The potential of woody plants as forage source in a changing climate in semi-arid communal grazing lands of South Africa: Dynamics of mineral contents of 26 woody species

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1. Background

- Trends towards increased woody plant abundance
  - long-term climate change have been proposed
- The encroachment -suppress grass production, but the loss can be partially compensated for by increased browse production and intake,
- the diets of livestock raised on extensive rangelands include a substantial proportion of browse
- Many woody plant species have been recognized to sufficiently provide essential nutrients
- Local farmers' knowledge of woody plants in the Eastern Cape province of South Africa identified over 28 woody plants as browsed by livestock and game species (Table 1).
- Extensive study on diversity and distribution, but no adequate research on the chemical composition and nutritional values.

Significance

- important for the management and sustainable exploitation of the rangeland resources
- suitably used as potential mineral supplements for lambing and/or during critical period such as dry and prolonged drought periods.
- aid determination of their adequacy and formulation of fodder flow plan to ensure adequate nutrients supply throughout the year.

Objectives

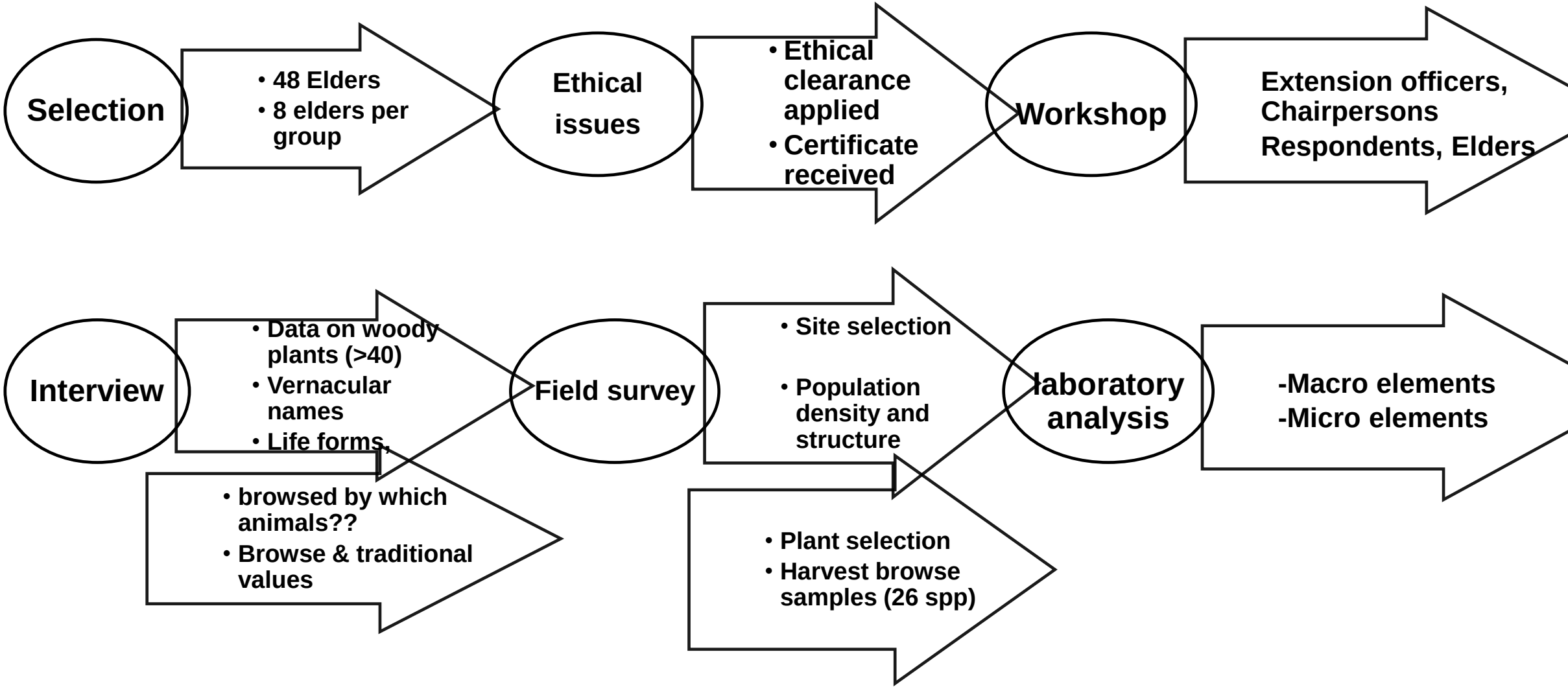
1) determine the macro and micro-elements status of 26 woody plant species, and
2) examine the effect of harvesting height on the concentrations of these elements.

This current study was part of a large research project focusing on the integration of local and scientific knowledge in rangeland resource management and utilization for sustainable small scale livestock production in semi-arid Eastern Cape Province of South Africa

2. Materials and Methods

- Location: University of Fort Hare, Mixed-bush veld savannas of the Eastern Cape.
- mixture of hills, undulating and flat bottomlands, and gentle to steep sloping landscapes.
- sampling sites: bottomland and gentle sloping landscapes
- coordinates of S 32 46^{o}.922' and E026^{o}.51.461' and
- altitude range: 500 m–550 m.
- mean annual rainfall: 400 mm to 600 mm,
- mean maximum and minimum temperature: 26.3^{o}C–15^{o}C in summer, and 18.4^{o}C–8 ^{o}C in winter.
- . The major geology and soil types: are homogeneous dominated by mudstones with subordinate sandstones of the Adelaide sub-group

Sampling procedure



Browse sampling and chemical analysis

- Leaves harvested by hand two height level (five mature plants per species);
  - low (< 1.5 m) - browses that are easily accessed by all livestock species,
  - and upper (>1.5 m)-may not be fully accessed but can be fed using cut and carry.

Statistical analysis

- Analyses of variance of nested effects (harvesting height levels nested within browse species) was conducted using the general linear models (GLM) procedure of SAS (1996).
- a completely randomized block experimental design
- The following statistical model was used:
- $Y_{ij} = \mu + T_i + H_j + (T \times H)_{ij} + E_{ij}$
- Where Y_{ij}= the dependent variable
- μ = overall mean
- T_i = the effect due to browse species
- H_j = the effect due to height (Low: <1.5 m; and upper: >1.5 m heights)
- $(S \times A)_{ij}$ = interaction between species and height
- E_{ijk} = the random error

Table 1. Scientific and vernacular name, growth forms and browse values of selected woody plants identified as potential forage source by the communal people (n=48)

Scientific Names	Vernacular Names	Growth Forms	Browsed by
Acacia karoo	Umnga	T	Goats, cattle, sheep and game
Azima tetracantha	Igcegceleya	S	Goats, cattle and game
Boscia oleoides	Umgqomo-gqomo	T	Cattle: results in unpleasantly tainted milk
Brachylaena elliptica	Isiduli	T	Goats, cattle
Carissa haematocarpa	Isabetha-Nkunzi	S	Goats, cattle
Coddia rudis	Intsinde	S	Goats, cattle, sheep and game
Combretum cafrum	Umdubi	T	Goats, cattle
Cussonia spicata	Umsenge	T	Goats, cattle and game
Ehretia rigida	Umhleli	T	Goats, cattle and game
Euphorbia tirucalli	Umhlontto	T	Goats, cattle and game
Grewia occidentalis	Umnqabaza	S/T	Goats, cattle
Grewia robusta	Umnqayi	S/T	Goats, cattle and game
Hippobromus pauciflorus	IIathile	T	Goats, cattle
Maytenus capitata	Umqaqoba	T	Game and goats
Maytenus heterophylla	Umqaqoba	S	Game and goats
Olea africana	Umnquma	T	Cattle, goat and game
Pappea capensis	iliTye or umGqalutye	T	Goats, cattle
Phyllanthus verrucosus	Impingelo	S	Goats, cattle
Portulacaria afra	Igwanishe	S	Cattle, goat, sheep and game animals, tortoises
Ptaeroxylon obliquum	Umthathi	T	Game animals
Rhus longispina	Umchani	S/T	Cattle, goats and game
Rhus refracta	Intlolokotshane	S	Cattle, goats and game
Schotia afra	Umnqonci	T	Game animals
Sideroxylon Irreme	Umgwahu	T	Goats, cattle
Scutia myrtina	Isiphingo	S/T	Cattle, goat and game
Ziziphus mucronata	Umphafa	T	Cattle, goat and game animals.

Table 2. Variations in the mineral content (%) of **tree leaves** harvested from the semi-arid communal rangelands of Eastern Cape, South Africa

Species	Ca	Mg	K	P
Acacia karoo	1.74^{d}	0.29^{d}	1.10^{h}	0.17^{g}
Boscia oleoides	1.51^{f}	0.56^{b}	0.77^{i}	0.06^{l}
Brachylaena elliptica	1.09^{i}	0.16^{e}	0.81^{i}	0.14^{i}
Combretum cafrum	2.34^{b}	0.55^{b}	0.73^{i}	0.24^{d}
Cussonia spicata	1.44^{g}	0.33^{d}	1.63^{e}	0.11^{k}
Ehretia rigida	2.63^{a}	0.72^{a}	3.20^{a}	0.29^{a}
Euphorbia tirucalli	1.36^{gh}	0.39^{c}	2.90^{b}	0.28^{a}
Hippobromus pauciflorus	2.28^{b}	0.20^{e}	1.96^{d}	0.21^{f}
Maytenus capitata	2.35^{b}	0.78^{a}	1.73^{e}	0.12^{j}
Olea africana	1.12^{i}	0.16^{e}	1.47^{g}	0.25^{d}
Pappea capensis	1.30^{h}	0.30^{d}	1.48^{g}	0.18^{g}
Ptaeroxylon obliquum	1.42^{g}	0.41^{c}	2.1^{d}	0.25^{d}
Schotia afra	2.18^{c}	0.18^{e}	1.63^{e}	0.27^{c}
Sideroxylon Irreme	0.85^{j}	0.22^{e}	1.51^{f}	0.14^{i}
Ziziphus mucronata	1.61^{e}	0.19^{e}	2.42^{c}	0.29^{a}
SE	0.05	0.04	0.04	0.005

Table 3. Variations in the micro-mineral content (ppm) of tree leaves harvested from the semi-arid communal rangelands of Eastern Cape, South Africa

Species	Cu	Zn	Mn	Fe
Acacia karoo	3.66^{h}	15.3^{d}	27.2^{g}	157^{b}
Boscia oleoides	2.23^{i}	96.9^{a}	171^{b}	95.7^{e}
Brachylaena elliptica	11.2^{a}	19.5^{cd}	136^{c}	115^{cd}
Combretum cafrum	3.36^{h}	12.8^{d}	167^{b}	175^{a}
Cussonia spicata	4.78^{f}	19.1^{cd}	178^{b}	98.3^{e}
Ehretia rigida	7.12^{c}	25.7^{c}	78^{d}	85.1^{e}
Euphorbia tirucalli	6.21^{d}	24.8^{c}	37.1^{fg}	82.7^{e}
Hippobromus pauciflorus	5.56^{e}	26.9^{c}	78.4^{d}	105^{d}
Maytenus capitata	4.27^{g}	25.7^{c}	49.0^{f}	123^{c}
Olea africana	9.39^{b}	19.8^{cd}	22.5^{g}	92.8^{e}
Pappea capensis	4.02^{g}	13.5^{d}	63.9^{e}	101de
Ptaeroxylon obliquum	11.2^{a}	55.2^{b}	232^{a}	128^{c}
Schotia afra	4.98^{f}	18.7^{cd}	18.2^{g}	136^{bc}
Sideroxylon irreme	4.22^{g}	14.9^{d}	24.5^{g}	58.6^{f}
Ziziphus mucronata	7.37^{c}	15.7^{d}	71.7^{de}	173^{a}
SE	0.32	4.56	10.7	14.3

Table 4. Variations in the mineral content (%) of shrub leaves harvested at two height levels from the semi-arid communal rangelands of Eastern Cape, South Africa

Species	Ca			Mg			K			P		
	Low[1]	High[2]	SE	Low	High	SE	Low	High	SE	Low	High	SE
Azima tetracantha	4.62^{Ab}	5.01^{Aa}	0.11	0.51^{Ba}	0.52^{Ba}	0.03	1.78^{Ca}	1.73^{CDa}	0.06	0.17^{Ca}	0.18^{Ca}	0.01
Carissa haematocarpa	2.34^{Cb}	2.53^{Da}	0.08	0.38^{Ca}	0.38^{Ca}	0.02	1.30^{Da}	1.33^{Fa}	0.05	0.28^{Aa}	0.28^{Aa}	0.01
Coddia rudis	1.72^{Da}	1.68^{Ea}	0.11	0.33^{Da}	0.34^{Da}	0.03	1.78^{Ca}	1.78^{Ca}	0.06	0.15^{CDa}	0.15^{Da}	0.01
Maytenus heterophylla	3.14^{Ba}	2.98^{Ba}	0.11	0.53^{Ba}	0.56^{Ba}	0.03	1.71^{Ca}	1.64^{Ea}	0.06	0.28^{Aa}	0.28^{Aa}	0.01
Portulacaria afra	1.34^{Eb}	2.83^{Ca}	0.08	1.59^{Aa}	0.84^{Ab}	0.03	2.02^{Ba}	1.96^{Ba}	0.05	0.15^{CDa}	0.04^{Eb}	0.01
Phyllanthus verrucosus	0.99^{Fa}	0.99^{Fa}	0.11	0.14^{Fa}	0.13^{Fa}	0.03	1.71^{Ca}	1.69^{DEa}	0.06	0.21^{Ba}	0.21^{Ba}	0.01
Rhus refracta	0.88^{Fa}	0.85^{Fa}	0.08	0.22^{Ea}	0.22^{Ea}	0.02	2.22^{Aa}	2.16^{Aa}	0.05	0.14^{Da}	0.14^{Da}	0.01
SE	0.06			0.02			0.04			0.01		

Table 4 cont'd

	Cu			Zn			Mn			Fe		
Species	**Low**	**high**	**SE**	**Low**	**high**	**SE**	**Low**	**high**	**SE**	**Low**	**high**	**SE**
Azima tetracantha	1.73^{Ea}	1.98^{Ca}	0.6	8.57^{Da}	10.4^{Ca}	1.9	117^{Ca}	122^{Ca}	29.8	119^{BCa}	112^{Ba}	15.5
Carissa haematocarpa	10.3^{Ba}	10.4^{Aa}	0.5	29.9^{Aa}	31.3^{Aa}	1.5	132^{Ca}	131^{Ca}	23.1	107^{Ca}	113^{Ba}	12.0
Coddia rudis	6.24^{Da}	5.86^{Ba}	0.6	11.6^{Ca}	11.7^{Ca}	1.9	70.1^{Da}	69.1^{Da}	29.8	196^{Aa}	179^{Aa}	15.5
Maytenus heterophylla	6.61^{CDa}	6.27^{Ba}	0.6	19.4^{Ba}	17.6^{Ba}	1.9	26.1^{Ea}	26.9^{Ea}	29.8	78.7^{Da}	87.9^{Ca}	15.5
Portulacaria afra	11.7^{Aa}	0.86^{Db}	0.5	13.1^{Ca}	17.5^{Ba}	1.5	433^{Aa}	440^{Aa}	23.1	76.2^{Da}	81.4^{Ca}	12.0
Phyllanthus verrucosus	6.76^{Ca}	6.98^{Ba}	0.6	28.9^{Aa}	28.3^{Aa}	1.9	211^{Ba}	201^{Ba}	29.8	38.2^{Ea}	50.9^{Da}	15.5
Rhus refracta	7.17^{Ca}	6.62^{Ba}	0.5	11.9^{Ca}	11.2^{Ca}	1.9	60.9^{Da}	68.7^{Da}	23.1	130^{Ba}	122^{Ba}	12.0
SE	0.42			1.35			21.1			10.9		

Table 5. Mineral content of (%) of woody leaves (intermediate growth) harvested from the semi-arid communal rangelands of Eastern Cape, South Africa.

Species	Ca			Mg			K			P		
	Low	**high**	**SE**	**Low**	**high**	**SE**	**Low**	**high**	**SE**	**Low**	**high**	**SE**
Grewia occidentalis	2.05^{Cb}	2.20^{Ba}	0.08	0.26^{Ca}	0.25^{Ca}	0.01	2.10^{Aa}	2.00^{Ab}	0.02	0.25^{Aa}	0.25^{Aa}	0.01
Grewia robusta	2.57^{Ba}	2.61^{Aa}		0.33^{Ba}	0.33^{Aa}		1.61^{Ca}	1.62^{Ca}		0.19^{Ba}	0.19^{Ba}	
Rhus longispina	2.88^{Aa}	1.45^{Db}		0.89^{Aa}	0.27^{Bb}		1.92^{Ba}	1.83^{Bb}		0.04^{Cb}	0.16^{Ca}	
Scutia myrtina	1.83^{Da}	1.86^{Ca}		0.21^{Da}	0.19^{Da}		1.28^{Da}	1.28^{Da}		0.17^{Ba}	0.18^{Ba}	
SE	0.06			0.01			0.03			0.01		
	Cu		**SE**	**Zn**		**SE**	**Mn**		**SE**	**Fe**		**SE**
Grewia occidentalis	8.13^{Aa}	8.53^{Aa}	0.39	25.5^{Ba}	26.7^{Ba}	1.62	75.9^{Ca}	79.0^{Ca}	26.4	195^{Ab}	206^{Aa}	7.40
Grewia robusta	4.25^{Ca}	4.41^{Ba}		35.9^{Aa}	36.7^{Aa}		45.9^{Ca}	45.8^{Ca}		80.7^{Ba}	78.2^{Ca}	
Rhus longispina	0.82^{Db}	8.10^{Aa}		18.9^{Ca}	20.6^{Ca}		517^{Aa}	135^{Bb}		47.6^{Cb}	121^{Ba}	
Scutia myrtina	5.29^{Ba}	3.89^{Bb}		10.1^{Da}	9.61^{Da}		204^{Ba}	192^{Aa}		89.9^{Ba}	66.9^{Db}	
SE	0.27			1.14			18.7			5.22		

Table 6: Analysis of the mineral contents of selected woody plants between the height classes (low and high). F=F ratio, P=probability value.

Shrubs			**Shrub-tree**		
Portulacaria afra	F	P	*Rhus longispina*	F	P
P	18.6	<0.0001	P	27.2	<0.0001
Ca	33.8	<0.0001	Ca	29.0	<0.0001
K	0.54	NS	K	3.94	0.04
Mg	68.7	<0.0001	Mg	262	<0.0001
Cu	53.9	<0.0001	Cu	34.1	<0.0001
Zn	500	<0.0001	Zn	0.50	NS
Mn	0.01	NS	Mn	27.5	<0.0001
Fe	68.5	<0.0001	Fe	8.5	<0.0001
Azima tetracantha			*Scutia myrtina*		
Ca	33.8	0.01	Cu	34.1	0.02
			Fe	8.5	0.04

Table 7: Analysis of the mineral contents of browse leaves among preference categories and between woody species within each preference category.

	Among preferential category		**Between species within each preferential category**									
			Game only		**GG**		**CG**		**CGG**		**CGGS**	
	F	P	F	P	F	P					F	P
P			1.67	0.22	605	<.0001	358	<.0001	60.4	<.0001	12.4	0.0002
Ca	334.89	<.0001	83.75	<.0001	15.7	0.001	190	<.0001	99.2	<.0001	1.59	0.23
K	107.48	<.0001	251	<.0001	1.26	0.28	684	<.0001	156	<.0001	740	<.0001
Mg	106.67	<.0001	2.01	0.18	3.87	0.07	4909	<.0001	25.1	<.0001	37.9	<.0001
Cu	22.25	<.0001	311.4	<.0001	5.87	0.03	248	<.0001	12.2	<.0001	1.38	0.27
Zn	44.35	<.0001	7.87	0.01	0.17	0.68	1584	<.0001	64.9	<.0001	7.91	0.002
Mn	20.86	<.0001	138	<.0001	0.25	0.63	268	<.0001	14.2	<.0001	101	<.0001
Fe	81.91	<.0001	0.03	0.87	0.74	0.40	133.8	<.0001	14.2	<.0001	0.65	0.53

Table 8 Proportion of browses species (%) below, above and within the normal macro (%) and micro (ppm) mineral requirement of ruminants

Minerals	Normal requirement	Trees			Shrubs		
		Below	above	Within	Below	above	Within
P	0.12-0.48	13	-	87	14		86
Ca	0.19-0.82	-	All species	-		All species	
K	0.5-1	-	80	20		All species	
Mg	0.1-0.25		80	20		57	43
Cu	7-11	67	13	20	71		29
Zn	20-40	60	13	27	71		29
Mn			all				
Fe	30-50		86	14		All species	

Minerals	Shrub/trees		
	Below	above	Within
P	25		75
Ca		All species	
K		All species	
Mg		50	50
Cu	50		50
Zn	50		50
Mn			
Fe		All species	

4. Conclusion

- Our results indicate that levels of macro elements in most browse species areadequate for ruminant production in the dry period.
- However, Cu and Zn are seriously deficient in browse plants and their amendments through supplementation may deserve consideration in any browse feeding program during critical periods.