CHAPTER 8

AN OVERVIEW OF WOODY VEGETATION UTILISATION IN TEMBE ELEPHANT PARK, KWAZULU-NATAL, SOUTH AFRICA

Abstract

A survey of woody plant species utilisation by elephants, large, medium and small browsers, man and natural damage, was conducted in nine vegetation units of Tembe Elephant Park, Maputaland, KwaZulu-Natal, South Africa. The study was conducted primarily to assess the risk from elephant utilisation for the conservation of the rare and diverse Sand Forest. Canopy removal was evaluated within two age ranges, (a) recent, 12 months prior to the study and (b) old, more than 12 months prior to the study. The overall density of utilisation was also evaluated. Results show that recent canopy removal by medium and small browsers was intensive, followed by elephant utilisation. However, older canopy removal values showed that elephant utilisation marks accumulated and that trees were utilised repeatedly preventing them from recovering. The overall density of utilisation showed that medium and small browsers removed the regeneration class, while elephants opened gaps in the canopy at a rapid rate. The extent of natural damage events appeared linked and possibly amplified by elephant utilisation. We conclude that the vegetation units conserved in Tembe Elephant Park are endangered by a combination of canopy removal by elephant utilisation and sapling removal by small and medium browsers. This browsing pressure could lead to the degradation of woodland to grassland as was found in east Africa under high densities of animals.

Keywords

Browsers, elephants, Maputaland, Sand Forest, tree utilisation, woodland

Introduction

A number of ecological problems have been documented relating to the over-concentration of animals, whether the area is small and unfenced (Walpole *et al.* 2004; Western In Press) or large and fenced (Eckhardt *et al.* 2000; Mosugelo *et al.* 2002). Among them is the often-observed transformation of a woodland landscape into shrubby grassland, or the suppression of woody vegetation growth (Bond and Loffell 2001; Western and Maitumo 2004; Wiseman *et al.* 2004). The problem of growing animal populations confined to small reserves in Africa, and to a greater extent in South Africa, has come to the forefront of conservation issues recently, because public,

scientific, and conservation opinions are divided on the way to manage this problem (Van Aarde *et al.* 1999; Lombard *et al.* 2001; Van Aarde and Jackson 2007), especially when charismatic animals such as the African elephant *Loxodonta africana* (Blumenbach 1797) are concerned.

The effect of growing animal populations is of particular importance when the vegetation in these reserves is rare, rich in biodiversity, and unlikely to recover from intense utilisation (Lombard *et al.* 2001; Guldemond and Van Aarde In Press; O'Connor *et al.* 2007). This is the case in Tembe Elephant Park, a 300 km^2 reserve in Maputaland where animal populations have been confined by fences since 1989, and where the Sand Forest occurs. Sand Forest is considered one of the most valuable vegetation types of the Maputaland – Pondoland – Albany hotspot of biodiversity found along the east coast of southern Mozambique and South Africa (Van Wyk 1996; Van Wyk and Smith 2001; Matthews 2006; Morley 2005; Guldemond and Van Aarde In Press). Tembe Elephant Park was created with the dual mandate of preserving Sand Forest and the last remnants of the Maputaland coastal plain elephant population (Matthews 2006).

The elephant population was estimated at 179 animals in 2004 (Morley 2005), and was expected to exceed 200 individuals by 2006, and there is now concern that such numbers are affecting the Sand Forest (Guldemond and Van Aarde In Press), but also the forest-like woodlands (Van Rensburg *et al.* 2000; Gaugris 2004) of the region. There is growing fear that these changes could be irreversible due to the delicate ecological balance that controls Maputaland's vegetation dynamics (Van Rensburg *et al.* 2000; Matthews 2006).

The present study investigates the utilisation of the woody vegetation by large herbivore browsers in Tembe Elephant Park to determine the current level of utilisation. Canopy removal and overall utilisation of woody species are investigated and quantified within two different periods. Because elephant management is such a contentious issue, elephant utilisation is explored in depth and the changes observed in woody species utilisation since a similar study in 1994 are discussed.

Study area

The study area is situated in Maputaland, northern KwaZulu-Natal, South Africa (-26.85º to -27.15º South and 032.35º to 032.60º East). Tembe Elephant Park covers an area of 30 000 ha and was proclaimed in 1983 after negotiations with the local tribal authorities. The management of the park was given to the then KwaZulu-Natal Bureau of Natural Resources. The park was subsequently completely fenced in 1989. Little

tourist development has occurred in the park and its main purpose was to preserve the region's rare wildlife (Kwazulu-Natal Nature Conservation Services 1997; Browning 2000). The park has also served as a barrier to protect the local people from elephants raiding their crops. A full description of the topography, geology, soils, climate and vegetation of Tembe Elephant Park is provided in Matthews *et al.* (2001).

The park is characterised by a sandy plain interspersed with ancient littoral dunes with the Muzi Swamp running along the eastern boundary. It is covered by an Open to Closed Woodland, with patches of Short Intermediate and Tall Sand Forest. Maputaland lies on the southern boundary of the tropical zone. The summers are hot, wet, and humid, while the winters are cool to warm and dry. Tembe Elephant Park received a mean annual rainfall of 721 mm in the period from 1981 to 2003 (Matthews 2006).

Methods

Fieldwork

Surveys were done during the dry winter period of 2004 (May to October). Rectangular plots were placed at least 50 m away from little-used management tracks and at least 100 m away from more established tourist tracks to avoid road-induced bias as much as possible. While the southern portion of the park is relatively well covered by the road network, the northern part is less accessible and could not be sampled in the same detail as the rest of the park. The exact geographical coordinates (map datum: WGS 84, Lat-Long coordinates) of the middle point of all plots were recorded by using a Global Positioning System (GPS) device.

Only woody species were evaluated and no other plant forms were recorded. Woody plants in the present study were defined as all plants with an erect to scrambling growth form and with a ligneous trunk. The methodology was designed to evaluate the vegetation structure and the utilisation of vegetation by herbivores. Both aspects were evaluated in 135 plots. Plot dimensions were density-dependent and varied from a minimum of 15 m by 2 m to a maximum length of 45 m by a 19 m width. Extremely dense stands of Short Sand Forest called for shorter and narrower lines than the less dense Tall Sand Forest stands. By following this approach a similar amount of information was gathered for most plots.

Plots were subdivided in two subsamples. All the woody plants with a height ≥ 0.4 m were sampled in the whole area defined by the plot's dimensions, while those smaller than the defined cut-off were sampled in an area restricted to half that of the full plot size. This was done by dividing the plot in two equal halves along its length and

walking the first half recording both subsamples, while only woody species of heights ≥ 0.4 m were sampled on the return leg. All woody individuals encountered in either subsample were recorded, identified and measured. The genus and species name were noted for each plant. The numbers of live and dead stems were counted and their diameters measured at the level where the stem became regular above the basal swelling. The plant height and the height to the base of the canopy (defined as the height where the larger lowest branches supporting at least 10% of the canopy are found) were then measured, followed by the largest canopy diameter (D1) and the diameter of the canopy perpendicular to it (D2). Standing dead trees were also measured, while fallen dead trees were imaginary reconstructed to estimate the size and space occupied by the tree before it died and fell.

The herbivore or human utilisation of the vegetation was evaluated for each plant. Any change or damage to the plant, i.e. canopy, trunk and roots, were considered. The following parameters were evaluated for each plant (see Table 1 for details of various items, note that Table 1 is informative, and all types and states possibilities are presented, although they were not all utilised in the field):

- the state of the plant
- the type of damage / utilisation
- the presumed agent for the observed damage / utilisation
- the age of the damage
- the estimated percentage of material removed (canopy / bark / roots) by damage / utilisation
- the growth response to the damage / utilisation

Whenever possible each utilisation episode was scored separately.

Data analysis

The data were captured in Microsoft Excel spreadsheets and subsequently transformed into a database in Microsoft Access for ease of utilisation and analysis. Software designed by Mr Bruce Page (School of Life and Environmental Sciences, University of Natal, Durban, South Africa) was used to design the queries to analyse the vegetation utilisation aspects.

The analyses presented further below in this section were conducted independently for different agents. Agents were classified on the basis of the height of utilisation rather than body size *per se*. The following categories of agents were recognised:

- elephant

Table 1 Codes used for evaluating the utilisation of vegetation by browsers, man and natural damage in Tembe Elephant Park, the coding is derived from a code database used for other studies in KwaZulu-Natal, Northern Maputaland, South Africa, and only the codes relevant to the present study are displayed

State of the woody plant as encountered

1	Normal growth
2	Normal with branch regrowth from breakage
3	Pollarded (main stem snapped off, height reduced) – tree living, resprouting
4	Pollarded (main stem snapped off, height reduced) – tree living, coppicing
5	Pollarded (main stem snapped off, height reduced) – tree living, no growth response
6	Pushed over, stem intact, still partially rooted - living
7	Pushed over, stem partially broken - living
8	Mostly normal growth with some hedge growth
9	Hedge growth from continuous, regular browsing
10	Coppice growth from larger (older) dead stem
11	Coppice growth from accumulated browsing of young plant
12	Coppice growth from repeated fire
13	Coppice growth from repeated moisture stress
20	Senescent
30	Tree dead - main stem partially broken
31	Tree dead - main stem completely broken (pollarded)
32	Tree dead - main stem pushed over (partially uprooted)
33	Tree dead - main stem debarked
34	Tree dead - main stem intact, accumulated branch removal
35	Tree dead - debarking and branches / stems removed
50	Tree dead - intact - cause of death unknown
51	Tree dead - intact - killed by moisture stress
52	Tree dead - intact - dead from shading
53	Tree dead - intact - dead from high light
54	Tree dead - killed by combination of moisture stress and branch removal
55	Tree dead - killed from combination of shading and branch removal
56	Tree dead - killed by fire
60	Tree dead - totally uprooted
72	Top kill - dieback from debarking
80	Windfall
90	Live – deciduous leaf loss
91	Dying some branches still alive
92	Hedge growth from human utilisation
93	Tree dead, pushed over and broken, not uprooted

Agent (Agt.) of utilisation

1	Elephant
2	Giraffe
3	Kudu
4	Eland
5	Black rhinoceros
6	Nyala
7	Impala
8	Bushbuck
9	Grey duiker
10	Red duiker
11	Suni
12	Unidentifiable mega browsers (elephant, giraffe)
13	Unidentifiable large/medium size browsers (kudu, nyala, eland, etc)
14	Unidentifiable medium/small size browsers (impala, bushbuck, duiker etc)
15	Moisture stress
16	Flooding
17	Shading
18	High light intensity
19	Fire
20	Frost
21	Wind
22	Accidental
23	Unknown
24	Human
25	Insects
26	Cane rat
27	Lightning
28	Cattle
29	Porcupine
30	Goats

Type of utilisation observed

1	Whole plant (canopy and roots) utilized
2	Whole canopy utilized (roots still intact in ground)
3	Leaves and small twigs removed
4	Leaves, twigs, small branches, and large branches removed
5	Branch ends bitten off
6	Leaves plucked off
7	Leaves stripped
8	Parts of leaves removed
9	Only young leaves and leaf buds removed
10	Only mature leaves removed
11	Only senescent leaves removed
12	Bark removed
13	Roots removed
14	Flowers removed
15	Fruit / seeds removed
16	Dieback of main vertical branches/stems from top down
17	Dieback of horizontal branches/branch ends
18	Main stem/s cut
20	Accidental damage
21	No use / not damaged
22	Fire
23	Lightning
24	Pushed over and main stem broken
25	Pushed over and main stem intact

Growth responses (G.R.) to branch removal, stem breaking and debarking

1	Coppice growth
2	Wound regrowth
3	Main stem resprouting
4	No coppice or regrowth - vigour appears unaffected
5	No coppice or regrowth - vigour appears reduced (tree dying)
6	Hedge growth
7	Mostly hedge growth with some normal growth
8	Mostly normal growth with some hedge growth
9	Tree dead

Age of utilization (Age)

1	< 1 month
2	> 1 – 2 months
3	> 2 – 4 months
4	> 4 – 6 months
5	> 6 – 12 months
6	> 12 – 24 months
7	> 24 months
8	Continuous Regular Use

Debarking – circumference (Brk.)

1	1 % - 10 %	of the circumference of the stem removed
2	11 % - 25 %	
3	26 % - 50 %	
4	51 % - 75 %	
5	76 % - 90 %	
6	91 % - 99 %	
7	100%	

Canopy volume removal

1	1 % - 10 %
2	11 % - 25 %
3	26 % - 50 %
4	51 % - 75 %
5	76 % - 90 %
6	91 % - 99 %

Debarking - stem height (Brk.)

	Percentage of Stem Height	
0.1	1 % - 10 %	of the height of stem removed
0.2	11 % - 25 %	
0.3	26 % - 50 %	
0.4	51 % - 75 %	
0.5	76 % - 90 %	
0.6	91 % - 100 %	
0.7	Whole stem plus branches	

- undetermined large browsers (giraffe *Giraffa camelopardalis* (Linnaeus), elephant)
- undetermined medium browsers (such as: kudu *Tragelaphus strepsiceros* (Pallas), eland *Tragelaphus oryx* (Pallas), black rhinoceros *Diceros bicornis* (Linnaeus))
- undetermined small browsers (such as: suni *Neotragus moschatus* (Von Dueben), red duiker *Cephalophus natalensis* (A. Smith), common duiker *Sylvicapra grimmia* (Linnaeus), nyala *Tragelaphus angasii* (Gray), impala *Aepyceros melampus* (Lichtenstein), bushbuck *Tragelaphus scriptus* (Pallas))
- man
- natural damage (all cases where the above agents could not be identified positively or where a natural cause such as wind, drought, fire, lightning, light conditions, was deemed the most likely reason for the observed damage).

A distinction was made in the analysis between utilisation events that only affected the canopy volume and those that represented overall utilisation events, which represented a combination of all utilisation events, including canopy removal but also bark damage, stem or branch breakages, uprooting and other damages as listed in Table 1. A further distinction was made to evaluate the canopy volume removal events in time, and two periods were considered. Recent events represented all events within the 12 months prior to when fieldwork started, while old events represented all events that took place more than 12 months prior to the date when fieldwork started. The overall utilisation events were not qualified in terms of time of utilisation / damage events as above for canopy removal, due to the difficulty linked to reliably estimate and represent a combined age of some of the utilisation / damage events other than canopy removals.

The number of woody species utilised by an agent by vegetation unit was evaluated, and expressed as a percentage of the total number of species sampled in that vegetation unit. The number of woody species was evaluated and expressed for recent and old canopy volume removal events as well as for overall utilisation events.

Plants were then classified into eight height classes (>0 to <0.1 m, 0.1 to <0.5 m, 0.5 to <1.5 m, 1.5 to <3.0 m, 3.0 to <5.0 m, 5.0 to <8.0 m, 8.0 to <12 m, ≥12 m) selected to be representative of the local vegetation structure evaluated in previous studies (Matthews *et al.* 2001; Gaugris 2004). The range of height classes that may potentially be utilised by an agent was evaluated as the range of height classes where any utilisation event was documented for that agent at any time in the present study,

and formed the basis for calculating the total number of height classes available to that agent. The total number of height classes available for an agent was calculated for all woody species in a vegetation unit and represented the total number of height classes available in a vegetation unit during the two periods defined above.

The canopy volume available and canopy volume removal per height class per woody species in a vegetation unit were estimated by using the method of Walker (1976) for estimating the percentage of the canopy volume removed. The number of height classes where canopy removal events by an agent were observed was counted at the vegetation unit level and expressed as a percentage of the total number of height classes available to that agent. The number of height classes where at least 50% of the canopy volume was removed and the number of height classes where 100% of the canopy was removed were then established at the vegetation unit level. These numbers were then represented as percentages of height classes utilised in a vegetation unit where these canopy removal thresholds had been met within the range of available height classes to the agent considered.

The total density of individuals and the density of utilised individuals by an agent were calculated for all woody species in a vegetation unit, and a total density of woody individuals available and total density of utilised woody individuals per height class was derived for each woody species. The sums of these densities were used to represent available and utilised densities at the vegetation unit level. The ratio of utilised density to available density was expressed as an overall utilisation percentage value per height class per vegetation unit. The number of height classes where utilisation by the agent occurred was calculated and presented as a percentage of the available height classes to the agent by vegetation unit. The number of height classes where at least 50% of all woody individuals in one species were used and where 100% of all woody individuals in one species were used were calculated and similarly expressed as percentages of utilised height classes reaching these thresholds of the total number height classes available to the agent.

Woody species selection by agent

Similar counts of number of height classes utilised by agent as above were made, for recent and old canopy removal as well as overall utilisation, but restricted to the woody species level. The total number of height classes utilised per agent (canopy volume and overall utilisation), woody species and vegetation unit, the number of height classes where utilisation is at least 50% and 100% (canopy volume and overall utilisation) were counted. In order to rank the utilisation of these woody species, they

were classified in decreasing order of total number of height classes used, total number of height classes where utilisation was at least 50% and the number of height classes where utilisation was 100%. For practical reasons only the first ten most utilised woody species by agent were presented in this manuscript. However, the complete list of woody species utilised by agent by vegetation unit is available from the author on request.

Elephant utilisation evaluation

The case of elephant utilisation was evaluated in further detail. The overall recent and old canopy removals per woody species were calculated as the percentage of canopy removed (all height classed included) from the total available canopy (all height classes sampled were included) at park level, and the species were ranked by order of canopy removal intensity. A similar park level evaluation was done for the overall utilisation. These results were presented in relation to the 13 species documented as heavily utilised in 1994 by Matthews and Page (in Prep). These authors classified the 13 species into three groups. Group 1 included species for which canopy removal was ≥ 50%, group 2 included species for which canopy removal was ≥ 25% but < 50%, and group 3 included species for which canopy removal ranged from ≥ 10% to < 25%. In order to document the utilisation by vegetation unit, the above analysis was repeated at the vegetation unit level.

Results

The new Sand Forest classification presented in Chapter 1 of the present study was followed. A total of 12 915 woody plants were evaluated in this study, and 168 woody species were sampled, or 84% of the woody species known to occur in Tembe Elephant Park (Tembe Herbarium Collection Records).

Sand Forest association

In the Sand Forest association and the *Afzelia quanzensis* clumps, medium and small browsers affected the greatest number of woody species as far as recent canopy removal was concerned (Table 2). Small browsers also appeared to utilise most woody species from the *Afzelia quanzensis* clumps. Recent canopy removal values showed that elephants and large browsers utilised less species than the medium and small browsers.

The older canopy removal values showed that the greatest number of woody species where utilisation marks remain was from elephants and natural damage. The

Table 2: The number of species utilised by various agents in the Sand Forest association of Tembe Elephant Park, Maputaland, northern KwaZulu-Natal, South Africa. Values are given for canopy removal (number of species where a percentage of canopy volume (CV) was removed) for the two periods evaluated (Recent: within 12 months prior to the study and Old: > 12 months prior to the study) and for the overall utilisation (O U), including all utilisation events, but time was undetermined

Vegetation unit →			***Afzelia quanzensis* clumps (VT 01.1.1)**		**Short Sand Forest (VT 01.2.1)**		**Intermediate Sand Forest (VT 01.2.2)**		**Tall Sand Forest (VT 01.2.3)**	
No of Species sampled →			25		60		71		53	
No of Species used by	Age	Type	Number	(%)	Number	(%)	Number	(%)	Number	(%)
Elephant	Recent	CV	2	8.00	17	28.33	26	36.62	17	32.08
	Old	CV	5	20.00	39	65.00	37	52.11	23	43.40
	All ages	O U	7	28.00	43	71.67	38	53.52	31	58.49
Large Browsers	Recent	CV	0	0.00	0	0.00	0	0.00	0	0.00
	Old	CV	0	0.00	1	1.67	0	0.00	1	1.89
	All ages	O U	0	0.00	1	1.67	0	0.00	1	1.89
Medium Browsers	Recent	CV	5	20.00	25	41.67	33	46.48	20	37.74
	Old	CV	3	12.00	11	18.33	20	28.17	8	15.09
	All ages	O U	5	20.00	28	46.67	37	52.11	27	50.94
Small Browsers	Recent	CV	19	76.00	25	41.67	35	49.30	20	37.74
	Old	CV	0	0.00	2	3.33	4	5.63	0	0.00
	All ages	O U	19	76.00	25	41.67	38	53.52	22	41.51
Man	Recent	CV	0	0.00	0	0.00	0	0.00	0	0.00
	Old	CV	0	0.00	2	3.33	4	5.63	0	0.00
	All ages	O U	0	0.00	2	3.33	5	7.04	0	0.00
Natural Damage	Recent	CV	0	0.00	12	20.00	17	23.94	5	9.43
	Old	CV	10	40.00	47	78.33	51	71.83	28	52.83
	All ages	O U	10	40.00	51	85.00	52	73.24	29	54.72

marks of utilisation from medium and small browsers were less noticeable after 12 months, especially in the case of small browsers where the number of woody species showing signs of canopy removal disappeared altogether or was greatly reduced. In the Short Sand Forest for example, the number of species utilised by small browsers was reduced from 41.67% to 3.33% (Table 2).

The overall utilisation also showed that elephants used the greatest number of woody species in the Sand Forest association and that small browsers are the greatest users in the *Afzelia quanzensis* clumps. However, in the Sand Forest association, marks from natural damage appeared to affect more woody species than any of the other agents respectively (Table 2).

No recent canopy removal was recorded as being from human activities, and only old signs of activity were observed (see Table 2). The human utilisation in Tembe Elephant Park was ancient and no longer clearly visible. Human activity was only observed along the boundaries of Tembe Elephant Park, and sites within the park were free from human influence.

From an examination of the percentage of height classes utilised by the agent, in the Sand Forest association, elephants utilised from 4.17% to 24.27% of the available height classes in terms of canopy removal, in the past 12 months (Table 3). There were hardly any signs of recent or old height class canopy removal by the large browsers group. The medium browsers utilised from 11.11% to 25.91% of height classes available to them during the 12 months prior to the study. The small browsers used the greatest part of the canopy available to them in the Sand Forest, with up to 60.47% of the height classes available to them showing signs of utilisation (Table 3). Recent canopy removal by way of natural damage was relatively low but up to 12.05% of the sampled height classes were affected (Table 3).

In terms of old canopy removal, marks from small and medium browsers disappeared with time as their share of utilisation was halved or fell below 1.0% of the available height classes (Table 3). However, the signs of elephant use appeared to persist for much longer and even to accumulate over time, as evidenced by the way the number of height classes utilised by elephant was higher for the old period throughout the Sand Forest association, as high as 38.96% of the available height classes for the Short Sand Forest. Canopy removal has reached high levels, and up to 9.65% of height classes in the Tall Sand Forest showed signs that utilisation had removed at least 50% of the height class canopy volume, while a further 2.63% of height classes were documented having suffered complete canopy removal (Table 3).

Table 3: The number and percentage of height classes (HC) utilised by the various agents in the Sand Forest association of Tembe Elephant Park, Maputaland, northern KwaZulu-Natal, South Africa. The number of height classes utilised is represented in three ways, a total number of height classes utilised within the range utilised by the agent, the number of height classes in that range where utilisation of at least 50% of the height class was observed for at least one species, and the number of height classes where 100% of individuals in one height class were utilised for at least one species. Values are given for canopy removal utilisation events (CV) for the two periods evaluated (Recent: within 12 months prior to the study and Old: > 12 months prior to the study) and for the overall utilisation (O U), including all utilisation events, but time was undetermined

Agent	Range of height classes used	Age	Type	Vegetation units																							
				Afzelia quanzensis clumps (VT 01.1.1)						Short Sand Forest (VT 01.2.1)						Intermediate Sand Forest (VT 01.2.2)						Tall Sand Forest (VT 01.2.3)					
				NHCS*	Total HC utilisation		HC use where > 50 % of HC used		HC use where 100% of HC used		NHCS*	Total HC utilisation		HC use where > 50 % of HC used		HC use where 100% of HC used		NHCS*	Total HC utilisation		HC use where > 50 % of HC used		HC use where 100% of HC used		NHCS*	Total HC utilisation		HC use where > 50 % of HC used		HC use where 100% of HC used	
					(No)	(%)	(No)	(%)	(No)	(%)		(No)	(%)	(No)	(%)	(No)	(%)		(No)	(%)	(No)	(%)	(No)	(%)		(No)	(%)	(No)	(%)	(No)	(%)
Elephant	**02 - 07**	Recent	CV	48	2	4.17	0	0.00	0	0.00	154	19	12.34	0	0.00	0	0.00	206	50	24.27	0	0.00	0	0.00	114	23	20.18	0	0.00	0	0.00
		Old	CV	48	5	10.42	0	0.00	0	0.00	154	60	38.96	6	3.90	1	0.65	206	77	37.38	8	3.88	0	0.00	114	35	30.70	11	9.65	3	2.63
		All ages	O U	48	7	14.58	7	14.58	4	8.33	154	67	43.51	42	27.27	20	12.99	206	86	41.75	29	14.08	9	4.37	114	47	41.23	36	31.58	23	20.18
Large Browsers	**03 - 06**	Recent	CV	36	0	0.00	0	0.00	0	0.00	125	0	0.00	0	0.00	0	0.00	164	0	0.00	0	0.00	0	0.00	90	0	0.00	0	0.00	0	0.00
		Old	CV	36	0	0.00	0	0.00	0	0.00	125	1	0.80	0	0.00	0	0.00	164	0	0.00	0	0.00	0	0.00	90	1	1.11	0	0.00	0	0.00
		All ages	O U	36	0	0.00	0	0.00	0	0.00	125	1	0.80	0	0.00	0	0.00	164	0	0.00	0	0.00	0	0.00	90	1	1.11	0	0.00	0	0.00
Medium Browsers	**02 - 06**	Recent	CV	45	5	11.11	1	2.22	0	0.00	146	32	21.92	1	0.68	0	0.00	193	50	25.91	2	1.04	0	0.00	109	26	23.85	2	1.83	0	0.00
		Old	CV	45	3	6.67	1	2.22	0	0.00	146	12	8.22	1	0.68	0	0.00	193	28	14.51	2	1.04	0	0.00	109	8	7.34	2	1.83	0	0.00
		All ages	O U	45	5	11.11	4	8.89	2	4.44	146	35	23.97	12	8.22	10	6.85	193	64	33.16	17	8.81	11	5.70	109	40	36.70	21	19.27	11	10.09
Small Browsers	**01 - 05**	Recent	CV	43	26	60.47	0	0.00	0	0.00	130	43	33.08	1	0.77	0	0.00	173	68	39.31	1	0.58	0	0.00	96	30	31.25	0	0.00	0	0.00
		Old	CV	43	1	2.33	0	0.00	0	0.00	130	0	0.00	0	0.00	0	0.00	173	4	2.31	0	0.00	0	0.00	96	0	0.00	0	0.00	0	0.00
		All ages	O U	43	27	62.79	26	60.47	21	48.84	130	43	33.08	21	16.15	10	7.69	173	72	41.62	32	18.50	11	6.36	96	32	33.33	23	23.96	12	12.50
Man	**02 - 07**	Recent	CV	48	0	0.00	0	0.00	0	0.00	154	0	0.00	0	0.00	0	0.00	206	0	0.00	0	0.00	0	0.00	114	0	0.00	0	0.00	0	0.00
		Old	CV	48	0	0.00	0	0.00	0	0.00	154	1	0.65	1	0.65	1	0.65	206	7	3.40	1	0.49	1	0.49	114	0	0.00	0	0.00	0	0.00
		All ages	O U	48	0	0.00	0	0.00	0	0.00	154	2	1.30	0	0.00	0	0.00	206	8	3.88	1	0.49	0	0.00	114	0	0.00	0	0.00	0	0.00
Natural Damage	**01 - 08**	Recent	CV	49	0	0.00	0	0.00	0	0.00	163	15	9.20	1	0.61	1	0.61	224	27	12.05	0	0.00	0	0.00	121	5	4.13	0	0.00	0	0.00
		Old	CV	49	14	28.57	1	2.04	1	2.04	163	90	55.21	2	1.23	1	0.61	224	123	54.91	3	1.34	1	0.45	121	46	38.02	0	0.00	0	0.00
		All ages	O U	49	14	28.57	13	26.53	9	18.37	163	96	58.90	78	47.85	45	27.61	224	128	57.14	90	40.18	44	19.64	121	49	40.50	33	27.27	21	17.36

NHCS* = Number of height classes sampled in the range used by the agent
HC = Height Classes
No = Number

Old signs of human utilisation show that some canopy removal took place in the past. The impression is given that human utilisation implied the complete removal of available height classes (Table 3) as evidenced by the complete removal of height classes in the Short and Intermediate Sand Forest. Signs of canopy removal from natural damage showed that like elephants, natural damage marks appeared to accumulate over time, and up to 55.21% of the available height classes were scarred in the Short Sand Forest. Natural damage had the highest percentage of complete canopy removal within height classes in most of the Sand Forest association (Table 3).

In terms of the overall utilisation, the values mirrored that of the old canopy removal, although the percentage of height classes used was usually higher for all agents. This was especially valid with regards to percentages of height classes where utilisation was documented to affect 50% to 100% individuals in height classes. Elephants completely utilised up to 20.18% (Table 3, Tall Sand Forest) of the height classes available to them. In general, the values for natural damage were even higher, indicating that many entire trees must have been damaged by this mechanism (Table 3).

Woodland vegetation group

With regards to the woodland communities, the number of woody species utilised recently was once again greatest for small and medium browsers followed by elephant (Table 4). The small browsers used more species in the Closed Woodland Thicket and Sparse Woodland on Sand than any other agent, and used at least 50% of woody species available in all woodland units. Natural damage affected less woody species than other agent related utilisation in most instances, except for man and large browsers.

With regards to old canopy removal, the number of woody species used by elephants was greater than recent removals and remained visible (Table 4), while the signs of utilisation by medium and small browsers were less or disappearing. Signs of natural damage to woody species were abundant and more than 50% of woody species showed signs of old natural damage in the Closed Woodland on Sand.

The overall utilisation of woody species showed that elephants used mainly the Closed Woodland on Clay and on Sand and Open Woodland on Sand (more than 50% of available woody species, Table 4). A similar picture emerged for the medium browsers, while the overall woody species utilisation by small browsers was consistently higher than 50% of sampled woody species in all woodland units. Natural

Table 4: The number of species utilised by various agents in the Woodland association of Tembe Elephant Park, Maputaland, northern KwaZulu-Natal, South Africa. Values are given for canopy removal (number of species where a percentage of canopy volume (CV) was removed) for the two periods evaluated (Recent: within 12 months prior to the study and Old: > 12 months prior to the study) and for the overall utilisation (O U), including all utilisation events, but time was undetermined

Vegetation Unit →			**Closed Woodland Thicket (VT 02.1.0)**		**Closed Woodland on Clay (VT 02.2.0)**		**Closed Woodland on Sand (VT 02.3.0)**		**Open Woodland on Sand (VT 03.1.0)**		**Sparse Woodland on Sand (VT 04.1.0)**	
No of Species sampled →			29		116		115		92		40	
No of Species used by	Age	Type	Number	(%)	Number	(%)	Number	(%)	Number	(%)	Number	(%)
Elephant	Recent	CV	5	17.24	54	46.55	40	34.78	30	32.61	4	10.00
	Old	CV	10	34.48	62	53.45	62	53.91	42	45.65	11	27.50
	All ages	O U	12	41.38	69	59.48	66	57.39	47	51.09	10	25.00
Large Browsers	Recent	CV	0	0.00	1	0.86	5	4.35	11	11.96	0	0.00
	Old	CV	0	0.00	1	0.86	0	0.00	4	4.35	0	0.00
	All ages	O U	0	0.00	3	2.59	5	4.35	14	15.22	1	2.50
Medium Browsers	Recent	CV	8	27.59	66	56.90	60	52.17	43	46.74	11	27.50
	Old	CV	5	17.24	35	30.17	37	32.17	23	25.00	4	10.00
	All ages	O U	8	27.59	89	76.72	78	67.83	60	65.22	15	37.50
Small Browsers	Recent	CV	16	55.17	79	68.10	76	66.09	72	78.26	21	52.50
	Old	CV	1	3.45	2	1.72	4	3.48	2	2.17	2	5.00
	All ages	O U	16	55.17	82	70.69	80	69.57	73	79.35	22	55.00
Man	Recent	CV	1	3.45	1	0.86	3	2.61	0	0.00	0	0.00
	Old	CV	0	0.00	0	0.00	1	0.87	0	0.00	1	2.50
	All ages	O U	1	3.45	2	1.72	4	3.48	0	0.00	1	2.50
Natural Damage	Recent	CV	1	3.45	28	24.14	20	17.39	38	41.30	7	17.50
	Old	CV	8	27.59	56	48.28	63	54.78	43	46.74	14	35.00
	All ages	O U	8	27.59	59	50.86	67	58.26	52	56.52	16	40.00

damage affected more than 50% of woody species available in the same vegetation units that the elephants and small to medium browsers used.

There were recent signs of human utilisation of woodland vegetation types, as evidenced by a number of species for which canopy removal was documented in the Closed Woodlands. No human utilisation was observed in the Open or Sparse Woodland on Sand.

In terms of recent canopy removal, small browsers appeared to utilise the greatest number of height classes (Table 5). Values for the medium browsers were slightly lower, and those for elephant utilisation even less. Utilisation by large browsers was seldom encountered. Man utilised the canopy in some height classes in the three closed woodlands, but hardly contributed to the total of utilisation. A noticeable number of height classes had their canopies reduced through natural damage, especially in the Open Woodland on Sand, where 31.14% of available height classes were affected. A number of height classes had their canopies fully removed in the Closed Woodland on Sand and Clay, the Open Woodland on Sand and the Sparse Woodland on Sand (Table 5).

Old canopy removal events followed similar trends as for the Sand Forest, whereby signs of utilisation by medium and small browsers tended to disappear (Table 5), whereas signs of utilisation from elephants and natural damage were emphasised. The canopies from 0.58% to 4.00% of height classes in the Closed Woodlands and the Open Woodland on Sand were completely removed by elephant. Natural damage canopy removal affected approximately a third of height classes throughout the Woodlands. Signs of old canopy removal by large browsers and man were low.

The overall utilisation of height classes values were generally higher than those for canopy removal and the percentage of height classes where all individual were used was noticeably higher especially by elephants (20.00%) in Closed Woodland Thicket, and by natural damage (19.48%) in Sparse Woodland on Sand (Table 5). Small browsers completely utilised height classes in more than 10.00% of the available total throughout the woodland group (Table 5). Utilisation by man and large browsers was low in general (Table 5).

Woody species selection by agent

A summary of the 10 (whenever possible) most utilised woody species by vegetation unit was presented for the different agents in Tables 6 (elephant), 7 (large browsers), 8 (medium browsers), 9 (small browsers), 10 (man) and 11 (natural damage).

Table 5: The number and percentage of height classes (HC) utilised by the various agents in the Woodland association of Tembe Elephant Park, Maputaland, northern KwaZulu-Natal, South Africa. The number of height classes utilised is represented in three ways, a total number of height classes utilised within the range utilised by the agent, the number of height classes in that range where utilisation of at least 50% of the height class was observed for at least one species, and the number of height classes where 100% of individuals in one height class were utilised for at least one species. Values are given for canopy removal utilisation events (CV) for the two periods evaluated (Recent: within 12 months prior to the study and Old: > 12 months prior to the study) and for the overall utilisation (O U), including all utilisation events, but time was undetermined

Agent	Range of height classes used	Age	Type	Vegetation units																					
				Closed Woodland Thicket (VT 02.1.0)						Closed Woodland on Clay (VT 02.2.0)						Closed Woodland on Sand (VT 02.3.0)						Open Woodland on Sand (VT 03.1.0)						Sparse Woodland on Sand (VT 04.1.0)					
				NHCS*	Total HC utilisation		HC use where > 50 % of HC used		HC use where 100% of HC used		NHCS*	Total HC utilisation		HC use where > 50 % of HC used		HC use where 100% of HC used		NHCS*	Total HC utilisation		HC use where > 50 % of HC used		HC use where 100% of HC used		NHCS*	Total HC utilisation		HC use where > 50 % of HC used		HC use where 100% of HC used	
					(No)	(%)	(No)	(%)	(No)	(%)		(No)	(%)	(No)	(%)	(No)	(%)		(No)	(%)	(No)	(%)	(No)	(%)		(No)	(%)	(No)	(%)	(No)	(%)
Elephant	**02 - 07**	Recent	CV	50	9	18.00	0	0.00	0	0.00	342	90	26.32	3	0.88	1	0.29	332	70	21.08	2	0.60	0	0.00	254	52	20.47	0	0.00	0	0.00	74	5	6.76	0	0.00	0	0.00
		Old	CV	50	17	34.00	3	6.00	2	4.00	342	130	38.01	8	2.34	2	0.58	332	110	33.13	18	5.42	3	0.90	254	96	37.80	8	3.15	1	0.39	74	16	21.62	2	2.70	0	0.00
		All ages	O U	50	21	42.00	15	30.00	10	20.00	342	151	44.15	92	26.90	49	14.33	332	128	38.55	78	23.49	34	10.24	254	107	42.13	65	25.59	36	14.17	74	17	22.97	8	10.81	6	8.11
Large Browsers	**03 - 06**	Recent	CV	41	0	0.00	0	0.00	0	0.00	261	1	0.38	0	0.00	0	0.00	262	5	1.91	0	0.00	0	0.00	188	12	6.38	0	0.00	0	0.00	48	1	2.08	0	0.00	0	0.00
		Old	CV	41	0	0.00	0	0.00	0	0.00	261	1	0.38	0	0.00	0	0.00	262	0	0.00	0	0.00	0	0.00	188	4	2.13	0	0.00	0	0.00	48	0	0.00	0	0.00	0	0.00
		All ages	O U	41	0	0.00	0	0.00	0	0.00	261	3	1.15	0	0.00	0	0.00	262	5	1.91	2	0.76	1	0.38	188	15	7.98	1	0.53	0	0.00	48	1	2.08	0	0.00	0	0.00
Medium Browsers	**02 - 06**	Recent	CV	50	16	32.00	0	0.00	0	0.00	333	131	39.34	5	1.50	0	0.00	317	115	36.28	2	0.63	0	0.00	246	91	36.99	0	0.00	0	0.00	72	18	25.00	4	5.56	2	2.78
		Old	CV	50	11	22.00	0	0.00	0	0.00	333	55	16.52	5	1.50	0	0.00	317	56	17.67	2	0.63	0	0.00	246	40	16.26	0	0.00	0	0.00	72	4	5.56	1	1.39	0	0.00
		All ages	O U	50	14	28.00	9	18.00	6	12.00	333	189	56.76	105	31.53	51	15.32	317	145	45.74	60	18.93	34	10.73	246	122	49.59	44	17.89	21	8.54	72	20	27.78	8	11.11	7	9.72
Small Browsers	**01 - 05**	Recent	CV	43	24	55.81	0	0.00	0	0.00	321	150	46.73	0	0.00	0	0.00	317	145	45.74	1	0.32	0	0.00	243	145	59.67	3	1.23	0	0.00	73	34	46.58	0	0.00	0	0.00
		Old	CV	43	1	2.33	0	0.00	0	0.00	321	2	0.62	0	0.00	0	0.00	317	4	1.26	1	0.32	0	0.00	243	14	5.76	0	0.00	0	0.00	73	5	6.85	0	0.00	0	0.00
		All ages	O U	43	26	60.47	18	41.86	15	34.88	321	156	48.60	74	23.05	37	11.53	317	153	48.26	78	24.61	45	14.20	243	148	60.91	71	29.22	30	12.35	73	34	46.58	26	35.62	11	15.07
Man	**02 - 07**	Recent	CV	50	1	2.00	0	0.00	0	0.00	342	1	0.29	0	0.00	0	0.00	332	3	0.90	0	0.00	0	0.00	254	0	0.00	0	0.00	0	0.00	74	0	0.00	0	0.00	0	0.00
		Old	CV	50	0	0.00	0	0.00	0	0.00	342	0	0.00	0	0.00	0	0.00	332	1	0.30	0	0.00	0	0.00	254	0	0.00	0	0.00	0	0.00	74	1	1.35	0	0.00	0	0.00
		All ages	O U	50	1	2.00	0	0.00	0	0.00	342	2	0.58	1	0.29	1	0.29	332	4	1.20	0	0.00	0	0.00	254	0	0.00	0	0.00	0	0.00	74	1	1.35	0	0.00	0	0.00
Natural Damage	**01 - 08**	Recent	CV	51	2	3.92	0	0.00	0	0.00	364	48	13.19	6	1.65	5	1.37	373	36	9.65	8	2.14	7	1.88	273	85	31.14	6	2.20	3	1.10	77	12	15.58	8	10.39	1	1.30
		Old	CV	51	16	31.37	0	0.00	0	0.00	364	107	29.40	8	2.20	5	1.37	373	132	35.39	12	3.22	7	1.88	273	109	39.93	10	3.66	4	1.47	77	23	29.87	4	5.19	0	0.00
		All ages	O U	51	17	33.33	9	17.65	6	11.76	364	119	32.69	50	13.74	25	6.87	373	134	35.92	74	19.84	49	13.14	273	132	48.35	63	23.08	23	8.42	77	32	41.56	22	28.57	15	19.48

NHCS* = Number of height classes sampled in the range used by the agent

HC = Height Classes

No = Number

Table 6: The 10 woody species most utilised by elephants in Tembe Elephant Park, by vegetation unit and age of damage (for canopy volume removal only). Values given reflect the number of height classes (HC) where utilisation was reported (HC 01), as well as the number of height classes where utilisation was > 50% (HC 02) and 100% (HC 03) of canopy removed or number of individuals utilised within a height class, and the highest height class where damage was observed (HC 04). Species highlighted in red represent situations where at least one height class was completely utilised. Maputaland, northern KwaZulu-Natal, South Africa

Number	Vegetation unit	Taxa	Canopy Volume removal < 12 months				Taxa	Canopy Volume removal > 12 months				Taxa	Overall Utilisation			
			HC 01*	HC 02*	HC 03*	HC 04*		HC 01*	HC 02*	HC 03*	HC 04*		HC 01*	HC 02*	HC 03*	HC 04*
1	VT 01.1.1	*Ochna barbosae*	1	0	0	05	*Afzelia quanzensis*	1	0	0	07	*Boscia filipes*	1	1	1	04
2	VT 01.1.1	*Tabernaemontana elegans*	1	0	0	05	*Boscia filipes*	1	0	0	04	*Manilkara concolor*	1	1	1	05
3	VT 01.1.1	-	-	-	-	-	*Manilkara concolor*	1	0	0	05	*Ochna barbosae*	1	1	1	05
4	VT 01.1.1	-	-	-	-	-	*Sclerocroton integerrimus*	1	0	0	05	*Sclerocroton integerrimus*	1	1	1	05
5	VT 01.1.1	-	-	-	-	-	*Vepris lanceolata*	1	0	0	04	*Afzelia quanzensis*	1	1	0	07
6	VT 01.1.1	-	-	-	-	-	-	-	-	-	-	*Tabernaemontana elegans*	1	1	0	05
7	VT 01.1.1	-	-	-	-	-	-	-	-	-	-	*Vepris lanceolata*	1	1	0	04
1	VT 01.2.1	*Brachylaena huillensis*	2	0	0	04	*Pteleopsis myrtifolia*	3	1	0	07	*Brachylaena huillensis*	4	1	0	06
2	VT 01.2.1	*Strychnos henningsii*	2	0	0	05	*Salacia leptoclada*	3	1	0	06	*Pteleopsis myrtifolia*	3	3	0	07
3	VT 01.2.1	*Cassipourea mossambicensis*	1	0	0	05	*Brachylaena huillensis*	3	0	0	06	*Psydrax obovata*	3	1	1	06
4	VT 01.2.1	*Cola greenwayi*		0	0	05	*Cola greenwayi*	3	0	0	06	*Salacia leptoclada*	3	1	1	06
5	VT 01.2.1	*Croton pseudopulchellus*		0	0	03	*Hymenocardia ulmoides*	3	0	0	06	*Cola greenwayi*	3	1	0	06
6	VT 01.2.1	*Hymenocardia ulmoides*		0	0	04	*Psydrax obovata*	3	0	0	06	*Hymenocardia ulmoides*	3	1	0	06
7	VT 01.2.1	*Lagynias lasiantha*		0	0	05	*Brachylaena discolor*	2	1	1	06	*Cleistanthus schlechteri*	2	2	1	07
8	VT 01.2.1	*Leptactina delagoensis*		0	0	04	*Cleistanthus schlechteri*	2	0	0	07	*Lagynias lasiantha*	2	2	1	05
9	VT 01.2.1	*Manilkara discolor*	1	0	0	05	*Dialium schlechteri*	2	0	0	06	*Strychnos henningsii*	2	2	1	05
10	VT 01.2.1	*Pavetta lanceolata*	1	0	0	04	*Drypetes arguta*	2	0	0	06	*Vitex ferruginea*	2	2	1	06
1	VT 01.2.2	*Cola greenwayi*	4	0	0	06	*Cola greenwayi*	5	0	0	06	*Cola greenwayi*	5	0	0	06
2	VT 01.2.2	*Drypetes arguta*	4	0	0	06	*Brachylaena huillensis*	4	1	0	06	*Haplocoelum foliolosum*	4	3	1	06
3	VT 01.2.2	*Dialium schlechteri*	3	0	0	07	*Hymenocardia ulmoides*	4	0	0	06	*Brachylaena huillensis*	4	0	0	06
4	VT 01.2.2	*Haplocoelum foliolosum*	3	0	0	05	*Grewia microthyrsa*	3	1	0	05	*Drypetes arguta*	4	0	0	06
5	VT 01.2.2	*Hymenocardia ulmoides*	3	0	0	06	*Psydrax obovata*	3	1	0	06	*Hymenocardia ulmoides*	4	0	0	06
6	VT 01.2.2	*Balanites maughamii*	2	0	0	05	*Ptaeroxylon obliquum*	3	1	0	06	*Erythrophleum lasianthum*	3	3	2	06
7	VT 01.2.2	*Boscia filipes*	2	0	0	05	*Cleistanthus schlechteri*	3	0	0	07	*Ptaeroxylon obliquum*	3	3	1	06
8	VT 01.2.2	*Brachylaena huillensis*	2	0	0	05	*Croton pseudopulchellus*	3	0	0	04	*Grewia microthyrsa*	3	3	0	05
9	VT 01.2.2	*Burchellia bubalina*	2	0	0	05	*Dialium schlechteri*	3	0	0	07	*Strychnos decussata*	3	2	1	06
10	VT 01.2.2	*Cassipourea mossambicensis*	2	0	0	06	*Drypetes arguta*	3	0	0	05	*Strychnos henningsii*	3	2	1	06

Table 6 continued

1	VT 01.2.3	*Cola greenwayi*	3	0	0	05	*Cola greenwayi*	4	0	0	06	*Cola greenwayi*	4	2	0	06
2	VT 01.2.3	*Drypetes arguta*	2	0	0	05	*Balanites maughamii*	2	1	1	07	*Ptaeroxylon obliquum*	3	3	0	06
3	VT 01.2.3	*Ptaeroxylon obliquum*	2	0	0	05	*Cleistanthus schlechteri*	2	1	1	06	*Balanites maughamii*	2	2	2	07
4	VT 01.2.3	*Strychnos gerrardii*	2	0	0	06	*Ptaeroxylon obliquum*	2	1	0	06	*Pteleopsis myrtifolia*	2	2	2	06
5	VT 01.2.3	*Vepris lanceolata*	2	0	0	05	*Pteleopsis myrtifolia*	2	1	0	06	*Strychnos gerrardii*	2	2	2	06
6	VT 01.2.3	*Acalypha glabrata*	1	0	0	04	*Acalypha glabrata*	2	0	0	05	*Cleistanthus schlechteri*	2	2	1	06
7	VT 01.2.3	*Cladostemon kirkii*	1	0	0	05	*Drypetes arguta*	2	0	0	05	*Psydrax obovata*	2	2	1	06
8	VT 01.2.3	*Erythroxylum emarginatum*	1	0	0	04	*Psydrax obovata*	2	0	0	06	*Strychnos decussata*	2	2	1	06
9	VT 01.2.3	*Hymenocardia ulmoides*	1	0	0	03	*Strychnos decussata*	2	0	0	06	*Strychnos henningsii*	2	1	1	05
10	VT 01.2.3	*Lagynias lasiantha*	1	0	0	05	*Strychnos henningsii*	2	0	0	05	*Drypetes arguta*	2	1	0	05
1	VT 02.1.0	*Euclea natalensis*	5	0	0	07	*Euclea natalensis*	4	0	0	07	*Euclea natalensis*	5	3	0	07
2	VT 02.1.0	*Afzelia quanzensis*	1	0	0	06	*Tabernaemontana elegans*	4	0	0	06	*Tabernaemontana elegans*	4	1	1	06
3	VT 02.1.0	*Grewia microthyrsa*	1	0	0	04	*Terminalia sericea*	2	1	1	06	*Sclerocroton integerrimus*	2	2	2	06
4	VT 02.1.0	*Rothmannia fischeri*	1	0	0	06	*Albizia adianthifolia*	1	1	1	06	*Terminalia sericea*	2	2	1	06
5	VT 02.1.0	*Sclerocroton integerrimus*	1	0	0	05	*Rhus gueinzii*	1	1	0	05	*Afzelia quanzensis*	1	1	1	06
6	VT 02.1.0	-	-	-	-	-	*Afzelia quanzensis*	1	0	0	06	*Albizia adianthifolia*	1	1	1	06
7	VT 02.1.0	-	-	-	-	-	*Combretum molle*	1	0	0	06	*Grewia microthyrsa*	1	1	1	04
8	VT 02.1.0	-	-	-	-	-	*Psydrax locuples*	1	0	0	04	*Rhus gueinzii*	1	1	1	05
9	VT 02.1.0	-	-	-	-	-	*Sclerocroton integerrimus*	1	0	0	06	*Rothmania fischeri*	1	1	1	06
10	VT 02.1.0	-	-	-	-	-	*Sclerocarya birrea*	1	0	0	04	*Sclerocarya birrea*	1	1	1	04
1	VT 02.2.0	*Afzelia q ensis*	4	1	0	07	*Spirostachys africana*	5	0	0	07	*Sclerocarya birrea*	5	5	4	07
2	VT 02.2.0	*Acacia bu*	4	0	0	07	*Strychnos spinosa*	5	0	0	06	*Terminalia sericea*	5	3	2	07
3	VT 02.2.0	*Sclerocarya birrea*	3	1	1	07	*Terminalia sericea*	5	0	0	07	*Strychnos spinosa*	5	3	1	06
4	VT 02.2.0	*Dialium schlechteri*	3	0	0	06	*Schotia brachypetala*	4	1	0	07	*Tabernaemontana elegans*	5	3	1	06
5	VT 02.2.0	*Psydrax locuples*	3	0	0	05	*Acacia burkei*	4	0	0	07	*Acacia burkei*	5	2	0	07
6	VT 02.2.0	*Pteleopsis myrtifolia*	3	0	0	06	*Afzelia quanzensis*	4	0	0	07	*Spirostachys africana*	5	0	0	07
7	VT 02.2.0	*Tabernaemontana elegans*	3	0	0	04	*Euclea natalensis*	4	0	0	07	*Afzelia quanzensis*	4	4	3	07
8	VT 02.2.0	*Terminalia sericea*	3	0	0	06	*Sclerocarya birrea*	4	0	0	07	*Schotia brachypetala*	4	3	1	07
9	VT 02.2.0	*Vepris lanceolata*	3	0	0	05	*Tabernaemontana elegans*	4	0	0	06	*Euclea natalensis*	4	0	0	07
10	VT 02.2.0	*Vernonia colorata*	3	0	0	05	*Vepris lanceolata*	4	0	0	06	*Vepris lanceolata*	4	0	0	06
1	VT 02.3.0	*Bridelia cathartica*	4	0	0	06	*Afzelia quanzensis*	4	1	0	07	*Dialium schlechteri*	5	1	0	07
2	VT 02.3.0	*Tabernaemontana elegans*	4	0	0	06	*Tabernaemontana elegans*	4	1	0	06	*Sideroxylon inerme*	4	3	1	07
3	VT 02.3.0	*Erythroxylum delagoense*	3	0	0	05	*Bridelia cathartica*	4	0	0	06	*Strychnos spinosa*	4	3	1	06
4	VT 02.3.0	*Strychnos decussata*	3	0	0	06	*Commiphora neglecta*	4	0	0	06	*Afzelia quanzensis*	4	3	0	07
5	VT 02.3.0	*Strychnos madagascariensis*	3	0	0	06	*Dialium schlechteri*	4	0	0	07	*Bridelia cathartica*	4	3	0	06
6	VT 02.3.0	*Acacia burkei*	3	0	0	07	*Vepris lanceolata*	4	0	0	06	*Dichrostachys cinerea*	4	3	0	05
7	VT 02.3.0	*Afzelia quanzensis*	3	0	0	07	*Acacia burkei*	3	0	0	07	*Tabernaemontana elegans*	4	3	0	06
8	VT 02.3.0	*Sideroxylon inerme*	3	0	0	07	*Combretum molle*	3	0	0	06	*Commiphora neglecta*	4	1	0	06

Table 6 continued

9	VT 02.3.0	*Margaritaria discoidea*	2	0	0	04	*Canthium anatum*	3	0	0	05	*Vepris lanceolata*	4	0	0	06
10	VT 02.3.0	*Ximenia caffra*	2	0	0	04	*Psydrax locples*	3	0	0	06	*Strychnos madagascariensis*	3	3	0	06
1	VT 03.1.0	*Terminalia sericea*	4	0	0	06	*Albizia versicolor*	5	2	0	07	*Albizia versicolor*	5	4	3	07
2	VT 03.1.0	*Acacia burkei*	3	0	0	07	*Acacia burkei*	5	0	0	07	*Strychnos madagascariensis*	5	3	1	06
3	VT 03.1.0	*Combretum molle*	3	0	0	06	*Strychnos radagascariensis*	5	0	0	06	*Acacia burkei*	5	2	0	07
4	VT 03.1.0	*Strychnos madagascariensis*	3	0	0	05	*Terminalia sricea*	5	0	0	07	*Terminalia sericea*	5	2	0	07
5	VT 03.1.0	*Acacia robusta*	2	0	0	06	*Vangueria ifausta*	4	1	1	06	*Vangueria infausta*	4	3	1	06
6	VT 03.1.0	*Albizia versicolor*	2	0	0	05	*Combreturmolle*	4	0	0	06	*Sclerocarya birrea*	4	3	0	07
7	VT 03.1.0	*Antidesma venosum*	2	0	0	06	*Dichrostachs cinerea*	4	0	0	05	*Sclerocroton integerrimus*	4	2	1	06
8	VT 03.1.0	*Commiphora neglecta*	2	0	0	04	*Sclerocroto integerrimus*	4	0	0	06	*Combretum molle*	4	2	0	06
9	VT 03.1.0	*Dichrostachys cinerea*	2	0	0	03	*Sclerocaryabirrea*	4	0	0	07	*Dichrostachys cinerea*	4	1	0	05
10	VT 03.1.0	*Garcinia livingstonei*	2	0	0	05	*Antidesma venosum*	3	1	0	06	*Acacia robusta*	3	3	2	07
1	VT 04.1.0	*Terminalia sericea*	2	0	0	05	*Strychnos radagascariensis*	4	0	0	05	*Strychnos madagascariensis*	4	1	0	05
2	VT 04.1.0	*Acacia burkei*	1	0	0	04	*Strychnos sinosa*	2	1	0	04	*Terminalia sericea*	3	1	0	05
3	VT 04.1.0	*Dichrostachys cinerea*	1	0	0	03	*Terminalia sricea*	2	0	0	05	*Acacia burkei*	2	1	1	05
4	VT 04.1.0	*Strychnos spinosa*	1	0	0	00	*Vangueria ifausta*	1	1	0	04	*Strychnos spinosa*	2	1	1	04
5	VT 04.1.0	-	-	-	-	-	*Acacia burkei*	1	0	0	05	*Albizia adianthifolia*	1	1	1	07
6	VT 04.1.0	-	-	-	-	-	*Albizia adiathifolia*	1	0	0	07	*Dialium schlechteri*	1	1	1	06
7	VT 04.1.0	-	-	-	-	-	*Dialium schechteri*	1	0	0	06	*Syzigium cordatum*	1	1	1	06
8	VT 04.1.0	-	-	-	-	-	*Dichrostachs cinerea*	1	0	0	03	*Vangueria infausta*	1	1	1	04
9	VT 04.1.0	-	-	-	-	-	*Euclea natænsis*	1	0	0	07	*Dichrostachys cinerea*	1	0	0	03
10	VT 04.1.0	-	-	-	-	-	*Syzigium ccdatum*	1	0	0	06	*Ximenia caffra*	1	0	0	03

VT 01.1.1 = *Afzelia quanzensis* clumps
VT 01.2.1 = Short Sand Forest
VT 01.2.2 = Intermediate Sand Forest
VT 01.2.3 = Tall Sand Forest
VT 02.1.0 = Closed Woodland Thicket
VT 02.2.0 = Closed Woodland on Clay
VT 02.3.0 = Closed Woodland on Sand
VT 03.1.0 = Open Woodland on Sand
VT 04.1.0 = Sparse Woodland on Sand

Table 7: The 10 woody species most utilised by large browsers in Tembe Elephant Park, by vegetation unit and age of damage (for canopy volume removal only). Values given reflect the number of height classes (HC) where utilisation was reported (HC 01), as well as the number of height classes where utilisation was > 50% (HC 02) and 100% (HC 03) of canopy removed or number of individuals utilised within a height class, and the highest height class where damage was observed (HC 04). Species highlighted in red represent situations where at least one height class was completely utilised. Maputaland, northern KwaZulu-Natal, South Africa

Number	Vegetation unit	Taxa	Canopy Volume removal < 12 months				Taxa	Canopy Volume removal > 12 months				Taxa	Overall Utilisation			
			HC 01*	HC 02*	HC 03*	HC 04*		HC 01*	HC 02*	HC 03*	HC 04*		HC 01*	HC 02*	HC 03*	HC 04*
	VT 01.2.1	-	-	-	-	-	*Cola greenwayi*	1	0	0	05	*Cola greenwayi*	1	0	0	05
	VT 01.2.3	-	-	-	-	-	*Afzelia quanzensis*	1	0	0	06	*Afzelia quanzensis*	1	1	1	06
1	VT 02.2.0	*Strychnos madagascariensis*	1	0	0	05	*Spirostachys africana*	1	0	0	04	*Combretum molle*	1	0	0	05
	VT 02.2.0	-	-	-	-	-	-	-	-	-	-	*Spirostachys africana*	1	0	0	04
	VT 02.2.0	-	-	-	-	-	-	-	-	-	-	*Strychnos madagascariensis*	1	0	0	05
1	VT 02.3.0	*Ancylanthos monteiroi*	1	0	0	04	-	-	-	-	-	*Ancylanthos monteiroi*	1	1	1	04
2	VT 02.3.0	*Dialium schlechteri*	1	0	0	04	-	-	-	-	-	*Trichilia emetica*	1	1	0	06
3	VT 02.3.0	*Canthium armatum*	1	0	0	04	-	-	-	-	-	*Dialium schlechteri*	1	0	0	04
4	VT 02.3.0	*Trichilia emetica*	1	0	0	06	-	-	-	-	-	*Canthium armatum*	1	0	0	04
5	VT 02.3.0	*Vepris lanceolata*	1	0	0	06	-	-	-	-	-	*Vepris lanceolata*	1	0	0	06
1	VT 03.1.0	*Strychnos spinosa*	2	0	0	05	*Brachylaena discolor*	1	0	0	03	*Strychnos spinosa*	2	0	0	05
2	VT 03.1.0	*Acacia burkei*	1	0	0	04	*Combretum molle*	1	0	0	05	*Lagynias lasiantha*	1	1	0	04
3	VT 03.1.0	*Brachylaena elliptica*	1	0	0	04	*Terminalia sericea*	1	0	0	05	*Acacia burkei*	1	0	0	04
4	VT 03.1.0	*Commiphora neglecta*	1	0	0	04	*Vepris lanceolata*	1	0	0	04	*Brachylaena discolor*	1	0	0	03
5	VT 03.1.0	*Dichrostachys cinerea*	1	0	0	04	-	-	-	-	-	*Brachylaena elliptica*	1	0	0	04
6	VT 03.1.0	*Garcinia livingstonei*	1	0	0	04	-	-	-	-	-	*Combretum molle*	1	0	0	05
7	VT 03.1.0	*Hymenocardia ulmoides*	1	0	0	03	-	-	-	-	-	*Commiphora neglecta*	1	0	0	04
8	VT 03.1.0	*Lagynias lasiantha*	1	0	0	04	-	-	-	-	-	*Dichrostachys cinerea*	1	0	0	04
9	VT 03.1.0	*Strychnos madagascariensis*	1	0	0	04	-	-	-	-	-	*Garcinia livingstonei*	1	0	0	04
10	VT 03.1.0	*Terminalia sericea*	1	0	0	04	-	-	-	-	-	*Hymenocardia ulmoides*	1	0	0	03
1	VT 04.1.0	*Terminalia sericea*	1	0	0	05	-	-	-	-	-	*Terminalia sericea*	1	0	0	05

VT 01.2.1 = Short Sand Forest
VT 01.2.3 = Tall Sand Forest
VT 02.2.0 = Closed Woodland on Clay
VT 02.3.0 = Closed Woodland on Sand
VT 03.1.0 = Open Woodland on Sand
VT 04.1.0 = Sparse Woodland on Sand

Table 8: *The 10 woody species most utilised by medium browsers in Tembe Elephant Park, by vegetation unit and age of damage (for canopy volume removal only). Values given reflect the number of height classes (HC) where utilisation was reported (HC 01), as well as the number of height classes where utilisation was > 50% (HC 02) and 100% (HC 03) of canopy removed or number of individuals utilised within a height class, and the highest height class where damage was observed (HC 04). Species highlighted in red represent situations where at least one height class was completely utilised. Maputaland, northern KwaZulu-Natal, South Africa*

Number	Vegetation unit	Taxa	Canopy Volume removal < 12 months				Taxa	Canopy Volume removal > 12 months				Taxa	Overall Utilisation			
			HC 01*	HC 02*	HC 03*	HC 04*		HC 01*	HC 02*	HC 03*	HC 04*		HC 01*	HC 02*	HC 03*	HC 04*
1	VT 01.1.1	*Tabernaemontana elegans*	1	1	0	03	*Tabernaemontana elegans*	1	1	0	03	*Catunaregam spinosa*	1	1	1	04
2	VT 01.1.1	*Catunaregam spinosa*	1	0	0	04	*Catunaregam spinosa*	1	0	0	04	*Psydrax locuples*	1	1	1	04
3	VT 01.1.1	*Ochna barbosae*	1	0	0	04	*Ochna barbosae*	1	0	0	04	*Tabernaemontana elegans*	1	1	0	03
4	VT 01.1.1	*Psydrax locuples*	1	0	0	04	-	-	-	-	-	*Tricalysia lanceolata*	1	1	0	04
5	VT 01.1.1	*Tricalysia lanceolata*	1	0	0	04	-	-	-	-	-	*Ochna barbosae*	1	0	0	04
1	VT 01.2.1	*Tricalysia junodii*	3	0	0	04	*Brachylaena huillensis*	2	0	0	05	*Tricalysia junodii*	3	1	0	04
2	VT 01.2.1	*Brachylaena huillensis*	2	0	0	05	*Pteleopsis myrtifolia*	1	1	0	02	*Oxyanthus latifolius*	2	1	1	04
3	VT 01.2.1	*Oxyanthus latifolius*	2	0	0	04	*Acalypha glabrata*	1	0	0	02	*Pavetta lanceolata*	2	1	1	04
4	VT 01.2.1	*Pavetta lanceolata*	2	0	0	04	*Burchelia bubalina*	1	0	0	04	*Tricalysia lanceolata*	2	1	1	04
5	VT 01.2.1	*Salacia leptoclada*	2	0	0	04	*Cassine papillosae*	1	0	0	05	*Brachylaena huillensis*	2	0	0	05
6	VT 01.2.1	*Tricalysia lanceolata*	2	0	0	04	*Combretum molle*	1	0	0	04	*Salacia leptoclada*	2	0	0	04
7	VT 01.2.1	*Pteleopsis myrtifolia*	1	1	0	02	*Croton pseudopulchellus*	1	0	0	03	*Acalypha glabrata*	1	1	1	02
8	VT 01.2.1	*Acalypha glabrata*	1	0	0	02	*Hymenocardia ulmoides*	1	0	0	04	*Cassine papillosae*	1	1	1	05
9	VT 01.2.1	*Burchelia bubalina*	1	0	0	04	*Ochna natalitia*	1	0	0	05	*Combretum molle*	1	1	1	04
10	VT 01.2.1	*Cassine papillosae*	1	0	0	05	*Psydrax obovata*	1	0	0	05	*Drypetes natalensis*	1	1	1	03
1	VT 01.2.2	*Croton pseudopulchellus*	4	0	0	05	*Croton pseudopulchellus*	4	0	0	05	*Croton pseudopulchellus*	4	0	0	05
2	VT 01.2.2	*Drypetes arguta*	3	0	0	05	*Drypetes arguta*	3	0	0	05	*Drypetes arguta*	4	0	0	05
3	VT 01.2.2	*Hymenocardia ulmoides*	3	0	0	06	*Cola greenwayi*	2	0	0	04	*Hymenocardia ulmoides*	4	0	0	06
4	VT 01.2.2	*Cola greenwayi*	2	0	0	04	*Monodora junodii*	2	0	0	05	*Cola greenwayi*	3	0	0	05
5	VT 01.2.2	*Haplocoelum gallense*	2	0	0	05	*Salacia leptoclada*	2	0	0	04	*Drypetes natalensis*	3	0	0	05
6	VT 01.2.2	*Monodora junodii*	2	0	0	05	*Deinbolia oblongifolia*	1	1	0	03	*Brachylaena discolor*	2	2	2	04
7	VT 01.2.2	*Pavetta lanceolata*	2	0	0	05	*Strychnos decussata*	1	1	0	04	*Boscia filipes*	2	2	1	05
8	VT 01.2.2	*Salacia leptoclada*	2	0	0	04	*Balanites maughamii*	1	0	0	04	*Balanites maughamii*	2	1	1	04
9	VT 01.2.2	*Suregada zanzibariensis*	2	0	0	04	*Boscia filipes*	1	0	0	03	*Cassipourea mossambicensis*	2	1	1	06
10	VT 01.2.2	*Toddaliopsis bremekampii*	2	0	0	05	*Brachylaena discolor*	1	0	0	04	*Monodora junodii*	2	1	1	05

Table 8 continued

1	VT 01.2.3	*Toddaliopsis bremekampii*	3	0	0	05	*Psydrax locuples*	1	1	0	04	*Balanites maughamii*	3	3	2	04
2	VT 01.2.3	*Grewia microthyrsa*	2	0	0	05	*Rhus gueinzii*	1	1	0	03	*Drypetes arguta*	3	0	0	05
3	VT 01.2.3	*Ptaeroxylon obliquum*	2	0	0	06	*Cola greenwayi*	1	0	0	04	*Toddaliopsis bremekampii*	3	0	0	05
4	VT 01.2.3	*Salacia leptoclada*	2	0	0	03	*Dialium schlechteri*	1	0	0	04	*Grewia microthyrsa*	2	2	2	05
5	VT 01.2.3	*Strychnos henningsii*	2	0	0	05	*Haplocoelum gallense*	1	0	0	04	*Drypetes natalensis*	2	1	1	05
6	VT 01.2.3	*Psydrax locuples*	1	1	0	04	*Hymenocardia ulmoides*	1	0	0	03	*Strychnos henningsii*	2	1	0	05
7	VT 01.2.3	*Rhus gueinzii*	1	1	0	03	*Ochna barbosae*	1	0	0	04	*Acalypha glabrata*	2	0	0	04
8	VT 01.2.3	*Cola greenwayi*	1	0	0	04	*Tricalysia lanceolata*	1	0	0	04	*Cola greenwayi*	2	0	0	04
9	VT 01.2.3	*Dialium schlechteri*	1	0	0	04	-	-	-	-	-	*Ptaeroxylon obliquum*	2	0	0	06
10	VT 01.2.3	*Grewia caffra*	1	0	0	04	-	-	-	-	-	*Salacia leptoclada*	2	0	0	03
1	VT 02.1.0	*Euclea natalensis*	4	0	0	06	*Euclea natalensis*	4	0	0	06	*Tabernaemontana elegans*	4	3	2	06
2	VT 02.1.0	*Tabernaemontana elegans*	4	0	0	06	*Tabernaemontana elegans*	3	0	0	06	*Euclea natalensis*	3	1	0	06
3	VT 02.1.0	*Combretum molle*	2	0	0	06	*Combretum molle*	2	0	0	06	*Combretum molle*	2	2	1	06
4	VT 02.1.0	*Rhus gueinzii*	2	0	0	05	*Rhus gueinzii*	1	0	0	04	*Lagynias lasiantha*	1	1	1	04
5	VT 02.1.0	*Lagynias lasiantha*	1	0	0	04	*Terminalia sericea*	1	0	0	05	*Rhus gueinzii*	1	1	1	04
6	VT 02.1.0	*Psydrax locuples*	1	0	0	03	-	-	-	-	-	*Sclerocarya birrea*	1	1	1	04
7	VT 02.1.0	*Sclerocarya birrea*	1	0	0	04	-	-	-	-	-	*Psydrax locuples*	1	0	0	03
8	VT 02.1.0	*Terminalia sericea*	1	0	0	05	-	-	-	-	-	*Terminalia sericea*	1	0	0	05
1	VT 02.2.0	*Tabernaemontana elegans*	5	0	0	06	*Spirostachys africana*	4	0	0	06	*Tabernaemontana elegans*	5	3	0	06
2	VT 02.2.0	*Rhus gueinzii*	4	1	0	05	*Berchemia zeyheri*	3	0	0	05	*Acacia burkei*	5	0	0	06
3	VT 02.2.0	*Plectroniella armata*	4	0	0	05	*Strychnos spinosa*	3	0	0	05	*Rhus gueinzii*	4	3	3	05
4	VT 02.2.0	*Scutia myrtina*	4	0	0	06	*Terminalia sericea*	3	0	0	05	*Scutia myrtina*	4	3	2	06
5	VT 02.2.0	*Spirostachys africana*	4	0	0	06	*Vepris lanceolata*	3	0	0	05	*Ziziphus mucronata*	4	2	2	06
6	VT 02.2.0	*Strychnos madagascariensis*	4	0	0	05	*Clerodendrum glabrum*	2	2	0	04	*Diospyros inhacaensis*	4	2	1	05
7	VT 02.2.0	*Strychnos spinosa*	4	0	0	05	*Rhus gueinzii*	2	1	0	03	*Plectroniella armata*	4	2	0	05
8	VT 02.2.0	*Ziziphus mucronata*	4	0	0	06	*Acacia gerrardii*	2	0	0	04	*Berchemia zeyheri*	4	1	0	05
9	VT 02.2.0	*Berchemia zeyheri*	3	0	0	05	*Euclea natalensis*	2	0	0	05	*Dialium schlechteri*	4	1	0	05
10	VT 02.2.0	*Euclea natalensis*	3	0	0	05	*Gymnosporia senegalensis*	2	0	0	04	*Spirostachys africana*	4	1	0	06
1	VT 02.3.0	*Sideroxylon inerme*	5	0	0	06	*Sideroxylon inerme*	4	0	0	06	*Tabernaemontana elegans*	5	3	0	06
2	VT 02.3.0	*Strychnos madagascariensis*	5	0	0	06	*Vepris lanceolata*	4	0	0	06	*Sideroxylon inerme*	5	1	0	06
3	VT 02.3.0	*Tabernaemontana elegans*	5	0	0	06	*Combretum molle*	3	0	0	05	*Dialium schlechteri*	5	0	0	06
4	VT 02.3.0	*Vepris lanceolata*	5	0	0	06	*Strychnos decussata*	3	0	0	05	*Vepris lanceolata*	5	0	0	06
5	VT 02.3.0	*Plectroniella armata*	4	0	0	05	*Strychnos madagascariensis*	3	0	0	05	*Plectroniella armata*	4	0	0	05
6	VT 02.3.0	*Sapium integerrimum*	4	0	0	06	*Tabernaemontana elegans*	3	0	0	06	*Sapium integerrimum*	4	0	0	06
7	VT 02.3.0	*Combretum molle*	3	0	0	05	*Diospyros inhacaensis*	2	1	0	04	*Strychnos madagascariensis*	4	0	0	05

Table 8 continued

8	VT 02.3.0	*Euclea natalensis*	3	0	0	05	*Dialium schlechteri*	2	0	0	05	*Hyperacanthus microphyllus*	3	3	2	05
9	VT 02.3.0	*Hymenocardia ulmoides*	3	0	0	05	*Psydrax locuples*	2	0	0	04	*Grewia caffra*	3	2	2	06
10	VT 02.3.0	*Hyperacanthus microphyllus*	3	0	0	05	*Tricalysia delagoensis*	2	0	0	05	*Diospyros inhacaensis*	3	2	1	05
1	VT 03.1.0	*Spirostachys africana*	4	0	0	06	*Dialium schlechteri*	3	0	0	05	*Spirostachys africana*	4	2	1	06
2	VT 03.1.0	*Strychnos madagascariensis*	4	0	0	05	*Dichrostachys cinerea*	3	0	0	04	*Acacia burkei*	4	1	0	05
3	VT 03.1.0	*Terminalia sericea*	4	0	0	06	*Strychnos madagascariensis*	3	0	0	05	*Albizia versicolor*	4	0	0	06
4	VT 03.1.0	*Dialium schlechteri*	3	0	0	05	*Strychnos spinosa*	3	0	0	05	*Combretum molle*	4	0	0	06
5	VT 03.1.0	*Dichrostachys cinerea*	3	0	0	04	*Terminalia sericea*	3	0	0	05	*Strychnos madagascariensis*	4	0	0	05
6	VT 03.1.0	*Garcinia livingstonei*	3	0	0	06	*Acacia burkei*	2	0	0	04	*Terminalia sericea*	4	0	0	06
7	VT 03.1.0	*Gymnosporia senegalensis*	3	0	0	04	*Bridelia cathartica*	2	0	0	05	*Tabernaemontana elegans*	3	2	2	05
8	VT 03.1.0	*Rhus gueinzii*	3	0	0	04	*Catunaregam spinosa*	2	0	0	05	*Bridelia cathartica*	3	2	1	05
9	VT 03.1.0	*Sapium integerrimum*	3	0	0	05	*Combretum molle*	2	0	0	05	*Sclerocarya birrea*	3	2	1	05
10	VT 03.1.0	*Sclerocarya birrea*	3	0	0	05	*Garcinia livingstonei*	2	0	0	05	*Garcinia livingstonei*	3	2	0	06
1	VT 04.1.0	*Euclea natalensis*	3	3	2	07	*Pteleopsis myrtifolia*	1	1	0	03	*Terminalia sericea*	3	1	0	05
2	VT 04.1.0	*Terminalia sericea*	3	0	0	05	*Acacia burkei*	1	0	0	04	*Combretum molle*	2	1	1	04
3	VT 04.1.0	*Strychnos madagascariensis*	2	0	0	05	*Dialium schlechteri*	1	0	0	04	*Acacia burkei*	2	0	0	04
4	VT 04.1.0	*Pteleopsis myrtifolia*	1	1	0	03	*Terminalia sericea*	1	0	0	04	*Dichrostachys cinerea*	2	0	0	03
5	VT 04.1.0	*Acacia burkei*	1	0	0	04	-	-	-	-	-	*Canthium inerme*	1	1	1	02
6	VT 04.1.0	*Dialium schlechteri*	1	0	0	04	-	-	-	-	-	*Dialium schlechteri*	1	1	1	04
7	VT 04.1.0	*Grewia microthyrsa*	1	0	0	04	-	-	-	-	-	*Grewia microthyrsa*	1	1	1	04
8	VT 04.1.0	*Hymenocardia ulmoides*	1	0	0	03	-	-	-	-	-	*Pteleopsis myrtifolia*	1	1	1	03
9	VT 04.1.0	*Hyphaene coriacea*	1	0	0	04	-	-	-	-	-	*Sclerocarya birrea*	1	1	1	03
10	VT 04.1.0	*Ozoroa englerii*	1	0	0	03	-	-	-	-	-	*Vangueria infausta*	1	1	1	04

VT 01.1.1 = *Afzelia quanzensis* clumps
VT 01.2.1 = Short Sand Forest
VT 01.2.2 = Intermediate Sand Forest
VT 01.2.3 = Tall Sand Forest
VT 02.1.0 = Closed Woodland Thicket
VT 02.2.0 = Closed Woodland on Clay
VT 02.3.0 = Closed Woodland on Sand
VT 03.1.0 = Open Woodland on Sand
VT 04.1.0 = Sparse Woodland on Sand

Table 9: The 10 woody species most utilised by small browsers in Tembe Elephant Park, by vegetation unit and age of damage (for canopy volume removal only). Values given reflect the number of height classes (HC) where utilisation was reported (HC 01), as well as the number of height classes where utilisation was > 50% (HC 02) and 100% (HC 03) of canopy removed or number of individuals utilised within a height class, and the highest height class where damage was observed (HC 04). Species highlighted in red represent situations where at least one height class was completely utilised. Maputaland, northern KwaZulu-Natal, South Africa

Number	Vegetation unit	Taxa	Canopy Volume removal < 12 months				Taxa	Canopy Volume removal > 12 months				Taxa	Overall Utilisation			
			HC 01*	HC 02*	HC 03*	HC 04*		HC 01*	HC 02*	HC 03*	HC 04*		HC 01*	HC 02*	HC 03*	HC 04*
1	VT 01.1.1	*Ochna barbosae*	3	0	0	05	-	-	-	-	-	*Ochna barbosae*	3	3	1	05
2	VT 01.1.1	*Vepris lanceolata*	3	0	0	04	-	-	-	-	-	*Vepris lanceolata*	3	3	1	04
3	VT 01.1.1	*Monanthotaxis caffra*	2	0	0	03	-	-	-	-	-	*Bridelia cathartica*	2	2	2	04
4	VT 01.1.1	*Ochna natalitia*	2	0	0	03	-	-	-	-	-	*Tricalysia lanceolata*	2	2	2	04
5	VT 01.1.1	*Tricalysia lanceolata*	2	0	0	04	-	-	-	-	-	*Ochna natalitia*	2	2	1	03
6	VT 01.1.1	*Boscia filipes*	1	0	0	04	-	-	-	-	-	*Monanthotaxis caffra*	2	1	1	03
7	VT 01.1.1	*Bridelia cathartica*	1	0	0	03	-	-	-	-	-	*Boscia filipes*	1	1	1	04
8	VT 01.1.1	*Canthium setiflorum*	1	0	0	03	-	-	-	-	-	*Canthium setiflorum*	1	1	1	03
9	VT 01.1.1	*Carissa tetramera*	1	0	0	03	-	-	-	-	-	*Carissa tetramera*	1	1	1	03
10	VT 01.1.1	*Mystroxylon aethiopicum*	1	0	0	04	-	-	-	-	-	*Mystroxylon aethiopicum*	1	1	1	04
1	VT 01.2.1	*Salacia leptoclada*	4	0	0	05	*Tricalysia junodii*	1	0	0	02	*Tricalysia junodii*	4	2	1	05
2	VT 01.2.1	*Tricalysia junodii*	4	0	0	05	*Vepris lanceolata*	1	0	0	02	*Salacia leptoclada*	4	1	0	05
3	VT 01.2.1	*Brachylaena discolor*	3	0	0	06	-	-	-	-	-	*Brachylaena discolor*	3	2	2	06
4	VT 01.2.1	*Cola greenwayi*	3	0	0	04	-	-	-	-	-	*Tricalysia lanceolata*	3	2	1	04
5	VT 01.2.1	*Toddaliopsis bremekampii*	3	0	0	04	-	-	-	-	-	*Cola greenwayi*	3	1	0	04
6	VT 01.2.1	*Tricalysia lanceolata*	3	0	0	04	-	-	-	-	-	*Toddaliopsis bremekampii*	3	1	0	04
7	VT 01.2.1	*Brachylaena huillensis*	2	0	0	04	-	-	-	-	-	*Drypetes natalensis*	2	2	1	03
8	VT 01.2.1	*Croton pseudopulchellus*	2	0	0	03	-	-	-	-	-	*Croton pseudopulchellus*	2	1	0	03
9	VT 01.2.1	*Drypetes arguta*	2	0	0	03	-	-	-	-	-	*Brachylaena huillensis*	2	0	0	04
10	VT 01.2.1	*Drypetes natalensis*	2	0	0	03	-	-	-	-	-	*Drypetes arguta*	2	0	0	03
1	VT 01.2.2	*Cola greenwayi*	5	0	0	06	*Brachylaena huillensis*	1	0	0	03	*Drypetes arguta*	5	1	0	05
2	VT 01.2.2	*Drypetes arguta*	5	0	0	05	*Cola greenwayi*	1	0	0	02	*Cola greenwayi*	4	1	0	05
3	VT 01.2.2	*Drypetes natalensis*	4	0	0	05	*Tarenna junodii*	1	0	0	03	*Drypetes natalensis*	4	1	0	05
4	VT 01.2.2	*Tricalysia delagoensis*	4	0	0	06	*Tricalysia junodii*	1	0	0	02	*Hymenocardia ulmoides*	4	0	0	06
5	VT 01.2.2	*Brachylaena huillensis*	3	0	0	04	-	-	-	-	-	*Pavetta lanceolata*	3	1	1	04
6	VT 01.2.2	*Croton pseudopulchellus*	3	0	0	04	-	-	-	-	-	*Salacia leptoclada*	3	1	0	04
7	VT 01.2.2	*Hymenocardia ulmoides*	3	0	0	04	-	-	-	-	-	*Tricalysia delagoensis*	3	1	0	05
8	VT 01.2.2	*Salacia leptoclada*	3	0	0	04	-	-	-	-	-	*Uvaria caffra*	3	1	0	06
9	VT 01.2.2	*Toddaliopsis bremekampii*	3	0	0	05	-	-	-	-	-	*Brachylaena huillensis*	3	0	0	04
10	VT 01.2.2	*Balanites maughamii*	2	0	0	04	-	-	-	-	-	*Croton pseudopulchellus*	3	0	0	04

Table 9 continued

1	VT 01.2.3	*Drypetes arguta*	3	0	0	05	-	-	-	-	-	*Drypetes arguta*	3	1	0	05
2	VT 01.2.3	*Acalypha glabrata*	2	0	0	03	-	-	-	-	-	*Dovyalis longispina*	2	2	1	03
3	VT 01.2.3	*Cola greenwayi*	2	0	0	04	-	-	-	-	-	*Drypetes natalensis*	2	2	1	04
4	VT 01.2.3	*Dovyalis longispina*	2	0	0	03	-	-	-	-	-	*Ptaeroxylon obliquum*	2	2	1	04
5	VT 01.2.3	*Drypetes natalensis*	2	0	0	04	-	-	-	-	-	*Tricalysia junodii*	2	2	1	03
6	VT 01.2.3	*Hymenocardia ulmoides*	2	0	0	03	-	-	-	-	-	*Hymenocardia ulmoides*	2	1	1	03
7	VT 01.2.3	*Ochna barbosae*	2	0	0	04	-	-	-	-	-	*Acalypha glabrata*	2	1	0	03
8	VT 01.2.3	*Ptaeroxylon obliquum*	2	0	0	04	-	-	-	-	-	*Ochna barbosae*	2	1	0	04
9	VT 01.2.3	*Tricalysia junodii*	2	0	0	03	-	-	-	-	-	*Cola greenwayi*	2	0	0	04
10	VT 01.2.3	*Boscia filipes*	1	0	0	03	-	-	-	-	-	*Boscia filipes*	1	1	1	03
1	VT 02.1.0	*Euclea natalensis*	4	0	0	07	*Strychnos madagascariensis*	1	0	0	03	*Euclea natalensis*	5	0	0	07
2	VT 02.1.0	*Tabernaemontana elegans*	3	0	0	04	-	-	-	-	-	*Tabernaemontana elegans*	3	2	0	04
3	VT 02.1.0	*Grewia microthyrsa*	2	0	0	04	-	-	-	-	-	*Grewia microthyrsa*	2	2	2	04
4	VT 02.1.0	*Psydrax locuples*	2	0	0	04	-	-	-	-	-	*Strychnos madagascariensis*	2	2	2	03
5	VT 02.1.0	*Sclerocroton integerrimus*	2	0	0	04	-	-	-	-	-	*Sclerocroton integerrimus*	2	1	1	04
6	VT 02.1.0	*Acacia burkei*	1	0	0	02	-	-	-	-	-	*Psydrax locuples*	2	1	0	04
7	VT 02.1.0	*Coddia rudis*	1	0	0	03	-	-	-	-	-	*Acacia burkei*	1	1	1	02
8	VT 02.1.0	*Combretum molle*	1	0	0	05	-	-	-	-	-	*Coddia rudis*	1	1	1	03
9	VT 02.1.0	*Lagynias lasiantha*	1	0	0	03	-	-	-	-	-	*Combretum molle*	1	1	1	05
10	VT 02.1.0	*Margaritaria discoidea*	1	0	0	03	-	-	-	-	-	*Lagynias lasiantha*	1	1	1	03
1	VT 02.2.0	*Acacia gerrardii*	3	0	0	04	*Sclerocarya birrea*	1	0	0	03	*Psydrax locuples*	4	2	0	05
2	VT 02.2.0	*Acacia burkei*	3	0	0	04	*Strychnos madagascariensis*	1	0	0	03	*Lagynias lasiantha*	3	3	3	04
3	VT 02.2.0	*Berchemia zeyheri*	3	0	0	04	-	-	-	-	-	*Monanthotaxis caffra*	3	3	1	04
4	VT 02.2.0	*Elaeodendron croceum*	3	0	0	04	-	-	-	-	-	*Pteleopsis myrtifolia*	3	3	1	04
5	VT 02.2.0	*Catunaregam taylori*	3	0	0	04	-	-	-	-	-	*Tricalysia lanceolata*	3	2	1	04
6	VT 02.2.0	*Coddia rudis*	3	0	0	04	-	-	-	-	-	*Erythroxylum delagoense*	3	2	0	04
7	VT 02.2.0	*Dialium schlechteri*	3	0	0	04	-	-	-	-	-	*Grewia caffra*	3	2	0	04
8	VT 02.2.0	*Dichrostachys cinerea*	3	0	0	04	-	-	-	-	-	*Gymnosporia senegalensis*	3	2	0	04
9	VT 02.2.0	*Dovyalis longispina*	3	0	0	04	-	-	-	-	-	*Strychnos madagascariensis*	3	2	0	04
10	VT 02.2.0	*Erythroxylum delagoense*	3	0	0	04	-	-	-	-	-	*Bridelia cathartica*	3	1	1	04
1	VT 02.3.0	*Dialium schlechteri*	5	1	0	05	*Salacia leptoclada*	1	1	0	03	*Tabernaemontana elegans*	5	1	0	05
2	VT 02.3.0	*Combretum molle*	4	0	0	05	*Strychnos madagascariensis*	1	0	0	02	*Dialium schlechteri*	5	0	0	05
3	VT 02.3.0	*Dalbergia obovata*	4	0	0	04	*Strychnos spinosa*	1	0	0	03	*Erythroxylum delagoense*	4	3	3	06
4	VT 02.3.0	*Grewia microthyrsa*	4	0	0	06	*Vepris lanceolata*	1	0	0	02	*Grewia microthyrsa*	4	3	2	06
5	VT 02.3.0	*Psydrax locuples*	4	0	0	04	-	-	-	-	-	*Dalbergia obovata*	4	2	1	04

Table 9 continued

6	VT 02.3.0	*Strychnos madagascariensis*	4	0	0	05	-	-	-	-	-	*Psydrax locuples*	4	2	0	04
7	VT 02.3.0	*Tabernaemontana elegans*	4	0	0	05	-	-	-	-	-	*Combretum molle*	4	1	1	05
8	VT 02.3.0	*Acacia burkei*	3	0	0	04	-	-	-	-	-	*Vepris lanceolata*	4	0	0	05
9	VT 02.3.0	*Bridelia cathartica*	3	0	0	05	-	-	-	-	-	*Strychnos madagascariensis*	3	3	2	04
10	VT 02.3.0	*Coddia rudis*	3	0	0	04	-	-	-	-	-	*Mundulea sericea*	3	3	1	04
1	VT 03.1.0	*Garcinia livingstonei*	5	1	0	05	*Strychnos madagascariensis*	4	0	0	04	*Strychnos madagascariensis*	5	3	0	05
2	VT 03.1.0	*Strychnos madagascariensis*	5	0	0	05	*Coddia rudis*	2	0	0	03	*Garcinia livingstonei*	5	2	2	05
3	VT 03.1.0	*Acacia burkei*	4	0	0	04	*Psydrax locuples*	2	0	0	03	*Strychnos spinosa*	4	2	0	05
4	VT 03.1.0	*Albizia versicolor*	4	0	0	06	*Clausena anisata*	1	0	0	03	*Dichrostachys cinerea*	4	1	1	04
5	VT 03.1.0	*Combretum molle*	4	0	0	06	*Dichrostachys cinerea*	1	0	0	03	*Sclerocroton integerrimus*	4	1	0	05
6	VT 03.1.0	*Dichrostachys cinerea*	4	0	0	04	*Garcinia livingstonei*	1	0	0	02	*Acacia burkei*	4	0	0	04
7	VT 03.1.0	*Sclerocroton integerrimus*	4	0	0	05	*Spirostachys africana*	1	0	0	02	*Combretum molle*	4	0	0	06
8	VT 03.1.0	*Strychnos spinosa*	4	0	0	05	*Terminalia sericea*	1	0	0	03	*Terminalia sericea*	4	0	0	05
9	VT 03.1.0	*Terminalia sericea*	4	0	0	05	*Tricalysia lanceolata*	1	0	0	02	*Albizia versicolor*	3	2	1	04
10	VT 03.1.0	*Brachylaena discolor*	3	0	0	04	-	-	-	-	-	*Grewia caffra*	3	2	1	04
1	VT 04.1.0	*Strychnos madagascariensis*	4	0	0	04	*Euclea natalensis*	3	0	0	05	*Strychnos madagascariensis*	4	3	0	04
2	VT 04.1.0	*Acacia burkei*	3	0	0	04	*Strychnos madagascariensis*	2	0	0	03	*Acacia burkei*	3	2	0	04
3	VT 04.1.0	*Dichrostachys cinerea*	3	0	0	04	-	-	-	-	-	*Dichrostachys cinerea*	3	2	0	04
4	VT 04.1.0	*Catunaregam taylori*	2	0	0	03	-	-	-	-	-	*Catunaregam taylori*	2	2	1	03
5	VT 04.1.0	*Combretum molle*	2	0	0	03	-	-	-	-	-	*Combretum molle*	2	2	1	03
6	VT 04.1.0	*Dialium schlechteri*	2	0	0	05	-	-	-	-	-	*Pavetta gardenophylla*	2	2	1	03
7	VT 04.1.0	*Pavetta gardenophylla*	2	0	0	03	-	-	-	-	-	*Strychnos spinosa*	2	2	0	04
8	VT 04.1.0	*Strychnos spinosa*	2	0	0	04	-	-	-	-	-	*Terminalia sericea*	2	0	0	04
9	VT 04.1.0	*Terminalia sericea*	2	0	0	04	-	-	-	-	-	*Boscia filipes*	1	1	1	02
10	VT 04.1.0	*Boscia filipes*	1	0	0	02	-	-	-	-	-	*Canthium inerme*	1	1	1	03

VT 01.1.1 = *Afzelia quanzensis* clumps
VT 01.2.1 = Short Sand Forest
VT 01.2.2 = Intermediate Sand Forest
VT 01.2.3 = Tall Sand Forest
VT 02.1.0 = Closed Woodland Thicket
VT 02.2.0 = Closed Woodland on Clay
VT 02.3.0 = Closed Woodland on Sand
VT 03.1.0 = Open Woodland on Sand
VT 04.1.0 = Sparse Woodland on Sand

Table 10: The 10 woody species most utilised by man in Tembe Elephant Park, by vegetation unit and age of damage (for canopy volume removal only). Values given reflect the number of height classes (HC) where utilisation was reported (HC 01), as well as the number of height classes where utilisation was > 50% (HC 02) and 100% (HC 03) of canopy removed or number of individuals utilised within a height class, and the highest height class where damage was observed (HC 04). Species highlighted in red represent situations where at least one height class was completely utilised. Maputaland, northern KwaZulu-Natal, South Africa

Number	Vegetation unit	Taxa	Canopy Volume removal < 12 months				Taxa	Canopy Volume removal > 12 months				Taxa	Overall Utilisation			
			HC 01*	HC 02*	HC 03*	HC 04*		HC 01*	HC 02*	HC 03*	HC 04*		HC 01*	HC 02*	HC 03*	HC 04*
1	VT 01.2.1	-	-	-	-	-	*Brachylaena huillensis*	1	0	0	04	*Brachylaena huillensis*	1	0	0	04
2	VT 01.2.1	-	-	-	-	-	*Croton pseudopulchellus*	1	1	1	05	*Croton pseudopulchellus*	1	0	0	05
1	VT 01.2.2	-	-	-	-	-	*Brachylaena huillensis*	3	1	1	06	*Brachylaena huillensis*	3	0	0	06
2	VT 01.2.2	-	-	-	-	-	*Hymenocardia ulmoides*	2	0	0	06	*Hymenocardia ulmoides*	2	0	0	06
3	VT 01.2.2	-	-	-	-	-	*Dialium schlechteri*	1	0	0	06	*Uvaria lucida*	1	1	0	06
4	VT 01.2.2	-	-	-	-	-	*Manilkara discolor*	1	0	0	06	*Dialium schlechteri*	1	0	0	06
5	VT 01.2.2	-	-	-	-	-	-	-	-	-	-	*Manilkara discolor*	1	0	0	06
1	VT 02.1.0	*Euclea natalensis*	1	0	0	04	-	-	-	-	-	*Euclea natalensis*	1	0	0	04
1	VT 02.2.0	*Vernonia colorata*	1	0	0	04	-	-	-	-	-	*Balanites maughamii*	1	1	1	07
2	VT 02.2.0	-	-	-	-	-	-	-	-	-	-	*Vernonia colorata*	1	0	0	04
1	VT 02.3.0	*Erythroxylum delagoense*	1	0	0	05	*Canthium armatum*	1	0	0	02	*Erythroxylum delagoense*	1	0	0	05
2	VT 02.3.0	*Grewia microthyrsa*	1	0	0	03	-	-	-	-	-	*Grewia microthyrsa*	1	0	0	03
3	VT 02.3.0	*Strychnos spinosa*	1	0	0	03	-	-	-	-	-	*Canthium armatum*	1	0	0	02
4	VT 02.3.0	-	-	-	-	-	-	-	-	-	-	*Strychnos spinosa*	1	0	0	03
1	VT 04.1.0	-	-	-	-	-	*Coddia rudis*	1	0	0	03	*Coddia rudis*	1	1	0	03

VT 01.2.1 = Short Sand Forest
VT 01.2.2 = Intermediate Sand Forest
VT 02.1.0 = Closed Woodland Thicket
VT 02.2.0 = Closed Woodland on Clay
VT 02.3.0 = Closed Woodland on Sand
VT 04.1.0 = Sparse Woodland on Sand

Table 11: The 10 woody species most utilised by natural damage in Tembe Elephant Park, by vegetation unit and age of damage (for canopy volume removal only). Values given reflect the number of height classes (HC) where utilisation was reported (HC 01), as well as the number of height classes where utilisation was > 50% (HC 02) and 100% (HC 03) of canopy removed or number of individuals utilised within a height class, and the highest height class where damage was observed (HC 04). Species highlighted in red represent situations where at least one height class was completely utilised. Maputaland, northern KwaZulu-Natal, South Africa

Number	Vegetation unit	Taxa	Canopy Volume removal < 12 months				Taxa	Canopy Volume removal > 12 months				Taxa	Overall Utilisation			
			HC 01*	HC 02*	HC 03*	HC 04*		HC 01*	HC 02*	HC 03*	HC 04*		HC 01*	HC 02*	HC 03*	HC 04*
1	VT 01.1.1	-	-	-	-	-	*Dialium schlechteri*	4	1	1	07	*Dialium schlechteri*	4	4	3	07
2	VT 01.1.1	-	-	-	-	-	*Vepris lanceolata*	2	0	0	06	*Vepris lanceolata*	2	2	0	06
3	VT 01.1.1	-	-	-	-	-	*Afzelia quanzensis*	1	0	0	07	*Mystroxylon aethiopicum*	1	1	1	04
4	VT 01.1.1	-	-	-	-	-	*Mystroxylon aethiopicum*	1	0	0	04	*Sclerocarya birrea*	1	1	1	07
5	VT 01.1.1	-	-	-	-	-	*Ochna barbosae*	1	0	0	03	*Spirostachys africana*	1	1	1	05
6	VT 01.1.1	-	-	-	-	-	*Sclerocarya birrea*	1	0	0	07	*Strychnos decussata*	1	1	1	05
7	VT 01.1.1	-	-	-	-	-	*Spirostachys africana*	1	0	0	05	*Tabernaemontana elegans*	1	1	1	05
8	VT 01.1.1	-	-	-	-	-	*Strychnos decussata*	1	0	0	05	*Toddaliopsis bremekampii*	1	1	1	04
9	VT 01.1.1	-	-	-	-	-	*Tabernaemontana elegans*	1	0	0	05	*Afzelia quanzensis*	1	1	0	07
10	VT 01.1.1	-	-	-	-	-	*Toddaliopsis bremekampii*	1	0	0	04	*Ochna barbosae*	1	0	0	03
1	VT 01.2.1	*Erythrophleum lasianthum*	3	1	1	07	*Cola greenwayi*	4	0	0	06	*Pteleopsis myrtifolia*	4	4	1	07
2	VT 01.2.1	*Salacia leptoclada*	2	0	0	03	*Pteleopsis myrtifolia*	4	0	0	07	*Cola greenwayi*	4	3	0	06
3	VT 01.2.1	*Acalypha glabrata*	1	0	0	04	*Erythrophleum lasianthum*	3	1	1	07	*Salacia leptoclada*	4	2	1	05
4	VT 01.2.1	*Cassipourea mossambicensis*	1	0	0	06	*Brachylaena huillensis*	3	0	0	06	*Vepris lanceolata*	3	3	3	06
5	VT 01.2.1	*Hyperacanthus microphyllus*	1	0	0	04	*Cleistanthus schlechteri*	3	0	0	07	*Psydrax locuples*	3	3	2	06
6	VT 01.2.1	*Leptactina delagoensis*	1	0	0	04	*Dialium schlechteri*	3	0	0	07	*Cassipourea mossambicensis*	3	3	1	06
7	VT 01.2.1	*Pavetta lanceolata*	1	0	0	05	*Hymenocardia ulmoides*	3	0	0	06	*Cleistanthus schlechteri*	3	3	1	07
8	VT 01.2.1	*Pteleopsis myrtifolia*	1	0	0	04	*Psydrax locuples*	3	0	0	06	*Toddaliopsis bremekampii*	3	3	0	05
9	VT 01.2.1	*Toddaliopsis bremekampii*	1	0	0	03	*Psydrax obovata*	3	0	0	06	*Dialium schlechteri*	3	2	1	07
10	VT 01.2.1	*Tricalysia junodii*	1	0	0	03	*Ptaeroxylon obliquum*	3	0	0	06	*Hymenocardia ulmoides*	3	2	1	06
1	VT 01.2.2	*Drypetes arguta*	4	0	0	05	*Cleistanthus schlechteri*	5	0	0	08	*Cleistanthus schlechteri*	5	4	2	08
2	VT 01.2.2	*Cola greenwayi*	3	0	0	05	*Cola greenwayi*	5	0	0	06	*Cola greenwayi*	5	3	0	06
3	VT 01.2.2	*Drypetes natalensis*	2	0	0	04	*Hymenocardia ulmoides*	5	0	0	07	*Hymenocardia ulmoides*	5	3	0	07
4	VT 01.2.2	*Hymenocardia ulmoides*	2	0	0	04	*Brachylaena huillensis*	4	0	0	07	*Salacia leptoclada*	5	2	2	06
5	VT 01.2.2	*Pavetta lanceolata*	2	0	0	05	*Croton pseudopulchellus*	4	0	0	06	*Drypetes arguta*	5	2	0	06
6	VT 01.2.2	*Salacia leptoclada*	2	0	0	03	*Dialium schlechteri*	4	0	0	07	*Manilkara discolor*	4	4	2	07
7	VT 01.2.2	*Uvaria lucida*	2	0	0	05	*Drypetes arguta*	4	0	0	06	*Haplocoelum galense*	4	4	1	07
8	VT 01.2.2	*Brachylaena huillensis*	1	0	0	04	*Drypetes natalensis*	4	0	0	06	*Drypetes natalensis*	4	3	1	06
9	VT 01.2.2	*Croton pseudopulchellus*	1	0	0	04	*Haplocoelum foliolosum*	4	0	0	07	*Toddaliopsis bremekampii*	4	3	0	06
10	VT 01.2.2	*Deinbollia oblongifolia*	1	0	0	03	*Manilkara discolor*	4	0	0	07	*Dialium schlechteri*	4	2	2	07

Table 11 continued

1	VT 01.2.3	*Balanites maughamii*	1	0	0	03	*Cola greenwayi*	3	0	0	06	*Vepris lanceolata*	4	2	1	06
2	VT 01.2.3	*Cola greenwayi*	1	0	0	04	*Dialium schlechteri*	3	0	0	06	*Dialium schlechteri*	3	3	1	06
3	VT 01.2.3	*Toddaliopsis bremekampii*	1	0	0	05	*Newtonia hildebrandtii*	3	0	0	08	*Newtonia hildebrandtii*	3	2	0	08
4	VT 01.2.3	*Vepris lanceolata*	1	0	0	03	*Vepris lanceolata*	3	0	0	06	*Cola greenwayi*	3	1	0	06
5	VT 01.2.3	*Ziziphus mucronata*	1	0	0	02	*Acalypha glabrata*	2	0	0	05	*Grewia microthyrsa*	2	2	2	05
6	VT 01.2.3	-	-	-	-	-	*Cleistanthus schlechteri*	2	0	0	07	*Tricalysia lanceolata*	2	2	1	06
7	VT 01.2.3	-	-	-	-	-	*Drypetes arguta*	2	0	0	05	*Cleistanthus schlechteri*	2	2	0	07
8	VT 01.2.3	-	-	-	-	-	*Grewia microthyrsa*	2	0	0	05	*Toddaliopsis bremekampii*	2	2	0	05
9	VT 01.2.3	-	-	-	-	-	*Monodora junodii*	2	0	0	06	*Acalypha glabrata*	2	1	1	05
10	VT 01.2.3	-	-	-	-	-	*Ptaeroxylon obliquum*	2	0	0	07	*Balanites maughamii*	2	1	1	08
1	VT 02.1.0	*Euclea natalensis*	2	0	0	05	*Euclea natalensis*	4	0	0	07	*Euclea natalensis*	5	0	0	07
2	VT 02.1.0	-	-	-	-	-	*Psydrax locuples*	3	0	0	05	*Psydrax locuples*	3	1	0	05
3	VT 02.1.0	-	-	-	-	-	*Acacia burkei*	2	0	0	06	*Acacia burkei*	2	2	2	06
4	VT 02.1.0	-	-	-	-	-	*Tabernaemontana elegans*	2	0	0	06	*Tabernaemontana elegans*	2	2	1	06
5	VT 02.1.0	-	-	-	-	-	*Terminalia sericea*	2	0	0	06	*Terminalia sericea*	2	1	0	06
6	VT 02.1.0	-	-	-	-	-	*Mystroxylon aethiopicum*	1	0	0	04	*Mystroxylon aethiopicum*	1	1	1	04
7	VT 02.1.0	-	-	-	-	-	*Combretum molle*	1	0	0	06	*Combretum molle*	1	1	1	06
8	VT 02.1.0	-	-	-	-	-	*Sclerocarya birrea*	1	0	0	04	*Sclerocarya birrea*	1	1	1	04
1	VT 02.2.0	*Acacia burkei*	7	4	4	07	*Acacia burkei*	7	4	4	07	*Acacia burkei*	5	2	0	07
2	VT 02.2.0	*Coddia rudis*	4	2	1	04	*Spirostachys africana*	5	0	0	07	*Spirostachys africana*	5	2	0	07
3	VT 02.2.0	*Dialium schlechteri*	4	0	0	06	*Coddia rudis*	4	2	1	04	*Warburgia salutaris*	4	3	3	06
4	VT 02.2.0	*Strychnos spinosa*	3	0	0	05	*Warburgia salutaris*	4	0	0	06	*Dialium schlechteri*	4	0	0	06
5	VT 02.2.0	*Bridelia cathartica*	2	0	0	05	*Acacia robusta*	3	0	0	06	*Sclerocarya birrea*	3	3	1	07
6	VT 02.2.0	*Catunaregam taylori*	2	0	0	04	*Combretum molle*	3	0	0	05	*Acacia robusta*	3	2	2	06
7	VT 02.2.0	*Combretum molle*	2	0	0	05	*Euclea natalensis*	3	0	0	07	*Croton pseudopulchellus*	3	2	1	05
8	VT 02.2.0	*Croton pseudopulchellus*	2	0	0	04	*Ochna barbosae*	3	0	0	05	*Schotia brachypetala*	3	2	1	07
9	VT 02.2.0	*Canthium armatum*	2	0	0	04	*Ochna natalitia*	3	0	0	05	*Vepris lanceolata*	3	2	1	06
10	VT 02.2.0	*Tricalysia lanceolata*	2	0	0	04	*Sclerocarya birrea*	3	0	0	07	*Catunaregam taylori*	3	1	0	05
1	VT 02.3.0	*Spirostachys africana*	6	3	3	07	*Spirostachys africana*	6	3	3	07	*Vepris lanceolata*	5	3	0	07
2	VT 02.3.0	*Strychnos madagascariensis*	6	3	3	06	*Strychnos madagascariensis*	6	3	3	06	*Dialium schlechteri*	4	3	1	07
3	VT 02.3.0	*Canthium armatum*	3	0	0	05	*Vepris lanceolata*	5	0	0	07	*Commiphora neglecta*	4	3	0	06
4	VT 02.3.0	*Albizia versicolor*	2	1	1	06	*Afzelia quanzensis*	4	1	0	07	*Sideroxylon inerme*	4	2	1	07
5	VT 02.3.0	*Acacia robusta*	2	1	0	07	*Combretum molle*	4	0	0	06	*Afzelia quanzensis*	4	1	0	07
6	VT 02.3.0	*Bridelia cathartica*	2	0	0	04	*Dialium schlechteri*	4	0	0	07	*Combretum molle*	4	1	0	06
7	VT 02.3.0	*Commiphora neglecta*	2	0	0	04	*Sideroxylon inerme*	4	0	0	07	*Spirostachys africana*	4	1	0	07
8	VT 02.3.0	*Afzelia quanzensis*	1	0	0	07	*Albizia versicolor*	3	1	1	07	*Bridelia cathartica*	4	0	0	06

Table 11 continued

9	VT 02.3.0	*Acalypha glabrata*	1	0	0	04	*Acacia burkei*	3	0	0	07	*Haplocoelum galense*	3	3	3	06
10	VT 02.3.0	*Acacia burkei*	1	0	0	07	*Bridelia cathartica*	3	0	0	06	*Toddaliopsis bremekampii*	3	3	3	05
1	VT 03.1.0	*Acacia burkei*	7	2	2	07	*Acacia burkei*	7	2	2	07	*Terminalia sericea*	6	3	1	07
2	VT 03.1.0	*Terminalia sericea*	6	0	0	07	*Albizia versicolor*	5	0	0	07	*Albizia versicolor*	6	1	0	07
3	VT 03.1.0	*Albizia versicolor*	5	0	0	07	*Terminalia sericea*	5	0	0	07	*Sclerocarya birrea*	5	3	1	07
4	VT 03.1.0	*Combretum molle*	4	0	0	05	*Vangueria infausta*	4	1	1	06	*Acacia burkei*	5	3	0	07
5	VT 03.1.0	*Strychnos madagascariensis*	4	0	0	05	*Combretum molle*	4	1	0	06	*Ziziphus mucronata*	5	3	0	06
6	VT 03.1.0	*Zanthoxylum capense*	3	1	1	05	*Catunaregam taylori*	4	0	0	05	*Combretum molle*	5	1	0	06
7	VT 03.1.0	*Catunaregam taylori*	3	0	0	04	*Dichrostachys cinerea*	4	0	0	05	*Catunaregam taylori*	4	2	1	05
8	VT 03.1.0	*Dialium schlechteri*	3	0	0	05	*Rhus gueinziinzii*	4	0	0	05	*Dichrostachys cinerea*	4	2	1	05
9	VT 03.1.0	*Dichrostachys cinerea*	3	0	0	04	*Sclerocroton integerrimus*	4	0	0	06	*Rhus gueinziinzii*	4	2	1	05
10	VT 03.1.0	*Gymnosporia senegalensis*	3	0	0	04	*Sclerocarya birrea*	4	0	0	07	*Strychnos spinosa*	4	2	0	05
1	VT 04.1.0	*Euclea natalensis*	3	3	1	05	*Dialium schlechteri*	3	1	0	06	*Terminalia sericea*	4	3	0	05
2	VT 04.1.0	*Dichrostachys cinerea*	3	1	0	04	*Strychnos madagascariensis*	3	0	0	05	*Strychnos madagascariensis*	4	2	0	05
3	VT 04.1.0	*Terminalia sericea*	2	1	0	03	*Terminalia sericea*	3	0	0	05	*Dialium schlechteri*	3	3	3	06
4	VT 04.1.0	*Combretum molle*	1	1	0	02	*Brachylaena discolor*	2	2	0	04	*Euclea natalensis*	3	3	2	07
5	VT 04.1.0	*Crotalaria monteiroi*	1	1	0	03	*Acacia burkei*	2	0	0	04	*Dichrostachys cinerea*	3	0	0	04
6	VT 04.1.0	*Mundulea sericea*	1	1	0	03	*Dichrostachys cinerea*	2	0	0	03	*Brachylaena discolor*	2	2	2	04
7	VT 04.1.0	*Strychnos madagascariensis*	1	0	0	05	*Vitex ferruginea*	1	1	0	03	*Mundulea sericea*	2	2	1	03
8	VT 04.1.0	-	-	-	-	-	*Albizia adianthifolia*	1	0	0	07	*Combretum molle*	2	1	1	03
9	VT 04.1.0	-	-	-	-	-	*Combretum molle*	1	0	0	03	*Acacia burkei*	2	0	0	04
10	VT 04.1.0	-	-	-	-	-	*Euclea natalensis*	1	0	0	07	*Albizia adianthifolia*	1	1	1	07

VT 01.1.1 = *Afzelia quanzensis* clumps
VT 01.2.1 = Short Sand Forest
VT 01.2.2 = Intermediate Sand Forest
VT 01.2.3 = Tall Sand Forest
VT 02.1.0 = Closed Woodland Thicket
VT 02.2.0 = Closed Woodland on Clay
VT 02.3.0 = Closed Woodland on Sand
VT 03.1.0 = Open Woodland on Sand
VT 04.1.0 = Sparse Woodland on Sand

Elephant utilisation evaluation

The overall percentage of canopy removal by species for the recent and old periods, and for the overall utilisation was presented in Table 12. More than 10% of the canopy was removed for seven species during the past 12 months, while canopy removal exceeded 10% for 65 species (39.15% of sampled species) during the old period. More significantly, canopy removal was greater than 40% for nine species, and greater than 50% for five of these species. Overall utilisation was ≥ 10% for 99 species, and > 50% for 29 of these species, meaning that more than 50% of the available individuals were used for each of these woody species. For comparative purposes the old canopy removal value was used to compare results with the 1994 study, because recent canopy removal only documented one year of utilisation. *Albizia versicolor* remained a highly utilised species and was still classified within group 1, with in excess of 80% of the canopy removed, whereas *Terminalia sericea* and *Albizia adianthifolia* canopy utilisation was lower and they fell within group 2. *Sclerocarya birrea, Spirostachys africana* and *Afzelia quanzensis* had less than 10% of their available canopy removed and therefore could no longer be classified into the original groups. The remainder of species initially described were now within group 3. The values for overall utilisation indicated that elephants utilised 127 species, or 75.60% of the sampled woody species (1994 study value was 66.00%).

The species level analysis by vegetation units showed that recent canopy removal was generally below 10% in the Sand Forest association except for the Tall Sand Forest unit where three species had nearly 40% of their canopy removed (Table 13) but old canopy removal exceeded 10% for almost half of the utilised species (Table 14), with remarkably high values for six species of the Tall Sand Forest unit. Recent canopy removal in the Woodlands (Table 15) exceeded 10% for two (50.00% of utilised species in the vegetation unit), nine (16.66%), seven (17.50%) and four (12.90%) species in the Closed Woodland Thicket, Closed Woodland on Clay, Closed Woodland on Sand, and Open Woodland on Sand respectively. *Phyllanthus reticulatus* was particularly utilised by elephants recently, as 94.50% of its canopy was removed in the Closed Woodland on Clay. Old signs of canopy removal (Table 16) showed that canopy removal was > 10% for the majority of utilised species in the Woodlands (55.55% in Closed Woodland Thicket and Closed Woodland on Clay, 69.35% in Closed Woodland on Sand, 62.79% in Open Woodland on Sand, and 70.00% in Sparse Woodland on Sand). The Closed Woodland on Sand had the most species where canopy removal was > 50% (9.67% of utilised species). *Albizia versicolor* was most

Table 12: The recent (12 months prior to the study) and old (>12 months prior to the study) canopy removal values due to elephant utilisation, as well as the overall utilisation of woody species linked to elephant utilisation, the values represent the percentage of the canopy removed or the overall utilisation of woody species by elephant action for all vegetation units combined in Tembe Elephant Park, Maputaland, northern KwaZulu-Natal, South Africa. Species are ranked by decreasing order of overall utilisation

Utilisation rank	Recent canopy volume removal (percentage of available canopy removed)		Old canopy volume removal (percentage of available canopy removed)		Overall utilisation (percentage of trees utilised)	
1	*Phyllanthus reticulatus*	94.50	*Lannea antiscorbutica*	94.77	*Bridelia micrantha*	100.00
2	*Cladostemon kirkii*	21.63	*Albizia versicolor* [1]	82.65	*Cladostemon kirkii*	100.00
3	*Cordia caffra*	17.50	*Mystroxylon aethiopicum*	73.37	*Cordia caffra*	100.00
4	*Clausena anisata*	14.97	*Dalbergia obovata*	53.27	*Lannea antiscorbutica*	100.00
5	*Tarenna supra-axilaris*	11.82	*Ptaeroxylon obliquum*	50.04	*Lantana rugosa*	100.00
6	*Vangueria infausta*	11.68	*Brachylaena discolor*	49.31	*Phyllanthus reticulatus*	100.00
7	*Erythroxylum delagoense*	10.95	*Antidesma venosum*	44.56	*Syzygium cordatum*	100.00
8	*Berchemia zeyheri*	9.68	*Leptactina delagoensis*	40.59	*Trichilia emetica* [3]	87.91
9	*Chaetacme aristata*	9.22	*Ximenia caffra*	40.16	*Albizia versicolor* [1]	82.95
10	*Gardenia volkensii*	8.92	*Canthium inerme*	35.73	*Ekebergia capensis*	82.76
11	*Sideroxylon inerme*	8.65	*Tarenna junodii*	29.83	*Erythroxylum emarginatum*	80.00
12	*Zanthoxylum leprieuri*	8.39	*Zanthoxylum leprieuri*	28.75	*Vitex ferruginea*	62.34
13	*Ochna barbosae*	7.72	*Ziziphus mucronata*	28.29	*Ochna arborea*	60.00
14	*Tricalysia lanceolata*	7.19	*Brachylaena elliptica*	25.92	*Gardenia volkensii*	60.00
15	*Psydrax locuples*	6.77	*Terminalia sericea* [1]	24.76	*Sclerocarya birrea* [2]	59.30
16	*Ziziphus mucronata*	6.77	*Erythroxylum emarginatum*	24.06	*Afzelia quanzensis* [3]	58.97
17	*Erythroxylum emarginatum*	6.01	*Trichilia emetica* [3]	23.28	*Ximenia caffra*	58.89
18	*Deinbollia oblongifolia*	5.68	*Kraussia floribunda*	23.17	*Manilkara discolor*	58.26
19	*Brachylaena discolor*	5.52	*Ehretia obtusiflora*	23.11	*Strychnos henningsii*	57.92
20	*Bridelia cathartica*	5.15	*Garcinia livingstonei*	22.22	*Chaetacme aristata*	57.14
21	*Lantana rugosa*	5.00	*Sclerocroton integerrimus*	22.16	*Antidesma venosum*	54.52
22	*Strychnos henningsii*	4.02	*Dovyalis longispina*	21.67	*Cassipourea mossambicensis*	51.67
23	*Garcinia livingstonei*	3.75	*Peltophorum africanum*	21.27	*Ptaeroxylon obliquum*	49.25
24	*Boscia filipes*	3.64	*Strychnos madagascariensis* [2]	20.49	*Garcinia livingstonei*	48.44
25	*Ochna natalitia*	3.48	*Strychnos henningsii*	20.47	*Vangueria infausta*	47.62
26	*Albizia versicolor* [1]	3.47	*Tabernaemontana elegans*	19.98	*Craibia zimmermannii*	47.09
27	*Vernonia colorata*	3.45	*Albizia adianthifolia* [1]	19.70	*Warburgia salutaris*	46.67
28	*Lagynias lasiantha*	3.42	*Grewia microthyrsa*	19.51	*Wrightia natalensis*	46.12
29	*Strychnos spinosa*	3.04	*Strychnos spinosa*	19.42	*Tarenna supra-axilaris*	43.21
30	*Vitex ferruginea*	2.96	*Vernonia colorata*	18.80	*Acalypha sonderiana*	40.00
31	*Zanthoxylum capense*	2.83	*Schotia brachypetala*	18.68	*Clerodendrum glabrum*	39.40
32	*Combretum molle* [3]	2.75	*Vangueria infausta*	18.57	*Lagynias lasiantha*	39.33
33	*Brachylaena elliptica*	2.75	*Hymenocardia ulmoides* [3]	18.29	*Margaritaria discoidea*	37.41
34	*Leptactina delagoensis*	2.52	*Strychnos decussata*	18.05	*Strychnos decussata*	36.97
35	*Cassipourea mossambicensis*	2.46	*Commiphora neglecta*	17.78	*Acacia robusta* [3]	36.65
36	*Strychnos madagascariensis* [2]	2.42	*Rhus gueinzii*	17.60	*Monodora junodii*	36.58
37	*Acalypha sonderiana*	2.30	*Bridelia micrantha*	17.50	*Ziziphus mucronata*	36.51
38	*Elaeodendron transvaalense*	2.25	*Bridelia cathartica*	17.43	*Terminalia sericea* [1]	36.14
39	*Afzelia quanzensis* [3]	2.20	*Acalypha sonderiana*	17.43	*Vernonia colorata*	35.09
40	*Manilkara discolor*	2.13	*Ochna arborea*	16.71	*Peltophorum africanum*	34.78
41	*Schotia brachypetala*	1.98	*Pavetta gardenophylla*	15.38	*Burchellia bubalina*	34.40
42	*Euclea natalensis*	1.95	*Grewia spp.*	14.61	*Pseudobersama mossambicensis*	34.09
43	*Terminalia sericea* [1]	1.91	*Monodora junodii*	14.33	*Boscia filipes*	33.80
44	*Drypetes arguta*	1.86	*Pteleopsis myrtifolia*	14.12	*Erythroxylum delagoense*	33.36
45	*Manilkara concolor*	1.78	*Wrightia natalensis*	14.11	*Tabernaemontana elegans*	33.29
46	*Trichilia emetica* [3]	1.76	*Acacia gerrardii*	14.09	*Ehretia obtusiflora*	32.79
47	*Tricalysia delagoensis*	1.75	*Mundulea sericea*	13.99	*Erythrophleum lasianthum*	31.93
48	*Warburgia salutaris*	1.66	*Canthium setiflorum*	13.79	*Manilkara concolor*	30.83
49	*Suregada africana*	1.66	*Euclea divinorum*	13.16	*Tricalysia delagoensis*	30.24
50	*Margaritaria discoidea*	1.64	*Ochna natalitia*	12.95	*Grewia microthyrsa*	29.99
51	*Acacia gerrardii*	1.61	*Dialium schlechteri* [2]	12.69	*Pteleopsis myrtifolia*	29.68
52	*Syzygium cordatum*	1.54	*Sideroxylon inerme*	12.34	*Bridelia cathartica*	29.17
53	*Burchellia bubalina*	1.44	*Cassipourea mossambicensis*	12.29	*Cleistanthus schlechteri*	27.32
54	*Hymenocardia ulmoides* [3]	1.30	*Combretum molle* [3]	12.23	*Balanites maughamii*	27.28
55	*Sclerocarya birrea* [2]	1.28	*Cola greenwayi*	12.05	*Suregada africana*	26.67
56	*Antidesma venosum*	1.24	*Acacia nilotica*	12.05	*Sideroxylon inerme*	26.55
57	*Sclerocroton integerrimus*	1.20	*Euclea natalensis*	11.27	*Strychnos spinosa*	26.50
58	*Canthium setiflorum*	1.15	*Syzigium cordatum*	11.13	*Combretum molle* [3]	26.10
59	*Hyphaene coriacea*	1.14	*Erythrophleum lasianthum*	11.07	*Sclerocroton integerrimus*	25.75
60	*Diospyros inhacaensis*	1.10	*Vitex ferruginea*	10.91	*Erythrococca berberidae*	25.10
61	*Haplocoelum foliolosum*	1.04	*Chaetacme aristata*	10.55	*Rothmania fischeri*	25.00
62	*Rhus gueinzii*	1.00	*Acacia robusta* [3]	10.38	*Eugenia natalitia*	25.00
63	*Hyperacanthus microphyllus*	0.93	*Acacia burkei* [2]	10.16	*Tarenna junodii*	24.87
64	*Cola greenwayi*	0.91	*Elaeodendron transvalense*	10.04	*Strychnos gerrardii*	24.87
65	*Grewia microthyrsa*	0.91	*Cleistanthus schlechteri*	10.03	*Hymenocardia ulmoides* [3]	24.85
66	*Pseudobersama mossambicensis*	0.90	*Sclerocarya birrea* [2]	9.79	*Combretum celastroides*	23.98

Table 12 continued

67	*Toddaliopsis bremekampii*	0.89	*Psydrax locuples*	9.07	*Mystroxylon aethiopicum*		23.63
68	*Strychnos gerrardii*	0.85	*Erythroxylum delagoense*	9.01	*Acacia burkei*	2	23.51
69	*Dichrostachys cinerea*	0.79	*Dichrostachys cinerea*	8.96	*Tricalysia lanceolata*		23.24
70	*Monodora junodii*	0.77	*Hyphaene coriacea*	8.74	*Brachylaena huillensis*		22.98
71	*Dialium schlechteri*	2 0.77	*Erythrococca berberidae*	8.56	*Leptactina delagoensis*		22.69
72	*Psydrax obovata*	0.77	*Diospyros inhacaensis*	8.52	*Psydrax obovata*		22.22
73	*Ximenia caffra*	0.75	*Drypetes arguta*	8.06	*Haplocoelum foliolosum*		22.13
74	*Canthium armatum*	0.70	*Tricalysia delagoensis*	8.00	*Dialium schlechteri*	2	22.11
75	*Tabernaemontana elegans*	0.69	*Brachylaena huillensis*	7.43	*Albizia adianthifolia*	1	20.93
76	*Acacia burkei*	2 0.60	*Boscia filipes*	7.34	*Strychnos madagascariensis*	2	20.60
77	*Brachylaena huillensis*	0.56	*Ekebergia capensis*	6.82	*Diospyros inhacaensis*		20.18
78	*Ptaeroxylon obliquum*	0.56	*Balanites maughamii*	6.71	*Acacia nilotica*		20.16
79	*Commiphora neglecta*	0.55	*Pseudobersama mossambicensis*	6.43	*Schotia brachypetala*		18.82
80	*Erythrococca berberidae*	0.53	*Combretum celastroides*	6.41	*Commiphora neglecta*		18.75
81	*Catunaregam taylori*	0.51	*Spirostachys africana*	3 6.31	*Suregada zanzibariensis*		16.51
82	*Spirostachys africana*	3 0.47	*Haplocoelum foliolosum*	5.99	*Newtonia hildebrandtii*		16.03
83	*Acalypha glabrata*	0.46	*Burchellia bubalina*	5.70	*Cola greenwayi*		16.01
84	*Coddia rudis*	0.45	*Lagynias lasiantha*	5.64	*Rhus gueinzii*		15.89
85	*Vepris lanceolata*	0.43	*Afzelia quanzensis*	3 5.57	*Elaeodendron croceum*		15.87
86	*Dalbergia obovata*	0.43	*Psydrax obovata*	5.34	*Drypetes arguta*		15.83
87	*Rothmannia fischeri*	0.35	*Tricalysia lanceolata*	5.25	*Grewia spp.*		14.93
88	*Pavetta lanceolata*	0.28	*Drypetes natalensis*	5.16	*Toddaliopsis bremekampii*		14.71
89	*Wrightia natalensis*	0.28	*Salacia leptoclada*	4.89	*Acacia gerrardii*		14.59
90	*Croton pseudopulchellus*	0.28	*Manilkara discolor*	4.52	*Drypetes natalensis*		14.27
91	*Acacia robusta*	3 0.27	*Uvaria lucida*	4.22	*Spirostachys africana*	3	13.60
92	*Balanites maughamii*	0.22	*Toddaliopsis bremekampii*	4.16	*Canthium setiflorum*		12.81
93	*Suregada zanzibariensis*	0.14	*Newtonia hildebrandtii*	4.16	*Kraussia floribunda*		12.60
94	*Tricalysia junodii*	0.13	*Clerodendrum glabrum*	4.13	*Elaeodendron transvalense*		12.00
95	*Pteleopsis myrtifolia*	0.11	*Strychnos gerrardii*	4.03	*Canthium armatum*		11.95
96	*Strychnos decussata*	0.09	*Zanthoxylum capense*	3.95	*Uvaria lucida*		11.45
97	*Grewia spp.*	0.04	*Suregada africana*	3.78	*Psydrax locuples*		10.68
98	*Mundulea sericea*	0.03	*Catunaregam taylori*	3.58	*Vepris lanceolata*		10.46
99	*Cleistanthus schlechteri*	0.02	*Ochna barbosae*	3.26	*Canthium inerme*		10.00
100	*Drypetes natalensis*	0.01	*Manilkara concolor*	3.03	*Ochna barbosae*		9.95
101	*Erythrophleum lasianthum*	0.00	*Margaritaria discoidea*	2.93	*Zanthoxylum capense*		9.94
102	*Uvaria lucida*	0.00	*Croton pseudopulchellus*	2.65	*Mundulea sericea*		9.92
103			*Canthium armatum*	2.37	*Uvaria caffra*		8.63
104			*Hyperacanthus microphyllus*	2.05	*Berchemia zeyheri*		8.33
105			*Uvaria caffra*	2.02	*Hyphaene coriacea*		8.14
106			*Gardenia volkensii*	1.96	*Dichrostachys cinerea*		7.78
107			*Ozoroa englerii*	1.93	*Acalypha glabrata*		7.60
108			*Suregada zanzibariensis*	1.79	*Hyperacanthus microphyllus*		7.32
109			*Eugenia natalitia*	1.75	*Euclea natalensis*		7.12
110			*Berchemia zeyheri*	1.75	*Clausena anisata*		6.36
111			*Craibia zimmermannii*	1.73	*Ochna natalitia*		5.86
112			*Tarenna supra-axilaris*	1.63	*Pavetta lanceolata*		5.18
113			*Vepris lanceolata*	1.58	*Brachylaena elliptica*		5.03
114			*Acalypha glabrata*	1.49	*Croton pseudopulchellus*		4.95
115			*Rothmania fischeri*	1.07	*Brachylaena discolor*		4.60
116			*Clausena anisata*	1.01	*Combretum mkuzense*		4.49
117			*Coddia rudis*	0.79	*Ozoroa englerii*		4.19
118			*Elaeodendron croceum*	0.61	*Euclea divinorum*		3.75
119			*Warburgia salutaris*	0.21	*Salacia leptoclada*		3.07
120			*Combretum mkuzense*	0.03	*Dalbergia obovata*		2.58
121					*Coddia rudis*		2.34
122					*Zanthoxylum leprieuri*		1.88
123					*Pavetta gardenophylla*		1.69
124					*Dovyalis longispina*		1.65
125					*Deinbollia oblongifolia*		1.36
126					*Catunaregam taylori*		0.75
127					*Tricalysia junodii*		0.53

Note: the values in the highlighted boxes to the right of the species names represent the rankings of overall woody species utilisation in the form of canopy removal from elephant observed by Matthews and Page (In prep) during a similar study conducted in 1994. Species were ranked in three groups based on the canopy volume removal observed at that stage, a rank of 1 was given to species where canopy volume removal was ≥ 50%, a rank of 2 was given to species where observed canopy removal varied from ≥ 25% to 49%, while a rank of 3 represented species where observed canopy removal ranged from ≥ 10% to 24%. The bold lines in the column separate these groups in the current sample.

Table 13: The recent (within 12 months prior to the study) woody species canopy volume removal linked to elephant utilisation observed in the Sand Forest association of Tembe Elephant Park, Maputaland, northern KwaZulu-Natal, South Africa, in 2004. The woody species are ranked by canopy volume removal intensity at the vegetation unit level

Utilisation rank	Recent canopy removal in the *Afzelia quanzensis* clumps (percentage of available canopy removed)		Recent canopy removal in the Short Sand Forest (percentage of available canopy removed)		Recent canopy removal in the Intermediate Sand Forest (percentage of available canopy removed)		Recent canopy removal in the Tall Sand Forest (percentage of available canopy removed)	
1	*Tabernaemontana elegans*	3.53	*Tricalysia lanceolata*	15.09	*Boscia filipes*	5.38	*Erythroxylum emarginatum*	37.50
2	*Ochna barbosae*	3.40	*Leptactina delagoensis*	8.41	*Strychnos henningsii*	4.86	*Tarenna supra-axilaris*	37.50
3			*Tricalysia delagoensis*	3.97	*Burchellia bubalina*	3.28	*Psydrax locuples*	37.46
4			*Lagynias lasiantha*	3.19	*Cassipourea mossambicensis*	2.88	*Cladostemon kirkii*	21.63
5			*Manilkara discolor*	2.94	*Manilkara discolor*	1.95	*Lagynias lasiantha*	14.44
6			*Psydrax obovata*	2.37	*Hymenocardia ulmoides*	1.72	*Tricalysia lanceolata*	7.33
7			*Cassipourea mossambicensis*	2.34	*Grewia microthyrsa*	1.46	*Cola greenwayi*	7.28
8			*Tarenna supra-axilaris*	2.17	*Drypetes arguta*	1.45	*Drypetes arguta*	6.85
9			*Strychnos henningsii*	1.91	*Haplocoelum foliolosum*	1.35	*Vepris lanceolata*	6.13
10			*Drypetes arguta*	1.57	*Tricalysia delagoensis*	1.19	*Toddaliopsis bremekampii*	5.07
11			*Suregada zanzibariensis*	1.47	*Pseudobersama mossambicensis*	0.90	*Strychnos gerrardii*	5.00
12			*Brachylaena huillensis*	0.68	*Toddaliopsis bremekampii*	0.74	*Manilkara concolor*	4.75
13			*Cola greenwayi*	0.66	*Suregada zanzibariensis*	0.48	*Leptactina delagoensis*	4.54
14			*Pavetta lanceolata*	0.35	*Brachylaena huillensis*	0.44	*Strychnos henningsii*	3.37
15			*Vitex ferruginea*	0.13	*Cola greenwayi*	0.42	*Hymenocardia ulmoides*	2.19
16			*Croton pseudopulchellus*	0.09	*Tricalysia junodii*	0.37	*Ptaeroxylon obliquum*	0.77
17			*Hymenocardia ulmoides*	0.08	*Wrightia natalensis*	0.29	*Acalypha glabrata*	0.23
18					*Dialium schlechteri*	0.24		
19					*Croton pseudopulchellus*	0.20		
20					*Pavetta lanceolata*	0.14		
21					*Balanites maughamii*	0.14		
22					*Pteleopsis myrtifolia*	0.05		
23					*Cleistanthus schlechteri*	0.03		
24					*Drypetes natalensis*	0.02		
25					*Strychnos decussata*	0.02		
26					*Erythrophleum lasianthum*	0.01		

Table 14: The old (more than 12 months prior to the study) woody species canopy volume removal linked to elephant utilisation observed in the Sand Forest association of Tembe Elephant Park, Maputaland, northern KwaZulu-Natal, South Africa, in 2004. The woody species are ranked by canopy volume removal intensity at the vegetation unit level

Utilisation rank	Old canopy removal in the *Afzelia quanzensis* clumps (percentage of available canopy removed)		Old canopy removal in the Short Sand Forest (percentage of available canopy removed)		Old canopy removal in the Intermediate Sand Forest (percentage of available canopy removed)		Old canopy removal in the Tall Sand Forest (percentage of available canopy removed)	
1	*Sclerocroton integerrimus*	37.50	*Tarenna junodii*	94.50	*Leptactina delagoensis*	58.56	*Ekebergia capensis*	94.50
2	*Boscia filipes*	17.50	*Uvaria caffra*	82.50	*Erythroxylum emarginatum*	37.50	*Ptaeroxylon obliquum*	77.15
3	*Manilkara concolor*	17.50	*Monodora junodii*	37.84	*Strychnos decussata*	34.97	*Schotia brachypetala*	76.56
4	*Vepris lanceolata*	0.45	*Newtonia hildebrandtii*	37.50	*Grewia microthyrsa*	30.48	*Tricalysia delagoensis*	62.50
5			*Strychnos decussata*	24.52	*Cassipourea mossambicensis*	24.77	*Boscia filipes*	61.84
6			*Strychnos henningsii*	22.96	*Strychnos henningsii*	21.15	*Haplocoelum foliolosum*	60.54
7			*Cleistanthus schlechteri*	18.78	*Hymenocardia ulmoides*	20.54	*Balanites maughamii*	22.17
8			*Ochna natalitia*	18.73	*Tricalysia lanceolata*	19.61	*Pteleopsis myrtifolia*	20.90
9			*Vitex ferruginea*	17.83	*Dialium schlechteri*	17.70	*Ochna arborea*	17.48
10			*Combretum celastroides*	17.50	*Suregada zanzibariensis*	17.12	*Strychnos decussata*	17.06
11			*Boscia filipes*	16.68	*Ptaeroxylon obliquum*	16.01	*Strychnos henningsii*	15.92
12			*Ptaeroxylon obliquum*	16.66	*Brachylaena huillensis*	14.71	*Drypetes arguta*	11.95
13			*Pteleopsis myrtifolia*	15.30	*Wrightia natalensis*	14.38	*Psydrax obovata*	9.75
14			*Tricalysia lanceolata*	13.24	*Pteleopsis myrtifolia*	12.96	*Cola greenwayi*	6.58
15			*Erythrophleum lasianthum*	12.89	*Monodora junodii*	12.35	*Acalypha glabrata*	5.97
16			*Cola greenwayi*	12.82	*Cola greenwayi*	12.29	*Manilkara concolor*	5.00
17			*Drypetes natalensis*	12.56	*Burchellia bubalina*	11.18	*Cleistanthus schlechteri*	4.86
18			*Dialium schlechteri*	11.78	*Salacia leptoclada*	10.79	*Leptactina delagoensis*	4.78
19			*Hymenocardia ulmoides*	10.83	*Tricalysia delagoensis*	7.78	*Monodora junodii*	4.48
20			*Lagynias lasiantha*	10.75	*Cleistanthus schlechteri*	7.27	*Hymenocardia ulmoides*	2.52
21			*Drypetes arguta*	10.40	*Haplocoelum foliolosum*	7.22	*Toddaliopsis bremekampii*	0.80
22			*Toddaliopsis bremekampii*	5.17	*Drypetes arguta*	6.45	*Salacia leptoclada*	0.16
23			*Cassipourea mossambicensis*	5.00	*Pseudobersama mossambicensis*	6.43	*Strychnos gerrardii*	0.05
24			*Wrightia natalensis*	4.75	*Combretum celastroides*	5.82		
25			*Grewia microthyrsa*	4.64	*Psydrax obovata*	5.68		
26			*Manilkara discolor*	4.58	*Uvaria lucida*	4.84		
27			*Psydrax obovata*	4.26	*Manilkara discolor*	4.17		
28			*Croton pseudopulchellus*	3.74	*Toddaliopsis bremekampii*	3.92		
29			*Salacia leptoclada*	2.67	*Erythrophleum lasianthum*	3.40		
30			*Tarenna supra-axilaris*	2.28	*Boscia filipes*	3.07		
31			*Combretum molle*	1.62	*Drypetes natalensis*	3.05		
32			*Burchellia bubalina*	1.39	*Hyperacanthus microphyllus*	2.83		
33			*Psydrax locuples*	1.39	*Vitex ferruginea*	2.07		
34			*Uvaria lucida*	1.29	*Eugenia natalitia*	1.75		
35			*Haplocoelum foliolosum*	1.25	*Uvaria caffra*	1.04		
36			*Balanites maughamii*	0.76	*Croton pseudopulchellus*	0.95		
37			*Brachylaena huillensis*	0.72	*Newtonia hildebrandtii*	0.85		
38			*Vepris lanceolata*	0.72				
39			*Acalypha glabrata*	0.35				

Table 15. The recent (within 12 months prior to the study) woody species canopy volume removal linked to elephant utilisation observed in the Woodland association of Tembe Elephant Park, northern Maputaland, KwaZulu-Natal, South Africa, in 2004. The woody species are ranked by canopy volume removal intensity at the vegetation unit level.

Utilisation rank	Recent canopy removal in the Closed Woodland Thicket (percentage of available canopy removed)		Recent canopy removal in the Closed Woodland on Clay (percentage of available canopy removed)		Recent canopy removal in the Closed Woodland on Sand (percentage of available canopy removed)		Recent canopy removal in the Open Woodland on Sand (percentage of available canopy removed)		Recent canopy removal in the Sparse Woodland on Sand (percentage of available canopy removed)	
1	*Grewia microthyrsa*	17.26	*Phyllanthus reticulatus*	94.50	*Brachylaena discolor*	58.13	*Commiphora neglecta*	26.90	*Dichrostachys cinerea*	0.72
2	*Afzelia quanzensis*	11.56	*Vitex ferruginea*	31.94	*Albizia versicolor*	21.99	*Cordia caffra*	17.50	*Terminalia sericea*	0.58
3	*Rothmania fischeri*	5.00	*Monodora junodii*	25.50	*Gardenia volkensii*	18.74	*Canthium setiflorum*	14.23	*Acacia burkei*	0.52
4	*Sclerocroton integerrimus*	2.50	*Clausena anisata*	20.08	*Ochna barbosae*	16.41	*Vangueria infausta*	10.91	*Strychnos spinosa*	0.30
5			*Vangueria infausta*	19.36	*Antidesma venosum*	15.77	*Brachylaena elliptica*	9.06		
6			*Erythroxylum delagoense*	18.43	*Chaetacme aristata*	14.67	*Zanthoxylum leprieuri*	8.77		
7			*Ochna barbosae*	12.73	*Hyperacanthus microphyllus*	10.30	*Acacia gerrardii*	7.31		
8			*Hyphaene coriacea*	11.15	*Vernonia colorata*	9.08	*Garcinia livingstonei*	7.28		
9			*Ochna natalitia*	10.05	*Sideroxylon inerme*	8.84	*Syzigium cordatum*	4.51		
10			*Berchemia zeyheri*	9.68	*Deinbollia oblongifolia*	8.41	*Dalbergia obovata*	2.99		
11			*Ptaeroxylon obliquum*	9.57	*Bridelia cathartica*	7.69	*Afzelia quanzensis*	2.99		
12			*Psydrax locuples*	8.77	*Balanites maughamii*	7.44	*Bridelia cathartica*	2.49		
13			*Ziziphus mucronata*	8.36	*Terminalia sericea*	7.04	*Vepris lanceolata*	2.36		
14			*Sclerocroton integerrimus*	7.53	*Strychnos spinosa*	5.89	*Acacia robusta*	2.29		
15			*Strychnos madagascariensis*	6.47	*Combretum molle*	5.80	*Ziziphus mucronata*	2.15		
16			*Euclea natalensis*	6.42	*Vangueria infausta*	5.19	*Strychnos madagascariensis*	1.72		
17			*Combretum molle*	6.10	*Erythroxylum delagoense*	4.34	*Terminalia sericea*	1.64		
18			*Pteleopsis myrtifolia*	5.77	*Ximenia caffra*	4.19	*Trichilia emetica*	1.41		
19			*Garcinia livingstonei*	5.40	*Psydrax locuples*	3.51	*Hymenocardia ulmoides*	1.07		
20			*Lantana rugosa*	5.00	*Dialium schlechteri*	3.03	*Antidesma venosum*	0.99		
21			*Zanthoxylum capense*	4.52	*Strychnos madagascariensis*	2.46	*Euclea natalensis*	0.83		
22			*Dialium schlechteri*	4.18	*Trichilia emetica*	2.37	*Sclerocarya birrea*	0.81		
23			*Diospyros inhacaensis*	4.15	*Acalypha sonderiana*	2.30	*Sclerocroton integerrimus*	0.74		
24			*Rhus gueinzii*	4.02	*Zanthoxylum capense*	2.23	*Combretum molle*	0.71		
25			*Sclerocarya birrea*	3.82	*Margaritaria discoidea*	1.78	*Strychnos spinosa*	0.57		
26			*Afzelia quanzensis*	3.54	*Afzelia quanzensis*	1.73	*Acacia burkei*	0.32		
27			*Tarenna supra-axilaris*	3.13	*Acacia burkei*	1.50	*Brachylaena discolor*	0.19		
28			*Haplocoelum foliolosum*	3.12	*Hymenocardia ulmoides*	1.24	*Catunaregam taylori*	0.11		
29			*Strychnos spinosa*	3.05	*Tabernaemontana elegans*	0.93	*Dichrostachys cinerea*	0.09		
30			*Croton pseudopulchellus*	2.94	*Canthium armatum*	0.78	*Albizia versicolor*	0.08		

Table 15 continued

31	*Manilkara discolor*	2.67	*Sclerocroton integerrimus*	0.74	*Mundulea sericea*	0.05
32	*Dichrostachys cinerea*	2.40	*Tricalysia lanceolata*	0.69		
33	*Elaeodendron transvalense*	2.27	*Tricalysia delagoensis*	0.53		
34	*Schotia brachypetala*	2.04	*Ziziphus mucronata*	0.41		
35	*Suregada africana*	1.72	*Spirostachys africana*	0.32		
36	*Warburgia salutaris*	1.66	*Strychnos decussata*	0.28		
37	*Vernonia colorata*	1.19	*Dichrostachys cinerea*	0.13		
38	*Catunaregam taylori*	1.15	*Vepris lanceolata*	0.13		
39	*Coddia rudis*	1.08	*Euclea natalensis*	0.04		
40	*Bridelia cathartica*	0.81	*Dalbergia obovata*	0.01		
41	*Vepris lanceolata*	0.69				
42	*Balanites maughamii*	0.66				
43	*Spirostachys africana*	0.59				
44	*Erythrococca berberidae*	0.57				
45	*Acacia burkei*	0.56				
46	*Acacia gerrardii*	0.54				
47	*Acalypha glabrata*	0.52				
48	*Terminalia sericea*	0.51				
49	*Canthium armatum*	0.45				
50	*Toddaliopsis bremekampii*	0.36				
51	*Tabernaemontana elegans*	0.21				
52	*Acacia robusta*	0.17				
53	*Suregada zanzibariensis*	0.09				
54	*Grewia spp.*	0.04				

Table 16. The old (more than 12 months prior to the study) woody species canopy volume removal linked to elephant utilisation observed in the Woodland association of Tembe Elephant Park, northern Maputaland, KwaZulu-Natal, South Africa, in 2004. The woody species are ranked by canopy volume removal intensity at the vegetation unit level.

Utilisation rank	Recent canopy removal in the Closed Woodland Thicket (percentage of available canopy removed)		Recent canopy removal in the Closed Woodland on Clay (percentage of available canopy removed)		Recent canopy removal in the Closed Woodland on Sand (percentage of available canopy removed)		Recent canopy removal in the Open Woodland on Sand (percentage of available canopy removed)		Recent canopy removal in the Sparse Woodland on Sand (percentage of available canopy removed)	
1	*Terminalia sericea*	76.22	*Mystroxylon aethiopicum*	80.09	*Albizia versicolor*	95.25	*Albizia versicolor*	70.87	*Vangueria infausta*	62.50
2	*Rhus gueinzii*	72.94	*Toddaliopsis bremekampii*	44.84	*Lannea antiscorbutica*	94.77	*Ximenia caffra*	70.64	*Strychnos spinosa*	61.40
3	*Albizia adianthifolia*	19.74	*Haplocoelum foliolosum*	37.40	*Terminalia sericea*	66.65	*Antidesma venosum*	45.33	*Terminalia sericea*	30.36
4	*Psydrax locuples*	18.36	*Trichilia emetica*	36.31	*Strychnos gerrardii*	64.74	*Trichilia emetica*	41.42	*Strychnos madagascariensis*	23.09
5	*Sclerocroton integerrimus*	16.33	*Grewia microthyrsa*	35.38	*Manilkara discolor*	62.50	*Canthium inerme*	37.49	*Ximenia caffra*	21.44
6	*Tabernaemontana elegans*	7.37	*Albizia versicolor*	34.91	*Dalbergia obovata*	62.10	*Zanthoxylum leprieuri*	30.06	*Albizia adianthifolia*	17.50
7	*Afzelia quanzensis*	5.29	*Manilkara discolor*	34.82	*Vangueria infausta*	49.39	*Ziziphus mucronata*	29.66	*Syzygium cordatum*	14.44
8	*Sclerocarya birrea*	4.51	*Pteleopsis myrtifolia*	32.99	*Cassipourea mossambicensis*	44.82	*Strychnos madagascariensis*	22.70	*Dialium schlechteri*	9.16
9	*Combretum molle*	1.89	*Ziziphus mucronata*	29.55	*Hymenocardia ulmoides*	44.27	*Acacia gerrardii*	22.65	*Acacia burkei*	0.32
10			*Elaeodendron croceum*	27.47	*Dovyalis longispina*	43.93	*Strychnos spinosa*	21.74	*Dichrostachys cinerea*	0.12
11			*Chaetacme aristata*	26.41	*Balanites maughamii*	37.48	*Peltophorum africanum*	21.37		
12			*Terminalia sericea*	24.73	*Brachylaena elliptica*	37.39	*Strychnos decussata*	19.36		
13			*Ehretia obtusiflora*	24.59	*Schotia brachypetala*	37.07	*Garcinia livingstonei*	18.19		
14			*Strychnos spinosa*	21.03	*Mystroxylon aethiopicum*	36.83	*Albizia adianthifolia*	18.01		
15			*Strychnos madagascariensis*	19.68	*Mundulea sericea*	35.05	*Rothmania fischeri*	17.50		
16			*Schotia brachypetala*	17.70	*Hyphaene coriacea*	32.56	*Bridelia micrantha*	17.50		
17			*Erythroxylum delagoense*	17.51	*Sclerocroton integerrimus*	30.22	*Vangueria infausta*	17.13		
18			*Cassipourea mossambicensis*	17.50	*Garcinia livingstonei*	27.21	*Terminalia sericea*	16.81		
19			*Euclea natalensis*	16.55	*Croton pseudopulchellus*	25.88	*Sclerocarya birrea*	16.21		
20			*Vernonia colorata*	16.31	*Kraussia floribunda*	25.85	*Sclerocroton integerrimus*	16.05		
21			*Grewia spp.*	14.96	*Tabernaemontana elegans*	25.68	*Acacia robusta*	14.83		
22			*Sclerocarya birrea*	14.66	*Vernonia colorata*	25.03	*Afzelia quanzensis*	14.07		
23			*Euclea divinorum*	13.16	*Diospyros inhacaensis*	23.84	*Dialium schlechteri*	13.79		
24			*Tabernaemontana elegans*	12.73	*Bridelia cathartica*	23.18	*Spirostachys africana*	13.36		
25			*Acacia gerrardii*	12.50	*Dichrostachys cinerea*	22.90	*Combretum molle*	12.58		
26			*Vangueria infausta*	12.43	*Rhus gueinzii*	22.36	*Tabernaemontana elegans*	11.72		
27			*Acacia robusta*	12.43	*Cola greenwayi*	20.94	*Psydrax locuples*	10.30		
28			*Boscia filipes*	12.41	*Pavetta gardenophylla*	20.38	*Acacia burkei*	8.25		
29			*Acacia burkei*	12.33	*Commiphora neglecta*	18.57	*Dichrostachys cinerea*	7.16		
30			*Acacia nilotica*	12.05	*Ozoroa englerii*	18.27	*Syzygium cordatum*	4.75		

Table 16 continued

31	*Combretum molle*	12.05	*Acalypha sonderiana*	17.43	*Hymenocardia ulmoides*	4.68
32	*Zanthoxylum capense*	11.83	*Strychnos spinosa*	17.32	*Grewia microthyrsa*	4.16
33	*Bridelia cathartica*	10.64	*Strychnos madagascariensis*	16.21	*Gardenia volkensii*	3.75
34	*Elaeodendron transvalense*	10.12	*Canthium setiflorum*	15.36	*Brachylaena discolor*	2.59
35	*Psydrax locuples*	10.09	*Acacia burkei*	15.09	*Mundulea sericea*	2.01
36	*STRY SPEC*	9.75	*Combretum molle*	15.03	*Euclea natalensis*	1.78
37	*Erythrococca berberidae*	9.19	*Ochna barbosae*	13.54	*Bridelia cathartica*	1.50
38	*Catunaregam taylori*	8.67	*Ziziphus mucronata*	13.17	*Vepris lanceolata*	1.44
39	*Garcinia livingstonei*	6.55	*Euclea natalensis*	13.06	*Combretum mkuzense*	0.96
40	*Ochna natalitia*	6.33	*Psydrax locuples*	13.03	*Ozoroa englerii*	0.90
41	*Croton pseudopulchellus*	5.90	*Ximenia caffra*	12.84	*Pteleopsis myrtifolia*	0.87
42	*Spirostachys africana*	5.84	*Sideroxylon inerme*	12.58	*Rhus gueinzii*	0.84
43	*Afzelia quanzensis*	5.72	*Trichilia emetica*	10.96	*Commiphora neglecta*	0.02
44	*Dichrostachys cinerea*	5.51	*Tricalysia delagoensis*	8.15		
45	*Ochna barbosae*	5.26	*Acacia robusta*	6.09		
46	*Ptaeroxylon obliquum*	4.88	*Lagynias lasiantha*	5.27		
47	*Balanites maughamii*	4.59	*Spirostachys africana*	3.82		
48	*Clerodendrum glabrum*	4.50	*Afzelia quanzensis*	3.75		
49	*Hymenocardia ulmoides*	4.40	*Margaritaria discoidea*	3.18		
50	*Dialium schlechteri*	4.17	*Albizia adianthifolia*	2.74		
51	*Suregada africana*	3.92	*Canthium armatum*	2.44		
52	*Strychnos decussata*	2.59	*Dialium schlechteri*	2.06		
53	*Canthium armatum*	2.34	*Vepris lanceolata*	1.90		
54	*Sclerocroton integerrimus*	2.23	*Craibia zimmermannii*	1.74		
55	*Rhus gueinzii*	2.19	*Erythroxylum delagoense*	1.43		
56	*Tarenna supra-axilaris*	2.03	*Chaetacme aristata*	1.22		
57	*Coddia rudis*	1.87	*Tricalysia lanceolata*	1.05		
58	*Sideroxylon inerme*	1.87	*Strychnos decussata*	0.91		
59	*Berchemia zeyheri*	1.75	*Sclerocarya birrea*	0.78		
60	*Clausena anisata*	1.35	*Zanthoxylum capense*	0.65		
61	*Acalypha glabrata*	1.01	*Rothmania fischeri*	0.57		
62	*Vepris lanceolata*	0.82	*Grewia microthyrsa*	0.17		
63	*Warburgia salutaris*	0.21				

heavily utilised in the Closed and Open Woodlands on Sand (> 70.00% canopy removal)

Discussion

The degree of utilisation of the vegetation by browsers in Tembe Elephant Park was rather intense. While elephant utilisation of trees is easily observed and has previously been recorded (Van Rensburg *et al.* 2000; Matthews 2006; Guldemond and Van Aarde In Press), browsing by medium and small herbivores in Tembe Elephant Park was equally intense, if not more so in some instances. However, with regards to canopy removal, there is a major difference in the way the agents affect the vegetation. While medium and small browsers utilise many of the available height classes, their actions leave little durable signs of utilisation as demonstrated by the decrease in old damage marks. The more permanent marks were some broken branches from animals such as kudu or nyala (van Eeden 2005). Elephants on the other hand leave a long-lasting mark on the vegetation. Elephants usually defoliate by breaking branches, and sometimes by breaking secondary or main stems, or even uprooting whole trees (O'Connor *et al.* 2007). These marks accumulate over time as evidenced by the higher percentage of height classes utilised in the old canopy removal.

In all Woodland vegetation units and to a lesser extent in the Sand Forest association, small and medium browsers utilised all individuals in a sizeable portion of the available height classes. Considering the size of these browsers, it is most likely that the height classes completely utilised are the smaller ones, especially those important for recruitment, such as seedlings and saplings. This could potentially limit future recruitment of woody species (Shaw *et al.* 2002; Western and Maitumo 2004), although the present study is not in measure to prove it.

The interesting question from the above is whether the utilisation levels are sustainable or not. Other studies have shown that herbivory by small mammals is usually not a limiting factor, although it may slow down regeneration in cases of high densities (Barnes 2001; Walpole *et al.* 2004; Western and Maitumo 2004). In Kenya, in the Masaai Mara National Reserve, 73% of woody species were utilised by small browsers, and although they were not believed to have an effect on regeneration, they were thought to be responsible for changes in species abundance, by facilitating some invasive species (Walpole *et al.* 2004). The levels of overall utilisation by small and medium browsers in Tembe Elephant Park are approaching such values, and therefore the risk that further small and medium browser population increases would lead to homogenisation of some vegetation units cannot be discarded. The homogenisation of

Open Woodlands through elephant action in Tembe Elephant Park is discussed by (Guldemond 2006) and the present study contends that this process could be aided by the current level of herbivory by small browsers.

Elephant utilisation, as is well known, can be destructive (O'Connor *et al.* 2007; Van Aarde and Jackson 2007). Elephants can shape landscapes and modify the ecological balance of an environment by removing trees, thus creating conditions more suitable for the herbaceous layer, which in turn becomes more fire-prone (Western and Maitumo 2004; Birkett and Stevens-Wood 2005; O'Connor *et al.* 2007). The implications of elephant utilisation are far reaching and need to be evaluated carefully when an environment has specific conservation needs. In the present study, elephants have removed some height classes for selected species completely. Unless the tree is completely uprooted and utilised, most tree species recover from the utilisation event, either by re-sprouting or coppicing. In time, the material removed during the utilisation event is usually replaced. A problem occurs when a subsequent utilisation happens before the previous one has been completely replaced. In that situation, the tree is under greater stress, and if the utilisation is repeated regularly, hedging occurs. The tree can be prevented from producing flowers and fruits in the normal way, and due to its reduced size, it becomes more susceptible to utilisation by other browsers or damage from fire (Styles and Skinner 2000; Barnes 2001; Bond and Loffell 2001; Birkett and Stevens-Wood 2005).

In the forest and possibly a closed woodland environment, canopy gaps are a driving mechanism for succession and are usually created through natural damage such as wind, lightning, or the fall of a large old tree (Brokaw and Busing 2000; Paul *et al.* 2004; Karlowski 2006). Depending on the size of the gap, it is subsequently re-colonised by pioneer or late secondary species favoured by the access to light (Babaasa *et al.* 2004; Karlowski 2006). In the case of Sand Forest, the constant occurrence of small canopy gaps is thought to be the way Sand Forest regenerates (Matthews 2006), and the sensitivity of Sand Forest is such that large gaps are thought to favour re-growth of a suite of species different from Sand Forest (Matthews 2006). Elephants are able to remove height classes of tall trees by pushing them over. Although the action can be likened to gap creation (O'Connor *et al.* 2007), the main difference lies in the frequency of the event. The present study shows that the scars of elephant utilisation events accumulate, or in other words that the interval between events is insufficient for the plants to recover. The elephant population in Tembe Elephant Park grows at a rate of 4.6% per year (Morley 2005), and unless management decisions are taken, the population will continue to grow until it

supposedly regulates itself (Van Aarde *et al.* 1999; Van Aarde and Jackson 2007). However, the level of self-regulation for Tembe Elephant Park is yet unknown. The present study therefore assumes that the elephant population will continue to grow, especially as the environment is suitable for young elephant growth (Mosugelo *et al.* 2002; Stokke and du Toit 2002; Smit *et al.* In Press), and becomes even more suitable as adult elephants push over more trees and stimulate re-growth at a low level (Stokke and du Toit 2002). With the current indication that utilisation events accumulate, and the above assumption with regards to elephant population growth, it appears straightforward that utilisation of vegetation by elephants will increase, and will become a problem as described for other areas (Western and Maitumo 2004; Van Aarde and Jackson 2007), if it has not already.

In an unfenced environment as idealised by the metapopulation concept, natural migratory movements of animal populations, following rainfall and food availability, should avail plants time to recover after an utilisation event (Van Aarde and Jackson 2007). Likewise, low animal population numbers should ensure that repeated use should be a rare event, and not the norm. However, in Tembe Elephant Park, the fences have restricted such migratory movements for elephants, and the size of the park does not allow simulated migratory movements for elephants (Van Aarde and Jackson 2007). It therefore appears logical that repeated utilisation events would occur. The implications in Tembe Elephant Park, especially in the Sand Forest, are that an abnormally high rate of canopy gaps are created, which is considered a threat to the Sand Forest conservation (Matthews 2006). Elephant damage in the woodland environment will probably lead to a succession towards a grassland environment. Elephant impact on woodlands in Tembe Elephant Park showed that elephants created a more heterogeneous Closed Woodland environment but homogenised the Open Woodland with a risk of forcing a succession towards Sparse Woodland (Guldemond and Van Aarde In Press). This risk is increased in Tembe Elephant Park by the presence of smaller browsers. Similar conditions have been shown to facilitate the succession from woodland to grassland in East Africa (Western and Maitumo 2004; Birkett and Stevens-Wood 2005).

The values for old canopy volume removal described in Table 12 reveal a change in utilisation levels of the 13 species described as most utilised in 1994. Apart from *Albizia versicolor*, for which canopy removal is extreme, most other species are now within group 3. Two possible explanations could be given, one option is that utilisation of these species has decreased altogether, while the other more plausible option would indicate that as abundance of these species has decreased due to

elephant utilisation since the 1994 study, and because of this lower abundance the utilisation has consequently become less. The purpose of the present paper is descriptive and a comparison of the results is not attempted here, however, the second option appears most likely as the abundance of some of the species utilised was documented as having fallen dramatically (see Chapters 6 and 7).

An interesting aspect in the present study is the intensity of utilisation-like events caused by natural damage. The latter, includes all natural phenomenon that can potentially break or even kill trees (wind, fire, lightning, moisture conditions, light conditions, disease, etc.), which are part of a natural system under normal conditions but also following some catastrophic events (Condit 1995; Whitmore and Burslem 1996; Lindenmayer *et al.* 2006). In the forests and woodlands of Tembe Elephant Park, it appears that utilisation-like events from natural damage affect a considerable number of species and also accumulate over time (Tables 2, 3, 4, 5) as in the case of animal utilisation (Kraft *et al.* 2004; Conybeare 2004; Sheil and Salim 2004). This accumulation is important in the Sand Forest and although lower in the woodlands, it remains a concern. In the Short Sand Forest, the percentage of available height classes removed completely nears 30.00% (Table 3). This value is extremely high for a vegetation type where wind should not have much effect due to the lack of tall trees that could break and fall, and where fire hardly occurs (Izidine *et al.* 2003; Matthews 2006). However, the abundance of plants and the height of this vegetation type make it particularly suited to elephant utilisation as has also been observed in Addo Elephant Park thicket vegetation (Lombard *et al.* 2001; Matthews 2006). In the present study the hypothesis is proposed that animals and elephants in fact induce some of the utilisation-like events contributed to natural damage.

Conclusion

An overview of the utilisation of woody vegetation in the Tembe elephant Park is presented. While the scope of this paper is descriptive, potentially serious problems are highlighted. In particular, it appears that elephant utilisation is creating gaps at an un-natural rhythm, and combined with intense herbivory from the smaller browsers, this process could force succession of Closed and Open Woodlands towards Sparse Woodlands, and Sand Forest towards Woodlands. While the gaps created by elephants are part of the natural dynamics of the vegetation of Maputaland, the current rate of disturbance appears alarmingly high as evidenced by the percentage of height classes that have been completely removed. The present study therefore concludes that elephant utilisation in Tembe Elephant Park is problematic, especially combined

with the current utilisation level of other browsing agents. Management authorities of Tembe Elephant Park are strongly advised to take measures in order to limit animal population growth, but also to force elephants out of sections of the park for periods long enough to allow a recovery of the vegetation to a level where canopy removed by utilisation is replaced before subsequent utilisation occurs.

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