An assessment of woody biomass as a sustainable energy source in a bush thickened area of northern Namibia

G.N. Smit[1], J.N. de Klerk[2] & M.B. Schneider[3]

[1]Dept. of Animal, Wildlife and Grassland Sciences, Univ. of the Free State, Bloemfontein, RSA

[2]P.O. Box 5846, Ausspannplatz, Windhoek, Namibia

[3]DRFN-Desert Research Foundation of Namibia, Windhoek, Namibia

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS·UV
NATURAL AND AGRICULTURAL SCIENCES
NATUUR- EN LANDBOUWETENSKAPPE

DRFN
Enhancing decision making for sustainable development


Bush thickening !

INTRODUCTION

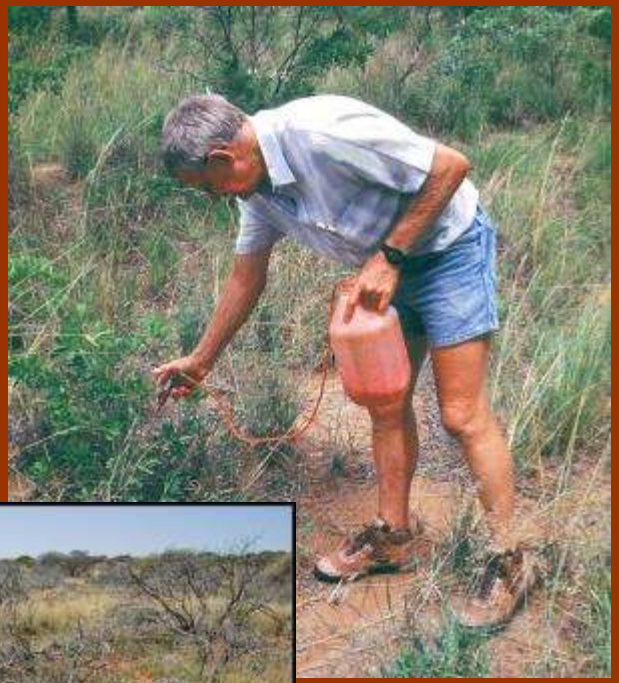
In southern Africa the phenomenon of the increase in woody plant abundance is commonly referred to as “bush encroachment”, though the term “bush thickening” is more appropriate.

It has long been considered an ecological and economic problem in the rangelands of Namibia and the area affected by bush thickening is estimated to be approximately 260 000 km^2.

THE SOLUTION

Common question by land owners: “What is the CHEAPEST, FASTEST and EASIEST method to get rid of the encroacher bush?”

Chemical control with our without mechanical cutting



THE SOLUTION

Mechanical with or without soil disturbances

THE SOLUTION

Enormous amounts of money and effort have already been put into treating the existing symptoms, but many attempts at combating the problem have in effect aggravated the problem.

Due to the cost of bush control measures there is an increasing awareness of woody plants as a harvestable resource with a monetary value.

THE SOLUTION

An area where large trees were harvested for charcoal production and which has since been invaded by *Grewia flava* and *G. flavescens* that form very dense, almost impenetrable, bush clumps.

OBJECTIVES

Conduct a detailed assessment of the woody biomass resource in a selected area of Namibia

Make recommendations regarding the sustainable harvesting of woody plants as a source of energy

20 MW power plant

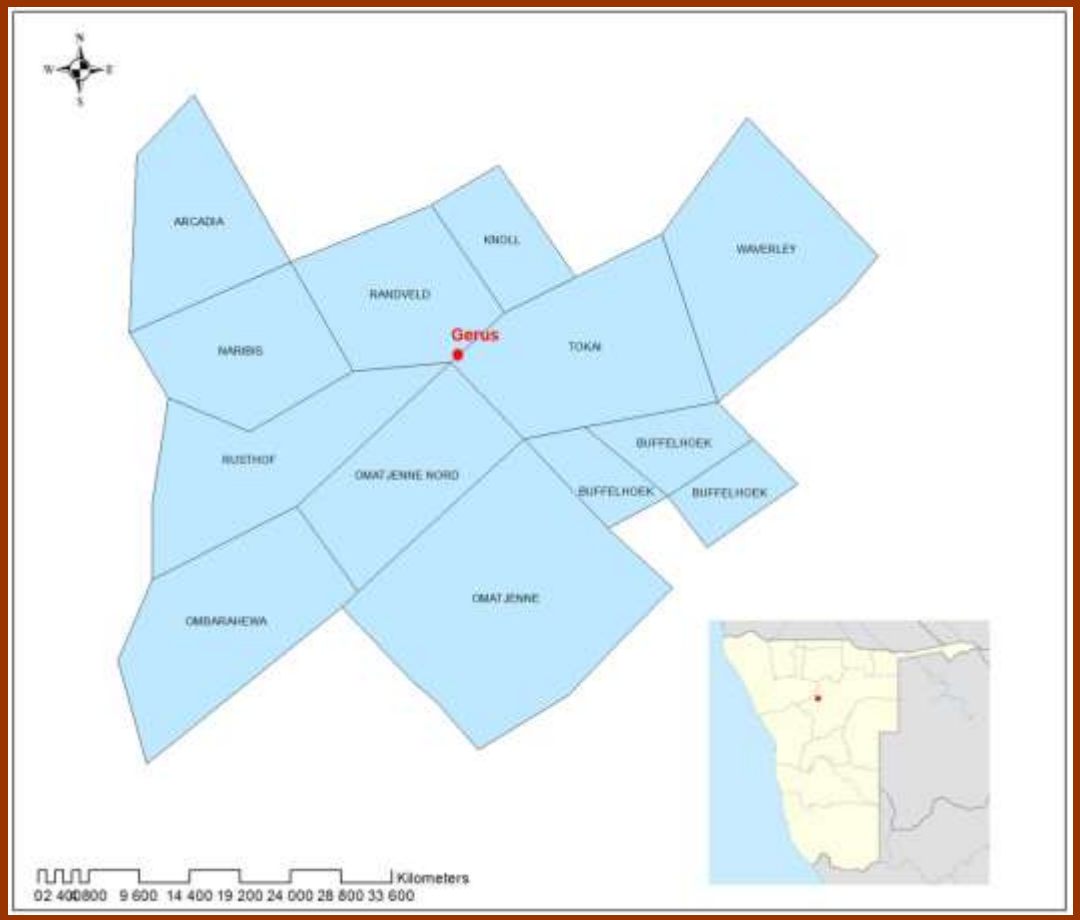
STUDY AREA

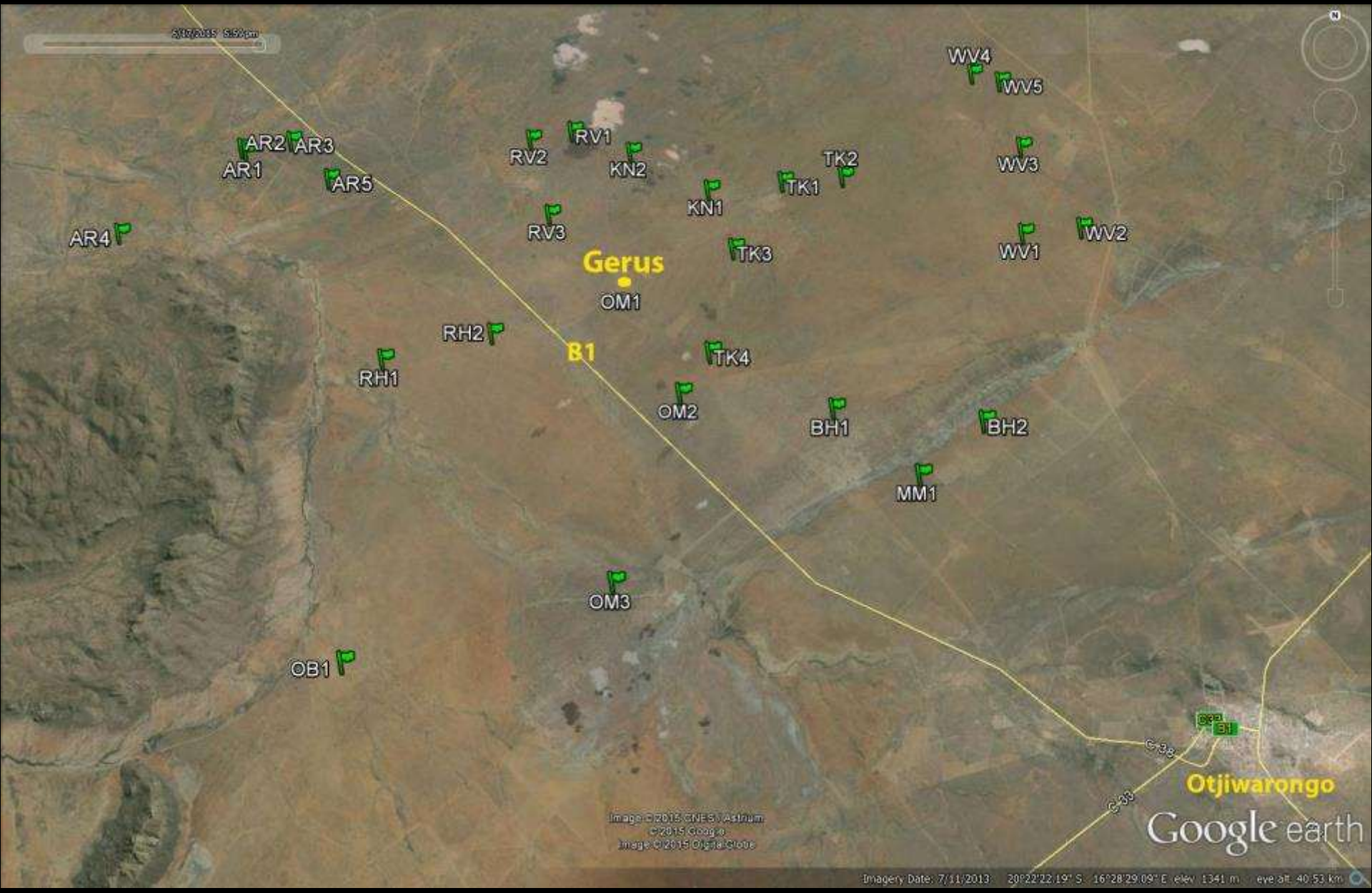
The study area is located north-west of Otjiwarongo - the focus was primarily on farms in close proximity of Nampower's Gerus substation.

Eight commercial farms were included and all of them are primarily used for extensive cattle farming.

Mean annual rainfall - 457 mm

A total of 28 plots were selected and surveyed.



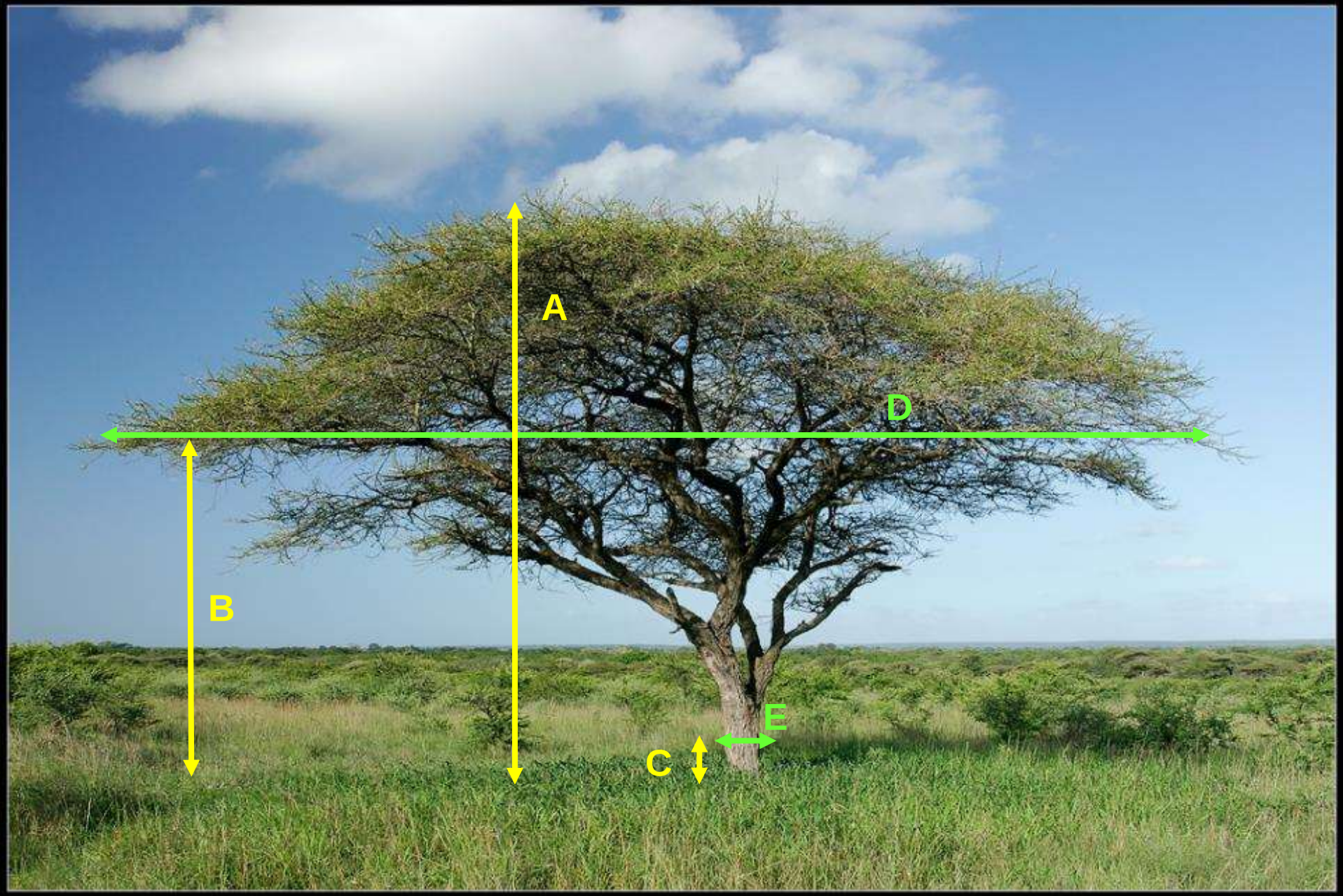

WV4
WV5
AR2
AR3
AR1
AR5
RV1
RV2
KN2
TK2
WV3
TK1
KN1
AR4
RV3
WV2
WV1
TK3
Gerus
OM1
RH2
B1
TK4
RH1
OM2
BH1
BH2
MM1
OM3
OB1
Otjiwarongo
Google earth

PROCEDURE

At each site a belt transect of 50 x 2.5m (125 m^2) was laid out in such a way as to best represent the woody vegetation of that site.

The dimensions of all rooted, live woody plants were measured.

Dry mass estimates of the leaves and wood calculated using the BECVOL 3-model.


A
B
C
D
E

PROCEDURE

Dependent variable	Regression model	n	r	r^2	P	a (intercept)		b (slope)	
						Value	SE	Value	SE
Leaf volume (cm^3)	Linear	65	0.85	0.72	<0.001	1 813.14	481.159	0.0001795	0.0000142
	Exponential		0.95	0.90	<0.001	−2.82646	0.438269	0.693414	0.0292608
	Multiplicative		0.94	0.88	<0.001	−20.0476*	1.2011	10.2335	0.446155
Leaf dry mass (g)	Linear	65	0.86	0.74	<0.001	909.231	222.264	0.0000877	0.0000066
	Exponential		0.95	0.90	<0.001	−3.84491	0.460117	0.712723	0.0307194
	Multiplicative		9.94	0.88	<0.001	−21.563*	1.25326	10.525	0.465532
Shoot dry mass (shoots <0.5 cm in diameter) (g)	Linear	20	0.94	0.88	<0.001	51.2957	440.102	0.0002313	0.0000196
	Exponential		0.93	0.97	<0.001	−6.57278	1.2686	0.887834	0.0804096
	Multiplicative		0.93	0.86	<0.001	−30.1215*	3.43185	13.6321	1.24674
Stem dry mass (stems >0.5–2.0 cm in diameter) (g)	Linear	20	0.91	0.83	<0.001	−662.919	1 729.09	0.0007155	0.0000771
	Exponential		0.93	0.86	<0.001	−7.68076	1.44271	1.01235	0.0914453
	Multiplicative		0.93	0.86	<0.001	−34.5205*	3.91018	15.5398	1.42051
Wood dry mass (wood >2.0 cm in diameter) (g)	Linear	20	0.92	0.85	<0.001	−7 883.3	4 342.77	0.0018934	0.0001936
	Exponential		0.89	0.79	<0.001	−17.4884	3.16515	1.63743	0.200621
	Multiplicative		0.90	0.81	<0.001	−61.7877*	8.126	25.4573	2.95205
Total wood dry mass (all fractions) (g)	Linear	20	0.93	0.86	<0.001	−8 670.07	6 109.71	0.0028448	0.000272
	Exponential		0.89	0.79	<0.001	−12.7454	2.61595	1.3855	0.16581
	Multiplicative		0.89	0.79	<0.001	−49.6601*	6.97412	21.3338	2.53359

* a = log a (for multiplicative regression model only), spatial canopy volume transformed to its normal logarithmic value, except for linear model

RESULTS

A total of 30 woody species (trees and shrubs) were recorded in the survey.

Group 1 Scarce and/or desirable species	Group 2 Potential problematic species - low biomass	Group 3 Potential problematic species - high biomass
Boscia albitrunca	*Grewia flava*	*Dicrostachys cinerea*
Boscia foetida	*Grewia flavescens*	*Combretum apiculatum*
Ehretia alba	*Grewia retinervis*	*Senegalia erubescens*
Commiphora pyracanthoides	*Grewia villosa*	*Senegalia fleckii*
Maerua parvifolia	*Lycium* spp.	*S. mellifera* subsp. *mellifera*
Philenoptera nelsii	*Catophractes alexandri*	*Senegalia senegal*
Ziziphus mucronata	*Rhigozum brevispinosum*	*Vachellia reficiens*
Vachellia erioloba	*Phaeoptilum spinosum*	*Vachellia luederitzii*
	Tarchonanthus camphoratus	*V. hebelacada* subsp. *hebeclada*
	Terminalia prunoides	*V. tortilis* subsp. *heteracantha*
		Terminalia sericea

RESULTS

In order to assess the severity of the bush thickening on any particular site, the calculated tree densities (plants/ha) and ETTE/ha of the survey plots were used as the main criteria.

As a general rule of thumb the median number of ETTE/ha that can be supported in a specific rainfall region without adversely affecting the grass layer, should not exceed 10x the mean annual rainfall.

Based on a mean annual rainfall of 457 mm for the study area, this implies a target figure of approximately 4 500 ETTE ha^{-1}.

RESULTS

The total wood dry mass (all fractions) of the 28 plots varied from a low 7 291 kg ha^{-1} to a high of 190 942 kg ha^{-1} with an average of 36 222 kg ha^{-1}.

RESULTS

On average the wood >2.0 cm in diameter made up 70.1 % of the total wood mass, while the stems >0.5-2.0 cm and shoots <0.5 cm made up 20.8 and 9.1 % of the total wood mass, respectively.

Should the trees be harvested during the summer months when the trees have their full leaf carriage, the leaves would add another 6.8 % to the total tree dry mass.

From the data it is clear that a high wood mass per hectare is without exception related to the presence of very large trees.

Wood mass per hectare increased exponentially with an increase in the number of very large trees, while plots with a predominance of small to medium sized trees - even at very high densities - yielded a much lower wood mass.

RESULTS

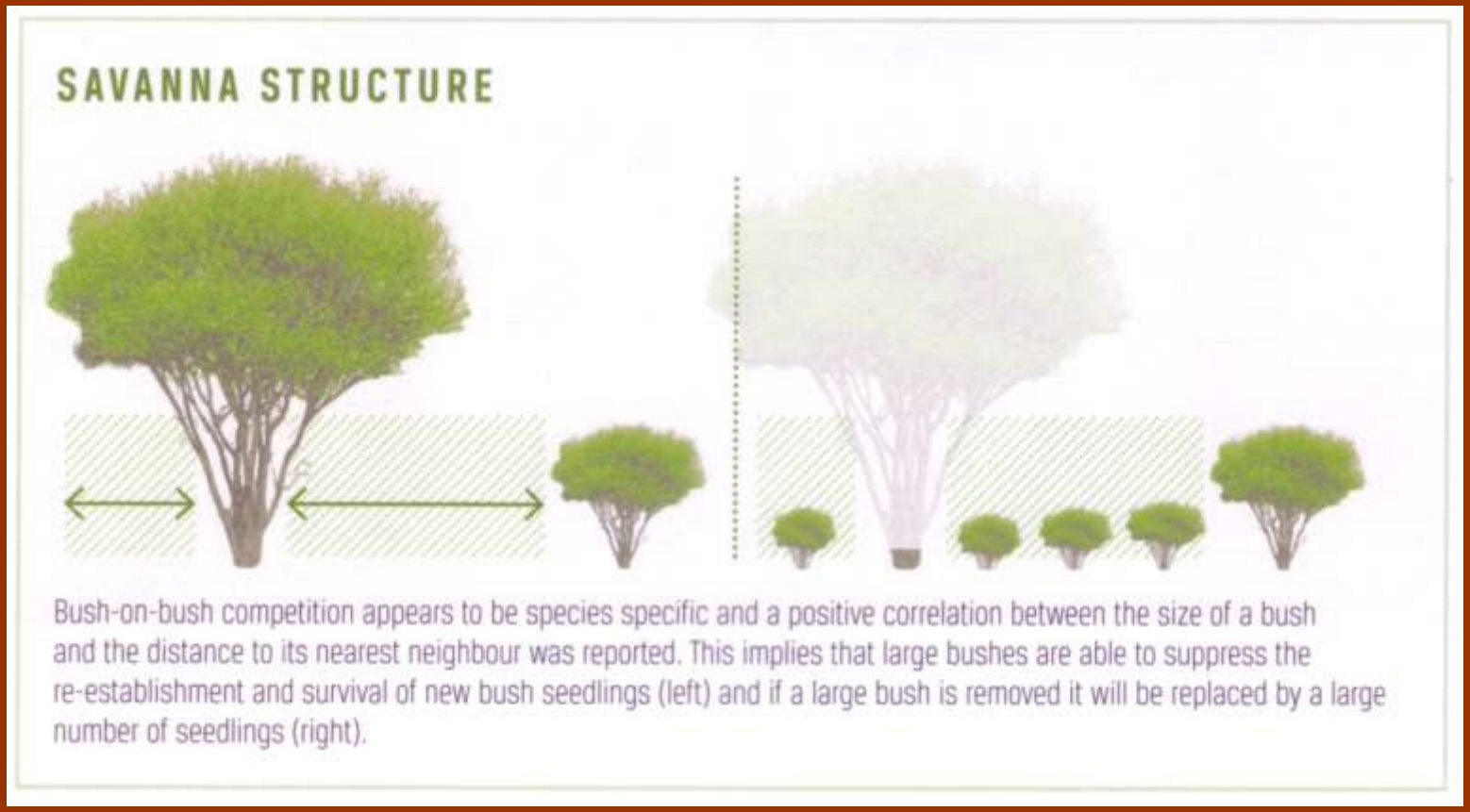
Based on the average of 36 222 kg ha^{-1} the study area of 45 000 ha carries an estimated wood biomass of 1.63 mil. metric tons.

Wood harvesting at a target density of 4 500 ETTE ha^{-1} will meet the minimum requirement of 10 000 kg ha^{-1} for the viability of an electricity plant .

RECOMMENDED TREE HARVESTING

If long-term restoration of the rangeland from bush thickening is an important objective, the most responsible ecological approach to wood harvesting should be selective thinning of the excess woody plants.

Tree-on-tree competition



Bush-on-bush competition appears to be species specific and a positive correlation between the size of a bush and the distance to its nearest neighbour was reported. This implies that large bushes are able to suppress the re-establishment and survival of new bush seedlings (left) and if a large bush is removed it will be replaced by a large number of seedlings (right).

RECOMMENDED TREE HARVESTING

It is recommended that trees be selectively harvested, starting with the smallest plants and progressively moving to larger plants until the target of 4 500 ETTE/ha has been reached.

Harvesting should concentrate on the potential problem species (groups 2 and 3).

If for example only trees larger than 5 m are retained at a target value of 4 500 ETTE/ha an average of 150 trees/ha will remain (since 1 tree >5 m equals approximately 30 ETTE) .

Height class (m)	ETTE/plant All species	ETTE/plant *A. mellifera*	ETTE/plant *A. luederitzii*	ETTE/plant *A. reficiens*	ETTE/plant *Grewia* spp.
>0.5 - 1.0	0.43	0.43	0.64	0.43	0.79
>1.0 – 2.0	1.63	1.90	2.52	1.74	2.21
>2.0 – 3.0	4.58	5.57	5.10	5.13	4.45
>3.0 – 4.0	10.97	11.71	10.52	11.66	5.98
>4.0 – 5.0	16.53	15.97	19.20	19.68	-
>5.0 – 6.0	28.14	29.05	32.90	-	-
>6.0	44.58	53.46	41.63	-	-

RECOMMENDED TREE HARVESTING

Treatment of harvested plants?

The last issue that needs be addressed is whether the harvested plants be treated or allowed to regrow producing another biomass harvest after a number of years.

A clear distinction must be made between existing plants that have been cut and that will regrow (coppice), versus new woody plants that will establish from seeds.

RECOMMENDED TREE HARVESTING

Treatment of harvested plants?

Coppice regrowth will result in a plant that is structurally different from the original plant (multi-stemmed shrub vs. single-stemmed tree) and may probably never render the same wood biomass as the original plant.

Photosynthesis takes place in green leaves and after damage the replacement of leaves will always be prioritised and not the replacement of wood biomass.

Height class (m)	Wood DM/plant	Leaf DM/plant	Leaf : Wood ratio	Leaf %
>0.5 - 1.0	0.184	0.104	1 : 1.769	56.52
>1.0 – 2.0	0.966	0.317	1 : 3.047	32.82
>2.0 – 3.0	6.557	1.147	1 : 5.716	17.50
>3.0 – 4.0	26.506	2.609	1 : 10.159	9.84
>4.0 – 5.0	60.341	3.909	1 : 15.436	6.78
>5.0 – 6.0	192.816	7.214	1 : 26.728	3.74
>6.0	579.353	11.387	1 : 50.878	1.97

RECOMMENDED TREE HARVESTING

Treatment of harvested plants?

The species composition of the woody plants after tree harvesting is likely to differ/alter from what it used to be before the harvesting.

Aggressive species such as *Dichrostachys cinerea*, *Grewia* species and *Catophractes alexandri* may invade and in time compete more severely with the grass layer, while producing less wood.

CONCLUSIONS

Is the planned harvesting of biomass of indigenous woody plants for electricity generation ecologically viable?

YES

Provided ….

Challenges of logistics be overcome and cooperation between all role players be obtained.

Priorities clearly identified prior to the harvesting operation and realistic targets set.

Responsibility and accountability are ensured:

- What is the priority? Electricity generation (wood harvesting) or rangeland restoration essential for viable beef production (must be a win-win situation for both enterprises).
- Short-term benefits versus long-term benefits (sustainability).

Training essential

ACKNOWLEDGEMENTS

Project commissioned and funded by the Desert Research Foundation of Namibia (DRFN) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).


Thank you