EFFECTS OF DOMESTIC STOCK HERBIVORY IN THE BOSBERG AFROMONTANE FORESTS

[1]H.J. Herd and [2]L. H. Watson
[1]South African National Parks, Knysna
[2]Department of Nature Conservation, Nelson Mandela Metropolitan Municipality, Saasveld Campus, George

Abstract

The influence of domestic stock on rangeland has been extensively studied in a number of vegetation types. Indigenous forest has received little attention in this field of study. Afromontane forest occurring on stock farms is generally not fenced off and is divided into camps that are used as rangeland. A preliminary survey of Afromontane forest in Somerset East indicated that forest may be over-exploited by domestic stock. This survey indicated that in contrast to forests unused by domestic stock, forests used by domestic stock had substantially lower numbers of saplings and saplings had higher levels of browsing (Stiles, 2001). This study also indicated a significantly higher percentage of spinescent seedlings in the browsed plot. In an attempt to further understand the dynamics of the effects of domestic stock browsing on Afromontane forest, forest patches that were used and unused by domestic stock were identified. Using line transects, sampling was done in 400 m^2 plots. Plots were then evenly grouped into treatments based on their floristic composition and their susceptibility to browsing pressure. Statistical analysis revealed the following. The Afromontane forest patch treatment not used as rangeland generally had the highest species richness and species diversity. There was statistical significance in browsing intensity between the treatments, particularly so between the non-utilized forest treatment and the other five forest rangeland treatments, the non-utilized forest treatment revealing the lowest browse intensity.

1. Introduction

African forest patches extend from Central Africa to the southern Western Cape in South Africa in an Archipelago fashion (Donald & Theron, 1983). South Africa is largely a semi-arid region not endowed with a large area of indigenous forests, and forest consequently forms the smallest, most widely distributed and most fragmented biome in South Africa. Recent predictions estimate that this biome represents only 0.25% of South Africa's surface area (Midgley *et al*., 1997). These indigenous forest fragments grow on all geological formations within areas receiving mean annual rainfall of between 600mm and 2000mm and occur from sea level to over 2100 m above sea level (Geldenhuys, 2000).

South African forests are generally classified as temperate forests (Cowling, 2002), due to the fact that South African forests are mainly located south or north of the tropics of Capricorn and Cancer, respectively, and south of the conifer - dominated boreal forests in the Northern Hemisphere. Afromontane forests are usually fine grained, which means that they have a large number of seedlings and saplings (i.e. advanced regeneration), which establish and survive in the shade under the canopy (Midgley *et al*., 1992) until conditions arrive that allow colonization of the canopy. Most species occupying the canopy are present in the sub-canopy and do not need large-scale disturbance to maintain species diversity. Saplings are adapted to grow through various strata and are very slow-growing (Everard *et al*., 1994). In fine-grained forests most tree sspecies usually have an inverse J-shaped size-class distribution, indicating continuous regeneration (Veblen *et al*., 1981).

Where Afromontane forest occurs on stock farms in the Eastern Cape interior, they are generally not fenced off and are divided into camps and used as rangeland. The depletive effects of introduced ungulates colonizing an area of forest have been described in a number of papers around the world, for example, (Holloway, 1950; McKelvey, 1959; James & Wallis, 1969; Wallis & James, 1972; McKelvey, 1973, Mark & Baylis 1975) for forests in New Zealand. In a South African study, performed by Castley (1997) in Adelaide in the Eastern Cape, showed that grazing of forest fragments significantly reduces the capacity of these fragments to regenerate and that exclusion of domestic livestock from these fragments promoted vegetation recovery. Usually, the initial impact is the removal of highly palatable sub-canopy species from the tiers which ungulates can browse. Continued pressure from the browsing animals usually impairs the ability of some species to regenerate (e.g. Johnson, 1972; Veblen & Stewart, 1980) and results in their under-representation, particularly in the lower forest tiers (e.g., Wardle & Hayward, 1970; Wallis & James, 1972).

A preliminary survey by Stiles (2001) on the effects of domestic stock on Afromontane forest occurring on the slopes of the Bosberg mountains at Glen Avon stock farm in the Eastern Cape Province, South Africa, indicated that forest might be over-exploited by domestic stock. This survey indicated that in contrast to forest not utilized as rangeland, forests used by domestic stock had substantially lower densities of natural regeneration and a higher incidence of browsing (Stiles, 2001). This study also indicated a significantly higher percentage of spinescent regeneration in the browsed plot. These armed seedlings are also not representative of the canopy species, which is unusual for an Afromontane forest. We hypothesized that domestic stock browsing is an important factor influencing the composition and regeneration dynamics of tree species in unfenced Afromontane forest patches utilized as rangeland. We assumed that browsing intensity decreased inwards from the forest margin. Our study had the following objectives: (a) To determine if differences exist in species richness and species diversity of woody species in sites differing in browse intensity. (b) To determine whether browsing intensity differs in sites exposed to different levels of browsing.

2. Study area

A recent broad forest classification approach yielded a hierarchical system of seven groups comprising 20 zonal and intrazonal forest types (von Maltitz, 2002). The Bosberg forest (study site) falls within group IV, the southern mistbelt forest group, IV3: Amatole mistbelt forests, which form part of the Afromontane division. These forests comprise forest patches varying in size located along the main escarpment encompassing a large area spanning surroundings of Somerset East, Amatole mountains, scarps of Transkei and KwaZulu-Natal Midlands. Here they occur in fire-shadow habitats on south-facing and southeast-facing slopes at an altitude of 850-1600 meters. Study site 1 (Glen Avon stock farm) and 2 (Bosberg nature reserve - non-utilized forest treatment) are situated in the Eastern Cape Province, approximately 4 km east of Somerset East. Glen Avon covers an area of 1340 ha, and according to Acocks (1988) the vegetation consists mainly of Dohne sourveld on the highlands and eastern Cape false thornveld on the lowlands. Patches of Afromontane forest, exist in the wind-shadow areas of the mountain range. On the Main Escarpment (Amatole, Transkei-Escarpment and KwaZulu-Natal Midlands) these forests are tall (15–20 m tall), multi-layered (having two layers of trees, a dense shrubby understorey and a very well developed herb layer). The forest of low-lying scarps are low (in places having character of scrub forest), and although less structured into different tree layers, they are still very species-rich. The tall-grown forests show a mix of coarse grain, canopy gap/disturbance driven dynamics and fine-grained, regeneration characteristics (Geldenhuys, 1992). The Amatole mistbelt forests are dominated by emergent trees of *Podocarpus falcatus* and a range of deciduous and semi-deciduous species, such as *Celtis africana*, *Calodendrum capense*, *Vepris lanceolata* and *Zanthoxylum davyi*.

The mean annual rainfall is 620 mm. Temperatures in winter drop below 0ºC and reach 35ºC and above during summer. Incidence of heavy summer mist is a most striking climatic characteristic of these forests (Low & Rebelo, 1996). The soils are well-developed, deep, loamy and with high nutrient status - developed on weathered dolerite intrusions or mudstones, shales and sandstones of Balfour Formation .

3. Methods

3.1 Sampling design

Forests used and unused by small stock were identified from consultation with landowners/users in the study area. Forests were surveyed by means of random circular sample plots of 0.04ha in area. Plots were spaced at approximately 100 meter intervals along transects. Transects were spaced at 200m intervals along the slope gradient. Plots were located systematically in the adjacent nature reserve on areas selected for similar site and forest canopy characteristics as the stock farm plots. 17 plots were located in the Glen Avon forest and three comparable plots were located in the Bosberg nature reserve forest.

3.2 Field measurements

Within each plot:

1. Trees: All stems of ≥5 cm DBH (Diameter at Breast Height) were measured and recorded by species. Each stem of a multi-stemmed tree was recorded separately, but indicating that it belongs to the specific tree.
2. Saplings: All stems between 1cm and 4.9 cm DBH were recorded by species.
3. Seedlings: All stems less then 1cm DBH were recorded by species.

4. Trees and saplings were divided into functional categories (e.g. sub-canopy, canopy species)
5. The cover abundance of each woody species was estimated with the Braun-Blanquet scale (Mueller-Dombois & Ellenberg, 1974).
6. Ground flora: The cover abundance was recorded per growth form.
7. All woody plant species were examined for evidence of browsing and the proportion of shoots eaten from each sapling estimated with the use of the eight-point scale of Walker (1976).
8. Forest canopy height was estimated.
9. Height class of all trees, saplings and seedlings.
10. Coppice presence.
11. A general description was made. This included a list of species present. Site information recorded included the grid reference, altitude, aspect, slope and macro-geomorphology (mountain; foothill; river valley slope; and river valley floor). Micro geomorphology (crest; upper-slope; middle-slope; foot-slope; and valley bottom.
12. General: Conditions of sites, relevant for later interpretation, were recorded such as past disturbance, proximity from the forest edge, and specific prominent species.

3.3 Analysis

TWINSPAN [Two-Way Indicator Species Analysis (Hill 1979)] was used to group plots into communities. All statistical analyses were performed in Statistica 6.1 (Statsoft Inc., 2001). Data were arcsine transformed for analysis. The analysis of variance (ANOVA) in Statistica 6.1 was used to determine significant differences between the means of various parameters. Plots with similar floristic affinity and browse intensity that occurred in close proximity within a specific browse zone were therefore grouped into six treatments of three plots for further analysis. Seedling species in the height class one tier were left out of most analyses since most had recently germinated and had escaped herbivory. The Shannon diversity index was used to measure species diversity for each site (Zar, 1984). The two-factor ANOVA and Tukey multiple comparison tests (Zar, 1984) were used to test for significance between the means of various parameters of the six treatments.

4. Results and discussion

4.1 Species richness and diversity

4.1.1 <u>Seedlings</u>

28 species were recorded across all the treatments (Table 1). The most species rich treatment (nature reserve) , had 22 species, this was followed by the margin-top treatment with 20 species, then by the east and west-margin treatments with 16 species, 15 species were recorded in the core treatment and the margin-bottom treatment was the most species poor with 13 species. Five of these species were common to all six treatments (*Carissa bispinosa*, *Clausena anisata*, *Diospyros whyteana*, *Mystroxylon aethiopicum* and *Scutia myrtina*).

Three species, *Cassine peragua*, *Pittosporum viridiflorum* and *Maytenus acuminata* only occurred in the nature reserve. *Gymnosporia buxifolia* was the only species that occurred in all the treatments except for the nature reserve treatment. *Canthium inerme* and *Scolopia mundii*, *Celtis africana*, *Lauridia tetragona*, *Rapanea melanophloeos* and *Rhamnus prinoides* were present in all treatments but absent in the core, margin-east and margin-bottom respectively. *Olinea emarginata* and *Vepris lanceolata* only occurred in the margin-top and core respectively. *Podocarpus falcatus*, although occurring in three treatments, is very poorly represented in two of the treatments (margin-top and margin-west-1 specimen) except in the nature reserve treatment where twenty specimens were recorded. *Olea europaea* is similar, with three being recorded in the margin-top and twenty in the commonage.

The species diversity showed a similar trend between the treatments (Table 1). The nature reserve had the highest species diversity with a Shannon diversity index of 1.122, whilst the lowest diversity was recorded in the margin-west treatment (0.773). The margin-bottom was the next lowest with an index of 0.820 and the margin-top treatment had the second highest index at 1.068. The margin-east and core treatments had similar indices at 0.872 and 0.867 respectively.

Table 1. Numbers of seedlings recorded per species over treatments

Species	Nature Reserve	Core	Margin Bottom	Margin East Middle	Margin Top	Margin West Middle	All Treatments
Apodytes dimidiata	20	8		12			40
Buddleja salvifolia	8				39	6	53
Canthium inerme	52		2	28	39	80	201
Carissa bispinosa	12	12	8	20	12	91	155
Cassine peragua	8						8
Celtis africana	8	16	84		33	111	252
Clausena anisata	36	288	24	376	14	95	833
Diospyros whyteana	176	68	3	24	76	19	366
Dovyalis caffra	128	12		128	2		270
Euclea natalensis	12		2		1		15
Grewia occidentalis	32			12	1	12	57
Gymnosporia buxifolia		4	6	128	34	8	180
Hippobromus pauciflorus	8		24				32
Kiggelaria africana		4			4		8
Lauridia tetragona	184	32		108	83	164	571
Maytenus acuminata	4						4
Mystroxylon aethiopicum	32	64	4	36	16	1	153
Olea europaea	20				3		23
Olinea emarginata					2		2
Pittosporum viridiflorum	68						68
Podocarpus falcatus	20				1	1	22
Rapanea melanophloeos	68	28		4	9	66	175
Rhamnus prinoides	4	80		4	11	2	101
Rhus chirindensis			2	8			10
Scolopia mundii	48		6	4	68	767	893
Scutia myrtina	68	24	13	32	51	159	347
Vepris lanceolata		4					4
Zanthoxylum davyi		40	13	40		1	94
Total	**1016**	**684**	**191**	**964**	**499**	**1583**	**4937**
Mean/plot	**338.6**	**228.0**	**63.6**	**321.3**	**166.3**	**527.6**	**1645.6**
No. of species	**22**	**15**	**13**	**16**	**20**	**16**	**28**
Shannon diversity index	**1.122**	**0.867**	**0.820**	**0.872**	**1.068**	**0.773**	**1.145**

4.1.2 Saplings

Saplings were most species poor of the three growth stages (seedlings, saplings and trees). The species richness values across treatments show a similar trend to seedlings (Figure 1). 28 species were recorded across all the treatments (Table 2). The most species rich treatment, the nature reserve treatment, had 21 species which was followed by the core with 15 species, then the margin-top with 14 species, margin-east with 12 species, margin-west with 11 species and finally, the margin-bottom being the most species poor with nine species. Three species were common to all six treatments (*Canthium inerme*, *Diospyros whyteana* and *Scutia myrtina*). Four species, *Halleria lucida*, *Maytenus acuminata*, *Olinea emarginata* and *Euclea natalensis* only occurred in the nature reserve. *Elaeodendron croceum*, *Hippobromus pauciflorus* and *Zanthoxylum davyi* only occurred in the margin-east, margin-bottom and core respectively. Species that occurred in two treatments but which prevailed in the nature reserve were *Apodytes dimidiata*, *Kiggelaria africana* and *Rhus chirindensis*. *Rapanea melanophloeos*, although occurring in three treatments, could also be grouped here. *Gymnosporia buxifolia*, *Scolopia mundii* and *Mystroxylon aethiopicum* occurred in all the treatments except for the nature reserve, margin-east and margin-west respectively. *Clausena anisata*, very well represented as a seedling in the margin-east treatment, is absent from the margin-east as a sapling. *Podocarpus falcatus* only occurred in the core and margin-west.

The species diversity showed a similar trend between the treatments (Figure 2). The exception, being that the core treatment had the highest species diversity index (0.992), followed closely by the nature reserve (0.980). The margin-west followed this at 0.866, then the margin- top at 0.851, margin-bottom at 0.809 and finally the margin-east treatment showed the lowest index at 0.645.

4.1.3 Trees

The trees were most species rich and showed a similar trend to the seedlings and saplings across treatments (Figure 1). 28 species were recorded across all the treatments (Table 2). The most species rich treatment, the nature reserve, had 22 species, followed closely by the core with 21 species, the margin-east and margin-west came next with 19 species each, the margin-top had 18 species, and finally, the margin-bottom had the lowest species richness with 15 species. Of these species, eight were common to all six treatments (*Celtis africana*, *Diospyros whyteana*, *Mystroxylon aethiopicum*, *Olea europaea*, *Podocarpus falcatus*, *Rhus chirindensis*, *Scolopia mundii* and *Scutia myrtina*). One species, *Dovyalis rhamnoides,* only occurred in the nature reserve. *Carissa bispinosa*, although occurring in two treatments, could also be grouped here. *Hippobromus pauciflorus* only occurred in the margin-bottom treatment. *Apodytes dimidiata, Canthium inerme* and *Gymnosporia buxifolia, Grewia occidentalis* and *Maytenus acuminata* occurred in all the treatments except for the margin-top, nature reserve and margin-bottom respectively.

The species diversity showed a similar trend between the treatments (Figure 2), the nature reserve treatment again having the highest species diversity index at 1.119. An exception being that the margin-top's diversity index (2nd highest at 1.059) was higher than the core (1.049) even though the core had more species. This is most probably due to a higher stocking rate per species in the margin-top treatment. The same applied to margin-west (1.028) that had a higher index than margin-east (the lowest index at 0.791) even though both treatments had 19 species each. This is most likely due to the disproportionately high *Diospyros whyteana* occurrence in margin-east that accounts for a large proportion of the total tree count. The margin-bottom had the second lowest diversity at 0.955.

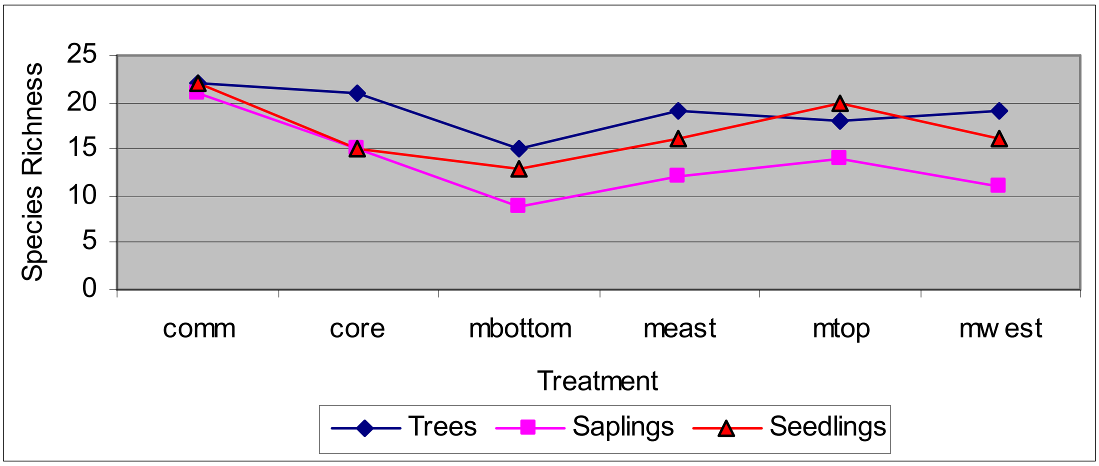

Figure 1. Species richness values over treatments.

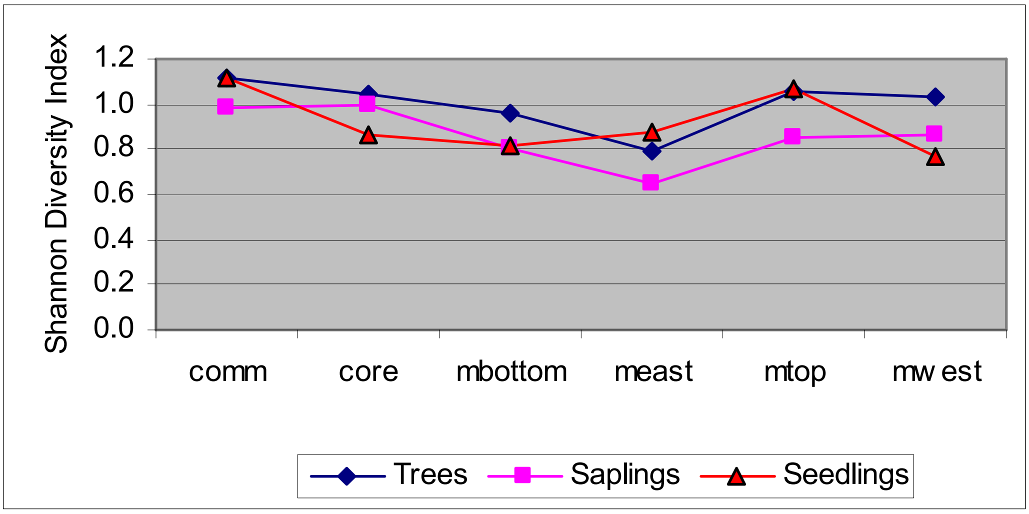

Figure 2. Shannon Weiner diversity index values over treatments.

Table 2. Numbers of saplings recorded per species over treatments

Species	Nature Reserve	Core	Margin Bottom	Margin East Middle	Margin Top	Margin West Middle	All Treatments
Apodytes dimidiata	5			1			6
Buddleja salvifolia	11	15			29	1	56
Canthium inerme	27	2	23	15	57	17	141
Carissa bispinosa	50	3			4	14	71
Celtis africana			1		6		7
Clausena anisata	3	14	2			1	20
Diospyros whyteana	147	19	1	62	17	16	262
Dovyalis caffra		2		6			8
Elaeodendron croceum				1			1
Grewia occidentalis	26	6		2		1	35
Gymnosporia buxifolia		3	3	2	1	1	10
Hallaria lucida	4						4
Heteromorpha trifoliata	2				4		6
Hippobromus pauciflorus			1				1
Kiggelaria africana	5				1		6
Lauridia tetragona	8			2	5		15
Maytenus acuminata	3						3
Mystroxylon aethiopicum	3	1	5	1	1		11
Olea europaea	1	1					2
Olinea emarginata	2						2
Podocarpus falcatus		1				6	7
Rapanea melanophloeos	18				1	2	21
Rhamnus prinoides	4	7		1	31		43
Rhus chirindensis	23			1			24
Scolopia mundii	30	2	4		9	11	56
Scutia myrtina	39	21	6	24	66	12	168
Euclea natalensis	2						2
Zanthoxylum davyi		11					11
Total	**413**	**108**	**46**	**118**	**232**	**82**	**999**
Mean per plot	**137.667**	**36.000**	**15.333**	**39.333**	**77.333**	**27.333**	**55.500**
Number of species	**21**	**15**	**9**	**12**	**14**	**11**	**28**
Shannon diversity index	**0.980**	**0.992**	**0.809**	**0.645**	**0.851**	**0.866**	**1.059**

Table 3. Numbers of trees recorded per species over treatments

Species	Nature Reserve	Core	Margin Bottom	Margin East Middle	Margin Top	Margin West Middle	All Treatments
Apodytes dimidiata	7	7	3	21		1	39
Buddleja salvifolia	12				16	15	43
Canthium inerme		2	11	4	44	16	77
Carissa bispinosa	11					1	12
Celtis africana	1	6	1	1	3	1	13
Clausena anisata	34	13	3	1			51
Cussonia spicata		1	8				9
Diospyros whyteana	72	59	21	156	35	58	401
Dovyalis caffra		1		9			10
Dovyalis rhamnoides	4						4
Euclea natalensis	1		4				5
Grewia occidentalis	7	1		1	5	1	15
Gymnosporia buxifolia		18	5	40	2	6	71
Hallaria lucida	11			1		4	16
Heteromorpha trifoliata	11	1		7	4		23
Hippobromus pauciflorus			9				9
Kiggelaria africana	10	2			14	10	36
Maytenus acuminata	5	5		6	3	9	28
Mystroxylon aethiopicum	7	12	36	33	4	3	95
Olea europaea	2	4	2	24	2	1	35
Olinea emarginata	8			1	4		13
Podocarpus falcatus	7	2	1	1	15	25	51
Rapanea melanophloeos	6	7			1	3	17
Rhamnus prinoides	5	13			30	6	54
Rhus chirindensis	35	4	40	2	9	31	121
Scolopia mundii	18	9	6	2	15	29	79
Scutia myrtina	52	35	33	9	36	42	207
Zanthoxylum davyi		4		1			5
Total	**326**	**206**	**183**	**320**	**242**	**262**	**1539**
Mean	**108.6**	**68.6**	**61.0**	**106.6**	**80.6**	**87.3**	**85.5**
Number of species	**22**	**21**	**15**	**19**	**18**	**19**	**28**
Shannon diversity index	**1.119**	**1.049**	**0.955**	**0.791**	**1.059**	**1.028**	**1.168**

4.2 Browsing intensity

4.2.1 Seedlings

Seedlings, and principally seedlings in the height class two and three (16cm – 100cm) tiers, were the most intensively browsed (Figure 3 & 4) growth stage over all treatments. This browse height preference is mentioned by other authors (Norton, 1995). Coppice shoots growing from the base of trees that were within this height class tier were also heavily browsed but since browsing intensity was determined as a percentage of the whole tree, this was of no consequence.

The nature reserve treatment had the lowest browse intensity (21.01%). The treatment with the highest browsing intensity was the margin-east (75.16%) followed closely by margin-bottom (74.32%). Margin-top and margin-west also had high browsing means at 69.6% and 69.37% respectively. The core had the 2nd lowest browse intensity at 53.51%. Significance in browsing intensity was found between the nature reserve (F = 13.17, P = 0.000) and four of the forest rangeland treatments (margin-bottom, margin-east margin-top and margin-west). Significance in browsing intensity was also found between the core (F = 13.17, P = 0.000) and three forest rangeland treatments (margin-bottom, margin-east and margin-top). There was no significant difference in browsing mean between the nature reserve and core treatments.

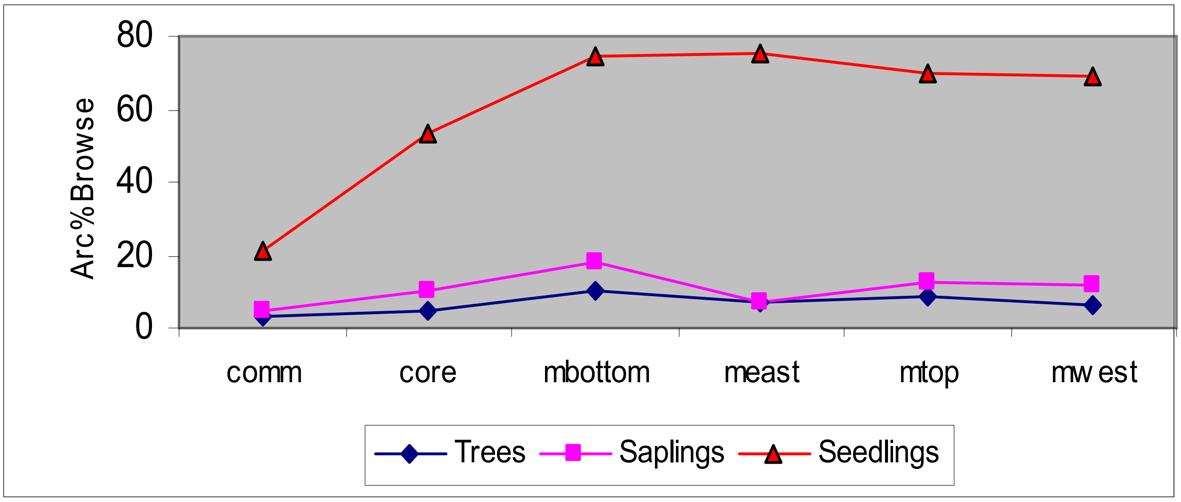

Figure 3. Browsing means over treatments.

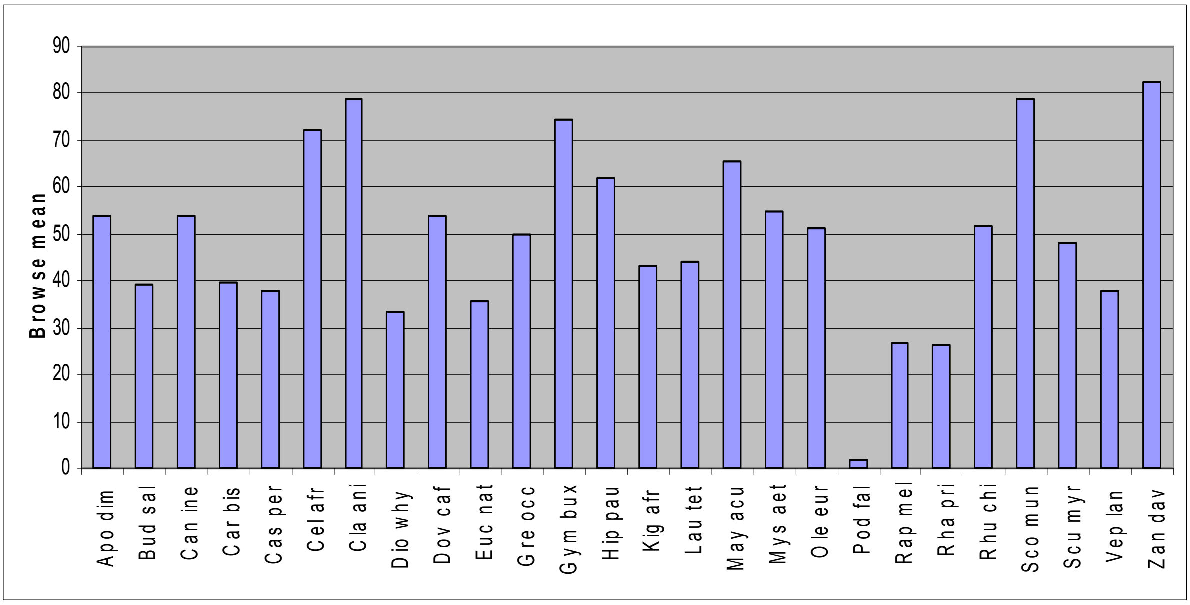

Figure 4. Browsing means of seedling species over all treatments.

The species with the highest mean browse (treatments combined) was *Zanthoxylum davyi* (Figure 4) at 83% and *Podocarpus falcatus* had the lowest browse intensity of 1.768% (Table 4). Other seedling species that were browsed heavily in order of intensity were *Scolopia mundii* (78.76%), *Clausena anisata* (78.66%), *Gymnosporia buxifolia* (74.53%), *Celtis africana* (72.18%), *Hippobromus pauciflorus* (61.88 %), *Mystroxylon aethiopicum* (54.09%), *Canthium inerme* (54.12%), *Apodytes dimidiata* (54.09%), *Dovyalis caffra* (53.79%) and *Rhus chirindensis* (51.57%). Apart from *Podocarpus falcatus*, other lightly browsed species were *Rhamnus prinoides* (26.49%), *Rapanea melanophloeos* (26.68%) and *Diospyros whyteana* (33.52%).

Table 4. Seedling browsing means over treatments

Species	Nature Reserve	Core	Margin Bottom	Margin East Middle	Margin Top	Margin West Middle	All Treatments
Apodytes dimidiata	41.48	51.10		77.10			54.09
Buddleja salvifolia	25.10				44.08	25.70	39.14
Canthium inerme	26.12		90.00	68.36	70.74	58.34	54.12
Carissa bispinosa	0.00	8.37	56.90	67.26	73.78	36.69	39.52
Cassine peragua	38.00						38.00
Celtis africana	25.10	41.90	76.96		77.57	74.71	72.18
Clausena anisata	17.13	79.26	77.23	85.18	82.60	74.16	78.66
Diospyros whyteana	21.90	27.61	52.23	23.75	60.20	65.01	33.52
Dovyalis caffra	28.36	46.73		79.30	90.00		53.79
Euclea natalensis	30.43		64.80		38.00		35.52
Grewia occidentalis	29.73			64.07	90.00	85.70	49.80
Gymnosporia buxifolia		0.00	48.07	77.50	79.52	62.93	74.53
Hippobromus pauciflorus	0.00		82.51				61.88
Kiggelaria africana		0.00			86.78		43.39
Lauridia tetragona	11.35	40.96		53.40	77.83	58.52	44.17
Maytenus acuminata	65.70						65.70
Mystroxylon aethiopicum	52.13	35.68	64.00	75.70	89.19	38.00	54.89
Olea europaea	45.82				85.70		51.02
Olinea emarginata					90.00		90.00
Pittosporum viridiflorum	0.00						0.00
Podocarpus falcatus	0.00				14.20	25.10	1.79
Rapanea melanophloeos	17.46	22.39		25.10	34.14	37.09	26.68
Rhamnus prinoides	25.10	27.17		0.00	36.54	0.00	26.49
Rhus chirindensis			77.85	45.00			51.57
Scolopia mundii	39.09		77.10	90.00	84.19	80.71	78.76
Scutia myrtina	13.79	23.97	56.99	61.61	57.72	59.46	47.91
Vepris lanceolata		38.00					38.00
Zanthoxylum davyi		75.92	82.41	88.71		77.10	82.27
MEAN	21.01	53.51	74.32	75.16	69.60	69.37	58.57

The highest browsing intensity is concentrated in the height classes two and three (16cm – 100cm) tiers (Figure 5) with browse intensities of 64.7% and 59.29% respectively. However, in the commonage height class three (27.24%) is more heavily browsed than height class two (17.80%). The lowest browse intensity was found in the height class 1 layer (0-15cm) since many seedlings had recently germinated and had escaped herbivory. The browsing values for height class two and three show a similar trend across individual treatments and treatments combined. Browsing intensity decreases abruptly from height class four. An exception is margin-east and margin-bottom that have relatively high browse intensities for seedlings in the height class four layer.

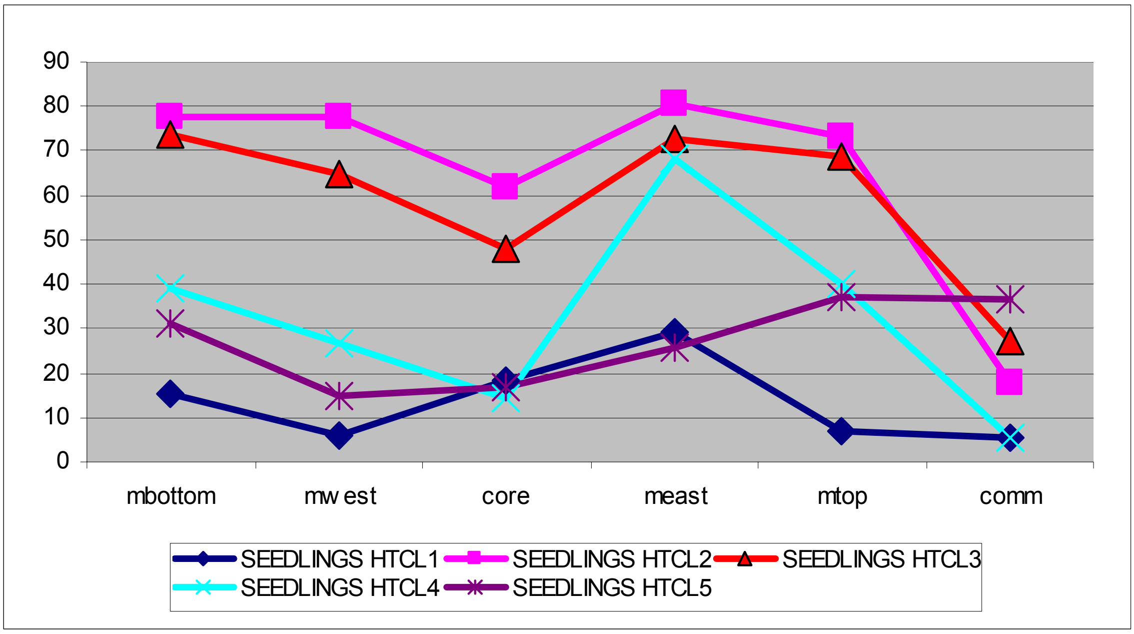

Figure 5. Browsing means over treatments (individual height classes).

4.2.2 Saplings

Saplings were not nearly as intensely browsed as seedlings and showed more resemblance to trees. For instance, in the margin-east treatment, the mean browse of trees (7.13%) is almost equal to the sapling browse mean of 7.35% (Figure 3). A probable reason for this similarity in browsing intensity is that 82% of the saplings fall within height class six, the level in which trees occur and therefore mostly out of reach for most mammalian browsers. Browsing intensity, as with seedlings, decreases with increasing height. Height class three (Figure 7) had the highest mean browse (38.5%) but saplings in this height class were rare and only seven specimens were recorded across all treatments. Height class four had the next highest browse intensity at 29.26% (Figure 7) followed by height class five (11.47%) and finally by height class six (7.31%). Height class two was represented by only one sapling, a *Diospyros whyteana* in margin-east. There is a sudden decrease in browse intensity between height class four and five. Species (Table 5 and Figure 6) with the higher mean browse levels (treatments combined) in descending order were *Hippobromus pauciflorus* at 25.1%, followed closely by *Grewia occidentalis* (24.67%) and Celtis africana at 22.43%. Five species (*Apodytes dimidiata*, *Elaeodendron croceum*, *Olea europaea*, *Euclea natalensis*, *Zanthoxylum davyi*) showed no signs of browsing. However, the occurrence of these unbrowsed species was rare which would aid in escape from herbivory. Apart from the five unbrowsed species, other lightly browsed species were *Rhus chirindensis* (0.59%), *Podocarpus falcatus* (2.03%), *Diospyros whyteana* (3.4%), *Lauridia tetragona* (3.79%), *Dovyalis caffra*, (4.91%) and *Carissa bispinosa* at 6.84%.

The nature reserve treatment (Figure 3 and 7) had the lowest browse intensity (5%) and the treatment with the highest browsing intensity was the margin-bottom (17.67%) followed by margin-top (12.71%) and margin-west was next at 11.43%. The core had the 3rd lowest browse intensity at 10.16% and margin-east had the 2nd lowest browse intensity at 7.35%. Significance in browsing intensity was found between the nature reserve (F = 16.567, P = 0.000) and four of the forest rangeland treatments (margin-bottom, core, margin-top and margin-west). Significance in browsing intensity was also found between the margin-east and margin-top, margin-east and margin-bottom (F = 16.567, P = 0.02) treatments. There was no significant difference in browsing mean between the nature reserve and the margin-east treatment.

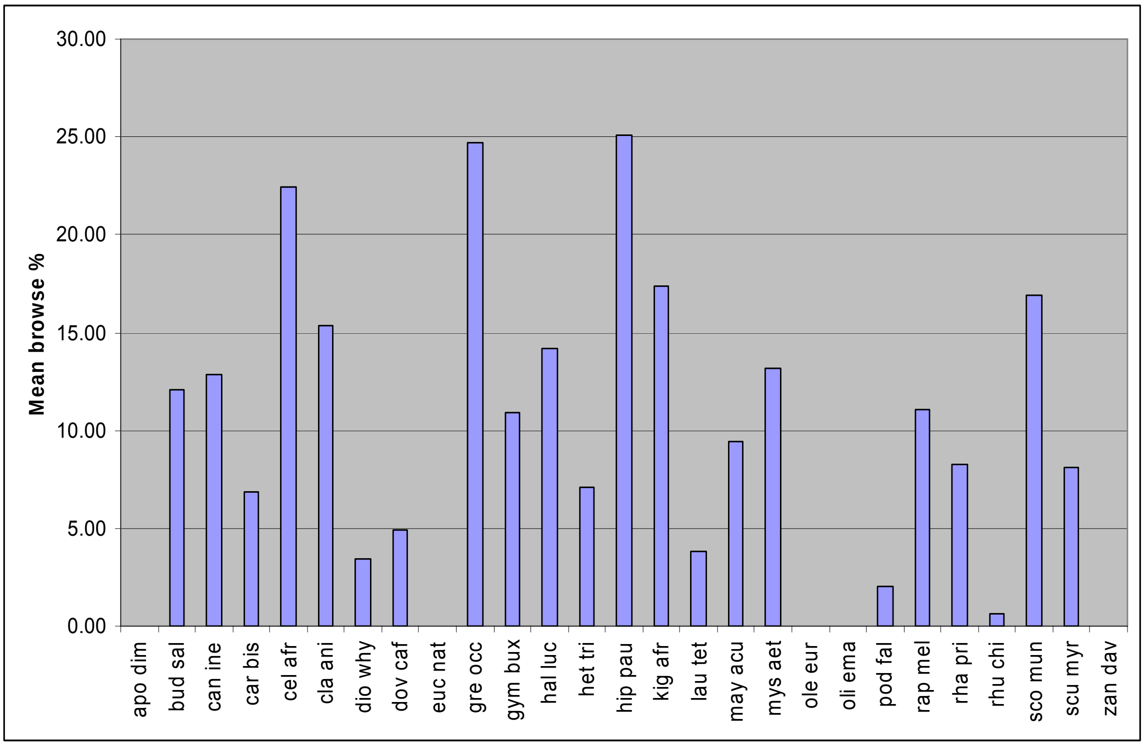

Figure 6. Browsing means of sapling species over all treatments.

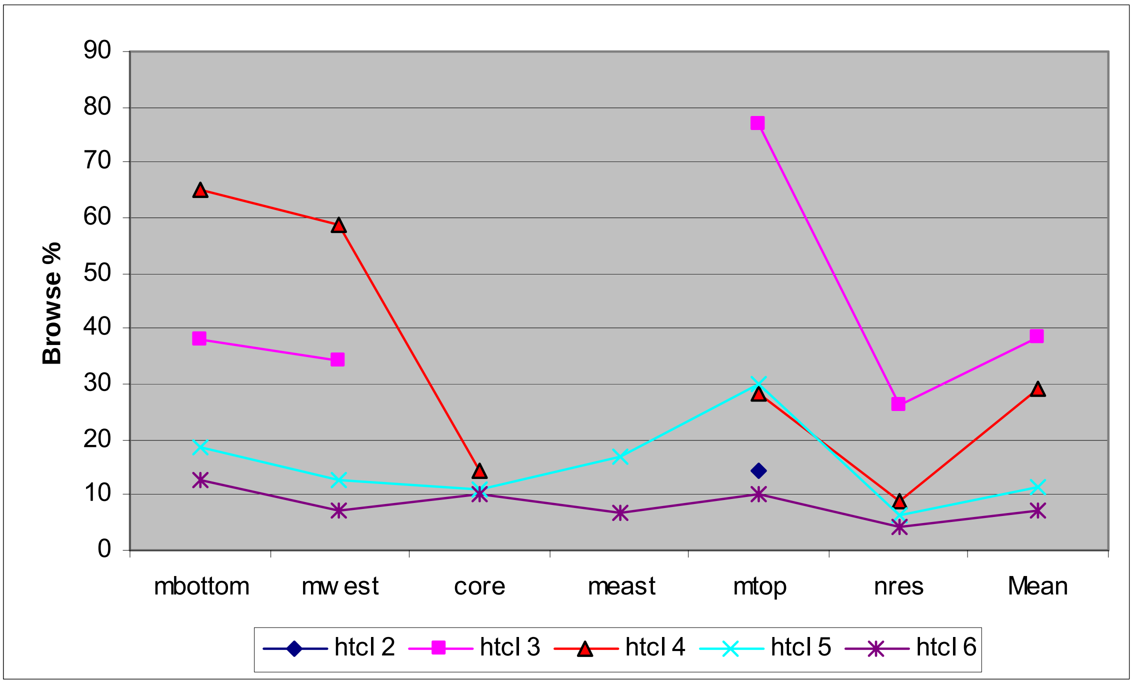

Figure 7. Browsing means of sapling species over treatments (individual height classes).

Table 5. Sapling browsing means over treatments

Species	Nature Reserve	Core	Margin Bottom	Margin East Middle	Margin Top	Margin West Middle	All Treatments
Apodytes dimidiata	0.00			0.00			0.00
Buddleja salvifolia	18.55	6.41			12.91	0.00	9.47
Canthium inerme	5.26	7.10	21.56	15.85	12.10	14.03	12.65
Carissa bispinosa	3.86	14.20			19.65	12.24	12.49
Celtis africana			0.00		26.17		13.08
Clausena anisata	0.00	15.50	45.00			0.00	15.13
Diospyros whyteana	1.64	4.48	14.20	4.70	11.83	3.55	6.73
Dovyalis caffra		12.55		2.37			7.46
Elaeodendron croceum				0.00			0.00
Grewia occidentalis	17.38	60.27		12.55		25.10	28.82
Gymnosporia buxifolia		9.47	22.23	7.10	0.00	0.00	7.76
Hallaria lucida	14.20						14.20
hettri	0.00				10.65		5.32
Hippobromus pauciflorus			25.10				25.10
Kiggelaria africana	2.84				90.00		46.42
Lauridia tetragona	0.00			7.10	8.52		5.21
Maytenus acuminata	9.47						9.47
Mystroxylon aethiopicum	12.67	0.00	13.54	14.20	25.10		13.10
Olea europaea	0.00	0.00					0.00
Olinea emarginata	0.00						0.00
Podocarpus falcatus		0.00				2.37	1.18
Rapanea melanophloeos	8.66				77.10	0.00	28.59
Rhamnus prinoides	6.28	16.84		14.20	6.41		10.93
Rhus chirindensis	0.00			14.20			7.10
Scolopia mundii	7.20	26.10	0.00		30.57	36.59	20.09
Scutia myrtina	7.67	2.70	8.92	9.47	10.56	2.37	6.95
Euclea natalensis	0.00						0.00
Zanthoxylum davyi		0.00					0.00
MEAN	**5.00**	**10.16**	**17.67**	**7.35**	**12.71**	**11.43**	**8.73**

5. Summary and conclusion

Internationally, the depletive effects of introduced ungulates colonizing an area of forest have been described in a number of papers, for example, (Holloway, 1950; Wallis & James, 1972). In South Africa, studies on browsing in forest vegetation are scant. Moll (1983) disclosed that the full impact of grazing in forests is also not fully understood because it has never been adequately studied. A preliminary survey of Afromontane forest in Somerset East indicated that forest might be over-exploited by domestic stock (Stiles, 2001).

The preliminary results of this paper suggest that forest exposed to differing levels of browsing may lead to a drop or increase in woody species richness and diversity. Although local environmental factors may influence forest species dynamics, it appears that forest seedlings and saplings exposed to very intense levels of herbivory are poorer in terms of species richness and diversity. Although not tested statistically yet, the more intensively browsed forest treatments also reveal much lower numbers of seedlings and saplings, particularly when compared to the least intensively browsed treatments. Of particular concern is the very low number of saplings occurring in treatments exposed to high herbivory. Since seedlings are numerous in the smallest size class there seems to be a bottleneck in reaching the sapling stage. This study indicated that seedlings in the 16cm-100 cm tiers were the most intensively browsed and this is very possibly where the bottleneck begins. Moreover, saplings had the lowest species richness and diversity possibly indicating that the future canopy species richness will be negatively affected. Most seedling and sapling species are browsed upon at varying intensities but it has not yet been determined statistically whether there are significant species preferences and whether these preferred seedling species are significantly less abundant.

In summary then it can be stated that the preliminary results of this study showed that domestic stock herbivory is affecting the species composition and structure of forest, which in turn could lead to environmental problems for small stock farmers in the sense that vital forest ecosystem services may be impaired.

References

ACOCKS, J.P.H. (1988). *Veld Types of South Africa*. Memoirs of the Botanical Survey of South Africa 57. National Botanical Institute, Pretoria.

CASTLEY, J.G. (1997). Vertebrate diversity in the indigenous forests of the Eastern Cape. PhD Thesis, University of Port Elizabeth, Port Elizabeth.

COWLING, R.M. (2002). Our Surprising Forests. *Veld and Flora* 88(2): 48

DONALD, D.G.M. & THERON, J.M. (1983). Temperate broad - leaved evergreen forests of Africa south of the Sahara. In: OVINGTON J.D. (ed.). *Temperate Broadleaved Evergreen Forests.* Elsevier Science Publishers, Amsterdam. pp135 – 168.

EVERARD, D.A., VAN WYK, G.F., & MIDGLEY, J.J. (1994). Disturbance and the diversity of forests in Natal, South Africa: Lessons for their utilization. *Strelitzia* 1: 275-285.

GELDENHUYS, C.J. (1992). Cyclic regeneration of canopy species in Groenkop forest, southern Cape. Unpublished report, CSIR, Pretoria.

GELDENHUYS, C.J. (2000). Classification and distribution of forests and woodlands in South Africa. In: Owen, D.L. & Vermeulen, W.J. (eds.). *South African Forestry Handbook 2000*, Vol 2, The Southern African Institute of Forestry, Pretoria. pp. 591-599.

HILL, M.O. (1979). *Twinspan: A Fortran Program for Arranging Multivariate Data in an Ordered Two-Way Table by Classification of the Individuals and the Attributes*, Cornell University, New York.

HOLLOWAY, J.T. (1950). Deer and the forests of Western Southland. *New Zealand Journal of Forestry* 6: 123-37.

JAMES, I. L. & WALLIS, F. P. (1969). A comparative study of the effects of introduced mammals on Nothofagus forest at Lake Waikareiti. *Proceedings of the New Zealand Ecological Society* 16: 1-6.

JOHNSON, P. N. (1972). Applied ecological studies of shoreline vegetation at Lakes Manapouri and Te Anau, Fiordland. Part I: Vegetation of Lake Manapouri shoreline. *Proceedings of the New Zealand Ecological Society* 19: 102-119.

LOW, B. & REBELO, A.G. (1996). *Vegetation of South Africa, Lesotho and Swaziland*. Department of Environmental Affairs and Tourism, Pretoria.

MARK, A.F. & BAYLIS, G.T.S. (1975). Impact of deer on Secretary Island, Fiordland, New Zealand. *Proceedings of the New Zealand Ecological Society* 22: 19-24.

MCKELVEY, P. J. (1959). Animal damage in North Island protection forests, *New Zealand Science Review* 17: 28-34.

MCKELVEY, P. J. (1973). The pattern of the Urewera forests. New Zealand Forest Service, Forest Research Institute, *Technical Paper* No. 59. 48pp.

MIDGLEY, J.J. (1992). Aspects of the dynamics of the high forest at Langebos (Alexandria forest type). *South African Forestry Journal* 161: 19-22.

MIDGLEY, J.J., COWLING, R.M., SEYDACK, A.H.W. & VAN WYK, G.F. (1997). Forest. In: COWLING, R.M. (ed.). *Vegetation of Southern Africa.* Cambridge University Press, Cape Town. pp.278 – 299.

MOLL, E.J. (1983). The southern cape forests. *Southern African Forestry Journal*. 127: 31-34.

MUELLER-DOMBOIS, D. & ELLENBERG, H. (1974). *Aims and Methods of Vegetation Ecology*. Wiley and Sons, New York.

NORTON, D.A. (1995). Vegetation on goat-free islands in a low-alpine lake, Paparoa Range, and implications for monitoring goat control operations. *New Zealand Journal of Ecology* 19(1): 67-72.

SHONE, AK. (1985). Indigenous Forests. *Forestry in Transkei*. The Department of Agriculture and Forestry. Republic of South Africa. pp. 23-26.

STILES, J.G. (2001). The influence of domestic stock browsing on forest saplings in Afromontane forest in the Eastern Cape. Unpublished project report. Saasveld Campus, Port Elizabeth Technikon.

VEBLEN, T. T. & STEWART, G. H. (1980). Comparison of forest structure and regeneration on Bench and Stewart Islands, New Zealand. *New Zealand Journal of Ecology* 3: 50-68.

VEBLEN, T.T., DONOSO, C., SCHLEGEL, F.M. & ESCOBAR, B., (1981). Forest dynamics in south-central Chile. *Journal of Biogeography* 8: 211–247.

VEBLEN, T.T. & STEWART, G.H. (1982). On the conifer regeneration gap in New Zealand: The dynamics of *Libocedrus bidwillii* stands on South Island. *Journal of Ecology* 70: 413-436.

VON MALTITZ, G., MUCINA, L., GELDENHUYS, C., LAWES, M., EELEY, H., ADIE, H., VINK, D., FLEMING, G. & BAILEY, C. (2003). Classification system for South African indigenous forests. An objective classification for the Department of Water Affairs and Forestry. Environmentek Report ENV-P-C 2003-017. CSIR, Pretoria. 275 pp.

WALKER, B. H. (1976). An approach to the monitoring of changes in the composition and utilization of woodland and savanna vegetation. *Southern African Journal of Wildlife Research* 6(1): 1-32.

WALLIS, F. R. & JAMES, I. L. (1972). Introduced animal effects and erosion phenomena in the northern Urewera forests. *New Zealand Journal of Forestry* 17: 21-36.

WARDLE, J. & HAYWARD, J. (1970). The forests and scrublands of the Taramakau and the effects of browsing by deer and chamois. *Proceedings of the New Zealand Ecological Society* 17: 80-91.

ZAR, J. H., (1984). *Biostatistical Analysis*. Prentice-Hall, New Jersey.