THE PLANT COMMUNITIES OF THE ANDOVER GAME RESERVE, SOUTH AFRICA

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ABSTRACT

Floristic characteristics of the Andover Game Reserve (AGR) were surveyed using an area-based survey technique and classified according to the data recorded from 88 relevés, using the PHYTOTAB-PC software package. Three plant communities, of which two each contain two variants, were described and mapped. The plant communities and their causative environmental factors were validated through detrended- and canonical correspondence multivariate analyses. The plant communities of the AGR were found to typify the floristics associated with the catenal sequences located in undulating areas on granite. Broad-leaved savanna is located at the crest and upper mid-slopes while fine-leaved savanna occurs along the footslopes of the AGR. Seeplines, a characteristic occurrence along catenas, are found at the transitional zone between the upper broad- and lower fine-leaved savanna plant communities. This study forms the basis for the compilation of a revised ecological management plan for the Andover Game Reserve.

Keywords: Plant communities, PHYTOTAB-PC, catena, savanna, granitic soils

Protected areas have been set aside for the protection of natural resources and to perpetuate the natural conditions (Visser *et al.* 1996) that are necessary for the continued existence of these systems. Management, in this context, is the practice by which that purpose is realised (Pyle 1980). For the effective management of any natural area a comprehensive description or base line study is of paramount importance (Barrett *et al.* 2006; Brown & Bezuidenhout 2000; Brown *et al.* 2005; Coombes & Mentis 1992; Reilly & MacFadyen 1992) as management decisions are based on a comprehensive understanding of the potential of an area. Management of a conservation area starts once the area has been defined on a map (Spinage 1979). Bredenkamp and Brown (2001) emphasised the use of plant communities as a reliable basis for ecological planning and management. This paper aims to describe the plant communities of the Andover Game Reserve (AGR), South Africa, and forms a critical part in the compilation of a revised ecological management plan for the reserve.

STUDY AREA

The AGR is situated between the southern latitudes 24˚ 33′ and 24˚ 38′ and eastern longitudes 31˚ 10′ and 31˚ 17′, and encompasses an area of 7 100 ha. The AGR is approximately 20 km southwest of the Orpen gate of the Kruger National Park. The physiography is characterised by an undulating landscape with interspersed drainages and upper landscapes arranged predominantly from a westerly to an easterly direction. The AGR is located within the Bushveld Lowveld region of the revised Köppen climate classification (Kruger 2004; Schulze 1994) and receives a mean annual precipitation of 782.9 mm (AGROMET 1996). Mean daily maximum temperatures in January and July are 31.7 ˚C and 24 ˚C, with the mean daily minimum being 20.1 ˚C and 9.2 ˚C for the same periods, respectively (AGROMET 1996). The geology of the Pilgrim's Rest area, which includes the Lowveld, has been described by Walraven (1989). The AGR is situated on the Swazian basement complex, which consists predominantly of gneisses and granites. The north-western section of the AGR comprises grey to pale-brown, medium- to course-grained quartz-feldspar-biotite gneiss with subordinate mafic to ultramafic xenoliths. The south-eastern section of the AGR consists of Makhutswi gneiss, which is light-grey, medium-grained biotite gneiss with course-grained quartz-feldspar leucosomes (Walraven 1986). The reserve incorporates a combination of two Veld Types, namely Veld Type 10 or Lowveld and Veld Type 11, also known as Arid Lowveld (Acocks 1988), and collectively described by Driver *et al.* (2005) as Granite Lowveld Bushveld. Recently this area has been described as the Granite Lowveld by Mucina and Rutherford (2006).

METHODS

The level of detail required from a particular study, determines the working scale or associated sampling scale, which in turn determines the smallest mappable unit area both in terms of field procedures and cartography (Rutherford & Westfall 1986). Pressey and Bedward (1991) and Panagos (1995) illustrated the effect of different scales on the same data set, where at so-called coarse scales the data set showed fewer groups than when classified for finer scales. Panagos (1995) and Westfall *et al.* (1996) recommend a sampling scale of 1:12 000 for areas less than 10 000 ha in extent. A recent (1996) monochrome 1:60 000 aerial photograph was used to construct a photographic mosaic that was then enlarged to a scale of approximately 1:13 000. The photographic mosaic was stratified into eight relatively homogeneous areas using a method that involved the recognition of pattern based on texture and grey values (Cronje 2004; Panagos *et al.* 1998). The number of sampling quadrats positioned in each homogeneous unit depended on the size of

the area: the larger the area the higher the number of sampling quadrats allocated to the unit. A minimum of four sampling quadrats was allocated to the smaller homogeneous units to maximise detection of variability. The sampling quadrat area was set at 200 m^2 (10 m x 20 m), relative to the sampling scale (Westfall *et al*. 1997). This quadrat size has become established as an optimised area for savanna (Boucher & Jarman 1977; Bredenkamp 1975; Panagos *et al*. 1998; Panagos & Reilly 2006; Theron 1973; van Rooyen 1983; Werger 1974). A total of 88 quadrats were subjectively placed throughout the homogeneous strata as identified on the aerial photographic mosaic. Relevés were located in the field using a Global Positioning System (GPS), the aerial photographic mosaic and a topographic map (Cronje 2004).

Each relevé was geo-referenced using a GPS and the environmental factors recorded at each quadrat included: topographic unit (*i.e.* crest, mid-slope, footslope, riverine); slope in degrees (estimated); aspect in degrees, with the aid of a compass; soil form, with diagnostic horizons identified up to a depth of 1.2 m according to MacVicar *et al*. (1991); soil characteristics were classified (sandy, loam or clay) based on a texture analysis using the 'sausage test' (Brady 1984); and the visual occurrence of fire and any other noticeable disturbances.

The floristic parameters recorded at each quadrat were species composition, growth forms (tree, shrub, dwarf shrub, grass, and forb) according to Edwards (1983) and Westfall (1992), and canopy cover determined with the use of the Plant Number Scale (Westfall & Panagos 1988; Westfall *et al*. 1996.) A community composition analysis (Panagos *et al*. 1998; Westfall *et al*. 1996) was carried out for each community and variant. It entailed calculating the projected canopy cover-to-frequency ratios of species in five growth form classes (tree, shrub, dwarf shrub, grass, and forb) using PHYTOTAB-PC (Westfall 1992). A linear relation between cover and frequency is assumed and the expected cover for the actual frequency of each species in a community is calculated according to the linear regressions. Three distinct groups are formed *i.e.* those with a higher cover and those with a lower cover than the standard error of the mean. The third group of species falls between the first two groups. The first group is referred to as strong competitor species because of the high individual resource-space requirements and the second group is called weak competitor species because of the low individual resource-space requirements. The third group is termed normal competitor species. Plant species nomenclature followed that of the National Herbarium, Pretoria (Germishuizen & Meyer 2003).

The floristic data were classified using the PHYTOTAB-PC program package (Westfall 1992, Westfall *et al*. 1997) and the resultant plant communities were validated using a Detrended Correspondence Analysis (DCA) using the CANOCO software package (ter Braak & Šmilauer 1998). A Canonical Correspondence Analysis (CCA) (ter Braak & Šmilauer 1998) was used to validate floristic and environmental relations.

RESULTS

Classification

A total of 333 plant taxa were recorded in three main plant communities, with the first two plant communities each having

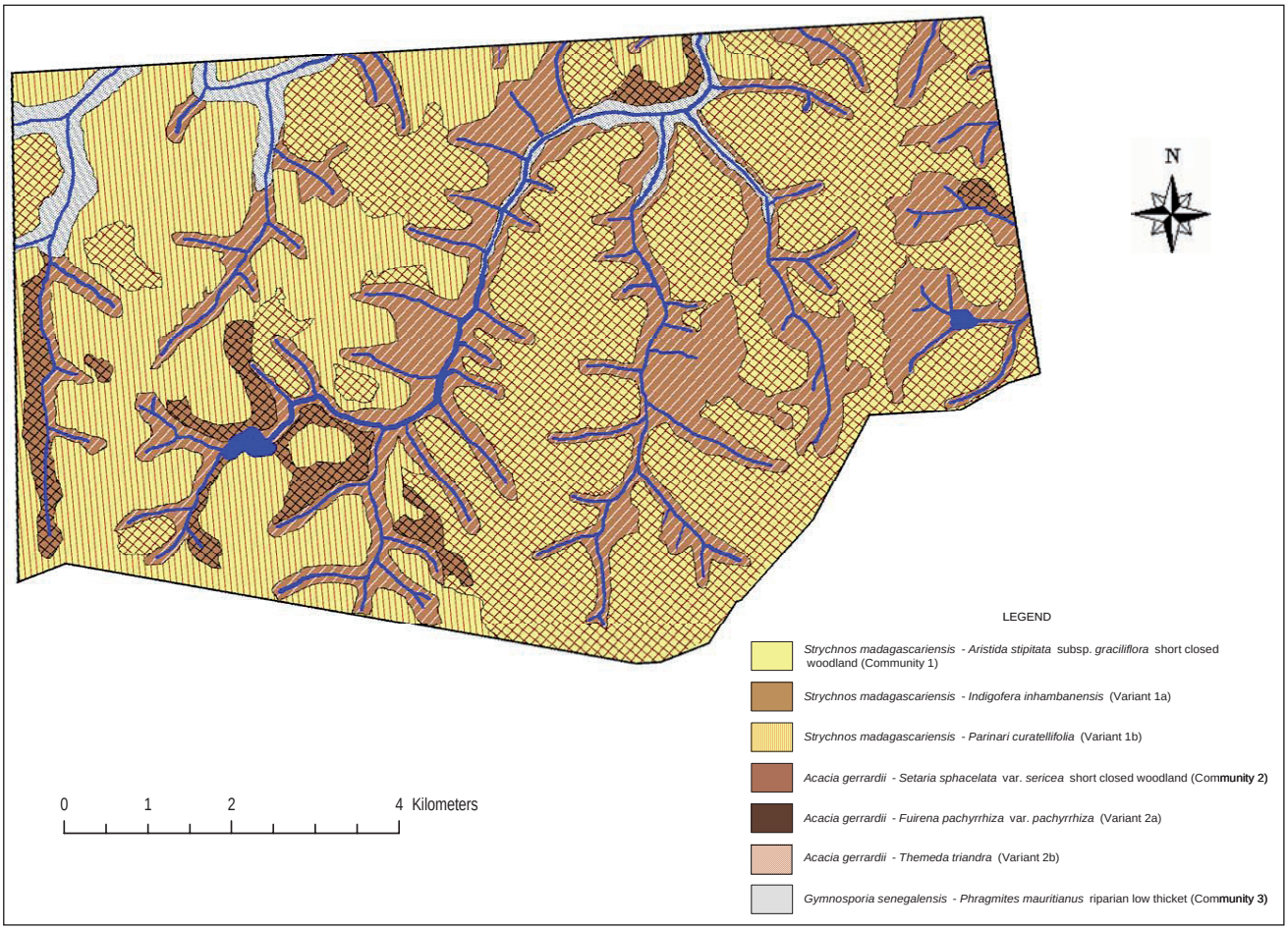

FIGURE 1
Plant communities of the Andover Game Reserve

TABLE 1
Phytosociological classification of the vegetation of the Andover Game Reserve

COMMUNITIES	1		2		3
VARIANTS	1a	1b	2a	2b	
RELEVÉ NUMBER	4 6 2 1 1 8 7 1 2 5 3 1 2 1 2 1 1 4 3 2 2 5 7 3 6 2 3 7	6 5 3 1 7 4 4 3 7 6 2 3 3 4 5 7 2 3 2 6	1 4 4 4 4 1 3 6	6 7 4 7 8 8 5 5 8 7 5 5 5 6 8 7 6 5 6	8 8 8 8
	5 3 4 8 7 4 7 1 2 8 3 3 9 3 6 8 6 2 4 0 4 2 5 6 5 0 1 8 1 7 3 6 7	2 0 8 1 2 3 6 7 4 9 9 0 9 9 2 5 7 5 1 5	2 9 0 2 8 4 7 5 1 4 3 8	6 0 1 6 3 0 8 5 1 9 4 7 6 0 2 3 1 9 4	8 7 5 6
Species group A: Diagnostic species of the *Strychnos madagascariensis - Aristida stipitata* var. *graciliflora* short closed woodland (Community 1)					
Strychnos madagascariensis	1 1 1 2 + 1 1 1 + 1 + + 4 1 + + + 4 + 1 + +	1 + + 1 1 1 1 1 + 3 1 +			
Limeum viscosum	2 5 1 1 3 1 1 + 3 1 2 1 1 2 1 + 1 1 1 1 5 2 2 2 +	+ 2 2 1 1 1 1 1			
Aristida stipitata subsp. *graciliflora*	1 2 1 2 2 + 2 1 1 1 1 1 1 1 3 2 2 1	2 1 2 2 1 1			
Macrotyloma axillare var. *axillare*	+ + 3 1 2 1 1 + 2 1 + + 1 1 1 1 + +	+ 2 2			
Philenoptera violacea	1 + + + 1 + 1 1 1 + 1 + 1 1 + 1	1 1 + +			
Hermbstaedtia odorata	+ + + + + + + + 1 1 1 1 1	+ 1 + + 1			
Strychnos spinosa	+ + 1 1 1 1 + + 4 2 + 1 +	+ 1 +		+	
Crotalaria schinzii	1 1 + 2 1 1 1 1 1 + + 1	+ 1 1 2			
Cleome monophylla	+ + 2 1 1 2 + + 1 + 1 +	1 3 1 1	1		
Rhynchosia totta var. *totta*	1 1 + 1 1 1 +	1 3 + 1			
Tephrosia longipes	3 2 3 + 6 1 +	1 1 +			
Sesamum alatum	+ + 1 1 + + 1 1	1 1			
Hermannia glanduligera	+ 2 + 1 1 +	1 1 + 1		2	
Indigofera daleoides var. *daleiodes*	1 3 1 1 1 5	1 1	1	1	
Crotalaria burkeana	+ + 2 1 + +	+ 1			
Eragrostis lehmanniana	1 + 1 1 2 1	1 1			
Wahlenbergia banksiana	2 4 2	1 J 2			
Commelina forskaolii	+ 1 2 1	1 2		+	
Oxygonum dregeanum subsp. *canescens*	2 1 + 1	1 1			
Oldenlandia affinis subsp. *fugax*	+ 2 + 1	1 +			
Pseudognaphalium oligandrum	1 + +	1			+
Species group B: Diagnostic species of the *Strychnos madagascariensis - Indigofera inhambanensis* Variant 1a					
Indigofera inhambanensis	2 2 1 1 2 2 1 + + 6 1 2 2 + 3 1 1 + + +				
Crotolaria sphaerocarpa	1 1 + 1 1 1 + 1 + 1 + + 2 1 1 1 +	+			
Leucas neuflizeana	+ 1 1 5 1 1 2 + 1 1 1 1 + + 1 1 1	1	1		
Indigofera astragalina	3 1 2 1 + 1 2 3 4 1 2 2 + + 1 2 1				
Kohautia caespitosa subsp. *brachyloba*	1 1 + 1 1 1 2 1 2 1 1 1				
Indigofera charlieriana var. *charlieriana*	1 1 1 2 + 1 2 + + 1 1 2	+			
Leonotis nepetifolia	1 1 1 1 1 2 2 + 1 1			1	
Chamaecrista biensis	+ + 1 1 + + + 2				
Hermannia quartiniana	2 + + + 1 + 1 1			+	
Zornia milneana	1 + 1 + 2 + 2 +	1			
Helichrysum candolleanum	+ + + 1 +			+	
Dicoma macrocephala	+ 1 1 +				
Hemizygia petrensis	2 1 2 1				
Eragrostis aspersa	1 1 1 +				
Helichrysum sp.	+ + 1 +				
Aristida meridionalis	+ 3 2 1	1			
Ficus thonningii	+ + +				
Commelina benghalensis	2 1 1				
Tephrosia villosa subsp. *ehrenbergiana*	+ + 2				

TABLE 1 (cont...)

COMMUNITIES	1		2		3
VARIANTS	1a	1b	2a	2b	
RELEVÉ NUMBER	4 6 2 1 1 8 7 1 2 5 3 1 2 1 2 1 1 4 3 2 2 5 7 3 6 2 3 7	6 5 3 1 7 4 4 3 7 6 2 3 3 4 5 7 2 3 2 6	1 4 4 4 4 1 3 6	6 7 4 7 8 8 5 5 8 7 5 5 5 6 8 7 6 5 6	8 8 8 8
	5 3 4 8 7 4 7 1 2 8 3 3 9 3 6 8 6 2 4 0 4 2 5 6 5 0 1 8 1 7 3 6 7	2 0 8 1 2 3 6 7 4 9 9 0 9 9 2 5 7 5 1 5	2 9 0 2 8 4 7 5 1 4 3 8	6 0 1 6 3 0 8 5 1 9 4 7 6 0 2 3 1 9 4	8 7 5 6
Stiga asiatica	1 + +				
Acanthospermum hispidum	+ + 1				
Annona senegalensis	+ 1 1				
Ficus stuhlmannii	1 1 +	+			
Hibiscus cannabinus	+ + 1				+
Jatropha spicata	+ +				
Monechma debile	2 2				
Cucumis zeyheri	+ +				
Schizachyrium jeffreysii	2 2	+			
Pterocarpus angolensis	1 +				
Sida alba	1 1				
Species group C: Diagnostic species of the *Strychnos madagascariensis - Parinari curatellifolia* Variant 1b					
Pterocarpus rotundifolia	+	+ + 1 1 +			
Hypericum lalandii		1 3 1			
Antidesma venosum	+	+ +			
Parinari curatellifolia		1 +			
Setaria sphacelata var. *sericea*		1 2			
Momordica balsamina		+ 1			1
Tephrosia rhodesica var. *rhodesica*		3 1			
Zinnia peruviana		+ 1			
Paspalum scrobiculatum		4 1			
Crotalaria lanceolata subsp. *lanceolata*		+ 2			
Species group D: Diagnostic species of the *Acacia gerrardii - Setaria sphecelata* var. *sericea* short closed woodland (Community 2)					
Acacia gerrardii		+	+ 1 1 5 5 1 + 1 1 +	3 9 A 1 5 5 6 6 4 8 7 6 A 5 4 C 8 3	+
Combretum hereroense			4 + 1 2 + + G	3 5 5 B 3 6 4 L 1 5 4 4 A 6 1 7 +	6 + +
Setaria sphacelata var. *sphacelata*			9 3 2 8	3 E 2 9 A 5 7 8 4 9 3 4 A 7 1 1	
Chaetacanthus setiger			3 3	5 3 1 4 + 2 6 1 8 3 2 4 5 5 7 2 A	1
Justicia protracta subsp. *rodesiana*		2	1 1	1 5 2 1 2 2 1 3 + 2 +	
Vernonia oligocephala			1 1 + +	2 + 3 1 + 2 + +	
Diheteropogon amplectens	4	+	2 3 + 2 2	3 2 1 8	
Helichrysum oxyphyllum		1	+ 2	+ 2 1 + 1 +	+
Louditia flavida			1 1	3 1 4 1 9 1	
Bothriochloa insculpta			1 1 +	+ + 2 1	1
Brachiaria xantholeuca			2 6 1	2 + 1	1
Murdannia simplex			1 1 1	2 1 1	
Kyllinga alba	+		1 + 1 1	1	2
Abutilon austro-africanum			1 2	+ 1	
Chloris virgata		1	1	1 1 +	
Solanum catombelense		+	1	+ + +	
Species group E: Diagnostic species of the *Acacia gerrardii - Fuirena pachyrrhiza* var. *pachyrrhiza* Variant 2a					
Fuirena pachyrrhiza var. *pachyrrhiza*		+ 2 A 9 2 E	4 1 1 1 4 3 1 3	4	
Vahlia capensis subsp. *valgaris* var. *vulgaris*		4 1 4	1 6 4 2 + 2	1	

TABLE 1 (cont...)

COMMUNITIES	1																																																					2																															3			
VARIANTS	1a																																	1b																				2a												2b																						
RELEVÉ NUMBER	4	6	2	1	1	8		7	1	2	5	3		1	2		1	2	1	1	4	3			2	2	5	7	3	6	2	3	7	6	5	3	1	7	4	4	3	7	6	2	3	3	4	5	7	2	3	2	6		1	4	4	4		4	1		3		6	6	7	4	7	8	8	5	5	8	7	5	5	5	6	8	7	6	5	6	8	8	8	8
	5	3	4	8	7	4	7	1	2	8	3	3	9	3	6	8	6	2	4	0	4	2	5	6	5	0	1	8	1	7	3	6	7	2	0	8	1	2	3	6	7	4	9	9	0	9	9	2	5	7	5	1	5	2	9	0	2	8	4	7	5	1	4	3	8	6	0	1	6	3	0	8	5	1	9	4	7	6	0	2	3	1	9	4	8	7	5	6
Brachiaria brizantha																																	1																5	2										2				1																								
Alysicarpus vaginalis var. *vaginalis*							+																														1																	1					3					1																							
Species group F: Diagnostic species of the *Acacia gerrardii* - *Themeda triandra* Variant 2b																																																																																										
Blepharis integrifolia var. *integrifolia*																																																																			3	+	+	+	2	1		1	1	+	+	1	1	+						
Themeda triandra																																																																						2	2	1		+	4	1	+	2		3		+	1		3		
Grewia bicolor																																																					1												1	1	1		1			+				+	+		+			+		1		+		
Ormocarpum trichocarpum	1																																																		+				+															+			+	1			1	+		+			+	+	1		+		
Microchloa caffra																																																																					1		1	1				2	2	2	6									
Plectroniella armata																									1																1																										2	+		+										+			+	+	+			
Pappea capensis																																																																				+					+									+	+		+				
Asparagus buchananii																																																																					+				+		+			+	+										
Tragia rupestris																																																					1																			1	1				1	1	+									
Gardenia volkensii																																																																					+				+							1		+	+						
Panicum coloratum																																																		+																												2		2	+	2						2	
Ipomoea obscura var. *obscura*																																																				+																		1				+						+		+						
Sporobolus nitens																																																					2			3																					+	2					2		2				
Acacia burkei																																																							+												6		+							+	1											
Abildgaardia trifolia																																																																												3	6	1		2									
Cymbopogon excavatus																																		+																																						3			2	+			2										
Buchnera sp.																																																																								+	1				+													
Indigofera sp.																																																																										3					+		1							1		
Barleria saxatilis														1																																																										+		1			1											
Eriochloa stapfiana																																																																										1		2	6												
Ledebouria sp.																																																																				1	+		1																	
Aloe marlothii																																																																			+						+	1														
Commiphora schimperi																																																	+																		1	1																+					
Hibiscus pusillus																																																					2																									1	1	2										
Acacia caffra																																																																											1						+								
Enteropogon monostachyus subsp. *africanus*																																																																																		4	8					
Zanthoxylum capense																																																																																1	+				+			
Orthosiphon suffrutescens																																																																								1							5							5		
Kalanchoe rotundifolia																																																																																		1	+					
Thesium pallidum																																																																						1	+																			
Species group G: Species common to Community 1 and Variant 2a																																																																																								
Hyperthelia dissoluta	H	H				2	A	F	4	+		8	9	5	2	B	+				C				8	8	4	H	1	1	1	G	8	7		2	C	1	6	L	9	1	+		I	F	9	7	1	B	D	8		9			6		J	5	D	G	6	F																								
Dicerocaryum senecioides	2	+	2	1	2	2	1	1	+	1	1	1	1		1	1		1	1		1	+	1		2	+		1	2		3	1	+	+	+	2	2		1	2		1	1		1	2			+		1	+		2			1			1		1																										
Hibiscus sp.	1	1	9		1		2		1	2	2	1	2	+	7	3	2	2	2	1	8		1	+		1	1	4			2	A	1	1	+		C	1		1					3	1	3	1	2	2		1		1			3			3	4	2																										
Chamaecrista absus	5		4	3	9	1	1	1		5	7		6	1	4	+	1	9	1	C	1	1	3	9		2	+	3	6	7	7	1	+			8		+	1	1	2	1	7	3						+		+								1					+				1																					
Tricliceras laceratum	2	1	1	1	3	1	1	1	+	1	+		+		1				1			1	+	1	1			1	+		+	1		+		1				2	+	1	1		+					1				1										1																								
Senna petersiana		+					+	+		1				1			+		1	+			2		1			+	1		1			+			1		1	1	+	1	1	+	1	1	+		+			+		2					2		+				1																							
Cynodon dactylon	2		4	1	1	1			2		2						3	9			8			1				2			2	2	1	1		1			E			1	5			2			3			C		1	1		2			G	5																											6
Lobelia erinus						1	1					1				+					2				1	1		+				2					2									+		1	1		1	1		1			1			1		2		1	+																				+			

TABLE 1 (cont...)

COMMUNITIES	1		2		3
VARIANTS	1a	1b	2a	2b	
RELEVÉ NUMBER	4 6 2 1 1 8 7 1 2 5 3 1 2 1 2 1 1 4 3 2 2 5 7 3 6 2 3 7	6 5 3 1 7 4 4 3 7 6 2 3 3 4 5 7 2 3 2 6	1 4 4 4 4 1 3 6	6 7 4 7 8 8 5 5 8 7 5 5 5 6 8 7 6 5 6	8 8 8 8
	5 3 4 8 7 4 7 1 2 8 3 3 9 3 6 8 6 2 4 0 4 2 5 6 5 0 1 8 1 7 3 6 7	2 0 8 1 2 3 6 7 4 9 9 0 9 9 2 5 7 5 1 5	2 9 0 2 8 4 7 5 1 4 3 8	6 0 1 6 3 0 8 5 1 9 4 7 6 0 2 3 1 9 4	8 7 5 6
Phyllanthus reticulatus	1 + + 1 1 + + 1 +	+ 1 1 + 1 2 + 1	2 1		3
Cyperus indecorus var. *indecorus*	1 + 1 1 1 1 1 1 1	1 2 + 1	1 1 1 1	1	
Piliostigma thonningii	+ + + + 1 1	+ + 2 1	1 + + 1 +		
Gomphocarpus fruticosus	1 2 + 1 1	1 +	+ 1		
Species group H: Species common to Variant 1b and Community 2					
Eragrostis inamoena	1	4 + 6 3 2	1 1 2 B	1 4 + 1 +	2
Cyperus denudatus	1	2 1 6 7	1 2 5 6 2 8 1	3 + 2	
Acacia swazica		+ +	+ + 1 + 9	1 2 2 4 G 1	
Pyrostria hystrix		+ +	+	1 1 + + + + + 1 + 1	
Carissa edulis		+ 1 +	1 + + +	+ + + + +	+
Carissa bispinosa		+ + + +	+	+ 1 + + + 1	
Heliotropium ovalifolium		1 +	1 2 1 +	+ + 1 1	
Eragrostis trichophora		1 1		+ + + + 1	
Species group I: Species common to Community 1 and 2					
Waltheria indica	2 1 1 3 2 3 3 4 1 1 1 8 1 2 2 1 1 1 1 + 3 4 1 + 1 4 2 + 8 7 4 1 1	3 2 2 1 2 3 2 2 2 1 1 4 1 4 + 2 2 2 2 1	2 2 1 3 5 1 1 2 2 2 1 1	1 4 2 1 3 1 1 + 1 2 1 + 1 + 1 1 2 + +	
Pogonarthria squarrosa	1 1 3 4 1 4 1 1 2 3 1 3 1 2 2 1 1 2 2 2 3 3 2 1 3 4 2 2 5 5 2 4 2	8 1 3 4 1 2 2 1 3 1 1 2 3 4 1 2 2 2 2	1 1 2 3 1 2 2 2 2 + 1	5 5 4 2 1 1 1 1 1 1 + 1 + 2 1	+
Terminalia sericea	6 A E 5 6 2 I 9 4 9 + H B 9 5 7 2 L 3 4 7 K 9 9 9 7 C Q D 6 5	1 1 3 C + 4 4 O J 1 A 6 6 C O 4 I F B	4 1 + 2 4 + 2 1 1 1 1	1 1 1 5 3 + + 2 + + +	+
Digitaria eriantha	2 2 4 3 2 3 1 3 5 3 3 1 2 1 6 2 5 2 3 1 3 5 1 2 + 2 5 J 9 2 1	4 4 3 3 1 5 5 2 3 1 4 1 2 3 8	3 5 1 3 1 3 1 3	2 3 1 2 3 9 8 1 B 4 4 6 3 1 2 1 1	2
Eragrostis rigidior	1 + 2 1 3 + 1 1 3 2 2 + 1 2 1 1 1 5 2 + 2 + 1 2 1 2 1 1 1	2 1 1 1 2 1 1 3 2 1 1 2 1 1	1 1 2 2 3 2 + 1 +	1 2 1 2 + 1 2 2 1 1 3 3 3 1 + 2 + 1	+
Perotis patens	2 2 8 A A I 1 1 2 8 1 5 2 1 6 1 1 2 1 3 9 2 1 3 4 2 2 6 3 1 5 3 1	A 2 6 2 1 9 1 1 3 2 2 2 1 1 1 2 3 1 1	1 3 4 1 1 1	1 1 2 1 2 + + 1	
Chamaecrista mimosoides	1 1 1 1 1 1 1 2 1 2 3 2 1 + 1 1 1 1 1 1 1 1 + 1 + 1 1 1 2 2 1	1 1 7 2 1 1 1 1 1 3 1 + 1 1 + 1 1	3 + 1 1 + 2 1 3 3 1	1 1 1 1 + 1 1	
Bulbostylis contexta	5 6 2 A 6 2 6 3 1 3 3 3 2 1 4 1 2 2 2 6 4 3 3 7 4 2 2 2	1 + 2 7 7 3 2 4 1 3 2 3 + 2 1 1	4 5 F 1 5 F 3 K 3 1	3 4 2 8 3 4 1 1 1 1 2	
Agathisanthemum bojeri subsp. *bojeri*	5 + 1 + 1 + + + + 2 1 6 + 1 1 1 7 1 1 + 1 G 7	2 1 1 9 1 2 2 1 2 2 2 5 5 7 8 2	1 + 3 A 3 1 2 8 3 + 2	1 6 4 2 3 2 5 + 1 1 2 3 2	1
Trichneura grandiglumis	2 1 2 3 2 2 1 + 1 2 2 2 2 2 3 1 1 2 3 5 1 + 1 4 1 2 2 2 1 3 2	6 1 6 1 1 4 1 3 1 1 1 1 2 1	1 1 1 1 1 3 + 1 1	3 1 1 2	
Sclerocarya birrea subsp. *caffra*	1 1 1 + 4 3 7 3 + 1 4 2 3 1 2 + 1 1 1 + 1 1 1 + 1 + 1 +	+ + 1 + + 1 + 1 1 + 1 1 + + + + + 1	+ + 1 + +	+ 1 + + + + +	+
Vernonia steetziana	2 1 D 8 C 5 3 5 1 3 2 5 2 4 5 2 1 F 6 B 7 2 6 + 3 2 3 F 5 B 8 +	2 + 7 1 1 1 3 2 4 3 1 1 + 1 2 1	+ 2 1 1	7 1 + 1 + 1	
Merremia tridentata subsp. *angustifolia*	6 1 2 2 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 1 1 1 1 3 1	3 1 1 1 + 1 1 2 2 + 3 2 1 + 1 1	1 1 1 2 3	1 1 + +	
Stylosanthus fruticosa	1 1 1 1 + + + 2 1 2 1 2 + 1 2 1	3 3 1 3 1 1 1 3 1 2 2 2 2	1 1 2 4 1 2 + 1 1 2 1	2 + 2 + + + + 2 1 + 2 3 1 1 1	+
Gymnosporia glaucophylla	+ + + 1 + + 2 + 1 + + +	+ 1 + 1 1 1 + 1 + + + + + + 1 1	+ + 1 1 + 2	1 2 1 1 1 1 + + + + + + 1 + 2 1 + + 1	
Aristida congesta subsp. *barbicollis*	2 2 1 2 + 1 1 1 1 1 3 1 2 1 1 1 1 + 1 2 1 2 1 1	2 2 2 1 1 2 1 + 1 +	2 1 1 1 2	1 1 + + 1 1 + 2 1 1 1 1 1 1	
Indigofera filipes	2 + 4 1 4 1 1 2 1 2 3 1 2 1 2 1 1 3 2 2 2 1 + 1 1 2 1 1 2 1 1 4 +	2 2 1 1 1 1 2 1 2 + 1	1 2 1 1 2	1 1	
Oldenlandia herbacea var. *herbacea*	+ + 1 1 4 + + 4 2 + 2 +	2 1 2 1 2 2 1 1 1 3 1 2 3 1 2	2 5 1 3 + 2	1 3 2 1 3 9 2 1 3 3 3 + 5 1 2 2 +	+
Tephrosia purpurea subsp. *leptostachya* var. *leptostachya*	1 1 + 1 3 1 4 1 1 + 1 1 3 1 1 1 1 1 1 1 1 1	1 6 2 + 2 1 2 1 + 2 + 1	1 + + +	1 1 1 + 2 + 2 + + + +	1
Urochloa mosambicensis	1 2 1 7 2 4 1 + 1 1 3 3 3 2 + 1 1 1 1 1	+ 1 5 1 1 B 1 5 1	7 1 3 1 +	1 3 1 1 1 2 1 + 3 + 2 1 1 2 1	+
Spermacoce senensis	2 3 1 2 1 2 2 1 1 1 3 2 8 1 3 2 2 1 2 + 4 1 3 1 5 4 4 6 2	2 1 2 1 2 3 2 2 + 1	2 1 1 1	2 3 1 +	
Sida cordifolia	1 + 1 + + 1 1 2 1 1 1 + 2 1	+ 1 1 1 1 1 2 1 2 1 2 1 2 1	1 1 2 1 + 2	2 1 2 + + + 1 +	+
Cyperus obtusiflorus var. *obtusiflorus*	+ 2 + 2 1 1 1 1 + 1 + 1 1 1 2 3	1 1 2 1 1 3 1 2 1 +	1 2 2 1 1 +	1 1 1 1 1 1 1 1 1 1	
Diospyros mespiliformis	1 + + + + + + + + + + + 1 + + 1 1	+ + 1 + + + 3 1 + +	+ + 1 2	1 + + + + + + +	2
Corchorus confusus	1 1 1 1 1 1 2 1 1 2 1 2 2 1 1 1 1 + 1 1 2 + 1 2 2	+ 2 1 + 1 1 + 1	1	1 1 + +	
Combretum collinum	1 2 9 + 4 3 2 + 3	3 1 + 1 + + + + + 5 + 1	1 + 5 + + + 3	1 2 7 1 2 + + 8 2	
Heteropogon contortus	+ 1 1 + 1 1 +	+ 2 2 + 2 1	2 2 3 + 1 1	1 7 2 1 1 4 4 3 2 3 5 2 6 1 2 1 1	2

TABLE 1 (cont...)

COMMUNITIES	1		2		3
VARIANTS	1a	1b	2a	2b	
RELEVÉ NUMBER	4 6 2 1 1 8 7 1 2 5 3 1 2 1 2 1 1 4 3 2 2 5 7 3 6 2 3 7	6 5 3 1 7 4 4 3 7 6 2 3 3 4 5 7 2 3 2 6	1 4 4 4 4 1 3 6	6 7 4 7 8 8 5 5 8 7 5 5 5 6 8 7 6 5 6	8 8 8 8
	5 3 4 8 7 4 7 1 2 8 3 3 9 3 6 8 6 2 4 0 4 2 5 6 5 0 1 8 1 7 3 6 7	2 0 8 1 2 3 6 7 4 9 9 0 9 9 2 5 7 5 1 5	2 9 0 2 8 4 7 5 1 4 3 8	6 0 1 6 3 0 8 5 1 9 4 7 6 0 2 3 1 9 4	8 7 5 6
Phyllanthus maderaspatensis	6 + 1 1 + 1 1 1 1 1 2 + +	1 1 2	1 1	1 1 1 1 1 + 1 1 1 + + 2 2 2 1 1	1
Euclea divinorum	+ + 1 + 1	+ 1 + + + + A	2 + 3	1 + 2 5 1 7 4 + + 4 5 + 3 2 4 E 7 6	+
Kohautia virgata	1 2 1 + 1 1 1 1 2	+ 5 1 1 4 2 1	1 6 + 1 3 1 1 3	2 1 3 + 1 + 1 1 +	
Coddia rudis	+ + + + + + +	+ + + 1 + + 1 +	+ +	1 + 1 + 2 1 + + + 2 + 1 + 1 1	+
Melinis nerviglumis	1 + 1 + + + + 1 + + + + 1 2	4 + 1 + 1 + 1 1 1	1 1 1	1 1 + + 1	
Albizia harveyi	+ + + + + + +	+ + 1 1 + 6	1 2 + 6	1 2 + 1 + + + + 1 1 8 3 1	1
Lantana rugosa	+ + + + + 1 + + 1	+ 1 + 1	+ +	2 1 1 1 1 + + 1 + 2 + 1 1 +	1
Conyza albida	1 + 1 1 3 3 + 1 + 1	1 1 2 1 + 1 + 5 + 1 1	1 2 1	1 + 1 1	+
Evolvulus alsinoides	+ + 1 + + 2 1 + 1 1 2 1 +	1 + +	1 1 1 1	1 + 2 2 1 + +	
Cheilanthes viridis var. *glauca*	+ + + 1 + + +	+ 1 3 1 + 1	1 1 5 + 2	1 2 1 1 1 + 1 +	1
Eragrostis gummiflua	1 6	+ 1 2 3	5 2 5 1 + 4 D +	1 1 5 9 1 7 1 5 3 3 8 7	
Commelina africana var. *lancispatha*	+ 1 2	+ 1 3 2 1 1 2 2	+ 2 1 +	1 2 1 + 1 + 1 2 + 1	+
Elaeodendron transvaalense	+ +	1 + 1 1 + + + +	+ + 1	+ + + + + + + + 1 + + +	
Pollichia campestris	+ + 2 + 1 + + 1 1 1 1 1 +	+ + + 1 + + +	1	+ 1	
Eragrostis superba	+ 1	1 1	4 1 1 1 1 1 1	2 + 2 1 1 1 1 2 2 +	
Ocimum gratissimum subsp. *gratissimum* var. *gratissimum*	+ + 1 + + 1 1 + + +	+ 1	1 1	2 1 1 + +	
Ocimum americanum var. *americanum*	1 + + 1 +	1 + + 1	7 1	1 1 2 1 2 + 2 +	
Melhania prostrata	+ + 1 + 3 + 1	1 1	1 +	1 1 1 + 1 + 1 1	+
Dalbergia melanoxylon	+ + + + + 1 2 +	+ + 1	+ +	1 3 1 + + +	
Wahlenbergia undulata	+ + + + 1	1 2 1 1 1	1 1 1 1 3	+ 1 +	+
Priva cordifolia var. *abyssinica*	+ + 1 + 1 + + +	+ 1 1 + +	1	+ + +	1
Triumfetta pentandra	1 1 2 6	3 2 2 3 2 1	1 5 1 1 4	1 1	
Monsonia angustifolia	1 2 1 1 + +	+ 3 1 5	1 1 1 2	1 +	+
Tephrosia purpurea subsp. *leptostachya* var. *pubenscens*	1 +	1 1 1 1 1	1 1 1 1	1 + + + 1	+
Hibiscus micranthus	+ + + + + + 1 +	+		+ 1	
Tricholaena monachne	+ 1 + + 1	+ 1 1		1 +	+
Heliotropium strigosum	1 2 1 +	+		1 + + + +	
Acacia exuvialis	1 + 1	+		1 + 1 + 2 1	2
Combretum molle	+ 1	1 + + + 1		2 +	
Sida dregei	1 +	2		+ + + 1 + 1	3
Combretum zeyheri	+ + 1	+		+ 1 + +	
Species group J: Diagnostic species of the Gymnosporia senegalensis - Phragmites mauritianus riparian low thicket (Community 3)					
Eustachys paspaloides				1	4 2 I 8
Cucumis metuliferus					2 1 + +
Hypoestes forskaolii 'form B'					A C I +
Persicaria conyzoides					2 1 4 3
Eriochloa meyeriana subsp. *meyeriana*					A 5 2 9
Gymnosporia senegalensis					K 3 1 +
Thunbergia neglecta		3			+ 1 +
Leuca glabrata var. *glabrata*					1 1 1
Phragmites mauritianus					8 N H

TABLE 1 (cont...)

COMMUNITIES	1		2		3
VARIANTS	1a	1b	2a	2b	
RELEVÉ NUMBER	4 6 2 1 1 8 7 1 2 5 3 1 2 1 2 1 1 4 3 2 2 5 7 3 6 2 3 7	6 5 3 1 7 4 4 3 7 6 2 3 3 4 5 7 2 3 2 6	1 4 4 4 4 1 3 6	6 7 4 7 8 8 5 5 8 7 5 5 5 6 8 7 6 5 6	8 8 8 8
	5 3 4 8 7 4 7 1 2 8 3 3 9 3 6 8 6 2 4 0 4 2 5 6 5 0 1 8 1 7 3 6 7	2 0 8 1 2 3 6 7 4 9 9 0 9 9 2 5 7 5 1 5	2 9 0 2 8 4 7 5 1 4 3 8	6 0 1 6 3 0 8 5 1 9 4 7 6 0 2 3 1 9 4	8 7 5 6
Ageratum conyzoides					5 4 1
Panicum desteum				2 2	4 3 1
Heteromorpha transvaalensis					+ 1
Cyperus sexangularis					2 2
Spirostachys africana				1	7 2
Species Group K: Species common to Variant 2b and Community 3					
Asparagus setaceus		1 +		+ + + + + + + + + 1 + 1	+ + +
Rhoicissus tridentata		1		+ + + + 1	+ + +
Species group L: Common and rare species arranged according to constancy values					
Panicum maximum	2 1 2 2 1 2 B A C C G 3 4 D 5 D 5 8 G A 5 A 6 2 A 5 3 7 A 9 6 6	6 A 5 2 L J 2 9 A 7 G 8 B 6 9 2 2 2 G	3 2 2 A 7 3 5 1 1 2 N	K 2 B 3 B 8 8 3 2 4 3 6 D 4 D K 5 A 8	6 E 6 7
Dichrostachys cinerea	+ 7 A 9 B 9 5 E B 5 7 F K 7 7 C 2 6 E A A 3 6 1 B A 5 2 5 5 7 5	H 9 6 2 E 7 6 A D 9 1 6 3 8 7 1 G C 5 B	5 7 8 I L 7 1 A 4 5 3 5	B F 1 A 8 + 8 4 + + + 4 + B 9 4 7 +	7 1 1
Phyllanthus parvulus var. *garipensis*	3 1 1 2 1 1 5 3 1 2 3 3 4 7 1 2 5 3 4 4 1 1 2 5 2 1 2 1 2 5 4 1	2 2 1 7 1 3 1 2 1 2 3 1 2 2 1 2 1 1 1 +	1 1 1 1 3 1 1 1 1 1 1	1 1 2 2 1 2 5 1 1 1 3 2 3 2 1 1 2 1 +	1 1 1
Polygala sphenoptera	2 + 1 + + 1 1 1 1 1 2 1 2 1 1 2 1 1 + 1 1 1 1 1 +	2 + 1 2 1 1 + 1 1 2 1 1 1 1	1 + 1 1 1 1 1 1	1 1 1 1 2 1 1 3 1 2 1 +	3 + +
Acacia nilotica	2 + 1 4 + 1 + + + 6 4 3 7 5 1 + 4 2 +	8 6 5 C 1 1 + 8 + + + 1 + 9	2 4 1 + 4 3	7 6 + + 1 + + + + 1 + + 6 + 7 P	+ + +
Bidens bipinnata	1 1 + 2 + 1 + 1 + 2 + 1 1 1 1 2 8 1 1 1 1 + 3 6 8 1	+ D 1 2 1 2 1 1 5 3 + 1 1 1 1 1	1 1 1 5 + 1	1	+ + 1 +
Jasminum fluminense	1 1 + + + 1 + 2 + 1 1 2 1 +	1 1 1 3 1 1 4 + 1 + 1	1 + 1 + 7	1 2 + 5 1 1 2 + 1 + 2 + 2 + + +	4 4 2 +
Euclea natalensis subsp. *angustiflia*	+ + + + + + 2 + + 1 1	+ + + + + 1 2 + + + +	+ + 1 1 + + 6	1 1 4 1 + + + + + + 1 + + + 1	+ + +
Ziziphus mucronata	+ + + + + + + + + + + + 1	+ + 1	1 + + + 1	1 + + 6 1 + + + + 1 + 3 2 1 + + 2 +	+ 1 2
Ehretia amoena	+ 1 + 1 + + 1 + 1 1 + 1 + +	+ + 1 + + + +	+ 1 + 1 1 2	+ + + + + + + 1 + + 1 1	+ +
Epaltes gariepina	5 3 + + + + 1 1 + + +	2 6 + 1 + 1 8	D L 3 6 4 5 D	6 E 2 2 A A 8 1 A 4 1 1 7 C	1 +
Flueggea virosa	1 + 1 + + + + + 1 +	+ + 1 + + + + + +	+ 1 + + 1	1 + + + + 1 + + + + + + 1	5 3 + +
Triumfetta sp.	2 1 5 1 1 + 1 1 3 1 6 5 1 1 8 2 1 1 + 1	2 1 1 1 1 + + 1 + 1	1	1 1 + + + 2	+ 1 1
Peltophorum africanum	1 + + + + + + + 1 + 1	+ + + 2 + + 3 1 + 6	3 + 3	1 1 + + + 1 + 1 + 4 1	1 + +
Grewia flavescens var. *flavescens*	+ + + 1 + 1 L +	+ + + + 1 + 1	+ 1 + + 3	2 + 1 + + + + 1 1 + 1 2	+ + +
Commelina eckloniana	1 + 2 + + 1 1 1 + 1 + + 2 + 2 1	1 + 2 1 1 1 + 1 1 +	1 1	+ + 1	2 2 1
Eragrostis curvula	+ 1	+ 1 1 9 2 2	2 1 E 5 2 2 +	1 3 3 2 5 9 1 6 2 3 5 3 A 6	1 1 +
Hoslundia opposita	1 + + + 1 2 3 + 1	+ + 1 4 3 + +	1 1	+ 2 1 + 1	1 +
Tagetes mimuta	1 4 1 6 2 + D 4 D 3 + 2 + 2 + 1 1 1	A + 2	1		+ +
Achyropsis leptostachya	2 1 1 + 1 1 1	1 + + 1	1 1 3	2 + 1 3	1 3 2 +
Schkuhria pinnata	1 1 + 2 1 2 2 + 1 + + +	2 6 1 1	1	+ +	1 +
Sporobolus africanus	+ + 1	2 2 2 2 5	1 2 1 1 2 4 1	1 3	2 1 + +
Combretum imberbe	1 4 + +	+ + +	3 + 5 + 1 3	+ 1 + + 2	N 2 2
Cyperus sphaerospermus	2 2 1 + 1 + 1 1 1 1 2 3	3 1 1 3	1 E		1 1
Acalypha villicaulis	2 3 1	3 + 2 2 1	2 5	5 + 3 + + 1	+ + +
Solanum panduriforme	2 + 1	+ 2 1 7	1 + 1	2 1 + + 1 3	+ 1 +
Ipomoea plebeia subsp. *africana*	+ + 1 2 1 1			+ 1	2 1
Species A (unidentified)	+ + 3	3 1 +			1 + 2
Lippia javanica	1 + +			+ + +	+ 1
Rhus pentheri	+	+	1	+ + 1	+
Lannea schweinfurthii var. *stuhlmannii*	+ + +	+	+	+	+
Kalanchoe crenata subsp. *crenata* var. *crenata*	1 +	+ 1		1 1 +	
Grewia monticola	+ +	+		+ + 1 1	

TABLE 1 (cont...)

COMMUNITIES	1																																																					2																															3			
VARIANTS	1a																																	1b																				2a												2b																						
RELEVÉ NUMBER	45	63	24	18	17	84	7	71	12	28	53	33	9	13	26	8	16	22	14	10	44	32	5	6	25	20	51	78	31	67	23	36	77	62	50	38	11	72	43	46	37	74	69	29	30	39	49	52	75	27	35	21	65	2	19	40	42	48	4	47	15	1	34	3	68	66	70	41	76	83	80	58	55	81	79	54	57	56	60	82	73	61	59	64	88	87	85	86
Abrus precatorius subsp. *africanus*																													1	1																				+		1																	+							+												
Ehretia obtusifolia																											+		+																								+														+						+			+												
Dombeya rotundifolia																																										+											+														+									+							1		
Phyllanthus incurvus																																																															1	1																								
Combretum apiculatum																																																																	1	1			3																	+		
Melhania forbesii	+																													1					3																															1																						
Berchemia zeyheri																																												+	1																									+													+				
Justicia flava																																																					1																													1				2		+
Turbina oblongata																																			+																			1																1											1							
Laggera crispata																									+												+															1							1																														
Cyphostemma subciliatum																																					1																													1																			+	+			
Gomphrena celosioides																																				1																+			2																													1				
Rhynchosia minima var. *minima*																			+															+																																					3											+					
Hyparrhenia filipendula																																							1																					1				3										1														
Richardia scabra																					4																+		1																																															+			
Oxalis obliquifolia																																+																																	1																+							
Cyperus kirkii																																																					+																																		1				
Tragus berteronianus																																																					1	1																																						
Pellaea calomelanos var. *calomelanos*												+																																			+																																														
Dipcadi viride																																																												1						1																						
Mundulea sericea																																																							+															+																	
Trochomeria macrocarpa subsp. *macrocarpa*																																								1																											1																						
Hypoxis villosa																																	+																																								+																	
Digitaria longiflora																																																					1																																		+				
Commiphora mollis																							+																																													+																					
Hibiscus schinzii																																1																+																																																									
Schotia brachypetala																					1																																																																					+	
Pavetta schumanniana																																+																																					+																				
Aristida adscensionis																								+																																																												+						
Pyrenacantha kaurabassana																							+																																										+																							
Lippia sp.																																												2																								1																						
Acacia robusta subsp. *clavigera*																																														+																																															6			
Mystroxylon aethiopicum																																														+																																															+			
Crotalaria laburnifolia subsp. *australis*																					1																																																						1															
Grewia caffra																																																					+																																		+				
Crassula lanceolata subsp. *transvaalensis*																									1																																																																					
Tephrosia lupinifolia																									1																																																																					
Aeschynomene micrantha																																																																	2																									
Pupalia lappacea var. *lappacea*																																																																		1																							
Hyptis pectinata																																																											2																																
Gladiolus densiflorus																																																																			1																							
Ceropegia racemosa subsp. *setifera*																																																																																		+							

TABLE 1 (cont...)

COMMUNITIES	1																																
VARIANTS	1a																																
RELEVÉ NUMBER	45	63	24	18	17	84	7	71	12	28	53	33	9	13	26	8	16	22	14	10	44	32	5	6	25	20	51	78	31	67	23	36	77
Dactyloctenium australe																																	
Dactyloctenium aegyptium																																	
Zornia glochidiata																							1										
Tribulus terrestris																																	
Tridax procumbens																													+				
Tephrosia forbesii subsp. *interior*							+																										
Ozoroa sphaerocarpa																								+									
Gisekia pharnacioides																													2				
Trichilia emetica																			+														
Diospyros lycioides subsp. *guerkei*																																	
Albizia versicolor									+																								
Sacciolepis curvata																																	
Vernonia fastigiata																																	
Dicoma tementosa											1																						
Species D (unidentified)																																	
Monopsis decipiens																																	
Crotalaria sphaerocarpa subsp. *sphaerocarpa*																																	
Lannea discolor																																	
Species B (unidentified)	+																																
Ornithogalum tenuifolium subsp. *tenuifolium*																																	
Setaria incrassata																																	
Ipomoea coptica var. *coptica*																																	
Asparagus cooperi																																	
Bothriochloa bladhii																																	
Acacia sieberiana var. *woodii*																																	
Indigofera lydenburgensis																																	
Monsonia glauca																																	
Indigofera dregeana																															+		
Species C (unidentified)																																	
Eragrostis barbinodis																																1	
Schmidtia pappophoroides																																	
Ludwiga octovalvis subsp. *octovalvis*																																	
Heliotropium zeylanicum																		+															
Pavonia burchellii																																	
Vernonia glabra var. *laxa*																																	
Verbenia bonariensis																																	
Sida rhombifolia																																	
Bauhinia galpinii																																	
Diospyros villosa var. *parvifolia*																																	
Cissampelos mucronata																																	
Abrus laevigatus																																	
Brachiaria serrata																																	

COMMUNITIES	1																				2											
VARIANTS	1b																				2a											
RELEVÉ NUMBER	62	50	38	11	72	43	46	37	74	69	29	30	39	49	52	75	27	35	21	65	2	19	40	42	48	4	47	15	1	34	3	68
Dactyloctenium australe										1																						
Dactyloctenium aegyptium																				1												
Zornia glochidiata																																
Tribulus terrestris													1																			
Tridax procumbens																																
Tephrosia forbesii subsp. *interior*																																
Ozoroa sphaerocarpa																																
Gisekia pharnacioides																																
Trichilia emetica																																
Diospyros lycioides subsp. *guerkei*																																+
Albizia versicolor																																
Sacciolepis curvata																2																
Vernonia fastigiata																																
Dicoma tementosa																																
Species D (unidentified)															2																	
Monopsis decipiens															A																	
Crotalaria sphaerocarpa subsp. *sphaerocarpa*										2																						
Lannea discolor																														+		
Species B (unidentified)																																
Ornithogalum tenuifolium subsp. *tenuifolium*																				1												
Setaria incrassata																																
Ipomoea coptica var. *coptica*																							+									
Asparagus cooperi																																
Bothriochloa bladhii																																
Acacia sieberiana var. *woodii*																															+	
Indigofera lydenburgensis																																
Monsonia glauca																																
Indigofera dregeana																																
Species C (unidentified)																																
Eragrostis barbinodis																																
Schmidtia pappophoroides			6																													
Ludwiga octovalvis subsp. *octovalvis*																																
Heliotropium zeylanicum																																
Pavonia burchellii																																
Vernonia glabra var. *laxa*																																
Verbenia bonariensis																																
Sida rhombifolia																																
Bauhinia galpinii																																
Diospyros villosa var. *parvifolia*																																
Cissampelos mucronata																																
Abrus laevigatus																																
Brachiaria serrata																																

COMMUNITIES	2																			3			
VARIANTS	2b																						
RELEVÉ NUMBER	66	70	41	76	83	80	58	55	81	79	54	57	56	60	82	73	61	59	64	88	87	85	86
Dactyloctenium australe																							
Dactyloctenium aegyptium																							
Zornia glochidiata																							
Tribulus terrestris																							
Tridax procumbens																							
Tephrosia forbesii subsp. *interior*																							
Ozoroa sphaerocarpa																							
Gisekia pharnacioides																							
Trichilia emetica																							
Diospyros lycioides subsp. *guerkei*																							
Albizia versicolor																							
Sacciolepis curvata																							
Vernonia fastigiata													+										
Dicoma tementosa																							
Species D (unidentified)																							
Monopsis decipiens																							
Crotalaria sphaerocarpa subsp. *sphaerocarpa*																							
Lannea discolor																							
Species B (unidentified)																							
Ornithogalum tenuifolium subsp. *tenuifolium*																							
Setaria incrassata											3												
Ipomoea coptica var. *coptica*																							
Asparagus cooperi		+																					
Bothriochloa bladhii																					1		
Acacia sieberiana var. *woodii*																							
Indigofera lydenburgensis				3																			
Monsonia glauca																					1		
Indigofera dregeana																							
Species C (unidentified)			1																				
Eragrostis barbinodis																							
Schmidtia pappophoroides																							
Ludwiga octovalvis subsp. *octovalvis*																						+	
Heliotropium zeylanicum																							
Pavonia burchellii																							+
Vernonia glabra var. *laxa*																							4
Verbenia bonariensis																							+
Sida rhombifolia																							2
Bauhinia galpinii																				+			
Diospyros villosa var. *parvifolia*																				1			
Cissampelos mucronata																				4			
Abrus laevigatus																				2			
Brachiaria serrata									3														

TABLE 1 (cont...)

COMMUNITIES	1																																
VARIANTS	1a																																
RELEVÉ NUMBER	45	63	24	18	17	84	7	71	12	28	53	33	9	13	26	8	16	22	14	10	44	32	5	6	25	20	51	78	31	67	23	36	77
Dicoma zeyheri																																	
Ximenia caffra																																	
Gerbera piloselloides																																	
Hibiscus altissimus																																	
Bonatea sp.																																	
Vernonia adoensis																																	
Solanum nigrum																																	
Urelytrum agropyroides																									3								
Eragrostis ciliaris																								+									
Solanum incanum																																	
Chlorophytum sp.																																	

COMMUNITIES																				
VARIANTS	1b																			
RELEVÉ NUMBER	62	50	38	11	72	43	46	37	74	69	29	30	39	49	52	75	27	35	21	65
Dicoma zeyheri																				
Ximenia caffra											+									
Gerbera piloselloides																				
Hibiscus altissimus										2										
Bonatea sp.								2												
Vernonia adoensis								1												
Solanum nigrum								+												
Urelytrum agropyroides																				
Eragrostis ciliaris																				
Solanum incanum																				
Chlorophytum sp.																				

COMMUNITIES	2											
VARIANTS	2a											
RELEVÉ NUMBER	2	19	40	42	48	4	47	15	1	34	3	68
Dicoma zeyheri												
Ximenia caffra												
Gerbera piloselloides												
Hibiscus altissimus												
Bonatea sp.												
Vernonia adoensis												
Solanum nigrum												
Urelytrum agropyroides												
Eragrostis ciliaris												
Solanum incanum							1					
Chlorophytum sp.												

COMMUNITIES																			
VARIANTS	2b																		
RELEVÉ NUMBER	66	70	41	76	83	80	58	55	81	79	54	57	56	60	82	73	61	59	64
Dicoma zeyheri									1										
Ximenia caffra																			
Gerbera piloselloides									1										
Hibiscus altissimus																			
Bonatea sp.																			
Vernonia adoensis																			
Solanum nigrum																			
Urelytrum agropyroides																			
Eragrostis ciliaris																			
Solanum incanum																			
Chlorophytum sp.															+				

COMMUNITIES	3			
VARIANTS				
RELEVÉ NUMBER	88	87	85	86
Dicoma zeyheri				
Ximenia caffra				
Gerbera piloselloides				
Hibiscus altissimus				
Bonatea sp.				
Vernonia adoensis				
Solanum nigrum				
Urelytrum agropyroides				
Eragrostis ciliaris				
Solanum incanum				
Chlorophytum sp.				

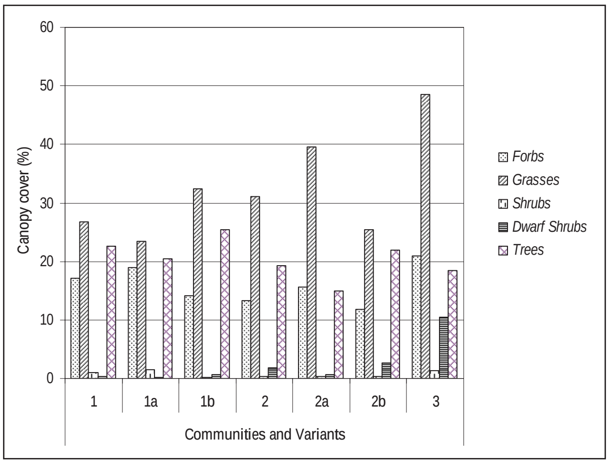

FIGURE 2
Histogram indicating the percentage canopy cover for the growth forms recorded in the main plant communities and their associated variants in the Andover Game Reserve

two variants (Table 1). The identified plant communities were as follows:

1. The *Strychnos madagascariensis* - *Aristida stipitata* var. *graciliflora* short closed woodland
   1a The *Strychnos madagascariensis* - *Indigofera inhambanensis* variant
   1b The *Strychnos madagascariensis* - *Parinari curatellifolia* variant

2. The *Acacia gerrardii* - *Setaria sphacelata* var. *sphacelata* short closed woodland
   2a The *Acacia gerrardii* - *Fuirena pachyrrhiza* var. *pachyrrhiza* variant
   2b The *Acacia gerrardii* - *Themeda triandra* variant

3. The *Gymnosporia senegalensis* - *Phragmites mauritianus* riparian low thicket

The species groups were arranged to highlight the environmental gradients associated with savanna sandveld ecosystems. The phytosociological classification consists of 12 species groups (A–L) of which 205 (61.7%) and 128 (38.4%) species constitute the diagnostic and non-diagnostic portions, respectively (Table 1). A vegetation map of the AGR providing the spatial occurrence of the plant communities is presented in Fig. 1.

Description of plant communities

The Strychnos madagascariensis - Aristida stipitata *var.* graciliflora *short closed woodland (Community 1)*

Community 1 (Fig. 1; Table 1, Species Group A) occurs throughout the reserve, predominating on the crests and upper mid-slopes of the landscape with a slope ranging between 2˚ and 5˚. The soils found in these physiographic units are deep sandy soils (mean clay > 5%), with a mean depth of 1 m. Soil forms associated with this plant community are Hutton, Clovelly and Cartref (MacVicar *et al*. 1991). This community contributes the most to the overall species richness of the AGR, with a total of 258 plant species (Table 2), of which the majority, 15.7% and 45.4%, of the species richness is within the grass and forb growth forms, respectively (Table 3). The woody component of the community is dominated (in terms of cover) primarily by *Terminalia sericea* and *Dichrostachys cinerea* with 12.2% and 8.2% cover, respectively (Table 4). *Terminalia sericea* forms dense fringes of varying degrees toward the lower portions of the mid-slopes. *Strychnos madagascariensis* is a weak competitor with a density of three trees per hectare (Table 4). *Digitaria eriantha, Hyperthelia dissoluta, Panicum maximum* (mainly under tree canopies) and *Perotis patens* are dominant (in terms of

TABLE 2
Community and variant statistics for the Andover Game Reserve

MEASUREMENTS	COMMUNITIES AND VARIANTS						
	1	1a	1b	2	2a	2b	3
Total no. relevés.	53	33	20	31	12	19	4
Total no. species.	258	197*	207*	222	147*	193*	118
Total diagnostic species.	181	132*	139*	160	97*	128*	72
Diagnostic proportion.	70.2%	67.1%	67.2%	72.1%	66%	66.3%	61%
Species richness in terms of mean species per relevé.	56	57	54	56	49	61	53
Community variation							
Minimum species per relevé.	37	37	40	33	33	47	41
Maximum species per relevé.	70	70	66	73	61	73	75
Range of species per relevé.	33	33	26	40	28	26	34
Mean species per relevé.	56	57	54	56	49	61	53
Standard error of the mean of species per relevé.	1.01	1.3	1.5	1.7	2.4	1.5	7.6
Community variation (proportion spp./relevé/ community).	21.6%	28.9%	25.9%	25.4%	33.4%	31.6%	44.9%
Community variation in terms of the standard deviation.	2.9%	3.8%	3.2%	4.2%	5.5%	3.4%	12.8%

* Several of the same species occurring in the main plant communities also occur in the variants and thus the species totals of the variants will not equate to the sum of the species in the main plant communities

cover) in the herbaceous layer (Table 4). *Aristida stipitata* subsp. *graciflora* occurs as a normal competitor (Table 4). The forbs, *Agathisanthemum bojeri* subsp. *bojeri*, *Chamaecrista absus*, *Vernonia steetziana, Tagetes minuta* and *Wahlenbergia banksiana* occur as strong competitors (Table 4). The actual cover contribution of each growth form in this community is shown in Fig. 2, with a high total percentage cover of 67.8%.

The Strychnos madagascariensis - Indigofera inhambanensis *variant 1a*

Variant 1a occurs mainly in the eastern half of the reserve (Fig. 1; Table 1, Species Group B), where the predominant underlying geology is grey to pale brown, medium- to course-grained quartz-feldspar-biotite gneiss with subordinate mafic to ultramafic xenoliths (Walraven 1986). The species richness consists of 197 plant species (Table 2), with the dwarf shrub (14.5%), grass (14.9%) and forb (49%) growth forms contributing the most to the species richness of this variant (Table 3). Dominant species (in terms of cover) include the trees *Dichrostachys cinerea*, *Terminalia sericea*, the grasses *Perotis patens*, *Digitaria eriantha*, *Bulbostylis contexta*, *Hyperthelia dissoluta*, *Panicum maximum,* and the forbs *Tagetes minuta*, *Chamaecrista absus*, *Vernonia steetziana* and *Agathisanthemum bojeri* subsp. *bojeri* (Table 5). *Indigofera inhambanensis* is within a normal competition range (Table 5). The vegetation structure in terms of the actual percentage cover relative to each growth form is illustrated in Fig. 2, with a total cover of 64.9%

The Strychnos madagascariensis - Parinari curatellifolia *variant 1b*

This variant (1b) of Community 1 occurs within the western portion of the reserve (Fig. 1; Table 1, Species Group C). The underlying geology consists of Makhutswi gneiss, which is light-grey, medium-grained biotite gneiss with course-grained quartz-feldspar leucosomes (Walraven 1986). The occurrences of frequent fires (annually) from the bordering rural communities may be an additional causative factor of this variant. The species richness of this variant is slightly higher (207 species) than that of Variant 1a (Table 2), with the grass (17.8%) and forb growth forms (43.9%) contributing the most to the variant's species richness (Table 3). *Dichrostachys cinerea* and *Terminalia sericea* remain strong competitors in the tree growth form (Table 6). *Euclea divinorum* and *Phyllanthus reticulatus* are strong competitors in the shrub and dwarf shrub growth forms, respectively (Table 6). *Fuirena pachyrrhiza* var. *pachyrrhiza, Perotis patens, Cynodon dactylon, Hyperthelia dissoluta* and *Panicum maximum* are dominant grasses in terms of cover, of which the latter two are also strong competitors (Table 6). Strong forb competitors include *Bidens bipinnata, Wahlenbergia banksiana* and *Agathisanthemum bojeri* subsp. *bojeri* (Table 6). The growth forms depicting community structure relative to their actual percentage canopy cover are shown in Fig. 2, with a high community cover of 72.8%.

TABLE 3
Species richness within the communities and their associated variants according to each growth form

GROWTH FORM	COMMUNITIES AND VARIANTS													
	1		1a		1b		2		2a		2b		3	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Trees	42	13.0	30	12.5	30	11.9	35	12.2	21	12.0	32	12.8	17	13.1
Shrubs	39	12.0	22	9.1	33	13.0	42	14.6	18	10.3	37	14.8	23	17.7
Dwarf shrubs	45	13.9	35	14.5	34	13.4	46	16.0	27	15.4	38	15.2	9	6.9
Grass	51	15.7	36	14.9	45	17.8	50	17.4	34	19.4	45	18.0	23	17.7
Forbs	147	45.4	118	49.0	111	43.9	114	39.7	75	42.9	98	39.2	58	44.6

* It is possible for more than one species to occurr in one or more growth forms in the woody plant categories

The Acacia gerrardii - Setaria sphacelata *var.* sphacelata *short closed woodland (Community 2)*

Community 2 (Fig. 1; Table 1, Species Group D) occurs on the lower mid-slopes and footslopes of the AGR, with a slope ranging between 5˚ and 10˚. The soils are sandy-loam (mean clay 5–10%) towards the lower mid-slopes, becoming more clayey (mean clay > 50%) on the footslopes. Soils occurring in the plant community are: Cartref, Fernwood, Katspruit, Kroonstad, Sepane, Valsrivier and Sterkspruit (MacVicar *et al.* 1991). The mean soil depth is 1 m along the lower mid-slopes, decreasing to 0.5 m along the footslopes. A total of 222 plant species (Table 2) occur in the community, with the highest species richness being in the forb (39.7%) growth form (Table 3). The dominant trees (in terms of cover) are *Aristida stipitata* subsp. *graciliflora*, *Acacia nilotica*, *Combretum hereroense*, *Dichrostachys cinerea* and the shrub *Euclea divinorum*, of which the latter three species are also strong competitors (Table 7). Dominant grasses (in terms of cover) include *Eragrostis gummiflua, Eragrostis curvula, Digitaria eriantha, Setaria sphacelata* var. *sphacelata, Bulbostylis contexta, Hyperthelia dissoluta* and *Panicum maximum,* with the four latter species also being strong competitors (Table 7). Although *Hyperthelia dissoluta* occurs as a strong competitor, its dominance in terms of cover (3.9%) is substantially lower in contrast to its dominance in Community 1 and its Variants 1a and 1b (Table 4, Table 5 and Table 6). Noticeably strong forb competitors are *Chaetacanthus setiger* and *Epaltes gariepina* (Table 7). The actual canopy cover contribution of each growth form within the plant community is shown in Fig. 2, with the total percentage cover for the community being 65.6%.

TABLE 4
Species and growth form relations in Community 1

SPECIES	GROWTH FORM*	COMP. STATUS**	CANOPY COVER (%)	CROWN DIAMETER (m)	IND./ HA***	CANOPY/ CANOPY GAP (m)
Terminalia sericea	T	Strong	12.2	3.2	150	6.0
Dichrostachys cinerea	T	Strong	8.2	3.5	85	8.7
Strychnos madagascariensis	T	Weak	0.1	1.9	3	60.3
Hyperthelia dissoluta	G	Strong	8.2	0.3	15 525	0.7
Panicum maximum	G	Strong	8.1	0.2	28 278	0.5
Digitaria eriantha	G	Weak	1.7	0.1	39 612	0.8
Perotis patens	G	Weak	2.3	0.1	15 872	0.8
Aristida stipitata subsp. graciliflora	G	Normal	0.1	0.1	4 334	1.7
Agathisanthemum bojeri subsp. *bojeri*	F	Strong	1.3	0.3	1 807	2.4
Chamaecrista absus	F	Strong	1.6	0.2	7 834	1.1
Vernonia steetziana	F	Strong	3.0	0.2	17 146	0.7
Tagetes minuta	F	Strong	1.0	0.1	7 441	1.2
Wahlanbergia banksiana	F	Strong	0.7	0.1	9 345	1.1
Hibiscus sp.	F	Strong	1.0	0.1	6 715	1.2

* T = Tree; G = Grass; F = Forb
** Competitor status
*** Individuals per hectre

TABLE 5
Species and growth form relations in Variant 1a

SPECIES	GROWTH FORM*	COMP. STATUS**	CANOPY COVER (%)	CROWN DIAMETER (m)	IND./ HA***	CANOPY/ CANOPY GAP (m)
Terminalia sericea	T	Strong	11.3	3.3	135	6.4
Dichrostachys cinerea	T	Strong	7.6	3.8	67	9.9
Strychnos madagascariensis	T	Weak	0.1	2.2	3	62.2
Hyperthelia dissoluta	G	Strong	7.1	0.3	14 960	0.7
Panicum maximum	G	Strong	6.8	0.2	25 241	0.5
Digitaria eriantha	G	Normal	2.1	0.1	51 377	0.4
Perotis patens	G	Normal	2.9	0.2	17 282	0.7
Agathisanthemum bojeri subsp. *bojeri*	F	Strong	1.3	0.3	179	2.5
Chamaecrista absus	F	Strong	2.2	0.2	9 145	1.0
Vernonia steetziana	F	Strong	4.5	0.2	22 850	0.6
Indigofera inhambanensis	F	Normal	0.2	0.3	334	5.8
Tagetes minuta	F	Strong	1.3	0.1	9 229	1.0

* T = Tree; G = Grass; F = Forb
** Competitor status
*** Individuals per hectre

The Acacia gerrardii - Fuirena pachyrrhiza *var.* pachyrrhiza *variant 2a*

This variant (Fig. 1 Table 1, Species Group E) is indicative of the seeplines and the transition areas between the broad- and fine-leaved savanna. Soils occurring in this vegetation unit have a characteristic G-Horizon, namely Katspruit and Kroonstad (MacVicar *et al*. 1991). As a result of the G-Horizon, seasonal water emerges to the surface forming wet-spots or seeplines, with characteristic hydromorphic species (*i.e.* within the grass and forb growth forms) dominating these areas. The floristic richness consists of 147 individual species (Table 2) with the grass and forb layers contributing 19.4% and 42.9% (Table 3), respectively, to the species richness of this variant. Diagnostic species are *Fuirena pachyrrhiza* var. *pachyrrhiza* and *Vahlia capensis* subsp. *vulgaris* var. *vulgaris* (Table 1, Species Group E), with *Eragrostis inamoena, Eragrostis gummiflua, Eragrostis curvula,*

TABLE 6
Species and growth form relations in Variant 1b

SPECIES	GROWTH FORM*	COMP. STATUS**	CANOPY COVER (%)	CROWN DIAMETER (m)	IND./ HA***	CANOPY/ CANOPY GAP (m)
Terminalia sericea	T	Strong	13.5	3.0	178	5.3
Dichrostachys cinerea	T	Strong	8.8	2.9	128	7.0
Strychnos madagascariensis	T	Weak	0.1	1.6	3	60.0
Euclea divinorum	S	Strong	1.0	1.9	36	16.7
Phyllanthus reticulatus	DS	Strong	0.02	0.4	19	25.0
Perotis patens	G	Weak	1.4	0.1	12 108	0.9
Hyperthelia dissoluta	G	Strong	10.0	0.3	16 578	0.6
Panicum maximum	G	Strong	10.2	0.2	32 380	0.4
Cynodon dactylon	G	Normal	1.9	0.1	115 500	0.3
Fuirena pachyrrhiza var. *pachyrrhiza*	G	Normal	1.9	0.2	7 614	1.1
Bidens bipinnata	F	Strong	1.1	0.1	7 114	1.2
Wahlenbergia banksiana	F	Strong	1.9	0.1	20129	0.7
Agathisanthemum bojeri subsp. *bojeri*	F	Strong	1.4	0.3	2 228	2.1

* T = Tree; DS = Dwarf shrub; G = Grass; F = Forb
** Competitor status
*** Individuals per hectre

TABLE 7
Species and growth form relations in Community 2

SPECIES	GROWTH FORM*	COMP. STATUS**	CANOPY COVER (%)	CROWN DIAMETER (m)	IND./ HA***	CANOPY/ CANOPY GAP (m)
Acacia gerrardii	T	Normal	2.9	3.50	29	17.3
Acacia nilotica	T	Normal	2.7	4.60	27.9	23.3
Acacia swazica	T	Normal	1.2	1.40	76	11.5
Combretum hereroense	T	Strong	3.9	2.70	67	11.0
Dichrostachys cinerea	T	Strong	6.5	3.30	76	9.6
Euclea divinorum	S	Strong	1.5	2.00	36	16.7
Panicum maximum	G	Strong	8.2	0.20	29 199	0.5
Hyperthelia dissoluta	G	Strong	3.9	0.30	7629	1.0
Bulbostylis contexta	G	Strong	3.5	0.10	179 581	0.2
Setaria sphacelata var. *sphacelata*	G	Strong	3.1	0.24	7 207	1.1
Eragrostis gummiflua	G	Normal	1.8	0.30	3703	1.6
Eragrostis curvula	G	Normal	1.9	0.10	15871	0.8
Digitaria eriantha	G	Normal	1.4	0.10	20113	0.7
Chaetacanthus setiger	F	Strong	1.3	0.10	2 289	2.1
Epaltes gariepina	F	Strong	5.5	0.30	55 418	0.4

* T = Tree; DS = Dwarf shrub; G = Grass; F = Forb
** Competitor status
*** Individuals per hectre

Cyperus denudatus and *Cyperus sphaerospermus* occurring as normal competitors in this hydromorphic vegetation unit (Table 8). Species growth relations within this variant are presented in Table 8. *Hyperthelia dissoluta* remains a strong grass competitor (Table 8), primarily occurring towards the upper regions of this lower mid-slope vegetation unit. *Epaltes gariepina* is a strong forb competitor indicative of wet or seepline areas (Table 8). *Dichrostachys cinerea* remains a strong competitor within the woody component of this vegetation unit (Table 8). The total percentage cover for the variant is 71.1%, with proportions within the woody, herbaceous and forb components being 15%, 39.6% and 15.7% (Fig. 2), respectively, clearly demonstrating the hydromorphic characteristic of the

TABLE 8
Species and growth form relations in Variant 2a

SPECIES	GROWTH FORM*	COMP. STATUS**	CANOPY COVER (%)	CROWN DIAMETER (m)	IND./ HA***	CANOPY/ CANOPY GAP (m)
Dichrostachys cinerea	T	Strong	9.5	3.4	105	7.6
Bulbostylis contexta	G	Strong	7.9	0.1	232 603	0.2
Hyperthelia dissoluta	G	Strong	10.0	0.3	19 710	0.6
Panicum maximum	G	Strong	6.2	0.2	19 737	0.6
Fuirena pachyrrhiza var. *pachyrrhiza*	G	Normal	0.5	0.3	593	4.6
Eragrostis inamoena	G	Normal	1.1	0.2	2539	2.0
Cyperus denudatus	G	Normal	1.1	0.1	10 141	1.0
Cyperus sphaerospermus	G	Normal	1.7	0.1	27 508	0.6
Eragrostis gummiflua	G	Normal	2.0	0.2	5 021	1.4
Eragrostis curvula	G	Normal	2.0	0.1	18 321	0.7
Vahlia capensis subsp. *vulgaris* var. *vulgaris*	F	Normal	0.5	0.2	8 654	1.1
Epaltes gariepina	F	Strong	7.3	0.1	61 276	0.3

* T = Tree; G = Grass; F = Forb
** Competitor status
*** Individuals per hectre

TABLE 9
Species and growth form relations in Variant 2b

SPECIES	GROWTH FORM*	COMP. STATUS**	CANOPY COVER (%)	CROWN DIAMETER (m)	IND./ HA***	CANOPY/ CANOPY GAP (m)
Dichrostachys cinerea	T	Strong	4.6	3.2	57	11.80
Combretum hereroense	T	Strong	4.9	2.7	88	9.30
Acacia nilotica	T	Strong	4.2	4.7	24	18.20
Acacia gerrardii	T	Strong	4.4	3.6	42	13.70
Euclea divinorum	S	Strong	2.4	2.0	53	13.50
Panicum maximum	G	Strong	9.6	0.2	35 989	0.41
Setaria sphacelata var. *sphacelata*	G	Strong	4.3	0.2	9 094	0.90
Digitaria eriantha	G	Normal	2.0	0.1	25 719	0.60
Epaltes gariepina	F	Strong	4.3	0.1	48 453	0.40
Chaetacanthus setiger	F	Strong	2.1	0.3	3 434	1.70

* T = Tree; DS = Dwarf shrub; G = Grass; F = Forb
** Competitor status
*** Individuals per hectre

seepline with a clear reduction in the occurrence of the woody components in these areas.

The Acacia gerrardii - Themeda triandra *variant 2b*

This variant (Fig. 1; Table 1, Species Group F) is restricted to the footslopes of the study area and follows the drainage lines originating in the south and flowing in a northerly direction. The variant is also located along the drainage lines in the eastern parts of the reserve. Soil forms in this vegetation unit are predominantly Sterkspruit, Sepane and Valsrivier, which are duplex soils (MacVicar *et al.* 1991). Duplex soils are characterised by an abrupt textural or structural transition between the surface horizon and the subsoil (Matthee 1996). The Glenrosa soil form (MacVicar *et al.* 1991) also occurs where the parent granite rock lies shallow below the surface. The species richness in this variant amounts to 193 individual species (Table 2), with the forbs contributing the most (39.2%) to this vegetation unit (Table 3). Dominant species (in terms of cover) include the trees *Dichrostachys cinerea*, *Combretum hereroense*, *Acacia nilotica*, *Acacia gerrardii*, the shrub *Euclea divinorum*, the grasses *Panicum maximum*, *Setaria sphacelata* var. *sphacelata*, *Digitaria eriantha*, and the forbs *Chaetacanthus setiger* and *Epaltes gariepina* (Table 9). The total canopy cover for this variant is 62.1% (Fig. 2).

TABLE 10
Species and growth form relations in Community 3

SPECIES	GROWTH FORM*	COMP. STATUS**	CANOPY COVER (%)	CROWN DIAMETER (m)	IND./ HA***	CANOPY/ CANOPY GAP (m)
Combretum imberbe	T	Strong	13.5	4.1	101	7.1
Spirostachys africana	T	Normal	1.3	5.1	6	40.6
Gymnosporia senegalensis	S	Strong	10.3	3.1	133	6.6
Flueggea virosa	DS	Strong	0.9	2.2	22	21.8
Phragmites mauritianus	G	Strong	22.2	0.5	11 640	0.6
Eriochloa meyeriana subsp. *meyeriana*	G	Normal	5.3	0.2	13 199	0.8
Eustachys paspaloides	G	Normal	10.3	0.3	20 282	0.5
Hypoestes forskaolii 'form B'	F	Strong	14.3	0.2	349 798	0.4

* T = Tree; DS = Dwarf shrub; G = Grass; F = Forb
** Competitor status
*** Individuals per hectre

TABLE 11
Statistical significance of a Detrended Correspondence Analysis presenting gradient lengths on four axes. Gradient lengths with standard deviations (SDs) of four or greater have statistical significance (ter Braak & Šmilauer 1998)

AXES	1	2	3	4	TOTAL INERTIA
Eigenvalues	0.86	0.59	0.43	0.29	9.72
Lengths of gradient (SD's)	**4.77***	**4.38***	**3.95**	**3.23**	
Cumulative percentage variance of species data	8.90	15.00	19.4	22.4	

* Significant gradients

TABLE 12
Influence of environmental variables on the community variation on the AGR computed by a Canonical Correspondence Analysis Monte Carlo Test. (full model. P-values ≤ 0.05 are significant (ter Braak & Šmilauer 1998))

ENVIRONMENTAL VARIABLES	VARIABLE NO.	LAMBDA-A	P-VALUE	F-VALUE
Soil	3	0.57	0.001	5.38
Slope	2	0.54	0.001	5.29
Physiographical units	1	0.20	0.001	2.05
Seeplines	4	0.21	0.001	2.07

The Gymnosporia senegalensis - Phragmites mauritianus *riparian low thicket (Community 3)*

This plant community (Fig. 1; Table 1, Species Group J) is found along the seasonal rivers occurring in the northern and north-western corner of the reserve. Alluvial soils are the predominant soils in the community. This community has the lowest species richness with a total of 118 species (Table 2), with the shrub (17.7%), grass (17.7%) and forb (44.6%) growth forms contributing the most to the species richness of this vegetation unit (Table 3). *Combretum imberbe* and *Gymnosporia senegalensis* are strong woody competitors (Table 10). Dominant herbaceous species (in terms of cover) include *Eriochloa meyeriana* subsp. *meyeriana*, *Eustachys paspaloides*, *Phragmites mauritianus* and *Panicum maximum*, of which *Phragmites mauritianus* is a strong competitor (Table 10). *Hypoestes forskaolii* 'form B' is a strong forb competitor (Table 10). The community structure expressed as a percentage actual cover contributed by each growth form is illustrated in Figure 2. The total class cover is 99.4% and is indicative of dense river vegetation, particularly within the grass (48.9%) and forb (21%) growth forms (Fig. 2). The woody proportion constitutes 18.4% of the total class cover (Fig. 2)

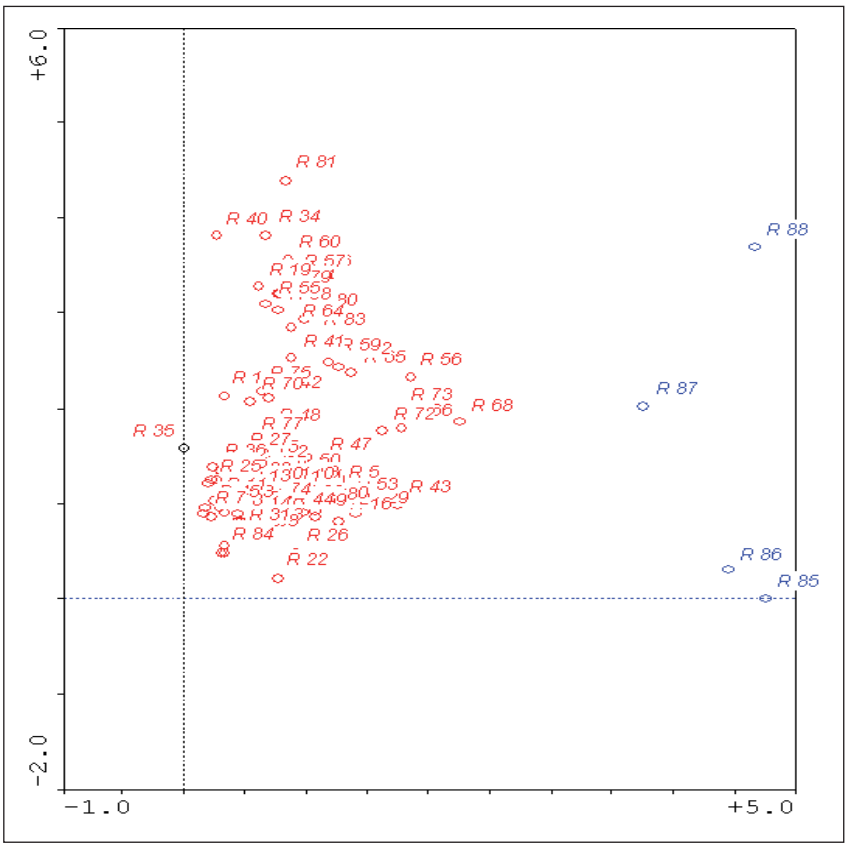

FIGURE 3
Detrended Correspondence Analysis (ter Braak & Šmilauer 1998) ordination of the complete data set of the Andover Game Reserve with a standard deviation (SD) of 4.77. Relevés highlighted in red represent Communities 1 and 2 and relevés highlighted in blue represent Community 3

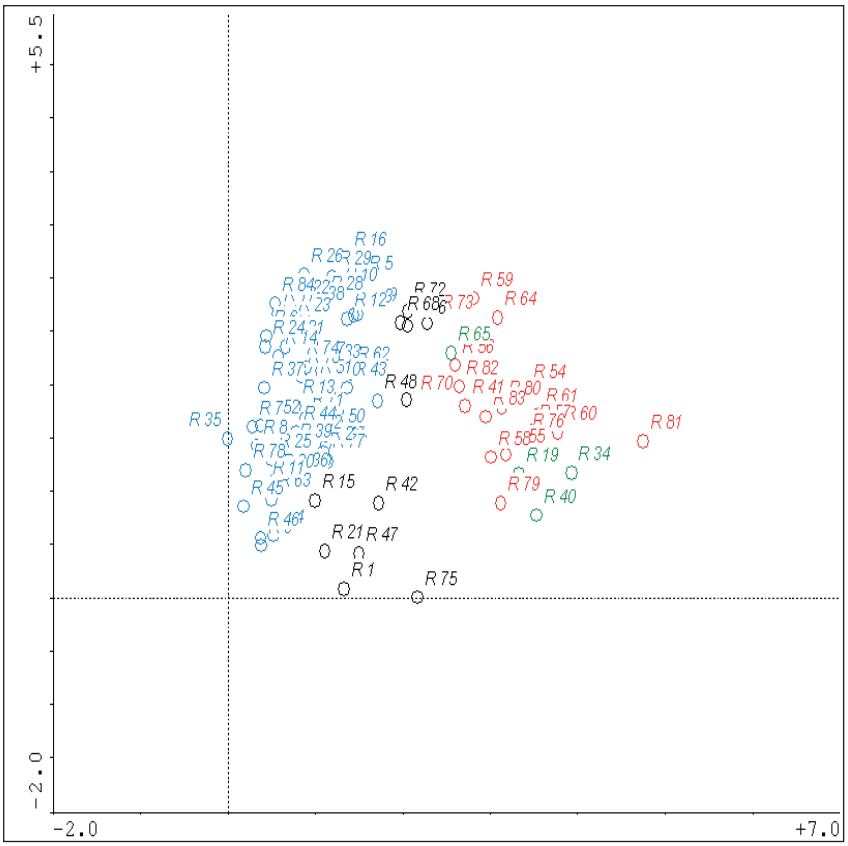

FIGURE 4
Detrended Correspondence Analysis (ter Braak & Šmilauer 1998) ordination of the data set of the Andover Game Reserve with a SD of 4.75 depicting the terrestrial communities (i.e. relevés representing Community 3 removed). Relevés highlighted in blue and red represent Communities 1 and 2. Relevés highlighted in black and green represent Variant 2a and outliers, respectively

and the high percentage grass cover found in this riparian community is due to the inclusion of the reed *Phragmites mauritianus* in the grass growth form, contributing 22.2% cover on its own (Table 10).

Verification of the plant communities

A DCA of the AGR data set using CANOCO (ter Braak & Šmilauer 1998) provided a significant standard deviation gradient of 4.7 on the first axis with further significant and modest gradients on axes 2, 3, and 4 (Table 11). The cluster diagrams generated by CANOCO (Fig. 3 & Fig. 4) reflect similar groupings to the relevé groupings generated by the PHYTOTAB-PC (Westfall 1992) classification programme (Table 1). A separation is evident between Community 3 (relevés highlighted in blue) and the terrestrial communities (1 & 2 plus their variants) (relevés highlighted in red) (Fig. 3). Excluding the riparian community (3) from the data set and performing another secondary ordination expands the terrestrial communities with relevés highlighted in blue, black and red, representing Community 1, Variant 2a and Community 2, respectively (Fig. 4). Outliers in terms of seepline (Variant 2a) relevés are highlighted in green. The lack of clustering of the seepline relevés (Fig. 4) can be attributed to the catenal phenomenon in terms of the variable width of the seeplines and their similarities to the adjacent plant communities with regard to being transitional between the upper and lower plant communities.

Of the environmental factors recorded, the factor most likely to have had the greatest influence computed by a CCA (Table 12) on the distribution of plant communities within the AGR was soil in terms of moisture and clay content.

DISCUSSION

The AGR's undulating granitic physiography resulted in the identification of a catenal sequence similar to that described by Scholes (1986, 1997). The plant communities of the AGR are thus a function of the catenal sequence in the Granite Lowevld Bushveld (Cronje 2004; Driver *et al.* 2005), reflecting a mosaic of units having a 'tortoise shell' appearance. Although plant species composition is influenced by such soil properties as nutrient status, pH, salinity and texture, the overwhelming factor determining the spatial distribution and productivity of forest, savanna and grassland is soil moisture balance (Tinley 1982; Walker 1985). At a scale of hundreds of meters to kilometres, the migration of fine soil particles and ions from ridge crests to valley floors, under the influence of water movement and gravity, establishes a topo-sequence of soils and associated vegetation known as a catena (Scholes 1997). The availability of this soil moisture to plants is dictated by the soil type, in terms of clay content. Fine-textured soils along the foot-slopes (high clay) are more xeric and thus water in these soils is limiting for much of the year. Under the same climatic conditions in sandy soils (*i.e.* along the crests and upper mid-slopes), moisture is much less of a limiting factor (Knoop & Walker 1985) although it is quickly lost to the bottomlands. The sandy soils generally have an acidic pH, with alkaline soils on the footslopes (Bredenkamp 1982; Scholes 1986). Therefore the differences in soil constituency reflect plant productivity, vegetation structure and species composition (O' Connor 1985). Floristic richness is also influenced by climate and management factors such as grazing and fire (O'Connor 1991; O'Connor 1995; Scholes 1997; Teague & Smit 1992).

The vegetation of the AGR relative to the catenal sequence described by Scholes (1997) has the broad-leaved savanna (Community 1) occurring on the crests and upper mid-slopes with sandy soils and the fine-leaved savanna (Community 2) on lower mid-slopes and footslopes with clay soils. Another characteristic feature of the catenal sequence is the formation of seeplines (*i.e.* an intermittent perched water table) that have characteristic hydromorphic or dambo grassland species (Scholes 1986; 1997) and is represented on the AGR by the community Variant 2a. The formation of this hydromorphic grassland is as a result of the interface between the sandy upland and the clayey bottomland (Scholes 1997).

The influence of the interface of the sand and clay is not necessarily limited to a specific area but can expand from the moist seepline areas into the broad-leaved savanna particularly with regard to hydromorphic sedges and forbs, which are clearly noticeable in the phytosociological table (Table 1), as indicated by the bold broken line between Variants 2a and 1b (Species Group E). A possible reason for this could be a damming-up effect causing moisture to move upwards from the seepline, resulting in a higher moisture content in the lower section of Variant 1b and thus creating hydromorphic conditions similar to that of a seepline. Water moving downslope towards the evident interface would then result in a higher soil moisture content up to the seepline, where the water emerges, creating a hydromorphic grassland. Variant 2a (*Acacia gerrardii - Fuirena pachyrrhiza* var. *pachyrrhiza*) is clearly recognisable by the predominance of sedges and hydromorphic grasses and the sparseness of trees, as reflected by the proportional cover values of the woody, grass and forb growth forms being 15%, 39.6% and 15.7%, respectively (Fig. 2). This hydromorphic community is more moist than the areas above and below it and therefore remains green and palatable for longer periods of time, thus making it a valuable habitat for wildlife, especially during the dry winter season (Scholes 1986).

Floristic and habitat correlation

Floristic and habitat correlations not only aid in the verification of the vegetation classification but also provide an understanding of the causes of community differentiation (Westfall 1992).

Finding a correlation between habitat and plant communities does not necessarily validate a classification, because with all the habitat factors available it should be possible to find some or other correlation with a specific group of plants. What is important however is that habitat factors shown to correlate with the plant communities should form some sort of environmental gradient (Panagos *et al.* 1998). The initial CANOCO DCA (ter Braak & Šmilauer 1998) ordination of all relevés provided a significant gradient (> 4 SD, Table 11). Scatter diagrams (Fig. 3 & Fig. 4) reflect relevé groupings similar to that produced by PHYTOTAB-PC (Westfall 1992). A CCA (ter Braak & Šmilauer 1998) conducted on the environmental factors (Table 12) recorded in this study indicated soil texture (*i.e.* sandy, sandy loam, loam and clay), and hence soil moisture, to be the environmental factor that had the greatest influence on the plant community differentiation. The relevé grouping produced both by PHYTOTAB-PC (Westfall 1992) and CANOCO (ter Braak & Šmilauer 1998) reflects a gradient relating to soil fertility and moisture clearly evident on catenas of granitic origin. Thus the DCA and the CCA supported and confirmed the vegetation classification of the AGR obtained in this study as analysed by PHYTOTAB-PC (Westfall 1992).

Conclusions

With the exception of the riverine work of Myburgh (1999), this is the first non-riverine application of a scale-related vegetation technique (Westfall *et al.* 1996) used in conjunction with PHYTOTAB-PC (Westfall 1992) in the Arid or Granitic Lowveld (Acocks 1988; Mucina & Rutherford 2006). The stratification and classification of the vegetation of the AGR at a scale of 1:13 000 has provided a map of the reserve with three main plant communities, two of which have two variants. The plant communities of the AGR are indicative of vegetation on deep sandy soils of the Granite Lowveld Bushveld Veld Type (Driver *et al.* 2005) with affinity to the catenal phenomenon. The

use of a multivariate data analysis technique on the AGR data set confirmed the phytosociological classification of AGR. The use of the scale-related vegetation survey technique (Westfall *et al.* 1996; Westfall & Panagos 1988) has provided quantitative data together with a vegetation map of the AGR, which can be used to formulate a management plan for the Andover Game Reserve.

An integral component of reserve management is the implementation of a vegetation monitoring programme for the Andover Game Reserve. The data collected in this study was objective with regard to the systematic manner (Cronje 2004) in which it was collected with the use of the Plant Number Scale (Westfall & Panagos 1988). It is recommended that an area-based monitoring technique that incorporates the data collected in this survey be used so that this baseline data can be expanded upon to benefit management decision support of the Andover Game Reserve.

ACKNOWLEDGEMENTS

The authors thank Mr A.J. Botha and Mr I.C. Sharp for logistical support and valued comments; the Tshwane University of Technology for funding; Dr W.J. Myburgh, Mr J.J. Kotze and Dr R.H. Westfall for assistance with data analysis; and Mrs I. Cronje for dedicated assistance and motivation.

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