

Natural woodland vegetation and plant species richness of the urban open spaces in Gauteng, South Africa

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It is estimated that approximately 60 % of the world's population will be living in urban areas by 2025. In Gauteng, the most densely populated province in South Africa, the natural open spaces are continually under threat from development. Vegetation is the most physical representation of the environment on which all animals are ultimately dependent. In order to evaluate an area's potential for development or conservation it is necessary to make a thorough inventory of the plant communities and their associated habitats. A survey of the natural woodlands was undertaken as part of a project describing the vegetation of the natural open spaces within the Gauteng region. Relevés were compiled in 73 stratified random sample plots in selected open spaces within the study area. A TWINSpan classification, refined by Braun-Blanquet procedures, indicated six woodland communities that can be grouped into two major woodland communities. A classification and description of these communities as well as their species richness are presented. The results indicate that there are still patches of well-preserved natural vegetation within the study area and contribute to the limited knowledge that presently exists for the vegetation of the area.

Key words: Braun Blanquet analysis, classification, plant communities, urban open space, TWINSpan.

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Introduction

Although the smallest of the nine provinces of South Africa, covering an area of only 16 191 km², Gauteng has a population of approximately 7.3 million people making it the most densely populated province in South Africa (Gauteng 2000). It is therefore understandable that urbanisation and its associated impacts are the biggest threats to the natural areas that still persist in the Gauteng urban areas. Kowarik (1990) confirms this by stating that human impact has been recognised as one of the most important influences on the composition of vegetation in urban environments. These impacts often include the loss of complete habitats due to the construction of residential, industrial or other

developments. Natural areas adjacent to urban areas are equally affected by human-related activities such as trampling, footpaths and exotic plant invasions, including stray products from gardens. Management practices such as mowing of natural grasslands and changing the natural veld fire frequency also have an effect on these natural ecosystems.

In the past, little attention was paid to the natural environment when making decisions on development in Gauteng. By overlooking the natural environment in urban development planning, wasteful exploitation of the natural resources occurred (Bredenkamp & Brown 1998a, 1998b). In European countries, landscape ecological mapping and evaluation

have become an essential part of the planning process (Spellerberg 1992). Such planning assists in restricting disturbance in areas with sensitive habitats or species and prevent undue fragmentation of wildlife habitat (Helliwell 1973). Until recently, vegetation surveys in urban areas in South Africa were unknown. After a pioneer survey in the Durban Municipal Area (Roberts 1993), surveys were undertaken in the urban areas of Potchefstroom (Cilliers & Bredenkamp 1998, 1999a, 1999b, 1999c, 2000; Cilliers *et al.* 1998), Klerksdorp (Van Wyk *et al.* 1997) in the North-West Province, and Bloemfontein (Dingaan 1999) in the Free State.

The natural areas of the Gauteng Province presently support a large number of plant species. Limited vegetation studies, mostly unpublished, have been done on small areas in the urban Gauteng (Behr & Bredenkamp 1988; Ellery 1992, 1994; Bredenkamp 1991, 1992, 1997a, 1997b; Bredenkamp & Brown 1998a, 1998b). Surveys of similar natural woodland vegetation in the Gauteng Province outside urban areas, include those of Bredenkamp & Theron (1978, 1980) and Coetzee *et al.* (1993a, 1993b, 1994, 1995).

The present study reports on a wider assessment of the vegetation of the urban areas of Gauteng, attempting to include areas of high species richness in urban areas and to consolidate the studies previously done in the study area. The purpose of this study was therefore to identify the plant communities of different types of habitat present in the urban areas of Gauteng. This information will help to motivate conservation actions, ensuring that nature conservation strategies are incorporated into land-use planning initiatives within the urban environment.

Study area

The study area is located between 27°40'E–28°25'E and 25°40'S–26°20'S approximately in the center of the Gauteng province (Fig. 1) and includes Pretoria, Midrand, Johannesburg and parts of the West Rand. Altitudes in Gauteng vary from 1081 m to 1899 m above

sea level, with a mean altitude of 1512 m (Gauteng 2000).

Mean monthly temperature in the study area is 16.8 °C with a mean maximum of 22.6 °C and a mean minimum of 10.8 °C. The mean winter temperature in the study area is 13.8 °C and mean summer temperature, 25.6 °C (Weather Bureau 2000). Mean annual rainfall in Gauteng is 670 mm per year (Gauteng 1997). The geology of the area includes the rock types dolomite, chert, quartzite, granite, diabase, shale and andesitic lava. The most important land type units in this study area are Ab, Bb, Ba that are mainly associated with flat or slightly undulating landscapes and the Ib land type which is often associated with ridge areas. The main soil forms found in the study area are Mispah and Glenrosa. (Land Type Survey Staff 1985, 1987a, 1987b).

Acocks (1988) described the vegetation of the study area as “False” Grassland of the Central variation of Bankenveld (Veld Type 61b). Patches of woodland vegetation are found at sheltered sites on hillslopes and rocky outcrops within this veld type. Bredenkamp & Van Rooyen (1996a) described this vegetation as the Rocky Highveld Grassland vegetation type, which covers the largest part of the study area. A small patch of Moist Cool Highveld Grassland (Bredenkamp & Van Rooyen 1996b) occurs in the southeastern corner of the study area. The area, therefore, predominantly represents the Grassland Biome (Rutherford & Westfall 1986). The open and closed woodland patches in the grassland biome resemble the vegetation of the Waterberg Moist Mountain Bushveld (Bredenkamp & Van Rooyen 1996b) also described by Acocks (1988) as Sour Bushveld (20). The woodland layer of the area is further represented by the Mixed Bushveld vegetation type (Bredenkamp & Van Rooyen 1996a) representing the savanna biome.

Currently, only 3.05 % of Mixed Bushveld and 8.55 % of the Waterberg Moist Mountain Bushveld is conserved (Bredenkamp & Van Rooyen 1996a, 1996c).

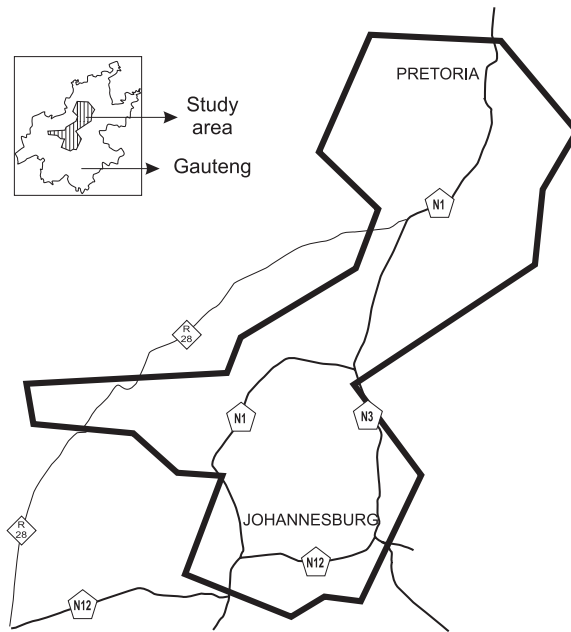


Fig. 1. Location of the study area within the Gauteng Province.

Methods

The open spaces within the study area were identified and delineated using 1:50 000 aerial photographs and were stratified into relatively homogeneous areas within which sample plots were randomly allocated. A total of 73 sample plots were randomly located within the woodland vegetation to ensure that all variations were considered and sampled. Plot sizes of 200 m² were used in accordance with Bredenkamp & Theron (1978).

Total floristic composition was noted for every sample plot. Additionally, the average height and percentage cover of the tree, shrub and herbaceous layers were estimated and recorded. The percentage cover of bare soil was also estimated and recorded. The coverage of the tree layer was based on crown cover where the canopies are vertically projected onto the ground (Werger 1974). The same technique was used for the shrub and herbaceous layers. The dominant tree, shrub, and herbaceous species were noted and the cover/abundance for each species was estimated according to the Braun Blanquet cover-abundance scale (Mueller-Dombois & Ellenberg 1974).

Environmental data included slope inclination measured in degrees, topography including hills, slopes and crests, aspect (north, south, west, east, and aspects in between) and disturbance factors such as exotic vegetation, trampling and erosion. Information on geology, land type, soil forms and clay contents were obtained from Land Type Survey Staff (1985, 1987). Soil classification is according to Macvicar (1991).

The computer programme TURBOVEG (Hennekens 1996a) and the TWINSpan classification algorithm (Hill 1979) were used for capture, processing and presentation of phytosociological data. Further refinement was achieved with Braun Blanquet procedures by using MEGATAB (Hennekens 1996b), a visual editor for phytosociological tables.

Names and authors of taxa are in accordance with Arnold & De Wet (1993). For the purposes of this study, *Aloe greatheadii* var. *davyana* and *Aloe transvaalensis* were lumped as one species and referred to as *Aloe greatheadii* var. *davyana*. The classification of species growth forms were done according to Van Wyk & Malan (1998).

Results

A mixture of tree, shrub and herbaceous species characterises the woodland areas of the entire study area. General species present in the woodlands are listed under Species Group K (Table 1).

The vegetation of all the woodland communities is characterised by the presence of the small trees *Diospyros lycioides*, *Canthium gilfillanii*, *Zanthoxylum capensis*, *Rhus leptodictya*, *Maytenus heterophylla* and *Rothmannia capensis* together with the exotics *Lantana camara* and *Solanum mauritianum*.

The small shrub *Asparagus suaveolens*, the forbs *Commelina africana*, *Helichrysum rugulosum*, the succulent *Aloe greatheadii* var. *davyana*, the slender twining herb *Pentarrhinum insipidum*, the exotic weeds *Tagetes minuta*, *Bidens pilosa*, the noxious parasite *Cuscuta campestris* and the fern *Pellaea calomelanos* are often encountered. Common grasses include *Melinis repens*, *Melinis nerviglumis*, *Themeda triandra*, *Setaria sphacelata*, *Cymbopogon validus*, *Panicum maximum*, *Hyparrhenia hirta*, *Eragrostis curvula*, *Brachiaria serrata*, *Heteropogon contortus* and *Digitaria eriantha*. These species are listed in Species Group K (Table 1) and will therefore not be repeated in the description of the various plant communities.

Hills and ridges in the study area are often covered by a mosaic of open woodland on the warmer and drier north-facing slopes, closed woodland in more sheltered sites below rocky cliffs, and grassland patches on more exposed, high altitude areas. Closed woodland communities are also found along rivers and streams. Cooler south-facing slopes may have *Protea caffra* woodland communities.

Two major plant communities were identified namely the *Acacia caffra*-*Rhus pyroides* open to closed Major Woodland community, mostly found on cooler and more moist, south facing, or exposed habitats and the *Combretum molle*-*Setaria lindenberghiana* Open to Closed Major Woodland communi-

ty, mostly associated with warmer and drier north-facing slopes.

The classification obtained from the TWINSPAN and refined by Braun-Blanquet procedures resulted in the following six plant communities that can be grouped into two major communities being identified in the woodland areas surveyed.

1. *Acacia caffra* – *Rhus pyroides* Open to Closed Major Woodland Community
 - 1.1 *Hypoestes forskoolii* – *Acacia caffra* Closed Woodland Community
 - 1.2 *Acacia caffra* – *Setaria lindenberghiana* Closed Woodland Community
 - 1.3 *Acacia caffra* – *Themeda triandra* Open to Closed Woodland Community
 - 1.3.1 *Acacia caffra* – *Themeda triandra* – *Asparagus laricinus* Open to Closed Woodland Sub-community
 - 1.3.2 *Acacia caffra* – *Themeda triandra* – *Hyparrhenia hirta* Open to Closed Woodland Sub-community
2. *Combretum molle*-*Setaria lindenberghiana* Open to Closed Major Woodland Community
 - 2.1 *Combretum molle* – *Burkea africana* Open to Closed Woodland Community
 - 2.2 *Combretum molle* – *Englerophytum magalismontanum* Open Woodland Community

Discussion

Floristically the *Acacia caffra*-*Rhus pyroides* Open to Closed Woodland shows strong floristic relationships with the Sub-humid Cool Temperate Mountain Bushveld of Coetzee *et al.* (1995), and also exhibits an affinity to the Afro-montane vegetation of the Drakensberg. The plant species composition of the *Combretum molle*-*Setaria lindenberghiana* Open to Closed Woodland relates to the Sub-humid Warm Temperate Bushveld as described by Coetzee *et al.* (1993b), and shows an affinity to the Bushveld vegetation

of the Savanna Biome (Rutherford & Westfall 1986). Bredenkamp & Brown (1998a, 1998b) also described vegetation to the west and north of Johannesburg indicating floristic resemblance to this vegetation unit. The vegetation of the Ruimsig Entomological Reserve in Roodepoort, also shows a floristical resemblance to the woodland species identified in this study (Deutschländer & Bredenkamp 1999).

The common species associated with the *Rhus pyroides* Forest and *Canthium gilfillanii*-*Aristida transvaalensis*-*Cymbopogon marginatus* Savanna communities identified by Bredenkamp & Theron (1978), and the *Euclea crispa*-*Rhoicissus tridentata* Bush and Savanna communities as well as the *Trachypogon spicatus*-*Themeda triandra* Grassland communities Bredenkamp & Theron (1980) compare well with the common species identified in the woodland communities for this study.

Vegetation description

1. *Acacia caffra* – *Rhus pyroides* Open to Closed Major Woodland Community

Habitat

This plant community is found scattered throughout the study area, among granite boulders, on rocky outcrops and hills. Slopes varies from gradual to very steep. A total of 54 % of the sample plots were on the Bb, and Ib land types. This plant community occurs on rocky areas with shallow soils and is associated with the Glenrosa, Mispah and Wasbank soil forms, with a clay content of 10–30 %.

Vegetation

Species group A (Table 1) characterises this community. The diagnostic species are the trees *Acacia caffra*, *Celtis africana*, *Rhus pyroides*, *Ehretia rigida*, *Dombeya rotundifolia*, *Ziziphus mucronata*, *Cussonia paniculata*, *Heteromorpha trifoliata* and *Euclea crispa*, the geophytes *Ledebouria revoluta* and *Scadoxus puniceus*, the exotic perennial

weed *Achyranthes aspera*, and the annual weed *Conyza albida*.

The species that dominate this plant community are the trees *Rhus leptodictya*, *Celtis africana*, *Acacia caffra*, *Canthium gilfillanii* and *Zanthoxylum capense*, the shrub *Diospyros lycioides* and small shrub *Asparagus suaveolens*, the succulent *Aloe greatheadii* var. *davyana*, the common weed *Tagetes minuta*, the asteraceous forb *Helichrysum rugulosum*, and the grasses *Themeda triandra*, *Hyparrhenia hirta* and *Setaria sphacelata*.

The high occurrence of the weed *Tagetes minuta* as well as the other exotic weedy species *Verbena bonariensis*, *Conyza albida*, *Lantana camara*, *Zinnia peruviana* and the succulent *Opuntia ficus-indica* in the herbaceous layer together with *Melia azedarach* in the shrub and tree layer, indicates that this plant community is susceptible to disturbance and generally not in a good condition in the study area.

An average of 37 species per 200 m² was recorded in this plant community.

In general, the species composition of this community compares well with that of the *Acacia caffra* – *Euclea crispa* woodland within the Sub-humid Cool Temperate Mountain Bushveld described by Coetzee *et al.* (1994, 1995), found on north-facing slopes, crests and upper south-facing steep slopes of the rocky outcrops mainly within the Ib Land Type in the Pretoria area.

This community also shows floristic resemblance with the *Acacia caffra* – *Setaria spacelata* Closed Woodland described by Coetzee *et al.* (1995), the *Acacia caffra* – *Setaria sphacelata* Closed Woodland in the Roodeplaataidam Nature Reserve (Van Rooyen 1984), the vegetation on the Bronberg in Pretoria (Bredenkamp 1997), the *Olea europaea* – *Cymbopogon excavatus* savanna and *Olea europaea* - *Schistotephium heptalobium* bush clumps vegetation of the Rietfontein Nature Reserve (Bredenkamp 1991), the *Acacia robusta* woodland (Ellery 1994) and the *Acacia caffra* vegetation of the

Table 1 (continued)

Species group D									
<i>Eragrostis chloromelas</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Hypoxis rigidula</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Nidorella hottentotica</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Graderia subintegra</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>A. congesta</i> subsp. <i>barbica</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Lantana rugosa</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Rhus zeyheri</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Pearsonia sessilifolia</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Justicia anagaloides</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Crabbea angustifolia</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Solanum elaeagnifolium</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Scabiosa columbaria</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
Species group E									
<i>Protasparagus laricinus</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Sida dregei</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Hibiscus lunariifolius</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Clematis brachiata</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Conyza albida</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Teucrium trifidum</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Pavonia burchellii</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Conyza podoccephala</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Oxalis corniculata</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Acacia karroo</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
Species group F									
<i>Tristachya leucothrix</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Eragrostis racemosa</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Athrixia elata</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Trachypogon spicatus</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Cynodon dactylon</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Chaetacanthus costatus</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Eliconurus muticus</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Protea cafra</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Lippia javanica</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>A. semialata</i> subsp. <i>ecklo</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Pentanisia angustifolia</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Kiggelaria africana</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Rhynchosia totta</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Vernonia galpinii</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Rhus discolor</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Protea roupelliae</i>	.....	.....	.....	.....	.....	.....	.....	.....	.....

Table 1
(continued)

Species Group G

Combretum molle	.....b...b.....	.....l...+.....	.....b...b++++.l+++	.....b+b+3a+.....	.....b+b.....
Vangueria infausta	.....+.....	.....+1.....	.....+...+.....+	.....+ba+.....	.....+.....+b+++
Englerophyllum magalimontanum	.....+.....	.....+.....	.....+...b...+..	.....+..	.....+abb+++aaa
Ochna pulchra	.....	.....+.....	.....+...+.....	.....+...+.....	.....+.....
Loudestia simplex	.....	.....+.....	.....+...+.....	.....+...+.....	.....+.....
Lannea discolor	.....	.....+.....	.....+...+.....	.....+...+.....	.....+.....
Kalanchoe paniculata	.....	.....+.....	.....+...+.....	.....+...+.....	.....+.....
Euphorbia schinzii	.....	.....+.....	.....+...+.....	.....+...+.....	.....+.....
Ochna pretoriensis	.....	.....+.....	.....+...+.....	.....+...+.....	.....+.....
Combretum zeyheri	.....	.....+.....	.....+...+.....	.....+...+.....	.....+.....
Commelina erecta	.....	.....+.....	.....+...+.....	.....+...+.....	.....+.....
Oldenlandia herbacea	.....	.....+.....	.....+...+.....	.....+...+.....	.....+.....
Nuxia congesta	.....	.....b.....+...+.....+...+.....+...+.....
Coleochloa setifera	.....	.....	.....+...+.....	.....+...+.....	.....+...+.....
Indigofera melanadenia	.....	.....	.....+...+.....	.....+...+.....	.....+...+.....
Crassula swaziensis	.....	.....	.....+...+.....	.....+...+.....	.....+...+.....

Species Group H

Burkea africana	.....	.....	.....+allb.b+la3+	.....+1+.....	.....
Strychnos pungens	.....	.....	.....+1.1+.alba+	.....+...+.....	.....
Helichrysum kraussii	.....	.....	.....+...+.....	.....+...+.....	.....
Rhynchosia nitens	.....	.....	.....+...+.....	.....+...+.....	.....
Dichapetalum cymosum	.....	.....	.....+...+.....	.....+...+.....	.....

Species Group I

Ancylobotrys capensis	.....	.....	.....+...+.....	.....+...+.....	.....+...+.....
Aristida transvaalensis	.....	.....	.....+...+.....	.....+...+.....	.....+...+.....
Crassula setulosa	.....	.....	.....+...+.....	.....+...+.....	.....+...+.....
Rhus magalimontana	.....	.....	.....+...+.....	.....+...+.....	.....+...+.....
Croton gratissimus	.....	.....	.....+...+.....	.....+...+.....	.....+...+.....
Walteria indica	.....	.....	.....+...+.....	.....+...+.....	.....+...+.....
Cyperus sp.	.....	.....	.....+...+.....	.....+...+.....	.....+...+.....
Oxyris lanceolata	.....	.....	.....+...+.....	.....+...+.....	.....+...+.....
Vernonia sutherlandii	.....	.....	.....+...+.....	.....+...+.....	.....+...+.....
Sutera caerulea	.....	.....	.....+...+.....	.....+...+.....	.....+...+.....
Pittosporum viridiflorum	.....	.....	.....+...+.....	.....+...+.....	.....+...+.....
Pouzolzia mixta	.....	.....	.....+...+.....	.....+...+.....	.....+...+.....
Enneapogon scoparius	.....	.....	.....+...+.....	.....+...+.....	.....+...+.....

Table 1 (continued)

Species group J	Species group X
<i>Diheteropogon amplexens</i>	<i>Tagetes minuta</i>
<i>Xerophyta retinervis</i>	<i>A. greatheadii</i> var. <i>davyana</i>
<i>Senecio venosus</i>	<i>Diospyros lycioides</i>
<i>Buibostylin burchellii</i>	<i>Melinis repens</i>
<i>Pollichia campestris</i>	<i>Protaspargus suaveolens</i>
<i>Cyanotis speciosa</i>	<i>Canthium gilfillanii</i>
<i>Schizogyrium sanguineum</i>	<i>Pellaea calomelanos</i>
<i>Brachylaena rotundata</i>	<i>Melinis nervigulumis</i>
<i>Senecio oxyrifolius</i>	<i>Commelina africana</i>
<i>Acalypha angustata</i>	<i>Themeda triandra</i>
<i>Hyperthemia tamba</i>	<i>Setaria spaciolata</i>
<i>Parinari capensis</i>	<i>Rhus leptodictya</i>
<i>Rhus zeyheri</i>	<i>Cymbopogon validus</i>
	<i>Helichrysum rugulosum</i>
	<i>Panicum maximum</i>
	<i>Hyperthemia hirta</i>
	<i>Zanthoxylum capensis</i>
	<i>Eragrostis curvula</i>
	<i>Brachiaria serrata</i>
	<i>Pentarrhinum insipidum</i>
	<i>Heteropogon contortis</i>
	<i>Maytenus heterophylla</i>
	<i>Digitaria eriantha</i>
	<i>Bidens pilosa</i>
	<i>Lantana camara</i>
	<i>Rothmannia capensis</i>
	<i>Solanum mauritianum</i>
	<i>Cuscuta campestris</i>

Fort Klapperkop Area in Pretoria (Bredenkamp 1997b). The Kloof communities: *Rhus pyroides* Forests, *Rhus pyroides-Buddleja salviifolia-Celtis africana* Forest and *Dombeya rotundifolia-Ziziphus mucronata* savanna identified by Bredenkamp & Theron (1978) also show resemblance to this community. Bredenkamp & Brown (1998a, 1998b) described similar vegetation to the west and north of Johannesburg.

Three communities were recognised under this major woodland community:

1.1 *Hypoestes forskoolii* – *Acacia caffra*
Closed Woodland Community

Habitat

This woodland community is found on gradual to moderately steep slopes and a variety of aspects of hills, ridges and between granite boulders as well as along rivers in lower lying areas in the Pretoria, Midrand, Sandton and Randburg areas. A 10-15 % clay content was observed in the soils associated with this plant community. This plant community was predominantly found in the Bb Land Type.

Vegetation

This community is characterised by the presence of the trees *Combretum erythrophyllum* and *Rhamnus prinoides* (along rivers), *Acalypha glabrata*, *Pavetta gardeniifolia* var. *gardeniifolia* and *Buddleja saligna*, the shrub *Asparagus* sp. and the shrublet *Aerva leucura*, the herb *Hypoestes forskoolii*, the erect *Cyperus esculentus* the shrubby perennial herb *Hibiscus calyphyllus*, the exotic climber *Araujia sericifera* and the grass *Setaria megaphylla* (Species group B Table 1)

Prominent species in this plant community include the trees *Rhus pyroides*, *Celtis africana*, *Acacia caffra*, *Euclea crispa*, *Canthium gilfillanii*, *Rhus leptodictya*, *Zanthoxylum capense*, the shrub *Diospyros lycioides*, the small shrub *Asparagus suaveolens*, and the weeds *Achyranthes aspera* and *Tagetes minuta*.

The average number of species recorded in this plant community per 200 m² is 32.

Showing resemblance to this community is the *Combretum erythrophyllum* - *Celtis africana* Major Community described by Behr & Bredenkamp (1988) from the Witwatersrand Botanic Garden in Roodepoort and the *Celtis africana* – *Ziziphus mucronata* community (Bredenkamp 1997b) from the Fort Klapperkop area in Pretoria and the Lonehill Nature Reserve (Bredenkamp 1992). Bredenkamp (1992) conducted a more detailed assessment on the small Lonehill Nature Reserve and described more communities. Bredenkamp & Brown (1998a, 1998b) described vegetation to the west and north of Johannesburg indicating resemblance to this community.

1.2 *Acacia caffra* – *Setaria lindenberghiana* Closed Woodland Community

Habitat

This closed woodland community has a limited distribution in the study area. It was observed on steep to very steep, north and south-facing slopes of hills and ridges throughout the study area except in the Midrand-Fourways area. It is generally associated with the Land Type Ib.

Vegetation

The species group C (Table 1) is diagnostic for this plant community. The diagnostic species are the grass *Setaria lindenberghiana* and the climber shrub *Rhoicissus tridentata*.

The most prominent species in this plant community include the trees *Acacia caffra*, *Celtis africana* and *Euclea crispa*, the shrub *Diospyros lycioides* and the bulbous geophyte *Ledebouria revoluta*, the noxious weed *Tagetes minuta* and the succulent *Aloe greatheadii* var. *davyana*. Disturbance to this plant community was recorded at most of the sites, with specific reference to the low herbaceous cover under the trees.

An average of 31 species per 200 m² was recorded for this plant community.

This community is related to the *Setaria lindenberiana* – *Ehretia rigida* Bush clumps (Coetzee *et al.* 1995), the *Setaria lindenberiana* – *Acacia caffra* Woodland described by Coetzee (1975) from the Rustenburg Nature Reserve, and the *Olea europaea* – *Cymbopogon excavatus* savanna and *Olea europaea* – *Schistotephium heptalobium* bush clumps vegetation of the Rietfontein Nature Reserve (Bredenkamp 1991).

1.3 *Acacia caffra* – *Themeda triandra* Open to Closed Woodland Community

Habitat

This open to closed woodland sub-community was found distributed throughout the study area on a variety of aspects, on gradual to moderately steep slopes of hills and ridges. It was recorded predominantly on Land Type Ib, characterised by Mispah and Glenrosa soil forms with a clay content of 10–20%.

Vegetation

The diagnostic species for the community are the small tree *Rhus zeyheri*, the grasses *Eragrostis chloromelas*, *Aristida congesta subsp. barbicollis*, the geophyte *Hypoxis rigidula*, the forbs *Nidorella hottentotica*, *Graderia subintegra*, *Pearsonia sessilifolia subsp. sessilifolia*, *Justicia anagalloides*, *Crabbea angustifolia* and *Scabiosa columbaria*, the small shrub *Lantana rugosa* and the exotic shrub *Solanum elaeagnifolium* (Species group D – Table 1).

The woody layer is dominated by trees *Rhus pyroides*, *Canthium gilfillanii*, *Rhus leptodictya*, and the shrub *Diospyros lycioides*, together with the shrublet *Asparagus suaveolens*. The succulent *Aloe greatheadii* var. *davyana*, the asteraceous *Helichrysum rugulosum*, the weed *Tagetes minuta* together with the grasses *Themeda triandra*, *Hyparrhenia hirta*, *Brachiaria serrata* and *Setaria sphacelata* are also prominent.

The average number of species recorded in this plant community per 200 m² is 41.

In parts of the plant community stands of *Protea caffra* (Species Group F) and the scarcer *Protea roupelliae* (Species Group F) are prominent, indicating an affinity with the Drakensberg Highveld Sourveld (Sourveld) vegetation.

The *Olea europaea* – *Cymbopogon excavatus* savanna and *Olea europaea* – *Schistotephium heptalobium* bush clumps vegetation of the Rietfontein Nature Reserve (Bredenkamp 1991) also show resemblance to this community.

Two sub-communities are recognised:

1.3.1 *Acacia caffra* – *Themeda triandra* – *Asparagus larycinus* Closed Woodland Sub-community

Habitat

This sub-community is found on gradual north and south-facing slopes predominantly in the Pretoria area, but also in Clayville, Fourways and Alberton. This plant community is associated with closed woodland in association with rocky outcrops. This plant community was recorded from the Ib1b land types.

Vegetation

Species that dominate the plant community are the trees *Acacia caffra*, *Celtis africana* and *Ehretia rigida*, the shrublet *Asparagus suaveolens*, the grasses *Themeda triandra*, *Setaria sphacelata*, the succulent *Aloe greatheadii* var. *davyana* and the asteraceous *Helichrysum rugulosum*. *Rhus pyroides* is locally dominant and *Panicum maximum* is sometimes prominent.

Species group E (Table 1) is diagnostic for this community. Diagnostic tree species include *Acacia karroo*, the shrub *Asparagus larycinus* that forms impenetrable thickets, the slender shrub *Sida dregei*, the erect shrublets *Hibiscus lunarifolius* and *Teucrium trifidum*, the herbaceous shrublet *Pavonia burchellii*, the twining forb *Clematis brachicata*, the forb *Conyza podocephala* and the exotic weeds *Oxalis corniculata* and *Conyza albida*.

The average number of species recorded in this plant community per 200 m² is 36.

The *Acacia karroo* – *Lippia javanica* closed woodland (Coetzee *et al.* 1995) shows resemblance to this community.

1.3.2 *Acacia caffra* – *Themeda triandra* – *Hyparrhenia hirta* Open to Closed Woodland Sub-community

Habitat

This sub-community is found throughout the study area on a variety of aspects and on gradual to steep slopes of ridges and hills and rocky outcrops. This plant community is prominent on the higher altitude slopes and crests.

Vegetation

Species group F (Table 1) is diagnostic for this vegetation. The diagnostic species are the trees *Kiggelaria africana*, *Protea caffra*, *Protea roupelliae* and *Rhus pyroides*, the shrublets *Athrixia elata*, *Pentanisia angustifolia*, *Rhus discolor*, and shrub *Lippia javanica*, the forbs *Chaetacanthus costatus*, *Vernonia galpinii* and *Rhynchosia totta*, and the grasses *Tristachya leucothrix*, *Eragrostis racemosa*, *Cynodon dactylon*, *Elionurus muticus* and *Alloteropsis semialata* subsp. *eckloniana*.

The plant community is dominated by the tree species *Rhus leptodictya* and *Canthium gilfillanii* the shrub *Diospyros lycioides*, the succulent *Aloe greatheadii* var. *davyana*, the asteraceous *Helichrysum rugulosum* and the grasses *Setaria sphacelata*, *Melinis repens*, *Melinis nerviglumis*, *Themeda triandra*, *Hyparrhenia hirta* and *Brachiaria serrata*.

An average of 44 species per 200 m² was recorded in this plant community.

This community resembles the *Protea caffra* – *Athrixia elata* Open Woodland (Coetzee 1995) from the Pretoria area. The common species of the *Tracypogon spicatus*–*Themeda triandra* Grassland of Bredenkamp & Theron (1980) compare well with this community. Bredenkamp & Brown (1998a, 1998b)

described vegetation to the west and north of Johannesburg indicating resemblance to this vegetation unit.

2. *Combretum molle*–*Setaria lindenbergiana* Open to Closed Major Woodland Community

Habitat

This plant community is mostly found on warmer and drier north-facing aspect on gradual to very steep slopes in kloofs, between granite boulders and on rocky outcrops, drainage lines, at the foot of quartzite ridges and hills and on rocky outcrops in the Pretoria and Johannesburg area. This plant community is mainly found in the Ib and Ba land types.

Vegetation

The diagnostic species of this plant community are the trees *Combretum molle*, *Vangueria infausta*, *Ochna pulchra*, *Combretum zeyheri*, *Nuxia congesta*, *Lannea discolor* and *Englerophytum magalismsontanum*. Other species include the shrub *Ochna pretoriensis*, the shrublet *Indigofera melanadenia*, and the succulents *Kalanchoe paniculata*, *Crassula swaziensis* and *Euphorbia schinzii*, forbs such as the tufted *Coleochloa setifera*, *Commelina erecta*, *Oldenlandia herbacea* var. *herbacea* and grasses such as *Setaria lindenbergiana* and *Loudetia simplex* (Species group G; Table 1).

The species that dominate this plant community are the succulent *Aloe greatheadii* var. *davyana*, the weed *Tagetes minuta*, the herb *Commelina africana* and the scrubby *Xerophyta retinervis*, the fern *Pellaea calome-lanos*, and the grasses *Cymbopogon validus*, *Melinis repens*, *Melinis nerviglumis* and *Diheteropogon amplexens*.

An average of 38 species per 200 m² was recorded in this plant community.

Invasion of exotic vegetation was often recorded in this plant community. Invasive exotic species include *Lantana camara*, *Cereus peruviana* and *Jacaranda mimosifolia*.

In general, this community compares well with the Sub-humid Warm Temperate Mountain Bushveld found on north-facing slopes, crests, and upper south-facing steep slopes of the rocky outcrops mainly within the Ib land type (Coetzee *et al.* 1995). Also resembling this community are the *Burkea africana*–*Bequartiodendron magalimontanum* Open Woodland (Coetzee 1994), *Setaria lindenbergiana*–*Combretum molle* community (Bezuidenhout 1993), *Sporobolus pectinatus*–*Chaetacanthus setiger* community (Coetzee 1993), *Canthium gilfillanii*–*Combretum molle* savanna community from the Witwatersrand National Botanic Garden (Behr & Bredenkamp 1988), *Nuxia congesta*–*Combretum molle* savanna (Bezuidenhout *et al.* 1988) vegetation on the Bronberg in Pretoria (Bredenkamp 1997a), the *Cryptolepis oblongifolia*–*Englerophytum*, *Burkea africana*–*Combretum molle* and *Brachylaena rotundata*–*Burkea africana* communities from the Fort Klapperkop Area (Bredenkamp 1997b).

Two sub-communities were recognised:

2.1 *Combretum molle* – *Burkea africana* Open to Closed Woodland Community

Habitat

This sub-community is predominantly found on shallow to moderately steep northern to north-eastern slopes of ridges and hills in the Pretoria area. It was mainly recorded in 1b Land Type.

Vegetation

Species group H (Table 1) is diagnostic for this sub-community. Diagnostic species include the trees *Burkea africana* and *Strychnos pungens* and the dwarf shrubs *Rhynchosia nitens* and *Helichrysum kraussii* and geoxylic suffrutescent *Dichapetalum cymosum*.

The most prominent species in this plant community are the trees *Combretum molle* and *Vangueria infausta*, the shrubs *Xerophyta retinervis*, the succulent *Aloe greatheadii*

var. *davyana*, the fern *Pellaea calomelanos* and the grass *Melinis nerviglumis*.

The average number of species recorded in this plant community is 40 per 200 m².

2.2 *Combretum molle* – *Englerophytum magalimontanum* Open Woodland Community

Habitat

This sub-community was found at high altitudes on northern aspects with gradual to very steep (55° and 50° at Bush Hill in Randburg and on Northcliff Hill in Northcliff) slopes, on top of ridges and hills, and in drainage lines on ridges in the Pretoria and Johannesburg areas. The plant community was recorded specifically in land types Ba and Ib. The soil form is mainly Mispah with a clay content of 10–20 % also indicating shallow soils on rock.

Vegetation

This sub-community is characterised by Species group I (Table 1). Characteristic species associated with this plant community are the trees *Pittosporum viridiflorum*, *Croton gratissimus*, *Osyris lanceolata* and *Pouzolzia mixta* and the shrubs *Ancylobotrys capensis* and *Rhus magalimontana* and the shrublet *Waltheria indica*. Other species include forbs like the succulent *Crassula setulosa*, *Vernonia sutherlandii*, *Cyperus* sp. and *Sutera caerulea* and the grasses *Aristida transvaalensis* and *Enneapogon scoparius*.

Species that dominate the plant community are the trees *Combretum molle*, *Vangueria infausta*, *Canthium gilfillanii* and *Diospyros lycioides* the grasses *Cymbopogon validus*, *Melinis repens* and the forb *Commelina africana*.

The average number of species recorded in this plant community is 36 per 200m².

Floristically the *Bequartiodendron magalimontanum* shrub land of Ellery (1994) also compares well with this community.

Discussion

The results of this study indicate that patches of well-preserved vegetation do occur in urban Gauteng. The sites chosen were relatively undisturbed and many could be important to conserve. Some sites are presently utilised for agricultural purposes. In spite of this, weedy species, eg., *Tagetes minuta* and *Bidens pilosa* occur on a large number of plots indicating disturbances of the herbaceous layer.

Species group J (Table 1) indicates a floristic relationship between the *Acacia caffra*–*Themeda triandra*–*Hyparrhenia hirta* Open to Closed Woodland and the *Combretum molle*–*Setaria lindenbergiana* Open to Closed Woodland. Both these communities occur on slopes of fairly high altitude.

The classification procedures followed, resulted in clearly defined vegetation units that can be related to the environmental factors observed. This classification contributes to the limited knowledge that presently exists for the vegetation of urban open spaces in Gauteng. The results of this study can be used as a baseline study and future studies can be measured against it. The species richness determined per 200 m² per vegetation type could also be used to determine environmental and ecological degradation and actions could be taken to manage these changes.

The results of this study could further be used to determine how the surrounding land-uses have influenced the vegetation of urban open spaces. The results could assist in guiding development in future open spaces in a constantly expanding urban environment.

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