A CRUDE QUANTIFICATION OF WOOD THAT IS AND CAN BE HARVESTED FROM BUSH THICKENING SPECIES IN NAMIBIA*

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ABSTRACT

The increasing rate at which thickening bushes are being harvested in Namibia requires better information on the availability and sustainability of the resource, in order to improve management. Two sources of data from the literature were combined to give a rough approximation of the standing biomass of wood of appropriate size for charcoal production, in each of nine bush-thickened zones. The overall estimate came to roughly 135 million tons of dry wood in about 260 000 square kilometres of Namibia, or an average of just over 5 t/ha. The legal commercial harvest for the 1999/2000 financial year came to the equivalent of just under 0.2 million tons of dry wood. Interviews with ten charcoal producers, and field data gathered at one site, suggest that harvesting could take place at intervals of roughly 20 years, provided that harvesting is selective and leaves sufficient bushes of different size classes for regeneration. However, it is likely that subsequent harvests would be lower and more difficult to obtain. Previously chopped bushes could then only be re-harvested on every third or fourth cycle, preferably after being pruned to maintain a more appropriate growth form, which is easier to harvest and more conducive to grass growth.

INTRODUCTION

Wood from thickening bush species in Namibia gets harvested commercially mainly for conversion to charcoal or for firewood. However it also gets used for other purposes, especially for bush fencing or as droppers for wire fencing. If wood is to be used for charcoal production, it should ideally have a diameter of between 20 and 150 mm (Galloway, *pers. comm.*). The smaller branches are then either left on the ground or converted into charcoal fines.

The Development Fund for Namibia (DFN, 1997) recommends that woodland management programs for charcoal production should concentrate on the aggressive growing species, which are in closest competition with grasses. If wood is only obtained from species of bush that have increased to well above their perceived natural density, then the nine thickening species appearing in Table 1 are the main species to be considered.

Table 1. Main species of thickening bush that get harvested for wood (apologies for lack of appropriate symbols for the Nama/Damara names)

Scientific name	Abbreviation	Oshiwambo	Otjiherero	Nama / Damara	Afrikaans
Acacia erubescens	*Aeru*	Omunkono	Omungongomui	!uri!gonis	Geelhaak
A. fleckii	*Afle*	Omumang	Omutaurambuku	!ürîgönè.s	Sandveldakasia
A. mellifera	*Amel*	Omunkono	Omusaona	!noes	Swarthaak
A. reficiens & *A. luederitzii*	*Aref*	Omutyuula	Omungondo	Dūs	Rooihaak Basterkameel
Colophospermum mopane	*Cmop*	Omusati	Omusati	//hains	Mopanie
Dichrostachys cinerea	*Dcin*	Ongete	Omutjete	/oes	Sekelbos
Terminalia prunioides	*Tpru*	Omuhama	Omuhama	≠niob	Sterkbos
T. sericea	*Tser*	Omugolo	Omuseasetu	≠gáb	Sandgeelhout

All these nine species have been harvested for commercial charcoal production, together with a few less commonly used species such as *Acacia hebeclada* and *A. nilotica*. There has been some confusion with naming of species. Harvesting permits have been issued for *A. haematoxylon* in central parts of Namibia where the species does not occur. This is because farmers commonly use the Afrikaans name of "Basterkameel" for *A. luederitzii*, instead of the correct name "Basterhaak-en-steek" (Piepmeyer, *pers. comm.*). There is so much similarity between *A. luederitzii* and *A. reficiens* that they are treated together and hereafter in this paper only referred to as *A. reficiens*.

A map drawn by Bester (1999) shows the area of Namibia considered to be influenced by thickening of bush species. Bester's map, which separates ten bush-thickened zones on the basis of main species and densities, appears in Figure 1. Nine of these zones could be suitable for producing wood for sale of charcoal or firewood, while zone 10, dominated by *Rhigozum trichotomum*, does not provide significant amounts of wood large enough for sale.

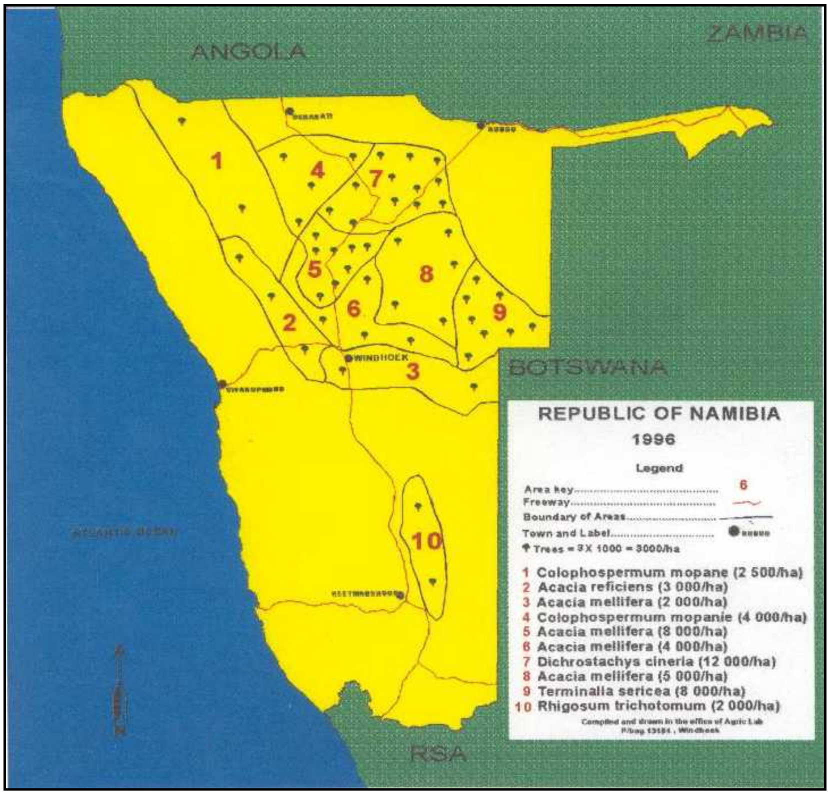

Figure 1. Map showing zones of major problem-bush species and densities (Reproduced with kind permission from Bester 1999).

There does not yet appear to be much data available on estimates of standing biomass of thickening bush species in Namibia. DFN (1997) uses the assumption that there is an average of 10 tons/ha of appropriate sized wood available over 10 million hectares, to come up with an estimate of 100 million tons of wood. DFN (1997) further assumes that 30% of this is harvestable on a sustainable basis over a 15 year cycle. It is unclear how all these assumptions were derived, but they did not include communal areas.

There is increasing pressure of wood harvesting being put on Namibia's natural vegetation, so it becomes increasingly necessary to determine the availability of wood and to propose sustainable patterns of harvesting, both over space and time. This study was undertaken as part of a consultancy for a proposed silicon smelter at Omaruru that would require about 125 000 tons of dry wood per year. This paper investigates the availability of wood from bush thickening species in Namibia and considers harvesting frequency, while a companion paper (Joubert and Zimmermann, *in. prep.*) examines the likely environmental impacts and suggests harvesting strategies to ensure sustainability.

MATERIALS AND METHODS

A desk study was undertaken to roughly estimate the standing biomass of harvestable wood on bush thickening species in Namibian farmland. This was done by combining spatial data from Bester (1999) with biomass data from Cunningham (1998).

The nine bush thickened zones, suitable for wood harvest, were roughly copied from the map of Bester (1999) by computer mouse onto Arcview GIS. The resulting map was then overlain with a land tenure map, to show each zone in commercial farmland and in communal land, while excluding National Parks and Game Reserves. The area of each relevant polygon was then obtained through the GIS software, and added together for each zone per tenure type, in order to estimate the area occupied by each of the nine bush thickening zones in both commercial and communal farmland.

The estimates of Cunningham (1998) had been obtained from small sample plots, located on seven farms in or near seven of Bester's bush-thickened zones. They were extrapolated in the current study to the nine bush-thickened zones of Bester (1999). Although one of the locations, Uitkomst Research Station, falls within the boundary of zone 7 on Bester's map, its bush species composition shows it to be more representative of zone 8, where it was therefore placed for the purpose of this analysis. For the two bush-thickened zones not represented by Cunningham's sample plots, an estimate was extrapolated from zones dominated by similar bush species, at a conservative rate relative to bush density. The measurements made by Cunningham (1998) were of fresh weight of wood. Although the measurements were made in the dry season (Cunningham, *pers. comm.*), for the sake of caution, a moisture content of 25% was used for converting to dry weight (Galloway, *pers. comm*.) In addition, the sample plots of Cunningham (1998) would not be representative of the whole bush-thickened zone, since bushes had already been cleared from some portions for harvesting wood, improved grazing, crop fields, roads, fencelines, firebreaks, villages, etc., while bushes cannot grow in some of the pans and floodplains that occur within these zones. Therefore a figure of 20% was arbitrarily used, for cleared land plus land without bushes, to come up with a biomass estimate of available wood.

To get an idea of the overall amount of wood presently harvested commercially in Namibia from thickening bush species, the Directorate of Forestry was asked for statistics on the permits they issued during 1999. The tonnage of charcoal exported last financial year was multiplied by 5 to convert to tonnage of dry wood, since small, mobile kilns produced most of the charcoal (Galloway, *pers. comm.*).

Ten charcoal producers, from different areas of Namibia, were interviewed by telephone. Questions included not only those on the farmers' strategies and what they had done, but also their future plans and expected regrowth rates in chopped areas.

The only fieldwork for the consultancy was done at the farm Okarusewa, in the Thornbush Savanna (Giess, 1971). Measurements were made at three sites, one where bushes had been chopped for bush control 15 years previously, another where bushes had been chopped for charcoal four years previously, and another where bushes had not yet been chopped. Canopy cover was measured at each site using a Bitterlich gauge (Friedel and Chewings, 1988) at 25 points. In the 15 year site, ten surviving bushes that had previously been chopped were selected at random for measuring the length and diameter of each resprouted branch.

RESULTS

Table 2 gives the approximate sizes of areas under communal and commercial farming tenure, for each of Bester's nine types of bush encroached zones, while Table 3 shows the rough estimates of available fresh wood biomass for each of seven zones, based on Cunningham's data. When these two sets of results were combined, converted to dry wood and adjusted for areas with no or few bushes, they produced the estimated figures shown in Table 4. This gives an estimate of roughly 135 million tons of dry wood of appropriate size available on bush encroaching species growing in about 260 000 square kilometres of Namibia, or an average of just over 5 t/ha.

Table 2. Approximate size of zones covered by nine categories of thickened bush under commercial and communal tenure

Category of thickened bush (according to Bester 1999)			Square kilometres under:		
No. on map	Main bush species	Density of bushes/ha	Commercial land	Communal land	Total Farmland
1	*C. mopane*	2 500	14 510	29 860	44 370
2	*Acacia reficiens*	3 000	16 760	6 910	23 670
3	*Acacia mellifera*	2 000	33 600	1 950	35 550
4	*C. mopane*	4 000	4 820	10 900	15 720
5	*Acacia mellifera*	8 000	20 670	130	20 800
6	*Acacia mellifera*	4 000	26 920	2 100	26 920
7	*Dichrostachys cinerea*	10 000	25 130	12 200	37 330
8	*Acacia mellifera*	5 000	9 500	24 530	34 030
9	*Terminalia sericea*	8 000	5 860	16 240	22 100
		Total	157 770	104 820	262 590

Table 3. Estimates of fresh wood biomass, of appropriate size for commercial charcoal production, from Cunningham (1998) spread over seven of the bush-thickened zones of Bester (1999), with extrapolation to the two other bush-thickened zones not sampled by Cunningham

		Standing tons per hectare of appropriate sized fresh wood (circumference more than 70 mm, or diameter more than 22 mm)								
Bush zone (bush density)	Bush species → Farm ↓	*Amel*	*Aref*	*Aeru*	*Afle*	*Cmop*	*Dcin*	*Tpru*	*Tser*	Total
1. *C. mopane* (2 500/ha)										Extrap. 10.0
2. *A. reficiens* (3 000/ha)	Okosongoro (Kalkveld)	0.8	3.0	4.4						6.2
3. *A. mellifera* (2 000/ha)										Extrap. 0.7
4. *C. mopane* (4 000/ha)	Cunningham (Outjo)					18.0		8.2		26.2
5. *A. mellifera* (8 000/ha)	Elandsvreugde (Otji)	1.9	0.3		2.0		4.3			8.5
6. *A. mellifera* (4 000/ha)	Amperdaar (Omatako)	13.2								13.2
7. *D. cinerea* (10 000/ha)	Louiseville (Tsumeb)						0.5	5.7		6.2
8. *A. mellifera* (5 000/ha)	Uitkomst (Grootfontein)	1.6								1.6
9. *T. sericea* (8 000/ha)	Sandveld (Gobabis)								14.9	14.9

Table 4. Estimated standing biomass of dry wood, of appropriate size for charcoal, in each of the nine bush-thickened zones of Namibia

Category of bush-thickened zone (according to Bester 1999)			Total dry weight (million tons) of standing wood of appropriate size for charcoal production		
No. on map	Main bush species	Density of bushes/ha	Commercial land	Communal land	Total Farmland
1	*Colophospermum mopane*	2 500	8.7	17.9	26.6
2	*Acacia reficiens*	3 000	8.3	3.4	11.7
3	*Acacia mellifera*	2 000	1.3	0.1	1.4
4	*Colophospermum mopane*	4 000	7.6	17.1	24.7
5	*Acacia mellifera*	8 000	10.5	0.1	10.6
6	*Acacia mellifera*	4 000	21.3	1.7	23.0
7	*Dichrostachys cinerea*	10 000	9.4	4.6	14.0
8	*Acacia mellifera*	5 000	0.9	2.3	3.2
9	*Terminalia sericea*	8 000	5.2	14.5	19.7
		Total	73.2	61.7	134.9

Information derived from the interviews with the ten charcoal producers, together with an indication of whether the farmer is bound by the principles of the Forestry Stewardship Council (FSC), is shown in Table 5.

Table 5. Yields of wood obtained by a sample of charcoal producers, together with some other information from interviews

Zone category (No. on map)	Main species harvested	Name of farm (or other description)	Approximate yields of dry wood obtained (tons/ha)	Applies FSC principles	Perceived years to regenerate
2	*A. erubescens*	Eileen	3.5	No	20
4	*A. mellifera*	contract on 9 farms	6.0	No	10
5	*A. reficiens*	Osongombo	11.0	Yes	15
5	*A. reficiens*	Klein Okarumue süd	5 .0	No	20
6	*A. reficiens*	Okanyete	1.6	Yes	10
7	*D. cinerea*	Dammbeck	25 .0	No	10
8	*A. reficiens*	Okarusewa	6.0	Yes	70
8	*A. mellifera*	Etemba	1.0	No	20
8	*A. mellifera*	Otjimbuku	4.5	Yes	20
8	*A. mellifera*	Okatambaka	18.0	Yes	15

There is an enormous variation in the estimates of wood yield obtained by the different farmers, which is not really surprising given their different management objectives, strategies and environmental conditions. It was thought likely that farmers would first select for harvesting the portions of their farms that were most densely covered by bush, which would provide higher yields. However, other considerations also influenced their selection of initial harvesting areas, such as wishing to start in the vicinity of their homes, or where they intended to clear new fields or fencelines. In fact, the highest yields were obtained by farmers who were harvesting all of the woody plants in some portions of their farms where they wanted to clear the land for fields or fencelines. In addition, four out of the nine farmers interviewed were also harvesting wood of more than 150 mm diameter. It is also likely that many of the current charcoal producers are in areas where the bush density was higher than the average for those zones. Hence it would not be valid to simply extrapolate the yields of current producers to the other land within their zones.

The interviewed charcoal producers were also asked how many years they thought it would take for a harvested area to re-grow to the extent that it would be worthwhile to re-harvest. Their opinions appear in the last column of Table 5. Those who thought that it would take ten years were mostly basing on harvesting from bushes that were already established, but small, during the first harvest. While the farmer who thought that it would take 70 years, was basing on re-harvesting the same mature bushes that had been cut during the first harvest.

The Directorate of Forestry's data base is not yet capable of differentiating between species, but the overall amount of fuel wood for which permits were issued during the 1999/2000 financial year are shown in Table 6 (Visagie, *pers. comm.*).

Table 6. Quantities of firewood and charcoal for which permits were issued by the Directorate of Forestry during the 1999/2000 financial year

	Harvesting permits	Export permits		Total wood for which permits were issued
		Commercial	Own use	
Firewood	30 153 tons wood	1 681 tons wood	229 tons wood	30 153 tons
Charcoal	32 510 tons charcoal	33 448 tons charcoal		167 240 tons
			Total	197 393 tons

The quantities in the permits are estimated to comprise about 70% of bush-thickening species (Visagie, *pers. comm.*) which would bring their legal commercial harvest for the last financial year to about 138 175 tons. This does not include wood harvested for own use, wood harvested for conversion to locally consumed charcoal and wood harvested illegally for commercial purposes.

At the farm Okarusewa, the most commonly harvested species was *A. reficiens*. None of the stumps were found to have re-sprouted in the area harvested four years previously. The stumps were nearly all larger than 150 mm diameter. The overall canopy cover of woody plants was higher in the harvested site, at 29%, than in the uncut site where it was only 20%. This difference was largely due to a much higher proportion of the palatable *Grewia flava* in the harvested site. Under such circumstances a second, viable, harvest of wood would depend upon seedlings, none of which could be found at this stage. This was the farm whose owner was of the opinion that it would take 70 years before it would be worthwhile to obtain a second harvest. In the area that had been cut 15 years previously, the number of re-sprouted stems, on the 10 randomly selected bushes of *A. mellifera*, varied between 6 and 20 per bush, with a mean of 8.7. Their lengths varied between 1.1 and 1.9 meters. Although 75% of the stems were over 20 mm diameter, it would not have been worthwhile to harvest them due to the large amount of effort that would be required to chop them out from the dense base, for the small returns in useable wood.

DISCUSSION

<u>Availability of wood</u>:

Until now, harvesting for commercial charcoal has been undertaken mainly on commercial farmland. Harvesting could in theory be extended to communal land, although it would be necessary to allocate conditional harvesting concessions to individuals or responsible groups in order to ensure sustainability.

There are many variables that could influence the amount of wood that contractors would be prepared to harvest and that authorities would allow to be harvested. These variables include the price offered for the wood, the ease of cutting and de-barking, the ease of reaching sites and transporting the wood out, the management objectives of the farmers or communities and the ecological sensitivity of the sites. A whole range of scenarios could be tested on the rough estimates in Table 4.

An initial simple scenario would be to assume that 10% of the bush-thickened area could be made available for harvesting (i.e. from an area of roughly 26 000 square kilometres, spread proportionately over the different zones), and within this area, 25% of the appropriate sized wood is harvested. The figure of 10% arbitrarily represents the farms and communal land upon which farmers would be willing to harvest. The figure of 25% allows for patch harvesting and for selection of species. This scenario would lead to the estimated harvests shown in Table 7, if both commercial and communal lands are harvested.

Table 7. Estimates of available harvest under the scenario of using 25% of appropriate sized wood in only 10% of the available area

Category of bush-thickened zone (according to Bester 1999)			Estimated tons of dry wood to be harvested if 25% is cut in 10% of the available area of Namibia		
No. on map	Main bush species	Density of bushes/ha	Commercial land	Communal land	Total farmland
1	*Colophospermum mopane*	2 500	217 500	447 500	665 000
2	*Acacia reficiens*	3 000	207 500	85 000	292 500
3	*Acacia mellifera*	2 000	32 500	2 500	35 000
4	*Colophospermum mopane*	4 000	190 000	427 500	617 500
5	*Acacia mellifera*	8 000	262 500	2 500	265 000
6	*Acacia mellifera*	4 000	532 500	42 500	575 000
7	*Dichrostachys cinerea*	10 000	235 000	115 000	350 000
8	*Acacia mellifera*	5 000	22 500	57 500	80 000
9	*Terminalia sericea*	8 000	130 000	362 500	492 500
		Total tons	1 830 000	1 542 500	3 372 500

The above scenario is a more conservative harvesting rate than that recommended by Piepmeyer (1996). This scenario would yield an average of about 1.3 tons of dry wood per hectare, which is considerably lower than yields obtained by most of the ten charcoal producers who were interviewed over the telephone (Table 5). There is an endless variety of ways in which wood requirements could be supplied from different species, size classes, areas, harvesting patterns and rates, but at present little is known about the variables that will influence this.

It is likely that there have been enormous natural fluctuations in the standing biomass of bushes over time. Some of the current charcoal producers are harvesting only dead wood, from bushes which died as a result of drought and/or fungus infestation, such as by *Phoma glomerata* on *A. mellifera* (Holz and Schreuder, 1989). The present high standing biomass may just be a temporary phase of a long fluctuation process.

Demand for the available wood:

It is clear from Table 6 that there is already a lot of trade in wood and charcoal, both for export and for local consumption, against which new demands would need to compete. One of the interviewed producers mentioned that he had recently exported 90 tons of charcoal from *C. mopane* for testing by a silicon smelter in South Africa. The planned silicon smelter in Omaruru would require about 125 000 tons of wood per year over at least 30 years. Mention was also made in the news about a company in the USA that wishes to purchase large quantities of charcoal from Namibia.

Which markets the producers eventually decide to sell to, will depend mainly on the relative profit margins, and partly on the reliability of contracts and the conditions imposed upon the producers. If prices remain low, then the current producers will probably continue to harvest only in those more easily accessible areas with higher availability of wood. Conversely, if the competition amongst buyers results in a significant price increase for the wood, then a flood of new producers may put a lot of pressure on the available wood resources.

Desired balance of bushes:

The majority of farmers who have up till now been harvesting live wood for commercial charcoal production have done so primarily to improve the grass conditions. They do not want to have the bush renewing itself to the extent that it was before harvesting. Some of them even chop out smaller bushes and/or apply arboricides to reduce the regrowth. They are treating a symptom of land degradation, which may have been caused by a combination of over-grazing of the palatable grasses, over-resting of the rangeland, lack of fierce fire late in an occasional dry season, and lack of browsing pressure especially by mega-herbivores such as elephants and black rhinos. If wood harvesting is to be sustainable under such conditions, the initial yield would be significantly higher than subsequent yields, which would achieve a higher production of grass and a lower production of bushes.

When the charcoal producers were asked what level of bush cover they were aiming to achieve for their grazing areas, their responses ranged between 10 and 30% cover, or between 600 and 2 000 stems per hectare. Many farmers prefer their woody biomass to consist of a greater proportion of palatable browse species, than of thickening species. Some farmers also want to keep their bushes low, within reach of their livestock, even for some of the thickening species such as *T. sericea* and *C. mopane*. The application of high browsing pressure is also likely to suppress the re-growth of bushes, and so lower the rate of wood production. By spreading seeds of some of the bush-thickening species in their dung, browsing animals are also likely to cause a high density of these bush seedlings during subsequent years of good rain.

<u>Sustainability of wood harvesting</u>:

Regrowth of harvested bushes can occur from both the establishment of seedlings and from re-sprouting of cut stumps. Seedling establishment is extremely sporadic and may only occur to a significant extent after at least two successive years of favourably spaced and high rainfall. This is likely to occur on a large scale only a few times per century. The success of seedling establishment depends largely on the vigour of the grass cover. Under poor grass conditions, the density of established young bushes may be far too high, resulting in many narrow stemmed bushes that are difficult to harvest. Under good grass conditions, fewer seedlings become established and are more likely to grow into large bushes with thicker stems that are easier to harvest.

Whether or not a cut stump re-grows after harvest, depends to a large extent on the species and the season of cutting, and to a lesser extent on the height at which the stem was cut (Strobach, 1999). Age of the bush is also likely to influence its ability to survive cutting. However, a coppicing stump usually produces many narrow stems, which makes it more difficult to subsequently harvest, and produces wood of smaller dimensions. Some farmers, especially those committed to FSC, prune bushes, in order to leave fewer stems that will produce better wood and encourage better grass growth underneath the bushes. Such pruning is done both while harvesting and during subsequent after-care.

If the first harvest takes place selectively, leaving many bushes of different sizes, then a subsequent harvest could take place sooner, especially if pruning of bushes has been taking place. Under such conditions the prediction by most farmers of a sustainable harvesting cycle of between ten and twenty years would appear to be quite realistic, but at a lower yield than most farmers obtain for their first harvests. The environmental sustainability of such harvesting also depends upon the impacts such harvesting may have on biodiversity. This is discussed in a companion paper (Joubert and Zimmermann, *in prep*.)

CONCLUSION

Bush densities are extremely variable, even within a small area, so extrapolation of data from sample plots to larger areas is not reliably valid unless sampling has been very extensive, hence the results of this study need to be treated with a lot of caution. Bester *et.al.* (1999) have derived regression formulae for estimating biomass from stem diameters of the eight thickening bush species. These formulae can, however, only be applied to determine standing biomass once data becomes available on diameters and densities of the bush species over large areas of Namibia. The gathering of such data over wider areas of Namibia has been initiated (Bester, *pers. comm.*), so in the not-to-distant future it will be possible to come up with a more reliable estimate of available wood. Remote sensing could possibly be applied to improve the accuracy of extrapolating ground data from sample plots to zones of differing woody biomass.

At present it is clear that there is potentially an enormous amount of wood that could be harvested over many decades. Whether or not it happens, will depend largely on the price offered for the wood. Whether or not it happens sustainably, will depend largely on the conditions imposed and how effectively they are enforced. The potential environmental impacts are discussed in a companion paper (Joubert and Zimmermann, *in prep*.).

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REFERENCES

BESTER, F.V. 1999. Major problem-bush species and densities in Namibia. Agricola **10**:1-3.

BESTER, F.V., J.A.J VAN ECK, H. KÖLLING, R. KROMMENHOEK, and G. PICKERING. 1999. Regression equations to estimate the wood biomass of problem bush in Namibia. Proceedings of the National Annual Agricultural Research Reporting and Planning Conference held in Swakopmund, 6-10 Sept. 1999.

BESTER, F.V. *Personal communication*. Directorate of Research and Training, Ministry of Agriculture, Water and Rural Development.

CUNNINGHAM, P.L. 1998. Potential wood biomass suitable for charcoal production in Namibia. Agri-Info **4**(5):4-8.

CUNNINGHAM, P.L. *Personal communication.* Polytechnic of Namibia.

DFN. 1997. Charcoal production in Namibia, Consultancy report produced for the Development Fund of Namibia.

FRIEDEL, M.H. and V.H. CHEWINGS. 1988. Comparison of crown cover estimates for woody vegetation in arid rangelands. Australian Journal of Ecology **13**:463-468.

GALLOWAY, I. *Personal communication*. Chairperson of the Charcoal Producers Association.

GIESS, W. 1971. A preliminary vegetation map of South West Africa. Dinteria **4**:5-114.

HOLZ, G. and W. SCHREUDER. 1989. Dieback of blackthorn (*Acacia mellifera* subsp. *detinens*) in South West Africa. Agricola **7**:32-36.

JOUBERT, D.F. and ZIMMERMANN, I. *In preparation*. The potential impacts of wood harvesting of bush thickening species on biodiversity and ecological processes.

PIEPMEYER, W. 1996. Proposed forest utilisation practice. Guidelines attached to harvesting permits issued by the Directorate of Forestry office in Otjiwarongo.

PIEPMEYER, W. *Personal communication*. Directorate of Forestry, Otjiwarongo

STROBACH, B. 1999. The effect of season and treatment on the survival rate and coppicing ability of five encroaching woody species (I: The effect of felling heights) Agricola **10**:99-105.

VISAGIE, H. H. *Personal communication*. Directorate of Forestry, Permit Office.

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