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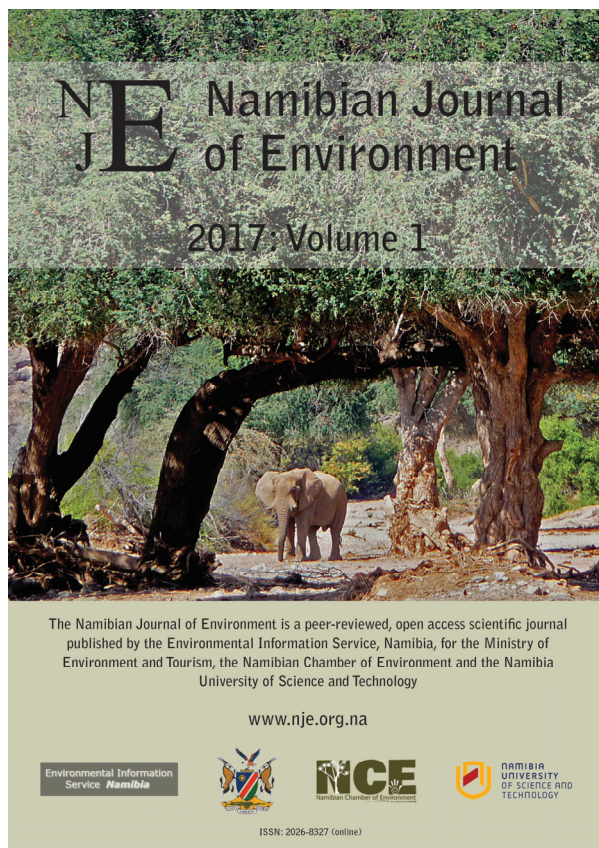
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# Determining age, growth rate and regrowth for a few tree species causing bush thickening in north-central Namibia

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## ABSTRACT

Age, growth rate and regrowth for some indigenous tree species causing bush thickening in Namibia were determined. The mean age varied between 25.5 years for *Acacia mellifera* subsp. *detinens* and 35.7 years for *Acacia reficiens* subsp. *reficiens*; the mean stem diameter growth rates varied between 2.78 mm/year for *Acacia tortillis* subsp. *heterocantha* and 3.79 mm/year for *Acacia mellifera* subsp. *detinens* and *Terminalia prunioides*. After harvest, the mean rate at which stumps resprouted varied between 45% for *Acacia reficiens* subsp. *reficiens* and 92.8% for *Dichrostachys cinerea* subsp. *africana*. Although our data are limited, they can be viewed as a first step to determining age, growth rate and regrowth for various tree species, although more research is required, including research on variables potentially influencing these parameters for a better understanding of the bush thickening problem in Namibia.

**Keywords:** *Acacia mellifera*; *Acacia reficiens*; *Acacia tortillis*; age; bush encroachment; bush thickening; *Colophospermum mopane*; *Combretum apiculatum*; *Dichrostachys cinerea*; growth rate; Namibia; regrowth; *Terminalia prunioides*

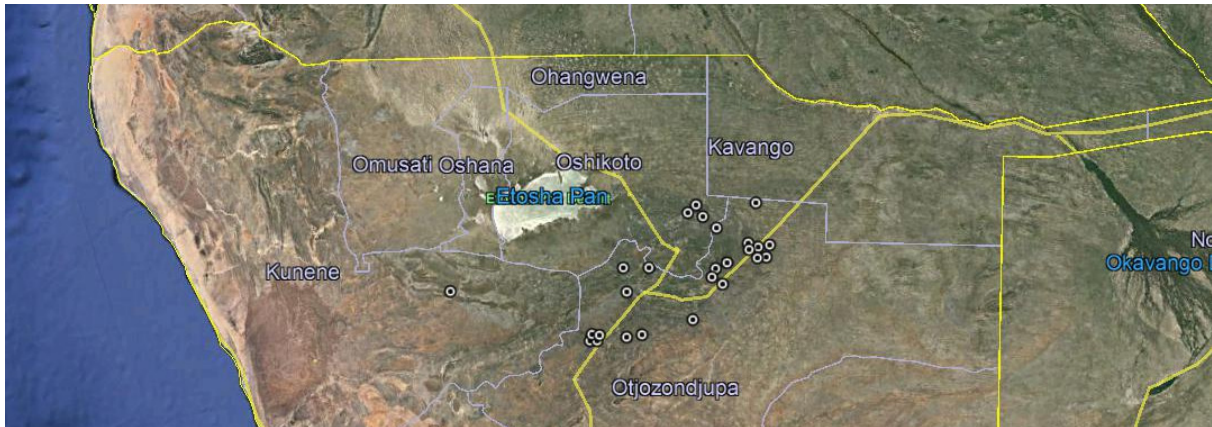
## INTRODUCTION

Bush thickening (generally referred to erroneously as encroachment) is a much-discussed topic in Namibia, although with a general paucity of scientific work investigating the issue. Although some papers have been published on bush thickening related issues such as densities (Cunningham 1998, Bester 1999), biomass available for charcoal (Cunningham 1998) and wood production (Zimmermann & Joubert 2002), historic review of bush thickening (Cunningham 2014), fire related issues (Joubert et al. 2012), seed predation (Joubert et al. 2013), vegetation dynamics of a single species (Joubert et al. 2008), identification of bush thickening related causes (Zimmerman et al. 2008), control measures and aftercare issues (e.g. Strobach 1999, Van Eck & Swanepoel 2008, Van Eck & Van Lill 2008) and general overview (De Klerk 2004), little has been published on determining age, growth rate and regrowth of these problem species. According to Smit et al. (2015), this is a priority for research.

Determining the age, growth rate and regrowth for the various species causing bush thickening is important for a better understanding of the problem as well as the successful (sustainable) management of these species. Many indigenous tree species are difficult to age as their rings are obscured by the deposition of heartwood, which is initiated when the

stems are about 50 mm in diameter and susceptible to heart rot e.g. *Colophospermum mopane* (Caughley 1976, Scholes 1990). However, with practice this can be achieved as demonstrated previously (Cunningham 1996).

Age, growth rate and regrowth (%) were determined for *Acacia (sensu lato) fleckii*, *A. mellifera* subsp. *detinens*, *A. reficiens* subsp. *reficiens*, *A. tortillis* subsp. *heterocantha*, *Colophospermum mopane*, *Combretum apiculatum* subsp. *apiculatum*, *Dichrostachys cinerea* subsp. *africana* and *Terminalia prunioides* on 26 farms in north-central Namibia (Figure 1). Soils on these farms (freehold farms focusing mainly on cattle production) were highly variable although dominated by leptosols and cambisols and the mean average annual rainfall varied between 350 and 500 mm. Levels of bush thickening varied roughly between 2,000 to 10,000 trees per hectare and is the reason for initiating charcoal production in an attempt to improve grazing as well as attempt diversification and improve cash-flow. These studies were initiated during mid-2016 in an attempt to ensure sustainable utilisation of this resource, with data collection ongoing.



**Figure 1:** Farms where data were collected in north central Namibia

## METHODS

### Age

Discs of the main stem of trees with a charcoal potential (i.e. bigger specimens between 75 mm and 118 mm as selected by charcoal workers as specimens with a good charcoal potential) were cut at basal height; polished with a belt sander to make the growth rings more visible; photographed and then imported to computer where the picture was enlarged (similar to using a magnifying glass) and the growth rings counted. When ‘heart rot’ was encountered, the average ring increment to the centre of the stem was calculated. An increment borer was initially used but the local hard woods and generally smaller trees made this technique unsuitable while carbon dating is also ineffective at the age range we dealt with. The aim was to determine the growth rate of certain problem species and we thus did not attempt age calculations for a variety of diameter classes and/or the mean diameter classes in each area, but rather focused on ‘charcoal producing’ diameter classes i.e. larger specimens.

Tree growth rings were determined as the light versus darker bands deposited between seasons. However, this is easier said than done as many of the indigenous species have hard woods with faint rings, often with false rings (i.e. rings that are not complete and do not signify a growth year) or are suffering from ‘heart rot’ where the core becomes spoiled. Although accepted as a rough field technique (no known-age trees were available for comparative purposes, while carbon dating is not feasible), with perseverance and practice one can actually count the growth rings and gather valuable data not previously attempted and viewed as the most practical way of determining age (Cunningham 1996) (Figures 2 & 3).

### Growth Rate

Mean growth rate was determined by dividing diameter (mm) by the age (years) for each sample/species and the mean annual growth rate was determined as diameter increase per year (mm/year).

### Regrowth

Percentage regrowth was calculated as the percentage of trees showing coppice after having been felled for



**Figure 2:** *Acacia reficiens subsp. reficiens* with growth rings clearly visible as light vs dark bands (~39 years).



**Figure 3:** *Terminalia prunioides* with distinctive ‘yellow wood’ and some external damage, which affects growth rings (~46 years).

charcoal purposes, for at least 50 tree stumps harvested per farm.

### Soil Texture

The soil texture and approximate clay content (%) were determined by feel using the soil texture decision model – i.e. where a soil sample is wetted, rolled into ball/ribbon/sausage, bent and checked for consistency, etc. This is a simple yet practical way of determining the clay/sand/silt content and is used as a field technique only.

## RESULTS AND DISCUSSION

### Age

The mean age of our samples ranged from 25.5±1.5 years for *Acacia mellifera* (n=36) to 35.7±1.8 years for *Acacia reficiens* (n=23) (Table 1). Strong positive linear correlations were observed between age and diameter for the species analysed: *Acacia mellifera* (r=0.80); *A. fleckii* (r=0.91); *A. reficiens* (r=0.54); *Combretum apiculatum* (r=0.99); *Colophospermum mopane* (r=0.94); *Dichrostachys cinerea* (r=0.72) and *Terminalia prunioides* (r=0.64). *Acacia tortilis* is excluded because of too few samples. Although tree height was not taken into consideration, Cunningham (1996) shows that age is better correlated with circumference (i.e. diameter) than with height for *Colophospermum mopane*.

### Growth rate

The mean growth rates varied between 2.78±0.3 mm/year for *Acacia tortilis* (n=2) and 3.79±0.2 mm/year for *Acacia mellifera* (n=36) and 3.79±0.3 mm/year for *Terminalia prunioides* (n=31) (Table 1).

Growth rates for the eight species we analysed were very similar, ranging between 2.78 and 3.79 mm/year. With a mean annual growth rate of 3.79 mm/year for *Acacia mellifera* and *Terminalia prunioides*, this would imply that it would take ~21.1-26.4 years to reach the diameter of 80-100 mm

viewed as the ‘best’ size for charcoal production. Cunningham (1996) indicated that it would take 23-25 years for various *Colophospermum mopane* woodlands to reach mean circumference classes of between 14.24 cm and 16.64 cm after harvesting in the Limpopo Province in South Africa. Using these growth rates to determine harvesting protocols should take cognisance of variables such as climate (growth rings show annual variation) and edaphic (various soil types) factors which are known to influence growth rate (Cunningham 1996).

### Regrowth

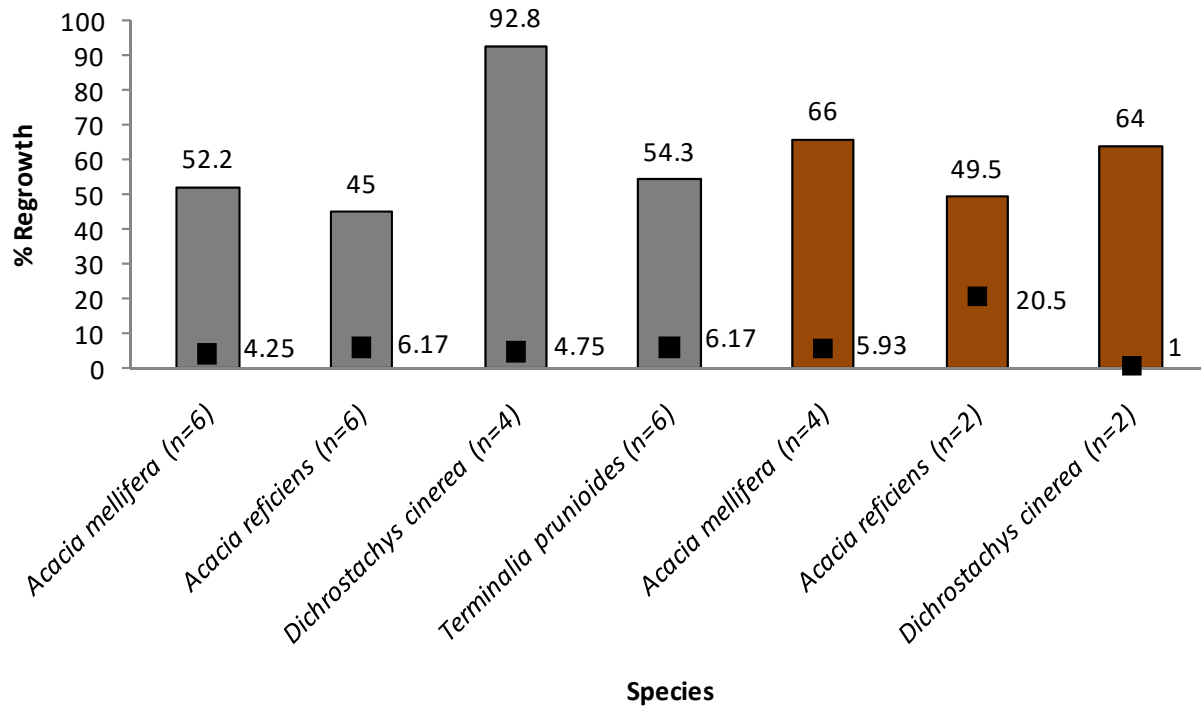
Regrowth of harvested trees has solicited much debate and depends on factors such as species, season harvested, size of tree harvested, method of harvest, rainfall, soil type and browsing impact. Some species coppice prodigiously, such as *Dichrostachys cinerea*, while other species do not, although once again there are a legion of reasons for this that have not been tested for here. It does, however, indicate that not all harvested individuals coppice, which would mean that ‘after care’ (something generally advocated by farmers) – especially by chemicals – may not be required for most species except *Dichrostachys cinerea*. This would have to be determined at farm level due to differences in factors such as species, soils and rainfall. However, regeneration also takes place from seed, although seed sometimes requires exceptional circumstances, such as at least two consecutive seasons of favourable rainfall for *Acacia mellifera*, to become established (Joubert et al. 2013).

Our data show a mean regrowth (%) varying from 45% for *Acacia reficiens* to 92.8% for *Dichrostachys cinerea* on black soils with approximate clay content of between 45-50% and 49.5% for *Acacia reficiens* to 66% for *Acacia mellifera* on red sandy/loamy soils with approximate clay content of between 20-35% (Figure 4). According to Cunningham (1996), growth rates for *Colophospermum mopane* are faster on deep/fertile soils and slowest on shallow/rocky soils, while high clay content can be responsible for stunted growth (Dye & Walker 1980). As we used a practical

**Table 1:** Mean diameter, age and growth rate for eight tree species causing bush thickening in north-central Namibia. (Values given ± SE).

Species	Mean diameter (mm)	Mean age (years)	Mean growth rate (mm/year)	n
<i>Acacia fleckii</i>	96.5±13.5	30±2	3.17±0.3	4
<i>Acacia mellifera</i>	91.38±4.4	25.5±1.5	3.79±0.2	36
<i>Acacia reficiens</i>	117.3±4.2	35.7±1.8	3.40±0.1	23
<i>Acacia tortilis</i>	90.5±10.5	32.5±0.5	2.78±0.3	2
<i>Colophospermum mopane</i>	108.2±14.7	29.8±3.1	3.59±0.2	5
<i>Combretum apiculatum</i>	97.8±11.1	32±1.6	3.02±0.2	5
<i>Dichrostachys cinerea</i>	76±6.7	27±2.5	2.86±0.2	6
<i>Terminalia prunioides</i>	105.2±6.2	30±1.9	3.79±0.3	31

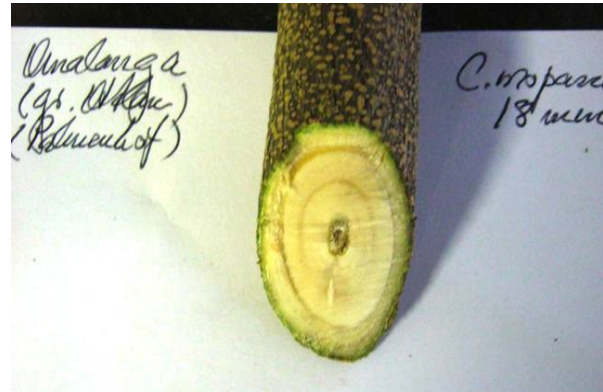




**Figure 4:** Mean regrowth (%) of harvested trees for some bush-thickening tree species on two soil types in north-central Namibia. The grey bars (to the left of the dotted line) occur on black soils (45-50% clay content) while the brown bars occur on red sandy/loamy soils (20-35% clay content). The n value indicates the number of farms surveyed, with 50 stumps each; thus n=6 indicates that 6 x 50 = 300 tree stumps were investigated for regrowth for the species indicated. The black squares indicate  $\pm$ SE.



**Figure 5:** Pruning of coppice from 3 shoots to 1 for the *Terminalia prunioides* individual above could enhance regrowth potential.



**Figure 6:** Regrowth for *Colophospermum mopane* (9 mm/year) two years after harvesting.

field technique to determine the soil texture, the clay percentages should be viewed as rough approximates only.

Regrowth is seldom in the shape of the original tree. For example, it could be bushy with multiple stems and could require a pruning regime similar to what is done under plantation forestry operations for some species (e.g. coppice gum/wattle) (Figure 5). Size classes below 80-100 mm could obviously be

harvested sooner and would depend on the market requirements and own operation strategies, but on average it would imply that an area could be harvested again after 21-26 years (if selecting for 80-100 mm diameter classes) using the eight species we studied from north-central Namibia. Scholes (1990) states that *Colophospermum mopane* recovers to a pre-cleared state in the Eastern Transvaal (Klaserie Private Nature Reserve) within 14 years, while Von Breitenbach (1965) indicates that *C. mopane*

coppices so vigorously that an entirely cleared area regenerates fully to dense forest within 15 years. However, regeneration from seed to a pre-cleared state could take up to 40 years. Recovery period is shortened by higher rainfall and lengthened by drought, according to growth simulations done on *C. mopane* (Scholes 1990). Determining growth rates could be used to plan for practical, sustainable, rotational-harvesting regimes for the charcoal and wood industries or retrospectively to understand events that caused bush thickening in certain areas in the past.

A first attempt to determine the growth rate of coppice (with known harvesting dates) varies between 2.6 mm/year for *Acacia reficiens* and 9 mm/year for *Colophospermum mopane* (Figure 6). There are numerous factors potentially affecting regrowth (e.g. species, initial fast growth, browsing impact, rainfall, frost and soil type) and although the current data are limited, further research could be refined over time to evaluate the effects of these variables.

More research on growth rate and regrowth for the various tree species, especially including variables potentially influencing these, is imperative to better understand the bush thickening problem in Namibia. Although our results are limited to eight species and few data, this note serves as an introduction to attempt raising the awareness of the value of bush thickening tree species as a potential sustainable resource rather than a curse to be eradicated at all costs. Perhaps it is time to change perceptions regarding sustainable 'agroforestry' especially in the trying environmental times in which we live.

## ACKNOWLEDGEMENTS

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## REFERENCES

Bester FV (1999) Major problem-bush species and densities in Namibia. *Agricola* 10: 1-3.  
 Caughley G (1976) The elephant problem - an alternative hypothesis. *East African Wildlife Journal* 14: 265-283.  
 Cunningham PL (1996) *Prospects for sustained harvesting of mopane (Colophospermum mopane) on the Venetia Limpopo Nature Reserve and its implications for*

*browsing ungulates*. MSc thesis, University of Stellenbosch, Stellenbosch, South Africa.  
 Cunningham PL (1998) Potential wood biomass suitable for charcoal production in Namibia. *Agri-Info* 4(5): 4-8.  
 Cunningham PL (2014) Bush thickening in Namibia – a historic perspective. *Journal of the Scientific Society of Namibia* 62: 164-185.  
 De Klerk JN (2004) *Bush encroachment in Namibia*. Ministry of Environment and Tourism, Windhoek, Namibia.  
 Dye PJ, Walker BH (1980) Vegetation-environment relations on sodic soils of Zimbabwe, Rhodesia. *Journal of Ecology* 68: 589-606.  
 Joubert DF, Rothauge A, Smit GN (2008) A conceptual model of vegetation dynamics in the semiarid Highland savanna of Namibia, with particular reference to bush thickening by *Acacia mellifera*. *Journal of Arid Environments* 72: 2201-2210.  
 Joubert DF, Smit GN, Hoffman MT (2012) The role of fire in preventing transitions from a grass dominated state to a bush thickened state in arid savannas. *Journal of Arid Environments* 87: 1-7.  
 Joubert DF, Smit GN, Hoffman MT (2013) The influence of rainfall, competition, predation and germination and the establishment of an encroaching *Acacia* in an arid Namibian savanna. *Journal of Arid Environments* 91: 7-13.  
 Scholes RJ (1990). The regrowth of *Colophospermum mopane* following clearing. *Journal of the Grassland Society of South Africa*. 7: 147-151.  
 Smit GJ, De Klerk JN, Schneider MB, Van Eck J (2015) *Quantifying harvestable encroacher bush*. GIZ, Windhoek, Namibia.  
 Strohbach B (1999) The effect of season and treatment on the survival rate and coppicing ability of five encroaching woody species (1: the effect of felling heights). *Agricola* 10: 99-105.  
 Van Eck JAJ, Swanepoel DJ (2008) Chemical bush control on various invader species, using different herbicides and control measures – An analysis. *Agricola* 18: 37-50.  
 Van Eck JAJ, Van Lill C (2008) Chemical bush control on *Rhigozum trichotomum* and *Acacia nebrownii* in southern Namibia using different herbicides and control measures. *Agricola* 18: 51-55.  
 Von Breitenbach F (1965) *The Indigenous Trees of Southern Africa*. Vol.3., part 2, Government Printer, Pretoria, South Africa.  
 Zimmermann I, Joubert DF (2002) *A crude quantification of wood that is and can be harvested from bush thickening species in Namibia*. Proceedings of the First National Forestry Research Workshop held on 12 and 13 March 2002, Windhoek, Namibia, Ministry of Environment and Tourism, Forestry Publication 9: 56-66.  
 Zimmermann I, Joubert DF, Smit GN (2008) A problem tree to diagnose problem bush. *Agricola* 18: 27-33.