THE PHYTOSOCIOLOGY OF THE NATURAL VEGETATION OCCURING IN THE CRADLE OF HUMANKIND WORLD HERITAGE SITE, GAUTENG. SOUTH AFRICA

by

GARETH ELOFF

Submitted in accordance with the requirements for the degree of

MAGISTER TECHNOLOGAE

In the subject

NATURE CONSERVATION

at the

UNIVERSITY OF SOUTH AFRICA,

SUPERVISOR: PROF L.R. BROWN

CO SUPERVISOR: PROF G.J. BREDENKAMP

NOVEMBER 2010

ABSTRACT

The natural vegetation of the Cradle of Humankind World Heritage Site (COH WHS) was classified using Braun-blanquet methodology. This identified 22 distinct plant communities and 2 variants. Sampling took place over two growing seasons with a total of 91 releves being compiled. A stratified random approach to sampling used Land Types as a means of primary area stratification, with terrain position providing the means for further refinement. The grassland comprised of 12 plant communities and 2 variants and the woodland comprised of 10 plant communities. The classification of the woodland areas included some bush clumps associated with the entrances of caves which were also described independently in which seven distinct plant communities were identified

A positive linear correlation exists between the size of the cave entrances and the extent to which the surrounding woody vegetation extends. This suggests the likelihood of cave entrance size influencing the surrounding vegetation.

KEYWORDS

Cradle of Humankind, World Heritage Site, Braun-blanquet, Land Type, TWINSPAN.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

CHAPTER 1

INTRODUCTION

1.1 World Heritage Site Establishment

On 16th November 1972 at a General Conference of the United Nations Educational, Scientific and Cultural Organisation (UNESCO) in Paris, the need to identify and permanently protect the world's special areas was recognized and the World Heritage Convention (WHC) was adopted. Founded on the principle of international cooperation, the mission of the convention was to encourage countries to sign the 1972 agreement and nominate cultural and natural heritage sites within their national territory for possible inclusion on the World Heritage List. The listing of Sites helps countries to safeguard these unique and irreplaceable sites against the threats of changing social and economic conditions and natural decay.

For the purposes of the WHC, the following conditions and definitions are supplied for those ‘cultural’ sites identified for potential listing:

Monuments: architectural works, works of monumental sculpture and painting, elements or structures of an archaeological nature, inscriptions, cave dwellings and combinations of features, which are of outstanding universal value from the point of view of history, art or science;

Groups of buildings: groups of separate or connected buildings which, because of their architecture, their homogeneity or their place in the landscape, are of outstanding universal value from the point of view of history, art or science;

Sites: works of man or the combined works of nature and man, and areas including archaeological sites which are of outstanding universal value from the historical, aesthetic, ethnological or anthropological point of view”.

Once a site is inscribed in the World Heritage List, it receives national and international recognition, which when combined with a well-targeted marketing strategy for a site, is likely to lead to an influx of tourists in the area which can contribute to economic growth and increased employment opportunities for the area and its people.

The capacity of a country to manage this potential change and the increase in tourism in an area is one of the main criteria in the World Heritage Convention (UNESCO World Heritage Convention, 1972).The South African government signed the 1972 UNESCO World Heritage Convention in 1997, thereby committing itself to the protection, preservation and promotion of the world's natural and cultural heritage. This made South Africa eligible to nominate sites of perceived unique international significance that are found within its borders.

During 1999 the National Department of Environmental Affairs and Tourism (DEAT), the office of the Premier of Gauteng and the then Gauteng Department of Agriculture, Conservation, Environment and Land Affairs (DACEL), (thereafter known as GDACE- Gauteng Department of Agriculture, Conservation and Environment, and who are now referred to as GDARD - Gauteng Department of Agriculture and Rural Development) nominated the fossil hominid sites of Sterkfontein, Swartkrans, Kromdraai and environments, collectively known as the "Cradle of Humankind (COH)", for inclusion into the UNESCO List of World Heritage Sites, as a site of Cultural significance.

The Sterkfontein caves were originally discovered in the late-19th century, by miners who through their daily activities found some fossils. These were shown to various groups and eventually became known to different scientists. In the 1930s the site began to be formally excavated, and within a couple of years it had provided science with the first fully-matured Australopithecine- 'Ape Man' (Clarke 1998). Since this first discovery, more than 500 hominid fossils have been found at the Sterkfontein site within the COH, making it the most productive site of its kind in the world (Berger & Hilton-Barber 2004). The COH has an incredible density of hominid (and other species) fossils, and has been the site for some of the most important fossil discoveries since the 1940s including those of Mrs. Ples and Little Foot (Berger & Hilton-Barber 2004).

Notwithstanding the faunal fossil discoveries, fossil woods excavated from the Sterkfontein Caves have also provided information on the vegetation of South

Africa during the Pliocene period (Bamford 1999), and the remnants of fossilized photosynthetic *cyanobacteria* or stromatolites, provide information on the importance of the area during the late Achaean age in terms of a substantial increase in primary production and the resultant establishment of an oxygen rich atmosphere some 2500-2600 million years ago (Knoll 1983).

Experts from the International Council of Museums and Sites (ICOMOS) and the IUCN (International Union for the Conservation of Nature) evaluated the site in January 1999, and recognizing this unique and rich fossil yield, recommended its listing to the World Heritage Committee in July 1999. The COH was inscribed on to the World Heritage List on 2 December 1999. In the same month, the World Heritage Convention was drafted into South African Legislation through the promulgation of the World Heritage Convention Act (Act 49 of 1999).

1.2. **Management Authority Establishment**

In terms of Section 8 of the World Heritage Convention Act, (Act 49 of 1999) the GDACE was appointed as the Management Authority over the Site concerned which meant that it has certain obligations as listed in section 13(2) which, unless otherwise prescribed by the Minister (defined by the Act to be the Minister of Environmental Affairs and Tourism), include:

a) developing measures for the cultural and environmental protection and sustainable development of, and related activities within, World Heritage Sites, and ensuring the values of the WHC. are given effect to;
b) to promote, manage, oversee, market and facilitate tourism and related development in connection with World Heritage Sites in accordance with applicable law, the WHC and the Operational Guidelines in such a way that the cultural and ecological integrity are maintained;
c) to identify cultural and natural heritage that must be transmitted to future generations;
d) to take effective and active measures for the protection, conservation and presentation of the cultural and natural heritage;

e) to facilitate steps that encourage investment and innovation;

f) to facilitate programs that encourage job creation;

g) to take measures that ensure the values of the WHC are promoted;

h) to establish and implement the Integrated Management Plan;

i) to initiate steps regarding research, education, training, awareness raising and capacity building; and

j) to liaise with, and be sensitive to, the needs of communities living in or near the World Heritage Sites.

In mid 1999 this Authority developed and implemented a comprehensive Integrated Environment and Conservation Management Plan following a number of specialist studies, including studies on the archaeology and palaeo-anthropology, geology, hydrology, ecology, land use and infrastructure, state of the environment, tourism and marketing, stakeholder participation and financial plans (Cradle of Humankind, 1999).

As per the legislative requirements of Article 29 of the Act (Act 49 of 1999), this plan was aligned with the World Heritage Convention and Operational Guidelines, as well as to other Development and Environmental Legislations and Frameworks, both of a National and Local context, which could have an influence over the Site. This plan would cover a period of years and require a submission of a progress report to the Minister of Environmental Affairs, who in turn would need to submit a report to the World Heritage Committee who would be responsible for reporting activities at each of the ordinary sittings of the General Conference of UNESCO. According to the requirements of this report, a monitoring and evaluation component that addressed certain key areas of ecological integrity and cultural heritage was implemented.

Although proclaimed as a site of cultural significance, the conservation of the biodiversity (fauna and flora) of the entire site features as an integral component of the mission statement for the Cradle of Humankind World Heritage Site (COH WHS) (http://www.cradleofhumankind.co.za).

The Environment and Conservation component of this monitoring and evaluation requirement would therefore require a key understanding of baseline ecological information, of which the description of the natural vegetation occurring in the COH WHS should be seen as an essential part.

1.3. **The Classification of Vegetation**

Vegetation is heterogeneous, consisting of numerous, relatively distinct plant communities each with their own species composition, structure and relative cover of each species respectively (Duigan & Bredenkamp 2003).

It is generally acknowledged that the rate at which these distinct plant communities develop is dependent on the suitability of the environment for the growth of the plant species present, and is affected by various biotic and abiotic factors and processes (Tainton 1988; Roberts & Wuest 1999).

The spatial distribution of plant communities is not constant and can be seen as a function of succession in response to various environmental factors (Peet 1993; Bridge & Johnson 2000). These include, but are not limited to edaphic factors (Johnson 1992; Neal Stewart Jr. & Nilsen 1993; Zak *et al.* 2003; Reddy *et al.* 2009 and Hutchings *et al*. 2003), topography (Riera *et al.*1998; Dirnbock *et al.* 2002; Fernandez-Palacios & de Nicolas 1995), climate (Fuhlendorf *et al.* 2001; Dunnett *et al.* 1998; Goward & Prince 1995; Lenihan *et al.* 2003), fire (Turner *et al.* 1994 ; Kerfoot 1987) anthropogenic factors (Kirkpatrick 1999) and herbivory (Adler *et al.* 2001) to name but a few.

Although there are numerous such factors and processes, there are certain of them that can be highlighted when classifying and describing the relatively distinct plant communities within especially Karst landscapes (Crowther 1982). Karst, named after the German name for Kras, refers to the region in Slovinia where the first scientific research on this type of ‘dissolvable’ landscape took place.

Karst landforms (including the fossil rich caverns of the COH WHS) are generally the result of mildly acidic water solutions acting on soluble limestone or dolostone bedrock.

This carbonic acid that forms these features is formed when rain passes through the atmosphere picking up CO_2 which dissolves in water particles in the atmosphere. Once the rain reaches the ground, it passes through the soil collecting even more CO_2 (added to through respiration from plant rootstocks) to form a weak carbonic acid solution $H_2O+CO_2 \rightarrow H_2CO_3$ (Brink & Partridge 1965).

A karst landscape, due primarily to the highly variable topography created through the dissolving of rock, would therefore lend itself to the creation of habitat and or environmental heterogeneity. This type of environmental heterogeneity is a main contributing factor to the possibility of high plant species densities being encountered (Goldblatt 1978).

Vegetation is a complex phenomenon which for various practical and academic reasons deserves to be described and classified (Mucina 1997). The classification of vegetation into relatively distinct units (plant communities) allows specific management actions to be applied to each delineated unit according to set objectives (Duigan & Bredenkamp 2003; Cleaver *et al*. 2005; Brown & Bezuidenhout 2005). A thorough understanding of the natural vegetation found in an area, both spatially and in terms of composition and structure is essential in order to facilitate and implement the effective ecological management of a landscape (Kent & Coker 1992; Van Rooyen *et al.* 1981).

As plant communities represent ecosystems, the knowledge of these communities and the understanding of the potentials of the associated ecosystems allow for the successful management of those areas (Brown & Brand 2004) especially as different ecosystems react differently to varying management practices (Bredenkamp 1982 & Bezuidenhout 1993), and exploitation by certain species (Brown *et al*. 2005).

Any alteration to the form and/or to the atmosphere or the overlying surface and catchment area has repercussions throughout the ecosystem and could be detrimental to the vegetation and associated sub-terrainean cave systems to a greater or lesser degree. These include both surface and subsurface activities, intentional or unintentional, and include the alteration of air and water pathways and percolation into the subterranean system (Gamble 1980).

The understanding of vital karst ecosystem driving processes such as groundwater recharge potential through the varying infiltration, runoff and evapo-transpiration rates of each identified plant community are enhanced through a detailed understanding of the extent and characteristics of each plant community respectively.

It can therefore be seen that a thorough understanding of the surface environment including the nature and extent of the different plant communities is essential in the management of any karst area, but in particular the COH which owes its World Heritage status to the wellbeing of its fossil bearing karst caverns. An initial vegetation classification forms a baseline from which to implement a monitoring and evaluation program that measures for and mitigates against harmful change (Brown & Bredenkamp 1994). It is therefore important that this baseline information is obtained for the COH to ensure scientifically sound ecosystem management.

The planning of any biological monitoring requires as much biological information as possible to be available before proceeding with the actual monitoring actions themselves. This available information should be responsible for determining the location and type of sampling sites and type of sampling strategy to be implemented (Spellerberg 1993). An ecological survey and phytosociological classification of the area can therefore add value to the development planning of the site and as well as the ongoing management thereof (Groves 2003).

Current levels of understanding of the vegetation of the COH WHS are limited to regional classifications conducted on a broad scale such as those undertaken by Acocks (1988), Low & Rebelo (1998), Mucina & Rutherford (2006), Bredenkamp & Brown (2003), Grobler *et al*. (2006), Grobler *et al*. (2002) and Bezuidenhout *et. al* (1994) or to classifications such as those conducted over only one specific farm as in Coetzee (1974) and Siebert & Siebert (2005).

Since the declaration of the Cradle of Humankind as a World Heritage Site, a series of research, management, and analytical studies were commissioned by the Gauteng Department of Agriculture, Conservation and Environment (GDACE) with the common objective of providing the necessary mechanisms and decision-support tools needed to contribute towards the overall vision for the area. One such study, conducted in 2001 was a Land Use Master Plan with the objective to provide a Zonation Plan to guide all future development in the area. A follow-up study, with the objectives to verify the proposed zones, to identify the land use patterns that are inconsistent with the zonation policy, and to propose mechanisms for conversion to more supportive land use patterns, was commissioned by GDACE (Cradle of Humankind 2001). This master plan however lacked suitable detail and subsequently a Land-use audit was commissioned. This audit therefore required the land-use of the area to be mapped at a level of detail that would allow for accurate analytical analysis of the existing zonation boundaries, existing land-use patterns and inconsistencies with the preferred land-use patterns, as listed and described by the previous studies completed (Cradle of Humankind 2003).

The boundaries of the identified zones were not reliably aligned to any meaningful ecological parameters for example Land Type or Geology, however a general indication of fragmentation, ecological and development footprints in the COH WHS was facilitated. The obtaining of useful information through the classifying and mapping of vegetation that are indeed aligned to meaningful parameters by identifying individual units of vegetation and arranging them in an orderly and meaningful will address this shortfall. Classifying vegetation is often problematic and full of difficulties, primarily as a result of the incorrect application of scale (Kuchler 1973). A description of the vegetation of the entire COH WHS is presently lacking at a suitable scale.

Despite the importance of the Grassland biome having been highlighted before in studies by inter alia Turner (1989), Fuls (1993) and Myburgh (1993), very little of the Bankenveld veld type (Acocks 1988) of the North Western Gauteng Province is protected within formal conservation areas (Edwards 1972; Siegfried 1989).

This is despite the increasing pressures placed upon it through agriculture (Anon 1987), industry & mining (Bezuidenhout 1988) and invasive species such as *Acacia mearnsii, Pinus* spp.*, Eucalyptus* spp. and *Campuloclinium macrocephalum* (Henderson *et al.* 1987). Bankenveld comprises approximately 2 356 800 ha (Edwards 1972) of the 11 500 000 ha (Department of Agriculture and Water Supply 1987) Highveld Region.

The fact that the Cradle of Humankind is a proclaimed World Heritage Site means it is afforded some level of protection in terms of the World Heritage Convention Act (Act 49 of 1999) and the National Environmental

Management: Protected Areas Act (Act 57 of 2003), placing emphasis on its correct management in order to retain this valuable status.

It is clear that plant communities and their associated habitats should form the basis of any scientifically based environmental management strategy for any natural area. The need for a suitable vegetation classification as a precursor to, and guiding principal behind, any long term monitoring and evaluation program is essential (Brown & Bezuidenhout 2000). A Vegetative inventory and plant community classification and description of the COH WHS for both Management and record purposes is therefore required to support and enhance local decision making capacity, policy formulation, sound land-use planning and management practices in general (Tueller 1988; Fuls *et al*. 1992; Fuls 1993; Bezuidenhout 1993; Brown *et al*. 1996).

1.4. **Aim and Objectives**

This study aims to address the shortfalls in site specific baseline information with regards to the distribution and description of the major plant communities occurring within the COH WHS through the classification of the natural vegetation on a floristic basis using Braun-Blanquet methodology on a suitable, semi-detailed local scale (Bredenkamp 1975; Coetzee 1974; van Rooyen 1984).

The objectives for this study are to:

- classify and describe the natural vegetation of the COH WHS on a suitably useful local scale
- relate the different plant communities identified to Land Types
- establish whether caves influence the composition and structure of the vegetation surrounding the entrances of the caves.

It is envisaged that in doing so, suitable information would be generated from which to initiate, guide and implement representative sampling as part of an ecological monitoring and evaluation program as per UNESCO and COH WHS management plan requirements.

1.5. **REFERENCES**

ACOCKS, J.P.H. 1988. Veld Types of South Africa. 3rd edn. Mem. Bot. Surv. S. Afr.57:1-146, Government Printer, Pretoria.

ADLER, F.B.; RAFF, D.A. & LAUENROTH, W.K. 2001. The effect of grazing on the spatial heterogeneity of vegetation. *Oecologia* 128: 465-479.

ANON. 1987. Agriculture in South Africa. 2nd Edition. Chris van Rensburg, Johannesburg,

BAMFORD, M. 1999. Pliocene fossil woods from an early hominid cave deposit, Sterkfontein, South Africa. *South African Journal of Science* 95: 231-236.

BERGER. L.R. & HILTON-BARBER. 2004. A Field Guide to the Cradle of Humankind; Sterkfontein, Swartkrans, Kromdraai and Environs World Heritage Site. Struik Publishers, Cape Town.

BEZUIDENHOUT, H. 1993. Syntaxonomy and synecology of western Transvaal grasslands, South Africa. Ph.d. Thesis. University of Pretoria, Pretoria.

BEZUIDENHOUT, H. 1988. n Plantsosiologiese studie van die Mooirivieropvanggebied, Transvaal. M.Sc. thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.

BEZUIDENHOUT, H; BREDENKAMP, G.J. & THERON, G.K. 1994. A classification of the vegetation of the western Transvaal dolomite and chert grassland, South Africa. *South African Journal of Botany,*1994. 60(3): 152-161.

BREDENKAMP, G.J. 1975. n Plantsosiologiese studie van die Suikerbosrandnatuurreservaat, Transvaal. M.Sc. thesis, University of Pretoria, Pretoria.

BREDENKAMP, G.J. 1982. n Plantekologiese studie van die Manyeleti-wildtuin. D.Sc. Thesis. University of Pretoria. Pretoria.

BREDENKAMP, G.J. & BROWN, L.R. 2003. A reappraisal of Acocks' Bankenveld: Origin & diversity of Vegetation Types. *South African Journal of Botany* 69(1) 7-26.

BRIDGE, S.R.J. & JOHNSON, E.A. 2000. Geomorphic Principles of Terrain Organization and Vegetation Gradients. *Journal of Vegetation Science*, 2000. 11(1): 57-70.

BRINK, A.B.A. & PARTRIDGE, T.C. 1965. Transvaal karst: some considerations of development and morphology, with special reference to sinkholes and subsidence on the far West Rand. *South African Geogr. J.* 47. 11-34.

BROWN, L.R. & BEZUIDENHOUT, H. 2000. The phytosociology of the De Rust section of the Mountain Zebra National Park, Eastern Cape. *Koedoe* 43(1): 1-18.

BROWN, L.R. & BEZUIDENHOUT, H. 2005. A vegetation description and classification of the farms Ingleside and Welgedacht on the Mountain Zebra National Park, Eastern Cape. *Koedoe* 48(2): 23-42.

BROWN, L.R. & BRAND, M.E. 2004. Research in nature conservation and tertiary education. Unpublished report. UNISA.

BROWN, L.R. & BREDENKAMP, G.J. 1994. The phytosociology of the southern section of the Borakolalo Nature Reserve, South Africa. *Koedoe* 37: 59-72.

BROWN, L.R; BREDENKAMP, G.J. & VAN ROOYEN, N. 1996. The phytosociology of the northern section of the Borakololo Nature Reserve. *Koedoe* 39: 9-24.

BROWN, L.R; MARAIS, H. & BARRETT, L. 2005. Vegetation classification as the basis for baboon management in the Bourke's Luck Section of the Blyde Canyon Nature Reserve, Mpumalanga. *Koedoe* 48(2): 71-92.

CLARKE, R.J. 1998. First ever discovery of a well preserved skull and associated skeleton of Australopithecus. *South African Journal of Science* 94: 460-463.

CLEAVER, G; BROWN, L.R. & BREDENKAMP, G.J. 2005. The phytosociology of the Vermaaks, Marnewicks and Buffelsklip Valleys of the Kammanassie Nature Reserve, Western Cape. *Koedoe*48(1): 1-16.

COETZEE, B.J. 1974. A Phytosociological classification of the vegetation of the Jack Scott Nature Reserve. *Bothalia* 11: 329-347.

CRADLE OF HUMANKIND MGMT AUTHORITY. 1999. Integrated Environment and Conservation Management Plan. Gauteng Dept. Agriculture, Conservation and Environment, Johannesburg.

CRADLE OF HUMANKIND MGMT AUTHORITY. 2001. Land Use master plan. Gauteng Dept. Agriculture, Conservation and Environment, Johannesburg.

CRADLE OF HUMANKIND MGMT AUTHORITY. 2003. Land Use Audit report. Gauteng Dept. Agriculture, Conservation and Environment, Johannesburg.

CROWTHER, J. 1982. Ecological observations in a tropical karst terrain, West Malaysia. I. Variations in topography, soils and vegetation. *Journal of Biogeography* 9: 65-75.

DEPARTMENT OF AGRICULTURE AND WATER SUPPLY. 1987. Landbou ontwikkelingsprogram: Hoeveldstreek 1986. Directorate Agricultural Information, Government Printer, Pretoria.

DIRNBOCK, T; HOBBS, R.J; LAMBECK, R.J. & CACETTA, P.A. 2002. Vegetation distribution in relation to topographically driven process in southwestern Australia. *Applied Vegetation Science* 5: 147-158.

DUIGAN, P.S & BREDENKAMP, G.J. 2003. The Vegetation Classification of Letamo Estates in North-Western Gauteng. Bsc. (Hons) Thesis. University of Pretoria.

DUNNETT, N.P; WILLIS, R; HUNT, R. & GRIME, J.P. 1998. A 38-year study of relations between weather and vegetation dynamics in road verges near Bibury, Gloucestershire. *Journal of Ecology* 86: 610-623.

EDWARDS, D. 1972. Conservation areas in relation to Veld Types. *Unpublished ms. Bot. Res. Inst. Pretoria. (In press Kudu).*

FERNANDEZ-PALACIOS, J.M. & NICOLAS, J.P. 1995. Altitudinal patterns of vegetation variation on Tenerife. *Journal of Vegetation Science* 6: 183-190. Opulus Press. Uppsala.

FUHLENDORF, S.D; BRISKE, D.D. & SMEINS, F.D. 2001. Herbaceous vegetation change in variable rangeland environments: The relative contribution of grazing and climate variability. *Applied Vegetation Science* 4: 177-188.

FULS, E.R. 1993. Vegetation ecology of the northern Orange Free State. Ph.D. dissertation, University of Pretoria, Pretoria.

FULS, E.R; BREDENKAMP, G.J; & VAN ROOYEN, N.1992. The plant communities of the undulating grassland of the Vredefort- Kroonstad- Lindley-Heilbron area, northern Orange Free State. *South African Journal of Botany* 58: 224-230.

GAMBLE, F.M. 1980. Disturbance of underground wilderness in karst caves. *Intern. J. Environmental Studies.1981.* Vol. 18. pp. 33-39.

GOLDBLATT, P. 1978. An analysis of the flora of Southern Africa: its characteristics, relationships and origins. *Ann Mo Bot Gard* 65: 369-436.

GOWARD, S.N. & PRINCE, S.D. 1995. Transient effects of climate on vegetation dynamics: satellite observations. *Journal of Biogeography* 22: 549-563.

GROBLER, C.H; BREDENKAMP, G.J. & BROWN, L.R. 2006. Primary grassland vegetation of open spaces in urban areas of Gauteng, South Africa. *South African Journal of Botany* 72: 367-377.

GROBLER, C.H; BREDENKAMP, G.J. & BROWN, L.R. 2002. Natural woodland vegetation and plant species richness of urban open spaces in Gauteng. *Koedoe* 45(1): 19-34.

GROVES, C.R. 2003. *Drafting a Conservation blueprint- a Practitioners guide to Planning for Biodiversity.* Island Press. Washington D.C.

HENDERSON, M; FOURIE, D.M.C; WELLS, M.J. & HENDERSON, L. 1987. Declared weeds and alien invader plants in South Africa. Department of Agriculture and Water Supply. Government Printer. Pretoria.

HUTCHINGS, M.J; JOHN, E.A. & WIJESINGHE, D.K. 2003. Toward understanding the consequences of soil heterogeneity for plant populations and communities. *Ecology* 84(9): 2322-2334.

JOHNSTON, M.H. 1992. Soil-vegetation relationships in a tabonuco forest community in the Luquillo Mountains of Puerto Rico. *Journal of Tropical Ecology* 8: 253-263.

KENT, M. & COKER, P. 1992. *Vegetation description and Analysis – a practical approach*. John Wiley and Sons. Chinchester, England.

KERFOOT, O. 1987. The geology, physiography and vegetation of the Witwatersrand floral region. In: Lowry, T.K.; Wright, S.(eds). The flora of the Witwatersrand: the Monocotyledonae, vol 1. Witwatersrand University Press. Johannesburg.

KIRKPATRICK, J.B. 1999. *A continent transformed: Human impact on the natural vegetation of Australia.* Oxford University Press. Melbourne.

KNOLL, A.H. 1983. Africa and Precambrian biological evolution. *Bothalia* 14, 3&4: 329-336.

KUTCHLER, A.W. 1973. Problems in classifying and mapping vegetation for ecological regionalization. *Ecology* 54(3): 512-523.

LENIHAN, J.M; DRAPEK, R; BACHELET, D. & NEILSON, R.P. 2003. Climate change effects on vegetation distribution, carbon, and fire in California. *Ecological Applications* 13(6): 1667-1681.

LOW, A.B. & REBELO, A.G. (ed.) 1998. Vegetation of South Africa, Lesotho and Swaziland. 2nd ed. Dept Environmental Affairs and Tourism, Pretoria.

MUCINA, L. 1997. Classification of vegetation: Past, present and future. *Journal of Vegetation Science* 8: 751-760.

MUCINA, L. & RUTHERFORD, M.C. (eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. *Strelizia* 19. South African National Biodiversity Institute, Pretoria.

MYBURGH, W.J. 1993. Die fitososiologie van die suurgrasveld in die Suidoos-Transvaalse Hoëveld. M.Sc. thesis, University of Pretoria, Pretoria.

NEAL STEWART Jr. C. & NILSEN, E.T. 1993. Association of Edaphic factors and vegetation in several isolated Appalachian peat bogs. *Bulletin of the Torrey Botanical Club* 120(2): 128-135.

PEET, R.K. 1992. Community Structure and Ecosystem function. In: Plant Succession: Theory and prediction, (reds.) D.C. GLENN-LEWIS; R.K. PEET & T.T. VEBLEN. Chapman and Hall, London.

REDDY, R.A; BALKWILL, K. & McCLELLAN, T. 2009. Plant species richness and diversity of the serpentine areas on the Witwatersrand. *Plant Ecol* 201: 365-381.

RIERA, J.L; MAGNUSON, J.J; van de CASTLE, J.R. & MACKENZIE, M.D. 1998. Analysis of Large-Scale Spatial Heterogeneity in Vegetation Indices among North American Landscapes. *Ecosystems* 1: 268-282.

ROBERTS, M.R. & WUEST, L.J. 1999. Plant Communities of New Brunswick in relation to Environmental variation. *Journal of Vegetation Science* 10: 321-334. Opulus Press. Upsala.

SIEBERT, F. & SIEBERT, S.J. 2005. Dolomitic vegetation of the Sterkfontein caves World Heritage Site and its importance in the conservation of Rocky Highveld Grassland. *Koedoe* 48(1): 17-31.

SIEGFRIED, W.R. 1989. Preservation of species in southern African nature reserves. B.J. Huntley (ed.) Biotic Diversity in southern Africa: Concepts and Conservation. Oxford University Press, Cape Town.

South Africa. 1999. World Heritage Convention Act 49 of 1999.Pretoria: Government Printer.

South Africa. 2003. National Environment Management:Protected Areas Act 57 of 2003. Pretoria: Government Printer

SPELLERBERG. 1993. Planning the Monitoring. In: Monitoring In Practice. Chapman and Hall. London.

TAINTON, N.M. 1988. Natural Grazing Lands and Their Ecology. In: Tainton (ed). Veld and Pasture Management in South Africa. University of Natal Press, Pietermaritzburg.

TUELLER, P.T. 1998.*Vegetation science applications for rangeland analysis and management*. Dordrecht: Kluwer Academic Publishers.

TURNER, B.J. 1989. A phytosociological study of the south-eastern Transvaal Highveld grasslands. M.Sc. thesis, University of Pretoria, Pretoria.

TURNER, M.G; HARGROVE, W.W; GARDNER, R.H. & ROMME, W.H. 1994. Effects of fire on landscape heterogeneity in Yellowstone National Park, Wyoming. *Journal of Vegetation Science* 5: 731-742.

UNITED NATIONS EDUCATION, SCIENTIFIC AND CULTURAL ORGANIZATION. 1972. The Convention Concerning the Protection of the World Cultural and Natural Heritage.

VAN ROOYEN, N. 1984. n Fenologiese studie van die plantegroei van die Roodeplaatdam-natuurreservaat. D.Sc. dissertation, University of Pretoria, Pretoria.

VAN ROOYEN, N; THERON, G.K. & GROBBELAAR, N. 1981. A floristic description and structural analysis of the communities of Punda Milia-Pafuri-Wambiya area in the Kruger National Park, Republic of South Africa. 1. The hygrophilous communities. *South African Journal of Botany*47: 213-246.

ZAK, D.R; HOLMES, W.E; WHITE, D.C; PEACOCK, A.D. & TILMAN, D. 2003. Plant diversity, soil microbial communities, and ecosystem function: Are there any links? *Ecology* 84(8): 2042-2050.

CHAPTER 2

STUDY AREA

2.1. Location, size, vegetation and topography

The COH WHS and its surrounding buffer zone occupies a northeasterly striking belt of land approximately 800 sq. kilometers, or 47 000 ha in size, between Krugersdorp in the southwest and Hartebeespoort Dam in the northeast. It is bounded by the Witwatersberg Range to the north and the outcrop of the Johannesburg granite dome in the south. The majority of the study site falls within the northwestern portion of the Gauteng Province (Figure 2.1), whilst a small portion extends across the provincial boundary into the Northwest Province. The study area is bounded by the latitudes 25°15’ S and 26°00’S and the longitudes 27°15’E and 27°45’E.

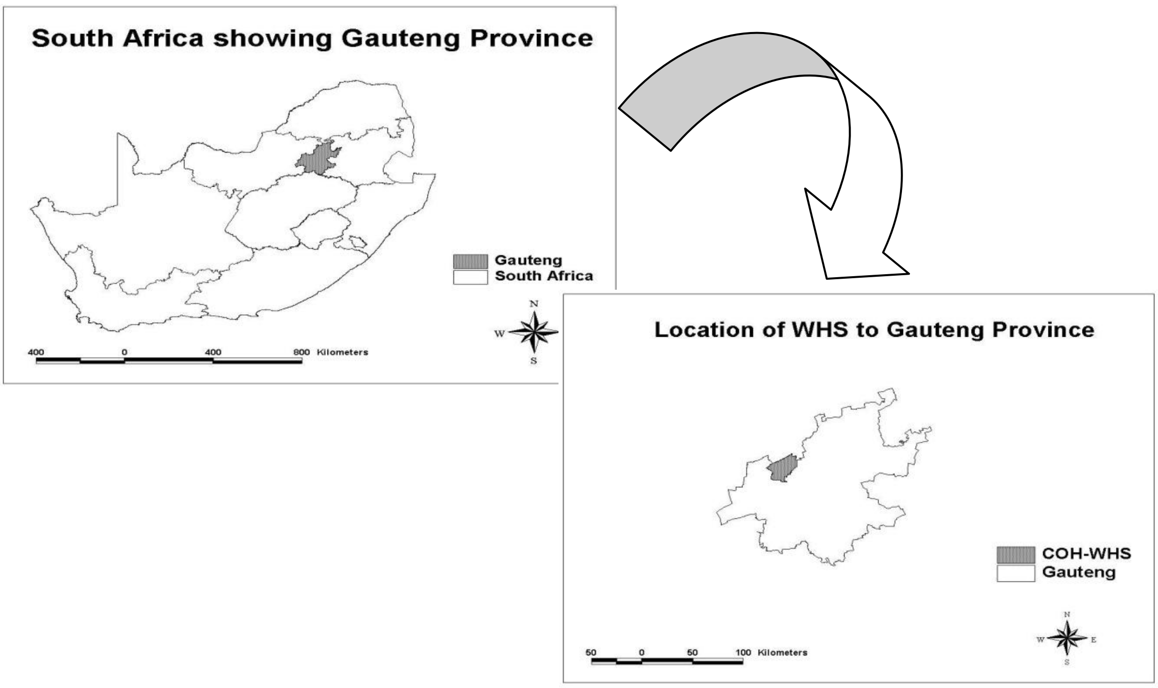


Figure 2.1: Map showing location of COH WHS in Gauteng Province.

The landscape is described as hilly rolling country dissected by valleys, located in the upper reaches of a zone forming the escarpment separating two major natural regions, the Highveld (1500-1600m) in the south, from the

Bushveld in the North (1000-1100m). These two regions represent surfaces pediplained by erosion cycles.

The Highveld zone corresponds more or less to the African Surface, which started to develop after a continental uplift during the Cretaceous (Button 1973), whilst the Bushveld zone corresponds more or less to an area dissected and lowered through subsequent erosion cycles (Partridge & Maud 1987). Aspect varies considerably due to the undulating topography with flat, gentle, moderate and steep slope classes (Pfab 2001) being represented throughout the site (Figure 2.2).

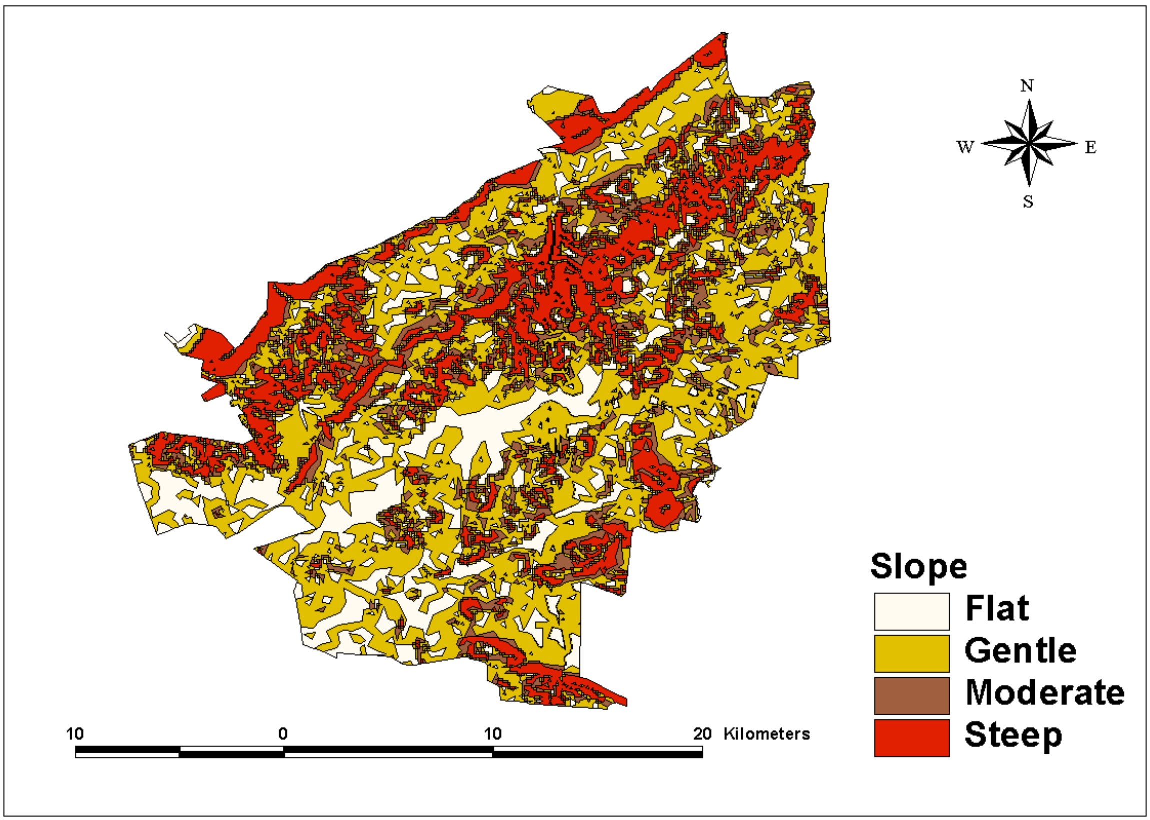


Figure 2.2: The COH WHS showing Slope classes as per Pfab (2001).

The vegetation across the study area is regionally accepted to coincide largely with the Rocky Highveld Grassland within the Grassland Biome of South Africa (Bredenkamp & Van Rooyen 1996) or the Bankenveld (Figure 2.3) as described by Acocks (1988). The refined Vegetation classification according to Muncina & Rutherford (2006) now lists 5 vegetation types as occurring within the borders of the COH WHS (Figure 2.4).

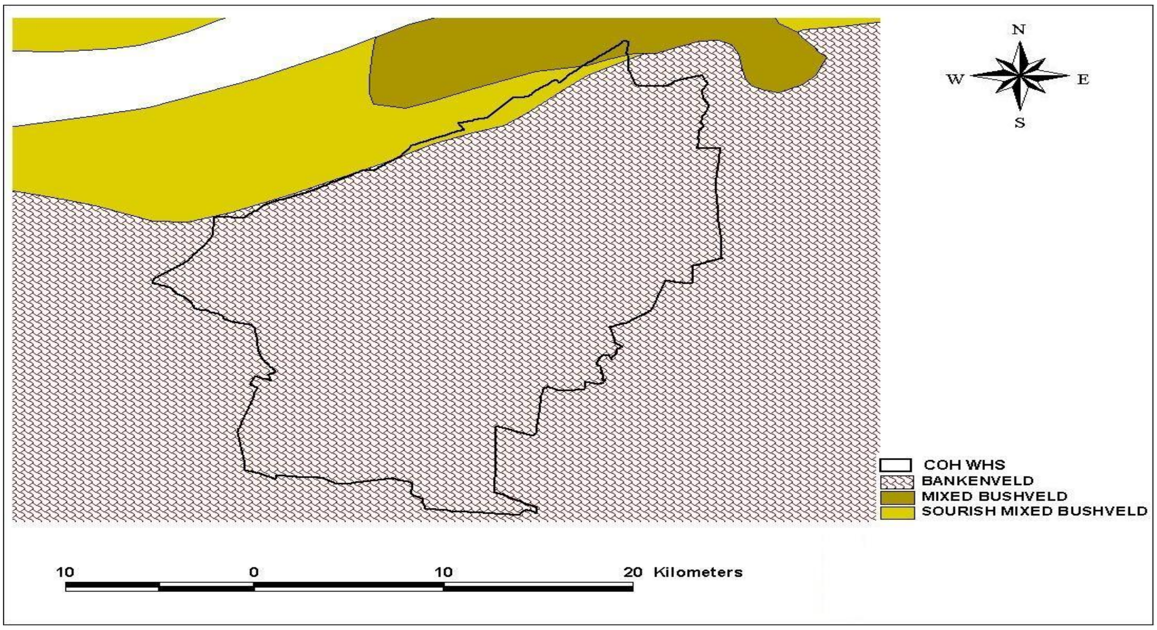


Figure 2.3: Acocks' (1988) veld types occurring in the COH WHS.

Rocky Highveld Grassland as described by Bredenkamp and Van Rooyen (1996) is fairly rare in its natural state with over 65% of it being classed as transformed. Development pressure and habitat fragmentation are responsible for the same scenario being experienced across the Carletonville Dolomitic Grassland, Egoli Granite Grassland, Soweto Highveld Grassland as described by Muncina and Rutherford (2006) (GDARD-C-Plan).

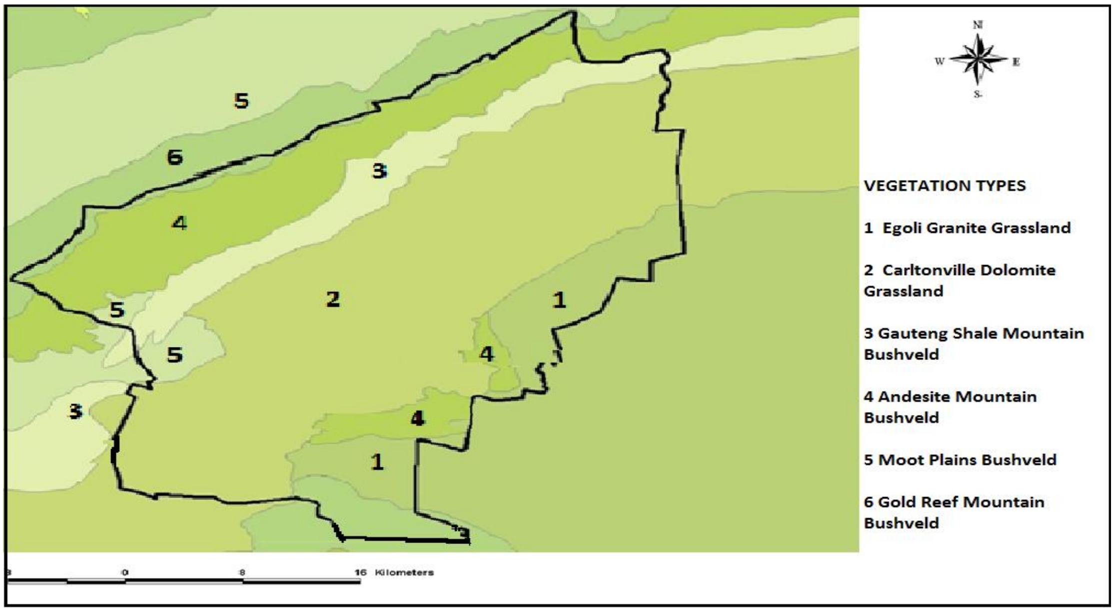


Figure 2.4: Muncina and Rutherford's (2006) vegetation types occurring in the COH WHS.

2.2. Geology

The COH WHS is located in the Malmani Subgroup of late Archaean age (2,5-2,6 billion years), which has been deposited in the intra-cratonic Transvaal Basin (Button 1973). The lithology (Figure 2.5) consists essentially of shallow marine stromatolitic dolostone with variable amounts of chert. The dolomite mineral is typically rich in Fe and Mn (up to 3% combined). Its thickness reaches 1450 m in the Sterkfontein area (Eriksson & Truswell, 1974). Based on the abundance of chert, the subgroup has been subdivided into 6 formations, two of which are represented within the COH.

The Oaktree Formation (180m thick) represents the basal unit, characterised by its very chert poor nature. The overlying unit, the Monte Christo Formation (700 m thick) is rich in chert. It has thin but spectacular oolitic beds at its base. The Sterkfontein Cave straddles the boundary between the two formations. The strata dip about 30° to the NW (Wilkinson 1973).

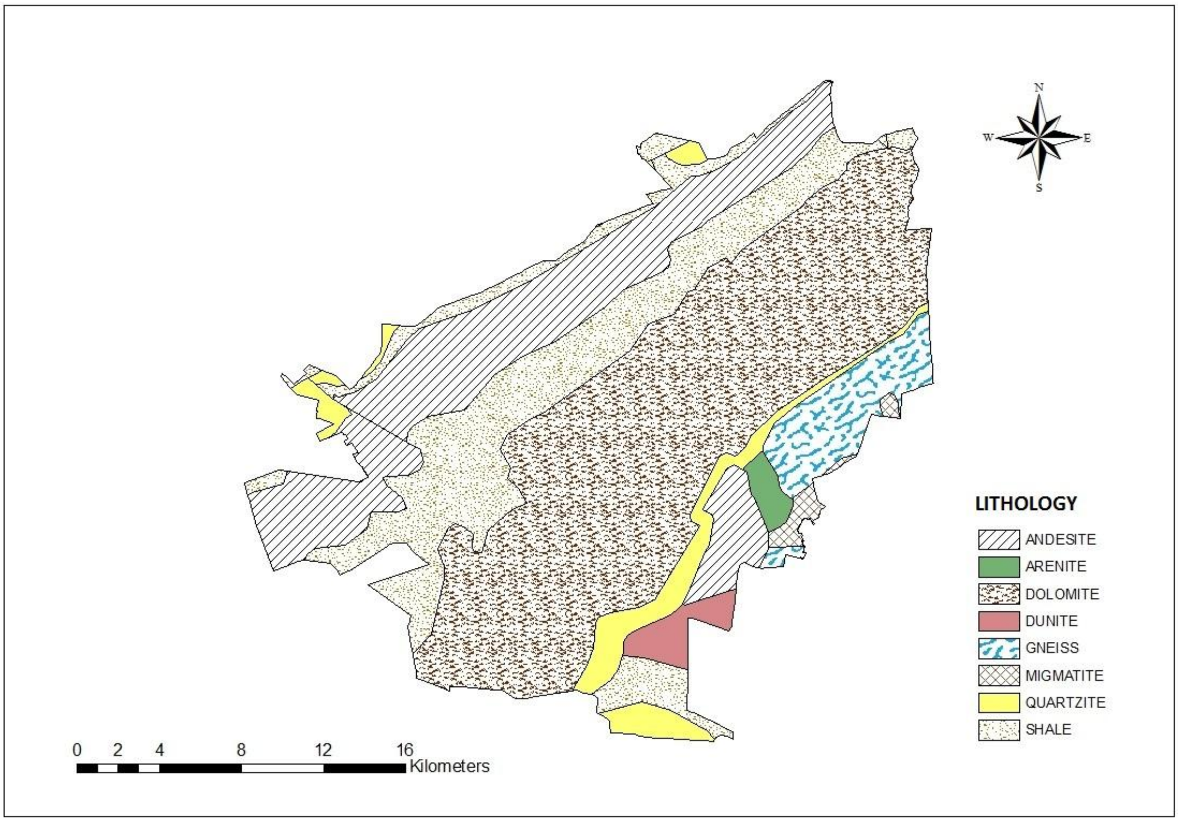


Figure 2.5: Localized Lithology in the COH WHS.

Dolerite dykes and sills are numerous in the area. Large parts of the COH WHS buffer zone extend over rocks of the Pretoria Group (Figure 2.6.)

in the north while some areas in the south and southeast are underlain by Basement Granite and Greenstones. The Transvaal Supergroup and its basal unit, the Black Reef Quartzite formation, rest on the basement lithologies of the Johannesburg Dome as well as the Ventersdorp volcanics and sediments. In the extreme south west of the area, the Black Reef rests upon the West Rand Group of the Witwatersrand Supergroup which rims the western and southern edge of the granite dominated Johannesburg Dome (Jamison *et al*. 2005).

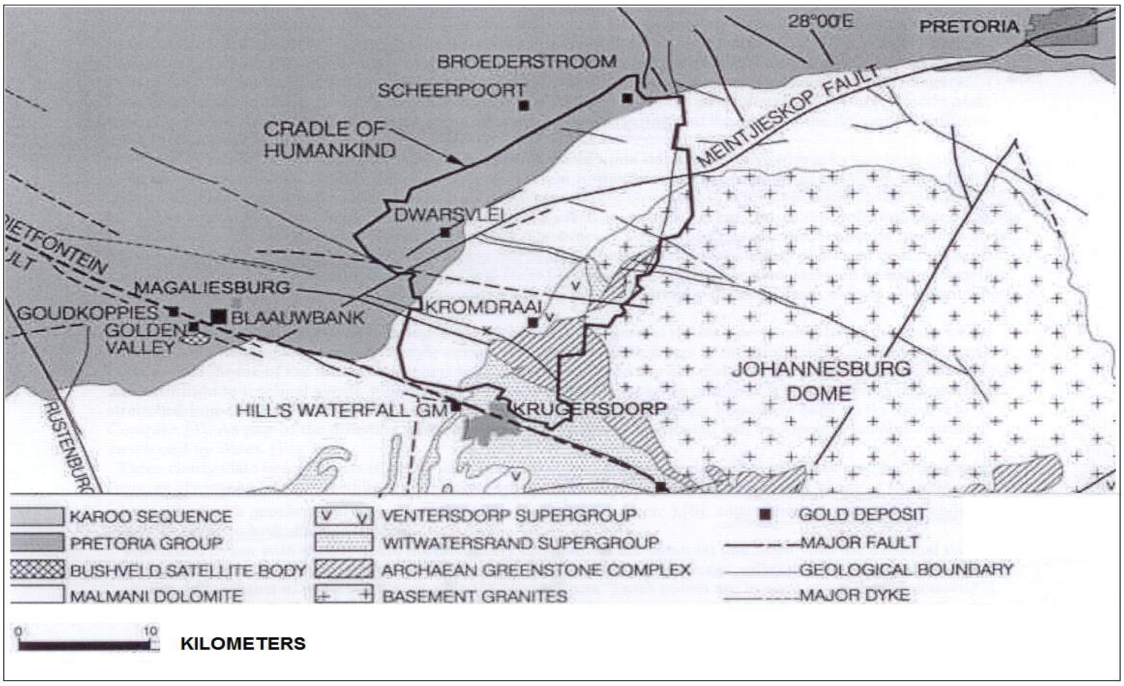


Figure 2.6: Regional Geology of the COH WHS, after Jamison *et al.* (2005).

The Geology of the site is fairly complex in the Southern corner, and is broadly described as mafic and ultramafic (Geological series 1986). The metamorphic Greenstone belts contain green minerals which form serpentinites, amphobolites and schists. Dolomites and chert from the Dolomite series are found to the north of the Black reef quartzites just above these greenstone belts. Shale and quartzite of the Timeball Hill stage of the

Pretoria series and the shale of the Daspoort stage of the Pretoria series dominate the northern expanses of the study site.

2.3. Land Types

Land types (Figure 2.7) are areas of uniform terrain form, soil pattern and climate and can be shown at 1: 250 000 scale (Land Type Survey Staff 1984). Bredenkamp & Theron (1978), Bezuidenhout (1993) and Bezuidenhout *et al.* (1988) amongst others have demonstrated correlations between vegetation communities and the contributing factors required to denote a Land Type, thereby highlighting also the valuable role that Land Types can play in primary stratification of study areas for vegetation surveying and sampling objectives.

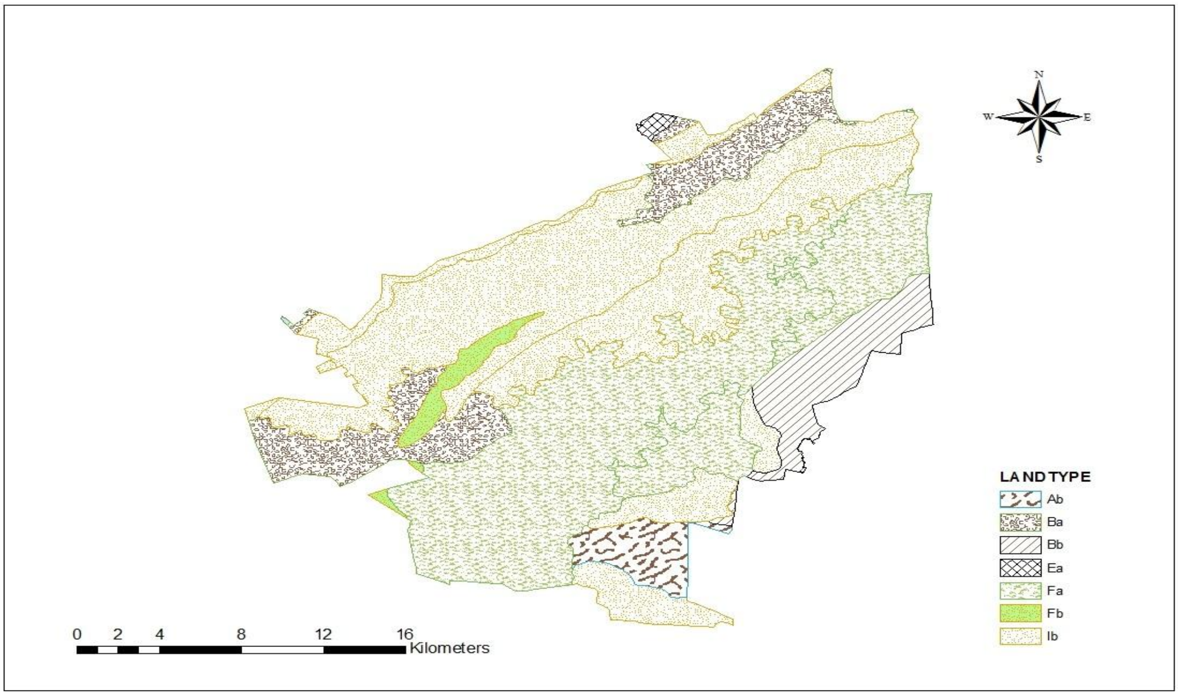


Figure 2.7: The Land Types occurring within the COH WHS.

The different land types are denoted with a specific character or letter of the alphabet e.g. A, B, F etc. where after each main group can be further subdivided as indicated with a lower case character eg. a, b, c, etc. It may happen that the same land type occurs more than once on the same map in which case a numerical character is used to denote the specific number of times that land type has already been encountered e.g. the eighteenth Fa land type or Fa18.

The dominant soil profile of each land type was described and analyzed (Land Type Survey Staff, 1984), providing sound indications of what soils can be expected in which areas. The A Land Type is denoted by freely drained yellow and red apedal soils without water tables. The Ab Land Type as found within the Cradle of Humankind is said to have shallower soils <300mm and be dominated by Hutton soil form (Land Type Survey Staff, 1984). The Ab Land Type covers some 1605.26 hectares or 3.4% of the COH WHS.

The B Land Type has a plinthic catena but the upland duplex and margalitic soils are rare. The Ba derivative is characterized by soils that are dystrophic and/or mesotrophic red apedal in nature. The Hutton soil form is dominant and it is strongly associated with the Ventersdorp Supergroup. The Bb derivative has red soils that are not as widespread (Land Type Survey Staff, 1984). A Total of 6 893.3 hectares or 14.6% of the COH WHS comprises of the B Land Type. (or 8 464.67 hectares when taking into account the proposed extension to include the World Heritage Site Interpretation Centre land at Maropeng.) The Bb Land Type covers 3 157.35 hectares or 6.7% and the Ba Land Type covers 3735.95 hectares or 7.9% of the COH WHS.

The F Land Type refers to pedologically young landscapes that are not predominantly rock and alluvial or Aeolian and in which the main soil forming processes have been rock weathering (Land Type Survey Staff, 1984). The formation of orthic topsoil horizons and clay illuviation have typically given rise to lithocutanic horizons. The F Land Type is dominated by the Glenrosa and Mispah soil forms. Both the Fa and Fb derivatives can be found in the COH WHS. The Fa Land Type refers to those soils in which lime is rarely encountered and the Glenrosa and Mispah soil forms are dominant and the Hutton form is also present. The Fa Land Type is strongly associated with the Chuniespoort Group of the Transvaal sequence. A total of 15738.14 hectares or 33.48% of the COH WHS is comprised of the Fa Land Type. The Fb Land Type refers to those soils in which lime regularly occurs within one or more valley bottoms. The dominant soil forms are Glenrosa and Mispah with rocks being prominent. The Fb Land Type is strongly associated with the

Witwatersrand Supergroup. A Total of 797.1 hectares or 1.69% of the COH WHS is comprised of the Fb Land Type.

The I Land Type refers to miscellaneous land classes (Land Type Survey Staff, 1984). The Ib Land Type indicates land types with exposed country rock, stones or boulders that cover 60-80% of the area. This Land Type consists of three terrain units, namely crests (20% of the area), midslopes (75% of the area) and valley bottoms constituting the remaining 5% of the area. Less than 20% of the area has slopes less than 8%. Local relief varies from 300-900m. The slope range of crests varies between 2-6% with slope length varying between 20-100m and soil rockiness approximates to 50%. Midslopes slope range varies between 10-60% with slope length varying between 100-1 000 m and soil Rockiness is estimated at 70%. Valley bottoms slope range varies between 2-4% with slope length varying between 10-50 m. Soil rockiness is estimated at 50% with stream beds comprising 10% of the landscape. Soils are shallower than 900mm. The Ib Land Type is mostly associated with the quartzites, conglomerates, shales and basalts of the Black Reef Formation within the Transvaal Sequence (Land Type Survey Staff, 1984). A total of 20 902.29 hectares or 44.47% of the COH WHS is comprised of the Ib Land Type.

2.4. Climate

The majority of the study site corresponds with the description of that of typical Highveld as described by Behr and Bredenkamp (1988) in that it falls within a summer rainfall area with temperate summers and frosty winters.

Site specific climatological data was obtained through the automatic measurements obtained by two Davis Vantage Pro II weather stations set to record all major variables, namely, temperature, rainfall, humidity and solar radiation on an hourly basis. As the study site is located on the transitional zone between the highveld grassland and the more sourish mixed bushveld (Acocks 1988), the placement of these stations (Figure 2.8) was done to attempt to capture any north-south climatological gradient fluctuations.

Climate plays an important role in land and soil forming processes (Strahler 1975) as well as vegetation distribution (Acocks 1988).

One station was therefore installed in the south eastern corner of the COH WHS at the Sterkfontein Caves, with the second one being installed at a private Game Reserve, Amazingwe, in the north western corner of the COH WHS, just south of the Hartebeespoort dam.

A full year cycle including all four seasons was thereby obtained for the period January 2004 to January 2005. Any reference hereafter to months therefore refers to them falling in the year 2004.

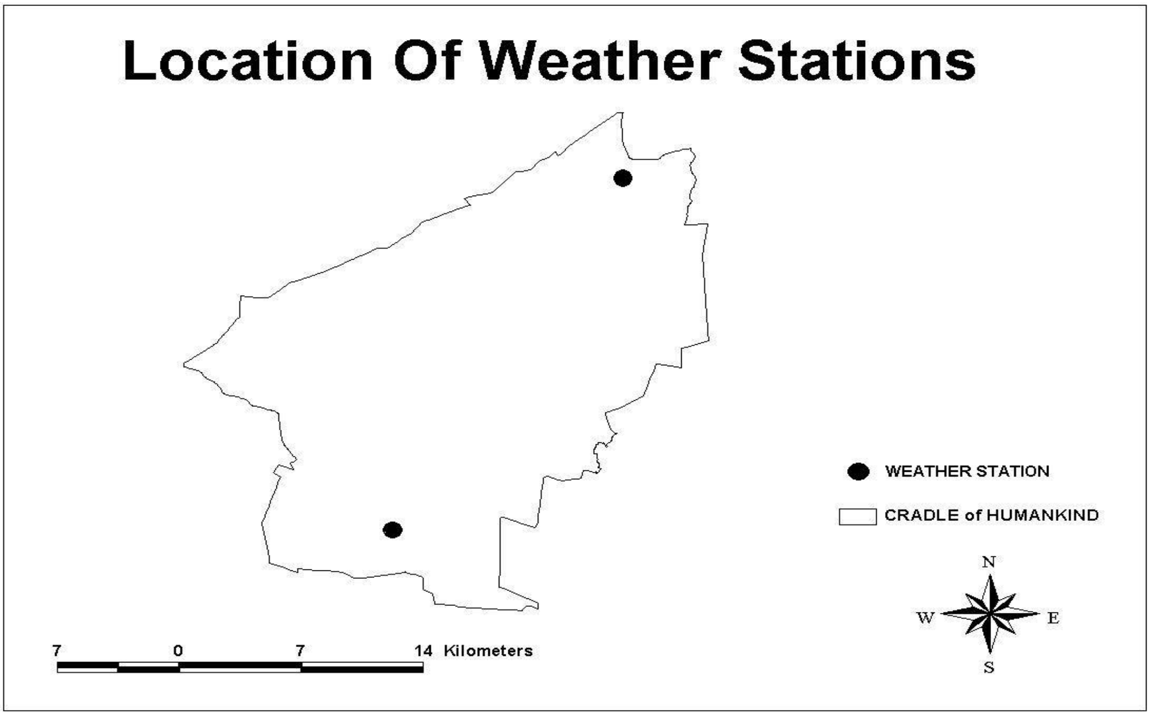


Figure 2.8: Location of the two Vantage Pro II weather stations in the COH WHS.

Amazingwe recorded its highest temperature of 36.3 degrees Celsius in October (Figure 2.9) with the lowest temperature being recorded in June at -1.8 degrees Celsius.

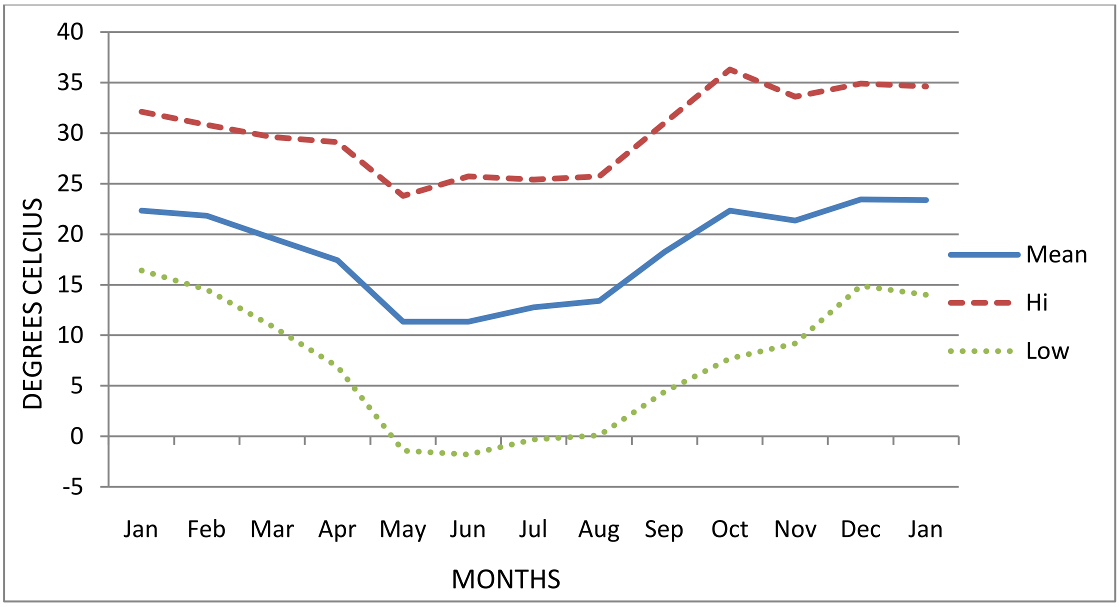


Figure 2.9: Temperatures at Amazingwe Station.

Sterkfontein recorded its highest temperature of 36.3 degrees Celsius in January (Figure 2.10) with its lowest temperature of -6 degrees Celsius being recorded in June as well.

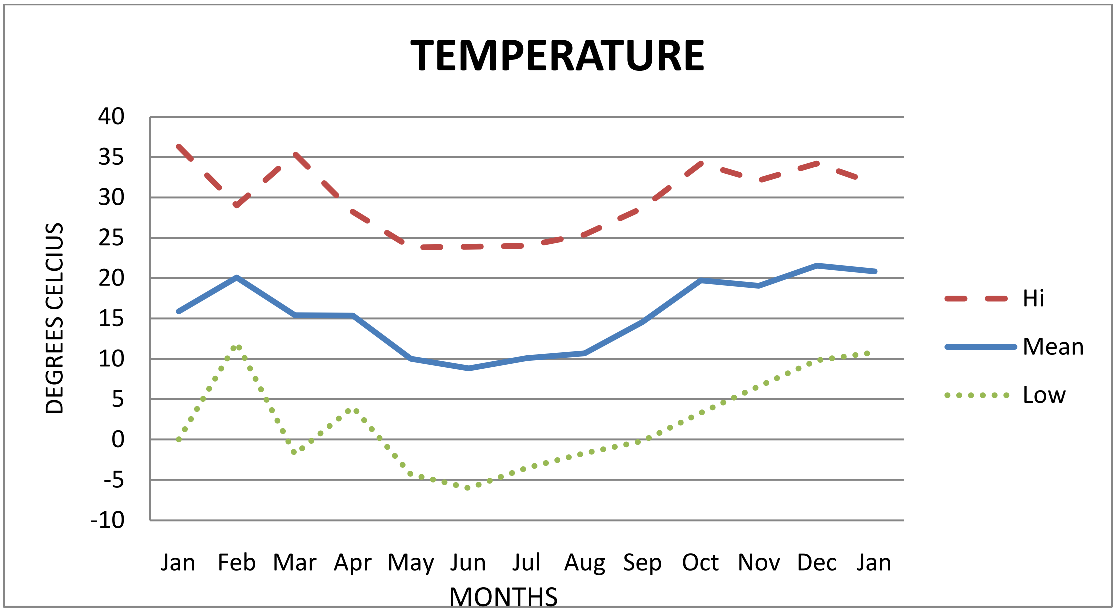


Figure 2.10: Temperatures at Sterkfontein Station.

When the mean monthly temperatures of Sterkfontein and Amazingwe stations are compared with one another (Figure 2.11), indications are that a higher mean temperature is consistently experienced in the Northern areas of the COH WHS.

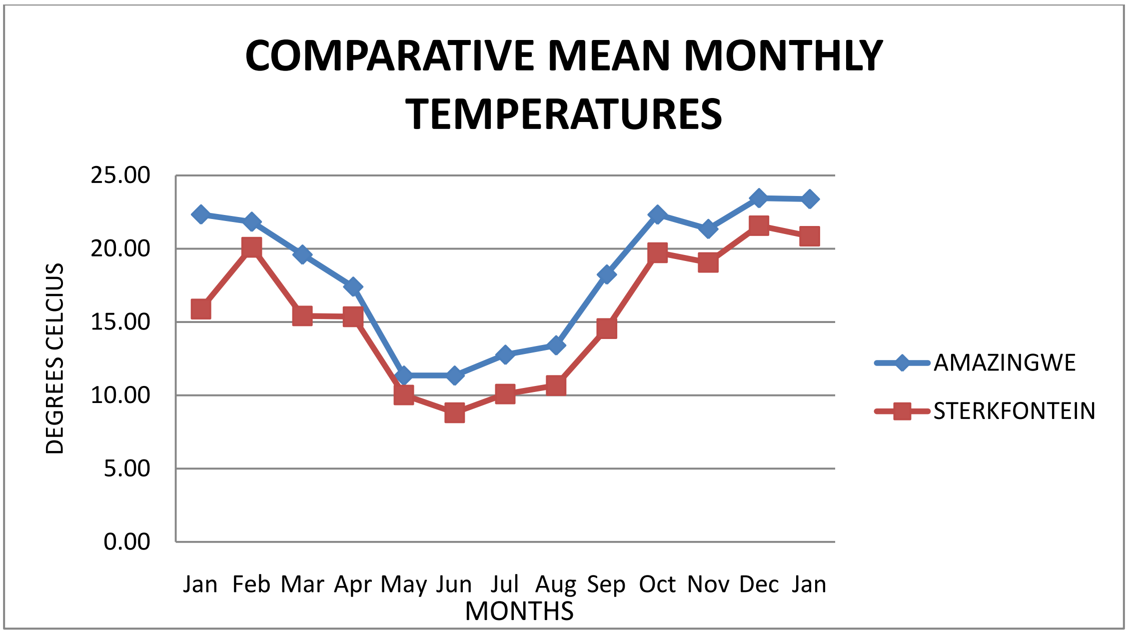


Figure 2.11: Comparative temperatures of Amazingwe and Sterkfontein.

Rainfall for the year during the field surveys (2004) amounted to 685.2mm in the north (Amazingwe), and 781.7mm in the south (Sterkfontein).

The highest rainfall figures at Amazingwe were experienced during the summer month of December (Figure 2.12).

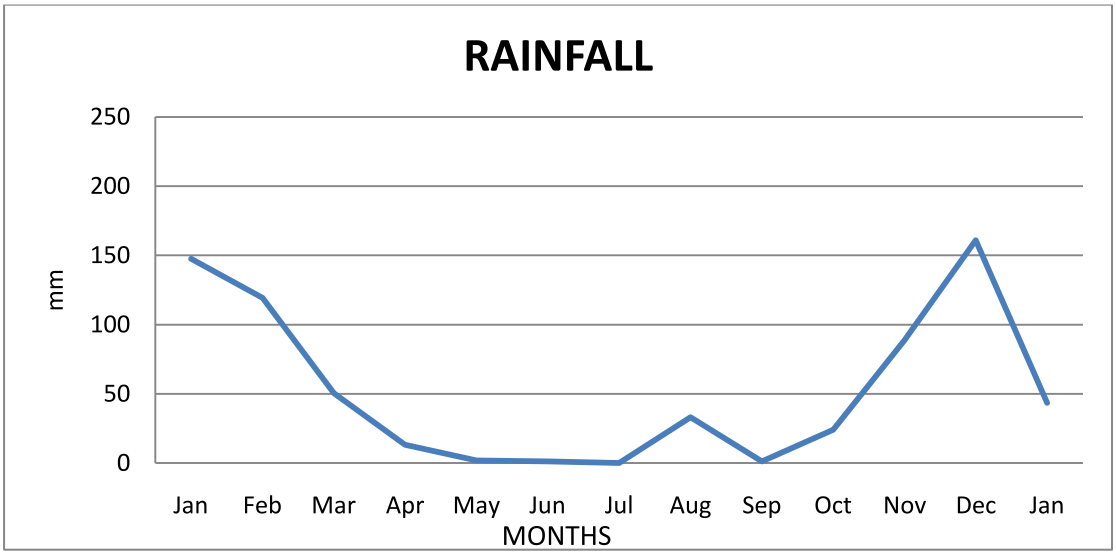


Figure 2.12: Monthly rainfall measured at Amazingwe Station.

The highest rainfall figures at Sterkfontein were experienced during the summer months of late February and early March (Figure 2.13).

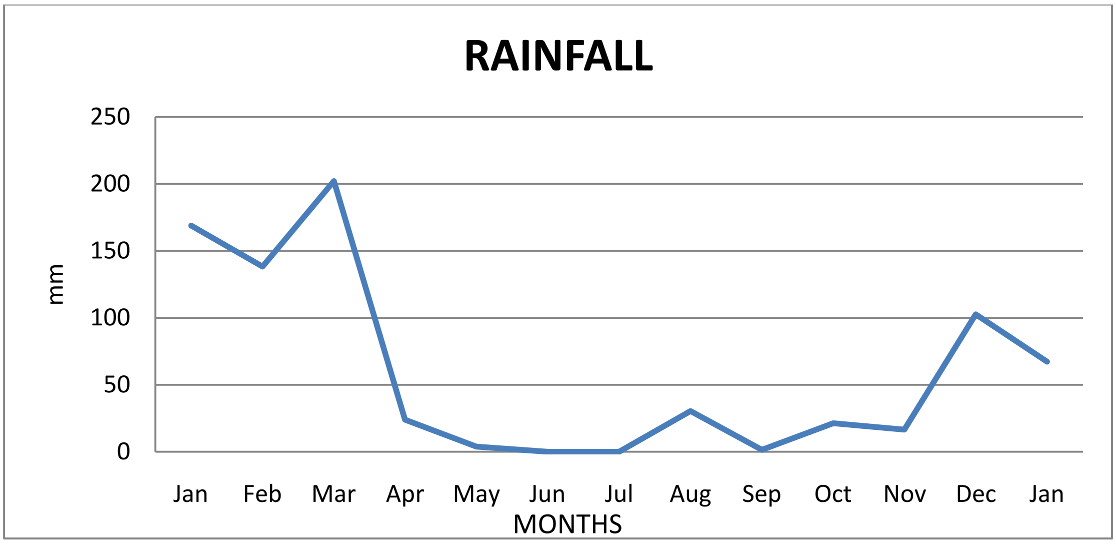


Figure 2.13: Monthly rainfall measured at Sterkfontein Station.

When the rainfall figures of both stations are compared to one another (Figure 2.14), it is noticeable that the patterns are fairly similar with summer rainfall patterns with the highest volumes measured between the months of November to March.

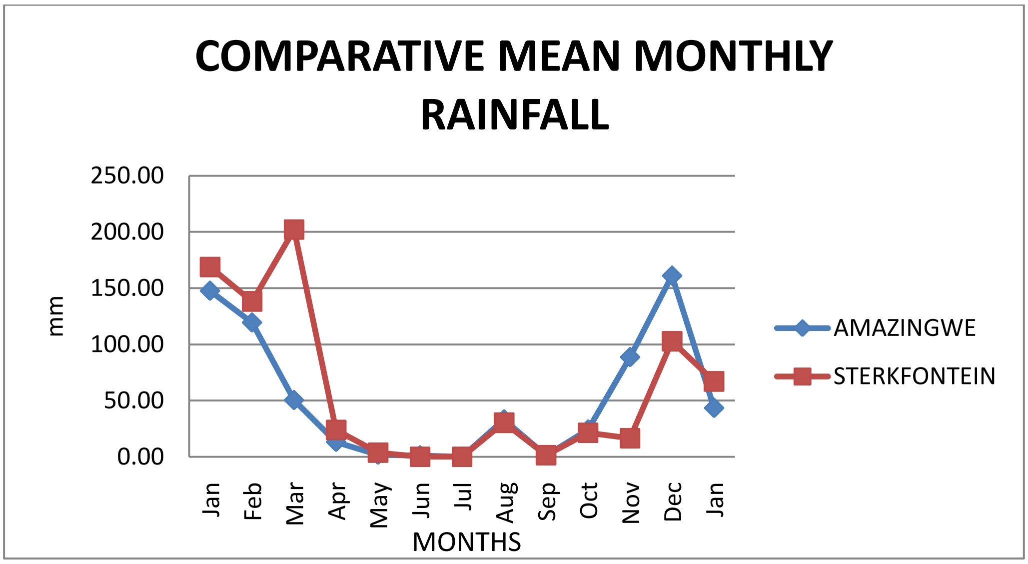


Figure 2.14: Comparative rainfall measured at Amazingwe and Sterkfontein.

The highest humidity at Amazingwe was recorded in February at 74.64% with the driest month being September when only 36.52% humidity was recorded. Sterkfontein's highest humidity of 80.06% was also recorded in February, with the driest month also being September where only 46.77% humidity was recorded (Figure 2.15).

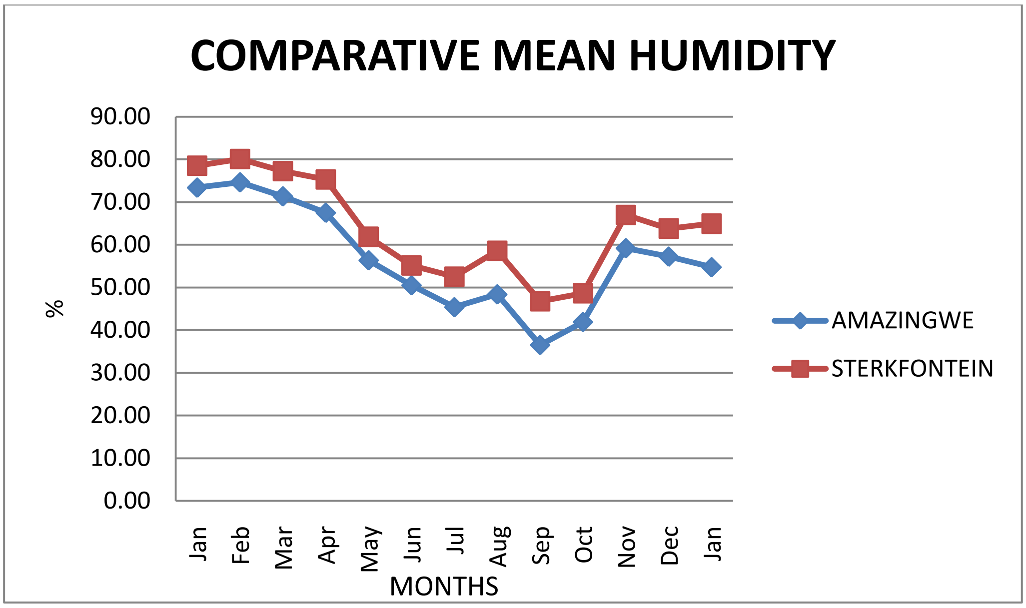


Figure 2.15: Comparative humidity recorded at Amazingwe and Sterkfontein.

The highest levels of solar radiation recorded fell within the months of June for Amazingwe, and December for Sterkfontein (Figure 2.16), however the anomalies of extremely high readings in June and low readings in May for Amazingwe are likely due to equipment faults. What is of more relevance is the trend of higher mean monthly readings being consistently recorded at the Amazingwe station.

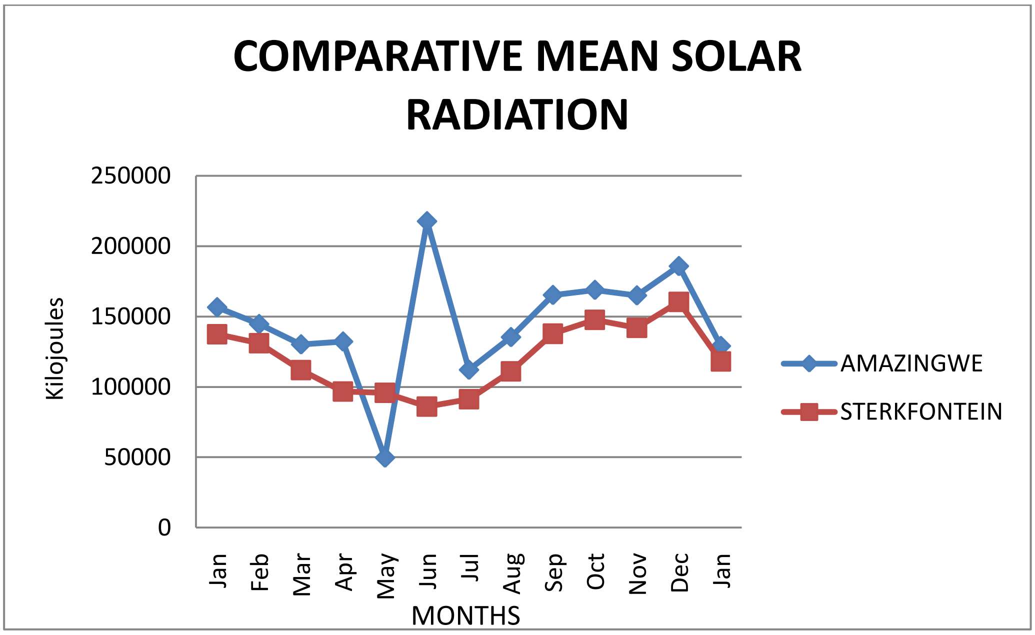


Figure 2.16: Comparative Solar Radiation recorded at Amazingwe and Sterkfontein.

Wind at the Amazingwe station was recorded as having its highest mean monthly speed in the month of November and the Sterkfontein station recorded its highest mean monthly wind speeds during the month of August. A Comparative summary (Figure 2.17) of monthly mean wind speeds indicate consistently higher wind speeds being recorded at the Sterkfontein station. At both stations, the highest average wind speeds were recorded in the month of August.

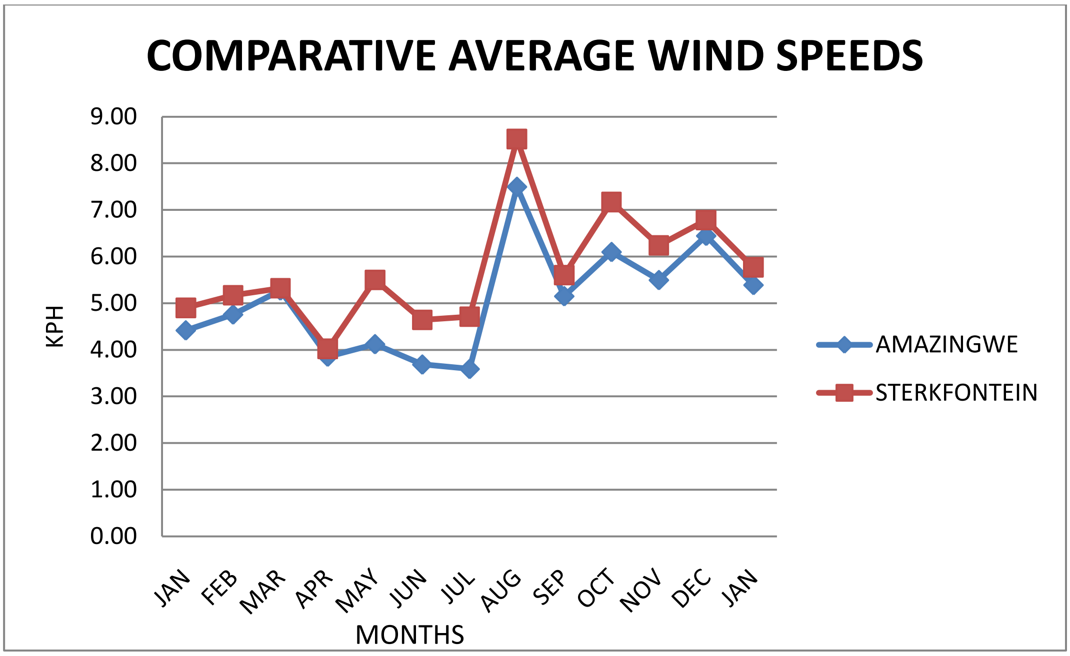


Figure 2.17: Comparative average wind speeds recorded at Amazingwe and Sterkfontein stations.

The majority of wind recorded at the Amazingwe station was found to be Northerly wind (Figure 2.18).

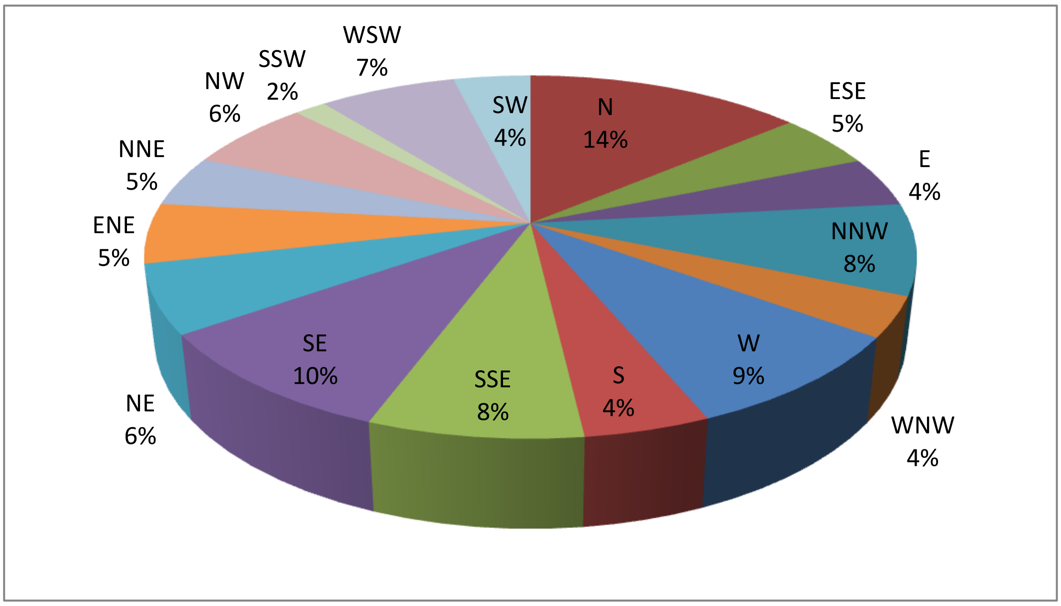


Figure 2.18: Percentage wind directions recorded at Amazingwe station.

Although the highest percentage depicted Northerly winds, South easterly, South south easterly, Westerly and North north westerly winds were also prominent.

The majority of wind recorded at the Sterkfontein station (Figure 2.19) was also found to be Northerly wind. Although, as with Amazingwe, the majority of wind was found to be Northerly wind, North easterly winds were also found to be prominent.

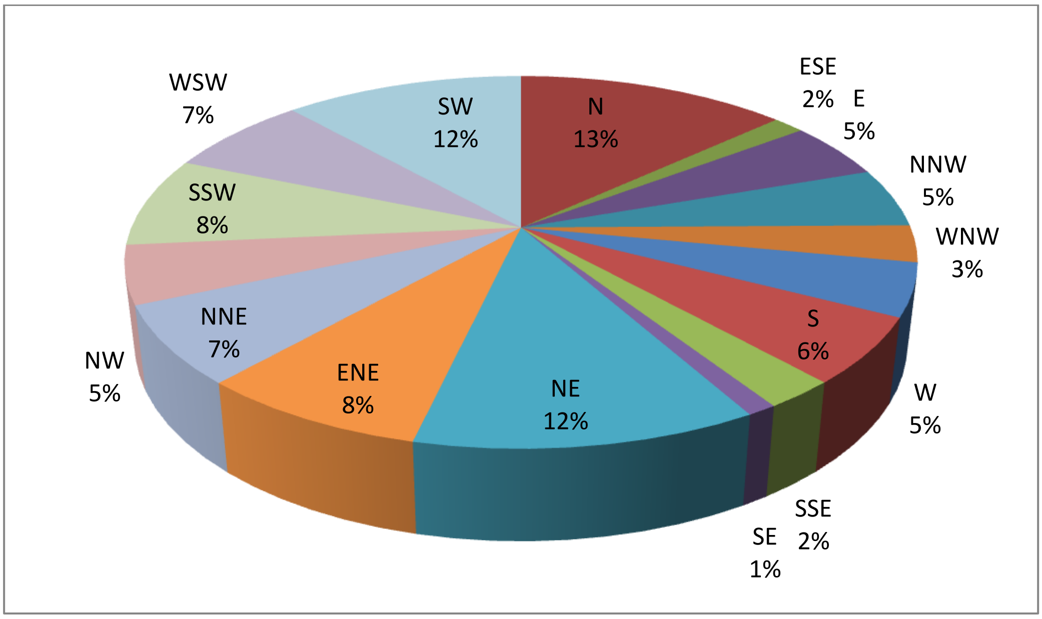
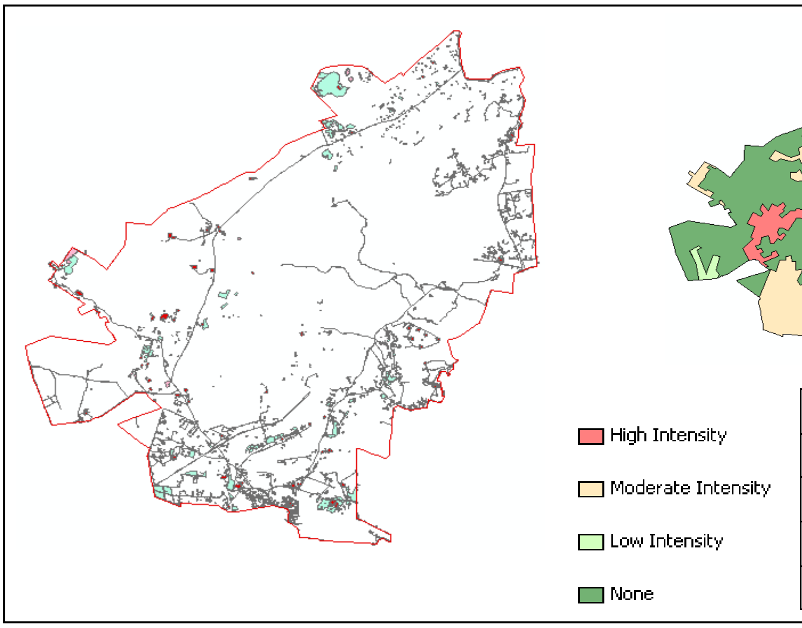


Figure 2.19: Percentage wind directions recorded at Sterkfontein station.

Prevailing wind conditions in the landscape during different seasons have a particular impact on the fire regime (Trollope *et al*. 2004) of the area, as well as seed dispersal (Cain *et al* 2000; Jongejans & Schippers 1999) and pollination (Honig *et al* 1992; Niklas 1987; Whitehead 1969) of certain of the plant species occurring there. The combustion rate of a fire is positively influenced by the rate of oxygen supplied to the fire (Brown & Davis 1973; Cheney 1981) hence the influence of wind speed on fire behaviour. With an increase in wind speed there is a greater rate of spread of fire and therefore an increase in intensity (Brown & Davis 1973; Luke & McArthur 1978). This is due primarily to wind causing the angle of flames to become more acute. With an increase in wind velocity, the flames are forced into the unburnt areas in the direction of the wind ahead of the fire front. This results in the efficient pre-heating of the fuel and a greater rate of spread in surface head fires (Luke & McArthur 1978; Cheney 1981). Fire in particular is known to effect plant species diversity and vegetation dynamics throughout the Biomes occurring in southern Africa (Bond *et al*. 2004), with fire characteristics such as wind-influenced intensity, direction and fire type (Head or Back Burning fire) effecting grass regrowth, re-seeding and bush damage on a localized scale and on a fire-by-fire basis. Wind is the most dynamic variable influencing fire behaviour (Trollope *et* al. 2004).

2.5. **Land Use**

The Land Use Audit commissioned by GDACE (Cradle of Humankind 2003) calculated the ecological and development footprints throughout the COH WHS using data from a high-resolution land-use classification spatial database refined from *QuickBird* satellite images. Low intensity development areas were not grouped into single polygons as part of this detailed mapping done at a scale of 1:5 000 and better. Areas in-between the individual buildings were therefore also mapped as ecological, and therefore regarded as undisturbed in terms of the audit's objectives. These areas are however highly fragmented in terms of natural habitats and species diversity and were regarded as continuous units of development areas, rather than single entities. Figure 2.20 shows the level of fragmentation for the entire COH WHS as identified in the Land-use audit (2003).

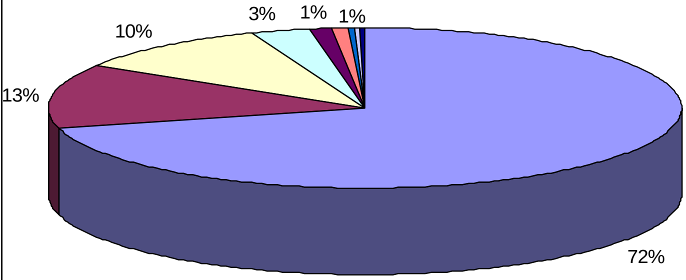


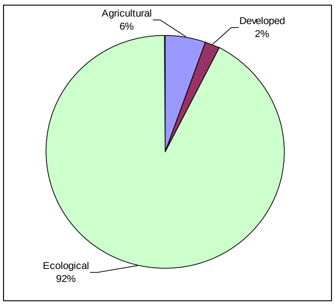
Class	Hectares	%
1	2496.50	4.72
2	11765.39	22.21
3	2856.79	5.39
4	35851.45	67.68

Figure 2.20: Summary of Habitat Fragmentation and remaining areas of Ecological integrity, after Cradle of Humankind (2003).

The overall undisturbed ecological habitat area for the COH was calculated as 67.68% or a little over two thirds. The Land use Audit staff calculated the ecological footprint for the COH WHS using information from the spatial database. Formal agriculture (cultivated, irrigated, planted grasslands and plantation forestry) and areas developed were excluded from their calculations. The percentages of each of these groupings were however indicated (refer to small pie-chart in Figure 2.21). The ecological footprint is based on the exact footprint of the area, ignoring habitat fragmentation. Natural areas in-between areas already developed, especially smallholdings and any other form of informal settlements, were therefore included as part of their calculations.

Figure 2.21 indicates the percentage areas grouped according to Agriculture, Developed and Ecological (small pie-chart), as well as the percentage and area in hectares grouping of the ecology-related land-uses for the COH WHS study area.





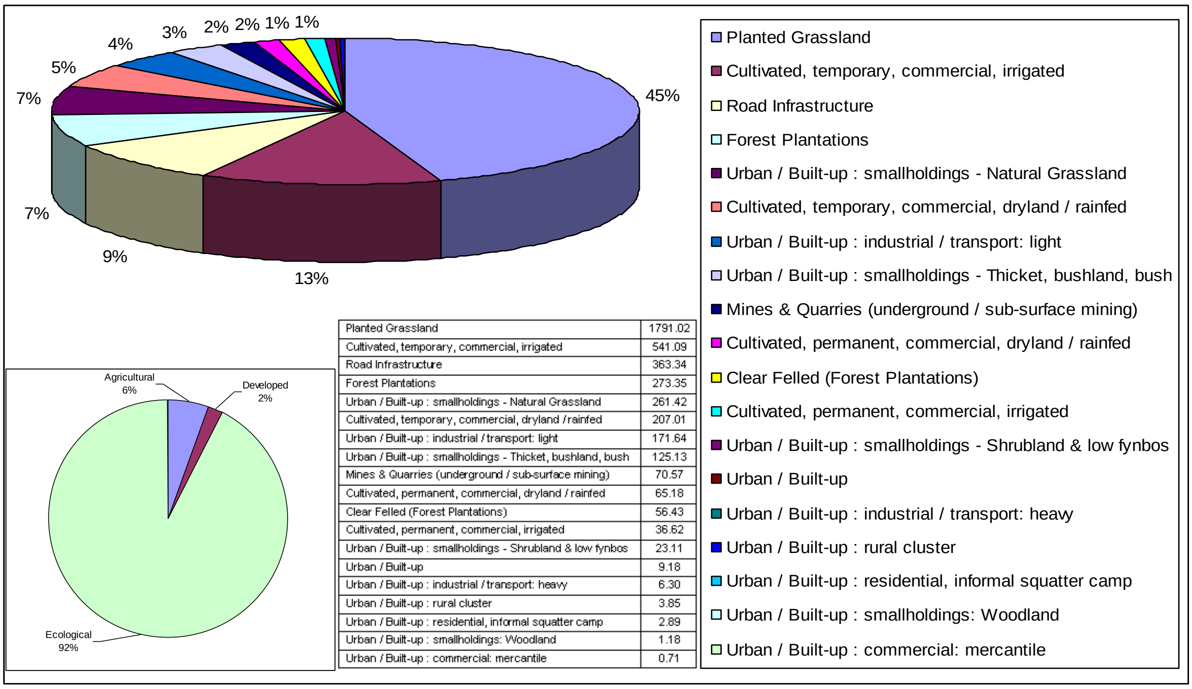
Natural Grassland	32016.56
Bushland, Bush Clumps	8660.27
Shrubland & Low Fynbos	4873.45
Thicket	1493.58
Degraded Natural Grassland	742.39
Bare Rock & Soil (natural surfaces)	585.41
Wetlands	273.21
Degraded Thicket, Bushland, Bush Clumps & High Fynbos	152.46
Dams	105.78
Bare Rock & Soil (soil erosion surfaces : sheet)	19.21
Bare Rock & Soil (soil erosion surfaces : dongas / gullies)	11.23
Forest (indigenous)	2.60
Rivers	0.36

Figure 2.21: The ecological footprint for the COH WHS as calculated from the *QuickBird* land-use classification results, after Cradle of Humankind (2003).

Using the same approach, the development footprints for the COH WHS were calculated. The figures are based on the exact areas occupied by individual structures and habitat fragmentation was not taken into account. Various formal structures are often associated with agricultural activities. These structures are, however often not visible on a 1:10 000 mapping scale.

Agriculture (excluding grazing) was therefore regarded as ‘developed’ and included as part of the calculations.

Figure 2.22 shows the development footprint summary for the area developed (2%) areas as calculated from the land-use classification results.



Planted Grassland	1791.02
Cultivated, temporary, commercial, irrigated	541.09
Road Infrastructure	363.34
Forest Plantations	273.35
Urban / Built-up : smallholdings - Natural Grassland	261.42
Cultivated, temporary, commercial, dryland / rainfed	207.01
Urban / Built-up : industrial / transport: light	171.64
Urban / Built-up : smallholdings - Thicket, bushland, bush	125.13
Mines & Quarries (underground / sub-surface mining)	70.57
Cultivated, permanent, commercial, dryland / rainfed	65.18
Clear Felled (Forest Plantations)	56.43
Cultivated, permanent, commercial, irrigated	36.62
Urban / Built-up : smallholdings - Shrubland & low fynbos	23.11
Urban / Built-up	9.18
Urban / Built-up : industrial / transport: heavy	6.30
Urban / Built-up : rural cluster	3.85
Urban / Built-up : residential, informal squatter camp	2.89
Urban / Built-up : smallholdings: Woodland	1.18
Urban / Built-up : commercial: mercantile	0.71

Figure 2.22: The development footprint for the COH WHS as calculated from the *QuickBird* land-use classification results, after Cradle of Humankind (2003).

As can be seen through this remote sensing exercise the majority of land surface area within the COH WHS is not heavily impacted on and therefore has the potential to fulfill a vital ecological role. Although 92% of land is indicated as largely ecological (Figure 2.22), this figure also entailed the inclusion of areas in between developed and impacted sites with known ecologically hindering factors such as “Edge Effects” not being factored into the calculations.

The figure of 67% as quoted in the habitat fragmentation portion, although generous, is perhaps a little more representative when compared with ground truthed observations.

These perceived natural areas are comprised mainly of natural grasslands and bush clumps with lowland shrublands, dense thick bush, surface rock and wetlands featuring prominently. The remaining 8 % of land was classed as those areas utilized for agricultural practices with only 2% of that being actively developed through activities such as the planting of pastures, infrastructure and road construction etc. (Figure 2.22). The areas most fragmented appear near the perimeter of the COH WHS especially in the

South and East of the study site. The core area of the COH WHS as can be seen is still largely intact. This particular piece of Bankenveld is therefore extremely valuable especially when considering the undisturbed nature of the majority of the COH WHS and the fairly low impact associated development taking place within its borders. This is of particular importance when looking at the level of transformation being experienced in this veld type in the rest of the country (Bredenkamp & Van Rooyen, 1996). A detailed phytosociological inventory of the remaining areas of ecological integrity within the COH WHS can therefore aid in the mitigation against any further negative development.

2.6. **References**

ACOCKS, J.P.H. 1988. Veld Types of South Africa. 3rd edn. Mem. Bot. Surv. S. Afr.57:1-146, Government Printer, Pretoria.

BEHR, C.M. & BREDENKAMP, G.J. 1988. A phytosociological classification of the Witwatersrand National Botanical Garden. *South African Journal of Botany* 54: 525-533.

BEZUIDENHOUT, H. 1993. Syntaxonomy and synecology of western Transvaal grasslands. Ph.D. Thesis. University of Pretoria. Pretoria.

BEZUIDENHOUT, H; BREDENKAMP, G.J. & ELSENBROEK, J.H. 1988. Die plantegroei van die alkaligraniet en aangrensende kwartsiet in die Vredefortkoepel, noordwes van Parys. *S. Afr. Tydskr. Natuurwet. & Tegnol.* 7: 4-9.

BOND, W.S; GELDENHUYS, C.J; EVERSON, T.M; EVERSON, C.S. & CALVIN, M.F. 2004. Fire Ecology: Characteristics of some important Biomes of Sub-Sahara Africa. 6-27p. In: Wildland Fire Management Handbook for Sub-Sahara Africa. (GOLDAMMER, J.G. & de RONDE, C. eds.). Global Fire Monitoring Centre (GFMC), 2004. 432 p.

BREDENKAMP, G.J. & THERON, G.K. 1978. A Synecological account of the Suikerbosrand Nature Reserve I. The Phytosociology of the Witwatersrand geological system. *Bothalia* 12: 513-329.

BREDENKAMP, G.J. & VAN ROOYEN, N. 1996. Rocky Highveld Grassland. Pp. 39. In: LOW, A.B. and REBELO, A.G. (eds). *Vegetation of South Africa, Lesotho and Swaziland.* Pretoria: Department of Environment and Tourism.

BROWN, A.A. & DAVIS, K.P. 1973. Forest fire control and use. McGraw Hill, New York. 686 p.

BUTTON, A. 1973. The stratigraphic history of the Malmani Dolomite in the eastern and northeastern Transvaal. *Trans. Geol. Soc. South Africa* **76**, 229-247.

CAIN, M.L; MILLIGAN, B.G; & STRAND, A.E. 2000. Long-distance seed dispersal in plant populations. *American Journal of Botany* 87: 1217-1227.

CHENEY, N.P. 1981. Fire Behaviour. In: Fire and the Australian Biota. (GILL,A.M.; GROVES, R.H. & NOLLE, I.R. eds.) 151-175 p. *Australian Acad. Sci.* Canberra. 582 p.

CRADLE OF HUMANKIND MGMT AUTHORITY. 2003. Land Use Audit report. Gauteng Dept. Agriculture, Conservation and Environment, Johannesburg.

ERIKKSON, K.A. & TRUSWELL, J.F. 1974. Stratotypes from the Malmani Subgroup north-west of Johannesburg, South Africa. *Trans. Geol. Soc. South Africa* **77**, 211-222.

GEOLOGICAL SERIES. 1986. 2626 West Rand. Prepared by the Department of Mineral and Energy Affairs, Pretoria. 1:250 000. Government Printer, Pretoria.

HONIG, M.A; LINDER, H.P. & BOND, W.J. 1992. Efficacy of wind pollination: Pollen load size and natural Microgametophyte populations in wind-pollinated Staberoha banksii (Restionaceae). *American Journal of Botany* 79(4): 443-448.

JAMISON, A.A; VAN NIEKERK, E. & VILJOEN, M.J. 2005. Bedding-parallel shear & sinistral wrench faulting influencing location and formation of caves in the Cradle of Humankind, Gauteng, South Africa. *Unpubl. IUCN Karst Working Group Document.*

JONGEJANS, E. & SCHIPPERS, P. 1999. Modelling seed dispersal by wind in herbaceous species. *Oikos* 87(2): 362-372.

LAND TYPE SURVEY STAFF. 1984. Land Types of the maps 2626 West Rand and 2726 Kroonstad. *Mem. Agric. Nat. resour. S. Afr.* 4:1-441.

LUKE, R.H. & McARTHUR, A.G. 1978. Bushfires in Australia. *Australian Gov. Publ. Serv.* Canberra. 359 p.

MUNCINA, L. & RUTHERFORD, M.C. (eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia* 19. South African National Biodiversity Institute, Pretoria.

NIKLAS, K.J. 1987. Pollen capture and wind induced movement of compact and diffuse grass panicles: Implications for pollen efficiency. *American Journal of Botany*. 74(1): 74-89.

PARTRIDGE, T.C. & MAUD, R.R. 1987. Geomorphic evolution of southern Africa since the Mesozoic. *South African Journal of Geology* 90: 179-208.

PFAB, M.F. 2001. Departmental Policy: development guidelines for ridges. A report prepared for the Department of Agriculture, Conservation, Environment and Land Affairs in the Directorate of Nature Conservation.

STRAHLER, A.N. 1975. Physical Geography. 4th edn. John Wiley and Sons, New York.

TROLLOPE, S.W; de RONDE, C. & GELDENHUYS, C.J. 2004. Fire Behaviour. 27-59p. In: Wildland Fire Management Handbook for Sub-Sahara Africa. (GOLDAMMER, J.G. & de RONDE, C. eds.). Global Fire Monitoring Centre (GFMC), 2004. 432 p.

WHITEHEAD, D.R. 1969. Wind pollination in angiosperms: Evolutionary and Environmental considerations. *Evolution* 23 (1): 28-35.

WILKINSON, M.J. 1973. Sterkfontein Cave System: evolution of a karst form. Unpublished M.A. thesis, University of the Witwatersrand, Johannesburg.

CHAPTER 3

METHODS AND MATERIALS

3.1. **Approach**

The collection of data should never be isolated from the aims and objectives and methods of analysis (Jongman *et al.*1987). With this as a guiding principal, the following considerations as prescribed by Kent & Coker (1992) were made, namely, the purpose of the survey; the scale of the study; the overall habitat type; and the resources available. Werger (1973) added that there are three essential requirements that any vegetation ecology study should meet. The Zurich-Montpellier method (Braun-Blanquet 1932) as used for this study satisfies all three, namely, (i) it is scientifically sound, (ii) it fulfills the necessity of the classification at an appropriate scale and (iii) it is the most efficient and versatile amongst comparable approaches.

3.2. **Distribution, number and size of sample plots**

A stratified random approach to sample site placement was used (Bredenkamp 1982; Bezuidenhout 1993; Brown & Bredenkamp 1994). Land types were used as the primary unit of stratification (Bezuidenhout 1993), with terrain types being used to further refine the stratification. Land types (Land Type Survey Staff 1984) were digitized into ArcGis (Geographic Information System) shape files and a secondary layer depicting slope classes was created and over-laid.

Slope was calculated as the percentage of the ratio of vertical change to horizontal change and was calculated with the aid of contours and intervals, and thereafter they were converted to degrees (Table 3.1). These were subsequently verified in the field with the aid of a clinometer.

Table 3.1: The four slope classes used for the purposes of this study.

Classes	**Flat (f)**	**Gentle (g)**	**Moderate (m)**	**Steep (s)**
Slope (deg.)	0-2	2-5	5-7	7-90

Optimal plot sizes suggested by Bezuidenhout & Bredenkamp (1990) were deemed to be 16 m^2 for grassland vegetation and 100 m^2 for woodland vegetation. For this study a total of 91 sample plots of 100m^2 were placed throughout the study area. Square plots were selected as they would also meet the sampling objectives outlined in Kent & Coker (1992).

The total number of plots selected is dependent on many factors, however the end result must be an adequate representation of the vegetation concerned (Bredenkamp 1982).The number of plots per slope class within each Land Type was allocated on a pro-rata basis (Bezuidenhout 1993: Coetzee 1974). The exact positioning of each plot was positioned subjectively but in such a way that it was an accurate representation of the surrounding vegetation (Werger 1973). As the exact boundaries of each Land type and slope class within each Land type are difficult to ascertain in the field, a GIS based approach was employed (Figure 3.1). The latitudinal and longitudinal co-ordinates for the centroid of each selected slope class per land type polygon, as well as the distance measurement to the nearest boundary concerned was measured from the selected shape file/s. This provided the means to directly travel to the middle of each selected unit of stratification in the field, using a GPS, and thereafter know the radial distance within which to place the representative plot (should one be found) whilst still being certain that the desired Land type was being sampled. Samples falling within the steep slope class were specifically placed to provide adequate representation of all major aspects, namely, North, South, East and West to account for expected topographic vegetative variation (Bridge & Johnson 2000; Dirnbock *et al.* 2002).

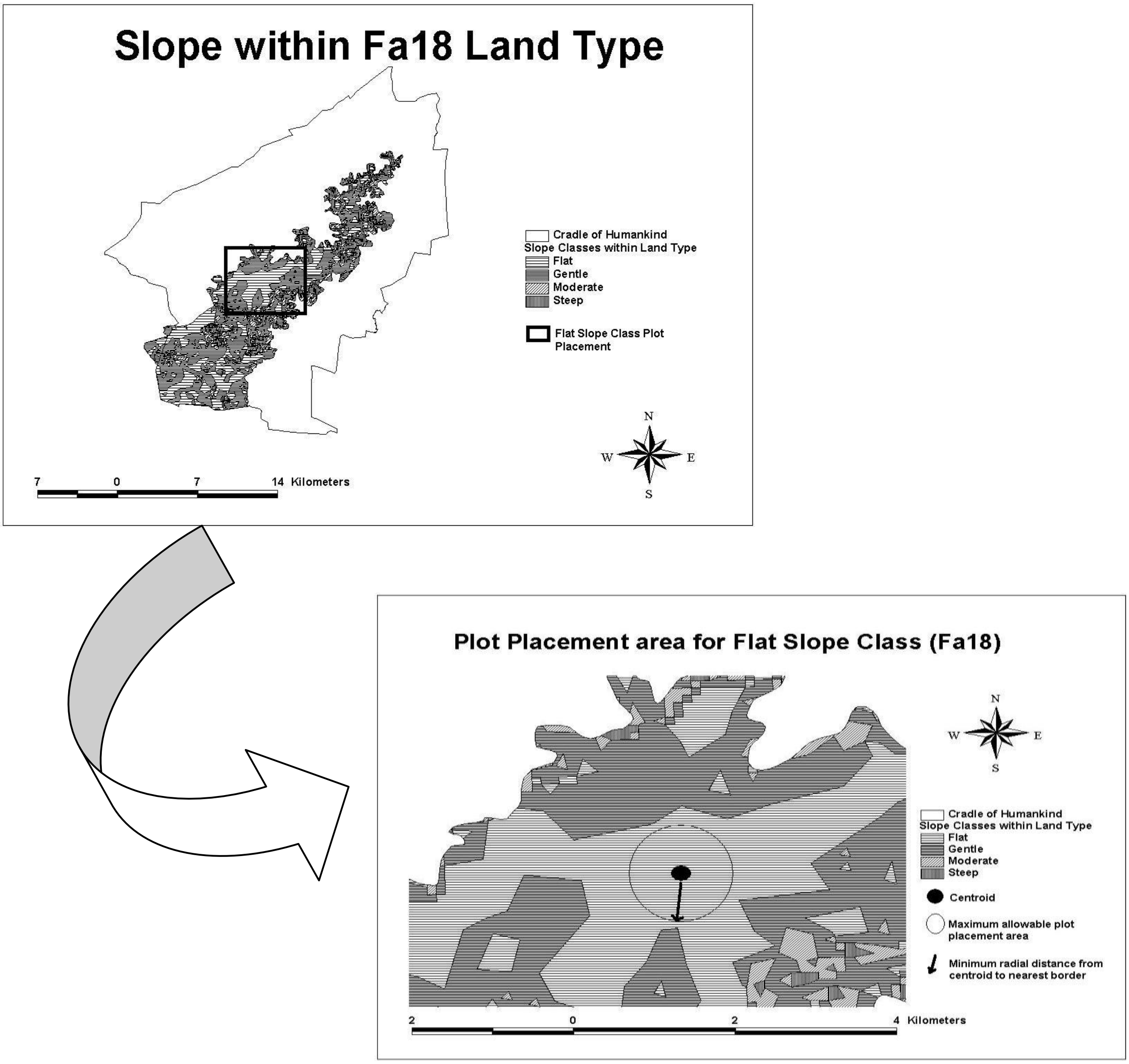


Figure 3.1: Diagrammatic representation of GIS based sample plot location selection.

3.3. **Sampling Methodology**

3.3.1. General Sampling

Both floristic and physiognomic characteristics were recorded for purposes of this study. The structural physiognomy of each species encountered was grouped into broad classes based on height and growth form, namely tree (woody plants taller than 2m), shrub (woody plants from 0 to 2m), grass or forb (herbaceous non grass species).

Habitat factors such as terrain types (landform), aspect, slope, surface rock % and estimated soil clay percentage were also determined at each site. Landform (Table 3.2) was based on the terrain morphology units as in Land Type Survey Staff (1984).

Table 3.2: Landforms according to Land Type Survey Staff (1984)

Classes:	**1**	**2**	**3**	**4**	**5**
Landform:	Crest	Scarp	Midslope	Footslope	Valley

Soil texture was estimated (Table 3.3) whereby a small amount of soil was obtained from the A-horizon and wetted. This was then rolled in the palm and the ability to form a "sausage" and bend without breaking was used to estimate the approximate clay percentage of the sample (Foth *et al*. 1978).

Table 3.3: Soil clay percentage estimation scale.

Class	**1-Sand**	**2-Loamy sand**	**3-Sandy loam**	**4- Sandy clay loam**	**5-Sandy clay**	**6- Clay**
Clay %	0-6	6-10	10-20	20-35	35-55	>55

An estimation of the rockiness on the soil surface was estimated and expressed as a percentage rocks and/or stones covering the total sample plot.

Floristic data collection entailed the placement of the 10m x 10m sample plots in the desired representative location and the identification according to standards implied in Gibbs Russell *et al.* (1985) of all plant species rooted within the plot (Bredenkamp 1982).

Where possible, species were identified and recorded on site, but where immediate identification was not possible, specimens were collected for later identification with keys (Bromilow 2001, Van Wyk & Malan 1998; Van Oudtshoorn 1999).

Taxon names conform to Germishuizen & Meyer (2003). Each plant species recorded was assigned a cover-abundance value (Mueller-Dombois & Ellenberg 1974, Werger 1974) according to the Braun-Blanquet scale (Table 3.4). At each plot, additional factors e.g. land use and or practices occurring on the land in which the sample plot was placed was also noted.

Table 3.4: Braun-Blanquet cover abundance symbols and corresponding values (Mueller-Dombois & Ellenberg 1974)

Classes	Description
r	One or few individuals (very rare) with less than 1% cover of total plot.
+	Occasional occurrence and less than 1% coverage of total plot.
1	Abundant but with very low cover, or less abundant with higher cover. 1-5% coverage of total plot.
2a	5% to 12.5% coverage irrespective of total number of individuals.
2b	12.5%to 25% coverage irrespective of total number of individuals.
3	25%to 50% coverage irrespective of total number of individuals.
4	50% to 75% coverage irrespective of total number of individuals.
5	75% to 100% cover irrespective of the total number of individuals.

3.3.2 **Cave Entrance Vegetation Sampling**

Cave entrances surveyed were selected from a database of known cave localities administered by the G.D.A.R.D. Caves known to have experienced minimal impact and disturbance in, on and around them, and of varying entrance size diameters were selected. Caves of each entrance size group were, where possible, selected to represent various aspects. Due to the naturally occurring geological dip of 30 degrees Northwest in the cave forming dolomites (Wilkinson 1973), dissolution that causes the formation of caves predominately occurs on the Southerly and Northerly facing slopes due to this dip and the resultant gravitationally aided flow of water. Caves on all other aspects are largely under represented as a result.

A total of nine caves were ultimately selected (Figure 3.2), comprising of three South facing, two West Southwest facing, one Southeast facing, two flat areas and one North Northeast facing entrances. Cave entrance specific data collection was facilitated as in those plots through the rest of the study area, by placing out 10m X 10m plots, over or as close to the entrance of each cave entrance surveyed. The sampling methodology as used for all other non-cave sites above (Section 3.3.1) was repeated.

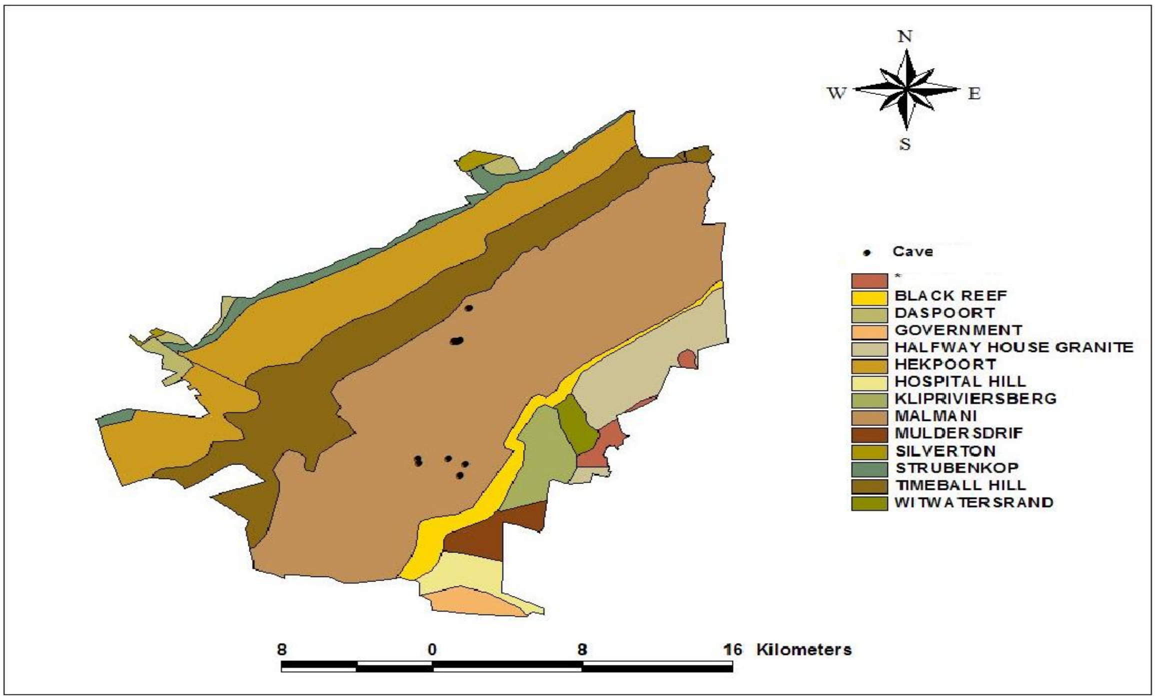


Figure 3.2: Location of caves selected for sampling, showing location within the Malmani Dolomites.

In addition to this however, four belt transects measuring 25m in length and 2m in width were also set out per cave to gather data on the woody species encountered as these would form the basis of measuring the effect of caves on the surrounding vegetation. They were placed over the cave entrance in the form of a cross with the centre point being the cave entrance. The “legs” of these transects extended up slope, down slope and contoured to the left and right.

A Tape measure was set out from the edge of the cave entrance so that the distance from the entrance to the tree or shrub encountered along this transect could be recorded. The species, height and canopy cover were recorded. Structural terminology is according to Edwards (1983). The woody stratum was divided into two height classes namely the lower height class (0-2m) and the upper height class (>2m).

Data on the radial variation of the herbaceous component from the cave entrances outwards was collected through a modified version of the Step Point method described by Mentis (1981). A rope with knots tied at 1m intervals was extended through the middle of the belt transects sampled during the application of the Belt transect method. Using these knots as reference points, “hits” and “misses” were recorded and the species under, or closest to the knot (If no direct hit) was recorded. This data could as part of a later refinement or further study be used to supplement the data on the woody species used for this study.A combined data sheet was drawn up for both the latter methods. Columns for species, height, diameter and distance from the cave entrance were used for the woody component in the belt transect method and species, distance from cave entrance and hits or misses were used for the herbaceous component.

The diameter of the cave entrance was measured by extending a tape measure across the widest part of the entrance. The sizes of the cave entrances varied between less than 1m and 10m.

3.4. **Data analysis**

All vegetative data was captured in the Turboveg database that placed the plant species data in a matrix of columns for each plot and rows for each of the plant species (Hennekens & Schaminee 2001). This system, developed originally in the Netherlands, was accepted as the standard computer package for the European Vegetation Survey in 1994 and as such is well tested and deemed suitable for purposes of this study.

The data was then exported into the JUICE program (Lubomír 2002), a multifunctional editor of phytosociological tables from where the objective statistical classification technique, two-way indicator species analysis, TWINSPAN (Hill 1979), was used to derive a first approximation of the floristic data. The results obtained through the TWINSPAN analysis were further refined through the application of Braun-Blanquet procedures. This meant that plant species found only in particular relevés were grouped together and the plant species with a wide distribution across many relevés were placed in a group towards the lower end of the table. These groupings formed the basis of the description of the plant communities identified in this study. A separation of the table between those vegetation communities shown to have a distinct affinity to typical grassland and those to woodlands was then undertaken with the cave specific sites also later separated to facilitate adequate plant community descriptions. Using the resulting phytosociological tables and the habitat information gathered during the sampling procedure, the different plant communities were identified and described (Brown & Bezuidenhout 2005). In calculating the effect of Cave Entrance size on the surrounding vegetation, a basic correlation analysis was used. This entailed determining whether there was indeed a correlation between the cave entrance size and the distance from each cave that woody plants were measured. To do this, the mean of the extent of woody vegetation from each cave entrance was calculated taking into account the upslope, downslope, left and right contours. This mean extent for each cave was graphically plotted against cave entrance sizes.

The correlation between cave entrance size and this mean extent of woody vegetation was calculated thereafter using the following equation to statistically determine the strength of any possible correlation whereby any positive answer would indicate a positive correlation and any negative answer would indicate a negative correlation:

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{n(\sum x^2) - (\sum x)^2}\ \sqrt{n(\sum y^2) - (\sum y)^2}}$$

The strength of the correlation would be indicated through the proximity of the answer to the numbers -1 (Strong Negative Correlation) or 1 (Strong Positive Correlation).

The measured distances from each cave entrance to each identified woody plant species encountered along each transect were then used to construct a profile diagram per cave to visually illustrate this relationship.

3.5. **References**

BEZUIDENHOUT, H. 1993. Syntaxonomy and synecology of the western Transvaal grasslands, South Africa. Ph.D. thesis. University of Pretoria, Pretoria.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1990. A recognaissance survey of the dolomitic region in the Potchefstroom-Ventersdorp-Randfontein area, South Africa. *Phytocoenologia* 18: 387-403.

BRAUN-BLANQUET, J. 1932. Plant sociology. Transl. by Fuller, G.D. and Conard, H.S. McGraw-Hill, New York.

BRIDGE, S.R.J. & JOHNSON, E.A. 2000. Geomorphic principles of terrain organization and vegetation gradients. *Journal of Vegetation Science* 11:1. 57-70.

BROMILOW, C. 2001. Problem plants of South Africa. Second edition. Briza Publishers, Pretoria.

BREDENKAMP, G.J. 1982. ‘n Plantekologiese studie van die Manyeleti-wildtuin. D.Sc. thesis. University of Pretoria, Pretoria.

BROWN, L.R. & BEZUIDENHOUT, H. 2005. A vegetation description and classification of the farms Ingleside and Welgedacht on the Mountain Zebra National Park, Eastern Cape. *Koedoe* 48(2): 23-42.

BROWN, L.R. & BREDENKAMP, G.J. 1994. The phytosociology of the southern section of the Borakolalo Nature Reserve, South Africa. *Koedoe* 37: 59-72.

COETZEE, B.J. 1974. A Phytosociological classification of the vegetation of the Jack Scott Nature Reserve. *Bothalia* 11: 329-347.

DIRNBOCK, T; HOBBS, R.J; LAMBECK, R.J. & CACETTA, P.A. 2002. Vegetation distribution in relation to topographically driven processes in southwestern Australia. *Applied vegetation Science.* 5:1. 147-158.

EDWARDS, D. 1983. A broad-scale structural classification of vegetation for practical purposes. *Bothalia* 14: 705-712.

FOTH, H.D; WITHEE, L.V., JACOBS, H.S. & THIEN, S.J. 1978. Laboratory manual for introductory: Soil Science. 4th edn. WM,C Brown Company Publishers, Dubuque, Iowa.

GERMISHUIZEN, G. & MEYER, N.L. (eds). 2003. Plants of southern Africa: an annotated checklist. Strelitzia 14. National Botanical Institute, Pretoria.

GIBBS-RUSSELL, G.E; WELMAN, W.G., REID, C; VAN ROOY, J. & SMOOK, L. 1985. List of species of southern African plants. 2nd edn. Part 1. *Mem. Bot. Surv. S. Afr.* 51: 1-152.

HENNEKENS, S. M. & SCHAMINEE, J. H. J. 2001. TURBOVEG, a comprehensive data base management system for vegetation data. *Journ. Veg. Science.* 12: 589-591.

HILL, M. O. 1979. TWINSPAN- A fortran program for arranging multivariate data in an ordered two-way table classification of individuals and attributes. Cornell University, New York.

JONGMAN, R.H.G; ter BRAAK, C.J.G. & van TONGEREN, O.F.R. 1987. *Data analysis in community and landscape ecology*. Pudoc, Wageningen.

KENT, M & COKER, P. 1992. *Vegetation description and Analysis – a practical approach*. John Wiley and Sons. Chinchister, England.

LUBOMÍR, T. 2002. JUICE, software for vegetation classification. *Journal of Vegetation Science* 13: 451-453.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation ecology. Wiley, New York.

VAN OUTSHOORN, F. 1999. Guide to the grasses of Southern Africa. Briza Publishers, Pretoria.

VAN WYK, A.E., & MALAN, S.J. 1998. Field guide to the wildflowers of the Highveld. 2nd edn. Struik Publishers, Cape Town.

WERGER, M.J.A. 1973. Phytosociology of the upper Orange River Valley, South Africa. Ph.D. dissertation, University of Nijmegen, Nijmegen.

WERGER, M. J. A. 1974. The concepts and techniques applied in the Zurich-Montpellier method of vegetation survey. *Bothalia* 11 (3): 309-323.

WILKINSON, M.J. 1973. Sterkfontein Cave System: evolution of a karst form. Unpublished M.A. thesis, University of the Witwatersrand, Johannesburg.

CHAPTER 4

RESULTS AND DISCUSSION- GRASSLANDS

4.1. **Introduction**

An analysis of high resolution *Quickbird* satellite images as part of a Land-use audit (Cradle of Humankind 2003) suggested that 72% of the open areas of the COH WHS, or some 31000 hectares is comprised of natural grassland. Whilst this provides at least a basic idea of the vegetative composition of the landscape it does not provide detail as to the ecological integrity, successional stage or physical state of the plant communities located therein. Landscape heterogeneity and climatic variation within the study area have caused a number of habitats to occur within the COH WHS, with twelve grassland plant communities with two variants being recognized as a result.

The grasses *Brachiaria serrata, Themeda triandra, Setaria sphacelata, Schizachyrium sanguineum* and *Trachypogon spicatus* (Species Group Y, Table 4.1) feature prominently throughout the grassland portion of the study site together with the herbs *Chaetacanthus costatus* and *Bewsia biflora* albeit not quite as prominently.

The data analysis and subsequent rearrangement of species in the resultant grasslands table (Table 4.1) produced the following hierarchically arranged plant communities diagnosed according to the various Species Groups:

1. *Loudetia simplex–Diheteropogon amplectens* Grassland.
    - 1.1 *Pittosporum viridiflorum–Englerophytum magalismontanum* Bush Clumps.
    - 1.2 *Monocymbium ceresiiforme–Schizachyrium sanguineum* Grassland.
    - 1.3 *Protea caffra–Themeda triandra* Woodland.
    - 1.4 *Setaria sphacelata–Pentanisia angustifolia* Grassland.
2. *Eustachys paspaloides–Sporobolus pectinatus* Grassland.
3. *Hyparrhenia hirta–Vernonia oligocephala* Grassland.
    - 3.1 *Hyparrhenia hirta–Ziziphus zeyheriana* Grassland.

3.1.1 *Hypoxis hemerocallidea* Variant.

3.1.2 *Acacia caffra* Variant.

3.2 *Hyparrhenia hirta–Digitaria eriantha* Grassland.

3.3 *Hyparrhenia hirta–Elephantorrhiza elephantina* Grassland.

3.4 *Hyparrhenia hirta–Cyperus rupestris* Grassland.

3.5 *Hyparrhenia hirta–Trachyandra asperata* Grassland.

4.2. **Description of the Plant Communities**

In the descriptions of the different plant communities, all species groups refer to those defined in table 4.1.

1. *Loudetia simplex–Diheteropogon amplectens* Grassland.

This Major Grassland community is fairly widespread across the central, eastern and southeastern regions of the study area at mainly higher altitudes with varying aspects, but predominantly on crests, scarps and mid-slopes with steeper gradients greater than 7 degrees, although also found to occur on gentler slopes and flat areas as well, albeit less frequently, along dryer, well drained bottomlands. The landscape is undulating with trees being largely absent or with very low cover (5%-30%) when they do indeed occur. Scattered chert outcrops are found throughout the area falling within the Ib and Fa Land types corresponding largely with the Dolomites of the Malmani group. Soil surface rock is generally low, (between 2 and 30%) but increasing to around 80% in some of the instances where the community occurs in these chert rich areas, and up to 60% where located in the Timeball Hill and Hospital Hill shales associated with the Ba Land type that borders the Fa Land type. Soil depths are shallow and range between 50mm and 150mm with low clay content (6-10%), whilst soil depths of between 250 mm and 1000mm where encountered on the bottomlands. Grass cover is high, up to 90% where the surface rock is lowest, and growing up to 1.5m in height, with forbs having cover values ranging from 10-40% and reaching heights of 1m.

Species characteristic for this major community (Species Group D) include the grasses *Urelytrum agropyroides, Loudetia simplex* and *Andropogon schirensis*, as well as the forbs *Parinari capensis* and *Pentanisia angustifolia*.

The vegetation is dominated by the grasses *Brachiaria serrata, Diheteropogon amplectens, Eragrostis racemosa* and *Schizachyrium sanguineum* (Species Group Y) with the forbs *Chaetacanthus costatus* (Species Group Y), *Senecio venosus* and *Pollichia campestris* (Species Group Q) also featuring prominently.

This community shows an affinity to the *Loudetio simplicis-Diheteropogonetum amplectentis* as described by Bezuidenhout *et al.* (1994) and is affiliated to four sub communities namely the *Pittosporum viridiflorum* – *Englerophytum magalismontanum* Bush Clump community, the *Monocymbium ceresiiforme* – *Schizachyrium sanguineum* Rocky Grassland community, the *Protea caffra* – *Themeda triandra* Open Woodland community and the *Setaria sphacelata* – *Pentanisia angustifolia* Grassland community.

TABLE 4.1: A Phytosociological table of the Grassland Vegetation of the COH WHS

Community Number	1																													2									3																								
	1.1		1.2										1.3									1.4																	3.1													3.2			3.3			3.4			3.5			
																																							3.1.1			3.1.2																					
Releve Number	40	41	28	29	30	31	32	33	11	13	34	35	42	43	44	77	78	79	80	81	82	2	6	7	9	10	18	25	26	1	4	5	8	12	17	20	21	24	22	23	73	51	53	55	56	57	59	60	62	72	74	54	75	76	36	49	50	64	65	66	61	68	63	67
Species Group A																																																																
Indigofera melanadenia	+	+																					+																																									
Cymbopogon pospischili	+	+	+																																																													
Pittosporum viridiflora	a																																																															
Cussonia paniculata	1																																											+					+															
Searsia magalismontana	+																																																															
Englerophytum magalismontanu	+																																																															
Adiantum capillus-venosa	+																																																															
Mundulea sericea		+																																																														
Senecio othonniflorus		+																																																														
Chaetacanthus setiger		+																																																														
Acalypha villicaulis		+																																																														
Cynodon hirsutus		+																																																														
Protea gaguedi		+																																																														
Species Group B																																																																
Panicum natalense	1			1	1		1	1	a	+	+														a	1		+	a								+																		1									
Monocymbium ceresiiforme	+			a		1	a	b	1	1						1	+								+	+																												+										
Acrotome hispida		+				a	a	1	1		+	1													r	+																								+														
Chrysopogon serrulatus					1			1	1		1														a	1																																						
Kohautia caespitosa			+	+			+	+																														+																										
Indigofera setiflora				+	1	1																																																										
Seriphium plumosum							1	1																																														+										
Thecacoris trichogyne									1	1			+																																																			
Bulbostylis burchellii			1							+																																																						
Cucumis zeyheri			1							+																																																						
Polygala hottentotta			1							+																																																						
Becium angustifolium							1		+																																																							
Species Group C																																																																
Thesium utile	+												+	1	1			+	+	+	+	+																																										
Tricholaena monachne													1					+	+	1	+																														1					+	+				r			
Protea caffra	b	1									r		1	a	+				b		3																					1			+																			
Dicoma anomala				r	+		+	1								+		+	+	+	+			1														1			+		+	+	+					+	+	+					+							
Felicia muricata							1		1	+					+	+		+		+										+											+					+		+	+															
Ectadiopsis oblongifolia														+				+	+		1					+																		+																				
Chamaecrista comosa		+												+	+				+	+			+			+								r				r	r															+										
Lotononis eriantha													r		+	+	+												r					a																														
Alloteropsis semialata																+	a									r																																						
Aster peglerae											+		+								a															r				r					+							+		+			+							
Psammotropha myriantha													+	+																																																		
Protea welwitschii																a																																															

Species																																																																
Species Group D																																																																
Parinari capensis		1		+	+	1			a	+	1	1	1	+	a			1	a	1	1	+		1	+	1		1								1																				1								
Urelytrum agropyroides		+	+	1					+		1	1	+	+	+	+	+	+	+			+		b	+				+								+								+						+					+								
Pentanisia angustifolia	+		1		+		+	1		r	1					+	+	+	+	+		r	a		+	+			a											+	+	+		+	1	+					1	+	1	+	+	+	+							
Loudetia simplex	+				a		r	a	a	r	b	a	a		+	a										a	1			+					1																													
Andropogon schirensis			a	a			b	3					1		a			1		1	1				+			a																								1				1	a		+		+			
Species Group E																																																																
Eustachys paspaloides															+							+	+			+				1	1	a	+	1		1	1	1		+			+	+																				
Cucumis zeyheri									+															+				+		+	r	1	+	+	+		r	a	1	1										+						+								
Trichoneura grandiglum															+							+						r	+	+	+	+				+		a	1									+																
Triraphis andropogonois																												1				+	b	a	a											+																		
Cyperus obtusiflorus											+											+								+	+			1	+																													
Melinis repens																																	1			+	r	+		+	+								+											r		+		
Euphorbia trichadenia																									r						r			r		r	+			r																								
Ozoroa paniculosa																			+		+						1					1	+		+																													
Aristida diffusa							+	+														+										+	+					+														r				r		r		r			1	
Lotononis foliosa									+	r																		+			r				+		+		+											+	+													
Zanthoxylum capense	+										1																			+	1			1																														
Aristida congesta s congesta									1																			+								+	+	1		1																								
Dichapetalum cymosum																													1				+	+																														
Digitaria monodactyla										1												1								+						+																			+									
Ipomoea crassipes			r																												+		+						1														+											
Species Group F																																																																
Xerophyta retinervis										r	1			+	+						+		+		+	1	+		1		r	1		+	+	+	+																											
Ruellia cordata									+														+		+	a	+			1		1	1	1										+																				
Searsia rigida																							1				1			+	1	b					1	1																								+		
Ursinia nana																											+	+	+		+				+	+	+																											
Chamaesyce inaequilate																						+	+							+	+					+		1	r	r																								
Jamesbrittenia aurantiaca															+										+	1						r		+				1						+				+										r	r			+		
Pogonarthria squarrosa										1	1		+														1		+							+	+	1																										
Gnidia sericocephala																						+		1		+				+	+																																	
Bidens bipinnata			+																					1	+		r								+																													
Jamesbrittenia burkeana																				1		+	+							1			+																															
Richardia brasiliensis				+					r															+			+								+	+					+									r	+			r										
Kalanchoe thyrsiflora																										+	+					+	+																															
Diospyros lycioides																										+	1			+														+																				
Dianthus mooiensis		r												+									1	+		r																																						
Rhoicissus tridentata																							+			+								1																														
Ipomoea transvaalensis																													1					1						1																								
Species Group G																																																																
Sporobolus pectinatus													1	+		+				+		b			a	1	1			1	1	b	+	+	+	a																												
Phyllanthus parvulus														+	+		+						+	+		r				+	+		+	+		+		+							+																			
Cyanotis speciosa										+				+	+	+							+	+		+	+				+	+				+	1																			+								
Oldenlandia herbacea										+			+		+	+								r	+	+				+		+	1	+																														
Sonchus nanus			r									+				+		+					+					+		+					+											+				+						+								
Vernonia natalensis																	+		+		+		r		+		+																				+							+	a	+								

Species Group H																																																																
Hypoxis hemerocallidea																																							+	+	+																r							
Hermannia transvaalensis																																							1	+																								
Microchloa caffra																														1						+			+	1																								
Senecio rhomboideus																																							r	r																								
Zornia linearis																																							+	+																								
Phyllobolus congestus							r	+																															1																									
Helichrysum acutatum									+																															1							+																	
Species Group I																																																															
Lantana rugosa														+							+																					+	+	+	+	+	+		+														
Acacia caffra														+					+																							a	+	a				+	b														
Euclea crispa																																										a	1	+			+	+															
Lotononis calycina																																				+							1			+	+		+														
Searsia zeyheri	1												+	+											+		1							+	1								+	+		+	+		1														
Ipomoea bathycolpos																																						1					+					+		+														
Indigastrum burkeanum																									+																	+	+		+																		
Vangueria infausta																																												a			+																
Indigofera hedyantha																			+																											+	1																
Hibiscus lunarifolius																																										+	+																					
Clematis brachiata																																										+							+														
Nesaea schinzii																																											+							+											+		
Gerbera viridifolia																																											+			+																	
Ximenia caffra																																										+	+																					
Species Group J																																																															
Ziziphus zeyheriana																																							1	a		1		a	1	+	+	a	1	a	1													1	1
Corchorus confusus																																	+						+	r	+	+		+	+		+		+	+	+	+												
Lippia javanica		1		+																						+											1			r	+		+				+		+	+		+												
Hebenstretia angolensis												1							+	+						+		+	+					r						+		+	+				+		+							+								
Ipomoea ommaneyi	+																																						+									+			+													
Convolvulus sagitatus																																											+	+																				
Gomphocarpus fruticosus																																									+										+													
Species Group K																																																															
Pellaea calomelanos	+	+									1	1		+	+	+			+		+		+		+	1	1		1	+	+	1		1	+	+	+		+				+	+					+															
Aristida transvaalens				+	+				a	+					1			+													r	+	+	+	+	+		+	+	+									+															
Dicoma zeyheri			+	+				1		r								+	+		+							+	+								+			1		+	+			+	+				+													
Tephrosia longipes	+	+							r						+					+	+			+									+										+							+	+					+	+			r				
Species Group L																																																															
Aloe greatheadii																						r	1		+	+	+	+	1		+	1	r		+	+	a	1	1	+			+	+	+	1	+	+	+	+						r								
Crabbea hirsuta																												+			1				r		+		+	1										+														
Searsia pyroides																													1	r										+		1																						
Species Group M																																																															
Digitaria eriantha											a						+							+						+			+			1															+		3	a										
Conyza bonariensis																							r																													+		+					r	r				
Nidorella anomala									+					+											+																								+					1										

Species	1	2	3	4	5	6	7	8	9	10	11
Species Group N											
Conyza podocephala				1		1 + +	+ + + + + + +	+ +			
Helichrysum coriaceum			+	+	c		+ + + 1 + +	+ +			
Eragrostis curvula		+	+ +		1 1 1	1	+ + +	+ + 1		1	1 +
Solanum panduriforme	+					+	+ + + +	+ +			
Aristitida conges s barbicollis			+			+	+ +	+		r r	
Species Group O											
Elephantorrhiza elephantina			+ +		a			+	3 1		
Raphionacme hirsuta				r	+ +				+ +		
Gnidia gymnostachya									+ +		
Digitaria diagonalis			+ +				a		4		
Cyperus rotundus									b		
Pearsonia sessilifolia			+ +	+		+			1		
Species Group P											
Helichrysum nudifolium	+	+ + r	+		r	1	+ + + + + 1 1 + 1	+ + +	+		
Indigofera filipes	+		1 + + + + + +				+ + 1 1	a 1	+ 1		
Chlorophytum cooperi		+	+ +	+ + r	+	1	+ + + +	+	a +		
Chlorophytum fascicula			+		+	+	+ + +	+	1 r +		
Hypericum aethiopicum			+	+			+ + +	+	+ +		
Gerbera piloselloides			+ + +			+	+ + +	+	1		
Senecio coronatus	+	r	+	r r	+ r		+ + +	+	+		
Polygala amatymbica		+					+ +	+	+		
Gnidia capitata		a r	1				+ +	+	+		
Species Group Q											
Senecio venosus	+	+ 1 1 + + 1 + +	+ + + + + + +	1 + 1 + + + +	a 1 1 + +	+ +	+ + + + + + + +	+ + +	a 1 +		
Melinis nerviglumis	+ +	+ + 1 1 a a + +	+ + + + + + + + + +	+ + + +	+ 1 1 1 +	+	+ + + + + + + + +		+ 1 +		
Pollichia campestris	r	+ 1 + 1 + 1 1	+ + + + + + +	+ 1 r + +	+ + + +	+ +	+ + + + + +	+ +	r + +		
Crabbea angustifolia		+ + r + 1	+	1 1 + 1	+ + 1 + +	+ +	+ + + + + + + + + + +	+	1 + +		
Helichrysum dasymallum		+ + r	+ + + + + +	+ + + + +	+ + + + r	r r	+ + + + + + +	+	+		
Sphenostylis angustifolia	+	1 + r a	+ + + + + +	+ + + + a	+ r r	+ +	+ + + + +	+	r +		
Athrixia elata	1 +	1 1 +	1 + +	+ + 1 + a			a 1 a + + + + + +	+ +			
Kohautia amatymbica		+ +	+ + + + + + +	+ + r r	+ + +	+	+ + + +	+	+ +		
Justicia anagalloides	+	r + 1 +	+ +	+ 1 1	1 1 1 + +		+ +		+ + +		
Becium obovatum		1 + +	+ 1 + +	+ +	+	1	+ + + + + 1 +	+ 1			
Nidorella hottentotica	+	+ + +	+ + + + +	+ + +	+	r	+ +	+	+		
Senecio pentactinus		1	+ + + + +	+	+ +		+ + + 1	a +			
Limeum viscosum		+	+	+ +	+ + +	+	+ +				
Species Group R											
Bulbostylis burchellii			+ + + + + + +	+ + + + +	+ + + + + +		+ + + +	+ +	+ +		
Ledebouria revoluta		r	+ +	+ + + +	1 + + 1 + + +	+ +	+ + + + + + +		+ +	r r	r
Helichrysum cephaloide			+ + + + + + + +	+	a + + r	+	+ + + + + +	+	+		r + r
Asparagus suaveolens	r		+ +	r + r + +	+ + + + +	+	+ + +		+		

	1	2	3	4	5	6	7	8	9	10	11
Species Group S											
Vernonia oligocephala		1	+	r + 1	1 + +	+ 1 1	+ 1 1 1 +	+ 1	1 + +		
Sonchus dregeanus		+ +		+ 1 + + +	r r + +	+	+ + + + + +	+	+ +		
Scabiosa columbaria				+ + + +	1 +	1 + +	+ + + + + + +	+ +		r	
Rhynchosia monophylla				1 + 1	+ r + a	+ +	+ +		+ +		
Hypoxis rigidula	+	1		r a 1	+ +			1 +	b		
Species Group T											
Cyperus rupestris										+ + +	r
Polygala uncinata			+							r r r	+
Aristida canescens										+ +	
Tephrosia capensis										+ r	
Hypoxis acuminata										r +	r
Eragrostis plana										+	+
Species Group U											
Trachyandra asperata										r	+ + +
Eragrostis capensis							+			r	r r r
Geigeria burkei		r		+ r						r	r r
Senecio consanguineus									+		r r
Setaria incrassata											b
Species Group V											
Helichrysum rugulosum		+ + 1 +		+ + + +		1 1 1	+ + + + + + + 1	+ 1 +	1 + +	+	+ + + +
Hyparrhenia hirta	+		+ +	+		a +	+ + + + +	1 + a	+	1 r	1 1 +
Cymbopogon excavatus		+ +	+ 1 + 1		+	+	+ + +	+ + +	+	1 r r	1 +
Species Group W											
Acalypha angustata			a				a +	+	b	r	a + 1
Cynodon dactylon		+ +			+		+ +	1 +	+	r r	+ + 1
Species Group X											
Elionurus muticus	r	r + r	1 + + + + + +	+ r r + +	+ 1 1 1 + + + +	1 1 1	+ + + + + +	+ +	1 + +	1 1 r	a + b 1
Heteropogon contortus		1 1	+ + 1 + +	+ a + + 1	+ 1 + 1 1 1 +	a 1	+ + 1 1 1 a a + +	+	+	a r	+ 1
Hermannia depressa			+ + +	+ + 1	1 1 1 1 +	a +	+ + + + 1 + + + 1 +	+ +	+ + 1	+ + +	+
Eragrostis chloromelas		1 1	+	a +	1 a a 1 1 1 1 1 1	1 a b	+ a +	1	+	+ 1 +	1 1 1 b
Andropogon chinensis		1 b b	1 a + 1 1 +	b 1	a b	1	+ + 1 1		1 1		+
Species Group Y											
Brachiaria serrata	+ +	a 3 b b a 1 a 1 1 a	+ 1 1 1 + a a	b b 3 b a 1 1 a	a + a 1 + 1 1 1 a	a 1 1	+ + + 1 1 1 1 1 1	+ a	1 + +	a a	1 + 1 a
Diheteropogo amplecten	1 +	4 3 4 4 3 a + 1 a	1 + 1 + + 1 1 + +	a b 1 a a a 1 3	+ 1 + a + 1 1	+	+ 1 1 + 1 + + + + +		+ + +	+ a	r 1
Themeda triandra	1 1	1 1 a a 1 1 a 1	a 1 b a a 1 1 b	+ + + + 1 1	b + 1 + 1 1	1 1 a	+ a a + b a a a 1	a 1	1 1	r a 1	r r +
Eragrostis racemosa	1 +	1 a 1 1 b a a a a a	r + + + a 1 + 1 +	+ 1 a 1 a 1 a	1 1 1	a 1 a	+ + 1 1	+ +	+ + +	r + +	+ 1
Setaria sphacelata	+ a	+ 1 + a	1 + + +	3 4 4 b a b a a	b a b 3 3 3 b a 1	1 1	+ + 1 1 + + + a	+	1 1 +	1 +	3 + 1
Schizachyriu sanguineu	a 1	3 a a a 1 1 b b b	a 1 1 + a + +	+ + + 1 1 3 a	r + + 1 a a	a	1 1 a 1 + 1 a		+ 1	+	
Trachypogon spicatus	+	a 3 a + 3 3	+ +	+ 1 1 a 1	a + 1 a a	a a +	a a b 1 b b b 1 a	a + +	+ +	+	r + + a
Chaetacanthus costatus	+	+ + + r r 1 1	+ + 1 + + +	+ 1 1 + +	+ +	+ 1 +	+ + + + + + + + +	+ +	+ + +	+ +	
Bewsia biflora	+	+ 1 1	+ + 1 1 1	1 r 1 1	+ + a a 1	+	1 + + + +		+ + +	r	+ +

1.1 *Pittosporum viridiflorum–Englerophytum magalismontanum* Bush Clumps.

This community is centrally located within the study site, on southern and easterly crest and mid-slopes underlain by dolomite where chert rich rocky outcrops dominate the undulating landscape within the Ib Land type. Surface rock covers up to 80% of the soil surface and the slope is generally steeper at 20-26 degrees. Soils are generally between 100mm and 200mm deep with relatively low clay content (6-10%) and a sandy consistency. Tree cover varies between 10-20% with heights of 3-4m. being reached in some instances. The shrub layer covers approximately 5-15% of the community up to a height of 1.5m. Grasses cover between 30 and 60 percent of the area depending on the percentage rock cover, and reach a height of 1.2m. Forbs account for between 10 and 40 percent of the vegetative cover of this community and grow to a height of 1m.

Species characteristic of this community (Species Group A) include the climax grass *Cymbopogon pospischili* (van Outshoorn. 1999) and the creeping grass *Cynodon hirsutus* as well as the dwarf shrublet *Searsia magalismontana*. The shrubs *Englerophytum magalismontanum, Acalypha villicaulis, Protea gaguedi* and *Mundulea sericea* and the trees *Cussonia paniculata* and *Pittosporum viridiflorum* forming part of this diagnostic species group attest to the rockiness of the habitat supporting this community. Forbs forming part of the diagnostic species grouping include *Indigofera melanadenia* and *Chaetacanthus cf. setiger* that also prefer rocky sloped habitats (van Wyk & Malan. 1997).

Prominent grasses found in this community include the fire climax grasses *Themeda triandra* (often growing alongside the diagnostic species *Cymbopogon pospischili*) and *Diheteropogon amplectens* as well as *Setaria sphacelata* and *Schizachyrium sanguineum* (Species Group Y). The presence of the climax grasses (van Outshoorn. 1999) *Melinis nerviglumis* (Species Group Q) and *Brachiaria serrata* (Species Group Y) suggests that the veld in which this community occurs is largely undisturbed.

The tree *Protea caffra* (Species Group C), whilst not diagnostic, features prominently in this community, with the highest densities and coverage occurring on the Southern slopes.

1.2 *Monocymbium ceresiiforme–Schizachyrium sanguineum* Rocky Grassland.

This community is located in the central, non fragmented areas of the study site where elevations are highest and the landscape takes on the appearance of gently rolling rocky grassland with isolated bush clumps only occurring amongst scattered large rock outcrops. This community is underlain by the Malmani Dolomites and Timeball Hill Shales of the Fa and Ib Land Types respectively. Slope consists mainly of flat to gentle gradients of between 1 and 4 degrees, but occasionally measured at a moderate 14 degrees across a scarp. Soil surface rock is relatively low at between 2- 30% but increasing to 60% where the slope gradient is steepest along scarps. The tree layer is absent from this community with shrubs only rarely encountered with cover values of up to only 5% being recorded. The grass layer has between 70-90% cover and reaches heights of 1.5m, whilst the forbs have between 15-30% cover and reach heights of 0.5m. Due to the largely flat nature of landscape, aspect was largely non-differential, however when gradients became moderate, this community was found more frequently on the easterly and westerly aspects. Soils remained shallow (100mm) with relatively low clay content (6-10%), however where the community was found to occur within shallow depressions in the landscape a soil texture class of up to 3 was recorded, perhaps mimicking the characteristics of bottomlands to a certain degree.

Characteristic species of this community include the grasses *Panicum natalense*, *Monocymbium ceresiiforme* and *Chrysopogon serrulatus*, together with the forbs *Acrotome hispida, Kohautia caespitosa* and *Thecacoris trichogyne* as well as the differential species *Indigofera setiflora, Becium angustifolium* and *Polygala hottentota* (Species Group B).

The vegetation throughout this community is dominated by the grasses *Schizachyrium sanguineum, Diheteropogon amplectens, Brachiaria serrata* and *Eragrostis racemosa* (Species Group Y).

Other grasses present that are also prominent include *Themeda triandra, Trachypogon spicatus* (Species Group Y), *Melinis nerviglumis* (Species group Q), *Loudetia simplex* (Species Group D) and *Urelytrum agropyroides* (Species Group D).

The forbs *Parinari capensis, Pentanisia angustifolia* (Species Group D), together with *Senecio venosus, Pollichia campestris* (Species Group Q) and *Chaetacanthus costatus* (Species Group Y), whilst not dominant, are nonetheless prominent within this community.

The presence of the species *Monocymbium ceresiiforme* (Species Group B), *Loudetia simplex* (Species Group D), *Panicum natalense* (Species Group B), *Themeda triandra* (Species Group Y) *and Cyanotis speciosa* (Species Group G) indicates an affinity to the Drakensberg vegetation that together with *Bewsia biflora* (Species Group Y) and *Eragrostis racemosa* (Species Group Y) are not dissimilar to the *Diheteropogon amplectens-Monocymbium ceresiiforme* grassland as described by Brown *et al.* 2005 or the *Monocymbium ceresiiforme-Loudetia simplex* grassland as described by Bredenkamp & Brown 2003.

1.3 *Protea caffra–Themeda triandra* Open Woodland

This community is found on the moderate to steep southern and south-westerly slopes of between 5 and 26 degrees within the chert rich dolomites of the Ib Land Type such as those within the Jack Scott Nature reserve, the steep south facing slopes of the Timeball Hill shales of the Ba Land Type such as those on the Mogales Gate property and the steep north easterly facing slopes of the quartzite ridges along the Protea Ridge (Kings Kloof) area located to the south west of the study site. Less rocky well drained steep scarps with a northern aspect particularly near the northern border between the Fa and Ib Land types within the Malmani dolomites also contain representations of this community. Soil surface rock is generally high with percentages of between 30- 70% being measured.

Soil is generally loamy sand however sandy loam soils were encountered on the plots located in the Ba Land type.

Vegetation cover comprises of forb, grass, shrub and tree layers, with maximum heights of 1m, 1.5m, 2m and 3m being recorded for each specific growth form class respectively.

Differences in species specific growth forms (maximum height and individual plant cover) within especially the *Proteaceae* were observed in terms of terrain position and aspect with individuals reaching 3m in height and maximum cover values of 30% within specifically southern aspects in the Ib Land type underlain by the cherty dolomites, 3m in height and up to 50% cover along the very steep north-eastern aspects of the Ib Land type underlain by the Hospital Hill quartzites and only reaching shrub status in the Ba Land type with maximum heights of 1-2m and 15% cover being attained there.

Characteristic species (Species Group C) of this community include the evergreen tree species *Protea caffra*, the grass species *Tricholaena monachne* that prefers this type of mixed bushveld habitat on sandy soils (van Outshoorn, 1999) and the forbs *Thesium utile, Dicoma anomala, Felicia muricata, Ectadiopsis oblongifolia, Chamaecrista comosa, Lotononis eriantha, Alloteropsis semialata* and *Aster peglerae*.

The dwarf deciduous shrublet, *Parinari capensis* (Species Group D) together with the forbs *Pellaea calomelanos* (Species group K), *Indigofera filipes* (Species Group P), *Senecio venosus, Pollichia campestris, Helichrysum dasymallum, Sphenostylis angustifolia, Kohautia amatymbica* (Species Group Q), *Bulbostylis burchellii, Helichrysum cephaloideum* (Species Group R), *Chaetacanthus costatus* (Species Group Y) and the grasses *Urelytrum agropyroides, Andropogon schirensis* (Species Group D), *Melinis nerviglumis* (Species Group Q), *Elionurus muticus, Andropogon chinensis* (Species Group X), *Brachiaria serrata, Diheteropogon amplectens, Themeda triandra* and *Schizachyrium sanguineum* (Species Group Y) feature prominently within this community.

A study conducted by Coetzee (1974) on the vegetation of the Jack Scott Nature Reserve differentiated variants of evergreen *Protea caffra* savanna within the grasslands of the area and correlated these variants to the various aspects and gradients associated with the geology, and in particular the Chert, Shale and Quartzite found there.

The presence of the forbs *Alloteropsis semialata* (Species Group C) as found in releves 77 and 78, *Bulbostylis burchellii* (Species Group R) as found in releves 42; 43; 44; 77; 78; 80; 82 and *Rhynchosia totta* (Species Group Z) as found in releve 79 show similarities to Coetzee (1974)'s "*Protea caffra* Evergreen Savanna on very steep south facing chert slopes; *Protea caffra-Bulbostylis burchellii* Savanna and Ecotonal *Protea caffra-Rhynchosia totta* Savanna" respectively.

1.4 *Setaria sphacelata–Pentanisia angustifolia* Grassland.

This community is centrally located within the study site and is found mainly on the dolomitic areas low in chert occurring exclusively in the Fa Land type. Soil surface rock is moderate at between 5 -45% at the gentler slope gradients but increases to between 40-60% where slope gradients are steep (between 13 and 23 degrees). Drainage lines and or floodplains are often encountered below the midslopes and plateaus where this community is found. Rock sheets are occasionally present just below the soil surface with soil depths in these cases being limited to around 200mm and less, otherwise soil is deeper at 250mm and greater. Soils are regarded as loamy sand. Westerly and south westerly aspects occur on the higher lying areas along plateaus and midslopes, but occasionally also on the high altitude bottomlands.

The vegetation has a rocky mountain grassland structure with the tree and shrub layers being virtually absent and the grasses dominating with cover values exceeding 80% and reaching heights of 1m. The forb layer is fairly underrepresented with low cover values of between 10-30% being recorded and maximum heights of 0.5m being reached.

As there is no characteristic Species Group for this community, it can be characterized by the presence of those species listed in Species Group D, in the absence of those species listed in Species Groups A, B and C respectively.

The grass *Setaria sphacelata* (Species Group Y) dominates this community together with *Brachiaria serrata, Eragrostis racemosa* and *Diheteropogon amplectens* with *Schizachyrium sanguineum* also featuring prominently. *Sporobolus pectinatus* (Species Group G) features in those sections of the community where rock sheets occur.

The succulent forb *Aloe greatheadii* (Species Group L), *Bulbostylis burchellii* (Species Group R), *Athrixia elata, Senecio venosus* (Species Group Q), *Xerophyta retinervis* (*Species Group F*) and *Parinari capensis* (Species Group D) feature prominently throughout the majority of the area in which this community is found. The grass *Panicum natalense* (Species Group B) features prominently where slope gradients increased and together with *Themeda triandra* (Species Group Y) were found to occur in areas that had been subjected to recent burning. Accessibility, together with the fairly palatable nature of the species within this community resulted in signs of heavy grazing being observed in patches. The 100% presence and high average cover of the climax grass (van Outshoorn, 1999) *Brachiaria serrata* (Species Group Y) is indicative of the veld still being in good condition.

2. *Eustachys paspaloides–Sporobolus pectinatus* Grassland.

This community occurs throughout the Malmani dolomites of the Fa Land type on flat to gentle slopes never exceeding 15 degrees but mostly less than 10 degrees. It is usually found on plateaus (Crests and Scarps). Aspect does not appear to be a limiting factor to its distribution in all likelihood due to the terrain position (Terrain positions 1 & 2). Soil surface rock is variable, but remains high at between 30-70%, with extensive rock sheets common. Soils are shallow (less than 250mm) and well drained and can be described as loamy sand.

The vegetation has a typical short rocky mountain grassland appearance with the tree layer being virtually absent from this community and only visible in association with large rock outcrops within the landscape, and with a retarded growth form. Shrubs account for around 2% of the vegetative cover and reach a maximum height of 1.2m. The grass layer dominates the vegetation with cover values of between 65-85% recorded, reaching heights of 1.2m. The forb layer accounts for between 10-75% of the vegetative cover but mainly accounts for less than 40% cover except in one releve. Maximum forb height is largely restricted to below 0.5m.

Characteristic species for this community (Species Group E) include the highly palatable climax grass *Eustachys paspaloides*, the sublimax grass *Trichoneura grandiglumis*, the unpalatable grasses *Triraphis andropogonoides* and *Melinis* *repens* (van Outshoorn, 1999), the forbs *Cucumis zeyheri* and *Cyperus obtusiflorus* and the shrubs *Zanthoxylum capense* and *Ozoroa paniculosa.*

Additional species that feature prominently within this community include the shrub *Searsia rigida* (Species Group F) and the grass *Sporobolus pectinatus* (Species Group G) that are strongly associated with the rock sheets prevalent throughout the area (van Outshoorn, 1999), the forbs *Xerophyta retinervis, Ruellia cordata, Chamaesyce aurantiaca* (Species Group F), *Phyllanthus parvulus* (Species Group G), *Pellaea calomelanos* (Species Group K), *Aloe greatheadii* (Species Group L), *Senecio venosus, Crabbea angustifolia, Justicia anagalloides* (Species Group Q), *Bulbostylis burchellii, Ledebouria revoluta, Asparagus suaveolens* (Species Group R) and the grasses *Setaria sphacelata* (that dominates the community) with *Brachiaria serrata, Diheteropogon amplectens* and *Themeda triandra* (Species Group Y) , *Eragrostis chloromelas, Heteropogon contortus, Elionurus muticus* (Species Group X) and *Aristida transvaalensis* (Species Group K).

The array of species representing different successional stages present suggest a highly heterogeneous landscape, however the prevalence of the readily overgrazed *Eustachys paspaloides* (Species Group E) in high cover values suggest that this is a natural phenomenon emphasizing the conservation value of this plant community particularly for Biodiversity related objectives.

3. *Hyparrhenia hirta–Vernonia oligocephala* Grassland.

This major community is found mostly on the non dolomitic areas of the study site on slopes that are located on the flat to gentle slope classes (0-9 degrees), where surface rock is low to very low (Between 5-40%). Surface rock percentages of up to 70% were however recorded on the steeper slopes (13-21 degrees) where the community occurred on andesite. Soils generally are classed as loamy sand when originating on quartzite, shale and basalt, however sandy loam soils were present, particularly on the steeper andesite areas with higher surface rock percentages, but remain moderate to shallow (<550mm.) and well drained. Aspect did not appear to be a limiting factor to this communities' distribution as it occurred on all aspects with a flat to gentle gradient, on midslopes, lower lying plateaus, as well as bottomlands.

The vegetation is dominated by tall grassland species comprising of a high percentage forb cover of between 40-60%, with a tree layer only present on the steep rocky slopes. Whilst this community occurs in the Ab, Ba and Bb land types, anthropogenic influences, either current or historical, appear to be a common factor, with evidence of grazing, burning and or cultivation being the common denominator.

The perennial herb *Helichrysum rugulosum*, together with the grasses *Hyparrhenia hirta* and *Cymbopogon excavatus* (Species Group V) are characteristic for this community.

The forbs *Pentanisia angustifolia* (Species Group D), *Helichrysum nudifolium* (Species Group P), *Senecio venosus, Crabbea angustifolia, Sphenostylis angustifolia* and *Kohautia amatymbica* (Species Group Q), *Vernonia oligocephala, Sonchus dregeanus* (Species Group S), *Hermannia depressa* (Species Group X) and *Chaetacanthus costatus* (Species Group Y) together with the grasses *Elionurus muticus* and *Heteropogon contortus* (Species Group X) and *Brachiaria serrata, Themeda triandra, Setaria sphacelata* and *Trachypogon spicatus* (Species Group Y) feature prominently throughout this community.

The high cover values for *Themeda triandra* (Species Group Y) and *Elionurus muticus* (Species Group X) together with the characteristic species *Hyparrhenia hirta* (Species Group V) confirm the anthropogenic influence on this community through the application of both fire and grazing to a greater or lesser degree.

This major plant community is divided into five sub-communities:

3.1 *Hyparrhenia hirta–Ziziphus zeyheriana* Grassland.

This sub community occurs on the areas of the study site falling within the Ib and Ba Land types situated on andesite in the north and arenite/gneiss in the south, as well as occasionally on previously cultivated, very flat areas within the Fa Land type just north of the Black Reef respectively. On the andesite sites, this sub community occurs on those areas with steeper slopes (6-20 degrees) and where percentage soil surface rockiness is higher at between 20 and 70% whilst on the arenite/gneiss areas, slope is flat to gentle at between 1 and 7 degrees and the percentage soil surface rock is much lower at 5%. On the areas associated with the old cultivated lands just north of the Black Reef, where the geology begins to convert to dolomites, percentage soil surface rock is moderate to low at 10 to 25% whilst slope remains flat at two degrees and less. Soil are generally shallow (<250mm) and well drained, largely corresponding with the loamy sand description, with slightly deeper sandy loam soil (250-350mm) found on the andesite and transitional dolomite areas.

The vegetation largely has the appearance of tall open grassland, with scattered trees and shrubs mainly occurring where the community is associated with the rockier areas occurring on andesite. In these areas, these trees only attain maximum heights of 4-5m with 30% cover, whilst the shrub layer has only between 2-30% cover reaching maximum heights of 1.5m. The grass layer remains dominant however with 50-80% cover values recorded and attaining heights of 1.2m. Forbs still feature prominently in terms of species variety, albeit with a relatively low percentage cover (40-60%) and reaching maximum heights of only 1m.

This sub community is characterised by those species occurring in Species Group J, including the shrubs *Ziziphus zeyheriana, Lippea javanica* and *Hebenstretia angolensis* together with the forb *Corchorus confuses*, with the forbs *Ipomoea ommaneyi* and *Convolvulus sagittatus var.* also featuring as diagnostic species albeit not as prominently.

The forbs *Dicoma anomala* (Species Group C), *Pentanisia angustifolia* (Species Group D), *Dicoma zeyheri* (Species group K), *Conyza podocephala* (*Species group N*), *Helichrysum nudifolium* (Species Group P), *Helichrysum rugulosum* (Species Group V), *Senecio venosus, Pollichia campestris, Crabbea angustifolia, Becium obovatum* (Species group Q), *Vernonia oligocephala, Scabiosa columbaria* (Species Group S) and *Hermannia depressa* (Species Group X), together with the grasses *Brachiaria serrata, Diheteropogon amplectens, Themeda triandra and Trachypogon spicatus* (Species Group Y) as well as the succulent forbs *Aloe greatheadii* (Species Group L) and *Ledebouria revolute* (Species Group R) feature prominently throughout this community.

The prominence and presence of the Increaser grasses (van Outshoorn, 1999) *Cymbopogon excavatus, Hyparrhenia hirta* (Species Group V), *Elionurus muticus* and *Heteropogon contortus* (Species group X) attest to the previously disturbed nature of this community.

Two variants are found within this Sub-community, namely the *Hypoxis hemerocallidea* variant and the *Acacia caffra* variant.

3.1.1 *Hypoxis hemerocallidea* Variant.

This variant is found on the flat areas (Less than 2 degrees) of the Fa Land type, in the areas with relatively low percentage surface rock cover (10-25%) at the point where the dominant geology transitions from the Black Reef formations to the Malmani dolomites, as well as the flat slopes of the Bb land type that are underlain by arenite and shale that also have low percentage soil surface rock at less than 5%.

Soils are gravelly and well drained, conforming largely to the loamy sand category and are shallow (<250mm). This variant shows no distinct affinity to any particular aspect due to the flat slopes on which it is found, thereby rendering aspect largely inconsequential, as is terrain position, with this variant occurring on both plateaus and foot slopes alike, although the plateaus themselves are low lying.

The vegetation presents as an open grassland, albeit marginally shorter with maximum grass height reaching only 1m. Trees are largely absent, or restricted to growth forms that place them in the shrub category at less than 2m in height, with trees and shrubs together only accounting for less than 10% cover. Grasses and forbs share cover values of around 50% each with the forb layer however displaying a high variety of species with on average 34 forb species being recorded at each site.

This variant is diagnosed by the presence of those species listed in Species Group H and includes the perennial herb *Hypoxis hemerocallidea,* the creeping herb *Hermannia transvaalensis* and the forb *Zornia linearis* and the grass *Microchloa caffra.*

Prominent forbs found in this variant include *Conyza podocephala* (Species Group N), *Helichrysum rugulosum* (Species Group V), *Vernonia oligocephala, Scabiosa columbaria* (Species Group S) and *Chaetacanthus costatus* (Species Group Y), whilst prominent grasses include *Elionurus muticus, Eragrostis chloromelas* (Species Group X), *Brachiaria serrata, Themeda triandra, Eragrostis racemosa* and *Trachypogon spicatus* (Species Group Y).

3.1.2 *Acacia caffra* Variant.

This variant is found on the deeper soils (350mm) underlain by the andesites of the Ib Land type in the North of the study site, as well as the areas to the south east of the study site that occur on soils derived from the migmatites of the Bb Land type, along scarps and midslopes.

When found on the Ib Land type, this variant occurs on mostly gentle to steep slopes (3 – 21 degrees) where the % soil surface rock is relatively high at between 10% and 70%, with the majority of sites found to contain above 40% soil surface rock. When found on the migmatites of the Bb Land type however, this variant occurs on the gentler slopes (3 - 7 degrees) where % soil surface rock is below 5%. In all cases, soils correspond largely to the Sandy loam soil description.

The vegetation has a well represented tree layer, covering between 5 – 30% of the area and reaching up to 5m in height particularly on the Northern and Eastern slopes of the areas falling within the Ib Land type, however no distinct affinity to any one aspect is evident as this variant is found on South and West facing slopes as well, albeit that the tree layer does not grow to quite as high in these instances. Shrubs are also well represented, with between 5 – 30% of the area being covered by them, reaching heights of 1.5m. 50 – 70% of the area is covered by the grass layer with 40 – 60% forb coverage occurring as well.

This variant is characterised by the presence of those species listed in Species Group I, and include the shrubs *Lantana rugosa* and *Searsia zeyheri*, and the trees *Acacia caffra* and *Euclea crispa*. The forbs *Lotononis calycina, Ipomoea bathycolpos, Indigastrum burkeanum, Indigofera hedyantha, Hibiscus lunarifolius, Clematis brachiata* and *Gerbera viridifolia*, as well as the shrubs *Vangueria infausta, Nesaea schinzii* and *Ximenia caffra* are also characteristic, albeit that they do not feature as prominently.

The grasses *Themeda triandra* and *Trachypogon spicatus* (Species Group Y) dominate the grass layer, with *Brachiaria serrata* and *Diheteropogon amplectens* also featuring prominently.

Ziziphus zeyheriana (Species Group J) features prominently in the shrub layer, with prominently featuring forbs including *Corchorus confuses* (Species Group J), *Aloe* *greatheadii* (Species Group L), *Helichrysum nudifolium* (Species Group P), *Crabbea angustifolia* (Species Group Q), *Hermannia depressa* (Species Group X) and *Chaetacanthus costatus* (Species Group Y).

3.2 *Hyparrhenia hirta–Digitaria eriantha* Grassland.

This sub-community occurs on the flat to very flat (<2 degrees) low lying slopes of the Ba and Ib Land types to the north and west of the study site where the soils are derived from the Timeball hill arenites and Hekpoort andesites respectively. Soils conform largely to the sandy loam soil class and are relatively deep (>400mm). Soil surface rock is very low and estimated to be less than 5%.

The tree layer is absent from this sub-community, with the shrub layer only occurring at heights below 800mm and covering less than 2% surface area. The grass layer dominates this sub-community with 60% coverage and heights of 1.2m being reached, whilst the forb layer has a 40% coverage reaching maximum heights of 1m.

Characteristic species for this sub-community include the grass *Digitaria eriantha* and the forbs *Conyza bonariensis* and *Nidorella anomala* (Species Group M).

Other species that also feature prominently include the grasses *Eragrostis curvula* (Species Group N), *Hyparrhenia hirta* (Species Group V) and *Trachypogon spicatus* (Species Group Y) as well as the forbs *Pentanisia angustifolia* (Species Group D) and *Helichrysum nudifolium* (Species Group P).

The presence of the grasses *Cymbopogon excavatus* and *Hyparrhenia hirta* (Species Group V) attest to the anthropogenic influences on this community as verified by the grazing regime observed in the field where large numbers of cattle were currently, or had recently been grazing in the area.

3.3 *Hyparrhenia hirta–Elephantorrhiza elephantina* Grassland

This sub-community occurs on the moderate (5 - 7 degrees) northerly and north westerly midslopes of the Black reef and Hospital hill formations found on the Ib and Ab Land types respectively. Percentage soil surface rock is moderate to low, with between 10 – 30% soil surface rock being recorded. Soils are shallow (<300mm), sandy and well drained, originating from the underlying quartzites, with soil corresponding with the Loamy sand soil description.

The tree layer is absent from this sub community, with the grass layer dominating the vegetation with between 70 – 80% coverage and heights of 1.2m being reached. Forbs account for between 20 – 60% coverage below a maximum height of 0.5m, with shrubs covering less than 10% of the area, reaching a maximum height of only 0.4m.

Characteristic species found in this sub community (Species Group O), include the shrublet *Elephantorrhiza elephantina*, the decumbent perennial herb *Raphionacme hirsuta* and the forb *Gnidia gymnostachya*. The grass *Digitaria diagonalis* and the forbs *Cyperus rotundus* and *Pearsonia sessilifolia*, whilst also characteristic, do not feature prominently in this sub community.

Dominant species within this sub community include the grasses *Elionurus muticus* (Species Group X), *Brachiaria serrata, Diheteropogon amplectens, Eragrostis racemosa* and *Setaria sphacelata* (Species Group Y) and the forbs *Pentanisia angustifolia* (Species Group D), *Helichrysum rugulosum* (Species Group V), *Senecio venosus, Crabbea angustifolia* and *Justicia* anagalloides (Species Group Q), *Vernonia oligocephala* (Species Group S), *Hermannia depressa* (Species Group X), *Chaetacanthus costatus* and *Bewsia biflora* (Species Group Y).

The grasses *Andropogon schirensis* (Species Group D), *Andropogon chinensis* (Species Group X), *Themeda triandra* and *Schizachyrium sanguineum* (Species Group Y) also feature prominently throughout this sub community.

Recent fire and moderate grazing was also found to have occurred in this sub community, with the presence and prominence of the fire climax grass (van Outshoorn, 1999) *Themeda triandra* (Species Group Y) attesting to this.

3.4 *Hyparrhenia hirta–Cyperus rupestris* Grassland.

This sub community occurs on mostly northern and westerly midslopes of the Ab land type where the soils are shallower (300 – 350mm) and are underlain by the Greenstone belts (Serpentines, amphibolites and schists) of the Swazian Erathem.

Percentage soil surface rock measures at between 30 – 50%, often with thin rock sheets on or near the soil surface with moisture present in the soil. Soil corresponds with the Sandy loam to Sandy clay loam soil descriptions.

The tree and shrub layers are absent from this community, with the grass layer dominating the landscape with between 50 – 60% coverage recorded with maximum growth heights measured at 1.2m. Forbs account for between 35 – 40% cover, reaching maximum growth heights of 0.8m.

This sub community is characterised by the presence of those species listed in Species Group T, and include the moisture preferring forbs (van Wyk & Malan, 1998) *Cyperus rupestris* and *Hypoxis acuminate* and the grass *Eragrostis plana*. The grass *Aristida canescens,* and the forbs *Polygala uncinata* and *Tephrosia capensis* are also characteristic.

The grasses *Eragrostis curvula* (Species Group N), *Hyparrhenia hirta, Cymbopogon excavatus* (Species Group V), *Elionurus muticus, Eragrostis chloromelas* (Species Group X), *Brachiaria serrata, Themeda triandra, Diheteropogon amplectens* and *Setaria sphacelata* (Species Group Y), although not characteristic, do feature prominently throughout this sub community.

3.5 *Hyparrhenia hirta–Trachyandra asperata* Grassland.

This sub community occurs on the gentle (3 - 6 degrees) mostly southern and easterly midslopes of the Ab land type where the soils, whilst still shallow, are slightly deeper than encountered in the *Hyparrhenia hirta–Cyperus rupestris* Grassland sub community with depths of between 350– 450mm occurring.

The underlying geology consists of the Greenstone belts (Serpentines, amphibolites and schists) of the Swazian Erathem, with percentage soil surface rock being low at between 15 – 30%, with moisture present in the soil. Soils are characterized as Sandy loam.

The tree layer is absent from this community, with shrubs accounting for only 10% coverage at maximum heights of 1m. The grass layer dominates the vegetation, with 60% coverage and maximum growth heights of 1.2m being reached. Forbs reach a maximum height of 1m and cover between 30 – 40% of the area.

Species diagnostic of this sub community are listed in Species Group U, and include the moisture loving grass-like perennial herb *Trachyandra asperata* (van Wyk & Malan, 1998) and the grass *Setaria incrassata*. The forbs *Senecio consanguineus* and *Geigeria burkei,* together with the grass *Eragrostis capensis*, whilst characteristic, are not prominent.

Species that feature prominently in this sub community include the shrublets *Ziziphus zeyheriana* (Species Group J) and *Acalypha angustata* (Species Group W), the grasses *Eragrostis curvula* (Species Group N), *Hyparrhenia hirta, Cymbopogon excavatus* (Species Group V), *Cynodon dactylon* (Species Group W), *Elionurus muticus, Eragrostis chloromelas* (Species Group X), *Brachiaria serrata, Setaria sphacelata* and *Trachypogon spicatus* (Species Group Y) and the forb *Helichrysum rugulosum* (Species Group V).

Evidence of previous disturbance exists, and is attested to by the high cover values of certain species known to increase in overgrazed and disturbed areas (van Outshoorn, 1999) and these include the grass *Elionurus muticus* (Species group X).

4.3. **References**

BEZUIDENHOUT, H.; BREDENKAMP, G.J. & THERON, G.K. 1994. A classification of the vegetation of the western Transvaal dolomite and chert grassland, South Africa. *South African Journal of Botany,*1994. 60(3): 152-161.

BREDENKAMP, G.J. & BROWN, L.R. 2003. A reappraisal of Acocks' Bankenveld: Origin & diversity of Vegetation Types. *South African Journal of Botany* 69(1) 7-26.

BROWN, L.R.; MARAIS, H. & BARRETT, L. 2005. Vegetation classification as the basis for baboon management in the Bourke's Luck Section of the Blyde Canyon Nature Reserve, Mpumalanga. *Koedoe* 48(2): 71-92.

COETZEE, B.J. 1974. A Phytosociological classification of the vegetation of the Jack Scott Nature Reserve. *Bothalia* 11: 329-347.

CRADLE OF HUMANKIND MGMT AUTHORITY. 2003. Land Use Audit report. Gauteng Dept. Agriculture, Conservation and Environment, Johannesburg.

EDWARDS, D. 1983. A broad scale structural classification of vegetation for practical purposes. *Bothalia* 14, (3&4): 705-712.

VAN OUTSHOORN, F. 1999. Guide to the grasses of Southern Africa. Briza Publishers, Pretoria.

VAN WYK, A.E., & MALAN, S.J. 1998. Field guide to the wildflowers of the Highveld. 2nd edn. Struik Publishers, Cape Town.

CHAPTER 5

RESULTS AND DISCUSSION- WOODLANDS

5.1. **Introduction**

An analysis of high resolution *Quickbird* satellite images as part of a Land-use audit (Cradle of Humankind 2003) suggested that 28% of the open areas of the COH WHS, or some 12107 hectares was comprised of natural open and dense woodlands of various forms. Whilst this provides at least a basic idea of the vegetative composition of the landscape it does not provide detail as to the ecological integrity, successional stage or physical state of the plant communities located therein. Landscape heterogeneity and climatic variation within the study area have caused a number of habitats to occur within the COH WHS, with ten woodland plant communities being identified as a result

The trees *Celtis africana, Rhoicissus tridentata, Searsia pyroides, Euclea crispa* and *Diospyros lycioides* (Species Group T) feature prominently throughout the woodland section of the study area together with the forbs *Bidens pilosa* and *Tagetes minuta*.

The data analysis and subsequent rearrangement of species in the resultant woodlands table (Table 5.1) produced the following hierarchically arranged plant communities diagnosed according to the various Species Groups.

1. *Zanthoxylum capense–Diheteropogon amplectens* Woodland.
    - 1.1 *Ozoroa paniculosa–Anthephora pubescens* Bush Clumps.
    - 1.2 *Searsia zeyheri–Trachypogon spicatus* Shrubveld.
2. *Acacia caffra–Combretum molle* Bushveld.
3. *Acacia karroo–Teucrium trifidum* Thornveld.

4. *Cussonia paniculata–Celtis africana* Bush Clumps.

   4.1 *Olea europaea* subsp *africana–Diospyros whyteana* Bush Clumps.

   4.2 *Cussonia paniculata–Combretum erythrophyllum* Bush Clumps.

5. *Ficus cordatum– Pappea capensis* Bush Clumps.

6. *Acacia ataxacantha–Celtis africana* Bush Clumps.

5.2. **Description of the Plant Communities**

In the descriptions of the different plant communities, all species groups refer to those defined in table 5.1. Plant communities 5 and 6 are represented by one releve each. These communities are small pockets within the study area that did not allow for more than one sampling plot to be placed within them. They do however form distinct separate communities that warrant their inlclusion in the classification.

1. *Zanthoxylum capense–Diheteropogon amplectens* Woodland.

This major plant community is found on the steep (10 – 25 degrees) north, south, east and west facing midslopes of the Fa and Ib Land types located centrally within the study site. The areas where this community occurs in the Ib Land type are underlain by the Andesites of the Hekpoort group from the Vaalian Erathem, whilst the areas falling within the Fa land type are underlain by the Malmani Dolomites, also of the Vaalian Erathem. Soil forms are variable, however they remain shallow (150 - 350mm) and well drained with Loamy sand soil prevailing. Percentage soil surface rock is high at between 50 – 80%, often with large boulders and rock piles and or chert rock outcrops present.

The vegetative composition of this major community has a well defined tree, shrub, grass and forb layer, with trees accounting for between 40 – 80% coverage, shrubs between 10 – 40% coverage, grasses between 40 -60% coverage and forbs between 15 – 40% coverage.

Maximum heights reached for the tree layer is 10m, with shrubs reaching 2m, grasses reaching 1.2m and forbs reaching 1.2m as well. The species listed in Species Group C are characteristic for this community, and include the grasses *Diheteropogon amplectens, Brachiaria serrata,* the differential species *Fingerhuthia africana* and *Sporobolus pectinatus,* as well as the shrublet *Searsia rigida*, and the forbs *Ruellia cordata, Phyllanthus parvulus, Bulbostylis burchellii, Hermannia depressa, Jamesbrittenia aurantiaca, Cucumis zeyheri, Crabbea angustifolia, Scabiosa columbaria* and *Ipomoea transvaalensis.*

The trees *Zanthoxylum capense* (Species Group R)*, Cussonia paniculosa* (Species Group N)*, Celtis africana, Rhoicissus tridentata* and *Diospyros lycioides* (Species Group T), together with the grasses *Elionurus muticus* (Species Group L), *Setaria sphacelata* and *Eragrostis chloromelas* (Species Group O), *Eustachys paspaloides* and *Heteropogon contortus* (Species Group R) and the forbs *Vernonia oligocephala* and *Ledebouria revoluta* (Species Group L), *Pellaea calomelanos* and *Aloe greatheadii* (Species Group R) as well as *Bidens pilosa* (Species Group T) all feature prominently throughout this major community.

This major community can be further sub divided into two sub communities, namely the *Ozoroa paniculosa–Anthephora pubescens* Bush Clump sub community scattered on North-facing slopes, and the *Searsia zeyheri–Trachypogon spicatus* Shrubveld sub community. The prominence of certain species such as *Searsia pyroides, Celtis africana* and *Diospyros lycioides* (Species Group T) suggest that this community shows an affinity to the *Grewio flavae–Rhoion pyroidis* all.nov. as described by Bredenkamp *et. al.* (1994), with the presence of the characteristic grass species *Fingerhuthia Africana* (Species Group C) perhaps suggesting a preference for this community to occur on those dolomitic areas rich in limestone (van Outshoorn, 1999).

1.1 *Ozoroa paniculosa–Anthephora pubescens* Bush Clumps

This sub community can be found centrally within the study area on the mostly steep (14 – 23 degrees) north facing midslopes of the Fa Land type that are underlain by the Malmani Dolomites. Soils are shallow (150 – 350mm) and covered with a high percentage surface rock at between 40 – 80% and have a relatively low clay content (6-10%) corresponding with the loamy sand soil class description.

The vegetation of this sub community can be broadly described as a mixed woodland, occurring as isolated bush clumps amongst large rocks within a limestone rich rocky grassland context. The tree layer, whilst prominent, accounts for only 5 – 40% coverage and reaches heights of between 2 - 5m. Shrubs reach heights of between 1.5 - 2m and account for between 10 - 20% of the vegetative cover. The grass layer accounts for 60% of the vegetative cover and reaches heights of 1m, with the forb layer experiencing fairly low cover values of just 15% and reaching heights of 0.5m.

This sub community can be characterised through the presence of those species listed in Species Group A, and these include the evergreen tree *Ozoroa paniculosa*, the differential grass species *Anthephora pubescens, Microchloa caffra* and *Stipagrostis uniplumis* and the forbs *Kalanchoe thyrsiflora*, *Cyanotis speciosa* and *Xerophyta retinervis.* The characteristic forb species *Jamesbrittenia burkeana* is also differential. The tree *Euclea natalensis*, the grasses *Schizachyrium sanguineum* and *Triraphis andropogonoides* as well as the forbs *Rhynchosia monophylla* and *Limeum viscosum* do not feature prominently, but remain characteristic of this sub community where they do indeed occur.

The trees *Zanthoxylum capense* (Species Group R), *Celtis africana, Rhoicissus tridentata, Searsia pyroides* and *Diospyros lycioides* (Species Group T), together with the shrub *Searsia rigida* (Species Group C), the grasses *Fingerhuthia africana* (Species Group C), *Melinis nerviglumis* (Species Group E), *Elionurus muticus* (Species Group L), *Setaria sphacelata* and *Eragrostis chloromelas* (Species Group O) and *Eustachys paspaloides* and *Heteropogon contortus* (Species Group R) as well as the forbs *Phyllanthus parvulus* (Species Group C), *Vernonia oligocephala* (Species Group E), *Ledebouria revoluta* (Species Group L) and *Pellaea calomelanos* and *Aloe greatheadii* (Species Group R), whilst not characteristic, do indeed feature prominently throughout this sub community.

It was observed that, whilst the genus *Euclea* is present in both sub communities of the major *Zanthoxylum capense–Diheteropogon amplectens* Woodland, the *Ozoroa paniculosa–Anthephora pubescens* Bush Clump sub community contains only *Euclea natalensis*, whilst the *Searsia zeyheri–Trachypogon spicatus* Shrubveld contains only *Euclea crispa*. The higher cover values for *Fingerhuthia africana* (Species Group C) within the *Ozoroa paniculosa–Anthephora pubescens* Bush Clump sub community could suggest that there is a potentially higher limestone content in the soil which could be acting as a differentiating habitat factor together with the topographical variation in aspect, and is as such, perhaps better suited for the propagation and persistence of *Euclea natalensis* over *Euclea crispa*. This is however untested and would require further investigation.

TABLE 5.1 A Phytosociological table of the Woodland Vegetation of the COH WHS

Community Number	1									2						3					4					5	6
	1.1			1.2																	4.1			4.2			
Releve Number	3	14	27	15	19	58	87	83	88	46	47	48	52	39	45	38	16	69	70	71	84	85	86	90	91	89	37
Species group A																											
Ozoroa paniculosa	a	b	b	a	.	.		.	.	.	.	.	+	+	.	.	.	.	.	.	1	+	.	.	.	.	.
Kalanchoe thyrsiflora	+	+	+	.	.	.		.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	+	.	.	+	.
Anthephora pubescens	.	a	b	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Acalypha villicaulis	.	1	+	.	.	.		.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Microchloa caffra	+	+	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cyanotis speciosa	+	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
James brittenia burkeana	+	.	+	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Xerophyta retinervis	+	.	+	.	.	.	1	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.
Stipagrostis uniplumis	.	.	3	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Euclea natalensis	b	.	.	.	.	.		.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.
Schizachyrium sanguineum	.	1	.	.	.	.		+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rhynchosia monophylla	.	1	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Triraphis andropogonoides	.	1	.	.	+	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Limeum viscosum	.	.	1	.	.	.		.	.	+	.	.	.	.	+	.	.	.	.	.	.	+	.	+	.	.	.
Species group B																											
Trachypogon spicatus	.	.	.	a	3	b		a	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gymnosporia heterophylla	1	.	.	.	1	a	+	a	1	.	.	.	.	.	.	.	.	.	.	+	1	.	+	1	1	.	.
Indigofera cryptantha	.	.	.	1	b	+		.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Lotononis eriantha	.	.	.	r	.	.		+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eragrostis racemosa	.	.	.	.	1	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.
Xerophyta viscosa	.	.	.	.	.	.		+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Indigofera zeyheri	.	.	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Phymaspermum athanasio	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Felicia muricata	.	.	.	+	.	+		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cyperus obtusiflorus	.	.	.	+	+	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sphenostylis angustifolia	.	.	.	+	+	.		.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Stipagrostis zeyheri	.	.	.	+	.	.		.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lippia rehmannii	.	.	.	a	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Halleria lucida	.	.	.	.	.	.		.	a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Andropogon chinensis	.	.	.	1	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Pentanisia angustifolia	.	.	.	1	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Tritonia nelsonii	.	.	.	.	1	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aristida transvaalensis	+	.	.	.	1	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Ximenia caffra	.	.	.	.	.	.		1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Species group C

Ruellia cordata	+	+	.	1	1	.	+	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Diheteropogon amplecter	.	3	.	.	1	1		1	1	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Brachiaria serrata	.	.	1	+	+	.		1	+	.	.	+	.	.	.	.	.	+	.	.	.	+	.	+	.	.	.
Phyllanthus parvulus	+	+	+	+	+	.		.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	+	.
Bulbostylis burchellii	+	.	+	r	+	.		.	+	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	+	.
Searsia rigida	a	.	1	1	1	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Sporobolus pectinatus	+	.	.	1	b	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hermannia depressa	.	+	.	+	1	+		.	.	.	.	.	+	.	.	.	.	r	.	r	+	.	.	.	.	.	.
Fingerhuthia africana	+	.	a	1	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
James brittenia aurantiac	.	.	+	1	.	.		.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cucumis zeyheri	.	+	.	+	.	.		+	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Crabbea angustifolia	.	.	+	+	.	+		.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Scabiosa columbaria	.	+	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Ipomoea transvaalensis	.	.	+	1	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Species group D

Lantana rugosa	+	.	.	+	.	.		.	.	+	+	+	+	+	.	+	+	.	.	.	.	.	.	+	.	.	.
Acacia caffra	.	.	.	.	.	1		.	.	b	a	a	b	a	.	.	.	.	+	.	.	.	.	.	.	.	.
Combretum molle	.	.	.	.	.	.		1	.	1	.	.	1	b	b	.	.	.	.	.	.	.	.	1	.	+	.
Vangueria infausta	.	.	.	.	.	.		.	.	.	1	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Solanum giganteum	.	.	.	.	.	.		.	.	+	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Hermannia floribunda	.	.	.	.	.	.		.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Cyperus esculentus	.	.	.	.	.	.		.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.

Species group E

Athrixia elata	.	.	.	1	+	+		+	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Ziziphus mucronata	.	.	.	.	.	a		.	1	1	.	.	1	.	.	+	.	.	.	+	.	.	+	.	.	+	.
Senecio inornatus	.	.	.	.	.	+	1	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hypoxis rigidula	.	.	.	.	.	+		+	.	.	+	.	+	.	.	.	.	.	.	.	.	+	.	+	.	.	.
Oxalis depressa	.	.	.	.	+	.		+	.	.	+	+	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.
Protea caffra	.	.	.	.	1	.		.	.	.	a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gymnosporia polyacanth	.	.	.	.	.	.		1	.	.	.	a	.	.	.	+	.	.	.	.	.	.	.	1	.	.	.

Species group F

Vernonia oligocephala	.	+	a	+	1	+	1	1	+	.	.	+	+	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Melinis nerviglumis	+	+	.	1	r	+		r	.	.	.	+	+	.	+	.	1	.	.	.	.	.	.	.	.	.	.
Searsia leptodictya	1	.	.	.	.	+		.	.	.	.	+	+	.	.	+	1	.	.	.	a	.	.	.	.	.	.

Species group G																											
Acacia karroo	.	.	.	.	.	.		.	.	.	.	.	.	.	.	b	4	b	b	4	.	.	.	.	.	.	.
Teucrium trifidum	.	.	.	.	.	.		.	.	.	.	.	+	.	.	b	1	+	a	1	.	.	.	.	.	.	+
Oxalis corniculata	.	.	.	.	.	.		.	.	.	.	.	.	.	.	+	.	r	r	+	.	.	.	.	.	.	.
Verbena brasiliensis	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	+	1	+	.	+	.	.	.	.	.
Eragrostis plana	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	r	r	+	.	.	.	.	.	.	.
Paspalum dilatatum	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	r	r	r	.	.	.	.	.	.	.
Asparagus laricinus	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	+	a	.	.	.	.	.	.	.
Ziziphus zeyheriana	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.
Solanum elaeagnifolium	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	r	+	.	.	.	.	.	.	.	.
Hypoxis acuminata	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	r	+	.	.	.	.	.	.	.	.
Olea europa subs. Africana	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	a	.	.	.	.	.	.	.	.	.	.	.
Salvia runcinata	.	.	.	.	.	.		.	.	.	.	.	.	.	.	1	.	.	.	.	+	.	.	.	.	.	.
Species group H																											
Themeda triandra	.	.	.	b	a	b		1	1	.	1	1	a	1	+	3	a	.	.	.	.	+	.	+	.	.	.
Searsia zeyheri	.	.	.	a	a	+	3	3	a	+	1	1	+	1	.	.	1	.	.	.	.	.	.	.	.	.	.
Asparagus suaveolens	.	.	.	.	+	+	1	+	+	+	+	+	+	+	.	1	.	1	.	.	.	.	.	.	.	.	.
Eragrostis curvula	.	.	.	.	.	.		1	+	1	.	.	+	1	.	b	.	r	.	+	.	1	+	+	.	.	.
Species group I																											
Digitaria eriantha	.	.	.	.	.	.		.	.	1	.	+	.	+	+	.	.	.	+	+	.	.	.	.	+	.	.
Cymbopogon plurinodis	.	.	.	.	.	.		.	+	+	+	.	.	.	+	.	.	r	.	+	.	.	.	+	.	.	.
Helichrysum rugulosum	.	.	.	.	.	.		.	.	.	+	+	.	.	.	.	.	+	1	.	.	.	+	+	.	.	.
Solanum panduriforme	.	.	.	.	.	.		.	.	.	.	.	+	1	.	a	.	.	.	.	.	.	.	.	.	.	.
Species group J																											
Diospyros whyteana	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	+	.	.	.	.	a	1	.	.	.	.
Adiantum capillus-venestris	.	.	.	.	.	.		+	+	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	+	.
Searsia dentata	.	.	.	.	.	+		.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.
Hyparrhenia tamba	.	.	.	.	.	.		.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Richardia brasiliensis	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.
Solanum incanum	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	+	r	.	.	.	.	.
Thecacoris trichogyne	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Hermannia transvaalensis	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Scadoxus cyrtanthiflora	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.
Helichrysum caespititium	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Mimulus gracilis	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Species group K																											
Cynodon dactylon	.	.	.	.	.	.		.	.	.	.	.	.	.	.	a	.	.	1	.	1	1	1	.	1	+	.
Hyparrhenia hirta	.	.	.	.	.	.		.	.	.	.	.	+	.	.	.	.	1	1	+	1	+	.	.	.	.	.
Melinis repens	+	.	+	.	.	.		.	+	.	.	.	.	1	.	.	.	+	+	.	r	+	+	.	.	.	.
Conyza podocephala	.	.	.	.	.	.		.	.	.	.	.	+	.	.	+	.	+	+	+	+	.	.	+	.	.	.
Species group L																											
Elionurus muticus	1	+	1	r	+	+		b	+	.	.	+	+	.	.	.	1	1	+	+	+	.	.	.	.	.	.
Ledebouria revoluta	+	r	1	+	+	.	+	r	+	.	+	.	+	+	.	1	.	.	r	+	+	+	.	.	.	+	.

Species groupM

Tarchonanthus camphoratus	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	b	.	.
Opuntia ficus-indica	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	a	.	.
Combretum erythrophyllum	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.
Pseudognaphalium luteo-album	.	.	.	.	.	.		.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	+	.	.
Eragrostis gummiflua	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Asclepias stellifera	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Coccinia sessilifolia	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Ipomoea purpurea	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Wahlenbergia virgata	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Andropogon schirensis	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Ipomoea ommaneyi	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Rhynchosia caribaea	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.

Species group N

Cussonia paniculata	1	.	.	r	1	1		1	+	+	.	+	.	.	.	.	1	.	.	.	1	a	1	b	a	.	.
Olea europaea	b	.	.	.	.	.		3	4	.	.	.	.	.	.	.	.	.	.	.	.	4	a	1	1	.	.
Asparagus setaceus	.	.	.	.	.	.		.	.	.	.	.	.	.	.	+	.	.	.	.	.	a	1	1	1	.	+
Ehretia rigida	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	a	.	1	r	.
Amaranthus hybridus	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.	.

Species group O

Setaria sphacelata	3	1	1	a	a	+		b	1	+	+	a	+	a	+	1	.	+	1	.	1	1	+	+	.	.	.
Eragrostis chloromelas	1	a	a	a	1	.		.	.	.	.	.	+	.	1	a	+	a	+	1	a	1	.	+	+	.	.

Species group P

Ficus cordata subs. Salicifolia	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	
Cyphostemma lanigerum	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	a	.
Pappea capensis	.	.	.	.	.	.		.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	a	.
Chrysopogon serrulatus	.	.	.	a	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Cleome monophylla	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Ipomoea magnusiana	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Leonotis ocymifolia v. Raineriana	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Parinari capensis	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Enneapogon scoparius	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Conyza albida	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.

Species group Q

Bidens bipinnata	.	.	a	.	.	.		.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	1	a	.
Zinnia peruviana	.	r	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.
Schkuhria pinnata	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	+	.	1	.
Rumex crispus	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.
Phyllobolus congestus	.	+	.	.	.	.		.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	+	.

Species group R																											
Zanthoxylum capense	1	.	1	1	1	+	+	1	+	+	.	a	+	.	.	.	1	.	.	.	.	+	1	1	.	1	.
Pellaea calomelanos	+	+	1	.	+	+	+	+	+	+	+	.	+	+	+	.	.	.	.	.	+	+	+	+	+	+	.
Searsia lancea	.	1	.	.	.	.		.	a	+	.	b	.	.	.	1	a	.	.	.	r	+	.	.	3	1	.
Dombeya rotundifolia	.	a	.	.	.	.		.	.	a	.	.	.	b	1	.	3	.	.	.	.	.	1	.	1	1	.
Eustachys paspaloides	1	b	a	1	.	.		1	1	+	.	r	.	a	.	.	.	.	r	.	+	1	+	+	+	.	.
Heteropogon contortus	.	1	1	+	.	1		1	a	1	.	+	1	a	.	.	.	+	+	+	.	.	.	.	+	+	.
Aloe greatheadii	1	+	1	1	a	1		.	.	+	+	+	+	.	.	1	r	.	.	.	.	1	+	+	+	.	.
Lippia javanica	1	.	.	.	.	1		a	+	+	+	+	.	1	+	.	+	.	.	.	.	.	.	.	.	1	.
Species group S																											
Acacia ataxacantha	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	b
Priva cordifolia	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	b
Hypoestes forskaolii	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	a
Commelina benghalensis	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Cuscuta campestris	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Cyperus species	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Species group T																											
Celtis africana	b	1	1	+	.	.	a	a	a	.	.	+	.	.	.	r	1	.	.	+	4	b	4	a	1	1	3
Rhoicissus tridentata	b	1	.	.	a	1	+	1	.	.	.	.	.	.	.	1	.	.	.	.	1	1	a	1	1	+	.
Searsia pyroides	a	.	a	.	a	.		.	.	1	1	1	.	.	1	a	.	1	1	+	a	.	+	a	.	.	+
Bidens pilosa	.	1	.	+	.	+		+	.	+	.	.	+	.	.	.	a	.	.	.	a	a	a	a	1	1	.
Euclea crispa	.	.	.	.	1	+		.	.	1	1	.	1	.	.	.	a	.	.	.	1	1	1	+	a	a	a
Tagetes minuta	+	.	.	.	.	.		.	1	+	.	.	.	.	.	.	.	.	r	.	3	a	a	a	a	a	1
Diospyros lycioides	b	a	.	.	1	+		1	.	.	.	.	.	.	.	a	a	.	.	+	.	.	.	1	+	1	1

1.2 *Searsia zeyheri – Trachypogon spicatus* Open Shrubveld.

This sub community is mostly found on the steep (9 – 25 degrees) scarp and midslopes (Terrain forms 2 and 3) of the Fa and Ib land types underlain by the Malmani Dolomites of the Vaalian Erathem and the Andesites of the Hekpoort group also from the Vaalian Erathem respectively. Aspect is variable, but never north facing, mainly with a southerly, westerly or west southwest orientation. Soil are shallow (150 – 350mm) and covered with a high percentage surface rock at between 40 – 80% , often in the form of Chert or Dolomite outcrops near cave systems and have a relatively low clay content (6-10%) corresponding with the loamy sand soil class description.

This community has the appearance of bush clump “islands” within a typical Rocky grassland landscape. There is a well established tree layer, with heights of up to 10m and up to 80% coverage being reached.

Shrubs account for between 5 – 40% coverage and reach heights of between 1.5 – 2m. The grass layer is less prevalent than in the *Ozoroa paniculosa–Anthephora pubescens* Bush Clump sub community, however the forb layer is more prominent. Grasses reach maximum heights of 1.2m and account for between 30 – 60% cover, whilst forbs reach maximum heights of 1.2m and account for between 20 – 40% of the vegetative cover.

This sub community is characterised by the presence of those species occurring in Species Group B. These include the trees *Gymnosporia heterophylla*, and the non prominent *Ximenia caffra*, which is however differential. The characteristic shrubs *Phymaspermum athanasioides* (found especially amongst the summit rocks of scarps), *Lippia rehmannii* and *Halleria lucida*, whist not prominent throughout this sub community, are differential. The differential grass species *Trachypogon spicatus* and the forb *Indigofera cryptantha* feature prominently as characteristic species (Species Group B). The non prominent grass *Stipagrostis zeyheri* is also differential with the grasses *Eragrostis racemosa, Andropogon chinensis* and *Aristida transvaalensis* featuring as non prominent characteristic species. There are numerous forbs that are both characteristic and differential, and these include *Lotononis eriantha, Xerophyta viscosa, Indigofera zeyheri, Felicia muricata, Cyperus obtusiflorus* (especially around cave entrances) and *Tritonia nelsonii*. The forbs *Sphenostylis angustifolia* and *Pentanisia angustifolia*, whilst neither prominent nor differential, remain characteristic.

Non characteristic species that do however feature prominently throughout this sub community include the trees *Cussonia paniculata* (Species Group N), *Zanthoxylum capense* (Species Group R) and *Diospyros lycioides, Celtis africana* and *Rhoicissus tridentata* (Species Group T) as well as the shrubs *Searsia zeyheri* and *Asparagus suaveolens* (Species Group H). Prominently featuring forbs include *Ruellia cordata* (Species Group C), *Athrixia elata* (Species Group F), *Vernonia oligocephala* (Species Group E) and *Pellaea calomelanos* (Species Group R). The grasses *Diheteropogon amplectens, Brachiaria serrata* and *Sporobolus pectinatus* (Species Group C), as well as *Themeda triandra* (Species Group H), *Elionurus muticus* (Species Group L) and *Eustachys paspaloides* and *Heteropogon contortus* (Species Group R) also feature prominently throughout this sub community.

2. *Acacia caffra–Combretum molle* Rocky Bushveld.

This community occurs on the steep to very steep (11 – 35 degrees) scarps and midslopes of the Ib Land type situated to the North and South of the study area, as well as in isolated instances on the steep slopes (19 – 21 degrees) of the Bb land type amongst large boulders in the East of the study area. The Ib Land type in the North of the study area is underlain by the Andesites of the Vaalian Erathem that are part of the Pretoria Group, whilst the Ib Land type in the South of the study area (which corresponds with the geographical landmark, the "Zwartkop") is also underlain by Andesite, however in this instance from the Randian Erathem from the Ventersdorp Supergroup. The eastern edge of the "Zwartkop", as well as the area to the east of it corresponding to the Ba Land Type is underlain with Gneiss of the Halfway House Granites. This major community is found on all aspects and % soil surface rock is high at between 50 – 90%. Soil is largely shallow (150 – 350mm) and well drained, corresponding largely with the Loamy sand soil description.

The vegetation is dominated by the tree layer, with cover values of between 50 – 90% occurring. The height of the tree layer ranges from 4 – 6m. Shrubs vary between 1.2 – 2m in height and comprise between 30 – 60 % of the vegetative cover of this community. The grass layer reaches heights of 1.2m and ranges between 40 – 60% cover with forbs covering between 15 – 55% of this community and reaching heights of up to 0.5m.

This community is characterised by the presence of species from Species Group D, and include the trees *Acacia caffra* and *Combretum molle*, the shrub *Lantana rugosa* and the forbs *Solanum giganteum, Hermannia floribunda* and *Cyperus esculentus*.

The tree *Dombeya rotundifolia* (Species Group R) together with the shrubs *Searsia zeyheri* (Species Group H) and *Lippia javanica* (Species Group R), the grasses *Themeda triandra* (Species Group H) and *Setaria sphacelata* (Species Group O) and the forb *Pellaea calomelanos* (Species Group R), whilst not characteristic, do indeed feature prominently throughout this community.

3. *Acacia karroo–Teucrium trifidum* Thornveld.

This major community is found on the mostly west facing moderate (10 – 14 degrees) low lying midslopes of the Ab Land type in the south of the study area, as well as in certain west facing bottomlands of the Ib Land type to the north west of the study site. Percentage soil surface rock is low at below 20%, with soil depths being regarded as moderately deep at between 450 – 500mm and are classed as sandy clay loam soils and are distinctively red in colour and appear to be associated with diabase dykes.

This woodland plant community is dominated by woody plants that are in total responsible for over 60% coverage, with the tree stratum reaching heights of between 2 – 10m and covering 30 – 40% of the area and the shrub layer covering 50% of the area and reaching heights of 2m. Grasses reach maximum heights of 1m and cover 30% of the area, with forbs reaching maximum heights of 0.8m and covering 34% of the area.

This major community is characterised by the presence of those species listed in Species Group G. These include the dominant tree *Acacia karroo* and shrublet *Teucrium trifidum*. The less prominent dwarf shrubs *Ziziphus zeyheriana* and *Asparagus laricinus*, together with the forbs *Oxalis corniculata, Verbena brasilliensis, Salvia runcinata, Solanum elaeagnifolium, Paspalum dilatatum* and the tree *Olea europaea subsp. africana* are also characteristic although they do not feature prominently throughout this community.

The tree *Searsia pyroides* (Species Group T), the shrub *Asparagus suaveolens* (Species Group H), the grasses *Hyparrhenia hirta, Cynodon dactylon* (Species Group K), *Elionurus muticus* (Species Group L), *Eragrostis chloromelas* (Species Group O) and *Heteropogon contortus* (Species Group R) as well as the forb *Conyza podocephala* (Species Group K) all feature prominently throughout this community.

The relatively fertile soils and higher moisture retention due in part to the diabase dyke acting as a barrier appear to translate into a higher palatability of available graze and browse placing additional pressure on this plant community through excessive utilization by wildlife. This plant community is similar to the *Acacia karroo–Teucrium trifidum* short closed woodland community as described by Duigan (2003).

4. *Cussonia paniculata–Celtis africana* Bush Clumps.

This major plant community occurs on the higher lying south facing crests, scarps and midslopes of the Fa land type that are underlain by the Malmani Dolomites of the Chuniespoort group from the Vaalian Erathem. Slopes vary with flat to gentle slopes (1 – 9 degrees) occurring when this community is located on the crests and scarps, with moderate to steep slopes (10 – 20 degrees) being encountered when this community is located on midslopes. Percentage soil surface rock is high at between 60 – 80%, comprised mainly of large rock outcrops around cave entrances. Soil is shallow (50 – 150mm) and well drained and correspond to the loamy sand soil description.

The vegetation around these caves presents as an open to dense woodland with the woody plants dominating in terms of both cover and variety with the grass layer being largely underrepresented. The forb layer, although higher in cover than the grass layer, generally has very low species diversity. Trees account for between 80 – 100% of the vegetative cover and reach heights of between 8 and 15m. Shrubs account for between 30 - 50% of the cover and reach heights of 2m. Grasses reach maximum heights of 1m and cover between 5 – 30% of the area whilst forbs cover between 40 – 70% of the area and reach maximum heights of 1m as well.

The trees *Cussonia paniculata, Olea europaea* and *Ehretia rigida* together with the shrub *Asparagus setaceus* and exotic forb *Amaranthus hybridus* are all characteristic species for this major community and are listed in Species Group N.

This community is dominated by the trees *Celtis africana* and *Rhoicissus tridentata* (Species Group T), together with the forbs *Bidens pilosa* and *Tagetes minuta* (Species Group T).

Additional species that feature prominently throughout this community include the trees *Gymnosporia buxiifolia* (Species Group B), *Zanthoxylum capense* (Species Group R), and *Euclea crispa* (Species Group T), the grasses *Eragrostis chloromelas* (Species Group H), *Cynodon dactylon* (Species Group K), *Setaria sphacelata, Eragrostis chloromelas* (Species Group O) and *Eustachys paspaloides* (Species Group R) and the forbs *Pellaea calomelanos* and *Aloe greatheadii* (Species Group R).

Caves are often used as permanent and temporary dwellings by many terrestrial mammals, and a result trampling around these entrances often occurs. This natural disturbance is attested to through the prominent presence of *Amaranthus hybridus* (Species Group N), *Cynodon dactylon* (Species Group K) and the introduced weeds *Tagetes minuta and Bidens pilosa* (Species Group T). Two sub communities can be recognized within this major community, namely the *Olea europaea* subsp *Africana-Diospyros whyteana* Bush Clump sub community and the *Cussonia paniculata–Combretum erythrophyllum* Bush Clump sub community.

4.1 *Olea europaea* subsp. *africana–Diospyros whyteana* Bush Clumps.

This sub community occurs on the flat to gentle (1 – 9 degrees) higher lying south facing crests and scarps of the Fa land type that are underlain by the Malmani Dolomites of the Chuniespoort group from the Vaalian Erathem. Percentage soil surface rock is high at between 60 – 70%, comprised mainly of large rock outcrops around cave entrances. Soil is shallow (50 – 150mm) and well drained and corresponds to the loamy sand soil description.

The vegetation of this sub community is described as open to dense woodland with the woody plants dominating in terms of both cover and variety with the grass layer being largely underrepresented.

The forb layer, although higher in cover than the grass layer, generally still has a low species diversity. Trees account for between 80 – 100% of the vegetative cover and reach heights of between 9 and 15m. Shrubs account for between 30 - 50% of the cover and reach heights of 2m. Grasses reach maximum heights of 1m and cover between 5 – 30% of the area whilst forbs cover between 40 – 70% of the area and reach maximum heights of 1m as well.

This sub community is characterised through the presence of those species listed in Species Group J. These include the trees *Diospyros whyteana* and *Searsia dentata*, along with the grass *Hyparrhenia tamba* and the forbs *Adiantum capillus-veneris, Richardia brasiliensis, Solanum incanum* and *Scadoxus cyrtanthiflorus.*

The vegetation is dominated by the trees *Olea europaea, Cussonia paniculata* (Species Group N), *Celtis africana* and *Rhoicissus tridentata* (Species Group T) and the forbs *Bidens pilosa* and *Tagetes minuta* (Species Group T).

The tree *Euclea crispa* (Species Group T), the grasses *Setaria sphacelata* (Species Group O) and *Cynodon dactylon* (Species Group K) and the forb *Pellaea calomelanos* (Species Group R) all feature prominently throughout this community.

4.2 Cussonia paniculata–Combretum erythrophyllum Bush Clumps.

This sub community occurs on the moderate to steep (10 – 15 degrees) higher lying south facing scarps and midslopes of the Fa land type that are underlain by the Malmani Dolomites of the Chuniespoort group from the Vaalian Erathem. Percentage soil surface rock is high at between 70 - 80%, comprised mainly of large rock outcrops and boulders around cave entrances. Soil is shallow (50 – 150mm) and well drained and corresponds with the loamy sand soil description.

The vegetation of this sub community is described as open to dense woodland with the woody plants dominating in terms of both cover and variety with the grass layer being largely underrepresented. The forb layer, although higher in cover than the grass layer, generally still has a low species diversity. Trees account for between 80 – 100% of the vegetative cover and reach heights of between 8 and 10m.

Shrubs account for between 30 - 40% of the cover and reach heights of 2m. Grasses reach maximum heights of 1m and cover between 10 – 15% of the area whilst forbs cover between 50 – 60% of the area and reach maximum heights of 1m as well.

This sub community is characterised through the presence of the trees *Tarchonanthus camphoratus* and *Combretum erythrophyllum*, the grasses *Eragrostis gummiflua* and *Andropogon schirensis* and the forbs *Pseudognaphaleum luteoalbum, Asclepias stellifera, Coccinia sicifolia, Ipomoea purpurea, Wahlenbergia virgata, Ipomoea ommaneyi* and *Rhynchosia caribaea*, all of which are listed in the characteristic Species Group M.

This sub community is dominated by the trees *Cussonia paniculata* (Species Group N) and *Celtis africana* (Species Group T), together with the forbs *Tagetes minuta* and *Bidens pilosa* (Species Group T).

Prominent species within this community include the trees *Gymnosporia heterophylla* (Species Group B), *Olea europaea* (Species Group N), *Searsia lancea* (Species Group R), *Rhoicissus tridentata, Euclea crispa* and *Diospyros lycioides* (Species Group T) and the shrub *Asparagus setaceus* (Species Group N).

5. *Ficus cordatum–Pappea capensis* Bush Clumps.

This community occurs on the steep (greater than 15 degrees) north easterly facing cliffs along the midslopes of the Ib Land type located centrally within the study area, just south of the interface between the Malmani Dolomites and the Shales of the Timeball Hill sequence of the Pretoria Group. Percentage soil surface rock cover is high (80%) and consists largely of Chert rich rock outcrops and exposed Dolomite, often around cave entrances. Soil is moderately shallow (150 – 300mm) and well drained and corresponds to the loamy sand soil description. The area is underlain by the Malmani Dolomites of the Chuniespoort group from the Vaalian Erathem.

The tree stratum dominates this plant community with 85% coverage and reaches heights of 10m.

Shrubs account for 30% coverage and reach maximum heights of 2m with grasses and forbs covering 10% and 40% of the area respectively, with both reaching a maximum height of 1m.

This community is characterised through the presence of those species listed in Species Group P. These include the trees *Ficus cordata* subsp*. salicifolia, Cyphostemma lanigerum* and *Pappea capensis*, the shrubs *Leonotis ocymifolia v. raineriana* and *Parinari capensis* , the grasses *Chrysopogon serrulatus* and *Enneapogon scoparius* and the forbs *Cleome monophylla, Ipomoea magnusiana* and *Conyza albida.*

This community is dominated by the tree *Euclea crispa* (Species Group T) and the forbs *Bidens bipinnata* (Species Group Q) and *Tagetes minuta* (Species Group T).

Species that feature prominently throughout this community include the trees *Zanthoxylum capense, Searsia lancea, Dombeya rotundifolia* (Species Group R), *Celtis africana* and *Diospyros lycioides* (Species Group T), the aromatic shrub *Lippia javanica* (Species Group R) and the forbs *Zinnia peruviana, Rumex crispus, Schkuhria pinnata* (Species Group Q) and *Bidens pilosa* (Species Group T).

6. *Acacia ataxacantha – Celtis africana* Bush Clumps.

This community is found on the very steep (greater than 25 degrees) drainage line that extends into a riverine area along a south facing crest and midslope interface in the Ib Land type in the far east of the study area (Mogales Gate). This community is underlain by the Shales of the Vaalian Erathem from the Pretoria Group, not far north of the interface between the Pretoria Group's Shales and Andesites. Percentage soil surface rock is very low (Less than 5%) with moderately deep (450 – 500mm) and moist sandy clay loam soils (Soil texture class 4) present along the drainage line.

The vegetation is dominated by the tree layer. Trees cover between 90 – 100% of the area and reach maximum heights of 18m. The shrub and grass layers are virtually absent with each only covering 5% of the area and reaching maximum heights of 1m and 0.3m respectively. There is a well established forb layer which, although lacking in diversity, accounts for 90% coverage, reaching a maximum height of 0.3m.

This community is characterised through the presence of those species listed in Species Group S, which include the tree *Acacia ataxacantha*, the shrub *Priva cordifolia* and the forbs *Hypoestes forskaolii, Commelina benghalensis, Cuscuta campestris* and *Cyperus sp.*

This community is dominated by the trees *Celtis africana* (Species Group T) and *Acacia ataxacantha* (Species Group S) with *Euclea crispa*, *Diospyros lycioides* (Species Group T) and the forb *Tagetes minuta* (Species Group T) featuring prominently.

This community shows an affinity to the *Acacio ataxacanthae-Celtidetum africanae* association as described by Mathews (1991), a community characteristic of valley bottoms and protected areas on valley sides.

5.3. **References**

BEZUIDENHOUT, H.; BREDENKAMP, G.J. & THERON, G.K. 1994. A classification of the vegetation of the western Transvaal dolomite and chert grassland, South Africa. *South African Journal of Botany,* 1994. 60(3): 152-161.

BREDENKAMP, G.J. & BROWN, L.R. 2003. A reappraisal of Acocks' Bankenveld: Origin & diversity of Vegetation Types. *South African Journal of Botany* 69(1) 7-26.

BROWN, L.R.; MARAIS, H. & BARRETT, L. 2005. Vegetation classification as the basis for baboon management in the Bourke's Luck Section of the Blyde Canyon Nature Reserve, Mpumalanga. *Koedoe* 48(2): 71-92.

COETZEE, B.J. 1974. A Phytosociological classification of the vegetation of the Jack Scott Nature Reserve. *Bothalia* 11: 329-347.

CRADLE OF HUMANKIND MGMT AUTHORITY. 2003. Land Use Audit report. Gauteng Dept. Agriculture, Conservation and Environment, Johannesburg.

DUIGAN, P.S & BREDENKAMP, G.J. 2003. The Vegetation Classification of Letamo Estates in North-Western Gauteng. BSc. (Hons) Thesis. University of Pretoria.

EDWARDS, D. 1983. A broad scale structural classification of vegetation for practical purposes. *Bothalia* 14, (3&4): 705-712.

MATHEWS, W.S. 1991. Phytosociology of the North-eastern Mountain sourveld. M.Sc. Dissertation. University of Pretoria. Pretoria.

PALGRAVE, K.C. 2002. Trees of Southern Africa. 3rd edn. Struik Publishers, Cape Town.

VAN OUTSHOORN, F. 1999. Guide to the grasses of Southern Africa. Briza Publishers, Pretoria.

VAN WYK, A.E. & MALAN, S.J. 1998. Field guide to the wildflowers of the Highveld. 2nd edn. Struik Publishers, Cape Town.

VAN WYK, A.E. & VAN WYK, P. 1997. Field guide to the trees of Southern Africa. Struik Publishers, Cape Town.

CHAPTER 6

RESULTS AND DISCUSSION- CAVES

6.1. **Introduction**

During field assessments as part of a study to describe the woody vegetation of the natural areas of the COH WHS, it was noticed that the vegetative composition around caves had a distinctly different appearance than that of the surrounding landscape.

Whilst it is well documented that surface features and land use practices surrounding caves have a marked influence on the underground functioning of that cave system (Gamble 1980), it was questioned whether the opposite could also be true? Could caves also influence surface features such as vegetative structure and functioning, and if so, to what degree?

The surveying of the bio inventory of caves within the Gauteng Province during 2005 and 2006 as conducted by GDACE added well over 240 caves to a database, the overwhelming majority of which are located within the boundaries of the COH WHS. The total contribution that these caves have on the surrounding vegetation should they indeed be found to influence vegetative structure and composition, would therefore be seen to be quite substantial.

Limited sample plots were placed within selected caves due to accessibility constraints and availability thus resulting in some under-sampling. The classification nonetheless still resulted in 7 distinct and different cave entrance zone plant communities being identified that are easily recognizable in the field.

The trees *Celtis africana, Rhoicissus tridentata,* and *Zanthoxylum capense* (Species Group Z) feature prominently throughout the caves zone vegetation of the study site together with the forb *Pellaea calomelanos.*

A data analysis and subsequent rearrangement of species in the resultant caves entrance vegetation table (Table 6.1) produced the following hierarchically arranged plant communities characterised according to the various Species Groups.

1. *Olea europaea* subsp*. africana–Searsia zeyheri* Woodland.

   1.1 *Searsia zeyheri–Gerbera viridifolia* Bush Clumps.

   1.2 *Searsia zeyheri–Elionurus muticus* Woodland.

2. *Celtis africana– Tagetes minuta* Major woodland community.

   2.1 *Celtis africana–Cussonia paniculata* Bush Clumps.

   2.2 *Euclea crispa – Cussonia paniculata* Woodland.

   2.3 *Ficus cordata* subsp. *salicifolia–Euclea crispa* Woodland.

6.2. **Description of the Plant Communities**

In the descriptions of the different plant communities, all species groups refer to those defined in table 6.1.

1. *Olea europaea* subsp*. africana–Searsia zeyheri* Woodland.

This plant community occurs around the cave entrances found on the Chert rich Malmani Dolomites that coincide with the Ib Land type that are centrally located within the study area. This community is found mainly on scarps where slopes are generally steep (9 – 20 degrees) and orientated in a southerly to west south westerly direction with percentage soil surface rock ranging from 70 – 80%. Soil is shallow (300 – 400mm) and freely drained and corresponds to the Loamy sand soil description.

TABLE 6.1: A Phytosociological table of the Cave Entrance Vegetation of the COH WHS

Community	1			2					
	1.1	1.2		2.1			2.2		2.3
Releve No.	5	1	6	2	3	4	8	9	7
SPECIES GROUP A									
Searsia zeyheri	3	3	a	.	.	.	.	.	.
Trachypogon spicatus	1	a	1	.	.	.	.	.	.
Heteropogon contortus	+	1	a	.	.	.	.	+	+
Diheteropogon amplectens	1	1	1	.	+	.	.	.	.
Brachiaria serrata	1	1	+	.	+	.	+	.	.
Vernonia oligocephala	1	1	+	.	.	.	.	.	.
Xerophyta viscosa	1	+	1	.	.	.	.	.	.
Athrixia elata	1	+	+	.	.	.	+	.	.
Asparagus suaveolens	1	+	+	.	.	.	.	.	.
Lotononis eriantha	+	+	+	.	.	.	.	.	.
Ruellia cordata	+	+	+	.	.	.	.	.	.
Aristida meridionalis	1	1	.	.	.	.	.	.	.
Helichrysum cephaloideum	1	+	.	.	+	.	.	.	.
Indigofera zeyheri	1	.	+	.	.	.	.	.	.
Senecio inornatus	1	.	+	.	.	.	.	.	.
Rubia horrida	+	+	.	.	.	.	.	.	.
Stachys natalensis	+	+	.	.	.	.	.	.	.
Indigofera melanadenia	+	.	+	.	.	.	.	.	.
Phymaspermum athanasioides	+	.	+	.	.	.	.	.	.
Becium obovatum	+	r	+	.	.	.	.	.	.
SPECIES GROUP B									
Gerbera viridifolia	1	.	.	.	.	.	.	.	.
Sporobolus pectinatus	+	.	.	.	.	.	.	.	.
Tristachya rehmannii	+	.	.	.	.	.	.	.	.
Acrotome angustifolia	+	.	.	.	.	.	.	.	.
Stipagrostis uniplumis v. Neesii	+	.	.	.	.	.	.	.	.
Loudetia simplex	+	.	.	.	.	.	.	.	.
Aristida diffusa	+	.	.	.	.	.	.	.	.
Xerophyta retinervis	+	.	.	.	.	.	.	.	+
Ipomoea ommaneyi	+	.	.	.	.	.	+	.	.
Convolvulus sagitattus subs. Sagitattus	+	.	.	.	.	.	.	.	.
Chaetacanthus costatus	+	.	.	.	.	.	.	.	.
Helichrysum dasymallum	+	+	.	.	.	.	.	.	.
Nidorella hottentotica	+	.	.	.	.	.	.	.	.
Ledebouria ovatifolia	+	.	.	.	.	.	.	.	.
Rhynchosia totta	+	+	.	.	.	.	.	.	.
Senecio affinis	+	.	.	.	.	.	.	.	.
Chironia palustris	+	.	.	.	.	.	.	.	.
Bewsia biflora	+	.	.	+	.	.	.	.	.
Scabiosa columbaria	+	.	.	.	.	+	.	.	.
Elephantorrhiza elephantina	+	.	.	.	.	.	.	.	.
Eragrostis capensis	+	.	.	.	.	.	.	.	.

SPECIES GROUP C									
Elionurus muticus	.	b	+	+	.	.	.	.	.
Lippia javanica	.	a	+	.	.	.	.	.	1
Halleria lucida	.	.	a	.	.	.	.	.	.
Ximenia caffra	.	1	.	.	.	.	.	.	.
SPECIES GROUP D									
Dovyalis zeyheri	.	1	+	.	1	+	.	.	.
Eragrostis curvula	.	1	+	.	1	+	+	.	.
Adiantum capillus-venestris	.	+	+	.	1	+	.	.	+
SPECIES GROUP E									
Setaria sphacelata	1	b	1	1	1	+	+	.	.
Themeda triandra	b	1	1	.	+	.	+	.	.
Ledebouria revoluta	+	r	+	+	+	.	.	.	+
Pollichia campestris	+	.	+	+	+	.	.	.	+
Hypoxis rigidula	+	+	.	.	+	.	+	.	.
SPECIES GROUP F									
Olea europaea	3	3	4	.	4	a	1	1	.
Gymnosporia heterophylla	+	a	1	1	.	+	1	1	.
SPECIES GROUP G									
Cussonia paniculata	.	1	+	1	a	1	b	a	.
Eustachys paspaloides	.	1	1	+	1	+	+	+	.
Gymnosporia polyacantha	.	1	.	.	.	.	1	.	.
SPECIES GROUP H									
Tagetes minuta	.	.	1	3	a	a	a	a	a
Bidens pilosa	.	+	.	a	a	a	a	1	1
Euclea crispa	.	.	.	1	1	1	+	a	a
Rhus lancea	.	.	a	r	+	.	.	3	1
Ehretia rigida	.	.	.	.	1	a	.	1	r
Cynodon dactylon	.	.	.	1	1	1	.	1	+
SPECIES GROUP I									
Diospyros whyteana	.	.	.	.	a	1	.	.	.
Searsia leptodictya	.	.	.	a	.	.	.	.	.
Ozoroa paniculosa	.	.	.	1	+	.	.	.	.
Hyparrhenia hirta	.	.	.	1	+	.	.	.	.
Searsia dentata	.	.	.	.	+	1	.	.	.
Melinis repens	.	.	+	r	+	+	.	.	.
Scadoxus cyrtanthiflora	.	.	.	.	+	+	.	.	.
Richardia brasiliensis	.	.	.	+	+	.	.	.	.
Grewia occidentalis	.	.	.	.	.	1	.	.	.
Hibiscus aethiopicus	.	.	.	.	.	1	.	.	.
Vangueria infausta	.	.	.	.	1	.	.	.	.
Hyparrhenia tamba	.	.	+	.	1	.	.	.	.
Panicum maximum	.	.	.	.	.	1	.	.	.
Aloe transvaalensis	.	.	.	+	.	.	.	.	.
Conyza podocephala	.	.	.	+	.	.	+	.	.
Cyanotis speciosa	+	.	.	.	1	.	.	.	.

SPECIES GROUP J									
Eragrostis chloromelas	.	.	.	a	1	.	+	+	.
Asparagus setaceus	.	.	.	.	a	1	1	1	.
Searsia pyroides	.	.	.	a	.	+	a	.	.
Acokanthera oppositifolia	.	.	.	.	a	1	.	1	.
Aloe greatheadii	.	.	.	.	1	+	+	+	.
Rhamnus prinoides	.	.	.	1	.	.	1	.	.
SPECIES GROUP K									
Bidens bipinnata	.	.	.	.	.	.	+	1	a
Diospyros lycioides	.	1	.	.	.	.	1	+	1
Dombeya rotundifolia	.	.	.	.	.	1	.	1	1
Rumex crispus	.	.	.	.	.	.	.	+	1
Schkuhria pinnata	.	.	.	.	.	.	+	.	1
Combretum molle	.	1	.	.	.	.	1	.	+
SPECIES GROUP L									
Tarchonanthus camphoratus	.	.	.	.	.	.	.	b	.
Opuntia ficus-indica	.	.	.	.	.	.	.	a	.
Combretum erythrophyllum	.	.	.	.	.	.	+	+	.
Pseudognaphalium luteo-album	.	.	.	.	.	.	+	+	.
Calpurnia villosa	.	.	.	.	.	.	.	1	.
Asclepias stellifera	.	.	.	.	.	.	+	.	.
Coccinia sessilifolia	.	.	.	.	.	.	+	.	.
Ipomoea purpurea	.	.	.	.	.	.	+	.	.
Wahlenbergia virgata	.	.	.	.	.	.	+	.	.
Rhynchosia caribaea	.	.	.	.	.	.	.	+	.
SPECIES GROUP M									
Ficus cordata subs. Salicifolia	.	.	.	.	.	.	.	.	4
Cyphostemma lanigerum	.	.	.	.	.	.	.	.	a
Pappea capensis	.	.	+	.	.	.	.	.	a
Chrysopogon serrulatus	.	.	.	.	.	.	.	.	1
Plectranthus madagascarensis	.	.	.	.	.	.	.	.	1
Setaria lindenbergiana	.	.	.	.	.	.	.	.	1
Cleome monophylla	.	.	.	.	.	.	.	.	+
Ipomoea magnusiana	.	.	.	.	.	.	.	.	+
Leonotis ocymifolia v. Raineriana	.	.	.	.	.	.	.	.	+
Ziziphus mucronata	.	.	1	.	.	+	.	.	+
Parinari capensis	.	.	.	.	.	.	.	.	+
Kalanchoe thyrsiflora	.	.	.	.	.	+	.	.	+
Grewia flava	.	.	.	.	.	.	.	.	+
Eragrostis racemosa	+	.	.	.	.	.	.	.	+
Hibiscus trionum	.	.	.	.	.	.	.	.	r
SPECIES GROUP N									
Celtis africana	a	a	a	4	b	4	a	1	1
Rhoicissus tridentate	+	1	.	1	1	a	1	1	+
Zanthoxylum capense	+	1	+	.	+	1	1	.	1
Pellaea calomelanos	+	+	+	+	+	+	+	+	+
Oxalis tetraphylla	+	.	.	.	+	.	.	.	+

The vegetation of this community is dominated by the tree layer, with individuals attaining heights of between 5 – 10m. The tree coverage is variable but moderate, with percentage coverage varying between 30 – 80%. Shrubs reach maximum heights of 2m and cover between 30 – 40% of the area with the grass layer covering between 30 – 50% of the area and reaching a height of 1.2m. Forbs account for between 20 – 40% coverage and reach maximum heights of 1.2m.

This major plant community is characterised through the presence of those species listed in Species Group A which include the tree *Searsia zeyheri*, the shrubs *Asparagus suaveolens* and *Phymaspermum athanasioides* as well as the grasses *Trachypogon spicatus, Heteropogon contortus, Diheteropogon amplectens, Brachiaria serrata* and *Aristida meridionalis* and the forbs *Vernonia oligocephala, Xerophyta viscose, Athrixia elata, Lotononis eriantha, Ruellia cordata, Helichrysum cephaloideum, Indigofera zeyheri, Senecio inornatus, Rubia horrida, Stachys natalensis, Indigofera melanadenia* and *Becium obovatum*.

This community is dominated by the trees *Olea europaea* (Species Group E) and *Celtis africana* (Species Group N), with the grasses *Setaria sphacelata* and *Themeda triandra* featuring prominently throughout this community.

Two sub communities are found within this major plant community, namely the *Searsia zeyheri–Gerbera viridifolia* Bush Clump sub community and the *Searsia zeyheri–Elionurus muticus* Woodland sub community.

1.1 *Searsia zeyheri–Gerbera viridifolia* Bush Clumps.

This sub community occurs around the caves of the steep (greater than 10 degrees) south facing midslopes of the Ib Land type in the centre of the study area that lie on top of the Malmani Dolomites of the Chuniespoort Sub Group from the Vaalian Erathem. Percentage soil surface rock is high at 80%, consisting mainly of large rock outcrops. Soil is shallow (300 – 400mm) and freely drained and corresponds to the Loamy sand soil description.

The vegetation of this sub community has well defined tree, shrub, grass and forb layers, with the highest coverage occurring within the grass and forb layers respectively. Trees cover 30% of the area and reach maximum heights of 6m. Shrubs reach maximum a height of 2m and cover 30% of the area as well. Grasses account for 50% coverage and reach heights of 1m, with forbs covering 40% of the area and reaching maximum heights of 1m.

This sub community is characterised through the presence of those species listed in Species Group B. These include the shrublet *Elephantorrhiza elephantina*, the grasses *Sporobolus pectinatus, Tristachya rehmannii, Stipagrostis uniplumis v. neesii, Loudetia simplex, Aristida diffusa* and *Eragrostis capensis* as well as the forbs *Gerbera viridifolia, Acrotome angustifolia, Xerophyta retinervis, Ipomoea ommaneyi, Convolvulus sagittatus* subsp *sagittatus, Chaetacanthus costatus, Helichrysum dasymallum, Nidorella hottentotica, Ledebouria ovatifolia, Rhynchosia totta, Senecio affinis, Chironia palustris, Bewsia biflora* and *Scabiosa columbaria.*

This sub community is dominated by the trees *Searsia zeyheri* (Species Group A), *Olea europaea* (Species Group E) and *Celtis africana* (Species Group N) and the grass *Themeda triandra* (Species Group F) with the shrub *Asparagus suaveolens* (Species Group A) and the grasses *Setaria sphacelata* (Species Group F), *Trachypogon spicatus, Diheteropogon amplectens, Brachiaria serrata* and *Aristida meridionalis* (Species Group A) all featuring prominently throughout.

1.2 *Searsia zeyheri–Elionurus muticus* Woodland.

This sub community occurs around the caves of the moderate to steep (10 - 20 degrees) west southwest facing scarps of the Ib Land type in the Centre of the study area that lie on top of the Malmani Dolomites of the Chuniespoort Sub Group from the Vaalian Erathem. Percentage soil surface rock is moderately high at 70 – 75%, consisting mainly of large rock outcrops. Soil is shallow (300 – 400mm) and freely drained and correspond to the Loamy sand soil description.

Trees dominate the vegetation, with the tree layer covering between 60 – 80% of the area and reaching maximum heights of 10m. Shrubs cover between 30 – 40% of the area and reach 2m in height with grasses covering 30% of the area and reaching heights of 1.2m. Forbs reach maximum heights of 1.2m as well, but account for only 20% of the coverage.

Species characteristic for this sub community (Species Group C) include the differential trees *Ximenia caffra* and *Halleria lucida*, with the shrub *Lippia javanica* and the grass *Elionurus muticus.*

The vegetation of this sub community is dominated by the trees *Olea europaea, Gymnosporia buxiifolia* (Species Group E) and *Celtis africana* (Species Group N) and the shrub *Searsia zeyheri* (Species Group A). The grasses *Trachypogon spicatus, Heteropogon contortus, Diheteropogon amplectens* (Species Group A), *Setaria sphacelata, Themeda triandra* (Species Group F) and *Eustachys paspaloides* (Species Group G) all feature prominently throughout this sub community.

2. *Celtis africana–Tagetes minuta* Woodland.

This community occurs around the caves found on the southerly orientated flat (1 – 2 degrees) crests and the moderate to steep (7 – 19 degrees) scarps and midslopes of the Fa Land type underlain by the Malmani Dolomites of the Chuniespoort Sub Group from the Vaalian Erathem, as well as the very steep (23 degrees) northerly orientated midslopes of the Ib Land type that is also underlain by the same Malmani Dolomites. Percentage soil surface rock is moderately high at between 60 – 80%, consisting mainly of large rock outcrops. Soil is very shallow at between 50 – 150mm and corresponds to the Loamy sand soil description.

The vegetation has a well defined tree, shrub, grass and forb layer with the trees dominating in terms of both cover values and height. Trees cover between 80 – 100% of the area and attain maximum heights of between 8 and 15m.

Shrubs reach heights of 2m and cover between 20 – 50% of the area with the grass layer covering between 5 and 30% of the area and reaching maximum heights of 1m. Forbs account for between 40 – 70% cover and reach heights of 1m.

This community is characterised through the presence of the trees *Euclea crispa* and *Searsia lancea,* the deciduous shrub *Ehretia rigida*, the grass *Cynodon dactylon* and the forbs *Tagetes minuta* and *Bidens pilosa* (Species Group H).

The vegetation is dominated by the trees *Celtis africana, Rhoicissus tridentata* (Species Group N) and *Euclea crispa* (Species Group H) and the forbs *Bidens pilosa* and *Tagetes minuta* (Species Group H), with *Pellaea calomelanos* (Species Group N) featuring prominently throughout this community.

There are three sub communities that can be distinguished within this plant community, namely the *Celtis africana–Cussonia paniculata* Bush Clumps, the *Euclea crispa–Cussonia paniculata* Woodland and the *Ficus cordata subs. salicifolia–Euclea crispa* Rocky Woodland.

2.1 *Celtis africana–Cussonia paniculata* Bush Clumps.

This sub community occurs around the caves of the flat and gentle (1 – 7 degrees) southerly orientated crests and scarps of the Fa Land type in the centre of the study area that lies on top of the Malmani Dolomites of the Chuniespoort Sub Group from the Vaalian Erathem. Percentage soil surface rock is moderate at 60 – 70%, consisting mainly of rock outcrops and loose boulders. Soil is shallow (150 – 250mm) and freely drained and corresponds to the Loamy sand soil description.

The vegetation is dominated by the tree layer which reaches heights of between 9 – 15m and covers between 80 – 100% of the area. Area coverage by shrubs ranges between 20 – 50% with individuals reaching maximum heights of 2m. Grasses cover between 5 – 30% of the area and reach heights of 1m, whilst forbs reach heights of between 0.5 – 1m and cover between 40 – 70% of the area.

This sub community is characterised through the presence of those species listed in Species Group I. These include the trees *Diospyros whyteana, Searsia leptodictya* and *Ozoroa paniculosa* as well as the shrubs *Searsia dentata,* and the less prominent *Grewia occidentalis* and *Vangueria infausta*, all of which are considered as differential species for this sub community amongst the cave entrance vegetation communities. The grasses *Hyparrhenia hirta, Melinis repens, Hyparrhenia tamba* and *Panicum maximum* as well as the forbs *Scadoxus cyrtanthiflorus, Richardia brasiliensis, Hibiscus aethiopicus, Aloe transvaalensis, Conyza podocephala* and *Cyanotis speciosa* are also all considered characteristic, albeit that they are not dominant.

The vegetation is dominated by the trees *Celtis africana, Rhoicissus tridentata* (Species Group N), *Olea europaea* (Species Group E) and the forbs *Tagetes minuta* and *Bidens pilosa* (Species Group H). The trees *Cussonia paniculata* (Species Group G) and *Euclea crispa* (Species Group H) together with the grass *Cynodon dactylon* (Species Group H) all feature prominently throughout this sub community.

The presence of certain moisture loving species such as *Hyparrhenia tamba, Panicum maximum* and *Scadoxus cyrtanthiflorus* (Species Group I) on these high lying areas surrounding caves that are nowhere near any discernable water body or soils with high moisture content could suggest that the caves themselves are responsible for “exhaling” moisture rich air from deep underground during the well known phenomenon known as cave breathing whereby temperature differentials between the internal cave environment and outside cause air to be either drawn into or pushed out of the cave.

2.2 *Euclea crispa–Cussonia paniculata* Woodland.

This sub community occurs around the caves of the moderate to steep (9 - 20 degrees) south facing scarps and midslopes of the Fa Land type in the centre of the study area that are underlain with the Malmani Dolomites of the Chuniespoort Sub Group from the Vaalian Erathem.

Percentage soil surface rock is moderately high at 70 – 80%, consisting mainly of large rock outcrops. Soil is shallow (100 – 250mm) and freely drained and corresponds to the Loamy sand soil description.

The vegetation is dominated by a tall, well established tree stratum which covers between 80 – 100% of the community and reaches heights of between 8 – 10m. Shrubs cover between 30 – 40% of the area and reach a maximum height of 2m with grasses accounting for between 10 – 15% coverage and reaching heights of 1m. The forb layer covers between 50 – 60% of the area and reaches a maximum height of 1m.

The species belonging to Species Group L are diagnostic for this sub community and they include the trees *Tarchonanthus camphoratus* and *Combretum erythrophylla* as well as the forbs *Asclepias stellifera, Pseudognaphaleum luteoalbum, Culpurnia villosa, Coccinia sessifolia, Wahlenbergia virgata, Rhynchosia caribaea* and the exotic *Opuntia ficus-indica* and *Ipomoea purpurea.*

The tree *Cussonia paniculata* (Species Group G) and the forb *Tagetes minuta* (Species Group H) dominate the vegetation of this sub community, with the trees *Olea europaea, Maytenus heterophylla* (Species Group E), *Celtis africana* and *Rhoicissus tridentata* (Species Group N), the shrub *Asparagus setaceus* (Species Group J), and the forb *Bidens pilosa* (Species Group H) all featuring prominently throughout this sub community.

The presence of the moisture preferring tree *Combretum erythrophylla* and forb *Pseudognaphaleum luteoalbum* (Species group L) could once again indicate that the caves themselves are responsible for “Exhaling” moisture rich air from deep underground as there is no nearby water body or moisture rich soils. This could be occurring during the well known phenomenon termed cave breathing, whereby temperature differentials between the internal cave environment and outside cause air to be either drawn into or pushed out of the cave.

2.3 *Ficus cordata* subsp*. salicifolia–Euclea crispa* Woodland

This sub community occurs around the caves located on the very steep (23 degrees) northerly orientated midslopes of the Ib Land type that is underlain by the Malmani Dolomites of the Chuniespoort Sub Group from the Vaalian Erathem. Percentage soil surface rock is high at 80%, consisting mainly of large rock outcrops and Chert boulders. Soils are very shallow at between 50 – 150mm and correspond to the Loamy sand soil description.

The vegetation comprises well established tree, shrub, grass and forb strata with the tree stratum dominating. Trees cover 85% of the sub community and reach heights of 10m with shrubs covering 30% of the area and reaching maximum heights of 2m. The grass stratum reaches heights of 1m and covers 10% of the area with the forbs covering 40% of the area and also reaching maximum heights of 1m.

This sub community is characterised through the presence of the trees *Ficus cordata subsp. salicifolia, Pappea capensis, Parinari capensis* and *Ziziphus mucronata*, the shrubs *Plectranthus madagascariensis* var*. ramosa, Leonotis ocymifolia v. raineriana* and *Grewia flava*, the grasses *Chrysopogon serrulatus, Setaria lindenbergiana* and *Eragrostis racemosa* as well as the forbs *Cyphostemma lanigerum, Cleome monophylla, Ipomoea magnusiana, Kalanchoe thyrsiflora* and *Hibiscus trionum.*

The vegetation of this sub community is dominated by the trees *Ficus cordata s. salicifolia, Pappea capensis* (Species Group M) and *Euclea crispa* (Species Group H) as well as the bushy perennial *Cyphostemma lanigerum* (Species Group M). The trees *Searsia lancea* (Species Group H), *Diospyros lycioides, Dombeya rotundifolia* (Species Group K), *Celtis africana* and *Zanthoxylum capense* (Species Group N) are all prominent species within this sub community.

6.3. **The Influence of Cave entrance size on the surrounding Vegetation**

From the nine cave entrances sampled, entrance diameters ranging from 0.5m to 10m (Table 6.2) were encountered and incorporated into the analysis of influence.

Whilst it is understood that subterrainean systems are incredibly complex (Gamble, 1980), with many variables involved that influence their functioning, such as underground void volume, cave type (Sack Type or Open), depth of cave etc., only entrance size was used for purposes of this study and purposes of comparison. Profile diagrams drawn from the belt transects placed out from the centre of each cave entrance along the left and right contours as well as the upslope and downslope, appear to suggest that the areas closest to the cave entrances generally have a higher density and maximum height of woody vegetation. The woody plants at cave entrances also appear to have much larger canopies than those further away from the cave entrances.

Table 6.2: Cave entrance sizes.

Cave number	Cave entrance size (m)
1	1.5
2	1
3	6
4	2
5	0.5
6	2.5
7	10
8	1.5
9	3.5

The entrance to Cave 1, measuring 1.5m in diameter is located within the *Searsia zeyheri–Elionurus muticus* Woodland. The extent of woody plant occurrence, diminishing with increased distance from the cave entrance is illustrated in Figure 6.1.

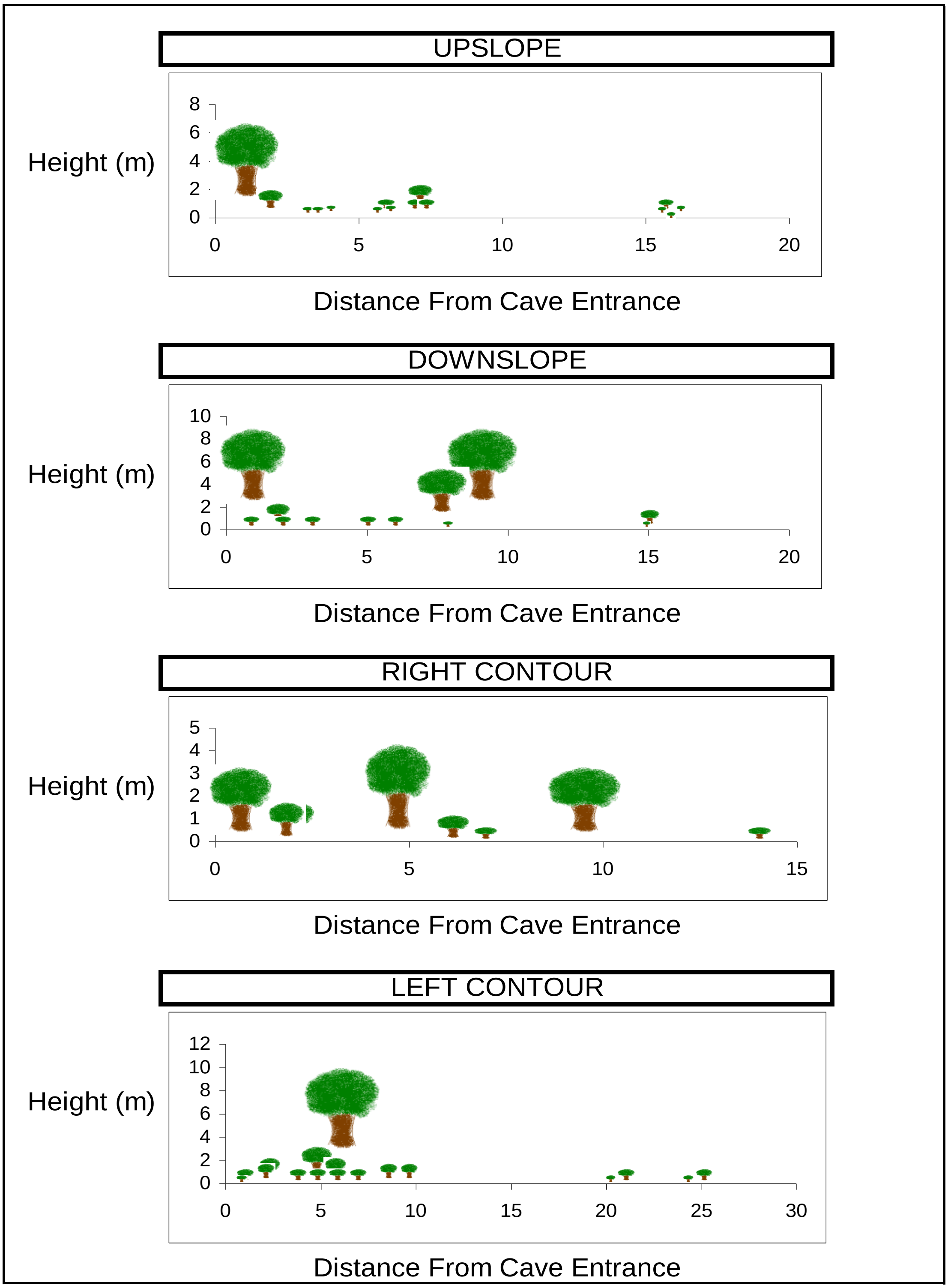


Figure 6.1: The Extent of Woody Vegetation around the entrance of Cave 1.

The entrance to Cave 2, measuring 1m in diameter is located within the *Celtis africana–Cussonia paniculata* Bush Clumps. The extent of woody plant occurrence, diminishing with increased distance from the cave entrance is illustrated in Figure 6.2.

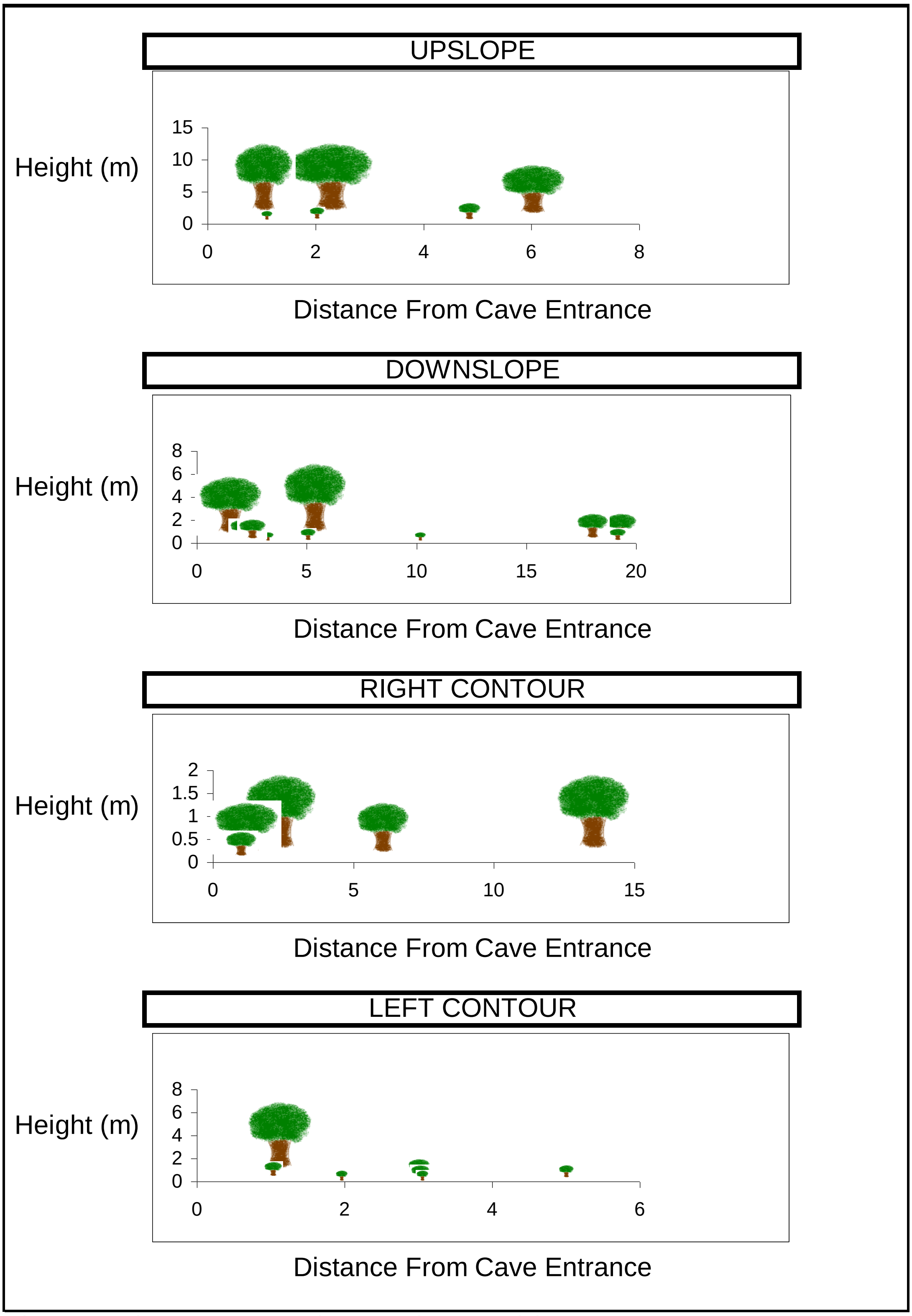


Figure 6.2: The Extent of Woody Vegetation around the entrance of Cave 2.

The entrance to Cave 3, measuring 6m in diameter is also located within the *Celtis africana–Cussonia paniculata* Bush Clumps. The extent of woody plant occurrence, diminishing with increased distance from the cave entrance is illustrated in Figure 6.3.

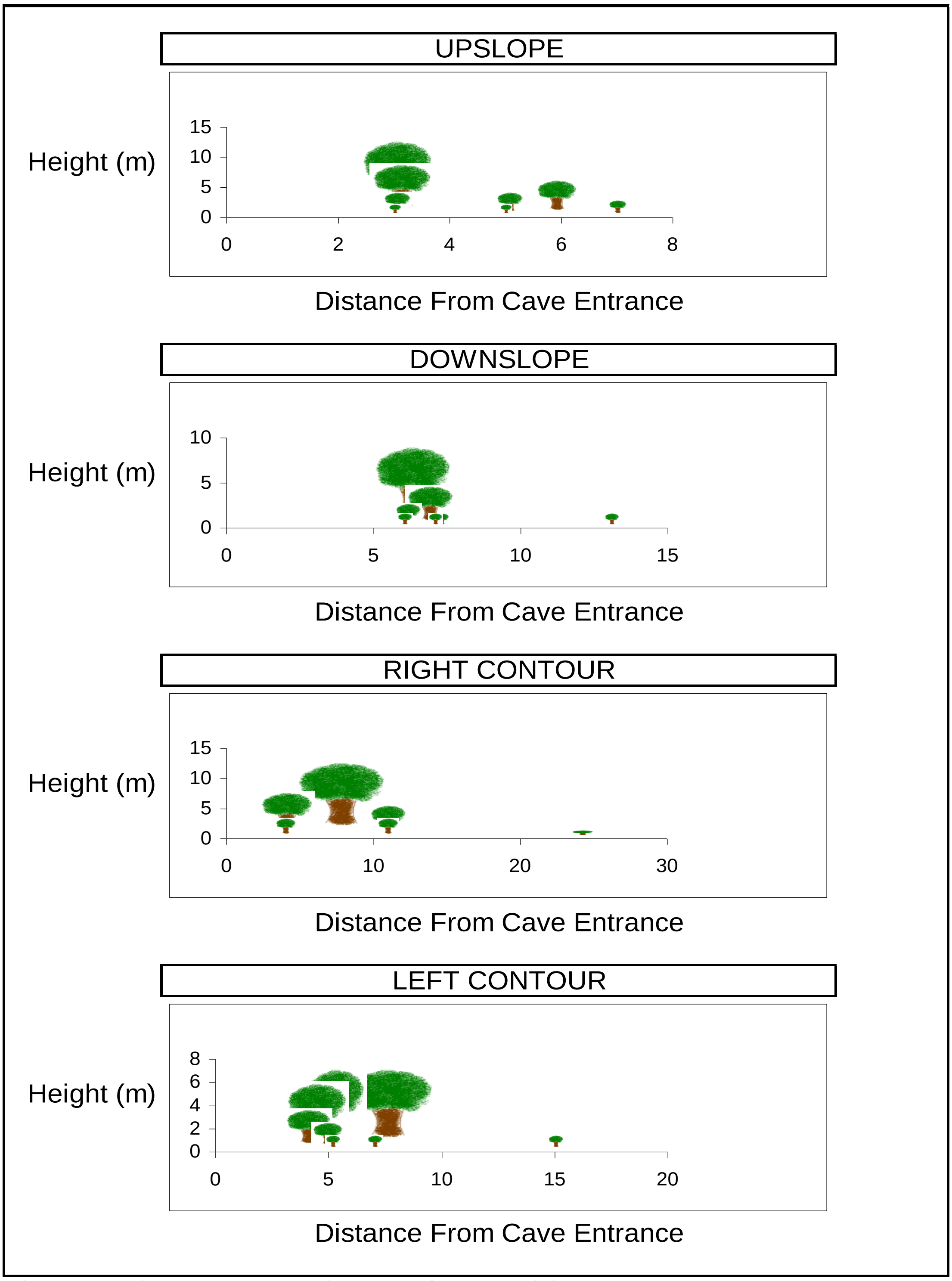


Figure 6.3: The Extent of Woody Vegetation around the entrance of Cave 3.

The entrance to Cave 4, measuring 2m in diameter is also located within the *Celtis africana–Cussonia paniculata* Bush Clumps. The extent of woody plant occurrence, diminishing with increased distance from the cave entrance is illustrated in Figure 6.4.

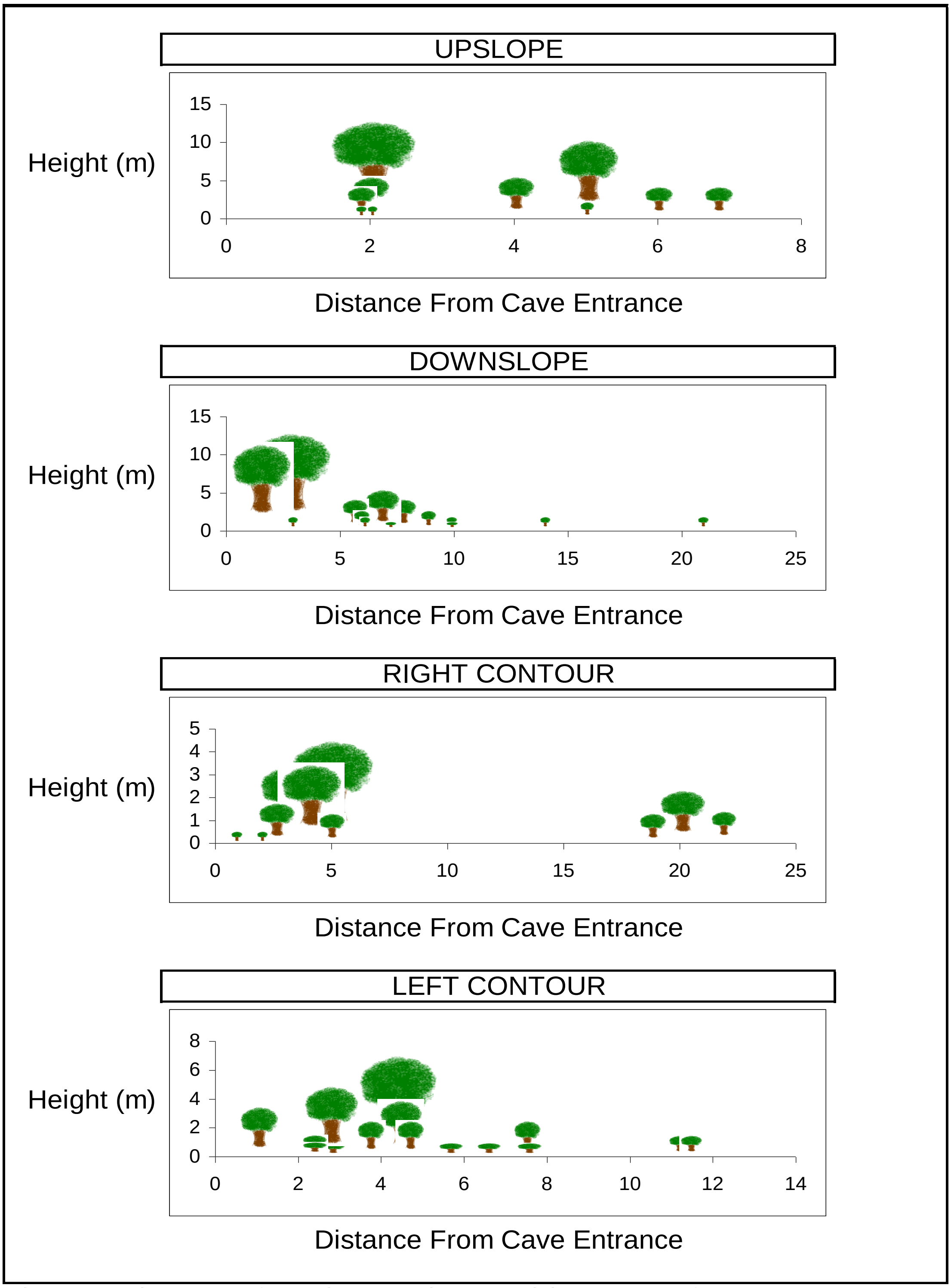


Figure 6.4: The Extent of Woody Vegetation around the entrance of Cave 4.

The entrance to Cave 5, measuring 0.5m in diameter is located within the *Searsia zeyheri–Gerbera viridifolia* Bush Clumps. The extent of woody plant occurrence, diminishing with increased distance from the cave entrance is illustrated in Figure 6.5.

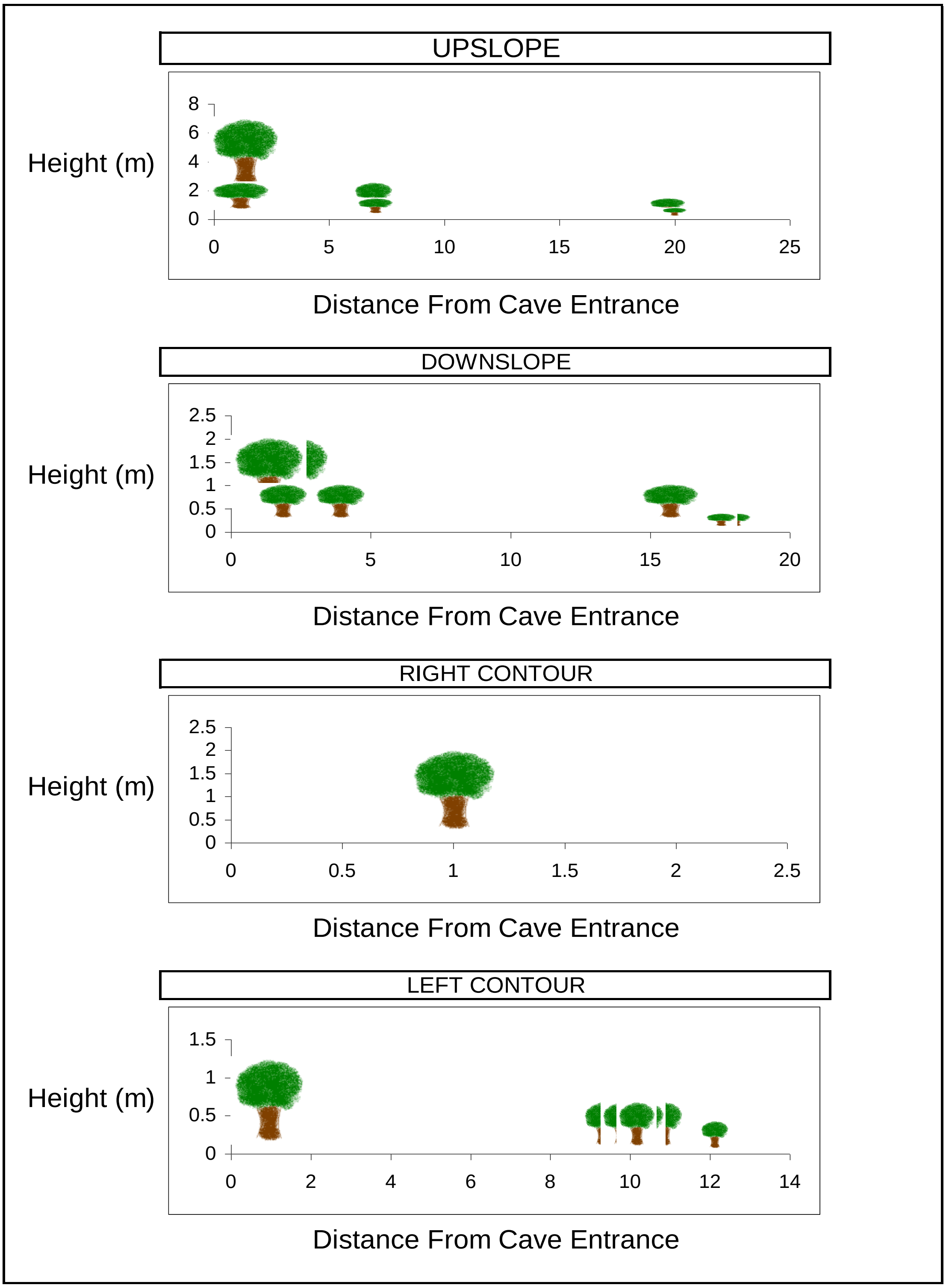


Figure 6.5 The Extent of Woody Vegetation around the entrance of Cave 5.

The entrance to Cave 6, measuring 2.5m in diameter is located within the *Searsia zeyheri–Elionurus muticus* Woodland. The extent of woody plant occurrence, diminishing with increased distance from the cave entrance is illustrated in Figure 6.6.

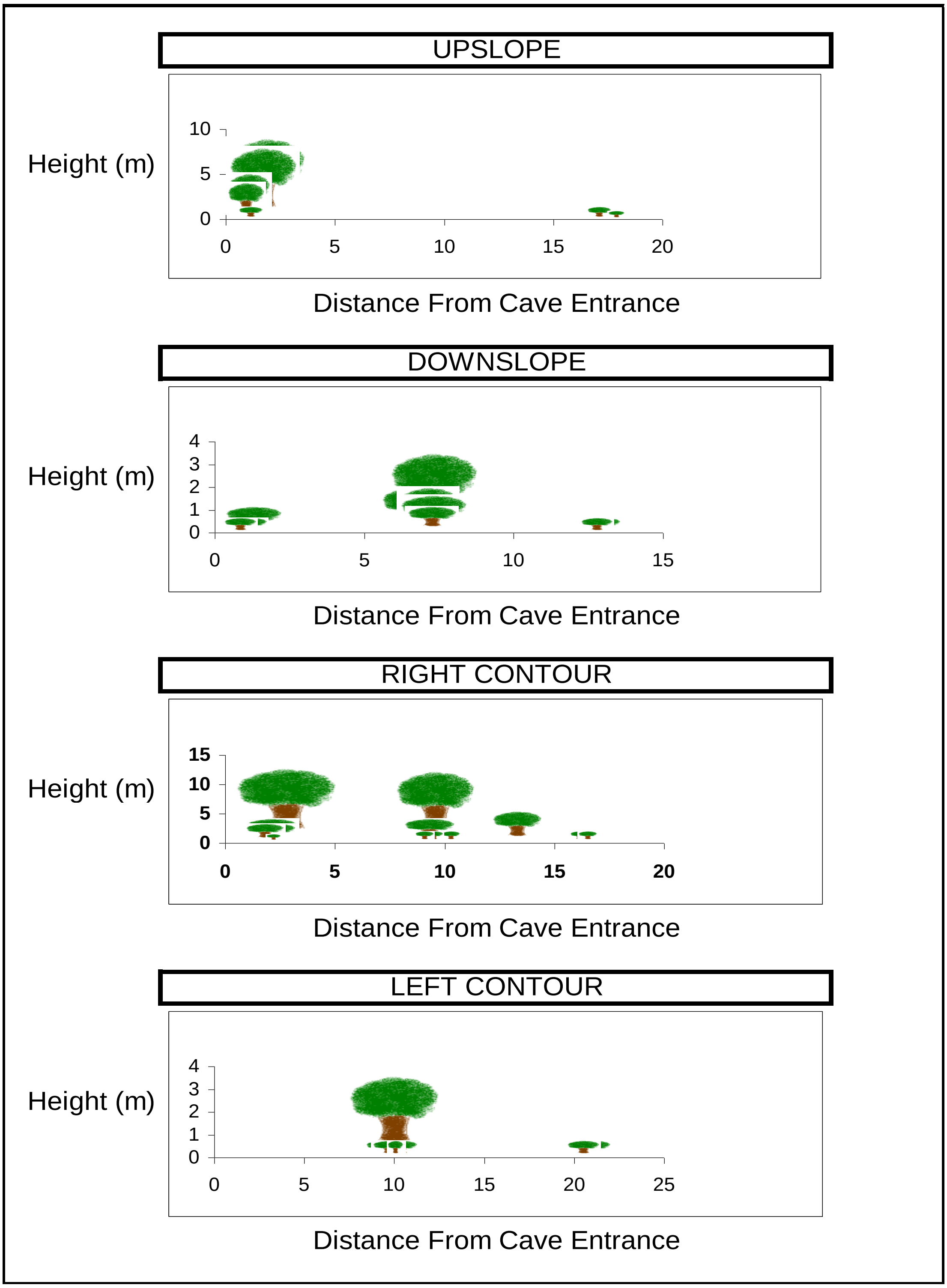


Figure 6.6 The Extent of Woody Vegetation around the entrance of Cave 6.

The entrance to Cave 7, measuring 10m in diameter is located within the *Ficus cordata subsp. salicifolia–Euclea crispa* Woodland. The extent of woody plant occurrence, diminishing with increased distance from the cave entrance is illustrated in Figure 6.7.

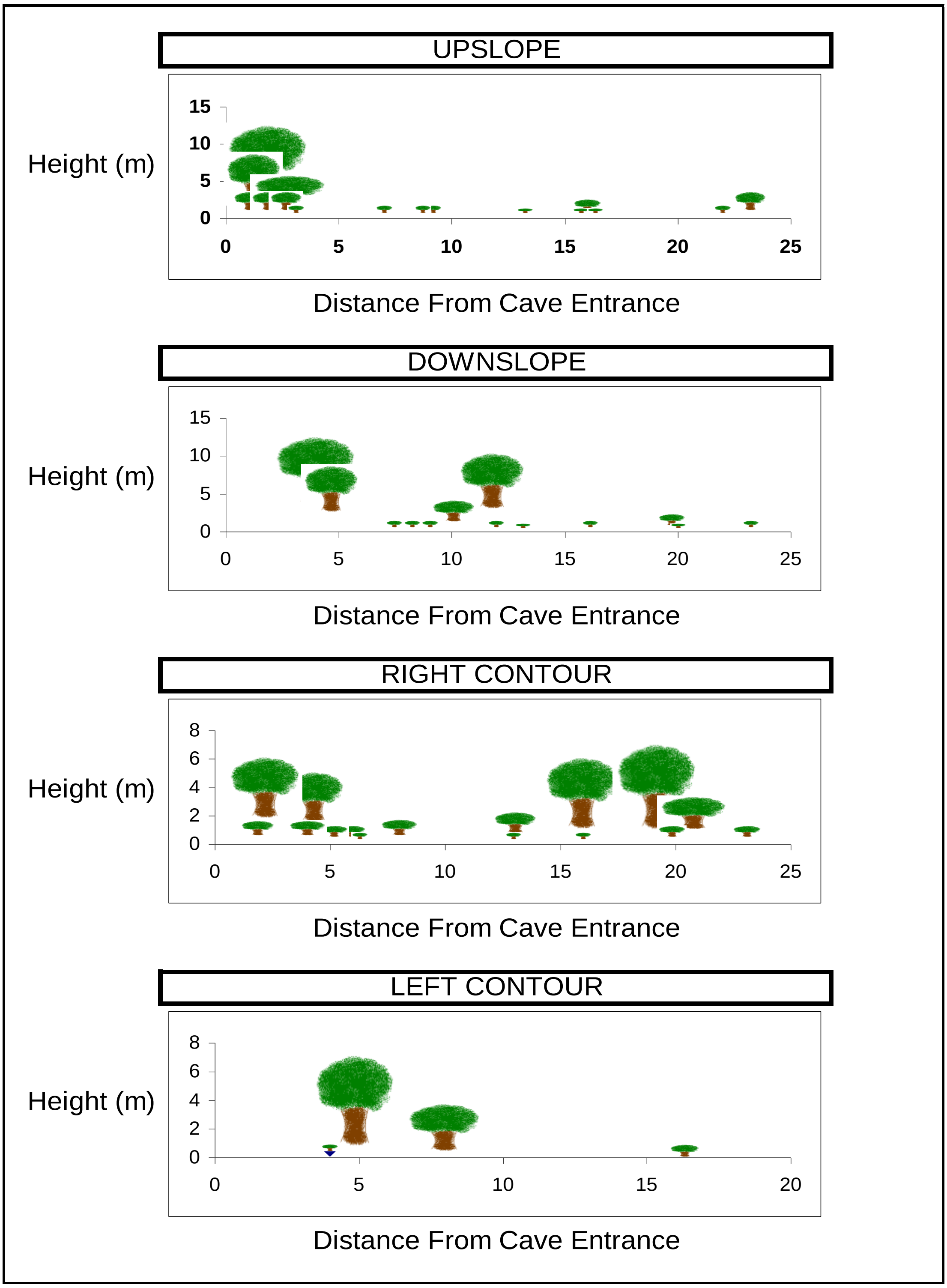


Figure 6.7 The Extent of Woody Vegetation around the entrance of Cave 7.

The entrance to Cave 8, measuring 1.5m in diameter is located within the *Euclea crispa–Cussonia paniculata* Woodland. The extent of woody plant occurrence, diminishing with increased distance from the cave entrance is illustrated in Figure 6.8.

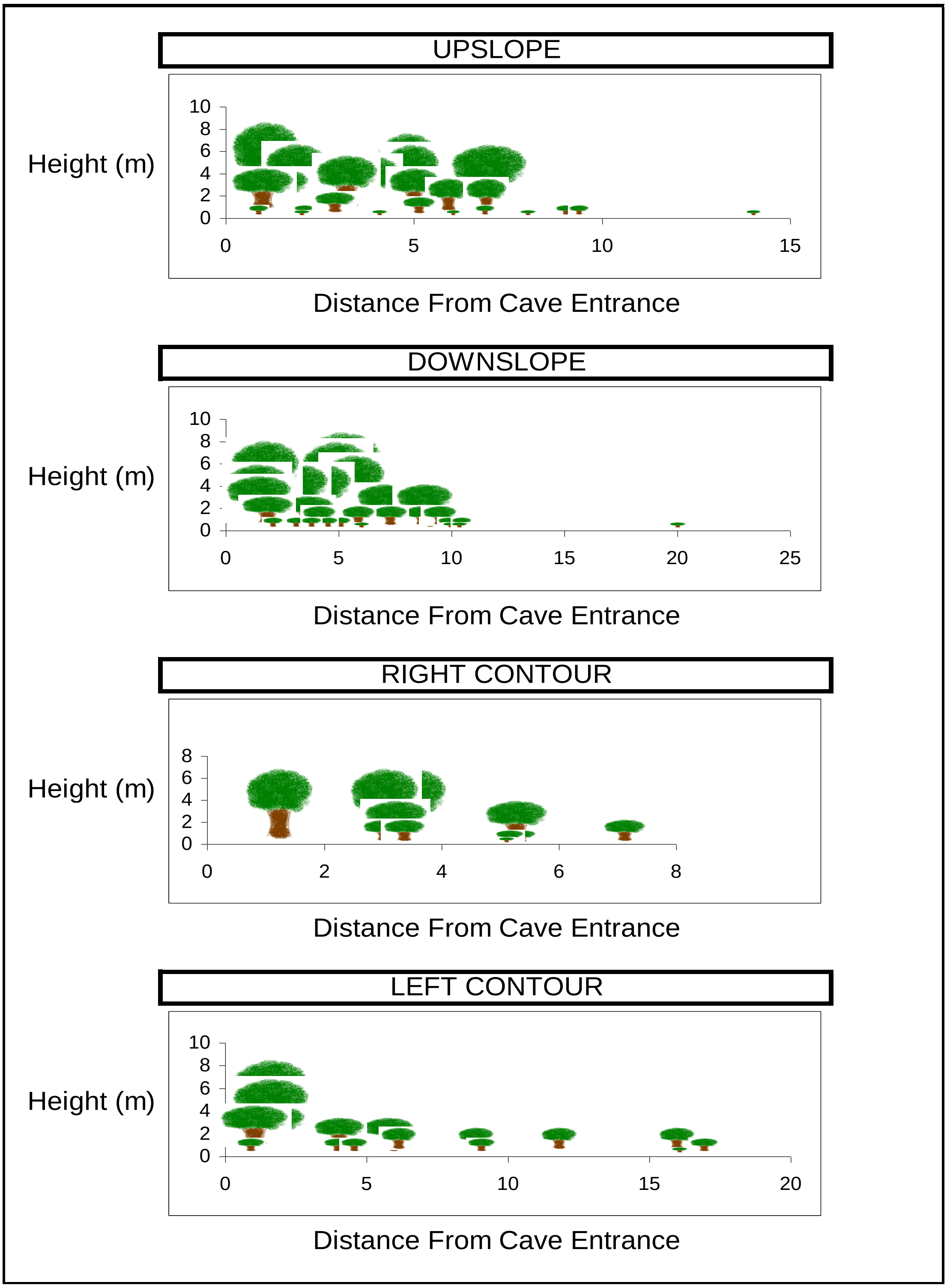


Figure 6.8 The Extent of Woody Vegetation around the entrance of Cave 8.

The entrance to Cave 9, measuring 3.5m in diameter is also located within the *Euclea crispa– ussonia paniculata* Woodland. The extent of woody plant occurrence, diminishing with increased distance from the cave entrance is illustrated in Figure 6.9.

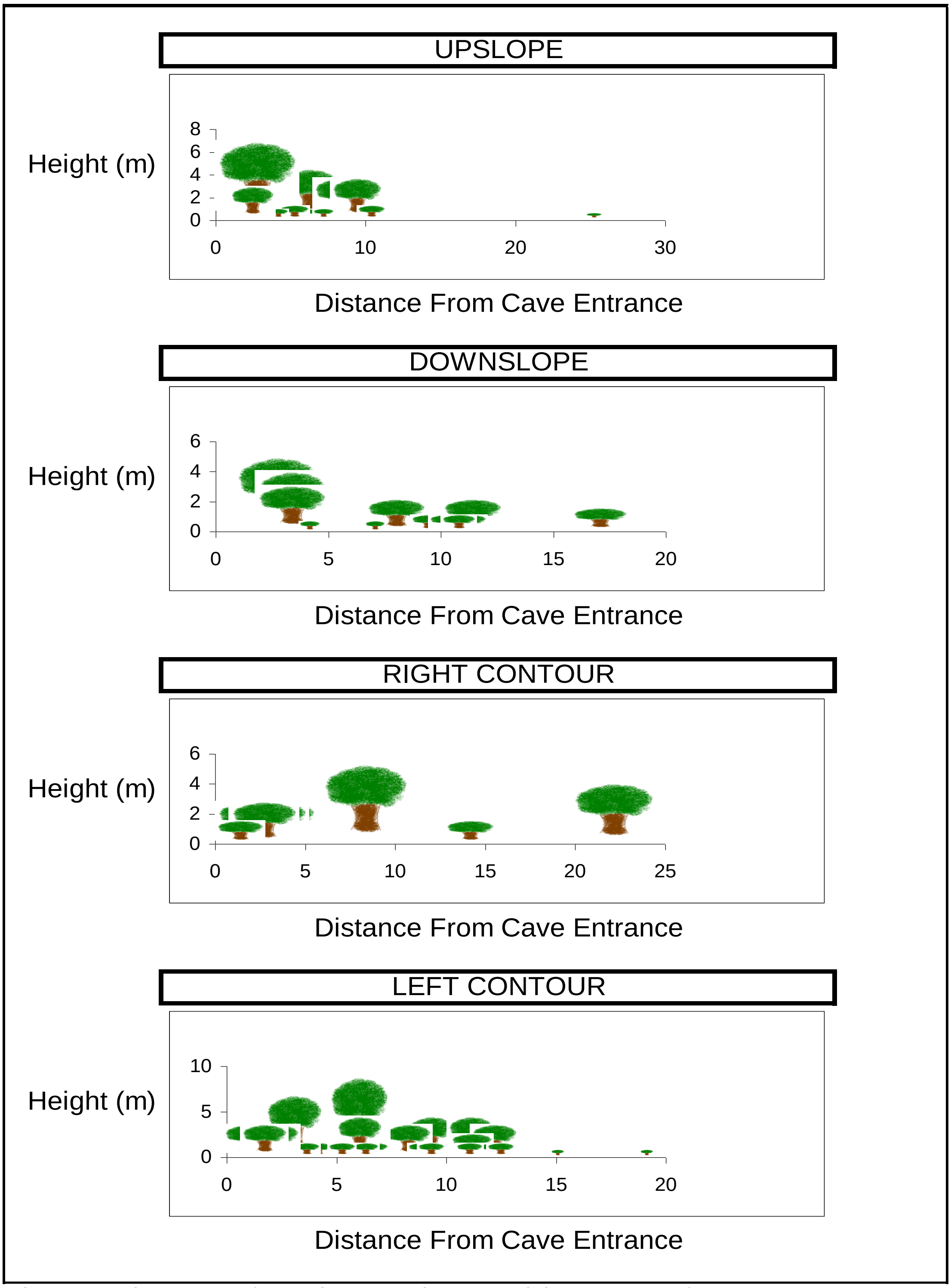


Figure 6.9 The Extent of Woody Vegetation around the entrance of Cave 9.

For purposes of this initial comparative analysis between cave entrance size and the extent to which this influences the surrounding vegetation, the extent to which woody vegetation was still encountered from each respective cave entrance was accepted as an indicator of influence.

The last woody plant encountered within 20m of the previous woody plant was taken to be the final extent, that is to say that if only herbaceous plants were encountered from a woody plant last measured at 7m for example up until the next encountered only at 30m away, the maximum distance considered for that cave would remain 7m. In order to obtain at least a basic statistical means of verification of influence of cave entrance size on the surrounding vegetation, the mean linear extent of woody vegetation occurrence from each cave entrance (obtained whereby the Upslope, Downslope, Left Contour and Right Contour distances were averaged) was calculated (Table 6.3) and thereafter correlated (Pearson product moment correlation coefficient) against the cave entrance sizes.

Table 6.3: The Mean Extent of Woody Vegetation Occurrence per Cave.

Cave	Cave Entrance Size (m)	Upslope (m)	Downslope (m)	Contour (L) (m)	Contour (R) (m)	Mean (m)
1	**1.5**	16	15	14	25	**17.5**
2	**1**	6	19	13	5	**10.75**
3	**6**	7	13	24	15	**14.75**
4	**2**	7	21	22	12	**15.5**
5	**0.5**	20	18	1	12	**12.75**
6	**2.5**	18	13	0	21	**17.33333**
7	**10**	23	23	23	16	**21.25**
8	**1.5**	14	21	7	17	**14.75**
9	**3.5**	25	17	22	19	**20.75**

This basic correlation analysis between the mean measurement of woody vegetation extent and cave entrance size yielded a result of r= 0,633418. This verifies statistically that there is a fairly strong positive linear correlation between the size of the cave entrances and the distance to which the woody vegetation surrounding these cave entrances extends, suggesting the likelihood of a positive influence of cave entrance size on the surrounding vegetation. The smaller cave entrances therefore coincided with the lowest mean extent of woody vegetation occurrence from cave entrances and the larger cave entrance sizes coincided with the highest extent of woody vegetation occurrence from cave entrances (Figure 6.3). For example, cave 2 with an entrance diameter of only 1 meter was found to coincide with woody vegetation that extended for an average of 10.75 meters whilst cave 7 with an entrance diameter of 10 meters was found to coincide with woody vegetation that extended for an average of 21.25 meters.

This relationship of influence is further illustrated in figure 6.10 wherein the mean extent of woody vegetation occurrence (x-axis) is plotted against each of the 9 cave entrance size diameters (y-axis), with the trend line clearly indicating the relationship whereby the extent to which Woody vegetation is encountered increases with an increase in cave entrance size.

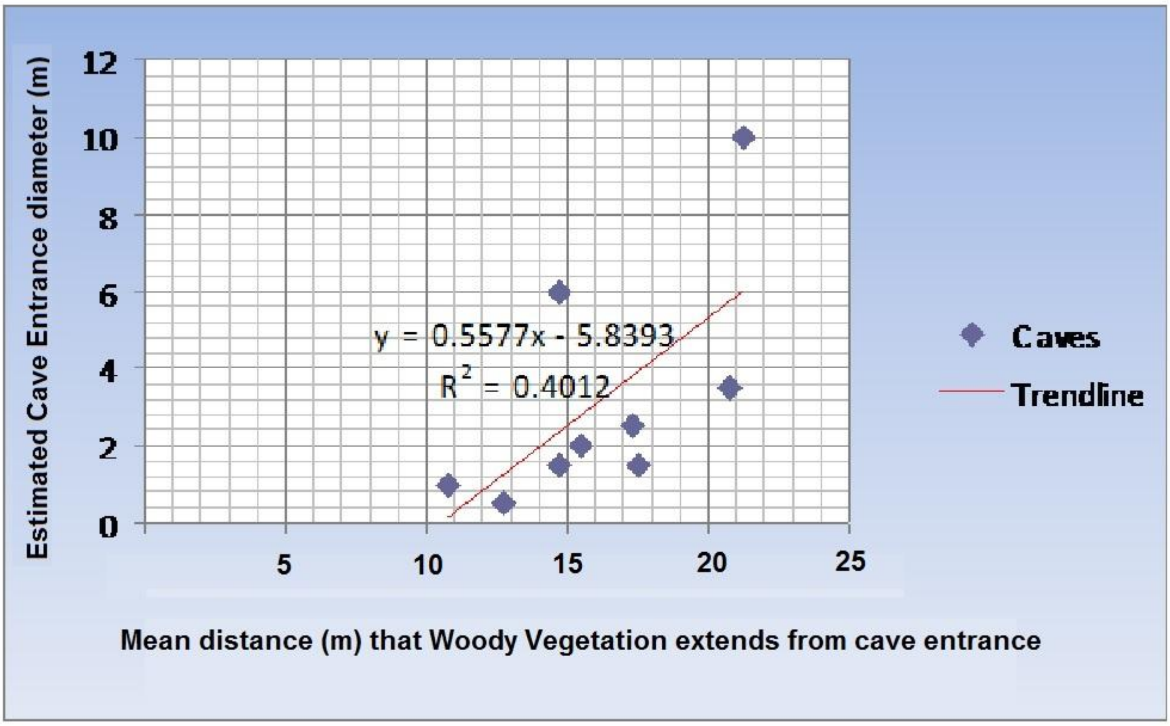


Figure 6.10: A Graphical Representation of the Relationship between Cave Entrance size and the extent of Woody Plant occurrence.

6.4. **References**

BEZUIDENHOUT, H.; BREDENKAMP, G.J. & THERON, G.K. 1994. A classification of the vegetation of the western Transvaal dolomite and chert grassland, South Africa. *South African Journal of Botany,* 1994. 60(3): 152-161.

BREDENKAMP, G.J. & BROWN, L.R. 2003. A reappraisal of Acocks' Bankenveld: Origin & diversity of Vegetation Types. *South African Journal of Botany* 69(1) 7-26.

BROWN, L.R.; MARAIS, H. & BARRETT, L. 2005. Vegetation classification as the basis for baboon management in the Bourke's Luck Section of the Blyde Canyon Nature Reserve, Mpumalanga. *Koedoe* 48(2): 71-92.

COETZEE, B.J. 1974. A Phytosociological classification of the vegetation of the Jack Scott Nature Reserve. *Bothalia* 11: 329-347.

CRADLE OF HUMANKIND MGMT AUTHORITY. 2003. Land Use Audit report. Gauteng Dept. Agriculture, Conservation and Environment, Johannesburg.

DUIGAN, P.S & BREDENKAMP, G.J. 2003. The Vegetation Classification of Letamo Estates in North-Western Gauteng. Bsc. (Hons) Thesis. University of Pretoria.

EDWARDS, D. 1983. A broad scale structural classification of vegetation for practical purposes. *Bothalia* 14, (3&4): 705-712.

GAMBLE, F.M. 1980. Disturbance of underground wilderness in karst caves. *Intern. J. Environmental Studies.1981.* Vol. 18. pp. 33-39.

MATTHEWS, W.S. 1991. Phytosociology of the North-eastern Mountain sourveld. M. Sc. Dissertation. University of Pretoria. Pretoria.

PALGRAVE, K.C. 2002. Trees of Southern Africa. 3rd edn. Struik Publishers, Cape Town.

VAN OUTSHOORN, F. 1999. Guide to the grasses of Southern Africa. Briza Publishers, Pretoria.

VAN WYK, A.E. & MALAN, S.J. 1998. Field guide to the wildflowers of the Highveld. 2nd edn. Struik Publishers, Cape Town.

VAN WYK, A.E. & VAN WYK, P. 1997. Field guide to the trees of Southern Africa. Struik Publishers, Cape Town.

CHAPTER 7

CONCLUSIONS

7.1. **Summary**

The classification of vegetation into relatively homogenous units or plant communities remains the fundamental requirement in the application of resource management practices to any given area as these communities represent ecosystems. Each ecosystem has its own unique thresholds and tolerances. Habitat factors play an important role in the determination of where these communities will persist and conversely where they will be restricted.

Anthropogenic influence, as well as abiotic processes such as fire and climate can further diversify the landscape, thereby adding to the segregating effect that naturally occurring structural environmental factors (geology, soil and topography etc.) already have on the spatial location of plant communities. The degree to which this segregation is investigated, and the associated plant communities are described is directly proportional to the required management associated objectives for the area thereby requiring the correct application of scale into any floristic assessment undertaken.

The objectives of this study, namely to classify and describe the natural vegetation of the COH WHS on a suitably useful local scale, to relate the different plant communities identified to Land Types and to establish whether caves influence the composition and structure of the vegetation surrounding the entrances of the caves were successfully met.

Sampling through the application of the habitat stratification method as described by Bezuidenhout (1993) that originally used Land Types as a primary method of stratification further refined using terrain units was successfully used, albeit that it was adapted further through the application of modern GIS and GPS techniques to aid with in-field sample site placement. The resultant stratified random approach to sampling (Werger 1973) ensured statistical acceptability.

The use of the numerical classification technique TWINSPAN (Hill. 1979) as a first approximation of the vegetation units, followed by further refinement using Braun-blanquet procedures as previously used by Fuls (1993), Coetzee (1993) and Bezuidenhout (1993) proved to be highly successful, with twenty nine plant communities and two variants being identified in the COH WHS. The described plant communities can be easily recognised in the field, with the resultant ecological units being regarded as scientifically sound and therefore useful in any land use planning exercise. They should form the first point for departure in the establishment of a long term monitoring and evaluation program as required in terms of World Heritage Site reporting mechanisms.

Within the grassland communities a total of 12 plant communities were identified with 2 variants. The spatial distribution of the major communities is largely associated with the location of various abiotic factors linked to land types, namely geology and soil, as well as topography linked to altitudinal differences. Secondary associated finer scale abiotic factors such as aspect, slope (degrees), soil depth, clay content and percentage surface rock differentiate between and spatial locations of the sub communities and associations within these communities (Figure 7.1).

The grassland communities of the COH WHS remain largely intact in those areas not negatively impacted on through anthropogenic activities such as agriculture (Anon 1987). Agricultural activities are, and were, largely opportunistically applied, with water and ease of access proving to both be limiting factors in its application throughout the landscape (In addition to the fundamental requirements of appropriate soil chemistry and climate). The high degree of difficulty associated with ploughing in the relatively rocky soils associated with the majority of the grassland areas within the COH WHS, could be a significant contributing factor to the relatively intact status observed in the field, with mainly only grazing having been put into practice. Those areas more readily associated with ease of access and reliable water, namely the flat sloped bottomlands particularly in the non dolomitic areas show a distinct anthropogenic influence (either directly as with ploughing or indirectly such as with an unnatural fire regime) within the species composition of the plant communities found there.

The significantly under conserved nature of Bankenveld (Edwards 1972; Siegfried 1989) exponentially increases the importance of those communities within the COH WHS that are representative of Bankenveld and that remain largely intact, namely the *Loudetia simplex – Diheteropogon amplectens* Grassland community and the *Eustachys paspaloides – Sporobolus pectinatus* Grassland community and their associated sub communities. In contrast to being regarded as areas with lower conservation potential, those anthropogenically influenced grassland communities, namely the *Hyparrhenia hirta – Vernonia oligocephala* Grassland community and its associated sub communities should rather be regarded as areas for potential restoration and areas set aside for the continuation of successional processes that also contribute to an increase in Biodiversity.

Despite the obvious threat that urbanization and development pose towards grasslands, alien invasive species and the incorrect application of fire are potential contributors to the destruction of these ecosystems and their associated processes. Many of the alien invasive species commonly associated with the grasslands of the Highveld are nowadays regarded as being naturalized and include the forbs, *Zinnia peruviana, Bidens spp.* and *Verbena brasiliensis* for example. Of far greater concern are those species able to invade pristine as well as disturbed areas for example *Campuloclinium macrocephalum.* This plant is largely regarded as one of the greatest threats to grassland biodiversity at present (South African National Biodiversity Institute website). Wind is an agent of dispersal of many of these alien invasive species, with the wind speeds and direction at the time of seeding (Late Summer) providing a valuable management insight into possible monitoring sites and areas for intervention due to being able to predict the direction and possible rate of spread. This would suggest that ongoing monitoring into the dispersal of in particular *Campuloclinium macrocephalum* needs to be implemented as a colonization of the pristine Bankenveld within the COH WHS is likely to take place from a north easterly direction heading south and west.

Whilst it is well documented that grasslands are fire dependent, anthropogenically induced accidental fire as a threat would also require monitoring, with the highest degree of flammability of the vegetation being used to predict possible ignitions thereby inform management interventions. These unnatural fires would be most likely when the vegetation and atmosphere is driest and when natural ignition (lightning) is unlikely, usually late winter and before the first spring showers. This time logically coincides with those months of the lowest rainfall, namely June, July and August. During these months, the dominant wind directions would suggest that fire could spread in a Southerly direction in the Northern sector of the COH WHS and in a northerly direction in the southern sector of the COH WHS. Theoretically this suggests a very high likelihood of the entire COH WHS being exposed to yearly burns if there is no formal intervention. The establishment of a Fire Protection Association should be regarded as an essential management action for this area, particularly when considering that the areas most likely to result in an unnatural ignition point, namely those areas with the highest human habitation, occur on the perimeter of the COH WHS along the northern border (Hartebeespoort area) in the northern sector and the south western border in the southern sector.

In the woodland areas, 10 plant communities were identified (Chapter 5), all of which are spatially arranged throughout the landscape in response to the presence of certain abiotic factors, in particular rock cover (size and % surface rock) aspect and slope (Figure 7.2). The classification of the woodland plant communities included the bush clumps associated with the entrances of caves. The increase in percentage soil surface rock linked also to the size of the rocks (also a common occurrence around cave entrances) appears to show an affinity towards an increase in woodland communities. Increased shading and moisture retention could be contributing factors towards this, however a more likely scenario would appear to be the sheltering from or the minimising of the intensity of fires that are a yearly event throughout the COH WHS. Alien invasive species that are prevalent in the woodland areas of the COH WHS are dominated by those species that are fruit producing and are encountered where birds and or primates are found to roost or congregate. Fortunately these invasive aliens are not cryptic and can be controlled when encountered. The lack of ease of access afforded the woodland areas of the COH WHS has resulted in the limited exposure of these areas to formal agriculture and therefore aided in their preservation in a natural state. In areas where the grasslands have been negatively impacted by fire or agriculture, “artificial” woodlands often occur, however these are easily identified due to the complete dominance of only a single woody species, often with most individuals belonging to the same age class. The inclusion of these successional woodlands should form part of a restoration plan for the COH WHS.

The cave entrance vegetation communities (Chapter 6) consists of seven plant communities that are spatially distributed in response to the various abiotic habitat factors as shown in the cave entrance vegetation dendrogram (Figure 7.3). The presence or absence of chert in large quantities within the geology of the cave entrances appears to be the main differentiating factor between the major plant communities and this appears to be linked to Land Type. Aspect and the degree of rockiness appear to differentiate between the various sub communities. The degree of rockiness of the cave entrances is often as a result of artificially created rock piles that are present as a result of the Lime mining industry that developed in support of the gold mining activities in the late 1800's and early 1900's. The conservation value of the cave entrance vegetation is unquestionable even if these woodlands are present only as a result of artificial rock piles in some instances. Cave entrance Woodlands assist in having a regulating effect on the subterrainean ecosystems through shading and therefore cooling the entrance zones of the caves. These caves are themselves refuges for many endangered and endemic cave dwelling species or "Trogolobites".

As can be seen, the thorough understanding of the natural vegetation occurring within the COH WHS remains the foundation upon which informed management decisions should be based and as such this phytosociological classification of the plant communities should be seen as an integral part and departure point from which to implement any management strategy. A justification for the ongoing protection of the COH as not only a World Heritage Site of cultural significance, but also as a vital component in the conservation of 'Bankenveld' and sub terrainean ecosystems associated with karst landscapes could thereby be accomplished.

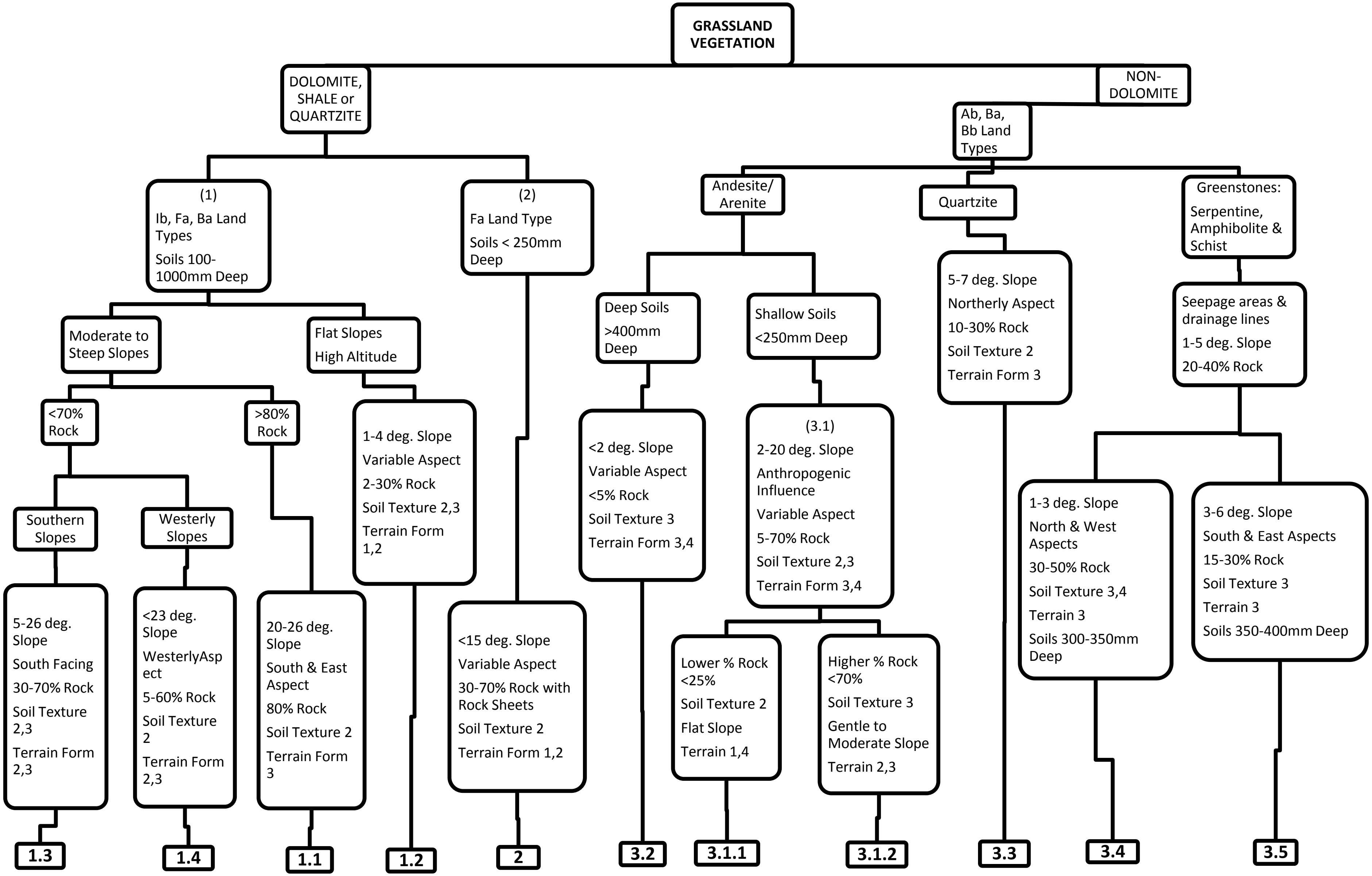


Figure 7.1 Dendrogram showing habitat factors leading to the establishment of grassland plant communities

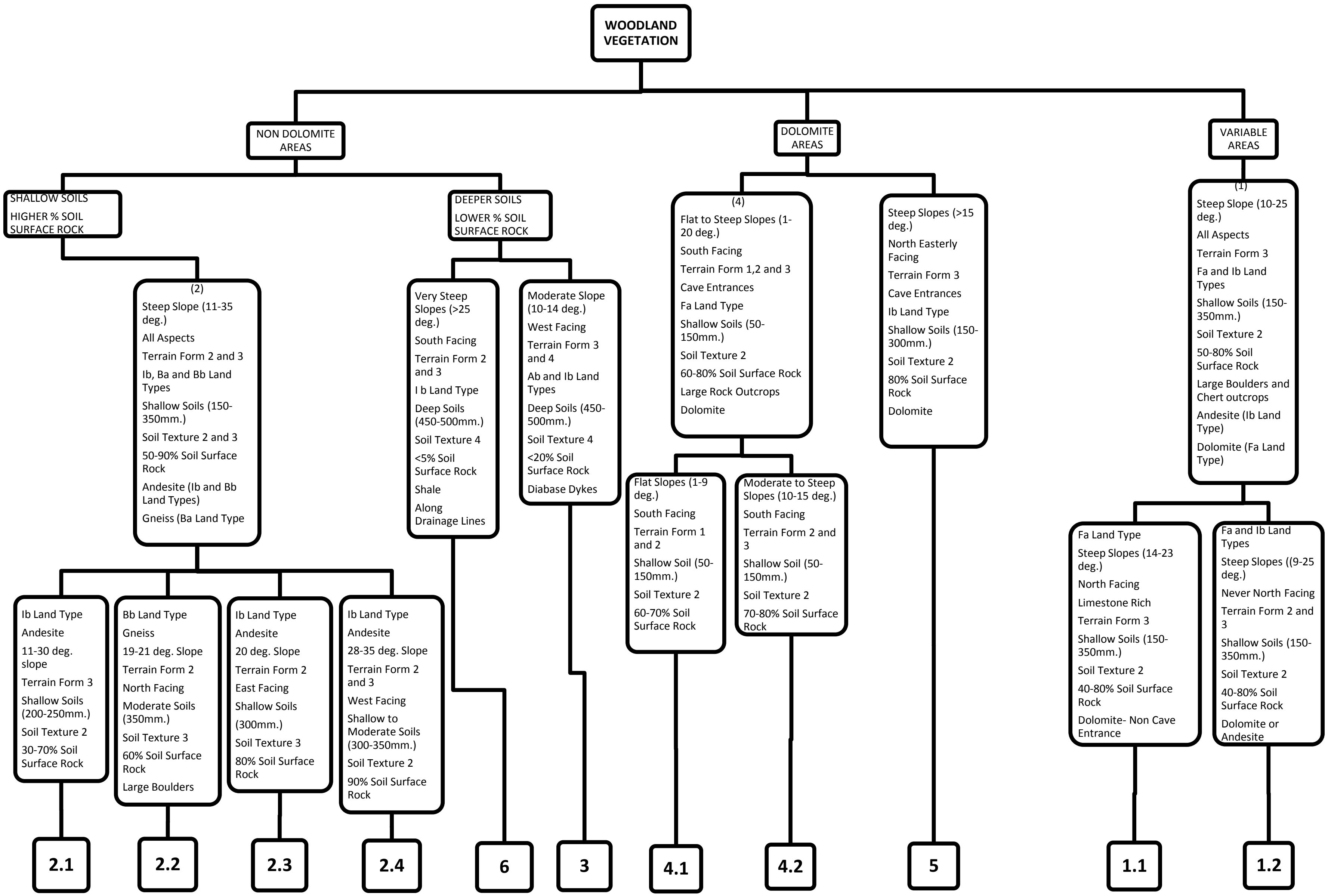


Figure 7.2 Dendrogram showing habitat factors leading to the establishment of woodland plant communities

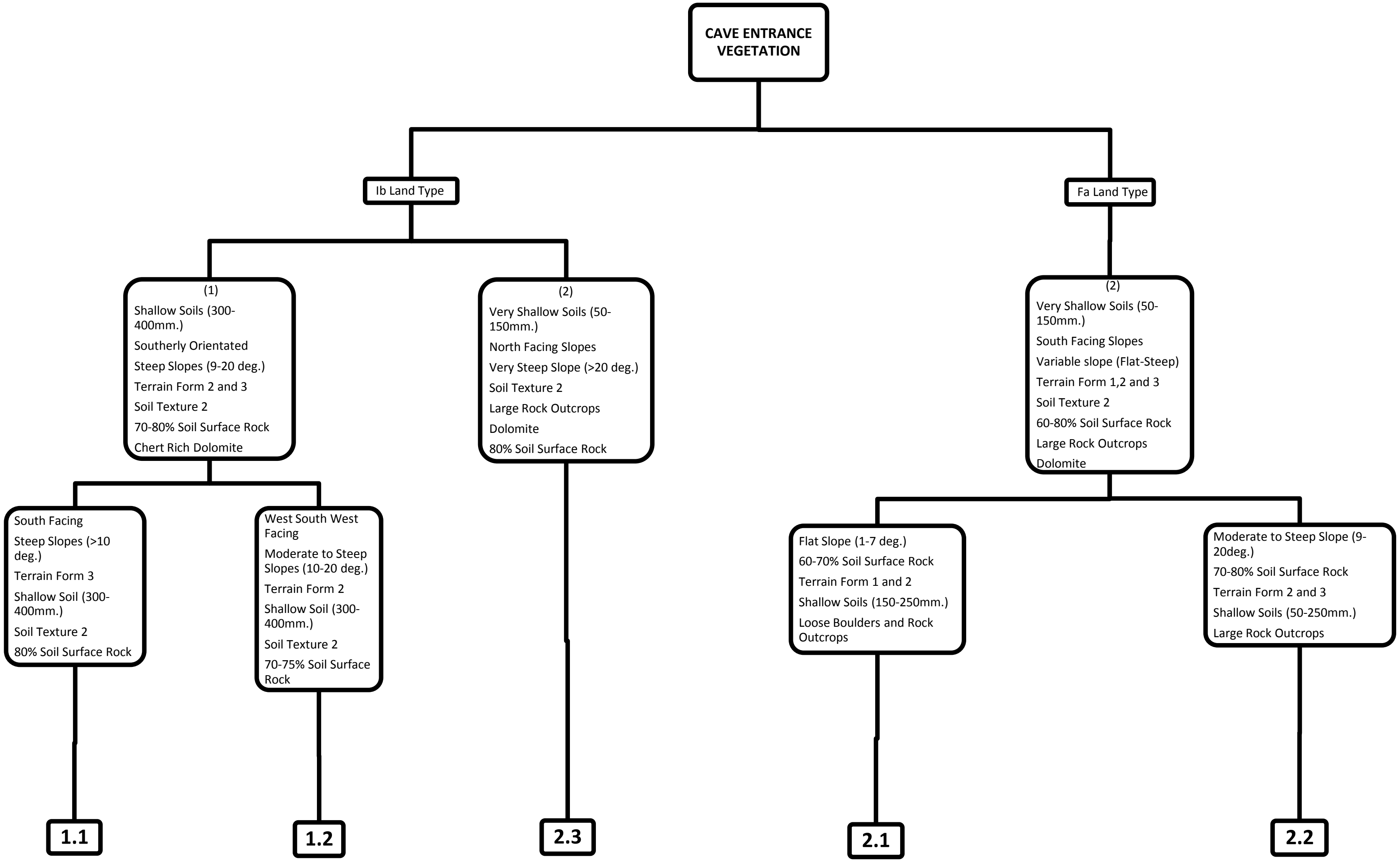


Figure 7.3 Dendrogram showing habitat factors leading to the establishment of cave entrance plant communities

7.2. **Future research**

In addition to the diagnostic plant species listed in the refined phytosociological tables in chapters 4, 5 and 6, numerous “companion species” (Kent and Coker 1992.) were omitted for simplification purposes due to the fact that they occur at low cover abundances across a wide distribution range throughout the study area. Whilst not essentially required for any syntaxonomical aspect of this study, these additional species together with those diagnostic species in the tables shown attest to the high species richness of the area and could form part of later floristic analyses into the various *families, genera* and *species* found to occur within the COH WHS. The compilation of a botanical species list and identification of Red Data species should be a consideration into future research outputs. Whilst a strong positive linear correlation was shown to exist between the size of cave entrances and the extent to which the woody vegetation was found to persist from the cave itself (possibly due to the small sample size (n=9)), the statistical significance thereof remains untested. The exact nature and mechanisms of this relationship, as well as the statistical significance thereof also requires further investigation, as there are still other possible correlating factors for this relationship, for example subterranean void size and associated air moisture content of the cave etc.

With all of the baseline vegetation work now available, its incorporation into an overarching and legally required Management Plan for this World Heritage Site should be undertaken. Follow up refinement of the data available should be consolidated into a “Bioregional Management Plan” as allowed for in the National Environmental Management: Biodiversity Act in an attempt to secure further protection of this highly valuable Karst ecosystem.

7.3. **References**

ANON. 1987. Agriculture in South Africa. 2nd Edition. Chris van Rensburg, Johannesburg.

BEZUIDENHOUT, H. 1993. Syntaxonomy and synecology of western Transvaal grasslands, South Africa. Ph.d. Thesis. University of Pretoria, Pretoria.

COETZEE, J.P. 1993. Phytosociology of the Ba and Ib land types in the Pretoria-Witbank-Heidelberg area. MSc. Thesis, University of Pretoria, Pretoria.

EDWARDS, D. 1972. Conservation areas in relation to Veld Types. *Unpublished ms. Bot. Res. Inst. Pretoria. (In press Kudu).*

FULS, E.R. 1993. Vegetation ecology of the northern Orange Free State. Ph.D. dissertation, University of Pretoria, Pretoria.

HENDERSON, M.; FOURIE, D.M.C.; WELLS, M.J., & HENDERSON, L. 1987. Declared weeds and alien invader plants in South Africa. Department of Agriculture and Water Supply. Government Printer. Pretoria.

HILL, M. O. 1979. TWINSPAN- A fortran program for arranging multivariate data in an ordered two-way table classification of individuals and attributes. Cornell University, New York.

KENT, M. & COKER, P. 1992. *Vegetation description and Analysis – a practical approach*. John Wiley and Sons. Chinchester, England.

SIEGFRIED, W.R. 1989. Preservation of species in southern African nature reserves. B.J. Huntley (ed.) Biotic Diversity in southern Africa: Concepts and Conservation. Oxford University Press, Cape Town.

WERGER, M.J.A. 1973. Phytosociology of the upper Orange River Valley, South Africa. Ph.D. dissertation, University of Nijmegen, Nigmegen.

Acknowledgements

My supervisor Professor L.R. Brown and co-supervisor Professor G.J. Bredenkamp are thanked for their ongoing guidance and leadership, with additional thanks extended to:

The Gauteng Department of Agriculture and Rural Development for affording me the opportunity to conduct the required field work.

The landowners and managers in the Cradle of Humankind for their accommodating nature especially:-

Mr. Hennie Visser

The Nash family.

Mr. Benji Liebman

Mr. Mark Reed

Mr. Stephan du Toit.

Mr. Gavin Doyle

Mr. Ed Hern

Mr. Frank Wessels

Mr. Willem Pretorius and Magales Gate Reserve.

Mr. John McLarren and Kloofzicht Lodge.

Mr. Alex Richter and Aloe Ridge.

Mr. Peter van der Merwe

Mr. Willie Joubert

Mr. Manie van Aaswegen.

A special acknowledgement of thanks is extended to Mr. Patrick Duigan for his support and assistance in the field, as well as to Mrs. Lorrain Mills for her assistance in the identification of some of the plant species and Ms. Pita Compaan for her assistance in the compilation of GIS maps. Mrs. Lindi Eloff is especially thanked for her ongoing support and understanding, as well as her ongoing assistance in the field and the home, especially as the hours grew longer and the patience shorter.