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SUMMARY

1 metre billets of known volume were stacked in $1m^3$ mendles to calculate the ratio of stacked to solid volume for miombo woodlands in Chikwawa and Dedza districts. An average conversion factor of 44% of stacked wood for solid volume was calculated.

Stand basal area (m^2ha^{-1}) varied between sample plots, and mean stackwood volume (m^3) per m^2 of basal area removed was $16.1m^3\ m^{-2}$.

Regressions of stackwood yield against mean height and basal area removed led to the development of prediction models for estimating stackwood volume for miombo woodland in Malawi.

indica. Timber species from the genera Pterocarpus, Terminalia and Combretum are present in small numbers.

The soils are escarpment lithosols, and mostly shallow and stony. They are acidic with a small proportion of silt and clay. The basement rock is precambrian metamorphic. The site is in relatively undisturbed customary (communally owned) woodland. The area has a history of low population density but is presently experiencing an inward migration of small farmers (Coote, Lowore, Luhanga, Abbot 1993b).

The site at Chongoni (Malawi College of Forestry) lies about 1700m a.s.l., with an average rainfall of 800 - 900mm. The canopy is dominated by Brachystegia floribunda and Faurea saligna. The sub-canopy is dominated by Uapaca kirkiana.

The soils at Chongoni are ferruginous, the sandy clay loam top soil is moderately acid. The parent rocks are basement complex. Although the site is within the Chongoni Forest Reserve, the surrounding area is heavily populated and has a sparse tree cover. Cattle are grazed in the Reserve by local people.

3.0 METHODOLOGY

The present study was based on information gathered during the establishment of silvicultural systems trials in 1992. The silvicultural treatments imposed were coppice, coppice with standards, and selective thinning. The fourth plot per block was left uncut as the control. At both sites the treatment layout was a simple random complete block design with the four treatments replicated in three blocks. All trees felled in the eighteen plots of 0.125 ha (25m x 50m) were measured. The proportion of trees felled varied in accordance with the treatment applied. The data used represent different intensities of basal area removal from study plots. This is therefore likely to be a source of data variation. No trees below 5cm diameter at breast height (dbh) were felled. In total, some 692 trees were measured and stacked. For all trees in the sample plots, species, height (m) and dbh (cm) were recorded.

All the felled trees were marked at 1 metre intervals along their length. Using rounded-down centimetre diameter tapes, mid-diameters (at 0.5m centres) were recorded for all 1m sections down to 5cm log mid-diameter. Billet volumes were estimated using Huber's formula[1]. For sticks of less than 5cm mid-diameter, butt-diameter was measured and recorded. Volume for these sticks was estimated using the equation for cone volume.

[1] Huber's Formula: $v = Lg_m$
Where L = Log length, m
g_m = Cross sectional area at midlength of log, m^2

[illegible]	[illegible]			
7	8.2 / 18.4	0.44	1.6	7.40
8	7.3 / 25.0	0.29	1.7	6.90
9	6.5 / 16.0	0.41	1.5	6.52
Means:	28.9 / 63.0	0.43	4.38	6.90
Chongoni Site:				
1	100.9 / 190.0	0.53	9.8	8.80
5	71.1 / 160.0	0.44	8.4	8.06
6	63.2 / 158.0	0.40	8.4	7.20
7	42.9 / 102.4	0.43	4.1	8.30
8	68.0 / 134.4	0.51	7.1	9.32
9	25.8 / 60.8	0.42	3.3	7.40
Means:	66.8 / 144.3	0.45	7.95	8.25

Making the general assumption that eucalypt billets are straighter than miombo billets, a solid to stackwood volume ratio for indigenous timbers would be expected to be lower than the 48% calculated by BCFP for eucalypts.

In Malawi, the Forestry Department usually stacks wood using piece work, with the result that stacks are likely to be less meticulously constructed in comparison to those constructed under research and reported on here. The ratio of 0.44 calculated in this study should be considered a maximum conversion figure and it might be prudent to recommend the lower 90% confidence interval of ≈ 0.42 as the operational stack:solid volume conversion ratio.

Stackwood Yield

Using the data collected from BCFP and Chongoni, mean stack-wood yield (m^3) per m^2 of basal area removed was $16.1 m^3 m^{-2}$ (Table 2). Chidumayo (1987) calculated a mean stackwood yield of $14.8 m^3$ per m^2 basal area removed for charcoal production in Zambia. He took 3.7cm (11cm butt-girth) as the minimum diameter used for measurement, compared to 2.0cm for the present study. This may contribute to the higher mean stack yield observed in this case.

Stackwood Yield Prediction Models

A number of prediction models for stackwood yield (per hectare) were calculated using regression analyses. A simple regression of stack volume on basal area removed (Table 1) gives the equation:

Stack Vol. = - 5.61 + 17.7 Basal Area Removed (1)

$r^2 = 93.8\%$

s = 15.66   n = 18

A multiple regression model based on the variables basal area removed and mean height of trees removed gives the equation:

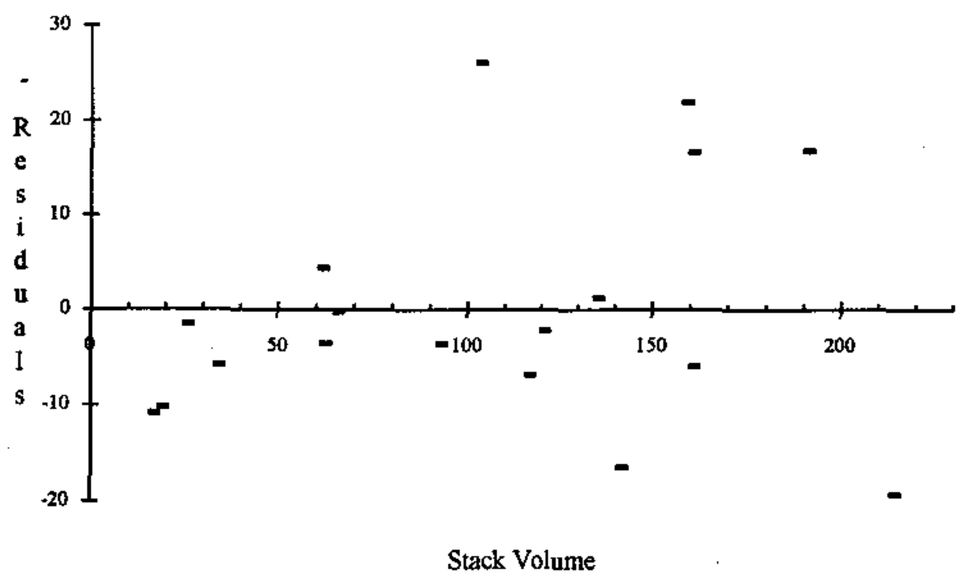
Stack Vol. = -63.9 + 15.7 Basal Area Removed + 9.35 Mean Height (2)

$r^2 = 95.8\%$

s = 13.21   n = 18

Figures 1 and 2 below plot the residuals between observed and fitted values for equations 1 and 2 respectively.

Figure 1: Plot of residuals against fitted values for equation 1.



5.0 CONCLUSION

Although the study was limited in geographical extent, to the authors' knowledge the results provide the most reliable information available on stackwood estimations for miombo woodland in Malawi.

The study results suggest that, until a more accurate survey is undertaken, the conversion ratio of stack to solid wood volume used for miombo woodlands in Malawi should be taken as 0.42.

Stackwood yield in Malawian miombo is variable and relates to climate, species composition and woodland use history. Mean stackwood yield per m^2 basal area was estimated as $16.1 m^3m^{-2}$.

The study has demonstrated the effectiveness of using regression models in predicting stackwood yield from standing wood stocks.

Since wood fuels provide a major energy source to the Malawian population, the study results should be of value to forest managers planning to manage their woodlands for energy production and requiring simple guidelines for the estimation of solid and stacked volume.

ACKNOWLEDGEMENTS

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APPENDIX Table and Chart for stack volume estimation

Table 3 and Figure 3 can be used to give a quick and approximate estimation of stack wood volume yield from a known basal area.

TABLE 3: Prediction of stacked and solid wood volume (m^3) from basal area at breast height (m^2ha^{-1}). Figures rounded to one decimal place.

BASAL AREA TO BE CUT	PREDICTED YIELD (m^3ha^{-1})	
m^2	Stacked	Solid
3.0	47.6	19.9
3.5	56.4	23.7
4.0	65.3	27.4
4.5	74.2	31.2
5.0	83.0	34.9
5.5	91.9	38.6
6.0	100.7	42.3
6.5	109.6	46.0
7.0	118.5	49.8
7.5	127.5	53.5
8.0	136.2	57.2
8.5	145.1	50.9
9.0	153.9	64.9
9.5	162.8	68.3
10.0	171.6	72.1
10.5	180.5	75.8
11.0	189.4	79.5
11.5	198.2	83.2
12.0	207.1	87.0
12.5	216.0	90.7
13.0	224.8	94.4
13.5	233.7	98.1
14.0	242.5	101.9
14.5	251.4	105.6
15.0	260.3	109.3
15.5	269.1	113.0
16.0	278.0	116.8

Using equation 1, Table 3 was drawn up for the prediction of stackwood yield and the corresponding solid volume estimate using basal area removed (m^2) as the predictor variable. In Table 3, stackwood yield is predicted from the basal area given in column one. Column three represents the solid volume estimated using the lower confidence limit of the calculated conversion ratio of 42% of stacked volume (from column 2).