8. INVENTORY OUTPUT: ABOVE-GROUND WOODY BIOMASS

Woody Biomass was calculated as follows.

FOR DRY WEIGHT: I used formulas for ABOVE-GROUND BIOMASS contained in the Wharton and Griffith's USDA Forest Service publication "Methods to Estimate Total Forest Biomass for Extensive Forest Inventories", 1994. I converted pounds and inches to kilogrammes and millimeters of diameter, and used the formula for Yellow birch, which is a hardwood which matches density and form of many of the miombo hardwoods. The formula is: Ln(biomass)=1.1297 + (2.3376)(Ln(Diameter))

FOR GREEN WEIGHT: I used ForestCalc's biomass formula, which is (0.124) x (diameter squared*ht).

Results are within range of similar work done in tropical forests in Bolivia (M. Boscolo et al: "The Cost of Inventorying and Monitoring Carbon", *Journal of Forestry*, September 2000) and wide areas in temperate United States (J. Smith et al.: "How to Estimate Forest Carbon for Large Areas from Inventory Data", *Journal of Forestry,* July/August 2004).

STAND NAME	HA	Main Plot TPH est.	Main Plot Dry Tons/HA	Green Tonnes/ HA	Regen TPH est.	Regen Dry Tons/HA	Total Dry Tonnes	Total Green Tonnes
Chakumanika	437	411	59.55	109	16,491	67.6	**55,519**	**106,414**
Chilandu	349	2,574	85.53	145	9,726	39.9	**43,816**	**78,417**
Fallow10 E	3,513	628	54.75	111	13,086	53.7	**380,825**	**767,952**
Fallow10 W	2,281	1,066	14.46	35	11,217	46.0	**137,862**	**289,560**
Fallow20 E	1,818	442	43.59	79	1,314	5.4	**89,025**	**164,093**
Fallow20 W	1,211	748	26.35	59	16,270	66.7	**112,712**	**233,482**
MiomboE	1,755	661	52.20	101	11,286	46.3	**172,811**	**339,977**
MiomboW	3,054	481	58.00	110	7,221	29.6	**267,510**	**517,821**
SawtimberE	2,776	498	60.51	110	8,965	36.8	**269,968**	**508,187**
SawtimberW	995	826	73.77	143	6,877	28.2	**101,429**	**198,777**
Grand Totals on 18,188ha							**1,631,479 kg Dry T.**	**3,204,680 kg Green T.**

NOTES:

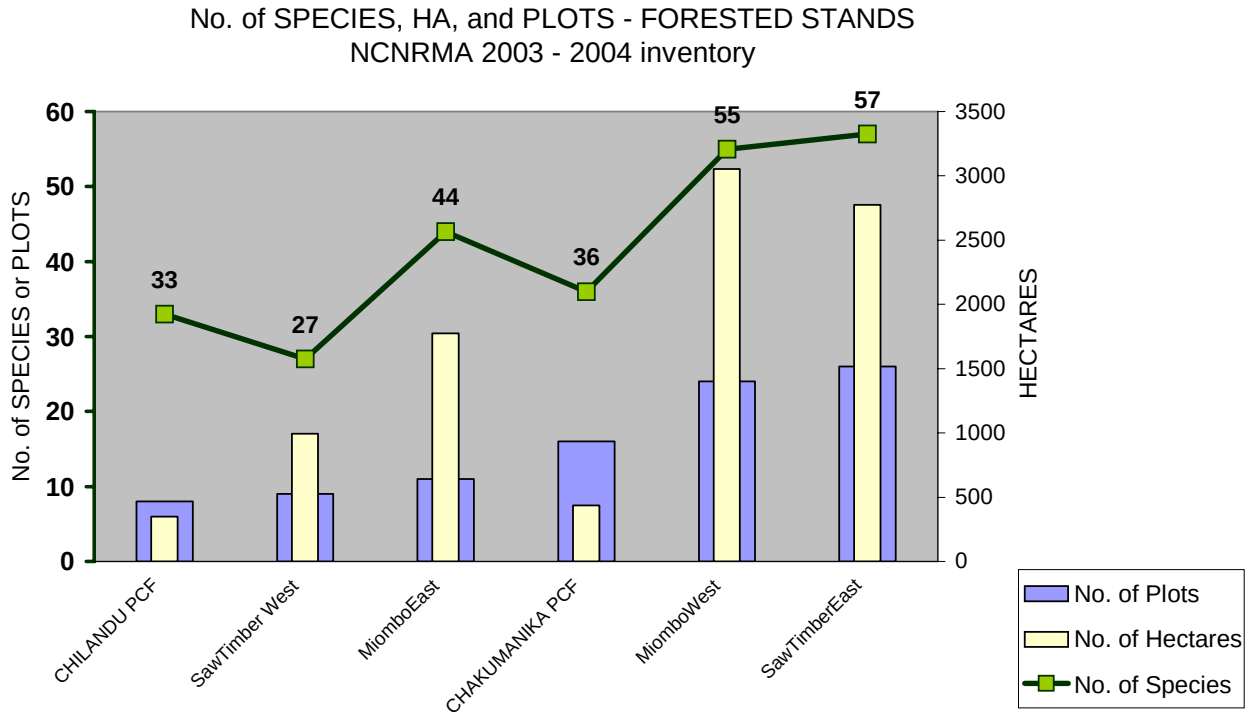
- To have a complete biomass calculation for all parts of the forest, it is suggested in the above publications to add another 25% to the total for "Below-Ground Biomass", and an additional 11% for foliage and small twigs.
- Biomass is converted to TONNES OF CARBON by a simple factor of one-half. The above weights then yield a total of about **815,000 tonnes of carbon** being stored (sequestered) in forest vegetation, plus the additional percentages just described.
- Any trading in carbon credits would involve calculating changes in today's biomass based on management activities. "Accounting" over several years would have to show calculated changes in the amount of carbon being stored in the forest.

9. INVENTORY OUTPUT: BIODIVERSITY INFORMATION

The following chart is an indication of the high number of species in the 20,000 hectares of NCNRMA.

About 100 woody species were found on the plots visited. This number compares with areas in Tanzania that are being put into nature reserves under IUCN because of their endemic species. Most likely, more species would be found in Nyamphande if more plots were visited.

There is an important wildlife component to the area which needs further exploration as well.



SPECIES ENCOUNTERED IN NCNRMA INVENTORY – 100 TOTAL SPECIES

TOTAL SPP IN REGEN PLOTS = 85 *TOTAL SPP IN MAIN PLOTS = 66*

BOTANICAL NAME	RE-GEN	Main Plot
Acacia	4	5
Acacia nigrescens	4	2
Acacia polyacantha	2	13
Acacia sieberana		1
Acacia tortilis	1	2
Afzelia quanzensis		4
Albizia amara		2
Albizia anthunesiana	4	2
Albizia harveyi	1	1
Albizia versicolor	3	5
Annona senegalensis	2	7
Bauhinia petersiana	25	7
Boscia salicifolia	2	1
Brachystegia allenii	6	42
Brachystegia boehmii	1	7
Brachystegia bussei	2	5
Brachystegia longifolia	4	5
Brachystegia sp.		4
Brachystegia spiciformis	5	16
Brachystegia utilis		2
Bridelia cathartica	1	
Burkea africana		1
Cassia abbreviata	10	3
Cassia or Senna,singueana	2	
Cassia singueana or abbreviata	5	3
Chintungulu	11	
chitongololo	3	
Combretum elaegnoides A51	4	7
Combretum fragrans	7	7
Combretum molle	14	40
Combretum molle or collinum	25	6
Commiphora africana	1	
Commiphora mollis or africana	5	
Crossopteryx febrifuga		1
Cut stump		1
Dalbergia melanoxylon	3	
Dalbergia nitidula	9	2
Dalbergiella nyasae	10	2
Dichrostachys cinerea	5	1
Diospyros kirkii	2	5
Diplorhynchus condylocarpon	42	30
Dombeya rotundifolia	2	1
Erythrina abyssinica	2	4
Ficus brachylepis		1
Flacourtia indica	5	
Garcinia	9	
Garcinia huillensis	2	
Hexalobus monopetalus	4	
Julbernardia globiflora	15	37
Kabambafila	1	
Kafunda	1	
Khaya nyasica	2	

BOTANICAL NAME	RE-GEN	Main Plot
Kirkia acuminata		3
Lannea stuhlmannii	2	1
Lannea stuhlmannii, discolor	1	1
Lannea discolor female?	8	6
Lonchocarpus capassa	15	7
Lumpunga	2	
Manjao	1	
Markhamia obtusifolia	36	9
Markhamia tomentosa	10	3
Mimusops zeyheri	3	
Monotes africanus	1	
Ochna?		1
Oncoba spinosa	4	
Peltophorum africanum	3	
Pericopsis angolensis	1	10
Phyllocosmus lemaireanus	2	
Piliostigma thonningii	6	6
Popowia obovata	1	
Protea welwitschii	1	
Pseudolachynostylis maprouneifolia	6	19
Pterocarpus angolensis	3	46
Pterocarpus chrysothrix	19	41
Ricinodendron rautanenii		8
Sclerocarya caffra or birrea		18
Securidaca longepedunculata	1	
Steganotaenia araliacea	12	
Sterculia africana	1	4
Sterculia quinqueloba		1
Stereospermum kunthianum	6	5
Strychnos cocculoides		3
Strychnos spinosa	2	1
Strychnos spinosa or cocculoides	3	
Sunde 1-hand tall	2	
Terminalia stenostachya	13	20
Terminalia mollis	4	
Terminalia sp.	9	17
Turraea nilotica	1	
Uapaca sansibarica	12	
Vangueria infausta or Bridelia c.		3
Vangueriopsis lanciflora	9	
Vellozia equisetoides	1	
Vitex doniana	3	1
Xeroderris stuhlmannii	1	2
Xeromphis obovata	2	
Ximenia americana	2	
Zanha africana (female)	5	1
Zanha africana (male)	8	5
Ziziphus abyssinica	4	11

SPECIES IN REGEN, NOT MAIN PLOTS (32)

Bridelia cathartica
Cassia or Senna
chintungulu
chitongololo
Commiphora africana
Commiphora mollis,africana
Dalbergia melanoxylon
Flacourtia indica
Garcinia huillensis
Hexalobus monopetalus
Kabambafila
Kafunda
Khaya nyasica
Lumpunga
Manjao
Mimusops zeyheri
Monotes africanus
Oncoba spinosa
Peltophorum africanum
Phyllocosmus lemaireanus
Popowia obovata
Protea welwitschii
Securidaca longepedunculata
Steganotaenia araliacea
Strychnos spinosa, cocculoides
Sunde 1-hand tall
Terminalia mollis
Turraea nilotica
Uapaca sansibarica
Vangueriopsis lanciflora
Vellozia equisetoides
Xeromphis obovata
Ximenia americana

SPECIES IN MAIN PLOT, NOT IN I12REGEN (16)

Acacia sieberana
Afzelia quanzensis
Albizia amara
Brachystegia sp.
Brachystegia utilis
Burkea africana
Crossopteryx febrifuga
Cut stump
Ficus brachylepis or Ochna
Kirkia acuminata
Ochna?
Ricinodendron rautanenii
Sclerocarya caffra or birrea
Sterculia quinqueloba
Strychnos cocculoides
Vangueria infausta OR Bridelia c.

10. RECOMMENDATIONS ON WHAT TO DO WITH THE DATA

Plan to present the data back to stakeholders

Data to present

- Totals of all products today
- A rough idea of distribution of products by area
- The status of next-lower size class and of regeneration of exploitable trees
- Proposed management activities that could lead to certification or carbon credit trading

How will you describe the data to the different stakeholders?

- Chief Nyamphande (the new one)
- Forestry Department at Central HQ
- District Environmental Committee
- Chief's Advisors/Village Headmen
- User groups

Use the data to answer some questions

- How can we calculate a sustainable offtake that matches policies in the management plan?
- What is going to be the timeframe for harvesting products that (the data say) are in the forest?
- How long will it take trees in smaller diameter classes to move up to larger ones?
- How many trees are left?
- Who will get the licenses for which products?
- Kwacha worth per hectare: What if all cleared trees were processed for highest value

Use the data in support of follow-up projects and funding

- Biodiversity reserve (101 woody spp.) based on chart of Species, Areas, and Plots
- Wildlife inventory and regeneration scheme based on proximity to GMA
- Biomass accounting for Carbon trading
- Establishment of Village Harvest Committees that ensure full use of all cleared trees
- Certification, supported by these aspects of the inventory:
  - ➔ Info on economic potential is calculated; forms the basis for defining sustainable yield
  - ➔ Non-timber and other forest uses are addressed; waste is discouraged
  - ➔ Requirement for local participation is fulfilled during the course of inventory and sensitisation
  - ➔ Mapped PCFs show where indigenous rights are tied to forest resources

Ideas for SENSITISATION activities based on inventory results

- Don't depend on current harvest rates of commercial sawtimber to be sustainable
- Promote other species as equally valuable
- "Waste no trees" message continues
- Pay attention to regeneration
- Relate diversity and abundance of wildlife to diversity and abundance of tree species/habitat
- **Solicit input from communities on how to achieve all the above**

Ideas for PROJECT activities based on inventory results (2)

- Set up a Biodiversity Reserve under UNEP/IUCN
- Set up Village Harvest Committees who will maximize economic benefit during field clearing
- Trade some carbon credits (requires detailing management plan actions and their effects on biomass)
- Open marketing centers for forest products
- Do more training on better techniques
- Sensitize on certification for eventual cert. project
- **Solicit input from communities on how to achieve all the above**

APPENDIX: HOW MANY TREES ARE LEFT?

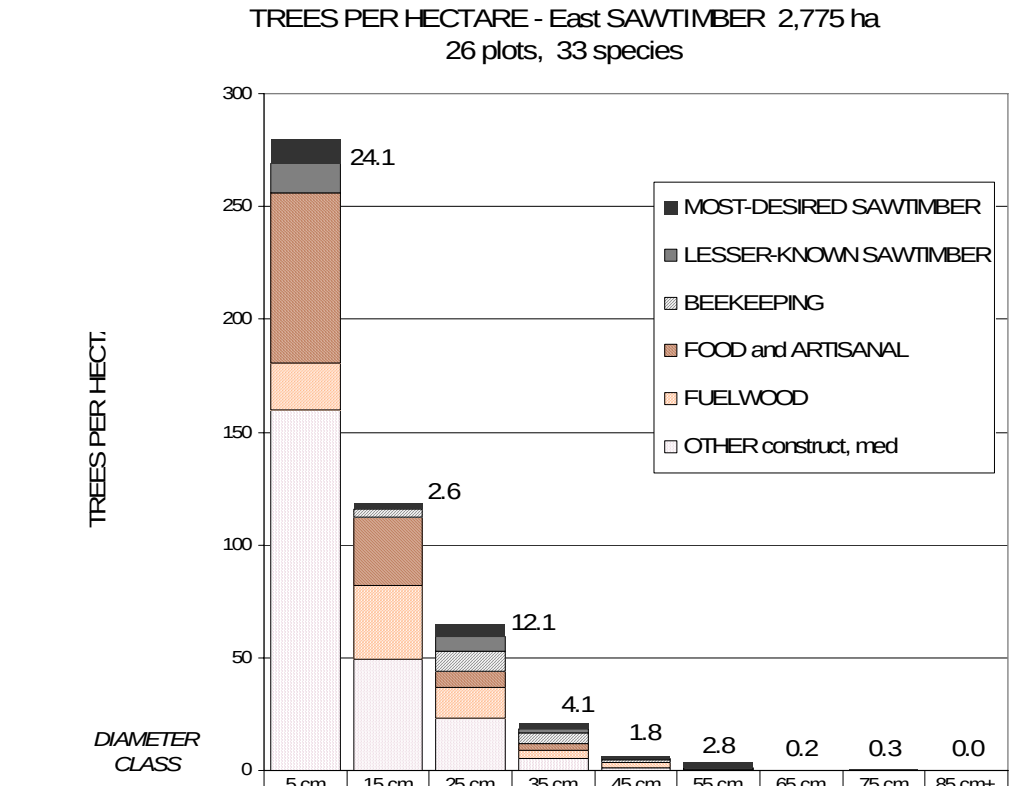
Most of the stands in Nyamphande area do not have good regeneration of the highest-value trees. Trees in the exploitable sawtimber (35cm) class are relatively few everywhere. The number of trees in the next class down is also usually low, even though these are the ones that are supposed to replace the current stand that may be harvested. And if you check the regeneration tables, there is only one case where mukwa was found in the 3-meter radius regeneration plots.

The purpose of looking at numbers of trees in different size classes is to decide how long today's crop trees have to last.

This is the question that must be put to the user groups in the area.

Therefore, it would be most useful for individual user groups to look at results for the trees that they use, and decide how they want to use those trees.

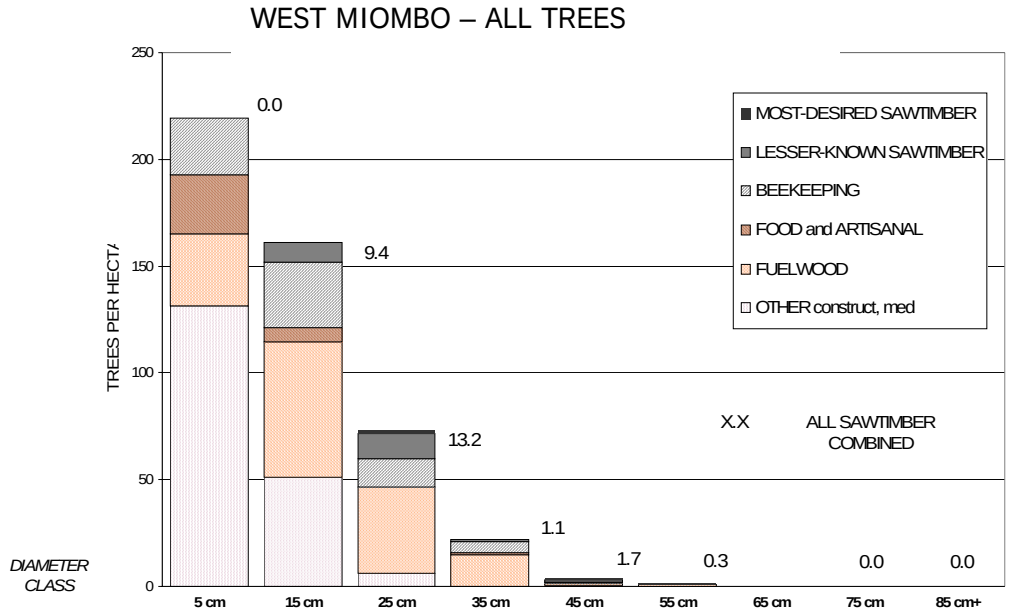
The normal "shape" of a natural forest's uneven-age trees-per-hectare structure is that of a "J": there should be a high number of the smallest stems, and ever-smaller numbers of larger stems as smaller trees die from drought, disease, browsing, or harvesting.

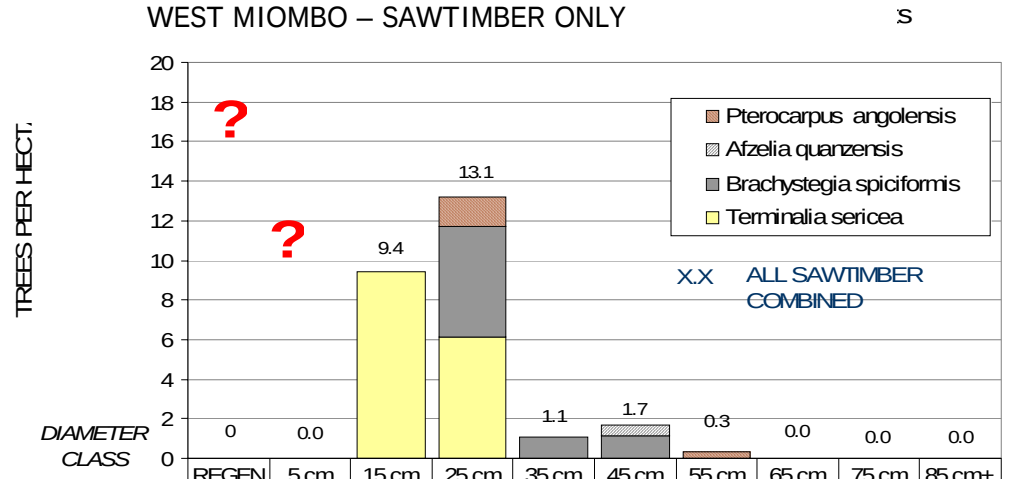


	5 cm	15 cm	25 cm	35 cm	45 cm	55 cm	65 cm	75 cm	85 cm+
MOST-DESIRED SAWTIMBER	10.9	2.6	5.4	2.4	1.4	2.1	0.2	0.3	0.0
LESSER-KNOWN SAWTIMBER	13.2	0.0	6.7	1.7	0.4	0.7	0.0	0.0	0.0
BEEKEEPING	0.0	3.4	8.6	4.5	0.9	0.0	0.0	0.0	0.0
FOOD and ARTISANAL	75.1	30.3	7.1	2.9	0.0	0.0	0.0	0.0	0.0
FUELWOOD	20.9	32.8	13.4	3.9	2.3	0.4	0.0	0.0	0.0
OTHER construct, med	159.8	49.3	23.5	5.2	1.5	0.4	0.0	0.0	0.0

EXAMPLE OF MIOMBO FOREST IN WESTERN NCNRMA:

Although the species populations are in the normal "J" shape when all species are counted. However, if you draw out only the high-valued sawtimber species, there is almost no sawtimber regeneration in this stand. In 10 years, after the maturing of the up-coming generation of sawtimber (in 25cm size class), there will not be enough trees to replace the current stocks.



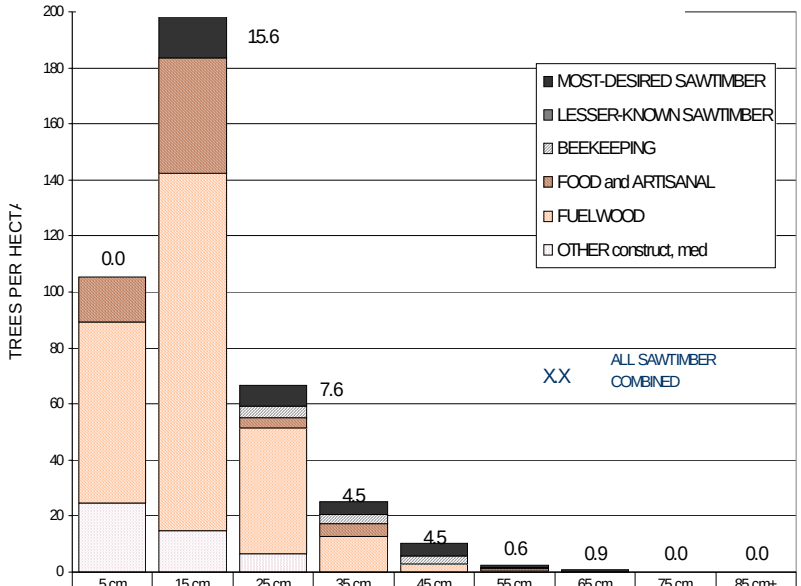


	REGEN	5 cm	15 cm	25 cm	35 cm	45 cm	55 cm	65 cm	75 cm	85 cm+
Pterocarpus angolensis	0	0.0	0.0	1.5	0.0	0.0	0.3	0.0	0.0	0.0
Afzelia quanzensis	0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0
Brachystegia spiciformis	0	0.0	0.0	5.6	1.1	1.1	0.0	0.0	0.0	0.0
Terminalia sericea	0	0.0	9.4	6.1	0.0	0.0	0.0	0.0	0.0	0.0

EXAMPLE OF CHAKUMANIKA PERMANENT COMMUNITY FOREST:

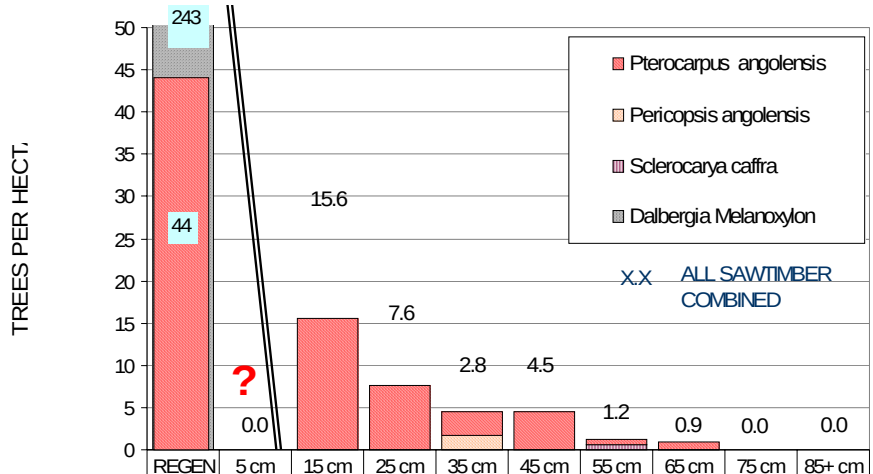
This sawtimber stand composed of many mukwa has mostly good mukwa regeneration. This is a characteristic of mukwa: it prefers to regenerate in pure stands after land clearing, but needs protection from fire and grazing.

CHAKUMANIKA – ALL TREES



	5 cm	15 cm	25 cm	35 cm	45 cm	55 cm	65 cm	75 cm	85 cm+
MOST-DESIRED SAWTIMBER	0.0	15.6	7.6	4.5	4.5	0.6	0.9	0.0	0.0
LESSER-KNOWN SAWTIMBER	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0
BEEKEEPING	0.0	0.0	3.8	3.4	2.9	0.0	0.0	0.0	0.0
FOOD and ARTISANAL	15.9	41.0	3.8	4.5	0.0	0.6	0.0	0.0	0.0
FUELWOOD	64.5	127.6	44.8	12.8	3.0	0.5	0.0	0.0	0.0
OTHER construct, med	24.9	14.7	6.6	0.0	0.0	0.0	0.0	0.0	0.0

CHAKUMANIKA – SAWTIMBER ONLY



	REGEN	5 cm	15 cm	25 cm	35 cm	45 cm	55 cm	65 cm	75 cm	85+ cm
Pterocarpus angolensis	44	0.0	15.6	7.6	2.8	4.5	0.6	0.9	0.0	0.0
Pericopsis angolensis	0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0
Sclerocarya caffra	0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0
Dalbergia Melanoxylon	243	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

MARKET PRICES USED FOR HECTARE AND STAND KWACHA WORTH VALUES

Unit Name	Use Class	Market Price		Unit Name	Use Class	Market Price
artisan other	artisanal	500		glue, heap	household	500
axe handle	tools	1,000		gum, heap	medicine	500
bark rope	fibre	500		headload	fuel	1,500
bark tray	household	500		hoe handle	tools	1,000
barkhive	beekeeping	2,000		household other	household	500
basket weaving	fibre	500		med cough	medicine	500
beam	construction	2,000		med digestive	medicine	500
bee forage	beekeeping	1,000		med malaria	medicine	1,000
canoe	artisanal	10,000		med pain	medicine	500
carving	artisanal	5,000		med reproduction	medicine	500
caterpillar host	food	2,000		med skin	medicine	500
charcoal 50-kg sack	**fuel**	**8,000**		med, other	medicine	500
charcoal 25-kg sack	**fuel**	**4,000**		mortar	household	8,000
charcoal 90-kg sack	**fuel**	**15,000**		mushroom host	food	1,000
coffin, carved	artisanal	5,000				
construct other	construction	1,000		**plank, 1in.x 2m**	**sawn wood**	**5,000**
cooking stick	household	1,500		**plank, 2 in. x 2m**	**sawn wood**	**10,000**
doorframe	construction	2,000		pole, forked	construction	1,000
drum	artisanal	5,000		post	construction	1,000
fibre (bark)	fibre	500		rafter	construction	1,000
firewood stick	fuel	300		**sawtimber, per m3**	**sawn wood**	**250,000**
firewood,oxcart	fuel	10,000				
fish poison	hunting	500		soup (Lvs/pods)	food	500
food other	food	500		stool	artisanal	2,000
forage animals	fodder	500		truss, 5cmX25cm	construction	5,000
fruit 20Lbucket	food	5,000		witchcraft	medicine	1,000

In year 2005, $US 1 = 4800 Zambian Kwacha