The Miombo Woodlands – A Resource Base for the Woodcraft Industry in Southern Zimbabwe

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Abstract

A forest inventory, applying a stratified systematic sample plot design, was carried out in southern Zimbabwe. Objectives were to determine: abundance, frequency, dominance, volume, and regeneration of tree species used by the woodcarving industry. Five classes of wood cover over three land use types were identified on 52,734 ha. Eighty sample plots were selected according to the size of each stratum and distributed randomly. Seventy-eight tree species were identified (avg. 11.2 m^3/ha). The species most frequently found were *Julbernardia globiflora* and *Brachystegia spiciformis.* The tree species used for wood carvings showed an average abundance of 3.9/ha (avg. 2.9 m^3/ha) and were dominated by *Kirkia acuminata* and *Sclerocarya birrea*. High variability was found between different land use types. The selective use of certain tree species for carving in Zimbabwe is likely to drive the species to local extinction.

Keywords: forest inventory, woodcarvings, miombo woodlands, Zimbabwe.

Introduction

It is estimated that over 40 million people inhabit areas of the miombo woodland formation in central, southern and eastern Africa, with an additional 15 million urban dwellers relying on miombo resources such as wood or charcoal (Campbell et al., 1996). The miombo in Zimbabwe is a deciduous non-spinescent woodland, dominated by the genera *Brachystegia* and *Julbernardia* (Frost, 1996). Since the late 1980s, woodcarvings produced out of miombo woods have become important handicraft articles which are sold as souvenirs along the roads to major tourist attractions of the country (Braedt and Standa-Gunda, in press). This sudden increase of markets selling forest products, predominantly made out of indigenous wood, has alarmed local environmentalists (Environment 2000, 1994; Koro, 1996), as well as governmental institutions and policy makers (ERCC, 1998; Forestry Commission, 1995). The decline of natural resources as the cause of new markets arising from the sale of forest based products has been documented for other regions (Harris 1998, Homma 1996, Momberg *et al*. 1997, Nepstad *et al*. 1992). In particular the demand for raw material by the woodcraft industry has the potential to impact forests negatively (Peters 1994). A case in point is the Kenyan woodcraft industry, recently facing problems associated with wood supply (Cunningham 1997, Hamilton 1997, Obunga 1995).

In Zimbabwe, despite possible adverse consequences on the resource base, government organisations and policy makers have hesitated to take action in controlling the use of indigenous trees for the woodcraft industry. The lack of knowledge about ecological effects caused by the timber harvest for the carving sector and possible negative effects for the economy of the industry are main reasons for the hesitant situation. To this end a study on the "Contributions of Non-Timber Forest Products to Socio-economic Development" in the miombo woodlands of Zimbabwe was initiated. This paper is part of a series of studies on the woodcraft industry, presenting results obtained from a forest inventory on the resource base sustaining the trade. The objectives were to determine: (1) abundance, (2) frequency, (3) dominance, (4) volumes, and (5) regeneration of tree species used by carvers.

Study Area

The research was carried out along the main road between Masvingo (province capital) and Beitbridge (main border post to South Africa). The study area on either side of this road mainly consists of communal and resettlement areas, and commercial farms. Resettlement areas were formerly large commercial farms (up to 2,000 - 5,000 ha each) that were purchased by the government after independence to resettle people from communal areas. Subsistence farming is the predominant livelihood of smallholder farmers in the area. The erratic rainfall (< 600 millimetres per season, with a coefficient of variation of 35-40%) in this semi-arid zone is too low for reliable crop production and extensive cattle ranching or game ranching is viable. The soils are largely sandy and of low fertility.

Methods

A forest inventory applying a stratified systematic sample plot design was carried out between November 1997 and February 1998. Five strata (rock outcrop, cultivated, woodland – medium dense, bush land, and woodland – dense) on three land use types (communal land, resettlement land, and commercial farm land), were assessed in an area comprising 52,734 ha. For the stratification satellite remote sensing data presenting digital classes in 1°x1° pixels (VegRIS, 1992) were used. A GPS and a topographic map (Surveyor General, 1979) served to locate the exact position of the sample plots, by using the central co-ordinates of each woody cover class pixel. The number of samples was selected in relation to the size of each stratum (PPS sampling: probability proportional to size) and distributed randomly (Table 1). Utilizing a confidence limit of $8 \pm t_{(0.10)} * s_8$ the sampling error for the sample lies at 22,6% tree species per ha (Loetsch et al., 1973). Although higher as the tabulated number of required sample plots, in total 80 were recorded to increase the confidence limit (Table 1).

Sample plots were numbered consecutively and chosen by a simple unrestricted random selection without replacement. A nested sampling plot design, consisting of circles (d = 30 m / 0,28ha) and inner squares (20 x 20 m and 10 x 10 m), was utilized. In the circle each tree with a dbh ≥10 cm was identified and dbh, total height of tree, and stem height were assessed. Information on regeneration was gathered in the 20 x 20 m sub-plot, where all trees ≥1.3 m of height were recorded. In the 10 x 10 m sub-square, all tree seedlings below 1.3 m of were noted. Measurements took place according to standard proceedings suggested by Zöhrer (1980) and Campbell (1989). Where possible, local informants

Table 1: Computed number of sample plots in relation to the size of each stratum (PPS sampling: probability proportional to size)

Land classes	Land use types [1]								Potential No. of plots [3]
	i. Communal		ii. State		iii. Private		Total study area [2]		
1. Rock outcrop	0	(2)	0	(1)	0	(0)	0	(3)	14
2. Cultivated	22	(20)	2	(6)	7	(7)	32	(33)	232
3. Woodland (medium dense)	17	(16)	7	(5)	6	(5)	31	(26)	163
4. Bush land	1	(2)	0	(0)	0	(0)	1	(2)	12
5. Woodland (dense)	3	(9)	3	(4)	2	(3)	10	(16)	14
Total No. of plots	43	(49)	12	(16)	15	(15)	74	(80)	455
Potential No. of plots [3]	319		47		89		455		
Area (ha)	36.975		6.060		9.699		52.734		

[1] Figures in brackets are number of plots actually measured in the inventory.

[2] Numbers are separately calculated values, they do not add up results of each stratum.

[3] Max. number of plots potentially encountered in the study area.

identified the tree species, otherwise a key was used (Coates Palgrave, 1996). Vernacular and scientific names were noted. The basal area in the 30 m circles was used to calculate the dominance of tree species ($g_{1.3} = Pi / 4 * d^2_{1.3}$). This figure was extrapolated to one ha. The volume of harvestable wood was calculated using the form factor developed by Banks and Burrows (quoted from DSF, 1995) (Volume = 4,81348 + 0,0371 $*$ dbh^2 $*$ tree height). The data analysis concentrated on nine tree species preferred by the wood carving industry (Table 2). Data and discussion on the five different land classes will be presented in subsequent work.

Results

A total of 78 different tree species were identified. Tree species in the 30 m circles totalled 56, whereas the remaining 22 species were only identified in the 400 m^2 and 100 m^2 sample plots.

Abundance

Tree species most frequently found in the research area are the dominating miombo woodland trees *Julbernardia globiflora* (Benth.)

Troupin (78 trees/ha) and *Brachystegia spiciformis* Benth. (45 trees/ha). The lowest stem number (all trees) per hectare was identified on communal land (36 trees/ha), followed by resettlement land (82 trees/ha), and commercial farm land (114 trees/ha). The nine tree species preferably used by the woodcarving industry showed an average abundance of 3.9 trees/ha, varying between the different land use types (Table 2).

Table 2: Number of trees/ha according to land use types and tree species used by the carving industry

Species[1]	**Land use types**							
	i. Communal		ii. Resettlement		iii. Commercial		Total area	
	No.	%	No.	%	No.	%	No.	%
Afzelia quanzensis	1,1	18,5	1,3	6,8	0,0	0,0	2,4	6,9
Pterocarpus angolensis	0,7	11,1	1,6	8,0	2,1	22,5	4,3	12,4
Combretum imberbe	0,1	1,2	0,0	0,0	0,0	0,0	0,1	0,2
Kirkia acuminata	1,7	29,7	8,4	42,7	4,0	42,5	14,1	40,4
Dalbergia melanoxylon	0,1	2,4	0,7	3,4	0,5	5,0	1,3	3,6
Sclerocarya birrea	1,7	28,5	3,8	19,1	1,9	20,0	7,3	20,9
Albizia amara	0,4	6,2	2,9	14,6	0,0	0,0	3,2	9,2
Ozoroa insignis	0,0	0,0	0,4	2,2	0,7	7,5	1,2	3,3
Albizia antunesiana	0,1	2,4	0,7	3,4	0,2	2,5	1,0	3,0
Average	**0,6**		**2,2**		**1,0**		**3,9**	

1) Tree species used for woodcarvings, listed in sequence of carved stock volumes (m^3) found on markets in the research area (Braedt and Standa-Gunda, in press).

Frequency

Figures for all 56 tree species show highest abundance of trees and diameter classes on commercial farm land. The diameter classes above 30 cm are relatively scarce on all three land use types, the frequency declines steadily in higher classes. Only considering the nine tree species used by wood carvers, the diameter class distribution does not show such a gradual trend (Table 3). A decline at the diameter class above 30 cm can also be noted, but on communal and commercial farm land figures increase in the following class. Noticeable is that trees with a dbh of >70 cm were neither detected on communal nor on resettlement land.

Table 3: Dbh frequency in all three land use classes (No. of trees/ha)

Land use types[1]	Diameter class						
	10-20	21-30	31-40	41-50	51-60	61-70	>70
Communal Land – I	16,0	10,5	4,4	3,0	1,2	0,4	0,0
Resettlement Area – I	55,3	21,0	4,4	2,2	0,4	1,2	0,0
Commercial Farm Land – I	70,5	28,8	7,3	5,9	2,4	1,2	0,0
Communal Land – II	1,5	1,6	0,9	1,2	0,4	0,2	0,0
Resettlement Area – II	3,5	3,1	0,9	0,7	0,2	0,4	0,0
Commercial Farm Land – II	9,7	4,7	2,1	2,3	1,4	0,9	0,2

[1)] I = all 56 tree species encountered; II = only nine tree species preferably used by carvers.

Dominance

The dominance was only calculated for the tree species used by carvers. The determined values vary extremely between species and within land use types (Table 4). The most dominant species in the research area was *Kirkia acuminata* Oliver on the commercial farm land, followed by *Afzelia quanzensis* Welw. and *Sclerocarya birrea* (A. Rich.) Hochst. on the same land use type. Disregarding land use classification, the three dominating tree species covered over 80% of the extrapolated basal area. *K. acuminata* also dominated in communal and resettlement areas, followed in both areas by *S. birrea* (Table 4).

Volume

In total a wood volume of 589,941 m^3 was computed for the entire research area (11.2 m^3/ha). The communal area encompassed 8.8 m^3/ha, the resettlement land 10.7 m^3/ha and the commercial farmland 19.3 m^3/ha respectively. The nine tree species found to be used on the craft markets account for over 25% of wood volume for all 56 tree species recorded. For the latter a total of 2.1 m^3/ha (77,747 m^3) was found on communal land, 2.0 m^3/ha (12,186 m^3) on resettlement land and 6.4 m^3/ha (62,432 m^3) on commercial farm land. On average a wood volume of 2.9 m^3/ha was calculated for tree species used by carvers.

Table 4: Dominance of tree species used by the carving industry (in m^2/ha) according to land use types

Species[1]	Land use types[2]							
	i. Communal		ii. Resettlement		iii. Commercial		Total area	
	m^2/ha	%	m^2/ha	%	m^2/ha	%	m^2/ha	%
Afzelia quanzensis	0,063 (12)	11,2	0,000	0,0	0,493 (02)	26,9	0,556	18,5
Pterocarpus angolensis	0,055 (13)	9,8	0,009 (10)	16,1	0,105 (09)	5,7	0,259	8,6
Combretum imberbe	0,002 (22)	0,4	0,000	0,0	0,000	0,0	0,002	0,1
Kirkia acuminata	0,185 (05)	32,9	0,307 (04)	49,9	0,740 (01)	40,4	1,232	40,9
Dalbergia melanoxylon	0,003 (21)	0,5	0,016 (14)	2,6	0,013 (15)	0,7	0,032	1,1
Sclerocarya birrea	0,141 (07)	25,0	0,180 (06)	29,3	0,399 (03)	21,8	0,720	23,9
Albizia amara	0,107 (08)	19,0	0,000	0,0	0,067 (11)	3,7	0,174	5,8
Ozoroa insignis	0,007 (18)	1,2	0,003 (20)	0,5	0,008 (17)	0,4	0,018	0,6
Albizia antunesiana	0,000	0,0	0,010 (16)	1,6	0,007 (19)	0,4	0,017	0,6
Average	**0,063**	**18,7**	**0,068**	**20,4**	**0,204**	**60,9**	**0,334**	

1) Tree species used for woodcarvings, listed in sequence of carved stock volumes (m^3) found on markets in the research area (Braedt and Standa-Gunda, in press).

2) Figures in brackets indicate dominance ranking of species over all three land use types (i.e. rank 1 = most dominant species; rank 22 = least dominant species).

Regeneration

Results from the 400 m^2 plots for the tree species used for carvings indicate a regeneration of 13.1 trees/ha and for the 100 m^2 plots of 16.9 seedlings/ha. Table 5 shows a relative equal distribution of these tree species on the three land use categories, but with strong variations between species. On average regeneration for the nine species listed in Table 5 is highest in communal areas, followed by commercial farm land and is lowest on resettled land. For all tree species encountered in the study area (N=78) the mean density of the regeneration was 4.3/ha in the 400 m^2 plots and 5.6/ha in the 100 m^2 plots.

Table 5: Number of trees ≥1.3 m of size and tree seedlings below 1.3 m of size according to land use types and tree species used by the carving industry

Species[1]	Land use types							
	i. Communal		ii. Resettlement		iii. Commercial		Total area[2]	
	≥1.3 m	<1.3 m	≥1.3 m	<1.3 m	≥1.3 m	<1.3 m	≥1.3 m	<1.3 m
Afzelia quanzensis	1,5	2,0	3,1	0,0	1,7	0,0	6,3 (5,4)	2,0 (1,3)
Pterocarpus angolensis	1,0	0,0	3,1	0,0	13,3	40,0	17,5 (14,8)	40,0 (26,3)
Combretum imberbe	6,1	6,1	0,0	0,0	0,0	0,0	6,1 (5,2)	6,1 (4,0)
Kirkia acuminata	2,6	4,1	7,8	6,3	13,3	0,0	23,7 (20,1)	10,3 (6,8)
Dalbergia melanoxylon	2,0	8,2	4,7	12,5	0,0	0,0	6,7 (5,7)	20,7 (13,6)
Sclerocarya birrea	3,6	16,3	7,8	6,3	0,0	6,7	11,4 (9,6)	29,3 (19,2)
Albizia amara	30,6	24,5	1,6	0,0	0,0	0,0	32,2 (27,3)	24,5 (16,1)
Ozoroa insignis	1,0	0,0	3,1	6,3	6,7	0,0	10,8 (9,2)	6,3 (4,1)
Albizia antunesiana	0,0	0,0	1,6	6,3	1,7	12,5	3,2 (2,7)	12,9 (8,5)
Average	**5,4**	**6,8**	**3,6**	**4,2**	**4,1**	**5,9**	**13,1**	**16,9**

1) Tree species used for woodcarvings, listed in sequence of carved stock volumes (m^3) found on markets in the research area (Braedt and Standa-Gunda, in press).
2) No. in brackets indicate the respective percentage of the total.

Discussion and Conclusion

Results obtained from this study allow a methodological and environmental, forestry based discussion. Depending on the objective of a forest inventory, normal forest practise envisages a sampling error of around 5 - 10% (Kramer and Akça, 1995). Considering financial and time constraints of the present study, a sampling error of around 20% was accepted. Subsequent research must not only consider land use types and wood cover classes, but should heed differences in tree specific site preferences. Species such as *Combretum imberbe* Wawra, a tree frequently occurring along rivers or dry water courses, might be under-represented in a conventional inventory. Preliminary surveys applying other inventory methods (i.e. transects) resulted less applicable. For the strata rock outcrop and cultivated land, the latter method proved satisfactorily, but due to the above mentioned limitations, the survey was restricted to only one approach. Furthermore, results from this study should be viewed as a base line for subsequent ecological studies and as an initial basis for calculations on the future viability of the woodcraft industry.

The absence of tree species used by the carving industry with dbh diameter classes >70 cm on communal and resettlement land, and the negligible occurrence on commercial farm land, is alarming. Also the rapid decline of bigger diameter classes >30 cm is striking. The fact that carvers predominantly use logs with a dbh above 30 cm indicates why trees with voluminous trunks are rare. Other uses of timber from trees of the diameter size preferred for carvings are of minor importance. At the onset of the carving industry the tree species *A. quanzensis* and *P. angolensis* were preferably used by carvers. With increasing numbers of craftsmen and diminishing amounts of favoured trees of sufficient size, other species gained importance. Especially *K. acuminata* and lately also *S. birrea* are increasingly being used. The development of the industry clearly marked a change in timber species offered on markets and also traditional taboos prohibiting the use of certain tree species are not respected anymore (Braedt and Schroeder, in prep.). Such shift in species is a sign of the decline in availability of the core species. Experiences from Kenya indicate that the most commonly used tree species for woodcarvings are close to extinction and can only be found in areas distant from markets selling craft products (Obunga, 1995; Hamilton, 1997).

Regeneration is found relatively everywhere, floristically it corresponds with the composition of the ”mature stand”, but is more diverse. Considering the advanced deforestation, the intensive grazing and the high population density on communal land, it is unexpected to observe higher regeneration for the valuable carving species, than on other land use types. However, although regeneration being highest on communal land does not meet the expectations, an abundance of seedling is by no means an indicator of the definitive establishment of young individuals (Lamprecht, 1989).

Matose et al. (1997), estimated an annual extraction rate of 657 m^3 per year for craft markets encountered along the Bulawayo-Victoria Falls road in western Zimbabwe. A total stock volume of approximately 235 m^3 was measured for nine tree species used by the carving industry on the Masvingo-Beitbridge road in the southern part of the country (Braedt and Standa-Gunda, in press). Since the latter surveys were conducted the number of markets on both roads have augmented and the turn-over of carvings and wood in stock is likely to have increased. Taking into account current extraction rates, standing volumes, and the tree diameter frequencies found in the study area, the resource base along the Masvingo-Beitbridge road won't sustain the woodcraft industry much longer. Over time, indigenous forests in the region will not persist the current harvesting rate. Especially in communal areas, where most craft markets in Zimbabwe are located and the lowest tree abundance was found, the selective use of certain tree species for carving is likely to drive the species to local extinction. Scientific findings on ecological impacts caused by woodcarvers are scant, yet they are necessary for taking decisions on the protection of some indigenous tree species and the future of the carving sector.

Acknowledgement

The research for this paper was financed by the German Federal Ministry for Economic Cooperation and Development (BMZ) as part of a long term comparative study being undertaken by the Center for International Forestry Research (CIFOR). The authors thank B.M. Campbell, P. Frost, R. Glauner, U. Kriebitzsch, D. Kwesha and the Forestry Commission of Zimbabwe for contributions, assistance and comments.

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