Analysis of the riparian vegetation (Ia land type) of the proposed Vhembe-Dongola National Park, Limpopo Province, South Africa

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The establishment of the Vhembe-Dongola National Park has been an objective of several conservationists for many years. The ultimate objective is that this park would become a major component of a transfrontier park shared by Botswana, Zimbabwe and South Africa. The aim of this study was to identify, classify and describe the plant communities present in the Ia land type of the proposed area for the park. Sampling was done by means of the Braun-Blanquet method. A total of 70 stratified random relevés were sampled in the Ia land type. All relevé data was imported into the database TURBOVEG after which the numerical classification technique TWINSPAN was used as a first approximation. Subsequently Braun-Blanquet procedures were used to refine data and a phytosociological table was constructed, using the visual editor, MEGATAB. From the phytosociological table four plant communities were identified and described in the Ia land type. The ordination algorithm, DECORANA, was applied to the floristic data in order to illustrate floristic relationships between plant communities, to detect possible gradients in and between communities and to detect possible habitat gradients and/or disturbance gradients associated with vegetation gradients.

Key words: national parks, phytosociology, vegetation classification, Braun-Blanquet procedures, Savanna Biome.

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Introduction

The establishment of the Vhembe-Dongola National Park has been an objective of several conservationists for many years and was finally approved by South African National Parks in 1994 (Robinson 1996). This action follows after a long history of proposals to this regard, starting in 1922 from an initiative of General J.C. Smuts to form the Dongola Botanical Reserve (Carruthers 1992). The conservation value of this area lies in it's rich biodiversity, it's great scenic beauty and the cultural importance of the archaeological treasures of Mapungubwe which is included in the proposed area for this national park. The artifacts found at Mapungubwe rank among the most important pieces of ancient history yet found in sub-Saharan Africa (Willcox 1966). The significance of this proposed park and its surrounding areas is further enhanced by the potential role of the area as a sanctuary for some of the most endangered mammals on earth, such as the Black Rhino and the African wild dog (Robinson 1996).

The ultimate objective is that the Vhembe-Dongola National Park would become a major component of a transfrontier park shared by Botswana, Zimbabwe and South Africa. The total area of this transfrontier park could potentially add up to 2530 km² (Robinson 1996). Certain parts of the proposed area for the Vhembe-Dongola National Park is, however, extremely degraded because of a combination of anthropogenic influences, such as mining, cultivation, over-

grazing and trampling by livestock as well as other management malpractices (Götze 2002). A large military base of the former South African Defence Force was also situated on the farm Greefswald, and contributed to the disturbance and degradation of the area. Old campsites litter the proposed area and the scars left by forgotten roads, quarries and dumpsites are a cruel sight to the eye (Götze 2002). It is, therefore, evident that specific restoration and rehabilitation practices should be implemented in an attempt to restore the land to a higher potential for the conservation of our precious fauna and flora.

Of all the land types in the Vhembe-Dongola National Park the Ia land type which include the riparian areas seems to be the most disturbed, mainly because of the extensiveness of this linear landscape, the high fertility of the soils and the consequent establishment of irrigation lands (Götze 2002). The riparian zone can be identified as the area of land adjacent to a stream or river, which is, at least periodically, influenced by fluctuations of the water level (Rogers 1995). Although the Ia land type is overutilised by small and large livestock, the destruction caused by migratory Tuli Elephants, from neighboring Botswana, is an additional cause for concern. Furthermore, riparian zones warrant special attention since their positioning in the landscape ensures that they play direct roles in the functioning of both the river system and the terrestrial landscape and are one of the major centers of biodiversity in a global context (Naiman et al. 1993). The narrow spatial dimensions and open endedness of riparian wetlands make them highly sensitive to landscape changes, with major consequences to the river ecosystems which they buffer from terrestrial influences (Naiman & Décamps 1990; Rogers 1995).

The current state of the proposed area for the Vhembe-Dongola National Park and the uniqueness of the area with respect to diversity and cultural importance warrant the establishment of detailed management practices. In the past decade conservation management has moved more in the direction of total environmental management. Emphasis in conservation is not on strictly policed, protected areas, primarily for large mammals anymore, but on sustainable resource use, maintenance of ecological processes and conservation of genetic diversity (Winterbach 1998). A sound knowledge of the vegetation ecology of areas of conservation significance is essential for the establishment of efficient wildlife and environmental management programs and the compilation of conservation policies (Bredenkamp & Theron 1978; Bredenkamp et al. 1993; Bezuidenhout 1996; Van Rooyen et al. 1981). Different ecosystems react differently to certain management practices (Bredenkamp & Theron 1976) and therefore, in order to formulate a management policy, where proper land use is emphasised, the classification of the vegetation is essential (Van Rooyen et al. 1981; Bezuidenhout 1993). It is widely recognised that a detailed description, identification, classification and mapping of the vegetation, form the basis for sound land-use planning and management (Fuls 1993; Bezuidenhout 1996; Brown 1997).

The aim of this study is to identify, classify and describe the plant communities present in the Ia land type of the proposed area for the Vhembe-Dongola National Park. This study forms part of a bigger study on the vegetation of all the land types included in the proposed Vhembe-Dongola National Park.

Study area

Location

The proposed area for the Vhembe-Dongola National Park is centered on the confluence of the Limpopo and Shashi Rivers, in the Limpopo Province, on the international borders between Botswana, Zimbabwe and South Africa (Robinson 1996) (Fig. 1). The primary core area spans from Pontdrif in the west to Weipe in the east incorporating 22

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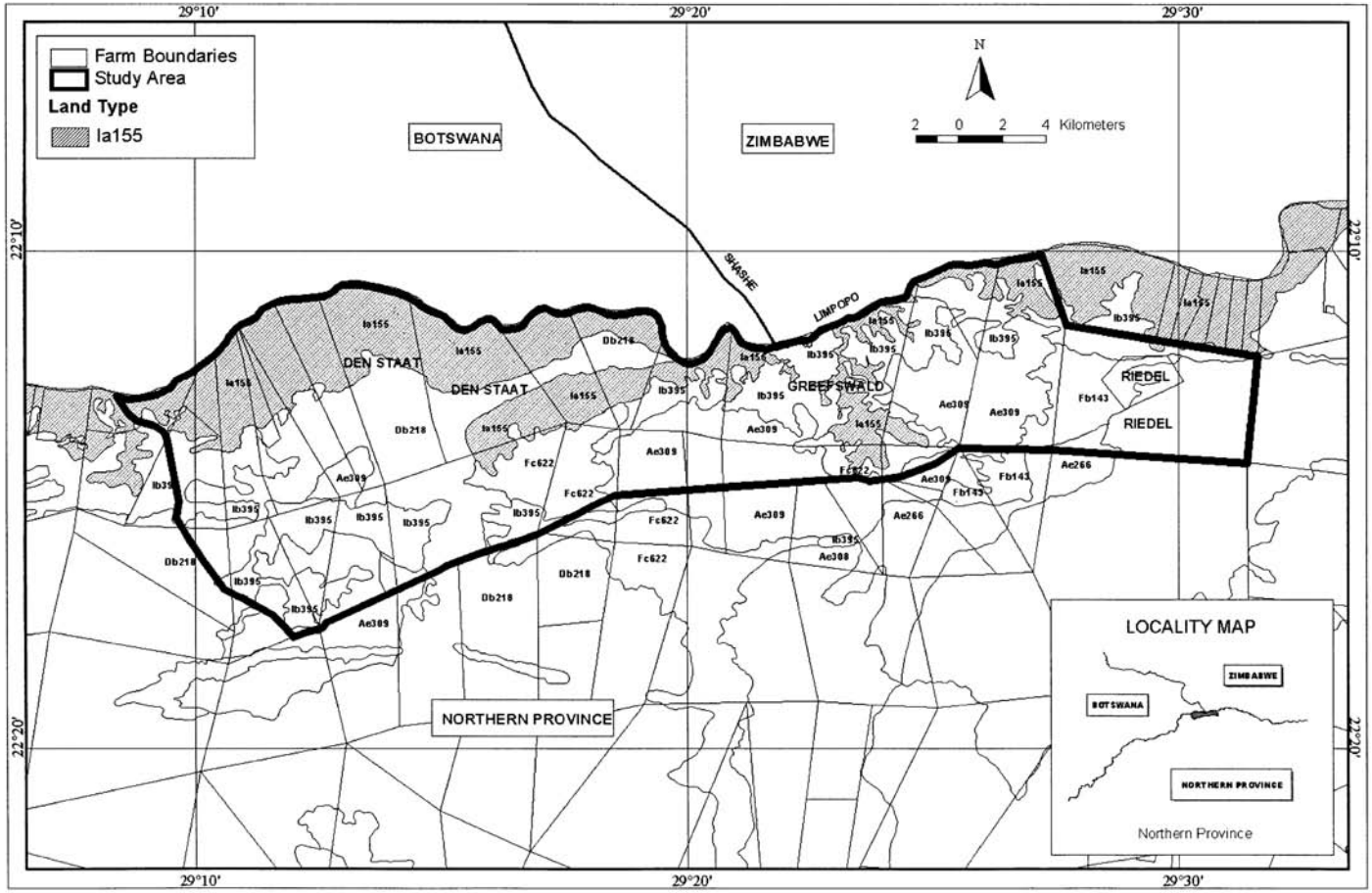
Fig. 1
Relative location of the Ia land type in the proposed area of the Vhembe-Dongola National Park



farms with a surface area of 28 000 ha (Fig. 1).

Land types

In South Africa land types have been used as a map unit denoting land, mappable at 1:250 000 scale, over which there is marked uniformity of climate, terrain form and soil pattern. The Ia land type (Fig. 1) includes the riverine and non-perennial wetland vegetation with deep to moderately deep soils with a high silt and clay content. Other land types which occur within the proposed area of the Vhembe-Dongola National Park are the Ae, Db, Fb and Ib land types (Fig. 1) (Land Type Survey Staff 2000).

Climate

The climate is semi-arid with the long-term mean annual rainfall ranging from 350 mm to 400 mm per annum (Willcox 1966; Robinson 1996). Rainfall is highly variable and usually falls during the summer months between October and March. Evaporation from free water surfaces is in excess of 2 500 mm per annum for the largest part of the area. In summer the temperatures rise as high as 45 °C (Weather Bureau 1986). The winters are mild, although frost may occur in low-lying areas (Robinson 1996).

Hydrology

Surface drainage is mostly in a northerly direction towards the Limpopo River. None of the rivers in the area, including the Limpopo, are perennial. Ground water supplies are generally poor in the region except where these occur along well-developed fault lines (Van den Heever 1983; Robinson 1996).

Geology, geomorphology and soils

The area is between 300 m and 780 m above sea level. South of the Limpopo River the ground tends to be flat with sandstone and conglomerate ridges and koppies. Closer to the Limpopo River the flats give way to a more rugged, hilly terrain. The soils of the Limpopo Valley are derived from rocks of the Archaean granite formations in the south and, more generally, from the Karoo-system (Stormberg, Ecca and Beaufort Series). The soils vary from red-brown sandy loam to dark brown clays with high silt content. Large areas are characterised by sandy, lime-rich soils (Robinson 1996). The geology of the Ia land type consists of sand and alluvium from the Quaternary System and deep red/brown, alluvial soil forms (Oakleaf) and some duplex soils (Valsrivier & Arcadia) dominate the soils of this land type (Land Type Survey Staff 2000).

Vegetation

According to Van Rooyen & Bredenkamp (1996), the area is situated in vegetation type no. 10, Mopane Bushveld, while Acocks (1988) placed it in veld type no.15, also Mopane Veld. According to Acocks (1988), there are two major blocks of *Colophospermum mopane* veld. One of these blocks of *Colophospermum mopane* is situated in the Limpopo Valley north of the Soutpansberg and the other to the east of the Soutpansberg. The conservation status of the eastern block, which occurs in the Kruger National Park is sound with 89% of the area protected. The western block is not well represented in conservation areas with only 0,36% being formally protected (Berry 1994; Robinson 1996).

The former Transvaal Provincial Administration (Transvaal Provincial Administration 1989) recognised three main vegetation units in the region: the riparian fringe along the Limpopo River and its tributaries, the *Acacia-Salvadora* communities of the Limpopo flats (including flood plains) and wetland areas, and the mixed mopane veld on ridges and flats south of the riparian fringe and flood plains. Other vegetation studies done in the Vhembe-Dongola National Park and surrounding areas in the past, include several unpublished studies, namely a terrain and vegetation evaluation by the former South

African Defence Force (South African Defence Force 1986a, 1986b), a study of vegetation types in the Limpopo-Venetia Nature Reserve (O'Connor 1991) and a vegetation survey of the Maramani/Tuli Area in Southwestern Zimbabwe (Timberlake & Mapaure 1999).

Cultural historical assets

Robinson (1996) stated that the proposed area of the Vhembe-Dongola National Park has numerous archaeological sites dating from the Early Stone Age to the present. Many of these sites, which are concentrated in the area of the confluence of the Limpopo and Shashi Rivers, are of major importance and scientific value. Of particular interest are the Zhizo site (AD 700-900) on the farm Schroda, and Mapungubwe Hill and the adjoining Bambandyanalo (AD 1100-1250) situated on Greefswald. According to Voigt & Plug (1981) the Mapungubwe site is considered to be of major importance in Sub-Saharan Africa and is the most remarkable Iron Age site in South Africa. Additional features of importance are the numerous rock paintings and petroglyphs found in the area.

Methods

Stratification

With the aid of 1:50 000 topographical maps, geological maps and vegetation and soil maps compiled by the old South African Defence Force 1986 a,b), a land type map of the area (Land Type Survey Staff 2000) and aerial photographs, a preliminary evaluation of the study area was made. In conjunction with the maps, a detailed reconnaissance of the area was done to determine homogeneous areas in the vegetation, before sampling commenced. Land types were used as a means of primary stratification of the study area.

Sampling

Making visual estimates, sampling was done by means of the Braun-Blanquet method (Mueller-Dombois & Ellenberg 1974). A total of 70 stratified random relevés were sampled in the Ia land type. Braun-Blanquet cover abundance values were appointed to all plant species encountered in the relevés (Table 1).

Plant species identification was done by following Arnold & De Wet (1993), but are updated according to the PRECIS floristic database of South Africa, managed by the National Botanical Institute in Pretoria. Soil classification is according to the Soil Classification Work Group (1991). Trees and shrubs were distinguished from each other using the guidelines set by Edwards (1983). Trees are classified as rooted, woody, self-supporting plants over 2 m high with one or up to three definite trunks and shrubs are classified as rooted, woody, self-supporting, multi-stemmed or single-stemmed plants less than 2 m high (Edwards 1983).

The habitat conditions including geology, soil forms and other edaphic factors, slope, aspect and the rockiness of the soil surface, of each relevé, were qualitatively described. This information was used in the description of the different plant communities. The coordinates of each relevé were determined and noted with the use of a GPS.

Data processing

All relevé data has been imported into the database TURBOVEG (Hennekens 1996a). The numerical classification technique TWINSPAN (Hill 1979a), which is regarded as a successful approach for classification by several phytosociologists (Mucina & Van Der Maarel 1989; Bredenkamp & Bezuidenhout 1995; Cilliers 1998) was used as a first approximation for the floristic data. Subsequently Braun-Blanquet procedures (Bezuidenhout *et al.* 1996) were used to refine data and construct a phytosociological table (Table 1) using a visual editor, MEGATAB (Hennekens 1996b). Uncommon species not diagnostic for any of the communities are not included in the table, but can be witnessed in Götze (2002). Using the phytosociological table and the habitat information gathered during the sampling period, the different plant communities were identified and described. No attempt was made in this study to formally name the plant communities. This will only follow after extensive studies on Savanna vegetation in South Africa to prevent synonymy of syntaxa names.

An ordination algorithm, DECORANA (Hill 1979b), was applied to the floristic data in order to illustrate floristic relationships between plant communities and to detect possible habitat gradients and/or disturbance gradients associated with vegetation gradients.

Table 1

Phytosociological table of the vegetation of the Ia land type of the Vhembe-Dongola National Park.

Relevé no.	1 1 1 1 1 1 0 1	1 1 1 1 1 2	2 2 2 2 2 0 1 1 1 1 1 0 1 0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0 1 0 1 0	1 1 1 1 1 1 1 1	1 1 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0
	6 6 6 5 5 5 1 4	6 4 4 8 2	1 1 1 1 8 1 1 1 1 2 2 1 7 7 8 9 9 0 0 0 0 0 0 7 8 9 9 9 9 0 9 0 2	1 2 1 1 2 1 1	0 0 8 7 7 0 1 8 8 8 8 8 8 9 9 9 0
	5 6 7 1 4 0 4 7	4 9 8 2 0	3 4 5 6 0 1 3 5 8 1 2 9 1 3 2 8 7 8 0 1 4 8 9 7 9 0 1 6 9 2 5 3 0	9 1 6 7 0 0 4	5 6 1 8 9 7 2 2 4 5 6 3 7 2 3 4 5
No. of species per releve	3 3 3 2 2 2 2 3	3 3 3 3 3	2 3 3 2 2 2 2 2 2 2 3 3 2 3 2 2 1 1 1 2 2 2 2 2 2 1 1 1 1 1 1 1 1 2 2	1 1 0 1 1 1 1	2 2 0 1 1 1 1 1 1 1 1 2 1 1 1 1 2
	8 5 3 8 1 3 4 7	0 2 2 8 3	4 2 4 8 5 4 7 3 3 5 2 3 8 0 4 1 9 2 8 0 2 8 4 7 5 8 3 7 6 9 6 2 8	3 5 9 3 2 8 8	0 0 9 7 6 9 6 2 8 4 2 2 6 8 2 6 4
Communities	1		2	3	4
Sub-communities	1.1 / 1.2 / 1.3		2.1 / 2.2	3.1 / 3.2	
Variants	1.2.1 / 1.2.2				
Species group A					
Cucumis zeyheri	1 1 1 1 1 + a	1 a a b 1	a 1 +		1 + +
Boerhavia erecta	+ + a a b	1 b a a a	1 1 + 1		
Heliotropium ovalifolium	+ 1 1 a +	1 + + +	a a b +	+ 1	+ + + +
Phyllanthus parvulus	+ + + + +	+ + + + +	+		
Acalypha indica	1 + 1 + 1	+ +	+ +	+	
Ipomoea sinensis subsp. *blepharosepala*	+ + + + +	+ + + +	+ + +		
Pupalia lappacea	+ + +	+	+ +		
Pergularia daemia var. *daemia*	+	1	+ +		
Acacia grandicornuta	3		3		
Species group B					
Colophospermum mopane	4 4 4		1 +	1 + a +	
Aristida adscensionis	1 1 1	+	+		
Brachiaria deflexa	+ + +	+	+ a + +	+	
Hibiscus micranthus	+ + +	+ +	+	+	
Tragus berteronianus	+ + + +	1 + + +	+ 1		+ 1
Eragrostis lehmanniana	a a	+	+ + + +	+ + +	
Aptosimum lineare	1 + +				
Phyllanthus angolensis	+ +				
Becium filamentosum	+ +				
Melhania rehmannii	+ +				
Sida species	+ +	+			

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Table 1
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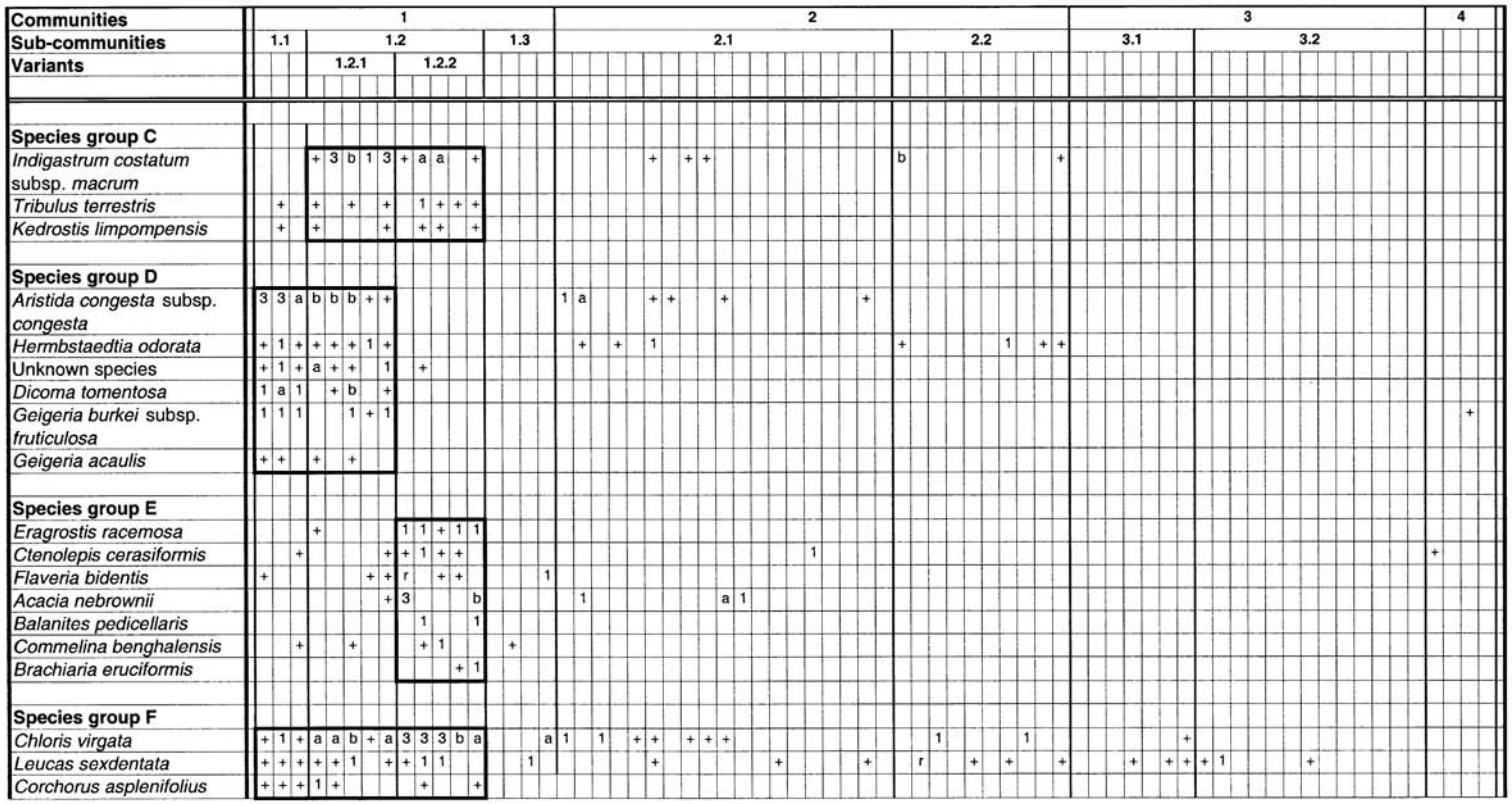

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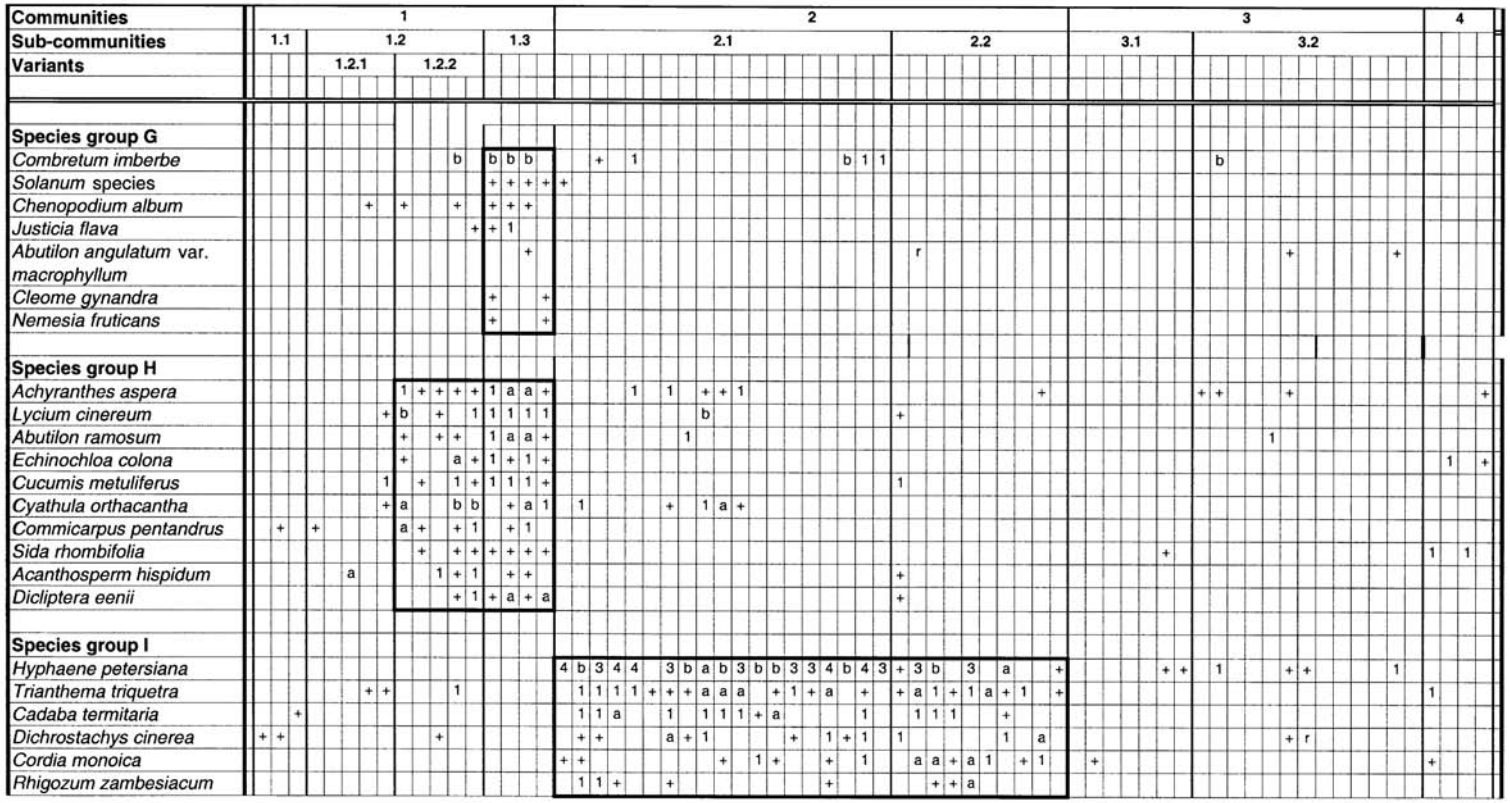

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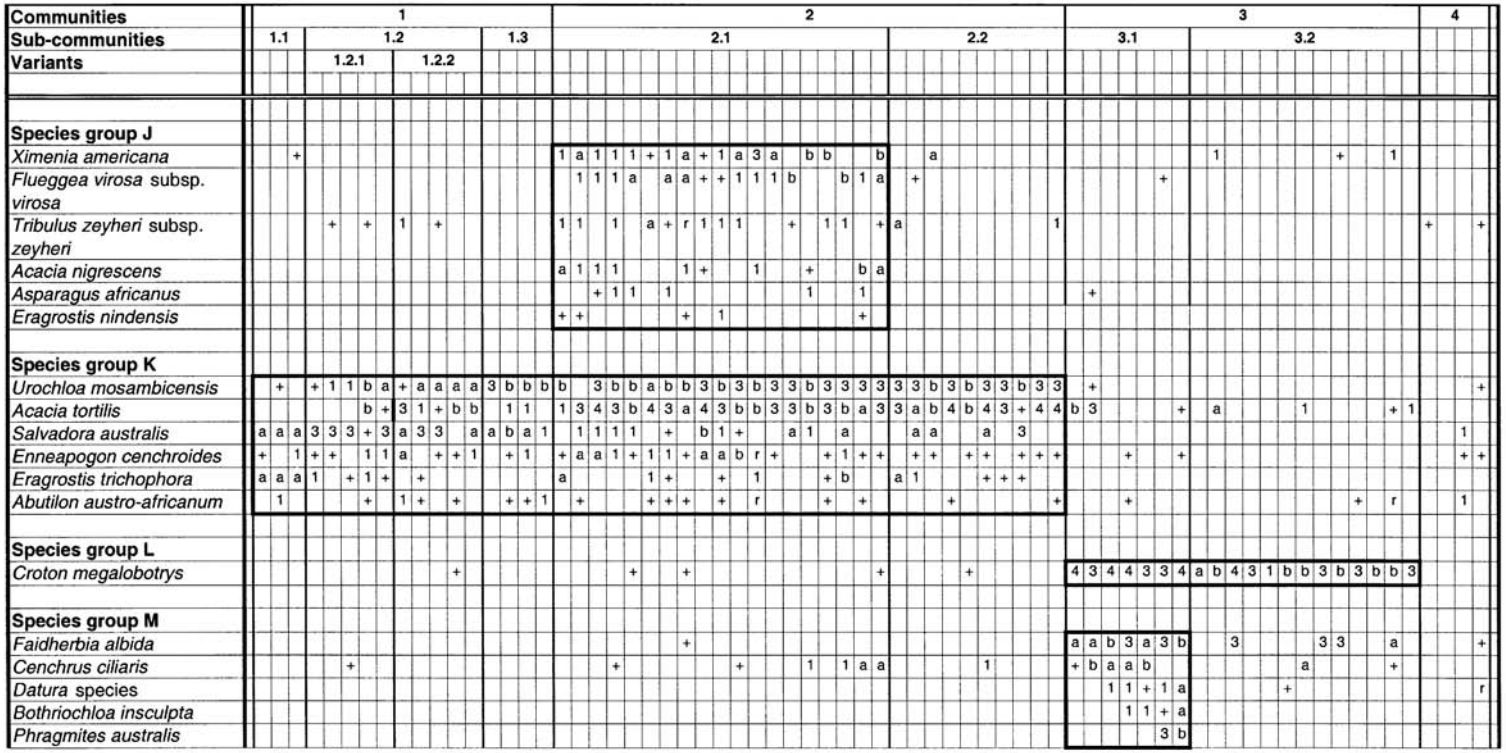

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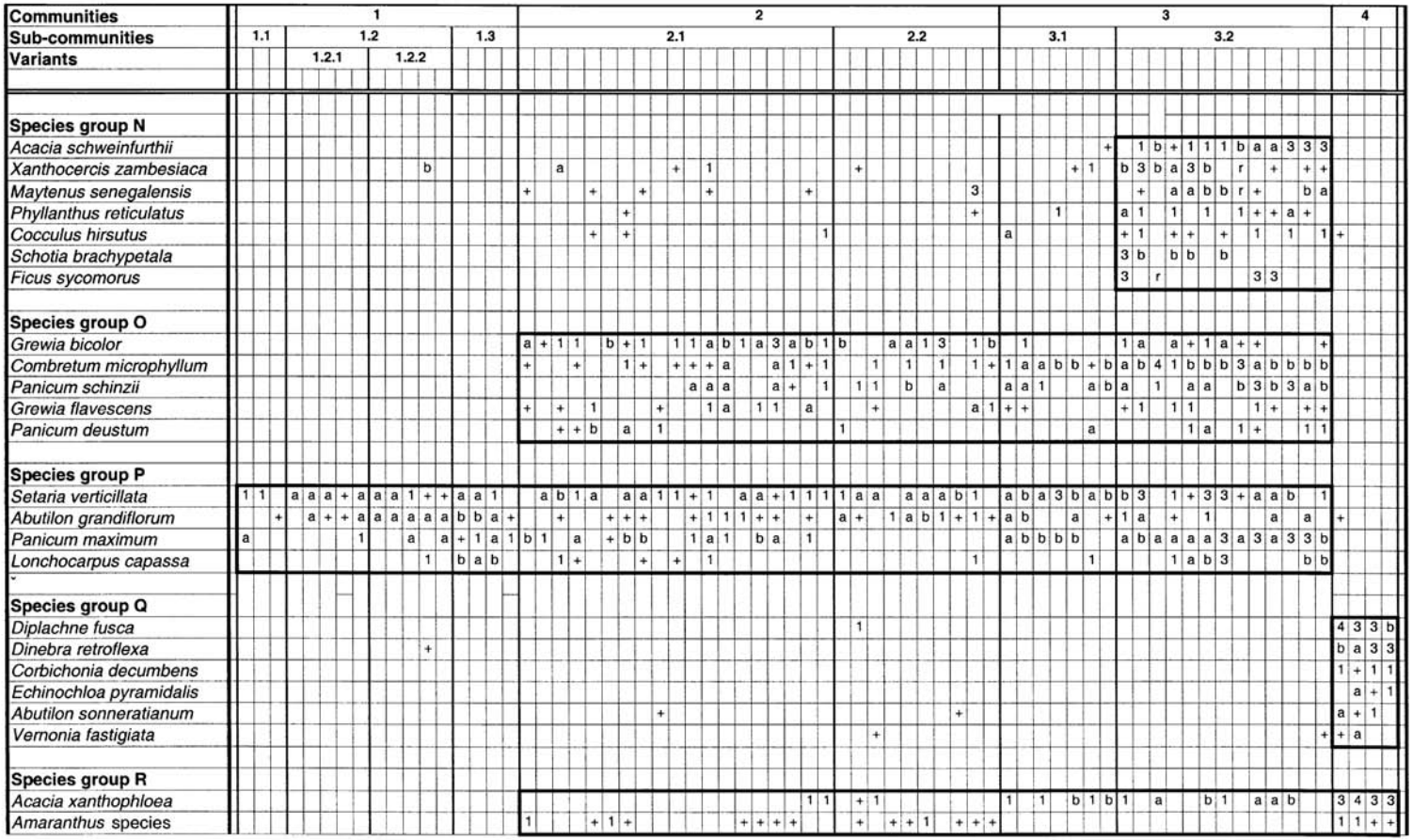

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Results and discussion

Classification

From the phytosociological table (Table 1) the following plant communities, sub-communities and variants were recognised:

1. *Salvadora australis-Cucumis zeyheri* Community
   - 1.1 *Colophospermum mopane-Eragrostis trichophora* Sub-community
   - 1.2 *Indigastrum costatum* subsp. *maculata-Setaria verticillata* Sub-community.
     - 1.2.1 *Aristida congesta-Leucas sexdentata* Variant.
     - 1.2.2 *Eragrostis racemosa-Acacia tortilis* Variant
   - 1.3 *Combretum imberbe-Abutilon ramosum* Sub-community
2. *Hyphaene petersiana - Acacia tortilis* Community
   - 2.1 *Ximenia americana-Flueggea virosa* Sub-community
   - 2.2 *Cordia monoica* Sub-community
3. *Croton megalobotrys-Combretum microphyllum* Community
   - 3.1 *Cenchrus ciliaris-Faidherbia albida* Sub-community.
   - 3.2 *Acacia schweinfurthii - Maytenus senegalensis* Sub-community.
4. *Diplachne fusca - Acacia xanthophloea* Community

Description of the plant communities

1. *Salvadora australis-Cucumis zeyheri* Community

This community mostly occurs on the floodplain, toward the outskirts of the lush riverine forest belt found along the main river systems in the study area. A wide spectrum of soil types was found, with Oakleaf being the dominant soil form and Hutton, and Valsrivier soil forms in close support. With the exception of one sub-community, the soils that are found in this community have a high silt and moderate clay content.

This community is situated higher above the annual flood level than its neighbouring communities, and as a result, appears to be drier. The slight slope is generally in the main direction leading towards the Limpopo River. A further observation was that the soil surface is compacted through years of overgrazing by cattle and a large number of game that frequent the area, and therefore a high degree of surface runoff is apparent. In some extreme cases this has led to a degree of surface erosion.

The vegetation of the *Salvadora australis – Cucumis zeyheri* Community varies between open woodland, thickets and forests. The diagnostic species of this community are found in Species group A (Table 1), and include the forbs *Cucumis zeyheri*, *Boerhavia erecta*, *Heliotropium ovalifolium*, *Phyllanthus parvulus* and *Ipomoea sinensis* subsp. *blepharosepala*. *Salvadora australis* (Species group K, Table 1) and the herbaceous *Cucumis zeyheri*, *Boerhavia erecta* (Species group A, Table 1) and *Setaria verticillata* (Species group P, Table 1) dominate the vegetation of this community. The absence of the species that are found in Species group O (Table 1) differentiates this community from most of the other communities in the Ia land type.

Three sub-communities were identified in this community:

1.1 *Colophospermum mopane-Eragrostis trichophora* Sub-community

This sub-community is situated on the very outskirts of the floodplain. It is situated on sandy Hutton soils with surface erosion clearly visible as there are usually drainage systems running off towards the Limpopo River, bisecting this vegetation unit.

Diagnostic species of this sub-community are found in Species group B (Table 1), which includes the tree species *Colophospermum mopane* the grass *Aristida adscensionis* and the forbs *Phyllanthus angolensis*,

Becium filamentosum and *Melhania rehmannii*. The tree layer is dominated by *Colophospermum mopane* (Species group B, Table 1) and to a lesser extent *Salvadora australis* (Species group K, Table 1). The shrub layer is sparse. The grass species *Eragrostis trichophora* (Species group K, Table 1) and the annual grass *Aristida congesta* subsp. *congesta* (Species group D, Table 1) dominate the herbaceous layer.

The tree layer of this sub-community reaches heights of between 2.5 m and 4.0 m and has an average crown cover of 35 %. The shrub layer has an average height of 1.4 m and the cover varies between 10 % and 35 %. The herbaceous layer reaches an average height of 0.5 m and a crown cover of between 45 % and 65 %.

1.2 *Indigastrum costatum* subsp. *maculata-Setaria verticillata* Sub-community.

The soil forms occurring in this sub-community are Hutton, Oakleaf and Valsrivier. The sub-community is situated on a level floodplain of which the soil surface gets trampled to a fine dust during the dry season. The area is targeted by high degree of grazing by game and, therefore the area shows signs of degradation through the appearance of bare patches in the grass layer. Due to flooding in high rainfall years, as well as the high resilience of this floodplain area, any restoration practices are uncertain at this stage.

The vegetation of this sub-community varies between open woodlands and thickets. The species that are diagnostic to this sub-community are found in Species group C (Table 1) and include *Indigastrum costatum* subsp. *maculata*, *Tribulus terrestris* and the scarce herbaceous climber *Kedrostis limpompensis*. The species of Species group F (Table 1), indicates a similarity between this sub-community and the *Colophospermum mopane – Eragrostis trichophora* Sub-community (1.1).

The tree layer of this sub-community reaches heights of between 2.2 m and 8 m (in some cases > 8 m). The crown cover of the tree layer varies between 20 % and 45 %. The shrub layer has an average height of 1.4 m and the crown cover varies between 5 % and 25%. The herbaceous layer is well developed with an average crown cover of 80% and heights varying from 0.2 m to 0.9 m.

The *Indigastrum costatum* subsp. *maculata – Setaria verticillata* sub-community has two variants, which differ from each other with respect to soil types and vegetation structure.

1.2.1 *Aristida congesta-Leucas sexdentata* Variant.

This variant comes in the form of open woodlands with *Salvadora australis* (Species group K, Table 1) occurring in bush-clumps. The soils that are found in this variant have a high silt content and consist of the Hutton and Oakleaf soil forms.

There are no diagnostic species to this variant. The absence of Species groups E and H (Table 1) as well as a low frequency of the tree species *Acacia tortilis* and the shrub *Abutilon austro-africana* (Species group K, Table 1) do, however, differentiate this variant. It is further distinguishable from the *Eragrostis racemosa – Acacia tortilis* Variant (1.2.2) by Species group D (Table 1) and the presence of the woody species *Acacia stuhlmannii*, and a high abundance of the grass *Eragrostis trichophora* (Species group K, Table 1).

The tree cover of this variant is between 20 % and 35 %, and the height of the trees alternating between 2.2 m to 4.0 m. In some isolated places there is no tree cover at all. The shrub layer reaches an average height of 1.3 m and the crown cover varies between 5 % and 20 %. The herbaceous layer covers between 60 % and 90% of the variant area and reaches an average height of 0.5 m.

1.2.2 *Eragrostis racemosa-Acacia tortilis* Variant

This thicket variant of the *Indigastrum costatum* subsp. *maculata – Setaria verticillata* Sub-community forms a boundary between the open woodlands of the *Aristida congesta – Leucas sexdentata* Variant (1.2.1) and the other riverine forest communities and sub-communities. The Valsrivier and Oakleaf soil forms found in this variant have a high clay content and appear to be less dry compared to the open woodland communities.

The species of Species group E (Table 1) are diagnostic to this variant, which include the grass species *Eragrostis racemosa* and the forb *Ctenolepis cerasiformis*. A species with high abundance that further differentiate this variant from the *Aristida congesta-Leucas sexdentata* Variant (1.2.1) is the woody species *Acacia tortilis* (Species group K, Table 1).

The vegetation cover of this variant is markedly higher than that of the *Aristida congesta-Leucas sexdentata* variant (1.2.1). *Salvadora australis* and *Acacia tortilis* (Species group K, Table 3) dominate the tree layer. The tree cover is 40 % on average and it reaches heights of between 3.5 m and > 8 m. The shrub layer has an average height of 1.4 m with an average crown cover of 20 %. The herbaceous layer has an average crown cover of 82 % and reaches an average height of 0.5 m.

1.3 *Combretum imberbe-Abutilon ramosum* Sub-community

This sub-community is situated in the riverine forest and in some cases on the fringes of the *Acacia xanthophloea - Diplachne fusca* Community (4) on the floodplain of this land type. Soil forms include Valsrivier, Oakleaf and Arcadia. In most cases the aspect is towards the middle of the adjacent water system, the slope is usually not to steep (2 -5º) and the soil surface is normally free of rocks.

Tall *Combretum imberbe* (Species group G, Table 1), *Lonchocarpus capassa* (Species group P, Table 1) and to a lesser extent, *Acacia tortilis* (Species group K, Table 1) trees and a high abundance of the shrub *Abutilon ramosum* (Species group H, Table 1) and the grass *Urochloa mosambicensis* (Species group K, Table 1) dominate the vegetation in this sub-community. Diagnostic species of the *Combretum imberbe-Abutilon ramosum* Sub-community is found in Species group G (Table 1), which include the tree species *Combretum imberbe* and the herbaceous *Solanum* species. The absence of the species that are found in Species group F (Table 1) differentiates this sub-community from the other two in the *Salvadora australis-Cucumis zeyheri* Community (1). Species with high cover abundance values that further differentiate this sub-community from the *Colophospermum mopane-Eragrostis trichophora* Sub-community (1.1) and the *Indigastrum costatum* subsp. *maculata-Setaria verticillata* Sub-community (1.2) are *Lycium cinereum* (Species group H, Table 1) in the woody component and the shrub *Abutilon austro-africanum* (Species group K, Table 1). The grasses *Echinochloa colona* (Species group H, Table 1) and *Panicum maximum* (Species group P, Table 1) and the forbs *Cucumis metuliferus* and *Dicliptera eenii* (Species group H, Table 1) also differentiate this sub-community.

Trees with an average height of more than 7 m and a crown cover of approximately 50 % dominate the vegetation of this sub-community. The shrub layer reaches an average height of 1.4 m and the shrub cover varies between 5 % and 30 %. The herbaceous layer covers between 30 % and 70 % of the sub-community with an average height of 0.4 m.

2. *Hyphaene petersiana - Acacia tortilis* Community

This community occurs on the flood plains; adjacent to the dense forest belt that occurs on the banks of the main rivers in the area. Soils of the Oakleaf form is the main soil type found in this community, with Arcadia and Valsrivier soils occurring on a more sporadic basis. The aspect and extremely gradual slope are mostly in a northerly direction as this is the general flow direction of the Limpopo River in respect to this community.

Rockiness of the soil surface is 1–6 % and the rocks and/or pebbles are often of a calcareous origin. This area is frequented by elephants and as a result is heavily utilised.

The diagnostic plant species of this community are found in Species group I (Table 1) and include the woody species *Hyphaene petersiana* and the forb *Trianthema triquetra*. Other species with high cover abundance values are *Acacia tortilis*, *Salvadora australis* (Species group K, Table 1) and *Grewia bicolor* (Species group O, Table 1) from the woody component as well as the grasses *Enneapogon cenchroides*, *Urochloa mosambicensis* (Species group K, Table 1) and *Setaria verticillata* (Species group P, Table 1).

The tree layer of this community covers 10–60 % of the area. The height of the tree layer varies between 3 m and 9 m. The height of the shrub layer varies between 1.2 m and 2.0 m and the crown cover between 10 % and 60 %. Grasses dominate the herbaceous layer. This layer has an average height of 0.5 m and a crown cover of between 37 % and 82 %.

This community is divided into two sub-communities based on differences in vegetation structure. In the *Ximenia americana - Flueggea virosa* Sub-community (2.1) the shrub layer is dominant and in the *Cordia monoica* Sub-community (2.2) the tree layer is dominant.

2.1 *Ximenia americana-Flueggea virosa* Sub-community

This sub-community covers the largest part of the *Hyphaene petersiana - Acacia tortilis* Community (2). The dominant soil forms are Oakleaf and Valsrivier with high silt content and a small number of the Arcadia soil form, which is a duplex soil with high clay content.

Diagnostic species of this sub-community are found in Species group J (Table 1) and include the woody species *Flueggea virosa* subsp. *virosa* and *Ximenia americana*. The dominant species are the tree species *Hyphaene petersiana* (Species group I, Table 1) and *Acacia tortilis* (Species group K, Table 1) as well as the grass species *Urochloa mosambicensis* (Species group K, Table 1). Other species distinguishing this sub-community from the *Cordia monoica* Sub-community (2.2) is the woody *Acacia nigrescens* (Species group J, Table 1), the grass *Panicum maximum* (Species group P, Table 1) and the annual forb *Tribulus zeyheri* subsp. *zeyheri* (Species group J, Table 1).

The tree layer has an average height of 5 m (in some cases as high as 9 m) and the crown cover varies between 10 % and 55 %. The shrub layer on the other hand enjoys a crown cover of between 36 % and 63 % and an average height of 1.7 m. The herbaceous layer has an average height of 0.5 m and covers 38 % to 80 % of the sub-community area.

2.2 *Cordia monoica* Sub-community

The habitat of this sub-community is in many ways similar to that of the *Ximenia americana - Flueggea virosa* Sub-community (2.1). The only difference being that this sub-community has established under drier conditions and mainly occurs on somewhat higher lying areas further away from the Limpopo River. The soils are also of the Oakleaf and Valsrivier forms with less occurrences of the Arcadia soil form.

There are no diagnostic species, which define this sub-community. The dominant species are *Acacia tortilis* and *Urochloa mosambicensis* (Species group K, Table 1) with *Hyphaene petersiana* (Species group I, Table 1) not as dominant as in the *Ximenia americana - Flueggea virosa* Sub-community (3.1). Species that further differentiate this sub-community are the woody species *Cordia monoica* (Species group I, Table 1) and the absence of the tree species *Lonchocarpus capassa* (Species group P, Table 1) and the grasses *Panicum deustum* (Species group O, Table 1) and *P. maximum* (Species group P, Table 1).

In the *Cordia monoica* Sub-community (2.2) the tree layer dominates the shrub layer. The tree layer reaches an average height of 5 m

and a crown cover of between 30 % and 60 % while the crown cover of the shrub layer varies between 10 % and 45 % and reach an average height of 1.6 m. The herbaceous layer covers between 37 % and 82 % of the sub-community and has an average height of 0.4 m.

3. *Croton megalobotrys-Combretum microphyllum* Community

This riverine community is mainly situated on the banks of the Limpopo River and to a lesser extent on the floodplain. It is characterised by tall trees and sometimes a dense undergrowth of shrubs, climbers and various other forbs and grasses. The utilisation by the Tuli elephants is of a big, but not totally destructive measure. The elephants trample the area as they frequent it, mainly for shelter at night. The soils of this unit consist of Oakleaf and Valsrivier soil forms. The aspect is once more chiefly in a northerly direction and the slope varies between gradual slopes (1-5 º), leading from the flood-plain unit to the river, and short steep inclines (10-20 º) leading to the river itself.

The diagnostic species is found in Species group L (Table 1) and in this case it is the woody species *Croton megalobotrys*, which occurs in tree and shrub form. The woody species *Croton megalobotrys* (Species group L, Table 1), the creeper *Combretum microphyllum* (Species group O, Table 1) and the grass species *Panicum maximum* (Species group P, Table 1) dominate the vegetation of this community. Other species with high cover abundance values are the tree species *Acacia xanthophloea* (Species group R, Table 1) and the grass species *Setaria verticillata* (Species group P, Table 1) and *Panicum schinzii* (Species group O, Table 1). The community is further characterised by the absence of the species of Species groups I and K (Table 1) as well as the herbaceous *Amaranthus* sp. (Species group R, Table 1).

The *Croton megalobotrys - Combretum microphyllum* Community has a high tree layer with the height of the trees varying between 7.8 m and 20.0 m and a crown cover of between 50 % and 90 %. The shrub layer has an average height of 1.6 m and covers between 18 % and 68 % of the total community area. The herbaceous layer reaches an average height of 0.7 m and a crown cover of between 8 % and 90 %.

This community is divided into two sub-communities:

3.1 *Cenchrus ciliaris-Faidherbia albida* Sub-community.

This sub-community is found on the riverbank of the Ia land type. The dominant soil form is Valsrivier and to a lesser extent the Oakleaf soil form. The habitat differs from the *Acacia schweinfurthii – Maytenus senegalensis* Sub-community (3.2) because of it being more associated with low-lying areas that are frequently flooded during the annual flooding of the Limpopo River, and its side branches. In some areas a layer of alluvial sand and flood-debris cover the soil surface only to be disturbed and washed away during the next flooding.

The tree species *Faidherbia albida*, the grass species *Cenchrus ciliaris* and *Bothriochloa insculpta* and the herbaceous species *Datura* sp. and *Phragmites australis* are diagnostic to this sub-community (Species group M, Table 1). Tall, sometimes-dense trees dominate the vegetation of this sub-community, of which *Croton megalobotrys* (Species group L, Table 1) is by far the most dominant. Other species, which distinguish this sub-community from the *Acacia schweinfurthii – Maytenus senegalensis* Sub-community (3.2) through their absence or low abundance, are the tree species *Grewia bicolor*, *Grewia flavescens* (Species group O, Table 1) and *Lonchocarpus capassa* (Species group P, Table 1) and the grass species *Panicum deustum* (Species group O, Table 1).

The tree layer covers between 58 % and 90 % of this community and reaches a height of between 7.8 m and 17.0 m. The shrub layer has an average height of 1.5 m and a crown cover of between 18 % and 60 %. The

herbaceous layer covers between 10 % and 80 % and has an average height of 0.5 m.

3.2 *Acacia schweinfurthii - Maytenus senegalensis* Sub-community.

The habitat of this sub-community is somewhat drier than that of the *Cenchrus ciliaris – Faidherbia albida* Sub-community (3.1). It is situated on the floodplain and the riverbank of the Ia land type on areas that are less frequently flooded. The soil forms are basically the same as in the *Faidherbia albida – Acacia xanthophloea* Sub-community (3.1) only with the Oakleaf soil form being more dominant than the Valsrivier soil form.

Diagnostic species to the *Acacia schweinfurthii – Maytenus senegalensis* sub-community are found in Species group N (Table 1). This includes the rambling woody species *Acacia schweinfurthii*, and the tree species *Xanthocercis zambesiaca*, *Maytenus senegalensis* and *Phyllanthus reticulatus* as well as the creeper *Cocculus hirsutus*. Tall trees with undergrowth, which proves to be impenetrable in places, dominate the vegetation of this sub-community. *Croton megalobotrys* (Species group L, Table 1) is less dominant in this sub-community and have lower cover abundance values than in the *Faidherbia albida – Acacia xanthophloea* Sub-community (3.1). Species, which further distinguish the *Acacia schweinfurthii – Maytenus senegalensis* Sub-community (3.2) from the *Cenchrus ciliaris-Faidherbia albida* Sub-community (3.1), are the tree species *Grewia bicolor*, *Grewia flavescens* (Species group O, Table 3) and *Lonchocarpus capassa* (Species group P, Table 1).

The tree layer of this sub-community covers between 50 % and 88 % of the area and the trees reach a height of between 8.0 m and 20.0 m. The shrub layer has more crown cover in this sub-community than is the case in the *Cenchrus ciliaris – Faidherbia albida* Sub-community (3.1). The shrub layer covers between 30 % and 63 % of the sub-community and reaches an average height of 1.7 m. The herbaceous layer has an average height of 0.8 m and a crown cover varying between 8 % and 90 %.

4. *Diplachne fusca - Acacia xanthophloea* Community

The *Diplachne fusca – Acacia xanthophloea* Community commonly occurs on heavy clayey duplex soils in non-perennial pans and wetlands in the Ia land type. Soil types commonly found in these areas belong to the Rensburg, Arcadia, Valsrivier and Sepane soil forms. The soil surface, which is covered by cracks in the dry season, is mostly clear of rocks. Aspect and slope is of no great significance in this community. It can however be stressed that most of the wetland/pan systems in the area drain towards the Limpopo River. The major degradation problems of this community lie outside the current boundaries of the Vhemeb-Dongola National Park, where large areas of these wetlands have been cleared for cultivation purposes. Large dams have also been built for irrigation purposes and large-scale fish farming is also practiced in these dams.

The diagnostic species to this community are found in Species group Q (Table 1). They are the grasses *Diplachne fusca*, *Dinebra retroflexa*, *Echinochloa pyramidalis* and the forbs *Corbichonia decumbens* and *Abutilon sonneratianum*. Dominant species are the woody species *Acacia xanthophloea* (Species group R, Table 1) and the grass *Diplachne fusca* (Species group Q, Table 1). The *Diplachne fusca – Acacia xanthophloea* Community is further characterised by the absence of the species found in Species groups O and P (Table 1), which occur in most of the other communities in this land type.

The tree layer has an average height of 8.2 m and a crown cover varying between 25 % and 35 %. The shrub layer is poorly developed with an average crown cover of only 3 % and an average height of 1.0 m. The herbaceous layer on the other hand is well developed with an average height of 1.3 m and a crown cover varying between 60 % and 90 %.

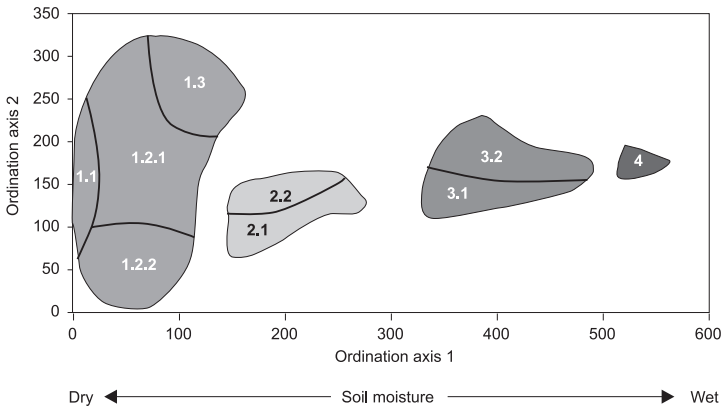

Fig. 2. The relative positions of the communities and sub-communities along the first two axes of the ordination of the relevés sampled in the Vhembe-Dongola National Park on the Ia land type.

Ordination

The distribution of the relevés of the Ia land type indicates a distinct discontinuity between the four communities along ordination axis one of the scatter diagram (Fig. 2). The gradient illustrated along the first ordination axis could be related to soil moisture and to a lesser extent clay content and soil depth .

The *Salvadora australis – Cucumis zeyheri* Community (1) is associated with flood plain areas on the outskirts of the riverine vegetation. On the scatter diagram (Fig. 2) it is clear that the habitat of this community is virtually opposite to that of the *Acacia xanthophloea - Diplachne fusca* Community (4), with regard to the gradients stipulated along the first ordination axis. The *Acacia xanthophloea - Diplachne fusca* Community (4) is found in and around pans and other wetland systems in the Vhembe-Dongola National Park on soils that are waterlogged for a long period during the year. The *Croton megalobotrys - Combretum microphyllum* Community (3) is found on the very edge of the Limpopo River and its tributaries. In these parts the water table should certainly be higher than is the case further away from the river in the *Salvadora australis – Cucumis zeyheri* Community (1) and the *Hyphaene petersiana – Acacia tortilis* Community (2). This latter community is found on an area between the drier *Salvadora australis – Cucumis zeyheri* Community (1) and the wetter *Croton megalobotrys - Combretum microphyllum* Community (3).

Concluding remarks

Some of the vegetation types described in the Ia land type are similar to plant communities previously described in other studies. The vegetation and habitat of the *Salvadora australis – Cucumis zeyheri* Community (1) are similar to the *Salvadora australis* Veld described in a vegetation report of the area by the former South African Defence Force (1986b), but different communities of riverine vegetation have not been described (South African Defence Force 1986 a,b). The *Hyphaene petersiana –Acacia tortilis* Community (2) and the *Croton megalobotrys-Combretum microphyllum* Community (3) thus occurs in the same vegetation unit,

which is referred to as Riverine vegetation in the vegetation report of the South African Defence Force (1986a,b). An *Eragrostis* Vlei Grass vegetation unit of which the habitat and vegetation compares well with the *Acacia xanthophloea - Diplachne fusca* Community (4) have also been described in the studies completed by the South African Defence Force (1986 a,b) in the area proposed for the Vhembe-Dongola National Park.

The riverine vegetation is more accurately described in the study of Timberlake & Mapaure (1999). The *Acacia/Faidherbia* Woodland Type described by Timberlake & Mapaure (1999) is further sub-divided into four sub-types namely the *Faidherbia albida* Woodland, the *Xanthocercis-Schotia* Woodland, the *Acacia xanthophloea* Woodland and the *Acacia tortilis* Woodland. *The Faidherbia albida* Woodland shows similarities with the *Cenchrus ciliaris-Faidherbia albida* Sub-community (3.1) and the *Xanthocercis-Scotia* Woodland with the *Acacia schweinfurthii – Maytenus senegalensis* Sub-community (3.2), Both are sub-communities of the *Croton megalobotrys-Combretum microphyllum* Community (3). In a phytosociological synthesis of the Mopane Veld, Du Plessis (2001) described the *Croton megalobotrys-Colophospermum mopane* vegetation type. This vegetation type and the *Croton megalobotrys-Combretum microphyllum* Community (3) described in the current study show similarities with respect to habitat and floristic composition.

The *Hyphaene petersiana–Acacia tortilis* Community (2) is comparable with the *Hyphaene* Shrubland and to a lesser extent to the *Acacia tortilis* Woodland described by Timberlake & Mapaure (1999). The dry pan and wetland areas in which the *Acacia xanthophloea - Diplachne fusca* Community (4) occurs was not specifically described by Timberlake & Mapaure (1999). It does, however, to a certain degree, resemble the *Acacia xanthophloea* Woodland described by these researchers.

The habitats described in different vegetation types by Timberlake & Mapaure (1999) and the South African Defence Force (1986 a,b) show similarities with the habitat descriptions of the different plant communities of the Ia land type in this study.

As a result of land clearing by intensive irrigation farming practices, as well as over-utilisation by small and large livestock and game (especially elephants), most communities of the Ia land type are degraded. Over-utilisation and destruction caused by migratory Tuli-elephants, from neighbouring Botswana, is a large cause for concern. The South African National Parks and the management of the Vhembe-Dongola National Park consider this in a serious light and a number of monitoring sites have been established. Another issue of concern observed in the Ia land-type was the damage caused by elephants to large trees through the stripping of bark which will eventually lead to the death of these trees. The trees mostly affected include *Acacia xanthophloea*, *Faidherbia albida* and *Ficus sycomorus*.

Plant communities described in this study and in other land types in the Vhembe-Dongola National Park (Götze 2002) should eventually be used in the compilation of a vegetation map of the park that can be used in the delineation of management units and the establishment of management plans.

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