameter Class 5. The information is summarized in Fig. 2.

The number of stems did not show a true reversed J-shape due to controlled harvesting, imposed by the central government. In order to harvest *D. melanoxylon* tree, a permit is required from the District Forest Officer (DFO) who decides on the amount to be harvested. The government has classified *D. melanoxylon* as Class 1A of the license system. This is the most expensive classification category and license for it cost T. Shs. 60,000 per m^3 (URT, 1996). This has led to harvest control because ordinary people cannot afford the fee.

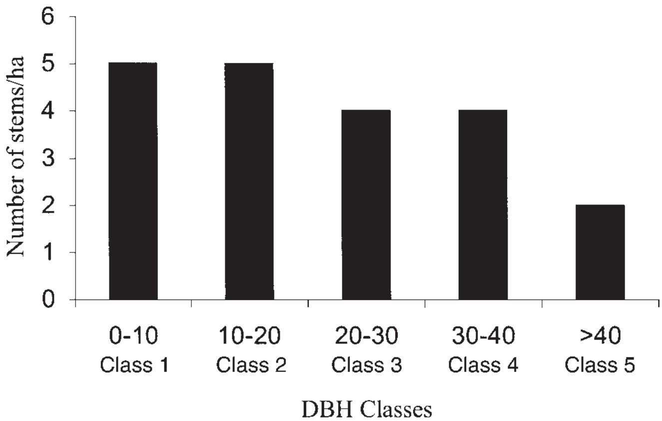

Fig. 2. Distribution of Number of Stems/ha in DBH Classes for *D. melanoxylon* in Nachingwea.

The number of stems per hectare reported in this study contributes to about 4% of the total stems and most of them were in clusters. Out of all visited plots 36.4% had *D. melanoxylon*. This is approximately similar to what was found by Malimbwi *et al.* (in press) for inland areas in southern Tanzania. Hawkins *et al.* (1995) reported the same stems (20 stems/ha) in Mikumi National Park but with 0.7% to the contribution of the total density. The low contribution is probably due to the large number of stems per hectare in that area.

II. Basal Area (G) and Volume (V)

1. *Basal area per hectare*

The average basal area per hectare for *D. melanoxylon* was found to be 0.02 m^2/ha, distributed in five diameter classes. 0.02 m^2/ha in diameter Class 1, 0.09

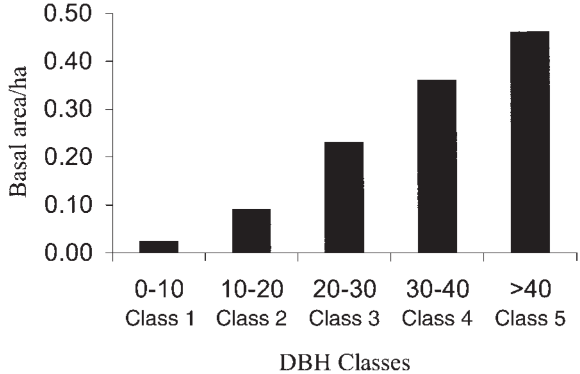

Fig. 3. Distribution of Basal Area/ha in DBH Classes for *D. melanoxylon* in Nachingwea.

m^2/ha in diameter Class 2, 0.23 m^2/ha in diameter Class 3, 0.36 m^2/ha in diameter Class 4 and 0.46 m^2/ha in diameter Class 5. See Fig. 3.

The distribution of basal area per hectare had a J-shape common in natural forests. As observed in the figure above, basal area increases with DBH. Since there is prolific *D. melanoxylon* regeneration, the difference in stocking at older age may be attributed to ecological factor, fire and other growth conditions. The easy accessibility to public land, which enhances harvesting, may be another factor.

2. *Volume per hectare*

The average *D. melanoxylon* volume was found to be 8.6 m^3/ha, distributed in five diameter classes. 0.11 m^3/ha in diameter Class 1, 0.58 m^3/ha in diameter Class 2, 1.93 m^3/ha in diameter Class 3, 3.11 m^3/ha in diameter Class 4 and 3.88 m^3/ha in diameter Class 5. The distribution is graphically presented in Fig. 4.

The volume is relatively greater than what was found by Malimbwi *et al.* (in press) in coastal and inland areas in southern Tanzania where the average volume was 7.5 m^3/ha.

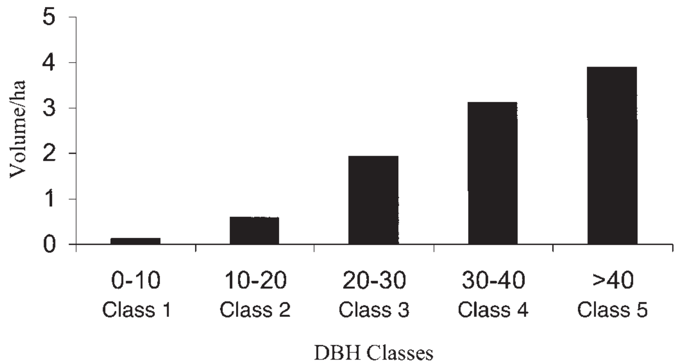

Fig. 4. Distribution of Volume/ha in DBH Classes.

CMP (1999) reported 1.03 m^3/ha of potentially harvestable logs in Kilwa district while in Cabo Delgado province in Macome (1996) reported a total overback volume of 2.2 m^3/ha. The reason for small volume in this area may be due to extraction of larger trees. Mills in Lindi region get most of their logs from Nachingwea (the area around Lionja Forest Reserve) and Ruangwa districts, and a few from Mtwara and Masasi (CMP, 1999). This is because most of *D. melanoxylon* in Nachingwea has brown colour heartwood preferred by customers.

3. *Excessive harvesting*

At present there are no known plantations for *D. melanoxylon* where extraction occurs, therefore, the timber trade is currently derived exclusively from natural forests or private lands. The study observed that there is a process of ‘high grading’, whereby only the most mature and the straightest and therefore the most marketable trees are removed from the ecosystem. Chuwa in the 1992 BBC-TV nature documentary, “The Tree of Music” said,

“If full grown, trees are being cut for timber, and the young ones are killed by fire, it won’t be long before there aren’t any mpingo left!”

This could leave the ecosystem ecologically out of balance with the regenerative ability of the remaining *D. melanoxylon* population much reduced, due to a lack of active reproductive trees. Any imbalance is further aggravated by the total lack of replanting in the study area by those involved in the exploitation of species. Sharman (1995) argues that, the slow growth rate of this species in the wild means reliance on only the natural reproductive capacity to replace those trees extracted, hence the future viability of the species as a commercial stock is questionable. This pattern of exploitation could signal the beginning of a downward spiral of increasing costs and a declining *D. melanoxylon* stock, which could lead toward commercial extinction.

Whilst it may not be biologically or ecologically threatened, *D. melanoxylon* may as well be commercially threatened. The constant removal of individuals of the same characteristics will be extremely harmful to the population structure, possibly into genetic erosion. The end result may be a constant decline in the population until it is commercially extinct. If it can, it will reproduce individuals without those characteristics so highly prized by the trade and human society and a population weak vulnerable to natural disaster and environmental change.

CONCLUSION

D. melanoxylon has been reduced in number and consequently in volume due to excessive exploitation. The study noted that most of the harvested *D. melanoxylon* goes to international markets. The number of stems per hectare for the species was found to be 20 stems/ha with the basal area, and volume of 1.2 m^2/ha and 8.6 m^3/ha, respectively. However, the study shows that there is good regeneration trend for all species because of large number of small trees being in lower diameter class than in large diameter class.

RECOMMENDATIONS

1. A national inventory for the species is urgently needed in order to know the existing stock, and to prescribe a sustainable harvesting regime.
2. People should be educated on the adverse effects of shifting cultivation. Peasant should be provided with soft loans so that they can start farm mechanization using modern technologies such as tractors and fertilizers. By doing so they can stay on the same farms for a long time without shifting, hence minimizing the adverse effects on *D. melanoxylon* and other tree species.
3. Artificial replanting of denuded areas previously covered by *D. melanoxylon* should only be done in special cases where there is important conservation justification. Otherwise, natural regeneration should be encouraged. The use of indigenous species in case of plantations should be established to enhance plantation yield.
4. The study observed that traders given license to harvest *D. melanoxylon* are not supervised when entering the forests to harvest trees. License or permit system should incorporate an inspection process to reduce frauds. Penalties should be revised from time to time so that they exceed potential gain from committing offences.
5. Licensing of *D. melanoxylon* harvesting should be based on estimates of the yield and not on existing demand.

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