



Nama-Karoo Biome

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Ladislav Mucina, Michael C. Rutherford, Anthony R. Palmer, Susanne J. Milton, Louis Scott, J. Wendy Lloyd †, Bertie van der Merwe, David B. Hoare, Hugo Bezuidenhout, Jan H.J. Vlok, Doug I.W. Euston-Brown, Leslie W. Powrie and Anthony P. Dold

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Figure 7.1 NKu 4 Eastern Upper Karoo: Typical Nama-Karoo landscape with tafelbergs and butts in the surrounds of Middelburg (Eastern Cape).

1. Introduction: Delimitation and Global Perspective

The Nama-Karoo is a large, landlocked region on the central plateau of the western half of South Africa and extends into southeastern Namibia. The name is derived from the Khoi San word *kuru* meaning 'dry'. Its extensive surface (248 284 km² or 19.6% of the area covered by the map) is flanked by six biomes: the Succulent Karoo to the south and west, Desert to the northwest, the arid Kalahari form of the Savanna Biome to the north, Grassland to the northeast, Albany Thicket to the southeast and small parts of Fynbos to the south. The Nama-Karoo has a continental-type climate. In South Africa, only the Desert Biome has a higher variability in annual rainfall and the Kalahari Savanna greater extremes in temperature. The Nama-Karoo has most rainfall in the summer half of the year, especially in late summer.

Biome boundary interfaces between the Nama-Karoo and Desert and Succulent Karoo Biomes have already been discussed under those two biomes. The gradual transitions between the Nama-Karoo and Grassland Biomes on the plains to the northeast make the border between the two particularly difficult to map. However, in the east, the boundary is more distinct, with grassland associated with higher altitudes on mountains, and Nama-Karoo with the plains below.

In addition, the part straddling the middle course of the Orange River was the area that John Acocks asserted had been grassland vegetation and was being invaded by Karoo (see further in Chapter 8 in this book). Much has been written about a second hypothesis of the presumed greater grassiness of the 'Karoo' before heavy grazing by domestic stock (Acocks 1953, Hoffman & Cowling 1990, Bousman & Scott 1994, Meadows 2003). It was probably Acocks's (1953) dramatic map depiction of replacement of Karoo vegetation by desert in much of the western part of the Karoo that caught attention. He also stated that extensive 'near deserts have developed' in the arid west. In 1979 he claimed that large changes in plant composition had also occurred further east in the Nama-Karoo. Dean & Milton (2003) caution against loose interpretation of Acocks's statements that the Karoo has become less grassy. Even in the less arid central and eastern parts of the Nama-Karoo (with higher stocking rates and hence grazing pressure), much of his discussion in 1979 relates to changes in vegetation of main drainage channels. Acocks himself was sometimes ambiguous. In 1979 he stated that 'the striking feature of the Arid Karoo was, and once more is, its grassiness...'. He also stated that his False Succulent Karoo 'in its original condition probably did not differ greatly from the Arid Karoo' veld type (Acocks 1979). In a reanalysis of Acocks's field data, Rutherford et al. (2003) found that the flora of his sample sites in False Succulent Karoo was very similar to that in his Arid Karoo veld type. Other aspects of vegetation dynamics are discussed in the section on Vegetation Structure and Dynamics of this chapter.

The boundaries between the Nama-Karoo and Savanna Biomes are complicated by the substrate pattern at a fine scale. This is the result of the alternation of longitudinal dunes and interdune valleys in the southern Kalahari, with Savanna elements dominant on the dunes but diluted by Nama-Karoo elements (e.g. *Rhigozum trichotomum*, *Stipagrostis obtusa* and *Pteronia mucronata*; Leistner 1967) in the intervening areas. The shallow rainfall gradient from south to north has not assisted rapid resolution of the debate regarding the status of the vegetation of the southern Kalahari (Leistner 1967, Leistner & Werger 1973). The southern limit of the main dune fields forms the boundary

of Nama-Karoo with Savanna in the west (Kalahari Duneveld Bioregion). The boundary to the east (Eastern Kalahari Bushveld Bioregion) corresponds to the area with Savanna generally on deeper consolidated sands or limestone with MAP of greater than 300 mm. Nama-Karoo shares a short border with one of the patches of Savanna in the Eastern Cape.

The southeastern boundary of the Nama-Karoo is complex, interfacing mostly with the Albany Thicket Biome and also with Fynbos, Succulent Karoo, Savanna and Grassland. The Nama-Karoo interface with Albany Thicket does not follow strict substrate lines where Thicket can occur on any substrate (Vlok & Euston-Brown 2002). The boundary between Nama-Karoo and Thicket may also involve a competitive element where 'the process of "thicket building" can be driven forward and backward repeatedly, depending on the occurrence of the disturbance regime' (Vlok & Euston-Brown 2002). Robertson & Palmer (2002) combined various climatic parameters to predict the occurrence of *Portulacaria afra*, an important component of many thicket types. It is, however, not clear which of these variables apply along the Nama-Karoo interface.

Nama-Karoo interfaces with the Fynbos at a few points in the Eastern Cape but is more commonly separated from Fynbos in this area by narrow belts of the Albany Thicket Biome. This vegetation catena corresponds to the sequence from Succulent Karoo through Thicket to Fynbos in some areas to the west. A short border is shared between the Fynbos Biome (represented by arid facies of Roggeveld Shale Renosterveld) and the Nama-Karoo Biome along the western edge of the Great Escarpment.

The present extent of the Nama-Karoo Biome is similar to the spatial extent of the biome of Low & Rebelo (1996), with the most notable difference in the southwestern Free State in the region around Fauresmith, Philippolis, Bethulie and Edenburg which is now recognised as dry facies of the Grassland Biome. This area formed the northeastern portion of Acocks's (1953) False Upper Karoo veld type which Acocks had postulated had formerly been grassland. Independent analysis of Acocks's field data (Rutherford et al. 2003) shows that the flora of this area differs from that of the southwestern portion of this veld type. The climate of this area also corresponds more closely with that of the Grassland Biome (Rutherford & Westfall 1994). Another notable difference to Low & Rebelo (1996) is the intrusion of the Desert Biome in the extreme northwest. This represents an eastern extension of the desert unit of Rutherford (1997) based on confirmed extreme aridity. Another difference is the recognition of Succulent Karoo rather than Nama-Karoo in the Steytlerville Karoo, in what is a climatically marginal area.

Most of the Gordonia Duneveld Bioregion of the Savanna Biome was considered as part of the Nama-Karoo Biome by Rutherford & Westfall (1994). Their approach was not floristic but based on dominant vegetation structure and climate. The life form combination typical of Nama-Karoo occurs in the interdune areas (except the far north) which dominate the much smaller areas of the savanna life form-carrying dunes. The net effect at their defined biome scale was, therefore, Nama-Karoo for this region. Rutherford & Westfall (1994) mapped Nama-Karoo also on the highest plateaus of Lesotho. Again, their biome criteria were structural and based on combinations of co-dominant life-forms, which, with the co-dominance of hemicyptophytes and chamaephytes, translated to Nama-Karoo. The argument for high-altitude physiological drought, rainfall inversion with altitude in high mountains, the rainshadow effect and presence of many plants with xeromorphic adaptations was also put forward. They, however, clearly acknowledged that 'the floristic affinities of much of the vegetation are altogether different...' to Nama-Karoo (Rutherford & Westfall 1994). Their classifica-

tion was not an attempt to place this area within various global schemes of biomes but rather followed a parsimonious system based on variation within the subcontinent following explicit biome criteria as defined by these authors. Rutherford (1997; see also Van Wyk & Smith 2001) has classified the salt pans of Etosha (Namibia) and Madigadigkadi (Botswana) as Nama-Karoo, again based on the grass and shrub combination that fringes the pans which, following their definition, can only be Nama-Karoo. The concept of azonality did not apply in Rutherford & Westfall's (1994) biome map at scale of 1:10 000 000.

Following the Evenari (1985) and Werger (1986) classification of Karoo (which includes Nama-Karoo) as a 'hot desert', analogous biomes can be found in both the northern and southern hemispheres. The climatically and structurally closest biome to the Nama-Karoo on the North American continent is the Chihuahuan Desert (MacMahon & Wagner 1985, Brown 1988, MacMahon 1988). The southeastern Australian chenopod shrublands (Goodall 1982, Williams & Calaby 1985) could form a southern-hemisphere analogue of the Nama-Karoo.

2. Climate, Geology and Soils

2.1 Climate

The climate of the Nama-Karoo is essentially continental and is little affected by the ameliorating influences of the oceans. Nama-Karoo is an arid biome. Most of the rivers are nonperennial. Apart from the Orange River and the few permanent streams in the southwest that originate in higher-rainfall neighbouring areas (and in the case of the latter terminate in shallow lakes—Bushmanland Vloere—that dry up in the dry season), the few perennial streams that originate in the Nama-Karoo are limited to the more mesic east, with the Great Fish River of note. MAP ranges from around 70 mm bordering the Desert Biome in the northwest to around 500 mm in the southeast. Most rain falls in late summer (December to April). The low rainfall is unreliable (coefficient of variation of annual rainfall up to 40%) and droughts are unpredictable and sometimes prolonged (Booyesen & Rowsell 1983). Rainfall quantity and reliability increase eastwards and the proportion of rain that falls during summer increases to the northeast. In the southwest, rain is brought by unpredictable late summer thunderstorms and occasional inland intrusions of winter high-pressure systems from the west, whereas convectional thunderstorms and southerly movement

of the intertropical convergence zone bring reliable summer rain to the northeast of the region (Desmet & Cowling 1999). Summers are hot (mean January maximum >30°C) and

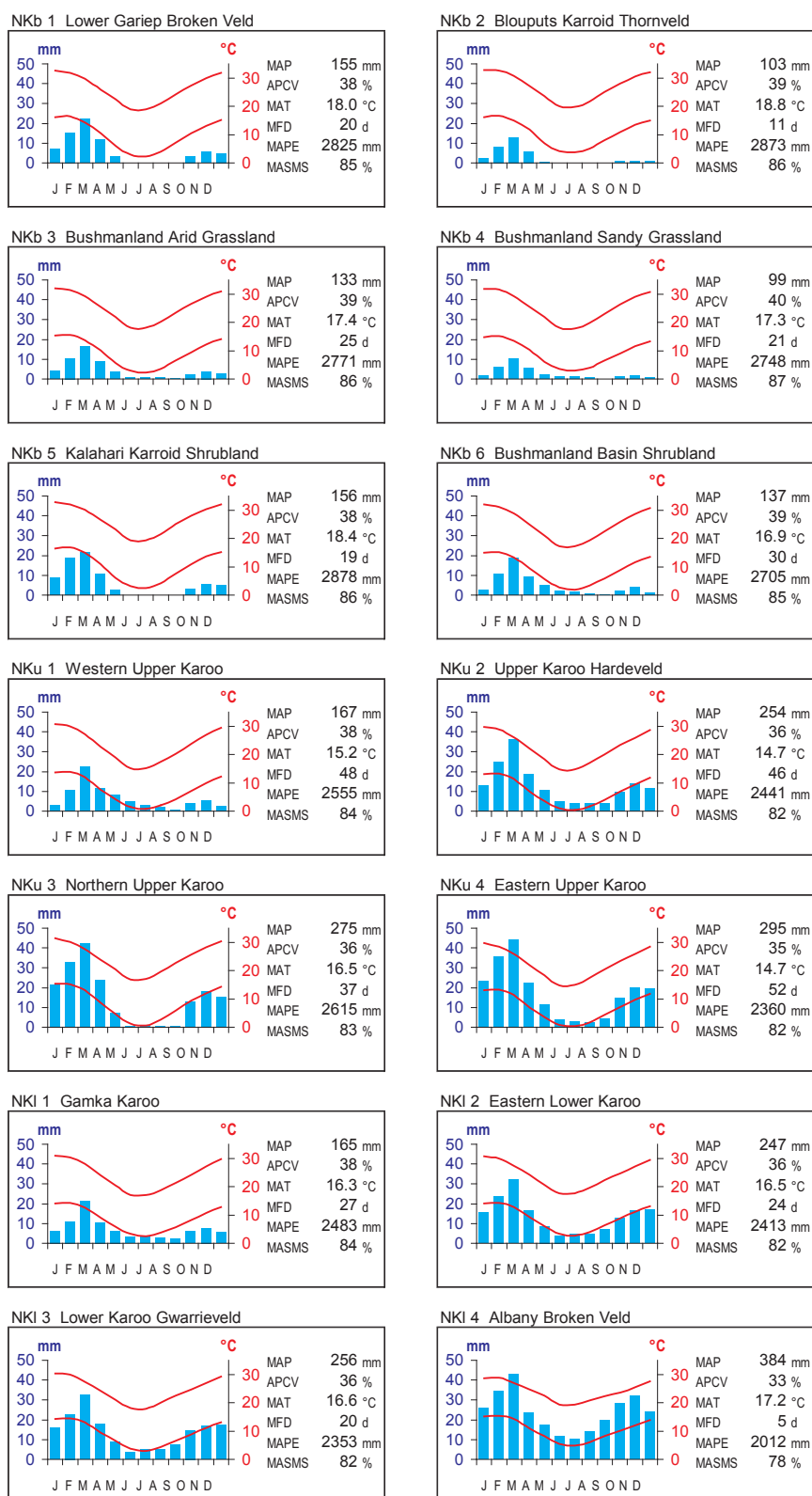


Figure 7.2 Climate diagrams of Nama-Karoo Biome units. Blue bars show the median monthly precipitation. The upper and lower red lines show the mean daily maximum and minimum temperature respectively. MAP: Mean Annual Precipitation; APCV: Annual Precipitation Coefficient of Variation; MAT: Mean Annual Temperature; MFD: Mean Frost Days (days when screen temperature was below 0°C); MAPE: Mean Annual Potential Evaporation; MASMS: Mean Annual Soil Moisture Stress (% of days when evaporative demand was more than double the soil moisture supply).

winters cold (mean July minimum close to zero in the Upper Karoo vegetation types). Temperature extremes range from -5°C in winter to 43°C in summer. Frost occurs in all areas except in the extreme southeast of the biome (Albany Broken Veld) in winter. Dust devils and small whirlwinds are frequent in summer but dust storms are uncommon (Desmet & Cowling 1999).

Rainfall peaks in March in all the vegetation types of Nama-Karoo, and this, together with the onset of frost soon afterwards in the higher-altitude areas, can provide a very short growth season for frost-sensitive species. For example, in the Western Upper Karoo, where very little rainfall is expected in the warm season before March (Figure 7.2), the average first date of heavy frost is in the first half of May (or even late April in the extreme south; Schulze 1997). The shortness of the growing season is further exacerbated in some years when rains arrive even later than usual or frost occurs earlier than average or, most seriously, when both of these occur in the same year.

2.2 Geology and Soils

Underlying the Nama-Karoo is a 3 000 m thick succession of sedimentary rocks. This includes the Cape Supergroup (of marine origin), followed by Dwyka tillites (deposited during southern glaciations 400–300 mya predominantly during the Carboniferous), and then, as southern Africa drifted away from the south pole, by other, fossil-rich, sediments of the Karoo Supergroup (including Eccca and Beaufort Groups) deposited in a great inland sea 300–180 mya. Igneous activity over a significant period 180 myrs ago contributed to local demise of the rich therapsid fauna due to voluminous outpourings of basaltic lava and also caused intrusion of dolerite sills and dykes into Karoo sediments (Meadows & Watkeys 1999). This marked the start of the Gondwanaland break-up (ca. 155 mya), when faulting-initiated erosion processes began shaping the present Karoo landscapes. The Great Escarpment today located 100–200 km from the coast and towering up to 1 000 m over the surrounding landscapes, separates the upper and lower regions of the Nama-Karoo. The escarpment is thought to have been initiated 138 mya during the separation of southern Africa and South America (Ollier & Marker 1985), and the erosion processes initiated then, continue to erode the escarpment, moving it gradually inland. Largely undisturbed by the intense folding in the south that formed the mountains and valleys of the Fynbos and Succulent Karoo Biomes (the Cape Fold Belt), the strata of the Nama-Karoo remained horizontal, giving rise to flat to gently undulating rocky or sandy plains, interrupted by boulder outcrops of igneous origin and flat-topped mesas sculpted by wind and rain. Altitude within the biome varies from 600 to 2 000 m. Much of the terrain in the northwest is interspersed with pans with no outlets.

A detailed soil map, covering most of the Nama-Karoo, is provided by Ellis & Lambrechts (1986). The soils, derived *in situ* under arid conditions from sedimentary rock, igneous intrusions (mainly Jurassic dolerites) and lime-rich evaporite, are generally base-rich, weakly structured and skeletal. Watkeys (1999) divides the Nama-Karoo into several soil regions. In the north from Bushmanland to around Prieska, the most common soils are red and yellow sands to non-swelling clays, generally freely drained. The A-horizon is orthic, as is typical of arid areas in South Africa. Duribank areas are widespread and the coarse soils associated with them may be high in most plant nutrients, especially potassium. In dune areas, such as the Koa River Valley, the soil is deep, uniform, coarse-textured sand poor in plant nutrients. In the interdune areas of Bushmanland, shallow, coarse sand to sandy loam soils of high nutrient status are associated

with dorbanks and hardpan calcretes. Further south, in the belt running north of the Great Escarpment, eastwards of Calvinia, most soils are shallow (<300 mm) and weakly structured. Soils overlying the dominant Karoo sediments tend to have lime in upland and bottomland positions. The dolerite outcrops, which are commonly interspersed in this region, develop shallow to moderately deep, calcareous, sandy-clay loams which contain calcrete and calcareous horizons. Around Hanover and further east, duplex soils are dominant, with the clay percentage of the B-horizon more than twice that of the A-horizon. This is associated with the increase in rainfall eastwards. The pattern of soils south of the Great Escarpment generally corresponds to that of the belt north of the escarpment, except that dolerite is absent southwest of Beaufort West. On the Great Escarpment from Fraserburg to around Middelburg, shallow lithosols predominate, with large areas of exposed rocks. Nama-Karoo occurs on the top of the escarpment in the west, but becomes replaced by Grassland at higher altitudes in an easterly direction. The soils developed on dolerites southwest of Middelburg often have a melanlic A-horizon and are markedly different from the soils on dolerites in the more arid Carnarvon-Brandvlei area. Soils of the alluvial habitats within the Nama-Karoo are discussed in the chapter on Inland Azonal Vegetation.

3. Biogeography: Origins, Diversity Patterns and Classifications

3.1 Origins of the Nama-Karoo Flora and Vegetation

There is some controversy about the origins of the Karoo flora (Hilton-Taylor 1987, Acocks 1988, Cowling & Hilton-Taylor 1999). Werger (1978a, b) considered the flora to be transitional, with Sudano-Zambezian affinities towards its northern and eastern boundaries, and Cape affinities towards the southwest. Pollen grains from a sediment-filled, volcanic pipe 80 km south of the Orange River suggests that around 70 mya (near the Cretaceous-Tertiary boundary) the climate was warmer (and wetter) than today, with dry forest containing probable fore-runners of fynbos that included Proteaceae-, Thymelaeaceae- and Ericaceae-like elements in the understorey (Scholtz 1985). The asteraceous shrub flora that dominates the region today was not present at that time. Low-spine pollen from Tertiary marine sediments off the west coast suggests that Mutisiae-like Asteraceae might have developed afterwards on the subcontinent during the early Tertiary (Scott et al. 1997, Zavada & De Villiers 2000, A. Cadman & L. Scott, unpubl. data). The present more typical modern members of the family with long-spine pollen apparently became prominent only in the late Tertiary (Coetzee 1978, Scott 1995, Scott et al. 1997). The pattern of Asteraceae evolution seems to parallel that found in South America (Barreda 1993). This change in the Late Miocene to biomes that approach the modern types (Coetzee 1978) was possibly in response to global cooling (Shackleton & Kennet 1975) and also resulted in the disappearance of the subtropical characteristics of the vegetation that existed in the Western Cape and the Nama-Karoo as indicated by pollen (Thiergart et al. 1962, Coetzee 1978, Scott 1995) and macrofossils (Bamford & De Wit 1993, De Wit & Bamford 1993). The development of karroid plant and animal communities is likely to have occurred in response to the increase in aridity associated with the growth of the Antarctic Ice Sheet during the late Miocene at a time when the modern winter-rain regime apparently developed in the Cape region (Coetzee 1978). In addition to global cooling during the late Tertiary (Miocene and Pliocene), continental

uplift raised the eastern Nama-Karoo plateau (Partridge 1997). The associated cooling and rainshadow effect could have played a role in the development of the flora and vegetation of the region during the replacement phase of dry woodlands by asteraceous shrubland. However, the absence of a well-dated and continuous fossil record precludes further speculation.

The timing of the evolution of vegetation in the Nama-Karoo and the surrounding region has not been clearly established. Although the Mutisiae-like pollen grains described by Zavada & De Villiers (2000) from marine cores are attributed to the Eocene, evidence for this has not yet been provided. There is uncertainty about how the sediments that contained the pollen should be tied in with unpublished chronometric and palaeontological age estimates of sediment cores (I. MacMillan, De Beers Marine, personal communication, A. Cadman & L. Scott, unpublished data). The proposed timing of the major vegetation change that apparently established the Nama-Karoo in the Late Miocene is also not based on chronometric dates, but on correlation with Shackleton & Kennet's (1975) ocean temperatures (Coetzee 1978). Furthermore, in view of the scarcity of fossil evidence, the original distribution of ancestral taxa to typical Nama-Karoo genera such as *Pentzia*, *Chrysocoma* and *Pteronia* remains unknown.

During the more recent Quaternary period (the last 1.8 myrs) when the present Nama-Karoo regime had already been established, there were widespread fluctuations in climate in the region. Pollen analyses from the Florisbad sediments (in the Grassland Biome to the north near Bloemfontein) suggest that there was a regular alternation of grassland and arid Karoo vegetation in response to fluctuating climates and environments over the last 250 000 years (Van Zinderen Bakker 1989, Grün et al. 1996). The results imply that Karoo vegetation expanded in pulses to cover wider areas than its present range. Van Zinderen Bakker (1957, 1989) and Coetzee (1967) attributed northward expansion of Karoo vegetation into the grassland region to warm, dry events. However, equator-ward shifts of vegetation types should generally be attributed to cooling. Therefore, it is likely that northward expansions of the Nama-Karoo are the result of cool or intermediate conditions where seasonal moisture shifts lowered the relative summer rain proportions and thereby the overall rainfall (Scott & Nyakale 2002). According to this pattern, dry Karoo-like shrublands that included *Elytropappus* or *Stoebe* or both, occupied current grassland areas in the highlands near Noupoot at the Pleistocene to early Holocene transitional period (Bousman et al. 1988). At times during the Late Pleistocene similar vegetation expanded northwards towards Equus Cave near Taung in the southern Kalahari (Scott 1987). At Aliwal North it was relatively grassy at the end of the Pleistocene, although the *Elytropappus/Stoebe* element was present (Coetzee 1967, Scott & Cooremans 1990, Meadows & Watkeys 1999). However, in the drier west of the subcontinent a pollen record from the Richtersveld suggests that Karoo shrub vegetation that included the *Elytropappus/Stoebe* element, occupied the current drier, warmer Succulent Karoo area during the terminal Pleistocene phase (Scott et al. 1995).

During the Holocene (the last 10 000 years) pollen and sedimentary evidence from the broad surrounds of Aliwal North, Noupoot and Beaufort West indicate moisture fluctuations that cause shifts between grass and shrubs suggesting sensitivity to changes in precipitation quantity or seasonality (Bousman et al. 1988, Meadows & Watkeys 1999). The Florisbad site was re-invaded by karroid Asteraceae by ca. 5 000 years BP during an event of apparent cooling and drying, but afterwards summer rains and good grass cover returned ca. 4 000 years BP (Scott & Nyakale 2002).

Northward spreading of Nama-Karoo shrubs at the expense of grasses during the 20th century was attributed to the increased, modern stock farming (Acocks 1953, 1988, see discussion above). However, pollen composition in fossil hyrax dung from the mountains near Noupoot suggests that a process of Asteraceae-spreading started as long as 400 years ago, i.e. before the intensification of stock farming (Bousman & Scott 1994). Furthermore, Hoffman & Cowling (1990) found little evidence that Karoo-spreading was a continuing process during the late 20th century (for further details of this phenomenon, see the chapter on the Grassland Biome).

Provisional observations seem to indicate that organic soils are usually visible in the upper sediments of most erosion gulleys of the eastern Karoo, attesting to the soil development during better moisture conditions in the second half of the Holocene (Bousman et al. 1988, Meadows 1988). However, gullies in the southwestern Karoo (e.g. between Beaufort West and Laingsburg) generally appear to be poor in or devoid of organics. This suggests that this region is typically dry and that marked influx of moisture, whether from the southern winter-rain regime or from the northern monsoon, was not widespread during the Holocene and probably also not during the late Pleistocene.

In view of the general northward shifting of vegetation zones during glacial phases, it is likely that if any arid corridor connections between southern Africa and the rest of Africa developed, they might have been possible during such times. However, according to the available useful sections of the pollen record of the Tswaing Crater (Pretoria Saltpan), Asteraceae increased during some events in the last 200 000 years but the general vegetation remained grassy rather than karroid.

3.2 Diversity and Taxonomic Patterns

The Nama-Karoo flora is not particularly rich, and in comparison with analogous biomes on other continents, does not stand out in contrast to the Succulent Karoo (Cowling et al. 1998). The Nama-Karoo Biome does not contain any centre of endemism (Van Wyk & Smith 2001). Unlike other biomes of southern Africa, local endemism is very low (the highest number of local endemics is concentrated in the Upper Karoo Hardeveld). This might indicate a relatively youthful biome linked to the remarkable geological and environmental homogeneity of the Nama-Karoo, despite genetic plasticity of some families such as Asteraceae—that dominate the Nama-Karoo vegetation. In common with floras of other arid and semi-arid areas, Asteraceae, Fabaceae and Poaceae are dominant families. To the south and west, the Nama-Karoo includes elements of the Succulent Karoo and Fynbos Biomes (Aizoaceae, Asteraceae) and to the north and east, Poaceae, Fabaceae and elements of tropical summer-rainfall floras (Acanthaceae, Capparaceae and Cucurbitaceae) become more prevalent. The contribution of succulent genera of the families Aizoaceae, Crassulaceae, Euphorbiaceae and Apocynaceae to species diversity and cover decreases to the north and east, as the contribution of grasses increases. At generic level, the flora of the Nama-Karoo appears to be a filtered subset of the floras of surrounding biomes (Hilton-Taylor 1987).

Rainfall seasonality and frequency are too unpredictable and winter temperatures too low to enable leaf succulents to dominate as they do under the more reliable winter rainfall of the Succulent Karoo. It is too dry in summer for dominance by perennial grasses alone, and the soils are generally too shallow and the rainfall is too low for trees. Grass dominates aeolian sand patches regardless of rainfall quantity and seasonality in

the Nama-Karoo. Soil type, soil depth and local differences in moisture availability cause abrupt changes in vegetation structure and composition.

At biome or landscape levels, the flora is not particularly species-rich. In 1987, Gibbs Russell estimated that there were 2 147 plant species in a region of 198 500 km²—the core area of the Nama-Karoo (about 30% of the region). However, there is still no reliable estimate of the size of this flora. At the 0.1 ha scale, plant species density averages 47 (range: 22–76) (Cowling & Hilton-Taylor 1999). There have been a number of attempts to explain the low alpha and beta diversities of the Nama-Karoo. Using J.P.H. Acocks's original data, Hoffman et al. (1994) reported that species richness was negatively correlated with energy in the Karoo (i.e. hot, dry areas supported fewer species than cold, dry or hot, mesic areas within the Karoo). This relationship is also evident at landscape level where small drainage lines support more plant species than surrounding plains (Milton 1990). Cowling & Hilton-Taylor (1999) found that the variables that best explain biome level species richness are the reliability of the rainfall together with the length of the gradient in rainfall quantity. High rates of extinction caused by unreliability of rainfall in the Nama-Karoo may prevent the rapid diversification evident in the Succulent Karoo.

3.3 Biogeographical and Vegetation Subdivisions

The Nama-Karoo, as defined by White (1976, 1983) and Werger (1978a, b) in this account, was classified as part of a large, climatologically and floristically heterogeneous phytochorion called the Karoo-Namib Region (Floristic Region in terms of Takhtajan 1986) to accommodate deserts and semideserts of southern Africa. Jürgens (1991), on the basis of an analysis of distribution areas of 1 700 taxa in this region, showed convincingly that two regions should rather be recognised—the *Succulent Karoo Region* and the *Nama Karoo Region* (in Jürgens's original orthography). The latter Region would form part of the Paleotropical Floristic Kingdom (or Afrotropics according to Burgess et al. 2004)—an idea undisputed since the seminal phytogeographical work of White (l.c.). Jürgens (1991) (see also Hilton-Taylor 1987) further suggested that the phytochorion of the Succulent Karoo Region (or rather Succulent Karoo Floristic Region) should form part of the Greater Cape Flora (or rather Cape Floristic Kingdom sensu Takhtajan 1986).

Five of Acocks's (1953) veld type units fall almost entirely within the Nama-Karoo Biome (Central Upper Karoo, Central Lower Karoo, Orange River Broken Veld, Arid Karoo and False Arid Karoo). Major parts of the False Upper Karoo and Karroid Broken Veld, and smaller proportions of the Namaqualand Broken Veld, False Karroid Broken Veld, False Succulent Karoo and Karroid *Danthonia* Mountain Veld fall within the biome. Low & Rebelo (1996) regrouped most of these units and part-units to form six vegetation types in the biome. A numerical analysis of Acocks's original field data (Rutherford et al. 2003) substantiated a number of Acocks's veld types, for example Orange River Broken Veld and Arid Karoo (albeit with modified boundaries). Not supported was the part of the False Succulent Karoo that occurs in the Nama-Karoo. Also not supported were several veld types or parts of veld types in the southeastern Karoo which appeared too finely dissected on Acocks's map. The analysis also supported Acocks's three north-south subdivisions of Arid Karoo. The current vegetation types, which are based on information in addition to Acocks's data, recognise in part these subdivisions of Arid Karoo, with Western Upper Karoo approximating his semisucculent southern form and Bushmanland Basin Shrubland approximating his Driedoring

Veld. Acocks's Blomkoolganna Veld in the north joins the current Bushmanland Arid Grassland. Acocks's fragmented veld types on the plains of the southeastern Karoo are reflected in a consolidated Eastern Lower Karoo.

Using data from the climatic responses for southern Africa (Dent et al. 1987) in a topo-moisture analysis, Palmer & Hoffman (1997) defined three geographically distinct biome subdivisions, namely (1) Griqualand West and Bushmanland, (2) the Great Karoo and Central Lower Karoo, and (3) the Upper Karoo and Eastern Cape Midlands. The bioregions of Nama-Karoo approximate these units in the form of Bushmanland, Lower Karoo and Upper Karoo, respectively. Main differences are: the Bushmanland Bioregion does not extend as far east, the Lower Karoo includes the plains around Graaff-Reinet and Aberdeen and the Upper Karoo Bioregion extends further west at higher altitudes.

The Bushmanland Bioregion is separated from the others by having the highest annual rainfall CV (39%), higher mean annual temperature (17.3°C), and low mean annual rainfall (137 mm). This region is dominated by arid shrublands and arid grasslands. The Upper Karoo Bioregion is the largest region and has a higher mean annual rainfall (266 mm), more reliable annual rainfall (CV: 36%) and lowest mean annual temperature (15.4°C). The higher elevation areas comprise montane shrublands, whereas the vast plains contain dwarf shrubland, grassy dwarf shrubland and patches of succulent dwarf shrubland. The Lower Karoo Bioregion is the smallest region and is located south of the Great Escarpment, and is generally climatically intermediate between the other two bioregions of the Nama-Karoo. This region consists of grassy scrub, arid shrubland and riparian woodland in the major river basins.

4. Vegetation Structure and Dynamics

Nama-Karoo is a complex of extensive plains, dominated by low (dwarf) shrubs (generally <1 m tall) intermixed with grasses, succulents, geophytes and annual forbs. Small trees occur only along drainage lines or on rocky outcrops—habitats with special hydrogeological microclimatic characteristics.

Despite relatively low floristic diversity, the Nama-Karoo vegetation has a high diversity of plant life forms. These include coexisting ephemerals, annuals, geophytes, C₃ and C₄ grasses, succulents, deciduous and evergreen chamaephytes and trees. This is probably a consequence of an ecotonal and climatically unstable nature of the region (Cowling et al. 1994), which gives no particular life form a consistent advantage. For example, winter rains favour C₃ grasses, succulents and chamaephytes, whereas summer rain and wet years appear to favour C₄ grasses and trees. Interannual variation in rainfall amount and seasonality, and in the frequency and timing of rain events, cause considerable variation in the appearance, structure, cover and productivity of the vegetation (Hoffman et al. 1990, Kellner & Booysen 1999), and may explain the conflicting description of the vegetation of the region given by explorers in the 18th century (Skead 1980).

Natural disturbance factors that drive many vegetation dynamics include many that are linked to human actions and many disturbances interact to modify effects. Factors include: grazing by domestic stock and wild herbivores (including insects), fire, rainfall and runoff (resulting in erosion) and other episodic events such as hailstorms.

Rainfall intensity can be high in the Nama-Karoo with its predominantly convective rain. This, coupled with the generally

low vegetation cover associated with aridity and with grazing pressure by domestic stock over two centuries, raises the potential for soil erosion. In semi-arid environments most of the nutrients are located near the soil surface where they are vulnerable to loss by grazing-induced sheet erosion (Snyman 1999). Soil erosion in the past is best illustrated by the Sterkspruit soil form found in the east of the biome. These soils are deep (>1 m) but grazing-induced erosion of the A-horizon in many places has exposed a relatively impermeable clay-rich B-horizon, resulting in minimal effective depth for rooting (Vorster 1985). Current modelled soil erosion (D. Pretorius, pers. comm.) shows very low to moderate erosion for the Bushmanland areas, mainly moderate erosion in the southern and southeastern Lower Karoo and highest variability in the northeastern Upper Karoo, with erosion varying from very low to high. Erosion in the last-mentioned area takes the form of sheet, gully and rill erosion, whereas in the first-mentioned area, wind erosion can occur (Ellis & Lambrechts 1986). One of the two dominant and shallow soil forms in the Nama-Karoo (Glenrosa) has a low erodibility on flats, gentle rises and apron slopes (Vorster 1985). Erodibility increases on steeper slopes of ridges, hills and mountains, although this is often ameliorated by stony deposits that reduce runoff intensity. The Mispah soil is the other dominant form in Nama-Karoo and is often found in association with Glenrosa. Mispah's erodibility is low. The deeper Hutton form soils are mainly derived from dolerite and old granite and are mainly without structure and have a very low erodibility. In contrast, the Sterkspruit and Swartland soil forms (with structured B-horizons with a high salt content) that are found overwhelmingly in the eastern Nama-Karoo, are very highly and highly erodible respectively, on sloping areas. Plant form can affect erosion. For example, grass cover resists erosion more effectively than shrub cover does (Roux & Opperman 1986). On the other hand, grasses tend to be more sensitive to erosion than shrubs. For example, seedlings of *Sporobolus fimbriatus* are sensitive to erosion, whereas *Psilocaulon coriarium* (= *P. absimile*) can establish itself under extreme conditions of surface disturbance and trampling (Roux & Opperman 1986).

A study of the effect of a hailstorm event in the Western Upper Karoo indicated that the supposed long-term damaging impact of hail on the vegetation of the Nama-Karoo may be seriously overstated (Powrie 1993). At the individual species level, however, plants with fine, brittle branches (*Eriocephalus spinescens* and *Pentzia spinescens*) and a leaf succulent [*Ruschia cradockensis* (= *Eberlanzia horrida*)] may have been adversely affected by hail. Recovery of vegetation after a hail event can be assisted by reducing grazing pressure for at least one year following the damaging event.

Fire in the western, more arid part of the Nama-Karoo is extremely rare. Even in the relatively mesic east, grazing and the highly variable rainfall result in low and discontinuous fuel loads, with only localised burns (Edwards 1984). Occasional fires may occur after successive years of good rainfall in combination with light grazing, resulting in an increased fuel load (Palmer et al. 1999). When it does occur, grass usually increases temporarily (Roux & Vorster 1983a). As a management tool in the dwarf shrublands of the eastern Nama-Karoo, fire should be avoided 'as post-fire recovery is extremely slow' (Palmer et al. 1999). Fire is potentially more common in the east along the southwestern edge of the Grassland Biome including the interface with this biome on the eastern mountains.

The Nama-Karoo region, because of its aridity and unpredictability, favours vagile herbivores such as ostrich (*Struthio camelus*) and springbok (*Antidorcas marsupialis*), nomadic granivorous birds such as finch-larks, lark-like buntings and sand

grouse (Dean 1997, 2000), and invertebrates with variable dormancy cued by rain, such as brown locust (*Locustana pardalina*) (Lea 1969, Todd et al. 2002) and Karoo caterpillar (*Loxostege frustralis*) (Anneck & Moran 1977). Populations of these 'boom or bust' species respond rapidly to nutritious post-drought regrowth, flowering and seeding, but when forage quality falls, they must move or die (Skinner et al. 1986, Owen-Smith 1988). Occasional irruptions of brown locust gregaria result in bands of hoppers that create grazing paths which are patchy (0.1–0.5 ha; Brown 1988) but can cover extensive areas (Boshoff 1988). Migrating swarms create grazing site areas at points along their flight path. Grass species are targeted, with only photosynthetically active material selected for grazing. Locust outbreaks do not occur throughout the Nama-Karoo and major outbreak areas seem to occur in the surrounds of Middelburg, De Aar and Hopetown (Erasmus 1988), where grass production potential is relatively high. Opportunistic insect predators are still a feature of Nama-Karoo, and large flocks of storks, bustards and kestrels and wattled starlings follow insect outbreaks (Barber 1980, Dean 2000). Huge herds of springbok periodically built up and moved through the Karoo in search of grazing (Skead 1980, Skinner 1993) until their numbers were diminished by hunting and their movements constrained by fences. Names of farms, hills and rivers in the Nama-Karoo conjure up the ghosts of migrants (buffalo, quagga, hartebeest, eland) and their predators (hyena, leopard, lion), all hunted to near extinction and now largely confined to nature reserves and game farms (Acoccks 1979, Dean & Milton 2003). Plant defence against herbivory and adaptations for seed dispersal by mammals are relatively uncommon in the Nama-Karoo, except along rivers and in seasonal pans, suggesting the transient nature of herbivory, except near water where herbivores lingered longer, exerting a greater selective pressure on plants (Milton et al. 1990, Milton 1991).

Since the 19th century, the vast herds of largely migratory ungulates indigenous to the biome have been almost completely replaced by domestic stock (sheep and goats) (Roux & Opperman 1986, Roux & Theron 1987). Following the Fencing Act of 1912, grazing stock was concentrated within farm boundaries. Subsequent subdivisions into camps were carried out on a large scale and stock numbers were increased 'with dire consequences' (Roux & Opperman 1986). The radical change in the grazing regime evoked major changes in the vegetation, especially in respect of species composition (Roux & Theron 1987). Grazing during and immediately after drought periods is a major cause of detrimental change. It appears, for example, that the drought of 1948 to 1950, coupled with heavy continuous grazing, was ultimately responsible for the death of large numbers of palatable plants (Roux & Theron 1987). A number of plant species are poisonous to domestic stock. Examples include species of *Kalanchoe* which cause prussic acid poisoning and *Tribulus terrestris* which is responsible for the most important metabolic disease *geeldikkop* (Vorster & Roux 1983). Game farming does occur in the Karoo, with springbok being overwhelmingly the most important game species (Jooste 1983). Most Nama-Karoo veld is regarded as 'sweet'. The grasses retain their palatability and nutritive value even when mature, and evergreen karroid dwarf shrubs and woody shrubs provide useful browsing in winter (Vorster 1999). The season of grazing can greatly alter plant dominance in the Nama-Karoo. A 30-year trial near Middelburg has shown that paddocks subjected to summer grazing by sheep become dominated by karroid shrubs while those grazed in winter become dominated by perennial grasses. This could be due to seasonal change in grazing preference of the sheep (which favour grasses in summer and herbs in winter) or to a differential response

by grasses to grazing in the growing season (summer) versus grazing in the dormant season (winter) (Palmer et al. 1999). Another analysis of data from these long-term grazing trials showed that plant community change was mostly driven by rainfall variation, but the influence of grazing treatments on longer-lived plants became more important over a longer time (O'Connor & Roux 1995).

Five phases of change in main components in the Upper Karoo over the last couple of centuries and into the future have been hypothesised assuming ongoing overgrazing and mismanagement and summarise some of the above (Roux & Vorster 1983b). Phase 1 is primary degradation in the 19th century and into the first quarter of the 20th century and is characterised by a dramatic decrease in cover of perennial sweet grass through the introduction of domestic stock. Phase 2 (primary denudation, until 1940/50) is characterised by further reduction in palatable species at a rate that could not be offset by the recruitment of these species in this phase. Phase 3 (re-vegetation, until 1970/80) is characterised by improved plant cover but largely in the form of unpalatable shrubs which recruit in the areas laid bare in the previous phase. Phase 4 (secondary degradation, at the time projected until 2000) is characterised by a relatively stable plant cover but with areas dominated by one or two unpalatable species. Phase 5 (desertified phase, projected beyond 2000) would lead to 'near complete degradation' as a result of reduced effectiveness of the rainfall and erosion. Roux & Vorster (1983b) do caution that much variation can occur in these phases and that no discrete breaks between phases should be expected.

5. Status

Very little of the Nama-Karoo has been transformed from natural vegetation to crops, dams, industry or other forms of land use that threaten natural diversity. The dominant land use is the ranching of small stock (wool and mutton sheep, mohair goats), cattle (to the north and east) and game farming with indigenous antelope (Hoffman et al. 1999). Most land is privately or communally owned. Ranches are fenced, but generally large (4 000–15 000 ha) as it takes 10–50 ha of Nama-Karoo to support one large animal unit (roughly equivalent to one head of cattle or seven sheep). Only 0.7% of land is statutorily conserved by national (Karoo and Augrabies Falls National Parks and part of Mountain Zebra National Park) and provincial agencies (Oviston Nature Reserve and parts of the Karoo and Commando Drift Nature Reserves). Additional areas are conserved by local authorities and private land-owners (Hilton-Taylor & Le Roux 1989). The conservation network has not been designed for efficient conservation of vegetation types or fauna. Conservation of birds and other vertebrates within the confines of a protected areas network is impractical given their nomadic response to climatic stochasticity (Dean & Siegfried 1997). The conservation status of the biome and its fauna therefore depends on the condition of the privately owned landscape matrix and the largely non-grazed corridors of vegetation adjacent to the road network. According to a recent assessment by Hoffman & Ashwell (2001), about 60% of the Nama-Karoo landscape has moderately to severely degraded soils and vegetation. Settled lifestyles, provision of drinking water from deep bore holes, virtual extermination of large predators and supplementary feeding of livestock during drought have enabled ranchers to keep animals on the rangeland for periods and at densities that can change vegetation and cause soil erosion.

Analysis of the conservation status of Nama-Karoo relative to the national level is covered in the relevant chapter. Some status

issues specific to a vegetation type are given in the description of the vegetation type.

6. Threats

The dynamic behaviour of Nama-Karoo vegetation influences the economy of the region. Grazing by domestic livestock, particularly during the summer growing season of most grasses, reduces the perennial grass component of Nama-Karoo vegetation relative to that of chamaephytes and ephemerals (Roux & Vorster 1983a, O'Connor & Roux 1995, Burke 2002). Interannual fluctuations in grassiness and biomass production influence grazing capacity (Van den Berg 1983, Novellie & Bezuidenhout 1994, O'Connor & Roux 1995, Venter 2001, Du Toit 2002). Prolonged droughts kill a high proportion of perennial plants, rapidly changing vegetation composition in favour of short-lived species with soil-stored seed banks (Henrici 1935a, Milton et al. 1995). Hailstorms cause similar changes at a smaller scale (Powrie 1993). Overgrazing following drought can delay vegetation recovery, exacerbating the effects of subsequent drought (Danckwerts & Stuart-Hill 1988). National and farm-level strategies for managing drought have attracted research and debate for the past century (Anonymous 1923, Booysen & Rowsell 1983) and will doubtless continue to do so, particularly if global warming would desertify the western Nama-Karoo as predicted (Hannah et al. 2002).

One approach to dealing with drought, endorsed by the Department of Agriculture during the 20th century (Turpin & Gill 1928, Whitlock 1961), was the establishment of plantations of alien, drought-hardy forage plants (cactus, saltbush, sisal). Unfortunately, this led to unwanted, bird- and livestock-facilitated invasions of *Prosopis glandulosa*, *P. juliflora* and *P. velutina* (Richardson et al. 2000) along drainage lines, Australian *Atriplex* species (*A. muelleri*, *A. nummularia*, *A. semibaccata*) on saline soils in the Sak River system, and Cactaceae (*Opuntia ficus-indica*, *O. humifusa*, *O. rosea*, *O. aurantiaca*, *Tephrocactus articulatus*) in the north and east of the biome (Milton et al. 1999, Dean & Milton 2000). Unpalatable (or poisonous) alien herbs such as *Atriplex lindleyi* subsp. *inflata* (Australia), *Salsola kali* and *Limonium sinuatum* (Europe) as well as American *Argemone ochroleuca* and *Schkuhria pinnata* became firmly established, especially in disturbed habitats (along roads, abandoned fields, overgrazed paddocks, sheep pens), diminishing the productivity and value of the land. Further information on alien plants is given under the specific vegetation type where relevant. A number of cogent reasons have been put forward for the likely spread of species of *Prosopis* in South Africa (including other parts of the Nama-Karoo), although other lesser understood factors may halt or reverse its potential for population growth and range expansion (Richardson et al. 2000). The forage availability to domestic stock is increasing by spreading *Prosopis*. However, this spread has a negative influence on the water supply downstream (Richardson et al. 2000).

Mining is not a major threat to habitat conservation in this biome. At present it is confined to igneous and metamorphic geology in the northwest of the region (copper, silver, gypsum, salt). A nuclear waste repository is situated at Vaalputs, Bushmanland, on the western border of the Nama-Karoo (Lloyd 1989a, b), in an area where natural radiation levels from igneous rock and in ground water are dangerously high.

Three climatic change scenarios (developed from GCMs and modelling a doubling of atmospheric CO₂ concentration) applied to South Africa (Rutherford et al. 1999a) indicated that the Nama-Karoo may be expected to exist in its current climate space only in the far eastern part of the existing biome (with

a small part displacing the southwestern Grassland Biome). Individual species, such as *Pentzia incana*, modelled using the same scenarios, indicate a sometimes less drastic reduction in range size in the Nama-Karoo. Rutherford et al. (1999b) attributed the relative vulnerability of the plant species of two national parks in the Nama-Karoo to climate change. Augrabies Falls National Park was indicated to be very vulnerable, with over 40% of its plant species at risk of extinction in the park. The Karoo National Park appeared much better buffered against projected climate change, with less than 1% of its plant species indicated to be at risk of extinction in the Park. Results of biogeoclimatic modelling of species such as *Opuntia ficus-indica* and the *Prosopis* species complex with climate change in the Nama-Karoo are not necessarily conclusive given doubt whether such aliens have yet attained their equilibrium distributions in South Africa (Richardson et al. 2000).

Threats at national level are addressed in the Chapter 17 in this book.

7. Action

The only way to improve the conservation status of the Nama-Karoo is to convince land owners that diverse indigenous vegetation is worth maintaining or conserving. To achieve this there has to be some financial incentive. This could be market-driven (for example farms in better condition should fetch better prices) or driven by national or provincial policy making provision for tax relief to individuals who own areas of particular conservation value and manage them well. The reality is that the Property Rates Bill may force land-owners to farm commercially or to sell their land to those who will do so. It is in the long-term interests of the country to ensure that such incentives for production in a harsh semidesert environment are accompanied by controls that ensure ecological sustainability.

8. Further Research

General reviews that summarise information on the Nama-Karoo environment, flora, fauna and land use include Cowling (1986), Cowling et al. (1986) and Cowling & Roux (1987). Werger (1978b, 1986) synthesised the literature on the phytogeography and phytosociology of the Karoo Biomes (Succulent and Nama), and these subjects have been updated and treated in more detail for the Nama-Karoo in Palmer & Hoffman (1997). Aspects of the environment, evolution, dynamics, utilisation, and conservation status of the Nama-Karoo are covered in a range management guide by Milton & Dean (1996) and in the multi-authored book edited by Dean & Milton (1999).

There has been relatively little in-depth and long-term research on the flora or vegetation of the Nama-Karoo other than that carried out by the Department of Agriculture (and its earlier equivalents) (Henrici 1935b, 1940, Botha et al. 1983, Vorster 1985, O'Connor & Roux 1995). These studies focused on the value of the vegetation for grazing by domestic livestock, and the effects of grazing and drought on vegetation composition. However, the economic costs of land degradation have not been quantified,

and this has to be done in order to develop rational conservation and farming policy. The debate around the effects of various grazing systems on the diversity, structure and resilience of Nama-Karoo vegetation still has to be resolved, as does the ecological cost of increasing grazing efficiency by reducing distances between stock watering points. Often, agricultural research emphasis has tended to ignore the total flora in a given area and hence, for example, information on diversity of annuals is scant.

The few phytosociological surveys carried out to date were mainly in protected areas (Palmer 1989, Du Preez & Venter 1990, Hoffman & Cowling 1991, Palmer 1991a, c, Cowling et al. 1994, Novellie & Bezuidenhout 1994, Palmer & Cowling 1994, Rubin & Palmer 1996, Burke 2001). The flora of the central Nama-Karoo remains under-collected (in fact many quarter-degree squares are devoid of collection records), despite the floristically and ecologically interesting inselbergs and outcrops of intrusive igneous rocks, stony plains, and isolated sand pockets in this area. Although ideal conservation networks have been proposed for individual taxa (Lombard 1995, Dean & Siegfried 1997), there is no integrative conservation planning. A multitaxa conservation strategy for the Nama-Karoo should be developed. This should consider the maintenance of the processes that have shaped the vegetation, and allow the vegetation to shift in response to climatic change. The feasibility of developing and maintaining corridors across private and state land therefore has to be investigated.

9. Descriptions of Vegetation Units

Bushmanland & West Griqualand

NKb 1 Lower Gariep Broken Veld

VT 32 Orange River Broken Veld (70%) (Acocks 1953). LR 51 Orange River Nama Karoo (95%) (Low & Rebelo 1996).

Distribution Northern Cape Province: Hardeveld along the Orange River from Onseepkans in the west, including the canyon below the Augrabies Falls and parts of Riemvasmaak and adjacent areas to Keimoes resuming from the Boegoeberg to



Figure 7.3 NKb 1 Lower Gariep Broken Veld: Ultrametamorphic koppies (locally called 'black hills') surrounded by sandy flats supporting *Stipagrostis hochstetteriana* karoo grasslands (Augrabies Falls National Park near Kakamas, Northern Cape).

around Prieska in the east. A series of inselbergs and koppies occurring between Keimoes and around Kakamas, and the ridge running west of Groblershoop from Karos in the north to around Marydale in the south. The unit also occurs in neighbouring Namibia. Most of the area varies from 400–1 200 m in altitude.

Vegetation & Landscape Features Hills and low mountains, slightly irregular plains but with some rugged terrain (e.g. downstream of the Augrabies Falls) with sparse vegetation dominated by shrubs and dwarf shrubs, with annuals conspicuous, especially in spring, and perennial grasses and herbs. Groups of widely scattered low trees such as *Aloe dichotoma* var. *dichotoma* and *Acacia mellifera* subsp. *detinens* occur on slopes of koppies and on sandy soils of foot slopes respectively.

Geology & Soils The region has a complicate geology: banded iron formation and amphibolites of the Asbestos Hills Subgroup are Vaalian and the carbonates and cherts of the Campbell Group are of the same Era. Metamorphic rocks of the Mokolian Erathem include quartzites and gneisses of the Korannaland Supergroup as well as the Riemvasmaak gneiss. Metamorphosed clastic sediments of the Uitdraai Formation are also Mokolian. The remaining half of the area is composed of many other stratigraphies, metamorphosed sediments and outcrops of the ultrametamorphic rocks of the Namaqualand Metamorphic Complex. The soils are shallow and skeletal (dominant soil forms are Mispah and Glenrosa), typical mainly of Ib and Ic land types, and to a lesser extent also of Fb land type.

Climate MAP ranges from about 70 mm in the west to 240 mm in the east. Mean maximum and minimum monthly temperatures for Kakamas are 41.3°C and –2°C for January and July respectively. Corresponding values for Prieska (near the eastern extremity) are 39.7°C and –4.1°C. Frost incidence varies from less than 10 days of frost per annum in the west to around 30 days in the east. See also climate diagram for NKb 1 Lower Gariep Broken Veld (Figure 7.2).

Important Taxa (^WWestern or ^EEastern part of this unit only) Succulent Trees: *Aloe dichotoma* var. *dichotoma*. Small Trees: *Acacia mellifera* subsp. *detinens* (d), *Commiphora gracilifrons*^W, *Ficus cordata*, *Pappea capensis*^W, *Rhus populifolia*^W, *Ziziphus mucronata* subsp. *mucronata*. Tall Shrubs: *Rhigozum trichotomum* (d), *Adenolobus garipensis*^W, *Antherothamnus pearsonii*^W, *Cadaba aphylla*, *Caesalpinia bracteata*, *Ehretia rigida* subsp. *rigida*, *Nymania capensis*, *Rhigozum obovatum*^E, *Rhus burchellii*. Epiphytic Semiparasitic Shrub: *Tapinanthus oleifolius*. Succulent Shrubs: *Ceraria namaquensis*, *Cryptolepis decida*^W, *Euphorbia avasmontana*, *E. gregaria*^W, *Kleinia longiflora*, *Lycium bosciifolium*, *Zygophyllum dregeanum*. Woody Succulent Climber: *Sarcostemma viminalis*. Low Shrubs: *Blepharis mitrata* (d), *Aizoon schellenbergii*, *Aptosimum albomarginatum*, *A. lineare*, *A. marlothii*, *Barleria rigida*, *Berkheya spinosissima* subsp. *namaensis*, *Dyerophytum africanum*, *Hermannia spinosa*, *H. vestita*, *Hibiscus elliotiae*, *Indigofera heterotricha*, *Limeum aethiopicum*, *Lophiocarpus polystachyus*, *Monechma spartioides*, *Phaeoptilum spinosum*, *Phyllanthus maderaspatensis*, *Polygala seminuda*, *Ptychobolium biflorum* subsp. *biflorum*, *Sericocoma avolans*, *Solanum capense*, *Stachys burchelliana*, *Talinum arnoetii*, *Tetragonia arbuscula*, *Zygophyllum rigidum*. Semiparasitic Shrub: *Thesium*

lineatum. Graminoids: *Aristida adscensionis* (d), *Enneapogon desvauxii* (d), *E. scaber* (d), *Eragrostis nindensis* (d), *Stipagrostis obtusa* (d), *S. uniplumis* (d), *Aristida congesta*, *A. engleri*, *Cenchrus ciliaris*, *Digitaria eriantha*, *Enneapogon cenchroides*, *Eragrostis annulata*, *E. lehmanniana*, *E. porosa*, *Schmidtia kalahariensis*, *Setaria verticillata*, *Sporobolus fimbriatus*^E, *Stipagrostis anomala*, *S. ciliata*, *Tragus berteronianus*, *Triraphis ramosissima*^W. Herbs: *Forsskaolea candida* (d), *Acanthopsis hoffmannseggiana*, *Barleria lichtensteiniana*, *Chamaesyce glanduligera*, *Chascanum garipense*, *Cleome angustifolia* subsp. *diandra*, *Codon royenii*, *Dicoma capensis*, *Garuleum schinzii*^E, *Rogeria longiflora*, *Sesamum capense*, *Tribulus zeyheri*, *Trichodesma africanum*. Succulent Herbs: *Orbea lutea* subsp. *lutea*, *Stapelia flavopurpurea*.

Endemic Taxon Succulent Shrub: *Ruschia pungens*.

Conservation Least threatened. Target 21%. Statutorily conserved in Augrabies Falls National Park (4%). Only a very small part transformed. Erosion is low (58%), very low (27%) and moderate (14%).

References Acocks (1953, 1988), Werger & Coetzee (1977), Bezuidenhout (1996), Zietsman & Bezuidenhout (1999).

NKb 2 Blouputs Karroid Thornveld

VT 33 Namaqualand Broken Veld (100%) (Acocks 1953). LR 51 Orange River Nama Karoo (100%) (Low & Rebelo 1996).

Distribution Northern Cape Province: An irregular belt of relatively flat areas skirting the Lower Gariep Broken Veld from around the Augrabies Falls, westwards on the plain above the Blouputs Valley, through the Narries area to the shallow valleys of Kotie se Laagte and Samoep se Laagte. The unit also occurs in southern Namibia. Altitude varies from 500–800 m.

Vegetation & Landscape Features An open shrubland on slightly undulating rocky plains dominated by patchy occurrences of *Acacia mellifera* subsp. *detinens*. Prominent lower shrubs include *Phaeoptilum spinosum*, *Boscia foetida* and *Cadaba aphylla*, while the dominant grasses include *Schmidtia kalahariensis* and *Stipagrostis ciliata*, *S. obtusa* and *S. uniplumis*.

Geology & Soils The geology is dominated by Mokolian gneisses such as those of the Hartbees River Complex and the younger Eendoorn Suite. Schists and quartzites of the



Figure 7.4 NKb 2 Blouputs Karroid Thornveld: *Acacia mellifera* subsp. *detinens* (with accompanying *Stipagrostis obtusa* and *S. uniplumis*) dominating thornveld in the western portion of the Augrabies Falls National Park (Northern Cape).

Bushmanland Group are also significant. Dorbank outcrops at many places and a very dense subdendritic drainage and dissection pattern. The dominating soil forms are Hutton and Mispah—coarse, sandy and shallow (0.1–0.3 m deep). Fb land type dominates the landscape.

Climate Lowest MAP of the vegetation types of the Nama-Karoo (80–120 mm). Seasonal rainfall peaks in March, winters are dry. Incidence of frost is relatively low. See also climate diagram for Nkb 2 Blouputs Karroid Thornveld (Figure 7.2).

Important Taxa Small Trees: *Acacia mellifera* subsp. *detinens* (d), *Boscia albi-trunca* (d), *B. foetida* subsp. *foetida* (d), *Acacia erioloba*, *Maerua gilgii*. Tall Shrubs: *Rhigozum trichotomum* (d), *Adenolobus garipensis*, *Cadaba aphylla*, *Caesalpinia bracteata*, *Ehretia rigida* subsp. *rigida*, *Nymanina capensis*, *Parkinsonia africana*. Epiphytic Semiparasitic Shrub: *Tapinanthus oleifolius*. Low Shrubs: *Phaeoptilum spinosum* (d), *Aptosimum marlothii*, *Berkheya spinosissima* subsp. *namaensis*, *Blepharis mitrata*, *Eriocephalus microphyllus* var. *pubescens*, *Galenia africana*, *Hermannia gariepina*, *H. spinosa*, *H. stricta*, *Indigofera pechuelii*, *Limeum aethiopicum*, *Lophiocarpus polystachyus*, *Microlooma incanum*, *Solanum capense*, *Tephrosia dregeana*, *Zygophyllum rigidum*. Succulent Shrubs: *Hoodia gordonii*, *Kleinia longiflora*, *Lycium bosciifolium*, *Salsola rabieana*. Semiparasitic Shrub: *Thesium lineatum*. Herbaceous Climbers: *Coccinia rehmannii*, *Pergularia daemia* var. *leiocarpa*. Herbs: *Amaranthus praetermissus*, *Chascanum garipense*, *Dicoma capensis*, *Forsskaolea candida*, *Limeum myosotis* var. *confusum*, *Mollugo cerviana*, *Sesamum capense*, *Tribulus cristatus*, *T. pterophorus*. Succulent Herbs: *Gisekia pharnacioides*, *Psilocaulon coriarium*, *Trianthema parvifolia*. Graminoids: *Schmidtia kalahariensis* (d), *Stipagrostis ciliata* (d), *S. hochstetteriana* (d), *S. obtusa* (d), *S. uniplumis* (d), *Aristida adscensionis*, *A. congesta*, *Cenchrus ciliaris*, *Enneapogon cenchroides*, *E. desvauxii*, *E. scaber*, *Eragrostis annulata*, *Leucophrys mesocoma*, *Setaria verticillata*, *Tragus racemosus*.

Conservation Least threatened. Target 21%. About 27% of the mapped area under statutory conservation (Augrabies Falls National Park), which is the highest value of any vegetation type in the Nama-Karoo. Only very small area has been transformed. Erosion is low (79%) and very low (21%).

Remarks This vegetation type has the smallest mapped area of all Nama-Karoo vegetation units. It also occurs in some areas in the Riemvasmaak region to the north of the Orange River where it was not mapped because of lack of GIS coverage.

References Werger & Coetzee (1977), Bezuidenhout (1996), Bezuidenhout & Jardine (2001).

Nkb 3 Bushmanland Arid Grassland

VT 29 Arid Karoo and Desert False Grassveld (36%), VT 32 Orange River Broken Veld (36%) (Acocks 1953). LR 51 Orange River Nama Karoo (51%) (Low & Rebelo 1996).

Distribution Northern Cape Province: Spanning about one degree of latitude from around Aggeneys in the west to Prieska in the east. The southern border of the unit is formed by edges



Figure 7.5 Nkb 3 Bushmanland Arid Grassland: Arid grassland dominated by species of *Aristida* and *Stipagrostis*, with a solitary koppie supporting vegetation of SKr 19 Bushmanland Inselberg Shrubland (Northern Cape, Aggeneys).

of the Bushmanland Basin while in the northwest this vegetation unit borders on desert vegetation (northwest of Aggeneys and Pofadder). The northern border (in the vicinity of Upington) and the eastern border (between Upington and Prieska) are formed with often intermingling units of Lower Gariep Broken Veld, Kalahari Karroid Shrubland and *Gordonia* Duneveld. Most of the western border is formed by the edge of the Namaqualand hills. Altitude varies mostly from 600–1 200 m.

Vegetation & Landscape Features Extensive to irregular plains on a slightly sloping plateau sparsely vegetated by grassland dominated by white grasses (*Stipagrostis* species) giving this vegetation type the character of semidesert 'steppe'. In places low shrubs of *Salsola* change the vegetation structure. In years of abundant rainfall rich displays of annual herbs can be expected.

Geology & Soils A third of the area is covered by recent (Quaternary) alluvium and calcrete. Superficial deposits of the Kalahari Group are also present in the east. The extensive Palaeozoic diamictites of the Dwyka Group also outcrop in the area as do gneisses and metasediments of Mokolian age. The soils of most of the area are red-yellow apedal soils, freely drained, with a high base status and <300 mm deep, with about one fifth of the area deeper than 300 mm, typical of Ag and Ae land types.

Climate Rainfall largely in late summer/early autumn (major peak) and very variable from year to year. MAP ranges from about 70 mm in the west to 200 mm in the east. Mean maximum and minimum monthly temperatures for Kenhardt are 40.6°C and –3.7°C for January and July respectively. Corresponding values for Pofadder are 38.3°C and –0.6°C. Frost incidence ranges from around 10 frost days per year in the northwest to about 35 days in the east. Whirl winds (dust devils) are common on hot summer days. See also climate diagram for Nkb 3 Bushmanland Arid Grassland (Figure 7.2).

Important Taxa ^(W)Western and ^(E)Eastern regions of the unit only) Graminoids: *Aristida adscensionis* (d), *A. congesta* (d), *Enneapogon desvauxii* (d), *Eragrostis nindensis* (d), *Schmidtia kalahariensis* (d), *Stipagrostis ciliata* (d), *S. obtusa* (d), *Cenchrus ciliaris*, *Enneapogon scaber*, *Eragrostis annulata*^E, *E. porosa*^E, *E. procumbens*, *Panicum lanipes*^E, *Setaria verticillata*^E, *Sporobolus nervosus*, *Stipagrostis brevifolia*^W, *S. uniplumis*, *Tragus berte-*

ronianus, *T. racemosus*^E. Small Trees: *Acacia mellifera* subsp. *detinens*^E, *Boscia foetida* subsp. *foetida*. Tall Shrubs: *Lycium cinereum* (d), *Rhigozum trichotomum* (d), *Cadaba aphylla*, *Parkinsonia africana*. Low Shrubs: *Aptosimum spinescens* (d), *Hermannia spinosa* (d), *Pentzia spinescens* (d), *Aizoon asbestinum*^E, *A. schellenbergii*^E, *Aptosimum elongatum*, *A. lineare*^E, *A. marlothii*^E, *Barleria rigida*, *Berkheya annectens*, *Blepharis mitrata*, *Eriocephalus ambiguus*, *E. spinescens*, *Limeum aethiopicum*, *Lophocarpus polystachyus*, *Monechma incanum*, *M. spartioides*, *Pentzia pinnatisecta*, *Phaeoptilum spinosum*^E, *Polygala seminuda*, *Pteronia leucoclada*, *P. mucronata*, *P. sordida*, *Rosenia humilis*, *Senecio niveus*, *Sericocoma avolans*, *Solanum capense*, *Talinum arnotii*^E, *Tetragonia arbuscula*, *Zygophyllum microphyllum*. Succulent Shrubs: *Kleinia longiflora*, *Lycium bosciifolium*, *Salsola tuberculata*, *S. glabrescens*. Herbs: *Acanthopsis hoffmannsegiana*, *Aizoon canariense*, *Amaranthus praetermissus*, *Barleria lichtensteiniana*^E, *Chamaesyce inaequilatera*, *Dicoma capensis*, *Indigastrium argyraeum*, *Lotononis platycarpa*, *Sesamum capense*, *Tribulus pterophorus*, *T. terrestris*, *Vahlia capensis*. Succulent Herbs: *Gisekia pharnacioides*^E, *Psilocaulon coriarium*, *Trianthema parvifolia*. Geophytic Herb: *Moraea venenata*.

Biogeographically Important Taxon (Bushmanland endemic)
Succulent Herb: *Tridentea dwequensis*.

Endemic Taxa Succulent Shrubs: *Dinteranthus pole-evansii*, *Larryleachia dinteri*, *L. marlothii*, *Ruschia kenhardtensis*. Herbs: *Lotononis oligocephala*, *Nemesia maxii*.

Conservation Least threatened. Target 21%. Only small patches statutorily conserved in Augrabies Falls National Park and Goegab Nature Reserve. Very little of the area has been transformed. Erosion is very low (60%) and low (33%).

Remarks This unit has a large longitudinal extent, with some species common in only part of the unit. Further research may lead to the split of this unit at a later stage.

References Acocks (1953, 1988), Du Toit (1996), L. Mucina (unpubl. data).

NKb 4 Bushmanland Sandy Grassland

VT 29 Arid Karoo and Desert False Grassveld (80%) (Acocks 1953). LR 49 Bushmanland Nama Karoo (71%) (Low & Rebelo 1996).

Distribution Northern Cape Province: Surrounds of Aggeneys (northern Bushmanland) and a few isolated patches south of Copperton on the eastern edge of the Bushmanland Basin suggesting the course of the paleoriverine system of the Orange River and its tributaries. The largest continuous patch of this vegetation type fills the shallow valley of the intermittent Koa River southeast and west of Aggeneys. Altitude varies mostly from 500–1 200 m.

Vegetation & Landscape Features Dense, sandy grassland plains with dominating white grasses (*Stipagrostis*, *Schmidtia*) and abundant drought-resistant shrubs. After rainy winters rich displays of ephemeral spring flora (*Grielum humifusum*, *Gazania lichtensteinii*) can occur.

Geology & Soils Mostly Quaternary sediments (sand, calcrete) with some contribution of the pre-Pleistocene Kalahari Group sediments in the east. Typically the surface is covered by red sands >300 mm deep, forming dunes in places. Af land type dominates.

Climate Major rainfall peak between February and April and a minor peak in November. MAP ranges from about 70–110 mm. See also climate diagram for NKb 4 Bushmanland Sandy Grassland (Figure 7.2).

Important Taxa Graminoids: *Schmidtia kalahariensis* (d), *Stipagrostis brevifolia* (d), *S. ciliata* (d), *S. obtusa* (d), *Aristida adscensionis*, *A. congesta*, *Centropodia glauca*, *Enneapogon desvauxii*, *Stipagrostis anomala*. Herbs: *Gazania lichtensteinii* (d), *Grielum humifusum* (d), *Tribulus zeyheri* (d), *Dicoma capensis*, *Hirpicium echinus*, *Manulea nervosa*, *Requienia sphaerosperma*, *Sesamum capense*. Succulent Herb: *Crassula muscosa*. Tall Shrubs: *Rhigozum trichotomum*, *Sisymbrium sparteum*. Low Shrubs: *Zygophyllum microphyllum* (d), *Barleria rigida*, *Berkheya spinosissima* subsp. *namaensis*, *Eriocephalus microphyllus* var. *pubescens*, *E. pauperrimus*, *Galenia fruticosa*, *Hermannia spinosa*, *Monechma incanum*, *Peliostomum leucorrhizum*, *Pentzia spinescens*, *Plinthus karoocicus*, *Pteronia mucronata*, *P. sordida*, *Rosenia humilis*, *Tetragonia arbuscula*. Succulent Shrubs: *Aridaria noctiflora* subsp. *straminea*, *Lycium bosciifolium*, *Ruschia robusta*, *Salsola tuberculata*, *Senecio cotyledonis*, *Zygophyllum flexuosum*, *Z. foetidum*. Woody Succulent Climber: *Sarcostemma viminalis*.

Conservation Least threatened. Target 21%. None conserved in statutory conservation areas. Very little of the area has been transformed. The alien shrub *Prosopis* sp. can be seen as a threat. Erosion is very low (82%) or moderate (17%).

Remarks This is a poorly known vegetation unit, separable from the surrounding units by its deep sands, often with red sand dunes. The occurrence of elements such as *Acacia erioloba*, *Schmidtia kalahariensis* and *Tribulus zeyheri* suggests similarity to southern Kalahari duneveld flora.

References Anderson & Van Heerden (2000), L. Mucina (unpubl. data).



Figure 7.6 NKb 4 Bushmanland Sandy Grassland: Dry shrubby grassland dominated by *Stipagrostis obtusa* and *S. brevifolia* on deep sands of the ancient Koa River wash near Aggeneys (Northern Cape).

NKb 5 Kalahari Karroid Shrubland

VT 16 Kalahari Thornveld and Shrub Bushveld (60%) (Acocks 1953). LR 29 Karroid Kalahari Bushveld (61%) (Low & Rebelo 1996).

Distribution Northern Cape Province: Typically forming belts alternating with belts of Gordonia Duneveld on plains north-west of Upington through Lutzputs and Noenieput to the Rietfontein/Mier area in the north. Other patches occur around Kakamas and north of Groblershoop. The unit is also found in the neighbouring Namibia. Altitude varies mostly from 700–1 100 m.

Vegetation & Landscape Features Low karroid shrubland on flat, gravel plains. Karoo-related elements (shrubs) meet here with northern floristic elements, indicating a transition to the Kalahari region and sandy soils.

Geology & Soils Cenozoic Kalahari Group sands and small patches also on calcrete outcrops and screes on scarps of intermittent rivers (mekgacha). In places Dwyka Group tillites outcrop. The soils are deep (>300 mm), red-yellow, apedal, freely drained, with a high base status, typical of Ae land type.

Climate MAP ranges from about 100–200 mm and most rain falls in late summer and early autumn. Winters are particularly dry, with lowest winter relative humidity compared to other Nama-Karoo types. Mean maximum and minimum monthly temperatures in Upington are 39.5°C and –4.2°C for January and July, respectively. Solar radiation is high and in winter is higher than in any other vegetation type of the Nama-Karoo. See also climate diagram for NKb 5 Kalahari Karroid Shrubland (Figure 7.2).

Important Taxa Small Trees: *Acacia mellifera* subsp. *detinens* (d), *Parkinsonia africana* (d), *Boscia foetida* subsp. *foetida*. Tall Shrub: *Rhigozum trichotomum* (d). Epiphytic Semiparasitic Shrub: *Tapinanthus oleifolius*. Low Shrubs: *Hermannia spinosa* (d), *Limeum aethiopicum* (d), *Phaeoptilum spinosum* (d), *Aizoon schellenbergii*, *Aptosimum albomarginatum*, *A. lineare*, *A. marlothii*, *A. spinescens*, *Barleria rigida*, *Hermannia modesta*, *Indigofera heterotricha*, *Leucosphaera bainesii*, *Monechma genistifolium* subsp. *genistifolium*, *Phyllanthus maderaspatensis*, *Polygala seminuda*, *Ptychobolium biflorum* subsp. *biflorum*, *Sericocoma avolans*, *Solanum capense*, *Tephrosia dregeana*. Herbs: *Dicoma capensis* (d), *Chamaesyce inaequilatera* (d), *Amaranthus praetermissus*, *Barleria lichtensteini*, *Chamaesyce glanduligera*, *Chascanum garipense*, *Cleome angustifolia* subsp. *diandra*, *Cucumis africanus*, *Geigeria ornativa*, *Hermannia abrotanoides*, *Indigastrium argyraeum*, *Indigofera alternans*, *I. auricoma*, *Kohautia cynanchica*, *Limeum argute-carinatum*, *Mollugo cerviana*, *Monsonia umbellata*, *Sesamum capense*, *Tribulus cristatus*, *T. pterophorus*, *T. terrestris*. Succulent Herbs: *Gisekia africana*, *G. pharnacioides*, *Trianthema parvifolia*. Graminoids: *Aristida adscensionis* (d), *Enneapogon desvauxii* (d), *E. scaber* (d), *Stipagrostis obtusa* (d), *Aristida congesta*, *Enneapogon cenchroides*, *Eragrostis annulata*, *E. homomalla*, *E. porosa*, *Schmidtia kalahariensis*, *Stipagrostis anomala*, *S. ciliata*, *S. hochstetteriana*, *S. uniplumis*, *Tragus berteronianus*, *T. racemosus*.

Biogeographically Important Taxon (Southwestern distribution limit) Graminoid: *Dinebra retroflexa*.

Conservation Least threatened. Target 21%. Very little statutorily conserved in Augrabies Falls National Park. Although only a small area has been transformed many of the belts of this type were preferred routes for early roads, thus promoting the introduction of alien plants (about a quarter of the unit has scattered *Prosopis* species). Erosion is very low (94%).

Remarks Vegetation of this mapping unit shows transitional features between the Kalahari proper (Savanna Biome) and the northern Nama-Karoo.

References Leistner (1967), Leistner & Werger (1973), Werger & Leistner (1975), Werger (1978b, 1986), Werger et al. (1979), Bezuidenhout (1996), Werger & Coetzee (1977).

NKb 6 Bushmanland Basin Shrubland

VT 29 Arid Karoo and Desert False Grassveld (88%) (Acocks 1953). LR 49 Bushmanland Nama Karoo (92%) (Low & Rebelo 1996).

Distribution Northern Cape Province: Large Bushmanland Basin centred on Brandvlei and Van Wyksvlei area, spanning Granaatboskolk in the west to Copperton in the east, and Kenhardt vicinity in the north to Williston vicinity in the south. Altitude ranges mostly from 800–1 200 m.

Vegetation & Landscape Features Slightly irregular plains with dwarf shrubland dominated by a mixture of low sturdy and spiny (and sometimes also succulent) shrubs (*Rhigozum*, *Salsola*, *Pentzia*, *Eriocephalus*), 'white' grasses (*Stipagrostis*) and in years of high rainfall also by abundant annuals such as species of *Gazania* and *Leysera*.

Geology & Soils Mudstones and shales of Ecce Group (Prince Albert and Volksrust Formations) and Dwyka tillites, both of early Karoo age, dominate. About 20% of rock outcrop is formed by Jurassic intrusive dolerite sheets and dykes. Soils are shallow Glenrosa and Mispah forms, with lime generally present in the entire landscape (Fc land type) and, to a lesser extent, red-yellow apedal, freely drained soils with a high base status and usually <15% clay (Ah and Ai land types) are also found. The salt content in these soils is very high.

Climate Rainfall occurs in late summer and early autumn. MAP ranges from about 100–200 mm. Mean maximum and minimum monthly temperatures in Brandvlei are 39.6°C and –2.2°C for January and July, respectively. Corresponding values for Van Wyksvlei are 39.5°C and –4.6°C. See also climate diagram for NKb 6 Bushmanland Basin Shrubland (Figure 7.2).

Important Taxa Tall Shrubs: *Lycium cinereum* (d), *Rhigozum trichotomum* (d). Low Shrubs: *Aptosimum spinescens* (d), *Hermannia spinosa* (d), *Pentzia spinescens* (d), *Zygophyllum microphyllum* (d), *Aptosimum elongatum*, *A. marlothii*, *Berkheya annectens*, *Eriocephalus microphyllus* var. *pubescens*, *E. pauperrimus*, *E. spinescens*, *Felicia clavipilosa* subsp. *clavipilosa*, *Limeum aethiopicum*, *Osteospermum armatum*, *O. spinescens*, *Pegolettia retrofracta*, *Phaeoptilum spinosum*, *Plinthus karooicus*, *Polygala seminuda*, *Pteronia glauca*, *P. inflexa*, *P. leucoclada*, *P. mucronata*, *P. sordida*, *Rosenia humilis*, *Selago albida*, *Senecio niveus*, *Tetragonia arbuscula*, *Zygophyllum lichtensteinianum*. Succulent Shrubs: *Salsola tuberculata* (d), *Aridaria noctiflora* subsp. *straminea*, *Brownanthus ciliatus* subsp. *ciliatus*, *Galenia sarcophylla*, *Lycium bosciifolium*, *Ruschia intricata*, *Salsola namibica*, *Sarcocaulon patersonii*, *S. salmoniflorum*, *Tripteris sinuata* var. *linearis*, *Zygophyllum flexuosum*. Semiparasitic Shrub: *Thesium hystrix*. Herbs: *Gazania lichtensteinii* (d), *Leysera tenella* (d), *Amaranthus praetermissus*, *Chamaesyce inaequilatera*, *Dicoma capensis*, *Indigastrium argyraeum*, *Lepidium desertorum*, *Monsonia umbellata*, *Radyera urens*, *Sesamum capense*, *Tribulus terrestris*, *T. zeyheri*. Succulent Herbs: *Mesembryanthemum crystallinum*, *M. stenandrum*, *Trianthema parvifolia*, *Zygophyllum simplex*. Graminoids: *Aristida adscensionis* (d), *Enneapogon desvauxii* (d), *Stipagrostis ciliata* (d), *S. obtusa* (d), *Aristida congesta*, *Enneapogon scaber*, *Stipagrostis anomala*, *Tragus berteronianus*, *T. racemosus*.



Figure 7.7 NKB 6 Bushmanland Basin Shrubland: Dwarf shrublands of the central Bushmanland with *Rhigozum trichotomum* and *Stipagrostis* species (Northern Cape, Brandvlei).

Biogeographically Important Taxon (Bushmanland endemic)
Succulent Herb: *Tridentea dwequensis*.

Endemic Taxa Herb: *Cromidon minutum*. Geophytic Herbs: *Ornithogalum bicornutum*, *O. ovatum* subsp. *oliverorum*.

Conservation Least threatened. Target 21%. None of the unit is conserved in statutory conservation areas. No signs of serious transformation, but scattered individuals of *Prosopis* sp. occur in some areas (e.g. in the vicinity of the Sak River drainage system), and some localised dense infestations form closed 'woodlands' along the eastern border of the unit with Northern Upper Karoo (east of Van Wyksvlei). Erosion is moderate (56%) and low (34%).

Remarks The Bushmanland Basin forms an environment for a number of endorheic pans (vloere) and extensive systems of intermittent river channels (including that of the Sak River). In comparison to the bordering Bushmanland Arid Grassland in the north, the vegetation of the Bushmanland Basin shows increased presence of shrubs (especially succulents) and plant indicators of high salt status of soil.

References Acocks (1953, 1988).

Upper Karoo

NKu 1 Western Upper Karoo

VT 29 Arid Karoo and Desert False Grassveld (82%) (Acocks 1953). LR 49 Bushmanland Nama Karoo (84%) (Low & Rebelo 1996).

Distribution Northern Cape Province and a small part in the Western Cape Province: Plains from the Fish River and upper reaches of the Renoster River in the west as far as Fraserburg and Carnarvon in the east, sandwiched between the Bushmanland Basin in the north and the Roggeveld Karoo and edges of the Great Escarpment

in the south. Altitude varies mostly from 1 000–1 500 m.

Vegetation & Landscape Features

Much dissected landscape in the south-west associated with the tributaries of the upper catchment of the Sak River (e.g. Renoster River, Riet River, Klein Sak River), often rocky. Mixture of small-leaved shrubs and shrubby succulents (*Brownanthus*, *Drosanthemum*, *Ruschia* etc.) with drought-resistant (mostly 'white') grasses is the determinant feature of the vegetation structure.

Geology & Soils Karoo sediments (shales, mudstones and arenites) of the Beaufort Group (Adelaide Subgroup) and to a lesser extent also of the Waterford Formation (Ecca Group). Intrusive dolerites of the Jurassic Karoo Dolerite Suite also feature. Glenrosa and Mispah soils (with lime generally present in the entire landscape) are overwhelmingly dominant. Fc land type dominates.

Climate Most of the precipitation occurs in autumn, peaking in March. MAP ranges from about 120–220 mm. Mean maximum and minimum monthly temperatures in Fraserburg are 36.2°C and –5.7°C for January and July, respectively. Corresponding values for Williston are 38.1°C and –4.5°C. Incidence of frost ranges from around 30 frost days per year in the north to about 60 days in the south. See also climate diagram for NKu 1 Western Upper Karoo (Figure 7.2).

Important Taxa Tall Shrubs: *Lycium cinereum* (d), *L. pilifolium*, *Rhigozum trichotomum*, *Tripteris sinuata* var. *linearis*. Low Shrubs: *Chrysocoma ciliata* (d), *Eriocephalus ericoides* subsp. *ericoides* (d), *E. spinescens* (d), *Helichrysum lucilioides* (d), *Osteospermum spinescens* (d), *Pentzia globosa* (d), *P. spinescens* (d), *Tetragonia arbuscula* (d), *Amphiglossa triflora*, *Aptosimum elongatum*, *A. indivisum*, *A. spinescens*, *Asparagus capensis* var. *capensis*, *Berkheya annectens*, *Eriocephalus decussatus*, *E. pauperrimus*, *Euryops imbricatus*, *E. multifidus*, *Felicia macrorrhiza*, *F. muricata*, *Hermannia cuneifolia*, *H. grandiflora*, *H. multiflora*, *H. spinosa*, *Limeum aethiopicum*, *Melolobium candicans*,



Figure 7.8 NKu 1 Western Upper Karoo: Shrub-rich karoo grasslands dominated by *Aristida* and *Stipagrostis* northeast of Williston (Northern Cape).

Microlooma armatum, *Pegolettia retrofracta*, *Pentzia incana*, *P. lanata*, *Plinthus karooicus*, *Polygala pungens*, *Pteronia adenocarpa*, *P. glauca*, *P. mucronata*, *P. sordida*, *Rosenia glandulosa*, *R. humilis*, *Selago albida*, *Stachys cuneata*, *Zygophyllum microphyllum*. Succulent Shrubs: *Ruschia intricata* (d), *Aridaria noctiflora* subsp. *straminea*, *Bassia salsoloides*, *Brownanthus ciliatus* subsp. *ciliatus*, *Drosanthemum ambiguum*, *D. lique*, *Euphorbia rectirama*, *Galenia sarcophylla*, *Salsola calluna*, *S. glabrescens*, *S. rabieana*, *S. tuberculata*, *Sarcocaulon patersonii*, *Zygophyllum flexuosum*. Herbs: *Lepidium africanum* subsp. *africanum*, *L. desertorum*, *Leysera tenella*, *Pelargonium minimum*, *Sutera pinnatifida*, *Ursinia nana*. Succulent Herbs: *Mesembryanthemum crystallinum*, *Psilocaulon coriarium*. Geophytic Herbs: *Drimia intricata*, *Oxalis depressa*, *Tritonia karooica*. Graminoids: *Aristida congesta* (d), *Enneapogon desvauxii* (d), *Stipagrostis ciliata* (d), *S. obtusa* (d), *Aristida adscensionis*, *A. diffusa*, *Eragrostis bicolor*, *E. obtusa*, *Fingerhuthia africana*, *Tragus berteronianus*, *T. koelerioides*.

Biogeographically Important Taxon (Western distribution limit) Graminoid: *Eragrostis lehmanniana*.

Endemic Taxa Succulent Shrub: *Stomatium villetii*. Herb: *Zaluzianskya bella*.

Conservation Least threatened. Target 21%. None conserved in statutory conservation areas. Very little transformed. Erosion is moderate (52%) and low (44%).

Remarks Even when present in relatively small quantities, species such as *Drosanthemum lique* and *Pteronia sordida* are shown by fistula samples to be consistently grazed by several types of sheep and goats in this vegetation type in all seasons of the year (Du Toit et al. 1995). By contrast, even when common, species such as *Pentzia globosa* appear to be consistently avoided by these animals throughout the year.

References Acocks (1953, 1988), Du Toit (1996).

NKu 2 Upper Karoo Hardeveld

VT 29 Arid Karoo and Desert False Grassveld (23%), VT 27 Central Upper Karoo (15%), VT 26 Karroid Broken Veld (12%), VT 35 False Arid Karoo (12%) (Acocks 1953). LR 50 Upper Nama Karoo (31%), LR 49 Bushmanland Nama Karoo (23%) (Low & Rebelo 1996).

Distribution Northern, Western and Eastern Cape Provinces: Discrete areas of slopes and ridges including dolerite dykes and sills in the region spanning Middelpos in the west and Strydenburg, Richmond and Nieu-Bethesda in the east. Most crest areas and steep slopes of the Great Escarpment facing south between Teekloofpas (connecting Leeu-Gamka and Fraserburg) and eastwards to Graaff-Reinet. Altitude varies mostly from 1 000–1 900 m.

Vegetation & Landscape Features Steep slopes of kop-pies, butts, mesas and parts of the Great Escarpment covered with large boulders and stones supporting sparse dwarf Karoo scrub with drought-tolerant grasses of genera such as *Aristida*, *Eragrostis* and *Stipagrostis*.

Geology & Soils Primitive, skeletal soils in rocky areas developing over sedimentary rocks such as mudstones and arenites of the Adelaide Subgroup of the Karoo Supergroup and to a lesser extent also the Ecca Group (Waterford and Volksrust Formations) as well as Jurassic dolerite sills and dykes and subsummit positions of mesas and butts with dolerite boulder slopes. Almost entirely lb land type.

Climate In the western part of its area this unit experiences the same climate as the Western Upper Karoo. In the eastern part

the climate is very close to that of Karoo Escarpment. The MAP ranges from about 150 mm in the northwest to 350 mm along some grassland margins on the Great Escarpment and in the east. Water concentrates between rocks as a result of rainfall runoff. Incidence of frost is relatively high, but ranging widely from <30 days per year at lower altitudes to >80 days at highest altitudes. See also climate diagram for NKu 2 Upper Karoo Hardeveld (Figure 7.2).

Important Taxa Tall Shrubs: *Lycium cinereum* (d), *Rhigozum obovatum* (d), *Cadaba aphylla*, *Diospyros austro-africana*, *Ehretia rigida* subsp. *rigida*, *Lycium oxycarpum*, *Melanthus comosus*, *Rhus burchellii*. Low Shrubs: *Chrysocoma ciliata* (d), *Eriocephalus ericoides* subsp. *ericoides* (d), *Euryops lateriflorus* (d), *Felicia muricata* (d), *Limeum aethiopicum* (d), *Pteronia glauca* (d), *Amphiglossa triflora*, *Aptosimum elongatum*, *A. spinescens*, *Asparagus mucronatus*, *A. retrofractus*, *A. striatus*, *A. suaveolens*, *Eriocephalus spinescens*, *Euryops annae*, *E. candollei*, *E. empetrifolium*, *E. nodosus*, *Felicia filifolia* subsp. *filifolia*, *Garuleum latifolium*, *Helichrysum lucilioides*, *H. zeyheri*, *Hermannia filifolia* var. *filifolia*, *H. multiflora*, *H. pulchella*, *H. vestita*, *Indigofera sessilifolia*, *Jamesbrittenia atropurpurea*, *Lessertia frutescens*, *Melolobium candicans*, *M. microphyllum*, *Microlooma armatum*, *Monechma incanum*, *Nenax microphylla*, *Pegolettia retrofracta*, *Pelargonium abrotanifolium*, *P. ramosissimum*, *Pentzia globosa*, *P. spinescens*, *Plinthus karooicus*, *Polygala seminuda*, *Pteronia adenocarpa*, *P. sordida*, *Rosenia humilis*, *Selago albida*, *Solanum capense*, *Sutera halimifolia*, *Tetragonia arbuscula*, *Wahlenbergia tenella*. Succulent Shrubs: *Aloe broomii*, *Drosanthemum lique*, *Faucaria bosscheana*, *Kleinia longiflora*, *Pachypodium succulentum*, *Trichodiadema barbatum*, *Zygophyllum flexuosum*. Semiparasitic Shrub: *Thesium lineatum* (d). Herbs: *Troglophyton capillaceum* subsp. *capillaceum*, *Dianthus caespitosus* subsp. *caespitosus*, *Gazania krebsiana*, *Lepidium africanum* subsp. *africanum*, *Leysera tenella*, *Pelargonium minimum*, *Sutera pinnatifida*, *Tribulus terrestris*. Geophytic Herbs: *Albuca setosa*, *Androcymbium albomarginatum*, *Asplenium cordatum*, *Boophone disticha*, *Cheilanthes bergiana*, *Drimia intricata*, *Oxalis depressa*, Graminoids: *Aristida adscensionis* (d), *A. congesta* (d), *A. diffusa* (d), *Cenchrus ciliaris* (d), *Enneapogon desvauxii* (d), *Eragrostis lehmanniana* (d), *E. obtusa* (d), *Sporobolus fimbriatus* (d), *Stipagrostis obtusa* (d), *Cynodon incompletus*, *Digitaria eriantha*, *Ehrharta calycina*, *Enneapogon scaber*, *E. scoparius*, *Eragrostis curvula*, *E. nindensis*, *E. procumbens*, *Fingerhuthia africana*, *Heteropogon contortus*, *Merxmüllera disticha*, *Stipagrostis ciliata*, *Themeda triandra*, *Tragus berteronianus*, *T. koelerioides*.

Endemic Taxa Succulent Shrubs: *Aloe chlorantha*, *Crassula barbata* subsp. *broomii*, *Delosperma robustum*, *Sceletium expanseum*, *Stomatium suaveolens*. Low Shrubs: *Cineraria polycephala*, *Euryops petraeus*, *Lotononis azureoides*, *Selago magnakarooica*. Tall Shrub: *Anisodonteia malvastroides*. Herbs: *Cineraria arctotidea*, *Vellereophyton niveum*. Succulent Herbs: *Adromischus falcatus*, *A. humilis*. Geophytic Herbs: *Gethyllis longistyla*, *Lachenalia auriolae*, *Ornithogalum paucifolium* subsp. *karooparkense*.

Conservation Least threatened. Target 21%. Only about 3% statutorily conserved in Karoo National Park and Karoo Nature Reserve. Small percentage also protected in private reserves such as Rupert Game Farm. Erosion is moderate (64%) and high (2%).

Remarks One of the richer floras of the Nama-Karoo Biome, this type also contains a substantial number of diagnostic species relative to the surrounding extensive flats (i.e. the Eastern, Northern and Western Upper Karoo vegetation units). Examples are the widespread occurrence of *Asparagus mucronatus*, *A. striatus*, *Cissampelos capensis*, *Pachypodium succulentum*,



Figure 7.9 NKu 2 Upper Karoo Hardeveld: Dolerite koppies supporting grassy karoo shrublands south of Loxton (Northern Cape).

Rhigozum obovatum and *Cenchrus ciliaris* in this unit. Many of the endemic species listed are found along the Great Escarpment part of this vegetation type.

Reference Palmer (1990).

NKu 3 Northern Upper Karoo

VT 35 False Arid Karoo (35%), VT 36 False Upper Karoo (27%) (Acocks 1953). LR 50 Upper Nama Karoo (44%), LR 52 Eastern Mixed Nama Karoo (24%) (Low & Rebelo 1996).

Distribution Northern Cape and Free State Provinces: Northern regions of the Upper Karoo plateau from Prieska, Vosburg and Carnarvon in the west to Philipstown, Petrusville and Petrusburg in the east. Bordered in the north by Niekerkshoop, Douglas and Petrusburg and in the south by Carnarvon, Pampoenpoort and De Aar. A few patches occur in Griqualand West. Altitude varies mostly from 1 000–1 500 m.

Vegetation & Landscape Features Shrubland dominated by dwarf karoo shrubs, grasses and *Acacia mellifera* subsp. *detinens* and some other low trees (especially on sandy soils in the northern parts and vicinity of the Orange River). Flat to gently sloping, with isolated hills of Upper Karoo Hardeveld in the south and Vaalbos Rocky Shrubland in the northeast and with many interspersed pans.

Geology & Soils Shales of the Volksrust Formation and to a lesser extent the Prince Albert Formation (both of the Ecce Group) as well as Dwyka Group diamictites form the underlying geology. Jurassic Karoo Dolerite sills and sheets support this vegetation complex in places. Wide stretches of land are covered by superficial deposits including calcretes of the Kalahari Group. Soils are variable from shallow to deep, red-yellow, apedal, freely drained soils to very shallow Glenrosa and Mispah forms. Mainly Ae, Ag and Fc land types.

Climate Rainfall peaks in autumn (March). MAP ranges from about 190 mm in the west to 400 mm in the northeast. Mean maximum and minimum monthly temperatures for Britstown are 37.9°C and –3.6°C for January and July, respectively. Corresponding values are 37.1°C and –4.8°C for De Aar and 39.0°C and –2.3°C for Kareekloof (northwest of Strydenburg). See also climate diagram for NKu 3 Northern Upper Karoo (Figure 7.2).

Important Taxa Small Trees: *Acacia mellifera* subsp. *detinens*, *Boscia albi-trunca*. Tall Shrubs: *Lycium cinereum* (d), *L. horridum*, *L. oxycarpum*, *L. schizocalyx*, *Rhigozum trichotomum*. Low Shrubs: *Chrysocoma ciliata* (d), *Gnidia polycephala* (d), *Pentzia calcarea* (d), *P. globosa* (d), *P. incana* (d), *P. spinescens* (d), *Rosenia humilis* (d), *Amphiglossa triflora*, *Aptosimum marlothii*, *A. spinescens*, *Asparagus glaucus*, *Barleria rigida*, *Berkheya annectens*, *Eriocephalus ericoides* subsp. *ericoides*, *E. glandulosus*, *E. spinescens*, *Euryops asparagoides*, *Felicia muricata*, *Helichrysum lucilioides*, *Hermannia spinosa*, *Leucas capensis*, *Limeum aethiopicum*, *Melolobium candicans*, *Microlooma armatum*, *Osteospermum leptolobum*, *O. spinescens*, *Pegolettia retrofracta*, *Pentzia lanata*, *Phyllanthus maderaspatensis*, *Plinthus karooicus*, *Pteronia glauca*, *P. sordida*, *Selago geniculata*, *S. saxatilis*,

Tetragonia arbuscula, *Zygophyllum lichtensteinianum*. Succulent Shrubs: *Hertia pallens*, *Salsola calluna*, *S. glabrescens*, *S. rabieana*, *S. tuberculata*, *Zygophyllum flexuosum*. Semiparasitic Shrub: *Thesium hystrix* (d), Herbs: *Chamaesyce inaequilatera*, *Convolvulus sagittatus*, *Dicoma capensis*, *Gazania krebsiana*, *Hermannia comosa*, *Indigofera alternans*, *Lessertia pauciflora*, *Radyera urens*, *Sesamum capense*, *Sutera pinnatifida*, *Tribulus terrestris*, *Vahlia capensis*. Succulent Herb: *Psilocaulon coriarium*. Geophytic Herb: *Moraea pallida*. Graminoids: *Aristida adscensionis* (d), *A. congesta* (d), *A. diffusa* (d), *Enneapogon desvauxii* (d), *Eragrostis lehmanniana* (d), *E. obtusa* (d), *E. truncata* (d), *Sporobolus fimbriatus* (d), *Stipagrostis obtusa* (d), *Eragrostis bicolor*, *E. porosa*, *Fingerhuthia africana*, *Heteropogon contortus*, *Stipagrostis ciliata*, *Themeda triandra*, *Tragus berteronianus*, *T. koelerioides*, *T. racemosus*.

Biogeographically Important Taxa Herb (western distribution limit): *Convolvulus boedeckerianus*. Tall Shrub (southern limit of distribution): *Gymnosporia szyszylowiczii* subsp. *namibiensis*.

Endemic Taxa Succulent Shrubs: *Lithops hookeri*, *Stomatium pluridens*. Low Shrubs: *Atriplex spongiosa*, *Galenia exigua*. Herb: *Manulea deserticola*.

Conservation Least threatened. Target 21%. None conserved in statutory conservation areas. About 4% has been cleared for cultivation (the highest proportion of any type in the Nama-Karoo) or irreversibly transformed by building of dams (Houwater, Kalkfontein and Smart Syndicate Dams). Areas of human settlements are increasing in the northeastern part of this vegetation type (Hoffman et al. 1999). Erosion is moderate (46.2%), very low (32%) and low (20%). *Prosopis glandulosa*, regarded as one of the 12 agriculturally most important invasive alien plants in South Africa, is widely distributed in this vegetation type (Hoffman et al. 1999). *Prosopis* occurs in generally isolated patches, with densities ranging from very scattered to medium (associated with the lower Vaal River drainage system and the confluence with the Orange River) to localised closed woodland on the western border of the unit with Bushmanland Basin Shrubland.

Remark This Karoo unit is found on floristic and ecological gradients between the Nama-Karoo, arid Kalahari savanna and arid highveld grasslands.

References Acocks (1953, 1988), Werger (1980), Palmer (1990).

NKu 4 Eastern Upper Karoo

VT 36 False Upper Karoo (54%) (Acocks 1953). LR 52 Eastern Mixed Nama Karoo (61%) (Low & Rebelo 1996).

Distribution Northern Cape, Eastern Cape and Western Cape Provinces: Between Carnarvon and Loxton in the west, De Aar, Petrusville and Venterstad in the north, Burgersdorp, Hofmeyr and Cradock in the east and the Great Escarpment and the Sneeuberge-Coetzeeberg mountain chain in the south. Altitude varies between mostly 1 000–1 700 m.

Vegetation & Landscape Features Flats and gently sloping plains (interspersed with hills and rocky areas of Upper Karoo Hardeveld in the west, Besemkaree Koppies Shrubland in the northeast and Tarkastad Montane Shrubland in the southeast), dominated by dwarf microphyllous shrubs, with 'white' grasses of the genera *Aristida* and *Eragrostis* (these become prominent especially in the early autumn months after good summer rains). The grass cover increases along a gradient from southwest to northeast.

Geology & Soils Mudstones and sandstones of the Beaufort Group (incl. both Adelaide and Tarkastad Subgroups) supporting duplex soils with prisma-cutanic and/or pedocutanic diagnostic horizons dominant (Da land type) as well as some shallow Glenrosa and Mispah soils (Fb and Fc land types). In places, less prominent Jurassic dolerites (Karoo Dolerite Suite) are also found.

Climate Rainfall mainly in autumn and summer, peaking in March. MAP ranges from about 180 mm in the west to 430 mm in the east. Incidence of frost is relatively high, but ranging widely from <30 days (in the lower-altitude Cradock area) to >80 days of frost per year (bordering the Upper Karoo Hardeveld on the Compassberg and mountains immediately to the west). Mean maximum and minimum monthly temperatures in Middelburg (Grootfontein) are 36.1°C and –7.2°C for January and July, respectively. Corresponding values are 37°C and –8°C for Victoria West and 36.6°C and –4.2°C for Hofmeyr. See also climate diagram for NKu 4 Eastern Upper Karoo.

Important Taxa Tall Shrubs: *Lycium cinereum* (d), *L. horridum*, *L. oxycarpum*. Low Shrubs: *Chrysocoma ciliata* (d), *Eriocephalus ericoides* subsp. *ericoides* (d), *E. spinescens* (d), *Pentzia glo-*

bosa (d), *P. incana* (d), *Phymaspermum parvifolium* (d), *Salsola calluna* (d), *Aptosimum procumbens*, *Felicia muricata*, *Gnidia polycephala*, *Helichrysum dregeanum*, *H. lucilioides*, *Limeum aethiopicum*, *Nenax microphylla*, *Osteospermum leptolobum*, *Plinthus karooicus*, *Pteronia glauca*, *Rosenia humilis*, *Selago geniculata*, *S. saxatilis*. Succulent Shrubs: *Euphorbia hypogaea*, *Ruschia intricata*. Herbs: *Indigofera alternans*, *Pelargonium minimum*, *Tribulus terrestris*. Geophytic Herbs: *Moraea pallida* (d), *Moraea polystachya*, *Syringodea bifucata*, *S. concolor*. Succulent Herbs: *Psilocaulon coriarium*, *Tridentea jucunda*, *T. virescens*. Graminoids: *Aristida congesta* (d), *A. diffusa* (d), *Cynodon incompletus* (d), *Eragrostis bergiana* (d), *E. bicolor* (d), *E. lehmanniana* (d), *E. obtusa* (d), *Sporobolus fimbriatus* (d), *Stipagrostis ciliata* (d), *Tragus koelerioides* (d), *Aristida adscensionis*, *Chloris virgata*, *Cyperus usitatus*, *Digitaria eriantha*, *Enneapogon desvauxii*, *E. scoparius*, *Eragrostis curvula*, *Fingerhuthia africana*, *Heteropogon contortus*, *Sporobolus ludwigii*, *S. tenellus*, *Stipagrostis obtusa*, *Themeda triandra*, *Tragus berteronianus*.

Endemic Taxa Succulent Shrubs: *Chasmatophyllum rouxii*, *Hertia cluytiifolia*, *Rabiea albinota*, *Salsola tetrandra*. Tall Shrub: *Phymaspermum scoparium*. Low Shrubs: *Aspalathus acicularis* subsp. *planifolia*, *Selago persimilis*, *S. walpersii*.

Conservation Least threatened. Target 21%. Statutorily conserved in Mountain Zebra and Karoo National Parks as well as in Oviston, Commando Drift, Rolfontein and Gariep Dam Nature Reserves. About 2% of the unit has been transformed, largely due to building of dams (Gariep, Grassridge, Killowen, Kommandodrift, Kriegerspoort, Lake Arthur, Modderpoort, Schuil Hoek, Vanderkloof, Victoria West, Wonderboom and Zoetvlei). *Medicago laciniata* is a common and widespread alien plant. Erosion is moderate (60%) and high (38%). Veld managers perceive much of the Eastern Upper Karoo to be experiencing changes in species composition requiring high-priority action (Hoffman et al. 1999).

Remarks This vegetation type has the largest mapped area of all vegetation units. The regions between Colesberg (Northern Cape) and Springfontein (Free State) fall within a broad ecotone where grassy Eastern Upper Karoo grades into Xhariep Karroid Grassland.

References Acocks (1953, 1988), Werger (1973, 1980), Van der Walt (1980), Palmer (1988, 1991a, b, c), Jooste (1989), Lloyd & Badenhorst (1995, 1996), Du Toit (1996), Low & Rebelo (1996, 1998), Hoffman et al. (1999), Pienaar et al. (2004), Brown & Bezuidenhout (2005).

Lower Karoo

NKI 1 Gamka Karoo

VT 26 Karroid Broken Veld (76%) (Acocks 1953). LR 53 Great Nama Karoo (70%) (Low & Rebelo 1996). BHU 91 Gamka Broken Veld (Cowling & Heijnis 2001).

Distribution Western Cape and Eastern Cape Provinces and marginally into the Northern Cape Province: Large basin between the Great Escarpment (Nuweveld Mountains) in the north and northwest and Cape Fold Belt Mountains (mostly Swartberg Mountains) in the south. From approximately the edge of



Figure 7.10 NKu 4 Eastern Upper Karoo: Typical winter view of karoo shrublands with species of *Pentzia*, *Eriocephalus*, *Rosenia* and *Lycium* and scattered 'white grasses' (species of *Aristida*, *Eragrostis*, *Stipagrostis*) south of Richmond (Northern Cape).



L. Mucina

Figure 7.11 NK1 1 Gamka Karoo: Dry karoo shrublands in the surrounds of the Gamka River at the foot of the Swartberg Mountains in the background near Leeuw-Gamka (Western Cape).

the Gamka basin catchment area (i.e. of the Dwyka River tributary) in the west to about the Kariega River in the east. Altitude varies mostly from 500–1 100 m.

Vegetation & Landscape Features Extremely irregular to slightly undulating plains covered with dwarf spiny shrubland dominated by Karoo dwarf shrubs (e.g. *Chrysocoma ciliata*, *Eriocephalus ericoides*) with rare low trees (e.g. *Euclea undulata*). Dense stands of drought-resistant grasses (*Stipagrostis*, *Aristida*) cover (especially after abundant rains) broad sandy bottomlands.

Geology & Soils Mudstones and sandstones of the Beaufort Group (Adelaide Subgroup) with some Ecca (Fort Brown Formation) shales supporting very shallow and stony soils of the Glenrosa and/or Mispah forms, typical of Fc land type.

Climate One of the most arid units of the Nama-Karoo Biome. Rainfall mainly in autumn and summer, with a marked peak in March and low levels of cyclonic rain in winter. This region is in the rainshadow of Cape Fold Belt mountains in the south, MAP ranging from about 100 mm in some areas between the Dwyka and Gamka Rivers to about 240 mm against the Great Escarpment. Mean maximum and minimum monthly temperatures in Beaufort West are 38.7°C and –3.2°C for January and July, respectively. Strong northwesterly winds occur in winter. See also climate diagram for NK1 1 Gamka Karoo (Figure 7.2).

Important Taxa Tall Shrubs: *Lycium cinereum* (d), *L. oxycarpum* (d), *Rhigozum obovatum* (d), *Acacia karroo*, *Cadaba aphylla*, *Lycium schizocalyx*, *Rhus burchellii*, *Sisyndite spartea*. Low Shrubs: *Chrysocoma ciliata* (d), *Eriocephalus ericoides* subsp. *ericoides* (d), *E. spinescens* (d), *Felicia muricata* (d), *Galenia fruticosa* (d), *Limeum aethiopicum* (d), *Pentzia incana* (d), *Pteronia adenocarpa* (d), *Rosenia humilis* (d), *Aptosimum indivisum*, *Asparagus burchellii*, *Blepharis mitrata*, *Eriocephalus microphyllus* var. *pubescens*, *Felicia filifolia* subsp. *filifolia*, *F. muricata* subsp. *cinerascens*, *Galenia secunda*, *Garuleum bipinnatum*, *G. latifolium*, *Gomphocarpus filiformis*, *Helichrysum lucilioides*, *Hermannia desertorum*, *H. grandiflora*, *H. spinosa*, *Melolobium candicans*, *Microloma armatum*, *Monechma spartioides*, *Pentzia pinnatisecta*, *Plinthus karooicus*, *Polygala seminuda*, *Pteronia glauca*, *P. sordida*, *P. viscosa*, *Selago geniculata*, *Sericocoma avolans*, *Zygophyllum microcarpum*, *Z. microphyllum*. Succulent Shrubs: *Ruschia intricata* (d), *Aridaria noctiflora* subsp. *straminea*,

Crassula muscosa, *Drosanthemum lique*, *Galenia sarcophylla*, *Kleinia longiflora*, *Ruschia spinosa*, *Salsola tuberculata*, *Sarcocaulon patersonii*, *Trichodiadema barbatum*, *Tripteris sinuata* var. *linearis*. Semiparasitic Shrub: *Thesium lineatum*. Herbs: *Gazania lichtensteinii* (d), *Chamaesyce inaequilatera*, *Dicoma capensis*, *Galenia glandulifera*, *Lepidium africanum* subsp. *africanum*, *L. desertorum*, *Lessertia pauciflora* var. *pauciflora*, *Leysera tenella*, *Osteospermum microphyllum*, *Sesamum capense*, *Tetragonia microptera*, *Tribulus terrestris*, *Ursinia nana*. Geophytic Herbs: *Drimia intricata*, *Moraea polystachya*. Graminoids: *Aristida congesta* (d), *A. diffusa* (d), *Fingerhuthia africana* (d), *Stipagrostis ciliata* (d), *S. obtusa* (d), *Aristida adscensionis*, *Cenchrus ciliaris*, *Digitaria argyrogrota*, *Enneapogon desvauxii*, *Enneapogon scaber*, *Eragrostis homomalla*, *E. lehmanniana*, *E. obtusa*, *Tragus berteronianus*, *T. koelerioides*.

Biogeographically Important Taxa (*Endemic to Great Karoo Basin) Succulent Shrubs: *Hereroa latipetala** (also found in Prince Albert Succulent Karoo), *H. odorata** (also found in Koedoesberge-Moordenaars Karoo), *Pleiospilos compactus* (southern and western limits of distribution), *Rhinephyllum luteum**, *Stapelia engleriana**. Geophytic Herb: *Tritonia tugwelliae**. Low Shrub: *Felicia lasiocarpa**. Succulent Herbs: *Piarranthus comptus**, *Tridentea parvipuncta* subsp. *parvipuncta**. Graminoid: *Oropetium capense* (westernmost limit of distribution).

Endemic Taxa Succulent Shrubs: *Chasmatophyllum stanleyi*, *Hereroa incurva*, *Hoodia dregei*, *Ruschia beaufortensis*. Low Shrubs: *Jamesbrittenia tenuifolia*. Herb: *Manulea karrooica*. Succulent Herb: *Piarranthus comptus*.

Conservation Least threatened. Target 16%. About 2% statutorily conserved in the Karoo National Park and some in private reserves, such as Steenbokkie Private Nature Reserve (near Beaufort West). Only small part has undergone transformation. The alien *Salsola kali* is a serious infestation problem locally. Erosion is moderate (78%), low (11%) and high (11%).

References Acocks (1953, 1979, 1988), Du Toit (1996), Low & Rebelo (1996, 1998), Rubin & Palmer (1996), Cowling & Hejnis (2001).

NK1 2 Eastern Lower Karoo

VT 30 Central Lower Karoo (43%), VT 26 Karroid Broken Veld (31%) (Acocks 1953). LR 54 Central Lower Nama Karoo (94%) (Low & Rebelo 1996). Grassy Dwarf Shrublands of the Camdebo and Aberdeen plains, Dwarf Shrublands (typicum) of the Camdebo & Succulent Dwarf Shrubland (Palmer 1991a).

Distribution Eastern Cape and Western Cape Provinces: Plains east of the Kariega and Buffels Rivers in the area south of the Camdebo Mountains and the line of mountains linking to the Coetzeeberge encompassing Aberdeen, Graaff-Reinet and Pearston (region called Camdebo) and plains south of Aberdeen to Klipplaat and Miller. Contains some higher elevation islands of Camdebo Escarpment Thicket, Groot Thicket and Lower Karoo Gwarrieveld. Altitude varies mostly from 500–1 100 m.

Vegetation & Landscape Features Plains interrupted by some dolerite dykes, butts and mesas. The dominating vegetation is low to middle-height microphyllous shrubland with

drought-resistant 'white' grasses becoming abundant in places, especially on sandy and silty bottomlands. Leaf-succulent dwarf shrubs of the families Aizoaceae and Crassulaceae can also be encountered.

Geology & Soils Flat or gently sloping pediments composed of mudstone and resistant sandstones of the Beaufort Group (Adelaide Subgroup), Ecca sediments and Dwyka tillites in the south, with some Jurassic dolerite intrusions in the north. About half the area has red-yellow, apedal, freely drained soils, <300 mm deep, with a high base status (Ag land type). Also shallow Glenrosa and/or Mispah soils (Fc land type).

Climate Rainfall mostly in late summer and early autumn, with main peak in March. MAP ranges from about 150 mm in the west to 350 mm in the east. Mean maximum and minimum monthly temperatures for Graaff-Reinet are 38.6°C and -0.3°C for January and July, respectively. See also climate diagram for NKL 2 Eastern Lower Karoo (Figure 7.2).

Important Taxa Small Trees: *Acacia karroo*. Tall Shrubs: *Lycium cinereum* (d), *L. oxycarpum* (d), *Cadaba aphylla*, *Carissa haematocarpa*, *Grewia robusta*, *Lycium schizocalyx*, *Rhigozum obovatum*. Low Shrubs: *Eriocephalus ericoides* subsp. *ericoides* (d), *Felicia muricata* (d), *Pentzia incana* (d), *Rosenia humilis* (d), *Aptosimum elongatum*, *Asparagus striatus*, *A. suaveolens*, *Barleria pungens*, *Blepharis capensis*, *B. mitrata*, *Chrysocoma ciliata*, *Euryops anthemoides*, *Felicia muricata*, *Galenia secunda*, *Garuleum latifolium*, *Helichrysum zeyheri*, *Hermannia cuneifolia*, *Indigofera sessilifolia*, *Limeum aethiopicum*, *Microloma armatum*, *Pegolettia retrofracta*, *Phymaspermum parvifolium*, *Plinthus karooicus*, *Polygala seminuda*, *Pteronia adenocarpa*, *P. glauca*, *P. sordida*, *Selago fruticosa*, *Senecio acutifolius*, *Sutera halimifolia*, *Zygophyllum microphyllum*. Succulent Shrubs: *Ruschia cradockensis* subsp. *cradockensis* (d), *Astroloba foliolosa*, *Crassula corallina*, *Drosanthemum lique*, *D. subspinosum*, *Euphorbia ferox*, *Mestoklema tuberosum*, *Pachypodium succulentum*, *Rhombophyllum nelii*, *Sarcocaulon camdeboense*, *S. patersonii*, *Trichodiadema barbatum*. Semiparasitic Shrub: *Thesium hystris*. Graminoids: *Aristida adscensionis* (d), *A. congesta* (d), *Eragrostis lehmanniana* (d), *E. obtusa* (d), *Tragus berteronianus* (d), *T. koelerioides* (d), *T. racemosus* (d), *A. diffusa*, *Chloris virgata*, *Cynodon incompletus*, *Enneapogon desvauxii*, *Eragrostis curvula*, *Stipagrostis obtusa*. Herbs: *Chamaesyce inaequilatera*, *Convolvulus sagittatus*, *Gazania krebsiana*, *Lepidium africanum* subsp. *africanum*, *Tribulus terrestris*. Succulent Herbs: *Crassula muscosa*, *Psilocaulon articulatum*, *P. coriarium*, *Senecio radicans*. Geophytic Herbs: *Albuca setosa*, *Drimia anomala*, *D. intricata*, *Moraea polystachya*.

Endemic Taxa Succulent Shrubs: *Aloinopsis rubrolineata*, *Chasmatophyllum nelii*, *Cylindrophyllum calamiforme*, *Euphorbia coerulans*, *Ruschia vanderbergiae*. Succulent Herbs: *Haworthia decipiens* var. *cyanea*, *H. greenii*.

Conservation Least threatened. Target 16%. Some of patches statutorily conserved in Aberdeen and Karoo Nature Reserves as well as in private reserves such as Minnawill Game Farm. Between 1% and 2% transformed by alien infestation. Erosion is high (45%) and moderate (45%).

Remarks Vegetation structure of the Eastern Lower Karoo differs from the Gamka Karoo with its higher proportion of succulent dwarf shrubs (species of *Ruschia*) and higher frequency of larger woody shrubs (*Diospyros*, *Euclea*, *Lycium*, *Rhus*) associated with rocky outcrops and other mesic patches.

References Acocks (1953, 1988), Palmer (1988, 1989, 1991a, c), Hoffman (1989a, b), Du Toit (1996).

NKL 3 Lower Karoo Gwarrieveld

VT 26 Karroid Broken Veld (56%) (Acocks 1953). LR 54 Central Lower Nama Karoo (63%) (Low & Rebelo 1996). STEP Sundays Gwarrieveld (61%) (Vlok & Euston-Brown 2002).

Distribution Eastern Cape Province: An irregular northeastern belt south of the Camdebo plains extends westwards along the northern edge of the usually higher-altitude thicket from Westondale (Pearston District), crossing the Sundays River in the Meerlust area (north of Jansenville) to Oatlands. To the west, it flanks the thicket on the Tierberg (Aberdeen District) and its associated ridges. Further south, a belt in the Baroe-Wolfefontein Valley encircles an area of lower-altitude Eastern Lower Karoo and also extends through Seekoeinek to the south. Altitude varies mostly from 500–1 000 m.

Vegetation & Landscape Features Hills and gentle slopes supporting shrubland with sparse canopy of *Euclea undulata*, *Schotia afra*, *Boscia oleoides* and *Pappea capensis*. Common shrubs include *Rhigozum obovatum* and *Eriocephalus ericoides*. Very little remains of the palatable grass component, while less palatable species, for example *Aristida diffusa*, are abundant in rocky outcrops. Isolated remnants of *Portulacaria afra* occur in places.

Geology & Soils Predominantly shallow soils of Glenrosa and/or Mispah forms over mostly mudstones and sandstones of the Beaufort Group (Adelaide Subgroup) and some sedimentary rocks of the Ecca Group. Fc land type dominates, Ag land type plays a subordinate role.

Climate Most rainfall in summer and autumn (peaking in March). MAP ranges from about 190–330 mm. See also climate diagram for NKL 3 Lower Karoo Gwarrieveld (Figure 7.2).

Important Taxa Succulent Tree: *Aloe ferox*. Small Trees: *Acacia karroo* (d), *Euclea undulata* (d), *Pappea capensis* (d), *Boscia oleoides*, *Schotia afra* var. *afra*. Tall Shrubs: *Lycium oxycarpum* (d), *Rhigozum obovatum* (d), *Cadaba aphylla*, *Carissa haematocarpa*, *Ehretia rigida* subsp. *rigida*, *Grewia robusta*, *Nymania capensis*, *Rhus longispina*. Woody Climbers: *Cissampelos capensis*, *Rhoicissus digitata*. Epiphytic Semiparasitic Shrub: *Viscum rotundifolium*. Low Shrubs: *Asparagus racemosus* (d), *A. striatus* (d), *Eriocephalus ericoides* subsp. *ericoides* (d), *Euryops anthemoides* (d), *Felicia muricata* (d), *Helichrysum dregeanum* (d), *Limeum aethiopicum* (d), *Pentzia incana* (d), *Aptosimum elongatum*, *Asparagus mucronatus*, *A. suaveolens*, *Barleria pungens*, *Blepharis capensis*, *Chrysocoma ciliata*, *Felicia muricata*, *F. ovata*, *Garuleum latifolium*, *Indigofera obcordata*, *Lantana rugosa*, *Phymaspermum parvifolium*, *Polygala seminuda*, *Rosenia humilis*, *Selago fruticosa*. Succulent Shrubs: *Euphorbia ferox* (d), *Aloe striata* subsp. *karasbergensis*, *Crassula muscosa*, *Drosanthemum lique*, *Euphorbia enopla* var. *viridis*, *E. esculenta*, *E. horrida* var. *noorsveldensis*, *E. mauritanica* var. *corallothamnus*, *Mestoklema tuberosum*, *Pachypodium succulentum*, *Portulacaria afra*, *Trichodiadema barbatum*. Herbs: *Aizoon glinoides*, *Chamaesyce inaequilatera*, *Hermannia pulverata*, *Lepidium africanum* subsp. *africanum*, *Tribulus terrestris*. Geophytic Herbs: *Drimia intricata*, *Sansevieria hyacinthoides*. Graminoids: *Aristida congesta* (d), *A. diffusa* (d), *Eragrostis lehmanniana* (d), *E. obtusa* (d), *Aristida adscensionis*, *Cynodon incompletus*, *Cyperus capensis*, *Enneapogon desvauxii*, *E. scoparius*, *Eragrostis curvula*, *Panicum maximum*, *Setaria verticillata*, *Sporobolus fimbriatus*, *Tragus koelerioides*.

Endemic Taxon Succulent Herb: *Haworthia bruynsii*.

Conservation Least threatened. Target 16%. None conserved in statutory conservation areas, but small patches protected in

private reserves such as Blaawbosch Game Farm. About 1% transformed by alien infestation (e.g. *Salsola kali*). Erosion is moderate (81%) and very low (10%).

Remarks This vegetation typically occurs sandwiched between Eastern Lower Karoo at lower altitudes and thicket types at higher altitudes. The western and southern sections are rich in succulents, whereas leaf succulents are uncommon in the north-eastern section. *Salsola kali* can be common in some areas.

References Vlok & Euston-Brown (2002), Vlok et al. (2003).

NKI 4 Albany Broken Veld

VT 37 False Karroid Broken Veld (62%) (Acocks 1953). LR 52 Eastern Mixed Nama Karoo (76%) (Low & Rebelo 1996). STEP Saltaire Karroid Thicket (54%) (Vlok & Euston-Brown 2002).

Distribution Eastern Cape Province: Immediately to the north of the Zuurberg Mountains and south of Middlewater, Ripon and the area around the confluence of the Great and Little Fish Rivers and extending eastwards, north of the mountain ridges around Riebeeck East to the Carlisle Bridge area and south of these ridges in the upper Bushmans River Valley past Alicedale and up the New Years River Valley. Including also some irregular linear patches east of Riebeeck East. Altitude varies mostly from 300–800 m.

Vegetation & Landscape Features Low mountain ridges and hills with an open grassy karroid dwarf shrubland with scattered low trees (*Boscia oleoides*, *Euclea undulata*, *Pappea capensis*, *Schotia afra* var. *afra*) with a matrix of dwarf shrubs (*Becium burchellianum*, *Chrysocoma ciliata*) and grasses (*Eragrostis obtusa*).

Geology & Soils Mainly shales and some sandstones of various stratigraphic units within the Witteberg Group of the Cape Supergroup and the Beaufort, Ecce and Dwyka Groups of the Karoo Supergroup. Mainly Glenrosa and/or Mispah soils (Fc land type) with some red-yellow, apedal, drained soils, with a high base status, generally <300 mm deep, typical of Ag land type.

Climate Bimodal rainfall with main peak in March and secondary peak in November. Some rain falls in the winter months. Rainfall relatively high for the Nama-Karoo. Incidence of frost

is low, with less than a tenth of the area experiencing more than 10 frost days per year. MAP ranges from about 290 mm in the west (in the rainshadow of the Zuurberg) to about 500 mm in the east. See also climate diagram for NKI 4 Albany Broken Veld (Figure 7.2).

Important Taxa Succulent Tree: *Aloe ferox*. Small Trees: *Acacia natalitia* (d), *Euclea undulata* (d), *Pappea capensis* (d), *Schotia afra* var. *afra* (d), *Boscia oleoides*, *Cussonia spicata*. Tall Shrubs: *Grewia robusta*, *Lycium cinereum*, *Putterlickia pyracantha*, *Rhigozum obovatum*, *Rhus incisa* var. *effusa*. Low Shrubs: *Asparagus striatus* (d), *A. suaveolens* (d), *Becium burchellianum* (d), *Chrysocoma ciliata* (d), *Selago fruticosa* (d), *Asparagus acokseii*, *A. racemosus*, *Eriocephalus ericoides* subsp. *ericoides*, *Felicia filifolia*, *F. muricata*, *Gnidia cuneata*, *Helichrysum dregeanum*, *Hermannia linearifolia*, *Indigofera sessilifolia*, *Limeum aethiopicum*, *Nenax microphylla*, *Pentzia incana*, *Polygala seminuda*, *Rosenia humilis*. Succulent Shrubs: *Cotyledon campanulata*, *Drosanthemum lique*, *Euphorbia meloformis*, *E. rectirama*, *Faucaria britteniae*, *F. tigrina*, *Mestoklema tuberosum*. Herbs: *Gazania krebsiana*, *Hermannia pulverata*, *Hibiscus pusillus*. Geophytic Herbs: *Bulbine frutescens*, *Drimia anomala*, *Eriospermum dregei*, *Ornithogalum dyeri*. Succulent Herbs: *Gasteria bicolor*, *Ophionella arcuata* subsp. *arcuata*, *Platythyra hackeliana*, *Senecio radicans*, *Stapeliopsis pillansii*. Graminoids: *Aristida congesta* (d), *Eragrostis obtusa* (d), *Sporobolus fimbriatus* (d), *Tragus berteronianus* (d), *Cynodon incompletus*, *Digitaria eriantha*, *Ehrharta calycina*, *Eragrostis curvula*, *Setaria sphacelata*, *Tragus koelerioides*.

Biogeographically Important Taxon (Western distribution limit) Succulent Shrub: *Sarcocaulon vanderietiae*.

Endemic Taxa Geophytic Herbs: *Brachystelma huttonii*, *Ornithogalum britteniae*, *O. perdurans*. Succulent Herbs: *Haworthia cymbiformis* var. *obtusata*. Succulent Shrubs: *Ceropegia fimbriata* subsp. *fimbriata*, *Euphorbia inermis* var. *huttoniae*, *Rhombophyllum albanense*, *R. dyeri*.

Conservation Least threatened. Target 16%. Only small percentage statutorily conserved in Greater Addo Elephant National Park, but considerable share (12%) enjoys protection in private reserves (Kuzuko Game Reserve, Frontier Safaris Game Farm, Aylesbury Nature Reserve, Rockdale Game Ranch and Woodlands Game Reserve). About 3% transformed for cultivation. Erosion is moderate (68%), low (16%) or high (14%).

Remarks This vegetation type differs in a number of respects from those of the rest of the Nama-Karoo. Apart from climatic differences (highest rainfall, least frost), this type has a number of important species that are regarded as not important elsewhere in the Nama-Karoo. It is also the only vegetation type within the Nama-Karoo in which species such as *Enneapogon desvauxii* do not qualify as an important species.

References Acocks (1953, 1988), Palmer (1981), Dold & Hammer (2003).

10. Credits

The first version of the map for the Nama-Karoo resulted from a joint effort between L. Mucina, the late J.W. Lloyd and B. van der Merwe. Important conceptual contributions to the delimitation of the units were made by M.C. Rutherford



A.R. Palmer

Figure 7.12 NKI 4 Albany Broken Veld: Dense karroid vegetation with *Pappea capensis*, *Aloe ferox* and dwarf-shrub undergrowth, north of Grahamstown (Eastern Cape).

(particularly in Nk 2, NKu 2 and NKI 3), J.H.J. Vlok and D.I.W. Euston-Brown (NKI 3 and NKI 4), H. Bezuidenhout (Nk 2) and D.B. Hoare (NKI 4). A.R. Palmer has co-authored units NKI 2, NKI 3 and NKI 4. The introductory text (sections 1 to 8) was shaped by contributions of S.J. Milton, M.C. Rutherford, A.R. Palmer and to a small extent by L. Mucina. L. Scott has provided section 3.1. Most of the text of the descriptions was supplied by L. Mucina—all Nk 2 units except Nk 2, all NKu units and all NKI units. In the latter, A.R. Palmer was the leading author. All descriptions were also co-authored by M.C. Rutherford, who contributed particularly to the sections on climate and conservation and to the species lists. A.P. Dold has contributed to species lists (especially list of endemic plants) in NKI 2, NKI 3 and NKI 4. L.W. Powrie and M.C. Rutherford supplied environmental and conservation-related data. All photographs except three (for acknowledgements see below) were provided by L. Mucina. M. Rouget, and others within the Directorate of Biodiversity Programmes, Policy & Planning of SANBI, provided quantitative information for each vegetation unit on conservation status and targets, areas currently conserved and areas transformed.

R.A. Ward kindly checked and corrected the geological terminology. A. Venter has checked the use of *Lycium* species in the text. E. Pienaar (opening double-page), G. Castley (Nk 2) and A.R. Palmer (NKI 4) each provided a photograph.

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Semela

*Helehelele semela, kobo ya lefatshe!
Seng sa hao se tletse naha ho pota.
Ekaba matswatlareng, ekaba motsitseng,
Ekaba mongobong, ekaba lehlabatheng,
Baheno ha ba hlome ba a jala sebele,
Ba jala ba dumellwa kapa ba hanelwa.*

*Ha o namme tjee maoto o a nka kae?
Ha o batalletse tjee maqheka o a nka kae?
Ke bua ka wena kobo ya lefatshe,
Ke bua ka wena palesa ya lefatshe,
Ha o palesa feela empa o bile o morena,
Hoba o ratwa ke batho le diphoofolo.*

*Ke se ke itse o hole o name semela,
Ke se itse peseletsa o peseletse kgutsana,
Nama o namele lefatshe o tlise ditharollo,
Ditharollo e be tsa tlala le ona malwetse;
Le hara malwetse ke bua ka ana a kajeno;
A kajeno ke afe ha e se bona bo HIV le AIDS?*

(Ka M.A. Dladla)

Grassland Biome

8

Ladislav Mucina, David B. Hoare, Mervyn C. Lötter, P. Johann du Preez, Michael C. Rutherford, C. Robert Scott-Shaw, George J. Bredenkamp, Leslie W. Powrie, Louis Scott, Kelson G.T. Camp, Sarel S. Cilliers, Hugo Bezuidenhout, Theo H. Mostert, Stefan J. Siebert, Pieter J.D. Winter, John E. Burrows, Linda Dobson, Robert A. Ward, Marc Stalmans, Edward G.H. (Ted) Oliver, Frances Siebert, Ernst Schmidt, Khotso Kobisi and Lerato Kose

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1. Introduction

1.1 Grassland Biome and 'grasslands': What's in the Name?

This chapter is a descriptive, biogeographical and conservation account of the Grassland Biome as defined by the new boundaries in the National Vegetation Map (Mucina et al. 2005; see also Chapter 18 in this book). Its primary aim is to describe patterns and variation in the floristic and plant-functional composition and environmental parameters of plant communities in the Grassland Biome. Ideas on the origins of plant diversity and biogeographical patterns in grasslands, the problems regarding the interface with other biomes, and the topical conservation issues are also featured. This chapter extends and updates previous reviews featuring the ecology and origins of the Grassland Biome patterns (e.g. Low & Rebelo 1996, O'Connor & Bredenkamp 1997, Bredenkamp et al. 2002) by presenting new data as well as new interpretations.

The term 'grassland' is one of the most used, misused and abused terms of vegetation ecology—both by vegetation ecologists and by users of the products of their work. Obviously, any piece of land dominated by grasses can be called 'grassland'. This term then is addressing purely the structural facet of this vegetation—it is neutral and basically all inclusive. Some researchers would take this approach to global level and call all grasslands of the world 'Grassland Biome' (e.g. Coupland 1993), including grasslands of both temperate and tropical provenience. And it is here where the conceptual problems with the term 'grassland' start. Following the definitions of biomes (Rutherford & Westfall 1986, Mucina 2000), we separate two major (so-called climatically controlled) grassland types into temperate and tropical. Despite major structural similarities and often common evolutionary roots, they differ in the major features of macroclimate, structure and, from a textural point of view, in composition of life forms and species. The analytical comparisons of these two different types of grassland are justified at the broad scale (across continents), but become very problematic due to different sets of ecological and evolutionary driving forces at detailed scales (such as landscape and habitats). The (sub)tropical grasslands are considered to be part of the (sub)tropical biomes such as the Savanna Biome and Indian Ocean Coastal Belt (see the relevant chapters in this book). The warm-temperate and cool-temperate grasslands (and shrublands embedded within these) of the Highveld, Drakensberg and its northern continuation in the form of the Northern Escarpment, a whole suite of sub-escarpment grasslands, and small pockets of (most) summit sourveld composed of grasslands and savannoid bushveld (see below) make up the

Grassland Biome in our view. There are also azonal (satellite) patches of Grassland Biome communities that occur outside the main biome boundaries, such as grassy shrublands on koppies of Gh 4 Besemkaree Koppies Shrubland embedded within Nama-Karoo. The existence of these communities is linked to special habitat conditions involving shallow soils and rocky outcrops (Figure 8.2).

The extent of the Grassland Biome in Low & Rebelo (1996) and that represented here differ, especially with respect to the edaphic grasslands occurring within the subtropical biomes of South Africa. For instance, Low & Rebelo (1996) mapped Grassland Biome along the eastern coast from the Albany region, through Pondoland as far as Maputaland in the north. We consider these grasslands either secondary (Albany Coastal Belt and Transkei Coastal Belt) or edaphic (Pondoland sourveld and Maputaland coastal grasslands). In the light of this and for climatic reasons, two 'grassland' units such as SVs 4 Ngongoni Veld and SVs 5 KwaZulu-Natal Sandstone Sourveld (both classified as Sub-Escarpment Savanna, see the chapter on Savanna Biome in this book) are not considered as Grassland Biome units. Our knowledge about the primary versus secondary status of the Ngongoni grasslands is in its infancy. We hypothesise that 'ngongoni' (*Aristida junciformis*) is a grass of high competitive potential and can, by virtue of building dense swards resistant to grazing damage, control recruitment of woody plants. In any

case, both of the latter units are of transitional character and further insights into their ecology (especially patterns of floristic composition) and origins may result in their re-classification.

In this chapter the term 'grassland' refers to herbaceous vegetation of relatively short and simple structure that is dominated by graminoids, usually of the family Poaceae. Woody plants are rare (usually low or medium-sized shrubs) or absent or are confined to specific habitats, such as smaller escarpments or koppies. Core grassland areas usually have deep, fertile soils although a wide spectrum of soil types occurs. Precipitation is strongly seasonal and the growing season lasts approximately half the year.

1.2 Global Patterns and Local Distribution

The Grassland Biome (latitude 25° to 33° S) is part of the global Temperate Grassland Biome, which comprises the Eurasian steppes and American prairies (Great Plains) in the northern hemisphere as well as the Argentinean and Uruguayan pampas (and to an extent also grassland of southern Brazil), the temperate grasslands of the Australian Alps and the tussock grasslands of New Zealand in the southern hemisphere. The most extensive temperate grasslands in the northern hemisphere are the Eurasian steppes, which extend almost a third of the way around the world between latitudes 45° and 60° N,

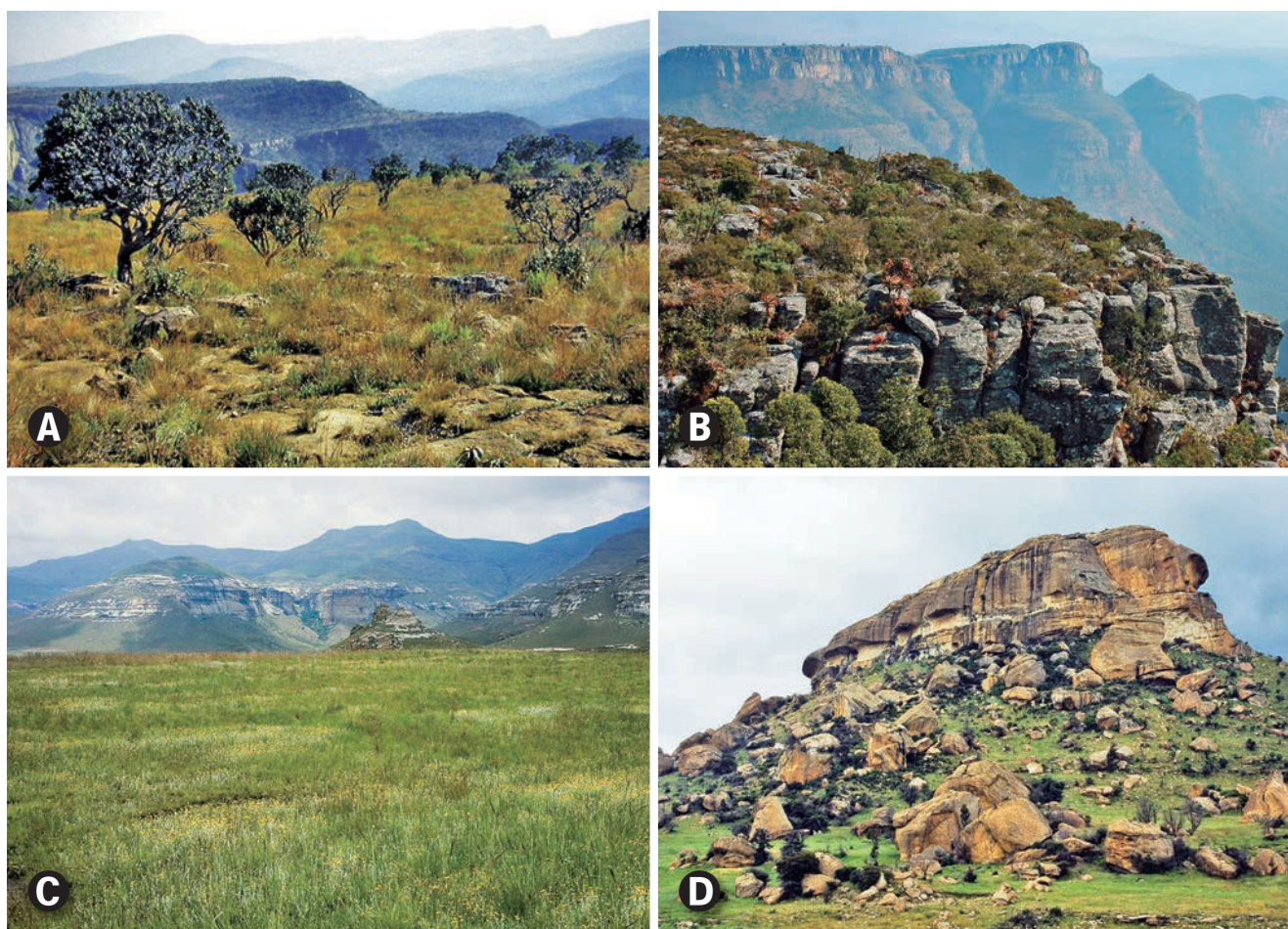


Figure 8.2 Various faces of plant communities of the Grassland Biome: A: Proteoid 'savanna' on shallow soils on quartzite with scattered *Protea rubropilosa* trees, near Aventura Blydepoort (Mpumalanga Escarpment); B: Dense shrubland of 'montane fynbos' on the Northern Escarpment of Mpumalanga; C: Typical species-rich high-altitude (2 000 m) moist grassland with *Monocymbium ceresiiforme* and numerous *Helichrysum* species on Clarens sandstone in the Golden Gate Highlands National Park near Clarens (Free State); D: Slope shrublands (with *Buddleja salviifolia*, *Euclea coriacea*, *Myrsine africana*, *Diospyros austro-africana* and *Heteromorpha frutescens* var. *abyssinica*) on a sandstone koppie near a Basotho Cultural Village in the Qwaqwa National Park near Phuthaditjhaba (Free State). All photographs by L. Mucina.

from the Dobrogea steppes near the mouth of the Danube (Romania), the northern shores of the Black Sea, through Ukraine and southern Russia, to northern Central Asia almost to the Yellow Sea in China (Manchuria). The entire Midwest of North America, ranging from the central Canadian provinces of Alberta, Saskatchewan and Manitoba to the Gulf of Mexico (30° to 55° N latitude) was covered by prairies prior to transformation. The Argentinean pampas are the largest continuous area of temperate grass steppe in the southern hemisphere and occur between 32° and 38° S.

The latitudinal differences between the two hemispheres in terms of occurrence of the temperate grasslands can be ascribed to the larger land mass concentrated in the northern hemisphere and consequently to harsher (more continental) climates governing the larger land stretches of North America and Eurasia as opposed to the more oceanic climates of the southern hemisphere.

In South Africa, the extent of the Grassland Biome can be reasonably well defined on the basis of vegetation structure in combination with environmental factors, primarily the amount of summer rainfall and minimum temperatures in winter (e.g. Rutherford & Westfall 1986). The Grassland Biome in South Africa occurs mainly on the high central plateau (Highveld), the inland areas of the eastern seaboard, the mountainous areas of KwaZulu-Natal and the central parts of the Eastern Cape. The topography is mainly flat to rolling, but also includes mountainous regions and the Escarpment. The elevation associated with grassland regions is from about 300–400 m (Gs 2 Ithala Quartzite Sourveld and Gs 9 Midlands Mistbelt Grassland, respectively) to Thabana Ntlenyana (3 482 m)—the highest mountain in southern Africa. The Lesotho Plateau and highest peaks of the Drakensberg are covered by a mosaic of grassland (Gd 8), heathlands (Gd 10) and mires (AZf 5), in which plants exhibit xeromorphic characteristics that reflect the severity of the climate at these localities. The effect of being at a high elevation in the interior of the continent results in large temperature differences from one time of the year to another and a high frequency of frost. In winter the climate on the Highveld is very cold and dry.

The occurrence of grasslands below the main Escarpment (Drakensberg), both in KwaZulu-Natal and the Eastern Cape, with floristic links to the high-altitude Drakensberg grassland, is interesting. One possible explanation for their occurrence is climatic anomalies such as the formation in winter of streams of cold air that descend from the Drakensberg and create severe climatic conditions that support frost-tolerant grasslands rather than savanna vegetation on the affected slopes and valleys.

2. Origins and Future of the Grassland Biome

2.1 Palaeoecological Patterns

Although fossil pollen records alone are not firm enough evidence for determining the time of origin of grasses, they suggest that Poaceae (the dominant element of the grasslands on global scale) and related families such as the Restionaceae, probably first developed in the Late Cretaceous (Jardine & Magloire 1965, Muller 1981, Scott & Srivastava 1984, Grass Phylogeny Working Group 2001). Earlier palaeontological studies suggested that the Poaceae was a minor component of global vegetation for several millions of years before grasslands finally became globally prominent in the Neogene worldwide (Leopold 1969, Thomasson 1988, Cerling et al. 1997) and in

southern Africa (Coetzee 1978, Van Zinderen Bakker 1984, Coetzee & Rogers 1982, Scholtz 1985, Scott 1995). However, recent findings from India (Piperno & Sues 2005, Prasad et al. 2005) reported that the grasses must not only have been well diversified in Gondwana by the Maastrichtian (the latest Cretaceous), but that they have also been incorporated into the diet of dinosaurs. In southern Africa the lack of terrestrial pollen records and uncertain dating of available evidence make it difficult to determine more precisely when significant grassland expansion took place (Van Zinderen Bakker 1984, Scott 1995). Cooling of global ocean temperatures is indicated in the marine isotope record (Shackleton & Kennet 1975) during the Late Miocene, and this seems to coincide with the development of modern biomes such as the Nama-Karoo, Fynbos and possibly also the Grassland Biome in southern Africa (Scott et al. 1997, Linder 2003). In southern Africa the global cooling during the Late Tertiary was accompanied by events of continental uplift, which started in the Early Miocene and culminated in significant vertical movement of up to 600–900 m in the southeastern part of the subcontinent during the Pliocene (Partridge 1997). This uplift moved a considerable area into colder higher altitudes more suitable for grasslands than for (sub)tropical savanna woodlands. Uplift in the central to western parts of the continent was much less pronounced, resulting in a sloping gradient from east to west. The effects of the gradient, enhanced by the east-west moisture gradient of the continent which was already in existence by then (Partridge 1997), may have determined the limits of grassland.

A major event in the continuing evolution of grasslands was the evolution of C_4 metabolism, which is today clearly manifested in the wide distribution of 'Kranz grasses' in the tropical and drier summer-rain regions of southern Africa (Vogel et al. 1978; see Gibbs Russell et al. 1991 for classification of the southern African grasses into various types of the C_4 syndrome). Although C_4 metabolism is most prominent in the grasses, this photosynthetic strategy is also found in some unrelated dicotyledonous families (e.g. Kadereit et al. 2003). The C_4 evolved many times during the Tertiary period (Cerling et al. 1997, Ehleringer et al. 1997, Keeley & Rundel 2003). Fossil chloridoid grasses were, however, reported from the Miocene of Kansas, and the Middle Miocene from Kenya (Thomasson et al. 1986, Retallack 1992). It is possible that plants with the C_4 strategy survived well under unique global environmental conditions including global cooling during the Neogene (Shackleton & Kennet 1975) and declining atmospheric pressures of CO_2 that developed during the Tertiary. The ability of C_4 species to bind CO_2 more effectively under dry tropical and subtropical conditions without excessive water loss furthermore give them the advantage to survive under low atmospheric CO_2 concentrations (Cerling et al. 1997, Ehleringer et al. 1997, Sage 2004). Since C_3 and C_4 metabolic mechanisms result in different degrees of ^{13}C isotope fractionation in grasses, data derived from soils, speleothems (stalagmites), fossil bones and fossil tooth enamel, can be used to trace the early history of C_4 grasses. Results suggest that grasslands dominated by C_4 grasses expanded rapidly during the Late Miocene (~ 8–4 mya) but the role of atmospheric CO_2 pressures as a possible trigger of this expansion remains uncertain. Some recent palaeoclimatic studies are at variance with the assumption that CO_2 played a significant role in the rapid spread of C_4 grasses since the CO_2 concentrations in Late Miocene were not as low as presumed earlier (Pagani et al. 1999, Pearson & Palmer 2000). Isotopes from soils, grass phytoliths and pollen evidence from the Last Glacial Maximum (LGM) suggest that at higher latitudes and altitudes C_4 grasses in southern Africa were less prominent, except in the dry southern Kalahari region where they were relatively prominent (Vogel 1978, Talma & Vogel 1992, Lee-Thorp

& Beaumont 1995, Lee-Thorp & Talma 2000, Scott 2002). Their distribution was probably limited by unfavourably low winter temperature extremes in the southern Highveld that cancelled out any advantages gained from lowered CO₂ concentrations in the atmosphere (Scott 2002).

The origin of South African grasslands (of the Grassland Biome in particular) has been the subject of a number of speculative reviews as well as serious scientific analyses (Bews 1929, Acocks 1953, Ellery et al. 1991, Meadows & Linder 1993, Scott et al. 1997, Anderson 1999, Bredenkamp et al. 2002). Several hypotheses have been formulated, especially addressing the question of lack of trees in the grassland:

- 1) Acocks (1953) ascribed the current extent of the grassland to recent human (agricultural) activity which destroyed large stretches of forests, considered the climatic climax in the area.
- 2) Tinley (1982) suggested that woody elements are excluded from grasslands by the waterlogging desiccation effect of shallow pan horizons.
- 3) Ellery et al. (1991) suggested that climate contributes to the maintenance of grassland by maintaining a disturbance (fire and grazing) regime that excludes woody plants.
- 4) Bredenkamp et al. (2002) argued that the South African grassland is a climatically controlled ecosystem in which cooler conditions at high altitudes are one of the major driving forces that prevent colonisation of trees of a generally tropical origin.

The first hypothesis has been convincingly rejected (Meadows & Linder 1993). O'Connor & Bredenkamp (1997) found the waterlogging argument incompletely supported in the Grassland Biome. The third (fire-related) hypothesis does not address the fact that both the Grassland and Savanna Biomes are fire-prone ecosystems (see also arguments in Bredenkamp et al. 2002). The case of the fourth hypothesis is still undecided, since it has not been corroborated by conclusive evidence rooted either in experimental studies of the life history of extant woody species or at least in a circumstantial manner by phylogenetic analyses.

However, these review accounts do not take into consideration the differences between the Highveld (dominated by C₄ grasses) and Drakensberg (dominated by C₃ grasses) regions of the Grassland Biome. Bredenkamp et al. (2002) did acknowledge the Drakensberg grasslands to be rich in endemic taxa and concluded that they must be primary and old, but their argument does not translate into a testable hypothesis addressing the reasons for the lack of trees in the Grassland Biome.

Firstly and most importantly, we have to admit that there are indeed woody species (including tall shrubs and trees) in some communities of the Grassland Biome. These 'shrubland' units, as featured in the section 8 of this chapter, are usually limited to special substrates showing a higher moisture input or retention ability (koppies, deep kloofs and gullies, steep slopes of incised valleys). Shrubland and tree-dominated vegetation embedded within the Grassland Biome also occurs on azonal alluvial soils. The shrubland units may be seen as relicts of past climates and vegetation patterns, and show phytogeographic links to various phytochoria. For instance the Gh 4 Besemkaree Koppies Shrubland straddles the Nama-Karoo/Grassland interface and Gh 8 Bloemfontein Karroid Shrubland may be a direct relict of the dry climate periods; the units Gm 5 Basotho Montane Shrubland, Gd 9 Western Lesotho Basalt Shrubland and Gm 2 Senqu Montane Shrubland show direct floristic links with Drakensberg grasslands and units such as Gh 12 Vaal Reefs

Dolomite Sinkhole Woodland, Gh 13 Klerksdorp Thornveld, Gm 21 Lydenburg Thornveld, Gm 7 Northern Free State Shrubland and Gs 5 Northern KwaZulu-Natal Shrubland, link floristically with the Savanna Biome.

Secondly, we have to address the question of the origin of the high-altitude, endemic-rich and C₃-dominated cool-temperate grasslands in a different way than the C₄-dominated highveld grasslands, both under dry and mesic conditions. The former vegetation experiences cold and wet conditions (MAP as high as 2 500 mm in places!; with some rainshadow anomalies in Lesotho) and relatively stable climatic conditions during the periods of large climatic fluctuations of the Plio-Pleistocene. The high-altitude ecosystem did clearly react to Plio-Pleistocene climatic cycles, as suggested for instance by Scott (1989) who found that montane fynbos tended to expand to lower altitudes during the LGM. The direct data on the phylogenetic age of the endemic Drakensberg lineages, such as for *Ehrharta longigluma* (Verboom et al. 2003), and the fact that the highest number of endemics is found in young, evolutionary dynamic families such as the Asteraceae and Scrophulariaceae suggest that the speciation events which led to the Drakensberg endemism are rather recent (last 5 my).

The major grassy components of the Drakensberg grasslands are of either northern (e.g. *Festuca*, *Bromus*, *Koeleria*) or southern (e.g. *Aristida*, *Merxmüllera*, *Pentaschistis*) provenience, hence showing links to the East African (and in effect further Eurasian) mountains on one hand or to the post-Gondwanan flora of the Cape on the other. The northern track is strong and represented by nongrassy genera such as *Erica* (McGuire & Kron 2005), *Helichrysum* (Bayer et al. 2000), *Ranunculus* (Hörandl et al. 2005), and presumably many northern genera such as *Festuca*, *Geum*, *Ajuga*, *Rorippa*, *Scabiosa*, *Myosotis* and *Alchemilla*. Many of the current Drakensberg floristic constituents have been found to be firmly embedded within the Cape clades: *Cliffortia* (Whitehouse 2002, Galley & Linder 2006), Restionaceae (Linder 2000), *Leucadendron* (Barker et al. 2004), *Ehrharta* (Verboom et al. 2003), *Protea* (Reeves 2001), *Disa* (Bellstedt et al. 2001), *Phyllis* (Richardson et al. 2001), *Mora* (Goldblatt et al. 2002), *Eucomis* and *Ledebouria* (Pfosser et al. 2003), *Metalasia* (Karis 1989) and *Heliophila* (Mummedorf et al. 2005), among others. We hypothesise the same patterns also for genera such as *Aristea*, *Berkheya*, *Cotula*, *Euryops*, *Felicia*, *Hesperantha*, *Passerina*, *Othonna*, *Romulea* and *Ursinia*, although not excluding the possibility of two-way migrations between the Cape and Drakensberg using the Karoo Escarpment as bridge. Notable local (Drakensberg) radiations include *Schizochilus* (Linder 1980), a *Ledebouria/Resnova* alliance (Pfosser et al. 2003), *Eucomis*, *Galtonia*, *Berkheya*, *Helichrysum* and *Hypoxis*.

Interpretation of the highveld grasslands poses a different evolutionary challenge. Here endemics are very rare and, if present, are mostly found in mainly quartzite sourveld communities, showing a clear link to the flora of the Escarpment (Drakensberg in the broad sense)—see the position of the centres of endemism (CE) as defined by Van Wyk & Smith (2001) and recognised migration links such as the Magaliesberg Extension (White 1978).

Determinants for grassland ecotones in southern Africa are discussed by O'Connor & Bredenkamp (1997). From the fossil pollen evidence it is clear that marked shifts in grassland composition and grassland boundaries within the Nama-Karoo, Savanna and afromontane fynbos did occur during the glacial and interglacial periods (Scott et al. 1997). During glacial periods a considerable lowering of vegetation zones forced temperate (frost-controlled) grasslands to spread over a much wider

area, extending its limits by more than 100 km to the north of the current Highveld region. The current high-altitude grassland of the Drakensberg, dominated by C_3 grasses and fynbos elements showing the same assimilation syndrome, followed this pattern (Scott 1989). While Late Quaternary grasslands were generally more extensive, interglacial events showed grassland/savanna distributions similar to the present pattern except during peak temperature or increased CO_2 -concentration events (Scott & Vogel 1983, Bond et al. 2003a). An example is a brief and limited southward expansion of savanna over the northern Highveld during the Middle Holocene temperature optimum (Scott & Vogel 1983). During the Early Holocene dry phase, karroid shrubs were prominent in the southern parts of the current Grassland Biome (Scott & Nyakale 2002, Scott et al. 2005) at the expense of grasses, but grass cover gradually increased to a maximum at ca. 2000 years BP, following the southernmost penetration of the Inter-Tropical Convergence Zone (Scott 1993, Tyson 1999, Scott & Nyakale 2002, Scott & Lee-Thorp 2004, Scott et al. 2005). Pollen records suggest the open nature of modern grasslands in the moist eastern parts of southern Africa was apparently not the result of recent anthropogenic activities (Acocks 1953), but that they were well established throughout the Holocene (Scott & Vogel 1983, Meadows & Linder 1993). Karoo expansion into the grassland areas during the 20th century was predicted by Acocks (1953), but did not realise as a result of lower grazing intensity and adequate rainfall (Hoffman & Cowling 1990).

2.2 Climate Change Outlook

Ellery et al. (1991) predicted (and illustrated their prediction on a simple map) that an increase of 2°C plus and 15% less precipitation than present would result in a dramatic change in the extent of the Grassland Biome. Their map has shown that basically only C_3 -dominated grasslands of the Drakensberg and their northern extensions along the Northern Escarpment would survive such dramatic change. Present predictions on the extent of the Grassland Biome under climate change scenarios (Rutherford et al. 1999; see also Figure 8.3) brought on by an increase in atmospheric carbon dioxide foresee a significant reduction in the extent of the biome. Modelling scenarios predict a 3°C warmer and much drier future for southern Africa, with January temperatures increasing most in the central interior and rainfall decreasing by 5% in the north and 25% in the south. This increased temperature and aridity may obliterate the western portion of the biome and possibly a third to 55% of the biome extent may be lost. Frosts, which often kill the seedlings of woody species, will become less frequent so that woody plants will be able to invade grasslands more easily, transforming them into savanna (WWF 2001).

Other modelling studies addressed the role of fire in controlling the distribution of southern African biomes, including the Grassland Biome. Using a Dynamic Global Vegetation Model, Bond et al. (2003b) showed that exclusion of fire in regions with MAP above 650 mm would lead to an expansion of fire-sensitive forests. The regions with precipitation below 650 mm per year would show an increase of woody cover, but no trend of changing composition to forest.

3. Environmental Features

3.1 Current Climate

The cold, dry conditions of the Highveld region are the result of the high elevation and inland continental aspect of these areas, and these factors are important in defining the current climate

of these areas. The temperate grasslands of southern Africa occur where there is summer to strong summer rainfall and winter drought. The rainfall may vary spatially from 400–2 500 mm per year and corresponds to the amount of rainfall found in other parts of the world where similar vegetation is found. Frost is a common phenomenon; the coldest periods (June–August) are exacerbated by aridity or along an increasing elevation gradient. Fog is found on the upper slopes of the Great Escarpment and seaward scarps, which support hygrophilous mistbelt vegetation. The biome has high lightning flash densities, making the incidence of lightning-induced fire a relatively high likelihood (Schulze 1984).

Studies of grassland vegetation activity from satellite data indicate that grasslands are strongly seasonal with a late summer maximum in vegetation activity and near complete termination of activity during the winter months. The areas on the western side of the biome, in the region that borders with Nama-Karoo and arid savanna, have the highest vegetation activity in February, March and April. There is a correlation between increasingly late summer to autumn maximum vegetation activity and proximity of the adjacent Nama-Karoo and arid parts of the Savanna Biome. The temperate eastern half of the Grassland Biome has a period of maximum vegetation activity in January. Some of the steeper mountain regions within this eastern region are more active in December (Hoare & Frost 2004).

3.2 Geology, Soils and Moisture Availability

The Grassland Biome covers large areas of the central part of South Africa. In the general geological description of the Savanna Biome (see the relevant chapter in this book) the history of the Kaapvaal Craton is summarised, which also applies here. The grasslands of South Africa cover a more significant portion of the Karoo Supergroup than the regions of the Savanna Biome, therefore somewhat more attention will be paid to this important sequence here.

The Kaapvaal Craton is the thick, stable block of continental crust that underlies most of the central, northern and eastern parts of South Africa. It was formed by the welding together of ancient blocks of crust by voluminous intrusions of granitoid plutons around 3 gya, which formed a continental crust strong and stable enough to preserve the thick volcano-sedimentary sequences of the Witwatersrand, Ventersdorp and Transvaal Supergroups as well as the massive intrusion of the Bushveld Igneous Complex.

During the Proterozoic, orogenic activity on the fringes of the craton formed the Namaqua-Natal Metamorphic Belt which marks the western and southern boundaries of the craton. In the north the Limpopo Belt forms the boundary between the Kaapvaal and the Zimbabwe Cratons.

The craton has survived several episodes of supercontinental assembly and break-up, such as those of Rodinia around 1 gya and Gondwana at the end of the Precambrian being the most recent. The Kaapvaal Craton and its adjacent orogenic belts came to support the Karoo depositional basin, one of several large basins in southern Gondwana, formed towards the end of the Carboniferous and still covered in large parts by these sediments.

The Pan-African orogenic cycle of around 550 mya resulted in the juxtaposition of several continental plates to form southern Gondwana. These have since rifted apart to form southern South America and the Falkland Islands, southern Africa, East Antarctica and the microplates of West Antarctica. Large, intra-

Current and potential (2050) distribution of South African biomes

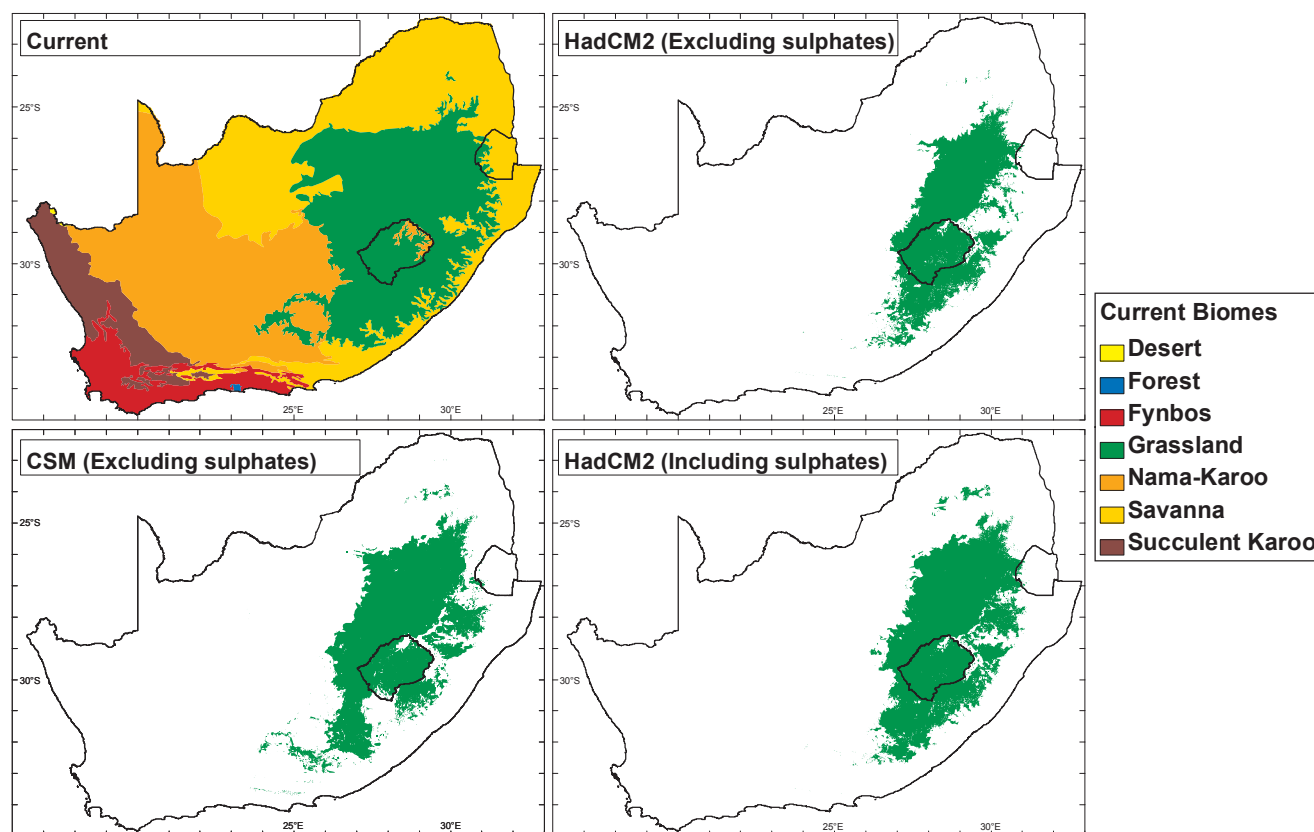


Figure 8.3 Potential distribution of the Grassland Biome with projected climate change corresponding to a doubling of CO₂ concentration from three scenarios generated by CSM and HadCM2 with and without sulphates (from Rutherford et al. 1999). The 'Current' biome coverage follows Rutherford & Westfall (1986).

continental basins formed on this land mass that at one stage, during the Early Permian, covered some 4.5 million km² and continued to accumulate sediments for over 100 my (Smith et al. 1993).

The supercontinent drifted over the South Pole during the Late Carboniferous, resulting in a large ice sheet that covered most of the early Karoo basin and surrounding highlands to form the widespread Dwyka Formation at the base of the Karoo Supergroup.

Smith et al. (1993), in their review paper on the Karoo-aged basins of southern Africa explain how subduction of the palaeo-Pacific plate below southern Gondwana resulted in the formation of the 'Gondwanide' mountains that deformed and truncated the southern rim of the Karoo basin. This folding of the older Karoo sediments is clearly visible in the southernmost parts of the Karoo. Furthermore, sediments derived from the erosion of this mountain chain accumulated in large deltas that built into an inland sea to form the Upper Ecca Group. These broad delta plains together with a humid climate promoted the formation of peat which would later form the vast coal reserves of southern Africa.

Overlying the Ecca sediments are those of the Beaufort Group that were deposited on broad alluvial plains during a time when the climate warmed and dried as the supercontinent drifted towards lower latitudes. These Permo-Triassic times saw an abundance of reptilian fauna; particularly prominent were the therapsids or 'mammal-like reptiles' of which the Karoo preserves the longest and most complete record (e.g. Cluver 1978, Smith et al. 1993).

Aridification continued in the upper Karoo Sequence during the Jurassic and culminated in the deposition of dune sands on a playa-like environment. These sediments of the Elliot and Clarens formation were eventually covered by thick outpourings of basalt of the Drakensberg Group which brought the Karoo sedimentation to a close. This volcanic activity occurred basin-wide during the Jurassic and included the intrusion of Karoo Dolerite dykes that form a characteristic feature of the Karoo and some of the grassland landscapes. These flood basalts formed as a result of the initial stages of the rifting apart of Gondwana during the Late Jurassic to form the more familiar arrangement of the continents today. For this reason, part of this flood basalt province is found on the Antarctic continent, where it is known as the Ferrar traps. The estimated volume of lava erupted in the Karoo basin, including the Ferrar basalts, is 2.5×10^6 km³ (Wignall 2001), which would have had a profound effect on the global climate and life on earth at the time.

Moisture availability is the major factor which can be used to divide the Grassland Biome into two classes (Ellery et al. 1995). Moist grassland consists of sour grasses, leached and dystrophic soils and high canopy cover, high plant production and high fire frequency. Dry grassland has sweet, palatable grasses, soils are less leached and are eutrophic and canopy cover, plant production and fire frequency are lower than in moist grasslands. Sweet grasses, mostly belonging to the subfamily Chloridoideae, have a lower fibre content and maintain a higher above-ground nutrient content in winter than sour grasses, belonging mostly to the subfamily Panicoideae (Andropogoneae), thus making them more palatable to stock (Rutherford & Westfall 1986).

Sour grasslands (sourveld) in South Africa are generally found at higher altitudes—usually linked to high water supply, and where parent material gives rise to soils with a low base status. Sweet grasslands (sweetveld) occur mainly at lower altitudes, in areas with lower water supply, and where parent material gives rise to soils with a high base status.

3.3 Fire

Grassland is a fire-prone ecosystem, hence fire is vital to the maintenance of both its structural and textural patterns (Edwards 1961, 1968, Granger 1976, Tainton 1981, Everson 1985, Bainbridge 1993, O'Connor & Bredenkamp 1997). Dynamic vegetation models indicate that without fire most of the eastern half of South Africa would be covered in trees (Bond et al. 2003b). Fire exclusion studies indicate that in the absence of fire there is a succession trend towards shrublands with fynbos affinities and then to forest in grasslands with annual rainfall of more than 650 mm. In grasslands with less than 650 mm of annual rainfall, the exclusion of fire leads to an increase in tree density without a change in species composition (Figure 8.4). Grassland vegetation with less than 650 mm annual rainfall is therefore climate-limited, whereas those areas with more than 650 mm annual rainfall are fire-limited and are in a meta-stable state, with alternate climate-dependent states (Bond et al. 2003b).

The key components of a fire regime are the frequency, seasonality and intensity of fires (Gill 1975). Fire in grasslands occurs every 1–4 years and, in montane grasslands, occurs mostly in late winter from July to September (Le Maitre & Midgley 1992). Fire intensity depends on fuel moisture, air temperature and wind speed. Lightning is the primary natural source of ignition for grassland fires. The Grassland Biome has a high frequency of lightning strikes per area of ground and thus natural fires that maintain grassland dominance over woodland are a natural ecological component of the landscape. Natural breaks such as drainage lines and man-made structures such as roads pose barriers to the large-scale fires, assisting in creation of landscapes composed of grassland patches in different stages of recovery (Figure 8.5).

The dominant grasses of the cool, temperate grasslands of South Africa are from the Panicoideae (Gibbs Russell 1988), specifically from the tribe Andropogoneae, including genera such as *Andropogon*, *Trachypogon*, *Heteropogon*, *Cymbopogon*, *Dihetero-*



Figure 8.5 Grassland mosaic created by wild fire in the Golden Gate Highlands National Park near Clarens (Free State).



Figure 8.6 Fire sweeping through *Acacia sieberiana* var. *woodii* savannoid grassland below the Van Reenen's Pass on a slope near Tugela Toll Plaza (KwaZulu-Natal).

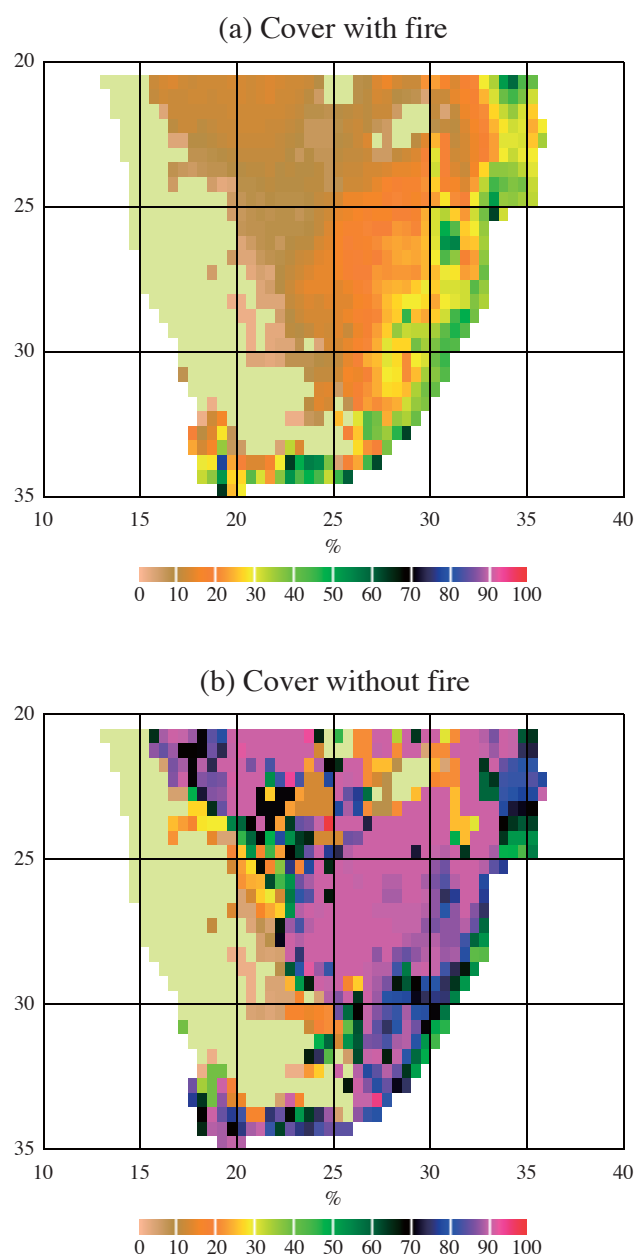


Figure 8.4 Simulated tree cover (%) using the Sheffield Dynamic Global Vegetation Model. The model is a global-scale tool, simulating carbon and water dynamics and structure of vegetation using input data of climate, soil properties and atmospheric CO₂. It also includes a fire module that approximates fire frequency based on empirical relationships between moisture content of plant litter (which can be simulated from climate) and fire return intervals. The upper figure (a) features modelling with fire included, while the lower picture (b) shows the modelling result with fire excluded. (After Bond et al. 2003b, Figure 4; courtesy of the authors and the South African Association of Botanists.)

pogon, *Monocymbium*, *Tristachya*, *Schizachyrium*, *Themeda* and *Hyparrhenia*. The low nutritional value and high tannin content (Ellis 1990) of these grasses cause slow decomposition rates and, therefore, the build-up of highly flammable fuel (Bond et al. 2003b). They also produce basal tillers, which make them susceptible to shading by old growth that persists from previous seasons (O'Connor & Bredenkamp 1997) and they therefore have an obligate dependence on defoliation. The dominant species of andropogonoid grasses often decline rapidly in importance in the absence of burning (Tainton & Mentis 1984), a trend also reported from North and South America,

Australia and Southeast Asia (Stott 1988, Silva & Castro 1989, Morgan & Lunt 1999). Woody species that are often found in temperate grasslands include small trees such as *Acacia sieberiana* var. *woodii* and species of *Protea* and *Cussonia* that have thick, fire-resistant bark that allows them to tolerate low-intensity (skimming), high-frequency fires (Figure 8.6). The proteas are furthermore serotinous but, in grasslands, almost all resprout to recover from fire rather than reseed (Le Maitre & Midgley 1992). Fire stimulates flowering in grassland geophytes (Frost 1984).

3.4 Grazing Pressure

Grazing has a major influence on canopy structure in grasslands as well as on species composition. The grass plant is well adapted to defoliation by grazing, fire or mowing: the basal meristems of grass leaves enable regrowth after defoliation and draw on carbohydrate reserves from the stem bases or rhizomes (Rutherford & Westfall 1986). Although this adaptation is effective, excessive or frequent defoliation can deplete reserves, with adverse consequences (Rutherford & Westfall 1986). Some species respond to grazing pressure by changing growth patterns (often preferred grazing species) thus allowing niche displacement in relation to grazing intensity. Grazing can alter plant density/size, plant longevity, community composition and diversity, vegetation response to climate patterns, and vegetation response to other abiotic factors such as soil depth. Besides defoliation, heavy grazing can affect grass seed production negatively. Grazing pressure (including density of grazers and composition of grazing herds) varies from farm to farm, dramatically shaping the overall appearance of grasslands by creating the so-called fence-line effect (Figure 8.7).

Degradation of grasslands, including the spread of karroid shrubland into the Grassland Biome, has been blamed on high stocking rates of domestic livestock in commercial farming areas. Many communal grazing lands are commonly stocked at 3–4 times the recommended stocking rates for commercial farming and, although these areas appear to be degraded, they have remained in a stable and apparently productive state for decades. Heavy grazing in the communal areas of the Transkei appears to have reduced overall species richness (Hoare 2002) and changed species composition to less palatable grasses, especially on nutrient-poor soils (Owen-Smith & Danckwerts 1997).

High concentrations of indigenous herbivores can also alter plant species cover and composition. The primary difference between domestic livestock and wild herbivores is scale-related (Owen-Smith & Danckwerts 1997): the provision of supplementary fodder in commercial farming areas during drought periods prevents animal mortality so that grazing pressure is maintained during all seasons, whereas wild herbivore impacts are more spatially and temporally heterogeneous.

Prominent wild ungulate herbivores in highveld grasslands include black wildebeest (*Connochaetes gnou*), blesbok (*Damaliscus dorcas phillipsi*), extinct quagga (*Equus quagga*), springbok (*Antidorcas marsupialis*) and eland (*Taurotragus oryx*; Figure 8.8). Historically, these species may have seasonally moved along rainfall gradients in areas near the Drakensberg, occurring near water sources in the dry season and away from water sources during the wet season. The abundance and grazing impact of small mammals may exceed that of ungulates, but the distribution of the former is patchy and abundances may vary considerably over time (Owen-Smith & Danckwerts 1997). Prominent species in grasslands include porcupine and several species of hare. Other wild herbivores in grasslands include

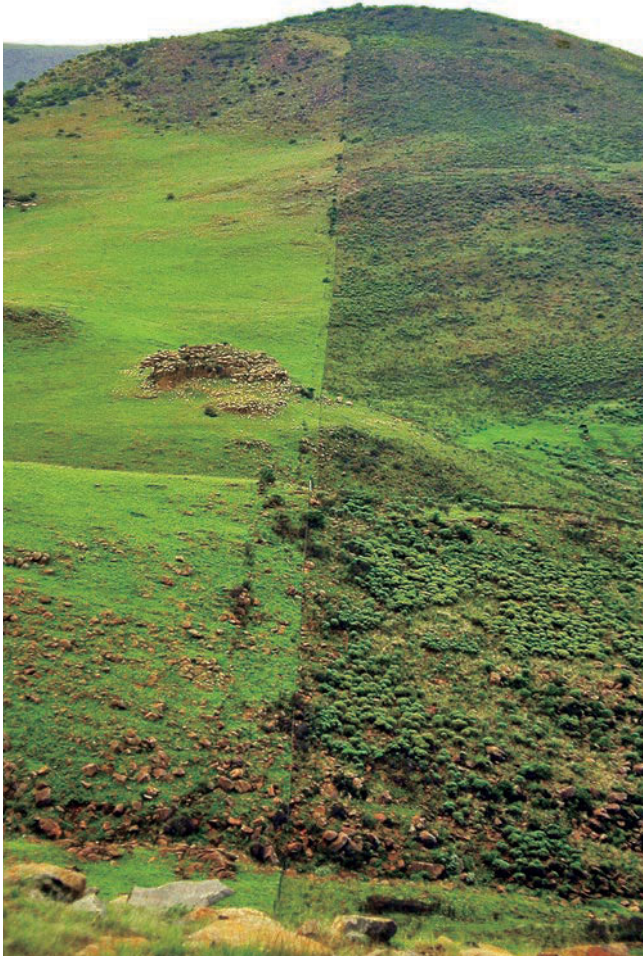


Figure 8.7 Typical fence-line effect (former 'national' border between the Cape and Transkei) marking the difference between a commercial farm with well-developed *Themeda triandra* grassland (left) and communal land with invading unpalatable *Euryops floribundus* (Asteraceae) near Elliot (Eastern Cape).

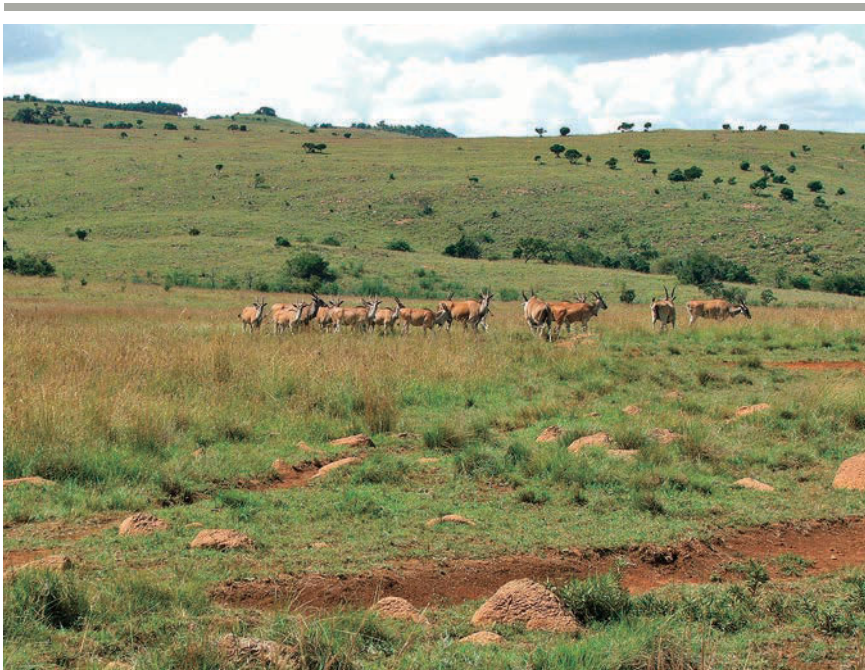


Figure 8.8 Eland (*Taurotragus oryx*) grazing in a grassland near Vryheid (northern KwaZulu-Natal).

leopard tortoises, hinged tortoises, grasshoppers and harvester termites. Although the last-named are strictly detritivores, they can cause severe denudation of grasses during drought periods. Avian granivores strip and consume many grass seeds from inflorescences. Granivory appears to affect species with large seeds, e.g. *Themeda triandra* and *Heteropogon contortus*, more than those with small seeds, e.g. species of *Aristida* (Owen-Smith & Danckwerts 1997).

Different kinds of herbivores may have different and complementary effects on different plant species. Domestic grazers, wild ungulates, small mammals and insects favour different grass species and may be sensitive to different secondary chemicals. Different plant defences are effective against different herbivores and no single deterrent is effective against all herbivores (Owen-Smith & Danckwerts 1997).

4. Vegetation Structure and Texture

Grasslands are structurally simple and strongly dominated by grasses (Poaceae). The canopy cover is moisture-dependant and decreases with lower mean annual rainfall, but is influenced by the amount and type of grazing and by the presence of fire. Minimum temperature plays a decisive role in structurally distinguishing temperate grasslands from those where frosts are rare (Walker 1993). Woody species, where they occur, are limited to specialised niches/habitats. Forbs form an important component of grasslands and, although not usually dominant, probably contribute more to the species richness of grasslands than grass species do. Annuals do not form a large component of the vegetation, but are important in filling gaps where disturbance occurs.

Above ground, there are two primary structuring forces within grasslands that operate in opposite directions: competition for canopy space (i.e. light) and ungulate grazing pressure (Diaz et al. 1992). Besides herbivory, rainfall (plant available moisture), soil type (nutrient availability) and fire are further major determinants of grassland structure and these are strongly interactive (Walker 1993). Diaz et al. (1992) identified six species modes (similar to functional types) in which sustained occupation of

above-ground space increases along a gradient from annuals to prostrate stoloniferous plants to rosette plants with below-ground storage organs to small graminoids to medium-sized graminoids to tussock grasses. Silvertown et al. (1992) demonstrated that heavy grazing conditions (reduced cover of dominant species) foster seedling emergence in annual dicotyledons, but also jeopardise subsequent survival (by grazing at various stages of life cycle), which is why productive grassland communities may contain few palatable dicotyledons since few of them can successfully complete their life cycle.

Grass species diversity of the subfamily Panicoideae is higher in the Grassland Biome than that of the Arundinoideae, Chloridoideae or Pooideae. The Panicoideae are a major C_4 photosynthesis group and tend to predominate in the Grassland Biome and moist parts of the Savanna Biome of South Africa (Vogel et al. 1978, Gibbs Russell 1986, Gibbs Russell et al. 1991). The most abundant

component of the Panicoideae is from the tribe Andropogoneae (Gibbs Russell et al. 1991). The Pooideae, an exclusively C_3 sub-family, have maximum diversity and abundance only at high altitude and in moist habitats and are important in the high Drakensberg region (Vogel et al. 1978, Gibbs Russell 1986, Rutherford & Westfall 1986).

5. Biodiversity and Biogeographical Patterns

5.1 Phytochorological Considerations

The Grassland Biome in South Africa coincides with two major phytochoria (White 1983): Kalahari-Highveld Regional Transition Zone and Afromontane and Afroalpine Region. The mountainous landscapes along the Northern Escarpment are within the Afromontane and Afroalpine Region of White (1983). These areas also include the most temperate components of the biome, both floristically and climatically. The largest part of the Grassland Biome boundary interfaces with the Savanna Biome, an area considered to be primarily linked to White's (1983) Kalahari-Highveld Regional Transition Zone and Zambezi Regions and, therefore, of more tropical affinity. The Grassland and Savanna Biomes both have strong rainfall seasonality and very similar summer-rainfall patterns and amounts. The major environmental factor separating them is summer aridity in combination with winter minimum temperature that leads to 'phanerophyte exclusion' (Rutherford & Westfall 1986), resulting in the absence of a major woody component. The clear floristic link between the Grassland and Savanna Biome (see also discussion on the origins of the Grassland Biome above) has been corroborated in the phytochorological classification of Takhtajan (1986). Most of the Grassland Biome as defined in our study falls within Takhtajan's Sudano-Zambezi Floristic Region (with tropical connotation). The Sub-Escarpment Grasslands are classified within the Uzambara-Zululand Floristic Region—a view which we do not share. The transitional Karoo Escarpment Grassland falls within the Karoo-Namib Floristic Region or, after current revisions (see the chapter on Nama-Karoo Biome in this book), in the Nama-Karoo Floristic Region. We do not subscribe to this view either and suggest that the boundaries of phytochoria on the Karoo/Grassland interface are revised.

The drier western and southwestern boundary of the Grassland Biome interfaces with the Nama-Karoo along a zone of high rainfall uncertainty. This region also represents a gradient of decreasing rainfall and lower elevation with distance westwards. It has been hypothesised that overgrazing by domestic livestock has led to the eastward expansion of the Nama-Karoo into the Grassland Biome through the reduction of perennial grass cover in this zone (Acocks 1953), but an alternative hypothesis suggests that cyclic shifts in rainfall amount and seasonality promote a dynamic change in the relationship between perennial grasses and karoo bushes (Hoffman & Cowling 1990).

There is little interface between grassland and fynbos, but a dynamic relationship exists between these two vegetation types and satellite grasslands occur in the Fynbos Biome in the mountains of the Eastern Cape and satellite fynbos occurs within the grasslands of the Northern Escarpment region, especially on nutrient-poor soils in areas protected from fire. Numerous studies have demonstrated the floristic linkages between the Fynbos Biome, the mountain regions of the Grassland Biome and afromontane regions further northwards in Africa (e.g. Weimarck 1934, 1940, Goldblatt 1978, Rourke 1980, Linder 1983, Linder & Ellis 1990, Hartmann 1991, Linder et al. 2005,

Galley & Linder 2006). The number of Cape species becomes less as the distance from the Fynbos Biome increases and the number of afromontane species increases.

Grassland interfaces with indigenous afrotemperate forests in many places, but especially along the Escarpment (Von Maltitz et al. 2003, Geldenhuys & Mucina 2006), where forest patches may be found on steep, south-facing slopes with high soil moisture or in deep, sheltered, moist gullies. In these topographic positions they survive the dry periods and from these positions they expand further along the slopes. As already argued (see Chapter 12 on forests in this book), fire plays a major role in forest/grassland border dynamics. Vegetation models suggest that without fire most of the eastern half of South Africa would be covered by dense tree-dominated vegetation (Bond et al. 2003b).

5.2 Endemism

Five Centres of Plant Endemism (CEs) have been identified within the borders of the Grassland Biome (Van Wyk & Smith 2001): Drakensberg Alpine, Barberton, Wolkberg, Sekhukhune and Soutpansberg. Only the Drakensberg Alpine CE and Wolkberg CE falls completely within the Grassland Biome, while the other CEs are shared with the Savanna Biome (Figure 8.9). As suggested by unpublished data sources and the descriptive accounts of vegetation units in this chapter, high concentrations of local (confirmed to only a single vegetation unit as defined in this study) or regional (shared by several geographically bordering and ecologically similar vegetation units) endemics are also found in the KwaZulu-Natal Midlands (C.R. Scott-Shaw, unpublished data), Sneeuwberg Mountains on the Karoo Escarpment (N. Barker & R. Clark, unpublished data), low Drakensberg (L. Mucina, M.C. Lötter & C.R. Scott-Shaw, unpublished data), and in the mountainous surrounds of Lydenburg (M.C. Lötter, unpublished data). Detailed analyses of the local floras of these regions as well as their phytogeographical links may reveal the existence of several new centres of endemism. The most extensive and most endemic-rich phytochorion of all the above is the Drakensberg Alpine CE with about 13% of endemism, counting about 334 endemic taxa and five endemic genera (Van Wyk & Smith 2001, Carbutt & Edwards 2004, 2006). There are a number of species linking the core of the Drakensberg Alpine CE (defined in our study by the extent of Gd units as currently delimited) with the Midlands, especially with the mountains lying south and southeast of the Escarpment in a triangle approximately defined by Himeville, Kokstad and Matatiele (and, importantly, also including the Ingeli Mountain). The vegetation map of these high-altitude islands (interestingly indicated by Carbutt & Edwards 2004 as parts of their Drakensberg Alpine CE) should be reconsidered and perhaps included in one of the Gd units in future. Species showing this distribution pattern are designated as Dg (Drakensberg/Griqualand East) and include, for instance, *Erica algida*, *E. thodei* and *Berkheya pannosa*.

The currently recognised centres of endemism are either linked to high altitudes (Drakensberg Alpine, Wolkberg) or special substrates, among which quartzites and rare ultramafics (Barberton and Sekhukhune regions) play the major role. Another interesting aspect of the location of the CEs is the fact that they occur in the Grassland-Savanna 'tension' zone. Here the endemic-rich grassland vegetation is usually a 'summit sourveld'—forming an elevated island surrounded by the 'hot sea' of the subtropical savanna vegetation. The Drakensberg Alpine CE may be the hub of this 'sourveld phenomenon', showing a number of distinct floristic and phytogeographical links westwards (towards Capensis via the Escarpment), northwards (via the low Drakensberg) towards the Northern Escarpment and fur-

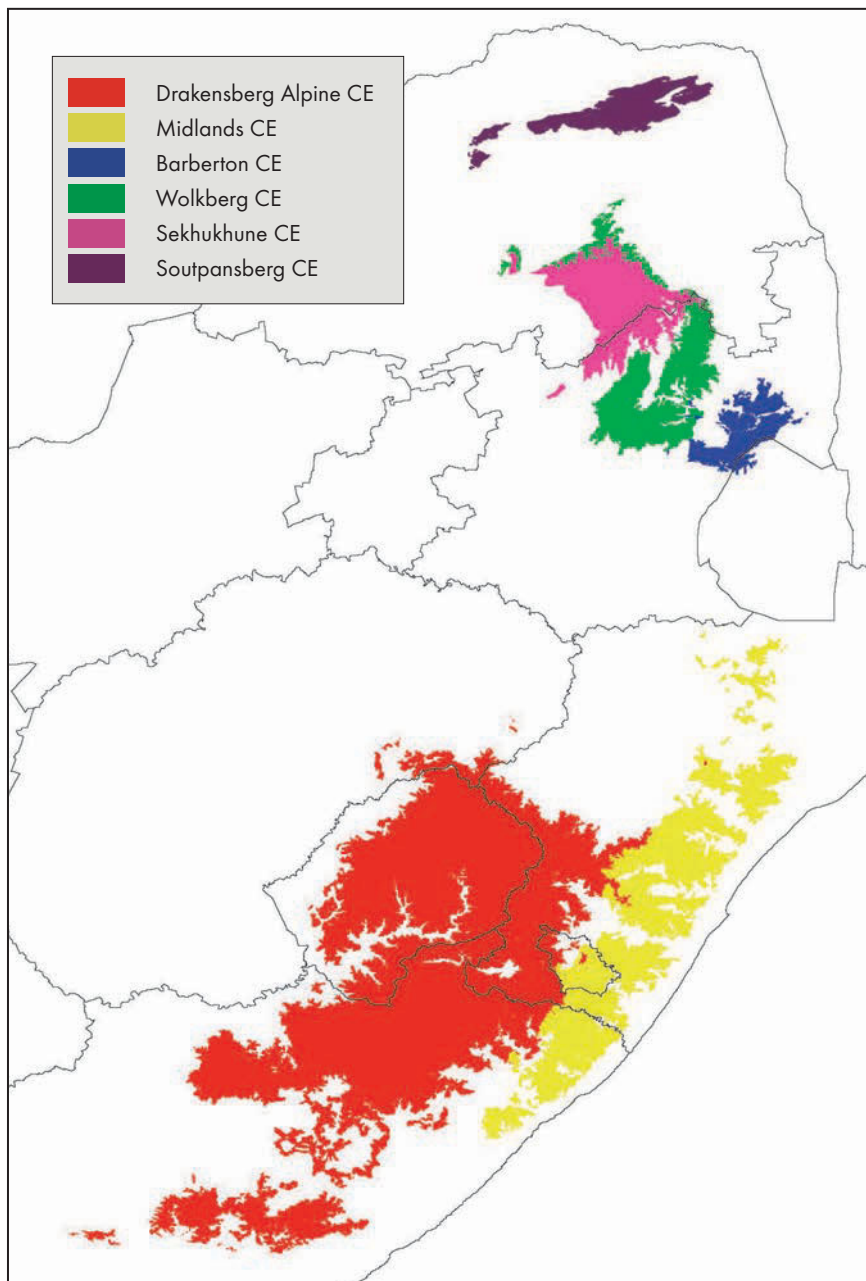


Figure 8.9 Six putative centres of endemism embedded within the Grassland Biome or straddling borders of the Grassland and Savanna Biomes.

ther north as far as the high mountains of eastern Zimbabwe (also shared with Mozambique in the Chimanimani Range) and southeastwards (at lower altitudes) towards the midlands of Transkei and KwaZulu-Natal and reaching the lowest altitude in Pondoland (see discussion in Carbutt & Edwards 2001, 2004). Van Wyk & Smith (2001) mentioned the multiple links between these phytochoria as well as with other 'summit sourveld' grasslands of the northern provinces several times. We believe that the definition, hierarchical position and demarcation of the relevant phytochoria of the current CEs within the Grassland Biome require revision. As a contribution to these future developments, we have introduced the concept of 'Northern sourveld endemics'. This category encompasses species shared by several currently recognised CEs and being confined to grassland habitats within these CEs.

It is also of significant importance to confirm that the core of the Grassland Biome (dominated by C_4 grasses) contains no

regions of endemism, indicating either a relatively young age of these grasslands and/or dramatic (recurrent) climatic changes causing repeated floral extinctions (see the discussion on the evolution of the Grassland Biome above).

There are 34 grass taxa that are endemic to the Grassland Biome of South Africa of which 13 are from the subfamily Arundinoideae and 11 from the Pooideae (Steenkamp et al. 2002). The Arundinoideae forms the dominant component of the winter-rainfall region of South Africa and the Pooideae are only occasionally dominant in high-altitude grasslands (Gibbs Russell 1986). It is unknown what the total levels of endemism amongst other taxa in the Grassland Biome are, but upper and lower values can be estimated. Assuming the proportion of endemism is equal across all taxonomic groups, then the number of endemics other than grasses may be 179. Of the grasses, most of the endemics are found only in the high-altitude montane grasslands and only five are found in highveld grasslands (Steenkamp et al. 2002). Only two endemic grass genera are known from the Grassland Biome so far—*Polevansia* and *Catalepis*.

Among the herbs, high endemism occurs in the orchids—of 161 orchid taxa found in the Grassland Biome, 67% are endemic (Linder et al. 2005). There are seven orchid clades identified in (but none restricted to) the flora of the Grassland Biome; the most speciose subtribes are the Habenariinae (55 taxa), Disinae (41 taxa) and Coryciinae (31 taxa; Linder et al. 2005). Generic endemism in herbs is not very high compared to that in the biomes of the winter-rainfall regions of South Africa. The endemic herb genera are concentrated especially in the Drakensberg (including the Low Escarpment and Northern Escarpment) and include: *Anisopappus*, *Arrowsmithia*, *Callilepis*, *Cymbopappus*, *Eumorphia*, *Glekia*, *Heteromma*, *Hilliardia*, *Inulanthera* and *Macowania* (Asteraceae), *Rhodohypoxis* (Hypoxidaceae), *Huttonaea*, *Dracomonticola* and *Schizochilus* (Orchidaceae), *Guthriea* (Achariaceae), *Galtonia* (Hyacinthaceae), *Glumicalyx* and *Strobilopsis* (both Scrophulariaceae), *Peltocalathos* (Ranunculaceae), *Hemizygia* and *Thorncroftia* (Lamiaceae), *Frithia*, *Khadia*, *Mossia* and *Neohenricia* (Aizoaceae), among others. Very speciose genera such as *Senecio*, *Helichrysum*, *Erica*, *Berkheya*, *Delosperma*, *Wahlenbergia*, *Ledebouria* and *Disa* also contribute a high number of species-level endemics (Figure 8.10).

5.3 Species Diversity Patterns

Data on patterns and maintenance of species richness in the grasslands of South Africa are relatively sparse (Cowling et al. 1989). A 100 m² plot in high-altitude grassland of the Eastern Cape or KwaZulu-Natal may contain 9–39 species within veg-

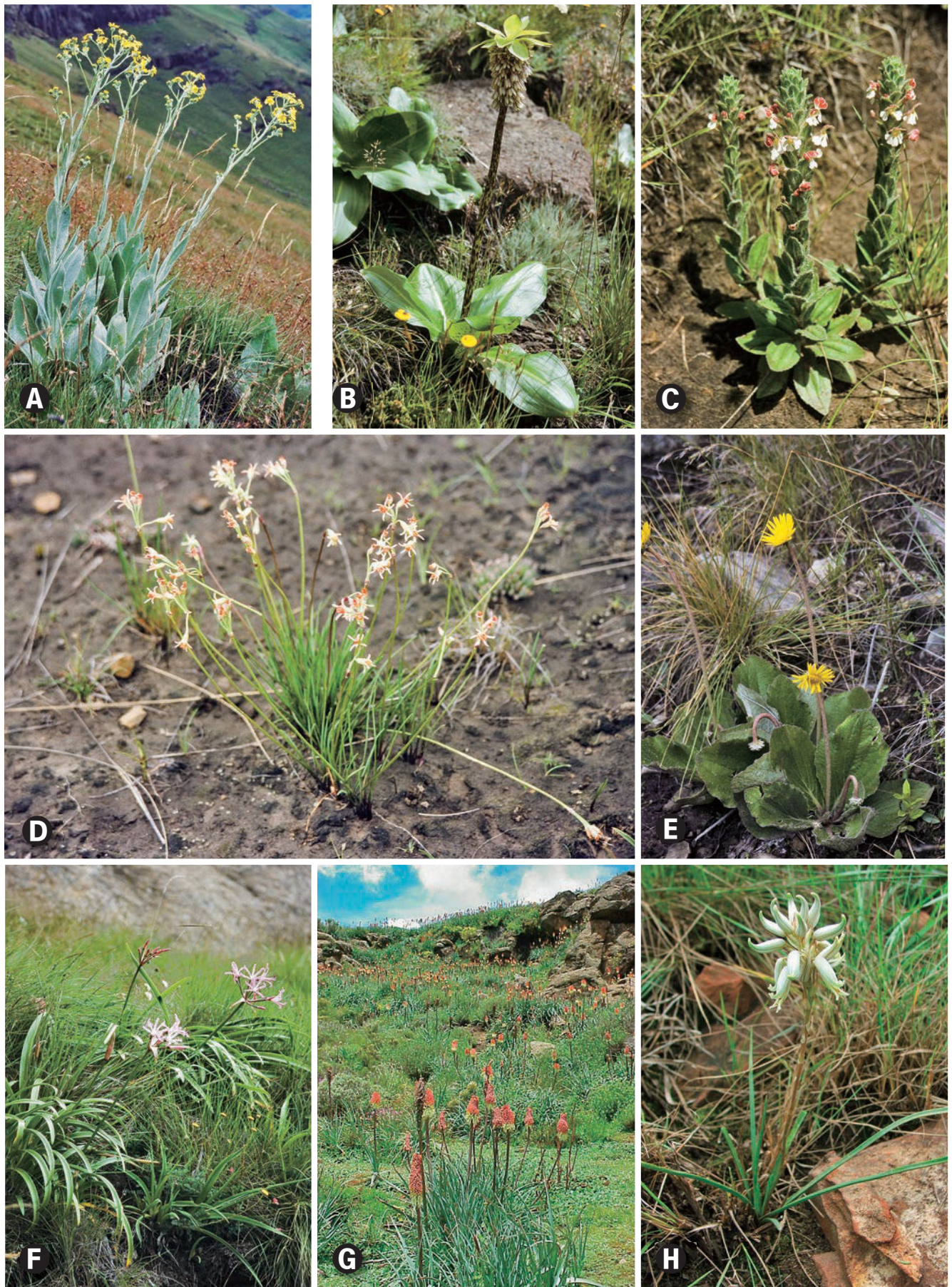


Figure 8.10 A selection of grassland endemics. A: *Senecio macrospermus* (Asteraceae), B: *Eucomis bicolor* (Hyacinthaceae), C: *Zaluzianskya microsiphon* (Scrophulariaceae), D: *Tulbaghia leucantha* (Alliaceae), E: *Haplocarpha nervosa* (Asteraceae), F: *Nerine bowdenii* (Amaryllidaceae), G: *Kniphofia caulescens* (Asphodelaceae), H: *Aloe albida* (Asphodelaceae). The taxa A–C, F and G are endemic to the Drakensberg CE, E is endemic to the Grassland Biome and H is endemic to the Barberton CE. Photographers: A–F: L. Mucina, G: M.C. Rutherford, H: M.C. Lötter.

etation with a single uniform grass layer (Eckhardt et al. 1996a, Hoare 1997). This may increase by 10 or more species in specialised habitats where multistructural vegetation is able to develop, e.g. rocky outcrops (Hoare 1997). There is a curvilinear relationship between species richness and the amount of surface rockiness in temperate grasslands, with intermediate amounts of surface rock containing the highest number of species (Hoare 2003). A 1 000 m² plot may contain 55–100 species. At a regional scale, grasslands have a high alpha diversity and a moderate gamma diversity; the Highveld region on its own has almost 4 000 species and contains centres of diversity for many speciose genera (Cowling et al. 1989).

High local species richness in grasslands is difficult to understand, considering the limited growth form richness in this vegetation. A number of explanations have been put forward to explain how so many species within the same functional guild coexist. These include the effects of differential responses to grazing, fire and local disturbance on competitive hierarchies, phenological separation and resource partitioning in mesic grasslands and the dampening of long-term competitive interactions due to the effects of variable climate patterns in semi-arid grasslands (Cowling et al. 1989). Management can have a strong effect on species richness and composition of grasslands by affecting competitive interactions amongst species. For example, communally managed grasslands of the Eastern Cape have 24 species per 100 m² plot in comparison to 34 species in commercially managed rangelands where all other environmental factors are constant. These poorly managed grasslands also have more exotic species, are dominated by forb species rather than grasses and have a higher dominance by individual species (Hoare 2002).

Species turnover in grasslands may be relatively high where topographical and environmental gradients are steep and, in the mountains and the Escarpment region, there may be high rates of turnover due to both rainfall and elevation: complete turnover of species may occur for every 400 mm change in amount of mean annual rainfall or for every 400 m of change in elevation (Hoare 2003). These high rates of beta diversity permit coexistence of species at a landscape level that contributes to the overall richness of the biome.

6. Transformation and Conservation

6.1 Patterns of Land Use and Threats to Grasslands

Land cover data (Fairbanks et al. 2000) indicate that almost 30% of the Grassland Biome of South Africa has been permanently transformed, primarily as a result of cultivation (23%), plantation forestry (4%), urbanisation (2%) and mining (1%). A further 7% has been severely degraded by erosion, agricultural improvement and other factors. Significant parts of the remaining vegetation may be secondary lands or may be degrading by gradual processes such as woody encroachment, but no exact statistics are available. Ground surveys of land cover in areas of the Eastern Cape with dense rural populations indicate that up to 80% of the 'natural' grassland may be old fields and therefore of a secondary nature (D.B. Hoare, unpublished data), suggesting that, at least in some of the worst-affected areas of South Africa, as little as 15% of the natural grassland is still in a natural state. This is consistent with statistics in Low & Rebelo (1996) in which the average level of transformation for all grassland types is given as 58%. Of additional concern is the fact that those areas of grassland that are untransformed

are highly fragmented and that as much as half the remaining areas of grassland may be composed of fragments of only a few hectares in extent.

Future threats to the vegetation of the Grassland Biome include continuous transformation by existing land uses due to the suitability of many areas of the biome for important economic activities and the threat of climate change, which may reduce the extent of the biome by up to 55% (see section above). Highveld grassland is particularly suitable for agricultural activities, and has significant mineral deposits and high urban densities. The latter two are likely to expand with economic growth in the future. The Escarpment and mountain regions are threatened mainly by afforestation with exotic *Pinus* and *Eucalyptus* species. It is estimated that this land use has doubled in the last ten years (Fairbanks et al. 2000) and that as much as 200 km² of grassland in these regions are lost to forestry alone every year (Van Wyk 1998). Furthermore, most of the communal land in the Grassland Biome occurs in the Escarpment region and is susceptible to overgrazing and the associated degradation.

The Grassland Biome contains 640 Red List species (Hilton-Taylor 1996, excluding species categorised as 'not threatened') of which 136 are threatened with extinction and six are already extinct. There are only nine grass species on this list.

6.2 Conservation Activities

There are numerous small reserves in the Grassland Biome, but together they make up only 2.2% of the biome area (Low & Rebelo 1996). This is not evenly distributed and the Highveld region is very poorly conserved in comparison to the Northern Escarpment and mountain regions. Nature reserves include Suikerbosrand, Rustenburg, Golden Gate, Qwaqwa, Blyde River Canyon and various dams. The reserves around dams are especially contentious since they were created around man-made structures for recreational purposes and are not based on systematic conservation principles.

The most important current conservation initiative under development is the Maloti-Drakensberg Transfrontier Park, which incorporates the Natal Drakensberg Park and the Drakensberg Mountains World Heritage Site declared in November 2000. The South African component of this Transfrontier Park is the uKhahlamba-Drakensberg Park, which contains spectacular natural landscapes and a rich biodiversity (Zunckel 2003). A total of 2 153 plant species have been recorded for the park (Derwent et al. 2001), of which more than 400 are endemic or near-endemic (Van Wyk & Smith 2001). Most of these are associated with the grasslands. There are 32 bird species, 11 mammal species and 40 frog species that are endemic to southern Africa that occur in the park and it is considered to be one of the eight major centres of diversity for reptiles and amphibians in southern Africa (Derwent et al. 2001).

Another conservation initiative being considered is the Pondoland National Park, which includes an area that has not been well conserved although deserving of special attention due to high diversity and endemism as well as exceptional scenic beauty. The area suggested for the proposed Pondoland National Park would include most of the Pondoland Centre of Floristic Endemism, which has about 1 800 plant species of which more than 120 are endemic or near-endemic (Van Wyk & Smith 2001).

The most significant conservation work being undertaken outside major conservation areas in the grasslands of southern Africa is often focused on highly threatened species, such as the blue swallow, various crane species, black and white rhinos

or Rudd's lark. The basis for these conservation efforts is the awareness that managing habitats is the key to managing the threats to these species since habitat loss is the primary reason for their decline. WWF South Africa plays a key role in supporting these initiatives. At the time of writing, a National Grasslands Initiative for conserving grasslands was in the process of being formalised. This is a nationwide South African project aiming at co-ordination of ongoing conservation planning within the grasslands, to identify gaps in these conservation plans, to highlight conservation priorities, and to ensure the successful implementation of these plans within the existing political and socio-economic framework of the region (Reyers & Tosh 2003). The project recognises that promoting off-reserve conservation on privately or communally owned land will have to form a major component of sustainable land management. Initial indications are that the project enjoys wide support among administrators at various levels in government, NGOs, academic institutions, agricultural bodies and international donors. An all-inclusive group will contain landowners as well and, once this has been achieved, this project should have all the components required to address sustainable long-term management of the Grassland Biome.

7. Subdivision of the Grassland Biome

The division between dry and moist grassland can be made on the basis of annual rainfall, with 500–700 mm rainfall marking the boundary. This corresponds to the dry limit of 500 mm annual rainfall of the Argentinean pampas and is consistent (under considerations of the role of parent material and soil nutrients) also with divisions of the grasslands in South Africa into sweetveld and sourveld (Huntley 1984, Ellery et al. 1995, Bond 1997). Above 600 mm of rainfall, sour andropogonoid grasses predominate, whereas below 600 mm sweet chloridoid grasses are more common. The 600 mm rainfall limit also corresponds to soil nutrient factors: plant growth in moist grasslands with dystrophic soils is mostly macronutrient-limited and in dry grasslands with eutrophic soils it is mostly water-limited. These ecological factors affect a number of other patterns found in grasslands, including, for example, diversity relationships within grassland plant communities which are explained by entirely different suites of factors in moist versus dry grasslands (D.B. Hoare, unpublished data) and structure, where moist grasslands are dependent on fire for maintaining structure, unlike dry grasslands (Bond et al. 2003b).

Altitude has a strong influence on most climatic variables. Generally, an increase in altitude corresponds with a decrease in temperature and an increase in rainfall. Mountains also have an orographic influence on rainfall, escarpment zones usually experiencing increased rainfall and

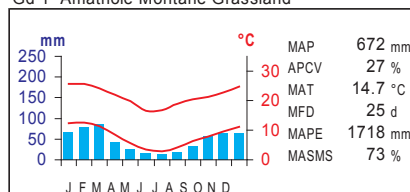
mists, and, depending on aspect, cause an increase or decrease in mean daily insolation levels. The major subdivisions of the Grassland Biome are based on gradients of altitude and moisture. Subdivisions of these groups were made on the basis of correlating floristic and environmental factors. The major subdivisions are the four bioregions described below.

8. Description of Vegetation Units

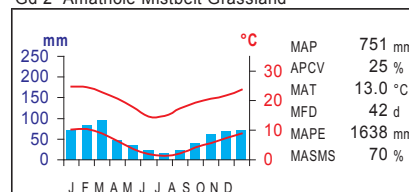
Drakensberg Grassland

Drakensberg grasslands are found primarily associated with the Great Escarpment of the Drakensberg region, including Lesotho and extending southwestwards into the Stormberg and Amathole Mountains. These are some of the highest elevation regions of southern Africa and the topography in these

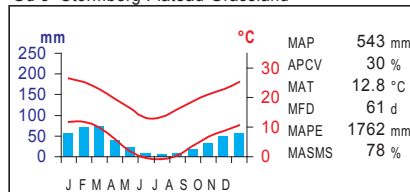
Gd 1 Amathole Montane Grassland



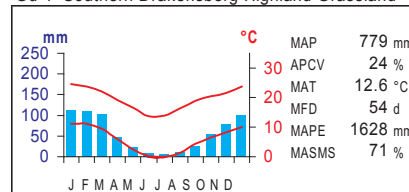
Gd 2 Amathole Mistbelt Grassland



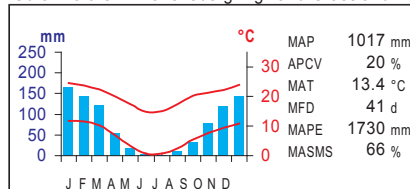
Gd 3 Stormberg Plateau Grassland



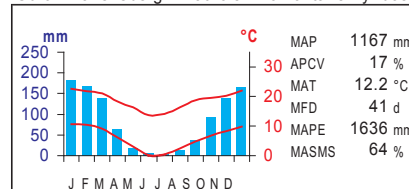
Gd 4 Southern Drakensberg Highland Grassland



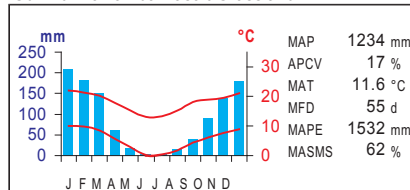
Gd 5 Northern Drakensberg Highland Grassland



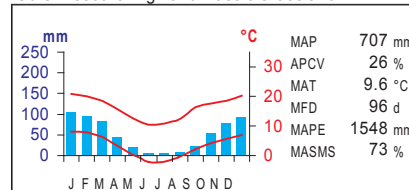
Gd 6 Drakensberg-Amathole Afro montane Fynbos



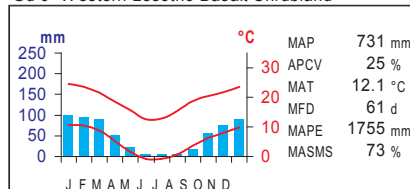
Gd 7 uKhahlamba Basalt Grassland



Gd 8 Lesotho Highland Basalt Grassland



Gd 9 Western Lesotho Basalt Shrubland



Gd 10 Drakensberg Afroalpine Heathland

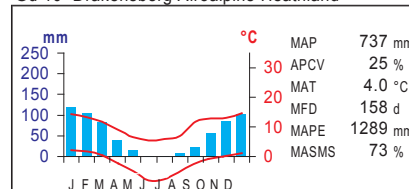


Figure 8.11 Climate diagrams of the Drakensberg Grassland Bioregion units. Blue bars show the median monthly precipitation. The upper and lower red lines show the mean daily maximum and minimum temperature respectively. MAP: Mean Annual Precipitation; APCV: Annual Precipitation Coefficient of Variation; MAT: Mean Annual Temperature; MFD: Mean Frost Days (days when screen temperature was below 0°C); MAPE: Mean Annual Potential Evaporation; MASMS: Mean Annual Soil Moisture Stress (% of days when evaporative demand was more than double the soil moisture supply).

areas may be very steep. The rainfall is generally very high, precipitation may occur at any time of the year and orographic mists supplement rainfall. At the highest elevations snow and frost are common and temperatures are usually cool to cold (Figure 8.11).

Heathlands are found either on steep slopes or in the extreme summit positions such as the highest mountain ridges, edges of flat mesas or damp, high-altitude plateaus. These are found in South Africa from the Soutpansberg to the Amathole, with larger patches occurring on the Lesotho plateau. The substrate in these localities is often leached by continuous precipitation and soils tend to be nutrient-poor. Similar heathlands may be found throughout the East African mountain chains and also in Madagascar and on the Mascarene Islands at similar (or higher) elevations (Hedberg 1951, 1955, 1964, White 1983, Carbutt & Edwards 2001).

Gd 1 Amathole Montane Grassland

VT 44 Highland Sourveld and Dohne Sourveld (73%) (Acocks 1953). LR 42 Moist Upland Grassland (52%) (Low & Rebelo 1996).

Distribution Eastern Cape Province: The main grassland unit of the Amathole, Winterberg and Kologha Mountains as well as the mountains just north of Somerset East (Bosberg and other outlying peaks). Also found on broken veld between Stutterheim and Komga. At altitudes 650–1 500 m.

Vegetation & Landscape Features Low mountain ranges and moderately undulating landscapes characterised by short grassland with high species richness of forbs, especially those of the family Asteraceae (especially *Helichrysum* and *Senecio*). The grasslands are dominated by a variety of grasses, including *Themeda triandra*, *Elionurus muticus*, *Sporobolus africanus*, *Eragrostis chloromelas*, *E. curvula*, *Heteropogon contortus*, *Alloteropsis semialata* and *Tristachya leucothrix*.

Geology & Soils On sedimentary rocks of the Beaufort Group (Karoo Supergroup) overlaid by deep, freely drained, highly weathered soils (Hartmann 1988). Weakly developed lithosols are also found in places. Most common land types Fb, Fa and Fc.

Climate Bimodal rainfall pattern with spring and late summer peaks. MAP around 670 mm (range 500–740 mm, up to 1 000 mm in isolated places). Rainfall the highest in high-altitude areas due to orographic factors and becoming lower with reduction in elevation and with distance westwards. Coefficient of variation in rainfall decreases with elevation, and ranges from 15–31% across the unit. Overall MAP close to 15°C. Winter frost is not common in the southeastern part of this unit, but it is more frequent (up to 80 days per year) in the western and northwestern regions. See also climate diagram for Gd 1 Amathole Montane Grassland (Figure 8.11).

Important Taxa Graminoids: *Cynodon dactylon* (d), *Eragrostis chloromelas* (d), *E. curvula* (d), *Microchloa caffra* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Agrostis lachnantha*, *Alloteropsis semialata* subsp. *eckloniana*, *Andropogon appendiculatus*, *Brachiaria serrata*, *Cymbopogon pospischilii*, *Cyperus usitatus*, *Elionurus muticus*, *Eragrostis capensis*, *E. plana*, *E. planiculmis*, *E. racemosa*, *Eulalia villosa*, *Harpochloa falx*, *Heteropogon contortus*, *Koeleria capensis*, *Kyllinga alata*, *Melica decumbens*, *Pennisetum sphacelatum*, *Pentaschistis cirrhulosa*, *P. tysonii*, *Schoenoxiphium sparteum*, *Sporobolus africanus*, *Trachypogon spicatus*. Herbs: *Ajuga ophrydis*, *Commelina africana*, *Gerbera piloselloides*, *Haplocarpha scaposa*, *Helichrysum nudifolium* var. *pilosellum*, *H. rugulosum*, *H. simillimum*, *H. umbraculigerum*, *Lepidium africanum* subsp. *africanum*, *Lobelia erinus*, *Rumex lanceolatus*, *Selago densiflora*, *Senecio erubescens* var. *crepidifolius*, *S. retrorsus*, *Tephrosia capensis* var. *acutifolia*, *Tolpis capensis*, *Trifolium burchellianum* subsp. *burchellianum*, *Wahlenbergia stellarioides*. Geophytic Herbs: *Disa tysonii*, *D. versicolor*, *Disperis oxyglossa*, *Eucomis autumnalis* subsp. *autumnalis*, *Geum capense*, *Gladiolus longicollis* subsp. *longicollis*, *Habenaria lithophila*, *Hypoxis argentea* var. *argentea*, *Oxalis smithiana*, *Satyrium cristatum*. Succulent Shrub: *Delosperma crassuloides*. Herbaceous Climber: *Rhynchosia totta*. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum*, *Chrysocoma ciliata*, *Felicia filifolia* subsp. *filifolia*, *F. muricata*, *Helichrysum asperum* var. *albidulum*, *H. odoratissimum*, *H. trilineatum*, *Otholobium caffrum*, *Senecio burchellii*, *S. pterophorus*.

Biogeographically Important Taxa (^DDrakensberg endemic, ^{D⁹}Drakensberg endemic extending to Griqualand East) Graminoids: *Bromus speciosus*^D, *Helictotrichon galpinii*^D, *Pentaschistis airoides* subsp. *jugorum*^D. Herbs: *Helichrysum aureum* var. *serotinum*^D, *Psammotropha mucronata* var. *marginata*^D. Geophytic Herb: *Disa stricta*^{D⁹}.

Endemic Taxa Herbs: *Alchemilla bolusii*, *Alepidea macowani*, *Cineraria vagans*, *Diascia ramosa*, *Helichrysum isolepis*, *Heliophila katbergensis*, *Hermannia violacea*, *Wahlenbergia laxiflora*. Geophytic Herbs: *Aspidoglossum uncinatum*, *Nerine filamentosa*, *Pachycarpus linearis*, *Watsonia amatolae*. Succulent Shrub: *Delosperma katbergense*. Semiparasitic Herb: *Thesium orientale*. Low Shrubs: *Abutilon flanagani*, *Arrowsmithia stypelioides*, *Erica amatolensis*, *Euryops ciliatus*, *Garuleum tanacetifolium*, *Indigofera cuneifolia* var. *angustifolia*, *Lotononis trichodes*, *Macowania revoluta*, *Muraltia rara*, *Phyllica galpinii*, *P. simii*, *Tephrosia polystachya* var. *longidens*.



D.B. Hoore

Figure 8.12 Gd 1 Amathole Montane Grassland: Montane grasslands north of Hogsback (Amathole, Eastern Cape) with Elandsberg in the background; *Themeda triandra* and a species of *Scabiosa* are prominent here.

Conservation Least threatened. Target 27%. Only about 5% conserved in 11 statutory conservation areas (Mpofu Game Reserve, Fort Fordyce, Bosberg, Bush Nek Outspan and Quacu Nature Reserves, Kologha Forest Reserve as well as in Kubusi, Hogsback, Isidenge, Katberg and Cathcart State Forests). Some patches are conserved in at least two private reserves (Bushy Park Natural Heritage Site, Oudekraal Game Farm). More than 10% already transformed for plantations and cultivation. Heavily grazed by cattle and horses (in places), resulting in a uniform, short grassland structure and several prominent indigenous weedy forbs (e.g. *Senecio retrorsus*). The alien invaders include *Acacia mearnsii* and *A. dealbata*. Erosion very low, low or moderate.

Remarks Northern and southern watersheds tend to have distinctive species compositions due to differences in solar insolation levels and moisture regime (Hoare 1997, Hoare & Bredenkamp 1999). Due to this factor, the northern watershed towards the western end of this unit forms a mosaic with and is then gradually replaced by Gh 1 Karoo Escarpment Grassland in the mountains. The Gd 2 Amathole Mistbelt Grassland unit is embedded within this unit at higher altitudes.

References Acocks (1953), Hoare (1997), Hoare & Bredenkamp (1999).

Gd 2 Amathole Mistbelt Grassland

VT 44 Highland Sourveld and Dohne Sourveld (98%) (Acocks 1953). LR 42 Moist Upland Grassland (92%) (Low & Rebelo 1996).

Distribution Eastern Cape Province: On the highest ridges of the Winterberg, Katberg, Amathole and Kologha ranges. Altitude 1 380–2 080 m, most of the area 1 500–1 680 m.

Vegetation & Landscape Features Mountains and moderately undulating slopes below peaks, often with ridges of rock or boulder outcrops. Vegetation is a short grassland dominated by *Themeda triandra*, *Heteropogon contortus*, *Alloteropsis semialata*, *Tristachya leucothrix*, *Festuca caprina* and *F. costata*, with a high diversity of asteraceous herbs, including *Helichrysum appendiculatum*, *H. aureum*, *H. asperum*, *H. simillimum*, *H. odoratissimum*, *H. nudifolium* and *H. anomalum*.

Geology & Soils Deep, freely drained, highly weathered soils overlying the Beaufort Group (predominantly Triassic Tarkastad Subgroup) sedimentary rocks. Dominant land type Fb (two thirds of the region), lb land type covers about a third.

Climate Bimodal spring-autumn rainfall pattern although rain can fall at any time of the year, and it increases from west to east as well as with increasing elevation. Coefficient of variation in MAP from 15–29% across the unit. MAP 550–1 100 mm (overall regional average 750 mm). Precipitation supplemented by orographically induced precipitation (mist and drizzle). MAT of 13°C indicates a cool-temperate climate. Incidence of frost is 20–95 days (average 42) per year, but the probability of the frost occurrence is higher in the western regions of the unit. See also climate diagram for Gd 2 Amathole Mistbelt Grassland (Figure 8.11).

Important Taxa Graminoids: *Heteropogon contortus* (d), *Themeda triandra* (d), *Alloteropsis semialata* subsp. *eckloniana*, *Andropogon appendiculatus*, *Cymbopogon marginatus*, *Elionurus muticus*, *Eragrostis capensis*, *E. chloromelas*, *E. planiculmis*, *Festuca caprina*, *F. costata*, *Melica decumbens*, *Microchloa caffra*, *Sporobolus africanus*, *Tristachya leucothrix*. Herbs: *Aster bakerianus*, *Cephalaria oblongifolia*, *Helichrysum glomeratum*, *H. mixtum*, *H. nudifolium* var. *pilosellum*, *H. rugulosum*, *H. simillimum*, *Lasiospermum bipinnatum*, *Lobelia erinus*,

L. flaccida, *Monopsis scabra*, *Selago densiflora*, *Senecio asperulus*, *Trifolium burchellianum* subsp. *burchellianum*. Geophytic Herb: *Moraea reticulata*. Low Shrubs: *Anthospermum paniculatum*, *Chrysocoma ciliata*, *Euphorbia striata*, *Felicia filifolia* subsp. *filifolia*, *Helichrysum anomalum*, *H. asperum* var. *albidulum*, *H. odoratissimum*, *Pentzia cooperi*, *Rubus ludwigii* subsp. *ludwigii*, *Stoebe plumosa*.

Endemic Taxa Herbs: *Galium amatymbicum*, *Nidorella undulata*. Geophytic Herb: *Hypoxis woodii*. Low Shrubs: *Helichrysum montis-cati* (d), *Euryops dyeri*, *Indigofera elandsbergensis*, *Lotononis holosericea*. Succulent Shrubs: *Delosperma alpinum*, *D. dyeri*.

Conservation Least threatened. Target 27%. About 4% conserved in units under governmental management: Hogsback State Forest, Kologha Forest Reserve, Katberg State Forest and Kubusi Indigenous State Forest. About 3% already transformed for plantations. Invasive alien *Acacia dealbata* is a local threat. Erosion very low or low.

Remarks There are some very isolated unmapped patches of Gd 6 Drakensberg-Amathole Afromontane Fynbos embedded within this grassland unit. This vegetation is probably what Acocks (1988) referred to when he remarked on the similarity of grassy fynbos to some parts of the Dohne Sourveld on the summits of the Amathole and Katberg Mountains. The number of *Helichrysum* species in this vegetation is noteworthy—a small plot can share as many as 10 species.

References Story (1952), Acocks (1953, 1988), Killick (1978b), Hoare (1997), Hoare & Bredenkamp (1999).

Gd 3 Stormberg Plateau Grassland

VT 59 Stormberg Plateau Sweet Veld (63%) (Acocks 1953). LR 44 South-eastern Mountain Grassland (76%) (Low & Rebelo 1996).

Distribution Eastern Cape Province: Gently sloping landscapes on the Stormberg Plateau north of Molteno and Dordrecht, east of Burgersdorp and extending northwards not much beyond Jamestown. Altitude 1 520–1 960 m, concentrated between 1 640 m and 1 680 m.

Vegetation & Landscape Features Relatively flat to undulating landscape with hills and mountain peaks jutting above the general landscape. The vegetation is a grassland with a strong dwarf shrub component and, on rocky outcrops, shrubland vegetation may occur. Common and dominant species include *Themeda triandra*, *Eragrostis chloromelas*, *Elionurus muticus*, *Karroochloa purpurea*, *Heteropogon contortus*, *Eragrostis capensis*, *Merxmuellera stictica*, *Helictotrichon turgidulum*, *Felicia filifolia* and *Chrysocoma ciliata*.

Geology & Soils Generally shallow soils (typical of Fb, Da and Db land types), with variable amounts of soil skeleton and overlying mudstones and sandstones of the Elliot Formation and in some areas also of the Molteno Formation (Stormberg Group, Karoo Supergroup).

Climate Variable. The rainfall pattern shows a spring-autumn bimodality with overall MAP 540 mm. There is an east-west rainfall gradient across this vegetation unit from 450 mm in the west to over 700 mm in the east. Coefficient of variation of MAP 30%, varying only slightly from 26–31% across the unit. MAT of nearly 13°C indicates a cool-temperate regime, with climate becoming extremely cold in places. One of the coldest recorded minimum temperatures in South Africa was –18.9°C at Buffelsfontein in the centre of this unit. Frosts can occur at any time of the year, but with a low probability in summer. Incidence of frost from 30–75 days, increasing with

elevation. See also climate diagram for Gd 3 Stormberg Plateau Grassland (Figure 8.11).

Important Taxa Graminoids: *Elionurus muticus* (d), *Eragrostis chloromelas* (d), *Merxmuellera disticha* (d), *Themeda triandra* (d), *Andropogon appendiculatus*, *Aristida diffusa*, *Cynodon incompletus*, *Cyperus usitatus*, *Digitaria eriantha*, *Eragrostis capensis*, *E. curvula*, *E. racemosa*, *Festuca scabra*, *Ficinia gracilis*, *Harpochloa falx*, *Helictotrichon turgidulum*, *Karoochloa purpurea*, *Koeleria capensis*, *Merxmuellera drakensbergensis*, *Microchloa caffra*, *Miscanthus capensis*, *Panicum gilvum*, *Pennisetum sphacelatum*, *Pentaschistis microphylla*, *Schoenoxiphium rufum*, *Tetrachne dregei*, *Tragus koelerioides*, *T. racemosus*. Herbs: *Ajuga ophrydis*, *Galium capense* subsp. *capense*, *Gazania krebsiana* subsp. *krebsiana*, *Gerbera piloselloides*, *Hebenstretia dentata*, *Helichrysum nudifolium* var. *pilosellum*, *H. rugulosum*, *Pseudognaphalium oligandrum*, *Senecio asperulus*, *S. retrorsus*, *Tribulus terrestris*, *Trifolium burchellianum* subsp. *burchellianum*, *Wahlenbergia stellarioides*. Succulent Herb: *Crassula lanceolata*. Low Shrubs: *Chrysocoma ciliata* (d), *Felicia filifolia* subsp. *filifolia*, *F. muricata*, *Gomphocarpus fruticosus* subsp. *fruticosus*, *Helichrysum asperum* var. *albidulum*, *H. dregeanum*, *H. trilineatum*, *Passerina montana*, *Pentzia globosa*, *Selago saxatilis*, *Wahlenbergia albens*. Tall Shrub: *Rhus pyroides*. Woody Climber: *Clematis brachiata*.

Biogeographically Important Taxa ^DDrakensberg endemic, ^{Dg}Drakensberg endemic extending to Griqualand East) Graminoid: *Pentaschistis galpinii*^D. Herbs: *Diascia integerima*^D, *Psammotropha mucronata* var. *marginata*^D. Low Shrub: *Relhania acerosa*^{Dg}. Tall Shrub: *Lotononis lotononoides*^D.

Endemic Taxon Low Shrub: *Euryops calvescens*.

Conservation Least threatened. Target 27%. None conserved in statutory conservation areas. About 9% transformed, mostly for cultivation. Erosion moderate, high and low.

Remarks The region of this unit forms a transitional zone between the Gh 1 Karoo Escarpment Grassland to the west and the Gd 4 Southern Drakensberg Highland Grassland towards the higher altitudes in the east. Floristic elements typical of both neighbouring regions meet here. Outcrops of the Drakensberg and Stormberg Groups (Karoo Supergroup) and pyroclastic rocks

within this unit support vegetation resembling that of the Gd 4 Southern Drakensberg Highland Grassland. On the other hand, rocky, dry aspects in the gently sloping landscapes tend to have more karoo elements. Within the Stormberg Plateau Grassland unit, the vegetation patterns are strongly influenced by moisture gradients (Hoare & Bredenkamp 2001). The bottomlands at the foot of the hills consist mostly of flat, wide, unchannelled drainage valleys containing dense hygrophilous grasslands dominated by species such as *Pennisetum sphacelatum*.

References Acocks (1953, 1988), Hoare & Bredenkamp (2001).

Gd 4 Southern Drakensberg Highland Grassland

VT 44 Highland Sourveld and Dohne Sourveld (40%), VT 58 *Themeda-Festuca* Alpine Veld (32%) (Acocks 1953). LR 44 South-eastern Mountain Grassland (36%), LR 42 Moist Upland Grassland (27%) (Low & Rebelo 1996). BRG 10 Montane Veld (Camp 1999b).

Distribution Eastern Cape and KwaZulu-Natal Provinces: An intricate system of patches and corridors across the highest mountains and ridges of the Stormberg, from Molteno to the surrounds of Dordrecht, also including the elevated broad valley of the Kraairivier (near Barkly East) and its tributaries. Further occurring in a broad band (and abutting onto Gd 8 Lesotho Highland Basalt Grassland at upper boundary) on steep slopes of head-valleys fringing the edge of the southern Drakensberg Escarpment covering the regions north and northwest of Indwe, Elliot, Ugie, Maclear, Mt Fletcher (all Eastern Cape) as far as Matatiele (KwaZulu-Natal). From about the Ramatseliso Nek (pass) north of Matatiele the upper boundary of this unit is formed by the Gd 7 uKhahlamba Basalt Grassland—from here the Gd 4 Southern Drakensberg Highland Grassland follows a system of high northwest-southeast-tending ridges as far north as the southeastern extension of the Giant's Castle buttress (KwaThabamnyana). Altitude 1 420–2 080 m, mainly between 1 720–1 840 m.

Vegetation & Landscape Features Steeply sloping mountainous areas on and below the summit of the Great Escarpment supporting dense tussock grassland on slopes sometimes with a dwarf-shrubby component and dwarf shrubland on exposed rocky areas. The tussock grassland is dominated by various species of *Festuca* and other grasses such as *Themeda triandra*, *Heteropogon contortus*, *Eragrostis racemosa*, *Eragrostis chloromelas*, *E. curvula*, *Elionurus muticus*, *Trachypogon spicatus*, *Andropogon appendiculatus*, *Harpochloa falx* and *Tristachya leucothrix*.

Geology & Soils Sandstones of the Clarens Formation and sandstones, siltstones and mudstones of the Elliot Formation (both formations belonging to the Stormberg Group, Karoo Supergroup) as well as the basaltic lava flows of the Drakensberg Group. Soils on the steep escarpment slopes tend to be deep and fine-grained, typical of land types Fa, Fb and Ea.

Climate Summer rainfall, with very dry winters. MAP 780 mm (500–1 120 mm), increasing from west to east to close to the southern border of Lesotho.



Figure 8.13 Gd 3 Stormberg Plateau Grassland: Grasslands with prominent *Themeda triandra*, *Eragrostis chloromelas*, *Cymbopogon pospischilii*, *Eragrostis gummiflua*, *Elionurus muticus*, north of Jamestown (Eastern Cape).



M.C. Rutherford

Figure 8.14 Gd 4 Southern Drakensberg Highland Grassland: High-altitude grasslands on the Pitseng Pass between Mount Fletcher and Naudesnek (Eastern Cape) with patches of unmapped FOZ 3 Southern Mistbelt Forest in the ravines.

Northeast of the latter region MAP increases with increasing elevation. The coefficient of variation of MAP 16–31% across the unit, with the highest values in the region around the Stormberg Plateau. Temperature regime cool-temperate (MAT around 13°C), typically montane, with cool day-time temperatures throughout the year and the potential for cold conditions at any time. Winter frost is common (30–90 days, average 54 days), incidence increasing with elevation. The areas of high altitude regularly receive snow in winter, sometimes in considerable quantities as a result of clashes of water-laden eastbound fronts with high-altitude cold air masses. See also climate diagram for Gd 4 Southern Drakensberg Highland Grassland (Figure 8.11).

Important Taxa Graminoids: *Alloteropsis semialata* subsp. *eckloniana* (d), *Aristida junciformis* subsp. *galpinii* (d), *Catalepis gracilis* (d), *Diheteropogon filifolius* (d), *Eragrostis caesia* (d), *E. chloromelas* (d), *E. planiculmis* (d), *E. racemosa* (d), *Festuca caprina* (d), *Microchloa caffra* (d), *Monocymbium cereiiforme* (d), *Pennisetum sphacelatum* (d), *Rendlia altera* (d), *Themeda triandra* (d), *Trachypogon spicatus* (d), *Tristachya leucothrix* (d), *Agrostis lachnantha*, *Andropogon appendiculatus*, *Aristida diffusa*, *Cymbopogon pospischilii*, *Elionurus muticus*, *Eragrostis capensis*, *E. curvula*, *E. plana*, *Festuca scabra*, *Fingerhuthia sesleriiformis*, *Harpochloa falx*, *Helictotrichon turgidulum*, *Heteropogon contortus*, *Juncus exsertus* subsp. *exsertus*, *Koeleria capensis*, *Pentaschistis cirrhulosa*, *P. microphylla*, *Poa binata*, *Schoenoxiphium sparteum*, *Sporobolus centrifugus*. Herbs: *Ajuga ophrydis*, *Aster bakerianus*, *Euphorbia epicyparissias*, *Galium capense* subsp. *capense*, *Gazania krebsiana* subsp. *krebsiana*, *Haplocarpha scaposa*, *Hebenstretia dentata*, *Helichrysum chionosphaerum*, *H. nudifolium* var. *pilosellum*, *H. rugulosum*, *H. umbraculigerum*, *Kohautia amatymbica*, *Lactuca inermis*, *Lasiospermum bipinnatum*, *Lobelia erinus*, *L. flaccida*, *L. vanreenensis*, *Pentanisia prunelloides* subsp. *latifolia*, *Psammotropha mucronata* var. *foliosa*, *Rumex lanceolatus*, *Salvia stenophylla*, *Selago densiflora*, *S. galpinii*, *Senecio asperulus*, *S. erubescens* var. *crepidifolius*, *Tolpis capensis*, *Trifolium burchellianum* subsp. *burchellianum*, *Wahlenbergia cuspidata*, *W. stellarioides*. Geophytic Herbs: *Cheilanthes hirta*, *Corycium dracomontanum*, *Disa fragrans* subsp. *fragrans*, *Disperis oxyglossa*, *Drimia macrocentra*, *Eriospermum ornithogaloides*,

Geum capense, *Hypoxis rigidula* var. *pilosissima*. Herbaceous Climber: *Rhynchosia totta*. Low Shrubs: *Chrysocoma ciliata*, *Erica caffrorum* var. *caffrorum*, *Euryops candollei*, *Felicia filifolia* subsp. *filifolia*, *F. muricata*, *Helichrysum asperum* var. *albidulum*, *H. splendidum*, *H. trilineatum*, *Passerina montivagus*, *Pentzia cooperi*, *Rubus ludwigii* subsp. *ludwigii*, *Selago albida*, *S. saxatilis*, *Senecio burchellii*.

Biogeographically Important Taxa

(^DDrakensberg endemic, ^{D⁹}Drakensberg endemic extending to Griqualand East) Graminoids: *Pentaschistis airoides* subsp. *jugorum*^D, *Polevansia rigida*^D, *Restio galpinii*^{D⁹}. Herbs: *Aster ananthocladus*^D, *Berkheya multijuga*^D, *Diascia integerrima*^D, *Wahlenbergia polytrichifolia* subsp. *dracomontana*^D. Geophytic Herbs: *Corycium alticola*^D, *Merwillia dracomontana*^D, *Rhodohypoxis rubella*^D, *Schizochilus bulbifera*^{D⁹}. Low Shrubs: *Erica aestiva* var. *aestiva*^D, *E. algida*^{D⁹}, *E. dominans*^D, *E. dracomontana*^D, *E. frigida*^D, *E. schlechterii*^D, *E. wyliei*^D, *Helichrysum glaciale*^D, *H. marginatum*^D, *Relhania acerosa*^{D⁹}. Tall Shrub: *Lotononis lotononoides*^D.

Endemic Taxa Graminoid: *Festuca vulpioides*. Herbs: *Alepidea insculpta*, *Aster confertifolius*, *Diascia megathura*, *Felicia caespitosa*, *Helichrysum longinquum*, *Osteospermum attenuatum*, *Selago leptothrix*, *Wahlenbergia appressifolia*. Geophytic Herbs: *Aspidonepsis cognata*, *Disa nivea*, *Trachyandra smalliana*. Low Shrubs: *Erica anomala*, *E. caffrorum* var. *glomerata*, *E. hillburtii*, *Lotononis jacottetii*, *L. minor*.

Conservation Least threatened. Target 27%. Almost 9% statutorily conserved in uKhahlamba Drakensberg Park and Malekgonyane (Ongeluksnek) Wildlife Reserve. More than 5% already transformed for cultivation. Alien invader *Acacia dealbata* occurs scattered in places. Erosion mainly very low (57%), to lesser extent low or moderate (13%).

Remark Unmapped patches of AZf 4 Drakensberg Wetlands are abundant in seepage areas (dominated by *Merxmüllera drakensbergensis*) and in drainage valleys, typically with the tall shrub *Leucosidea sericea* dominant.

References Acocks (1953, 1988), Bester (1998), Camp (1999b), Hoare & Bredenkamp (2001).

Gd 5 Northern Drakensberg Highland Grassland

VT 44 Highland Sourveld and Dohne Sourveld (81%) (Acocks 1953). LR 41 Wet Cold Highveld Grassland (51%) (Low & Rebelo 1996). BRG 10 Montane Veld (55%) (Camp 1999b).

Distribution KwaZulu-Natal and Free State Provinces: Northeastern and eastern slopes of valleys and buttresses of the Drakensberg in KwaZulu-Natal where most of the region is locally known as Little Berg, from Giant's Castle to slopes in any direction in the surrounds of Clarens in the Free State. Altitude 1 460–2 060 m, mostly 1 780–1 840 m.

Vegetation & Landscape Features Mountainous region characterised by steep slopes of broad valleys and supporting mainly short, sour grasslands, rich in forbs. So-called 'Protea



L. Mucina

Figure 8.15 Gd 5 Northern Drakensberg Highland Grassland: Sandstone cliffs with *Leucosidea sericea* shrubland in a belt of *Protea subvestita* in the Golden Gate Highlands National Park near Clarens (Free State).

savannas'—grasslands that contain widely scattered trees of *Protea caffra* and occasionally *P. roupelliae*—fall within this unit. Sandstone cliffs, a major characteristic of this landscape, create a multitude of special habitats (often fire-protected) for many special plant communities.

Geology & Soils Mudstone and sandstone of the Elliot Formation and sandstone of the Clarens Formation (Stormberg Group, Karoo Supergroup) supporting soils typical of the Fc land type (dominant) as well as Ac and Bb land types (of lesser importance).

Climate Summer-rainfall region, with MAP broadly ranging from 720–1 630 mm (overall average MAP 1 017 mm). Snowfalls are occasional and last several days. Summer mists frequent. Hot dry winds frequent from July to October. Summers warm and winters cold, with frequent considerably severe frost events. Overall regional MAT 13.4°C. See also climate diagram for Gd 5 Northern Drakensberg Highland Grassland (Figure 8.11).

Important Taxa Graminoids: *Setaria sphacelata* (d), *Themeda triandra* (d), *Agrostis lachnantha*, *Andropogon schirensis*, *Aristida adscensionis*, *A. bipartita*, *A. diffusa*, *A. junciformis* subsp. *galpinii*, *Brachiaria eruciformis*, *B. serrata*, *Bulbostylis densa* subsp. *densa*, *B. humilis*, *Catalepis gracilis*, *Digitaria flaccida*, *D. monodactyla*, *D. ternata*, *Diheteropogon filifolius*, *Elionurus muticus*, *Eragrostis capensis*, *E. chloromelas*, *E. gummiflua*, *E. plana*, *E. racemosa*, *E. sclerantha*, *Harporchloa falx*, *Heteropogon contortus*, *Hyparrhenia dregeana*, *H. hirta*, *Kyllinga melanosperma*, *K. pauciflora*, *Melinis nerviglumis*, *Microchloa caffra*, *Monocymbium ceresiiforme*, *Panicum natalense*, *Pennisetum sphacelatum*, *Setaria nigrirostris*, *Stipagrostis zeyheri* subsp. *sericans*, *Trachypogon spicatus*, *Trichoneura grandiglumis*, *Tristachya leucothrix*. Herbs: *Ajuga ophrydis*, *Berkheya*

P.J. du Preez



Figure 8.16 Gd 5 Northern Drakensberg Highland Grassland: Species-rich moist grassland on sandstone with scattered *Protea caffra* at Cathkin Peak, Drakensberg (KwaZulu-Natal).

discolor, *Cineraria lyratiformis*, *Conyza podocephala*, *Helichrysum adenocarpum*, *H. chionosphaerum*, *H. glomeratum*, *H. rugulosum*, *Hermannia depressa*, *Hibiscus aethiopicus* var. *ovatus*, *Indigastrum fastigiatum*, *Monopsis decipiens*, *Salvia repens* var. *keiensis*, *S. stenophylla*, *Senecio erubescens* var. *crepidifolius*, *S. latifolius*. Geophytic Herbs: *Disa versicolor*, *Eucomis autumnalis* subsp. *autumnalis*, *E. bicolor*, *Pteridium aquilinum*. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum*, *Clutia affinis*, *Erica drakensbergensis*, *Felicia muricata*, *Gnidia kraussiana*, *Helichrysum hypoleucum*, *Protea dracomontana*, *P. simplex*, *Wahlenbergia dieterlenii*. Succulent Shrub: *Crassula dependens*. Small Trees: *Protea caffra* subsp. *caffra* (d), *P. roupelliae* subsp. *roupelliae* (d), *P. subvestita* (d).

Biogeographically Important Taxa

^(D)Drakensberg endemic, ^(Dg)Drakensberg endemic extending to Griqualand East) Herbs: *Alepidea pilifera*^(D), *Chironia peglerae*^(D). Geophytic Herbs: *Asclepias*

oreophila^(D), *Elaphoglossum drakensbergense*^(D), *Eucomis schijffii*^(D), *Galtonia regalis*^(D), *Merwillia dracomontana*^(D), *Ornithogalum diphyllum*^(Dg). Low Shrubs: *Erica ebracteata*^(D) (d), *E. aestiva* var. *aestiva*^(D), *E. algida*^(Dg).

Endemic Taxa Geophytic Herbs: *Gladiolus loteniensis*, *Hesperantha scopulosa*.

Conservation Least threatened. Target 27%. Some 38% statutorily conserved in the uKhahlamba Drakensberg Park, Sterkfontein Dam Nature Reserve, Golden Gate Highlands National Park, Qwaqwa National Park and Pocolan Nature Reserve. About 7% already transformed by cultivation, urban sprawl or by the building of dams. Alien plant invasions are generally localised, but can be severe. Some important problem species include: *Acacia dealbata*, *A. mearnsii*, *Hypericum perforatum*, *Pinus patula*, *Populus canescens*, *Pyracantha angustifolia*.

lia, *P. crenulata*, *Robinia pseudoacacia*, *Rubus cuneifolius* and *Salix fragilis*. Erosion very low (72%) or low (25%).

References Acocks (1953, 1988), Killick (1963), Edwards (1967), Du Preez & Bredenkamp (1991), Hill (1996), Camp (1999b).

Gd 6 Drakensberg-Amathole Afromontane Fynbos

VT 44 Highland Sourveld and Dohne Sourveld (57%) (Acocks 1953). LR 46 Altitude Mountain Grassland (41%), LR 41 Wet Cold Highveld Grassland (21%) (Low & Rebelo 1996). BRG 10 Montane Veld p.p. (Camp 1999b). Subalpine Fynbos & Subalpine Heath (Killick 1978a). Including *Cymbopogon*–*Passerina* Macchia (Roberts 1966).

Distribution KwaZulu-Natal, Eastern Cape and Free State Provinces (presumably also in Lesotho): Series of isolated patches in deeply incised Drakensberg valleys (both in the Northern and Southern Berg) with the southernmost outliers on the Amathole Mountains (Eastern Cape) as well as odd outliers deep into KwaZulu-Natal at high altitude (e.g. Madlozi Mountain) north of Qudeni in the Nkandla District. Most patches found at altitudes around 1 660 m, and then from 1 900–2 060 m, with notable outliers situated as low as 1 520 m and as high as 2 600 m.

Vegetation & Landscape Features Steep valleys and escarpment slopes at the head of rivers with small stands in stream gullies and depressions. Evergreen shrublands 1–3 m tall, many shrubs with ericoid leaves. The most prominent shrubland elements comprise genera such as *Passerina*, *Cliffortia*, *Erica*, *Euryops*, *Helichrysum*, *Macowania*, *Protea*, *Widdringtonia* and *Ischyrolepis*.

Geology & Soils Jurassic basalts (Drakensberg Group) and a variety of Karoo Supergroup sedimentary rocks (mainly sandstone of the Clarens Formation of the Stormberg Group) giving rise to soils of varying depth and nutrient status. Dominant land type Ac, followed by Fa and Ad.

Climate Summer-rainfall region, with MAP 800–1 820 mm (overall regional MAP 1 167 mm). Snowfalls are occasional and summer mists occur frequently. Overall regional MAT of 12.2°C might be misleading since summer days can be quite hot and frost occurs frequently in winter (more than 40 days) and the sheltered position of the afromontane fynbos habitats (steep slopes), often out of direct sun, probably has a profound influence on local microclimate. Hot, dry winds are common from July to October. See also climate diagram for Gd 6 Drakensberg-Amathole Afromontane Fynbos (Figure 8.11).

Important Taxa Small Trees: *Widdringtonia nodiflora* (d), *Encephalartos ghellinckii*, *Protea lacticolor*, *P. subvestita*. Low Shrubs: *Passerina montana* (d), *Cliffortia linearifolia*, *C. nitidula*, *C. paucistaminea*, *Clusia natalensis*, *Erica caffrorum* var. *caffrorum*, *E. cerinthoides*, *E. evansii*, *Gymnopentzia bifurcata*, *Otholobium caffrum*, *Protea dracomontana*, *Rhus discolor*, *Stoebe plumosa*. Graminoids: *Aristida junciformis* subsp. *galpinii*, *Cymbopogon nardus*, *Ischyrolepis schoenoides*. Herb: *Helichrysum cooperi*.

Biogeographically Important Taxa (^DDrakensberg endemic, ^{Dg}Drakensberg endemic extending to Griqualand East) Tall Shrub: *Lotononis lotononoides*^D (d). Low Shrubs: *Erica ebracteata*^D (d), *E. algida*^{Dg}, *E. dissimulans*^D, *E. frigida*^D, *Euryops tysonii*^D, *Helichrysum albirosulatum*^D.

Endemic Taxa Tall Shrubs: *Melanthus villosus*, *Polemannia montana*. Low Shrubs: *Cliffortia spathulata* (d), *Helichrysum argyrophyllum* (d), *Erica brownleeae*, *E. westii*, *Helichrysum setosum*, *H. tenax*, *H. tenuifolium*, *Macowania conferta*, *Phylca*

thodei, *Senecio haygarthii*. Herbs: *Berkheya macrocephala*, *Selago longipedicellata*.

Conservation Target 27%. Least threatened due to poor accessibility and formal protection (more than 50% of the mapped area) in conservation areas such as the uKhahlamba Drakensberg Park (KwaZulu-Natal), Tšehlanyane National Park (Lesotho), Golden Gate Highlands National Park and Qwaqwa National Park (Free State). Those patches that occur some distance away from the Drakensberg Escarpment are threatened by increased fire frequencies.

Remarks Two structurally similar, but floristically very different afromontane fynbos (or fynbos-like) shrublands can be recognised in the Drakensberg and broader surrounds. These two subunits are also differentiated in terms of altitude and the grasslands within which they are embedded. A low-altitude (and relatively species-poor) fynbos-like shrubland with *Passerina montana* is still found on edges of some high eastern Free State tafelbergs, such as Thaba 'Nchu (Roberts 1961), and Korannaberg (Du Preez 1992) as well as at the foot of Clarens sandstone cliffs in the Golden Gate Highlands National Park. *P. montana* also dominates extensive areas of Gd 8 Lesotho Highland Basalt Grassland in Lesotho (see description below). The patches in the Nkandla District are embedded within the Midlands Mistbelt Grassland and we hypothesise that they are evidence of an earlier larger extent that these 'fynbos-like' shrublands might have experienced in some wetter Plio-Pleistocene



Figure 8.17 Gd 6 Drakensberg-Amathole Afromontane Fynbos: Shrubland on Korannaberg (eastern Free State) dominated by *Passerina montana* and accompanied by species of the genera *Cliffortia*, *Metasias*, *Erica*, *Muraltia*, *Selago* and *Anthospermum*.

periods. The high-altitude fynbos is a unit with clear afromontane links (*sensu* White 1978) and is limited to Killick's (1963) 'subalpine belt'. Terms such as 'Subalpine Fynbos', 'Subalpine Heath' and '*Passerina-Philippia-Widdringtonia* Fynbos' were coined to designate this unit. Killick (1963), following the then in vogue Clementsian doctrine, considered this fynbos to be the climax of his 'subalpine belt'—an assertion which we do not share.

This vegetation unit is one of the most endemic-rich in the Drakensberg Alpine Centre of Regional Endemism (as defined by Van Wyk & Smith 2001).

Hundreds of small patches of this unique fynbos have not yet been mapped (especially in the Drakensberg and even more so in the Amathole Mountains where none have yet been mapped) due to lack of formal data. In the Amathole Mountains some sites can be regarded as azonal (afromontane) fynbos and contain, among others, *Protea subvestita*, *Erica peltata* and *Cliffortia paucistaminea* (Hoare 1997, Hoare & Bredenkamp 1999). Similar azonal fynbos, including species of *Cliffortia*, *Erica*, *Protea*, *Restio* and others may be found on the slopes of Gaika's Kop near Hogsback. Previous studies have indicated that in the absence of fire and management, mountain grasslands in this area change to a *Cliffortia-Erica*-dominated, fynbos-type vegetation (Story 1952).

References Story (1952), Acocks (1953, 1988), Roberts (1961, 1966), Killick (1963, 1978a, b, 1994), Edwards (1967), Trollope & Booysen (1971), Trollope (1973), Downing et al. (1978), Potgieter (1982), Killick (1990), Du Preez & Bredenkamp (1991), Du Preez (1992), Hill (1996), Hoare (1997), Hoare & Bredenkamp (1999), Van Wyk & Smith (2001).

Gd 7 uKhahlamba Basalt Grassland

VT 58 *Themeda-Festuca* Alpine Veld (54%) (Acocks 1953). LR 46 Alti Mountain Grassland (65%) (Low & Rebelo 1996). BRG 10 Montane Veld p.p. (Camp 1999b).

Distribution KwaZulu-Natal and to a small extent also the Free State and Eastern Cape Provinces and very slightly in Lesotho: Uppermost slopes of the Drakensberg Mountains just below the edge of the highland plateau. Altitude 1 820–3 300 m.



Figure 8.18 Gd 7 uKhahlamba Basalt Grassland: Dramatic montane landscape of basalt slopes and peaks of the northern Drakensberg supporting the northernmost occurrence of the high-altitude, species-rich basalt grassland below the Sentinel (Qwaqwa region, close to the meeting point of three political regions: KwaZulu-Natal, the Free State and the Kingdom of Lesotho).

Vegetation & Landscape Features Species-rich grasslands of varying levels of density, forming girlands (terraced tussocks) due to steepness of slopes. Comprising a series of communities dominated by *Bromus speciosus*, *Pentaschistis tysoniana*, *Cymbopogon nardus*, *Festuca caprina*, *Rendlia altera* and *Themeda triandra* that are accompanied by numerous (and in places dominant) herbs (*Agapanthus*, *Merwillia*, *Helichrysum*) and shrubs (*Erica*, *Helichrysum*, *Euryops*). Deep gullies on basalt support luxuriant tall-herb vegetation. Steep basalt rock faces and terraces (the most imposing array of cliffs in southern Africa) are the most dramatic landscape element characteristic of the uKhahlamba (The Barrier of Spears).

Geology & Soils Jurassic Basalts of the Drakensberg Group (Karoo Supergroup)—a result of prolonged volcanic activity accompanying the birth of the African continent by breaking from Gondwana. Deep nutrient-rich soils are formed on less steep slopes, while basalt outcrops usually do not carry any fine soil, except for shallow pockets of basalt rubble. Dominant land type Fa, followed by Ac and Ic.

Climate Summer rainfall, with MAP 830–1 820 mm (overall regional MAP 1 234 mm). Great temperature differences between summer (some days with temperature exceeding 30°C) and winter, characterised by occurrence of snow (does not persist for long on steep exposed slopes) and frequent frost (55 days per year). Morning summer mists are also frequent, but so are hot, dry winds from July to October. Depending on altitude and aspect, the climate characteristics vary considerably. See also climate diagram for Gd 7 uKhahlamba Basalt Grassland (Figure 8.11).

Important Taxa Graminoids: *Cymbopogon nardus* (d), *Eragrostis caesia* (d), *E. curvula* (d), *Festuca costata* (d), *Harporchloa falx* (d), *Heteropogon contortus* (d), *Merxmüllera disticha* (d), *M. stricta* (d), *Monocymbium cerasiiforme* (d), *Pentaschistis tysonii* (d), *Rendlia altera* (d), *Themeda triandra* (d), *Trachypogon spicatus* (d), *Tristachya leucothrix* (d), *Agrostis barbiger*, *Alloteropsis semialata* subsp. *eckloniana*, *Andropogon appendiculatus*, *Aristida junciformis* subsp. *galpinii*, *A. monticola*, *Brachypodium bolusii*, *Bulbostylis humilis*, *B. schoenoides*, *Carex glomerabilis*, *Cymbopogon marginatus*, *Cyperus schlechteri*, *Digitaria flaccida*, *D. ternata*, *Diheteropogon filifolius*, *Elionurus muticus*, *Eragrostis capensis*, *Festuca scabra*, *Ficinia stolonifera*, *Koeleria capensis*, *Loudetia simplex*, *Merxmüllera stereophylla*, *Panicum ecklonii*, *Pentaschistis aurea* subsp. *pilosogluma*, *P. cirrhulosa*, *P. natalensis*, *Poa binata*, *Scirpus falsus*, *Stiburus alopecuroides*, *Styppeiochloa gynoglossa*, *Tetraria cuspidata*. Herbs: *Cynium racemosum* (d), *Xerophyta viscosa* (d), *Aster bakerianus*, *Berkheya discolor*, *B. rhapontica* subsp. *rhapontica*, *Craterocapsa tarsodes*, *Cyphia elata*, *Galium capense* subsp. *capense*, *Gnaphalium griquense*, *Helichrysum adenocarpum*, *H. aureonitens*, *H. aureum* var. *monocephalum*, *H. ecklonis*, *H. hyphocephalum*, *H. nanum*, *H. rugulosum*, *H. setigerum*, *H. spiralepis*, *H. subglomeratum*, *H. umbraculigerum*, *Lobelia vanreenensis*, *Protea dracomontana*, *Psammotropha alternifolia*, *P. obovata*, *Sebaea sedoides* var. *confertiflora*, *Senecio arabisifolius*, *S. asperulus*, *Sutera neglecta*, *Wahlenbergia and-*

rosacea, *W. undulata*, *Zaluzianskya microsiphon*. Geophytic Herbs: *Agapanthus campanulatus* (d), *Brunsvigia natalensis* (d), *Corycium nigrescens* (d), *Eucomis autumnalis* subsp. *clavata* (d), *Nerine bowdenii* (d), *Albuca shawii*, *Brownleea galpinii*, *Chlorophytum acutum*, *Corycium dracomontanum*, *Dipcadi gracillimum*, *Disa fragrans* subsp. *fragrans*, *D. sankeyi*, *D. versicolor*, *Disperis oxyglossa*, *D. renibractea*, *Drimia macrocentra*, *Eriospermum ornithogaloideis*, *Eucomis bicolor*, *Gladiolus dalenii*, *G. ecklonii*, *G. longicollis* subsp. *longicollis*, *Habenaria lithophila*, *Haemanthus humilis* subsp. *hirsutus*, *Hesperantha baurii*, *Holothrix thodei*, *Huttonaea oreophila*, *Hypoxis multi-ceps*, *Kniphofia ritualis*, *K. triangularis*, *Moraea modesta*, *M. robusta*, *Neobolusia tysonii*, *Oxalis depressa*, *Pachycarpus vexillaris*, *Pterygodium cooperi*, *P. hastatum*, *Rhodohypoxis baurii* var. *baurii*, *Satyrion cristatum*, *S. longicauda*, *S. microrrhynchum*, *Schizochilus flexuosus*, *Tulbaghia leucantha*, *Watsonia gladioloides*, *W. lepida*, *Xysmalobium prunelloides*. Semiparasitic Herb: *Thesium durum*. Low Shrubs: *Helichrysum sutherlandii* (d), *Anthospermum hispidulum*, *Chrysocoma ciliata*, *Dichilus strictus*, *Erica caespitosa*, *E. glaphyra*, *E. woodii*, *Eriocephalus strictus*, *Euryops pedunculatus*, *Gnidia gymnostachya*, *Helichrysum swynnertonii*, *Pelargonium sidoides*. Succulent Shrubs: *Aloe pratensis*, *Crassula sarcocaulis*, *C. tetragona* subsp. *acutifolia*.

Biogeographically Important Taxa (^DDrakensberg endemic, ^{D9}Drakensberg endemic extending to Griqualand East) Graminoids: *Bromus speciosus*^D (d), *Carex monotropa*^D, *Helictotrichon galpinii*^D, *Pentaschistis exserta*^D, *P. galpinii*^D, *Restio galpinii*^{D9}. Herbs: *Berkheya multijuga*^D (d), *Alchemilla colura*^{D9}, *Aster ananthocladus*^D, *Berkheya pannosa*^{D9}, *Cephalaria galpiniana* subsp. *simplicior*^D, *Chironia peglerae*^D, *Cotula lineariloba*^D, *Diascia anastrepta*^D, *D. vigilis*^D, *Felicia linearis*^{D9}, *Glumicalyx flanaganii*^D, *Helichrysum albirosulatum*^D, *H. album*^D, *H. argentissimum*^{D9}, *H. aureum* var. *scopulosum*^{D9}, *H. aureum* var. *serotinum*^D, *H. basalticum*^D, *H. bellum*^D, *H. subfalcatum*^D, *Psammotropha mucronata* var. *marginata*^D, *Senecio tugelensis*^D. Geophytic Herbs: *Galtonia regalis*^D (d), *Asclepias oreophila*^D, *Cyrtanthus flanaganii*^D, *Dierama tysonii*^{D9}, *Disa cephalotes* subsp. *frigida*^D, *D. oreophila* subsp. *erecta*^D, *D. stricta*^{D9}, *D. thodei*^D, *Elaphoglossum drakensbergense*^D, *Eucomis schijffii*^D, *Gladiolus microcarpus*^D, *Hesperantha schelpeana*^D, *Huttonaea grandiflora*^D, *H. woodii*^{D9}, *Miraglossum superbum*^D, *Moraea alticola*^D, *Saniella verna* (generic link to Hantam-Roggeveld CE), *Schizochilus angustifolius*^D, *Schizoglossum montanum*^D, *Tulbaghia montana*^D. Herbaceous Climber: *Cyphia tysonii*^D. Low Shrubs: *Berkheya rosulata*^D, *Combhoriza virgata*^D, *Erica flanaganii*^D, *E. straussiana*^D, *E. thodei*^{D9}, *E. wyliei*^D, *Euryops decumbens*^D, *E. evansii* subsp. *evansii*^D, *E. montanus*^D, *Gnidia compacta*^D, *Helichrysum glaciale*^D, *H. milfordiae*^D, *H. sessilioides*^D, *H. witbergense*^D, *Passerina drakensbergensis*^D.

Endemic Taxa (^NNorthern Berg and ^SSouthern Berg only, respectively) Graminoids: *Merxmuellera aureocephala*. Herbs: *Aplanodes doidgeana*, *Berkheya draco*^N, *B. leucaugea*^N, *Diascia austromontana*, *D. purpurea*, *D. tugelensis*, *Dracosciadium saniculifolium*^N, *Geranium drakensbergensis*^S, *Gerbera parva*, *H. amplexens*^N, *H. evansii*^N, *H. heterolasium*, *H. mollifolium*, *Heliophila formosa*^S, *Hermannia malvifolia*, *Indigofera pseu-doevansii*, *Melpomene flabelliformis*, *Nemesia glabriuscula*, *Pimpinella krookii*, *Satureja compacta*, *S. grandibracteata*, *Sebaea radiata*, *Selago trauseldii*, *Senecio basalticus*^N, *S. breviorus*, *S. cristimontanus*, *S. dissimulans*, *S. maurice*^S, *S. parentalis*, *S. polelensis*^S, *S. praeteritus*, *S. qathlambanus*, *S. saniensis*^N, *S. telmateius*, *S. thamathuensis*^N, *Wahlenbergia pulvillus-gigantis*^N, *W. tetramera*^N, *Xerophyta longicaulis*, *Xysmalobium woodii*. Geophytic Herbs: *Albuca affinis*^N, *Brachystelma alpinum*^N, *Crocospia pearse*^N, *Cyrtanthus erubescens*^N, *Disa dracomontana*^N, *Drimia saniensis*^N, *Gladiolus flanaganii*, *G. symon-*

sii, *Glossostelma xysmalobioides*, *Hesperantha altimontana*^N, *H. curvula*^N, *H. pubinervia*^N, *Moraea vigilans*^N, *Rhodohypoxis incompta*^S, *R. thodiana*^S, *Schizoglossum crassipes*, *S. elingue* subsp. *elingue*, *S. elingue* subsp. *purpureum*, *S. hilliardiae*^N, *Wurmbea burtii*, *W. tenuis* subsp. *australis*. Parasitic Herb: *Harveya leucopharynx*. Low Shrubs: *Erica aestiva* var. *minor*^N, *E. caffrorum* var. *luxurians*^N, *E. flanaganii*, *Eumorphia prostrata*^S, *Euryops brevipes*, *E. evansii* subsp. *parvus*, *Gnidia renniana*, *Helichrysum confertum*^N, *H. drakensbergense*, *H. haygarthii*, *Inulathera montana*, *Lessertia stipulata*^N, *Lotononis virgata*, *Macowania deflexa*^N, *M. hamata*, *M. sororis*, *Otholobium fumeum*, *Protea nubigena*^N, *Struthiola angustiloba*^N. Succulent Shrubs: *Delosperma lavisiae*^N, *Othonna burtii*^N.

Conservation Least threatened. The target of 27% has been superseded, since 75% of the unit's surface enjoys statutory protection in the uKhahlamba Drakensberg Park (South Africa). Some patches are also protected in the Sehlabathebe National Park (Lesotho). Erosion very low (76%) and low (19%).

Remarks This unit forms the core of the Drakensberg Alpine CE (as defined by Van Wyk & Smith 2001).

References Acocks (1953, 1988), Killick (1963, 1978a, b, 1994), Edwards (1967), Jacot Guillarmod (1971), White (1978), Hilliard & Burt (1987), Killick (1990), Hill (1996), Camp (1999b), Van Wyk & Smith (2001).

Gd 8 Lesotho Highland Basalt Grassland

VT 58 *Themeda-Festuca* Alpine Veld (84%) (Acocks 1953). LR 45 Afro Mountain Grassland (55%) (Low & Rebelo 1996).

Distribution Lesotho, Eastern Cape, Free State (and partly also into southern KwaZulu-Natal): Most of the high dissected basalt plateau of Lesotho, including most of the districts of Mokhotlong, Thaba-Tseka, Qacha's Nek and Quthing and the eastern parts of Butha-Buthe, Leribe, Berea, Maseru, Mafeteng and Mohale's Hoek. Extends on the basalt from around 'Makholo (Ben Macdhui) into the Eastern Cape southwards to the vicinity of Barclay East, and westwards along the Witteberge to the vicinity of Lady Grey. Extends in a small area of the northeastern Free State on the high basalt mountains such as Ribbokkop (within the Golden Gate Highlands National Park) and on the top of Oorsprongsberg. Altitude about 1 900–2 900 m. The unit extends to KwaZulu-Natal at the lower parts of the Escarpment edge (e.g. around the Loteni and Mkhomazi Passes). The areas of Drakensberg Afroalpine Heathland (above 2 900 m) are embedded in this unit as are some Lesotho Mires (at higher altitudes). For practical reasons, the vegetation unit includes a small area of high-altitude sandstone (up to about 2 600 m) that is limited to the eastern edge of Lesotho (notably in the Sehlabathebe National Park).

Vegetation & Landscape Features Landscape consists of many plateaus and high ridges of mountains separated by often deep valleys. Although many valley slopes are steep, major cliff faces are only occasionally encountered, especially along parts of the main Maloti Mountain chain. Vegetation is closed, short grassland with many areas also with *Passerina montana*-dominated shrubland. The much smaller shrubs, such as *Chrysocoma ciliata* and *Pentzia cooperi*, are often very common also in clearly disturbed areas (especially on the warmer slopes at higher altitudes). *Chrysocoma ciliata* is the typical component of 'sehalahala scrub' (Anonymous 2000). Within the considerable altitude range in the unit there are many plant species that extend to various altitudinal levels or belts. Also in terms of dominants, for example, *Themeda triandra* tends to be more important at the lower and middle elevations and *Festuca caprina* at higher

altitudes, although there is considerable altitudinal overlap between these species. Although *Kniphofia caulescens* has a wide altitudinal distribution, its large aggregate patches (often hundreds of square metres in extent) are mostly evident in the upper half of the altitudinal range corresponding to larger sponge areas (2 500 to 2 900 m with most mass flowering displays best observed around 2 700 m within Lesotho). The medium-tall distinctive grass *Merxmuellera macowanii* occurs along water courses and drainage lines.

Geology & Soils The area is almost entirely underlain by basaltic lava flows of the Drakensberg Group, with some of the shallow soils covering sandstones of the Clarens Formation (Stormberg Group, Karoo Supergroup) in the form of disintegrating carpets. Soils derived from the basalt have fairly even proportions of coarse sand, fine sand, silt, clay and organic matter. The organic matter increases from about 20% on the slopes to about 26% in the valleys (Herbst & Roberts 1974a). The high organic content (acid, slowly decomposing humus formed largely by decaying grass roots) results in a high water-retention capacity of the soil. Water redistribution through seeps is frequent. Main land type, at least in the South African section, is Ea.

Climate Summer rainfall, with little rain in winter, particularly away from the Northern Escarpment. Much of the area is in a rainshadow with weather stations such as Mokhotlong at an elevation of 2 377 m with a MAP of only 575 mm (Tyson et al. 1976, Killick 1978a). MAP is higher along the eastern edge, for example, 928 mm at Qacha's Nek and also in the southeast, with 686 mm at Barkly East Golf Club. Mean monthly maximum and minimum temperatures for Barkly East Golf Club are 31.4°C and -10.5°C for December and July, respectively. Frost occurs throughout winter and on occasion even in summer at higher elevations. Snow occurs in winter, especially at higher elevations where some light snow can occur in summer. There is a high incidence of lightning in summer and hail is common. See also climate diagram for Gd 8 Lesotho Highland Basalt Grassland (Figure 8.11).

Important Taxa Graminoids: *Bulbostylis humilis* (d), *Cymbopogon dieterlenii* (d), *Elionurus muticus* (d), *Eragrostis curvula* (d), *Festuca caprina* (d), *Harpochloa falx* (d), *Koeleria capensis* (d), *Merxmuellera disticha* (d), *Pentaschistis oreodoxa* (d), *Poa binata* (d), *Scirpus falsus* (d), *Aristida junciformis* subsp. *galpinii*, *Carex glomerabilis*, *Cymbopogon marginatus*, *Eragrostis caesia*, *Helictotrichon turgidulum*, *Luzula africana*, *Merxmuellera drakensbergensis*, *Rendlia altera*. Herbs: *Helichrysum subglomeratum* (d), *Anthospermum herbaceum*, *Cerastium arabidis*, *Cotula hispida*, *Dimorphotheca jucunda*, *Haplocarpha scaposa*, *Helichrysum acutatum*, *H. cerastioides*, *H. setigerum*, *Senecio asperulus*, *Silene burchellii*, *Trifolium burchellianum* subsp. *burchellianum*, *Ursinia montana*, *Zaluzianskya microsiphon*. Geophytic Herbs: *Disa sankeyi*, *D. tysonii*, *Geum capense*, *Moraea modesta*, *Oxalis depressa*, *Rhodohypoxis baurii* var. *baurii*, *R. baurii* var. *confecta*, *R. baurii* var. *platypetala*, *Satyrion longicauda*. Succulent Herb: *Crassula peploides*. Semiparasitic Herb: *Thesium nigrum*. Low Shrubs: *Euphorbia striata*, *Hebenstretia dura*, *Helichrysum infaustum*, *H. odoratis-*



Figure 8.19 Gd 8 Lesotho Highland Basalt Grassland: Mass display of *Kniphofia caulescens* at an altitude of about 2 700 m on basalt at Tiffindell (Eastern Cape) in the southern Drakensberg.

simum, *H. sessile*, *H. sutherlandii*, *Pentzia cooperi*. Succulent Shrub: *Delosperma crassuloides*.

Biogeographically Important Taxa (^DDrakensberg endemic, ^{Dg}Drakensberg endemic extending to Griqualand East) Graminoids: *Ehrharta longigluma*^D, *Helictotrichon galpinii*^D, *Pentaschistis airoides* subsp. *jugorum*^D, *P. exserta*^D, *P. galpinii*^D, *Polevansia rigida*^D, *Restio galpinii*^{Dg}. Herbs: *Alchemilla colura*^{Dg}, *Alepidea pilifera*^D, *Berkheya cirsiifolia*^D, *B. multijuga*^D, *Cephalaria galpiniana* subsp. *simplicior*^D, *Diascia anastrepta*^D, *Felicia linearis*^{Dg}, *Glumicalyx flanaganii*^D, *G. lesuticus*^D (Lesotho endemic), *G. montanus*^D, *Helichrysum album*^D, *H. aureum* var. *scopulosum*^{Dg}, *H. aureum* var. *serotinum*^D, *H. basalticum*^D, *H. bellum*^D, *H. elegantissimum*^D, *H. palustre*^D, *H. subfalcatum*^D, *Heliophila alpina*^D, *Lobelia galpinii*^D, *Psammotropha mucronata* var. *marginata*^D, *Sebaea thodeana*^D, *Senecio tugelensis*^D, *Wahlenbergia polytrichifolia* subsp. *dracomontana*^D, *Zaluzianskya rubrostellata*^D. Geophytic Herbs: *Corycium alticola*^D, *Cyrtanthus flanaganii*^D, *Disa cephalotes* subsp. *frigida*^D, *D. stricta*^{Dg}, *D. thodei*^D, *Eucomis schijffii*^D, *Euryops decumbens*^D, *E. evansii* subsp. *evansii*^D, *E. tysonii*^D, *Galtonia regalis*^D, *Gladiolus microcarpus*^D, *Hesperantha schelpeana*^D, *Huttonaea grandiflora*^D, *Moraea alticola*^D, *Rhodohypoxis rubella*^D, *Schizochilus angustifolius*^D, *S. bulbinnella*^{Dg}, *Tulbaghia montana*^D. Semiparasitic Herb: *Thesium decipiens*^D. Herbaceous Climber: *Cyphia tysonii*^D. Low Shrubs: *Helichrysum sessilioides*^D (d), *Berkheya rosulata*^D, *Clutia nana*^D, *Erica algida*^{Dg}, *E. dissimulans*^D, *E. dominans*^D, *E. dracomontana*^D, *E. flanaganii*^D, *E. schlechteri*^D, *E. straussiana*^D, *Eumorphia sericea* subsp. *sericea*^D, *Felicia drakensbergensis*^D, *Gnidia compacta*^D, *G. propinqua*^D, *Helichrysum marginatum*^D, *H. trilineatum*^D, *H. witbergense*^D, *Inulanthera thodei*^D, *Passerina drakensbergensis*^D, *Relhania acerosa*^{Dg}, *R. dieterlenii*^D. Succulent Shrub: *Delosperma nubigenum*^D.

Endemic Taxa Herbs: *Argyrolobium summomontanum*, *Conium fontanum* var. *alticola*, *Cynoglossum alticola*, *Glumicalyx apiculatus*, *Helichrysum nimbicola*, *Jamesbrittenia beverlyana*, *Lessertia dykei*, *Polygala erubescens*, *Selago melliodora*, *Strobilopsis wrightii*, *Zaluzianskya oreophila*. Geophytic Herbs: *Dryopteris dracomontana*, *Gladiolus saundersii*, *Hesperantha exiliflora*, *Kniphofia hirsuta*, *Moraea alpina*, *Ornithogalum septonii*.

Parasitic Herb: *Harveya pulchra*. Low Shrubs: *Clutia alpina*, *Erica caffrorum* var. *aristula*, *E. dracomontana*, *Euryops evansii* subsp. *dendroides*, *E. inops*, *Jamesbrittenia lesutica*, *Macowania pulvinaris*. Succulent Shrubs: *Aloe polyphylla* (Lesotho endemic), *Delosperma aliwalense*, *D. clavipes*.

Conservation Least threatened. Target 27%. Only slightly more than 1% statutorily conserved in the Malekgonyane (Ongeluksnek) Wildlife Reserve, Golden Gate Highlands National Park (both South Africa) and Sehlabathebe National Park (Lesotho). This does not include the portion conserved in the lower reaches of the Bokong Nature Reserve. The planned Maloti-Drakensberg Transfrontier Park would increase the conservation status of the higher-altitude parts of this unit in the north. Almost 10% of the unit has already been transformed, mainly by cultivation, which seldom occurs above an altitude of 2 500 m (usually as narrow isolated belts of maize). This vegetation type has also been affected by the relatively recent completion of the Katse Dam on Malibamatso River and the Mohale Dam on Sengunyane River, representing the highest concrete arch dam and highest rock fill dam on the African continent, respectively. The unit is heavily utilised for grazing (under a communal system; see Tshabalala 1995) by sheep, goats, cattle and donkeys (Chakela 1999), with the most impact at lower altitudes. High-altitude grazing is limited to the warmer months of the year. The large shrub component (*Passerina montana*,

Chrysocoma ciliata etc.) is probably a consequence of high grazing pressure over many years. Even if grazing has increased the incidence of *P. montana*, it is in turn partly controlled by serving as a major source of fuel for local people. Erosion is very evident in many areas and includes dramatic streaks on some steeper slopes. *Aloe polyphylla* has a relatively high market value for collectors and has vanished from virtually all sites in the Front Range of the Maloti (Anonymous 2000).

Remark 1 Along the southern edge of this unit in the Eastern Cape, some of Bester's (1998) vegetation types occur across the basalt and the lower elevation sedimentary rocks. Only his *Euryops tysonii*-*Cotula socialis* scrub community is confined to the basalt. Within the Golden Gate Highlands National Park, at least five vegetation types have been identified as occurring exclusively on the basalt (Kay et al. 1993), although there are a number of others that straddle the basalt and sandstone. Further research will reveal whether the flora of the relatively well-collected (in the Sehlabathebe National Park) high-altitude sandstone area is, as Hilliard & Burtt (1987) assert, significantly different from that of the undercollected and often inaccessible basalt areas at the same elevation towards the interior. Hilliard & Burtt (1987) also stated that this elevated sandstone block marks the northeasterly limit of many species from the south (i.e. these species do not continue northwards on the high-altitude basalt substrate). Morris et al. (1993) suggest partitioning this unit into an upper subalpine belt (approximately at 2 900–2 290 m) and a montane belt below 2 290 m. Herbst & Roberts (1974a, b), who included about 30% of the altitude range of their study area in the Drakensberg 'Afro-Alpine Heathland' and the rest in the Lesotho Highland Basalt Grassland, pointed to a very different species composition between these areas and equivalent elevation areas in uKhahlamba Basalt Grassland.

Remark 2 This unit constitutes the major part (in terms of area) of the Drakensberg Alpine Centre of Endemism (Van Wyk & Smith 2001). The Sehlabathebe area has a remarkably high bulbous component such as orchids, which require high soil moisture over prolonged periods of time. The dominant shrub of the slopes of the Western Lesotho Basalt Shrubland (*Leucosidea sericea*) seems, curiously, to be largely absent from even the lower slopes of this unit.

References Herbst & Roberts (1974a, b), Killick (1978a, b), Potgieter (1982), Wieland (1982), Martin (1986), Hilliard & Burtt (1987), Backéus (1988), Morris (1990), Mokuku (1991), Kay et al. (1993), Morris et al. (1993), Morris (1994), Bester (1998), Willis et al. (1999), Anonymous (2000), Wyk & Smith (2001), Kobisi (2005).

Gd 9 Western Lesotho Basalt Shrubland

VT 58 *Themeda-Festuca* Alpine Veld (49%), VT 48 *Cymbopogon-Themeda* Veld (sandy) (43%) (Acocks 1953). LR 45 Afro Mountain Grassland (87%) (Low & Rebelo 1996).

Distribution Lesotho: Almost all confined to the Maseru and Mafeteng Districts. Relatively limited area on lower-altitude basalt along the southwestern end of the Front Range from around Bushman's Pass in the north to around Matelile/Malealea in the south and including the lower basalt slopes of the broad Makhaleng River Valley, including the Ramabanta area. Altitude 1 680–2 400 m, mostly 1 780–1 820 m.

Vegetation & Landscape Features Gentle to sometimes steep lower mountain slopes of basalt supporting medium-tall extensive shrublands alternating in places with patches of grassland. Overwhelmingly dominated by a shrubby form of *Leucosidea sericea*, whose dominance is not limited to drainage lines.



Figure 8.20 Gd 8 Lesotho Highland Basalt Grassland on the slopes of the Malibamatso River valley immediately below Katse Dam in northern Lesotho.

L.W. Powrie

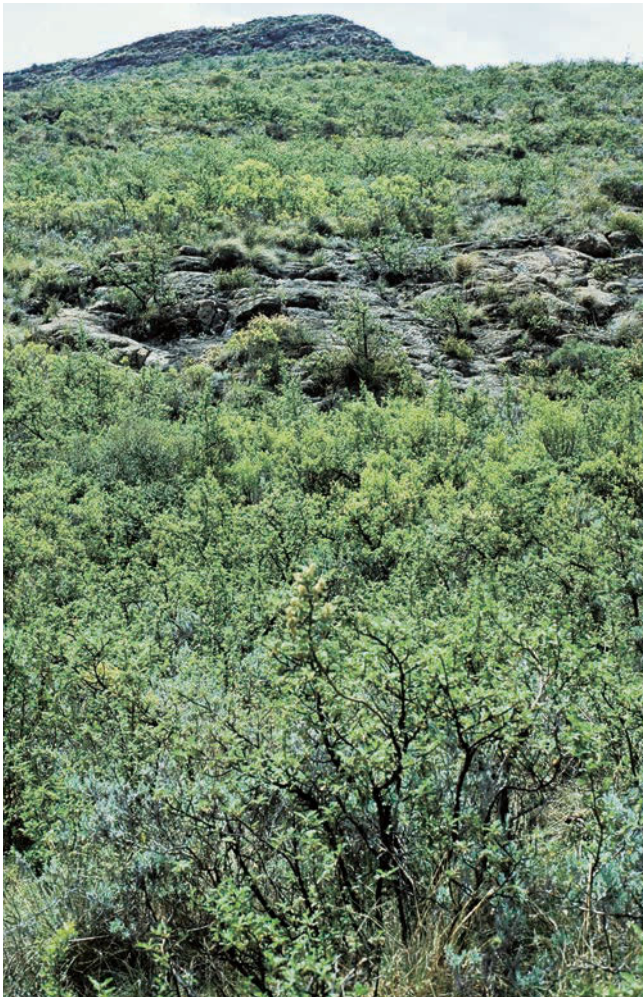


Figure 8.21 Gd 9 Western Lesotho Basalt Shrubland: Dense shrubland dominated by *Leucosidea sericea*, with some *Rhus pyroides* at an altitude of 2 025 m northwest of Ha Ramabanta, Lesotho.

Geology & Soils The Jurassic basalts of the Drakensberg Group (Karoo Supergroup) dominate this area. Soils are shallow to sometimes deep, with a significantly high organic content.

Climate Summer rainfall, with very little rain in winter. MAT is the highest of the four main grassland types on basalt. Snow is of limited duration in winter. See also climate diagram for Gd 9 Western Lesotho Basalt Shrubland (Figure 8.11).

Important Taxa Tall Shrubs: *Leucosidea sericea* (d), *Buddleja loricata*, *Rhamnus prinoides*, *Rhus pyroides*. Low Shrubs: *Chrysocoma ciliata* (d), *Felicia muricata*, *Hebenstretia dura*, *Helichrysum splendidum*, *Jamesbrittenia stricta*, *Rhus divaricata*. Graminoids: *Digitaria eriantha* (d), *Eleocharis dregeana*, *Festuca caprina*, *Hyparrhenia hirta*, *Merxmuellera stereophylla*, *Pennisetum thunbergii*. Herbs: *Ajuga ophrydis*, *Conium chaerophylloides*, *Cysticapnos pruinosa*, *Felicia petiolata*, *Galium capense* subsp. *garipense*, *Geranium magniflorum*, *G. robustum*, *Helichrysum aureum* var. *monocephalum*, *Ipomoea oblongata*, *Manulea crassifolia* subsp. *crassifolia*, *Myosotis afropalustris*, *Pimpinella caffra*, *Polygala gracilentia*, *P. rhinostigma*, *Rumex lanceolatus*, *Salvia repens* var. *repens*, *Sebaea repens*, *Senecio glaberrimus*, *Stachys dregeana*. Geophytic Herbs: *Bulbine frutescens*, *Corycium dracomontanum*, *Dierama robustum*, *Dipcadi viride*, *Gladiolus permeabilis* subsp. *edulis*, *Kniphofia ritualis*.

Biogeographically Important Taxa (both Drakensberg endemics) Herbs: *Alepidea pilifera*, *Diascia integerrima*.

Conservation Least threatened. Target 28%. None conserved in statutory conservation areas. About 16% already transformed, mainly by cultivation. Being close to major concentrations of human settlements in the lowlands, it has probably been subjected to prolonged grazing pressure. Although erosion is high in places, it appears far less eroded than the surrounding lowlands. Although a number of alien plants are concentrated around settlements, they do not appear to have had a major impact on the vegetation yet. *Aloe polyphylla* has a relatively high market value for collectors and has vanished from virtually all sites in the Front Range of the Maloti (Anonymous 2000).

Remarks This unit approximates the southern part of what has been regarded as the Foothills Ecological Zone (Anonymous 2000), although this zone often includes the sandstone belt below the basalt. Very little is known about this unit and future research should attempt to determine to what extent it may be a derived type. Of interest is that some of the typical species (*Leucosidea sericea*, *Rhamnus pyroides*, *Buddleja saligna*) are indicative of forest precursors (C.J. Geldenhuys, personal communication). *L. sericea* tends to invade formerly disturbed (overgrazed) wet grasslands. It is not only the case in Lesotho, but also in the bordering regions where, for instance, Eastern Free State Wet Grassland and Drakensberg Montane meet (Qwaqwa and Golden Gate Highlands National Parks, Van Rheenen's Pass near Harrismith).

References Anonymous (2000), Kobisi (2005).

Gd 10 Drakensberg Afroalpine Heathland

VT 58 *Themeda-Festuca Alpine Veld* (99%) (Acocks 1953). LR 46 *Alti Mountain Grassland* (81%) (Low & Rebelo 1996).

Distribution Lesotho and very marginally also in KwaZulu-Natal Province: The highest plateaus and mountain ridges above an altitude of about 2 900 m in northeastern Lesotho. This includes the highest mountain in southern Africa (Thabana-Ntlenyana, 3 482 m). Further away from the edge of the Drakensberg Escarpment it is particularly extensive in the area of the Tlaeen Pass and Pass of Guns (between Mokhotlong and Oxbow) with good examples visible on the Kotisephola Pass (between Sani Pass top and Mokhotlong), Mafika-Lisiu Pass (between Lejone and Pitseng) and Matebeng Pass (between Sehlabathebe and Sehonghong). Altitude range 2 900–3 400 m, mainly 2 980–3 110 m.

Vegetation & Landscape Features Rolling plateaus with steep slopes in places. Very variable but short vegetation from shrub-dominated areas, for example by *Helichrysum trilineatum*, to grassland with shrubs, to grassland with few shrubs. The most dominant grass is *Merxmuellera disticha* (Herbst 1971, Herbst & Roberts 1974b, Morris et al. 1993). Cushion plants (e.g. *H. sessilioides*) and plants forming low mats (e.g. *H. praecurrens*) are common. As elsewhere in the highlands of Lesotho, *Chrysocoma ciliata* is common in disturbed areas and even in some apparently little disturbed areas. Many Lesotho Mires are embedded in this unit. The medium-tall grass *M. drakensbergensis* extends well away from watercourses and drainage lines.

Geology & Soils The area occurs entirely on basalt of the Drakensberg Group (Karoo Supergroup). Soils are Mollisols indicating an Udic moisture regime and frigid temperature regime. Frost action is important in alpine soil formation (Mokuku 1991). The freezing and thawing of the soil heaves the soil material, resulting in gradual removal of finer soil particles downslope, mainly from the existing micro-erosion terraces. Soils derived



C.R. Scott-Shaw

Figure 8.22 Gd 10 Drakensberg Afroalpine Heathland: Moist heathland dominated by *Erica dominans* and *E. glaphyra* on the summit of the Eastern Butress, Amphitheatre area, with the steep cliffs of the uKhahlamba Basalt Grassland (Gd 7) in the background.

from the basalt have fairly even proportions of coarse sand, fine sand, silt, clay and, importantly, organic matter (around 20%). In many areas the soil is shallow, with surface rock, including some areas with mostly rock rubble, for example on Thabana Ntlenyana (Killick 1990).

Climate Summer rainfall, but subject to some precipitation from cold fronts in winter. MAP has a considerable range, with 1 609 mm at the top of the Organ Pipes Pass on the Escarpment at 2 927 m elevation, and only 634 mm at a point 365 m higher at 3 292 m, but between 15 and 20 km away from the Escarpment edge (Killick 1979). There is thus a rapid decline in MAP from near (2–3 km) the edge of the Escarpment (but further in the Oxbow area) to the interior even at higher elevations (Bawden & Carrol 1968, Chakela 1999). The mean annual temperature of about 4.0°C is lower than that of any of the other vegetation units. Frost occurs probably more than half the year, including occasionally in summer. Letseng-la-Terae, at an altitude of 3 000 m, holds the record for the lowest temperature ever recorded in Lesotho (–20.4°C in June 1967). See also climate diagram for Gd 10 Drakensberg Afroalpine Heathland (Figure 8.11).

Important Taxa Low Shrubs: *Chrysocoma ciliata* (d), *Anisodontea julii* subsp. *pannosa*, *Erica glaphyra*, *Pentzia cooperi*, *Selago flanaganii*, *Syncolostemon macranthus*. Graminoids: *Merxmuellera drakensbergensis* (d), *Pentaschistis aurea* subsp. *pilosogluma*.

Biogeographically Important Taxa (^DDrakensberg endemic, ^{Dg}Drakensberg endemic extending to Griqualand East) Low Shrubs: *Erica dominans*^D (d), *Eumorphia sericea* subsp. *sericea*^D (d), *Helichrysum trilineatum*^D (d), *Clutia nana*^D, *Erica frigida*^D, *E. thodei*^{Dg}, *Euryops decumbens*^D, *E. montanus*^D, *Felicia drakensbergensis*^D, *Gnidia propinqua*^D, *Helichrysum milfordiae*^D, *H. witbergense*^D, *Inulathera thodei*^D. Succulent Shrub: *Delosperma nubigenum*^D. Herbs: *Cotula lineariloba*^D, *Felicia uliginosa*^D, *Glumicalyx lesuticus*^D (Lesotho endemic), *Helichrysum basalticum*^D, *H. bellum*^D, *H. palustre*^D, *Heliophila alpina*^D, *Lobelia galpinii*^D, *Sebaea thodeana*^D. Geophytic Herbs: *Romulea luteoflora* var. *sanisensis* (specific link to Hantam-Roggeveld CE),

Saniella verna^D (generic link to Hantam-Roggeveld CE). Graminoid: *Ehrharta longigluma*^D.

Endemic Taxa Low Shrubs: *Euryops acraeus*, *Helichrysum pagophilum*, *Muraltia flanaganii*. Herbs: *Aster erucifolius*, *Cotula radicalis*, *Helichrysum lineatum*, *H. praecurrens*, *Jamesbrittenia jurassica*, *Manulea platystigma*, *Psammotropha obtusa*, *Zaluzianskya chrysops*, *Z. turritella*. Geophytic Herbs: *Disa basutorum*, *Hesperantha alborosea*, *H. altimontana*, *Wurmbea pusilla*.

Conservation Least threatened. Target 27%. About 2% statutorily conserved in the uKhahlamba Drakensberg Park as well as in the upper parts of the Bokong Nature Reserve. The planned Maloti-Drakensberg Transfrontier Park could conserve almost all the area of this unit. Very little has been transformed, but grazing pressure in summer is high. Already in 1938, Staples & Hudson referred to a considerable increase in *Helichrysum trilineatum*, *Passerina montana* and an *Erica* species and a *Pentzia* species 'in

places above 9500 feet' (2 896 m). Although the increase in *H. trilineatum* may be promoted by its poor palatability to stock, it may be partly counteracted by its use 'as fuel, the branches burning readily when green' (Hilliard 1983).

Remarks The *Erica*–*Helichrysum*–*Eumorphia* sedge heath of Jacot Guillarmod (1971), although occasionally found on cold wet slopes below the 2 900 m, is 'the climax community over most of the area only above 2 900 metres'. Morris et al. (1993) supported the notion of general altitudinal limit of 2 900 m for this unit, but also suggested that it extends to somewhat lower altitudes on southern slopes. This unit also comprises the *Merxmuellera drakensbergensis*–*Festuca caprina* high-altitude Austro-afro Alpine grassland of Du Preez & Bredenkamp (1991). The often common *Themeda triandra* in the eastern grasslands of southern Africa is rare in this unit. Families rich in geophytes (Iridaceae, Hyacinthaceae, Orchidaceae) appear to lose significance with increasing altitude (Herbst & Roberts 1974b), yet orchids are prominent along the Escarpment edge (Killick 1990). The strong diminishing precipitation gradient from the Escarpment edge inland probably helps explain the apparent contradictions between especially earlier accounts of the flora and vegetation based on studies on the edge of the Escarpment and what is observed further into Lesotho. It could be argued that the narrow strip on top of the Escarpment would be better grouped (as a subtype) with the uKhahlamba Basalt Grassland.

References Killick (1963, 1978a, b, 1990), Edwards (1967), Jacot Guillarmod (1971), Herbst & Roberts (1974b), White (1978), Hilliard & Burt (1987), Du Preez & Bredenkamp (1991), Morris et al. (1993), Hill (1996), Van Wyk & Smith (2001), Kobisi (2005).

Dry Highveld Grassland

Highveld grasslands are found on the extensive central plateau of South Africa. The topography is flat to undulating, occasionally broken by small mountains, typically found in the Free State, or incised river valleys, such as the Orange, Vaal and Olifants Rivers. The major environmental factor controlling vegetation patterns and the recognition of different vegetation types is

annual rainfall, which forms an east to west gradient of decreasing moisture across the Highveld.

Dry Highveld Grassland prevails in the western regions of the Grassland Biome where annual rainfall is below 600 mm per annum (Figure 8.23). These grasslands therefore fall into the 'sweet' grassland type with a predominance of chloridoid grasses. These areas are found mostly within the Free State, North-West and Eastern Cape Provinces in a north-south band. The grassland types are mostly plains grasslands distinguished primarily on substrate characteristics, but also include the topographically complex, steep mountain grasslands of the Karoo Escarpment. Also included within Dry Highveld Grassland are a number of intrazonal units containing shrubland on koppies or woodland on other substrates (Figure 8.24). These shrublands form a distinctive structural vegetation type within the matrix of grasslands and are restricted to rocky slopes and outcrops where the surface rockiness is high and where soils are mostly shallow and stony.

Gh 1 Karoo Escarpment Grassland

VT 60 Karrooid *Danthonia* Mountain Veld (69%) (Acocks 1953). LR 44 South-eastern Mountain Grassland (69%) (Low & Rebelo 1996).

Distribution Eastern, Northern and Western Cape Province: Occurs on the Karoo Escarpment, running in an east-west direction from Molteno to Noupoort in the north, and from Somerset East in a northwesterly direction towards Nieu-Bethesda. Also found on the north-facing slopes of the Winterberg Mountains around Tarkastad. The westernmost locality is on the highest-altitude flat-topped mesas of the Escarpment in the Karoo National Park near Beaufort West. Altitude about 1 100–2 502 m at the summit of the Kompasberg.

Vegetation & Landscape Features Mountain summits, low mountains and hills with wiry, tussock grasslands, usually dominated by *Merxmüllera disticha*. Other common species include the grasses typical of dry grasslands (genera *Eragrostis*,

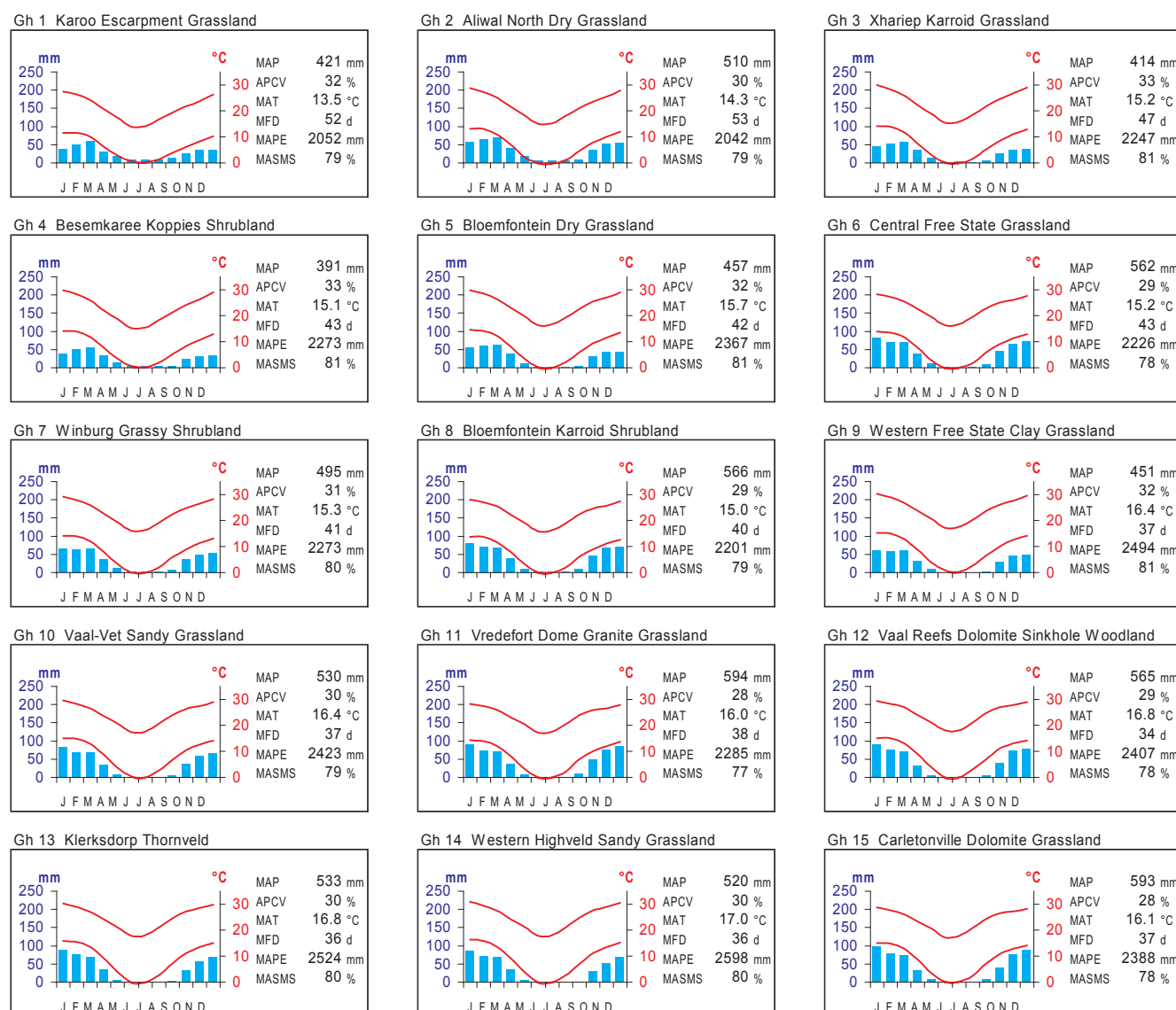


Figure 8.23 Climate diagrams of the Dry Highveld Grassland Bioregion units. Blue bars show the median monthly precipitation. The upper and lower red lines show the mean daily maximum and minimum temperature respectively. MAP: Mean Annual Precipitation; APCV: Annual Precipitation Coefficient of Variation; MAT: Mean Annual Temperature; MFD: Mean Frost Days (days when screen temperature was below 0°C); MAPE: Mean Annual Potential Evaporation; MASMS: Mean Annual Soil Moisture Stress (% of days when evaporative demand was more than double the soil moisture supply).

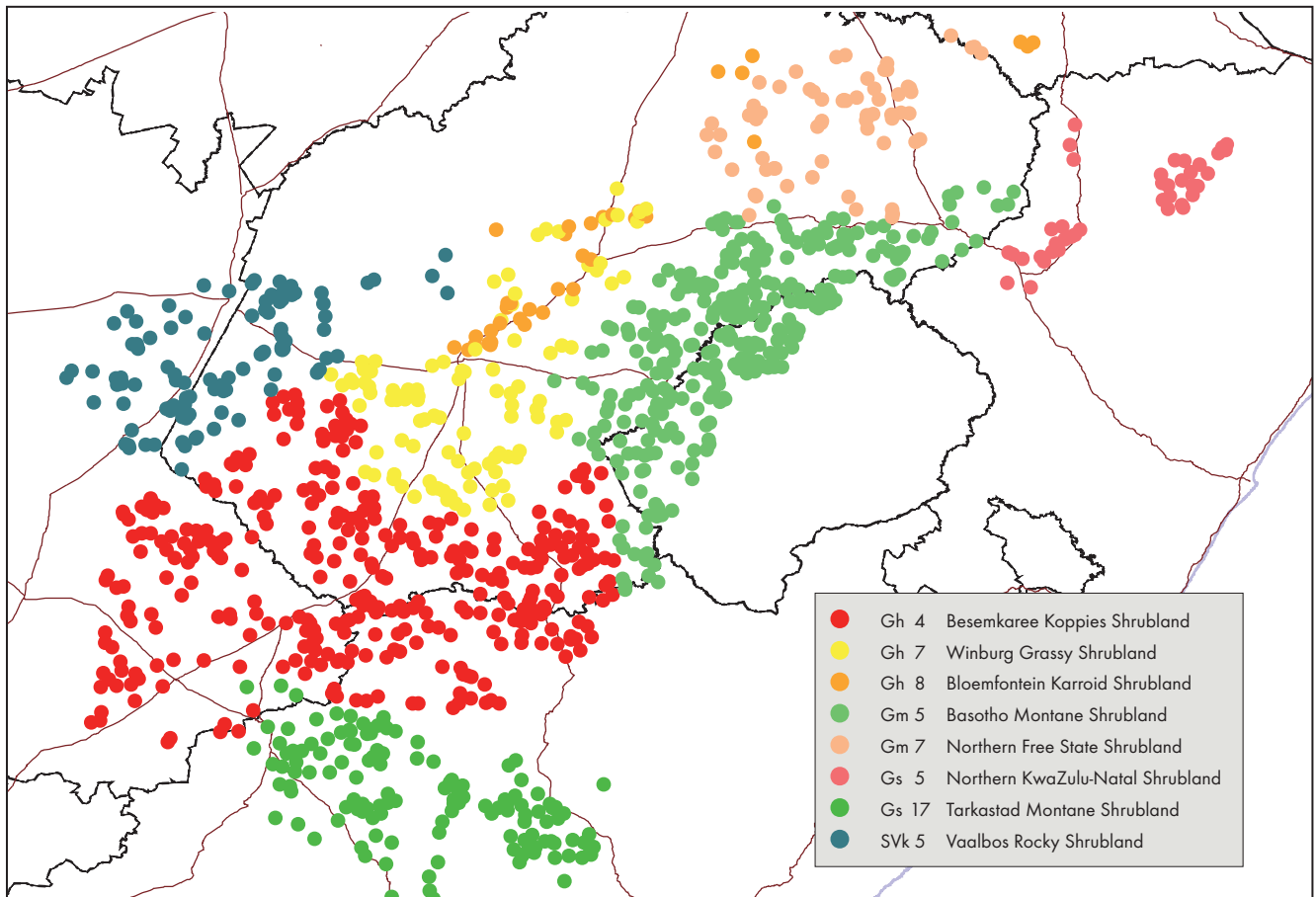


Figure 8.24 Simplified map of patches of various shrubland units (see the legend) occupying special geological and topographical situations within the Grassland Biome.

Tetrachne, *Karoochloa*, *Helictotrichon*, *Melica*, *Tragus*, *Elionurus* and *Aristida*). An important low shrub component occurs throughout this grassland unit.

Geology & Soils Shallow soils typical of Ib, Fb and Fc land types on mudstones and sandstones of the Beaufort Group (Karoo Supergroup). Jurassic dolerite intrusions form ridges in the area.

Climate Rainfall showing minor (possibly insignificant) peaks in March and November–December. Very dry winters. MAP 300–580 mm, increasing from west to east as well as with increasing elevation. The coefficient of variation of MAP 27–36% across the unit. The incidence of frost is from less than 20 to more than 100 days, the higher values occurring at higher elevation. There may be a number of days of snow per year, especially at higher elevations and near the edge of the Great Escarpment. See also climate diagram for Gh 1 Karoo Escarpment Grassland (Figure 8.23).

Important Taxa Graminoids: *Aristida congesta* (d), *A. diffusa* (d), *Cynodon incompletus* (d), *Ehrharta calycina* (d), *Eragrostis chloromelas* (d), *Heteropogon contortus* (d), *Merxmuellera disticha* (d), *Themeda triandra* (d), *Tragus koelerioides* (d), *Cymbopogon pospischilii*, *Cynodon dactylon*, *Elionurus muticus*, *Eragrostis curvula*, *E. lehmanniana*, *E. obtusa*, *Eustachys paspaloides*, *Karoochloa purpurea*, *Melica decumbens*, *Panicum stapfianum*, *Tetrachne dregei*. Herbs: *Berkheya pinnatifida*, *Convolvulus sagittatus*, *Dianthus caespitosus* subsp. *caespitosus*, *Diascia capsularis*, *Dimorphotheca zeyheri*, *Galium capense* subsp. *capense*, *Gazania krebsiana* subsp. *krebsiana*, *Hebenstretia dentata*, *Helichrysum nudifolium* var. *nudifo-*

lium, *H. tysonii*, *Lasiospermum bipinnatum*, *Lepidium africanum* subsp. *africanum*, *Rumex lanceolatus*, *Senecio asperulus*. Geophytic Herbs: *Boophone disticha*, *Cheilanthes bergiana*, *C. hirta*, *Eucomis autumnalis* subsp. *autumnalis*, *Haemanthus humilis* subsp. *humilis*, *Oxalis depressa*. Succulent Herb: *Tripteris aghillana* var. *integrifolia*. Low Shrubs: *Chrysocoma ciliata* (d), *Felicia muricata* (d), *Anthospermum rigidum* subsp. *pumilum*, *Atriplex semibaccata* var. *appendiculata*, *Elytropappus rhinocerotis*, *Erica caespitosa*, *E. cafferorum* var. *cafferorum*, *E. woodii*, *Eriocephalus eximius*, *Euryops annae*, *E. anthemoides* subsp. *astrotrichus*, *E. candollei*, *E. floribundus*, *E. oligoglossus* subsp. *oligoglossus*, *Felicia filifolia* subsp. *filifolia*, *Helichrysum asperum* var. *albidulum*, *H. dregeanum*, *H. lucilioides*, *H. niveum*, *H. rosum*, *H. zeyheri*, *Indigofera sessilifolia*, *Limeum aethiopicum*, *Nemesia fruticans*, *Passerina montana*, *Selago albida*, *S. saxatilis*, *Senecio burchellii*, *Sutera pinnatifida*, *Wahlenbergia albens*. Succulent Shrubs: *Euphorbia clavarioides* var. *clavarioides*, *E. mauritanica*. Tall Shrubs: *Cliffortia arborea*, *Diospyros austro-africana*, *Rhus lucida*.

Biogeographically Important Taxa (C)Camdeboo endemic, (P)Link to Drakensberg Alpine CE Graminoids: *Pentaschistis cirrhulosa*^P, *P. microphylla*^P. Low Shrubs: *Helichrysum sessile*^P, *Pentzia cooperi*^P. Succulent Shrub: *Delosperma congestum*^P. Succulent Herb: *Duvalia modesta*^C.

Endemic Taxa Graminoid: *Schoenoxiphium rufum* var. *dregeanum*. Herbs: *Lithospermum diversifolium*, *Wahlenbergia sphaerica*. Geophytic Herbs: *Kniphofia acraea*, *Syringodea pulchella*. Low Shrubs: *Euryops dentatus*, *E. trilobus*, *Helichrysum scitulum*, *Selago bolusii*. Succulent Shrub: *Delosperma gramineum*.



R. Clark

Figure 8.25 Gh 1 Karoo Escarpment Grassland: Dry grassland with *Merxmüllera stricta* in the Sneeu Berg (a view towards the summit reaching 2 100 m) in the Graaff-Reinet area (Eastern Cape), with shrubby species such as *Rhus dregeana*, *Melolobium microphyllum* and *M. candicans* scattered on the slopes.

Conservation Least threatened. Target 24%. Nearly 3% statutorily conserved in the Mountain Zebra and Karoo National Parks as well as in the Tsolwana and Karoo Nature Reserves. Slightly higher portions also protected in game farms and private nature reserves, such as Buchanon, Asanta Sana, Samara, Karoo Safaris, Hoeksfontien, Glen Harry, Oudekraal and Rupert. Erosion moderate (49%) and high (42%).

Remark 1 This unit occurs across a wide geographical area with associated floristic variability. The biome classification of this unit is controversial since both Karoo and Grassland elements are strongly represented in the species composition. However, the presence of many (and dominant) C_3 grasses surrounded by vegetation containing C_4 grasses as well as the remarkable share of fynbos-related elements (*Elytropappus rhinocerotis*, *Erica caffra*, *Cliffortia ramosissima*, *Ursinia montana*, *Pentzia cooperi*, *Euryops* species, *Passerina montana*, *Cliffortia arborea* and also a new species of *Erica*—E.G.H. Oliver, personal communication) supports the decision to classify this vegetation within the Grassland Biome (see also Acocks 1988, Low & Rebelo 1996).

Remark 2 The mountain ranges with this arid type of grassland are one of the centres of diversification of the genus *Euryops* (Nordenstam 1968).

References Acocks (1953, 1988), Van der Walt (1980), Palmer (1991a, b), Low & Rebelo (1996), Rubin & Palmer (1996), Hoare (1997), Hoare & Breidenkamp (2001), Brown & Bezuidenhout (2005).

Gh 2 Aliwal North Dry Grassland

VT 50 Dry *Cymbopogon–Themeda* Veld (47%), VT 49 Transitional *Cymbopogon–Themeda* Veld, (33%) (Acocks 1953). LR 37 Dry Sandy Highveld Grassland (69%) (Low & Rebelo 1996).

Distribution Eastern Cape and Free State Provinces: In the broad surrounds of Aliwal North, running in an east-west direction along the northern foothills of the Stormberg Plateau, extending northwards up the Caledon River Valley in the

Free State to around Wepener and De Wetsdorp. Altitude 1 320–1 660 m.

Vegetation & Landscape Features

Broken terrain and irregular plains supporting open grassland with patches of dwarf karroid shrubs (similar to Gh 3 Xhariep Karroid Grassland). The dominance of grasses *Themeda triandra* and *Tetrachne dregei* is notable. In years of low precipitation the dwarf karroid shrubs become more visible, especially during the winter months and early spring.

Geology & Soils Alternating layers of mudstone and sandstone of the Tarkastad Subgroup (Beaufort Group, Karoo Supergroup) dominate the undulating topography. In areas protected from erosion, a sandy layer also covers the clayey subsoils. About two thirds of the soils of the area is dominated by soils with diagnostic pedocutanic and prisma-cutanic (dark clayey) B-horizons of the Db land type. In this land type the dominant soil forms are Estcourt, Rensburg and Oakleaf forms. Dominant land type Db, followed by Da.

Climate Overall MAP 510 mm, reaching 600 mm in Wepener (northeastern region of the unit), falling predominantly during summer. MAT around 14°C, with more than 50 days of frost. See also climate diagram for Gh 2 Aliwal North Dry Grassland (Figure 8.23).

Important Taxa Graminoids: *Aristida adscensionis* (d), *A. congesta* (d), *Cymbopogon pospischilii* (d), *Cynodon incompletus* (d), *Elionurus muticus* (d), *Eragrostis chloromelas* (d), *E. lehmanniana* (d), *E. obtusa* (d), *Heteropogon contortus* (d), *Microchloa caffra* (d), *M. kunthii* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Tragus koelerioides* (d), *Aristida diffusa*, *Cynodon dactylon*, *Cyperus usitatus*, *Digitaria eriantha*, *Eragrostis capensis*, *E. curvula*, *E. plana*, *Helictotrichon turgidulum*, *Sporobolus fimbriatus*, *Tetrachne dregei*, *Trichoneura grandiglumis*, *Triraphis andropogonoides*. Herbs: *Berkheya onopordifolia* var. *onopordifolia*, *Galium capense* subsp. *capense*, *Gazania krebsiana* subsp. *krebsiana*, *Helichrysum rugulosum*, *Hermannia coccocarpa*, *Indigofera alternans*, *Jamesbrittenia aurantiaca*, *Lotononis listii*, *Nolletia ciliaris*, *Pseudognaphalium luteo-album*, *Salvia stenophylla*, *Selago densiflora*, *Trichogyne verticillata*. Geophytic Herb: *Oxalis depressa*. Low Shrubs: *Helichrysum dregeanum* (d), *Pentzia globosa* (d), *Anthospermum rigidum* subsp. *pumilum*, *Atriplex semibaccata* var. *appendiculata*, *Berkheya annectens*, *Chrysocoma ciliata*, *Euryops annae*, *E. oligoglossus* subsp. *oligoglossus*, *Felicia muricata*, *Helichrysum niveum*, *H. rosum*, *Nenax microphylla*, *Selago saxatilis*, *Senecio burchellii*.

Conservation Least threatened. Target 24%. Only small patch statutorily conserved in the Caledon Nature Reserve. Some 12% already transformed for cultivation and building of dams (Rolandseck, Smithfield, Welbedacht). This grassland is also prone to karoo-bush encroachment when overgrazed. Erosion moderate (43%), low (34%) and high (22%).

Remarks This vegetation unit is interspersed with rock outcrops capped with dolerite upon which Gh 4 Besemkaree Koppies Shrubland is found. It also borders on the Orange River, along which a riverine shrubland/thicket is found and forms the transition between high-altitude grassland vegetation and low-altitude karroid shrublands.

References Acocks (1953, 1988), Werger (1973a, b, 1980), Du Preez & Bredenkamp (1991), Malan (1993, 1998), Hoare (1997), Hoare & Bredenkamp (2001).

Gh 3 Xhariep Karroid Grassland

VT 36 False Upper Karoo (90%) (Acocks 1953). LR 52 Eastern Mixed Nama Karoo (90%) (Low & Rebelo 1996).

Distribution Free State Province and very slightly into the Northern Cape Province: Southern regions including the vicinity of Luckhoff (west), Edenburg (north), Gariep Dam (south) and Smithfield (east). Altitude 1 260–1 560 m.

Vegetation & Landscape Features Extensive, even or slightly undulating bottomland flats forming a matrix of large landscape patches interrupted by high dolerite sills, koppies and conspicuous ring dykes (bearing Gh 4 Besemkaree Koppies Shrubland) and supporting low- to medium-height, open grassland intermingled with small patches of dwarf karroid shrubs. The grass element becomes more visible, especially in summer, particularly in years of high precipitation. The open grassland intermingled with patches of dwarf karroid shrubs resembles the physiognomy of the Gh 2 Aliwal North Dry Grassland, although many of the species show a greater affinity for the slightly lower rainfall than in the latter grassland unit. Low cover of grasses such as *Themeda triandra*, *Cymbopogon pospischilii* and *Digitaria eriantha* is indicative of the relatively low rainfall. In years of low precipitation, dwarf karroid shrubs become more prominent and barren patches of soil become more visible, especially during the winter months and early spring.

Geology & Soils Alternating layers of mudstone and sandstone mostly of the Permian Adelaide Subgroup (Beaufort Group, Karoo Supergroup). Part of the area is covered with soils with diagnostic pedocutanic and prisma-cutanic (dark clayey) B-horizons and belongs to soil forms such as Estcourt, Rensburg and Oakleaf. In some areas, especially towards the more arid west, patches of calcrete on the soil surface are notable—here the soil forms such as Kimberley and Plooyburg prevail (dwarf karroid shrubs usually concentrate on these areas of limestone-rich patches). The entire area has been classified as Da or Db land types.

Climate Seasonal climatic region, with summer rainfall peaking in early autumn, and with overall relatively low MAP (slightly above 410 mm). Some of the localities can, however, reach mean yearly rainfall values as high as 580 mm (Edenburg). MAT around 15°C, but winter frost very common (around 50 days on average). See also climate diagram for Gh 3 Xhariep Karroid Grassland (Figure 8.23).

Important Taxa Graminoids: *Aristida adscensionis* (d), *A. canescens* (d), *A. congesta* (d), *Chloris virgata* (d), *Cynodon incompletus* (d), *Eragrostis chloromelas* (d), *E. lehmanniana* (d), *E. obtusa* (d), *Fingerhuthia africana* (d), *Panicum coloratum* (d), *P. stapfianum* (d), *Themeda triandra* (d), *Tragus koelerioides* (d), *Aristida diffusa*, *Cymbopogon pospischilii*, *Digitaria eriantha*, *Eragrostis curvula*, *Sporobolus fimbriatus*. Herbs: *Gazania krebsiana* subsp. *krebsiana* (d), *Convolvulus boedeckerianus*, *Dimorphotheca zeyheri*, *Hermannia coccocarpa*, *Indigofera alternans*, *Lepidium africanum* subsp. *africanum*, *Lessertia pauciflora*, *Rumex lanceolatus*, *Salvia stenophylla*, *Selago densiflora*. Geophytic Herbs: *Moraea pallida* (d), *Oxalis depressa*. Succulent Herb: *Tripteris aghillana* var. *integrifolia*. Low Shrubs: *Chrysocoma ciliata* (d), *Eriocephalus ericoides* (d), *E. spinescens* (d), *Felicia filifolia* subsp. *filifolia* (d), *F. muricata* (d), *Pentzia globosa* (d), *P. incana* (d), *Amphiglossa triflora*, *Aptosimum elongatum*, *Atriplex semibaccata* var. *appendiculata*, *Berkheya annectens*, *Gnidia polyccephala*, *Helichrysum asperum* var. *albidulum*, *H. dregeanum*, *H. lucilioides*, *Lycium cinereum*, *Melolobium candicans*, *Nenax microphylla*, *Oligomeris dregeana*, *Osteospermum spinescens*, *Rosenia humilis*, *Selago saxatilis*, *Wahlenbergia albens*, *W. nodosa*. Succulent Shrubs: *Euphorbia clavarioides* var. *clavarioides*, *Hertia pallens*, *Ruschia hamata*, *R. rigida*, *Salsola calluna*, *S. glabrescens*. Tall Shrub: *Rhus ciliata*.

Endemic Taxa Herb: *Manulea flanaganii*. Succulent Shrubs: *Phyllobolus rabiei*, *Ruschia calcarea*.

Conservation Least threatened. Target 24%. About 2.5% statutorily conserved in Gariep Dam, Tussen Die Riviere, Kalkfontein Dam, Oviston, Wurasdam and Rolfontein Nature Reserves. Some 4% already transformed by cultivation and dam-building (Bethulie, Gariep, Kalkfontein, Straussfontein and Tierpoort Dams). This dry grassland is prone to encroachment of low, unpalatable karroid shrubs when exposed to heavy grazing. Erosion moderate (71%) and low (19%).

Remarks Xhariep Karroid Grassland occupies a central position along a rainfall gradient between Gh 5 Bloemfontein Dry Grassland (to the north) and dwarf karroid shrub-dominated NKu 4 Eastern Upper Karoo (to the south). Most of the unit was viewed by Acocks (1953) as a karoo type of vegetation that had originally been grassland.

References Acocks (1953, 1988), Werger (1973a, b, 1980), Du Preez & Bredenkamp (1991), Malan (1993, 1998), Malan et al. (1994).

Gh 4 Besemkaree Koppies Shrubland

VT 36 False Upper Karoo (79%) (Acocks 1953). LR 52 Eastern Mixed Nama Karoo (76%) (Low & Rebelo 1996).

Distribution Northern Cape, Free State and Eastern Cape Provinces: On plains of Eastern Upper Karoo (between Richmond



Figure 8.26 Gh 3 Xhariep Karroid Grassland: Herb-rich dry grassland with prominent species of *Helichrysum* near Donkerpoort (southwest of Springfontein, southern Free State).



Figure 8.27 Gh 4 Besemkaree Koppies Shrubland: Open shrublands of *Rhus erosa* on a dolerite koppie near Smithfield (Free State).

and Middelburg in the south and the Orange River) and within dry grasslands of the southern and central Free State. Extensive dolerite-dominated landscapes along the upper Orange River belong to this unit as well. Extends northwards to around Fauresmith in the northwest and to the Wepener District in the northeast. Altitude 1 120–1 680 m.

Vegetation & Landscape Features Slopes of koppies, butts and tafelbergs covered by two-layered karroid shrubland. The lower (closed-canopy) layer is dominated by dwarf small-leaved shrubs and, especially in precipitation-rich years, also by abundant grasses, while the upper (loose canopy) layer is dominated by tall shrubs, namely *Rhus erosa*, *R. burchellii*, *R. ciliata*, *Euclea crispa* subsp. *ovata*, *Diospyros austro-africana* and *Olea europaea* subsp. *africana*.

Geology & Soils Dolerite koppies and sills embedded within Karoo Supergroup sediments. The dolerite dykes and sills are igneous intrusions that are the result of extensive volcanic activity, which accompanied the break-up of Gondwana in the Jurassic. In places the slopes of mesas and butts carrying this vegetation type have a mixed geology where dolerites occur together with sandstones and mudstones of the Ecca and Beaufort Groups. Fb land type covers almost 60% of the area, followed by Ib.

Climate Due to the large extent of the area, the rainfall pattern differs slightly from west to east. Seasonal summer rainfall prevails when the patches are found embedded within other units of the Grassland Biome, but the southern and southwestern regions show hints of bimodal climate patterns typical of the Nama-Karoo. Far more importantly, despite an overall MAP of almost 400 mm, MAP ranges from about 280 mm in the west (De Aar) to more than double, 580 mm, in the east (Edenburg). Much of the rainfall is of convectional origin. MAT 15°C. See also climate diagram for Gh 4 Besemkaree Koppies Shrubland (Figure 8.23).

Important Taxa Small Trees: *Cussonia paniculata*, *Ziziphus mucronata*. Tall Shrubs: *Diospyros austro-africana* (d), *Euclea crispa* subsp. *ovata* (d), *Olea europaea* subsp. *africana* (d), *Rhus burchellii* (d), *R. ciliata* (d), *R. erosa* (d), *Buddleja saligna*, *Diospyros lycioides* subsp. *lycioides*, *Ehretia rigida*, *Grewia occidentalis*, *Gymnosporia polyacantha*, *Tarchonanthus minor*. Low Shrubs: *Asparagus suaveolens* (d), *Chrysocoma ciliata* (d),

Amphiglossa triflora, *Aptosimum elongatum*, *Asparagus striatus*, *Diospyros palens*, *Eriocephalus ericoides*, *E. spinescens*, *Euryops empetrifolius*, *Felicia filifolia* subsp. *filifolia*, *F. muricata*, *Helichrysum dregeanum*, *H. lucilioides*, *Hermannia multiflora*, *H. vestita*, *Lantana rugosa*, *Limeum aethiopicum*, *Lycium cinereum*, *Melolobium candicans*, *M. microphyllum*, *Nenax microphylla*, *Pegolettia retrofracta*, *Pentzia globosa*, *Rhigozum obovatum*, *Selago saxatilis*, *Stachys linearis*, *S. rugosa*, *Sutera halimifolia*, *Wahlenbergia albens*. Succulent Shrubs: *Aloe broomii*, *Chasmatophyllum musculinum*, *C. verdoorniae*, *Cotyledon orbiculata* var. *dactyloopsis*, *Pachypodium succulentum*. Graminoids: *Aristida adscensionis* (d), *A. congesta* (d), *A. diffusa* (d), *Cenchrus ciliaris* (d), *Cymbopogon caesius* (d), *Cynodon incompletus* (d), *Digitaria eriantha* (d), *Eragrostis curvula* (d), *E. lehmanniana* (d), *Heteropogon contortus* (d), *Setaria lindenbergiana* (d), *Themeda*

triandra (d), *Tragus koelerioides* (d), *Cymbopogon pospischilii*, *Enneapogon scoparius*, *Eragrostis chloromelas*, *E. obtusa*, *Eustachys paspaloides*, *Fingerhuthia africana*, *Hyparrhenia hirta*, *Sporobolus fimbriatus*. Herbs: *Convolvulus sagittatus*, *Dianthus caespitosus* subsp. *caespitosus*, *Gazania krebsiana* subsp. *krebsiana*, *Hibiscus pusillus*, *Indigofera alternans*, *I. rhytidocarpa*, *Lepidium africanum* subsp. *africanum*, *Pollichia campestris*. Herbaceous Climber: *Argyrobolium lanceolatum*. Geophytic Herbs: *Albuca setosa*, *Asplenium cordatum*, *Cheilanthes bergiana*, *C. eckloniana*, *Freesia andersoniae*, *Haemanthus humilis* subsp. *humilis*, *Oxalis depressa*, *Pellaea calomelanos*. Succulent Herbs: *Aloe grandidentata*, *Crassula nudicaulis*, *Duvalia caespitosa*, *Euphorbia pulvinata*, *Huernia piersii*, *Stapelia grandiflora*, *S. olivacea*, *Tridentea gemmiflora*.

Endemic Taxa Small Tree: *Cussonia* sp. nov. (P.J. du Preez 3666 BLFU). Succulent Shrubs: *Euphorbia crassipes*, *Neohenricia sibbettii*, *N. spiculata*.

Conservation Least threatened because largely excluded from intensive agricultural activities. Target 28%. About 5% statutorily conserved in the Rolfontein, Tussen Die Riviere, Oviston, Gariep Dam, Caledon and Kalkfontein Dam Nature Reserves. In addition a small patch is also protected in the private Vulture Conservation Area. About 3% of the area has been lost through building of dams (Bethulie, Egmont, Gariep, Kalkfontein, Vanderkloof and Welbedacht Dams). Erosion moderate (68%), high (20%) and low (10%).

Remarks The diversity of the shrub component is lower than in the Gm 5 Basotho Montane Shrubland—a similar shrubland unit occurring on the Drakensberg foothills. The density of shrubs marking the slopes of the koppies decreases along a northeast-southwest gradient. On the southern edges of the distribution area of this unit, shrubs retreat to drainage lines and onto the base of dolerite caps, while the slopes themselves remain covered by dwarf shrublands of the NKu 4 Eastern Upper Karoo. In the northeastern areas which receive a higher rainfall, the sheltered sites have larger trees such as *Rhus lancea* and *Celtis africana*.

References Acocks (1953, 1988), Werger (1973a, b, 1983), Jooste (1989), Du Preez (1991), Du Preez & Bredenkamp (1991), Malan (1993, 1998), Malan et al. (1994, 1998, 1999), Lloyd & Badenhorst (1995, 1996), Müller (2002), Botha (2003).

Gh 5 Bloemfontein Dry Grassland

VT 36 False Upper Karoo (60%) (Acocks 1953).
LR 52 Eastern Mixed Nama Karoo (58%) (Low & Rebelo 1996).

Distribution Free State Province: South-central part of the province, with Bloemfontein more or less centrally. Extending from Petrusburg in the west to the Rustfontein Dam in the east and from Reddersburg in the south to the Soetdoring Nature Reserve in the north. Altitude 1 200–1 480 m, but mostly 1 320–1 420 m.

Vegetation & Landscape Features Slightly undulating bottomland landscape covered with tall, dense grassland alternating with patches of karroid scrub occurring especially over calcrete.

Geology & Soils Sedimentary mudstones and layers of sandstone mainly of the Adelaide Subgroup (Beaufort Group, Karoo Supergroup). Volksrust Formation mudstones of the Ecca Group (also Karoo Supergroup) dominate the western part of the area. Deep (>300 mm) layer of red sand (aeolian origin) covers the more clayey B-horizons. Soil forms such as arable Hutton, Bainsvlei and Bloemdal occur here and are typical of the Ca land type. The Ea land type has shallow gravelly soils underlain by dolerite sills. Ca and Ae land types are nearly equally represented.

Climate Summer-rainfall region, with MAP around 450 mm. Most of the rainfall is of convectional origin and peaks in late summer. Overall MAT is within warm-temperate ranges (nearly 16°C), with high incidence of frost in winter. See also climate diagram for Gh 5 Bloemfontein Dry Grassland (Figure 8.23).

Important Taxa Graminoids: *Antheophora pubescens* (d), *Aristida congesta* (d), *A. diffusa* (d), *Cynodon dactylon* (d), *Digitaria argyrograptia* (d), *Elionurus muticus* (d), *Eragrostis chloromelas* (d), *E. lehmanniana* (d), *E. obtusa* (d), *E. plana* (d), *E. superba* (d), *E. trichophora* (d), *Heteropogon contortus* (d), *Panicum stapfianum* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Tragus koelerioides* (d), *Aristida stipitata* subsp. *graciliflora*, *Chloris virgata*, *Cymbopogon pospischilii*, *Pogonarthria squarrosa*, *Sporobolus fimbriatus*, *Trichoneura grandiglumis*, *Triraphis andropogonoides*. Herbs: *Selago densiflora* (d), *Berkheya onopordifolia* var. *onopordifolia*, *Blepharis integrifolia* var. *clarkei*, *Chamaesyce inaequilatera*, *Commelina africana*, *Dicoma macrocephala*, *Gazania krebsiana* subsp. *krebsiana*, *Geigeria ornativa*, *Harpagophytum procumbens*, *Helichrysum caespitium*, *Heliotropium ciliatum*, *Hermannia comosa*, *H. tomentosa*, *Indigofera alternans*, *Lactuca dregeana*, *Lotononis listii*, *Monsonia burkeana*, *Nolletia ciliaris*, *Pollichia campestris*. Geophytic Herbs: *Oxalis depressa* (d), *Haemanthus humilis* subsp. *humilis*. Succulent Herb: *Tripteris aghillana* var. *integrifolia*. Low Shrubs: *Chrysocoma ciliata* (d), *Felicia filifolia* subsp. *filifolia* (d), *Pentzia globosa* (d), *P. incana* (d), *Amphiglossa triflora*, *Anthospermum rigidum* subsp. *pumilum*, *Asparagus striatus*, *Felicia muricata*, *Gnidia polycephala*, *Helichrysum dregeanum*, *Nenax microphylla*, *Osteospermum leptolobum*, *Polygala hottentotta*, *Selago saxatilis*. Succulent Shrub: *Hertia pallens*.

Conservation Endangered. Target 24%. Only a small portion is statutorily conserved in the Soetdoring Nature Reserve. More than 40% already transformed, e.g. for crop production (mainly



Figure 8.28 Gh 5 Bloemfontein Dry Grassland: Typical central Free State grasslands (dominated by *Themeda triandra* in well-managed facies) along the N1 road south of Leeuokop near Bloemfontein.

Ae and Ca land types) as well as by urban (and related) development (the largest part of this vegetation unit on the Ae land type is situated in the Genl De Wet military training area, west of Bloemfontein). Especially those grasslands on shallow gravelly soils as well as the low-lying areas on clayey soils are prone to karoo-bush encroachment when overgrazed. Erosion low (50%), very low (37%) or moderate (13%).

Remarks This unit differs from the southern and western units (Gh 3 Xhariep Karroid Grassland, Gh 2 Aliwal North Dry Grassland and NKu 3 Northern Upper Karoo) in that a thicker sandy layer (>300 mm) covers the calcrete subsoils. This limits the distribution of dwarf karroid shrub species to a large extent. The deeper sandy soils also provide suitable habitat for psammophytes such as *Harpagophytum procumbens* and *Dicoma macrocephala*. The units to the east and north (Gh 6 Central Free State Grassland, Gh 9 Western Free State Clay Grassland) receive relatively higher rainfall, which supports denser grasslands.

References Acocks (1953, 1988), Malan (1993, 1998), Malan et al. (1995), Dingaen (1999).

Gh 6 Central Free State Grassland

VT 49 Transitional *Cymbopogon*–*Themeda* Veld (50%) (Acocks 1953). LR 39 Moist Cool Highveld Grassland (78%) (Low & Rebelo 1996).

Distribution Free State Province and marginally into Gauteng Province: A broad zone from around Sasolburg in the north to Dewetsdorp in the south. Other major settlements located within this unit include Kroonstad, Ventersburg, Steynsrus, Winburg, Lindley and Edenville. Altitude 1 300–1 640 m, most of the area at 1 400–1 460 m.

Vegetation & Landscape Features Undulating plains supporting short grassland, in natural condition dominated by *Themeda triandra* while *Eragrostis curvula* and *E. chloromelas* become dominant in degraded habitats. Dwarf karoo bushes establish in severely degraded clayey bottomlands. Overgrazed and trampled low-lying areas with heavy clayey soils are prone to *Acacia karroo* encroachment.

Geology & Soils Sedimentary mudstones and sandstone mainly of the Adelaide Subgroup (Beaufort Group, Karoo Supergroup)

as well as those of the Ecce Group (Karoo Supergroup) found in the extreme northern section of this grassland, giving rise to vertic, melanic and red soils (typical forms are Arcadia, Bonheim, Kroonstad, Valsrivier and Rensburg)—typical of Dc land type (dominating the landscape). The less common intrusive dolerites of the Jurassic Karoo Dolerite Suite support dry clayey soils typical of the Ea land type.

Climate Summer-rainfall seasonal precipitation region, with MAP 560 mm. Much of the rainfall is of convectional origin and peaks in December to January. The overall MAT around 15°C. Incidence of frost relatively high (43 days on average). See also climate diagram for Gh 6 Central Free State Grassland (Figure 8.23).

Important Taxa Graminoids: *Aristida adscensionis* (d), *A. congesta* (d), *Cynodon dactylon* (d), *Eragrostis chloromelas* (d), *E. curvula* (d), *E. plana* (d), *Panicum coloratum* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Tragus koelerioides* (d), *Agrostis lachnantha*, *Andropogon appendiculatus*, *Aristida bipartita*, *A. canescens*, *Cymbopogon pospischilii*, *Cynodon transvaalensis*, *Digitaria argyrograptis*, *Elionurus muticus*, *Eragrostis lehmanniana*, *E. micrantha*, *E. obtusa*, *E. racemosa*, *E. trichophora*, *Heteropogon contortus*, *Microchloa caffra*, *Setaria incrassata*, *Sporobolus discosporus*. Herbs: *Berkheya onopordifolia* var. *onopordifolia*, *Chamaesyce inaequilatera*, *Conyza pinnata*, *Crabbea acaulis*, *Geigeria aspera* var. *aspera*, *Hermannia depressa*, *Hibiscus pusillus*, *Pseudognaphalium luteo-album*, *Salvia stenophylla*, *Selago densiflora*, *Sonchus dregeanus*. Geophytic Herbs: *Oxalis depressa*, *Raphionacme dyeri*. Succulent Herb: *Tripteris aghillana* var. *integrifolia*. Low Shrubs: *Felicia muricata* (d), *Anthospermum rigidum* subsp. *pumilum*, *Helichrysum dregeanum*, *Melolobium candicans*, *Pentzia globosa*.

Conservation Vulnerable. Target 24%. Only small portions enjoy statutory conservation (Willem Pretorius, Rustfontein and Koppies Dam Nature Reserves) as well as some protection in private nature reserves. Almost a quarter of the area has been transformed either for cultivation or by building of dams (Allemanskraal, Erfenis, Groothoek, Koppies, Kroonstad, Lace Mine, Rustfontein and Weltevrede). No serious infestation by alien flora has been observed, but encroachment of dwarf karoo shrubs becomes a problem in the degraded southern parts of this vegetation unit. Erosion low (45%), moderate (30%) or very low (20%).

Remarks On cool moist southern slopes, elements of the Gm 4 Eastern Free State Sandy Grassland are notable. Stands of Gh 7 Winburg Grassy Shrubland are present on outcrops (dykes and sills) of dolerite embedded within this grassland.

References Acocks (1953, 1988), Müller (1986), Du Preez & Bredenkamp (1991), Fuls et al. (1992), Müller (2002).

Gh 7 Winburg Grassy Shrubland

VT 50 Dry *Cymbopogon–Themeda* Veld (63%) (Acocks 1953). LR 37 Dry Sandy Highveld Grassland (63%) (Low & Rebelo 1996).

Distribution Free State Province: Series of larger patches between Trompsburg through Bloemfontein and Winburg to Ventersburg. Altitude 1 300–1 660 m, mainly 1 360–1 440 m.



Figure 8.29 Gh 7 Winburg Grassy Shrubland: An *Olea europaea* subsp. *africana* shrubland on slopes of a dolerite koppie north of Bloemfontein (central Free State).

Vegetation & Landscape Features Solitary hills, slopes and escarpments of mesas creating a mosaic of habitats ranging from open grassland to shrubland. Tall shrubs and sometimes small trees are sheltered against frequent periods of frost during the winter months and regular veld fires in late winter to early spring. The medium-height evergreen shrublands are dominated by a combination of *Olea europaea* subsp. *africana*, *Euclea crispa* subsp. *crispa*, *Gymnosporia buxifolia*, *Diospyros lycioides*, *Rhus burchellii*, *R. ciliata*, *R. erosa* (mainly in the south), *Clutia pulchella* and *Grewia occidentalis*. Trees such as *R. lancea*, *Celtis africana* and *Ziziphus mucronata* are found in more deeply incised drainage lines.

Geology & Soils Extensive dolerite sills forming ridges, plateaus and slopes of koppies, and small escarpments marking the erosion terraces. The sills cover alternating layers of mudstone and sandstone of sedimentary origin (Adelaide Subgroup of the Beaufort Group). Prominent soil forms are the stony Mispah and gravel-rich Glenrosa derived from Jurassic dolerite. Dominating land type Ea, with Dc also present in places.

Climate Summer-rainfall region, with MAP around 500 mm. Much of the rainfall is of convectional origin. Overall MAT is slightly higher than 15°C, with more than 40 days of frost in winter. See also climate diagram for Gh 7 Winburg Grassy Shrubland (Figure 8.23).

Important Taxa Small Trees: *Acacia karroo*, *Celtis africana*, *Cussonia paniculata*, *Pittosporum viridiflorum*, *Rhus lancea*, *Scolopia zeyheri*, *Ziziphus mucronata*. Tall Shrubs: *Buddleja saligna* (d), *Euclea crispa* subsp. *ovata* (d), *Gymnosporia polyantha* (d), *Olea europaea* subsp. *africana* (d), *Rhus burchellii* (d), *R. erosa* (d), *Diospyros lycioides* subsp. *lycioides*, *Grewia occidentalis*, *Gymnosporia buxifolia*, *Tarchonanthes camphoratus*. Low Shrubs: *Helichrysum dregeanum* (d), *Pentzia globosa* (d), *Anthospermum rigidum* subsp. *pumilum*, *Asparagus cooperi*, *A. laricinus*, *Berkheya annectens*, *Chrysocoma ciliata*, *Clutia pulchella*, *Euryops empetrifolius*, *Felicia filifolia* subsp. *filifolia*, *F. muricata*, *Nenax microphylla*, *Osyris lanceolata*, *Rosenia humilis*, *Selago saxatilis*, *Solanum tomentosum* var. *coccineum*. Graminoids: *Aristida adscensionis* (d), *A. congesta* (d), *A. diffusa* (d), *Cymbopogon pospischilii* (d), *Cynodon dactylon* (d), *C. incompletus* (d), *Eragrostis chloromelas* (d), *E. lehmanniana* (d), *E. micrantha* (d), *E. obtusa* (d), *E. trichophora* (d), *Eustachys*

paspaloides (d), *Heteropogon contortus* (d), *Panicum stapfianum* (d), *Setaria lindenberghiana* (d), *S. sphacelata* (d), *Sporobolus fimbriatus* (d), *Themeda triandra* (d), *Tragus koelerioides* (d), *Digitaria argyrograpta*, *Elionurus muticus*, *Enneapogon scoparius*, *Eragrostis plana*, *E. superba*, *Tragus berteronianus*, *T. racemosus*, *Triraphis andropogonoides*. Herbs: *Berkheya onopordifolia* var. *onopordifolia*, *Hermannia coccocarpa*, *Indigofera alternans*, *Mohria caffrorum*, *Pupalia lappacea*, *Salvia repens*. Geophytic Herbs: *Oxalis corniculata*, *O. depressa*. Succulent Herb: *Crassula lanceolata*.

Conservation Least threatened. Target 28%. Almost 2% statutorily conserved in the Willem Pretorius Nature Reserve. More than 10% transformed for cultivation and by urban sprawl. Erosion low (57%), very low (24%) and moderate (18%).

Remarks The vegetation of this unit differs considerably in species composition and structure, from analogous shrubland typical of koppies south and southwest of Bloemfontein (Gh 4 Besemkaree Koppies Shrubland), in having some afromontane elements and a more mesic character. Dolerite hills along the Sand River as well as those found in the Willem Pretorius Nature Reserve are home to some sourveld shrub species, such as *Elaeodendron transvaalense*, *Scolopia zeyheri*, *Rhus leptodictya* and *Helinus integrifolius*.

References Acocks (1953, 1988), Du Preez (1979), Roussouw (1983), Müller (1986), Du Preez (1991), Malan (1993, 1998), Malan et al. (1994, 1995), Dingaen (1999), Müller (2002).

Gh 8 Bloemfontein Karroid Shrubland

VT 50 Dry *Cymbopogon–Themeda* Veld (47%), VT 49 Transitional *Cymbopogon–Themeda* Veld, (35%) (Acocks 1953). LR 37 Dry Sandy Highveld Grassland (64%) (Low & Rebelo 1996).

Distribution Free State and Mpumalanga (only in the southwest) Provinces: An archipelago of isolated patches found on koppies, butts and ridges embedded mainly within dry highveld grasslands in the region extending over large distances between Bloemfontein in the southwest, Verkeerdevlei and Lindley in the southeast, Standerton in the northeast as well as Heilbron and Bultfontein in the northwest. Altitude 1 320–1 840 m, mostly 1 400–1 440 m.

Vegetation & Landscape Features

Plateaus or slightly sloping flanks of dolerite outcrops supporting low shrubland dominated by dwarf small-leaved karroid and succulent shrubs. Grasses are restricted to depressions and crevices filled with fine soils. Remarkable is the presence of abundant geophytic herbs. Solitary shrubs or small shrub groups with *Diospyros austro-africana*, *Euclea crispa* subsp. *ovata*, *Rhus burchellii*, *R. ciliata* and *R. erosa* are occasionally present, especially in habitats where root penetration into deeper crevices is possible.

Geology & Soils Restricted to Jurassic dolerite intrusions (sills) embedded within sediments of the Adelaide Subgroup (Beaufort Group, Karoo Supergroup). Typical feature of this habitat is a shallow (only 1–5 cm thick) layer of sand of aeolian origin that overlies sheets of

dolerite. Dominant land type is Ea, followed by Dc and Fa (the last-named on the Karoo Supergroup sediments).

Climate Summer-rainfall area, with MAP close to 570 mm and from 550 mm (Bloemfontein) to 650 mm (Standerton). Much of the rainfall is of convectional origin. MAT 15°C, indicating a warm-temperate climatic regime. Winters can be very cold and frost incidence is high (40 days). See also climate diagram for Gh 8 Bloemfontein Karroid Shrubland (Figure 8.23).

Important Taxa Tall Shrubs: *Diospyros austro-africana*, *Euclea crispa* subsp. *ovata*, *Rhus burchellii*, *R. erosa*, *R. tridactyla*. Low Shrubs: *Eriocephalus ericoides* (d), *Euryops empetrifolius* (d), *Anthospermum rigidum* subsp. *pumilum*, *Asparagus suaveolens*, *Felicia muricata*, *Helichrysum dregeanum*, *Heliophila suavis-sima*, *Jamesbrittenia pristisepala*, *Nenax microphylla*, *Pentzia globosa*, *Phyllanthus parvulus*, *Selago albida*. Succulent Shrubs: *Chasmatophyllum musculinum* (d), *Euphorbia mauritanica* (d), *Ruschia spinosa* (d), *Stomatium mustellinum* (d), *Cotyledon orbiculata* var. *dactyloopsis*, *Euphorbia rectirama*, *Kalanchoe paniculata*, *Othonna protecta*, *Pachypodium succulentum*, *Ruschia hamata*, *R. unidens*, *Sarcocaulon salmoniflorum*, *Stapelia grandiflora*. Succulent Woody Climber: *Sarcostemma viminale*. Graminoids: *Aristida diffusa* (d), *Eragrostis nindensis* (d), *Heteropogon contortus* (d), *Oropetium capense* (d), *Aristida adscensionis*, *A. congesta*, *Cymbopogon caesius*, *C. pospischilii*, *Cyperus rupestris* var. *rupestris*, *Digitaria eriantha*, *Enneapogon scoparius*, *Eragrostis chloromelas*, *E. obtusa*, *E. superba*, *E. trichophora*, *Eustachys paspaloides*, *Melinis repens* subsp. *repens*, *Microchloa caffra*, *Themeda triandra*, *Tragus koelerioides*, *T. racemosus*. Herbs: *Berkheya onopordifolia* var. *onopordifolia*, *B. rigida*, *Chamaesyce inaequilatera*, *Commelina africana*, *Gazania linearis* var. *linearis*, *Geigeria aspera* var. *aspera*, *G. filifolia*, *Hermannia coccocarpa*. Geophytic Herbs: *Cheilanthes eckloniana* (d), *Albuca setosa*, *Dipcadi ciliare*, *D. viride*, *Nerine lat-coma*, *Pellaea calomelanos*, *Trachyandra saltii*. Succulent Herbs: *Senecio radicans* (d), *Adromischus trigynus*, *Aloe grandidentata*, *Anacampseros telephiastrum*, *Avonia ustulata*, *Crassula nudicaulis*, *Duvalia corderoyi*, *Orbea cooperi*, *Orbeopsis lutea*, *Tripteris aghillana* var. *integrifolia*.

Endemic Taxon Geophytic Herb: *Brachystelma glenense*.



Figure 8.30 Gh 8 Bloemfontein Karroid Shrubland: Dolerite rocky sheet with pockets of shallow soil supporting low grassy karroid shrubland with prominent succulent shrubs, xerophilous ferns, bulbous herbs and the prominent grass *Eragrostis nindensis*; near the entrance to the Free State National Botanical Garden in Bloemfontein (central Free State).

Conservation Some sites of this vegetation are exposed to considerable urban developmental pressures, especially within the borders of the Mangaung Municipality (see Haasbroek 2003). Target 28%. None conserved in statutory conservation areas, but small portions are found on the premises of the Free State National Botanical Garden in Bloemfontein. About 10% already transformed, mainly by cultivation. Erosion low (66%) and very low (24%).

Remarks Potts & Tidmarsh (1937) were the first to describe this vegetation and to recognise the fact that it is a unique 'island' of succulent-dominated karroid shrub community in the Grassland Biome. They named the identified units *Mesembryanthemum spinosum*–*Euphorbia mauritanica* Scrub, and *Euryops sulcatus*–*Euphorbia mauritanica* Scrub (Potts & Tidmarsh 1937). Dingaen & Du Preez (2002) and Haasbroek (2003)

recently surveyed this unique vegetation. Although there is a strong affinity to some of the vegetation units of the arid west (Upper Karoo Hardeveld, Western Upper Karoo and Northern Upper Karoo), it also has a notable grass component including *Oropetium capense*, *Eragrostis nindensis*, *Aristida congesta*, *E. trichophora*, *E. lehmanniana*, *Heteropogon contortus*, *Themeda triandra* and *Digitaria eriantha*. We suggest that the occurrence of a karroid shrubland within highveld grasslands relates to physiological drought due to shallow soils, high runoff, high evaporation rates and impeded infiltration of rainwater. These factors create a soil-controlled microhabitat for vegetation, which might be considered a relict of drier (and presumably colder) past climatic periods.

References Potts & Tidmarsh (1937), Acocks (1953, 1988), Mostert (1958), Müller (1986), Du Preez & Bredenkamp (1991), Dingaen (1996), Dingaen & Du Preez (2002), Haasbroek (2003).

Gh 9 Western Free State Clay Grassland

VT 50 Dry *Cymbopogon*–*Themeda* Veld (52%) (Acocks 1953). LR 37 Dry Sandy Highveld Grassland (81%) (Low & Rebelo 1996).

Distribution Free State Province: Region covering part of the western Bloemfontein District (south), Boshof (southwest), Hertzogville (west), Wesselsbron (north) and Brandfort (east) and consisting of three main areas, of which the southern and middle sections are separated by a slightly elevated area (dolerite hills) between Hertzogville, Boshof and Soutpan. The Vet River Valley separates the middle and northern sections and all three sections are separated from one another by belts of Gh 10 Vaal-Vet Sandy Grassland. Altitude 1 200–1 420 m.

Vegetation & Landscape Features Restricted to flat bottomlands which support dry, species-poor grassland with a high number of salt pans (playas) embedded. Dwarf karoo shrublands surround the playas in disturbed habitats.

Geology & Soils Deposits of sandstone, mudstone and shale (Volksrust Formation, Ecce Group) underlie extensive areas of flat to undulating plains, interrupted by dolerite sills in places. No rivers or streams drain away from these plains, and all the water drains into the numerous playas (pans)—a unique feature of this landscape. Dry, clayey, duplex soils typical of land types Da, Db and Dc. Fc land type also occurs.



Figure 8.31 Gh 9 Western Free State Clay Grassland: Dry grassland with abundant karroid elements near Uitkyk (Boshof District, Free State) as photographed in the 1960s.

Climate Seasonal rainfall concentrated from November–March (overall MAP 450 mm). Cool temperate regime with MAT 16–17°C. Occurrence of frost frequent. See also climate diagram for Gh 9 Western Free State Clay Grassland (Figure 8.23).

Important Taxa Graminoids: *Aristida adscensionis* (d), *A. bipartita* (d), *Cynodon dactylon* (d), *Eragrostis chloromelas* (d), *E. lehmanniana* (d), *Panicum coloratum* (d), *Themeda triandra* (d), *Aristida congesta*, *Cymbopogon pospischilii*, *Digitaria eriantha*, *Eragrostis bicolor*, *E. curvula*, *E. micrantha*, *E. obtusa*, *E. plana*, *E. superba*, *E. trichophora*, *Heteropogon contortus*, *Setaria nigrirostris*, *Tragus berteronianus*, *T. koelerioides*, *T. racemosus*. Herbs: *Berkheya onopordifolia* var. *onopordifolia*, *Chamaesyce inaequilatera*, *Gnaphalium declinatum*, *Indigofera alternans*, *Kohautia cynanchica*, *Nidorella microcephala*, *Platycarpha parvifolia*, *Salvia stenophylla*, *Selago paniculata*, *Stachys spathulata*. Geophytic Herbs: *Bulbine narcissifolia*, *Oxalis depressa*. Succulent Herb: *Tripteris aghillana* var. *integrifolia*. Low Shrubs: *Lycium cinereum* (d), *Pentzia globosa* (d), *Amphiglossa triflora*, *Aptosimum elongatum*, *Berkheya annectens*, *Felicia filifolia* subsp. *filifolia*, *F. muricata*, *Gnidia polyccephala*, *Helichrysum dregeanum*, *Melolobium candicans*, *Nenax microphylla*, *Rosenia humilis*, *Selago saxatilis*. Succulent Shrub: *Hertia pallens*.

Conservation Least threatened. Target 24%. None conserved in statutory conservation areas. Almost 20% already transformed for maize and wheat cultivation. A species of *Prosopis* appears as occasional invasive alien. Erosion very low (38%), low (30%) and moderate (28%).

Remarks The vegetation of the salt pans embedded within this grassland unit is treated as a separate vegetation unit AZi 10 Highveld Salt Pans.

References Kooij (1990), Kooij et al. (1990a).

Gh 10 Vaal-Vet Sandy Grassland

VT 50 Dry *Cymbopogon*–*Themeda* Veld (47%), VT 48 *Cymbopogon*–*Themeda* Veld (sandy) (24%) (Acocks 1953). LR 37 Dry Sandy Highveld Grassland (74%) (Low & Rebelo 1996).

Distribution North-West and Free State Provinces: South of Lichtenburg and Ventersdorp, stretching southwards to

Klerksdorp, Leeudoringstad, Bothaville and to the Brandfort area north of Bloemfontein. Altitude 1 220–1 560 m, generally 1 260–1 360 m.

Vegetation & Landscape Features Plains-dominated landscape with some scattered, slightly irregular undulating plains and hills. Mainly low-tussock grasslands with an abundant karroid element. Dominance of *Themeda triandra* is an important feature of this vegetation unit. Locally low cover of *T. triandra* and the associated increase in *Elionurus muticus*, *Cymbopogon pospischilii* and *Aristida congesta* is attributed to heavy grazing and/or erratic rainfall.

Geology & Soils Aeolian and colluvial sand overlying sandstone, mudstone and shale of the Karoo Supergroup (mostly the Ecca Group) as well as older Ventersdorp Supergroup andesite and basement gneiss in the north. Soil forms are mostly Avalon, Westleigh and Clovelly. Dominant land type Bd, closely followed by Bc, Ae and Ba.

Climate Warm-temperate, summer-rainfall climate, with overall MAP of 530 mm. High summer temperatures. Severe frost (37 days per year on average) occurs in winter. See also climate diagram for Gh 12 Vaal-Vet Sandy Grassland (Figure 8.23).

Important Taxa Graminoids: *Antheophora pubescens* (d), *Aristida congesta* (d), *Chloris virgata* (d), *Cymbopogon caesius* (d), *Cynodon dactylon* (d), *Digitaria argyrograptia* (d), *Elionurus muticus* (d), *Eragrostis chloromelas* (d), *E. lehmanniana* (d), *E. plana* (d), *E. trichophora* (d), *Heteropogon contortus* (d), *Panicum gilvum* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Tragus berteronianus* (d), *Brachiaria serrata*, *Cymbopogon pospischilii*, *Digitaria eriantha*, *Eragrostis curvula*, *E. obtusa*, *E. superba*, *Panicum coloratum*, *Pogonarthria squarrosa*, *Trichoneura grandiglumis*, *Triraphis andropogonoides*. Herbs: *Stachys spathulata* (d), *Barleria macrostegia*, *Berkheya onopordifolia* var. *onopordifolia*, *Chamaesyce inaequilatera*, *Geigeria aspera* var. *aspera*, *Helichrysum caespitium*, *Hermannia depressa*, *Hibiscus pusillus*, *Monsonia burkeana*, *Rhynchosia adenodes*, *Selago densiflora*, *Vernonia oligocephala*. Geophytic Herbs: *Bulbine narcissifolia*, *Ledebouria marginata*. Succulent Herb: *Tripteris aghillana* var. *integrifolia*. Low Shrubs: *Felicia muricata* (d), *Pentzia globosa* (d), *Anthospermum rigidum* subsp. *pumilum*, *Helichrysum dregeanum*, *H. paronychioides*, *Ziziphus zeyheriana*.

Endemic Taxon Herb: *Lessertia phillipsiana*.

Conservation Endangered. Target 24%. Only 0.3% statutorily conserved in the Bloemhof Dam, Schoonspruit, Sandveld, Faan Meintjies, Wolwespruit and Soetdoring Nature Reserves. More than 63% transformed for cultivation (ploughed for commercial crops) and the rest under strong grazing pressure from cattle and sheep. Erosion very low (85.3%) and low (11%).

References Louw (1951), Morris (1973, 1976), Bredenkamp & Bezuidenhout (1990), Kooij et al. (1990b, 1992), Bezuidenhout et al. (1994a).

Gh 11 Vredefort Dome Granite Grassland

VT 48 *Cymbopogon–Themeda* Veld (sandy) (49%), VT 61 Bankenveld (25%) (Acocks 1953). LR 34 Rocky Highveld Grassland (95%) (Low & Rebelo 1996).

Distribution Free State and North-West Provinces: Central portion of the Vredefort Dome around Parys and Vredefort. Altitude 1 340–1 520 m.

Vegetation & Landscape Features Slightly undulating plains with mainly short, *Themeda triandra*-dominated grassland, though mostly grazed and often degraded. One of the most scenic landscapes of the Highveld, with the Vaal River cutting through the mountainous landscape (Savanna Biome) of the Vredefort Dome. Big boulders of granite are conspicuous in the area, creating microhabitats for a diversity of plant species.

Geology & Soils Granite and gneiss at the core of the Vredefort Dome underlie this area and includes the Inlandsee Gneiss. Various soil types including the Hutton, Mispah and Avalon forms, representing plinthic soils, which can be dystrophic and/or mesotrophic (Ba land type) or eutrophic (Bc land type). Red soils are generally widespread.

Climate Warm-temperate, summer-rainfall region, with overall MAP of 594 mm. Summer temperatures are high. Severe frost (38 days per year on average) occurs in winter. See also climate diagram for Gh 11 Vredefort Dome Granite Grassland (Figure 8.23).

Important Taxa Graminoids: *Aristida congesta* (d), *Chloris virgata* (d), *Cynodon dactylon* (d), *Digitaria eriantha* (d), *Elionurus muticus* (d), *Eragrostis biflora* (d), *E. lehmanniana* (d), *E. trichophora* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Tragus berteronianus* (d), *Aristida diffusa*, *Brachiaria serrata*, *Cymbopogon pospischilii*, *Eragrostis chloromelas*, *E. gummiflua*, *E. racemosa*, *E. superba*, *Heteropogon contortus*, *Hyparrhenia hirta*, *Trichoneura grandiglumis*, *Triraphis andropogonoides*. Herbs: *Barleria macrostegia*, *Berkheya setifera*, *Chamaesyce inaequilatera*, *Crabbea acaulis*, *Helichrysum rugulosum*, *Hermannia depressa*, *Ipomoea oblongata*, *I. obscura*, *Lepidium capense*, *Lotononis listii*, *Selago densiflora*, *Vernonia oligocephala*. Herbaceous Climber: *Rhynchosia totta*. Low Shrubs: *Felicia muricata* (d), *Anthospermum rigidum* subsp. *pumilum*, *Deverra burchellii*, *Polygala hottentotta*.

Conservation Endangered. Target 24%. None conserved in statutory conservation areas and almost half already transformed by cultivation (maize fields), by urban development or by road-building. Erosion is very low (96%).



S.S. Cilliers

Figure 8.32 Gh 11 Vredefort Dome Granite Grassland: *Melinis repens*-dominated grassland on granite (with a granite dome in the background) of the Vredefort Dome—an ancient large asteroid impact site near Potchefstroom (border region of the Free State and North-West Provinces).

Remarks Vredefort Dome is an interesting geological structure—a strongly eroded remnant of one of the largest impact craters of the world, about 2.2 billion years old.

References Du Preez (1986), Bezuidenhout et al. (1988, 1994c), Breidenkamp et al. (1989), Du Preez & Venter (1990), Bezuidenhout (1993).

Gh 12 Vaal Reefs Dolomite Sinkhole Woodland

VT 61 Western variation of the Bankenveld (55%), VT 48 *Cymbopogon-Themedata* veld (45%) (Acocks 1988). LR 34 Rocky Highveld Grassland (55%), LR 37 Dry Sandy Highveld Grassland (45%) (Low & Rebelo 1996).

Distribution North-West and Free State Provinces: Small area associated with the dolomite sinkholes in and around Stilfontein and Orkney (Vaal Reefs). The Vaal River forms the southern distribution limit of this vegetation unit. Altitude 1 280–1 380 m.

Vegetation & Landscape Features Slightly undulating landscape dissected by prominent rocky chert ridges and supporting a grassland-woodland vegetation complex. The most typical vegetation feature is the woodland, which occurs naturally in clumps around sinkholes, especially in places of dolomite outcrops.

Geology & Soils This area occurs almost exclusively on the dolomites of the Malmani Subgroup (Chuniespoort Group, Transvaal Supergroup), where underground dissolution of the rock causes sinkholes. More than 50% of the main soil types are relatively shallow (50–150 mm) and rocky, with the dominant soil forms Mispah, Glenrosa and shallow Hutton. The latter soils are associated with the Fa land type.

Climate Warm-temperate summer-rainfall region, with overall MAP around 560 mm. The summer temperatures are high. Severe frequent frost occurs in winter. See also climate diagram for Gh 12 Vaal Reefs Dolomite Sinkhole Woodland (Figure 8.23).

Important Taxa Small Trees: *Acacia erioloba* (d), *Celtis africana* (d), *Rhus lancea* (d), *Acacia caffra*, *A. karroo*, *A. robusta* subsp. *clavigera*. Tall Shrubs: *Diospyros lycioides* subsp. *lycioides* (d), *Ehretia rigida* (d), *Grewia flava* (d). Low Shrubs: *Asparagus sua-*

veolens (d), *Gymnosporia heterophylla* (d), *Pavonia burchellii* (d), *Sida dregei* (d), *Anthospermum hispidulum*, *Asparagus laricinus*, *Diospyros pallens*, *Felicia muricata*, *Indigofera heterotricha*, *Menodora africana*, *Phyllanthus incurvus*, *Triumfetta sonderi*, *Ziziphus zeyheriana*. Geoxylic Suffrutex: *Elephantorrhiza elephantina*. Woody Climber: *Asparagus africanus*. Graminoids: *Aristida congesta* (d), *Digitaria eriantha* (d), *Eragrostis biflora* (d), *E. curvula* (d), *Themeda triandra* (d), *Antheophora pubescens*, *Aristida canescens*, *Bewisia biflora*, *Brachiaria nigropedata*, *B. serrata*, *Chloris pycnothrix*, *Cymbopogon caesius*, *C. pospischilii*, *Cynodon dactylon*, *Cyperus margaritaceus*, *Diheteropogon amplexans*, *Elionurus muticus*, *Eragrostis chloromelas*, *E. lehmanniana*, *E. racemosa*, *E. superba*, *Eustachys paspaloides*, *Heteropogon contortus*, *Melinis repens* subsp. *repens*, *Panicum coloratum*, *Setaria sphacelata*, *Triraphis andropogonoides*. Herbs: *Commelina africana* (d), *Barleria macrostegia*, *Chamaecrista mimosoides*, *Chamaesyce inaequilatera*, *Chascanum hederaceum*, *Crabbea angustifolia*, *Cyanotis speciosa*, *Dicoma anomala*, *Hermannia depressa*, *Indigofera daleoides*, *I. torulosa* var. *angustiloba*, *Ipomoea obscura*, *Justicia angaloides*, *Nidorella hottentotica*, *Osteospermum muricatum* subsp. *longiradiatum*, *Pollichia campestris*, *Pterodiscus speciosus*, *Vernonia oligocephala*. Geophytic Herb: *Albuca setosa*.

Conservation Vulnerable. Target 24%. Only a small patch conserved in the statutory conservation area of Sterkfontein Caves (part of the Cradle of Humankind World Heritage Site)—the legendary archaeological site associated with the discovery of a skeleton of *Australopithecus africanus*. The proposed 'Highveld National Park' is supposed to conserve a considerable area of this vegetation unit. Aesthetically this is one of the most scenic landscapes in the western Grassland Biome and certainly deserves high conservation priority. Almost a quarter has been transformed already—mainly by mining, cultivation, urban sprawl and road-building. The region of this unit contains possibly the highest concentration of mines of any other vegetation in South Africa. Erosion is generally very low.

Remarks The mapped extent of the dolomite sinkhole woodlands should be revisited at a more detailed scale than that offered by our current coverage. Clear separation (expressed in appropriate mapping coverage) between this unit and the adjacent Gh 15 Carletonville Dolomite Grassland is needed.

References Louw (1951), Acocks (1953, 1988), Morris (1973), Coetzee (1974), Van Wyk (1983), Van Wyk & Breidenkamp (1986), Bezuidenhout (1993), Bezuidenhout et al. (1994b, c, e), Siebert & Siebert (2005).

Gh 13 Klerksdorp Thornveld

VT 50 Dry *Cymbopogon-Themedata* Veld (44%), VT 19 Sourish Mixed Bushveld (29%) (Acocks 1953). LR 37 Dry Sandy Highveld Grassland (70%) (Low & Rebelo 1996).

Distribution North-West Province: In two sets of patches, one in the Wolmaransstad, Ottosdal and Hartbeesfontein region, and the other from the Botsolano Game Park north of Mafikeng to the vicinity of Madibogo in the south. Altitude 1 260–1 580 m.

Vegetation & Landscape Features Plains or slightly irregular undulating plains with open to dense *Acacia karroo* bush clumps in dry grassland.



S.S. Cilliers

Figure 8.33 Gh 12 Vaal Reefs Dolomite Sinkhole Woodland: Isolated woodland patches composed of trees *Acacia erioloba* and *Celtis africana* and shrubs such as *Grewia flava*, *Ehretia rigida* and *Asparagus laricinus* indicating the position of a dolomite sinkhole, surrounded by tall grassland with *Themeda triandra* (near Potchefstroom, North-West Province).

Geology & Soils Shale, slate and quartzite of the Pretoria Group with interlaid diabase sills and Hekpoort lava supporting relatively shallow and rocky soils (Glenrosa and Mispah forms), typical of the Fb land type. Equally represented are eutrophic red plinthic soils (Hutton form), derived mainly from a thick succession of volcanics and sediments of the Ventersdorp Supergroup (Bc land type). Bd and Ae of minor occurrence.

Climate Warm-temperate, summer-rainfall region, with overall MAP of 533 mm. Summer temperatures are high. Frequent frosts occur in winter. See also climate diagram for Gh 13 Klerksdorp Thornveld (Figure 8.23).

Important Taxa Small Trees: *Acacia karroo* (d), *A. caffra*, *Celtis africana*, *Rhus lancea*, *Ziziphus mucronata*. Tall Shrubs: *Acacia hebeclada*, *Diospyros lycioides* subsp. *lycioides*, *Ehretia rigida*, *Grewia flava*, *Gymnosporia buxifolia*, *Rhus pyroides*, *Tarchonanthus camphoratus*. Woody Climber: *Asparagus africanus*. Low Shrubs: *Asparagus laricin* (d), *A. suaveolens* (d), *Felicia muricata* (d), *Anthospermum hispidulum*, *A. rigidum* subsp. *pumilum*, *Aptosimum elongatum*, *Gnidia capitata*, *Gomphocarpus fruticosus* subsp. *fruticosus*, *Helichrysum dregeanum*, *Leucas capensis*, *Pavonia burchellii*, *Pentzia globosa*, *Solanum supinum* var. *supinum*, *Triumfetta sonderi*, *Ziziphus zeyheriana*. Graminoids: *Aristida congesta* (d), *Cynodon dactylon* (d), *Eragrostis lehmanniana* (d), *E. trichophora* (d), *Microchloa caffra* (d), *Panicum coloratum* (d), *Sporobolus fimbriatus* (d), *Themeda triandra* (d), *Andropogon schirensis*, *Antheophora pubescens*, *Aristida junciformis* subsp. *galpinii*, *A. stipitata* subsp. *graciliflora*, *Brachiaria nigropedata*, *B. serrata*, *Bulbostylis burchellii*, *Cymbopogon pospischilii*, *Digitaria eriantha*, *Diheteropogon amplexans*, *Elionurus muticus*, *Eragrostis curvula*, *E. obtusa*, *E. racemosa*, *E. superba*, *Eustachys paspaloides*, *Heteropogon contortus*, *Setaria sphacelata*, *Sporobolus africanus*, *Tragus berteronianus*, *Trichoneura grandiglumis*, *Triraphis andropogonoides*. Herbs: *Acalypha angustata*, *Acanthospermum australe*, *Berkheya onopordifolia* var. *onopordifolia*, *B. setifera*, *Blepharis integrifolia* var. *clarkei*, *Chamaesyce inaequilatera*, *Chascanum adenostachyum*, *Dicoma macrocephala*, *Helichrysum nudifolium* var. *nudifolium*, *Hermannia lancifolia*, *Hibiscus pusillus*, *Justicia anagalloides*, *Lippia scaberima*, *Nidorella microcephala*, *Nolletia ciliaris*, *Pollichia camp-*

estris, *Rhynchosia adenodes*, *Salvia radula*, *Selago densiflora*, *Teucrium trifidum*, *Tolpis capensis*. Geophytic Herbs: *Bulbine narcissifolia*, *Ledebouria marginata*, *Ornithogalum tenuifolium* subsp. *tenuifolium*, *Raphionacme hirsuta*. Herbaceous Climber: *Rhynchosia venulosa*.

Conservation Vulnerable. Target 24%. Only about 2.5% conserved in the statutory Mafikeng Game Reserve, private Botsolano Game Park and Faan Meintjes Nature Reserve. Almost a third already transformed for cultivation and by urban sprawl. This vegetation unit has a high grazing capacity and this leads to overutilisation and degradation, and subsequent invasion of *Acacia karroo* into adjacent dry grassland. Due to the great habitat and floristic diversity and for aesthetical reasons, the landscape deserves to be conserved.

References Louw (1951), Morris (1973, 1976), Bredenkamp & Bezuidenhout (1990), Bezuidenhout (1993), Bezuidenhout et al. (1994c, d).

Gh 14 Western Highveld Sandy Grassland

VT 50 Dry *Cymbopogon-Themeda* Veld (61%) (Acocks 1953). LR 37 Dry Sandy Highveld Grassland (74%) (Low & Rebelo 1996).

Distribution North-West Province: From Mafikeng to Schweizer-Reneke in the south and from Broedersput and Kameel in the west to Lichtenburg and Ottosdal in the east. Altitude 1 280–1 520 m, main area at 1 340–1 380 m.

Vegetation & Landscape Features Flat to gently undulating plains with short, dry grassland, with some woody species occurring in bush clumps.

Geology & Soils Basaltic lavas of the Klipriviersberg Group and andesitic lavas of the Allanridge Formation (both Ventersdorp Supergroup) covered by aeolian sand (western part of the area) or calcrete, with the eutrophic plinthic soils, which are mainly yellow apedals (Avalon and Pinedene) and rarely red apedals (Hutton) or Clovelly in bottomlands. Bd land type dominant.

Climate Warm-temperate, summer-rainfall region, with overall MAP of 520 mm. Summer temperatures are high. Severe frequent frost occurs in winter. See also climate diagram for Gh 14 Western Highveld Sandy Grassland (Figure 8.23).

Important Taxa Graminoids: *Antheophora pubescens* (d), *Aristida congesta* (d), *A. diffusa* (d), *Cymbopogon pospischilii* (d), *Cynodon dactylon* (d), *Eragrostis lehmanniana* (d), *E. trichophora* (d), *Panicum coloratum* (d), *Pogonarthria squarrosa* (d), *Setaria sphacelata* (d), *Sporobolus africanus* (d), *Themeda triandra* (d), *Aristida adscensionis*, *A. canescens*, *A. stipitata* subsp. *graciliflora*, *Brachiaria serrata*, *Digitaria argyrograpt*, *D. eriantha*, *Diheteropogon amplexans*, *Elionurus muticus*, *Eragrostis chloromelas*, *E. curvula*, *E. gummiflua*, *E. racemosa*, *Eustachys paspaloides*, *Heteropogon contortus*, *Melinis nerviglumis*, *Sporobolus discosporus*, *S. fimbriatus*, *Trichoneura grandiglumis*, *Triraphis andropogonoides*. Herbs: *Gazania krebsiana* subsp. *krebsiana* (d), *Stachys spathulata* (d), *Barleria macrostegia*, *Berkheya onopordifolia* var. *onopordifolia*, *Chamaecrista mimosoides*, *Chamaesyce inaequilatera*, *Dicoma anomala*, *D. macrocephala*, *Helichrysum callicomum*, *Hermannia depressa*, *H.*



E.M. Daemane

Figure 8.34 Gh 13 Klerksdorp Thornveld: *Acacia karroo*-dominated thickets in a grassland matrix of the eastern highveld near Klerksdorp (North-West Province).

tomentosa, *Kyphocarpa angustifolia*, *Lippia scaberrima*, *Monsonia burkeana*, *Nolletia ciliaris*, *Osteospermum muricatum* subsp. *longiradiatum*, *Pollichia campestris*, *Rhynchosia adenodes*, *Sebaea grandis*, *Trichodesma angustifolium* subsp. *angustifolium*, *Vernonia oligocephala*. Geophytic Herb: *Boophone disticha*. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum* (d), *Aptosimum elongatum*, *Felicia muricata*, *Gnidia capitata*, *Helichrysum paronychioides*, *Indigofera comosa*, *Leucas capensis*, *Polygala hottentotta*, *Sida dregei*, *Solanum panduriforme*, *Stoebe plumosa*. Tall Shrubs: *Acacia hebeclada*, *Diospyros lycioides* subsp. *lycioides*.

Conservation Endangered. Target 24%. Only a very small portion statutorily conserved (Barberspan Nature Reserve). More than 60% has been ploughed. Nonarable parts are on shallow aeolian soils which become easily overutilised through grazing. Erosion is very low. About 95% of this land is suitable for cultivation, but the low rainfall makes it a high-risk area for agriculture. Therefore the natural vegetation is often restricted to nonarable bush clumps, shallow soils, aeolian sands and pans.

Remarks Many endorheic pans (AZi 10 Highveld Salt Pans; see the chapter on Inland Azonal Vegetation in this book) are embedded within this grassland, especially in the north.

References Morris (1973, 1976), Bezuidenhout (1993), Bezuidenhout et al. (1993, 1994c).

Gh 15 Carletonville Dolomite Grassland

VT 61 Bankenveld (65%) (Acocks 1953). LR 34 Rocky Highveld Grassland (88%) (Low & Rebelo 1996).

Distribution North-West (mainly) and Gauteng and marginally into the Free State Province: In the region of Potchefstroom, Ventersdorp and Carletonville, extending westwards to the vicinity of Ottoshoop, but also occurring as far east as Centurion and Bapsfontein in Gauteng Province. Altitude 1 360–1 620 m, but largely 1 500–1 560 m.

Vegetation & Landscape Features Slightly undulating plains dissected by prominent rocky chert ridges. Species-rich grasslands forming a complex mosaic pattern dominated by many species.

Geology & Soils Dolomite and chert of the Malmani Subgroup (Transvaal Supergroup) supporting mostly shallow Mispah and Glenrosa soil forms typical of the Fa land type, dominating the landscapes of this unit. Deeper red to yellow apedal soils (Hutton and Clovelly forms) occur sporadically, representing the Ab land type.

Climate Warm-temperate, summer-rainfall region, with overall MAP of 593 mm. Summer temperatures high. Severe frequent frost occurs in winter. See also climate diagram for Gh 15 Carletonville Dolomite Grassland (Figure 8.23).

Important Taxa Graminoids: *Aristida congesta* (d), *Brachiaria serrata* (d), *Cynodon dactylon* (d), *Digitaria tricholaenoides* (d),



Figure 8.35 Gh 15 Carletonville Dolomite Grassland: Grassy rocky outcrop at Vlakplaats, west of Valhalla near Centurion (Gauteng) with prominent grasses such as *Loudetia simplex*, *Hyparrhenia hirta*, *Brachiaria serrata* and *Heteropogon contortus* and scattered shrubs including *Euclea undulata*, *Rhus magalismontana*, *Zanthoxylum capense* and *Diospyros lycioides*.

Diheteropogon amplexans (d), *Eragrostis chloromelas* (d), *E. racemosa* (d), *Heteropogon contortus* (d), *Loudetia simplex* (d), *Schizachyrium sanguineum* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Alloteropsis semialata* subsp. *eckloniana*, *Andropogon schirensis*, *Aristida canescens*, *A. diffusa*, *Bewisia biflora*, *Bulbostylis burchellii*, *Cymbopogon caesus*, *C. pospischilii*, *Elionurus muticus*, *Eragrostis curvula*, *E. gummiflua*, *E. plana*, *Eustachys paspaloides*, *Hyparrhenia hirta*, *Melinis nerviglumis*, *M. repens* subsp. *repens*, *Monocymbium ceresiiforme*, *Panicum coloratum*, *Pogonarthria squarrosa*, *Trichoneura grandiglumis*, *Triraphis andropogonoides*, *Tristachya leucothrix*, *T. rehmannii*. Herbs: *Acalypha angustata*, *Barleria macrostegia*, *Chamaecrista mimosoides*, *Chamaesyce inaequilatera*, *Crabbea angustifolia*, *Dianthus mooiensis*, *Dicoma anomala*, *Helichrysum caespitium*, *H. miconiifolium*, *H. nudifolium* var. *nudifolium*, *Ipomoea ommaneyi*, *Justicia anagalloides*, *Kohautia amatymbica*, *Kyphocarpa angustifolia*, *Ophrestia oblongifolia*, *Pollichia campestris*, *Senecio coronatus*, *Vernonia oligocephala*. Geophytic Herbs: *Boophone disticha*, *Habenaria mossii*. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum*, *Indigofera comosa*, *Pygmaeothamnus zeyheri* var. *rogersii*, *Rhus magalismontana*, *Tylosema esculentum*, *Ziziphus zeyheriana*. Geoxylic Suffrutices: *Elephantorrhiza elephantina*, *Parinari capensis* subsp. *capensis*.

Endemic Taxon Succulent Shrub: *Delosperma davyi*.

Conservation Vulnerable. Target 24%. Small extent conserved in statutory (Sterkfontein Caves—part of the Cradle of Humankind World Heritage Site, Oog Van Malmanie, Abe Bailey, Boskop Dam, Schoonspruit, Krugersdorp, Olifantsvlei, Groenkloof) and in at least six private conservation areas. Almost a quarter already transformed for cultivation, by urban sprawl or by mining activity as well as the building of the Boskop and Klerkskraal Dams. Erosion very low (84%) and low (15%).

References Louw (1951), Morris (1973, 1976), Coetzee (1974), Coetzee & Werger (1975), Van Wyk (1983), Van Wyk & Bredenkamp (1986), Bezuidenhout & Bredenkamp (1990), Scogings & Theron (1990), Bezuidenhout et al. (1994b, c, f), Bredenkamp et al. (1994), Grobler (2000), Hartmann (2001), Siebert & Siebert (2005), Grobler et al. (2006).

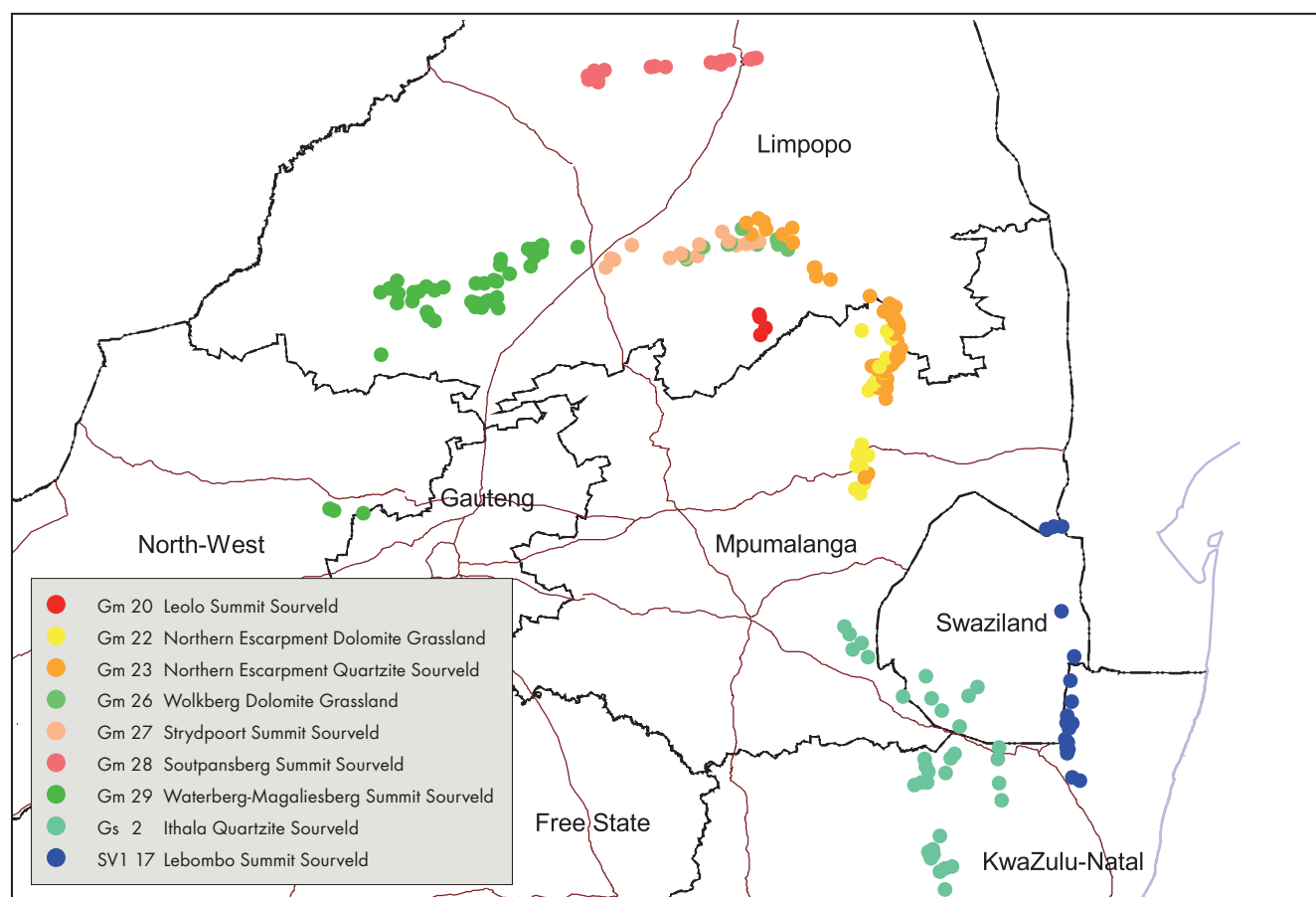


Figure 8.37 Position of the 'sourveld' grassland units, usually straddling the border of the Grassland and Savanna Biomes in the northern and northeastern regions of South Africa and Swaziland.

Mesic Highveld Grassland

Mesic Highveld Grassland is found mainly in the eastern, precipitation-rich regions of the Highveld, extending as far as the Northern Escarpment (Figure 8.36). These are considered to be 'sour' grasslands, and are dominated primarily by andropogonoid grasses. The different grassland units are distinguished on the basis of geology and other substrate properties, as well as elevation, topography and rainfall.

Shrublands are found on outcrops of rock within Mesic Highveld Grassland (Figure 8.24), where the surface topography creates habitats in which woody vegetation is favoured above grasses. This may include protection from fire and grazing or conditions under which woody plants can access subterranean water supplies. Generally, the higher the surface rock cover, the higher the cover of woody vegetation relative to herbaceous vegetation. The rocky outcrops are mostly of volcanic origin, e.g. dolerite, and are more resistant to weathering in addition to having more nutrient-rich soils.

Summit grasslands are a unique subgroup of the Mesic Highveld Grassland. They are sourvelds found on the summit of the mountain ranges that occur embedded within the Savanna Biome north of the 25° S latitude (Figure 8.37). There is a physical separation between these grasslands and other grassland vegetation in the core biome area of the central Highveld due to the presence of extensive areas of savanna woodlands in between. They are therefore extrazonal grassland vegetation units. The climate in these areas is generally warm and moist and it is the lack of well-developed soils as well as the unique

geological influences on these mountains that determines the presence of grassland vegetation instead of savanna in these areas, although the local increased elevation also simulates conditions found in the core Grassland Biome. Due to the substrate factors, the grasslands in these areas often have unique floristic elements and high levels of endemism.

Gm 1 Zastron Moist Grassland

VT 48 *Cymbopogon-Themedra* Veld (sandy) (77%) (Acocks 1953). LR 40 Moist Cold Highveld Grassland (80%) (Low & Rebelo 1996).

Distribution Eastern Cape and Free State Provinces and Lesotho: Surrounds of Zastron, extends just short of Van Stadensrus (north) to Mhales Hoek (northeast) and Rouxville (west). A narrow corridor extends south towards Jamestown and Dordrecht. Altitude 1 400–1 720 m.

Vegetation & Landscape Features Undulating plains, broken in places due to sandstone outcrops forming extensive terraces. These plains bear a mosaic of moist open sour grassland with affinity to Gm 4 Eastern Free State Sandy Grassland, on elevated areas above sandstone outcrops and Gm 3 Eastern Free State Clay Grassland in low-lying eroded areas as well as mudstone outcrops.

Geology & Soils Relatively deep sandy layer over the sandstone layers of the Tarkastad Subgroup (Molteno and Elliot Formations) of the Beaufort Group (Karoo Supergroup). Typical soil forms present on these sandstone terraces are Clovelly and Avalon. Clayey soils, which were formed by weathering and leaching processes, are concentrated in low-lying drainage lines,



Figure 8.38 Gm 1 Zastron Moist Grassland: Grasslands at the foot of Aasvoëlberg (2 208 m) near Zastron (Free State), with open shrublands of Gh 4 Besemkaree Koppies Shrubland on the slopes.

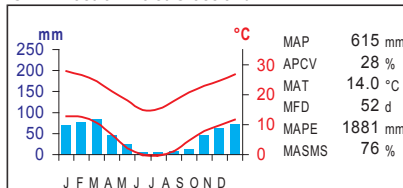
valley bottoms and depressions. Db land type dominates, with typical soil forms such as Estcourt and Oakleaf forms present. Fb and Ca land types of minor importance.

Climate Summer rainfall which peaks in March. MAP 615 mm. MAT of 14°C indicates cool-temperate climate. The inland position of the unit results in high thermal continentality: summers are very hot, while winter can be bitterly cold. Frost is a common phenomenon. See also climate diagram for Gm 1 Zastron Moist Grassland (Figure 8.36).

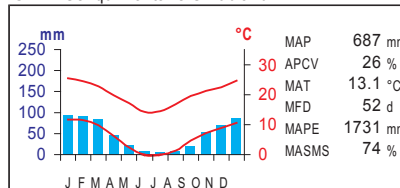
Important Taxa Graminoids: *Aristida congesta* (d), *Cymbopogon pospischilii* (d), *Digitaria argyrograptia* (d), *Eragrostis chloromelas* (d), *Microchloa caffra* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Andropogon appendiculatus*, *Brachiaria serrata*, *Cynodon incompletus*, *Cyperus obtusiflorus* var. *obtusiflorus*, *Elionurus muticus*, *Eragrostis capensis*, *E. curvula*, *E. lehmanniana*, *E. plana*, *E.*

L. Mucina

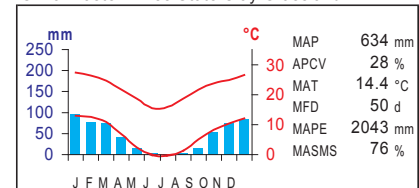
Gm 1 Zastron Moist Grassland



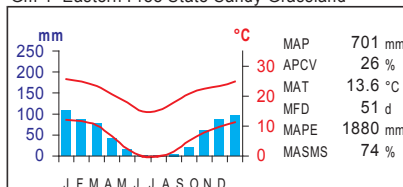
Gm 2 Senqu Montane Shrubland



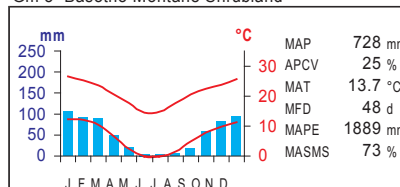
Gm 3 Eastern Free State Clay Grassland



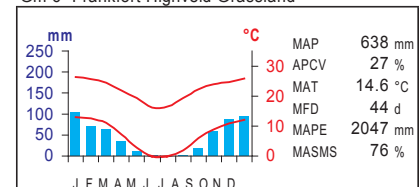
Gm 4 Eastern Free State Sandy Grassland



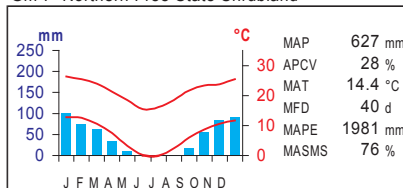
Gm 5 Basotho Montane Shrubland



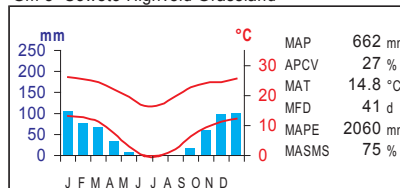
Gm 6 Frankfort Highveld Grassland



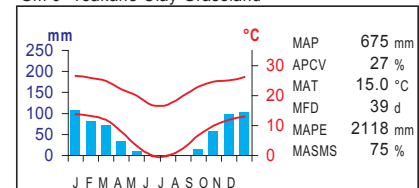
Gm 7 Northern Free State Shrubland



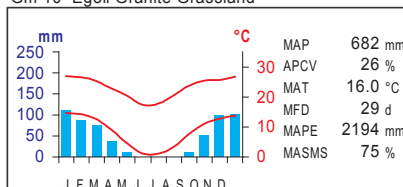
Gm 8 Soweto Highveld Grassland



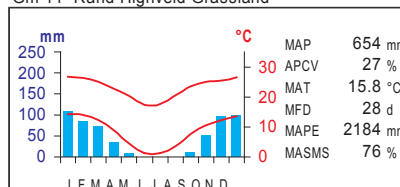
Gm 9 Tsakane Clay Grassland



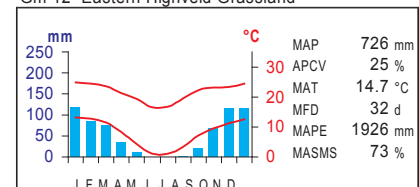
Gm 10 Egoli Granite Grassland



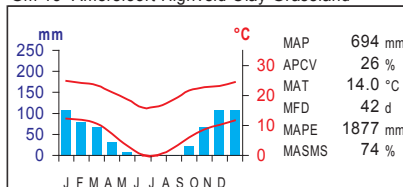
Gm 11 Rand Highveld Grassland



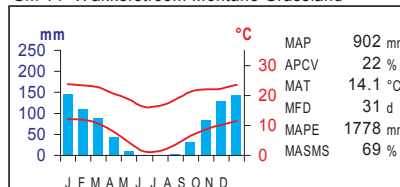
Gm 12 Eastern Highveld Grassland



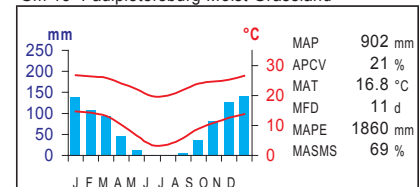
Gm 13 Amersfoort Highveld Clay Grassland



Gm 14 Wakkerstroom Montane Grassland



Gm 15 Paulpietersburg Moist Grassland



racemosa, *Festuca scabra*, *Harpochloa falx*, *Heteropogon contortus*, *Panicum gilvum*, *Sporobolus africanus*, *Tetrachne dregei*, *Trichoneura grandiglumis*, *Triraphis andropogonoides*. Herbs: *Berkheya onopordifolia* var. *onopordifolia*, *Dianthus thunbergii*, *Gazania krebsiana* subsp. *krebsiana*, *Helichrysum rugulosum*, *Hermannia depressa*, *Limeum argute-carinatum*, *Nolletia ciliaris*, *Salvia stenophylla*, *Senecio erubescens* var. *crepidifolius*, *Trichogyne paronychioides*, *Wahlenbergia denticulata*. Geophytic Herb: *Moraea pallida*. Low Shrubs: *Helichrysum dregeanum* (d), *Anthospermum rigidum* subsp. *pumilum*, *Chrysocoma ciliata*, *Felicia muricata*, *Helichrysum asperum* var. *albidulum*, *H. niveum*, *Selago saxatilis*, *Senecio burchellii*.

Endemic Taxon Geophytic Herb: *Dierama jucundum*.

Conservation Vulnerable. Target 24%. None conserved in statutory conservation areas and only very small portion protected in private Vulture Conservation Area. Almost a third already transformed by cultivation or by urban sprawl. Erosion high (45%), moderate (26%), very high (19%) and low (10%).

Remarks This unit is a mosaic of sweet and sour grassland communities interspersed with rock outcrops capped with dolerite and supporting Gh 4 Besemkaree Koppies Shrubland, or capped by sandstone and supporting Gm 5 Basotho Montane Shrubland. The slopes of the higher mountains such as Aasvoëlberg, Elandsberg, Vegkop and the like in the Zastron

District support Gm 5 Basotho Montane Shrubland containing some afromontane elements. This is the only area in the Free State where extensive stands of *Aloe ferox* are found. It is furthermore, together with the Gm 2 Senqu Montane Shrubland, the highest above sea level and furthest inland localities in the distribution range of *A. ferox*. Karroid shrublands are present in areas (such as Sterkspruit) that have suffered heavy overgrazing.

References Acocks (1953, 1988), Werger (1980), Du Preez & Bredenkamp (1991), Malan (1998), Malan et al. (1999).

Gm 2 Senqu Montane Shrubland

VT 48 *Cymbopogon–Themeda* Veld (sandy) (48%), VT 58 *Themeda–Festuca* Alpine Veld (47%) (Acocks 1953). LR 45 Afro Mountain Grassland (50%) (Low & Rebelo 1996).

Distribution Lesotho as well as in Eastern Cape and Free State Provinces (only marginal patches): Mainly in the lower Senqu Valley, particularly in the Moyeni (Quthing)–Mount Moorosi regions, strongly attenuating upstream northwards in the direction of Thaba-Tseka. Extends into South Africa mainly south of the Orange River (continuation of the Senqu River from Lesotho) in the Herschel District. This shrubland unit covers the

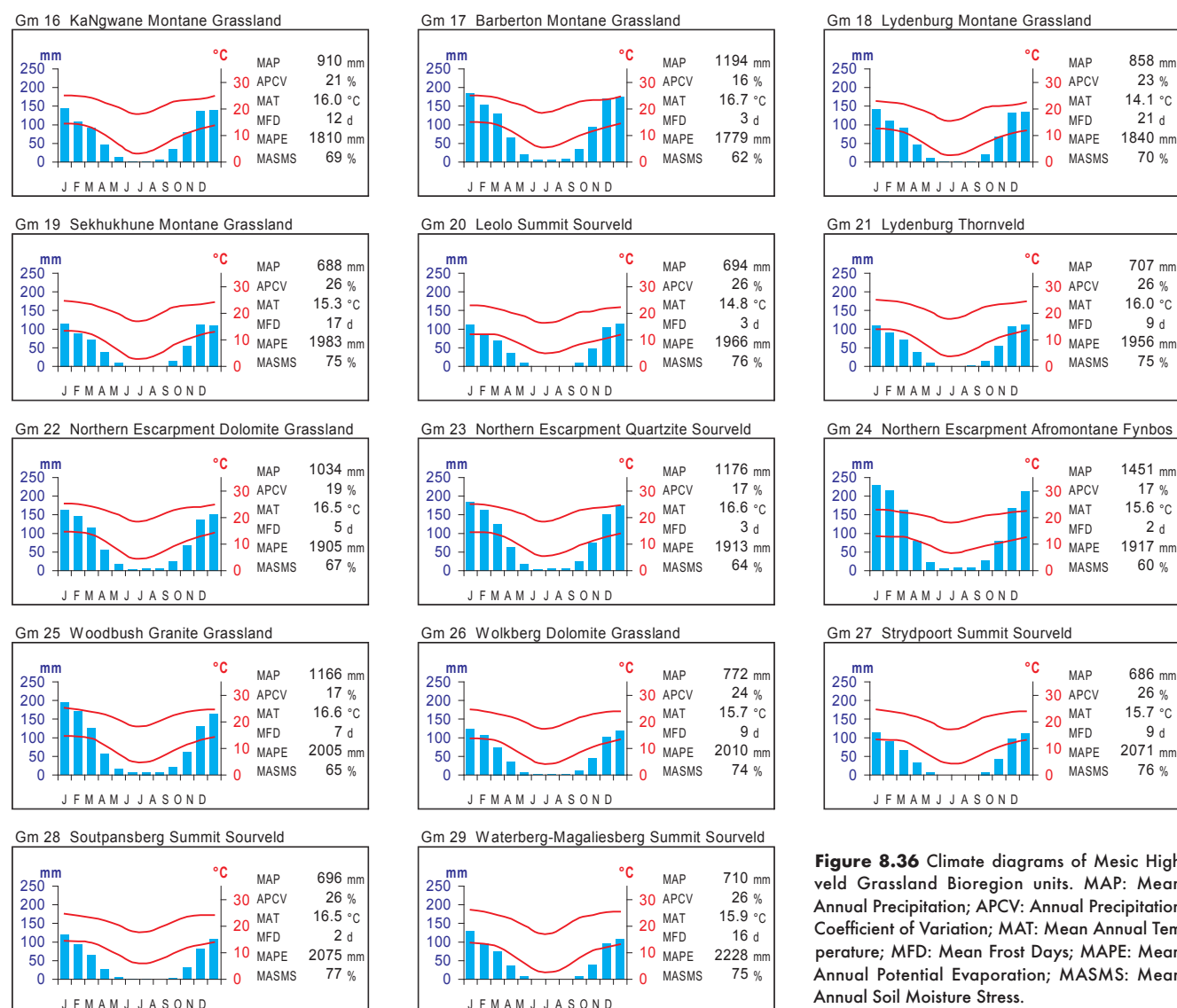


Figure 8.36 Climate diagrams of Mesic Highveld Grassland Bioregion units. MAP: Mean Annual Precipitation; APCV: Annual Precipitation Coefficient of Variation; MAT: Mean Annual Temperature; MFD: Mean Frost Days; MAPE: Mean Annual Potential Evaporation; MASMS: Mean Annual Soil Moisture Stress.



M.C. Rutherford

Figure 8.39 Gm 2 Senqu Montane Shrubland: Steep northern slopes of Thaba Moorosi dominated by *Aloe ferox* and shrubs including *Rhus erosa* and *Olea europaea* subsp. *africana* in the lower valley of the Quthing River shortly before it joins the Senqu River, north of the town of Mount Moorosi, Lesotho.

valley slopes of the Senqu River as well as its numerous tributaries. Altitude 1 600–1 900 m, with outliers found as low as 1 440 m and reaching 1 960 m in places.

Vegetation & Landscape Features Restricted to steep, boulder-strewn slopes of valleys and deep gullies, supporting open-canopy montane shrubland. The shrub species diversity decreases towards low-lying, southwestern areas. The vegetation is dominated by evergreen shrubs, namely *Rhus erosa*, *Olea europaea* and *Diospyros austro-africana*. In a few sheltered inaccessible areas the shrubland turns into thicket with *Kiggelaria africana*, *Leucosidea sericea* and *Rhamnus prinoides*.

Geology & Soils Karoo Supergroup sedimentary rocks of the Clarens, Elliot and Molteno Formations as the Senqu River cuts through the landscape in the low-lying southwestern regions. Intrusive Drakensberg Group (Jurassic) basalts at high altitudes at the interface with the Gd 8 Lesotho Highland Basalt Grassland. Dominant land type Fa, followed by the Ea. The most common soil forms that dominate these land types are Mispah and Glenrosa.

Climate Summer rainfall, with overall MAP of 687 mm. Much of the rainfall is convectional. Cool-temperate thermic pattern (MAT around 13°C), with 52 days of frost incidence. See also climate diagram for Gm 2 Senqu Montane Shrubland (Figure 8.36).

Important Taxa Succulent Tree: *Aloe ferox* (d). Small Trees: *Acacia karroo*, *Celtis africana*, *Cussonia paniculata*, *Kiggelaria africana*, *Pittosporum viridiflorum*. Tall Shrubs: *Diospyros austro-africana* var. *rubriflora* (d), *D. lycioides* subsp. *lycioides* (d), *Euclea coriacea* (d), *Rhamnus prinoides* (d), *Rhus divaricata*

(d), *R. erosa* (d), *Buddleja loricata*, *B. salviifolia*, *Clutia pulchella*, *Euclea crispa* subsp. *crispa*, *Grewia occidentalis*, *Gymnosporia heterophylla*, *Heteromorpha arborescens* var. *abyssinica*, *Myrsine africana*, *Olea europaea* subsp. *africana*, *Passerina montana*, *Polygala virgata* var. *decora*, *Rhus burchellii*, *R. dentata*, *R. pyroides*, *Tarchonanthus minor*. Low Shrubs: *Artemisia afra* (d), *Chrysocoma ciliata* (d), *Felicia filifolia* (d), *Helichrysum melanacme* (d), *Agathosma ovata*, *Anthospermum rigidum* subsp. *pumilum*, *Clutia hirsuta*, *Eriocephalus tenuifolius*, *Euryops oligoglossus* subsp. *oligoglossus*, *Gomphocarpus fruticosus* subsp. *fruticosus*, *Gomphostigma virgatum*, *Helichrysum odoratissimum*, *H. zeyheri*, *Heliophila carnosae*, *Indigofera nigromontana*, *Lantana rugosa*, *Melolobium candicans*, *Morella serrata*, *Muraltia saxicola*, *Nenax microphylla*, *Polygala uncinata*, *Printzia auriculata*, *Rhus dregeana*, *Rubus ludwigii*, *Senecio pterophorus*, *Solanum tomentosum*, *Stachys rugosa*. Succulent Shrubs: *Aloe broomii*, *Chasmatophyllum musculinum*, *C. verdoorniae*, *Delosperma ashtonii*, *D. concavum*, *D. congestum*, *D. hirtum*, *D. obtusum*, *Euphorbia clavarioides* var. *clavarioides*, *E. pulvinata*. Semiparasitic Shrub: *Osyris lanceolata*. Semiparasitic Epiphytic Shrub: *Viscum hoolei*. Graminoids: *Eragrostis curvula* (d), *Hyparrhenia hirta* (d), *Agrostis subulifolia*, *Andropogon appendiculatus*, *Aristida bipartita*, *A. congesta*, *A. diffusa*, *A. junci-formis* subsp. *galpinii*, *Brachiaria nigropedata*, *Cymbopogon nardus*, *C. pospischilii*, *Elionurus muticus*, *Eragrostis capensis*, *E. chloromelas*, *E. pallens*, *E. plana*, *E. planiculmis*, *E. racemosa*, *E. trichophora*, *Harpochloa falx*, *Helictotrichon longifolium*, *Heteropogon contortus*, *Hordeum capense*, *Hyparrhenia anamesa*, *Koeleria capensis*, *Melica decumbens*, *M. racemosa*, *Melinis nerviglumis*, *Merxmüllera disticha*, *Microchloa caffra*, *Pennisetum macrourum*, *P. sphacelatum*, *Pentstemon setifolia*, *Setaria sphacelata*, *Sporobolus africanus*, *S. centrifugus*, *S. fimbriatus*, *Stipagrostis uniplumis* var. *neesii*, *Streblochaete longiarista*, *Tetrachne dregei*, *Themeda triandra*, *Trachypogon spicatus*, *Tragus racemosus*, *Tristachya leucothrix*. Woody Climber: *Clematis brachiata*. Herbs: *Aster bakerianus*, *Berkheya setifera*, *Chamaesyce inaequilatera*, *Commelina africana*, *Convolvulus thunbergii*, *Dicoma anomala*, *Erucastrum strigosum*, *Geigeria filifolia*, *Gerbera piloselloides*, *Haplocarpha scaposa*, *Helichrysum caespititium*, *H. chionosphaerum*, *Hermannia coccocarpa*, *H. depressa*, *H. gerrardii*, *Lobelia flaccida*, *Monsonia angustifolia*, *Nemesia rupicola*, *Rhynchosia pentheri*, *Salvia stenophylla*, *Sebaea natalensis*, *Selago galpinii*, *Senecio asperulus*, *S. bupleuroides*, *S. subcoriaceus*, *Tribulus terrestris*, *Ursinia saxatilis*. Herbaceous Climbers: *Dolichos linearis*, *Kedrostis nana*. Geophytic Herbs: *Albuca setosa*, *Androcymbium burkei*, *Asclepias gibba*, *A. multicaulis*, *Bulbine abyssinica*, *B. capitata*, *B. frutescens*, *Cheilanthes eckloniana*, *C. viridis*, *Ledebouria cooperi*, *Moraea pallida*, *Pellaea calomelanos*, *Raphionacme hirsuta*, *Schizoglossum bidens* subsp. *bidens*, *Zantedeschia albomaculata* subsp. *albomaculata*. Succulent Herbs: *Aloe maculata*, *A. pratensis*, *Crassula capitella*, *C. lanceolata* subsp. *lanceolata*, *C. muscosa*, *C. nudicaulis*. Semiparasitic Herbs: *Alectra capensis*, *Thesium costatum* var. *juniperinum*.

Biogeographically Important Taxa (^DDrakensberg endemic, ^{Dg}Drakensberg endemic extending to Griqualand East) Low Shrubs: *Euryops tysonii*^D, *Relhania acerosa*^{Dg}, *R. dieterlenii*^D. Herbs: *Diascia integerrima*^D, *Helichrysum elegantissimum*^D.

Conservation Least threatened. Target 28%. None conserved in statutory conservation areas. Some 14% already transformed for cultivation. Wood collection is putting this vegetation under severe pressure. Accessible areas have been severely degraded and the shrubland has been reduced. Erosion (ranging across large scales of intensity), caused by degradation of the shrubland vegetation, has resulted in the formation of dongas that cut back into the valleys, destroying the remaining riparian

vegetation in places. Much of the upper reaches of this vegetation unit will disappear should the planned further phases (II, III and IV) of the Lesotho Highlands Water Project be implemented and result in the construction of the Mashai, Tsoelike and Ntoahae Dams.

Remarks This unit is possibly one of the driest of the moist grassland units, some areas with MAP below 600 mm and possibly in places even less than 550 mm (Anonymous 2000). Upstream along the Senqu River, at the Koma-Koma Causeway, the area appears almost hyper-arid, although it is difficult to assess the contribution of the high impact of human and animal pressures. This unit is also recognised by Anonymous (2000) as one of four 'ecological zones' of Lesotho.

References Boucher & Tlale (1999a, b), Anonymous (2000).

Gm 3 Eastern Free State Clay Grassland

VT 48 *Cymbopogon-Themeda* Veld (sandy) (83%) (Acocks 1953). LR 39 Moist Cool Highveld Grassland (73%) (Low & Rebelo 1996).

Distribution Free State Province and marginally in Lesotho: Low-lying areas of the eastern regions of the province, covering the vicinities of Wepener (south), Petrus Steyn (north), Excelsior and east of Winburg (west) and Warden (east) and a thin extension between Maseru and Fouriesburg. Altitude 1 380–1 740 m.

Vegetation & Landscape Features Flat to gently rolling land surfaces covered with grassland dominated by *Eragrostis curvula*, *Themeda triandra*, *Cymbopogon pospischilii*, *Eragrostis plana*, *Setaria sphacelata*, *Elionurus muticus* and *Aristida congesta*. Overgrazing in certain areas and selective grazing of the grassland create a patchy appearance, with dominant and diagnostic species associated with small to large patches of a few hectares in diameter. A wide range of grazing regimes on the macro-scale and within grazing units in the area on the micro-scale, create this fragmentation (Fuls 1993).

Geology & Soils Mudstones and sandstones of the Adelaide Formation (Beaufort Group) underlie this flat to slightly undulating terrain in the north, while the Tarkastad Formation (Beaufort

Group) dominates the geology in the south. Dolerite dykes and sills as well as sandstone outcrops, resistant to weathering, form isolated hills and ridges (Gm 5 Basotho Montane Shrubland) that create a broken landscape, especially in the southern parts of the unit. Sepane, Arcadia, Estcourt and Rensburg forms dominate the moist bottomlands while the Glenrosa, Bonheim, Avalon, Clovelly and Mayo forms dominate the outcrops and slightly elevated areas. Major land types Ca and Bd.

Climate Summer-rainfall region, with MAP around 630 mm. Much of the precipitation falls in form of thunderstorms between November and March. One of the coldest regions of the Highveld. Frost is very frequent in winter. See also climate diagram for Gm 3 Eastern Free State Clay Grassland (Figure 8.36).

Important Taxa Graminoids: *Andropogon appendiculatus* (d), *Aristida congesta* (d), *Brachiaria serrata* (d), *Cymbopogon pospischilii* (d), *Cynodon dactylon* (d), *Elionurus muticus* (d), *Eragrostis chloromelas* (d), *E. plana* (d), *Harpochloa falx* (d), *Heteropogon contortus* (d), *Microchloa caffra* (d), *Miscanthus capensis* (d), *Panicum gilvum* (d), *Pennisetum sphacelatum* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Aristida junciformis* subsp. *galpinii*, *Eragrostis capensis*, *E. gummiflua*, *E. racemosa*, *Panicum stapfianum*, *Setaria nigrirostris*, *Trichoneura grandiglumis*. Herbs: *Vernonia oligocephala* (d), *Ajuga ophrydis*, *Berkheya onopordifolia* var. *onopordifolia*, *Chamaesyce inaequilatera*, *Cineraria lyratiformis*, *Crabbea acaulis*, *Geigeria aspera* var. *aspera*, *Haplocarpha scaposa*, *Helichrysum rugulosum*, *Hermannia depressa*, *Hibiscus microcarpus*, *Monsonia burkeana*, *Nolletia ciliaris*, *Selago densiflora*, *Sonchus dregeanus*, *S. nanus*, *Tolpis capensis*. Geophytic Herbs: *Boophone disticha*, *Crinum bulbispermum*, *Kniphofia ritualis*, *Ledebouria macowanii*. Herbaceous Climber: *Rhynchosia totta*. Low Shrubs: *Helichrysum dregeanum* (d), *Anthospermum rigidum* subsp. *pumilum*, *Felicia muricata*, *Pentzia globosa*, *Stoebe plumosa*. Succulent Shrub: *Euphorbia clavarioides* var. *clavarioides*.

Conservation Endangered. Target 24%. Only a small portion statutorily conserved (Willem Pretorius Nature Reserve). More than half already transformed by cultivation or building of dams (Allemanskraal, Armenia, Egmont, Loch Lomond, Lovedale, Mushroom Valley and Newberry Dams). Erosion very low (34%), low (30%) and moderate (26%).

Remarks Several clusters of AZf 3 Eastern Temperate Freshwater Wetlands (playas) occur in an area between Lindley, Bethlehem, Warden and Petrus Steyn. These playas are probably the remains of palaeodrainage lines (Seaman 1987).

References Scheepers (1975), Seaman (1987), Du Preez (1991), Fuls (1993).

Gm 4 Eastern Free State Sandy Grassland

VT 56 Highland Sourveld to *Cymbopogon-Themeda* Veld Transition (Eastern Free State Highveld) (42%), VT 48 *Cymbopogon-Themeda* Veld (sandy) (31%) (Acocks 1953). LR 40 Moist Cold Highveld Grassland (60%) (Low & Rebelo 1996).

Distribution Free State Province, Lesotho and marginally into KwaZulu-Natal Province: Ladybrand (west) to the base of foothills of the Drakensberg (Maloti) and the Escarpment in the vicinity



L. Mucina

Figure 8.40 Gm 3 Eastern Free State Clay Grassland: Tall grasslands in the broad valley of the Klerkspruit near Bothasberg south of Kestell (eastern Free State). The peaks of the Rooiberge (Golden Gate Highlands National Park) are visible in the background.

ity of Harrismith (east) and Mafeteng (south). The towns of Marquard, Paul Roux, Bethlehem, Memel and Vrede bound this unit on its northern border. Altitude 1 520–1 800 m, but reaching 2 020 m in places.

Vegetation & Landscape Features Flat to slightly undulating and undulating terrain with streams and rivers that drain the foothills of the Drakensberg. Closed grassland dominated by *Eragrostis curvula*, *Tristachya leucothrix* and *Themeda triandra*. Other dominant grasses include *E. capensis*, *E. racemosa*, *Cymbopogon pospischilii*, *Elionurus muticus*, *Eragrostis plana* and *Aristida junciformis*. Numerous herb species (especially Asteraceae: species of *Helichrysum*, *Vernonia*, *Berkheya*) increase alpha diversity considerably. Embedded within many hills and small mountains carrying Gm 5 Basotho Montane Shrubland. Due to wide range of grazing and fire regimes, the grassland has a patchy appearance.

Geology & Soils Mudstones, sandstones and shale of the Beaufort Group (Tarkastad Formation in the south and Adelaide Formation in the north). Glenrosa, Bonheim, Avalon and Mayo soil forms dominate the outcrops and slightly elevated areas while Sepane, Arcadia and Rensburg soil forms are typical for moist bottomlands. Major land types Bb, Bd and Ca.

Climate Summer-rainfall region, with MAP around 700 mm. Much of the precipitation falls in form of thunderstorms between November and March. Great differences between the average temperatures in winter and summer as well as very frequent occurrence of frost confirm a continental climate. See also description of climate for Gm 3 Eastern Free State Clay Grassland and climate diagram for Gm 4 Eastern Free State Sandy Grassland (Figure 8.36).

Important Taxa Graminoids: *Aristida junciformis* subsp. *galpinii* (d), *Cymbopogon pospischilii* (d), *Digitaria monodactyla* (d), *D. tricholaenoides* (d), *Elionurus muticus* (d), *Eragrostis chloromelas* (d), *E. curvula* (d), *E. plana* (d), *E. racemosa* (d), *Harpochloa falx* (d), *Heteropogon contortus* (d), *Hyparrhenia hirta* (d), *Microchloa caffra* (d), *Monocymbium cerasiiforme* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Andropogon appendiculatus*, *A. schirensis*, *Aristida congesta*, *A. diffusa*, *Brachiaria serrata*, *Cymbopogon*

caesius, *Cynodon dactylon*, *Cyperus obtusiflorus* var. *flavissimus*, *C. obtusiflorus* var. *obtusiflorus*, *Diheteropogon amplexans*, *Ehrharta capensis*, *Eragrostis capensis*, *Helictotrichon natalense*, *H. turgidulum*, *Koeleria capensis*, *Panicum gylvum*, *Setaria nigrirostris*, *Trachypogon spicatus*, *Trichoneura grandiglumis*. Herbs: *Barleria monticola* (d), *Berkheya onopordifolia* var. *onopordifolia* (d), *B. speciosa* (d), *Dicoma anomala* (d), *Helichrysum psilolepis* (d), *Acalypha angustata*, *A. peduncularis*, *Ajuga ophrydis*, *Anthospermum herbaceum*, *Berkheya pinnatifida*, *B. setifera*, *Crabbea acaulis*, *Cynium racemosum*, *Dianthus basuticus*, *Haplocarpha scaposa*, *Hebenstretia dentata*, *H. dura*, *Helichrysum ammitophilum*, *H. aureonitens*, *H. caespititium*, *H. cephaloideum*, *H. herbaceum*, *H. nudifolium* var. *nudifolium*, *H. nudifolium* var. *pilosellum*, *H. oreophilum*, *H. rugulosum*, *H. spiralepis*, *Hermannia depressa*, *Hirpicium armerioides*, *Ipomoea crassipes*, *I. pellita*, *Kohautia amatymbica*, *Lactuca inermis*, *Nolletia ciliaris*, *Pelargonium luridum*, *Pentania prunelloides* subsp. *prunelloides*, *Selago densiflora*, *S. galpinii*, *Senecio coronatus*, *S. erubescens* var. *crepidifolius*, *S. inornatus*, *Sonchus nanus*, *Tolpis capensis*, *Trifolium burchellianum*, *Vernonia natalensis*, *V. oligocephala*. Geophytic Herbs: *Boophone disticha*, *Crinum bulbispermum*, *Cyrtanthus stenanthus*, *Drimiopsis maculata*, *Eucomis autumnalis* subsp. *autumnalis*, *Gladiolus dalenii*, *G. papilio*, *Hypoxis rigidula* var. *pilosissima*, *Ledebouria ovatifolia*, *Watsonia lepida*, *Xysmalobium involu-cratum*, *X. undulatum*. Herbaceous Climber: *Rhynchosia totta*. Low Shrubs: *Helichrysum melanacme* (d), *Anthospermum rigidum* subsp. *pumilum*, *Euphorbia striata* var. *cuspidata*, *Gnidia kraussiana*, *Helichrysum dasycephalum*, *Polygala hottentotta*, *Tephrosia capensis* var. *acutifolia*.

Biogeographically Important Taxon (Low Escarpment endemic) Low Shrub: *Heteromma krookii*.

Conservation Endangered. Target 24%. Around 2% statutorily conserved in the Qwaqwa and Golden Gate Highlands National Parks as well as in the Sterkfontein Dam Nature Reserve. Almost half already transformed for cultivation (maize), building of dams (e.g. Sterkfontein, Loch Athlone, Saulspoort). *Cirsium vulgare*, *Cosmos bipinnatus* (forming spectacular displays along road verges and on old fields), *Hypochaeris radicata*, *Plantago virginica*, *Tagetes minuta*, *Verbena bonariensis*, *V. brasiliensis*, *Richardia brasiliensis*, *Guilleminea densa* and others are frequent alien invaders and diminish the agricultural and biodiversity value of these grasslands. Erosion low (44%), very low (22%), moderate (19%) or high (15%).

Remark The abundance of many species of *Helichrysum* is conspicuous.

References Scheepers (1975), Potgieter (1982), Du Preez (1991), Eckhardt (1993), Fuls (1993), Fuls et al. (1993a), Kay et al. (1993), Eckhardt et al. (1995), Smit et al. (1995c).

Gm 5 Basotho Montane Shrubland

VT 48 *Cymbopogon-Themeda* Veld (sandy) (58%) (Acocks 1953). LR 40 Moist Cold Highveld Grassland (67%) (Low & Rebelo 1996).

Distribution Free State Province, Lesotho and very marginally into KwaZulu-Natal Province: Foothills of the west-facing Drakensberg (also Maloti) and mainly on the slopes of mesas over a wide area



L. Mucina

Figure 8.41 Gm 4 Eastern Free State Sandy Grassland: Species-rich grassland with *Helichrysum psilolepis* (and other seven congeners) on the Qwaqwa Campus of the University of the Free State at Phuthadijhaba (eastern Free State).



Figure 8.42 Gm 5 Basotho Montane Shrubland: Mosaic of grassland and shrubland with *Euclea crispa* and *Diospyros austro-africana* (*Buddleja salviifolia* and *Myrsine africana* in deeper kloofs) on Clarens sandstone at the foot of the northern slopes of the Qwaqwa Mountain near Phuthaditjhaba (eastern Free State).

in the vicinity of Zastron in the southwest, the surrounds of Mafeteng, Hobhouse, Maseru, Roma, Ladybrand, Clocolan, Excelsior, Ficksburg, Buttha-Buthe, Fouriesburg, Paul Roux, Bethlehem, Phuthaditjhaba as far as Harrismith in the northeast. This shrubland unit covers extensive areas in deeply incised river valleys of western Lesotho, especially those opening towards the south and west. Altitude 1 480–1 940 m.

Vegetation & Landscape Features Steep talus slopes and kloofs of the mesas and other mountain flanks supporting tall, in places very dense shrubland dominated by broad-leaved mesophyllous shrubs such as *Rhus erosa*, *Olea europaea* subsp. *africana*, *Euclea crispa* subsp. *crispa*, *Buddleja salviifolia*, *Leucosidea sericea*, *Rhus burchellii*, *Rhamnus prinoides*, *Scutia myrtina* and *Gymnopentzia buxifolia*. Mesas are often encircled by striking upper cliffs of Clarens Sandstone.

Geology & Soils The upper layers of the mudstones and sandstones of the Molteno, Elliot and Clarens Formations (Stormberg Group, Karoo Supergroup). The variations in weathering rates of the rocks resulted in the formation of numerous terraces along the slopes. In places the dolerite dykes cut through the thick sandstones, resulting in the formation of sheltered ravines. The soil surface is strewn with sandstone rocks and boulders. lb land type, characterised by miscellaneous soil forms, specially the Mispah, and Glenrosa forms, is dominant. Other land types of minor occurrence are Fa, Bb and Db.

Climate This unit receives more than 720 mm of MAP. Wepener and Harrismith score 629 and 624 mm, respectively, while some patches found closer to the Maloti Mountain range (such as on Qwaqwa Mountain near Phuthaditjhaba) may receive more than 1 400 mm in particularly wet years. Most of the rain falls in summer and much of it as convectional rain, with torrential storms. The overall MAT is 13.7°C. Summers are wet and hot, while winters are (as a rule) dry and with frequent frost. Snowfall is a rare event. See also climate diagram for Gm 5 Basotho Montane Shrubland (Figure 8.36).

Important Taxa Tall Shrubs: *Buddleja salviifolia* (d), *Euclea crispa* subsp. *ovata* (d), *Olea europaea* subsp. *africana* (d), *Diospyros whyteana*, *Heteromorpha arborescens* var. *abyssinica*, *Leucosidea sericea*, *Rhamnus prinoides*, *Rhus dentata*,

Tarchonanthus minor. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum*, *Euphorbia striata* var. *cuspidata*, *Felicia filifolia* subsp. *filifolia*, *F. muricata*, *Gnidia capitata*, *Myrsine africana*. Graminoids: *Andropogon appendiculatus* (d), *A. schirensis* (d), *Aristida congesta* (d), *Cymbopogon pospischilii* (d), *Cynodon dactylon* (d), *Elionurus muticus* (d), *Eragrostis chloromelas* (d), *E. plana* (d), *E. racemosa* (d), *Heteropogon contortus* (d), *Hyparrhenia hirta* (d), *Microchloa caffra* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Aristida diffusa*, *Brachiaria serrata*, *Digitaria tricholaenoides*, *Eragrostis capensis*, *E. curvula*, *Harpochloa falx*, *Pennisetum sphacelatum*, *Setaria nigrirostris*. Herbs: *Ajuga ophrydis*, *Cineraria lyratiformis*, *Conyza podocephala*, *Dicoma anomala*, *Haplocarpha scaposa*, *Helichrysum caespitium*, *H. nudifolium* var. *nudifolium*, *H. rugulosum*, *Hermannia depressa*, *Hibiscus microcarpus*, *Ipomoea crassipes*, *Nolletia ciliaris*, *Pollichia campestris*, *Selago densiflora*, *Senecio erubescens* var.

crepidifolius, *Tolpis capensis*, *Vernonia oligocephala*. Geophytic Herb: *Hypoxis rigidula* var. *pilosissima*. Herbaceous Climber: *Rhynchosia totta*.

Endemic Taxa Herbs: *Lessertia tenuifolia*, *Leucaena latisiliqua*.

Conservation Vulnerable. Target 28%. Only about 2% statutorily conserved in the Qwaqwa National Park, Golden Gate Highlands National Park and Sterkfontein Dam Nature Reserve. Erosion occurs at a wide range of intensity, including high (33%), moderate (26%) and very low (16%).

Remarks This shrubland unit is embedded in wet/moist grasslands such as the Eastern Free State Sandy Grassland and Zastron Moist Grassland. Locally, in deep, sheltered kloofs, this shrubland on rare occasions comes into contact with Northern Afrotemperate Forests. The unit includes the historically significant mesa of Thaba Bosiu in Lesotho.

References Müller (1986), Du Preez (1991), Du Preez & Bredenkamp (1991), Malan (1998), Malan et al. (1998, 1999), Müller (2002).

Gm 6 Frankfort Highveld Grassland

VT 53 *Themeda* Veld to *Cymbopogon*–*Themeda* Veld Transition (patchy) (79%) (Acocks 1953). LR 39 Moist Cool Highveld Grassland (95%) (Low & Rebelo 1996).

Distribution Free State and marginally Mpumalanga Provinces: Northeastern Free State—south and southeast of the Vaal Dam in the vicinity of Heilbron, Frankfort and Vrede. Altitude 1 460–1 800 m (mostly below 1 660 m).

Vegetation & Landscape Features Flat to slightly undulating and undulating terrain, with grassland dominated by *Eragrostis curvula* and *Themeda triandra*, accompanied by *E. capensis*, *E. plana*, *E. racemosa*, *Cymbopogon pospischilii*, *Elionurus muticus* and *Aristida junciformis*.

Geology & Soils Mudstone or shale with sandstone of the Adelaide Subgroup (Beaufort Group) with Jurassic Karoo dolerite intrusions. Soils are Glenrosa, Bonheim and Avalon, with Mayo forms dominating the outcrops and slightly elevated

areas, while the Sepane, Arcadia and Rensburg forms dominate the moist bottomlands. Much of the area (three quarters) is classified as Ea, while the rest is Ca land type.

Climate Summer-rainfall region, with MAP of 638 mm (much of which falls in the form of thunderstorms). MAT 14–15°C, indicating a cool to warm-temperature climate, characterised by great temperature differences between summer and winter (thermic continentality due to the deep-inland situation and high altitude of the unit). Occurrence of frost is frequent in winter. See also climate diagram for Gm 6 Frankfort Highveld Grassland (Figure 8.36).

Important Taxa Graminoids: *Aristida bipartita* (d), *A. diffusa* (d), *Brachiaria serrata* (d), *Cymbopogon pospischilii* (d), *Cynodon dactylon* (d), *Digitaria tri-cholaenoides* (d), *Elionurus muticus* (d), *Eragrostis chloromelas* (d), *E. curvula* (d), *E. plana* (d), *E. racemosa* (d), *Harpochloa falx* (d), *Heteropogon contortus* (d), *Hyparrhenia hirta* (d), *Setaria nigrirostris* (d), *S. sphacelata* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Andropogon appendiculatus*, *Aristida congesta*, *A. junciformis* subsp. *galpinii*, *Cymbopogon caesius*, *Cynodon hirsutus*, *Diheteropogon amplexans*, *Eragrostis capensis*, *Helictotrichon turgidulum*, *Koeleria capensis*, *Melinis nerviglumis*, *Microchloa caffra*, *Panicum stapfianum*, *Pennisetum sphacelatum*. Herbs: *Dicoma anomala* (d), *Vernonia oligocephala* (d), *Berkheya onopordifolia* var. *onopordifolia*, *B. pinnatifida*, *Crabbea acaulis*, *Geigeria aspera* var. *aspera*, *Haplocarpha scaposa*, *Helichrysum nudifolium* var. *nudifolium*, *H. rugulosum*, *Hermannia depressa*, *Jamesbrittenia aurantiaca*, *Kohautia amatymbica*, *Rhynchosia effusa*, *Selago densiflora*. Geophytic Herbs: *Boophone disticha*, *Hypoxis rigidula* var. *pilosissima*. Herbaceous Climber: *Rhynchosia totta*. Low Shrubs: *Anthospermum hispidulum*, *A. rigidum* subsp. *pumilum*, *Berkheya annectens*, *Solanum panduriforme*.

Conservation Vulnerable. Target 24%. None conserved in statutory conservation areas. More than a third already transformed for cultivation (maize) or flooded by dams (Vaal Dam). Erosion is very low (95%).

References Eckhardt et al. (1993a, b), Fuls et al. (1993c).

Gm 7 Northern Free State Shrubland

VT 48 *Cymbopogon–Themeda* Veld (sandy) (40%), VT 53 *Themeda* Veld to *Cymbopogon–Themeda* Veld Transition (patchy) (34%) (Acocks 1953). LR 39 Moist Cool Highveld Grassland (89%) (Low & Rebelo 1996).

Distribution Free State Province and marginally also into Mpumalanga Province: Northeastern regions of the Free State in the surrounds of Lindley (southwest), Bethlehem, Reitz, Frankfort and Vrede (northeast). Altitude 1 460–1 800 m, mostly 1 540–1 640 m.

Vegetation & Landscape Features Mainly restricted (as isolated pockets) to south-facing slopes of koppies, butts and tafelbergs as well as steep slopes of deeply incised rivers, where sandstone outcrops occur. Typically a two-layered, closed-canopy shrubland dominated by tall shrubs such as *Rhamnus prinoides*, *Leucosidea sericea*, *Buddleja salviifolia*, *Rhus dentata*,



Figure 8.43 Gm 7 Northern Free State Shrubland: Shrubland on the slopes of a solitary koppie, Houtkop (1 751 m), south of Reitz (eastern Free State).

Euclea crispa subsp. *crispa*, *Diospyros lycioides* and *Kiggelaria africana*. The lower layer is sparse grassland.

Geology & Soils Outcrops of especially Adelaide Subgroup (Beaufort Group, Karoo Supergroup) sandstones and to a lesser extent dolerite sills that protect sedimentary layers of sandstone, mudstone and siltstone from erosion. Soil forms that are typical of these rocky outcrops are the Glenrosa and Mispah forms. Ea land type is dominant (more than 50% of the area), accompanied by Dc and Bb.

Climate Summer-rainfall region, with 627 mm MAP. Much of the rainfall is convectional. The frost incidence is around 40 days. See also climate diagram for Gm 7 Northern Free State Shrubland (Figure 8.36).

Important Taxa Small Trees: *Kiggelaria africana* (d), *Cussonia paniculata*. Tall Shrubs: *Diospyros austro-africana* (d), *D. lycioides* subsp. *lycioides* (d), *Heteromorpha arborescens* var. *abyssinica* (d), *Leucosidea sericea* (d), *Rhamnus prinoides* (d), *Buddleja salviifolia*, *Calpurnia villosa*, *D. whyteana*, *Euclea crispa* subsp. *crispa*, *E. undulata*, *Grewia occidentalis*, *Melanthus dregeanus*, *Rhus dentata*, *R. pyroides*. Woody Climbers: *Asparagus asparagoides* (d), *Clematis oweniae*, *Dioscorea sylvatica*. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum*, *C. affinis*, *C. hirsuta*, *C. pulchella*, *Euphorbia striata* var. *cuspidata*, *Felicia muricata*, *F. petiolata*, *Garuleum woodii*, *Indigofera filipes*, *I. woodii*, *Myrsine africana*, *Rhus discolor*, *Rubus rigidus*, *Senecio burchellii*, *S. harveianus*, *Solanum panduriforme*, *Sutera polelensis* subsp. *polelensis*. Succulent Shrub: *Crassula dependens*. Semiparasitic Shrub: *Osyris lanceolata*. Graminoids: *Elionurus muticus* (d), *Eragrostis chloromelas* (d), *Hyparrhenia hirta* (d), *Microchloa caffra* (d), *Themeda triandra* (d), *Aristida congesta*, *A. diffusa*, *A. junciformis* subsp. *galpinii*, *Brachiaria serrata*, *Cymbopogon pospischilii*, *Eragrostis capensis*, *E. curvula*, *E. gummiflua*, *E. plana*, *Harpochloa falx*, *Helictotrichon turgidulum*, *Heteropogon contortus*, *Koeleria capensis*, *Melinis nerviglumis*, *Panicum gilvum*, *Pennisetum sphacelatum*, *Schoenoxiphium rufum*, *Setaria sphacelata*, *Tragus racemosus*, *Tristachya leucothrix*. Herbs: *Ajuga ophyridis*, *Centella asiatica*, *Chamaesyce inaequilatera*, *Cineraria aspera*, *Commelina africana*, *Convolvulus dregeanus*, *Conyza podocephala*, *Cyathula cylindrica*, *Erucastum austroafricanum*, *Geranium schlechteri*, *Helichrysum cephaloideum*, *H. rugulosum*,

Hermannia depressa, *Hibiscus aethiopicus* var. *ovatus*, *Lactuca inermis*, *Pollichia campestris*, *Pseudognaphalium undulatum*, *Rubia horrida*, *Salvia runcinata*, *Senecio hieracioides*, *S. isatideus*, *Solanum retroflexum*, *Stachys hyssopoides*, *S. natalensis*, *Trifolium africanum*, *Vernonia natalensis*. Geophytic Herbs: *Agapanthus campanulatus*, *Asclepias multicaulis*, *Cheilanthes quadripinnata*, *Eucomis autumnalis* subsp. *autumnalis*, *Hypoxis hemerocallidea*, *Mohria caffrorum*, *Oxalis corniculata*, *Pellaea calomelanos*, *Zantedeschia albomaculata* subsp. *albomaculata*. Succulent Herbs: *Crassula lanceolata*, *C. setulosa* var. *setulosa*.

Conservation Least threatened. Target 28%. None conserved in statutory conservation areas. Erosion very low (65%), low (23%) and moderate (12%).

References Fuls (1993), Fuls et al. (1993a, b), Eckhardt et al. (1997).

Gm 8 Soweto Highveld Grassland

VT 52 *Themeda* Veld (Turf Highveld) (56%) (Acocks 1953). LR 35 Moist Clay Highveld Grassland (51%) (Low & Rebelo 1996).

Distribution Mpumalanga, Gauteng (and to a very small extent also in neighbouring Free State and North-West) Provinces: In a broad band roughly delimited by the N17 road between Ermelo and Johannesburg in the north, Perdekop in the southeast and the Vaal River (border with the Free State) in the south. It extends further westwards along the southern edge of the Johannesburg Dome (including part of Soweto) as far as the vicinity of Randfontein. In southern Gauteng it includes the surrounds of Vanderbijlpark and Vereeniging as well as Sasolburg in the northern Free State. Altitude 1 420–1 760 m.

Vegetation & Landscape Features Gently to moderately undulating landscape on the Highveld plateau supporting short to medium-high, dense, tufted grassland dominated almost entirely by *Themeda triandra* and accompanied by a variety of other grasses such as *Elionurus muticus*, *Eragrostis racemosa*, *Heteropogon contortus* and *Tristachya leucothrix*. In places not disturbed, only scattered small wetlands, narrow stream alluvia, pans and occasional ridges or rocky outcrops interrupt the continuous grassland cover.



Figure 8.44 Gm 8 Soweto Highveld Grassland: Typical mesic highveld grassland with *Themeda triandra* and several *Eragrostis* species still found in some parts of southern Gauteng in natural condition.

Geology and Soils Shale, sandstone or mudstone of the Madzaringwe Formation (Karoo Supergroup) or the intrusive Karoo Suite dolerites which feature prominently in the area. In the south, the Volksrust Formation (Karoo Supergroup) is found and in the west, the rocks of the older Transvaal, Ventersdorp and Witwatersrand Supergroups are most significant. Soils are deep, reddish on flat plains and are typically Ea, Ba and Bb land types.

Climate Summer-rainfall region (MAP 662 mm). Cool-temperate climate with thermic continentality (high extremes between maximum summer and minimum winter temperatures, frequent occurrence of frost, large thermic diurnal differences, especially in autumn and spring). See also climate diagram for Gm 8 Soweto Highveld Grassland (Figure 8.36).

Important Taxa Graminoids: *Andropogon appendiculatus* (d), *Brachiaria serrata* (d), *Cymbopogon pospischilii* (d), *Cynodon dactylon* (d), *Elionurus muticus* (d), *Eragrostis capensis* (d), *E. chloromelas* (d), *E. curvula* (d), *E. plana* (d), *E. planiculmis* (d), *E. racemosa* (d), *Heteropogon contortus* (d), *Hyparrhenia hirta* (d), *Setaria nigrirostris* (d), *S. sphacelata* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Andropogon schirensis*, *Aristida adscensionis*, *A. bipartita*, *A. congesta*, *A. junciformis* subsp. *galpinii*, *Cymbopogon caesius*, *Digitaria diagonalis*, *Diheteropogon amplexans*, *Eragrostis micrantha*, *E. superba*, *Harpochloa falx*, *Microchloa caffra*, *Paspalum dilatatum*. Herbs: *Hermannia depressa* (d), *Acalypha angustata*, *Berkheya setifera*, *Dicoma anomala*, *Euryops gilfillanii*, *Geigeria aspera* var. *aspera*, *Graderia subintegra*, *Haplocarpha scaposa*, *Helichrysum miconiifolium*, *H. nudifolium* var. *nudifolium*, *H. rugulosum*, *Hibiscus pusillus*, *Justicia anagalloides*, *Lippia scaberrima*, *Rhynchosia effusa*, *Schistostephium crataegifolium*, *Selago densiflora*, *Senecio coronatus*, *Vernonia oligocephala*, *Wahlenbergia undulata*. Geophytic Herbs: *Haemanthus humilis* subsp. *hirsutus*, *H. montanus*. Herbaceous Climber: *Rhynchosia totta*. Low Shrubs: *Anthospermum hispidulum*, *A. rigidum* subsp. *pumilum*, *Berkheya annectens*, *Felicia muricata*, *Ziziphus zeyheriana*.

Conservation Endangered. Target 24%. Only a handful of patches statutorily conserved (Waldrift, Krugersdorp, Leeuwkuil, Suikerbosrand, Rolfe's Pan Nature Reserves) or privately conserved (Johanna Jacobs, Tweefontein, Gert Jacobs, Nikolaas and Avalon Nature Reserves, Heidelberg Natural Heritage Site). Almost half of the area already transformed by cultivation, urban sprawl, mining and building of road infrastructure. Some areas have been flooded by dams (Grootdraai, Leeukuil, Trichardtsfontein, Vaal, Willem Brummer). Erosion is generally very low (93%).

References Bredenkamp (1975, 1976, 1977), Bredenkamp & Theron (1978), Bezuidenhout & Bredenkamp (1991a).

Gm 9 Tsakane Clay Grassland

VT 48 *Cymbopogon-Themeda* Veld (sandy) (58%) (Acocks 1953). LR 39 Moist Cool Highveld Grassland (64%) (Low & Rebelo 1996).

Distribution Gauteng and Mpumalanga Provinces: In patches extending in a narrow band from Soweto to Springs, broadening southwards to Nigel and from there towards Vereeniging, as well

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as north of the Vaal Dam and between Balfour and Standerton (including Willemsdal). Altitude 1 480–1 680 m.

Vegetation & Landscape Features Flat to slightly undulating plains and low hills. Vegetation is short, dense grassland dominated by a mixture of common highveld grasses such as *Themeda triandra*, *Heteropogon contortus*, *Elionurus muticus* and a number of *Eragrostis* species. Most prominent forbs are of the families Asteraceae, Rubiaceae, Malvaceae, Lamiaceae and Fabaceae. Disturbance leads to an increase in the abundance of the grasses *Hyparrhenia hirta* and *Eragrostis chloromelas*.

Geology & Soils The most significant rock is the basaltic lava of the Klipriviersberg Group (Ventersdorp Supergroup), together with the sedimentary rocks of the Madzaringwe Formation of the Karoo Supergroup. Soils typical of Ba and Bb land types.

Climate Strongly seasonal summer rainfall, with very dry winters. MAP 630–720 mm. The overall MAT of 15°C indicates a transition between a cool-temperate and warm-temperate climate. The incidence of frost frequent, increasing towards the southeast. See also climate diagram for Gm 9 Tsakane Clay Grassland (Figure 8.36).

Important Taxa Graminoids: *Brachiaria serrata* (d), *Cynodon dactylon* (d), *C. hirsutus* (d), *Digitaria ternata* (d), *Elionurus muticus* (d), *Eragrostis chloromelas* (d), *E. patentipilosa* (d), *E. plana* (d), *E. racemosa* (d), *Heteropogon contortus* (d), *Hyparrhenia hirta* (d), *Microchloa caffra* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Trachypogon spicatus* (d), *Abildgaardia ovata*, *Andropogon schirensis*, *Cymbopogon caesius*, *Diheteropogon amplexans*, *Melinis nerviglumis*, *Panicum gilvum*, *Setaria nigrirostris*. Herbs: *Acanthospermum australe*, *Ajuga ophrydis*, *Eriosema salignum*, *Euryops transvaalensis* subsp. *transvaalensis*, *Gerbera viridifolia*, *Helichrysum nudifolium* var. *nudifolium*, *H. rugulosum*, *Hermannia depressa*, *Lotononis macrosepala*, *Nidorella hottentotica*, *Pentanisia prunelloides* subsp. *latifolia*, *Peucedanum caffrum*, *Rotheca hirsuta*, *Selago paniculata*, *Senecio coronatus*, *S. inornatus*, *Sonchus nanus*, *Vernonia oligocephala*. Geophytic Herbs: *Aspidoglossum ovalifolium*, *Hypoxis rigidula* var. *pilosissima*. Semiparasitic Herb: *Striga asiatica*. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum*, *Chaetacanthus setiger*, *Tephrosia capensis* var. *acutifolia*. Semiparasitic Shrub: *Thesium impletum*.

Conservation Endangered. Target 24%. Only 1.5% conserved in statutory reserves (Suikerbosrand, Olifantsvlei, Klipriviersberg, Marievale) and a small portion also in private nature reserves (Avalon, Ian P. Coetser, Andros). More than 60% transformed by cultivation, urbanisation, mining, dam-building and roads. Large portions of Alberton, Springs, Tsakane and part of Soweto (all south and east of Johannesburg) were built in the area of this vegetation unit. Urbanisation is increasing and further expansion of especially the southern suburbs of Johannesburg and the towns of the East Rand (especially the Brakpan District) will bring further pressure on the remaining vegetation. Erosion very low (87%) and low (11%) across the entire unit.

Remark 1 Grasslands in a part of this unit have been described as *Helichrysum rugulosum*–*Conyza podocephala* Grassland by Coetzee et al. (1995).

Remark 2 The unit contains a number of small pans, many of which have been disturbed, drained or are overgrazed and trampled.

References Acocks (1953, 1988), Bredenkamp (1975, 1976, 1977), Bredenkamp & Theron (1980), Coetzee et al. (1995).

Gm 10 Egoli Granite Grassland

VT 61 Bankenveld (100%) (Acocks 1953). LR 34 Rocky Highveld Grassland (100%) (Low & Rebelo 1996).

Distribution Gauteng Province: Johannesburg Dome extending in the region between northern Johannesburg in the south, and from near Lanseria Airport and Centurion (south of Pretoria) to the north, westwards to about Muldersdrif and eastwards to Tembisa. Altitude 1 280–1 660 m.

Vegetation & Landscape Features Moderately undulating plains and low hills supporting tall, usually *Hyparrhenia hirta*-dominated grassland, with some woody species on rocky outcrops or rock sheets. The rocky habitats show a high diversity of woody species, which occur in the form of scattered shrub groups or solitary small trees.

Geology & Soils Archaean granite and gneiss of the Halfway House Granite at the core of the Johannesburg Dome supporting leached, shallow, coarsely grained, sandy soil poor in nutrients of Glenrosa form. Small area is built by ultramafics. Dominant land types Bb and Ba.

Climate Strongly seasonal summer-rainfall region, with very dry winters. MAP 620–800 mm (overall average 680 mm). The coefficient of variation in MAP from 24–27% across the unit. Incidence of frost frequent, but higher in the south than the north. See also climate diagram for Gm 10 Egoli Granite Grassland (Figure 8.36).

Important Taxa Graminoids: *Aristida canescens* (d), *A. congesta* (d), *Cynodon dactylon* (d), *Digitaria monodactyla* (d), *Eragrostis capensis* (d), *E. chloromelas* (d), *E. curvula* (d), *E. racemosa* (d), *Heteropogon contortus* (d), *Hyparrhenia hirta*



Figure 8.45 Gm 10 Egoli Granite Grassland: Rocky outcrop at Knoppieslaagte, west of Valhalla near Centurion (Gauteng) with *Aloe greatheadii*, *Hypoxis rigidula*, *Pygmaeothamnus zeyheri*, *Thesium magalismontanum* and *Crassula capitella* and grasses such as *Elionurus muticus*, *Tristachya leucothrix*, *Melinis repens* and *Trachypogon spicatus*.

(d), *Melinis repens* subsp. *repens* (d), *Monocymbium cerasiiforme* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Andropogon eucomus*, *Aristida aequiglumis*, *A. diffusa*, *A. scabrivalvis* subsp. *borumensis*, *Bewisia biflora*, *Brachiaria serrata*, *Bulbostylis burchellii*, *Cymbopogon caesius*, *Digitaria tricholaenoides*, *Diheteropogon amplexans*, *Eragrostis gummiflua*, *E. sclerantha*, *Panicum natalense*, *Schizachyrium sanguineum*, *Setaria nigrirostris*, *Tristachya rehmannii*, *Urelytrum agropyroides*. Herbs: *Acalypha angustata*, *A. peduncularis*, *Becium obovatum*, *Berkheya insignis*, *Crabbea hirsuta*, *Cyanotis speciosa*, *Dicoma anomala*, *Helichrysium rugulosum*, *Justicia anagalloides*, *Kohautia amatymbica*, *Nidorella hottentotica*, *Pentanisia prunelloides* subsp. *latifolia*, *Pseudognaphalium luteo-album*, *Senecio venosus*. Geophytic Herbs: *Cheilanthes deltoidea*, *C. hirta*. Small Tree: *Vangueria infausta*. Tall Shrub: *Rhus pyroides*. Low Shrubs: *Anthospermum hispidulum*, *A. rigidum* subsp. *pumilum*, *Gnidia capitata*, *Helichrysium kraussii*, *Ziziphus zeyheriana*. Succulent Shrub: *Lopholaena coriifolia*.



Figure 8.46 Gm 11 Rand Highveld Grassland: Grasslands south of Bronkhorstspuit (Mpumalanga) dominated by grasses such as *Themeda triandra*, *Elionurus muticus*, *Diheteropogon amplexans* and *Tristachya leucothrix*.

Conservation Endangered. Target 24%. Only about 3% of this unit is conserved in statutory reserves (Diepsloot and Melville Koppies Nature Reserves) and a number of private conservation areas including Motsetse and Isaac Stegmann Nature Reserves, Kingskloof Natural Heritage Site, Melrose and Beaulieu Bird Sanctuaries as well as the Walter Sisulu National Botanical Garden. More than two thirds of the unit has already undergone transformation mostly by urbanisation, cultivation or by building of roads. Current rates of transformation threaten most of the remaining unconserved areas. There is no serious alien infestation in this unit, although species such as *Eucalyptus grandis*, *E. camaldulensis* and *E. sideroxylon* are commonly found. Erosion is moderate and very low.

Remark 1 This grassland is considered by some to be primary, though is heavily utilised, poor in species and degraded, and often resembles secondary grassland that developed on old fields.

Remark 2 So-called Witwatersrand serpentine sourveld (Reddy et al. 2001)—rocky grasslands on ultramafic rocks of a greenstone belt of uncertain origin—falls within this vegetation unit. Unlike in the Barberton region (see SVI 13 Barberton Serpentine Sourveld), the floristic composition of the Witwatersrand serpentines does not support separation of the ultramafic sourveld as a separate unit. So far no endemic taxa have been discovered on the Witwatersrand serpentines, the floristic composition of which is similar to that of the surrounding granite grassland.

References Acocks (1953, 1988), Grobler (2000), Ellery et al. (2001), Reddy et al. (2001).

Gm 11 Rand Highveld Grassland

VT 61 Bankenveld (64%) (Acocks 1953). LR 34 Rocky Highveld Grassland (45%), LR 38 Moist Sandy Highveld Grassland (21%) (Low & Rebelo 1996).

Distribution Gauteng, North-West, Free State and Mpumalanga Provinces: In areas between rocky ridges from Pretoria to Witbank, extending onto ridges in the Stoffberg and Roosenekal regions as well as west of Krugersdorp centred in

the vicinity of Derby and Potchefstroom, extending southwards and northeastwards from there. Altitude 1 300–1 635 m, but reaches 1 760 m in places.

Vegetation & Landscape Features Highly variable landscape with extensive sloping plains and a series of ridges slightly elevated over undulating surrounding plains. The vegetation is species-rich, wiry, sour grassland alternating with low, sour shrubland on rocky outcrops and steeper slopes. Most common grasses on the plains belong to the genera *Themeda*, *Eragrostis*, *Heteropogon* and *Elionurus*. High diversity of herbs, many of which belong to the Asteraceae, is also a typical feature. Rocky hills and ridges carry sparse (savannoid) woodlands with *Protea caffra* subsp. *caffra*, *P. welwitschii*, *Acacia caffra* and *Celtis africana*, accompanied by a rich suite of shrubs among which the genus *Rhus* (especially *R. magalismonata*) is most prominent.

Geology & Soils Quartzite ridges of the Witwatersrand Supergroup and the Pretoria Group as well as the Selons River Formation of the Rooiberg Group (last two are of the Transvaal Supergroup), supporting soils of various quality (shallow Glenrosa and Mispah forms especially on rocky ridges), typical of Ba, Bc, Bb and Ib land types.

Climate Strongly seasonal summer-rainfall, warm-temperate region, with very dry winters. MAP is 654 mm, ranging between 570 mm and 730 mm, slightly lower in the western regions. The coefficient of variation of MAP is 28% in the west and 26–27% in the east, and varies only slightly from 25% to 29% across the unit. The incidence of frost is higher in the west (30–40 days) than in the east (10–35 days). See also climate diagram for Gm 11 Rand Highveld Grassland (Figure 8.36).

Important Taxa Graminoids: *Ctenium concinnum* (d), *Cynodon dactylon* (d), *Digitaria monodactyla* (d), *Diheteropogon amplexans* (d), *Eragrostis chloromelas* (d), *Heteropogon contortus* (d), *Loudetia simplex* (d), *Monocymbium cerasiiforme* (d), *Panicum natalense* (d), *Schizachyrium sanguineum* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Trachypogon spicatus* (d), *Tristachya biseriata* (d), *T. rehmannii* (d), *Andropogon schirensis*, *Aristida aequiglumis*, *A. congesta*, *A. junciformis* subsp. *galpinii*, *Bewisia biflora*, *Brachiaria nigropedata*, *B. serrata*, *Bulbostylis burchellii*, *Cymbopogon caesius*, *Digitaria tricholaenoides*, *Elionurus muticus*, *Eragrostis capensis*, *E. curvula*, *E. gummiflua*, *E. plana*,

E. racemosa, *Hyparrhenia hirta*, *Melinis nerviglumis*, *M. repens* subsp. *repens*, *Microchloa caffra*, *Setaria nigrirostris*, *Sporobolus pectinatus*, *Trichoneura grandiglumis*, *Urelytrum agropyroides*. Herbs: *Acanthospermum australe* (d), *Justicia anagaloides* (d), *Pollichia campestris* (d), *Acalypha angustata*, *Chamaecrista mimosoides*, *Dicoma anomala*, *Helichrysum caespitium*, *H. nudifolium* var. *nudifolium*, *H. rugulosum*, *Ipomoea crassipes*, *Kohautia amatymbica*, *Lactuca inermis*, *Macledium zeyheri* subsp. *argyrophylum*, *Nidorella hottentotica*, *Oldenlandia herbacea*, *Rotheca hirsuta*, *Selago densiflora*, *Senecio coronatus*, *Sonchus dregeanus*, *Vernonia oligocephala*, *Xerophyta retinervis*. Geophytic Herbs: *Boophone disticha*, *Cheilanthes hirta*, *Haemanthus humilis* subsp. *humilis*, *Hypoxis rigidula* var. *pilosissima*, *Ledebouria ovatifolia*, *Oxalis corniculata*. Succulent Herb: *Aloe greatheadii* var. *davyana*. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum*, *Indigofera comosa*, *Rhus magalismontana*, *Stoebe plumosa*. Succulent Shrub: *Lopholaena coriifolia* (d). Geoxylic Suffrutex: *Elephantorrhiza elephantina*.

Biogeographically Important Taxa (all Northern sourveld endemics) Geophytic Herbs: *Agapanthus inapertus* subsp. *pendulus*, *Eucomis vandermerwei*. Succulent Herb: *Huernia insigniflora*. Low Shrub: *Melhania randii*.

Endemic Taxa Herbs: *Melanospermum rudolfii*, *Polygala spicata*. Succulent Herbs: *Anacampseros subnuda* subsp. *lubbersii*, *Frithia humilis*. Succulent Shrubs: *Crassula arborescens* subsp. *undulatifolia*, *Delosperma purpureum*. Small Trees: *Encephalartos lanatus*, *E. middelhburgensis*.

Conservation Endangered. Target 24%. Poorly conserved (only 1%). Small patches protected in statutory reserves (Kwaggavoeetpad, Van Riebeeck Park, Bronkhorstspuit, Boskop Dam Nature Reserves) and in private conservation areas (e.g. Doornkop, Zemvelo, Rhenosterpoort and Mpopomeni). Almost half has been transformed mostly by cultivation, plantations, urbanisation or dam-building. Cultivation may also have had an impact on an additional portion of the surface area of the unit where old lands are currently classified as grasslands in land-cover classifications and poor land management has led to degradation of significant portions of the remainder of this unit (D.B. Hoare, personal observation). Scattered aliens (most prominently *Acacia mearnsii*) occur in about 7% of this unit. Only about 7% has been subjected to moderate to high erosion levels.

Remark This vegetation unit is very varied and geographically disjunct and requires further investigation.

References Acocks (1953, 1988), Bezuidenhout (1988), Bezuidenhout & Breidenkamp (1991b), Coetzee (1993), Coetzee et al. (1994, 1995), Smit et al. (1997), Burgoyne et al. (2000), Grobler (2000), Grobler et al. (2006).

Gm 12 Eastern Highveld Grassland

VT 61 Bankenveld (42%), VT 57 North-Eastern Sandy Highveld (33%) (Acocks 1953). LR 38 Moist Sandy Highveld Grassland (69%) (Low & Rebelo 1996).

Distribution Mpumalanga and Gauteng Provinces: Plains between Belfast in the east and the eastern side of Johannesburg



Figure 8.47 Gm 12 Eastern Highveld Grassland: Grasslands of the Warburton area (Mpumalanga) with species of *Berkheya* and *Ipomoea* prominent in the foreground.

in the west and extending southwards to Bethal, Ermelo and west of Piet Retief. Altitude 1 520–1 780 m, but also as low as 1 300 m.

Vegetation & Landscape Features Slightly to moderately undulating plains, including some low hills and pan depressions. The vegetation is short dense grassland dominated by the usual highveld grass composition (*Aristida*, *Digitaria*, *Eragrostis*, *Themeda*, *Tristachya* etc.) with small, scattered rocky outcrops with wiry, sour grasses and some woody species (*Acacia caffra*, *Celtis africana*, *Diospyros lycioides* subsp. *lycioides*, *Parinari capensis*, *Protea caffra*, *P. welwitschii* and *Rhus magalismontanum*).

Geology & Soils Red to yellow sandy soils of the Ba and Bb land types found on shales and sandstones of the Madzaringwe Formation (Karoo Supergroup). Land types Bb (65%) and Ba (30%).

Climate Strongly seasonal summer rainfall, with very dry winters. MAP 650–900 mm (overall average: 726 mm), MAP relatively uniform across most of this unit, but increases significantly in the extreme southeast. The coefficient of variation in MAP is 25% across most of the unit, but drops to 21% in the east and southeast. Incidence of frost from 13–42 days, but higher at higher elevations. See also climate diagram for Gm 12 Eastern Highveld Grassland (Figure 8.36).

Important Taxa Graminoids: *Aristida aequiglumis* (d), *A. congesta* (d), *A. junciformis* subsp. *galpinii* (d), *Brachiaria serrata* (d), *Cynodon dactylon* (d), *Digitaria monodactyla* (d), *D. tricholaenoides* (d), *Elionurus muticus* (d), *Eragrostis chloromelas* (d), *E. curvula* (d), *E. plana* (d), *E. racemosa* (d), *E. sclerantha* (d), *Heteropogon contortus* (d), *Loudetia simplex* (d), *Microchloa caffra* (d), *Monocymbium cerasiiforme* (d), *Setaria sphacelata* (d), *Sporobolus africanus* (d), *S. pectinatus* (d), *Themeda triandra* (d), *Trachypogon spicatus* (d), *Tristachya leucothrix* (d), *T. rehmannii* (d), *Alloteropsis semialata* subsp. *eckloniana*, *Andropogon appendiculatus*, *A. schirensis*, *Bewisia biflora*, *Ctenium concinnum*, *Diheteropogon amplexans*, *Eragrostis capensis*, *E. gummiflua*, *E. patentissima*, *Harpochloa falx*, *Panicum natalense*, *Rendlia altera*, *Schizachyrium sanguineum*, *Setaria nigrirostris*, *Urelytrum agropyroides*. Herbs: *Berkheya setifera* (d), *Haplocarpha scaposa* (d), *Justicia anagaloides* (d), *Pelargonium luridum* (d), *Acalypha angustata*, *Chamaecrista*

mimosoides, *Dicoma anomala*, *Euryops gilfillanii*, *E. transvaalensis* subsp. *setilobus*, *Helichrysum aureonitens*, *H. caespitium*, *H. callicomum*, *H. oreophilum*, *H. rugulosum*, *Ipomoea crassipes*, *Pentanisia prunelloides* subsp. *latifolia*, *Selago densiflora*, *Senecio coronatus*, *Vernonia oligocephala*, *Wahlenbergia undulata*. Geophytic Herbs: *Gladiolus crassifolius*, *Haemanthus humilis* subsp. *hirsutus*, *Hypoxis rigidula* var. *pilosissima*, *Ledebouria ovatifolia*. Succulent Herb: *Aloe ecklonis*. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum*, *Stoebe plumosa*.

Conservation Endangered. Target 24%. Only very small fraction conserved in statutory reserves (Nooitgedacht Dam and Jericho Dam Nature Reserves) and in private reserves (Holkrans, Kransbank, Morgenstond). Some 44% transformed primarily by cultivation, plantations, mines, urbanisation and by building of dams. Cultivation may have had a more extensive impact, indicated by land-cover data. No serious alien invasions are reported, but *Acacia mearnsii* can become dominant in disturbed sites. Erosion is very low.

References Acocks (1953, 1988), Turner (1989), Coetzee (1993), Coetzee et al. (1994, 1995), Smit et al. (1997).

Gm 13 Amersfoort Highveld Clay Grassland

VT 54 *Themeda* Veld to Highland Sourveld Transition (43%), VT 57 North-Eastern Sandy Highveld (29%) (Acocks 1953). LR 41 Wet Cold Highveld Grassland (30%), LR 38 Moist Sandy Highveld Grassland (29%) (Low & Rebelo 1996).

Distribution Mpumalanga and KwaZulu-Natal Provinces: This unit extends in a north-south band from just south of Ermelo, down through Amersfoort to the Memel area in south. Altitude 1 580–1 860 m.

Vegetation & Landscape Features Comprised of undulating grassland plains, with small scattered patches of dolerite outcrops in areas. The vegetation is comprised of a short closed grassland cover, largely dominated by a dense *Themeda triandra* sward, often severely grazed to form a short lawn.

Geology & Soils Restricted to vertic clay soils derived from dolerite that is intrusive in the Karoo sediments of the Madzaringwe Formation in the north and the Volksrust Formation and the Adelaide Subgroup in the south. Dominant land type Ca, while Ea land type is of subordinate importance.

Climate Rainfall mainly in early summer, from 620 mm in the west to 830 mm in the east (MAP 694 mm). MAT 14°C, with temperatures higher in the west than the east. Winters are cold and summers are mild. Incidence of frost very high. Also see climate diagram for Gm 13 Amersfoort Highveld Clay Grassland (Figure 8.36).

Important Taxa Graminoids: *Andropogon appendiculatus* (d), *Brachiaria serrata* (d), *Digitaria monodactyla* (d), *D. tricholae-noides* (d), *Elionurus muticus* (d), *Eragrostis capensis* (d), *E. chloromelas* (d), *E. plana* (d), *E. racemosa* (d), *Harpochloa falx* (d), *Heteropogon contortus* (d), *Microchloa caffra* (d), *Panicum natalense* (d), *Setaria nigrirostris* (d), *S. sphacelata* (d), *Themeda*



Figure 8.48 Gm 13 Amersfoort Highveld Clay Grassland: Short grasslands with *Themeda triandra* and various *Helichrysum* species in the area between Volksrust and Ermelo (Mpumalanga).

triandra (d), *Trichoneura grandiglumis* (d), *Tristachya leucothrix* (d), *Abildgaardia ovata*, *Andropogon schirensis*, *Aristida bipartita*, *A. congesta*, *A. junciformis* subsp. *galpinii*, *A. stipitata* subsp. *graciliflora*, *Bulbostylis contexta*, *Chloris virgata*, *Cymbopogon caesius*, *C. pospischilii*, *Cynodon dactylon*, *Digitaria diagonalis*, *D. ternata*, *Diheteropogon amplexans*, *Eragrostis curvula*, *Koeleria capensis*, *Panicum coloratum*, *Setaria incrassata*. Herbs: *Berkheya setifera* (d), *Vernonia natalensis*, *V. oligocephala* (d), *Acalypha peduncularis*, *A. wilmsii*, *Berkheya insignis*, *B. pin-natifida*, *Crabbea acaulis*, *Cynoglossum hispidum*, *Dicoma anomala*, *Haplocarpha scaposa*, *Helichrysum caespitium*, *H. rugulosum*, *Hermannia coccocarpa*, *H. depressa*, *H. transvaalensis*, *Ipomoea crassipes*, *I. oblongata*, *Jamesbrittenia silenoides*, *Pelargonium luridum*, *Pentanisia prunelloides* subsp. *latifolia*, *Peucedanum magalismontanum*, *Pseudognaphalium luteo-album*, *Rhynchosia effusa*, *Salvia repens*, *Schistostephium crataegifolium*, *Sonchus nanus*, *Wahlenbergia undulata*. Herbaceous Climber: *Rhynchosia totta*. Geophytic Herbs: *Boophone disticha*, *Eucomis autumnalis* subsp. *clavata*, *Hypoxis villosa* var. *obliqua*, *Zantedeschia albomaculata* subsp. *macrocarpa*. Tall Shrubs: *Diospyros austro-africana*, *D. lycioides* subsp. *guerkei*. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum* (d), *Helichrysum melanacme* (d), *Chaetacanthus costatus*, *Euphorbia striata* var. *cuspidata*, *Gnidia burchellii*, *G. capitata*, *Polygala uncinata*, *Rhus discolor*. Succulent Shrub: *Euphorbia clavarioides* var. *truncata*.

Conservation Vulnerable. The conservation target is 27% but none is protected. Some 25% of unit is transformed, predominantly by cultivation (22%). The area is not suited to afforestation. Silver and black wattle (*Acacia* species), and *Salix babylonica* invade drainage areas. Erosion potential is very low (57%) and low (40%).

Remarks Overgrazing leads to invasion of *Stoebe vulgaris* (aptly named bankrupt bush). Parts of this unit were once cultivated and now lie fallow and have been left to re-vegetate with pioneer species. These transformed areas are not picked up by satellite for transformation coverage and the percentage of grasslands still in a natural state may be underestimated.

References Acocks (1953, 1988), Breytenbach (1991), Smit (1992), Breytenbach et al. (1993), Smit et al. (1995a, c).

Gm 14 Wakkerstroom Montane Grassland

VT 57 North-Eastern Sandy Highveld (57%) (Acocks 1953). LR 38 Moist Sandy Highveld Grassland (49%), LR 41 Wet Cold Highveld Grassland (27%) (Low & Rebelo 1996).

Distribution KwaZulu-Natal and Mpumalanga Provinces: Occurring from the Escarpment just north of Sheepmoor (north), to southeast of Utrecht, and then from the vicinity of Volksrust in the west to Mandhlangampisi Mountain near Luneburg in the east. Altitude 1 440–2 200 m.

Vegetation & Landscape Features This unit is a less obvious continuation of the Escarpment that links the southern and northern Drakensberg escarpments. It straddles this divide and is comprised of low mountains and undulating plains. The vegetation comprises predominantly short montane grasslands on the plateaus and the relatively flat areas, with short forest and *Leucosidea* thickets occurring along steep, mainly east-facing slopes and drainage areas. *L. sericea* is the dominant woody pioneer species that invades areas as a result of grazing mismanagement.

Geology & Soils The mudstones, sandstones and shale of the Madzaringwe and Volksrust Formations (Karoo Supergroup) were intruded by voluminous Jurassic dolerite dykes and sills. Ac land type dominant, while Fa and Ca are of subordinate importance.

Climate Rainfall peaks in midsummer. Rainfall 800–1 250 mm per year (MAP 902 mm). This unit experiences an orographic effect which results in a locally higher precipitation than the adjacent areas. Winters very cold and summers mild (MAT 14°C). See also climate diagram for Gm 14 Wakkerstroom Montane Grassland (Figure 8.36).

Important Taxa Small Trees: *Canthium ciliatum*, *Protea subvestita*. Tall Shrubs: *Buddleja salviifolia* (d), *Leucosidea sericea* (d), *Buddleja auriculata*, *Diospyros lycioides* subsp. *guerkei*, *Euclea crispa* subsp. *crispa*, *Rhus montana*, *R. rehmanniana*, *R. transvaalensis*. Low Shrubs: *Asparagus devenishii* (d), *Cliffortia linearifolia* (d), *Helichrysum melanacme* (d), *H. splendidum* (d), *Anthospermum rigidum* subsp. *pumilum*, *Clutia natalensis*, *Erica oatesii*, *Felicia filifolia* subsp. *filifolia*, *Gymnosporia heterophylla*, *Helichrysum hypoleucum*, *Hermannia geniculata*, *Inulanthera dregeana*, *Metalasia densa*, *Printzia pyrifolia*, *Rhus discolor*,

Rubus ludwigii subsp. *ludwigii*. Graminoids: *Andropogon schirensis* (d), *Ctenium concinnum* (d), *Cymbopogon caesius* (d), *Digitaria tricholaenoides* (d), *Diheteropogon amplexans* (d), *Eragrostis chloromelas* (d), *E. plana* (d), *E. racemosa* (d), *Harpochloa falx* (d), *Heteropogon contortus* (d), *Hyparrhenia hirta* (d), *Microchloa caffra* (d), *Themeda triandra* (d), *Trachypogon spicatus* (d), *Tristachya leucothrix* (d), *Alloteropsis semialata* subsp. *eckloniana*, *Aristida junciformis* subsp. *galpinii*, *Brachiaria serrata*, *Diheteropogon filifolius*, *Elionurus muticus*, *Eragrostis capensis*, *Eulalia villosa*, *Festuca scabra*, *Loudetia simplex*, *Rendlia altera*, *Setaria nigrirostris*. Herbs: *Berkheya onopordifolia* var. *glabra* (d), *Cephalaria natalensis* (d), *Pelargonium luridum* (d), *Acalypha depressinerva*, *A. peduncularis*, *A. wilm-sii*, *Aster bakerianus*, *Berkheya setifera*, *Euryops transvaalensis* subsp. *setilobus*, *Galium thunbergianum* var. *thunbergianum*, *Geranium ornithopodioides*, *Helichrysum cephaloideum*, *H. cooperi*, *H. monticola*, *H. nudifolium* var. *nudifolium*, *H. oreophilum*, *H. simillimum*, *Pentanisia prunelloides* subsp. *latifolia*, *Plectranthus laxiflorus*, *Sebaea leiostyla*, *S. sedoides* var. *sedoides*, *Selago densiflora*, *Vernonia hirsuta*, *V. natalensis*, *Wahlenbergia cuspidata*. Geophytic Herbs: *Hypoxis costata* (d), *Agapanthus inapertus* subsp. *intermedius*, *Asclepias aurea*, *Cheilanthes hirta*, *Corycium dracomontanum*, *C. nigrescens*, *Cyrtanthus tuckii* var. *transvaalensis*, *Disa versicolor*, *Eriospermum cooperi* var. *cooperi*, *Eucomis bicolor*, *Geum capense*, *Gladiolus ecklonii*, *G. sericeovillosus* subsp. *sericeovillosus*, *Hesperantha coccinea*, *Hypoxis rigidula* var. *pilosissima*, *Moraea brevistyla*, *Rhodohypoxis baurii* var. *confecta*. Semiparasitic Herb: *Striga bilabiata* subsp. *bilabiata*.

Biogeographically Important Taxa (^LLow Escarpment endemic, ^NNorthern sourveld endemic) Low Shrubs: *Bowkeria citrina*^L, *Lotononis amajubica*^L, *Protea parvula*^N. Succulent Herb: *Aloe modesta*^N.

Endemic Taxa Herbs: *Helichrysum aureum* var. *argenteum*, *Selago longicalyx*. Geophytic Herbs: *Kniphofia* sp. nov. ('*laxiflora* Form C'), *Nerine platypetala*. Woody Climber: *Asparagus fractiflexus*.

Conservation Least threatened. Conservation target 27%, less than 1% is statutorily protected in the Paardeplaats Nature Reserve. There are 10 South African Natural Heritage Sites in this unit, although very little of it is formally protected. Land use pressures from agriculture are low (5% cultivated) probably owing to the colder climate and shallower soils. The area is also suited to afforestation, with more than 1% under *Acacia mearnsii* and *Eucalyptus* plantations. The black wattle (*Acacia mearnsii*) is an aggressive invader of riparian areas. Erosion very low (78%) and low (19%).

Remarks This unit represents the northernmost distribution limit for many plant taxa that occur on the Drakensberg Escarpment (e.g. *Helichrysum hypoleucum* and *Protea subvestita*) to the south, as well as the southernmost limit for plants occurring on the Northern Escarpment (e.g. *Protea parvula*). It also contains many of its own endemics and is under investigation as a possible centre of endemism. The higher rainfall and more temperate climate on a somewhat raised escarpment have possibly been conducive to the evolution of local endemics. Unlike its adjacent units, the



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Figure 8.49 Gm 14 Wakkerstroom Montane Grassland: Frost-tolerant grasslands of the Wakkerstroom area (Mpumalanga) with herbs *Senecio scitus* and *Helichrysum nudifolium* and dominated by the grass *Themeda triandra*.

Wakkerstroom Montane Grassland is largely devoid of *Pteridium aquilinum*.

References Acocks (1953, 1988), Codd (1968), Eckhardt et al. (1997).

Gm 15 Paulpietersburg Moist Grassland

VT 64 Northern Tall Grassveld (Transition between Piet Retief Sourveld and Southern Tall Grassveld) (60%) (Acocks 1953). LR 43 North-eastern Mountain Grassland (86%) (Low & Rebelo 1996). BRG 11 Moist Transitional Tall Grassveld (53%) (Camp 1999a).

Distribution KwaZulu-Natal and Mpumalanga Provinces: Broad surrounds of Piet Retief, Paulpietersburg and Vryheid, extending westwards to east of Wakkerstroom. Occurs in the uppermost catchments of the Phongolo River. Altitude 920–1 500 m.

Vegetation & Landscape Features Mainly undulating with moderately steep slopes, but valley basins are wide and flat and mountainous areas occur mostly along the northern and eastern boundary. Tall closed grassland rich in forbs and dominated by *Tristachya leucothrix*, *Themeda triandra* and *Hyparrhenia hirta*. Evergreen woody vegetation is characteristic on rocky outcrops.

Geology & Soils This area is underlain by Archaean granite and gneiss partly covered by Karoo Supergroup sediments (Madzaringwe Formation) and intruded by Karoo Dolerite Suite dykes and sills. Dominant soils on the sedimentary parent material are yellow apedal, well drained, with a depth of >800 mm and a clay content of >35%, representing the soil series: Hutton, Clovelly and Griffin. Shortlands soils are dominant on dolerite. Dominant land type Ac, with Fa and Ba of subordinate importance.

Climate Summer rainfall, with MAP 900 mm. Warm-temperate climate, MAT close to 17°C, with fairly frequent frosts. See also climate diagram for Gm 15 Paulpietersburg Moist Grassland (Figure 8.36).

Important Taxa Graminoids: *Alloteropsis semialata* subsp. *eckloniana* (d), *Andropogon schirensis* (d), *Brachiaria serrata* (d), *Ctenium concinnum* (d), *Cymbopogon caesus* (d), *Digitaria tricholaenoides* (d), *Eragrostis racemosa* (d), *Harpochloa falk* (d), *Heteropogon contortus* (d), *Hyparrhenia hirta* (d), *Loudetia simplex* (d), *Microchloa caffra* (d), *Monocymbium cereiiforme* (d), *Rendlia altera* (d), *Setaria nigrirostris* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Andropogon appendiculatus*, *Cynodon hirsutus*, *Diheteropogon amplexans*, *D. filifolius*, *Elionurus muticus*, *Eragrostis chloromelas*, *E. curvula*, *E. plana*, *Festuca scabra*, *Melinis nerviglumis*, *Panicum ecklonii*, *P. natalense*, *Trachypogon spicatus*, *Urelytrum agropyroides*. Herbs: *Argyrobolus speciosus* (d), *Cissus diversilobata* (d), *Dicoma zeyheri* (d), *Eriosema kraussianum* (d), *Geranium wakkerstroomianum* (d), *Helichrysum nudifolium* var. *nudifolium* (d), *Ipomoea oblongata* (d), *Pelargonium luridum* (d), *Acalypha glandulifolia*, *A. peduncularis*, *Acanthospermum australe*, *Aster bakerianus*, *Becium filamentosum*, *Berkheya setifera*, *Dicoma anomala*, *Euryops laxus*, *E. transvaalensis* subsp. *setilobus*, *E. transvaalensis* subsp. *transvaalensis*, *Helichrysum rugulosum*, *H. similimum*, *Indigofera hiliaris* var. *hiliaris*, *I. velutina*, *Kohautia amatymbica*, *Pearsonia grandifolia*, *Pentanisia prunelloides* subsp. *latifolia*, *Senecio bupleuroides*, *S. coronatus*, *S. inornatus*, *S. isatideus*, *S. latifolius*, *Sonchus nanus*,



Figure 8.50 Gm 15 Paulpietersburg Moist Grassland: Short grassland along the old Piet Retief–Wakkerstroom road (northern KwaZulu-Natal) interrupted by drainage lines supporting shrublands with *Leucosidea sericea*.

Thunbergia atriplicifolia, *Vernonia capensis*, *V. natalensis*, *Xerophyta retinervis*. Herbaceous Climber: *Rhynchosia totta*. Geophytic Herbs: *Chlorophytum haygarthii* (d), *Gladiolus aurantiacus* (d), *Agapanthus inapertus* subsp. *intermedius*, *Asclepias aurea*, *Cheilanthes hirta*, *Cyrtanthus tuckii* var. *transvaalensis*, *Hypoxis colchicifolia*, *H. costata*, *H. rigidula* var. *pilosissima*, *Moraea brevistyla*, *Pteridium aquilinum*, *Watsonia latifolia*, *Zantedeschia rehmannii*. Succulent Herbs: *Aloe ecklonis*, *A. maculata*, *Lopholaena segmentata*. Small Trees: *Canthium ciliatum* (d), *Dombeya rotundifolia*, *Vangueria infausta*. Succulent Tree: *Aloe marlothii* subsp. *marlothii*. Tall Shrubs: *Calpurnia sericea* (d), *Rhus rehmanniana* (d), *Diospyros lycioides* subsp. *guerkei*, *Euclea crispa* subsp. *crispa*. Low Shrubs: *Rhus discolor* (d), *Anthospermum rigidum* subsp. *pumilum*, *A. rigidum* subsp. *rigidum*, *Clusia monticola*, *Diospyros galpinii*, *Erica oatesii*, *E. woodii*, *Hermannia geniculata*, *Indigofera arrecta*, *Otholobium wilmsii*, *Polygala uncinata*, *Pseudarthria hookeri*, *Rubus rigidus*. Succulent Shrub: *Euphorbia pulvinata*.

Biogeographically Important Taxa (all Low Escarpment endemics) Succulent Herb: *Aloe modesta*. Low Shrubs: *Bowkeria citrina*, *Hemizygia macrophylla*, *Lotononis amajubica*.

Endemic Taxon Succulent Shrub: *Aloe reitzii* var. *vernalis*.

Conservation Vulnerable. Target 24%. Only very small portion statutorily conserved in Witbad, Vryheid Mountain, Paardeplaats and Phongola Bush Nature Reserves. Some private reserves protect small patches (Rooikraal, Mhlongamvula, Kombewaria). About one third already transformed by plantations or cultivated land. Heavy livestock grazing and altered fire regimes have greatly reduced the area of grasslands of high conservation value. Aliens such as species of *Acacia*, *Eucalyptus* and *Pinus* are of major concern in places. Erosion very low (80%) or low (13%).

References Acocks (1953, 1988), Eckhardt et al. (1996a, c), Eckhardt (1998), Camp (1999a).

Gm 16 KaNgwane Montane Grassland

VT 63 Piet Retief Sourveld (57%) (Acocks 1953). LR 43 North-eastern Mountain Grassland (98%) (Low & Rebelo 1996).

Distribution Mpumalanga and Swaziland, and marginally into northern KwaZulu-Natal: Occurs along the gentle slopes of the



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Figure 8.51 Gm 16 KaNgwane Montane Grassland: Lush mesophilous grassland with rich post-fire display of herbs (*Gerbera viridifolia*, *Chascanum latifolium*) near Piet Retief (Mpumalanga).

Escarpment, from the Phongolo Valley in the south, northwards to the Usutu Valley and to the uppermost Lomati Valley near Carolina, including the western grassland areas of Swaziland. Altitude 880–1 740 m.

Vegetation & Landscape Features Largely comprised of undulating hills and plains that occur on the eastern edge of the Escarpment. This unit is transitional between the Highveld and Escarpment and contains elements of both. The vegetation structure is comprised of a short closed grassland layer with many forbs, and a few scattered shrubs on the rocky outcrops.

Geology & Soils Mostly on granite of the Mpuluzi Granite (Randian Erathem), Archaean gneiss giving rise to melanitic soils, with intrusions of diabase. Land types Ac, Fa and Ba.

Climate Early summer rainfall, with MAP 910 mm, ranging between 800 and 1 250 mm. This unit has a wide range of frost frequency (3–20 days per year), with most frost days occurring in the western regions. See also climate diagram for Gm 16 KaNgwane Montane Grassland (Figure 8.36).

Important Taxa Graminoids: *Alloteropsis semialata* subsp. *eckloniana* (d), *Brachiaria serrata* (d), *Cyperus obtusiflorus* (d), *Diheteropogon amplexans* (d), *D. filifolius* (d), *Eragrostis racemosa* (d), *Heteropogon contortus* (d), *Hyparrhenia hirta* (d), *Loudetia simplex* (d), *Monocymbium cerasiiforme* (d), *Rendlia altera* (d), *Themeda triandra* (d), *Trachypogon spicatus* (d), *Tristachya leucothrix* (d), *Andropogon schirensis*, *Bewisia biflora*, *Bulbostylis burchellii*, *Ctenium concinnum*, *Cymbopogon caesioides*, *Cyperus obtusiflorus* var. *obtusiflorus*, *Digitaria diagonalis*, *D. tricholaenoides*, *Eragrostis chloromelas*, *E. plana*, *Eulalia villosa*, *Panicum ecklonii*, *P. natalense*, *Paspalum scrobiculatum*, *Schizachyrium sanguineum*, *Setaria nigrirostris*, *S. sphacelata*. Herbs: *Ipomoea oblongata* (d), *Acalypha peduncularis*, *A. villicaulis*, *Alepidea setifera*, *Argyrolobium speciosum*, *Aster harveyanus*, *Berkheya setifera*, *Corchorus confusus*, *Cyathula cylindrica*, *Dicoma zeyheri*, *Dimorphotheca jucunda*, *Eriosema cordatum*, *Euryops laxus*, *E. transvaalensis* subsp. *setilobus*, *Helichrysum adenocarpum*, *H. cephaloideum*, *H. nudifolium* var. *nudifolium*, *Mohria caffrorum*, *Pentanisia angustifolia*, *P. prunelloides* subsp. *latifolia*, *Ruellia patula*, *Schistostephium crataegifolium*, *Senecio panduriformis*, *Sonchus wilmsii*, *Thunbergia atriplicifolia*, *Vernonia natalensis*, *V. oligocephala*. Geophytic Herbs: *Agapanthus inapertus* subsp. *inapertus*, *Boophone*

disticha, *Cheilanthes deltoidea*, *C. hirta*, *Eucomis montana*, *Gladiolus ecklonii*, *Habenaria dregeana*, *Hypoxis iridifolia*, *H. rigidula* var. *pilosissima*, *Moraea pubiflora*, *Pteridium aquilinum*, *Watsonia latifolia*, *Zantedeschia albomaculata* subsp. *macrocarpa*. Succulent Herbs: *Aloe integrifolia*, *A. kniphofioidea*. Small Trees: *Acacia caffra*, *Faurea rochetiana*, *Pachystigma macrocalyx*. Tree Fern: *Cyathea dregei*. Tall Shrubs: *Calpurnia glabrata*, *Cephalanthus natalensis*, *Diospyros lycioides* subsp. *guerkei*, *Vernonia tigna*. Low Shrubs: *Heteromorpha involucrata* (d), *Anthospermum rigidum* subsp. *rigidum*, *Asparagus cooperi*, *A. virgatus*, *Athrixia phyllicoides*, *Diospyros scabrida* var. *cordata*, *Gymnosporia heterophylla*, *Indigofera comosa*, *Myrsine africana*, *Rhus discolor*, *Schistostephium rotundifolium*.

Biogeographically Important Taxa

(^{BC}Barborton endemic, ^NNorthern sourveld endemic) Herbs: *Hemizygia modesta*^{BC}, *H. thorncroftii*^{BC}, *Selago stewartii*^{BC}. Geophytic Herb: *Watsonia watsonioides*^N. Succulent Herb: *Kleinia galpinii*^N. Low Shrub: *Hemizygia albiflora*^N.

Endemic Taxa Herbs: *Lotononis difformis*, *L. spicata*, *Streptocarpus occultis*. Low Shrub: *Syncolostemon comptonii*.

Conservation Vulnerable. The conservation target 27% with only 0.4% protected within any formally proclaimed nature reserves (Malalotja, Nooitgedacht Dam and Songimvelo). A number of private conservation areas protect small patches of this unit. It is well suited for afforestation and 30% has already been converted to plantations of alien trees. A further 6% is under cultivation. Erosion potential very low (55%) and low (7%).

Remark This area occurs on the southern edge of the Barborton Centre of Endemism.

References Acocks (1953, 1988), De Frey (1999), Van Wyk & Smith (2001).

Gm 17 Barborton Montane Grassland

VT 9 Lowveld Sour Bushveld (41%), VT 8 North-Eastern Mountain Sourveld (34%) (Acocks 1953). LR 21 Sour Lowveld Bushveld (54%) (Low & Rebelo 1996).

Distribution Mpumalanga Province and northwestern Swaziland: From Barborton westwards towards Nelshoogte, northwards along the high-lying grassland areas towards Kaapmuiden and Malelane, and southeast towards Piggs Peak. It generally occurs at high altitudes in the Barborton region, ranging from 760 m in the north to 1 640 m in the southwest.

Vegetation & Landscape Features This unit occurs along the high mountains above Barborton, which rise above the surrounding Lowveld. The terrain is steep, rugged and accessibility is limited. The dominant vegetation is short rocky grassland and gradually becomes woodland along the lower slopes.

Geology & Soils Barborton Supergroup schists, gneiss, felspathic quartzites and various lavas of the Figtree, Moodies, and Onverwacht Formations. Land types Fa (60%) and Ac (20%).

Climate Early summer rainfall, concentrated between November and March. MAP varies between 950 mm in the

west, to 1 470 mm in the east (overall MAP 1 194 mm). Frosts are very infrequent during winter (3 days per year) and increase towards the west (10 days). Hot dry winds occur from August to October. See also climate diagram for Gm 17 Barberton Montane Grassland (Figure 8.36).

Important Taxa Small Trees: *Faurea galpinii*, *F. rochetiana*, *F. saligna*, *Rapanea melanophloeos*. Tree Fern: *Cyathea dregei*. Tall Shrubs: *Cephalanthus natalensis* (d), *Euryops brevipapposus*, *Gerrardina foliosa*, *Protea gaguedi*. Low Shrubs: *Phymaspermum athanasoides* (d), *Clutia pulchella*, *Erica cerinthoides*, *E. drakensbergensis*, *E. woodii*, *Helichrysum odoratissimum*, *Heteromorpha involucrata*, *Leucospermum gerrardii*, *Protea simplex*, *Psoralea glabra*, *Schistostephium rotundifolium*, *Siphonoglossa linifolia*. Succulent Shrub: *Aloe vryheidensis*. Graminoids: *Alloteropsis semialata* subsp. *eckloniana* (d), *Andropogon schirensis* (d), *Ctenium concinnum* (d), *Eragrostis racemosa* (d), *Eulalia villosa* (d), *Loudetia simplex* (d), *Monocymbium cerasiiforme* (d), *Rendlia altera* (d), *Themeda triandra* (d), *Brachiaria serrata*, *Brachypodium flexum*, *Digitaria monodactyla*, *Diheteropogon amplexans*, *Hyparrhenia hirta*, *Ischyrolepis schoenoides*, *Melinis nerviglumis*, *Panicum ecklonii*, *P. natalense*, *Pentastichis natalensis*, *Setaria nigristrostris*, *Trachypogon spicatus*, *Tristachya leucothrix*. Herbs: *Acalypha caperonioides*, *A. glandulifolia*, *Euryops laxus*, *Helichrysum adenocarpum*, *H. nudifolium* var. *oxyphyllum*, *H. pallidum*, *Selago procera*, *Xerophyta retinervis*. Geophytic Herbs: *Agapanthus inapertus* subsp. *intermedius*, *Cheilanthes hirta*, *Eucomis montana*, *Haemanthus montanus*, *Ledebouria sandersonii*, *Merwillia natalensis*, *Satyrium cristatum*.

Biogeographically Important Taxa (^{BC}Barberton endemic, ^NNorthern sourveld endemic, ^PPondoland link) Small Trees: *Encephalartos paucidentatus*^N, *Faurea galpinii*^N, *Protea compactonii*^N. Tall Shrub: *Tricalysia capensis* var. *galpinii*^N. Low Shrubs: *Asparagus rigidus*^N, *Helichrysum milleri*^N, *H. mimetes*^N, *H. reflexum*^N, *Hemizygia parvifolia*^N, *Heteromorpha pubescens*^N, *Kotschyia parvifolia*^N, *Melhanie randii*^N, *Protea parvula*^N, *Syncolostemon eriocephalus*^N. Succulent Shrubs: *Aloe chortolirioides* var. *chortolirioides*^N, *A. suprafoliata*^N. Herbs: *Senecio rhyncholaenus*^P (d), *Hemizygia foliosa*^N, *H. modesta*^{BC}, *H. thorn-*

croftii^{BC}, *H. transvaalensis*^N, *Inezia integrifolia*^N, *Monsonia transvaalensis*^N, *Pearsonia aristata*^N, *Phymaspermum argenteum*^N, *Selago stewartii*^{BC}, *S. villosa*^N, *Streptocarpus galpinii*^N, *Thorncroftia longiflora*^N. Geophytic Herbs: *Agapanthus inapertus* subsp. *hollandii*^N, *Aspidonepsis shebae*^N, *Cyrtanthus thorncroftii*^N, *Gladiolus varius*^N, *Watsonia occulta*^N, *W. watsonioides*^N. Succulent Herbs: *Aloe craibii*, *Kleinia galpinii*^N.

Endemic Taxa Small Trees: *Encephalartos heenanii*, *Protea caffra* subsp. *falcata*, *P. roupelliae* subsp. *hamiltonii*. Tall Shrub: *Tinnea barbata*. Herbs: *Euryops discoideus*, *Helichrysum calocephalum*, *Hemizygia stalmansii*, *Holothrix culveri*, *Streptocarpus pogonites*, *Thorncroftia thorncroftii*. Geophytic Herb: *Disa intermedia*. Succulent Herb: *Aloe albidia*.

Conservation Vulnerable. The conservation target of 27% has almost been reached as 26% of this unit is protected within nature reserves (Songimvelo Game Reserve and Mountainlands Nature Reserve). Almost 40% has been transformed by plantations. Erosion potential very low (75%) and low (9%).

Remarks This vegetation unit occurs within the Barberton Centre of Plant Endemism and the endemics are predominantly comprised of herbaceous plants on a dystrophic substrate. Pockets of forests occur in fire-protected areas.

References Acocks (1953, 1988), Stalmans et al. (1999), Van Wyk & Smith (2001).

Gm 18 Lydenburg Montane Grassland

VT 57 North-Eastern Sandy Highveld (53%) (Acocks 1953). LR 43 North-eastern Mountain Grassland (73%) (Low & Rebelo 1996).

Distribution Mpumalanga Province: From just above Pilgrim's Rest in the north, southwards and westwards skirting Lydenburg, extending to Dullstroom, to Belfast and Waterval Boven in the south. It includes both the Steenkampsberg and Mauchsberg. Altitude 1 260–2 160 m.

Vegetation & Landscape Features High-altitude plateaus, undulating plains, mountain peaks and slopes, hills and deep valleys of the Northern Escarpment region, supporting predominantly very low grasslands on the high-lying areas. Height of the grass sward increases on the lower slopes. The grassland is very rich in forb species.

Geology & Soils The soils are mostly derived from shale and quartzite as well as lavas and dolomites of the Pretoria Group of the Transvaal Supergroup (Vaalian Erathem). Land types Ac and Fa cover areas of approximately equal size.

Climate Orographic precipitation and mists throughout most months of the year support a unique flora, including rich mesophytic plants such as the Orchidaceae. MAP 858 mm (660–1 180 mm), augmented by the frequent mists. Frost days 21 days per year, varying greatly between 3 and 40, generally more frost to the west. See also climate diagram for Gm 18 Lydenburg Montane Grassland (Figure 8.36).

Important Taxa Small Trees: *Protea roupelliae* subsp. *roupelliae* (d), *Faurea*



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Figure 8.52 Gm 17 Barberton Montane Grassland: A mosaic of short grassland and rocky shrubland with *Burchellia bubalina*, *Helichrysum reflexum*, *Psychotria capensis* and *Aloe albidia* on the Saddleback Mountain, southeast of Barberton (Mpumalanga).

galpinii. Low Shrubs: *Phymaspermum acerosum* (d), *Anthospermum rigidum* subsp. *rigidum*, *Cliffortia repens*, *Erica cerinthoides*, *E. woodii*, *Felicia filifolia* subsp. *filifolia*, *Gnidia caffra*, *Helichrysum odoratissimum*, *H. swynnertonii*, *Heteromorpha involucreta*, *Polygala uncinata*, *Tenrhynea phyllicifolia*. Succulent Shrubs: *Lopholaena disticha* (d), *Delosperma lydenburgense*. Graminoids: *Andropogon schirensis* (d), *Aristida junceiformis* subsp. *galpinii* (d), *Brachiaria serrata* (d), *Digitaria monodactyla* (d), *D. tricholaenoides* (d), *Diheteropogon filifolius* (d), *Harpochloa falx* (d), *Heteropogon contortus* (d), *Hyparrhenia hirta* (d), *Loudetia simplex* (d), *Monocymbium cerasiiforme* (d), *Setaria nigrirostris* (d), *Sporobolus centrifugus* (d), *Themeda triandra* (d), *Trachypogon spicatus* (d), *Tristachya leucothrix* (d), *Alloteropsis semialata* subsp. *eckloniana*, *Aristida sciurus*, *Bulbostylis oritrephes*, *Ctenium concinnum*, *Cymbopogon caesius*, *Diheteropogon amplexans*, *Elionurus muticus*, *Eragrostis capensis*, *E. chlo-romelas*, *E. curvula*, *E. gummiflua*, *E. plana*, *E. racemosa*, *E. sclerantha*, *Eulalia villosa*, *Ischyrolepis schoenoides*, *Koeleria capensis*, *Microchloa caffra*, *Panicum ecklonii*, *P. natalense*, *Pentastichis natalensis*, *Rendlia altera*, *Schizachyrium sanguineum*, *Sporobolus pectinatus*, *Tristachya rehmannii*. Herbs: *Senecio gerrardii* (d), *Acalypha angustata*, *A. depressinerva*, *Alepidea longifolia*, *Dicoma anomala*, *Dimorphotheca jucunda*, *D. spectabilis*, *Eriosema kraussianum*, *Gerbera ambigua*, *Haplocarpha scaposa*, *Helichrysum caespititum*, *H. chionosphaerum*, *H. nudifolium*, *H. rugulosum*, *H. spiralepis*, *H. subglomeratum*, *H. umbraculigerum*, *Monopsis decipiens*, *Myosotis afropalustris*, *Pelargonium luridum*, *Pentanisia prunelloides* subsp. *latifolia*, *Polygala amatymbica*, *Psammotropha myriantha*, *Rhynchosia monophylla*, *Schistostephium crataegifolium*, *Sebaea erosa*, *S. sedoides* var. *confertiflora*, *Selago procera*, *Senecio laevigatus*, *Vernonia hirsuta*, *V. natalensis*, *V. oligocephala*, *Wahlenbergia undulata*, *Zornia capensis*. Herbaceous Climber: *Rhynchosia totta*. Geophytic Herbs: *Gladiolus longicollis* subsp. *platypetalus* (d), *Agapanthus inapertus* subsp. *inapertus*, *A. inapertus* subsp. *intermedius*, *Chlorophytum haygarthii*, *Corycium dracomontanum*, *C. nigrescens*, *Disa fragrans* subsp. *fragrans*, *D. versicolor*, *Disperis renibractea*, *Gladiolus ecklonii*, *Habenaria dives*, *H. dregeana*, *H. lithophila*, *Haemanthus humilis* subsp. *hirsutus*, *Holothrix scopularia*, *Hypoxis costata*, *H. galpinii*, *H. rigidula* var. *pilosissima*, *Merwillia natalensis*, *Pachycarpus transvaalensis*, *Raphionacme galpinii*, *Satyrion longicauda*, *Zantedeschia albomaculata* subsp. *macrocarpa*. Succulent Herbs: *Aloe dyeri*, *A. graciliflora*, *A. longibracteata*, *Crassula vaginata*.

Biogeographically Important Taxa (all Northern sourveld endemics) Herbs: *Graderia linearifolia*, *Helichrysum truncatum*, *Hemizygia foliosa*, *Inezia integrifolia*, *Monsonia transvaalensis*, *Selago compacta*, *S. villosa*, *Streptocarpus galpinii*, *Tetraselago wilmsii*. Geophytic Herbs: *Agapanthus inapertus* subsp. *hollandii*, *A. inapertus* subsp. *parviflorus*, *A. inapertus* subsp. *pendulus*, *Gladiolus calcaratus*, *G. exiguus*, *Watsonia occulta*. Succulent Herb: *Aloe affinis*. Low Shrubs: *Helichrysum albilanatum*, *H. mariepsopicum*, *H. milleri*, *H. reflexum*, *H. rudolfii*, *Hemizygia albiflora*, *H. subvelutina*, *Sutera polelensis* subsp. *fraterna*.

Endemic Taxa Low Shrubs: *Erica atherstonei*, *E. holtii*, *Helichrysum lesliei*, *H. summo-montanum*. Succulent Shrub:



Figure 8.53 Gm 18 Lydenburg Montane Grassland: Short rocky mistbelt grassland with *Rhus tumulicola*, *Vernonia hirsuta* and species of *Berkheya* and *Helichrysum* at Kemps Heights, 17 km southeast of Lydenburg (Mpumalanga).

Khadia alticola. Herbs: *Crotalaria monophylla*, *Cymbopappus piliferus*, *Knowltonia transvaalensis* var. *pottiana*, *Pearsonia hirsuta*, *Streptocarpus cyaneus* subsp. *longi-tommii*, *S. hilbur-tianus*. Geophytic Herbs: *Disa alticola*, *D. amoena*, *D. clavicornis*, *Eucomis vandermerwei*, *Gladiolus cataractarum*, *G. exiguus*, *G. malvinus*, *Kniphofia rigidifolia*, *Riocrexia aberrans*, *Schizochilus cecillii* subsp. *transvaalensis*, *S. lilacinus*, *Watsonia occulta*, *W. wilmsii*. Succulent Herb: *Crassula setulosa* var. *deminuta*.

Conservation Vulnerable. The conservation target is 27%, with 2.4% formally protected within reserves (Gustav Klingbiel, Makobulaan, Mt Anderson, Ohrigstad Dam, Sterkspruit and Verlorenvlei) as well as in a number of private conservation areas (Buffelskoof, Crane Creek, ETT, In-de-Diepte, Kaalboom, Kalmoesfontein, Mbesan, Mondl Indigenous Forest, Mt Sheba, Waterval etc.). The level of transformation is relatively high at 23%, with mostly alien plantations (20%) and cultivated lands (2%). Erosion potential very low (74%) and low (12%).

Remark 1 This unit has an afromontane flora with links to the Zimbabwean highlands in the north (e.g. *Morella microbracteata*, *Selago procera*, *Helichrysum swynnertonii*) and the southern Drakensberg in the south (e.g. *Polypodium vulgare*, *Helichrysum spodiophyllum*, *Selago compacta*, *Holothrix scopularia*). It has also been proposed as a centre of plant endemism. Over 2 266 plant taxa have been identified in an area roughly corresponding to that of the Lydenburg Montane Grassland, with a list of 51 endemics. The recognition of two subcentres was also proposed, namely the Long Tom Pass and the Steenkampsberg Subcentres. The flora varies between these two areas, with the Long Tom Pass region having several elements linking it to escarpment flora of the north, while the Steenkampsberg has several elements linking it to the flora in the south, as in Wakkerstroom and southern Drakensberg. Elements linking the Long Tom Pass to the north (Wolkberg and northwards) include *Helichrysum rudolfii*, *H. mariepsopicum*, *Dierama adelpicum*, *Schizochilus cecillii* subsp. *transvaalensis* and *Kniphofia splendida*. The elements linking the Steenkampsberg to the south include *Aloe modesta*, *Helichrysum subglomeratum*, *Brunsvigia natalensis*, *Habenaria tysonii* and *Disperis oxyglossa*. Furthermore, in the Long Tom Pass area, *Psoralea latifolia* and *Lopholaena disticha* are replaced by *Otholobium wilmsii* and *L. segmentata*.

Remark 2 Small forests and shrub-like thickets are common along drainage lines, faults, and narrow diabase dykes (which are common in this unit).

References Acocks (1953, 1988), Deall (1985), Bloem (1988), Deall et al. (1989), Bloem et al. (1993), Burgoyne (1995), Emery et al. (2002).

Gm 19 Sekhukhune Montane Grassland

VT 61 Bankenveld (49%), VT 57 North-Eastern Sandy Highveld (40%) (Acocks 1953). LR 18 Mixed Bushveld (59%) (Low & Rebelo 1996).

Distribution Mpumalanga Province: continuous undulating norite hills in the Roossenekal region, from Stoffberg in the south, northwards through Mapochs Gronde to Schurinksberg in the north, with the Steelpoort River in the west. Altitude 1 300–1 960 m.

Vegetation & Landscape Features Major chains of hills transect the area and have a north-south orientation, creating moderately steep slopes with predominantly eastern and western aspects. Large norite boulders and stones cover the shallow soils on the hillsides. Dense, sour grassland occur on slopes of mountains and undulating hills, with scattered clumps of trees and shrubs in sheltered habitats. Turf and clay soils characterise the open plains between the chains of hills and culminate in a open plain in the Stoffberg area. Dense, tall grassland is found on the plains and encroachment by indigenous or invasion by alien microphyllous tree species is common in places.

Geology & Soils The area mostly overlies the mafic intrusive rocks of the Upper and Main Zones of the Rustenburg Layered Suite, which is economically the most important part of the Bushveld Igneous Complex (Vaalian Erathem). The west of this area is dominated by diorite and gabbro (often magnetite-rich) of the Roossenekal Subsuite, whereas the east is dominated by gabbro and norite of the Dsjate Subsuite. In the extreme north-east of the area are metasediments of the Pretoria Group (also Vaalian Erathem) that were metamorphosed by the intrusion of the Bushveld Igneous Complex. Substrates of the undulating hills are generally heterogeneous rocky areas with miscellaneous soil types and those of the southern plains have diagnostic horizons that are vertic, melanitic or red-structured. Dominant soil forms have a high clay content and include Arcadia, Mayo, Milkwood, Mispah, Shortlands and Steendal. Ea land type covers 40% of the area, with minor occurrences of Ib and Ab.

Climate This unit experiences a similar climate to the adjacent Lydenburg Montane Grassland, although frost incidence decreases towards the north. Summer-rainfall regime with the MAP from about 720 mm in the east to 600 mm in the west, much of the rain falling in the form of thunderstorms in summer from November to January. Mean daily temperature ranges from a minimum of 2.8°C in winter to a maximum of 24.9°C in summer. Daily temperatures vary considerably at different localities, with higher temperatures on the plains and lower temperatures on higher-lying plateaus. See also climate diagram for Gm 19 Sekhukhune Montane Grassland (Figure 8.36).

Important Taxa Small Trees: *Protea caffra* subsp. *caffra* (d), *Acacia caffra*, *Apodytes dimidiata* subsp. *dimidiata*, *Canthium suberosum*, *Cussonia transvaalensis*, *Seemannaralia gerrardii*. Woody Climbers: *Rhoicissus tridentata* (d), *Jasminum quinquatum*, *Triaspis glaucophylla*. Tall Shrubs: *Euclea crispa* subsp. *crispa* (d), *Brachylaena ilicifolia*, *Diospyros austro-africana*, *Euclea linearis*, *Pavetta zeyheri*. Low Shrubs: *Gnidia caffra* (d), *Senecio microglossus* (d), *Dyschoriste rogersii*, *Elephantorrhiza praetermissa*, *Leonotis leonurus*, *Polygala uncinata*, *Rhus discolor*, *R. tumulicola* var. *meeuseana*, *R. wilmsii*. Geoxylic Suffrutex: *Elephantorrhiza*

elephantina. Graminoids: *Aristida junciformis* subsp. *galpinii* (d), *Diheteropogon amplexans* (d), *Elionurus muticus* (d), *Eragrostis chloromelas* (d), *E. racemosa* (d), *Heteropogon contortus* (d), *Microchloa caffra* (d), *Monocymbium cereisiiforme* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Andropogon schirensis*, *Aristida aequiglumis*, *Brachiaria serrata*, *Cymbopogon caesus*, *Digitaria diagonalis*, *D. monodactyla*, *Ehrharta capensis*, *Eragrostis capensis*, *E. nindensis*, *E. plana*, *Hyparrhenia hirta*, *Loudetia simplex*, *Panicum natalense*, *Setaria nigrirostris*, *Trachypogon spicatus*, *Triraphis andropogonoides*. Herbs: *Acalypha punctata* (d), *Berkheya setifera* (d), *Rothea hirsuta* (d), *Senecio latifolius* (d), *Tephrosia purpurea* subsp. *leptostachya* (d), *Berkheya insignis*, *Gerbera jamesonii*, *Helichrysum nudifolium* var. *nudifolium*, *Ipomoea crassipes*, *Jamesbrittenia silenoides*, *Macledium zeyheri* subsp. *argyrophylum*, *Pegolettia lanceolata*, *Pentanisia prunelloides* subsp. *prunelloides*, *Senecio coronatus*, *Vernonia galpinii*, *V. natalensis*, *V. oligocephala*, *Xerophyta retinervis*. Geophytic Herbs: *Hypoxis rigidula* var. *pilosissima* (d), *Cheilanthes hirta*, *Eucomis montana*, *Hypoxis hemerocallidea*, *Pachycarpus transvaalensis*. Succulent Herb: *Kleinia stapeliiformis*.

Biogeographically Important Taxa ^NNorthern sourveld endemic, ^{SK}Sekhukhune endemic) Small Trees: *Euclea sekhukhuniensis*^{SK}, *Lydenburgia cassinoides*^{SK}, *Rhus sekhukhuniensis*^{SK}. Woody Climber: *Rhoicissus sekhukhuniensis*^{SK}. Tall Shrub: *Vitex obovata* subsp. *wilmsii*^N. Low Shrubs: *Dyschoriste perrottetii*^{SK}, *Grewia vernicosa*^N, *Helichrysum uninervium*^N, *Jamesbrittenia macrantha*^{SK}, *Melhania randii*^N. Succulent Shrub: *Aloe castanea*^N, Herbs: *Berkheya densifolia*^N, *Cyanotis pachyrrhiza*^N, *Graderia linearifolia*^N, *Ipomoea bathycolpos* var. *sinuatodentata*^{SK}, *Rhynchosia rudolfii*^N, *Tetraselago wilmsii*^N. Geophytic Herbs: *Gladiolus sekukuniensis*^{SK}, *Zantedeschia pentlandii*^{SK}. Succulent Herb: *Huernia insigniflora*^N.

Endemic Taxa Succulent Shrubs: *Aloe reitzii* var. *reitzii*, *Delosperma deilanthoides*. Geophytic Herbs: *Resnova* sp. nov. ('megaphylla'), *Zantedeschia pentlandii*.

Conservation Vulnerable. Conservation target 24%. Approximately 30% of this area is under commercial or subsistence cultivation. Vast areas are mined for vanadium using strip mining, and in recent years mining of gabbro has increased substantially (Siebert et al. 2002c). There is no formal conservation in the region, although many farmers have embarked on ecotourism initiatives. Erosion very low (56%), moderate (18%) and high (16%).

Remarks This vegetation comprises the Roossenekal Subcentre of the Sekhukhuneland CE (Van Wyk & Smith 2001) with numerous endemic plant species, many of which are not yet described. The Roossenekal area comprises heterogeneous rocky habitats (Siebert et al. 2003) and numerous floristic links with other grassland areas have been identified. In terms of floristic diversity, species richness and vegetation structure, this vegetation is related to Gm 11 Rand Highveld Grassland, Gm 18 Lydenburg Montane Grassland and Gm 17 Barberton Montane Grassland (Siebert et al. 2002b, Bredenkamp & Brown 2003). A floristic link exists with other mesic mountainous areas in South Africa (Mpumalanga and KwaZulu-Natal) and Swaziland and is supported by the following species: *Dyschoriste rogersii*, *Eucomis montana*, *Jamesbrittenia silenoides*, *Pachycarpus transvaalensis*, *Pegolettia lanceolata*, *Seemannaralia gerrardii* and *Thesium multiramulosum*. Floristic links also exist with the Northern Cape, namely *Amphiglossa triflora* and *Nuxia gracilis*, and the Eastern Cape, namely *Brachylaena ilicifolia* and *Maytenus alba*. Species such as *Euclea linearis* and *Melhania randii* are shared with the Great Dyke in Zimbabwe that is located on similar ultramafic rock (Siebert et al. 2001).

References Acocks (1953, 1988), Siebert (2001), Siebert et al. (2001, 2002a, b, c, 2003), Van Wyk & Smith (2001), Bredenkamp & Brown (2003).

Gm 20 Leolo Summit Sourveld

VT 57 North-Eastern Sandy Highveld (88%) (Acocks 1953). LR 18 Mixed Bushveld (100%) (Low & Rebelo 1996).

Distribution Limpopo Province: Discontinuous summits on the Leolo Mountain range, which forms an extension to the norite massif of the Dwars River Mountains further south. Sekhukhune is the major town in the vicinity and lies on the western foot slopes of the mountain. The unit is restricted to altitudes of 1 700–1 920 m.

Vegetation & Landscape Features Summit plateaus on a major mountain range with steep slopes. Large norite boulders and stones cover the shallow soils on the hillsides and plateau. Dense, sour grassland occurs on the high-altitude upper slopes and summit of the mountain; scattered clumps of trees and shrubs occur in sheltered, rocky habitats on the plateau.

Geology & Soils Underlain by the banded gabbros, norites and anorthosites of the Dsjate Subsuite of the Rustenburg Layered Suite (part of the Vaalian Bushveld Igneous Complex). The Dsjate Subsuite forms part of the Main Zone of the Rustenburg Layered Suite. Substrates of the undulating plateau are soils of especially the Mayo and Oakleaf forms in the flat areas, with miscellaneous rocky soil forms, such as Glenrosa and Mispah, occurring on the mountain slopes. Dominant soil forms have a high clay content. The almost exclusive land type is Fb.

Climate This area experiences a similar climate to the Gm 18 Lydenburg Montane Grassland. MAP 694 mm with about half of the rain falling as thunderstorms in summer from November to January. Mean daily temperatures on the summit are considerably lower than those of the surrounding Steelpoort River Valley. See also climate diagram for Gm 20 Leolo Summit Sourveld (Figure 8.36).

Important Taxa Small Trees: *Cussonia transvaalensis*, *Greyia radlkoferi*, *Maytenus albata*, *Protea caffra* subsp. *caffra*, *P. roupelliae* subsp. *roupelliae*. Tall Shrubs: *Euryops brevipapposus* (d), *Vernonia myriantha* (d), *Buddleja auriculata*, *B. saligna*, *Euclea crispa* subsp. *crispa*, *Leucosidea sericea*, *Pavetta zeyheri*. Low Shrubs: *Helichrysum splendidum* (d), *Clutia pulchella*, *Gnidia caffra*, *Polygala uncinata*, *P. virgata*, *Rhus discolor*, *Senecio microglossus*. Succulent Shrub: *Aloe arborescens*. Geoxyllic Suffrutex: *Elephantorrhiza elephantina*. Graminoids: *Diheteropogon amplexans* (d), *Elionurus muticus* (d), *Eragrostis capensis* (d), *E. curvula* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Brachiaria serrata*, *Hyparrhenia hirta*, *Sporobolus centrifugus*. Herbs: *Hirpicium bechuanense* (d), *Pentanisia prunelloides* subsp. *prunelloides* (d), *Acalypha punctata*, *Anagallis huttonii*, *Berkheya insignis*, *Jamesbrittenia silenoides*, *Lotononis foliosa*, *Manulea parviflora*, *Pegolettia lanceolata*, *Rotheca hirsuta*, *Senecio latifolius*, *Xerophyta viscosa*. Geophytic Herb: *Hypoxis rigidula* var. *pilosissima*.

Biogeographically Important Taxa ^(N)Northern sourveld endemic,

^{SK}Sekhukhune endemic, ^ZLink to Zimbabwe) Tall Shrub: *Vitex obovata* subsp. *wilmsii*^N. Woody Climber: *Rhoicissus sekhukhuniensis*^{SK}. Low Shrubs: *Asparagus sekukuniensis*^{SK}, *Grewia vernicosa*^N, *Helichrysum rudolfii*^N, *H. uninervium*^N, *Hibiscus barnardii*^{SK}, *Jamesbrittenia macrantha*^{SK}, *Melhania randii*^N, *Plectranthus venteri*^Z. Herbs: *Berkheya densifolia*^N, *Cyanotis pachyrrhiza*^N, *Nemesia zimbabwensis*^Z. Herbaceous Climber: *Cyphia transvaalensis*^N. Geophytic Herbs: *Gladiolus sekukuniensis*^{SK}, *Zantedeschia jucunda*^{SK}. Succulent Herb: *Aloe affinis*^N.

Conservation Vulnerable. Target 24%. Although sparsely populated, very little of the Grassland Biome on the Leolo Mountains has remained undisturbed due to extensive subsistence agriculture. Threatened by the mining of granite for dimension stone. Although the moist summit of the Leolo Mountains has important value as a water source to the surrounding arid valleys, it has never been regarded as a conservation priority. Erosion very high (48%) and moderate (45%).

Remark 1 This vegetation comprises the Leolo Subcentre of the Sekhukhune CE (Van Wyk & Smith 2001), with several taxa still pending description. Interesting biogeographical patterns have been documented for *Triaspis glaucophylla* (link to the Waterberg), *Limosella maior* (link to the Drakensberg) and *Nemesia zimbabwensis* (link to Mount Inyangani in Zimbabwe; Siebert & Van Wyk 2005).

Remark 2 Leolo Summit Sourveld is a high-altitude variant of Sekhukhune Montane Grassland, with the main difference being its much shorter vegetation structure and poorer floristic diversity (Siebert et al. 2002b). It also shares many species with the high-altitude areas of the Lydenburg Montane Grassland, as both are characterised by wetlands and vast seepage areas rich in organic matter.

References Acocks (1953, 1988), Siebert (2001), Van Wyk & Smith (2001), Siebert et al. (2002a, b, c, 2003), Siebert & Van Wyk (2005).

Gm 21 Lydenburg Thornveld

VT 19 Sourish Mixed Bushveld (28%), VT 8 North-Eastern Mountain Sourveld (22%) (Acocks 1953). LR 43 North-eastern Mountain Grassland (80%) (Low & Rebelo 1996).

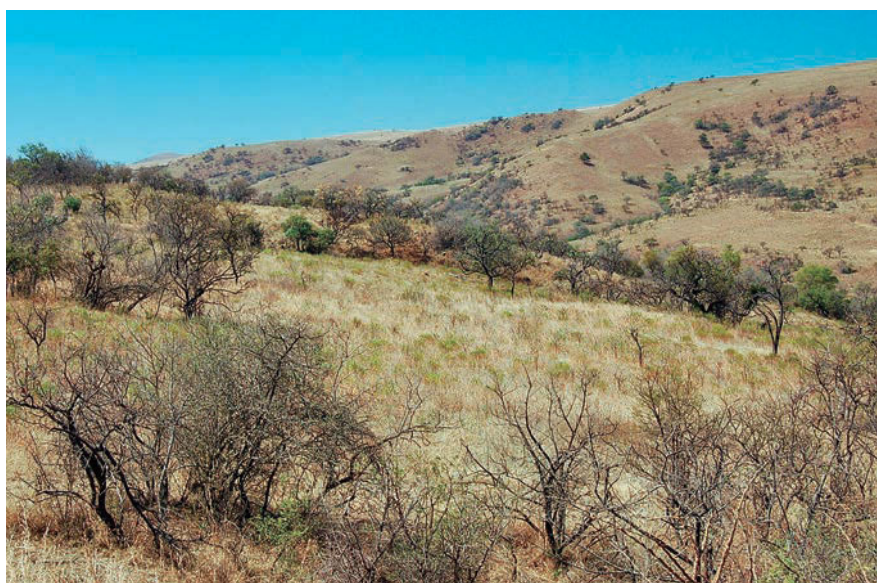


Figure 8.54 Gm 21 Lydenburg Thornveld: A late spring view of a thornveld in the Lydenburg surrounds, with *Acacia karroo*, *Rhus pyroides*, *Celtis africana*, *Senecio microglossus*, *Argyrolobium wilmsii* and *Aloe longibracteata*.

Distribution Mpumalanga Province: Situated in a broad band between the high-lying mountains from just north of Ohrigstad, tapering southwards through Lydenburg to as far south as the area in the vicinity of the Kwena Dam. Altitude 1 160–1 660 m.

Vegetation & Landscape Features This unit occurs at lower levels at the foot of the mountains and on undulating plains. This is open, frost-hardy woodland. Structurally this unit comprises closed grassland which is almost always wooded, sometimes densely so in rocky areas and less so in frost-ridden valleys where *Acacia karroo* is still able to persist. Many woody plants have evolved a suffrutex habit (*Argyrobium wilmsii*), where aerial parts die back to an underground rootstock during cold winters.

Geology & Soils Red clay soils mostly derived from shales of the Pretoria Group (including the Silverton and Timeball Hill Formations). Shales occasionally intersected with bands of quartzite or andesite. Land types Ba, Fa, Ib and Ae, with predominantly Mispah, Glenrosa or Hutton soil forms.

Climate This unit occurs in the rainshadow of the Escarpment, where the climate is much drier and the winters are very cold (MAT 16°C). The rainfall is generally lower than in surrounding areas since it falls within a rainshadow. Rainfall 580–810 mm (MAP 707 mm). Most of this unit experiences fairly infrequent frost. See climate diagram for Gm 21 Lydenburg Thornveld (Figure 8.36).

Important Taxa Small Trees: *Acacia robusta* subsp. *robusta* (d), *Cussonia transvaalensis* (d), *Acacia caffra*, *A. karroo*, *Combretum erythrophyllum*, *Cussonia paniculata*, *Dombeya rotundifolia*. Tall Shrubs: *Diospyros lycioides* subsp. *guerkei*, *Euclea crispa* subsp. *crispa*, *Ormocarpum kirkii*, *Rhamnus prinoides*, *Vernonia crataegifolia*. Woody Climbers: *Jasminum quinquatum* (d), *Acacia ataxacantha*. Low Shrubs: *Rubus transvaaliensis* (d), *Senecio microglossus* (d), *Anthospermum rigidum* subsp. *pumilum*, *Lippia javanica*, *Nemesia fruticans*, *Polygala nodiflora*, *Rhus gerrardii*. Succulent Shrubs: *Euphorbia clavarioides* var. *truncata*, *Lopholaena coriifolia*. Geoxylic Suffrutex: *Elephantorrhiza elephantina*. Graminoids: *Aristida canescens* (d), *A. congesta* (d), *A. diffusa* (d), *Brachiaria serrata* (d), *Bulbostylis burchellii* (d), *Digitaria tricholaenoides* (d), *Eragrostis racemosa* (d), *Heteropogon contortus* (d), *Microchloa caffra* (d), *Schizachyrium sanguineum* (d), *Trachypogon spicatus* (d), *Tristachya leucothrix* (d), *Andropogon schirensis*, *Bewisia biflora*, *Cymbopogon caesus*, *Diheteropogon amplexans*, *Elionurus muticus*, *Eragrostis chloromelas*, *E. gumiflua*, *E. patentissima*, *E. plana*, *Eulalia villosa*, *Hyparrhenia hirta*, *Melinis repens* subsp. *repens*, *Monocymbium ceresiforme*, *Panicum natalense*, *Schizachyrium ursulus*, *Setaria nigrirostris*, *S. sphacelata*, *Sporobolus centrifugus*, *S. pyramidalis*, *Themeda triandra*, *Tristachya biseriata*, *T. rehmannii*. Herbs: *Acalypha glandulifolia*, *Dicoma anomala*, *Eriosema kraussianum*, *Geigeria burkei* subsp. *burkei*, *Helichrysum cephaloideum*, *H. rugulosum*, *Kohautia amatymbica*, *Macledium zeyheri* subsp. *argyrophyllum*, *Rothea hirsuta*, *Schistostephium crataegifolium*, *Senecio bupleuroides*, *S. coronatus*, *Vernonia oligocephala*. Geophytic Herbs:

Hypoxis multiceps, *H. rigidula* var. *pilosissima*. Succulent Herbs: *Aloe fosteri*, *A. greatheadii* var. *davyana*, *Kleinia stapeliiformis*.

Endemic Taxa Low Shrubs: *Argyrobium wilmsii* (d), *Adenia wilmsii*. Geophytic Herb: *Gladiolus rufomarginatus*.

Conservation Vulnerable. The conservation target is 27% and 2% is protected (Gustav Klingbiel and Ohrigstad Dam Nature Reserves). A total of 22% of this unit has been transformed, mainly by dryland and irrigated cultivation. Rainfall generally too low for plantations. Erosion from very low (45%), low (26%) and moderate (18%).

Remark It is a transition zone between the high-lying grasslands and the warmer and drier bushveld areas.

References Acocks (1953, 1988).

Gm 22 Northern Escarpment Dolomite Grassland

VT 8 North-Eastern Mountain Sourveld (70%) (Acocks 1953). LR 43 North-eastern Mountain Grassland (75%) (Low & Rebelo 1996).

Distribution Mpumalanga Province: From the high-lying dolomite grasslands of the Abel Erasmus Pass and Motlatse (Blyde) River (Vaalhoek) areas in the north, it extends southwards in a broad dolomite band along the Northern Escarpment, to as far south as the vicinity of Kaapsehoop. Altitude 1 000–1 620 m.

Vegetation & Landscape Features Very species-rich grasslands that occur along the Escarpment dolomite belt. The grasslands are characterised by a very diverse shrub layer which varies in height and density. The herbaceous component becomes more dense northwards as the climate becomes drier.

Geology & Soils Malmani dolomites of the Chuniespoort Group (Transvaal Supergroup) which overlies the Black Reef Quartzite Formation. Soils usually have a high pH, are rich in calcium and magnesium, and with low phosphorus status.

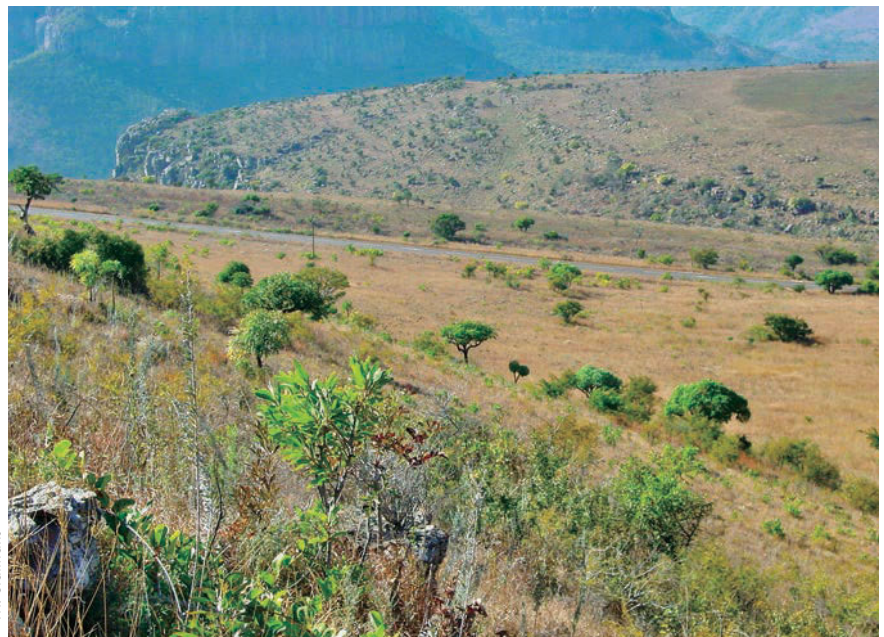


Figure 8.55 Gm 22 Northern Escarpment Dolomite Grassland: Rocky dolomite grassland on the Farm Dientjie (Blyde River Canyon National Park, Mpumalanga) with the grass *Loudetia simplex* and scattered woody species such as *Cussonia paniculata*, *Protea caffra*, *Ziziphus mucronata* and *Smilax kraussiana*.

Deep Hutton and Griffin soil forms are common. Land types Fa, Ab and Ac.

Climate Summer rainfall, varying from 700 mm in the north, increasing southwards to 1 420 mm (MAP 1 034 mm). Most of this unit occurs in the mistbelt, with increased precipitation. Warm-temperate climate, with low frequency of frost. Temperature increases northwards, ranging from MAT of 15°C in the south to 17°C in the northern regions of the unit. See also climate diagram for Gm 22 Northern Escarpment Dolomite Grassland (Figure 8.36).

Important Taxa Small Trees: *Seemannaralia gerrardii* (d), *Cussonia natalensis*, *Faurea rochetiana*, *F. saligna*, *Hippobromus pauciflorus*, *Ozoroa albicans*, *Protea caffra* subsp. *caffra*, *P. roupelliae* subsp. *roupelliae*. Tall Shrubs: *Pavetta lanceolata* (d), *Diospyros lycioides* subsp. *sericea*, *Protea gaguedi*, *Rhus rehmanniana*, *Tarchonanthus parvicapitulatus*. Low Shrubs: *Argyrobolus transvaalense*, *Athrixia arachnoidea*, *Chaetacanthus burchellii*, *Erica drakensbergensis*, *Helichrysum splendidum*, *Pelargonium dolomiticum*, *Phymaspermum acerosum*, *Rhus tumulicola* var. *meeuseana*, *Schistostephium rotundifolium*, *Stoebe plumosa*, *Tenryhnea phyllicifolia*. Graminoids: *Cymbopogon caesius* (d), *C. nardus* (d), *Elionurus muticus* (d), *Eragrostis capensis* (d), *Hyparrhenia filipendula* (d), *Loudetia simplex* (d), *Monocymbium ceresiiforme* (d), *Schizachyrium sanguineum* (d), *Trichopteryx dregeana* (d), *Tristachya leucothrix* (d), *Alloteropsis semialata* subsp. *eckloniana*, *Andropogon schirensis*, *Digitaria maitlandii*, *Diheteropogon filifolius*, *Eragrostis plana*, *E. racemosa*, *Festuca costata*, *Melinis nervigulum*, *M. repens* subsp. *repens*, *Rendlia altera*, *Sporobolus africanus*, *S. pectinatus*, *Stiburus alopecuroides*, *Themeda triandra*. Herbs: *Hypodematum crenatum* (d), *Barleria ovata*, *Conostomium natalense*, *Dicoma anomala*, *Helichrysum miconiifolium*, *H. thapsus*, *Pearsonia sessilifolia* subsp. *marginata*, *P. sessilifolia* subsp. *sessilifolia*, *Rhynchosia monophylla*, *Senecio panduriformis*, *Vernonia natalensis*, *Xerophyta retinervis*. Geophytic Herbs: *Cheilanthes pentagona* (d), *Pteris vittata* (d). Succulent Herbs: *Aloe fouriei*, *Crassula sarcocaulis*.

Biogeographically Important Taxa (^NNorthern sourveld endemic, ^WWolkberg endemic) Low Shrubs: *Berkheya pauciflora*^W, *Heteromorpha pubescens*^N. Herbs: *Hemizygia transvaalensis*^N (d), *Phymaspermum argenteum*^N, *Scabiosa transvaalensis*^W.

Endemic Taxa Small Tree: *Ozoroa* sp. nov. ('*laetans*'). Low Shrubs: *Salvia dolomitica* (d), *Pelargonium album*. Succulent Shrub: *Aloe alooides*. Semiparasitic Shrub: *Thesium davidsonae*. Geophytic Herbs: *Gladiolus macneilii*, *G. pavonia*, *Ledebouria parvifolia*.

Conservation Endangered. Target 27%. Only 2% protected within the Blyde River Canyon National Park, but larger portion protected in private Driekop Caves and London heritage sites in the north and in the Mooifontein and Mondi Cycad Reserve heritage sites in the south. More than half of this unit has been transformed (52%), mainly by plantations (47%) and cultivated lands (5%). Erosion potential very low (17%), low (51%) and moderate (28%).

Remarks Large variation in altitude and rainfall results in differences in species

composition. These dolomites support species usually associated with the Wolkberg Centre of Plant Endemism, although some species are also shared with the Sekhukhune Centre of Plant Endemism (e.g. *Dombeya autumnalis*).

References Acocks (1988), Matthews (1991), Matthews et al. (1992a, b, 1993, 1994), Siebert (2001), Van Wyk & Smith (2001).

Gm 23 Northern Escarpment Quartzite Sourveld

VT 8 North-Eastern Mountain Sourveld (72%) (Acocks 1953). LR 21 Sour Lowveld Bushveld (53%) (Low & Rebelo 1996).

Distribution Limpopo and Mpumalanga Provinces: Occurring along the high-altitude crests of the Northern Escarpment, from Haenertsburg in the north, southeastwards, then bending southwards past Blyde River Canyon, Graskop and as far south as the vicinity of Kaapsehoop. Altitude 1 000–1 740 m.

Vegetation & Landscape Features The landscape is characteristically very rugged, with steep east-facing cliffs. This escarpment is intersected in some areas with large east-flowing rivers. Short, closed grassland rich in forb species with scattered trees and shrubs. This unit is very rocky and occurs on weather-resistant quartzite. The nutrient-poor soils lead to a lower biomass which, together with the rocky landscape, results in a reduced frequency and intensity of fires. It therefore has slightly more woody elements than the adjacent units.

Geology & Soils Black Reef Group and Wolkberg Group quartzite (formed 2.5 gya and occurring at the base of the Transvaal Supergroup), covered with shallow rocky soils of the Mispah form. Dominant land type Ab, with Ib, Fa and Ac of subordinate importance.

Climate Summer rainfall, but orographic effects enhance precipitation (overall regional MAP 1 176 mm). Mist common along the highest areas. Warm-temperate climate (MAT 16.6°C), with infrequent frost. See also climate diagram for Gm 23 Northern Escarpment Quartzite Sourveld (Figure 8.36).



Figure 8.56 Gm 23 Northern Escarpment Quartzite Sourveld: Complex of short grassland with scattered woody vegetation (*Protea roupelliae*, *P. rubropilosa*, *Schefflera umbellifera* and *Erica caffrorum*) occurring on quartzitic outcrops of the Wolkberg summit on the eastern escarpment.

Important Taxa Small Trees: *Protea roupelliae* subsp. *roupelliae* (d), *Faurea galpinii*, *F. rochetiana*, *Syzygium cordatum* var. *cordatum*. Tree Fern: *Cyathea dregei*. Tall Shrub: *Vernonia myriantha*. Low Shrubs: *Athrixia phyllicoides*, *Clutia monticola*, *Crotalaria doidegeae*, *Erica woodii*, *Euryops pedunculatus*, *Helichrysum kraussii*, *H. obductum*, *H. wilmsii*, *Phymaspermum acerosum*, *P. bolusii*, *Rhus tumulicola* var. *meeuseana*. Succulent Shrubs: *Lopholaena coriifolia* (d), *Aloe arborescens*, *Crassula sarcocaulis*. Graminoids: *Aristida junciformis* subsp. *galpinii* (d), *Loudetia simplex* (d), *Melinis nerviglumis* (d), *Monocymbium cerasiiforme* (d), *Panicum ecklonii* (d), *Trachypogon spicatus* (d), *Tristachya leucothrix* (d), *Alloteropsis semialata* subsp. *eckloniana*, *Andropogon appendiculatus*, *Cymbopogon nardus*, *Digitaria maitlandii*, *Diheteropogon filifolius*, *Elionurus muticus*, *Festuca costata*, *Hyparrhenia poecilotracha*, *Ischyrolepis schoenoides*, *Juncus lomatothyllus*, *Koeleria capensis*, *Merxmüllera drakensbergensis*, *Microchloa caffra*, *Pentastichis natalensis*, *Rendlia altera*, *Schizachyrium sanguineum*, *Sporobolus pectinatus*, *Stiburus alopecuroides*, *Themeda triandra*, *Trichopteryx dregeana*. Herbs: *Rhynchosia woodii* (d), *Acalypha glandulifolia*, *Anisopappus smutsii*, *Aster harveyanus*, *Berkheya echinacea*, *Craterocapsa tarsodes*, *Dicoma anomala*, *Eriosema angustifolium*, *Geigeria burkei* subsp. *burkei*, *Gerbera ambigua*, *Helichrysum acutatum*, *H. appendiculatum*, *H. cephaloideum*, *H. nudifolium* var. *pilosellum*, *H. oreophilum*, *H. umbraculigerum*, *Indigofera sanguinea*, *Kohautia amatymbica*, *Lobelia flaccida*, *Monsonia attenuata*, *Pearsonia sessilifolia* subsp. *marginata*, *Rabdosiella calycina*, *Selago hyssopifolia*, *Senecio panduriformis*, *S. scitus*, *Vernonia centaureoides*, *V. natalensis*, *V. poskeana*, *Wahlenbergia squamifolia*. Herbaceous Climber: *Rhynchosia caribaea*. Geophytic Herbs: *Asplenium aethiopicum*, *Cheilanthes hirta*, *Pteridium aquilinum*, *Schizocarpus nervosus*. Succulent Herbs: *Crassula alba*, *C. vaginata*, *Craterostigma wilmsii*.

Biogeographically Important Taxa (^NNorthern sourveld endemic, ^WWolkberg endemic) Small Trees: *Protea rubropilosa*^N (d), *Encephalartos paucidentatus*^N. Tall Shrub: *Tricalysia capensis* var. *galpinii*^N. Low Shrubs: *Asparagus rigidus*^W, *Berkheya carlinopsis* subsp. *magalismontana*^N, *Helichrysum mimetes*^N, *H. reflexum*^N, *H. rudolfii*^N, *H. uninervium*^N, *Hemizygia parvifolia*^N, *H. rehmannii*^W, *H. subvelutina*^N, *Kotschy parvifolia*^N, *Protea parvula*^N, *Sutera poleensis* subsp. *fraterna*^N, *Syncolostemon eriocephalus*^N. Succulent Shrub: *Aloe chortolirioides* var. *wooliana*^N. Semiparasitic Shrubs: *Thesium gracilentum*^W, *T. multiramulosum*^N. Herbs: *Anisopappus junodii*^W, *Cyanotis pachyrrhiza*^N, *Hemizygia transvaalensis*^N, *Monsonia transvaalensis*^N, *Pearsonia aristata*^N, *Scabiosa transvaalensis*^W. Geophytic Herbs: *Agapanthus inapertus* subsp. *hollandii*^N, *A. inapertus* subsp. *parviflorus*^N, *Aspidonepsis shebae*^N, *Brachystelma stellatum*^N, *Cyrtanthus thorncroftii*^N, *Disa extinctoria*^N, *Gladiolus calcaratus*^N, *G. exiguus*^N, *G. varius*^N, *G. vernus*^N, *Ledebouria minima*^N, *Tulbaghia transvaalensis*^N. Succulent Herbs: *Aloe affinis*^N, *A. thompsoniae*^W.

Endemic Taxa Small Trees: *Encephalartos brevifoliolatus*, *E. cupidus*, *E. nubimontanus*, *Protea laetans*. Low Shrubs: *Erica rivularis*, *Euclea dewinteri*, *Hemizygia rugosifolia*, *Lopholaena festiva*. Graminoid: *Schoenoxiphium schwei-*

ckerdtii. Herbs: *Cineraria hederifolia*, *Inezia speciosa*, *Monopsis kowynensis*, *Monsonia lanuginosa*, *Schistostephium artemisiifolium*, *Streptocarpus decipiens*. Geophytic Herbs: *Brachystelma pachypodium*, *Crocasmia mathewsiana*, *Cyrtanthus huttonii*, *C. junodii*, *Dierama adelphicum*, *Disa aristata*, *Drimiopsis davidsonae*, *Ledebouria* sp. nov. ('*rupestris*'), *L. galpinii*, *L. petiolata*, *Schizochilus crenulatus*, *Tulbaghia coddii*, *T. simmleri*, *Watsonia strubeniae*. Succulent Herb: *Aloe nubigena*.

Conservation Vulnerable. The conservation target is 27% and 15% is protected within the Lekgalameetse and Blyde River Canyon National Park. As much as 38% of this unit has been transformed mainly by plantations (37%), with limited cultivated areas. Estimated erosion potential levels very low (39%), low (47%) and moderate (14%).

Remark 1 This vegetation type closely coincides with the Wolkberg Centre of Endemism and is rich in endemic plants. Although this centre does incorporate the dolomites of Gm 22 Northern Escarpment Dolomite Grassland and SVcb 25 Pong Dolomite Mountain Bushveld, it is also comprised of two subcentres, namely the Serala and Blyde Subcentres. The Serala Subcentre is found to the north of the Olifants River along the Northern Escarpment, with approximately 36 endemics and near-endemics. The Blyde Subcentre is found to the south of the Olifants River along the Northern Escarpment, with approximately 15 endemic or near-endemic species.

Remark 2 Patches of FOz 4 Northern Mistbelt Forest are common in protected rocky areas.

References Smith (1972), Deall (1985), Deall et al. (1989), Stalmans (1990), Matthews (1991), Matthews et al. (1991, 1992a, 1993, 1994), Stalmans & Mentis (1993), Van Wyk & Smith (2001), Emery et al. (2002), Brown et al. (2005).

Gm 24 Northern Escarpment Afromontane Fynbos

VT 8 North-Eastern Mountain Sourveld (92%) (Acocks 1953). LR 2 Afromontane Forest (41%), LR 21 Sour Lowveld Bushveld (22%) (Low & Rebelo 1996).



Figure 8.57 Gm 24 Northern Escarpment Afromontane Fynbos: Montane fynbos shrublands with *Aloe arborescens*, *Cliffortia serpyllifolia*, *Hemizygia albiflora*, *Syncolostemon eriocephalus*, *Eumorphia davyi*, *Podocarpus latifolius* and *Cyrtanthus huttonii* on the summit of Mariepskop (Blyde River Canyon National Park, Mpumalanga).

Distribution Limpopo and Mpumalanga Provinces: Restricted distribution from the peaks of Thabakgolo Mountains above Penge, southwards along highest peaks only, through Mariepskop and as far south as Graskop. Also found in fragments on the summits of the Blouberg and Soutpansberg Mountains (the latter unmapped). Altitude 1 640–1 900 m, with outliers found as low as 1 300 m.

Vegetation & Landscape Features The dominant structural form is shrubland comprised of sclerophyllous shrubs and herbs, many with ericoid growth forms. It occurs in fragmented patches of high-lying quartzite ridges that experience frequent mist. Terrain is very rocky and fires are very rare.

Geology & Soils Predominantly quartzite of the Black Reef Formation and the Wolkberg Group but also on the westerly Timeball Hill Formation and other quartzitic formations of the Pretoria Group (Transvaal Supergroup). The overwhelmingly dominant land type is Ib, with Ac having a subordinate position.

Climate Summer rainfall generally greater than 1 400 mm, augmented by mist during large parts of the year. Temperature cooler than surrounding areas (MAT 15.6°C). Frosts infrequent. See climate diagram for Gm 24 Northern Escarpment Afromontane Fynbos (Figure 8.36).

Important Taxa ^(B)Also on Blouberg) Small Trees: *Protea caffra* subsp. *caffra*^B, *P. roupelliae* subsp. *roupelliae*^B. Tall Shrub: *Psoralea latifolia*. Succulent Shrub: *Aloe arborescens* (d). Low Shrubs: *Anthospermum hispidulum* (d), *Cliffortia nitidula* (d), *C. serpyllifolia* (d), *Erica natalitia* var. *natalitia* (d), *Hypericum revolutum* (d), *Passerina montana* (d), *Cliffortia linearifolia*^B, *Erica revoluta*, *E. simii*^B, *Euryops pedunculatus*, *Helichrysum obdutum*, *H. splendidum*, *H. wilmsii*, *Macowania tenuifolia*, *Morella pilulifera*^B, *Myrsine africana*, *Otiophora cupheoides*, *Phyllica paniculata*^B, *Phymaspermum acerosum*, *Schistostephium rotundifolium*. Graminoids: *Ischyrolepis schoenoides* (d), *Scleria transvaalensis* (d), *Cyperus pseudoleptocladus*. Herbs: *Plectranthus rubropunctatus* (d), *Blechnum punctulatum*. Geophytic Herb: *Drimia elata*^B.

Biogeographically Important Taxa ^(W)Wolkberg endemic, ^(N)Northern sourveld endemic, ^(B)Also on Blouberg, ^(Z)Link to Zimbabwe) Small Trees: *Faurea galpinii*^N, *Protea rubropilosa*^W, *Widdringtonia nodiflora*^{B,Z}. Low Shrubs: *Helichrysum rudolfii*^N (d), *Hemizygia albiflora*^N (d), *Asparagus rigidus*^W, *Helichrysum mariescopicum*^N, *Leucospermum saxosum*^Z, *Syncolostemon eriocephalus*^N. Herb: *Anisopappus junodii*^W (d). Geophytic Herbs: *Agapanthus inapertus* subsp. *pendulus*^N. Succulent Herb: *Aloe nubigena*^W.

Endemic Taxa Low Shrub: *Eumorphia davyi*. Herb: *Stachys reticulata*. Geophytic Herb: *Gladiolus saxatilis*.

Conservation The conservation target of 27% has been superseded since 56% of the unit enjoys formal protection in the Blyde River Canyon National Park and Mac Mac Conservation Area. The patches on the summits of Blouberg and Soutpansberg also enjoy formal and private protection. The landscape is rugged and soils shallow, therefore very little transformation of this unit has occurred. Transformation levels currently stand at 0.7% (plantations). Erosion very low (35%), low (44%) and moderate (20%).

Remarks This vegetation unit contains a unique combination of plant species with convergent growth forms and taxonomic links to that of the Fynbos Biome with genera such as *Cliffortia*, *Erica*, *Passerina*, *Phyllica*, *Protea*, *Ischyrolepis* and *Stoebe*, typical of dystrophic soils. This unit also incorporates a suite of other taxa from the Grassland and Afrotropical Forest Biomes.

Forestry management has increased the exclusion of fires from certain areas and subsequently increased the occurrence of the afromontane fynbos vegetation. Under these conditions, this vegetation type may be a precursor to forest, but establishment of forest may be possible only if the soil is deep enough and the impact of desiccation and frosts can be avoided.

References Van der Schijff (1963), Smith (1972), Matthews (1991).

Gm 25 Woodbush Granite Grassland

VT 8 North-Eastern Mountain Sourveld (93%) (Acocks 1953). LR 43 North-eastern Mountain Grassland (61%) (Low & Rebelo 1996).

Distribution Limpopo Province: Occurs on the Woodbush Plateau and its outliers, to the north of the Wolkberg, on the Groot Letaba watershed west of Duiwelskloof, Tzaneen and Lenyenye. Altitude 1 080–1 800 m.

Vegetation & Landscape Features Mountainous plateau covered by grassland, showing increased low-shrub density on steep south- and east-facing slopes.

Geology & Soils Archaean granite, gneiss and greenstone basement: Turfloop granite (Randian) and relicts of Goudplaats gneiss (Swazian) and occasional dolerite dykes or sills, and quartz veins. Dominant land type Ab, with Hutton (Glenrosa and Shortlands) soils.

Climate Summer rainfall, with MAP from 700 mm in the east to 1 500 mm in the west (MAP 1 166 mm), with peak in January. Some precipitation may also occur in winter. Mist is common and there is an orographic effect on the Escarpment. Temperature is generally lower in the west than in the east (overall MAT 16.6°C). Frost infrequent. See also climate diagram for Gm 25 Woodbush Granite Grassland (Figure 8.36).

Important Taxa Graminoids: *Eragrostis plana* (d), *E. racemosa* (d), *Hyparrhenia hirta* (d), *Microchloa caffra* (d), *Monocymbium cerasiiforme* (d), *Paspalum scrobiculatum* (d), *Stipa dregeana* var. *dregeana* (d), *Themeda triandra* (d), *Alloteropsis semialata* subsp. *eckloniana*, *Andropogon schirensis*, *Cymbopogon nardus*, *Festuca costata*, *Panicum natalense*, *Rendlia altera*. Herbs: *Berkheya echinacea*, *Chamaecrista mimosoides*, *Helichrysum cephaloideum*, *H. nudifolium* var. *pilosellum*, *Hypolepis sparsisora*, *Selago procera*, *Vernonia oligocephala*. Geophytic Herbs: *Asplenium sandersonii* (d), *Agapanthus inapertus* subsp. *inapertus*, *Asplenium lobatum*, *Merwillia natalensis*, *Pteridium aquilinum*. Succulent Herb: *Aloe lettyae*. Tall Shrub: *Tricalysia lanceolata*. Low Shrubs: *Asparagus virgatus*, *Dicliptera clinopodia*, *Eriosema nutans*, *Euryops pedunculatus*, *Hypericum revolutum*, *Protea simplex*.

Biogeographically Important Taxa ^(N)Northern sourveld endemic, ^(Z)Link to Zimbabwe) Succulent Herb: *Huernia insigniflora*^N. Low Shrub: *Eriosema buchanani*^Z.

Endemic Taxa Herb: *Wahlenbergia brachiata*. Geophytic Herbs: *Chlorophytum radula*, *Kniphofia crassifolia* (extinct). Low Shrub: *Indigofera rehmannii*.

Conservation Critically endangered. Conservation target (27%) can hardly be met since only about 10% of this unit is still in a natural state. There are no conservation areas protecting patches of this unit. The major land transformation is due to silviculture (69%) and to a much lesser degree to cultivation and urban development. Erosion potential very low (7%), low (88%) and moderate (5%). Frequent alien plants include *Acacia mearnsii*, *A. dealbata*, *Prunus serotina*, *Lilium formosanum*, *Agrimonia procera*, *Solanum mauritianum* and

Acanthospermum australe. The vegetation is subject to bush encroachment (from both scrub forest and sour bushveld) exacerbated by exclusion of fire.

Remark 1 This unit is distinct from the Gm 26 Wolkberg Dolomite Grassland, mainly due to the combination of the plateau topography, different geology and soils, and the prevalence of fog frequently precipitating over the plateau. The landscape is similar to higher-lying parts of the Figtree Plateau in the Sabie-White River area.

Remark 2 It is likely that the lower mapped area around Duiwelskloof falls within the sour bushveld rather than in this grassland unit.

References Acocks (1953, 1988), P.J.D. Winter (unpublished data).

Gm 26 Wolkberg Dolomite Grassland

VT 8 North-Eastern Mountain Sourveld (87%) (Acocks 1953). LR 43 North-eastern Mountain Grassland (98%) (Low & Rebelo 1996).

Distribution Limpopo Province: Occurs along the summit of the Strydpoort and Wolkberg Mountains, from the Lekgalameetse Nature Reserve in the east, along the dolomite belt to Mogodi in the west. Altitude 1 260–1 840 m.

Vegetation & Landscape Features Series of broad mountain ridges, broad elevated plateaus and adjacent slopes covered with species-rich short, closed grasslands rich in forbs, often dominated by *Loudetia simplex* and *Diheteropogon amplexans*.

Geology & Soils Malmani dolomites of the Chuniespoort Group (Transvaal Supergroup) form the underlying geology of this area. Dominant land types Ib and Ab, with Fa of subordinate importance.

Climate Summer-rainfall regime, 560–980 mm (MAP 772 mm). The adjacent Escarpment catches most of the orographic precipitation (fog, orographic rain), hence this area falls within a

rainshadow. Frost infrequent. See also climate diagram for Gm 26 Wolkberg Dolomite Grassland (Figure 8.36).

Important Taxa Small Trees: *Acacia davyi* (d), *Vitex rehmannii* (d), *Acacia caffra*, *Combretum molle*, *Cussonia paniculata*, *C. transvaalensis*, *Dombeya rotundifolia*, *Faurea rochetiana*, *F. saligna*, *Greyia radlkoferi*, *Lippia javanica*, *Protea caffra* subsp. *caffra*, *P. roupelliae* subsp. *roupelliae*. Tall Shrub: *Protea gaguedi*. Low Shrubs: *Asparagus schroederi*, *Chrysanthemoides monilifera*. Succulent Shrub: *Aloe vryheidensis*. Graminoids: *Andropogon schirensis* (d), *Brachiaria serrata* (d), *Diheteropogon amplexans* (d), *Heteropogon contortus* (d), *Loudetia simplex* (d), *Monocymbium cereiiforme* (d), *Rendlia altera* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Bewisia biflora*, *Elionurus muticus*, *Eragrostis capensis*, *E. chloromelas*, *E. racemosa*, *Panicum natalense*, *Sporobolus pectinatus*, *Trachypogon spicatus*. Herbs: *Dicoma anomala*, *Gerbera ambigua*, *Ipomoea atherstonei*, *Oxygonum dregeanum*, *Xerophyta retinervis*, *X. schlechteri*. Succulent Herb: *Aloe fosteri*. Semiparasitic Herb: *Buchnera longespicata*.

Biogeographically Important Taxa (all Northern sourveld endemics) Low Shrubs: *Berkheya pauciflora*, *Heteromorpha pubescens*. Herbaceous Climber: *Cyphia transvaalensis*.

Endemic Taxa Succulent Shrubs: *Aloe dolomitica*, *Euphorbia restricta*. Herbs: *Barleria dolomitica*, *Becium citriodorum*, *B. coddii*, *Dicliptera fionae*, *Lotononis pariflora*.

Conservation Least threatened. The conservation target of 27% has been superseded since more than 48% of this unit is formally protected within the Bewaarkloof and Lekgalameetse Nature Reserves as well as the Wolkberg Wilderness Area. Only a very small portion of this unit has been transformed by plantations. Erosion potential very low (49%), low (36%) and moderate (16%).

Remarks This unit forms the core of the Wolkberg CE, divided further into two subcentres—the Serala and Blyde Subcentres (Van Wyk & Smith 2001).

References Acocks (1953, 1988), Stalmans (1990), Matthews et al. (1993), Stalmans et al. (1997), Van Wyk & Smith (2001).



Figure 8.58 Gm 26 Wolkberg Dolomite Grassland: Rocky grassland on dolomite on the Farm The Downs near Makwens in the Lekgalameetse Nature Reserve (Mpumalanga) with *Aloe marlothii*, *Boophone disticha* and the shrub *Parinari curatellifolia*.

Gm 27 Strydpoort Summit Sourveld

VT 8 North-Eastern Mountain Sourveld (62%) (Acocks 1953). LR 43 North-eastern Mountain Grassland (59%) (Low & Rebelo 1996).

Distribution Limpopo Province: A series of isolated patches in high-lying areas of the Strydpoortberge, from Bewaarkloof in the east as far as the mountains just above Mokopane (Potgietersrus) in the west. Altitude largely 1 440–1 800 m, but up to 1 940 m.

Vegetation & Landscape Features Short to tall grasslands along rocky summits and mountain slopes. The landscape has a very broken topography with deeply incised valleys. The slopes are steep and rocky, and sparsely wooded.

Geology and Soils Acidic sandy soil derived from sandstone, quartzite and shale of the Wolkberg Group and the Black Reef Formation as well as the

Pretoria Group in the westernmost parts. In the eastern half of this area a large part is underlain by the Penge Banded Iron Formation of the Chuniespoort Group. All of the above form part of the Transvaal Supergroup. Dominant land type Ib.

Climate Strongly seasonal, with precipitation in summer. Rainfall 530–870 mm (MAP 686 mm). Frost infrequent. See also climate diagram for Gm 27 Strydpoort Summit Sourveld (Figure 8.36).

Important Taxa Small Trees: *Acacia caffra* (d), *Combretum molle* (d), *Cussonia paniculata* (d), *Englerophytum magalismontanum* (d), *Protea caffra* subsp. *caffra* (d), *Cussonia transvaalensis*, *Faurea saligna*, *Mundulea sericea*, *Protea roupelliae* subsp. *roupelliae*, *P. rubropilosa*, *Vangueria infausta*. Tall Shrub: *Rhus dentata*. Woody Climbers: *Ancylobotrys capensis*, *Rhoicissus tri-dentata*. Low Shrubs: *Rhus magalismontana* (d), *Aeschynomene rehmannii*, *Anthospermum hispidulum*, *Chrysanthemoides monilifera* subsp. *septrionalis*, *Justicia betonica*, *Leonotis ocymifolia*, *Polygala hottentotta*. Graminoids: *Aristida transvaalensis* (d), *Loudetia simplex* (d), *Monocymbium ceresiiforme* (d), *Schizachyrium sanguineum* (d), *Themeda triandra* (d), *Trachypogon spicatus* (d), *Tristachya leucothrix* (d), *Alloteropsis semialata* subsp. *eckloniana*, *Andropogon chinensis*, *Bulbostylis burchellii*, *Diheteropogon amplexans*, *D. filifolius*, *Elionurus muticus*, *Eragrostis racemosa*, *Sporobolus pectinatus*. Herbs: *Acalypha angustata*, *Helichrysum nudifolium* var. *nudifolium*, *Monsonia attenuata*, *Pearsonia sessilifolia* subsp. *sessilifolia*, *Rhynchosia monophylla*, *Selaginella dregei*, *Vernonia galpinii*, *V. natalensis*, *Xerophyta retinervis*. Herbaceous Climber: *Rhynchosia totta*. Succulent Herbs: *Aloe fosteri*, *Crassula swaziensis*, *Kleinia stapeliiformis*.

Biogeographically Important Taxa (^NNorthern sourveld endemic, ^WWolkberg endemic) Small Trees: *Encephalartos eugene-maraisii*^N, *Protea rubropilosa*^W. Tall Shrub: *Vitex obovata* subsp. *wilmsii*^N. Low Shrubs: *Berkheya carlinopsis* subsp. *magalismontana*^N, *Helichrysum uninervium*^N. Succulent Herbs: *Aloe affinis*^N, *A. thompsoniae*^W.

Endemic Taxa Succulent Shrub: *Thorncroftia media*. Semiparasitic Shrub: *Thesium gracilentum*. Herb: *Aster nubimontis*.

Conservation Least threatened. Target 24%. About 17% of the area enjoys statutory protection in the Bewaarkloof Nature Reserve. A further small portion is protected in the Wolkberg Wilderness Area. Transformation levels are very low. Erosion potential also very low (73%), low (17%) and moderate (10%).

Remark This unit shares several elements with the Gm 29 Waterberg-Magaliesberg Summit Sourveld, such as *Encephalartos eugene-maraisii* and *Vitex obovata* subsp. *wilmsii*.

References Stalmans & De Klerk (1991, 1992).

Gm 28 Soutpansberg Summit Sourveld

VT 20 Sour Bushveld (77%) (Acocks 1953). LR 11 Soutpansberg Arid Mountain Bushveld (98%) (Low & Rebelo 1996).

Distribution Limpopo Province: Confined to the higher-lying crests and plateaus situated above 1 200 m above

sea level and include the highest peaks on the Soutpansberg (Letjuma, 1 747 m) and still higher Blouberg (2 051 m).

Vegetation & Landscape Features Rugged summit crests and adjacent steep rocky slopes supporting a mosaic of low, wiry, closed grasslands and scattered closed-canopy bush clumps. The extent of the bush clumps within the grasslands depends largely on the extent of rock outcrops, rock boulders and the local soil depth. Due to frequent mist the surface of rocks and woody vegetation support rich epilithic and epiphytic lichen and bryophyte flora.

Geology & Soil Sandstone, quartzite and shale of Mokolian age (Soutpansberg Group, Wyllie's Poort Formation) giving rise to extremely shallow, coarse-sand Glenrosa and Mispah soils. These soils drain quickly, leading to leached and acidic conditions. The impermeable rock beds on the relatively flat plateaus often prevent water from draining away, leading to the formation of temporary rock pools. The deeper soils may function as sponges, slowly releasing water to feed mountain streams over prolonged periods. Dominant land type Ib, with Fa of minor importance.

Climate Summer rainfall, with most rain falling between November and February. Van Wyk & Smith (2001) mention precipitation to be as high as 2 000 mm on the highest peaks. The higher-lying crests and ridges are exposed to strong winds. During the summer months, these winds carry moisture in from the Indian Ocean, covering the vegetation in mist almost daily. During the prolonged dry season, the prevailing winds cause dehydration and desiccation of the soils and vegetation (Hahn 2002). Frost infrequent and MAT 16–17°C. See also climate diagram for Gm 28 Soutpansberg Summit Sourveld (Figure 8.36).

Important Taxa (^BAlso Blouberg) Small Trees: *Acacia caffra* (d), *Combretum molle* (d), *Englerophytum magalismontanum* (d), *Protea caffra* subsp. *caffra* (d), *Cussonia natalensis*, *Faurea saligna*^B, *Mundulea sericea*, *Protea roupelliae* subsp. *roupelliae*, *Vangueria infausta*. Tall Shrubs: *Euryops brevipapposus*^B, *Hyperacanthus amoenus*, *Rhus dentata*. Woody Climber: *Ancylobotrys capensis*. Low Shrubs: *Aeschynomene rehmannii*, *Anthospermum hispidulum*, *Erica woodii*^B, *Justicia betonica*, *Leonotis ocymifolia*, *Myrsine africana*, *Passerina montana*, *Polygala hottentotta*. Succulent Shrub: *Cotyledon barbeyi*. Graminoids: *Aristida transvaalensis* (d), *Monocymbium ceresii*.



D. Gwynne-Evans

Figure 8.59 Gm 28 Soutpansberg Summit Sourveld: Local endemic shrub *Callilepis caerulea* (Asteraceae) on a ridge of the Soutpansberg (Limpopo Province).

forme (d), *Schizachyrium sanguineum* (d), *Themeda triandra* (d), *Trachypogon spicatus* (d), *Andropogon chinensis*, *Bulbostylis burchellii*, *Diheteropogon amplexans*, *Eragrostis racemosa*, *Ischyrolepis schoenoides*^B, *Panicum maximum*, *Pentaschistis natalensis*^B, *Tristachya rehmannii*. Herbs: *Acalypha angustata*, *Helichrysum nudifolium* var. *nudifolium*, *H. subglomeratum*^B, *Rhynchosia monophylla*, *Selaginella dregei*, *Tephrosia purpurea* subsp. *leptostachya*, *Vernonia galpinii*, *Waltheria indica*, *Xerophyta retinervis*. Herbaceous Climber: *Rhynchosia totta*. Geophytic Herb: *Agapanthus inapertus* subsp. *intermedius*^B. Succulent Herb: *Crassula swaziensis*.

Biogeographically Important Taxa

(^BAlso on Blouberg, ^NNorthern sourveld endemic, ^SSoutpansberg endemic) Low Shrubs: *Berkheya carlinopsis* subsp. *magalismontana*^N, *Eriocephalus longifolius*^N. Herb: *Tetraselago wilmsii*^N.

Geophytic Herbs: *Agapanthus dyeri*^{N,B}, *Cyrtanthus thorncroftii*^N. Succulent Herb: *Aloe vossii*^S.

Endemic Taxa Tall Shrub: *Callilepis caerulea*. Low Shrubs: *Rhus magalismontana* subsp. *coddii* (d). Succulent Shrubs: *Delosperma zoutpansbergense*, *Khadia borealis*. Succulent Herb: *Aloe soutpansbergensis*.

Conservation Least threatened. Target 24%. About 18% statutorily conserved in the Blouberg and Happy Rest Nature Reserves and further in the private Soutpansberg Conservancy. Some of the area is transformed by *Eucalyptus* and *Pinus* plantations. Overgrazing by cattle and donkeys and inappropriate introduction of game from savanna plains are recognised as further threats to this vegetation unit. Erosion very low (52%) and low (39%).

Remarks This unit is part of the Soutpansberg Centre of Endemism (Van Wyk & Smith 2001). Pockets of Gm 24 Northern Escarpment Afromontane Fynbos and FOz 4 Northern Mistbelt Forest border on this summit grassland sourveld.

References Scholes (1979), Van Wyk & Smith (2001), Hahn (2002).

Gm 29 Waterberg-Magaliesberg Summit Sourveld

Distribution Limpopo and North-West Provinces and marginally into Gauteng: Isolated patches on summits of the Waterberg (including the Sandrivierberge, Hoekberge, Hanglipberge and Swaershoekberge), Pilanesberg (not mapped) and Magaliesberg. Altitude 1 500–2 088 m in the Waterberg, 1 853 m in the Magaliesberg and 1 687 m in the Pilanesberg.

Vegetation & Landscape Features Higher slopes and summit positions including crests, and steep rocky scarps and cliff faces, covered with grassland (and accompanying rocky outcrops) dominated by wiry tussock grasses. Patches of open *Protea caffra* savannoid vegetation and open shrubland with *Englerophytum magalismontanum* and *Landolphia capensis* are common and typical of this sourveld vegetation type.

Geology and Soils Acidic sandy, loamy to gravel soil derived from coarse, clastic sedimentary sandstone, quartzite, conglomerate or shale of the Kransberg Subgroup (Waterberg Group,



Figure 8.60 Gm 29 Waterberg-Magaliesberg Summit Sourveld: Grassland on the summit of the Magaliesberg viewed from an altitude of 1 770 m in the Magaliesberg Conservation Area, south of the Krom River near Rustenburg (North-West Province).

Mokolian Erathem). Ib and Fa land types (both 42%) are co-dominant, with Ac covering a smaller area (12%).

Climate Summer rainfall, with MAP 710 mm. Cool-temperate climate (MAT close to 16°C) due to higher altitude. Frost fairly infrequent. See also climate diagram for Gm 29 Waterberg-Magaliesberg Summit Sourveld (Figure 8.36).

Important Taxa (^RMainly on rocky outcrops) Small Trees: *Englerophytum magalismontanum* (d), *Protea caffra* subsp. *caffra* (d), *P. roupelliae* subsp. *roupelliae* (d), *Acacia caffra*, *Brachylaena rotundata*, *Combretum moggi*, *C. molle*, *Faurea saligna*, *Vangueria infausta*, *Zanthoxylum capense*. Tall Shrubs: *Elephantorrhiza burkei*, *Indigofera comosa*^R, *Protea gaguedi*, *Rhus dentata*. Woody Climber: *Ancylbotrys capensis* (d). Low Shrubs: *Lopholaena coriifolia*^R (d), *Passerina montana* (d), *Rhus magalismontana* (d), *Acalypha angustata*, *Aeschynomene rehmannii*, *Anthospermum hispidulum*, *A. rigidum* subsp. *rigidum*, *Erica drakensbergensis*, *Euryops pedunculatus*, *Myrothamnus flabellifolius*^R, *Myrsine africana*, *Polygala hottentotta*, *Protea welwitschii*, *Rhynchosia nitens*, *Tephrosia longipes*. Succulent Shrubs: *Euphorbia clavarioides* var. *truncata*^R, *E. schinzii*^R, *Raphionacme burkei*^R. Semiparasitic Shrubs: *Thesium transvaalense*, *T. utile*. Geoxylic Suffrutices: *Elephantorrhiza elephantina*, *Parinari capensis*. Graminoids: *Aristida transvaalensis* (d), *Bulbostylis burchellii* (d), *Coleochloa setifera*^R (d), *Diheteropogon amplexans* (d), *Eragrostis nindensis*^R (d), *Loudetia simplex* (d), *Melinis nerviglumis* (d), *Schizachyrium sanguineum* (d), *Trachypogon spicatus* (d), *Tristachya biseriata* (d), *Andropogon schirensis*, *Aristida aequiglumis*, *Brachiaria serrata*, *Cymbopogon caesius*, *Cyperus rupestris*^R, *Digitaria brazzae*, *Eragrostis racemosa*, *E. stapfii*^R, *Microchloa caffra*^R, *Monocymbium ceresiiforme*, *Panicum natalense*, *Themeda triandra*, *Tristachya rehmannii*. Herbs: *Selaginella dregei* (d), *Acalypha angustata*, *Commelina africana*, *C. erecta*, *Helichrysum nudifolium* var. *nudifolium*, *Indigofera hedyantha*, *I. melanadenia*, *Ipomoea omaneyi*, *Nidorella hottentotica*, *Oldenlandia herbacea*, *Pseudognaphalium undulatum*, *Rhynchosia monophylla*, *Vernonia galpinii*, *Xerophyta retinervis*^R. Herbaceous Climber: *Rhynchosia totta*. Geophytic Herbs: *Albuca setosa*^R, *Lapeirousia sandersonii*^R, *Ledebouria marginata*, *Pellaea calomelanos*. Succulent Herb: *Crassula lan- ceolata* subsp. *transvaalensis*.

Biogeographically Important Taxa (^NNorthern sourveld endemic, ^RMainly on rocky outcrops) Small Tree: *Encephalartos*

eugene-maraisii^N. Low Shrubs: *Berkheya carlinopsis* subsp. *magalismontana*^N, *Eriocephalus longifolius*^N, *Helichrysum uninervium*^N. Succulent Shrubs: *Adromischus umbraticola*^N, *Aloe peglerae*^N. Herb: *Cyanotis pachyrrhiza*^N. Geophytic Herb: *Ledebouria minima*^N. Succulent Herbs: *Frithia pulchra*^{N,R}, *Khadia acutipetala*^{N,R}.

Conservation Least threatened. Target of 24% has already been achieved since more than 27% of the unit is statutorily conserved in the Marekele National Park, Entabeni Nature Reserve, Magaliesberg Nature Area (including the Rustenburg Nature Reserve). The unmapped portion in the Pilanesberg

Game Park is fully conserved. A further 4% enjoys protection in private conservation areas. Only a very small area transformed. Erosion low (60%) and very low (34%).

Remark 1 Embedded within this sourveld there are abundant rocky sheets found on exposed mountain tops and ridges, supporting sparse edaphic grassland/herbland with classical resurrection plants such as *Myrothamnus flabellifolius* and *Selaginella dregei*. It is here where succulents (some endemic) of the genera *Frithia*, *Khadia* and *Delosperma* (Aizoaceae), *Adromischus* (Crassulaceae), *Anacampseros* (Portulacaceae) and numerous low succulent representatives of *Euphorbia* are found.

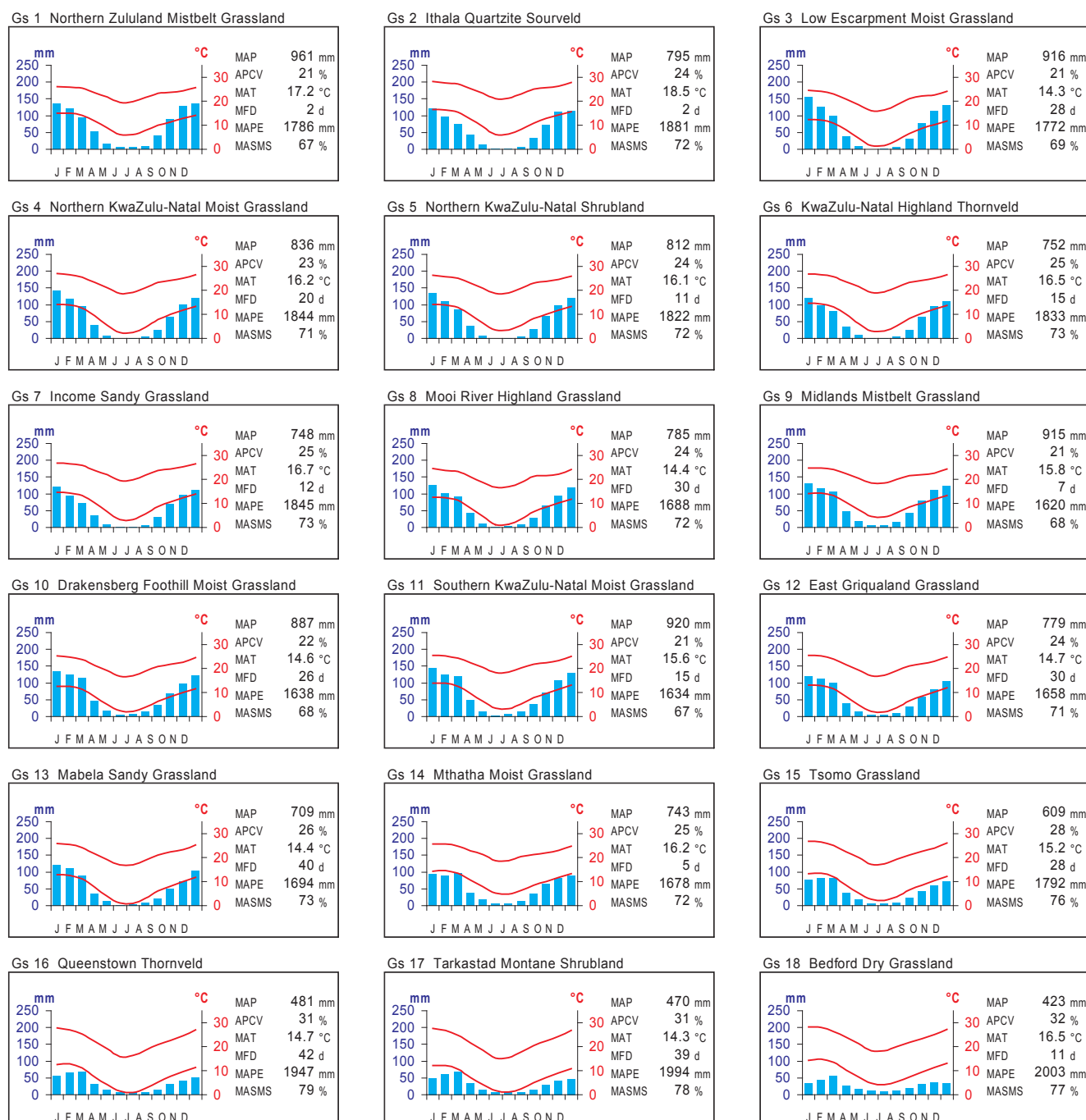


Figure 8.61 Climate diagrams of the Sub-Escarpment Grassland Bioregion units. Blue bars show the median monthly precipitation. The upper and lower red lines show the mean daily maximum and minimum temperature respectively. MAP: Mean Annual Precipitation; APCV: Annual Precipitation Coefficient of Variation; MAT: Mean Annual Temperature; MFD: Mean Frost Days (days when screen temperature was below 0°C); MAPE: Mean Annual Potential Evaporation; MASMS: Mean Annual Soil Moisture Stress (% of days when evaporative demand was more than double the soil moisture supply).

Remark 2 We are aware of the existence of patches of this unit on the highest summits of the Pilanesberg near Rustenberg in the North-West Province, but have not been able to map them due to lack of sufficient data.

References Acocks (1953, 1988), Coetzee (1974, 1975), Coetzee & Werger (1975), Van der Meulen (1979a, b), Westfall (1981), Burgoyne et al. (2000), Van Staden (2002), Bredenkamp & Brown (2003), Van Staden & Bredenkamp (2005).

Sub-Escarpment Grassland

Sub-Escarpment Grassland is found on the rolling hills and flat plains of the foothills of the Drakensberg and Northern Escarpment. The physical nature of these areas is determined by the rate at which the landscape ascends into the main Escarpment region as well as the degree to which the landscape has been shaped by geomorphological forces. The result is a diversity of land forms, including rolling hills, such as the Valley of a Thousand Hills in KwaZulu-Natal, and flat plains such as those found south of the Amathole Mountains. A strong decrease in rainfall can be observed in the Sub-Escarpment Grassland from northeast to southwest (Figure 8.61). In areas with undulating landscapes, common in Transkei and KwaZulu-Natal, the orographic influence of the rising landscape furthermore results in regular mists in these areas and thus the formation of numerous mistbelt regions.



Figure 8.62 Gs 1 Northern Zululand Mistbelt Grassland: Species-rich grasslands on the Ngome Mountain between Nongoma and Vryheid.

Gs 1 Northern Zululand Mistbelt Grassland

VT 64 Northern Tall Grassveld (Transition between Piet Retief Sourveld and Southern Tall Grassveld) (46%), VT 8 North-Eastern Mountain Sourveld (36%) (Acocks 1953). LR 25 Natal Central Bushveld (59%) (Low & Rebelo 1996). BRG 11 Moist Transitional Tall Grassveld (47%), BRG 7 Northern Mistbelt (31%) (Camp 1999a).

Distribution KwaZulu-Natal Province: Crests and slopes of the Ngome Mountain range and the Ngoje Mountain surrounding Louwsburg as well as some smaller mountainous areas of Langkrans, KwaCeza, KwaNtimbankulu and Nhlazatshe. Altitude 780–1 540 m.

Vegetation & Landscape Features Gentle to steep upper slopes of mountains formed by hard dolerite dykes dominated by relatively forb-rich, tall sour *Themeda triandra* grasslands.

Geology & Soils Shales and sandstones of the Madzaringwe and Pietermaritzburg Formations (both Karoo Supergroup) as well as intrusive rocks of the Karoo Dolerite Suite. Dominant soil forms are Hutton, Clovelly and Griffin and are well drained, having 15–35% clay in the A-horizon. Dominant land type Ac, followed in importance by Fa and Ab.

Climate Summer rainfall, with overall MAP around 960 mm, reaching 1 130 mm in places. Moisture-laden air frequently blows in from the southeast and is forced up 400–500 m over the mountains, creating 'mistbelt' conditions (particularly in spring and summer) that contribute to precipitation. MAT is 17.2°C (16–17.4°C) and mean annual range of evaporation is close to 1 790 mm. See also climate diagram for Gs 1 Northern Zululand Mistbelt Grassland (Figure 8.61).

Important Taxa Graminoids: *Themeda triandra* (d), *Tristachya leucothrix* (d), *Alloteropsis semialata* subsp. *eckloniana*, *Andropogon schirensis*, *Aristida monticola*, *Brachiaria ser-rata*, *Cymbopogon nardus*, *Cyperus albobistriatus*, *Ehrharta erecta* var. *erecta*, *Elionurus muticus*, *Eragrostis plana*, *E. racemosa*, *Hyparrhenia hirta*, *Loudetia simplex*, *Microchloa caffra*, *Monocymbium ceresiiforme*, *Panicum deustum*, *Paspalum scrobiculatum*, *Rendlia altera*, *Schizachyrium sanguineum*, *Setaria nigrirostris*, *Sporobolus africanus*, *Trachypogon spicatus*. Herbs: *Aeschynomene micrantha*, *Conostomium natalense*, *Helichrysum chionosphaerum*, *H. nanum*, *H. nudifolium* var. *oxyphyllum*, *H. nudifolium* var. *pilosellum*, *H. umbraculigerum*, *Hermannia grandistipula*. Geophytic Herbs: *Cheilanthes hirta*, *Oxalis smithiana*, *Watsonia latifolia*. Small Tree: *Apodytes dimidiata* subsp. *dimidiata*. Low Shrubs: *Asparagus virgatus*, *Clusia pulchella*. Succulent Shrub: *Aloe arborescens*.

Biogeographically Important Taxon (Low Escarpment endemic) Herb: *Melanospermum italae*.

Endemic Taxa Herbs: *Dracosciadium italae*, *Helichrysum ingomense*, *Selago barbula*. Geophytic Herbs: *Brachystelma ngomense*, *Dierama erectum*, *Schizoglossum ingomense*.

Conservation Vulnerable. Target 23%. Only about 3% statutorily conserved in the Ithala Nature Reserve and in the Ntendeka Wilderness Area of the Ngome State Forest (Scott-Shaw et al. 1996, Scott-Shaw 1999). Some 22% has been transformed for plantations or cultivated land. Threats to the remaining grasslands are heavy selective grazing by livestock and extensive annual burning. Spread of alien *Acacia mearnsii* and *Eucalyptus* species is of serious concern. Erosion very low (47%), moderate (29%), low (14%) and high (10%).

Remarks This vegetation unit surrounds a large patch of Northern Midlands Mistbelt Forest (Von Maltitz et al. 2003) at Ngome. Camp (1999a) indicated that a striking difference between this unit and his BRG 5 and BRG 7 (constituting Midlands Mistbelt Grassland) is the lack of *Aristida junciformis* subsp. *junciformis*. A number of endemic species confined to the region of the Northern Zululand Mistbelt Grassland add to this differentiation.

References Acocks (1953, 1988), Scott-Shaw et al. (1996), Camp (1999a), Scott-Shaw (1999).

Gs 2 Ithala Quartzite Sourveld

VT 64 Northern Tall Grassveld (Transition between Piet Retief Sourveld and Southern Tall Grassveld) (34%), VT 10 Lowveld (32%) (Acocks 1953). LR 43 North-eastern Mountain Grassland (54%) (Low & Rebelo 1996). BRG 20 Dry Zululand Thornveld (42%), BRG 16 Dry Lowland Tall Grassveld (9%) (Camp 1999c, d).

Distribution KwaZulu-Natal and Mpumalanga Provinces and Swaziland: Confined to large quartzite patches that occur from Amsterdam, southwards east of Piet Retief and through Mahamba, to the Paris Dam and Ithala Game Reserve, with isolated outcrops near Magudu. Altitude 440–1 360 m.

Vegetation & Landscape Features Low mountain ranges and undulating hills with rocky lowlands. The general pattern is a mosaic of woody shrubs and small trees in rocky areas, interspersed in the grass layer. Vegetation structure varies according to altitude and rockiness, but the basal density of the grass sward is relatively low. This unit occurs in the zone between Grassland and Savanna where the dominant grassland gives way to woodland as elevation decreases. The grasslands are species-rich covering a variety of altitudes but sharing common species unique to the dystrophic quartzite geology.

Geology & Soils Quartzite of the Mozaan Group (Pongola Supergroup) of the Randian age supporting shallow soils typical of Fb (prevalent) and Fa (marginal) land types.

Climate Rainfall peaks in midsummer. MAP from about 1 200 mm in the west to 570 mm in the east (MAP 795 mm). Frost does occur, but is infrequent. See also climate diagram for Gs 2 Ithala Quartzite Sourveld (Figure 8.61).

Important Taxa Small Trees: *Combretum molle* (d), *Englerophytum magalismontanum* (d), *Syzygium legatii* (d), *Acacia caffra*, *A. davyi*, *Cassipourea swaziensis*, *Cussonia natalensis*, *Dombeya cymosa*, *Faurea rochetiana*, *F. saligna*, *Ficus burt-davyi*, *Lannea discolor*, *Pachystigma macrocalyx*, *Pavetta edentula*, *Protea caffra* subsp. *caffra*, *P. roupelliae* subsp. *roupelliae*, *Pterocarpus angolensis*. Tall Shrubs: *Morella pilulifera* (d), *Pavetta gracilifolia* (d), *Protea gaguedi*, *Rhus pallens*, *R. pentheri*. Woody Climber: *Jasminum multipartitum*. Low Shrubs: *Gymnosporia tenuispina* (d), *Helichrysum lepidissimum*

(d), *Lopholaena platyphylla*. Succulent Shrub: *Crassula sarco-caulis*. Graminoids: *Heteropogon contortus* (d), *Hyperthelia dissoluta* (d), *Loudetia simplex* (d), *Monocymbium ceresiiforme* (d), *Panicum natalense* (d), *Themeda triandra* (d), *Trachypogon spicatus* (d), *Bothriochloa insculpta*, *Diheteropogon amplex-tens*, *Melinis nerviglumis*, *Pogonarthria squarrosa*, *Sporobolus pectinatus*. Herbs: *Anisopappus smutsii* (d), *Xerophyta retinervis*. Succulent Herb: *Aloe cooperi* subsp. *cooperi*. Succulent Herbaceous Climber: *Ceropegia sandersonii*.

Biogeographically Important Taxa (^LLow Escarpment endemic, ^NNorthern sourveld endemic) Small Tree: *Protea comptonii*^N. Tall Shrub: *Tricalysia capensis* var. *galpini*^N (d). Low Shrub: *Hemizygia macrophylla*^L. Succulent Shrub: *Aloe suprafoliata*^N (d). Herbs: *Melanospermum itala*^L, *Thorncroftia longiflora*^N. Geophytic Herb: *Gladiolus vernus*^N.

Endemic Taxa Tall Shrub: *Euclea natalensis* subsp. *magutensis*. Succulent Shrub: *Aloe dewetii*. Graminoid: *Danthoniopsis scopulorum*. Geophytic Herb: *Gladiolus scabridus*.

Conservation Least threatened. The target of 27% has not been reached. A total of 10% of this unit is protected within the Ithala Game Reserve. Land use pressures on this unit are low, probably because of its low nutrient status and rocky nature. Approximately 5% is under plantations and a further 5% has been transformed into cultivated land. Soil erosion potential is low.

Remarks This naturally fragmented vegetation unit is characterised by its rocky and nutrient-poor soils which support a unique assemblage of plant species. It shares some species with the nutrient-poor soils of the Northern Escarpment (e.g. *Syzygium legatii*) and Barberton areas (e.g. *Thorncroftia longiflora*, *Protea comptonii*). These latter units have a higher MAP.

References Acocks (1953, 1988), M.C. Lötter (unpublished data).

Gs 3 Low Escarpment Moist Grassland

VT 44 Highland Sourveld and Dohne Sourveld (54%) (Acocks 1953). LR 41 Wet Cold Highveld Grassland (54%) (Low & Rebelo 1996). BRG 8 Moist Highland Sourveld (70%) (Camp 1999b).

Distribution KwaZulu-Natal, Free State and Mpumalanga Provinces: Slopes of the Drakensberg, on both sides of the provincial boundary from Oliviershoek (near Harrismith) to Volksrust. Altitude 1 300–2 000 m.

Vegetation & Landscape Features Complex mountain topography. Steep, generally east- and south-facing slopes, with a large altitudinal range. Supporting tall, closed grassland with *Hyparrhenia hirta* and *Themeda triandra* dominant. *Protea caffra* communities and patches of *Leucosidea* scrub feature at higher altitudes.

Geology & Soils Ecca and Beaufort Groups (Karoo Supergroup) mudstone or shale. Soils are mainly of the Hutton form, but also shallower forms such as Glenrosa and Mispah. Half of the area is classified as Fa land type, while the rest is shared among Ac, Bb and Ad land types.

Climate Summer rainfall, with peak from December to January. Frequent fog adds



M.C. Lötter

Figure 8.63 Gs 2 Ithala Quartzite Sourveld: Sparse rocky grassland with shrubby *Englerophytum magalismontanum*, *Aloe suprafoliata* and *Acacia karroo* on quartzite ridges in the Ithala Game Reserve (northern KwaZulu-Natal).

to the overall precipitation. MAP is almost 920 mm and mean annual evaporation reaches 1 770 mm. MAT of 14.3°C and almost 30 days of frost indicate that the unit is found close to the lower limit of warm-temperate climate. See also climate diagram for Gs 3 Low Escarpment Moist Grassland (Figure 8.61).

Important Taxa Graminoids: *Alloteropsis semialata* subsp. *eckloniana* (d), *Andropogon schirensis* (d), *Diheteropogon filifolius* (d), *Eragrostis plana* (d), *Hyparrhenia hirta* (d), *Monocymbium cerasiiforme* (d), *Themeda triandra* (d), *Trachypogon spicatus* (d), *Tristachya leucothrix* (d), *Andropogon appendiculatus*, *Brachiaria serrata*, *Brachypodium flexum*, *Cynodon dactylon*, *C. transvaalensis*, *Digitaria diagonalis*, *D. monodactyla*, *D. tricholaenoides*, *Diheteropogon amplexans*, *Eragrostis capensis*, *E. chloromelas*, *E. curvula*, *E. gummiflua*, *E. racemosa*, *Harpochloa falx*, *Hyparrhenia tamba*, *Koeleria capensis*, *Loudetia simplex*, *Panicum ecklonii*, *P. natalense*. Herbs: *Acanthospermum australe* (d), *Vernonia natalensis* (d), *Acalypha depressinerva*, *Adenocline acuta*, *Berkheya rhapontica* subsp. *rhapontica*, *Corchorus confusus*, *Crabbea acaulis*, *Cucumis zeyheri*, *Eriosema cordatum*, *Graderia scabra*, *Haplocarpha scaposa*, *Helichrysum miconiifolium*, *H. oreophilum*, *H. psilolepis*, *H. rugulosum*, *H. spiralepis*, *Kohautia amatymbica*, *Lotononis procumbens*, *Nidorella anomala*, *Pentanisia prunelloides* subsp. *latifolia*, *Selago densiflora*, *Senecio venosus*, *Zaluzianskya microsiphon*. Herbaceous Climber: *Rhynchosia totta*. Geophytic Herbs: *Corycium dramontanum*, *C. nigrescens*, *Gladiolus crassifolius*, *Habenaria dives*, *Hypoxis hemerocallidea*, *H. multiceps*, *H. rigidula* var. *pilosissima*, *Pteridium aquilinum*. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum*, *Chaetacanthus burchellii*, *Clusia pulchella*, *Gnidia kraussiana*, *Helichrysum hypoleucum*, *H. infaustum*, *Phyllanthus glaucophyllus*.

Biogeographically Important Taxon (Low Escarpment endemic) Low Shrub: *Heteromma krookii*.

Endemic Taxon Geophytic Herb: *Holothrix majubensis*.

Conservation Least threatened. Target 23%. Only 2% statutorily conserved in the Sterkfontein Dam Nature Reserve (Free State) and Ncandu Nature Reserve (KwaZulu-Natal). About 6% has been transformed by plantations or cultivated land. Alien *Acacia dealbata* occurs in places. Erosion very low (56%) and low (38%).

Remark A series of patches of Northern KwaZulu-Natal Mistbelt Forests (see Von Maltitz et al. 2003) are embedded within this type of grassland in sub-escarpment regions and deep-kloof positions.

References Acocks (1953, 1988), Edwards (1967), Smit (1992), Smit et al. (1992, 1993b, 1995a, b), Camp (1999b).

Gs 4 Northern KwaZulu-Natal Moist Grassland

VT 65 Southern Tall Grassveld (70%) (Acocks 1953). LR 43 North-eastern Mountain Grassland (53%) (Low & Rebelo 1996). BRG 11 Moist Transitional Tall Grassveld (54%) (Camp 1999a).

Distribution KwaZulu-Natal Province: Northern and northwestern regions of the Province, where it forms a discontinuous rim around the upper Thukela Basin and is situated almost entirely within the catchment of the Thukela River. It lies between the drier Gs 6 KwaZulu-Natal

Highland Thornveld and the moist upland vegetation of mainly Gs 3 Low Escarpment Moist Grassland to the north and Gs 10 Drakensberg Foothill Moist Grassland to the west. The most extensive areas are in the vicinity of Winterton, Bergville, Fort Mistake, Dannhauser, Dundee, north of Ladysmith and west of Newcastle. At higher altitudes this unit is usually surrounded by Gs 3 Low Escarpment Moist Grassland in the north and Gs 10 Drakensberg Foothill Moist Grassland in the west and south. At lower altitudes Gs 6 KwaZulu-Natal Highland Thornveld and SVs 2 Thukela Thornveld usually occur to the east. Altitude 1 040–1 440 m.

Vegetation & Landscape Features Hilly and rolling landscapes supporting tall tussock grassland usually dominated by *Themeda triandra* and *Hyparrhenia hirta*. Open *Acacia sieberiana* var. *woodii* savannoid woodlands encroach up the valleys, usually on disturbed (strongly eroded) sites.

Geology & Soils Mudstones, sandstones and shales of the Beaufort and Ecca Groups of the Karoo Supergroup predominate and are intruded by dolerites of Jurassic age. Land types Bb, Ac, Fa and Ca.

Climate Summer rainfall, with overall MAP of 840 mm (710–1 120 mm; Camp 1999a), mainly as summer thunderstorms. Mist occurs frequently on hilltops in spring and early summer, but summer droughts are also frequent. Summers are warm to hot, with maximum temperature recorded in the hottest month of January (Bergville MAT 27.8°C). MAT is around 16°C, but some localities may reach 17°C. Frosts are severe and occur about 20 days per year. Mean annual evaporation recorded at Bergville is 1 895 mm. See also climate diagram for Gs 4 Northern KwaZulu-Natal Moist Grassland (Figure 8.61).

Important Taxa Graminoids: *Alloteropsis semialata* subsp. *eckloniana* (d), *Aristida congesta* (d), *Cynodon dactylon* (d), *Digitaria tricholaenoides* (d), *Elionurus muticus* (d), *Eragrostis patentissima* (d), *E. racemosa* (d), *Harpochloa falx* (d), *Hyparrhenia hirta* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Abildgaardia ovata*, *Andropogon appendiculatus*, *A. eucomus*, *A. schirensis*, *Aristida junciformis* subsp. *galpinii*, *Brachiaria serrata*, *Cymbopogon caesius*, *C. pospischilii*, *Cynodon incompletus*, *Digitaria monodactyla*, *D. san-*



Figure 8.64 Gs 4 Northern KwaZulu-Natal Moist Grassland: Savannoid grasslands with *Acacia sieberiana* var. *woodii* near Weenen (northern KwaZulu-Natal).

ginalis, *Diheteropogon amplexans*, *D. filifolius*, *Eragrostis chloromelas*, *E. plana*, *E. planiculmis*, *E. sclerantha*, *Festuca scabra*, *Heteropogon contortus*, *Hyparrhenia dregeana*, *Melinis nerviglumis*, *Microchloa caffra*, *Panicum natalense*, *Paspalum scrobiculatum*, *Setaria nigrirostris*, *Sporobolus africanus*. Herbs: *Acanthospermum australe* (d), *Argyrobolus speciosus* (d), *Eriosema kraussianum* (d), *Geranium wakkerstroomianum* (d), *Pelargonium luridum* (d), *Acalypha peduncularis*, *Chamaecrista mimosoides*, *Dicoma anomala*, *Euryops transvaalensis* subsp. *setilobus*, *Helichrysum caespitium*, *H. rugulosum*, *Hermannia depressa*, *Ipomoea crassipes*, *Pearsonia grandifolia*, *Pentanisia prunelloides* subsp. *latifolia*, *Sebaea grandis*, *Senecio inornatus*, *Thunbergia atriplicifolia*, *Zaluzianskya microsiphon*. Geophytic Herbs: *Chlorophytum haygarthii* (d), *Gladiolus aurantiacus* (d), *Asclepias aurea*, *Cyrtanthus tuckii* var. *transvaalensis*, *Gladiolus crassifolius*, *Hypoxis colchicifolia*, *H. multiceps*, *Moraea brevistyla*, *Zantedeschia rehmannii*. Succulent Herbs: *Aloe ecklonis*, *Lopholaena segmentata*. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum*, *Erica oatesii*, *Hermannia geniculata*. Succulent Shrub: *Euphorbia pulvinata*.

Biogeographically Important Taxa (both Low Escarpment endemics) Succulent Herb: *Aloe modesta*. Low Shrub: *Bowkeria citrina*.

Conservation Vulnerable. Target 24%. Only about 2% statutorily conserved in the uKhahlamba Drakensberg Park as well as in the Chelmsford, Spioenkop, Moor Park, Wagendrift, Ncandu Nature Reserves. More than a quarter has already been transformed either for cultivation, plantations and urban sprawl or by building of dams (Chelmsford, Driel, Kilburn, Mtoti, Wagendrift, Windsor and Woodstock). Alien *Acacia dealbata*, *Rubus*, *Eucalyptus* and *Populus* are invasive in places. Bush encroachment is common. Erosion very low (53%), low (2%) and moderate (20%).

References Acocks (1953, 1988), Smit (1992), Smit et al. (1993a, 1995a, c), Camp (1999a).

Gs 5 Northern KwaZulu-Natal Shrubland

VT 65 Southern Tall Grassveld (68%) (Acocks 1953). Interior *Acacia caffra* Scrub and Tree Veld & *Diospyros lycioides* Scrub (Edwards 1967). LR 25 Natal Central Bushveld (60%) (Low & Rebelo 1996). BRG 11 Moist Transitional Tall Grassveld (42%), BRG 12 Moist Tall Grassveld (34%) (Camp 1999a, c).

Distribution KwaZulu-Natal Province: A widely scattered group of patches. Embedded within Sub-Escarpment Grassland units of Gs 4, Gs 6 and Gs 7, from Ladysmith in the west to Vryheid in the northeast. Large portions of this unit are found in the surrounds of Newcastle. Altitude 1 100–1 540 m.

Vegetation & Landscape Features Small dolerite koppies and steeper slopes of ridges with sparse grass cover and typical occurrence of scattered shrubland pockets (and locally also thickets). *Acacia caffra*, *A. natalitia*, *Clerodendrum glabrum*, *Diospyros lycioides*, *Rhus pyroides*, *R. pentheri*, *Scutia myrtina* etc. are the most prominent shrubs and small trees.

Geology & Soils Karoo Sequence sediments underlie this area: Madzaringwe Formation shale and sandstones are found in the east and Adelaide Subgroup and Volksrust Formation mudrocks occur in the west. The most significant feature is the intrusive dolerite dykes and sills which give rise to heavy clayey soils. Fa and Fb land types have an equal importance, followed by Ea.

Climate Summer rainfall, with MAP 800 mm. Overall MAT of 16.1°C indicates a transition between cool- and warm-temperate climates. Frost fairly infrequent. See also climate diagram for Gs 5 Northern KwaZulu-Natal Shrubland (Figure 8.61).

Important Taxa Small Trees: *Acacia caffra* (d), *A. natalitia* (d), *A. sieberiana* var. *woodii*, *Cussonia paniculata*, *Euclea crispa* subsp. *crispa*, *Heteromorpha arborescens* var. *abyssinica*, *Hippobromus pauciflorus*, *Scutia myrtina*, *Ziziphus mucronata*. Tall Shrubs: *Diospyros lycioides* subsp. *lycioides* (d), *Rhus rehmanniana* var. *rehmanniana* (d), *Acokanthera oppositifolia*, *Asparagus setaceus*, *Canthium mundianum*, *Cephalanthus natalensis*, *Clerodendrum glabrum*, *Diospyros whyteana*, *Euclea natalensis* subsp. *angustifolia*, *Leonotis leonurus*, *Lippia javanica*, *Pavetta gardeniifolia* var. *gardeniifolia*, *Rhus dentata*, *R. lucida*, *R. pentheri*, *R. pyroides*, *Scolopia zeyheri*. Woody Climbers: *Clematis brachiata*, *Dalbergia obovata*, *Dioscorea sylvatica*, *Jasminum breviflorum*, *Rhoicissus tridentata*. Succulent Woody Climber: *Sarcostemma viminalis*. Low Shrubs: *Barleria obtusa* (d), *Anthospermum rigidum* subsp. *pumilum*, *Artemisia afra*, *Chaetacanthus burchellii*, *Euryops pedunculatus*, *Grewia hispida*, *Phyllanthus glaucophyllus*, *Pygmaeothamnus chamaedendrum*. Succulent Shrub: *Euphorbia clavarioides* var. *clavarioides*. Graminoids: *Cymbopogon caesus* (d), *Eragrostis racemosa* (d), *Hyparrhenia hirta* (d), *Themeda triandra* (d), *Bothriochloa insculpta*, *Cymbopogon nardus*, *Eragrostis curvula*, *E. plana*, *Hyparrhenia dregeana*, *Setaria sphacelata*. Herbs: *Acalypha caperonioides*, *A. punctata*, *Aster bakerianus*, *Commelina africana*, *Conyza obscura*, *Corchorus confusus*, *Crabbea angustifolia*, *Dicoma anomala*, *Eriosema cordatum*, *Helichrysum rugulosum*, *Ipomoea oblongata*, *Monsonia angustifolia*, *Selago densiflora*, *Stachys natalensis*. Geophytic Herbs: *Cheilanthes hirta*, *C. quadripinnata*, *Hypoxis rigidula* var. *pilosissima*, *Ledebouria ovatifolia*, *Oxalis obliquifolia*, *Pellaea calomelanos*, *Raphionacme hirsuta*. Succulent Herbs: *Aloe maculata*, *Crassula alba*.

Biogeographically Important Taxon (endemic to northern KwaZulu-Natal) Herb: *Cissus cussonioides*.

Endemic Taxon Tall Shrub: *Calpurnia woodii*.

Conservation Least threatened. Target 23%. Less than 1% statutorily conserved in the Spioenkop Nature Reserve. About 3% transformed by cultivation. Erosion very low (35%), moderate (29%), low (22%) and high (10%).

Remark This vegetation is floristically similar to sourveld of the Highveld region (e.g. Suikerbosrand) on the one hand and to montane shrublands of the Drakensberg area on the other.

References Smit et al. (1995b), Eckhardt et al. (1997), Eckhardt (1998), Robesson (1998).

Gs 6 KwaZulu-Natal Highland Thornveld

VT 65 Southern Tall Grassveld (57%) (Acocks 1953). *Acacia sieberiana* Tree Veld (Edwards 1967). LR 25 Natal Central Bushveld (72%) (Low & Rebelo 1996). BRG 13 Dry Tall Grassveld (89%) (Camp 1999c).

Distribution KwaZulu-Natal Province: A series of several patches in the central-northern regions of KwaZulu-Natal, where it occurs on both dry valleys and moist upland. The most extensive area is found in the region from Ladysmith, Winterton, Estcourt and Colenso, between Mooi River and Greytown, between Pomeroy and Babanago, and further north in a triangle between Vryheid, Paulpietersburg and Louwsburg as well as a large patch around Newcastle. Altitude 920–1 440 m.

Vegetation & Landscape Features Hilly, undulating landscapes and broad valleys supporting tall tussock grassland usually dominated by *Hyparrhenia hirta*, with occasional savannoid woodlands with scattered *Acacia sieberiana* var. *woodii* and in small pockets also with *A. karroo* and *A. nilotica*.

Geology & Soils A variety of Karoo Supergroup rocks occur in the area, including the Dwyka, Ecce and Beaufort Groups and marginally also Jurassic dolerite intrusions. Yellow-brown soils over plinthic subsoil and shallow duplex soils are common. Red and black heavy soils are derived from dolerites and show high resistance to erosion. The unit falls within various land types, including Ca, Fb, Fa, Db and Bb.

Climate Summer rainfall. MAP about 750 mm (79 rain days per year; Camp 1999c). The midwinter months of June and July have 2.6 rain days on average. Much of the summer precipitation comes in form of thunderstorms (63 and 56 thunderstorm days per year for Ladysmith and Estcourt, respectively). Mist is uncommon (14 days of mist per year for both Ladysmith and Estcourt). MAT 15.6–19.0°C (overall average 16.5°C). Summers are warm to hot, winters are cool. There are 15 frost days per year. The mean annual evaporation recorded at Estcourt is 1 725 mm, while the range for the entire vegetation unit is 1 706–1 918 mm (Camp 1999c), the overall average 1 830 mm. See also climate diagram for Gs 6 KwaZulu-Natal Highland Thornveld (Figure 8.61).

Important Taxa Small Trees: *Acacia sieberiana* var. *woodii* (d), *A. natalitia*, *A. nilotica*, *Cussonia spicata*, *Ziziphus mucronata*. Tall Shrub: *Dichrostachys cinerea*. Low Shrubs: *Barleria obtusa* (d), *Anthospermum rigidum* subsp. *pumilum*, *Chaetacanthus setiger*, *Gymnosporia heterophylla*. Semiparasitic Shrub: *Thesium costatum*. Graminoids: *Abildgaardia ovata* (d), *Andropogon eucomis* (d), *Aristida bipartita* (d), *A. congesta* (d), *Chloris virgata* (d), *Cynodon dactylon* (d), *Elionurus muticus* (d), *Eragrostis capensis* (d), *E. chloromelas* (d), *E. plana* (d), *E. racemosa* (d), *E. superba* (d), *Heteropogon contortus* (d), *Hyparrhenia hirta* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Andropogon appendiculatus*, *Brachiaria serrata*, *Cymbopogon caesius*, *C. marginatus*, *C. pospischilii*, *Cyperus obtusiflorus* var. *obtusiflorus*, *Digitaria monodactyla*, *D. tricholaenoides*, *Diheteropogon amplexens*, *Eragrostis curvula*, *E. gummiflua*, *E. patentissima*, *Harpochloa falx*, *Microchloa caffra*, *Panicum natalense*, *Setaria nigrirostris*, *Sporobolus africanus*, *S. pyramidalis*. Herbs: *Hermannia depressa* (d), *Becium filamentosum*, *Chamaecrista mimosoides*, *Euryops transvaalensis* subsp. *setilobus*, *Haplocarpha scaposa*, *Helichrysum rugulosum*. Herbaceous Climber: *Rhynchosia totta*. Geophytic Herb: *Haemanthus montanus*. Succulent Herbs: *Aloe dominella*, *A. greenii*, *Orbea woodii*.

Endemic Taxa Low Shrub: *Barleria greenii*. Succulent Shrub: *Aloe gerstneri*. Succulent Herb: *Aloe inconspicua*.

Conservation Least threatened. Target 23%. Only about 2% statutorily conserved in the Spioenkop, Weenen, Ntinini, Wagendrift, Moor Park and Tugela Drift Nature Reserves. More than 16% has been transformed for cultivation and by urban sprawl as well as by building of dams (Craigie Burn, Spioenkop, Wagendrift and Windsor). Alien *Opuntia*, *Eucalyptus*, *Populus*, *Acacia* and *Melia* are becoming invasive in places, but probably the greatest threat to the remaining natural areas of this unit is bush encroachment. Erosion very low (34%), low (29%), moderate (2%) and high (12%).

Remarks The presence of sparse woodlands with *Acacia* are considered a management problem and ascribed to 'bush encroachment' (Edwards 1967, Camp 1999c). One may, however, argue that the region of this vegetation unit has always been a natural mosaic of open tall grassland and sparse woodland (with virtually the same species composition as the neighbouring grassland), with progressive encroachment of woody elements into grassland, especially in heavily disturbed areas.

References Acocks (1953, 1988), Edwards (1967), Adams (1996), Morris

& Tainton (1996), Roos & Allsopp (1997), Robesson (1998), Camp (1999c), Scott-Shaw (1999).

Gs 7 Income Sandy Grassland

VT 66 Natal Sour Sandveld (68%) (Acocks 1953). LR 25 Natal Central Bushveld (85%) (Low & Rebelo 1996). BRG 14 Sour Sandveld (76%) (Camp 1999c).

Distribution KwaZulu-Natal Province: In a large triangle between Newcastle, Vryheid and Dundee and larger polygon in the Wasbank area in northern KwaZulu-Natal. Altitude 880–1 340 m (mainly 1 120–1 240 m).

Vegetation & Landscape Features Very flat extensive areas with generally shallow, poorly drained, sandy soils supporting low, tussock-dominated sourveld forming a mosaic with wooded grasslands (with *Acacia sieberiana* var. *woodii*) and on well-drained sites with the trees *A. karroo*, *A. nilotica*, *A. caffra* and *Diospyros lycioides*. On disturbed sites *A. sieberiana* var. *woodii* can form sparse woodlands. *Aristida congesta*, *Cynodon dactylon* and *Microchloa caffra* are common on shallow soils (Camp 1999c).

Geology & Soils Sandstones and shale of the Madzaringwe Formation (Ecce Group of Karoo Supergroup) supporting poorly drained sandy soils, mostly of the Glenrosa form. Most important land types Ca, Bb and Fb.

Climate Region of summer rainfall, with most precipitation occurring between October and March (overall MAP 750 mm; range 650–800 mm), much of which falls as thundershowers often accompanied by hail. MAT is just below 17°C, and mean annual evaporation 1 845 mm. Frost moderate (Camp 1999c). See also climate diagram for Gs 7 Income Sandy Grassland (Figure 8.61).

Important Taxa Graminoids: *Andropogon appendiculatus* (d), *Brachiaria serrata* (d), *Cynodon dactylon* (d), *Digitaria monodactyla* (d), *D. tricholaenoides* (d), *Eragrostis curvula* (d), *E. gummiflua* (d), *E. plana* (d), *E. racemosa* (d), *Heteropogon contortus* (d), *Hyparrhenia hirta* (d), *Loudetia simplex* (d), *Paspalum scrobiculatum* (d), *Tristachya leucothrix* (d), *Alloteropsis semialata* subsp. *eckloniana*, *Andropogon eucomis*, *A. schirensis*, *Aristida congesta*, *A. junciformis* subsp. *galpinii*, *Cymbopogon caesius*, *Diheteropogon amplexens*, *D. filifolius*, *Elionurus muticus*, *Eragrostis capensis*, *E. chloromelas*, *E. planiculmis*, *E. sclerantha*, *Harpochloa falx*, *Melinis repens* subsp. *repens*, *Microchloa caffra*, *Monocymbium ceresiiforme*, *Panicum natalense*, *Perotis patens*, *Pogonarthria squarrosa*, *Setaria nigrirostris*, *Sporobolus africanus*, *Stiburus conrathii*, *Themeda triandra*, *Trichoneura grandiglumis*. Herbs: *Helichrysum rugulosum* (d), *Berkheya onopordifolia* var. *glabra*, *B. setifera*, *Chamaecrista mimosoides*, *Dicoma anomala*, *Euryops transvaalensis* subsp. *setilobus*, *Helichrysum caespitium*, *H. cephaloideum*, *H. simillimum*, *Hermannia depressa*, *H. transvaalensis*, *Kohautia amatymbica*, *K. virgata*, *Macledium zeyheri* subsp. *argyrophyllum*, *Pentania prunelloides* subsp. *latifolia*, *Senecio coronatus*, *Zornia capensis*. Herbaceous Climber: *Rhynchosia totta*. Geophytic Herb: *Hypoxis rigidula* var. *pilosissima*. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum*, *Stoebe plumosa*.

Conservation Vulnerable. Target 23%. None conserved in statutory conservation areas. Some 27% has been transformed for cultivation, plantations and by urban sprawl. Small portion of the area has been lost to the building of dams (Klipfontein, Mvunyané). No serious invasions of aliens have been observed (probably due to low nutrient status of soils). Erosion moderate (38%), high (30%) and low (15%).

Remarks The differences between this unit and the Gs 13 Mabela Sandy Grassland (in East Griqualand), lie especially in some climatic and vegetation patterns. Cedarville (in Gs 13 Mabela Sandy Grassland) is much colder (MAT 14°C), shows lower transpiration, has higher incidence of frost and hence lacks indigenous trees.

References Acocks (1953, 1988), Eckhardt et al. (1996a, b), Eckhardt (1998), Camp (1999c).

Gs 8 Mooi River Highland Grassland

VT 44 Highland Sourveld and Dohne Sourveld (77%) (Acocks 1953). LR 42 Moist Upland Grassland (48%), LR 43 North-eastern Mountain Grassland (27%) (Low & Rebelo 1996). BRG 9 Dry Highland Sourveld (99%) (Camp 1999b).

Distribution KwaZulu-Natal Province: Centre of occurrence in the Mooi River Basin, several scattered large patches near Underberg and Greytown, and on the Helpmekaar Plateau southeast of Dundee. Altitude 1 340–1 620 m.

Vegetation & Landscape Features Mainly rolling and partly broken landscape, covered in grassland dominated by short bunch grasses. *Heteropogon contortus*, *Themeda triandra* and *Tristachya leucothrix* are dominant in well-managed veld.

Geology & Soils A mosaic of generally shallow and poorly drained soils derived from sedimentary rocks, mostly of the Adelaide Subgroup (Beaufort Group) of the Karoo Sequence. Deep well-drained apedal soils of the intrusive igneous rocks of the Karoo Dolerite Suite also occur. Almost half of the area is classified as Ac land type, followed by Bb and to lesser extent also Fa.

Climate The region has a MAP of 785 mm, falling mostly in summer. Mist and snow are not frequent. Overall MAT is slightly higher than 14°C. Light, but relatively frequent (30 days per year) frosts may occur for six months in the year (Camp 1999b). See also climate diagram for Gs 8 Mooi River Highland Grassland (Figure 8.61).

Important Taxa Graminoids: *Diheteropogon filifolius* (d), *Eragrostis curvula* (d), *E. plana* (d), *E. racemosa* (d), *Heteropogon contortus* (d), *Microchloa caffra* (d), *Monocymbium cerasiiforme*

(d), *Panicum ecklonii* (d), *P. gilvum* (d), *Sporobolus africanus* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Alloteropsis semialata* subsp. *eckloniana*, *Andropogon schirensis*, *Aristida junciformis* subsp. *galpinii*, *Brachiaria serrata*, *Cynodon dactylon*, *Digitaria monodactyla*, *D. tricholaenoides*, *Diheteropogon amplexans*, *Eragrostis capensis*, *E. chloromelas*, *Harpochloa falx*, *Pycnus flavescens*, *P. niger* subsp. *niger*, *Setaria nigrirostris*. Herbs: *Acalypha depressinerva*, *Becium filamentosum*, *Berkheya setifera*, *Conyza pinnata*, *Didymodora caffra*, *Geranium ornithopodioides*, *Pentanisia prunelloides* subsp. *latifolia*, *Plectranthus laxiflorus*, *Salvia repens*, *Schistostephium crataegifolium*, *Sebaea grandis*, *Senecio gregatus*, *Vernonia natalensis*. Herbaceous Climbers: *Rhynchosia caribaea* (d), *R. totta*. Geophytic Herb: *Oxalis purpurea*. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum*, *Senecio burchellii*.

Conservation Vulnerable. Target 23%. Only a tiny part statutorily conserved in the Swamp Nature Reserve. Almost a quarter of the area has been transformed for cultivation (maize, beef and dairy farming) or plantations. Alien woody plants such as *Acacia dealbata*, *Rubus* species, *Melia azedarach*, *Sesbania punicea*, *Populus x canescens*, *P. alba* and *Eucalyptus* species are invaders in some places. Erosion is very low (70%) and low (25%).

Remark This unit is a dry version of Gs 10 Drakensberg Foothill Moist Grassland, generally occurring in an adjacent rainshadow area.

References Acocks (1953, 1988), Camp (1999b).

Gs 9 Midlands Mistbelt Grassland

VT 45 Ngongoni Veld of Natal Mist-belt (38%), VT 44 Highland Sourveld and Dohne Sourveld (33%) (Acocks 1953). LR 42 Moist Upland Grassland (41%), LR 47 Short Mistbelt Grassland (37%) (Low & Rebelo 1996). BRG 5 Moist Midlands Mistbelt, BRG 6 Dry Midlands Mistbelt (Camp 1999a).

Distribution KwaZulu-Natal and Eastern Cape Provinces: KwaZulu-Natal Midlands—scattered in broad belt in the form of several major patches including Melmoth-Babanango area, Kranskop and Greytown, Howick Lions River, Karkloof, Balgowan, Cedara, Edendale, Hilton, Richmond, the Ixopo-Highflats area, Mount Malowe in the Umzimkhulu enclave of the Eastern Cape Province and the Harding-Weza area. The southwesternmost section in the Eastern Cape Province falls in the Bulembu, Gxwaleni, Longweni and Flagstaff areas. Altitude 760–1 400 m.

Vegetation & Landscape Features

Hilly and rolling landscape mainly associated with a discontinuous east-facing scarp formed by dolerite intrusions (south of the Thukela River). Dominated by forb-rich, tall, sour *Themeda triandra* grasslands transformed by the invasion of native 'Ngongoni grass (*Aristida junciformis* subsp. *junciformis*). Only a few patches of the original species-rich grasslands remain.

Geology & Soils Apedal and plinthic soil forms derived mostly from Ecca Group (Karoo Supergroup) shale and minor sandstone and less importantly from



P.J. du Preez

Figure 8.65 Gs 8 Mooi River Highland Grassland: Patch of Sub-Escarpment Grassland near Mooi River (western KwaZulu-Natal) dominated by grasses such as *Themeda triandra*, *Harpochloa falx*, *Tristachya leucothrix* and *Hyparrhenia hirta* supporting a rich herb flora.

Jurassic dolerite dykes and sills. Dominant land type Ac, followed by Fa.

Climate Summer rainfall, with MAP of 915 mm, range 730–1 280 mm. Heavy and frequent occurrence of mist provides significant amounts of additional moisture (Cedara near Pietermaritzburg has 46 misty days per year). Some of the rain is in the form of cold frontal activity, mainly in winter, spring and early summer. Thunderstorms are common in summer and autumn (Cedara: 60 days of thunderstorms per year). Mean annual evaporation 1 463–1 797 mm (Camp 1999a). MAT 15.8°C, absolute minimum temperature was recorded in this region in June (–10.8°C). Frosts are generally moderate, but occasional severe frost may also occur. Further climatic conditions include short-term drought spells, hail and hot northwestern berg winds occurring particularly in spring and early summer. See also climate diagram for Gs 9 Midlands Mistbelt Grassland (Figure 8.61).



J.E. Granger

Figure 8.66 Gs 9 Midlands Mistbelt Grassland: Grasslands in the Lions River region near Howick (KwaZulu-Natal) with common herbs such as *Senecio bupleuroides*, *Helichrysum pallidum* and *Alepidea longifolia*.

Important Taxa Graminoids: *Andropogon appendiculatus* (d), *Aristida junciformis* subsp. *galpinii* (d), *Diheteropogon filifolius* (d), *Eragrostis plana* (d), *Hyparrhenia hirta* (d), *Sporobolus africanus* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Alloteropsis semialata* subsp. *eckloniana*, *Andropogon schirensis*, *Brachiaria serrata*, *Cymbopogon caesius*, *C. nardus*, *Digitaria diagonalis*, *D. tricholaenoides*, *Diheteropogon amplexans*, *Elionurus muticus*, *Eragrostis capensis*, *E. curvula*, *E. racemosa*, *Eulalia villosa*, *Harporchloa falx*, *Heteropogon contortus*, *Loudetia simplex*, *Microchloa caffra*, *Monocymbium cerasiiforme*, *Panicum aequinerve*, *P. ecklonii*, *P. natalense*, *Paspalum dilatatum*, *P. scrobiculatum*, *P. urvillei*, *Setaria nigrirostris*, *S. sphacelata*, *Sporobolus centrifugus*, *Trachypogon spicatus*. Herbs: *Acalypha glandulifolia*, *Acanthospermum australe*, *Berkheya rhapontica* subsp. *aristosa*, *B. setifera*, *Commelina africana*, *Conyza pinata*, *Eriosema salignum*, *Helichrysum cephaloideum*, *H. simillimum*, *Indigostrum fastigiatum*, *Kohautia amatymbica*, *Nidorella auriculata*, *Pentanisia prunelloides* subsp. *latifolia*, *Sebaea sedoides* var. *schoenlandii*, *Spermacoce natalensis*, *Thunbergia atriplicifolia*, *Vernonia dregeana*, *V. natalensis*, *Wahlenbergia undulata*. Herbaceous Climber: *Vigna nervosa*. Geophytic Herbs: *Pteridium aquilinum* (d), *Corycium nigrescens*, *Drimia macrocentra*, *Eriospermum ornithogaloideum*, *Gladiolus ecklonii*, *Habenaria dives*, *H. dregeana*, *Hypoxis multiceps*, *H. rigidula* var. *pilosissima*, *Rhodohypoxis baurii* var. *baurii*, *R. baurii* var. *platyptala*, *Satyrium longicauda*. Low Shrubs: *Helichrysum sutherlandii*, *Leonotis ocymifolia*, *Otholobium caffrum*.

Biogeographically Important Taxa (both Southern distribution limit) Herb: *Anisopappus smutsii*. Succulent Herb: *Aloe kniphofioides*.

Endemic Taxa Herbs: *Acalypha entumenica*, *Selago longiflora*. Geophytic Herbs: *Asclepias woodii*, *Albuca xanthocodon*, *Dierama luteoalbum*, *Kniphofia latifolia*, *Pachycarpus rostratus*, *Watsonia canaliculata*. Low Shrubs: *Helichrysum citricephalum*, *Syncolostemon latidens*.

Conservation Endangered (one of the most threatened vegetation types of KwaZulu-Natal). Target 23%. Only a small fraction (about 0.5%) statutorily conserved in number of reserves such as Ngeli, Impendle, Blinkwater, Qudeni, Doreen Clark, Karkloof and Queen Elizabeth Park—still heavily underrepresented in

conservation plans (see also analysis of 'Natal Mistbelt' by Scott-Shaw et al. (1996). More than half already transformed for plantations, cultivated land or by urban sprawl. Uncontrolled fires and poorly regulated grazing by livestock add to threats to this unique grassland. Some aliens (including *Solanum mauritanium*, species of *Rubus*, *Acacia*, *Pinus* and *Eucalyptus*) are of concern in places. Erosion is very low (68%) and low (24%).

Remark 1 As pointed out by Camp (1999a), the difference between BRG 5 (Moist Midlands Mistbelt) and BRG 6 (Dry Midlands Mistbelt) lies basically in precipitation: the latter occurring in regions receiving between 738–825 mm, while the former receives more than 800 mm on average per year as a rule. Both BRGs are considered by Camp (1999a) as different moisture phases of the same vegetation type. The consideration of 800 mm is very informative from the point of view of moisture status of soils and might also be of agricultural importance. However, the lack of striking differences in vegetation patterns does not justify separation of the BRGs as distinct vegetation units. Extensive patches of the Eastern Mistbelt Forests in KwaZulu-Natal and Transkei Mistbelt Forests in the Eastern Cape (for the concepts see Von Maltitz et al. 2003) are embedded within the region of the Midlands Mistbelt.

Remark 2 The Mistbelt of KwaZulu-Natal is an important, although still not a formally recognised, centre of endemism (see Van Wyk & Smith 2001).

References Acocks (1953, 1988), Colvin (1984), Scott-Shaw et al. (1996), Camp (1999a), Scott-Shaw (1999).

Gs 10 Drakensberg Foothill Moist Grassland

Mountain Tussock Veld (Bews 1917). VT 44 Highland Sourveld and Dohne Sourveld (90%) (Acocks 1953). LR 42 Moist Upland Grassland (82%) (Low & Rebelo 1996).

Distribution KwaZulu-Natal and Eastern Cape Provinces: Broad arc of Drakensberg piedmonts covering the surrounds of Bergville in the north, Nottingham Road, Impendle, Bulwer in the east, and Kokstad, Mount Currie, Underberg (KZN) and the surrounds of Mt Fletcher, Ugie, Maclear and Elliot (Eastern Cape) in the southwest. Altitude 880–1 860 m.

Vegetation & Landscape Features Moderately rolling and mountainous, much incised by river gorges of drier vegetation types and by forest, and covered in forb-rich grassland dominated by short bunch grasses including *Themeda triandra* and *Tristachya leucothrix*.

Geology & Soils Geology is dominated by mudstones and sandstones of the Tarkastad Subgroup and the Molteno Formation (Karoo Supergroup) as well as intrusive dolerites of Jurassic age. The dominant soils on the sedimentary parent material are well drained, with a depth of more than 800 mm and clay content from 15–55%, representing soil forms such as Hutton, Clovelly, Griffin and Oatsdale. On the volcanic parent material (dolerite) the soils are represented by forms such as Balmoral, Shortlands and Vimy. Most common land types Ac and Fa.

Climate Summer rainfall, with MAP almost 890 mm. MAT of 14.6°C and 26 frost days per year are indicative of a cooler, submontane form of warm-temperate climate. See also the climate diagram Gs 10 Drakensberg Foothill Moist Grassland (Figure 8.61).

Important Taxa Graminoids: *Diheteropogon filifolius* (d), *Elionurus muticus* (d), *Eragrostis capensis* (d), *E. chloromelas* (d), *E. curvula* (d), *E. plana* (d), *E. racemosa* (d), *Heteropogon contortus* (d), *Microchloa caffra* (d), *Monocymbium ceresii-forme* (d), *Panicum natalense* (d), *Rendlia altera* (d), *Sporobolus africanus* (d), *Themeda triandra* (d), *Trachypogon spicatus* (d), *Tristachya leucothrix* (d), *Agrostis lachnantha*, *Alloteropsis semialata* subsp. *eckloniana*, *Aristida junciformis* subsp. *galpinii*, *Brachiaria serrata*, *Digitaria tricholaenoides*, *Harpochloa falx*, *Hyparrhenia hirta*, *Panicum ecklonii*, *Paspalum dilatatum*. Herbs: *Helichrysus simillimum* (d), *Senecio retrorsus* (d), *Acalypha depressinerva*, *Ajuga ophrydis*, *Berkheya rhapontica* subsp. *aristosa*, *Conyza pinnata*, *Dicoma anomala*, *Euryops laxus*, *Haplocarpha scaposa*, *Helichrysus chionosphaerum*, *H. cooperi*, *H. herbaceum*, *H. nudifolium* var. *pilosellum*, *H. subglomeratum*, *H. umbraculigerum*, *Hesperantha ingeliensis*, *Kohautia amatymbica*, *Mohria caffrorum*, *Pentanisia prunelloides* subsp. *latifolia*, *Schistostephium crataegifolium*, *Sebaea sedoides* var. *schoenlandii*, *S. sedoides* var. *sedoides*, *Senecio asperulus*, *Vernonia natalensis*, *Wahlenbergia undulata*. Herbaceous Climber: *Rhynchosia totta*. Geophytic Herbs: *Oxalis depressa* (d), *Cheilanthes deltoidea*, *C. hirta*, *Chlorophytum acutum*, *Disperis renibractea*, *Habenaria dregeana*, *H. lithophila*, *Haemanthus humilis* subsp. *hirsutus*, *Hesperantha coccinea*, *Hypoxis rigidula* var. *pilosissima*, *Ledebouria sandersonii*, *Moraea modesta*, *Nerine bowdenii*, *Oxalis corniculata*, *Rhodohypoxis baurii* var. *platypetala*, *Watsonia pillansii*, *Xysmalobium tysonianum*, *Zantedeschia albomaculata* subsp. *albomaculata*. Small Trees: *Protea roupelliae* subsp. *roupelliae* (d), *Encephalartos ghellinckii*. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum*, *Chrysocoma ciliata*, *Felicia filifolia* subsp. *filifolia*, *Gnidia kraussiana*, *Helichrysus odoratissimum*, *H. sutherlandii*, *Rhus discolor*, *Senecio burchellii*.

Biogeographically Important Taxa ^(D)Drakensberg endemic, ^(Dg)Drakensberg endemic extending to Griqualand East) Geophytic Herb: *Schizochilus bulbinella*^{Dg}. Graminoid: *Schoenoxiphium burtii*^D.

Endemic Taxa Herbs: *Alchemilla incurvata*, *Argyrolobium sericosemium*, *Diascia esterhuyseniae*, *Stachys rivularis*. Geophytic Herbs: *Brachystelma molaventi*, *Dioscorea brownii*, *Ornithogalum baurii*. Succulent Shrub: *Delosperma wiunii*.

Conservation Least threatened. Target 23%. Only 2–3% statutorily conserved in the uKhahlamba Drakensberg Park, Ntsikeni Wildlife Reserve as well as in the Karkloof, Mount Currie, Coleford, Fort Nottingham, Impendle, Ngeli, and Umgeni Vlei

Nature Reserves. Almost 20% already transformed for cultivation, plantations and by urban sprawl. Alien woody species of *Rubus* and *Acacia dealbata* and *Solanum mauritanum* may become invasive in places. Erosion is very low (49%), low (28%) and moderate (17%).

Remarks Due to the considerable concentration of local endemics as well as Drakensberg endemics, this unit might be reclassified as a Gd grassland unit after detailed analysis and its area included within the realm of the Drakensberg Alpine CE.

References Bews (1917), Acocks (1953, 1988), Killick (1963), Hurt et al. (1993), Camp (1999b), KZN DAEA (2003).

Gs 11 Southern KwaZulu-Natal Moist Grassland

VT 65 Southern Tall Grassveld (48%), VT 44 Highland Sourveld and Dohne Sourveld (35%) (Acocks 1953). LR 43 North-eastern Mountain Grassland (44%), LR 42 Moist Upland Grassland (36%) (Low & Rebelo 1996). BRG 11 Moist Transitional Tall Grassveld (77%) (Camp 1999a, c).

Distribution KwaZulu-Natal and Eastern Cape Provinces: Interior valley basins at Creighton, Malenge and Centocow in the south and the upper Mkomazi River and Howick in the north. Altitude 880–1 480 m.

Vegetation & Landscape Features Gently sloping valley bottoms of tall mixed veld dominated by *Hyparrhenia hirta* and sparsely scattered *Acacia sieberiana*. *Themeda triandra* is the dominant grass on veld that has been well managed and many species of Gs 10 Drakensberg Foothill Moist Grassland are well represented and include *Diheteropogon filifolius*, *Harpochloa falx* and *Trachypogon spicatus*. Overgrazed areas become dominated by 'mtshiki' species such as *Eragrostis curvula*, *E. plana*, *Sporobolus africanus* and *S. pyramidalis*. Selective overgrazing causes certain wiregrass species (*Elionurus muticus* and *Aristida junciformis*) to become abundant (Camp 1999a, c).

Geology & Soils Karoo Supergroup mudstones dominate this area, those of the Volksrust Formation occurring to the south and those of the Adelaide Subgroup to the north. Jurassic dolerite dykes are also present. The dominant soils are mottled and poorly drained, with a depth of 300–500 mm; the clay content ranges from 15–35%, representing soil forms such as Wasbank, Wesselnek, Longlands and Cartref, and Oatsdale on well drained soils. Half of the area is classified as Ac land type, with Fa and Ab of minor occurrence.

Climate Summer rainfall, with MAP of 920 mm. Cooler form of warm-temperate climate (MAT 15.6°C; 15 frost days a year). See also climate diagram for Gs 11 Southern KwaZulu-Natal Moist Grassland (Figure 8.61).

Important Taxa Graminoids: *Alloteropsis semialata* subsp. *eckloniana* (d), *Andropogon appendiculatus* (d), *A. schirensis* (d), *Cynodon incompletus* (d), *Digitaria ternata* (d), *Eragrostis chloromelas* (d), *E. curvula* (d), *E. plana* (d), *Hyparrhenia hirta* (d), *Microchloa caffra* (d), *Paspalum dilatatum* (d), *Setaria nigrirostris* (d), *Sporobolus africanus* (d), *Tristachya leucothrix* (d), *Brachiaria serrata*, *Cyperus albostratus*, *Digitaria sanguinalis*, *D. tricholaenoides*, *Elionurus muticus*, *Heteropogon contortus*, *Panicum aequinerve*, *Pycnus rehmannianus*, *Setaria sphacelata*, *Themeda triandra*, *Trachypogon spicatus*. Herbs: *Acrotome inflata* (d), *Conyza pinnata* (d), *Acanthospermum australe*, *Ajuga ophrydis*, *Berkheya setifera*, *Chamaecrista mimosoides*, *Cynoglossum lanceolatum*, *Eriosema kraussianum*, *Helichrysus nudifolium* var. *nudifolium*, *Lobelia erinus*, *Spermacoce natalensis*, *Vernonia natalensis*. Herbaceous Climber: *Rhynchosia totta*. Geophytic Herbs: *Oxalis corniculata* (d), *O. smithiana* (d),

Pteridium aquilinum (d), *Cheilanthes bergiana*, *Zantedeschia albomaculata* subsp. *albomaculata*. Low Shrubs: *Asparagus virgatus*, *Erica caffrorum* var. *caffrorum*, *Rubus cuneifolius*.

Endemic Taxon Low Shrub: *Erica psittacina*.

Conservation Vulnerable. Target 23%. About 4% statutorily conserved in the Impendle, Midmar, Igxalingenwa and Ingelabantwana Nature Reserves as well as in the Soada Forest Nature Reserve and in the uKhahlamba Drakensberg Park. More than one third already transformed for cultivation, plantations, by urban sprawl and building of dams (Midmar). Several woody aliens (*Solanum mauritianum*, *Arundo donax*, *Eucalyptus* species, *Melia azedarach*, *Sesbania punicea*, *Populus alba*) occur in these grasslands, but their impact is only of local importance. Erosion is very low (47%) and low (46%).

References Acocks (1953, 1988), Camp (1999a, c), KZN DAFA (2003).

Gs 12 East Griqualand Grassland

VT 44 Highland Sourveld and Dohne Sourveld (58%) (Acocks 1953). LR 42 Moist Upland Grassland (90%) (Low & Rebelo 1996).

Distribution KwaZulu-Natal and Eastern Cape Provinces: Major portion of this unit covers most of East Griqualand (with Kokstad and Matatiele as centres). Altitude 920–1 740 m.

Vegetation & Landscape Features Hilly country with slopes covered by grassland in places, with patches of bush clumps with *Leucosidea sericea* (only wet sites) or *Diospyros lycioides*, *Acacia karroo* and *Ziziphus mucronata* in low-lying and very dry sites.

Geology & Soils Mudstone and sandstone of the Beaufort Group of the Karoo Sequence predominate, but sedimentary rocks of the Molteno, Elliot and Clarens Formations are also present. The dominant soils on the sedimentary parent material are well drained, with a depth of 500–800 mm and clay content from 15–55%. The soils are of Hutton, Clovelly, Oatsdale forms on sediments and Shortlands on dolerite. Most common land types Fa and Ac.

Climate The region has mostly summer rainfall, with MAP of 780, mm ranging from 620–816 mm. Kokstad records 88 rain days in a year and three of those occur in the midwinter (June–July). Both mist and snow occur less frequently than in Gd 4 Southern Drakensberg Highland Grassland (Kokstad 26 misty days per year) and much of the rain comes in the form of thunderstorms (Kokstad 45 days). MAT 12.9–15.6°C (overall MAT 14.7°C). Moderately severe frosts occur 30 days in a year. Mean annual evaporation 1 457–1 723 mm (Camp 1999b). See also climate diagram for Gs 12 East Griqualand Grassland (Figure 8.61).

Important Taxa Graminoids: *Alloteropsis semialata* subsp. *eckloniana* (d), *Aristida congesta* (d), *A. junciformis* subsp. *galpinii* (d), *Brachiaria serrata* (d), *Digitaria tricholaenoides* (d), *Elionurus muticus* (d), *Eragrostis chloromelas* (d), *E. plana* (d), *E. racemosa* (d), *Harpochloa falx* (d), *Heteropogon contortus* (d), *Hyparrhenia hirta* (d), *Melinis nerviglumis* (d), *Microchloa caffra* (d), *Paspalum*



Figure 8.67 Gs 12 East Griqualand Grassland: Over-grazed, species-poor grasslands on sandy soils on slopes prone to erosion near Mount Frere (northeastern Eastern Cape). The grasslands at higher altitudes belong to Gs 10 Drakensberg Foothill Moist Grassland—a transitional type between Sub-Escarpment and Drakensberg Grasslands.

dilatatum (d), *Sporobolus africanus* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Abildgaardia ovata*, *Andropogon appendiculatus*, *Cynodon incompletus*, *Cyperus obtusiflorus* var. *obtusiflorus*, *Digitaria ternata*, *Eragrostis capensis*, *Eulalia villosa*, *Hemarthria altissima*, *Setaria nigrirostris*, *Trachypogon spicatus*, *Urochloa panicoides*. Herbs: *Acanthospermum australe*, *Centella asiatica*, *Conyza podocephala*, *Haplocarpha scaposa*, *Helichrysum herbaceum*, *H. nudifolium* var. *pilosellum*, *Hermannia depressa*, *Hibiscus aethiopicus* var. *ovatus*, *Ipomoea crassipes*, *Kohautia amatymbica*, *Lessertia harveyana*, *Pentania prunelloides* subsp. *latifolia*, *Rhynchosia effusa*, *Senecio retorsus*, *Stachys aethiopica*, *Tolpis capensis*, *Vernonia natalensis*. Herbaceous Climber: *Rhynchosia totta*. Geophytic Herbs: *Cheilanthes deltoidea*, *C. hirta*, *Haemanthus humilis* subsp. *hirsutus*, *Ledebouria sandersonii*, *Rhodohypoxis baurii* var. *baurii*, *Watsonia pillansii*, *Zantedeschia albomaculata* subsp. *albomaculata*. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum* (d), *Chaetacanthus setiger*, *Erica caffrorum* var. *caffrorum*, *Felicia filifolia* subsp. *filifolia*, *F. muricata*, *Helichrysum dregeanum*, *Rubus rigidus*. Succulent Shrub: *Euphorbia clavarioides* var. *clavarioides*.

Biogeographically Important Taxon (Sub-Escarpment Grassland endemic) Small Tree: *Encephalartos friderici-guilielmi*.

Endemic Taxa Herbs: *Alepidea duplidens*, *Berkheya griquana*, *Wahlenbergia dentata*, *W. ingrata*.

Conservation Vulnerable. Target 23%. Only 0.2% is statutorily conserved in the Malekgonyane (Ongeluksnek) Wildlife Reserve and Mount Currie Nature Reserve. Over one quarter of the area has already been transformed for cultivation (maize), plantations and by urban sprawl. *Acacia dealbata* and *A. mearnsii* are invading these grasslands in some places. Erosion is low (31%), very low (30%) and moderate (30%).

References Acocks (1953, 1988), Hurt et al. (1993), Camp (1999b).

Gs 13 Mabela Sandy Grassland

VT 56 Highland Sourveld to *Cymbopogon-Themeda* Veld Transition (Eastern Free State Highveld) (95%) (Acocks 1953). LR 42 Moist Upland Grassland (100%) (Low & Rebelo 1996). BRG 14 Sour Sandveld (65%) (Camp 1999c).

Distribution KwaZulu-Natal and Eastern Cape Provinces: Cedarville Flats (basin draining into Umzimvubu River) in the region of Cedarville-Matatiele (southwestern KwaZulu-Natal) as well as a small area in a basin of Simi and Ramohlakoana in the Kinira River Valley in Transkei (west of Matatiele). Altitude 1 440–1 500 m, but up to 1 550 m in a few places.

Vegetation & Landscape Features Flat valley basins with a relatively high proportion of poorly drained soils with a generally low nutrient status. Dominated by species-poor, low tussock-dominated, sour grasslands without indigenous trees, with *Sporobolus pyramidalis* and *Aristida junciformis* as indicator species.

Geology & Soils Tarkastad Subgroup mudstones and sandstones underlie this area to the east as do the Molteno and Elliot Formation sandstones and minor mudstones in the west (all of the Karoo Supergroup). The dominant soils are poorly drained, with a depth of 200–300 mm and a clay content of less than 15%. They are classified into soil forms of Katspruit and Longlands and Oatsdale, Vimy and Clovelly (in well-drained habitats). Most common land types Ia and Ca.

Climate Summer rainfall, with MAP of around 710 mm and mean evaporation up to 1 700 mm. MAT 14.4°C. Frost very frequent (40 days per year). See also the climate diagram Gs 13 Mabela Sandy Grassland (Figure 8.61).

Important Taxa Graminoids: *Abildgaardia ovata* (d), *Andropogon eucomus* (d), *Cynodon dactylon* (d), *C. incompletus* (d), *Elionurus muticus* (d), *Eragrostis patentissima* (d), *Heteropogon contortus* (d), *Paspalum distichum* (d), *Pennisetum clandestinum* (d), *Setaria sphacelata* (d), *Sporobolus pyramidalis* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Aristida bipartita*, *A. congesta*, *A. junciformis* subsp. *galpinii*, *Brachiaria eruciformis*, *B. serrata*, *Cymbopogon pospischilii*, *Digitaria argyrograptia*, *D. monodactyla*, *D. ternata*, *D. tricholaenoides*, *Ehrharta calycina*, *Eragrostis capensis*, *E. chloromelas*, *E. gumiflua*, *E. plana*, *E. racemosa*, *Harpochloa falx*, *Hyparrhenia hirta*, *Imperata cylindrica*, *Microchloa caffra*, *Pennisetum thunbergii*, *Setaria nigrirostris*, *Sporobolus discosporus*, *Stipagrostis zeyheri* subsp. *sericans*, *Tragus racemosus*, *Trichoneura grandiglumis*. Herbs: *Acanthospermum australe*, *Monopsis decipiens*, *Psammotropha mucronata* var. *foliosa*. Geophytic Herbs: *Bulbine narcissifolia*, *Zantedeschia albomaculata* subsp. *albomaculata*. Geoxylic Suffrutex: *Elephantorrhiza elephantina*.

Conservation Vulnerable. Target 23%. Only a very small part statutorily conserved in the Malekgonyane (Ongeluksnek) Wildlife Reserve. More than 20% already transformed for cultivation (maize) and by urban sprawl. Threats to the remaining grasslands are heavy selective grazing by livestock, particularly in communal areas. Overgrazing increases the risk of local erosion.

Remark Much of the bottomland area is subject to floods and therefore extensive sites of AZf 3 Eastern Temperate Freshwater Wetlands are found embedded within this vegetation unit.

References Acocks (1953, 1988), Camp (1999c), KZN DAEA (2003).

Gs 14 Mthatha Moist Grassland

VT 44 Highland Sourveld and Dohne Sourveld (81%) (Acocks 1953). LR 42 Moist Upland Grassland (90%) (Low & Rebelo 1996).

Distribution Eastern Cape Province: Plains between Mthatha and Butterworth parallel to the coastline and excluding the river valleys that intrude landwards into this unit. Altitude 600–1 080 m.

Vegetation & Landscape Features Undulating plains and hills supporting species-poor, sour, wiry grassland with *Eragrostis plana* and *Sporobolus africanus*; although in good condition, it is more likely to be dominated by *Themeda triandra*.

Geology & Soils Mudstones of the Tarkastad and Adelaide Subgroups (Beaufort Group, Karoo Supergroup) underlie this area, with highly leached soils typical of the Fa land type.

Climate Summer rainfall, with MAP 600–970 mm. The coefficient of variation of MAP 25–30% across the unit, but drops to approximately 15% on the southeast-facing inland mountain slopes. Incidence of frost 2–14 days, but is higher further from the coast. See also climate diagram for Gs 14 Mthatha Moist Grassland (Figure 8.61).

Important Taxa Graminoids: *Cyperus obtusiflorus* var. *obtusiflorus* (d), *Elionurus muticus* (d), *Eragrostis curvula* (d), *Heteropogon contortus* (d), *Microchloa caffra* (d), *Paspalum dilatatum* (d), *Sporobolus africanus* (d), *Themeda triandra* (d), *Abildgaardia ovata*, *Alloteropsis semialata* subsp. *eckloniana*, *Aristida congesta*, *Brachiaria serrata*, *Chloris virgata*, *Cymbopogon marginatus*, *Cynodon dactylon*, *Cyperus haematocephalus*, *C. obtusiflorus* var. *flavissimus*, *Digitaria eriantha*, *D. ternata*, *Eragrostis capensis*, *E. plana*, *Eustachys paspaloides*, *Harpochloa falx*, *Hemarthria altissima*, *Hyparrhenia hirta*, *Panicum ecklonii*, *Paspalum scrobiculatum*, *Setaria nigrirostris*, *Tristachya leucothrix*. Herbs: *Senecio coronatus* (d), *Centella asiatica*, *Chamaecrista mimosoides*, *Cyanotis speciosa*, *Eriosema salignum*, *Falkia repens*, *Helichrysum rugulosum*, *Indigofera*



Figure 8.68 Gs 14 Mthatha Moist Grassland: Over-grazed grassland on a stony slope near Tsole (Eastern Cape). The yellow-flowered daisy is the unpalatable *Senecio coronatus* (Asteraceae).

hedyantha, *I. hilaris* var. *hilaris*, *Ipomoea crassipes*, *Lobelia flaccida*, *Pentanisia prunelloides* subsp. *latifolia*, *Senecio retrorsus*, *Sonchus dregeanus*, *Vernonia capensis*, *V. natalensis*, *Wahlenbergia stellarioides*. Herbaceous Climber: *Rhynchosia totta*. Geophytic Herbs: *Boophone disticha*, *Habenaria dives*. Small Tree: *Acacia natalitia*. Low Shrubs: *Senecio pterophorus* (d), *Coddia rudis*, *Erica caffrorum* var. *caffrorum*, *Felicia filifolia* subsp. *filifolia*, *Hermannia parviflora*.

Biogeographically Important Taxon (Sub-Escarpment Grassland endemic) Small Tree: *Encephalartos friderici-guilielmi*.

Conservation Endangered. Target 23%. Only a small fraction is statutorily conserved in the Luchaba and Nduli Wildlife Reserves. More than 40% transformed for cultivation and plantations or by dense rural human settlements. Previously cultivated or fallow lands possibly constitute an estimated additional 25% (Steenkamp et al. 2005). *Acacia mearnsii*, *Solanum mauritianum* and *Richardia humistrata* are the most important aliens. Erosion a serious problem, with high to very high erosion levels in 34% of the unit, moderate erosion in 35%, and the remainder having low and very low erosion.

Remarks There is a high level of utilisation of this unit leading to degradation and transformation and the vegetation shows various stages of overutilisation (Steenkamp et al. 2005). Shifting cultivation and the effects of development have caused continuous disturbance of the soil surface, which has led to secondary succession changes in the grassland (documented in Smits et al. 1999). Poor grazing management has led to the dominance of unpalatable grasses and invasion by weedy, mostly alien, forb species (Hoare 2002).

References Acocks (1953, 1988), Smits et al. (1999), Hoare (2002), Steenkamp et al. (2005).

Gs 15 Tsomo Grassland

VT 44 Highland Sourveld and Dohne Sourveld (49%), VT 22 Invasion of Grassveld by *Acacia karroo* (36%) (Acocks 1953). LR 42 Moist Upland Grassland (51%) (Low & Rebelo 1996).

Distribution Eastern Cape Province: In the region to the east of the Queenstown Basin. The villages of Tsomo, Cala and Engcobo define the eastern extent of this unit and Cathcart, Queenstown and Sterkstroom the western extent. This vegetation unit occupies the plains in between the mountain peaks and ridges in this region. Altitude 760–1 580 m.

Vegetation & Landscape Features Flat or gently undulating lowland plains intersected by mountains. The vegetation is a grassland or open thornveld, often grazed short or replaced by dwarf shrubland dominated by species of *Euryops*. Dominant and common species include omnipresent representatives of the genera *Cymbopogon*, *Elionurus*, *Eragrostis*, *Aristida* and *Themeda*. Asteraceae and Fabaceae are prominent among the forbs.

Geology & Soils Mudstones of the Tarkastad Subgroup (Karoo Supergroup) overlain mostly by soils of moderate depth typical of Fb and Db land types.

Climate Late summer rainfall, although some rain may fall at other times of the year. MAP 430–790 mm, increasing from west to east. The coefficient of variation in MAP 25–31% across the unit. Incidence of frost is variable (7–65 days), but is higher in the northwest. See also climate diagram for Gs 15 Tsomo Grassland (Figure 8.61).

Important Taxa Graminoids: *Aristida congesta* (d), *Cynodon dactylon* (d), *Digitaria argyrograptia* (d), *Elionurus muticus* (d), *Eragrostis chloromelas* (d), *E. curvula* (d), *E. plana* (d), *Eustachys paspaloides* (d), *Heteropogon contortus* (d), *Hyparrhenia hirta* (d), *Microchloa caffra* (d), *Themeda triandra* (d), *Tragus berteronianus* (d), *Abildgaardia ovata*, *Andropogon appendiculatus*, *Aristida diffusa*, *Brachiaria serrata*, *Cymbopogon pospischilii*, *Eragrostis capensis*, *E. lehmanniana*, *E. racemosa*, *Harpochloa falx*, *Microchloa kunthii*, *Schoenoxiphium sparteum*, *Sporobolus africanus*, *Tristachya leucothrix*, *Urochloa panicoides*. Herbs: *Argyrolobium pauciflorum*, *Aster bakerianus*, *Berkheya onopordifolia* var. *onopordifolia*, *Commelina africana*, *Cyanotis speciosa*, *Gazania linearis* var. *linearis*, *Haplocarpha scaposa*, *Helichrysum rugulosum*, *Ipomoea crassipes*, *Pollichia campestris*, *Senecio retrorsus*, *Vernonia capensis*. Herbaceous Climber: *Rhynchosia totta*. Geophytic Herbs: *Oxalis depressa* (d), *Pelargonium sidoides*. Small Tree: *Acacia natalitia*. Low Shrubs: *Chaetacanthus setiger*, *Felicia muricata*, *Helichrysum odoratissimum*, *Senecio burchellii*, *Sutera pinnatifida*, *Tephrosia capensis* var. *acutifolia*. Tall Shrub: *Euryops floribundus* (d).

Conservation Vulnerable. Target 23%. None conserved in statutory conservation areas. Only 1% conserved in private reserves. Some 27% transformed mainly for cultivation and by dense concentrations of rural settlements. Increased occurrence of alien *Schkuhria pinnata* and *Tagetes minuta* indicates heavy disturbance. Erosion is a serious problem and it is high in 33% of this unit, moderate in 32%, and low and very low in 34% of the area.

Remarks The name is derived from the village of Tsomo, which falls entirely within this plains type vegetation, the others tending to occupy positions on adjacent slopes. There is high rural occupancy and utilisation of this unit, leading to degradation and transformation. A number of dams of medium size have also been built within this unit. The vegetation shows various stages of overutilisation and also a gradient from grassland to thornveld. Mountain ridges within this unit are often wooded



Figure 8.69 Gs 15 Tsomo Grassland: Over-grazed grassland with abundant species of *Aristida* and *Elionurus muticus* and the invading unpalatable shrub *Euryops floribundus* (Asteraceae) near Tsomo (former Transkei, Eastern Cape).

and this woody component easily spreads into the surrounding vegetation where ecological conditions permit. Many of the other vegetation units in the region, both grassland and woody vegetation, grade into this one, so that there is a naturally high rate of species turnover.

References Acocks (1953, 1988), Hoare & Bredenkamp (2001).

Gs 16 Queenstown Thornveld

VT 22 Invasion of Grassveld by *Acacia karroo* (77%) (Acocks 1953). LR 44 South-eastern Mountain Grassland (52%) (Low & Rebelo 1996).

Distribution Eastern Cape Province: From the vicinity of Queenstown in the east to the vicinity of Tarkastad in the west, and Sterkstroom in the north. Altitude 980–1 500 m.

Vegetation & Landscape Features Flat bottomlands of intramountain basins with adjacent slopes supporting a complex of *Acacia natalitia* thornveld and grassland dominated by *Aristida congesta*, *Cymbopogon pospischilii*, *Eragrostis curvula* and *Tragus koelerioides*, with scattered shrubs and low *Acacia* in places (Hoare 1997, Hoare & Bredenkamp 1999).

Geology & Soil Sedimentary rocks of the Tarkastad Subgroup (Beaufort Group, Karoo Supergroup) overlain with clay-loam soils typical of Da and Fc land types.

Climate Rainfall peaks in late summer. MAP mainly 380 mm in the west, increasing to 640 mm in the east. The coefficient of variation in MAP from 28–34% across the unit. Incidence of frost is 22–58 days, higher in the northwest than the southeast. See also climate diagram for Gs 16 Queenstown Thornveld (Figure 8.61).

Important Taxa Small Tree: *Acacia natalitia* (d). Tall Shrub: *Euryops floribundus* (d). Low Shrubs: *Asparagus laricinus*, *Atriplex semibaccata* var. *appendiculata*, *Felicia filifolia* subsp. *filifolia*, *F. muricata*, *Helichrysum asperum* var. *albidulum*, *H. dregeanum*, *Melolobium microphyllum*, *Pentzia globosa*, *Sutera pinnatifida*, *Tephrosia capensis* var. *acutifolia*. Succulent Shrub: *Hertia pallens*. Graminoids: *Aristida canescens* (d), *A. con-*

gesta (d), *A. diffusa* (d), *Cymbopogon pospischilii* (d), *Cynodon incompletus* (d), *Digitaria argyrograpta* (d), *D. eriantha* (d), *Eragrostis chloromelas* (d), *E. curvula* (d), *E. lehmanniana* (d), *E. obtusa* (d), *E. trichophora* (d), *Heteropogon contortus* (d), *Microchloa caffra* (d), *Panicum stapfianum* (d), *Themeda triandra* (d), *Tragus koelerioides* (d), *Brachiaria serrata*, *Cynodon dactylon*, *Cyperus usitatus*, *Elionurus muticus*, *Eustachys paspaloides*, *Microchloa kunthii*, *Sporobolus fimbriatus*, *Tragus racemosus*. Herbs: *Arctotis microcephala*, *Blepharis integrifolia* var. *clarkei*, *Commelina africana*, *Cyanotis speciosa*, *Gazania krebsiana* subsp. *krebsiana*, *Helichrysum pedunculatum*, *H. rugulosum*, *Hermannia depressa*, *Indigofera alternans*, *Salvia stenophylla*, *Senecio asperulus*, *Tribulus terrestris*. Herbaceous Climber: *Rhynchosia totta*. Geophytic Herbs: *Oxalis corniculata*, *O. depressa*.

Conservation Least threatened. Target 23%. Nearly 1% statutorily conserved in the Tsolwana Nature Reserve. Some 10% transformed primarily by cultivation and urbanisation. Urbanisation of this unit is expanding at a rapid rate and the amount of transformation due to this factor may be higher. Overgrazing in this vegetation unit is serious, especially by goats close to urban areas. Erosion is high (24%), moderate (54%), low and very low (22%).

Remark A core community of this vegetation landscape was described as the *Trago koelerioidis*-*Acacietum karroo* by Hoare (1997).

References Acocks (1953, 1988), Low & Rebelo (1996), Hoare (1997), Hoare & Bredenkamp (1999).

Gs 17 Tarkastad Montane Shrubland

VT 60 Karroid *Danthonia* Mountain Veld (25%), VT 22 Invasion of Grassveld by *Acacia karroo* (23%), VT 37 False Karroid Broken Veld (20%) (Acocks 1953). LR 52 Eastern Mixed Nama Karoo (37%), LR 44 South-eastern Mountain Grassland (33%) (Low & Rebelo 1996).

Distribution Eastern Cape and marginally into Northern Cape Province: Noupoot, Middelburg and a point west of Cradock define the western extent of this unit and Cathcart, Queenstown and Sterkstroom the eastern extent. The unit falls within the area between the Great Escarpment in the north, marked by the Bamboesberg and Stormberg Mountains, and the minor escarpment, marked by the Winterberg and Amathole Mountains in the south. Altitude 1 020–1 780 m.

Vegetation & Landscape Features

Ridges, hills and isolated mountain slopes, characterised by high surface rock cover, this often consisting of large, round boulders. The vegetation is low, semi-open, mixed shrubland with 'white' grasses and dwarf shrubs forming a prominent component of the vegetation.

Geology & Soils Sedimentary rocks of the Tarkastad Subgroup (Beaufort Group, Karoo Supergroup), widely affected by intrusions of Jurassic dolerites forming numerous dykes and sills. Soils typical of land types lb, Fb and Fc.

Climate Rainfall in late summer to autumn (peak in February–March). MAP 280–720 mm (overall MAP 470 mm),



D.B. Hoare

Figure 8.70 Gs 16 Queenstown Thornveld: *Acacia natalitia* thornveld near Sada and the Water-down Dam south of Queenstown (Eastern Cape) with the undergrowth containing grasses such as *Cymbopogon pospischilii*, *Aristida congesta*, *Tragus koelerioides* and *Heteropogon contortus*.



Figure 8.71 Gs 17 Tarkastad Montane Shrubland: The rare cycad *Encephalartos friderici-guilielmi* in the shade of *Cussonia paniculata* in montane shrubland close to the Waterdown Dam south of Sada (Eastern Cape).

increasing from west to east. Coefficient of variation of MAP from 22–35% across the unit (31% overall APCV), decreasing with distance eastwards. Incidence of frost 7–68 days (average: 39 days), increasing with proximity to the Escarpment. See also climate diagram for Gs 17 Tarkastad Montane Shrubland (Figure 8.61).

Important Taxa Succulent Tree: *Aloe ferox* (d). Small Tree: *Acacia karroo* complex. Tall Shrubs: *Diospyros austro-africana* (d), *Cadaba aphylla*, *Ehretia rigida*, *Rhus burchellii*, *Tarchonanthus minor*. Woody Climbers: *Asparagus racemosus*, *A. retrofractus*. Low Shrubs: *Euryops annae* (d), *Aptosimum elongatum*, *Asparagus striatus*, *Blepharis mitrata*, *B. villosa*, *Chrysocoma ciliata*, *Diospyros pallens*, *Eriocephalus ericoides*, *Felicia filifolia* subsp. *filifolia*, *F. muricata*, *Gymnosporia heterophylla*, *Helichrysum dregeanum*, *H. zeyheri*, *Hermannia filifolia*, *Indigofera sessilifolia*, *Lantana rugosa*, *Limeum aethiopicum*, *Melolobium microphyllum*, *Nenax microphylla*, *Pegolettia retrofracta*, *Pentzia globosa*, *Phymaspermum parvifolium*, *Rosenia humilis*, *Sutera pinnatifida*, *Wahlenbergia albens*. Succulent Shrubs: *Lycium schizocalyx*, *Pachypodium succulentum*, *Sarcocaulon camdeboense*. Semiparasitic Shrub: *Thesium hystrix*. Graminoids: *Aristida adscensionis* (d), *A. congesta* (d), *A. diffusa* (d), *Cynodon incompletus* (d), *Enneapogon scoparius* (d), *Eragrostis chloromelas* (d), *E. lehmanniana* (d), *E. obtusa* (d), *Heteropogon contortus* (d), *Tragus berteronianus* (d), *T. koelerioides* (d), *Chloris virgata*, *Cymbopogon pospischilii*, *Digitaria eriantha*, *Eragrostis curvula*, *Eustachys paspaloides*, *Fingerhuthia*

africana, *Sporobolus fimbriatus*, *Themeda triandra*, *Tragus racemosus*. Herbs: *Commelina africana*, *Gazania krebsiana* subsp. *krebsiana*, *Hibiscus pusillus*, *Indigofera alternans*, *Lepidium africanum* subsp. *africanum*, *Tribulus terrestris*. Geophytic Herbs: *Asplenium cordatum*, *Boophone disticha*, *Cheilanthes deltoidea*, *C. hirta*, *Oxalis depressa*. Succulent Herb: *Crassula muscosa*.

Biogeographically Important Taxa (^{SE}Sub-Escarpment Grassland endemic, ^EEastern distribution limit) Small Tree: *Encephalartos friderici-guilielmi*^{SE}. Low Shrubs: *Eriocephalus africanus*^E, *Senecio acutifolius*^E.

Conservation Least threatened. Target 28%. Around 1–2% conserved in statutory conservation areas (Commando Drift, Tsolwana Nature Reserves, Mountain Zebra National Park). About 2% transformed for cultivation or by building of dams (Kommandodrif and Waterdown). Erosion is moderate (51%), high (28%) and low (18%).

Remarks Physiographically similar landscapes to the north support Gh 4 Besemkaree Koppies Shrubland and to the west (along the Great Escarpment) NKu 2 Upper Karoo Hardeveld. These two units and the current unit are all shrublands primarily associated with dolerite intrusions. The Upper Karoo Hardeveld has lower rainfall, but the Besemkaree Koppies Shrubland is distinguishable climatically (on the basis of slightly lower minimum temperatures and higher summer rainfall) and floristically.

References Acocks (1953, 1988), Palmer (1988, 1989, 1991a, b), Rubin & Palmer (1996), Brown & Bezuidenhout (2000), De Klerk et al. (2003), Brown & Bezuidenhout (2005).

Gs 18 Bedford Dry Grassland

VT 21 False Thornveld of Eastern Province (40%), VT 68 Eastern Province Grassveld (25%) (Acocks 1953). Dry Bedford Grassland (Martens & Morris 1994, Martens et al. 1996). Moist Bedford Grassland (Martens et al. 1996). LR 15 Subarid Thorn Bushveld (71%) (Low & Rebelo 1996).

Distribution Eastern Cape Province: South of the Winterberg Mountains from Bruinjtjieshoogte and Somerset East in the west to Bedford and Adelaide, and to Fort Beaufort in the east. The eastern section lies north of the Great Fish River Valley. Altitude 480–990 m.

Vegetation & Landscape Features Gently undulating plains supporting open, dry grassland interspersed with *Acacia karroo* woodland vegetation (especially along the drainage lines). The grassland is relatively short (10–100 cm) and is dominated by *Digitaria argyrograpta*, *Tragus koelerioides*, *Eragrostis curvula* and *Cymbopogon caesus*. It contains a dwarf shrubby component of karroid origin in the southern and southwestern parts of its range.

Geology & Soils Loam or clay-loam soils typical of Fc (most of the region) as well as Db and Fb land types on the mudstones and sandstones of the Adelaide Subgroup (Beaufort Group, Karoo Supergroup).

Climate Bimodal rainfall occurring in spring and late summer. MAP 310–550 mm. MAP is relatively uniform across this unit, but increases closer to the mountains and slightly from west to east. The coefficient of variation in MAP varies from 28–35% across the unit. Incidence of frost 3–31 days, higher towards the west than the east. See also climate diagram for Gs 18 Bedford Dry Grassland (Figure 8.61).

Important Taxa Graminoids: *Cynodon dactylon* (d), *C. incompletus* (d), *Cyperus usitatus* (d), *Digitaria argyrograpta* (d), *D. eriantha* (d), *Eragrostis capensis* (d), *E. chloromelas* (d), *E. curvula* (d), *E. obtusa* (d), *Heteropogon contortus* (d), *Microchloa caffra*

(d), *Panicum maximum* (d), *P. stapfianum* (d), *Sporobolus fimbriatus* (d), *Themeda triandra* (d), *Tragus koelerioides* (d), *Aristida congesta*, *A. diffusa*, *Cymbopogon caesius*, *C. pospischilii*, *Eragrostis plana*, *Eustachys paspaloides*, *Melica decumbens*, *Setaria sphacelata*, *Sporobolus nitens*. Herbs: *Cyanotis speciosa* (d), *Blepharis integrifolia* var. *clarkei*, *Chamaesyce inaequilatera*, *Commelina africana*, *Emex australis*, *Gazania krebsiana* subsp. *krebsiana*, *Helichrysum rugulosum*, *Hermannia althaeifolia*, *H. coccocarpa*, *Lepidium africanum* subsp. *africanum*. Geophytic Herbs: *Oxalis depressa*, *Pelargonium sidoides*. Succulent Herb: *Crassula expansa*. Small Tree: *Acacia karroo*. Low Shrubs: *Atriplex semibaccata* var. *appendiculata* (d), *Helichrysum dregeanum* (d), *Nenax microphylla* (d), *Asparagus striatus*, *Chrysocoma ciliata*, *Euryops anthemoides* subsp. *anthemoides*, *Felicia muricata*, *Garuleum latifolium*, *Hermannia althaeoides*, *Indigofera sessilifolia*, *Jamesbrittenia microphylla*, *Limeum aethiopicum*, *Lycium cinereum*, *Melolobium burchellii*, *Pelargonium aridum*, *Pentzia globosa*, *Selago fruticosa*, *S. saxatilis*, *Talinum arnotii*, *Tephrosia capensis* var. *acutifolia*. Succulent Shrubs: *Cotyledon orbiculata* var. *oblonga*, *Mestoklema tuberosum*.

Conservation Least threatened. Target 23%. None conserved in statutory conservation areas and only 1% conserved in private reserves (Kingsdale Game Farm, Woodlands Game Reserve, Glen Avon Falls Kloof and Kruizemuntfontein Natural Heritage Sites). Some 3% transformed for cultivation. Erosion high in 25% of this unit, moderate in 31% and low to very low in 44%.

Remarks Drainage lines within this unit contain *Acacia karroo*-dominated woodland and the incised river valleys intruding from the south of this unit contain AT 8 Kowie Thicket and NK1 4 Albany Broken Veld. The grasslands of this unit furthest from the mountain range have a strong karroid element which enters from the dry Great Fish River Valley. This grassland unit falls within the Albany CE, which contains an extensive endemic flora, especially of succulents. The Smaldeel area is considered to be an important goat production area (Martens & Morris 1994, Martens et al. 1996).

References Acocks (1953, 1988), Martens & Morris (1994), Martens et al. (1996), Hoare (1997), Hoare & Bredenkamp (1999).

9. Credits

The introductory text is a team effort by D.B. Hoare and L. Mucina, assisted by R.A. Ward (geology: Section 3.2) and L. Scott (palaeoecological patterns: Section 2.1). M.C. Rutherford extensively edited the introductory text and contributed especially to Sections 2.2 and 3.1.

The original subdivision of the Grassland Biome into bioregions was coined by L. Mucina and modified by M.C. Rutherford. The conceptual delimitation of the Drakensberg Grassland units as currently accepted in our chapter is the result of co-operation between D.B. Hoare (Southern Berg units), M.C. Rutherford (Lesotho units) and L. Mucina (other, especially Free State and KwaZulu-Natal Gd units). The units occurring (if only in part) in KwaZulu-Natal were delimited on the basis of K.G.T. Camp's map of resource units and their boundaries further modified by L. Mucina and C.R. Scott-Shaw. D.B. Hoare and L. Mucina co-authored the units Gd 2–4. The unit Gd 1 was coined and described by D.B. Hoare as sole author. The units Gd 6 and 7 were co-authored by C.R. Scott-Shaw, K.G.T. Camp and L. Mucina, while the units Gd 8–10 were co-authored by M.C. Rutherford and L. Mucina. P.J. du Preez and L. Mucina were instrumental in the circumscription of the units Gh 1–9. They

were assisted by D.B. Hoare in units Gh 1 and 2 and by G.J. Bredenkamp in Gh 3, 5, 6 and 9. The units Gh 10–15 were described through a team effort by H. Bezuidenhout, L. Mucina, G.J. Bredenkamp and S.S. Cilliers. L.W. Powrie helped to delimit the unit Gh 4. The major effort in mapping delimitation and description of the Gm units was contributed by M.C. Lötter (units Gm 6, 8, 11–18 and 21–27, 29), L. Mucina (Gm 1–12, 15, 22–24, 26, 28 and 29), M.C. Rutherford (Gm 2, 4, 5, 8, 9, 11, 13–15, 18–21, 28 and 29) and G.J. Bredenkamp (Gm 4, 6, 8, 10–13, 16, 18–20, 22 and 23). D.B. Hoare contributed to units Gm 8–12, P.J. du Preez to units Gm 1, 3–7 and J.E. Burrows to Mpumalanga units Gm 14, 16–18, 21, 22 and 24. P.J.D. Winter defined Gm 25 and contributed map boundaries for Limpopo sections of units Gm 11, 23 and 25–27. M. Stalmans participated in four Mpumalanga (Gm 22 and 23) and Limpopo (26 and 27) units. S.J. Siebert and F. Siebert contributed substantially to the Sekhukhune Grassland units (Gm 19 and 20). The following colleagues each contributed to one Montane Grassland unit: K. Kobisi and L. Kose (Gm 2), L.W. Powrie (Gm 5), C.R. Scott-Shaw (Gm 15), L. Dobson (Gm 16), E. Schmidt (Gm 17), P.J.D. Winter (Gm 25) and T.H. Mostert (Gm 28). The major contributors to Gs units were K.G.T. Camp (whose boundaries were followed in many cases; co-author of Gs 1, 6–13), C.R. Scott-Shaw (co-author of Gs 1, 3, 4 and 6–13), M.C. Lötter (co-author of Gs 1, 3 and 7) and D.B. Hoare (author of mapping concepts and descriptions of the Eastern Cape units Gs 14–18). L. Mucina co-authored almost all Gs units (except Gs 2, 14 and 15), M.C. Rutherford contributed to Gs 4, 6, 12 and 16 and G.J. Bredenkamp to unit Gs 3. The Ithala Quartzite Sourveld unit (Gs 2) was coined by M.C. Lötter and J.E. Burrows. The species lists were compiled by L. Mucina on the basis of source data provided by particular authors of the descriptions of vegetation units. L.W. Powrie assisted with extraction of species lists from the SANBI databases (PRECIS, ACKDAT). M.C. Lötter and M. Stalmans assisted in checking the endemic status of species in Mpumalanga vegetation units, while C.R. Scott-Shaw helped with a similar check for KwaZulu-Natal units. E.G.H. Oliver kindly checked the *Erica* species in each vegetation unit. R.A. Ward kindly checked and corrected the sections on geology in all descriptions of the vegetation units. L.W. Powrie was instrumental in the preparation of working versions of mapping material for the contributors at various stages of the Project. G.J. Bredenkamp was technically assisted with GIS expertise by W.H. de Frey and R.A.J. Robesson during the initial mapping of the northern provinces. We also acknowledge the help of R.G. Bennett and C. Oellerman.

Most of the photographs were contributed by L. Mucina, M.C. Lötter, D.B. Hoare and P.J. du Preez. The rest of the photographs were kindly provided by (in alphabetical order): S.S. Cilliers, R. Clark, E.M. Daemane, J.E. Granger, D. Gwynne-Evans, I. Johnson, A. Linström, J.C. Manning, W.S. Matthews, D.J. McDonald, L.W. Powrie, M.C. Rutherford, C.R. Scott-Shaw, P. Scher, M. Stalmans and T. Steyn. One picture by the late J.P.H. Acocks was made available through the archives of SANBI. All captions have been prepared by L. Mucina using data provided by the particular photographers.

Figure 8.3 was reproduced with kind permission of SANBI and Figure 8.4 with kind permission of the South African Association of Botanists. Figures 8.24 and 8.37 were created by L. Mucina with technical assistance of L.W. Powrie. Figure 8.9 was created jointly by L. Mucina and M.C. Lötter, with technical assistance of L.W. Powrie. The concept of the Lydenburg Centre of Endemism was suggested by M.C. Lötter. M.C. Rutherford and L.W. Powrie prepared the figures featuring the climate diagrams and also compiled the data for the conservation sections of descriptions of all vegetation units. The quantitative

information on conservation status and targets, areas currently conserved, and areas transformed through road construction for each vegetation unit was kindly provided by M. Rouget and the team of the Directorate of Biodiversity Programmes, Policy and Planning of SANBI.

The list of references was compiled and collated by L. Mucina using own as well as co-authors' sources.

M.A. Dladla (Phuthaditjhaba, Free State) kindly contributed the poem celebrating the grassland flowers. E.M. Daemane (Kimberley, Northern Cape) translated the poem from Sesotho to English.

These credits have been compiled by L. Mucina and edited by M.C. Rutherford, M.C. Lötter and P.J.D. Winter.

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Plants

*Plants, we adore you, the ones who cover the world!
Your species are distributed all around the world,
In rocky areas and in flood plains, you grow,
In wet soils and sandy soils, you grow,
Your seeds grow well,
In favourable conditions, your seeds grow,
In unfavourable conditions, your seeds persist.*

*So abundant, where do you get the feet to stretch?
So abundant, where do you get the tricks to grow?
The blanket that covers the whole world,
The beauty of the world,
You are not only beautiful, but also the king,
Human race and animals equally adore you.*

*Grow in abundance,
Like an orphan, be persistent, be strong, and carry on,
Grow in abundance, cover the world and bring resolutions,
Resolutions bringing end to poverty and diseases,
Emerging diseases of this world,
Such are the epidemics of HIV and AIDS.*

by M.A. Dladla (English translation by E.M. Daemane)



Savanna Biome

9

Michael C. Rutherford, Ladislav Mucina, Mervyn C. Lötter, George J. Bredenkamp, Jacobus H.L. Smit, C. Robert Scott-Shaw, David B. Hoare, Peter S. Goodman, Hugo Bezuidenhout, Louis Scott, Freddie Ellis, Leslie W. Powrie, Frances Siebert, Theo H. Mostert, Barend J. Henning, Catharina E. Venter, Kelson G.T. Camp, Stefan J. Siebert, Wayne S. Matthews, John E. Burrows, Linda Dobson, Noel van Rooyen, Ernst Schmidt, Pieter J.D. Winter, P. Johann du Preez, Robert A. Ward, Sandra Williamson and P. Johan H. Hurter

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1. Introduction: Delimitation and Global Perspective

The savanna vegetation of South Africa and Swaziland constitutes the southernmost extension of the most widespread biome in Africa. It represents 32.8% of South Africa (399 600 km²) and 74.2% of Swaziland (12 900 km²). It extends beyond the tropics to meet the Nama-Karoo Biome on the central plateau, the Grassland Biome at higher altitudes towards the east and extends down the eastern seaboard interior and valleys where it grades into Albany Thicket in the Eastern Cape.

More specifically, savanna occupies most of the far-northern part of the Northern Cape, the western and northeastern parts of North-West Province, extreme western parts of the Free State Province, northern Gauteng with more isolated occurrences in the south of this province, almost the entire Limpopo Province, northwestern and northeastern Mpumalanga, most of central and eastern Swaziland, low-altitude parts of the eastern seaboard, inland of the Indian Ocean Coastal Belt in KwaZulu-Natal and the Eastern Cape Provinces, and with the southernmost extension abutting Albany Thicket of the Komga to Albany Districts.

Savannas are largely tropical and occupy the greater area of the southern continents (Huntley & Walker 1982) and also some parts of the northern continents. Most of the savannas are associated with old planation surfaces and are believed to represent a legacy of the vegetation which flourished during the Tertiary and even earlier geological periods when under hot, wet climatic conditions laterisation processes were active (Cole 1982, 1986). Savanna types north of South Africa and Swaziland extend from southern Mozambique in the east and

from the central interior of Namibia in the west through to the coast of central Angola and to the margins of evergreen tropical forest of the Congo Basin and extend further north into eastern Africa. Most of this area of savanna in south-central Africa south of Kenya (and excluding Botswana, Namibia, South Africa and Swaziland) is the miombo woodland or savanna. From Kenya, savanna extends into southernmost Somalia and to the southern and western flanks of the Ethiopian highlands. From here it extends east-west as a great belt between the Sahel to the north and the humid semideciduous forests to the south in West Africa to reach the coast of Senegal (Okigbo 1985, Scholes & Walker 1993). In South America, main savanna forms are the moist cerrado positioned between the Amazon forest and the Atlantic forest in Brazil and the arid caatinga east of the cerrado in northeast Brazil (Eiten 1982, Cochrane et al. 1985) and at least parts of arid chaco mainly in Paraguay and Argentina with parts in Bolivia and Brazil (Bucher 1982). The Orinoco savannas (llanos) occur from the Guaviare River in Colombia to the east coast of Venezuela (Sarmiento 1983, Medina & Silva 1990). Areas of savanna are also found in the Guayana region of Venezuela. Savanna woodlands in Australia are widespread north of the Tropic of Capricorn (Gillison 1983) but also extend southwards in eastern Australia (Lacey et al. 1982, Mott et al. 1985). Savannas on northern continents are limited, and occur mainly in India as well as in various other parts of southeast Asia (Blasco 1983, Pemadasa 1990, Yadava 1990). Savanna is also found in southwest Texas and into northern Mexico (Archer 1990). Savanna can also occur as small isolated areas, e.g. on the Nicoya Peninsula in the extreme west of Costa Rica (Sarmiento 1983). Many dominant grass genera of southern African savanna are shared with savannas of other continents. These include, for example, *Heteropogon* (Africa, India, Australia and America), *Andropogon* (Africa, India and America) and *Themeda* (Africa, India and Australia) (Johnson & Tothill 1985).

More recent major reviews that include southern African savanna are those of Huntley & Walker (1982), Bourlière (1983), Tothill & Mott (1985) and Cole (1986), with other reviews including Furley (2004). For definitions of savanna and considerations for its delimitation in southern Africa see the chapter on Biomes and Bioregions.

2. Climate, Geology and Soils

2.1 Climate

The macroclimatic patterns of the Savanna Biome region are tightly linked to climatic differences between the Atlantic and Indian Ocean coasts of the southern African subcontinent. Among the major macroclimatic traits characterising the Savanna Biome are: (1) seasonality of precipitation (alternation of wet summer and dry winter periods), and (2) (sub)tropical thermal regime with no or usually low incidence of frost. Brief inspection of maps of southern Africa featuring average temperature regime and temperature differences reveal several major trends (see Schulze & McGee 1978), such as (a) an expected overall temperature increase towards the equator (hence the regions of Mopane Savanna bioregion showing the highest yearly temperatures), (b) isotherms being parallel along long stretches of the coast indicating the ameliorating thermal influence of the sea, and along the Indian Ocean coast of the warm Agulhas Current, and (c) the high summer maxima in the Kalahari region as well as increasing differences between minimum and maximum temperatures towards the interior, reflecting the thermal continentality effect.

The steep precipitation gradient spanning the west and east coasts is ascribed to various factors, among which the earth's largest cross-continental zonal asymmetry of tropical convection is supposed to play a major role (Stokes et al. 1997). In the southwestern Indian Ocean, the Inter-Tropical Convergence Zone (ITCZ) reaches its southernmost position at 23° S in the austral summer (Schneider 1996), causing the Indian Ocean to reach temperatures as high as 27.5°C at these latitudes (mid-value for January). In the eastern Atlantic, on the other hand, the ITCZ is seldom found south of 5° S (Stokes et al. 1997). On the other side of the subcontinent, in the southern Atlantic Ocean, the sea surface temperature is almost 6°C lower than at the same latitude in the Indian Ocean—possibly a combined effect of low convection and the cold Benguela Current. The relative position and latitudinal and longitudinal movements of South Atlantic and South Indian Ocean Anticyclones (or cells of high pressure) as well as more to the south, Ferrar lows have been invoked as another, very important source of the precipitation patterns in southern Africa (for detailed discussion of these climatic systems see Tyson 1986). As also noted by the latter author, Streten (1980) and later also Harrison (1986) argued that the anticyclone affecting (eastern) southern Africa in winter is not the South Indian Ocean Anticyclone, but a separate one which owes its origin to anticyclonogenesis in a poleward stream of subsiding air originating in the Indian monsoon system of Asia. The regions occupied by the Savanna Biome clearly have a summer-rainfall regime. Stokes et al. (1997) argued that the elevated southern African land mass cools through long-wave emission, thereby providing an interhemispheric sink for Asian monsoon outflow. In summer, the Mascarene Anticyclone propels tropical easterlies—waves of moisture-laden tropical air over the eastern regions of the southern African continent, bringing abundant rain to the Savanna Biome. These waves get blocked in their westward movement by the relatively stable high-pressure system with its core located offshore of the West Coast over the Benguela Current, causing the summer aridity of the western regions of the subcontinent.

Savanna in South Africa and Swaziland does not occur at high altitudes and is found mostly below 1 500 m and extending to 1 800 m on parts of the highveld mainly along the southernmost edges of the Central Bushveld. Temperatures are therefore higher than those of the adjacent Grassland at higher altitudes. The mean daily maximum temperature for February rarely drops below 26°C and exceeds 32°C in the Kalahari region and some low-altitude parts of savanna in the east (Schulze 1997a). In July this temperature remains above 20°C for most of the area, with some temperatures at the highest altitudes dropping to 18°C. The mean daily minimum temperature in February rarely drops below 16°C, with the temperature of substantial parts of lower lowveld remaining above 20°C. The very low occurrence of positive chill units in savanna outside the highveld and Ghaap Plateau area, suggests the irrelevance of a chilling period for breaking dormancy in most savanna plants. Minimum temperatures in winter are much more variable across savanna. In limited areas in the extreme east, the mean daily minimum temperature for July remains above 10°C but drops to below 0°C on the highveld (southern edge of the Central Bushveld) and high-altitude parts of the Eastern Kalahari Bushveld such as the Ghaap Plateau. The average dates of heavy frost are also the earliest (May) and latest (September) in the two last-named areas. In savanna, the Ghaap Plateau shows the longest period in the year when frosts can occur (>120 days). Only lower-lying parts of the Mopane, Lowveld and Sub-Escarpment Savanna Bioregions can be regarded as frost-free. Diurnal temperature ranges ($T_{\max}$ minus $T_{\min}$) also differ considerably across savanna from a range of <9°C in Eastern Valley Bushveld to >15°C in

SVkd 1 Gordonia Duneveld in February. Corresponding values for winter (July) are about 12°C and >18°C, respectively. Mean annual temperature varies from about 16°C on parts of the highveld to >22°C in some lower parts of the Lowveld. Summer heat units correlate especially well with savanna, with most of the area with heat units above 2 200 degree days (October–March, base 10°C) falling within savanna. Summer (January) solar radiation is the lowest (< 28 MJm⁻²d⁻¹) in the eastern parts of savanna (Lowveld and Sub-Escarpment Savanna) and highest (>34 MJm⁻²d⁻¹) in the southern parts of Kalahari Duneveld (Schulze 1997b). In July this drops to a low (<13 MJm⁻²d⁻¹) in the southern parts of Sub-Escarpment Savanna (Schulze 1997a).

MAP varies from less than 200 mm in the west in southern Gordonia Duneveld to about 1 350 mm at the highest altitude parts of Swaziland Sour Bushveld in the east. Outside the Kalahari areas, most of the savanna experiences a MAP of between 500 mm and 750 mm. Coefficients of variation in annual precipitation vary from over 35% in the dry west to less than 25% in the more mesic parts of the east (Schulze 1997a). Concentrations of rainfall are generally high in savanna, peaking at a concentration index of more than 65% in the Kalahari Duneveld and northern parts of the Central Bushveld and Mopane regions (Schulze 1997a). A concentration index of 100% implies that the rainfall of a location is very concentrated in a single month, while 0% means that the rain in all months of the year is the same. Most of the savanna has rainfall concentrated in midsummer (January) but in late summer (February) in the Kalahari areas. There are some areas of savanna in the east, especially at higher altitudes, that have rainfall concentration in early summer (December).

Worldwide, savanna has a strongly seasonal rainfall with wet summers and dry winters (Nix 1983). Savanna has a distinct dry season, with most of the area in South Africa receiving less than 5 mm of rain in each of the months of June, July and August. Only in parts of the Sub-Escarpment Savanna is this slightly exceeded (especially in August). Most savanna areas in southern Africa have what is classified as strong summer rainfall or summer rainfall (Bailey 1979, Rutherford & Westfall 1994).

Although savannas have a distinct dry season and, in southern Africa, with a wet season that is essentially unimodal, there are areas of savanna, such as those of northern Tanzania, Kenya and southern Ethiopia, that have very distinctive bimodal rains usually with the 'short rains' peaking around November and the 'long rains' peaking around April, with the dry season centred in July. The summer-rainfall depression (lowest in February) in some of these savanna areas can be considerable, dropping to less than 10% of that of the peak rainfall month of the short rains, effectively creating a second, but shorter dry season (especially in southern Ethiopia and more arid parts of Kenya; Müller 1982). The magnitude of the rainfall in the 'long' and 'short' rainy seasons can be very similar in some areas in the north of the region. There are many species of southern African savanna that also thrive in these strongly bimodal rainfall systems.

The pattern of relative humidity in summer generally approximates the MAP pattern but in winter the relative humidity in the western part of savanna forms a belt of lowest values from around Lephalale (Limpopo Province) to Van Zylsrus (Northern Cape Province) and shows higher humidity into the lower-rainfall area of southwestern Gordonia, possibly due to the influence of cyclonic systems from the west during winter. Nowhere in South African savanna do winter daily minimum relative humidities (i.e. those that typically occur at the hottest period of the day) reach the extremely low levels experienced in savanna some hundreds of kilometres to the north of the country in the central parts of southern Africa where values of

close to 0% have been recorded. Potential evaporation in summer (January) is low in parts of the Sub-Escarpment Savanna (<180 mm A-pan equivalent), but increases northwards in the Central Bushveld (200–300 mm) and westwards to high values in Gordonia Duneveld (>360 mm). The extreme variation in potential evaporation in savanna is reflected in the mean annual amounts which vary from less than 1 600 mm in parts of Eastern Valley Bushveld of the eastern seaboard area to more than 3 000 mm in Nossob Bushveld of the Kalahari.

Hail and flash density of lightning on the ground are relatively low compared to that in the surrounding Grassland Biome. Surface winds are generally light in the region of South African savanna, although on the Polokwane Plateau strong winds from the east are sometimes experienced in summer (Schulze 1965). Savanna includes some areas of relatively windless conditions with, for example, Pretoria experiencing a frequency of 41% calms in January and 57% in July.

There has been a long local history of relating the climate of a region to its vegetation, especially in KwaZulu-Natal (Phillips 1983). Climate regions as relating to zones of vegetation have also been proposed at the national level in South Africa (Kruger 2004). Climatic relationships with a number of different savanna species in southern Africa have been established (e.g. Rutherford et al. 1999a, b). By way of but one example, areas where mean annual rainfall of less than 400 or 450 mm intersect with the highest number of heat units (in South Africa) correspond closely to that area of the Limpopo River Basin (and that of some of its tributaries) in which *Adansonia digitata* (Figure 9.2) occurs in South Africa.

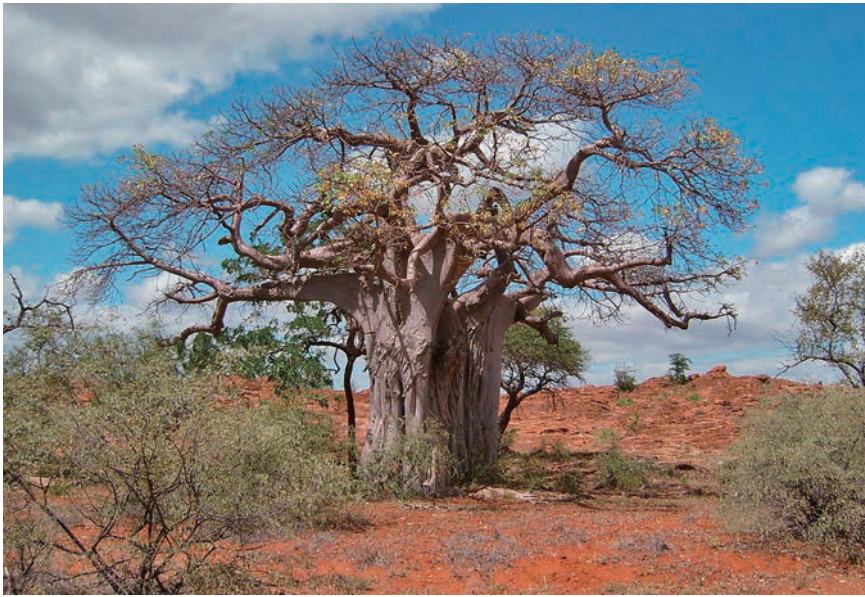
2.2 Geology

In South Africa, the Savanna Biome is located mostly in the northeastern part of the country. The geology of this area is dominated by a very stable block of ancient continental crust, known as the Kaapvaal Craton. The Kaapvaal Craton began to form by a process of accretion over 3.5 billion years ago (gya) and has been largely unaffected by crustal processes, except on its fringes, for the last 2 ga. The craton also hosts a number of significant sedimentary basins and igneous intrusions, thus preserving a geological record spanning most of geological time.

The Barberton mountain lands consist of some of the oldest rocks on earth and preserve the first evidence of the assembly of the Kaapvaal Craton (Poujol et al. 2003). This area includes the Barberton Greenstone Belt, a volcano-sedimentary sequence, as well as granitoid and gneissose rocks to the north and south. To the south of the greenstone belt is the Ancient Gneiss Complex in Swaziland which hosts the oldest rocks on the craton, some of which formed over 3.6 gya. Similar, but slightly younger greenstone belts are found elsewhere in the craton such as the Giyani, Murchison, Pietersburg and Kraaipan Greenstone Belts. These belts preserve clastic and chemical sediments as well as volcanic rocks that characteristically include ultramafic extrusives.

The assembled crustal blocks and associated greenstone belts were thickened and stabilised by the intrusion of many large bodies of potassic granitoid rocks that started around 3.1 gya. Such batholiths include the Nelspruit, Mpuluzi and Heerenveen bodies.

This stabilised crust became the basement on which large deposits of sediments could form and be preserved to the present day. The rich gold fields of South Africa formed among the sedimentary rocks of the Witwatersrand Supergroup that were deposited between 3 and 2.7 gya. This thick succession



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Figure 9.2 *Adansonia digitata* (baobab) with shrubs of *Grewia flava* on the edge of a sandstone ridge at an altitude of 555 m in the Mapungubwe National Park in early April. The baobab is one of the earliest savanna tree species to drop its leaves after summer in South Africa.

of quartzite, conglomerate and shale formed the world's greatest gold resource due to a unique set of circumstances on the stable crustal block during the Late Archaean. It was at a similar time that the Pongola Supergroup sediments were deposited to the east.

It is believed that these basins formed during the approach and eventual collision of the Kaapvaal Craton and a similarly stable block, the Zimbabwe Craton. Shortly after the deposition of the Witwatersrand sediments ceased, a phase of rift-related volcanism and associated sedimentation formed the thick Ventersdorp Supergroup. Rocks of this succession cover large areas of the North-West Province. This marked the end of significant tectonic activity on the craton.

During the early Proterozoic, subsidences lead to the development of stable continental platforms on parts of the craton that formed large sedimentary basins. The two large basins were the Transvaal basin, near the centre of the craton, and the Griqualand West basin on the western edge. Hence, the Griqualand West Supergroup correlates both chronologically and genetically to the Transvaal Supergroup. These two successions host similar deposits, most noticeably thick packages of chemical sediments (of the Ghaap and Chuniespoort Groups, respectively), including dolomites and Banded Iron Formations (BIF). The BIFs host important iron and manganese deposits for the country and, interestingly, formed as a result of (cyclically) elevated oxygen levels in the atmosphere and oceans due to the sudden increase of photosynthetic organisms (blue-green algae).

Deposition of the Transvaal Sequence continued for several hundred million years, amounting to a total thickness of accumulated sediment of over 20 km.

At ca. 2 060 mya the intrusion of the Bushveld Igneous Complex (BIC) formed one of the most recognisable features on the Kaapvaal Craton. This enormous structure forms the largest layered mafic intrusion on earth and is also host to the greater part of the world's platinum group metal, vanadium and chromium resources. It is intrusive into the upper part of the Transvaal Supergroup, namely between the Pretoria Group below, and the Rooiberg Group above. The intrusion consists of a mafic part

that formed its characteristic compositional layering by means of a settling out of minerals from the melt as they crystallised and is known as the Rustenburg Layered Suite. The other part of the intrusion consists of a voluminous amount of granitic material that lies above the mafic part, in the centre of the structure. This is the Lebowa Granite Suite and it contains some large fragments of older Transvaal Supergroup rocks.

Shortly after the intrusion of the BIC, another event around 2 gya generated the interesting Vredefort Dome. This structure has at its core Swazian Erathem basement gneiss and surrounding this, sediments of the Witwatersrand and Transvaal Supergroups which become younger away from the core. Until recently the reason for this doming and extreme up-warping of the basement and overlying sediments remained enigmatic. The interpretation of shock-metamorphism of the gneiss associated with the doming event is that a meteorite strike was the cause. This catastrophic event resulted in the rebounding of the crust to form what is now called the Vredefort impact structure.

Between ca. 1.9 and 1.6 gya the clastic sediments of the Soutpansberg and Waterberg Groups were deposited in the northern part of the craton. At a similar time the sediments and volcanics of the Olifantshoek Supergroup were laid down on the western edge of the craton. These are all of the Mokolian Erathem.

The next significant sedimentary basin to form on the Kaapvaal Craton was the Karoo Basin, during more recent times. The Karoo was one of several basins on the Gondwana Supercontinent, of which the Kaapvaal Craton formed a part, covering a total area of some 4.5 million km² during early Permian times (Smith et al. 1993). Sediments and volcanics of the Karoo cover large parts of the craton and its boundaries with adjacent crustal material.

The boundaries of the craton are in fact the zones of pervasively deformed rocks that represent old orogenic (mountain-building) events that occurred after 2.7 gya. The Limpopo Belt to the north of the craton represents the collision between the Kaapvaal and Zimbabwe cratons beginning at around 2.7 gya. Remobilisation of this orogenic belt occurred at around 2 gya, hence it forms the northern boundary of the craton. To the south and west of the craton, the mesoproterozoic (ca. 1 gya) Namaqua-Natal Metamorphic Belt forms the craton boundary. This belt extends from KwaZulu-Natal, beneath the younger Karoo rocks that cover it in the interior to the Namaqualand region and into Namibia. The Namaqua-Natal Metamorphic Belt is one of several belts of similar age throughout the world.

Although kimberlite pipes occur across large parts of southern Africa, it is only those that intruded into a craton that bear diamonds. Those that intruded into the Namaqua-Natal Metamorphic Belt or further west, are barren. This is consistent with the fact that the conditions for diamond growth are only found beneath old, rigid cratonic crust.

For more detailed accounts of the geology that include savanna areas, see Smith et al. (1993), Thomas et al. (1994), Eriksson et al. (1995), Robb & Meyer (1995), Brandl & De Wit (1996) and Poujol et al. (2003).

2.3 Soils

Since the early 1970s, our knowledge on the distribution and properties of soils has increased significantly, especially in the traditionally uncultivated parts of the country. Careful field observations of soil-plant relationships in the savanna regions by MacVicar (1962), Van Rooyen (1971), Verster (1974), Eloff (1984), Venter (1990) and others, including land type surveys (Land Type Survey Staff 1984a, b, c, 1985, 1986a, b, 1987, 1988, 1989a, b) have made it possible to understand the ecological significance of the soils better. The land type survey programme was initiated by the Department of Agriculture (later the ARC Institute of Soil, Climate and Water) in 1972.

With our improved knowledge of the occurrence and main properties of different soils, we can determine how they are likely to behave under a certain set of given environmental factors. For example, it is now known that there exists a much closer relationship between soils and vegetation in dry regions, such as much of the savanna areas, than in higher-rainfall regions (e.g. the surrounding mesic parts of the Grassland Biome). In low-rainfall areas, where water is the main limiting growth factor, it is mainly those physical factors that determine the rainfall efficiency, that have the greatest influence on the vegetation composition.

Local influences of soil properties (e.g. variation on a scale of as small as 0.25 ha) may have a pronounced influence on the pattern and type of tree-grass coexistence in an area. Such properties may be soil crust formation (Mills 2003) on certain soils (enhancing water runoff and therefore less available soil water in the profile, but possibly raising available nutrient levels; Dougill & Thomas 2004), swelling (cracking) clay soils that formed on basic parent materials (high storing capacity for soil water but with seasonal root pruning taking place), duplex soils with a root-impenetrable clay pan below or skeletal soils (shallow, usually also stony soils, but with fissures and cracks in the saprolite where some water may be stored and roots may penetrate).

Under extreme conditions of a high evapotranspiration and low annual rainfall (e.g. Kalahari), deep soils are needed for the trees and shrubs to survive. As the rainfall increases and the evapotranspiration decreases, shallower soils can also support the growth of trees and shrubs. Where duplex soils with a prismatic B-horizon (e.g. Estcourt soil form) dominate within a region, grass will dominate over trees and shrubs. Similarly, where high clay content swelling soils occur, despite favourable climate-soil water conditions, grasses will dominate because they can adapt to seasonal root pruning better than the perennial trees and shrubs. Grass quality, i.e. foliar nutrients, can also be closely related to soil texture (Mutanga et al. 2004).

The contributions of the different soil groups per broad savanna region are given in Box A. In the broad Kalahari area, Van Rooyen (1971) reported that the strongest relation between soil and vegetation was found on the deep red sandy soils (Hutton soil form (Orthic A—Red apedal B); Soil Classification Working Group 1991). The soils are base-saturated and have a considerable water storage capacity. *Acacia erioloba* and *A. haematoxylon* plants serve as distinctive

indicators of these soils when they are generally deeper than 1 m. On the same soils but on slightly higher elevations than the former and on northern slopes, dense communities of *A. mellifera* and *A. tortilis* dominate. In contrast to vegetation on the deep red soils, on yellow-coloured, sandy but calcareous soils [Augrabies (Orthic A—Neocarbonate B—Unspecified) and Addo soil form (Orthic A—Neocarbonate B—Soft carbonate B)], treeless grass vegetation dominates. Very little soil covers the dolomite formation of the Ghaap Plateau. The soils are usually calcareous [Coega soil form (Orthic A—Hardpan Carbonate)], with *Tarchonanthus camphoratus*, *Olea europaea* subsp. *africana* and some *Rhus* species. Red, yellow and greyish, excessively drained sandy soils (arenosols according to WRB terminology, where WRB is the World Reference Base for Soil Resources of the International Society for Soil Science (ISSS), the International Soil Reference and Information Centre (ISRIC) and the Food and Agriculture Organization (FAO) of the United Nations) dominate the dune areas (Box A). While these soils are still dominant in the areas where savanna vegetation occurs, deep red weakly structured soils (some of which might be calcareous below) with a slightly higher clay content than the dune sands occupy about one third of the area. It is on these soils (mostly luvisols and some calcisols) where most of the trees and shrubs occur. Shallow soils on rock (mostly leptosols) dominate on the ridges.

In Central Bushveld and including Mopane Savanna the soil variation is quite large (Box A). Although deep red weakly structured soils with a loamy to clay texture dominate on the more level land, soils with a high clay content and swelling properties (mostly vertisols and phaeozems) occupy almost 10% of the area. Where the region borders with the Grassland Biome to the south, the soils are mostly red and yellow, weakly structured with a low to medium base status, reflecting a higher effective rainfall than in the rest of the region. Shallow soils on rock (mostly leptosols) also dominate on the ridges and low mountains, while many rock outcrops occur on some of the mountains. On the shallow gravelly coarse sand of the Wasbank [Orthic A—Hardpan ferricrete (broken type)] and Glenrosa (Orthic A—Lithocutanic B—Saprolite) soil forms carry various woody plants including *Combretum zeyheri*, *C. apiculatum* and *Acacia caffra* (Verster 1974). These plants seem to be adapted to soils with a relatively dry soil climate, strong to medium acid conditions and a low inherent soil fertility. On the other hand, no trees (with the exception of a few) have been reported on

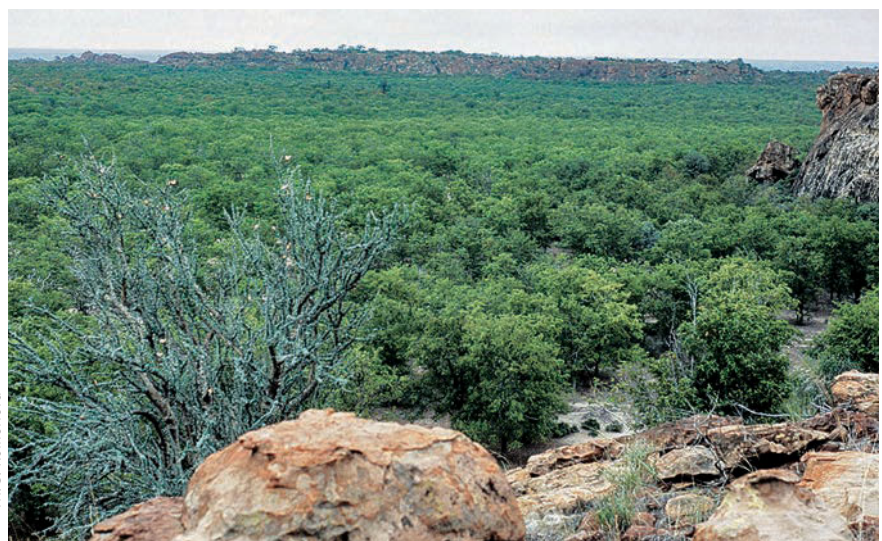


Figure 9.3 *Colophospermum mopane* overwhelmingly dominant on the heavier soils on the plains of Musina Mopane Bushveld with *Sesamothamnus lugardii* in the foreground, uncharacteristically on rock, in the Mapungubwe National Park (Limpopo Province).

the shallow coarse sand of the Wasbank and Dresden (Orthic A—Hardpan ferricrete) soil forms where the ferricrete is hard and solid below. Here grasses (e.g. *Trachypogon spicatus*) dominate. On many imperfectly drained floodplains (e.g. the Nyl River east of Mookgophong) with calcareous moderately structured clay soils [Sepane soil form (Orthic A—Pedocutanic B—Unconsolidated material with signs of wetness)], *Spirostachys africana*, *Acacia mellifera* and *A. tortilis* dominate. These plants therefore can tolerate the seasonally wet conditions, the stronger soil structure and prefer the high base status. In the mopane veld north of the Soutpansberg Mountains, *Colophospermum mopane* seems to be the best adapted to the unfavourable environmental conditions where it occurs on red and dark-coloured loamy and clay soils (Figure 9.3). In contrast, the perennial grasses such as species of *Digitaria*, *Schmidtia* and *Eragrostis* prefer the more sandy soils in this region. Only certain tree and shrub species are present on the black swelling clay ('turf') soils [mainly Arcadia soil form (Vertic A—Saprolite)]. It seems that *Acacia tortilis*, *A. robusta*, *A. nilotica*, *A. tenuispina* and *A. karroo* can tolerate the swelling properties of these soils.

In Lowveld bushveld, Venter (1990) has used the land type concept as basis for his ecological studies and management planning of the Kruger National Park (KNP). He found that a significant correlation existed between geology, landform and soils. Differences in these parameters were well reflected in both species composition and structural features of the vegetation that form the basis for habitat differentiation within the KNP.

The soil variation in this region is also quite large with soils of almost all soil groups present (Box A). However, it is the soils with limited pedological development (mostly leptosols) that dominate the area, with soils with high clay content and swelling properties (mostly vertisols and phaeozems that are associated with the base-rich parent materials, e.g. basalt) that have the highest percentage coverage of all the Savanna Biome groups. Here again, as with the Central Bushveld region, where the region borders on the Grassland Biome to the west, the soils are mostly red and yellow, weakly structured and with a low to medium base status, reflecting a higher effective rainfall than the rest of the region.

Box A. Relative contribution of soil groups within each savanna bioregion.

Bioregion	Soil group (%)											
	A2	A3	A4	A5	AR	B1	B2	C1	D1	E1	G1	H1
Central Bushveld	6	2	38	2	6	3	0	1	9	19	12	2
Mopane	0	0	32	0	16	0	0	4	1	45	0	1
Lowveld	8	1	7	1	5	1	1	2	15	53	3	0
Sub-Escarpment Savanna	6	2	1	0	0	0	1	5	1	83	0	0
Eastern Kalahari Bushveld	0	0	27	1	49	0	0	2	0	17	5	0
Kalahari Duneveld	0	0	1	0	99	0	0	0	0	0	0	0

Soil groups are as follows (classification according to World Reference Base (WRB) soil groups given in brackets):

Red-yellow well-drained soils lacking a strong texture contrast:

A2—Red and yellow, massive or weakly structured soils with low to medium base status (association of well-drained Ferralsols, Acrisols and Lixisols). Land type: Ab.

A3—Red and yellow, massive or weakly structured soils with medium to high base status (association of well-drained Ferralsols, Acrisols and Lixisols and one or more of Regosols, Leptosols, Calcisols and Durisols). Land types: Ac & Ad.

A4—Red, massive or weakly structured soils with high base status (association of well-drained Lixisols, Cambisols, Luvisols). Land type: Ae.

A5—Red, massive or weakly structured soils with high base status (association of well-drained Lixisols, Cambisols, Luvisols and one or more of Regosols, Leptosols, Calcisols and Durisols). Land types: Ag & Ah.

Soils within a plinthic catena:

B1—Red, yellow and greyish soils with low to medium base status (association of Ferralsols, Acrisols, Lixisols and Plinthosols. In addition, other soils with plinthic and gleyic properties may also be present). Land types: Ba & Bb.

B2—Red, yellow and greyish soils with high base status (association of Lixisols, Cambisols, Luvisols and Plinthosols. In addition, other soils with plinthic and gleyic properties may also be present). Land types: Bc & Bd.

Soils with a strong texture contrast:

C1—Soils with a marked clay accumulation (association of Luvisols, Planosols and Solonetz. In addition, one or more of Plinthosols, Vertisols and Cambisols may be present). Land types: Da, Db & Dc.

Soils with a high clay content and swelling properties:

D1—Black and red, strongly structured clayey soils with high base status (association of Vertisols, Phaeozems, Kastanozems and Nitisols. In addition, one or more Leptosols, Calcisols and Cambisols may be present). Land type: Ca.

Soils with limited pedological development:

E1—Soils with minimal development, usually shallow on hard or weathering rock, with or without intermittent diverse soils (association of Leptosols, Regosols, Calcisols and Durisols. In addition, one or more of Cambisols, Luvisols and Phaeozems may be present). Land types: Fa, Fb & Fc.

AR—Red, yellow and greyish excessively drained sandy soils (Arenosols). Land types: Af & Ha.

H1—Soils with negligible to weak profile development usually occurring on recent flood plains (association of Fluvisols, Cambisols, Luvisols and Gleysols). Land type: Ia.

Rocky areas:

G1—Rock with limited soils (association of Leptosols, Regosols, Durisols, Calcisols and Plinthosols). Land types: Ib & Ic.

Within the Sub-Escarpment Savanna, MacVicar (1962) has done some pioneering work on correlating soil with vegetation types in the Tugela Basin. The soil variation in the region is similar to what has been described for the Lowveld, also quite large, with soils of almost all soil groups present (Box A). There is, however, an absence of rocky areas and very sandy (red and greyish coloured, weakly structured) soils and deep soils that occur on large floodplains. Large areas of soils with high clay content that have swelling properties are also very limited. Although the soil group that represents soils with limited pedological development covers about 80% of the whole region, it actually indicates a great variation in the occurrence of soil types (without any of the other soil groups that dominate). One can therefore expect that, besides leptosols, soils such as regosols, cambisols, luvisols, planosols and phaeozems will occur. Again, where the region borders on the Grassland or Afrotemperate Forest Biomes to the west and north, the soils are mostly red and yellow, weakly structured and with a low to medium base status, reflecting a higher effective rainfall than the rest of the region.

3. Biogeography: Origins, Diversity Patterns and Classifications

3.1 *Origins of the Savanna Flora and Vegetation*

Judging from the wide extent of the Zambezan or Sudano-Zambezan Floristic Region and similarities of broad-leaved woodland and thorn bushland on both sides of the equator (White 1983, O'Brein & Peters 1999), evolution of the southern African savanna must have occurred in a wide African context. Middle and Upper Cretaceous floras are remote in terms of age and therefore have little significance in our assessment of the modern southern African savanna woodland. For instance, late Cretaceous wood from Mahura Muthla, North-West Province (Bamford 2000), and fossil leaves and pollen from Orapa, Botswana (Scholtz in Rayner et al. 1991, Bamford 2000), may have Gondwana features, but the numerous dicotyledonous leaves and other plant remains from Orapa are not identifiable to modern family level (Bamford 2000). We therefore look for clues of the southern African savanna woodland in the Tertiary period rather than the Cretaceous. There is little direct fossil evidence for the origin of savanna vegetation from the Tertiary period in southern Africa, but clues exist of how the vegetation in the current savanna region of southern Africa could have developed during this time.

Pollen of families that are typical in African savanna woodland seems to be present since the early Tertiary (Muller 1981) although they did not at that stage, represent vegetation similar to the current types in Africa. Eocene fossil leaves from Tanzania of *Acacia* and *Caesalpinaceae* suggest that woodland elements related to current savanna species were already present in Africa by this time (Herendeen & Jacobs 2000, Jacobs & Herendeen 2004). Fossil Eocene wood in southern Africa at Bogenfels in Namibia indicates the presence of families like *Balanitaceae*, *Burseraceae*, and *Euphorbiaceae* that have members in modern savanna woodland (Bamford 2000). Eocene wood from Mozambique (Bamford 2000) could give similar indications. More tropical conditions in the current savanna region, than at present, are likely to have prevailed for long periods in southern Africa during the Tertiary. We infer this from the observation that subtropical vegetation occurred in the southern and southwestern Cape and Namaqualand regions during the Palaeogene and

Early Neogene (Coetzee & Rogers 1982, Scholtz 1985, Scott 1995, Bamford 2000). For example, Bamford (2000) reported on Lower and Middle Miocene wood of *Combretaceae* from the Namaqualand region indicating wetter and forested conditions. The observation that warmer ocean waters surrounded the subcontinent (Shackleton & Kennet 1975) supports this scenario.

For the Neogene (the Late Miocene and Early Pliocene), Axelrod & Raven (1978) and O'Brein & Peters (1999) envisage scenarios suitable for large expanses of broad-leaved and seasonal and semi-arid woodland in Africa. The development of modern savanna is closely linked with the evolution of C_4 photosynthesis in grasses that took place after 8.5 mya, possibly together with declining atmospheric pressures of CO_2 (Cerling et al. 1997, Ehleringer et al. 1997, Jacobs 2004, Sage 2004). Jacobs (2004) reviewed plant and vertebrate fossil evidence relating to savanna woodland development and suggests that forest changed to open woodland between 12.6 and 6.8 mya in the Tugen Hills, Kenya. The oldest finds of typical savanna components in the southern hemisphere of Africa (*Acacia*, *Combretaceae*, *Commiphora* and *Dichrostachys* pollen types) are recorded in marine sediment cores along Namibia from the Atlantic Ocean from Deep Sea Drilling Project cores off Angola and northern Namibia of Late Miocene (Partridge 1978) and Early Pliocene age (Van Zinderen Bakker 1980). Bonnefille (1995) reports the presence of fossil pollen typical of Sudano-Zambezan flora in 4 mya (Pliocene) sediments from East Africa. Several fossil wood fragments from Member 4 in the Sterkfontein Cave include a liana typical of riverine and gallery forest, suggesting that trees were present at the time between 2.8–2.6 mya (Bamford 2000, Partridge 2000). Pliocene uplift in southern Africa and cooling (Partridge et al. 1995) seem to correspond with a transition from closed to more open woodland as inferred from fossil antelope faunas from sediments in South African hominid sites representing the period between 2.6 and 2 mya (Vrba 1985, 1995). Open grassy *Protea* savanna occurred by then on the boundary between the current Savanna and Grassland Biomes as indicated by pollen in deposits from Kromdraai and Sterkfontein (Scott & Bonnefille 1986, Scott 1995). The situation was different from but resembled the contemporary one.

Long-term boundary shifts and changes in floral composition in the Neogene were a characteristic feature of the vegetation history following regular transitions from glacial, stadial and interglacial conditions. These regular cyclic changes are visible in a stalagmite isotope record from Lobatse Cave (Holmgren et al. 1995), and in pollen records over the last 200 000 years from the Tswaing Crater (Pretoria Saltpan) and Wonderkrater (near Mookgophong), suggesting transitions from broad-leaved savanna to other types like montane forests, upland fynbos, thornveld or even karoo-like vegetation (Scott 1982, 1999a, b). During moist phases, for instance ca. 50 000 yr BP montane forests with *Podocarpus/Afrocarpus* and *Olea* must have occupied parts of the interior plateau that is currently under savanna woodland. During coldest Last Glacial Maximum (LGM) times between ca. 30 000 to 16 000 years ago, grassland with fynbos replaced this vegetation, which found refugia at lower elevations. Pollen spectra covering the last 20 000 years at Wonderkrater were presented in a calibrated time scale of radiocarbon dates and reflect the history since the decline of upland fynbos during the LGM. Thornveld developed ca. 10 000 years ago, broad-leaved woodland ca. 7 000 years ago, and more open woodland, associated with Late Holocene cooling, ca. 5 000 years ago (Scott et al. 2003). A nearby stalagmite record (stable isotopes) in the Makapansgat Valley provides a much higher resolution than the pollen record (Holmgren et al. 2003). Apart from the millennial-scale environmental changes

observed in both the pollen and stalagmite records, the stalagmite data show that the savanna vegetation was subject to short-term drought cycles on a decadal scale while the Little Ice Age represented a marked dry event ca. 1750 AD (Holmgren et al. 1999, 2003).

3.2 Diversity and Taxonomic Patterns

The number of species at broad geographical levels (gamma diversity) has been given as 5 788 (Gibbs Russell 1987) for the Savanna Biome in southern Africa, which in turn gives a relatively low species area ratio of $9.2 \times 10^3/10^6 \text{ km}^2$ (Van Rooyen & Van Rooyen 1998). For the southern Kalahari part of this biome, the ratio drops even lower to $4.4 \times 10^3/10^6 \text{ km}^2$ (Van Rooyen & Van Rooyen 1998). A broad-scale analysis indicates a gradient of sharply decreasing diversity of tree and larger shrub species from east to west within the Savanna Biome (O'Brien 1993, O'Brien et al. 2000). Cowling et al. (1997) found that heterogeneity (length of the temperature gradient) was the strongest predictor of regional species richness in South African savanna and grassland taken together. Savanna is well known for its diversity of mammals but many other animal groups are also well represented, for example dragonflies in the lowveld (Samways 1999).

An analysis of plant species diversity in the Sand River catchment in the lowveld revealed the following diversity patterns (Shackleton 2000b). The total number of species increased with increasing mean annual rainfall across the rainfall gradient, representing about 100 km from the border of the KNP to the eastern escarpment (Figure 9.4). Plant species numbers doubled over this gradient from around 50 to over 100 species per 0.1 ha. Plant species richness was substantially higher on eutrophic bottomlands than on dystrophic toplands. However, species turnover was greater along the rainfall gradient (about 85%) than along the catenal gradient between toplands and bottomlands (about 40%). There were significantly fewer species in protected areas than on the adjacent, highly utilised, communal lands. In the KNP, Whittaker et al. (1984) reported 78 plant species per 0.1 ha in habitat dominated by *Combretum zeyheri* and *Pterocarpus angolensis* and 93 species per 0.1 ha in habitat dominated by *C. zeyheri* and *C. apiculatum*.

In the Central Bushveld in the Nylsvley Nature Reserve, a similar range of plant species richness was found to that in the Lowveld (Whittaker et al. 1984: Table 4). The typical sandy

savanna dominated by *Burkea africana* and *Terminalia sericea* had between 80 and 100 species per 0.1 ha, which is indicated to be high compared to diversity in various USA plant communities (Whittaker et al. 1984). The highest set of values were for an area unburned for more than four years. More moderate diversity levels of between 40 and 60 species per 0.1 ha were found on rocky hills dominated by *Diplorhynchus condylocarpon*, and areas with somewhat more clay (than the surrounding sands) dominated by *Acacia tortilis* and *A. nilotica*. This lower range is still ranked as 'moderately high' compared with plant communities in the USA (Whittaker et al. 1984). Cowling & Hilton-Taylor (1997) regard the southern African section of the (Sudano-) Zambesian (Floristic) Region as 'relatively depauperate'. Cowling et al. (1989, 1997) indicate an average of about 67 species per 0.1 ha for South African savanna from a variety of sources.

Van Rooyen & Van Rooyen (1998) extracted data at a slightly different scale (0.001 ha or 100 m²) from Leistner & Werger (1973) to show various plant diversity patterns in the southwestern Kalahari. Species number per 0.001 ha was 32 on the red sand interdune valleys and dropped to 23 on the red sand dune tops in the north (with *Terminalia sericea* and *Albizia anthelmintica*), but only to 28 on the other dune tops (with *Stipagrostis amabilis*) common throughout the region. By contrast, the dune crests and slopes covered by red sand had the highest values according to the Shannon-Wiener index (which combines both richness and equitability) from 2.59 to 3.04. Beta diversity (turnover of species along a gradient) is extremely low for the communities of the large and homogeneous sandy areas (excluding riverbeds and pans) in the southwestern Kalahari.

At the point scale (1 m²) in the Sand River catchment, means of 7.9 and 8.2 species were found for toplands and bottomlands, respectively (Shackleton 2000b). Cowling et al. (1989) indicated a point scale mean of 9 for the Savanna Biome. On a savanna site in Namibia (MAP approximately 520 mm), naturally protected from long-term herbivory or disturbance by larger ungulates and with many plant species in common with South African savanna, point diversity averaged only 5.1 species (Rutherford 1975). Out of 1 200 samples of 1 m², there were no empty points; 1.4% had only one species, whereas a similar low percentage of points had 10 or more species (maximum 13).

3.3 Biogeographical and Vegetation Subdivisions

There is no widely accepted and overarching classification system for southern African savannas (Scholes 1997). At a very general phytocorior level, Werger (1978a) considers most of the savanna (and most grassland) in the present work to be part of the Zambesian Domain of the Sudano-Zambesian (Floristic) Region. However, he excluded the Kalahari area, which he placed within the Karoo-Namib Region, as the Southern Kalahari Subdomain. Kalahari has been delimited in many different, and often conflicting, ways (Thomas & Shaw 1991). White (1983) includes this area in the Sudano-Zambesian Phytogeographical Region. The area is, however, transitional between the tree and shrub flora of mainly Sudano-Zambesian affinity and the flora of the lower layers (at least in the Kalahari Duneveld Bioregion), with strong affinities with the Karoo-Namib Region (Werger 1973). The fact that the interdune valleys with mainly lower shrubs are wider than the parallel dunes that carry most of the larger shrubs and trees (Leistner & Werger 1973) was a deciding majority-area consideration in Rutherford & Westfall (1986) placing much of the Kalahari duneveld region in the structurally and climatically defined Nama-Karoo Biome and later extend-

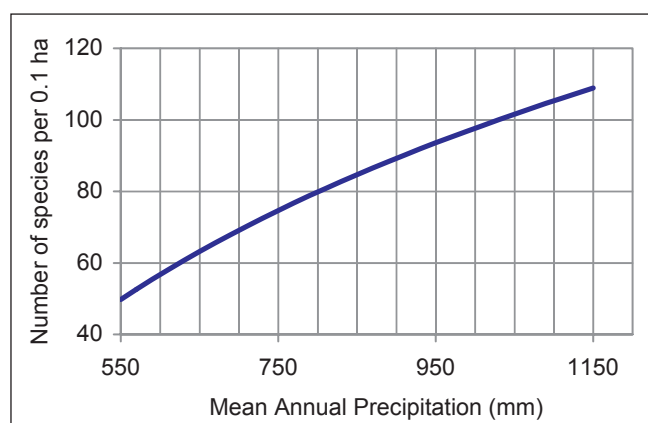


Figure 9.4 Relationship between mean annual rainfall and number of plant species in the Sand River catchment of the Lowveld (Mhala and Pilgrim's Rest Districts). Equation is: Number of species/ 0.1 ha = $80.09 \ln(\text{MAP}) - 455.57$ with $r^2 = 0.67$, $P < 0.00001$ and $n = 40$ (Shackleton 2000b).

ing it northwards (Rutherford & Westfall 1994: 74, Rutherford 1997) and including only the Nossob Bushveld in the far north in the Savanna Biome. This northern extension was also independently made through recent work on plant structure (Westfall & Van Staden 1996).

Werger & Coetzee (1978) recognised three broad vegetation units in the savanna of our region, namely 'Open *Acacia* savanna of the southern Kalahari' (corresponding to the Eastern Kalahari Bushveld and Kalahari Duneveld Bioregions), '*Colophospermum mopane* vegetation' (corresponding to the Mopane Bioregion) and 'Other woodland, savanna, thicket and bushveld vegetation' (corresponding to the Central Bushveld, Lowveld and Sub-Escarpment Bioregions). Their three units extend farther into Africa to limited degrees. Half of the 'Open *Acacia* savanna of the southern Kalahari' is in South Africa and extends towards Windhoek in Namibia, with a minor extension into southwestern Botswana. The 'Other woodland, savanna, thicket and bushveld vegetation' extends into large sections of central and northern Botswana and parts of central-north Namibia as well as into the far southern part of Mozambique. In this view, the savannas of South Africa and Swaziland are different to much of the rest of savanna (notably miombo) in Africa. The '*Colophospermum mopane* vegetation' does occur farther north, but then only as far as the southwestern corner of Angola and parts of the Zambezi River Valley with the most northerly extension up the Luangwa River Valley in Zambia (Henning & White 1974). Of the eight countries with this vegetation, South Africa is least represented (after Malawi) with only 4% of the total area of *Colophospermum mopane* vegetation (Mapaure 1994). There are, however, floristic elements in some South African savannas that re-occur in most African savannas. For example, the *Burkea africana* tree that occurs in several vegetation units of the Central Bushveld Bioregion is found to varying degrees in most of the African savanna to the north and through West Africa (Rutherford 1982a). The vegetation of the main study site of the South African Ecosystems Research Programme in the Nylsvley Nature Reserve is dominated by *Burkea africana*, and has also sometimes been regarded an impoverished form of miombo vegetation (Scholes & Walker 1993).

Huntley (1982) recognised two broad divisions of savanna (also applying to savannas northwards to the equator). These were moist/dystrophic savanna and arid/eutrophic savanna also called broad-leaved savanna and fine-leaved savanna, respectively (with mopane's broad-leaved being regarded as the exception; Scholes 1997). As mapping units, Huntley's (1982) moist/dystrophic savanna corresponds to the higher-lying areas of the Central Bushveld Bioregion (and to the eastern escarpment slopes west of the Lowveld; Huntley 1984). The arid/dystrophic savanna corresponds to the lower-lying parts of the Central Bushveld Bioregion and to the Lowveld, Sub-Escarpment Savanna, Mopane, Eastern Kalahari Bushveld and Kalahari Duneveld Bioregions. Scholes (1997) introduced a type intermediate between these two major units called 'mixed savanna', which corresponds to most of the Central Bushveld and Lowveld Bioregions (and also occurs in part of central Zimbabwe).

4. Vegetation Structure and Dynamics

4.1 Vegetation Structure and Patterns

Most savanna has a herbaceous layer usually dominated by grass species and a discontinuous to sometimes very open tree layer. 'Savanna grasslands' may grade into 'tree savanna', 'shrub savanna', 'savanna woodland' or 'savanna parkland' (Scholes & Archer 1997). In many savanna areas in southern Africa the term

bushveld is appropriate since the woody component does often not form a distinct layer as in miombo vegetation to the north but presents an irregular series of interlocking, often low, canopies with openings and sometimes little distinction between tall shrubs and small trees. This continuum between shrub and tree has been reflected in a 'shrubbiness index' developed for a range of savanna species in the Central Bushveld (Rutherford 1982b). Scholes et al. (2004) referred to 'stemminess' of savanna woody plants and pointed out that the distinction between trees and shrubs along a broad-scale Kalahari transect is somewhat arbitrary with savanna trees being typically multitemmed, but with fewer stems than shrubs. Structure of the woody component of savanna is important to animals—for example tree height which determines the available browse, dense woody entanglements forming impenetrable barriers, availability of shade, and protection against predators or scavengers. In arid savanna, such as the southwestern Kalahari, the configuration of the sparse woody component can also become critical as cover for hunting leopards (Bothma et al. 1994).

Floristically similar vegetation can be structurally different. For example, on black vertic clays, *Acacia tortilis* may form a woodland or occur as low shrubs embedded within grassland and kept low possibly by fire and frost (Van der Meulen & Westfall 1980). Substrate appears to play an important role in differentiating between the tall dominant trees of *Colophospermum mopane* on shale in SVmp 3 Cathedral Mopane Bushveld and the dominant shrubs of the same species in an adjacent vegetation unit (SVmp 4 Mopane Basalt Shrubland) on basalt in the KNP. Substrate also plays a key role in determining structure in the western parts of the Central Bushveld, where on particularly heavy clays (>55% clay in all horizons) most other woody plants are excluded and the diminutive *Acacia tenuispina* dominates at a height of less than 1 m above ground (Figure 9.5). On the sandy clay loam soils (with not more than 35% clay in the upper horizon, but high in the lower horizons) *A. erubescens* at over 5 m tall is the most prominent tree (Pauw 1988) (Figure 9.6). Some other plant relationships with soils are discussed in the section on soils.

The moist and arid savanna types (see Section 3.3) do not only differ predictably with lower woody plant leaf area index (LAI) and canopy cover (Privette et al. 2004) as well as basal cover (Scholes et al. 2002) in the arid savanna type. Finer but distinct structural differences include tree leaves changing from a horizontal orientation to a more random orientation and a strong decline in specific leaf area in arid savanna (Scholes et al. 2004), which, together with decreased LAI, indicates thinner leaves in arid savanna (along a Kalahari transect). Even when rainfall is similar, soil fertility differences result in nutrient-poor savanna (with many properties of moist savanna) and nutrient-rich savanna (with many properties of arid savanna). The nutrient-poor savanna also differs from nutrient-rich savanna in larger leaf size, higher root:shoot ratio, lower grass palatability, greater woody biomass, lower herbaceous water use efficiency and more conspicuous litter layer (Scholes 1990a). In nutrient-poor savanna, woody plant antiherbivore strategy is chemical (tannins, polyphenolics, etc.), whereas it is structural (thorns) in nutrient-rich savanna. Combretaceae and Caesalpiniaceae dominate the former, with Mimosaceae dominating the latter. The soil fauna is high and dominated by termites in nutrient-poor savanna and is low and ant-dominated in nutrient-rich savanna (Scholes 1990a). Both tree and herbaceous layers of nutrient-rich savanna are preferred by kudu over these layers in the nutrient-poor savanna in the Nylsvley Nature Reserve (Owen-Smith 1993). More generally, Owen-Smith (1982) listed 34 large African herbivore species with their preference for either arid/eutrophic or mesic/dystrophic systems; 23 species

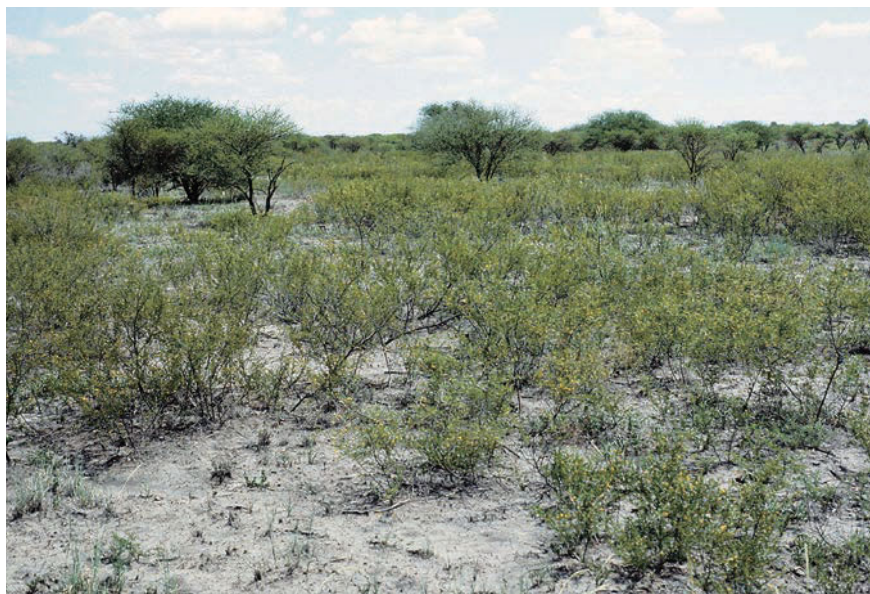


Figure 9.5 *Acacia tenuispina* dominant in the foreground on soil with a very high clay content west of Thabazimbi, between the Crocodile and Marico Rivers (SVcb 1 Dwaalboom Thornveld).

preferred arid/eutrophic (e.g. the browser black rhinoceros and grazer impala), seven preferred mesic/dystrophic (e.g. the browser grey duiker and the grazer buffalo) and four species fell in both categories (e.g. the grazer and browser Cape eland and the grazer tsessebe). The nutrient-poor systems relate to their position on acid crystalline rocks and old erosional surfaces, while the nutrient-rich systems are on fine-grained sediments and young surfaces (Scholes & Scholes 1997). In some special cases the origin of nutrient-rich patches of *Acacia tortilis* embedded within nutrient-poor broad-leaved savanna has been found to be anthropogenic, arising from Iron Age settlements (Blackmore et al. 1990).

There is often an excellent correlation between vegetation patterns and soil types, as exemplified in the KNP (Venter & Gertenbach 1986, Venter et al. 2003). However, there is much floristic variation along rainfall gradients, even with similar substrate such as demonstrated along the Kalahari gradient in Botswana (Ringrose et al. 2003). Even within the broad group of so-called Kalahari sands a variety of soils occur (Van Rooyen 1984) and the proportion of the coarse sand fraction is associated with the occurrence of certain tree species (Moore & Attwell 1999).

Termitaria are a common feature in many savanna types, also throughout many savannas of the world (Josens 1983). On granite-derived soil in the KNP a density of 111 active termite mounds per km² has been quoted (Naiman et al. 2003). Termite mounds form islands of significantly elevated nutrient concentrations and are associated with palatable grasses such as *Cenchrus ciliaris* and are heavily used by herbivores, especially in the dry season (Naiman et al. 2003). In the lowveld, Griffioen & O'Connor (1990) found that the percentage clay, pH, conductivity and sodium of the soil of termite mounds were significantly higher than that of the top soils of the

adjacent areas. They point out that the elevated pH is at variance with results from some termitaria elsewhere in Africa. Furthermore, they found that *Cenchrus ciliaris* was only associated with termite mounds in the open and did not occur at all on mounds under the canopies of trees. *Panicum maximum* was far more prolific on termite mounds than off the mounds under the canopies of trees. *Heteropogon contortus* does not occur on termite mounds. In a study in the SVs 6 Eastern Valley Bushveld in KwaZulu-Natal (Gower et al. 1992), woody plants were found to be absent around young, active termitaria, and only started to appear once the termitaria began to degenerate and become recolonised by ants or nongrass-harvesting termite species. *Acacia nilotica* was the first to colonise, followed by species such as *Ehretia rigida* and *Maytenus heterophylla*. The older termitaria had bush clumps with a closed canopy including *Ziziphus mucronata*, *Grewia occidentalis*, *Burchellia bubalina*,

Dovyalis zeyheri and *Cussonia spicata*. Termitaria can serve as a prominent perch for birds with a greatly increased probability for seed to be dispersed on them (Kemp et al. 2003).

Dambos are seasonally waterlogged bottomlands typically embedded within savannas of south-central Africa (Tinley 1982, Von der Heyden 2004). They are often associated with a catenary sequence (Scholes 1997). Although not as frequently encountered in South Africa as in the savannas further north, there are good examples of this kind of catena such as in the Nylsvley Nature Reserve. Here the catena extends from the hydromorphic grassland of the dambo through the yellow-brown sands of the lower slopes to the yellow-red sands of the midslope to the red-brown sands of the upper slope (Von Harmse 1977), a sequence also broadly associated with a plant species gradient (Scholes & Walker 1993). The catenary pattern of sandy uplands to clayey bottomlands is common in parts of the lowveld (Scholes et al. 2001, Venter et al. 2003), where the



Figure 9.6 Moderately dense woodland dominated by *Acacia erubescens* on less clayey soils on the Farm Portugal, west of Dwaalboom, Thabazimbi District (SVcb 1 Dwaalboom Thornveld).

catena can include a clear seep zone such as in the Sabi Sand area of the lowveld (see Tinley 1982: Figure 4). Where toplands have been heavily utilised for communal grazing in the lowveld, they become so modified that they classify outside the topland-bottomland dichotomy that characterises this region (Higgins et al. 1999).

Various pattern analyses of plants have been undertaken in southern African savanna vegetation. In the southern Kalahari, both actual and modelled tree spacing tends to be even at small scales, clumped at intermediate scales, and random or clumped at large scales (Jeltsch et al. 1999). Species differences may be important. In a field study in the arid Kalahari, *Acacia erioloba* saplings were found to be aggregated, small trees were randomly or regularly distributed and large trees were randomly spaced. However, in open stands of *A. mellifera* subsp. *detinens* aggregation increased with the size of the shrub (Skarpe 1991b). From a number of sites across a range of conditions on Kalahari sands, Caylor et al. (2003) concluded that small individuals were more aggregated than large ones, and put forward a number of possible mechanisms to explain this pattern. In dystrophic broad-leaved savanna in the Nylsvley Nature Reserve a lack of pattern in the herbaceous layer was attributed mainly to the large number of annual and perennial pioneer and disturbance-indicating species (Theron et al. 1984). Whitaker et al. (1984) concluded that on this site the woody vegetation dominated the pattern. Clearly more studies are needed to elucidate different spatial groupings of plants in the diverse savanna systems.

Roots of savanna plants play a critical role in patterning and function. A well-developed root system allows savanna plants to survive both drought and fire (Menaut 1983). Savanna plants are renowned for their well-developed root systems. A brief summary of the root component and some of its wide variation is given below.

Below-ground plant mass can be considerable. Values such as 29 790 kg ha⁻¹ in an area overwhelmingly dominated by small trees of *Colophospermum mopane* are exceptionally high and comparable with that of woodlands elsewhere with much taller trees (Smit & Rethman 1998b). The ratio of below-ground to above-ground parts (root:shoot ratio) in the tall shrub *Ochna pulchra* is still relatively high at a value of about 1 (averaged for the whole population at a site; Rutherford 1982a). Root:shoot ratios of around 5 have been found for shrubby savanna dominated by *Terminalia sericea* (see Rutherford 1982a). The large investment in plant material below ground is believed to be critical for the persistence of the plant under conditions that adversely affect its above-ground parts.

Many savanna woody plants have extensive shallow root systems, but not necessarily to the exclusion of some deeper running roots. The shallow root system enables them to make use of relatively light showers when water does not penetrate far into the ground. The very strongly developed lateral root system can sometimes extend 7–12.5 times that of the canopy radius, and it includes species such as *Terminalia sericea*, *Burkea africana* and *Colophospermum mopane* (Rutherford 1980, 1983, G.N. Smit, personal communication). *Combretum apiculatum* is also reported to have a well-developed shallow lateral root system (Fraser et al. 1987). The high root:shoot ratio and the relatively shallow rooting of *Colophospermum mopane* make it a particularly effective competitor with herbaceous plants (Smit & Rethman 1998b). Some other species have very limited lateral extension such as up to only 1.5 times that of the canopy radius in *Commiphora pyracanthoides* (Jordaan et al. 1998). Contrary to trees of many other savanna systems, this species also has little intergrowth of roots of other tree species. It is also unusual in that, in addition to a tap root system, it has a well-developed

fleshy, tuber-like secondary root system that contains a large amount of moisture.

Savanna evergreen trees tend to have deep root systems—at least in dry savanna (Skarpe 1996). *Boscia albitrunca* in the central Kalahari appears to hold the world record for a maximum rooting depth of 68 m (Canadell et al. 1996). In a study in the southern Kalahari dunefield (Gordonia District) Schulze et al. (1998) found downward transport of water in roots (inverse hydraulic lift) with water flow into deeper soil layers. They suggested that inverse hydraulic lift may serve as an important mechanism to facilitate root growth through the dry soil layers underlying the upper profile where precipitation penetrates.

Several low plant species in savanna have stems which are widely interconnected below ground and include geoxyllic suffrutices such as *Dichapetalum cymosum*, *Fadogia monticola*, *Lannea edulis*, *Parinari capensis* and *Pygmaeothamnus zeyheri* in the Nylsvley Nature Reserve (Rutherford 1980). In the same reserve several legume species, such as *Elephantorrhiza obliqua* and *Chamaecrista mimosoides*, produce long rhizomes which interconnect widely spaced shoots (Grobbelaar & Rösch 1981); even individuals of *Ochna pulchra* (large shrub, sometimes tree) are sometimes interconnected below ground (Rutherford 1980, 1983).

Leistner (1967) provided an extensive account of the root systems of a wide range of plant species of the southern Kalahari and confirmed that the roots of some species can reach great depths, and that trees can have shallow lateral roots stretching far from the tree. He pointed to several specialist structural features including root sand coats and spongy cortex, succulent roots and contractile roots in monocotyledons and 'deciduous' roots, succulence and wiriness and to suckering in dicotyledons. The ability of plants to sprout from exposed roots is common in species such as *Senna italica* subsp. *arachnoides*, *Heliotropium ciliatum*, *Hermannia tomentosa* and *Lycium hirsutum* and even in adult specimens of *Albizia anthelmintica* (Leistner 1967), and may confer a survival advantage in areas with sometimes unstable sand dunes. Even in deep sandy areas in more humid savanna, the ability of roots to sucker, when exposed and damaged, is very common in *Ochna pulchra* (Rutherford 1983) which, if caused by burrowing animals and small mammals feeding, for example, on soil insects, could result in aerial extension of, and competitive advantage for the plant.

4.2 Plant Interactions

Three major reviews have addressed tree-grass interactions in savannas (Scholes & Archer 1997, Sankaran et al. 2004) or their interaction in the wider context of mixed tree-forb plant systems (House et al. 2003). Here, we emphasise some locally important features of these and other plant interactions that pertain to our region.

Tree-grass mixtures have been regarded as fundamentally unstable, but the simulation models to explore the organisation and dynamics of tree-grass ecosystems are still in their infancy (House et al. 2003). Four classes of hypotheses (models) are recognised for explaining how the woody and herbaceous life forms coexist (House et al. 2003): (1) Niche separation, where woody and herbaceous plants partition resources in space (e.g. preferential access to deep water by woody plants) versus more effective use of shallow soil water by grasses, or in time (e.g. phenological displacement of physiological activity); (2) Balanced composition, where woody and herbaceous plants compete for rather than partition resources, and intraspecific competition (e.g. grass-on-grass and tree-on-tree) dominates over interspecific (e.g. tree on grass) competition; (3) Competitive exclusion,

where the system is driven away from a relatively stable equilibrium and over time the one life form sufficiently pre-empts and monopolises resources so as to virtually eliminate the other. However, disturbances, which have a greater effect on the competitively superior life form, may prevent those plants from achieving or maintaining dominance; (4) Multiple stable states, where the spatial and temporal heterogeneity of resource availability and disturbance is incorporated into equilibrium models so that contrasting tree-grass ratios might exist for a given site at various times. All four the above have elements that should be included (together with many other key factors occurring at various spatial and temporal scales) in a comprehensive model.

By way of example of one of the above, Van Langevelde et al. (2003) suggested the following, based on an interaction between fire and herbivory: an increase in the level of grazing leads to reduced fuel load, which makes fire less intense and, thus, less damaging to trees and, consequently, results in an increase in woody vegetation. The system then switches from a state with trees and grasses to a state with solely trees. Similarly, browsers may enhance the effect of fire on trees because they reduce woody biomass, thus indirectly stimulating grass growth. This consequent increase in fuel load results in a more intense fire and further decline of biomass. The system then switches from a state with solely trees to a state with trees and grasses.

Some locally applied models have shown that rainfall and the competition for water alone were not sufficient to guarantee tree-grass co-existence and to maintain a scattered distribution of Kalahari savanna trees in a cellular automaton model (Jeltsch et al. 1996). In the absence of small-scale heterogeneities (e.g. patches of disturbance), the system is generally driven to a state of either pure grassland or pure woodland. With the introduction of such small-scale heterogeneities, coexistence of trees and grass can occur under a broad range of conditions (Jeltsch et al. 1998). Similarly, Higgins et al. (2000) demonstrated grass-tree coexistence in a model that included fire intensity and its (patchy) variance and its effect on tree recruitment.

The niche separation hypothesis applied locally needs qualification. Contrary to Walker et al. (1981) and Walker & Noy-Meir (1982), grasses do have access to subsoil water, but the two-layer model can still operate, provided each component is the superior competitor in a different layer (Knoop & Walker 1985). Further caution is advised since it has been found that some woody species extract water from a wide range of soil depths, including those near the surface. For instance, whereas *Ochna pulchra* extracts water mostly from above 60 cm depth, extraction of water occurs throughout the whole of the soil profile under *Grewia flavescens* (Moore et al. 1982).

Following an analysis of data from 854 savanna sites across Africa, Sankaran et al. (2005) provide an elegant generalisation of the determinants of co-dominance of trees and grasses in savanna. In savanna with a MAP of less than about 650 mm, water constrains woody cover and permits grasses to exist, while fire, herbivory and soil properties interact to reduce woody cover below the MAP-controlled upper bound. For areas with a MAP above 650 mm, rainfall is sufficient for woody canopy closure, and disturbances (fire, herbivory) are required for the coexistence of trees and grass. They view the latter savanna system as 'unstable'.

Scholes & Archer (1997) suggested that many semi-arid areas on relatively fertile or clayey soils were relatively treeless in pre-colonial times, but were encroached rapidly and apparently irreversibly when grazed continuously by cattle. This is in contrast to semi-arid environments on sandy, low-fertility soils which are seldom treeless. Bush encroachment has long been regarded

as a problem for range farmers and wildlife managers (Van der Schijff 1959) and a number of long-term studies have shown a trend for a progressive increase in both tree and shrub cover, e.g. in the Hluhluwe-iMfolozi Park (Watson & Macdonald 1983). Most often woody plant increases have been ascribed to poor land use practices but Bond et al. (2003a) suggested that the general increase in savanna trees in South Africa in more recent times has been assisted by increasing CO₂ concentrations. Ward (2005) contended that causes of bush encroachment are not simple and that bush encroachment, for example, can occur on both heavily grazed areas as well as on areas where grazing is infrequent and light.

The long-term (58 years) increase of woody plant cover on granite substrates and the substantial decline on the basalt substrates in the KNP has been partly ascribed to a difference in competitive intensity of the grasses (Eckhardt et al. 2000). It is thought that the provision of surface water has led to overgrazing of grasses which do not recover rapidly on the granite substrates as opposed to their rapid recovery even after heavy grazing on the relatively nutrient-rich basalts. The sharp decline of woody plant cover on the basalt substrates, however, is more importantly linked to the regular, short-interval prescribed burning over the past 40 years. Bond et al. (2001) demonstrate experimentally at Hluhluwe Game Reserve that both the above-ground and below-ground effects of the herbaceous plants negatively affect both *Acacia nilotica* and *A. theronii*. In Eastern Cape savanna vegetation, removal of the herbaceous layer resulted in an increase in the growth of the *A. karroo* trees illustrating the suppressive effect of the grass-dominated herbaceous layer on woody plants (Stuart-Hill & Tainton 1989). In a broad-leaved nutrient-poor savanna in the Nylsvley Nature Reserve, the effect of the herbaceous vegetation on woody plants was found to be negligible—at least in a period of two years (Knoop & Walker 1985). However, in a nutrient-rich *Acacia* community with seven times more herbaceous biomass, mature woody-plant growth was reduced by the grass-dominated herbaceous layer, especially in a wetter year. Hudak et al. (2003) suggested that soil carbon sequestration may initially increase with bush encroachment, but then it would decline if bush densities become so high that they inhibit understorey grass growth.

There can be major differences in the herbaceous layer under canopies and areas between tree canopies (Scholes & Archer 1997, Smit 2004). Soil nutrient enrichment (N, Ca, K, Mg and Na) and increased soil organic matter is found under trees, especially large ones, due to various mechanisms including leaf litter, stemflow and throughfall of rain and N-fixation under leguminous trees (Smit 2004). In an *Acacia luederitzii*-dominated part of the Kalahari in southern Botswana, significantly higher levels of soil organic carbon and soil organic nitrogen were found under the canopies of the woody vegetation (Feral et al. 2003). Large *A. erioloba* trees in the Kalahari have a close association with animals resting in the shade of the canopy, with the soil enriched with nutrients through faeces, fallen nest material and carcass remains (Dean et al. 1999). In a study in SVk 1 Mafikeng Bushveld near the Molopo, significant development of cyanobacterial soil crusts under the canopies of *A. mellifera* may enable the supply of additional nutrients to the plant (Dougill & Thomas 2004). Despite similar canopy dimensions, soil crust development was found to be greatly reduced under *Grewia flava*, possibly relating to less light reaching the soil surface than with *A. mellifera*. Woody plants can serve as sites of protection for certain grass species, such as for *Themeda triandra* and *Heteropogon contortus* on some heavily grazed areas in the lowveld (O'Connor 1995b).

Acacia karroo trees in the Eastern Cape were found to suppress grass growth up to 9 m away (Stuart-Hill & Tainton 1989). Increasing density of *A. mellifera* individuals strongly depressed herbaceous production in the Molopo area (Rutherford 1978) and grass productivity was strongly inversely related to the LAI of trees in modelling output from the Kalahari (Caylor & Shugart 2004). Scholes (2003) found this a general pattern in savanna where grass declined more steeply per unit increase in tree quantity at low tree cover than at high tree cover. This 'convex relationship' he suggested is explained mainly by the geometry of the spatial interaction between the tree root system and grasses, and the effect of differing phenology (the time course of leaf area exposure) on the acquisition of water and nutrients.

Panicum maximum is a grass commonly associated with under-tree habitats in many South African savanna areas (Griffioen & O'Connor 1990, Smit & Swart 1994, Smit 2004). Tree size is important and *P. maximum* ranged from virtually absent under small trees of *Acacia tortilis*, *A. karroo* and *Dichrostachys cinerea* subsp. *africana* to pure stands under larger trees (Smit & Romburgh 1993). Griffioen & O'Connor (1990) found that *P. maximum* was far more prolific on termite mounds under the canopy of trees. Several species such as *Aristida bipartita* and *Heteropogon contortus* tend to avoid the habitat under the canopy of trees (Griffioen & O'Connor 1990). In some cases the herbaceous species composition under trees in comparison with the open habitat, is not greatly influenced, for example, by the tree layer dominated by *Burkea africana* in the Nylsvley Nature Reserve (Theron et al. 1984), possibly partly relating to the canopy of this species allowing more than 25% light throughfall (Van der Meulen & Werger 1984). Grass species under canopies of woody plants on this site were all C₄ photosynthetic type (Cresswell et al. 1982). However, on the same site, total biomass was significantly greater in the open than under *B. africana* trees while the amount of crude protein was greater under these trees than in the open (Grossman et al. 1980).

Thinning or even total removal of savanna trees is a common practice to counter the apparent suppression of herbaceous plants to improve grazing (Scholes 1990b). However, although thinning of *Colophospermum mopane* confirmed an increase in herbaceous plants, thinning of *Salvadora australis* in the same area appeared to show the reverse on herbaceous plants (Smit 2003b). Scholes's (2003) guideline to thinning suggests that if one needs to keep some trees on the land, the most cost-beneficial pattern of clearing is to remove all the trees in a portion of the landscape, rather than remove a portion of the trees in all of the landscape. In other words, to begin with, the least encroached areas rather than the usual 'intuitive' practice of tackling the most densely treed areas first. This patchy clearing is more easily managed with fire as a clearing mechanism and the dispersal of tree propagules into the cleared area is reduced.

Thinning of *Colophospermum mopane* also reduced inter-tree competition and resulted in a marked increase in the flowering and fruiting of the remaining trees (Smit & Rethman 1998a). Removal of trees closely neighbouring *Acacia nilotica* led to a significant increase of growth when compared with control trees (Smith & Goodman 1986). In bottomland *Acacia* communities in the Pilanesberg Game Reserve, spatial analysis suggested competition among trees as a mechanism controlling their size and density (Smith & Walker 1983). However, of 45 sites spread across the Savanna Biome in South Africa, only at four was the presence of interspecific competition between woody plants indicated (Shackleton 2002). At only 10 of 31 sites tested was intraspecific competition indicated. Despite

the limitations of the method used (nearest-neighbour analysis), this does suggest that niche separation between species and within species is generally greater than previously argued. Alternatively, if competition is occurring, its impact is relatively low, both at the level of specific pairs of trees, as well as the community as a whole (Shackleton 2002).

At a site (Vastrap, northeast of Upington) on Kalahari sands, the number of small trees under dominant trees was significantly lower than that expected by chance and is possibly ascribed to limited water supply forcing individuals to disperse away from each other (Caylor et al. 2003). This differed to wetter sites on Kalahari sand in Botswana where the number of small trees under dominant trees was found to be significantly higher than expected. The association with frugivorous birds results in a high frequency of often woody plant species with fleshy fruits (*Boscia*, *Grewia*, *Lycium* and *Solanum*) beneath large trees of *Acacia erioloba* (Dean et al. 1999). Savanna tree species respond differently to shading. Shading reduced survival of *A. tortilis* seedlings in the Nylsvley Nature Reserve (Smith & Shackleton 1988). In the Mkhuzi Game Reserve establishment of *A. nilotica* seedlings was restricted to open areas with no woody canopy cover (Smith & Goodman 1987). However, in the same area, seedling establishment of *Euclea divinorum* was limited to areas beneath the canopies of established *Acacia* individuals. *Pappia capensis*, which is widespread in South African savanna, has been shown to perform very poorly in deep shade (Holmes & Cowling 1993). However, in dry years shade may increase moisture availability as evidenced in SVs 7 Bhishe Thornveld where shading dramatically increased survival of seedlings of *A. natalitia* in a drought year (O'Connor 1995a). *Burkea africana* is able to establish under its own canopy and that of some other species (Wilson & Witkowski 2003).

The most commonly observed plant parasites in savanna are mistletoes with a study indicating that mistletoe host preference is negatively correlated with host wood density, which translates in turn to host species preferences (Dzerefos et al. 2003). Thus in lowveld, for example, they found *Sclerocarya birrea* (wood density 560 kg/m³) was a clearly preferred host species, while *Combretum apiculatum* (wood density 1 230 kg/m³) was avoided by the woodrose-forming mistletoes *Erianthemum dregei* and *Pedistylis galpinii*. Some species with low wood density were also avoided.

In contrast to the Fynbos, Grassland and Forest Biomes in southern Africa, the most widespread alien invader plants are herbs in the Savanna Biome (Richardson et al. 1997). Most of these are from South America and include *Alternanthera pungens*, *Bidens bipinnata*, *Conyza albida*, *Datura ferox*, *D. stramonium*, *Schkuhria pinnata*, *Solanum elaeagnifolium*, *Tagetes minuta*, *Verbena bonariensis* and *Zinnia peruviana*. Several succulents from the Americas are also important and include *Agave sisalana* and *Cereus jamacaru*. Woody alien invader plants are given in the section on Descriptions of Vegetation Units.

4.3 Rainfall and Temperature Effects

Savanna vegetation structure changes the rainfall that reaches the ground. Studies in areas of the Central Bushveld with a MAP of about 650 mm showed that although the average stemflow of trees per storm was often less than 5% of the gross rainfall; it represented a concentrated application of water to the soil at a point where conditions were ideal for entry (De Villiers 1982). Also interception losses of rainfall are significant and vary mainly between 15% and 20% of the gross rainfall. Stemflow and interception may relate to the sometimes marked ecologi-

cal differences below savanna trees (see section 4.2), but they may also tend to cancel out the net effect of both.

In years of above average rains, savanna deciduous woody species commonly retain their leaves for longer periods, sometimes dropping only a week or two before the new flush of leaves.

Duration of leaf retention into winter as determined by soil moisture is also shown in *Acacia tortilis*. Along a gradient from the Thukela River in midwinter (July) there was 71% leaf retention on the river banks dropping successively to only 10% at 200 m above the river (Milton 1983). A few deciduous savanna woody species characteristically have a particularly long seasonal leaf duration with a very short leafless period (e.g. *Colophospermum mopane*; Dekker & Smit 1996). Many savanna trees produce new leaves before the first rains of the season (Mistry 2000). In some species, the first seasonal activity is flowering, which can start as early as late July in *A. robusta* and *Dombeya rotundifolia*. Slow absorption of water during the leafless period allows for growth to resume before the first rains fall (Van Rooyen et al. 1986). It has also been suggested that the magnitude of shoot growth in a given growth season in certain savanna woody species is influenced by the rainfall of the previous season (Rutherford 1984).

In the hyperarid savanna in the southwestern Kalahari periods of drought and the variability of rainfall appear to have a significant influence on herbaceous species in the short term, while there was not much variation in the woody species composition or density (Van Rooyen et al. 1984). In the southern Kalahari after a year of severe drought, Leistner (1967) noted that in contrast to the decimation of all grass species on a particular dune, the survival rate of plants with subterranean storage organs (*Acanthosicyos naudinianus*, *Harpagophytum procumbens* and *Talinum caffrum*) appeared high. Other most obvious survivors were trees and tall shrubs. Herbaceous species composition changed dramatically following a severe drought in savanna of the lowveld east of Acornhoek (O'Connor 1995b). In the Klaserie Nature Reserve after a severe drought, mortality of grasses was very high, but that of woody plants was low (Scholes 1985). Over 80% mortality, for example, was found for *Panicum maximum* and *Schmidtia pappophoroides*. The depauperate state of the herbaceous layer at high densities of *Colophospermum mopane* trees (Figure 9.7) is relatively independent of rainfall (Smit & Rethman 1999).

After some severe drought years in the vicinity of Pontdrif, mortality of *Colophospermum mopane* was most pronounced for individuals less than 1 m tall and with no mortality for individuals taller than 3 m (O'Connor 1998). Dieback of mopane was less on sandier soils in this area (MacGregor & O'Connor 2002). Despite the relatively large leaves of mopane, it is partly protected from desiccation by the oils in its leaves (Venter et al. 2003). In the KNP, after a major drought, 30–40% of mopane were killed in one area while exceptionally high mortality (93%) of *Acacia tortilis* was recorded, but was localised (Viljoen 1995).

In a study replicated in many parts of the KNP, it was found that none of 18 key grass species were lost from the park following the 'severest drought in living memory' (Kennedy et al. 2003).



Figure 9.7 Very low cover of the herbaceous plant layer between and under *Colophospermum mopane* and *Commiphora viminea* trees, east of Pontdrif in Limpopo Province.

The percentage abundance of these grasses declined during the drought to 87.5% of the pre-drought value. The relative abundance of species such as *Digitaria eriantha* declined while that of *Urochloa mosambicensis* increased, with the latter also spreading to new sites after the drought had past.

Effect of frost on woody savanna plants can be remarkably species-dependent. In the growth season following an unusually cold winter with 11 nights of moderate to heavy frost (−3.5°C measured at 1.5 m above ground: average annual minimum screen temperature of 2.1°C) in SVcb 15 Springbokvlakte Thornveld dominated by *Dichrostachys cinerea* on the Towoomba Research Station, many trees experienced topkill, but with most of these resprouting from the base (Smit 1990). Species significantly damaged by the frost were *D. cinerea*, *Acacia nilotica*, *A. gerrardii* and *A. robusta*. Little affected by the frost were *A. caffra*, *A. karroo*, *A. tortilis*, *Diospyros lycioides*, *Ehretia rigida*, *Grewia flava*, *G. flavescens*, *Rhus leptodictya* and *Ziziphus mucronata*. Of the frost-sensitive *Acacia* species, individuals above a height of 2 m were relatively unaffected by the frost. Smit (1990) observed that fewer of the frost-sensitive species were affected in camps with higher density of woody plants. It was also clear that solitary individuals were damaged more than individuals in groups. Groups of trees taller than 2 m appeared to be more effective in providing protection against frost. Smit (1990) attributed this 'protection' to heat radiated from the earth being reflected downwards by tree canopies. It is perhaps to be expected that almost all the frost-resistant species listed above are distributed farther into colder parts of South Africa than the frost-sensitive species listed.

On Kalahari sand in Hwange National Park in Zimbabwe, strongly species-specific reactions to unusually severe frost were found in a shrubby (height generally 1–2 m) savanna (Rushworth 1975). After frost of −14.4°C measured at ground level (compared to average annual minimum ground temperature of −3.3°C), many woody species experienced 100% (or very close to 100%) death of their main growing stem. These included *Acacia ataxacantha*, *Bauhinia macrantha*, *Burkea africana*, *Combretum collinum*, *C. zeyheri* and *Pterocarpus angolensis*. Data after a different, apparently less severe frost in this area indicated the last two mentioned species to be particularly susceptible to such frost. *A. fleckii*, *Terminalia sericea* and *Ochna pulchra* were remarkably resistant to even the more severe frost.

Individuals damaged by frost usually produced multiple coppice stems following the event.

4.4 Fire

The strong seasonality of rainfall in southern African savanna allows for plant material produced in the wet season to dry and be burned during the dry season. Fire has undoubtedly been an important factor in savanna ever since the ascension of the grass layer to dominance. Fire has long been regarded as a tool for directly influencing the woody plant components of savanna. As a management tool, a popular view is that in the moist savannas fire *per se* can be used to control bush encroachment, whereas in the arid savannas fire has the role of maintaining trees and shrubs at an available height and in an acceptable state for browsing animals (Trollope 1980).

Biomass burning is an important ecosystem process in southern Africa, also with significant implications for regional and global atmospheric chemistry and biogeochemical cycles. Fire is a significant source of trace gases and aerosols from savannas (Korontzi et al. 2003). The seasonal tropospheric ozone enhancement is a result of biomass burning (Scholes & Andreae 2000). At a local level, fire oxidizes organically bound elements in the vegetation and litter and releases them in forms available to plants. Elements that are not volatilised, are added to the soil, but such nutrient increases are usually limited to the surface layers of the soil and after an initial peak, concentration may decline rapidly (Frost & Robertson 1987). Nitrogen loss by fire in the KNP is replenished in burned areas, but the mechanisms by which this is achieved are unclear (Aranibar et al. 2003). In southern Africa, the main fuel is dry grass which burns with high efficiency and produces relatively low emissions of methane, carbon monoxide and aerosols per unit mass of fuel consumed (Scholes et al. 1996).

Studies show that the effect of fires on savanna plants can be highly variable. A study on the effects of fire on populations of *Sclerocarya birrea* in the lowveld showed that although the lower individuals (<2 m tall) were greatly affected by fire, density was unaffected (Jacobs & Biggs 2001). In savanna dominated by *Dichrostachys cinerea* and *Acacia gerrardii* in the Central Bushveld, height of trees less than 3 m was reduced due to severe topkill, but trees higher than 3 m were unaffected by the fire (Jordaan 1995). A very hot fire in *Acacia nigrescens*–*Combretum apiculatum* in eastern Botswana resulted in topkill of all plants below a height of 2 m and declining degrees of partial topkill with increasing heights (Sweet & Tacheba 1985). Almost all the plants that suffered complete above-ground kill exhibited basal coppice, as did many of those showing only partial topkill. In the Nylsvley Nature Reserve, mortality (total kill) of woody plants after fire was very low and where this occurred often involved plants lower than 25 cm tall (Rutherford 1981). *Grewia flavescens* has one of the highest fuel loads within the plant canopy and many plants are completely consumed by fire yet no mortality was found after fire. Mortality of *Ochna pulchra* was higher (5%) in a faster burn than in a slower burn (1%), where the latter type of fire allows for greater concentration of heat nearer the ground. *A. karroo* is hardly affected by back fires in the Eastern Cape despite the concentration of heat closer to the ground in contrast to that in head fires which cause significant topkill of trees up to a height of 3 m (Trollope 1984). Bond (1997) suggested that the occasional killing of large savanna trees through fire relates to the loss of the insulating properties of their bark.

Average shrub and tree mortality of only 1.3% has been quoted for 43 fires across a broad range of savanna areas in the KNP

(Shea et al. 1996). By contrast, in hyperarid savanna of the southwestern Kalahari, where fire occurs infrequently usually after periods of exceptionally high rainfall, a fire killed approximately one third of *Acacia erioloba* trees, with most extensive damage occurring amongst fully grown trees (Van der Walt & Le Riche 1984).

Fire does not necessarily affect production of the grass layer (Grossman et al. 1981). However, grass species may respond differently to fire. In the Nylsvley Nature Reserve, a long-term study indicated that fire resulted in a basal area reduction of *Eragrostis pallens*, an increase of *Heteropogon contortus*, but had no effect on *Digitaria eriantha* (Van Rooyen et al. 1993). Annual burning combined with the effect of fire on soil moisture availability keeps the individual grass plants small, leaving space for the colonisation of opportunistic species such as *Melinis repens*, *Schizachyrium jeffreysii*, *Pogonarthria squarrosa*, *Aristida mollissima* subsp. *argentea*, *A. stipitata* and *A. congesta* (Yeaton et al. 1988).

Exclusion of fire was found to lead to increased biomass of woody plants such as *Acacia nilotica* in the Hluhluwe Game Reserve (Skowno et al. 1999). The large increase in *Dichrostachys cinerea* in Hlane National Park, Swaziland, is due to restricted occurrence of fire (Roques 2004). Possibly related to this is that this park also has an unusual age structure of *A. nigrescens*—the only species above 6 m height in the area (Gertenbach & Potgieter 1978). Using a Dynamic Global Vegetation Model (DGVM), simulations suggest that most of the eastern half of South Africa could support much higher tree cover without fire (Bond et al. 2003b). Savanna in areas with a MAP below 650 mm showed a less compelling trend to woodiness.

The effects of fire on vegetation is very much a function of the behaviour and characteristics of the fire. The intensity and duration of the dry winter season and the frost period (where applicable) determine the degree of inflammability (Edwards 1984). Co-occurrence of independent episodic events, for example a severe late frost coinciding with a high grass fuel load, and followed by a dry summer can result in exceptionally intense fires as occurred in southern Africa in 1968/9 (Walker 1985). The degree of combustion of plant fuels is greater during back fires as compared to head fires (Trollope et al. 1996). However, behaviour of head fires may be more variable than that of back fires, with a greater range in fire intensity in the former (Trollope et al. 1996). Combustion efficiency in savanna was found to be mainly determined by the interaction between the standing grass and litter (see Ward et al. 1996). Fireline intensities and flame lengths were regarded as the best descriptors of the degree of topkill of savanna trees and shrubs (Van Wilgen & Willis 1988). Higher frequency fires on the drier soils in the shrub mopane areas of the KNP had a detrimental effect on the herbaceous vegetation (Gertenbach & Potgieter 1979).

Mean fire return period during wet phases was found to be less than for dry phases in the Hluhluwe-iMfolozi Park (Balfour & Howison 2001). There is a direct positive relationship between grass biomass and probability of fire (Van Wilgen et al. 2003). Lightning fires tend to start at the start of the wet season, during October and November, while anthropogenic fires are usually started during the dry season, between July and August. A long-term study in the *Colophospermum mopane*-dominated Mooiplaas area of the KNP showed that compared to the vegetation with the early-wet season fires, the mid-dry season fires yield a shorter, more scrubby and coppiced savanna (Kennedy & Potgieter 2003). This might be ascribed to fires that occur during the mid-dry season being likely to burn hotter than fires that occur in the early-wet season when the grass layer has

been dampened by the early spring rains, and when there is the possible presence of some new green growth.

Some plants avoid fire by being associated with generally fire-protected habitats in savanna. Examples of such habitats include rocky outcrops (*Cussonia natalensis*), termitaria (*Diospyros mespiliformis*, *Schotia brachypetala*, *Mimusops zeyheri*) and bush clumps (*Ehretia rigida*, *D. lycioides*; Frost 1985b).

Three candidate approaches to fire management have been put forward in the KNP: a lightning fire (letting nature take its course) approach; a patch mosaic burning approach which aims to establish a mosaic of vegetation structure types; and an approach based on the assessment of grass biomass and the species composition of the grass sward. Van Wilgen et al. (1998) compared the advantages and disadvantages of these approaches. A patch-mosaic system of burning is based on the premise that fire pattern is a surrogate for diversity, producing a range of patches in the landscape with unique patch characteristics and fire histories (Parr & Brockett 1999).

4.5 Vegetation-animal Interactions

4.5.1 Impact of Animals

The savannas of Africa are occupied by the earth's richest and most spectacular large mammal fauna. This fauna was even richer in the distant past and it is reasonable to expect that these large animals have long influenced the plants on which they feed and through them the form of the savannas (Cumming 1982, Sinclair 1983). The African Savanna Biome includes more extant ungulate species than any other continent (Du Toit 2003). However, even termites can be the main herbivore resulting in decline of plant cover in places of the lowveld with fairly dense cover of *Grewia bicolor* and *Dichrostachys cinerea* and a relatively low density of herbivores (Braack 1995). In the Nylsvley Nature Reserve, of the annual herbaceous layer production, grasshoppers were estimated to remove over a third of that utilised by all herbivore species (which included a herd of cattle) on the site (Gandar 1982). On occasion lepidopteral outbreaks and subsequent herbivory can result in trees having to replace up to 75% of their leaf biomass in a single season (Frost 1985a).

The dependence of animals on plants has many wide-ranging effects on the plants and vegetation in savanna. O'Connor (1996) reviewed the consequences of browsing of savanna woody plants by ungulates for their physiological functioning, growth, and demographic processes. Many effects are of a generalist nature, i.e. not discriminating between different plants within a given functional guild. Many other effects are species-specific, for instance the dependence of gall-forming insects on a very limited range of plant species in South African savanna (Veltman & McGeoch 2003). Grazers can be bulk grazers, that is, they do not exercise a high degree of selective grazing (for example buffalo and domestic cattle), or can be concentrate grazers which are generally small grazing animals (such as impala and domestic sheep), with very selective grazing (Trollope 1990). However, large herbivores can also avoid certain plants, e.g. *Combretum apiculatum* is not utilised by black rhino in the Ithala Game Reserve (Kotze & Zacharias 1993). Giraffe can have dramatically different effects within the same genus of tree in the Ithala Game Reserve (Bond & Loffell 2001). Populations of *Acacia davyi* have become extinct in areas accessible to giraffe following their introduction some 20 years earlier. By contrast, *A. tortilis* showed no or very low mortality attributable to giraffe browsing. Food preferences can change with season, as was found in the North-West Province. *Ziziphus mucronata* and *Peltophorum africanum* were important food

plants for giraffe during the wet season as opposed to *A. tortilis* and *C. hereroense* during the dry season (Sauer et al. 1977). There is a tendency to widen the dietary acceptance range as the overall abundance of favoured food species declines (Owen-Smith 1982). Domestic herbivores are less mobile than many wild species, impeding large-scale selectivity, and are kept at less variable and usually higher densities, preventing small-scale selectivity (Skarpe 1991a).

Elephant have the potential to literally shape African savannas. Savanna woodlands have been changed to wooded grasslands, bushed grasslands or even grasslands in many parts of eastern, central and southern Africa by the activities of elephant (Cumming 1982). Damage by elephants broadly takes three forms: the tearing of leaves and branches, the stripping of bark from the main stem, and the pushing over of an entire tree (Scholes et al. 2003). Elephants clearly affect woody plant population structures. This is dramatically visible, for example, where there are few large trees outside an elephant-proof enclosure in the KNP and a more even spread woody plant structure inside the enclosure without elephant (Trollope et al. 1998). Studies in savanna in western Zimbabwe show that tree species associated with sandy soils are less preferred by elephants than species on more fertile soils such as those associated with termite mounds (Holdo 2003). *Acacia nigrescens* is the tree species most affected by ringbarking by elephant in Hlane Royal National Park in Swaziland (Bowen 2004). In the northern KNP, ringbarking of *A. nigrescens* is more than twice as prevalent than pushing over these trees (Engelbrecht 1979). The pushing over of *A. nigrescens* trees is almost exclusively limited to young adult trees (with shallow root systems). Elephant impact on *Sclerocarya birrea* decreases with distance from roads, with the zone of high impact 10 m from roads and relatively low impact beyond 50 m from roads (Coetzee et al. 1979). Substantially higher impact also occurs along the boundaries of populations of *Sclerocarya birrea*. Utilisation is often highly selective, as for example in the Songimvelo Game Reserve near Barberton, where *Cussonia spicata* and *Pterocarpus angolensis*, despite being less common than other species present, are much selected by elephant (Steyn & Stalmans 2001). In the Sabi Sand Reserve, significantly higher levels of N, Na and Mg were found in the cambium of the species most regularly bark-stripped by elephant (Hiscocks 1999). Some species showed a high level of resilience to elephants, with one study indicating that all elephant-damaged trees survived in an area of the lowveld (Botha et al. 2002).

Using an experimental approach, Capon & O'Connor (1990) showed that predation of grass seed by ants and rodents in lowveld savanna was high and could potentially decimate the input of fresh seed. They suggest that predation is one of the major processes responsible for the well-recorded poor correlation between the abundance of certain perennial grasses (with large seeds) in the vegetation and their virtual absence from the seed bank.

There have been numerous studies in southern African savanna on the nature of the piosphere effect where animals trample and utilise vegetation in the vicinity of water points (Figure 9.8). Introduction of artificial water points in the arid Kalahari, where in earlier times there had only been a few natural water points, has been a concern for multiplying the number of areas of vegetation damaged around water points (Palmer & Van Rooyen 1998). Water points in the Kalahari create trampling gradients where a model indicates negligible recovery even after 100 years after withdrawal of cattle (Jeltsch et al. 1997a). There is an almost complete lack of woody plants in the vicinity of artificial watering points ('sacrifice area') on Satara basaltic soils with

a zone of high utilisation of woody vegetation extending far beyond this area (Brits et al. 2002). Impact around such dams can be species-specific with, for example, more annual grass species with increasing impact (Thrash et al. 1993). Amongst dominant woody plants *Combretum apiculatum* was more sensitive to these impacts than *Colophospermum mopane* (Thrash et al. 1991b), but the woody stratum as a whole was less sensitive to the effect of the dam than the basal cover of the herbaceous stratum (Thrash et al. 1991a). Based on a study on the Klaserie Nature Reserve, Parker & Witkowski (1999) found greater impact on herbaceous plants around seasonal water points than around perennial water points, suggesting preferential utilisation of ephemeral surface water by herbivores during the wet season. In the KNP, borehole closure led to an increase in the relative abundance of decreased grass species, suggesting that here the piosphere effects on herbaceous community composition may be reversible (Gaylard et al. 2003). Around water points in an area of SVk 4 Kimberley Thornveld near Barkly West, change in bare ground and vegetation height within the diminishing grazing gradient was discernible up to 75 m from the water point (Smet & Ward 2005). Abundance of *Schmidtia pappophoroides* increased from very low near the water point and stabilised at about 200 m from the water point. Up to 50 m from a goat kraal in the Thukela Valley, extensive browsing by Boer goats resulted in great mortality of the succulent *Aloe ferox*, with small plants being the most heavily utilised (Breebaart et al. 2002).

Different and complex impact gradients can occur around rural human settlements both as a combination of the effects of local domestic animal stock and use of other resources by people around the settlement. Around rural settlements in the lowveld, at distances up to 450 to 3 100 m from the periphery of the village, woody vegetation decreased (at different amounts according to species), but herbaceous cover increased (Shackleton et al. 1994). Wood is the primary domestic energy source in these settlements.

Grazing pressure elsewhere often has predictable results, but not always. The ratio of unpalatable to palatable grasses depends on the level of grazing pressure and whether this level has been increasing or decreasing (a hysteresis effect with a higher ratio if decreasing for the same given level of grazing pressure; Walker 1987). Shrub encroachment was found to occur in the southern

Kalahari by simulating cattle grazing beyond a threshold pressure under all rainfall scenarios (Jeltsch et al. 1997b, Weber et al. 1998). Low grazing pressure (33 ha lsu^{-1}) had no effect on shrub cover and distribution. But increasing the grazing pressure to 22 ha lsu^{-1} led to a continuous increase in shrub cover. Reduced grass competition, combined with some years of relatively high rainfall, favour shrub establishment. In arid Kalahari savanna, *Acacia mellifera* shows the greatest increase in response to overgrazing (Skarpe 1990). Woody species richness does not appear to be sensitive to different stocking rates by game and cattle as shown at a wide range of sites in Zimbabwean savannas (Richardson-Kageler 2003). In a lowveld herbaceous sward, the proportion of annuals was highest in communal cattle lands and the proportion of perennial species highest on commercial game farms (Parsons et al. 1997). Communal management appears to markedly reduce densities of most tree species (Shackleton 1993).

4.5.2 Plant Response Types and Features

Savanna woody plants have a range of deterrents to browsing. Secondary compounds can be digestibility-reducing, mostly tannins, or contain toxic substances which interfere directly with the physiology of the consumer (e.g. alkaloids, amines; Owen-Smith 1982). Sensitivity can vary according to animal type. For example, in *Burkea* savanna, cattle are susceptible to monofluoroacetate poisoning from ingestion of the leaves of *Dichapetalum cymosum* in spring, but wild ungulates seem unaffected (Owen-Smith 1982). Structural repellents such as thorns, spines or twiggy growth form, usually found in plants with highly nutritious foliage, do not prevent feeding on such plants by browsers such as kudu and giraffe, but could affect relative preferences through their influence on bite sizes and biting rates (Owen-Smith 1982). *Acacia mellifera*, with its strong hook thorns, is a preferred food species by black rhinoceros who bite off shoots up to a thickness of 10 mm, with thorns appearing in the dung (Joubert & Eloff 1971). Also kudu, under dry season conditions of food shortage, have been observed eating thorny *Acacia* twig ends (Owen-Smith 1985). Grasses have also evolved grazing deterrents (Stuart-Hill & Mentis 1982). Chemical protection is found in such species as *Bothriochloa insculpta* and *Elionurus muticus*. Physical protection is conferred, for example in *Aristida junciformis*, by the high breaking tension of its leaves which makes it difficult for herbivores to break off the leaves. *Setaria sphacelata* has hairy leaves which collect dust, rendering them unacceptable to the animal.

As with their response to fire, many savanna plants recover well after removal of plant material (without the heat of fire) and appear to occupy a long-lasting persistence niche. A wide range of woody plants of savannas exhibit a strong coppicing ability following cutting (Shackleton 2000a, Smit 2003a). The longevity of savanna tree species explains the lag between heavy utilisation and species loss (Higgins et al. 1999). It has also been found in the Bushbuckridge part of the lowveld that the taller the potential height of a species, the fewer were the coppice shoots per stump surface area (Shackleton 2000a). *Acacia tortilis* trees in the Central Bushveld were tolerant of damage and continued



L. Mucina

Figure 9.8 The piosphere effect around a drinking hole (Kumana Dam, north of Tshokwane) in the Kruger National Park. The piosphere extends well beyond the visibly impacted terrain nearest the water.

to increase in size even when all the current season's shoots were removed (Milton 1988). Coppicing of *Colophospermum mopane* trees from the main stem ('hedging') when broken by elephant, provides these animals with an increased availability of preferred size range of branches of this preferred food species (Smallie & O'Connor 2000). Productivity of woody plants and browse production are reviewed by Smit et al. (1996) and are not repeated here. Many grasses are tolerant of grazing, for instance through tillering. Tillering after removal of the apex of the parent tiller stimulates profuse vegetative reproduction, for example in *Themeda triandra* (Stuart-Hill & Mentis 1982).

Plant species have been classified according to their response to grazing which is in turn used to determine a veld condition score for veld condition assessment. The classification results in various forms of increaser and decreaser plant species. We look at an example of one such classification system. Van Rooyen et al. (1991) recognise five response types with examples from southern Kalahari savanna. (1) Species characteristic of under-utilised veld which decrease in frequency along the grazing gradient. These are usually absent from veld that is moderately to over-grazed (Decreaser species). An example is *Aristida meridionalis*. (2) Species rare or low in frequency in under-utilised veld, but which increase when the veld is lightly grazed. Moderate to heavy grazing decreases their numbers (Intermediate 1 species). An example is *Centropodia glauca*. (3) Species that rarely occur in lightly grazed veld but that increase in frequency when the veld is moderately or selectively grazed (Intermediate 2 species). An example is *Stipagrostis amabilis*. (4) Species that are rare in light to moderately grazed veld but that increase when the veld is fairly heavily grazed (Increaser species). An example is *Schmidtia kalahariensis*. (5) Species that are absent in lightly grazed veld but that become dominant in severely overgrazed veld (Encroacher species). An example is *Chamaesyce inaequilatera*. Van Rooyen et al. (1991) provide useful graphical representations of these five categories with many examples. The concept of decreaser and increaser plant categories has been applied in many other savanna areas (e.g. indicator species for Nylsvley Nature Reserve; Dörgeleh 1999a), also being related to preferred grazing areas (Wentzel et al. 1991).

There are of course also clear-cut benefits of animals to plants. The dependence of plants on animals includes pollinators. For instance in the KNP, honey bees are regarded as key pollinators without which many plant species would be dramatically reduced in abundance and distribution, if not become extinct (Braack & Kryger 2003). In contrast, fig wasps have an extraordinarily narrow and interdependent relationship with fig species (Naiman et al. 2003). Even giraffe are regarded as a pollinator of *Acacia nigrescens* potentially effective through a home range of more than 250 km² (Naiman et al. 2003). Dispersal of seeds of some species is effected by birds (Naiman et al. 2003). Mistletoes have a close relationship with birds, depending on them for pollination and for dispersal to suitable establishment sites on host trees (Kemp et al. 2003). Although the floras of the Kalahari savanna are considered to be mainly wind-dispersed, endozoochory is a primary or secondary dispersal mechanism in many plants (Milton & Dean 2001).

4.6 Management

Various tools have been developed to manage savanna, including a decision analysis approach (Norton & Walker 1985), range condition and grazing capacity assessment models (Steenekamp & Bosch 1995), and many others. To various degrees, these tools take into account the relations between trees and grass, tree and tree, animal and plant, and other issues described in the previous sections. However, they usually must add eco-

nomic and logistical factors for practical application. There is also a bid to account for farming with game in developing these tools. There has been a great increase in game farming in South Africa in recent years following the earlier debates about the extent to which the increase in grass growth after bush clearing offsets the loss in edible and available browse (Walker 1976). Less commonly incorporated as an integrative tool are restoration interventions. Smit (2004) advocates that any restoration programme in savanna (chemical, mechanical or biological) of areas encroached by woody plants should focus on tree thinning rather than on clearing of all woody plants (but see Scholes 2003, section 4.2). It is important to achieve a balanced compromise between the reduction of the competitive effect of the trees on the herbaceous layer and the preservation of the positive influences that the trees may have, but there are divergent views on how to achieve this.

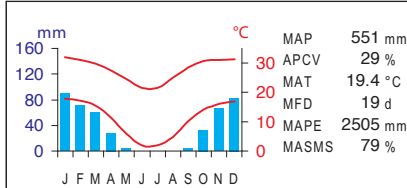
Barnes (1982) summarised various management options for utilisation of savanna in southern Africa for maximising animal production. These include intensifying secondary production through modification of the ecosystem so as to ensure the presence of the most desirable plants, and to create, within the limitations of the local environment, optimal conditions for plant growth. This includes the manipulation of the herbivore population for more efficient utilisation of the vegetation. Matching the animal population and the food supply includes consideration of multispecies herbivore populations or mixing domestic and wild ungulates. Introduction of selected pasture legumes in the herbaceous layer (as opposed to application of fertiliser) is likely to be successful only in higher-rainfall areas of savanna and is obviously one of the management options least compatible with nature conservation objectives. Control of animal distribution and management of grazing involves matters such as drinking water supplies, the feeding of supplements, and consideration of grazing management systems, including rotational grazing. Hadley (1985) gave an overview of resource management in savanna environments, including social perspectives. For further discussion of management issues, often on a biome basis, see extensive contributions by Tainton (1999).

In a situation very different from that of wishing to maximise animal production, the KNP has relatively recently adopted a system of adaptive ecosystem management (Strategic Adaptive Management; Biggs & Rogers 2003). This system embraces spatiotemporal heterogeneity and includes the concept of Thresholds of Potential Concern (TPCs), a set of operational goals that together define the spatiotemporal heterogeneity conditions for which the KNP ecosystem is managed. TPCs are defined as upper and lower levels along a continuum of change in selected environmental indicators. When this level is reached, or is predicted will be reached, it prompts an assessment of the causes of the change and forms a basis for deciding whether management action is needed to moderate the change. Policy has also recently shifted towards burning under diverse rather than fixed conditions (Van Wilgen et al. 2003). Patch mosaic burning is the current view as opposed to the previous quasi-agricultural block burning in KNP (Biggs 2003). Elephants with their possible ultimate 'major simplification of habitats' make management of elephant numbers a major topic of debate in wildlife systems (Whyte et al. 2003).

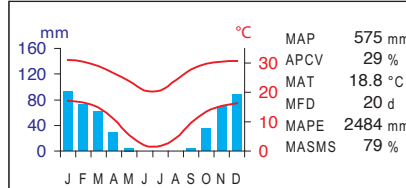
5. Conservation

There has been a substantial loss of savanna area due to cultivation, more so than other transformational land use practices. Most of the agricultural expansion took place before the 1960s, especially in the wetter eastern parts of the country (Biggs & Scholes 2002). Impacts have been analysed by various sources

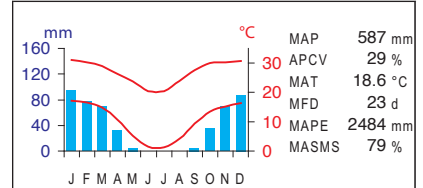
SVcb 1 Dwaalboom Thornveld



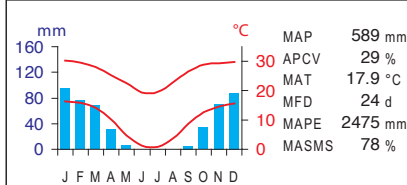
SVcb 2 Madikwe Dolomite Bushveld



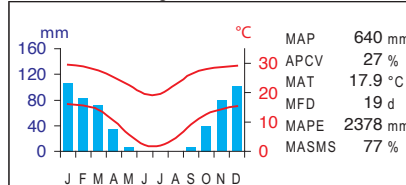
SVcb 3 Zeerust Thornveld



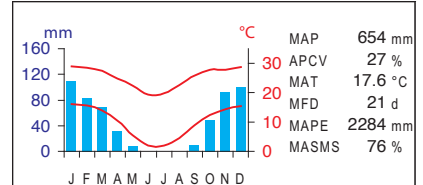
SVcb 4 Dwarsberg-Swartruggens Mountain Bushveld



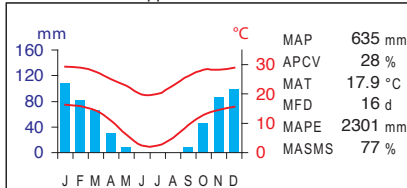
SVcb 5 Pilanesberg Mountain Bushveld



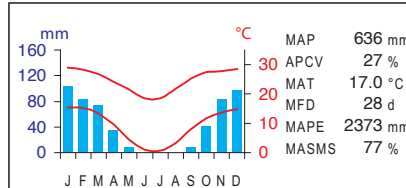
SVcb 6 Marikana Thornveld



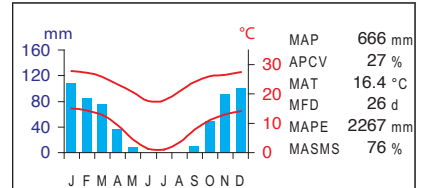
SVcb 7 Norite Koppies Bushveld



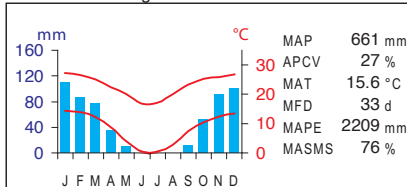
SVcb 8 Moot Plains Bushveld



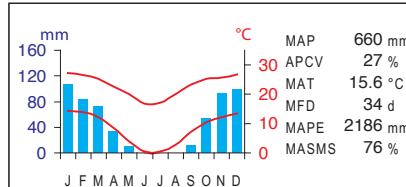
SVcb 9 Gold Reef Mountain Bushveld



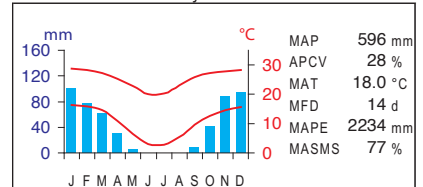
SVcb 10 Gauteng Shale Mountain Bushveld



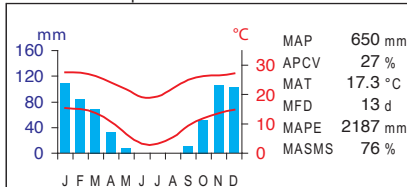
SVcb 11 Andesite Mountain Bushveld



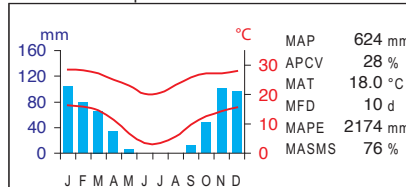
SVcb 12 Central Sandy Bushveld



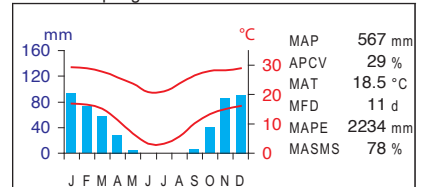
SVcb 13 Loskop Mountain Bushveld



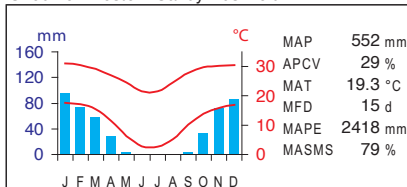
SVcb 14 Loskop Thornveld



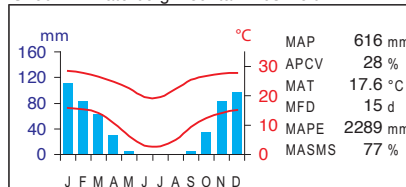
SVcb 15 Springbokvlakte Thornveld



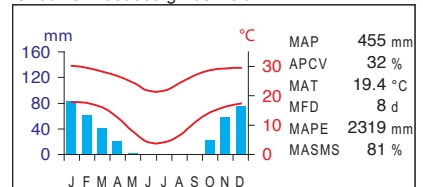
SVcb 16 Western Sandy Bushveld



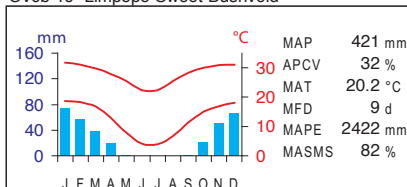
SVcb 17 Waterberg Mountain Bushveld



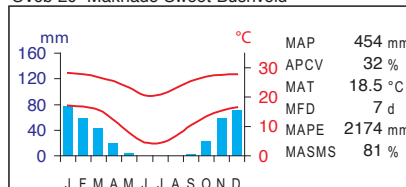
SVcb 18 Roodeberg Bushveld



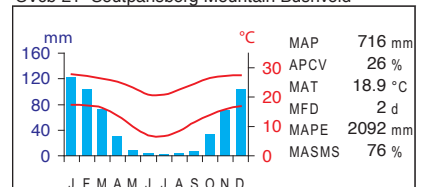
SVcb 19 Limpopo Sweet Bushveld



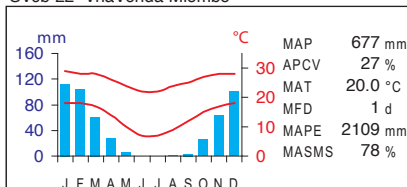
SVcb 20 Makhado Sweet Bushveld



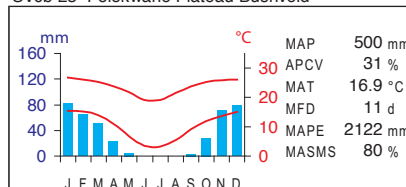
SVcb 21 Soutpansberg Mountain Bushveld



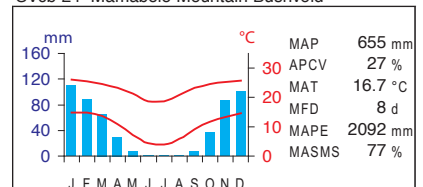
SVcb 22 VhaVenda Miombo



SVcb 23 Polokwane Plateau Bushveld



SVcb 24 Mamabolo Mountain Bushveld



that include the savanna areas (e.g. Thompson et al. 2001). Many aspects relating to conservation in savanna are expanded upon by Huntley (1989) and by Rebelo (1997), and it is clear that substantial progress has been made (also more recently) since the consideration of the state of nature conservation in southern Africa at a meeting held in Skukuza in 1976 (De Graaff & Van der Walt 1977).

Wessels et al. (2003) identified potential conflict areas between land transformation and biodiversity conservation in the north-eastern part of South Africa. This transformation deals with the change from natural vegetation to other land uses, such as crop cultivation and urban development. The analysis included the Lowveld and Mopane Savannas as well as most of the Central Bushveld and Sub-Escarpment Savannas. Potential future agricultural conflict areas include the Waterberg–Dwaalboom–Thabazimbi area where particularly within the valleys of the Waterberg (northern part of SVcb 12 Central Sandy Bushveld) there could be a threat to a unique area of significant conservation importance.

Climate change has been predicted to reduce the area of the Grassland Biome at the cost of expanding savanna vegetation in the northern and eastern sectors (Ellery et al. 1991). Three climate change scenarios (developed from GCMs and modelling a doubling of atmospheric CO₂ concentration) applied to South Africa (Rutherford et al. 1999a) indicated that the Savanna Biome might be less severely impacted than some other biomes further west. Kalahari is possibly the most vulnerable area. Individual species are likely to respond differently and it is possible that *Colophospermum mopane* might expand southwards in the lowveld into newly climatically suitable areas under projected climate change. Rutherford et al. (1999b) assigned the relative vulnerability of individual plant species of two national parks in the Savanna Biome to climate change. The number of species at risk of extinction in the Kgalagadi Transfrontier Park was marginally greater than that in the Vaalbos National Park.

Many plant species are specifically targeted by local communities for a wide range of uses not only for human application, but also for applying to livestock. For example, in a communal area in northern KwaZulu-Natal, farmers use *Cissus quadrangularis* for treating worm infestations and coughs, and *Sarcostemma viminale* for increasing milk production in their livestock (Kunene et al. 2003). Less abundant targeted species are obviously at risk of local extinction with sustained pressure of utilisation.

Alien plant species continue to pose a threat to areas of savanna although in areas such as the KNP (outside riverine habitats)

this is sometimes localised, for instance along road verges (Freitag-Ronaldson & Foxcroft 2003). Indigenous woodland in the Kalahari has been found to support a significantly higher diversity of bird species than areas invaded by alien *Prosopis* species (Dean et al. 2002), confirming the conservational need for control of alien species. Threats are usually relative and can (sometimes correctly) divert resources for remedial action. In the Hluhluwe-iMfolozi Park in KwaZulu-Natal, the savanna was reported as less threatened than the adjacent riverine and forest-edge habitats (Macdonald 1983).

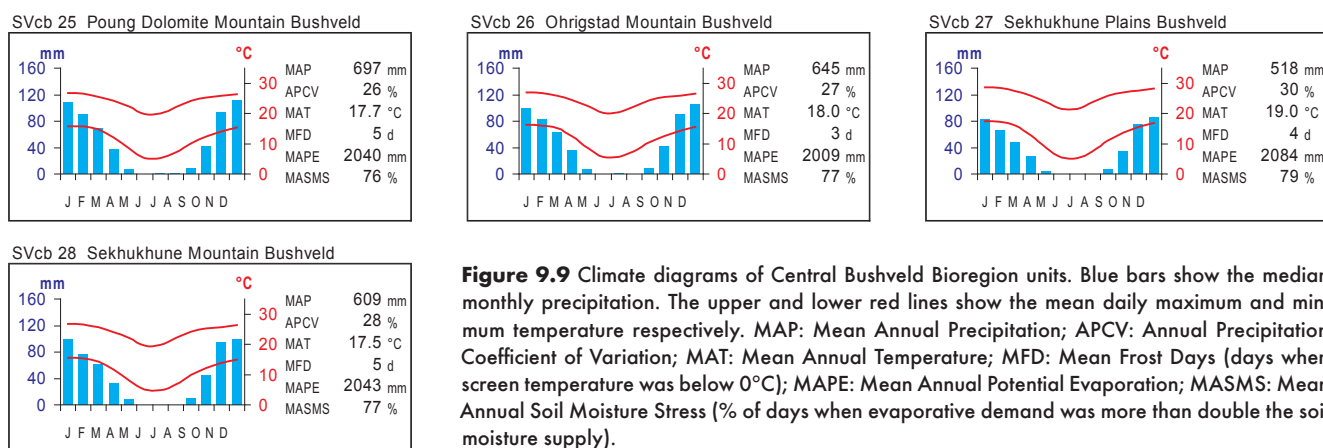
Research has included studies that point to specific actions, for example showing that cleared patches covered with grass litter experience the greatest colonisation of grasses (O'Connor 1991). More such explicit results are needed for rehabilitation programmes. But overall, there is a need to reach conservation goals more quickly to minimise losses in biodiversity (Reyers 2004).

For further information relating to conservation in savanna, see the chapters on Ecosystem Status and on Vulnerability of Vegetation Types in this book.

6. Further Research

Although there have been several earlier regional floristic accounts of savanna vegetation (e.g. Van der Schijff 1971, Van der Meulen 1978, Van der Meulen & Westfall 1979) and numerous more detailed surveys given in the references to the descriptions of each vegetation unit, the coverage is still very incomplete. Analysis of diversity patterns is, surprisingly, still in its infancy in savanna. Studies on demography of African savanna grasses are scant (O'Connor 1994), as for other savanna plant forms. Investigation of the full implications of the persistence niche of woody plants in savanna has barely started. We still have no idea of the true age structures of populations of such plants as opposed to the potentially misleading analyses of age (actually size) distributions based on above-ground plant parts only. A comprehensive model that explains both coexistence and the relative productivity of the tree and grass components across the diverse savannas of the world has yet to emerge (Sankaran et al. 2004).

As with many endeavours within the natural sciences, there is a clear need to integrate social and economic spheres into our current biophysical thinking (Biggs 2003) to ensure viable and sustainable systems of biodiversity and their associated ecosystem services in savannas.



7. Descriptions of Vegetation Units

Central Bushveld

SVcb 1 Dwaalboom Thornveld

VT 13 Other Turf Thornveld (58%) (Acocks 1953). LR 14 Clay Thorn Bushveld (48%), LR 18 Mixed Bushveld (43%) (Low & Rebelo 1996).

Distribution Limpopo and North-West Provinces: Flats north of the Dwarsberge and associated ridges mainly west of the Crocodile River in the Dwaalboom area but including a patch around Sentrum. South of the ridges it extends eastwards from the Nietverdiend area, north of the Pilanesberg to the Northam area. Altitude 900–1 200 m.

Vegetation & Landscape Features Plains with layer of scattered, low to medium high, deciduous microphyllous trees and shrubs with a few broad-leaved tree species, and an almost continuous herbaceous layer dominated by grass species. *Acacia tortilis* and *A. nilotica* dominate on the medium clays (at least 21% clay in the upper soil horizon but high in the lower horizons; Figure 9.10). On particularly heavy clays (>55% clay in all horizons) most other woody plants are excluded and the diminutive *A. tenuispina* dominates at a height of less than 1 m above ground (Figure 9.5). On the sandy clay loam soils (with not more than 35% clay in the upper horizon but high in the lower horizons) *A. erubescens* is the most prominent tree (Pauw 1988; Figure 9.6). The alternation of these substrate types creates a mosaic of patches typically 1–5 km across, for example in the unit west of Thabazimbi.

Geology & Soils Vertic black ultramafic clays which developed from norite and gabbro, also locally in small depressions along streams. Some areas have less clay. Some with high base status and eutrophic red soils. Underlying geology is an Archaean granite-gneiss terrane of the Swazian Erathem that is covered in parts by the mainly clastic as well as chemical sediments and volcanics of the Rayton and Silverton Formation, both of the Pretoria Group (Transvaal Supergroup). Mafic intrusive rocks of the Rustenburg Layered Suite, Bushveld Igneous Complex (Late Vaalian) are present in the east and include the Bierkraal Manetite Gabbro. Bronzite, harzburgite, norite and anorthosite

are the major mafic rocks of the Rustenburg Suite. Land types mainly Ea and Ae.

Climate Summer rainfall with very dry winters. MAP ranges from about 500–600 mm. This unit has the highest mean annual potential evaporation of savanna vegetation units outside the two Kalahari bioregions. Frost is fairly frequent in winter. See also climate diagram for SVcb 1 Dwaalboom Thornveld.

Important Taxa Tall Tree: *Acacia erioloba*. Small Trees: *Acacia erubescens* (d), *A. nilotica* (d), *A. tortilis* subsp. *heteracantha* (d), *A. fleckii*, *A. mellifera* subsp. *detinens*, *Combretum imberbe*, *Rhus lancea*, *Ziziphus mucronata*. Tall Shrubs: *Acacia hebeclada* subsp. *hebeclada*, *Combretum hereroense*, *Diospyros lycioides* subsp. *lycioides*, *Euclea undulata*, *Grewia flava*, *Tarchonanthus camphoratus*. Low Shrubs: *Acacia tenuispina* (d), *Abutilon austro-africanum*, *Aptosimum elongatum*, *Hirpicium bechuanaense*, *Pavonia burchellii*, *Solanum delagoense*. Succulent Shrubs: *Kalanchoe rotundifolia*, *Talinum caffrum*. Herbaceous Climber: *Rhynchosia minima*. Graminoids: *Aristida bipartita* (d), *Bothriochloa insculpta* (d), *Digitaria eriantha* subsp. *eriantha* (d), *Ischaemum afrum* (d), *Panicum maximum* (d), *Cymbopogon pospischilii*, *Eragrostis curvula*, *Sehima galpinii*, *Setaria incrassata*. Herbs: *Heliotropium ciliatum*, *Kohautia caespitosa* subsp. *brachyloba*, *Nidorella hottentotica*.

Conservation Least threatened. Target 19%. Some 6% statutorily conserved, mostly within the Madikwe Game Reserve in the west. About 14% transformed mainly by cultivation. Erosion is very low to low. Main use is extensive cattle grazing.

Remarks Contains some very clayey soils that swell when wet and shrink when dry. On the clays, woody plant biomass is generally low and productivity of woody plants is usually lower than that of herbaceous plants. These areas with ultramafic soils are, contrary to Sekhukhuneland, low in species diversity and in endemic species.

References Coetzee (1971), Morris (1972), Van der Meulen (1979), Van der Meulen & Westfall (1980), Pauw (1988), Rutherford (1993), Winterbach (1998).

SVcb 2 Madikwe Dolomite Bushveld

VT 18 Mixed Bushveld (36%), VT 19 Sourish Mixed Bushveld (27%) (Acocks 1953). LR 18 Mixed Bushveld (78%) (Low & Rebelo 1996).

Distribution North-West and Limpopo Provinces: Extends along the low ridge from the international border at Ramotswa in the west via the Rand Van Tweede Poort, Tlhapitse and Maakane to Modimong in the east. It is also found on dolomite hills between Assen and Northam. Altitude 1 000–1 300 m.

Vegetation & Landscape Features Gentle ridges and low hills up to about 100–150 m above the surrounding plains. Tree and shrub layers often not clearly distinct, especially on steeper slopes; they are dominated by deciduous trees, particularly *Combretum apiculatum* and *Kirkia wilmsii* (especially in the east). Herbaceous layer continuous, dominated by grasses.

Geology & Soils Stony, shallow soils of the Glenrosa and Mispah forms underlain mainly by dolomite, subordinate chert, minor carbonaceous shale, lime-

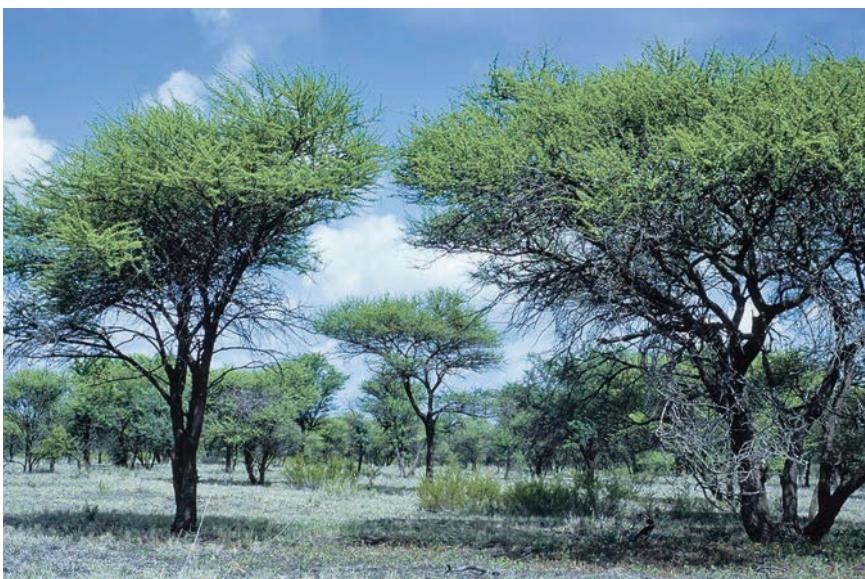


Figure 9.10 SVcb 1 Dwaalboom Thornveld: *Acacia tortilis* trees and *Acacia tenuispina* low shrubs on medium clay soil, Steendal west-northwest of Dwaalboom, Limpopo Province.



Figure 9.11 SVcb 2 Madikwe Dolomite Bushveld: Tall *Combretum imberbe* and *Sclerocarya birrea* trees and smaller trees and shrubs of *C. apiculatum* on the Farm Abjaterskop with the vegetation type extending over the hill of Abjaterskop in the northern Marico District.

stone and quartzite of the Malmani Subgroup (Chuniespoort Group, Transvaal Supergroup, Vaalian Erathem). Land type is mainly Fa.

Climate Summer rainfall with very dry winters. MAP from about 520 mm in the west to 650 mm in the east. Frost fairly frequent in winter. See also climate diagram for SVcb 2 Madikwe Dolomite Bushveld.

Important Taxa Tall Tree: *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Combretum apiculatum* (d), *Kirkia wilmsii* (d), *Ozoroa paniculosa* (d), *Rhus lancea* (d), *Combretum imberbe*, *Rhus leptodictya*, *Ximenia americana*, *Ziziphus mucronata*. Tall Shrubs: *Grewia flava* (d), *Tarchonanthus camphoratus* (d), *Vitex zeyheri* (d), *Clerodendrum glabrum*, *Grewia bicolor*, *G. monticola*. Graminoids: *Enneapogon scoparius* (d), *Heteropogon contortus* (d), *Aristida congesta*, *Panicum coloratum*, *P. maximum*.

Conservation Least threatened. Target 19%. Some 17% statutorily conserved in the Madikwe Nature Reserve. Only 1% transformed mostly by cultivation. Erosion is low to very low.

Remarks Some species distributions are associated with the east-west climatic gradient, for example *Kirkia wilmsii* is restricted to the eastern parts of the unit. In contrast to bush encroachment seen on the red clay loams surrounding this unit, the rocky soils of dolomitic origin support a more open canopy structure (Hudak & Wessman 2001).

References Zacharias (1994), Hudak & Wessman (2001).

SVcb 3 Zeerust Thornveld

VT 19 Sourish Mixed Bushveld (56%) (Acocks 1953). LR 18 Mixed Bushveld (55%) (Low & Rebelo 1996).

Distribution North-West Province: Extends along the plains from the Lobatsi River in the west via Zeerust, Groot Marico and Mabaalstad to the



Figure 9.12 SVcb 3 Zeerust Thornveld: Moderately dense bushveld dominated by *Acacia tortilis* in the valley of the Doring River on Rykvoorby north of Zeerust, North-West Province.

flats between the Pilanesberg and western end of the Magaliesberg in the east (including the valley of the lower Selons River). Altitude mainly 1 000–1 250 m.

Vegetation & Landscape Features

Deciduous, open to dense short thorny woodland, dominated by *Acacia* species with herbaceous layer of mainly grasses on deep, high base-status and some clay soils on plains and lowlands, also between rocky ridges of SVcb 4 Dwarsberg-Swartruggens Mountain Bushveld.

Geology & Soils Sediments of the Pretoria Group (Transvaal Supergroup) in this area, particularly the Silverton and Rayton Formations, are mostly shale with less quartzite and conglomerate. Carbonates, volcanic rocks, breccias and diamictites also occur in the Pretoria Group. Bronzite, harzburgite, gabbro and norite of the Rustenburg Layered Suite (Bushveld Igneous Complex) are also found. Soils are mostly deep, red-yellow, apedal, freely drained with high base status also with some vertic or melanitic clays. Land types mainly Ae and Ea.

Climate Summer rainfall with very dry winters. MAP has a relatively narrow range: 550–600 mm. Frost fairly frequent in winter. Mean monthly maximum and minimum temperatures for Marico-Irr weather station 36.7°C and –0.4°C for January and June, respectively. See also climate diagram for SVcb 3 Zeerust Thornveld.

Important Taxa Tall Trees: *Acacia burkei* (d), *A. erioloba* (d). Small Trees: *Acacia mellifera* subsp. *detinens* (d), *A. nilotica* (d), *A. tortilis* subsp. *heteracantha* (d), *Rhus lancea* (d), *Acacia fleckii*, *Peltophorum africanum*, *Terminalia sericea*. Tall Shrubs: *Diospyros lycioides* subsp. *lycioides*, *Grewia flava*, *Myroxylon aethiopicum* subsp. *burkeanum*. Low Shrubs: *Agathisanthemum bojeri*, *Chaetacanthus costatus*, *Clerodendrum ternatum*, *Indigofera filipes*, *Rhus grandidens*, *Sida chrysantha*, *Stylosanthes fruticosa*. Graminoids: *Eragrostis lehmanniana* (d), *Panicum maximum* (d), *Aristida congesta*, *Cymbopogon pospischilii*. Herbs: *Blepharis*

integrifolia, *Chamaecrista absus*, *C. mimosoides*, *Cleome maculata*, *Dicoma anomala*, *Kyphocarpa angustifolia*, *Limeum viscosum*, *Lophiocarpus tenuissimus*.

Endemic Taxon Low Shrub: *Rhus maricoana*.

Conservation Least threatened. Target 19%. Less than 4% statutorily conserved, spread between four reserves including the Pienaar and Marico Bushveld Nature Reserves. Some 16% transformed mainly by cultivation, with some urban or built-up. A few areas with scattered plants of the alien *Cereus jamacaru* and several other alien species very scattered elsewhere. Erosion is mainly very low to low.

Remark This unit is somewhat more temperate than the SVcb 1 Dwaalboom Thornveld that borders it to the north.

References Van Wyk (1959), Van der Meulen (1979), Van der Meulen & Westfall (1980), Malan & Van Niekerk (2005).

SVcb 4 Dwarsberg-Swartruggens Mountain Bushveld

VT 19 Sourish Mixed Bushveld (80%) (Acocks 1953). LR 18 Mixed Bushveld (87%) (Low & Rebelo 1996).

Distribution North-West Province: Occurs on hills and ridges east of the Lobatsi River through the Zeerust and the Swartruggens areas to Mabeskraal and the Selons River Valley in the east. Also occurs on the parallel ridges of the Dwarsberge from Witkleigat in the west to the hills of the Dwarsberg area in the east. Altitude about 1 000–1 500 m.

Vegetation & Landscape Features Rocky low to medium high hills and ridges with some steep faces in places. Height above the surrounding plains can reach about 300 m. Variable vegetation structure depending on slope, exposure, aspect and local habitat—various combinations of tree and shrub layers often with dense grass layer. Bush clumps also occur.

Geology & Soils Shales, quartzites and andesites of the Pretoria Group (Transvaal Supergroup) with stony shallow soils of the Glenrosa and Mispah soil forms, with some deep, freely drained soils. Land types mainly Fb, Ib and Ae.

Climate Summer rainfall with very dry winters. MAP from about 550–650 mm. Frost fairly frequent in winter in lower-lying areas, less so on the hills. Mean monthly maximum and minimum temperatures for Lindleyspoort-Irr weather station 35.2°C and –0.4°C for January and June, respectively. See also climate diagram for SVcb 4 Dwarsberg-Swartruggens Mountain Bushveld.

Important Taxa Tall Tree: *Acacia robusta* (d). Small Trees: *Acacia caffra* (d), *A. erubescens* (d), *Burkea africana* (d), *Combretum apiculatum* (d), *Faurea saligna* (d), *Protea caffra* (d), *Combretum imberbe*, *C. molle*, *Cussonia paniculata*, *C. transvaalensis*, *Dombeya rotundifolia*, *Ozoroa paniculosa*, *Pappea capensis*, *Peltophorum africanum*, *Spirostachys africana*, *Vangueria infausta*, *Ziziphus mucronata*. Succulent Tree: *Aloe marlothii* subsp. *marlothii* (d). Tall Shrubs: *Dichrostachys cinerea* (d), *Croton pseudopulchellus*, *Ehretia rigida* subsp. *rigida*, *Grewia flava*, *Mundulea sericea*, *Tarchonanthus camphoratus*, *Vitex zeyheri*. Low Shrubs: *Athrixia elata*, *Pavonia burchellii*, *Rhus magalismontana* subsp. *magalismontana*, *R. rigida* var. *rigida*. Woody Climber: *Asparagus africanus*. Graminoids: *Aristida canescens* (d), *Cenchrus ciliaris* (d), *Chrysopogon serrulatus* (d), *Digitaria eriantha* subsp. *eriantha* (d), *Enneapogon scoparius* (d), *Loudetia simplex* (d), *Schizachyrium sanguineum* (d), *Setaria lindenberghiana* (d), *Bewisia biflora*, *Bothriochloa insculpta*, *Cymbopogon caesius*, *C. pospischilii*, *Elionurus muticus*, *Eragrostis rigidior*, *Fingerhuthia africana*, *Heteropogon contortus*, *Melinis nerviglumis*, *Panicum maximum*, *Setaria sphacelata*, *Themeda triandra*, *Trachypogon spicatus*, *Tristachya biseriata*. Herbs: *Barleria macrostegia*, *Commelina africana*, *Hermannia depressa*, *Senecio venosus*. Geophytic Herbs: *Hypoxis hemerocallidea*, *Pellaea calomelanos*, *Tritonia nelsonii*.

Biogeographically Important Taxon (Central Bushveld endemic) Tall Shrub: *Erythrophysa transvaalensis*.

Endemic Taxon Succulent Shrub: *Euphorbia perangusta*.

Conservation Least threatened. Target 24%. Less than 2% statutorily conserved, mainly in the Marico Bushveld Nature Reserve. Some 7% transformed, mainly by cultivation. Aliens include scattered *Cereus jamacaru* and *Acacia mearnsii* in few areas. Erosion is mainly very low to low.

Remarks This vegetation has some similarities with the SVcb 9 Gold Reef Mountain Bushveld to the east but is drier and warmer than this unit. The unit extends into Botswana, for example on the hills around Lobatse.

References Van der Meulen (1979), Zacharias (1994), Bredenkamp (1999).

SVcb 5 Pilanesberg Mountain Bushveld

VT 20 Sour Bushveld (83%) (Acocks 1953). LR 18 Mixed Bushveld (100%) (Low & Rebelo 1996).

Distribution North-West Province: Hills and mountains immediately north of Sun City and west of Heystekrand (Mankwe District). Altitude about 1 100–1 500 m.

Vegetation & Landscape Features A near circular (diameter 23–27 km) complex constituting an intrusive and extrusive massif with the original volcanic caldera almost eroded away leaving a broken ring of hills and low mountains as



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Figure 9.13 SVcb 4 Dwarsberg-Swartruggens Mountain Bushveld: Northwestern slopes with *Vangueria infausta*, *Dombeya rotundifolia*, *Acacia caffra* and *Rhus* species in the foreground, on Sephton's Nek, north of Zeerust.



Figure 9.14 SVcb 5 Pilanesberg Mountain Bushveld: Bushveld with *Combretum molle* on south-facing slopes above Mankwe Dam in the centre of the Pilanesberg Game Reserve.

well as the eroded intrusions of the core remaining in the form of many hills and low mountains. Valley floors between the hills and mountains tend to be at most 1–2 km wide. Broad-leaved deciduous bushveld with trees and shrubs with grass layer on slopes of mountains and hills, with mountain summits more grassy and valley floors sometimes less woody but the latter may be related to past disturbance (see section on Conservation below).

Geology & Soils The alkaline complex consists of potassium- and sodium-rich, silica-poor rocks, mainly foyaite, lava and tuff with some syenite. Wide range of elements found, particularly rare earth elements and fluorine in the form of CaF_2 (flourite). Due to the original volcanic actions, subsequent fracturing, emplacement of intrusions, collapse and resurgence of magma and radial emplacement of dykes, a complex geological pattern exists. Pilanesberg is one of the very few large alkaline ring complexes in the world, approximately 1.3 gya old. Soils are shallow, rocky lithosols on the hills and mountains of the Glenrosa and Mispah soil forms, but with deeper soils on the valley floors. Land type is mostly Ib.

Climate Summer rainfall with very dry winters. MAP from about 600–700 mm. Frost fairly frequent in winter in lower-lying areas, less so on the hills. Mean monthly maximum and minimum temperatures for Manyane Gate (eastern entrance to Pilanesberg Game Reserve) 36.7°C and –2.2°C for February and July, respectively. See also climate diagram for SVcb 5 Pilanesberg Mountain Bushveld.

Important Taxa Small Trees: *Combretum apiculatum* (d), *C. molle* (d), *C. zeyheri* (d), *Strychnos cocculoides* (d), *Croton gratissimus*, *Englerophytum magalismsontanum*, *Rhus leptodictya*, *Vangueria parvifolia*. Tall Shrubs: *Diplorhynchus condylocarpon* (d), *Elephantorrhiza burkei* (d), *Grewia flava*, *Hibiscus calyphyllus*, *Mundulea sericea*, *Steganotaenia araliacea*, *Vitex rehmannii*. Low Shrub: *Polygala hottentotta*. Graminoids: *Chrysopogon serrulatus* (d), *Elionurus muticus* (d), *Panicum maximum* (d), *Themeda triandra* (d), *Enneapogon scoparius*, *Hyperthelia dissoluta*, *Panicum deustum*. Herbs: *Abutilon pycnodon*, *Chamaesyce inaequilatera*, *Hermannia depressa*, *Nidorella resedifolia*, *Xerophyta retinervis*. Succulent Herb: *Crassula lan- ceolata* subsp. *transvaalensis*.

Biogeographically Important Taxon (Central Bushveld endemic) Tall Shrub: *Erythrophysa transvaalensis*.

Conservation Least threatened. Target of 24% exceeded, with 96% statutorily conserved in the Pilanesberg Game Reserve. Almost 2% transformed, mainly by urban development on the periphery. Prior to the proclamation of the reserve in 1979 some of the area had been intensively farmed and included some bush-clearing. Some of these areas are still visible, for example high grass cover and low tree cover in the lowlands. A few old mining sites occur. There are some scattered alien plant populations of *Cereus jamacaru*. Erosion is very low.

Remarks This unit is a meeting ground for several species of *Grewia*, for example northwestern limits of *G. occidentalis*, southwestern limits of *G. monticola* and *G. hexamita* and southeastern limits of *G. retinervis*. The vegetation of the southern slopes of this unit is similar to that of the

southern slopes of the northeastern end of the Magaliesberg (SVcb 9 Gold Reef Mountain Bushveld) whereas the northern slopes of the two units have distinct physiognomic differences (Van Wyk 1959).

Reference Van Wyk (1959).

SVcb 6 Marikana Thornveld

VT 19 Sourish Mixed Bushveld (46%), VT 13 Other Turf Thornveld (34%) (Acoccks 1953). LR 14 Clay Thorn Bushveld (60%) (Low & Rebelo 1996).

Distribution North-West and Gauteng Provinces: Occurs on plains from the Rustenburg area in the west, through Marikana and Brits to the Pretoria area in the east. Altitude about 1 050–1 450 m.

Vegetation & Landscape Features Open *Acacia karroo* woodland, occurring in valleys and slightly undulating plains, and some lowland hills. Shrubs are more dense along drainage lines, on termitaria and rocky outcrops or in other habitat protected from fire.

Geology & Soils Most of the area is underlain by the mafic intrusive rocks of the Rustenburg Layered Suite of the Bushveld Igneous Complex. Rocks include gabbro, norite, pyroxenite and anorthosite. The shales and quartzites of the Pretoria Group (Transvaal Supergroup) also contribute. Mainly vertic melanic clays with some dystrophic or mesotrophic plinthic catenas and some freely drained, deep soils. Land types mainly Ea, Ba and Ae.

Climate Summer rainfall with very dry winters. MAP between about 600 and 700 mm. Frost fairly frequent in winter. Mean monthly maximum and minimum temperatures for Brits-Agr 35.3°C and –3.3°C for January and June, respectively. Corresponding values are 35.3°C and –1.4°C for Rustenburg (November and July) and 32.8°C and –1.0°C for Pretoria University Experimental Farm (January and July). This unit has a relatively more temperate climate than the SVcb 1 Dwaalboom Thornveld. See also climate diagram for SVcb 6 Marikana Thornveld.



Figure 9.15 SVcb 6 Marikana Thornveld: *Acacia nilotica*-dominated clay thornveld north of Pretoria (near Ga-Rankuwa, Gauteng) after recent fire.

Important Taxa Tall Tree: *Acacia burkei*. Small Trees: *Acacia caffra* (d), *A. gerrardii* (d), *A. karroo* (d), *Combretum molle* (d), *Rhus lancea* (d), *Ziziphus mucronata* (d), *Acacia nilotica*, *A. tortilis* subsp. *heteracantha*, *Celtis africana*, *Dombeya rotundifolia*, *Pappea capensis*, *Peltophorum africanum*, *Terminalia sericea*. Tall Shrubs: *Euclea crispa* subsp. *crispa* (d), *Olea europaea* subsp. *africana* (d), *Rhus pyroides* var. *pyroides* (d), *Diospyros lycioides* subsp. *guerkei*, *Ehretia rigida* subsp. *rigida*, *Euclea undulata*, *Grewia flava*, *Pavetta gardeniifolia*. Low Shrubs: *Asparagus cooperi* (d), *Rhynchosia nitens* (d), *Indigofera zeyheri*, *Justicia flava*. Woody Climbers: *Clematis brachiata* (d), *Helinus integrifolius*. Herbaceous Climbers: *Pentarrhinum insipidum* (d), *Cyphostemma cirrhosum*. Graminoids: *Elionurus muticus* (d), *Eragrostis lehmanniana* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Aristida scabrivalvis* subsp. *scabrivalvis*, *Fingerhuthia africana*, *Heteropogon contortus*, *Hyperthelia dissoluta*, *Melinis nerviglumis*, *Pogonarthria squarrosa*. Herbs: *Hermannia depressa* (d), *Ipomoea obscura* (d), *Barleria macrostegia*, *Dianthus mooiensis* subsp. *mooiensis*, *Ipomoea oblongata*, *Vernonia oligocephala*. Geophytic Herbs: *Ledebouria revoluta*, *Ornithogalum tenuifolium*, *Sansevieria aethiopica*.

Conservation Endangered. Target 19%. Less than 1% statutorily conserved in, for example, Magaliesberg Nature Area. More conserved in addition in other reserves, mainly in De Onderstepoort Nature Reserve. Considerably impacted, with 48% transformed, mainly cultivated and urban or built-up areas. Most agricultural development of this unit is in the western regions towards Rustenburg, while in the east (near Pretoria) industrial development is a greater threat of land transformation. Erosion is very low to moderate. Alien invasive plants occur localised in high densities, especially along the drainage lines.

Remark A few small ridges of SVcb 9 Gold Reef Mountain Bushveld in the Pretoria area have not been mapped separately from this unit.

References Van der Meulen (1979), Van Rooyen (1983, 1984), Panagos et al. (1998).

SVcb 7 Norite Koppies Bushveld

VT 19 Sourish Mixed Bushveld (82%) (Acocks 1953). LR 14 Clay Thorn Bushveld (87%) (Low & Rebelo 1996). *Croton gratissimus*–*Setaria lindenbergiana* Woodland (Van der Meulen 1979).

Distribution North-West and Gauteng Provinces: Embedded in Marikana Thornveld, north of the Magaliesberg, on rocky hills between Rustenburg and Pretoria with the highest hills (e.g. Kareepoortberg) near Brits. Altitude about 1 100–1 350 m.

Vegetation & Landscape Features A low, semi-open to closed woodland up to 5 m tall, consisting of dense deciduous shrubs and trees with very sparse undergrowth on shallow soils, with large areas not covered by vegetation. Tree and shrub layers are continuous. The stands

of this unit are found on noritic outcrops and koppies, many appearing as inselbergs above the surrounding plains.

Geology & Soils Mostly gabbro and norite with interlayered anorthosite of the Pyramid Gabbro-Norite, Rustenburg Layered Suite, with a small area of the Rashoop Granophyre Suite (felsic igneous rocks), both of the Bushveld Complex (Vaalian). Large rock boulders and very shallow lithosols occur. Soils are well-drained, Glenrosa and Mispah forms; in some areas vertic, melanic clays are found as well. Land types mainly lb, with some Ea also occurring.

Climate Summer rainfall with dry winters. MAP from 600–700 mm. Frost fairly frequent around the base of hills in winter but less so on the hills. See also climate diagram for SVcb 7 Norite Koppies Bushveld.

Important Taxa Tall Tree: *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Combretum molle* (d), *Croton gratissimus* (d), *Ficus abutilifolia* (d), *Pappea capensis* (d), *Acacia caffra*, *Bridelia mollis*, *Combretum apiculatum*, *Cussonia paniculata*,



Figure 9.16 SVcb 7 Norite Koppies Bushveld: Small norite koppie overlooking plains covered with Marikana Thornveld northeast of Rustenburg, North-West Province.

Dombeya rotundifolia, *Faurea saligna*, *Ficus glumosa*, *Lannea discolor*, *Obetia tenax*, *Peltophorum africanum*, *Rhus leptodictya*, *Vangueria infausta*, *Ziziphus mucronata*. Succulent Tree: *Euphorbia cooperi*. Tall Shrubs: *Triaspis glaucophylla* (d), *Canthium gilfillanii*, *Clerodendrum glabrum*, *Diplorhynchus condylocarpon*, *Euclea natalensis*, *Grewia flavescens*, *G. monticola*, *Gymnosporia nemorosa*, *G. polyacantha*, *Pavetta eylesii*, *Pouzolzia mixta*, *Psydrax livida*, *Vitex zeyheri*. Low Shrubs: *Jatropha latifolia* var. *latifolia* (d), *Abutilon austro-africanum*, *Hermannia floribunda*, *Hibiscus subreniformis*, *Rhus zeyheri*. Succulent Shrub: *Tetradenia brevispicata*. Semiparasitic Shrub: *Osyris lanceolata*. Woody Climbers: *Helinus integrifolius*, *Rhoicissus tridentata*, *Turraea obtusifolia*. Woody Succulent Climber: *Sarcostemma viminale*. Herbaceous Climber: *Cyphostemma lanigerum*. Graminoids: *Chrysopogon serrulatus* (d), *Setaria lindenberghiana* (d), *Aristida congesta*, *Bulbostylis humilis*, *Eustachys paspaloides*, *Heteropogon contortus*, *Loudetia simplex*, *Melinis nerviglumis*, *Panicum maximum*, *Themeda triandra*. Herb: *Hibiscus sidiformis*. Geophytic Herbs: *Pellaea calomelanos*, *P. viridis*, *Scadoxus puniceus*.

Conservation Least threatened according to remote sensing data, but ground truthing suggests that it is rather susceptible. Target 24%. None conserved in statutory reserves but 4% conserved in De Onderstepoort Nature Reserve. About 10% transformed (but more recent assessment suggests about 20%), especially at the unit fringes, mainly by mining as well as urban and built-up developments and cultivated areas. Mining is primarily in the form of granite quarries on koppies, but also affects surrounding lower-lying areas. Areas close to human settlements are often severely disturbed and many woody species may have been harvested from these areas for fuel or building materials. Weeds, including a number of declared aliens, are more common in these disturbed sites. Erosion is very low to moderate.

Remarks Vegetation patterns on norite koppies are primarily determined by the amount of rockiness and aspect, warmer north-facing slopes and cooler south-facing slopes bearing floristically distinct vegetation. A number of the woody species, e.g. species of *Ficus*, are typical chasmophytes, penetrating the rocks with their roots (Van der Meulen 1979). The vegetation unit is transitional between xeric lowland bushveld and mesophyllous woodland in cooler more moist upland areas associated with the Magaliesberg and may be considered to be a more xeric phase of these upland areas (Van der Meulen 1979).

References Van der Meulen (1979), Panagos (1996).

SVcb 8 Moot Plains Bushveld

VT 19 Sourish Mixed Bushveld (57%) (Acocks 1953). LR 18 Mixed Bushveld (83%) (Low & Rebelo 1996).

Distribution North-West and Gauteng Provinces: Main belt occurs immediately south of the Magaliesberg from the Selons River Valley in the west through Maanhaarrand, filling the



Figure 9.17 SVcb 8 Moot Plains Bushveld: *Rhus lancea* and *Acacia nilotica* dominant on flats at an altitude of 1 325 m at Hekpoort, west of Pretoria.

valley bottom of the Magalies River, proceeding east of the Hartebeestpoort Dam between the Magaliesberg and Daspoort mountain ranges to Pretoria. It also occurs as a narrow belt immediately north of the Magaliesberg from Rustenburg in the west to just east of the Crocodile River in the east: also south of the Swartuggens–Zeerust line. Altitude typically about 1 050–1 450 m.

Vegetation & Landscape Features Open to closed, low, often thorny savanna dominated by various species of *Acacia* in the bottomlands and plains as well as woodlands of varying height and density on the lower hillsides. Herbaceous layer is dominated by grasses.

Geology & Soils Clastic sediments and minor carbonates and volcanics of the Pretoria Group (including the Silverton Formation) and some Malmani dolomites in the west, all of the Transvaal Supergroup (Vaalian). There is also some contribution from mafic Bushveld intrusives. Soils often stony with colluvial clay-loam but varied, including red-yellow apedal freely drained, dystrophic and eutrophic plinthic catenas, vertic and melanitic clays, and some less typical Glenrosa and Mispah forms. Land types Ae, Ba, Ea, Bc, Ac and less typically Fb.

Climate Summer rainfall with very dry winters. MAP from about 55 mm in the west to about 700 mm in the east. Frost frequent in winter. Mean monthly maximum and minimum temperatures for Pretoria-Pur 33.6°C and –3.1°C for January and June, respectively. See also climate diagram for SVcb 8 Moot Plains Bushveld.

Important Taxa Small Trees: *Acacia nilotica* (d), *A. tortilis* subsp. *heteracantha* (d), *Rhus lancea* (d). Tall Shrubs: *Buddleja saligna* (d), *Euclea undulata* (d), *Olea europaea* subsp. *africana* (d), *Grewia occidentalis*, *Gymnosporia polyacantha*, *Myroxylon aethiopicum* subsp. *burkeanum*. Low Shrubs: *Aptosimum elongatum*, *Felicia fascicularis*, *Lantana rugosa*, *Teucrium trifidum*. Succulent Shrub: *Kalanchoe paniculata*. Woody Climber: *Jasminum breviflorum*. Herbaceous Climber: *Lotononis bainesii*. Graminoids: *Heteropogon contortus* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Aristida congesta*, *Chloris virgata*, *Cynodon dactylon*, *Sporobolus nitens*, *Tragus racemosus*. Herbs: *Achyrocline satureioides*, *Corchorus asplenifolius*, *Evolvulus alsinoides*, *Helichrysum nudifolium*, *H. undulatum*, *Hermannia depressa*, *Osteospermum muricatum*, *Phyllanthus maderaspatensis*.

Conservation Vulnerable. Target 19%. Some 13% statutorily conserved mainly in the Magaliesberg Nature Area. About 28% transformed mainly by cultivation and urban and built-up areas. Very scattered occurrences to sometimes dense patches in places of various alien plants including *Cereus jamacaru*, *Eucalyptus* species, *Jacaranda mimosifolia*, *Lantana camara*, *Melia azedarach* and *Schinus* species. Erosion is mainly very low to low, moderate in some areas.

References Coetzee (1975), Van der Meulen (1979).

SVcb 9 Gold Reef Mountain Bushveld

VT 61 Bankenveld (50%) (Acocks 1953). LR 18 Mixed Bushveld (44%), LR 34 Rocky Highveld Grassland (43%) (Low & Rebelo 1996).

Distribution North-West, Gauteng, Free State and Mpumalanga Provinces: Occurs along rocky quartzite ridges of the Magaliesberg and the parallel ridge to the south, from around Boshhoek and Koster in the west to near Bronkhorstspuit in the east. The west-east-trending ridge of the Witwatersrand from around Krugersdorp in the west, through Roodepoort and Johannesburg to Bedfordview (Germiston District). Inner ridges (e.g. Dwarsberg and Witkop) of the Vredefort Dome on the Vaal River northwest of Parys and part of the Suikerbosrand and some other hills around Heidelberg. Altitude 1 200–1 750 m.

Vegetation & Landscape Features Rocky hills and ridges often west-east trending with more dense woody vegetation often on the south-facing slopes associated with distinct floristic differences (e.g. preponderance of *Acacia caffra* on the southern slopes). Tree cover elsewhere is variable. Tree and shrub layers are often continuous. Herbaceous layer is dominated by grasses.

Geology & Soils This area consists predominantly of quartzites, conglomerates and some shale horizons of the Magaliesberg, Daspoort and Silverton Formations (Vaalian Pretoria Group) and the Hospital Hill, Turffontein and Government Subgroups (Randian Witwatersrand Supergroup). Soils are shallow, gravel lithosols of the Mispah and Glenrosa forms. Land types mainly lb and Fb.

Climate Summer rainfall with very dry winters. MAP about 600–750 mm. Frost frequent in winter (especially in the south), but less common on the ridges and hills. Mean monthly maximum and minimum temperatures for Krugersdorp 30.8°C and –1.8°C for January and July, respectively. See also climate diagram for SVcb 9 Gold Reef Mountain Bushveld.

Important Taxa Small Trees: *Acacia caffra* (d), *Combretum molle* (d), *Protea caffra* (d), *Celtis africana*, *Dombeya rotundifolia*, *Englerophytum magalismontanum*, *Ochna pretoriensis*, *Rhus leptodictya*, *Vangueria infausta*, *V. parvifolia*, *Ziziphus mucronata*. Tall Shrubs: *Canthium gilfillanii*, *Ehretia rigida* subsp. *rigida*, *Grewia occidentalis*, *Gymnosporia buxifolia*, *Mystroxydon aethiopicum* subsp. *burkeanum*. Low Shrubs: *Athrixia elata*, *Pearsonia cajanifolia*, *Rhus magalismontana* subsp. *magalismontana*, *R. rigida* var. *rigida*. Woody Climber: *Ancylotrys capensis*. Graminoids: *Loudetia simplex* (d), *Panicum natalense*



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Figure 9.18 SVcb 9 Gold Reef Mountain Bushveld: *Protea caffra* and the dominant *Acacia caffra* on the southern slopes of the Magaliesberg at an altitude of 1 655 m in the Magaliesberg Conservation Area, north of Boschfontein and southeast of Rustenburg.

(d), *Schizachyrium sanguineum* (d), *Trachypogon spicatus* (d), *Alloteropsis semialata* subsp. *eckloniana*, *Bewisia biflora*, *Digitaria tricholaenoides*, *Diheteropogon amplexans*, *Sporobolus pectinatus*, *Tristachya biseriata*, *T. leucothrix*. Herbs: *Helichrysum nudifolium*, *H. rugulosum*, *Pentanisia angustifolia*, *Senecio venosus*, *Xerophyta retinervis*. Geophytic Herbs: *Cheilanthes hirta*, *Hypoxis hemerocallidea*, *Pellaea calomelanos*.

Endemic Taxa Succulent Shrub: *Aloe peglerae*. Succulent Herb: *Frithia pulchra*.

Conservation Least threatened. Target 24%. Some 22% statutorily conserved mainly in the Magaliesberg Nature Area and much smaller proportions in the Rustenburg, Wonderboom and Suikerbosrand Nature Reserves. At least an additional 1% conserved in other reserves brings the total conserved very close to target. About 15% transformed mainly by cultivation and urban and built-up areas. Some areas with dense stands of the alien *Melia azedarach* but which is often associated with drainage lines or alluvia (i.e. azonal vegetation) embedded within this unit. Erosion is very low to low.

Remark A few small ridges of this unit in the Pretoria area have not been mapped.

References Van Vuuren & Van der Schijff (1970), Bredenkamp (1975), Coetzee (1975), Bredenkamp (1977), Bredenkamp & Theron (1978), Behr & Bredenkamp (1988), Bezuidenhout et al. (1988), Du Preez & Venter (1990), Coetzee et al. (1993), Bezuidenhout et al. (1994), Coetzee et al. (1994, 1995), Grobler et al. (2002).

SVcb 10 Gauteng Shale Mountain Bushveld

VT 61 Bankenveld (98%) (Acocks 1953). LR 34 Rocky Highveld Grassland (85%) (Low & Rebelo 1996).

Distribution Gauteng and North-West Provinces: Occurs mainly on the ridge of the Gatsrand south of Carletonville–Westonaria–Lenasia. Also occurs as a narrow band along the ridge that runs from a point between Tarlton and Magaliesberg in the west, through Sterkfontein, Pelindaba, Atteridgeville to Klapperkop and southeastern Pretoria in the east. Altitude 1 300–1 750 m.

Vegetation & Landscape Features Low, broken ridges varying in steepness and with high surface rock cover. Vegetation is a short (3–6 m tall), semi-open thicket dominated by a variety of woody species including *Acacia caffra*, *Rhus leptodictya*, *R. magalismontana*, *Cussonia spicata*, *Ehretia rigida*, *Maytenus heterophylla*, *Euclea crispa*, *Zanthoxylum capense*, *Dombeya rotundifolia*, *Protea caffra*, *Celtis africana*, *Ziziphus mucronata*, *Vangueria infausta*, *Canthium gilfillanii*, *Englerophytum magalismontanum*, *Combretum molle*, *Ancylobotrys capensis*, *Olea europaea* subsp. *africana* and *Grewia occidentalis*. The understorey is dominated by a variety of grasses. Some of the ridges form plateaus above the northern slopes that carry scrubby grassland with high surface rock cover.

Geology & Soils Dominated by shale and some coarser clastic sediments as well as significant andesite from the Pretoria Group (Transvaal Supergroup), all sedimentary rocks. A part of the area is underlain by Malmani dolomites of the Chuniespoort Group (Transvaal Supergroup). Soils are mostly shallow Mispah, but are deeper at the foot of the slopes. Land type is mostly Fb, with some Ib.

Climate Summer rainfall with very dry winters. MAP 600–750 mm, increasing from west to east as well as with higher elevation. Frost frequent, higher in the west and south. See also climate diagram for SVcb 10 Gauteng Shale Mountain Bushveld.

Important Taxa Small Trees: *Acacia caffra* (d), *Dombeya rotundifolia* (d), *Acacia karroo*, *Celtis africana*, *Combretum molle*, *Cussonia spicata*, *Englerophytum magalismontanum*, *Protea caffra*, *Rhus leptodictya*, *Vangueria infausta*, *Zanthoxylum capense*, *Ziziphus mucronata*. Tall Shrubs: *Asparagus laricinus*, *Canthium gilfillanii*, *Chrysanthemoides monilifera*, *Dichrostachys cinerea*, *Diospyros austro-africana*, *D. lycioides* subsp. *lycioides*, *Ehretia rigida* subsp. *rigida*, *Euclea crispa* subsp. *crispa*, *Grewia occidentalis*, *Gymnosporia polyacantha*, *Olea europaea* subsp. *africana*, *Tephrosia capensis*, *T. longipes*. Low Shrubs: *Acalypha angustata*, *Asparagus suaveolens*, *Athrixia elata*, *Felicia muricata*, *Indigofera comosa*, *Rhus magalismontana* subsp. *magalismontana*. Geoxylic Suffrutex: *Elephantorrhiza elephantina*. Succulent Shrub: *Kalanchoe rotundifolia*. Woody Climber: *Ancylobotrys capensis*. Graminoids: *Hyparrhenia dregeana* (d), *Cymbopogon caesius*, *C. pospischilii*, *Digitaria eriantha* subsp. *eriantha*, *Eragrostis curvula*. Herbs: *Dicoma zeyheri*, *Helichrysum nudifolium*, *H. rugulosum*, *Hermannia lancifolia*, *Hibiscus pusillus*, *Selaginella dregei*, *Senecio venosus*, *Vernonia natalensis*, *V. oligocephala*. Geophytic Herbs: *Cheilanthes hirta*, *Pellaea calomelanos*, *Scadoxus puniceus*.

Conservation Vulnerable. Target 24%. Less than 1% statutorily conserved in, for example, the Skanskop and Hartbeesthoek Nature Reserves, Magaliesberg Nature Area and Groenkloof National Park. Additionally, over 1% conserved in other reserves including the John Nash Nature Reserve, Cheetah Park and Hartbeesthoek Radio Astronomy Observatory. About 21% transformed mainly by urban and built-up areas, mines and quarries, cultivation and plantations. Wattles a common invasive plant in places. Erosion very low to low.



Figure 9.19 SVcb 10 Gauteng Shale Mountain Bushveld: Typical semi-open bushveld on rocky slope with a variety of woody species, including *Cussonia spicata*, *Euclea crispa* and *Dombeya rotundifolia* in Groenkloof Nature Reserve, Pretoria. The tall grass in the foreground is *Hyparrhenia dregeana*.

Remarks This unit represents the arid western part of the ridges of Rocky Highveld Grassland (Low & Rebelo 1996) or Bankenveld (Acocks 1988). In species composition and vegetation structure it is similar to and positioned adjacent to SVcb 11 Andesite Mountain Bushveld. This unit occurs more frequently on warmer north-facing slopes and is underlain by rocks of sedimentary origin, whereas SVcb 11 Andesite Mountain Bushveld occurs more frequently on cooler south-facing slopes and is underlain by rocks of volcanic origin.

References Coetzee (1972, 1974), Bezuidenhout et al. (1994).

SVcb 11 Andesite Mountain Bushveld

VT 61 Bankenveld (62%) (Acocks 1953). LR 39 Moist Cool Highveld Grassland (45%), LR 34 Rocky Highveld Grassland (37%) (Low & Rebelo 1996).

Distribution Gauteng, North-West, Mpumalanga and Free State Provinces: Several separate occurrences of which the main are: the Bronberg Ridge in eastern Pretoria extending to Welbekend; from Hartbeesthoek in the west along the valley between the two parallel ranges of hills to Atteridgeville; hills in southern Johannesburg; several hills encompassing Nigel, Willemsdal, Coalbrook and Suikerbosrand (in part); and the outer ring of ridges of the Vredefort Dome and some hills to the northwest around Potchefstroom. Altitude about 1 350–1 800 m.

Vegetation & Landscape Features Dense, medium-tall thorny bushveld with a well-developed grass layer on hill slopes and some valleys with undulating landscape.

Geology & Soils Tholeiitic basalt of the Kliprivierberg Group (Randian Ventersdorp Supergroup), also dark shale, micaceous sandstone and siltstone and thin coal seams of the Madzaringwe Formation [Karoo Supergroup, and andesite and conglomerate of the Pretoria Group (Vaalian Transvaal Supergroup)]. Weathering of these rocks gives rise to shallow,



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Figure 9.20 SVcb 11 Andesite Mountain Bushveld: *Acacia caffra* and *Euclea crispa* on a rocky koppie at an altitude of 1 385 m on Hartebeeshoek north of Krugersdorp.

rocky, clayey soils of mainly Mispah and Glenrosa soil forms. Land types mainly Ib and Fb, with some Ba and Bb.

Climate Summer rainfall with very dry winters. MAP from about 550 mm in the southwest to about 750 mm in the northeast. Frequent frost in winter, but less on the ridges and hills. See also climate diagram for SVcb 11 Andesite Mountain Bushveld.

Important Taxa Small Trees: *Acacia caffra* (d), *A. karroo* (d), *Celtis africana*, *Protea caffra*, *Zanthoxylum capense*, *Ziziphus mucronata*. Tall Shrubs: *Asparagus larinus* (d), *Euclea crispa* subsp. *crispa* (d), *Rhus pyroides* var. *pyroides* (d), *Diospyros lycioides* subsp. *lycioides*, *Gymnosporia polyacantha*, *Lippia javanica*, *Rhamnus prinoides*. Low Shrubs: *Asparagus suaveolens* (d), *Rhus rigida* var. *margaretae*, *Teucrium trifidum*. Soft Shrub: *Isoglossa grantii*. Woody Climber: *Rhoicissus tridentata*. Graminoids: *Eragrostis curvula* (d), *Hyparrhenia hirta* (d), *Setaria sphacelata* (d), *Themeda triandra* (d), *Cymbopogon pospischilii*, *Digitaria eriantha* subsp. *eriantha*, *Elionurus muticus*, *Eragrostis racemosa*, *E. superba*, *Panicum maximum*. Herbs: *Commelina africana*, *Vernonia galpinii*, *V. oligocephala*. Succulent Herb: *Aloe greatheadii* var. *davyana*.

Conservation Least threatened. Target 24%. About 7% statutorily conserved mainly in the Suikerbosrand Nature Reserve and Magaliesberg Nature Area. An additional 1–2% conserved in other reserves mainly in the Hartbeesthoek Radio Astronomy Observatory. Some 15% already transformed, mainly cultivated and some urban and built-up areas. Some of the unit fringes on major urban areas. Erosion is generally very low.

References Bredenkamp (1975, 1977), Bredenkamp & Theron (1980), Du Preez & Venter (1990), Coetzee et al. (1995), Grobler (2000).

SVcb 12 Central Sandy Bushveld

VT 18 Mixed Bushveld (44%), VT 19 Sourish Mixed Bushveld (32%) (Acocks 1953). LR 18 Mixed Bushveld (73%) (Low & Rebelo 1996).

Distribution Limpopo, Mpumalanga, Gauteng and North-West Provinces: Undulating terrain occurs mainly in a broad arc south of the Springbokvlakte from the Pilanesberg in the west through Hammanskraal and Groblersdal to GaMasemola in the east. A generally narrow irregular band along the north-

western edge of the Springbokvlakte (including Modimolle) extending into a series of valleys and lower-altitude areas within the Waterberg including the upper Mokolo River Valley near Vaalwater, the corridor between Rankins Pass and the Doorndraai Dam, and the lowlands from the Mabula area to south of the Hoekberge. Some isolated sandy rises are found on the Springbokvlakte. Altitude about 850–1 450 m.

Vegetation & Landscape Features

Low undulating areas, sometimes between mountains, and sandy plains and catenas supporting tall, deciduous *Terminalia sericea* and *Burkea africana* woodland on deep sandy soils (with the former often dominant on the lower slopes of sandy catenas) and low, broad-leaved *Combretum* woodland on shallow rocky or gravelly soils. Species of *Acacia*, *Ziziphus* and *Euclea* are found on flats and lower slopes on eutrophic sands and some less sandy soils. *A. tortilis* may

dominate some areas along valleys. Grass-dominated herbaceous layer with relatively low basal cover on dystrophic sands.

Geology & Soils The large southern and eastern parts of this area are underlain by granite of the Lebowa Granite Suite and some granophyre of the Rashoop Granophyre Suite (both Bushveld Complex, Vaalian). In the north, the sedimentary rocks of the Waterberg Group (Mokolian Erathem) are most important. Specifically, sandstone, conglomerate and siltstone of the Alma Formation and sandstone, siltstone and shale of the Vaalwater Formation. Well-drained, deep Hutton or Clovelly soils often with a catenary sequence from Hutton at the top to Clovelly on the lower slopes; shallow, skeletal Glenrosa soils also occur. Land types mainly Bb, Fa, Ba, Bd and Ac.

Climate Summer rainfall with very dry winters. Effectively three seasons, namely a cool dry season from May to mid-August, a hot dry season from mid-August to about October and a hot wet season from about November to April. MAP from about 500–700 mm. Frost fairly infrequent. Mean monthly maximum and minimum temperatures for Goedeheop (in the northern part of this vegetation unit) 35.3°C and –3.1°C for November and June, respectively. See also climate diagram for SVcb 12 Central Sandy Bushveld.

Important Taxa Tall Trees: *Acacia burkei* (d), *A. robusta*, *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Burkea africana* (d), *Combretum apiculatum* (d), *C. zeyheri* (d), *Terminalia sericea* (d), *Ochna pulchra*, *Peltophorum africanum*, *Rhus leptodictya*. Tall Shrubs: *Combretum hereroense*, *Grewia bicolor*, *G. monticola*, *Strychnos pungens*. Low Shrubs: *Agathisanthemum bojeri* (d), *Indigofera filipes* (d), *Felicia fascicularis*, *Gnidia sericocephala*. Geoxylic Suffrutex: *Dichapetalum cymosum* (d). Woody Climber: *Asparagus burchanani*. Graminoids: *Brachiaria nigropedata* (d), *Eragrostis pallens* (d), *E. rigidior* (d), *Hyperthelia dissoluta* (d), *Panicum maximum* (d), *Perotis patens* (d), *Antheophora pubescens*, *Aristida scabrivalvis* subsp. *scabrivalvis*, *Brachiaria serrata*, *Elionurus muticus*, *Eragrostis nindensis*, *Loudetia simplex*, *Schmidtia pappophoroides*, *Themeda triandra*, *Trachypogon spicatus*. Herbs: *Dicerocaryum senecioides* (d), *Barleria macrostegia*, *Blepharis integrifolia*, *Crabbea angustifolia*, *Evolvulus alsinoides*, *Geigeria burkei*, *Hermannia lancifolia*, *Indigofera daleoides*, *Justicia anagaloides*, *Kyphocarpa angustifolia*, *Lophiocarpus tenuissimus*, *Waltheria indica*, *Xerophyta humilis*. Geophytic

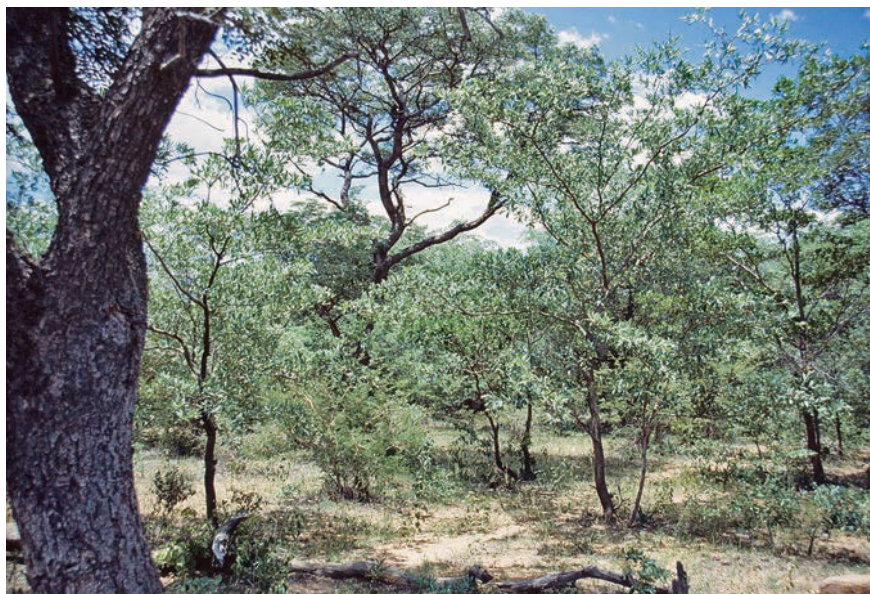


Figure 9.21 SVcb 12 Central Sandy Bushveld: Open savanna dominated by *Burkea africana* and *Terminalia sericea* on a sandy ridge south of Mookgophong (Naboomspruit).

Herb: *Hypoxis hemerocallidea*. Succulent Herb: *Aloe greatheadii* var. *davyana*.

Biogeographically Important Taxa (Central Bushveld endemics) Graminoid: *Mosdenia leptostachys*. Herb: *Oxygonum dregeanum* subsp. *canescens* var. *dissectum*.

Conservation Vulnerable. Target 19%. Less than 3% statutorily conserved spread thinly across many nature reserves including the Doorndraai Dam and Skuinsdraai Nature Reserves. An additional 2% conserved in other reserves including the Wallmansthal SANDF Property and a grouping of private reserves, which include most of the Nylsvlei freshwater wetlands. About 24% transformed, including about 19% cultivated and 4% urban and built-up areas. Much of the unit in the broad arc south of the Springbokvlakte is heavily populated by rural communities. Several alien plants are widely scattered but often at low densities; these include *Cereus jamacaru*, *Eucalyptus* species, *Lantana camara*, *Melia azedarach*, *Opuntia ficus-indica* and *Sesbania punicea*. Erosion very low to high, especially in some places north-east of Groblersdal.

Remarks *Acacia sieberiana* occurs in the transition zone with grassland in the east, while *A. caffra* and *Faurea saligna* are dominant in the transition zone to SVcb 17 Waterberg Mountain Bushveld in the western parts of this unit. Central Sandy Bushveld is similar to SVcb 16 Western Sandy Bushveld, but the former is generally moister and cooler and generally lacks species such as *A. erubescens* and *A. nigrescens*. The climate seasons described above also apply to many other vegetation units of the Central Bushveld Bioregion. This vegetation unit includes probably the most intensively studied South African savanna field site of the South African Savanna Ecosystem Programme in the Nylsvley Nature Reserve (Limpopo Province).

References Grunow (1965), Coetzee et al. (1976), Van der Meulen (1979), Van der Meulen & Westfall (1980), Lubke et al. (1983), Lubke & Thatcher (1983), Scholes & Walker (1993), Dörgeloh (1998, 1999a, b).

SVcb 13 Loskop Mountain Bushveld

VT 18 Mixed Bushveld (49%), VT 19 Sourish Mixed Bushveld (47%) (Acocks 1953). LR 18 Mixed Bushveld (61%) (Low & Rebelo 1996).

Distribution Mpumalanga, Gauteng and Limpopo Provinces: Occurs on mountains in the vicinity of Loskop Dam extending southwestwards towards Bronkhorstspuit on mountains including the Gouwsberge and westwards to Rust de Winter on mountains including Dithabane. Altitude about 1 050–1 500 m.

Vegetation & Landscape Features

Low mountains and ridges with open tree savanna on lower-lying areas dominated by *Burkea africana* and a denser broad-leaved tree savanna on lower slopes and midslopes with prominent *Diplorhynchus condylocarpon*, *Combretum apiculatum* and *Acacia caffra*. Herbaceous layer is dominated by grasses.

Geology & Soils Rhyolite of the Selons River Formation (Rooiberg Group, Transvaal Supergroup) and sandstone with subordinate conglomerate and minor shale of the Wilge River Formation (Mokolian Waterberg Group) are most abundant. The Rashoop Granophyre Suite and granite of the Lebowa Granite Suite, (both Bushveld Igneous Complex, Vaalian) are also represented, as are some mudrock, sandstone, conglomerate and volcanic rocks of the Loskop Formation (Vaalian Transvaal Supergroup). Rocky areas with miscellaneous soils



Figure 9.22 SVcb 13 Loskop Mountain Bushveld: Open broad-leaved woodland occurring on mountain slopes with *Rhynchosia nervosa*, *Mundulea sericea*, *Combretum molle* and *C. zeyheri* in the Loskop Dam Nature Reserve.

ranging from sandy to sandy loams, sandy clays and some clays. Land type is mainly lb.

Climate Summer rainfall with very dry winters. Frost fairly infrequent. MAP about 600–750 mm. See also climate diagram for SVcb 13 Loskop Mountain Bushveld.

Important Taxa Tall Tree: *Acacia burkei*. Small Trees: *Acacia caffra* (d), *Burkea africana* (d), *Combretum apiculatum* (d), *C. zeyheri* (d), *Croton gratissimus* (d), *Faurea saligna* (d), *Heteropyxis natalensis* (d), *Ochna pulchra* (d), *Protea caffra* (d), *Pseudolachnostylis maprouneifolia* (d), *Terminalia sericea* (d), *Brachylaena rotundata*, *Combretum molle*, *Englerophytum magalismontanum*, *Ozoroa sphaerocarpa*, *Pappea capensis*, *Rhus leptodictya*, *Strychnos cocculoides*, *Vangueria parvifolia*. Tall Shrubs: *Diplorhynchus condylocarpon* (d), *Elephantorrhiza burkei* (d), *Combretum moggii*, *Grewia flava*, *Mundulea sericea*, *Pavetta zeyheri*, *Psydrax livida*, *Vitex rehmannii*. Low Shrub: *Rhus zeyheri* (d). Succulent Shrub: *Aloe castanea*. Graminoids: *Aristida transvaalensis* (d), *Loudetia simplex* (d), *Trachypogon spicatus* (d), *Digitaria eriantha* subsp. *eriantha*, *Enneapogon pretoriensis*, *Heteropogon contortus*, *Setaria sphacelata*, *Themeda triandra*, *Tristachya biseriata*. Herb: *Xerophyta retinervis*.

Endemic Taxa Geophytic Herb: *Gladiolus pole-evansii*. Succulent Herb: *Haworthia koelmaniorum*.

Conservation Least threatened. Target 24%. About 15% statutorily conserved mainly in the Loskop Dam and Mabusa Nature Reserves. About 2% additionally conserved in other reserves. Less than 3% transformed mainly by cultivation and urban and built-up areas. Erosion is mostly very low to low.

Remark The great variation in geology and topography in the area is associated with a wide variety of plant communities.

Reference Theron (1973).

SVcb 14 Loskop Thornveld

VT 18 Mixed Bushveld (91%) (Acocks 1953). LR 18 Mixed Bushveld (71%) (Low & Rebelo 1996).

Distribution Mpumalanga Province and very marginally into Limpopo Province: South of Groblersdal, the valley of the Bloed River towards Stoffberg and the valley of the Olifants River

to the Loskop Dam as well as valleys west of Groblersdal to Dennilton. Altitude about 950–1 300 m.

Vegetation & Landscape Features Valleys and plains of parts of the upper Olifants River catchment. Open, deciduous to semideciduous, tall, thorny woodland, usually dominated by *Acacia* species.

Geology & Soils Gabbro, norite and anorthosite of the Dsjate Subsuite, olivine diorite, magnetite gabbro and gabbro-norite of the Roossenekal Subsuite (both Rustenburg Layered Suite, Bushveld Igneous Complex), mudstone siltstone, sandstone, andesitic lava and carbonates of the Bloempoot Formation, mudstone, sandstone, conglomerate and volcanic rocks of the Loskop Formation (both Transvaal Supergroup, Vaalian Erathem), and granophyre of the Rashoop Granophyre Suite, also of Bushveld (Vaalian Erathem). Soils are vertic, melanic clays, plinthic catena, eutrophic and widespread red soils. Red-yellow apedal, freely drained soils, high base status. Deep soils with Hutton, Rensburg and Arcadia forms are common. Land types mainly Ea, Bc and Ae.

Climate Summer rainfall with very dry winters. MAP about 550–650 mm. Frost fairly infrequent. Mean monthly maximum and minimum temperatures for Loskop Dam-Irr are 35.7°C and 3.6°C for January and July, respectively. See also climate diagram for SVcb 14 Loskop Thornveld.

Important Taxa Tall Trees: *Acacia burkei*, *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Acacia gerrardii* (d), *A. sieberiana* var. *woodii* (d), *A. nilotica*, *A. tortilis* subsp. *heteracantha*, *Berchemia zeyheri*, *Combretum zeyheri*, *Pappea capensis*, *Peltophorum africanum*, *Rhus leptodictya*. Tall Shrubs: *Euclea crispa* subsp. *crispa* (d), *Rhus pyroides* var. *pyroides* (d), *Dichrostachys cinerea*, *Euclea undulata*, *Grewia flava*, *Olea europaea* subsp. *africana*. Low Shrubs: *Asparagus suaveolens*, *Leonotis ocymifolia*, *Orthosiphon fruticosus*, *Vernonia poskeana* subsp. *botswanaica*. Succulent Shrub: *Kalanchoe paniculata*. Woody Climber: *Clematis brachiata* (d). Woody Succulent Climber: *Senecio pleistocephalus*. Herbaceous Climber: *Rhynchosia minima* (d). Graminoids: *Bothriochloa insculpta* (d), *Digitaria argyrograpta* (d), *Themeda triandra* (d), *Aristida congesta*, *Bulbostylis humilis*, *Cenchrus ciliaris*, *Cymbopogon nardus*, *Enneapogon scoparius*, *Eragrostis trichophora*, *Eustachys paspaloides*, *Setaria verticillata*. Herb: *Kyphocarpa angustifolia*.

Biogeographically Important Taxon (Broadly disjunct distribution) Small Tree: *Acacia thetonii* (d).

Conservation Vulnerable. Target 19%. About 11% statutorily conserved in the Loskop Dam Nature Reserve (with an additional 3.2% represented by the water surface of the reservoir). About a quarter of the area already transformed, mainly for agricultural crops requiring irrigation. The most common crops include maize, cotton, citrus, grapes and wheat (winter crop). There has been a dramatic increase in the establishment of vineyards. Old lands are invaded by *Acacia tortilis* and *Hyparrhenia hirta*. Alien plants, for example *Cereus jamacaru*, *Opuntia ficus-indica*, *Melia azedarach*, *Lantana camara* and *Solanum seafortianum*, have invaded various parts of this unit. Erosion is generally moderate to very low.

Reference Theron (1973).



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Figure 9.23 SVcb 14 Loskop Thornveld: Deciduous open woodland occurring in valleys with dominant species including *Acacia sieberiana*, *A. tortilis* and *A. thetonii*, east of Loskop Dam.

SVcb 15 Springbokvlakte Thornveld

VT 12 Springbok Flats Turf Thornveld (48%), VT 18 Mixed Bushveld (42%) (Acocks 1953). LR 14 Clay Thorn Bushveld (55%) (Low & Rebelo 1996).

Distribution Limpopo, Mpumalanga, North-West and Gauteng Provinces: Flats from Zebediela in the northeast to Hammanskraal and Assen in the southwest as well as from Bela-Bela and Mookgophong in the northwest to Marble Hall and Rust de Winter in the southeast. Altitude about 900–1 200 m.

Vegetation & Landscape Features Open to dense, low thorn savanna dominated by *Acacia* species or shrubby grassland with a very low shrub layer. Occurs on flat to slightly undulating plains.

Geology & Soils Rocks are part of the volcano-sedimentary Karoo Supergroup. Most abundant in the area are the mafic volcanics (tholeiitic and olivine basalts and nephelinites) of the Letaba Formation, then the mudstones of the Irrigasie Formation and the shale, with sandstone units, of the Eccia Group. Soils are red-yellow apedal, freely drained with high base status and self-mulching, black, vertic clays. The vertic soils, with a fluctuating water table, experience prolonged periods of swelling and shrinking during wet and dry periods, considerable soil cracking when dry, a loose soil surface, high calcium carbonate content and gilgai micro-relief. Land types mainly Ae and Ea.

Climate Summer rainfall with very dry winters. MAP about 500–650 mm. Frost fairly infrequent in winter. Mean monthly maximum and minimum temperatures for Warmbaths–Towoomba are 35.2°C and –2.0°C for October and July, respectively. Corresponding values are 36.8°C and –1.2°C for Marble Hall for January and June, respectively. See also climate diagram for SVcb 15 Springbokvlakte Thornveld.

Important Taxa Small Trees: *Acacia karroo* (d), *A. luederitzii* var. *retinens* (d), *A. mellifera* subsp. *detinens* (d), *A. nilotica* (d), *Ziziphus mucronata* (d), *Acacia tortilis* subsp. *heteracantha*, *Boscia foetida* subsp. *rehmanniana*. Tall Shrubs: *Euclea undulata* (d), *Rhus engleri* (d), *Dichrostachys cinerea*, *Diospyros lycioides* subsp. *lycioides*, *Grewia flava*, *Tarchonanthus camphoratus*. Low Shrubs: *Acacia tenuispina* (d), *Ptycholobium plicatum*. Succulent Shrub: *Kleinia longiflora*. Herbaceous Climbers: *Momordica balsamina*, *Rhynchosia minima*. Graminoids: *Aristida bipartita* (d),

Dichanthium annulatum var. *papillosum* (d), *Ischaemum afrum* (d), *Setaria incrassata* (d), *Aristida canescens*, *Brachiaria eruciformis*. Herbs: *Aspilia mossambicensis*, *Indigastrium parviflorum*, *Nidorella hottentotica*, *Orthosiphon suffrutescens*, *Senecio apiifolius*.

Biogeographically Important Taxon (Central Bushveld endemic) Graminoid: *Mosdenia leptostachys*.

Conservation Endangered. Target 19%. Only 1% statutorily conserved, mainly in the Mkombo Nature Reserve. Roughly three times this area is conserved in a number of other reserves. At least 49% transformed, including about 45% cultivated and 3% urban and built-up. Dense rural populations in parts of the southern and eastern side of the unit. Very scattered alien plants over wide areas include *Cereus jamacaru*, *Eucalyptus* species, *Lantana camara*, *Melia azedarach*, *Opuntia ficus-indica* and *Sesbania punicea*. Erosion is very low to moderate.

Remark The high clay content of the soil increases soil moisture stress and SVcb 15 Springbokvlakte Thornveld is more xeric than adjacent vegetation units (except for SVcb 27 Sekhukhune Plains Bushveld in the extreme northeast).

References Galpin (1926), Coetzee et al. (1976), Van der Meulen (1979), Van der Meulen & Westfall (1980), Winterbach (1998).

SVcb 16 Western Sandy Bushveld

VT 18 Mixed Bushveld (58%) (Acocks 1953). LR 18 Mixed Bushveld (75%) (Low & Rebelo 1996).

Distribution Limpopo and North-West Provinces: Occurs on flats and undulating plains from Assen northwards past Thabazimbi and remaining west of the Waterberg Mountains towards Steenbokpan in the north. Some patches occur between the Crocodile and Marico Rivers to the west. Mostly at altitudes of 900–1 200 m

Vegetation & Landscape Features Varies from tall open woodland to low woodland, broad-leaved as well as microphyllous tree species prominent. Dominant species include *Acacia erubescens* on flat areas, *Combretum apiculatum* on shallow soils of gravelly upland sites and *Terminalia sericea* on deep sands. Occurs on slightly undulating plains.

Geology & Soils Sandstone and mudstone of the Matlabas Subgroup and sandstone, subordinate conglomerate, siltstone and shale of the Kransberg Subgroup (both Mokolian Waterberg Group) are found in the north. Archaean granite and gneiss of the Swazian Erathem and granite of the Lebowa Granite Suite (Bushveld Igneous Complex) are found in the west and southeast of the area, respectively. Soils are plinthic catena, eutrophic, red-yellow apedal, freely drained, high base status, Hutton and Clovelly with some Glenrosa and Mispah soil forms. Several areas have less sandy soil than that of SVcb 12 Central Sandy Bushveld. Land types mainly Bd, Ah, Ae and Fa.

Climate Summer rainfall with very dry winters. MAP from about 450 mm in the north to about 650 mm in the south. Fairly frequent light frost in winter. Mean monthly maximum and minimum tem-



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Figure 9.24 SVcb 15 Springbokvlakte Thornveld: Open savanna dominated by *Acacia nilotica*, *A. tortilis* and *A. karroo* on turf flats on Uitzicht northeast of Roedtan at an altitude of 985 m. Cleared land for crops, typically encountered in this unit, is visible in the background.



Figure 9.25 SVcb 16 Western Sandy Bushveld: Open bushveld dominated by *Combretum apiculatum*, *Acacia nigrescens* and *Sporobolus* species on Ruigtevlei, Thabazimbi District.

peratures for Thabazimbi 36.0°C and –3.7°C for February and June, respectively. See also climate diagram for SVcb 16 Western Sandy Bushveld.

Important Taxa Tall Trees: *Acacia erioloba*, *A. nigrescens*, *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Acacia erubescens* (d), *A. mellifera* subsp. *detinens* (d), *A. nilotica* (d), *A. tortilis* subsp. *heteracantha* (d), *Combretum apiculatum* (d), *C. imberbe* (d), *Terminalia sericea* (d), *Combretum zeyheri*, *Lannea discolor*, *Ochna pulchra*, *Peltophorum africanum*. Tall Shrubs: *Combretum hereroense* (d), *Euclea undulata* (d), *Coptosperma supra-axillare*, *Dichrostachys cinerea*, *Grewia bicolor*, *G. flava*, *G. monticola*. Low Shrubs: *Clerodendrum ternatum*, *Indigofera filipes*, *Justicia flava*. Graminoids: *Antheophora pubescens* (d), *Digitaria eriantha* subsp. *eriantha* (d), *Eragrostis pallens* (d), *E. rigidior* (d), *Schmidtia pappophoroides* (d), *Aristida congesta*, *A. diffusa*, *A. stipitata* subsp. *graciliflora*, *Eragrostis superba*, *Panicum maximum*, *Perotis patens*. Herbs: *Blepharis integrifolia*, *Chamaecrista absus*, *Evolvulus alsinoides*, *Geigeria burkei*, *Kyphocarpa angustifolia*, *Limeum fenestratum*, *L. viscosum*, *Lophiocarpus tenuissimus*, *Monsonia angustifolia*.

Conservation Least threatened. Target 19%. About 6% statutorily conserved, just over half of which in the Marakele National Park. About 4% transformed, mainly by cultivation. Erosion is generally low to very low.

Remark This unit is drier than the SVcb 12 Central Sandy Bushveld vegetation unit and is distinguished from it by the presence of such species as *Acacia erubescens*, *A. nigrescens* and *Combretum imberbe* and general absence of species such as *Burkea africana* and *Ochna pulchra*.

References Herbst (1973), Peel et al. (1991), Brown & Bredenkamp (1994), Brown et al. (1995, 1996, 1997), Winterbach (1998), Winterbach et al. (2000).

SVcb 17 Waterberg Mountain Bushveld

VT 20 Sour Bushveld (73%) (Acocks 1953). LR 12 Waterberg Moist Mountain Bushveld (83%) (Low & Rebelo 1996).

Distribution Limpopo Province: Waterberg Mountains, including the foothills, escarpment and tablelands south of the line between Lephalale and Marken and north of Bela-Bela and west of Mokopane and with outliers in the southwest such as the Boshofsberge and Vlieëpoortberge near Thabazimbi. Altitude about 1 000–1 600 m and generally at a lower altitude than the Gm 29 Waterberg-Magaliesberg Summit Sourveld.

Vegetation & Landscape Features Rugged mountains with vegetation grading from *Faurea saligna*–*Protea caffra* bushveld on higher slopes (in turn grading into the Gm 29 Waterberg-Magaliesberg Summit Sourveld) through

broad-leaved deciduous bushveld (dominated by *Diplorhynchus condylocarpon*) on rocky mid- and footslopes to *Burkea africana*–*Terminalia sericea* savanna in the lower-lying valleys as well as on deeper sands of the plateaus. The grass layer is moderately developed or well developed.

Geology & Soils Mainly sandstone, subordinate conglomerate, siltstone and shale of the Kransberg Subgroup and medium- to coarse-grained sandstone, conglomerate, trachytic lava and quartz porphyry of the Swaershoek Formation, Nylstroom Subgroup (both Mokolian Waterberg Group). Dystrophic, acidic sandy, loamy to gravelly soil. Glenrosa and Mispah Forms. Land types mainly lb, Ac, Fa and Ad.

Climate Summer rainfall with very dry winters. MAP from about 500 mm in the lower-altitude northwest to about 750 mm on the higher parts of the main east-west range. Frost fairly frequent in winter. See also climate diagram for SVcb 17 Waterberg Mountain Bushveld.

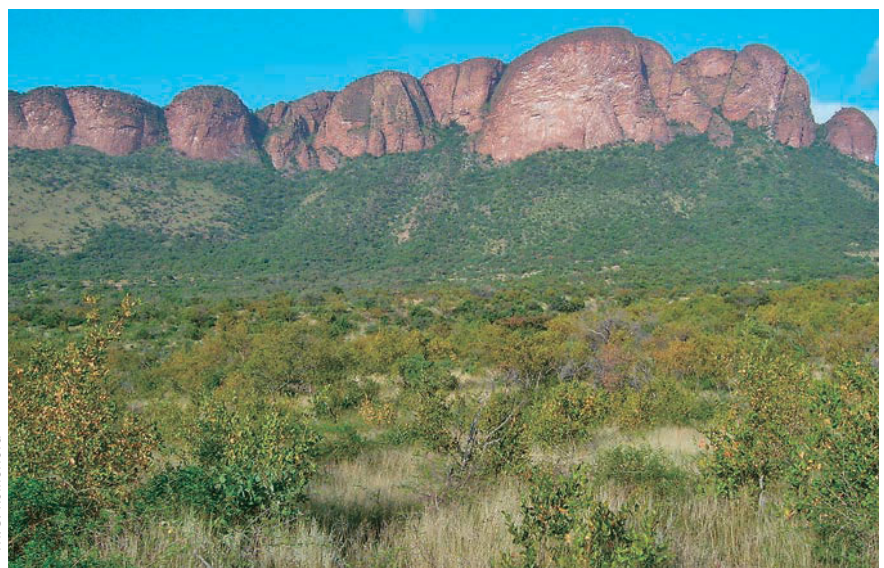


Figure 9.26 SVcb 17 Waterberg Mountain Bushveld: West-facing slopes with *Combretum apiculatum*, *Dichrostachys cinerea* and *Grewia monticola* at 1 235 m within the Marakele National Park, Thabazimbi District.

Important Taxa Tall Tree: *Acacia robusta*. Small Trees: *Acacia caffra* (d), *Burkea africana* (d), *Combretum apiculatum* (d), *Croton gratissimus* (d), *Cussonia transvaalensis* (d), *Faurea saligna* (d), *Heteropyxis natalensis* (d), *Ochna pulchra* (d), *Protea caffra* (d), *Albizia tanganyicensis*, *Combretum molle*, *Englerophytum magalismontanum*, *Ficus burkei*, *F. glumosa*, *Ochna pretoriensis*, *Pseudolachnostylis maprouneifolia*, *Rhus lancea*, *Terminalia sericea*, *Vangueria infausta*, *V. parvifolia*. Tall Shrubs: *Diploerhynchus condylocarpon* (d), *Elephantorrhiza burkei* (d), *Combretum moggii*, *C. nelsonii*, *Dichrostachys cinerea*, *Euclea crispa* subsp. *crispa*, *Gnidia kraussiana*, *Olea capensis* subsp. *enervis*, *O. europaea* subsp. *africana*, *Rhus pyroides* var. *pyroides*, *Strychnos pungens*, *Vitex rehmannii*. Low Shrubs: *Anthospermum rigidum* subsp. *rigidum*, *Barleria affinis*, *Felicia muricata*, *Helichrysum kraussii*, *Protea welwitschii* subsp. *welwitschii*, *Rhus rigida* var. *dentata*. Geoxylic Suffrutes: *Dichapetalum cymosum*, *Parinari capensis* subsp. *capensis*. Succulent Shrubs: *Aloe chabaudii*, *Lopholaena coriifolia*. Woody Climbers: *Ancylobotrys capensis* (d), *Rhoicissus revollii*. Graminoids: *Loudetia simplex* (d), *Schizachyrium sanguineum* (d), *Trachypogon spicatus* (d), *Brachiaria serrata*, *Digitaria eriantha* subsp. *eriantha*, *Elionurus muticus*, *Enneapogon scoparius*, *Setaria sphacelata*, *Themeda triandra*, *Tristachya leucothrix*. Herbs: *Berkheya insignis*, *Chamaecrista mimosoides*, *Geigeria elongata*, *Hibiscus meyeri* subsp. *transvaalensis*, *Xerophyta retinervis*. Geophytic Herbs: *Haemanthus humilis* subsp. *humilis*, *Hypoxis rigidula*.

Biogeographically Important Taxa (^{CB}Central Bushveld endemic, ^NNorthern Sourveld endemic) Small Tree: *Encephalartos eugene-maraisii*^N. Tall Shrub: *Erythrophysa transvaalensis*^{CB}. Soft Shrub: *Chorisochora transvaalensis*^N. Graminoid: *Mosdenia leptostachys*^{CB}.

Endemic Taxa Tall Shrubs: *Grewia rogersii*, *Pachystigma triflorum*. Herb: *Oxygonum dregeanum* subsp. *canescens* var. *pilosum*.

Conservation Least threatened. Target 24%. About 9% statutorily conserved mainly in the Marakele National Park and Moepel Nature Reserve. More than 3% transformed, mainly by cultivation. Human population density is low. Erosion is generally very low to low.

Remark Carrying capacity of the vegetation for domestic stock animals is low, especially during the dry season.

References Coetzee et al. (1981), Westfall (1981), Westfall et al. (1983, 1985), Ben-Shahar (1988), Van Staden (2002), Van Staden & Bredenkamp (2005).

SVcb 18 Roodeberg Bushveld

VT 18 Mixed Bushveld (65%) (Acocks 1953). LR 18 Mixed Bushveld (60%) (Low & Rebelo 1996).

Distribution Limpopo Province: Straddling the Tropic of Capricorn, occurs from Marken and Villa Nora in the south through Baltimore to near Swartwater in the north and to the plains around the base of the Blouberg and Lerataupje Mountains in the northeast. Altitude about 850–1 100 m.



Figure 9.27 SVcb 18 Roodeberg Bushveld: Moderately dense bushveld dominated by *Kirkia acuminata*, *Combretum apiculatum*, *Dichrostachys cinerea*, *Terminalia sericea* and *Acacia* species on the Farm Goedgedacht west of Marken in the Mokopane District.

Vegetation & Landscape Features Plains and slightly undulating plains, including some low hills, with short closed woodland to tall open woodland and poorly developed grass layer. *Kirkia acuminata* trees not limited to hills.

Geology & Soils Mainly sandstone, conglomerate, siltstone and shale of the Kransberg and Matlabas Subgroups (Mokolian Waterberg Group). Gneisses, metasediments and metavolcanic rocks of the Malala Drift Group, Beit Bridge Complex (Swazian Erathem) occur in the north. Granite of the Lebowa Granite Suite (Bushveld Igneous Complex) is also present. A variety of soil types, but mostly sandy soils, red-yellow apedal high base status, also dystrophic or mesotrophic. Almost half the area is Ae land type, with remainder divided between mainly Fa, Bc, Ac, Fc, Ia and Fb.

Climate Summer rainfall with very dry winters. MAP 400–550 mm. Frost fairly infrequent. Mean monthly maximum and minimum temperatures for Marnitz 37.1°C and 0.2°C for November and June, respectively. See also climate diagram for SVcb 18 Roodeberg Bushveld.

Important Taxa Tall Trees: *Acacia burkei* (d), *A. nigrescens* (d), *A. robusta* (d), *A. erioloba*, *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Acacia erubescens* (d), *A. mellifera* subsp. *detinens* (d), *A. nilotica* (d), *A. tortilis* subsp. *heteracantha* (d), *Combretum apiculatum* (d), *Kirkia acuminata* (d), *Acacia grandicornuta*, *A. luederitzii* var. *retinens*, *A. senegal* var. *leiorhachis*, *Albizia harveyi*, *Combretum imberbe*, *Commiphora mollis*, *Rhus lancea*, *Terminalia sericea*, *Ziziphus mucronata*. Tall Shrubs: *Dichrostachys cinerea* (d), *Grewia flava* (d), *Euclea crispa* subsp. *crispa*, *E. undulata*, *Grewia monticola*, *Hibiscus micranthus*. Low Shrubs: *Commiphora africana*, *Melhaniea acuminata*, *Sida cordifolia*, *Solanum delagoense*. Graminoids: *Aristida canescens* (d), *Chloris virgata* (d), *Digitaria eriantha* subsp. *eriantha* (d), *Enneapogon cenchroides* (d), *Eragrostis rigidior* (d), *Panicum maximum* (d), *Urochloa mosambicensis* (d), *Aristida congesta*, *Brachiaria deflexa*, *Cymbopogon pospischilii*, *Cynodon dactylon*, *Eragrostis rotifer*. Herbs: *Achyranthes aspera*, *Corbichonia decumbens*, *Hemizygia elliottii*, *Kyphocarpa angustifolia*, *Seddera capensis*, *Tephrosia purpurea* subsp. *leptostachya*, *Waltheria indica*.

Conservation Least threatened. Target 19%. Almost 6% statutorily conserved, mainly in the Wonderkop and Blouberg (Malebocho) Nature Reserves. An additional 3% conserved in other reserves, mainly in areas adjacent to the Wonderkop Nature Reserve. About 18% transformed, mainly by cultivation, with very little urban and built-up areas. Erosion is low to high. The area is mostly used for game ranching.

References Schmidt et al. (1993, 1994), Schulze et al. (1994), Winterbach (1998), J.M. van Staden (unpublished data).

SVcb 19 Limpopo Sweet Bushveld

VT 14 Arid Sweet Bushveld (74%) (Acocks 1953). LR 17 Sweet Bushveld (65%) (Low & Rebelo 1996).

Distribution Limpopo Province: Extends from the lower reaches of the Crocodile and Marico Rivers around Makoppa and Derdepoort, respectively, down the Limpopo River Valley including Lephalale and into the tropics past Tom Burke to the Usutu border post and Taaiboschgroet area in the north. Altitude about 700–1 000 m. The unit also occurs on the Botswana side of the border.

Vegetation & Landscape Features Plains, sometimes undulating or irregular, traversed by several tributaries of the Limpopo River. Short open woodland; in disturbed areas thickets of *Acacia erubescens*, *A. mellifera* and *Dichrostachys cinerea* are almost impenetrable.

Geology & Soils The northern half of the area is dominated by gneisses, metasediments and metavolcanics of the Malala Drift Group, Beit Bridge Complex (Swazian Erathem), basalts of the Letaba Formation (Lebombo Group of the Karoo Supergroup) are also found in the northeast. Sandstone, siltstone and mudstone of the Clarens Formation (Karoo Supergroup), as well as of the Matlabas Subgroup (Mokolian Waterberg Group) are found to the south and west. Soils with calcrete and surface limestone layers, brownish sandy (Clovelly soil form) clayey-loamy soils (Hutton soil form) on the plains and low-lying areas, with shallow, gravelly, sandy soils on the slightly undulating areas, localised areas of black clayey soils (Valsrivier or Arcadia soil forms) and Kalahari sand. Land types mainly Ae, Ah and Fc.

Climate Summer rainfall with very dry winters including the shoulder months of May and September. MAP from about 350 mm in the northeast to about 500 mm in the southwest.

Frost fairly infrequent. Mean monthly maximum and minimum temperatures for Lephalale 38.2°C and 2.1°C for December and June, respectively. See also climate diagram for SVcb 19 Limpopo Sweet Bushveld.

Important Taxa Tall Trees: *Acacia robusta* (d), *A. burkei*. Small Trees: *Acacia erubescens* (d), *A. fleckii* (d), *A. nilotica* (d), *A. senegal* var. *rostrata* (d), *Albizia anthelmintica* (d), *Boscia albi-trunca* (d), *Combretum apiculatum* (d), *Terminalia sericea*. Tall Shrubs: *Catophractes alexandri* (d), *Dichrostachys cinerea* (d), *Phaeoptilum spinosum* (d), *Rhigozum obovatum* (d), *Cadaba aphylla*, *Combretum hereroense*, *Commiphora pyracanthoides*, *Ehretia rigida* subsp. *rigida*, *Euclea undulata*, *Grewia flava*, *Gymnosporia senegalensis*. Low Shrubs: *Acacia tenuispina* (d), *Commiphora africana*, *Felicia muricata*, *Gossypium herbaceum* subsp. *africanum*, *Leucosphaera bainesii*. Graminoids: *Digitaria eriantha* subsp. *eriantha* (d), *Enneapogon cenchroides* (d), *Eragrostis lehmanniana* (d), *Panicum coloratum* (d), *Schmidtia pappophoroides* (d), *Aristida congesta*, *Cymbopogon nardus*, *Eragrostis pallens*, *E. rigidior*, *E. trichophora*, *Ischaemum afrum*, *Panicum maximum*, *Setaria verticillata*, *Stipagrostis uniplumis*, *Urochloa mosambicensis*. Herbs: *Acanthosicyos naudinianus*, *Commelina benghalensis*, *Harpagophytum procumbens* subsp. *transvaalense*, *Hemizygia elliottii*, *Hermibstaedtia odorata*, *Indigofera daleoides*. Succulent Herbs: *Kleinia fulgens*, *Plectranthus neochilus*.

Biogeographically Important Taxon (Central Bushveld endemic) Succulent Herb: *Piранthus atosanguineus*.

Conservation Least threatened. Target 19%. Less than 1% statutorily conserved and limited to reserves straddling the southeastern limits of the unit, for example the D'Nyala Nature Reserve. Very little conserved in other reserves. About 5% transformed, mainly by cultivation. Erosion is low to high.

Remark Though limited by low rainfall, this is a good area for game and cattle farming due to the high grazing capacity of sweet veld.

References Bosch (1971), Herbst (1973), Panagos et al. (1986), Pauw (1988), Peel (1990), Van Staden (1991).

SVcb 20 Makhado Sweet Bushveld

VT 18 Mixed Bushveld (51%) (Acocks 1953). LR 18 Mixed Bushveld (44%), LR 17 Sweet Bushveld (43%) (Low & Rebelo 1996).

Distribution Limpopo Province: Straddling the Tropic of Capricorn, occurs on the plains south of the Soutpansberg, east of the Waterberg and on the apron surrounding the Blouberg and Lerataupje Mountains, and north of the Polokwane Plateau and west of the escarpment, with extensions to Mokopane to the south and to the north near Vivo. Altitude about 850–1 200 m.

Vegetation & Landscape Features Slightly to moderately undulating plains sloping generally down to the north, with some hills in the southwest. Short and shrubby bushveld with a poorly developed grass layer.

Geology & Soils The area is underlain by the gneisses and migmatites of the Hout River Gneiss (Randian Erathem) and the potassium-deficient gneisses



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Figure 9.28 SVcb 19 Limpopo Sweet Bushveld: Open bushveld dominated by *Acacia senegal* at 740 m on the Farm Kwarel between Maasroom and Alldays (Limpopo Province).

of the Goudplaats Gneiss (Swazian Erathem). Sandstones and mudstones of the Matlabas Subgroup (Mokolian Waterberg Group) are also found. Soils include deep, greyish sands, eutrophic plinthic catenas, red-yellow apedal freely drained soils with high base status, clayey in bottomlands. Land types mainly Bd, Bc, Ae and Ia.

Climate Summer rainfall with very dry winters. MAP about 350–550 mm. Frost fairly infrequent. Mean monthly maximum and minimum temperatures for Mara-Agr 36.5°C and –0.8°C for November and June, respectively. See also climate diagram for SVcb 20 Makhado Sweet Bushveld.

Important Taxa Small Trees: *Acacia erubescens* (d), *A. gerrardii* (d), *A. mellifera* subsp. *detinens* (d), *A. rehmanniana* (d), *Boscia albitrunca* (d), *Combretum apiculatum* (d), *Acacia tortilis* subsp. *heteracantha*, *Terminalia sericea*. Tall Shrubs:

Commiphora pyracanthoides, *Dichrostachys cinerea*, *Grewia flava*, *Hibiscus calyphyllus*, *Lycium shawii*, *Rhigozum obovatum*. Low Shrubs: *Barleria lancifolia*, *Hirpicium bechuanense*, *Indigofera polioties*, *Melhanie rehmannii*, *Pechuel-Loeschea leubnitziae*. Graminoids: *Antheophora pubescens* (d), *Aristida stipitata* subsp. *graciliflora* (d), *Cenchrus ciliaris* (d), *Enneapogon scoparius* (d), *Brachiaria nigropedata*, *Eragrostis trichophora*, *Panicum coloratum*, *P. maximum*, *Schmidtia pappophoroides*, *Urochloa mosambicensis*. Herbs: *Chamaecrista absus*, *Corbichonia decumbens*, *Geigeria acaulis*, *Harpagophytum procumbens* subsp. *transvaalense*, *Heliotropium steudneri*, *Hemizygia elliottii*, *Hermbsstaedtia odorata*, *Leucas sexdentata*, *Osteospermum muricatum*, *Tephrosia purpurea* subsp. *leptostachya*.

Endemic Taxon Herb: *Dicliptera minor* subsp. *pratis-manna*.

Conservation Vulnerable. Target 19%. About 1% statutorily conserved, mainly in the Bellevue Nature Reserve. Some 27% transformed, mainly by cultivation, with some urban and built-up areas. The southwestern half of the unit has densely populated rural communities. Erosion is low to high.

Remark This area is transitional between the higher-lying Polokwane Plateau and the lower-lying vegetation units of the Limpopo River Valley.

Reference Peel (1990).

SVcb 21 Soutpansberg Mountain Bushveld

VT 8 North-Eastern Mountain Sourveld (38%), VT 19 Sourish Mixed Bushveld (34%) (Acocks 1953). LR 21 Sour Lowveld Bushveld (56%) (Low & Rebelo 1996).

Distribution Limpopo Province: Occurs on the slopes of the Soutpansberg Mountain, and Blouberg and Lerataupje Mountains in the west. Extends eastward on lower ridges including Khaphamali and Makonde Mountains. Altitude about 600–1 500 m.

Vegetation & Landscape Features Low to high mountains, highest in the west, splitting into increasing number of lower mountain ridges towards the east. Dense tree layer and poorly developed grassy layer. The topography of the east-west-



Figure 9.29 SVcb 21 Soutpansberg Mountain Bushveld: Sour bushveld on steep slopes of the Soutpansberg in the Wyllie's Poort north of Makhado, Limpopo Province.

orientated ridges of the mountain changes drastically over short distances, resulting in orographic rain on the southern ridges, and a rainshadow effect on the northern ridges. Because of this topographic diversity, the Soutpansberg Mountain Bushveld comprises a complex mosaic of sharply contrasting kinds of vegetation within limited areas. The main vegetation variations within the Soutpansberg Mountain Bushveld are subtropical moist thickets (mainly along the lower-lying southern slopes, on steep clayey soils of volcanic origin), mistbelt bush clumps (within the mistbelt of the southern and central ridges of the mountain, on rugged quartzitic outcrops with shallow sandy soils), relatively open savanna sandveld (on both deep and shallow quartzitic sands along the relatively dry middle and northern slopes of the mountain), and arid mountain bushveld (along the very arid northern ridges of the mountain).

Geology & Soils Reddish or brown, sandstone and quartzite, conglomerate, basalt, tuff, shale and siltstone of the Soutpansberg Group (including the Wyllie's Poort, Fundudzi and Nzhelele Formations), Mokolian Erathem. Rocky areas with miscellaneous soils including acidic dystrophic to mesotrophic sandy to loamy soil. Glenrosa and Mispah soil forms are common. Land types mainly Ib, Ab, Fa, Fb, Ae and Ia.

Climate Summer rainfall with dry winters. MAP about 450–900 mm. Frost infrequent. See also climate diagram for SVcb 21 Soutpansberg Mountain Bushveld.

Important Taxa **Subtropical moist thickets:** Small Trees: *Catha edulis* (d), *Acacia karroo*, *Berchemia zeyheri*, *Bridelia mollis*, *Combretum molle*, *Dombeya rotundifolia*, *Dovyalis zeyheri*, *Kirkia acuminata*, *Mystroxydon aethiopicum* subsp. *schlechteri*, *Plectroniella armata*, *Zanthoxylum capense*, *Ziziphus mucronata*. Tall Shrubs: *Flueggea virosa* (d), *Carissa edulis*, *Grewia occidentalis*, *Rhus pentheri*. Low Shrub: *Pavonia burchellii*. **Mistbelt bush clumps:** Small Trees: *Englerophytum magalismontanum* (d), *Mimusops zeyheri* (d), *Syzygium legatii* (d), *Apodytes dimidiata* subsp. *dimidiata*, *Combretum molle*, *Heteropyxis natalensis*, *Maytenus undata*. Tall Shrubs: *Coddia rudis*, *Combretum moggii*, *Euclea linearis*, *Hyperacanthus amoenus*, *Olea capensis* subsp. *enervis*, *Vitex rehmannii*. Low Shrubs: *Rhus magalismontana* subsp. *coddii* (d), *Helichrysum kraussii*, *Heteromorpha stenophylla* var. *transvaalensis*, *Myrothamnus flabellifolius*. Geoxylic Suffrutex: *Parinari capensis* subsp. *capensis* (d). Succulent

Shrubs: *Aloe arborescens*, *Kalanchoe sexangularis*. Graminoids: *Coleochloa setifera* (d), *Setaria sphacelata* (d), *Melinis nerviglumis*, *Trachypogon spicatus*. Herbs: *Fadogia homblei* (d), *Dicoma anomala*, *Felicia mossamedensis*, *Gerbera viridifolia*, *Vernonia natalensis*. Succulent Herbs: *Crassula swaziensis*, *Plectranthus cylindraceus*. **Open savanna sandveld:** Small Trees: *Burkea africana* (d), *Ochna pulchra* (d), *Combretum apiculatum*, *Ochna pretoriensis*, *Pseudolachnostylis maprouneifolia*, *Terminalia sericea*. Tall Shrubs: *Corchorus kirkii*, *Diplorhynchus condylocarpon*, *Elephantorrhiza burkei*, *Strychnos madagascariensis*. Graminoids: *Centropodia glauca* (d), *Enneapogon cenchroides*. Herb: *Xerophyta retinervis* (d). **Arid mountain bushveld:** Tall Trees: *Acacia nigrescens*, *Adansonia digitata*. Small Trees: *Combretum apiculatum*, *Commiphora glandulosa*, *C. mollis*. Tall Shrub: *Tinnea rhodesiana*. Low Shrubs: *Blepharis diversispina*, *Gossypium herbaceum* subsp. *africanum*. Woody Climber: *Acacia ataxacantha*. Herb: *Hibiscus meyeri* subsp. *transvaalensis*. Succulent Herb: *Kleinia fulgens*.

Biogeographically Important Taxa (Soutpansberg endemics) Succulent Herbs: *Aloe vossii*, *Huernia whitesloaneana*, *Orbea conjuncta*, *Stapelia clavicorona*.

Endemic Taxa Tall Shrubs: *Combretum vendae*, *Vangueria soutpansbergensis*. Low Shrubs: *Blepharis spinipes*, *Dicoma montana*, *Justicia montis-salinarum*, *Tylophora coddii*. Succulent Shrub: *Kalanchoe crundallii*. Herbaceous Climber: *Ipomoea bisavium*. Graminoid: *Panicum dewinteri*. Herb: *Streptocarpus caeruleus*. Succulent Herbs: *Aloe swynnertonii*, *Huernia nouhuysii*.

Conservation Vulnerable. Target 24%. Just over 2% statutorily conserved in the Blouberg, Happy Rest and Nwanedi Nature Reserves. A smaller area is conserved in other reserves. Some 21% transformed, with about 14% cultivated and 6% plantations. High rural human population densities in some of the lower lying parts of the eastern section of the unit. Erosion is very low to moderate.

Remarks This unit is part of the Soutpansberg CE (Van Wyk & Smith 2001). The unit has patches of Northern Mistbelt Forest and Northern Escarpment Afromontane Fynbos embedded in its generally south-facing, upper elevation reaches in the central-western parts. Also embedded are patches of Soutpansberg Summit Sourveld, generally but not always, at elevations higher than the unit. VhaVenda Miombo is also embedded very locally at a lower elevation in the eastern part of the unit. Further research, particularly in the eastern section of this unit, may indicate a revision of this unit.

References Scholes (1979), Van Jaarsveld & Hardy (1991), Van Wyk & Smith (2001), N. Hahn (unpublished data), T.H.C. Mostert (unpublished data), C.H. Verwey (unpublished data).

SVcb 22 VhaVenda Miombo

VT 19 Sourish Mixed Bushveld (100%) (Acocks 1953). LR 11 Soutpansberg Arid Mountain Bushveld (100%) (Low & Rebelo 1996).

Distribution Limpopo Province: As far as is known, it is limited to a small area in the upper reaches of the Mbodi River Valley

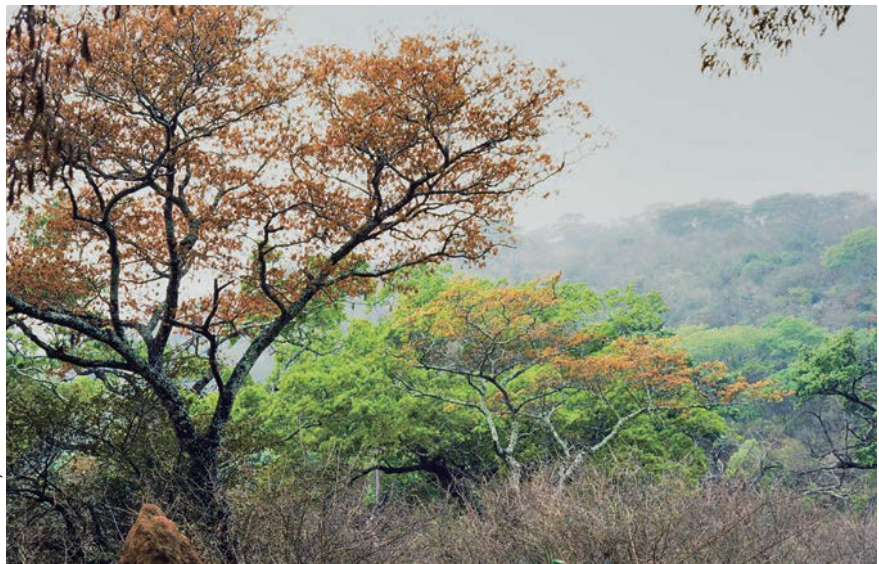


Figure 9.30 SVcb 22 VhaVenda Miombo: Hillslopes with savanna dominated by *Brachystegia spiciformis* in the Mbodi River Valley (Soutpansberg), Limpopo Province.

between Shakadaza and Mafukani within the eastern extension of SVcb 21 Soutpansberg Mountain Bushveld. Altitude about 750–850 m.

Vegetation & Landscape Features Moderately gentle to some steeper slopes with surface stone, in a narrow valley straddling a north-flowing section of the Mbodi River. Fragmented, archipelago of patches with tallest *Brachystegia spiciformis* trees toward the centres of the islands. Tree layer very broken and irregular cover of larger and smaller shrubs. Understorey is species-poor with mainly *Senecio barbertonicus* on deeper soils and *Cyanotis lapidosa* on the shallow soils. Very sparse ground cover with grasses virtually limited to streambanks.

Geology & Soils Sandstone and quartzite of the Wyllie's Poort Formation (Mokolian Soutpansberg Group). Shallow sand with rock and deeper sands in some places. Land type is Ib.

Climate Summer rainfall with very dry winters. MAP about 670–680 mm. Frost very infrequent. See also climate diagram for SVcb 22 VhaVenda Miombo.

Important Taxa Small Trees: *Azelia quanzensis*, *Albizia adianthifolia*, *Berchemia discolor*, *Bridelia mollis*, *Burkea africana*, *Combretum collinum* subsp. *gazense*, *Englerophytum magalismontanum*, *Erythrina lysistemon*, *Ficus glumosa*, *F. sansibarica*, *F. sur*, *Parinari curatellifolia*, *Peltophorum africanum*, *Plectroniella armata*, *Syzygium cordatum*, *S. guineense*, *Tabernaemontana elegans*, *Ximenia caffra*, *Xylopia odoratissima*, *Zanthoxylum capense*, *Z. lepreurii*, *Ziziphus mucronata*. Succulent Trees: *Euphorbia confinalis*, *E. ingens*, *E. tirucalli*. Tall Shrubs: *Coddia rudis*, *Grewia flavescens*, *Hexalobus monopetalus*, *Lagynias dryadum*, *Strychnos madagascariensis*, *S. pungens*. Low Shrub: *Rhus magalismontana* subsp. *coddii*. Succulent Shrubs: *Senecio barbertonicus* (d), *Kalanchoe lanceolata*, *K. rotundifolia*, *K. sexangularis*. Woody Climbers: *Acacia schweinfurthii*, *Artabotrys brachypetalus*, *Bauhinia galpinii*, *Cissus quadrangularis*, *Tecoma capensis*. Herbaceous Climber: *Senecio tamoides*. Herbs: *Cyanotis lapidosa*, *Portulaca kermesina*. Geophytic Herbs: *Asplenium schelpei*, *Cheilanthes viridis* var. *glauca*, *Cyrtorchis praetermissa*, *Sansevieria aethiopica*, *S. hyacinthoides*. Succulent Herbs: *Aloe aculeata*, *Crassula lanceolata*. Epiphytic Succulent Herb: *Ansellia africana*.

Biogeographically Important Taxon (Southern distribution limit in South Africa) Small Tree: *Brachystegia spiciformis* (d).

Conservation The unit is not conserved. The village of Gundane is in very close proximity to and extends into the southern part of the unit. The vegetation is heavily impacted by grazing (with grass cover virtually zero), wood-collecting (with at least half of the *Brachystegia spiciformis* trees estimated to have been removed, also to allow for a *Eucalyptus* plantation; P.J.H. Hurter, personal communication) and slash agriculture, mainly maize and a type of *Solanum* used as a relish. The alien *Opuntia ficus-indica* is common. A popular ecotourism lodge is situated within the unit.

Remarks *Brachystegia spiciformis* is one of the most important dominant species of miombo woodlands typical of southern, central and parts of eastern Africa, where they cover more than 2.7 million km². The occurrence of this species in South Africa was scientifically ascertained only recently (Van Wyk & Hurter 2000). It has been previously known from pollen records dated 19 000 years BP (Scott 1982) and its occurrence in the Soutpansberg (where it totals only a few thousand individuals) might be a relict of former larger distribution of miombo (see also Campbell 1996). Despite the assertion that these *Brachystegia spiciformis* patches do not constitute miombo relict vegetation (Hahn 2002), there are a number of species in the unit that occur in various miombo vegetation types to the north. These include: *Azelia quanzensis*, *Albizia adianthifolia*, *Burkea africana*, *Combretum collinum*, *Parinari curatellifolia*, *Strychnos pungens*, *Syzygium guineense* and *Tabernaemontana elegans* (Werger & Coetzee 1978). The vegetation unit contains an unusually high proportion of succulent species compared to other miombo types. None of the Soutpansberg endemic species have been recorded in the unit.

References Van Wyk & Hurter (2000), Hurter & Van Wyk (2001), Willis et al. (2001), Hahn (2002).

SVcb 23 Polokwane Plateau Bushveld

VT 67 Pietersburg Plateau Grassveld (50%) (Acocks 1953). LR 18 Mixed Bushveld (88%) (Low & Rebelo 1996).

Distribution Limpopo Province: The higher-lying plains around Polokwane, north of the Strydpoort Mountains and south of the SVcb 20 Makhado Sweet Bushveld. Altitude about 1 100–1 500 m.



Figure 9.31 SVcb 23 Polokwane Plateau Bushveld: Very open savanna with low *Acacia tortilis* trees at an altitude of 1 250 m on Pilgrimshoop, north of Polokwane.

Vegetation & Landscape Features Moderately undulating plains with short open tree layer with a well-developed grass layer to grass plains with occasional trees at higher altitudes (for example the Mashashane area in the southwest and the south-eastern watershed of the Sand River catchment, such as around Eersteling). Hills and low mountains of SVcb 24 Mamabolo Mountain Bushveld are embedded within this unit.

Geology & Soils Migmatites and gneisses of the Hout River Gneiss and the Turfloop Granite (both of Randian Erathem) are dominant. Some ultramafic and mafic metavolcanics, quartzite and chlorite schist of the Pietersburg Group (Swazian Erathem) are also found. Soils variable, with freely drained soils with high base status, some dystrophic/mesotrophic, eutrophic plinthic catenas. Glenrosa and Mispah soil forms. Land types mainly Ae, Bd, Ah, Ab, Bc and Fa.

Climate Summer rainfall with very dry winters. MAP from about 400 mm in the northwest to about 600 mm where it borders on the foot of mountains to the east and south. Frost fairly infrequent. Mean monthly maximum and minimum temperatures for Polokwane 33.2°C and 0.6°C for October and June, respectively. See also climate diagram for SVcb 23 Polokwane Plateau Bushveld.

Important Taxa Small Trees: *Acacia caffra* (d), *A. permixta* (d), *A. rehmanniana* (d), *A. karroo*, *A. tortilis* subsp. *heteracantha*, *Combretum molle*, *Ormocarpum kirkii*, *Ziziphus mucronata*. Succulent Tree: *Aloe marlothii* subsp. *marlothii*. Tall Shrubs: *Acacia hebeclada* subsp. *hebeclada* (d), *Gymnosporia senegalensis* (d), *Combretum hereroense*, *Diospyros lycioides* subsp. *sericea*, *Euclea crispa* subsp. *crispa*, *Heteromorpha arborescens* var. *abyssinica*, *Lippia javanica*, *Rhus pyroides* var. *pyroides*, *Tephrosia rhodesica*, *Triumfetta pilosa* var. *tomentosa*. Low Shrubs: *Anthospermum rigidum* subsp. *rigidum*, *Gymnosporia glaucophylla*, *Hirpicium bechuanense*, *Lantana rugosa*, *Senecio burchellii*, *Sida rhombifolia*, *Solanum panduriforme*. Succulent Shrub: *Aloe cryptopoda*. Woody Climber: *Asparagus africanus*. Herbaceous Climbers: *Momordica balsamina*, *Rubia petiolaris*. Graminoids: *Aristida diffusa* (d), *Brachiaria nigropedata* (d), *Digitaria eriantha* subsp. *eriantha* (d), *Eragrostis curvula* (d), *Themeda triandra* (d), *Aristida congesta*, *Cymbopogon caesus*, *Cynodon dactylon*, *Digitaria diagonalis*, *Diheteropogon amplexens*, *Elionurus muticus*, *Eragrostis gummiflua*, *E. racemosa*, *E. superba*, *Eustachys paspaloides*, *Panicum maximum*, *Pogonarthria squarrosa*, *Sporobolus africanus*. Herbs: *Felicia mossamedensis*, *Hermibstaedtia odorata*, *Pollichia campestris*. Geophytic Herbs: *Eulophia petersii*, *Hypoxis hemerocallidea*. Succulent Herb: *Aloe greatheadii* var. *greatheadii*.

Biogeographically Important Taxa (Central Bushveld endemics) Graminoid: *Mosdenia leptostachys*. Herb: *Oxygonum dregeanum* subsp. *canescens* var. *dissectum*. Geophytic Herb: *Ledebouria crispa*.

Conservation Least threatened according to remote sensing sources, but with over one third of the remaining vegetation regarded as degraded, would probably be regarded as susceptible. Target 19%. Less than 2% statutorily conserved mainly in the Percy Fyfe and Kuschke Nature Reserves. In addition, 0.7% conserved in other reserves, for example the Polokwane Game Reserve. Some 17% transformed, including about 10% cul-

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tivated and 6% urban and built-up. Dense concentration of rural human settlements is found particularly in the eastern and northwestern parts of the unit. In some regions, scattered populations of alien *Agave*, *Jacaranda mimosifolia*, *Melia azedarach*, *Opuntia ficus-indica* and *Ricinus communis* are of concern. Erosion is high to moderate.

Remark Woody plants have increased in parts of the unit in the past few decades.

References Bredenkamp & Van Vuuren (1977), Bredenkamp (1986b), Winterbach (1998).

SVcb 24 Mamabolo Mountain Bushveld

VT 19 Sourish Mixed Bushveld (43%), VT 8 North-Eastern Mountain Sourveld (32%) (Acocks 1953). LR 43 North-eastern Mountain Grassland (53%) (Low & Rebelo 1996).

Distribution Limpopo Province: East and south of the Polokwane Plateau along the foothills of the west-facing part of the eastern escarpment and of the Strydpoort and Makapan Mountains. Also on main isolated hills and small mountains embedded within the Polokwane Plateau as far as Mogoshi Mountain in the west and De Loskop (near Mogwadi) and Renosterkoppies (around Zandriviervoorpoort) to the north. Altitude mostly 1 200–1 600 m.

Vegetation & Landscape Features Low mountains, lower slopes of Strydpoort and Makapan ranges, and rocky hills. Slopes are moderate to steep, and very rocky, covered by small trees and shrubs. Rock slabs or domes are sparsely vegetated, and then mostly with a mixture of xerophytic or resurrection plants, with several succulents.

Geology & Soils Very varied geology includes basement granite and gneiss, clastic sediments of the Pretoria Group (Vaalian) and ultramafic and mafic metavolcanics of the Pietersburg Group (Swazian). Shallow and skeletal soil (including Mispah and Glenrosa soil forms). Land types mainly Ib and Fa.

Climate Summer rainfall with dry winters. MAP about 450–750 mm. Frost fairly infrequent. With the coolest mean annual temperature of all savanna units apart from the three mountain

bushveld units of the Highveld. See also climate diagram for SVcb 24 Mamabolo Mountain Bushveld.

Important Taxa Tall Tree: *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Combretum molle* (d), *Croton gratissimus* (d), *Heteropyxis natalensis* (d), *Acacia caffra*, *A. davyi*, *A. gerrardii*, *A. nilotica*, *Berchemia zeyheri*, *Cussonia natalensis*, *C. transvaalensis*, *Dombeya rotundifolia*, *Erythrina lysistemon*, *Lannea discolor*, *Maytenus undata*, *Pappea capensis*, *Rhus leptodictya*, *Schotia brachypetala*. Succulent Trees: *Euphorbia cooperi* (d), *Aloe marlothii* subsp. *marlothii*, *Euphorbia ingens*. Tall Shrubs: *Clerodendrum glabrum* (d), *Elephantorrhiza burkei* (d), *Acokanthera oppositifolia*, *A. rotundata*, *Buddleja saligna*, *Canthium mundianum*, *Carissa edulis*, *Ehretia obtusifolia*, *Euclea crispa* subsp. *crispa* (short, small-leaved form), *Grewia occidentalis*, *Hibiscus calyphyllus*, *Olea europaea* subsp. *africana*, *Pouzolzia mixta*, *Rhus pentheri*, *R. rehmanniana*, *Scutia myrtina*, *Tarchonanthes parvicapitulatus*. Low Shrubs: *Diospyros lycioides* subsp. *nitens* (d), *Grewia vernicosa* (d), *Barleria rotundifolia*, *Gossypium herbaceum* subsp. *africanum*, *Gymnosporia glaucophylla*, *Hermannia floribunda*, *Heteromorpha stenophylla* var. *transvaalensis*, *Lantana rugosa*, *Myrothamnus flabellifolius*, *Plinthus rehmannii*. Succulent Shrubs: *Kalanchoe sexangularis* (d), *Kleinia longiflora* (d), *Aloe arborescens*, *Cotyledon barbeyi*, *C. orbiculata* var. *orbiculata*, *Kalanchoe paniculata*, *K. rotundifolia*, *Senecio barbertonicus*, *Tetradenia riparia*. Woody Climbers: *Asparagus burchanani* (d), *Jasminum multipartitum* (d), *Acacia ataxacantha*, *Cryptolepis cryptolepidioides*. Herbaceous Climber: *Pentarrhinum insipidum*. Graminoids: *Cymbopogon caesius* (d), *Digitaria eriantha* subsp. *eriantha* (d), *Heteropogon contortus* (d), *Aristida congesta*, *A. diffusa*, *Enneapogon scoparius*, *Eragrostis rigidior*, *Tricholaena monachne*, *Triraphis andropogonoides*. Herb: *Vahlia capensis* subsp. *vulgaris*. Geophytic Herbs: *Boophone disticha*, *Drimia altissima*, *D. robusta*, *Eulophia petersii*. Succulent Herbs: *Aloe greatheadii* var. *greatheadii* (d), *Aeollanthus rehmannii*, *Avonia rhodesica*, *Crassula swaziensis*, *Plectranthus grandidentatus*, *P. hadiensis*.

Endemic Taxa Succulent Shrubs: *Euphorbia clivicola*, *Khadia media*.

Conservation Least threatened. Target 24%. Almost 8% statutorily conserved mainly in the Witvinger and Bewaarkloof Nature Reserves. About 6% transformed, including about 2% each of urban and built-up areas, plantations and cultivated land. Land uses include grazing, wood harvesting and medicinal plant collecting. Alien plants include *Nicotiana glauca*, *Opuntia* species and *Zinnia peruviana*. Erosion is generally moderate to very low, and high in some areas.

References Winter & Hahn (1999), Ndwana Exploration (Pty) Ltd (2003).

SVcb 25 Pong Dolomite Mountain Bushveld

VT 19 Sourish Mixed Bushveld (44%), VT 8 North-Eastern Mountain Sourveld (43%) (Acocks 1953). LR 43 North-eastern Mountain Grassland (96%) (Low & Rebelo 1996).

Distribution Limpopo and Mpumalanga Provinces: Mountain slopes from the area of the Abel Erasmus Pass in the south, more or less continuously northwards along the western rainshadow side of the escarpment, including Pong



Figure 9.32 SVcb 24 Mamabolo Mountain Bushveld: Granite koppie with abundant *Euphorbia cooperi* near Ga-Mankoen, east of Polokwane.

Mountain near Penge becoming discontinuous towards the Wolkberg and westwards along the Strydpoort Mountains to Chuniespoort and Mokopane. Altitude about 600–1 500 m extending to about 1 600 m in parts of the west.

Vegetation & Landscape Features Open to closed woodland with well-developed shrub layers. Low to high mountain slopes. Various slope angles, aspects and altitude, especially along the western extension.

Geology & Soils Geology almost entirely Malmani Formation dolomite of the Transvaal Supergroup with chert always inter-layered. Soils with high pH, rich in calcium and magnesium, and with low levels of phosphorus. Soils are usually shallow (Mispah soil form) and occasionally deep (Hutton and Griffin soil forms). Land types mainly lb and Fa.

Climate Summer rainfall with dry winters. MAP about 500–900 mm, lowest in the escarpment rainshadow and peaking near the border, with grassland at higher altitudes on the escarpment, lower on the Strydpoort Mountain part of this unit than on the escarpment. Mist absent and frost infrequent. See also climate diagram for SVcb 25 Pong Dolomite Mountain Bushveld.

Important Taxa Small Trees: *Hippobromus pauciflorus* (d), *Kirkia wilmsii* (d), *Seemannaralia gerrardii* (d), *Boscia albitrunca*, *Combretum hereroense*, *Croton gratissimus*, *Dombeya autumnalis*, *Vitex obovata* subsp. *wilmsii*. Succulent Tree: *Euphorbia tirucalli* (d). Tall Shrubs: *Pouzolzia mixta*, *Senna petersiana*. Low Shrubs: *Asparagus intricatus* (d), *Barleria rotundifolia*, *Euchaetis schlechteri*, *Rhynchosia nitens*. Geoxylic Suffrutex: *Ozoroa albicans*. Succulent Shrub: *Plectranthus xerophilus* (d). Woody Climbers: *Pristimera longipetiolata*, *Tecoma capensis*. Graminoids: *Bewsia biflora* (d), *Brachiaria serrata* (d), *Eragrostis lehmanniana* (d), *Loudetia simplex* (d), *Melinis repens* (d), *Panicum maximum* (d), *Themeda triandra* (d), *Enneapogon scoparius*, *Heteropogon contortus*, *Melinis nerviglumis*, *Panicum deustum*, *Tragus berteronianus*. Herb: *Stylochaeton natalensis*. Geophytic Herbs: *Cheilanthes dolomiticola* (d), *Sansevieria hyacinthoides*. Succulent Herb: *Plectranthus neochilus*.

Biogeographically Important Taxa (^NNorthern Sourveld endemic, ^{SK}Sekhukhune endemic) Small Tree: *Lydenburgia cassinoides*^{SK} (d). Low Shrub: *Asparagus fourei*^N. Soft Shrub: *Chorisochora transvaalensis*^N. Megaherb: *Dracaena transvaalensis*^N (d). Geophytic Herb: *Haemanthus pauculifolius*^N.



Figure 9.33 SVcb 25 Pong Dolomite Mountain Bushveld: Rocky deciduous woodland, dominated by *Kirkia wilmsii* and *Combretum hereroense* with *Aloe fosteri*, *Sarcostemma viminale* and *Plectranthus xerophilus* northeast of Penge Mine, Limpopo Province.

Endemic Taxa Small Trees: *Encephalartos dolomiticus*, *E. inopinus*. Low Shrub: *Melhania integra*. Succulent Shrubs: *Delosperma vandermerwei*, *Euphorbia grandialata*. Herbs: *Barleria dolomiticola*, *Lotononis pariflora*. Geophytic Herbs: *Brachystelma minor*, *B. parvulum*, *Gladiolus dolomiticus*, *G. pavonia*, *Ledebouria dolomiticola*. Succulent Herbs: *Aloe brandraaiensis*, *A. monotropa*, *Gasteria batesiana* var. *dolomitica*, *Huernia blyderiverensis*, *Plectranthus dolomiticus*.

Conservation Least threatened. Target 24%. Some 10% statutorily conserved mainly in the Bewaarkloof and Lekgalameetse Nature Reserves. An additional 6% conserved in other reserves including the Wolkberg (Serala) Wilderness Area. About 6% transformed, mainly for cultivation. Erosion is very low to moderate.

Remark Species are often associated with the Wolkberg CE, although some species are also shared with the Sekhukhuneland CE (e.g. *Dombeya autumnalis*, *Orthosiphon tubiformis*) and other northern sourveld units.

References Stalmans (1990), Matthews (1991), Stalmans & De Klerk (1991, 1992), Van Wyk & Smith (2001).

SVcb 26 Ohrigstad Mountain Bushveld

VT 19 Sourish Mixed Bushveld (44%), VT 18 Mixed Bushveld (33%) (Acocks 1953). LR 43 North-eastern Mountain Grassland (52%) (Low & Rebelo 1996).

Distribution Limpopo and Mpumalanga Provinces: Mountain slopes and steep valleys from the Blyde River Canyon, Ohrigstad and Burgersfort in the south continuing in the vicinity of the western side of the escarpment northwards to the Mhlapitse Valley and eastwards along the Strydpoort Mountains as far as Chuniespoort. Altitude varies widely from around 500 m (in the Olifants River Gorge) to about 1 400 m.

Vegetation & Landscape Features Open to dense woody layer, with associated woody and herbaceous shrubs and closed to open grass layer. Moderate to steep slopes on mountainsides and sometimes deeply incised valleys; also fairly flat terrain in a few places.

Geology & Soils Primarily on quartzite and shale (Timeball Hill and Silvertown Formations of the Pretoria Group), with some chemical sediments of the Chuniespoort Group, weathering to shallow rocky soils of either Glenrosa or Mispah soil forms. Land types mainly lb, Ae and Fa.

Climate Summer rainfall with very dry winters. MAP about 500–800 mm. Frost infrequent. See also climate diagram for SVcb 26 Ohrigstad Mountain Bushveld.

Important Taxa Tall Tree: *Sclerocarya birrea* subsp. *caffra* (d). Small Trees: *Acacia exuvialis* (d), *A. karroo* (d), *A. tortilis* subsp. *heteracantha* (d), *Combretum apiculatum* (d), *C. molle* (d), *Kirkia wilmsii* (d), *Acacia caffra*, *Berchemia zeyheri*, *Boscia foetida* subsp. *rehmanniana*, *Commiphora mollis*, *Croton gratissimus*, *Englerophytum magalismontanum*, *Hippobromus pauciflorus*, *Pappea capensis*, *Terminalia prunioides*, *Vitex obovata* subsp. *wilmsii*, *Ziziphus mucronata*. Succulent Trees: *Euphorbia tirucalli* (d), *E. cooperi*. Tall Shrubs: *Dichrostachys*



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Figure 9.34 SVcb 26 Ohrigstad Mountain Bushveld: Moderately dense woodland on hillslopes with rocky substrate with common species including *Acacia caffra*, *Aloe marlothii*, *Elaeodendron transvaalense*, *Euclea crispa* (blue-leaved form) and *Englerophytum magalismontanum* near Crystal Springs Mountain Lodge, about 10 km from Ohrigstad.

cinerea (d), *Combretum petrophilum*, *Crotalaria monteiri*, *Grewia bicolor*, *G. monticola*, *Hexalobus monopetalus*, *Karomia speciosa*, *Olea europaea* subsp. *africana*, *Tarchonanthus camphoratus*. Low Shrubs: *Grewia vernicosa* (d), *Psiadia punctulata* (d), *Euclea crispa*. Succulent Shrubs: *Aloe castanea* (d), *A. cryptopoda*, *A. globuligemma*. Woody Climber: *Pterolobium stellatum* (d). Graminoids: *Loudetia simplex* (d), *Andropogon chinensis*, *Aristida congesta*, *Brachiaria nigropedata*, *Eragrostis rigidior*, *Melinis repens*, *Panicum maximum*. Succulent Herb: *Aloe fosteri* (d).

Biogeographically Important Taxon (Central Bushveld endemic) Low Shrub: *Petalidium oblongifolium*.

Endemic Taxa Small Tree: *Encephalartos cupidus*. Woody Climbers: *Asparagus lymnettae*, *Rhoicissus laetans*. Succulent Herbaceous Climber: *Ceropegia distincta* subsp. *verruculosa*.

Conservation Least threatened. Target 24%. Almost 8% statutorily conserved, mainly in the Bewaarkloof and Blyde River Canyon Nature Reserves. At least an additional 4% in other reserves, mainly the Wolkberg (Serala) Wilderness Area. At least 9% transformed, mostly by cultivation. Aliens include scattered *Melia azedarach*, *Caesalpinia decapetala* and *Nicotiana glauca*. Erosion is very variable, from very low to very high in parts of the Sekhukhune region.

Remarks Most of the unit is relatively dry mountain bushveld in the rainshadow west of the northern parts of the Drakensberg. The northern area of this unit has been included in the Wolkberg CE (Van Wyk & Smith 2001).

Reference Van Wyk & Smith (2001).

SVcb 27 Sekhukhune Plains Bushveld

VT 18 Mixed Bushveld (71%) (Acocks 1953). LR 18 Mixed Bushveld (97%) (Low & Rebelo 1996). *Acacia tortilis*-*Dichrostachys cinerea* Arid Northern Dry Bushveld (Siebert et al. 2002a).

Distribution Limpopo and Mpumalanga Provinces: Lowland area from Burgersfort and the lower basin of the Steelpoort River in the south, northwards through the plains of the Motse River basin to Jobskop and Legwareng (south of the Strydpoort

Mountains). Continues up the basin of the Olifants River to around Tswaing and the valleys of the Lepellane and Molalets Rivers. Altitude mostly about 700–1 100 m.

Vegetation & Landscape Features

Mainly semi-arid plains and open valleys between chains of hills and small mountains running parallel to the escarpment. Predominantly short, open to closed thornveld with an abundance of *Aloe* species and other succulents. Heavily degraded in places and overexploited by man for cultivation, mining and urbanisation. Both man-made and natural erosion dongas occur in areas containing clays rich in heavy metals. Encroachment by indigenous microphyllous trees and invasion by alien species is common throughout the area.

Geology & Soils Complex geology, with rocks mainly mafic and ultramafic intrusive rocks of the main to lower zones of the Rustenberg Layered Suite on the

eastern lobe of the Bushveld Igneous Complex (Vaalian). The zones (subsuites) are dominated by concentric belts of norite, gabbro, anorthosite and pyroxenite, with localised protrusions of magnetite, chromitite, serpentinitised harzburgite, olivine diorite, shale, dolomite and quartzite. Most of the area consists of red apedal soils. Deep, loamy Valsrivier soils are characteristic of the plains and shallow Glenrosa soils are found on the low-lying, rocky hills. Patches of erodable black, melanic structured horizons are common around small mountains. Some Steendal soils are underlain by gypsum. Land types mainly Ae, Ib, Ea and Ia.

Climate Summer rainfall with very dry winters. MAP about 400–600 mm, but at the lower end of this range on the central plains increasing to about 500 mm on the plains east of the Leolo Mountains. Frost very infrequent. Mean monthly maximum and minimum temperatures for Tswelopele 37.3°C and –0.9°C for January and June, respectively. Daily temperatures vary considerably at different localities, with higher temperatures on the western plains and lower temperatures on higher-lying plateaus. See also climate diagram for SVcb 27 Sekhukhune Plains Bushveld.

Important Taxa Tall Trees: *Acacia erioloba*, *Philenoptera violacea*. Small Trees: *Acacia mellifera* subsp. *detinens* (d), *A. nilotica* (d), *A. tortilis* subsp. *heteracantha* (d), *Boscia foetida* subsp. *rehmanniana* (d), *Acacia grandicornuta*, *Albizia anthelmintica*, *Balanites maughamii*, *Combretum imberbe*, *Commiphora glandulosa*, *Maerua angolensis*, *Markhamia zanzibarica*, *Mystroxydon aethiopicum* subsp. *schlechteri*, *Ptaeroxylon obliquum*, *Schotia brachypetala*, *Ziziphus mucronata*. Succulent Tree: *Euphorbia tirucalli* (d). Tall Shrubs: *Rhus engleri* (d), *Cadaba termitaria*, *Dichrostachys cinerea*, *Ehretia rigida* subsp. *rigida*, *Grewia bicolor*, *Karomia speciosa*, *Maerua decumbens*, *Rhigozum brevispinosum*, *R. obovatum*, *Tinnea rhodesiana*, *Triaspis glaucophylla*. Low Shrubs: *Felicia clavipilosa* subsp. *transvaalensis* (d), *Seddera suffruticosa* (d), *Gnidia polycephala*, *Gossypium herbaceum* subsp. *africanum*, *Jamesbrittenia atropurpurea*, *Jatropha latifolia* var. *latifolia*, *Lantana rugosa*, *Melhanie rehmannii*, *Monechma divaricatum*, *Myrothamnus flabellifolius*, *Pechuel-Loeschea leubnitziae*, *Plinthus rehmannii*. Succulent Shrubs: *Aloe cryptopoda* (d), *Euphorbia enormis* (d), *Kleinia longiflora* (d), *Aloe castanea*, *A. globuligemma*. Woody Succulent

Climber: *Sarcostemma viminalis*. Herbaceous Climbers: *Coccinia rehmannii*, *Decorsea schlechteri*. Graminoids: *Cenchrus ciliaris* (d), *Enneapogon cenchroides* (d), *Panicum maximum* (d), *Urochloa mosambicensis* (d), *Aristida adscensionis*, *A. congesta*, *Eragrostis barbinodis*, *Paspalum distichum*, *Schmidtia pappophoroides*, *Stipagrostis hirtigluma* subsp. *patula*, *Tragus berteronianus*. Herbs: *Becium filamentosum* (d), *Phyllanthus madeiraspatensis* (d), *Blepharis integrifolia*, *Corchorus asplenifolius*, *Hibiscus praeteritus*, *Ipomoea magnusiana*. Geophytic Herbs: *Drimia altissima*, *Sansevieria pearsonii*.

Biogeographically Important Taxa (^NNorthern Sourveld endemic, ^{CB}Central Bushveld endemic, ^{SK}Sekhukhune endemic, ^DBroadly disjunct distribution) Small Tree: *Lydenburgia cassioides*^{SK}. Tall Shrub: *Nuxia gracilis*^D. Low Shrubs: *Amphiglossa triflora*^D, *Asparagus fourei*^N, *Hibiscus barnardii*^{SK}, *Orthosiphon fruticosus*^{CB}, *Petalidium oblongifolium*^{CB}, *Rhus batophylla*^{SK}. Woody Climber: *Asparagus sekukuniensis*^{SK}. Herb: *Aneilema longirrhizum*^{SK}. Geophytic Herb: *Chlorophytum cyperaceum*^{SK}. Succulent Herb: *Piранthus atosanguineus*^{CB}.

Conservation Vulnerable. Target 19%. Nearly 2% statutorily conserved in Potlake, Bewaarkloof and Wolkberg Caves Nature Reserves. Approximately 25% of this area has been transformed and is mainly under dry-land subsistence cultivation. A small area is under pressure from chrome and platinum mining activities and the associated urbanisation. Depending on commodities, this threat could increase in the future. There is a high level of degradation of much of the remaining vegetation by unsustainable harvesting and utilisation. Erosion widespread at usually high to very high levels with donga formation. Alien *Agave* species, *Caesalpinia decapetala*, *Lantana camara*, *Melia azedarach*, *Nicotiana glauca*, *Opuntia* species, *Verbesina encelioides* and *Xanthium strumarium* are widespread but scattered.

Remarks This semi-arid bushveld is a disturbed and degraded system with many erosion dongas. However, much of the erosion can be attributed to inherent edaphic properties. The unit is situated in the Sekhukhuneland CE (Van Wyk & Smith 2001). Several endemic taxa of this unit still require formal description (Siebert et al. 2001). It is related to SVcb 28 Sekhukhune Mountain Bushveld, SVcb 23 Polokwane Plateau Bushveld and SVcb 15 Springbokvlakte Thornveld in terms of floristic diversity, species richness and vegetation structure (Breebaart & Deutschländer 1997, Siebert et al. 2002b).

References Breebaart & Deutschländer (1997), Siebert (2001), Siebert et al. (2001, 2002a, b, d, 2003a), Van Wyk & Smith (2001).

SVcb 28 Sekhukhune Mountain Bushveld

VT 19 Sourish Mixed Bushveld (50%) (Acocks 1953). LR 18 Mixed Bushveld (86%) (Low & Rebelo 1996). *Kirkia wilmsii*–*Terminalia prunioides* Closed Mountain Bushveld, *Combretum hereroense*–*Grewia vernicosa* Open Mountain Bushveld, *Hippobromus pauciflorus*–*Rhoicissus tridentata* Rock Outcrop Vegetation (Siebert et al. 2002a).

Distribution Limpopo and Mpumalanga Provinces: Mountains and undulating hills above the lowlands of the SVcb 27 Sekhukhune Plains Bushveld, including the steep slopes of the Leolo Mountains (except areas of Gm 20 Leolo Summit Sourveld), Dwars River Mountains (except areas of Gm 19 Sekhukhune Montane

Grassland) and Thaba Sekhukhune, and a number of isolated smaller mountains (e.g. Phepane and Morone). Also the undulating small hills in the valley of the Steelpoort River up to and along the Klip River flowing past Roosenekal. Altitude about 900–1 600 m.

Vegetation & Landscape Features Dry, open to closed microphyllous and broad-leaved savanna on hills and mountain slopes that form concentric belts parallel to the northeastern escarpment. Open bushveld often associated with ultramafic soils on southern aspects. Bushveld on ultramafic soils contain a high diversity of edaphic specialists. Bushveld of mountain slopes generally taller than in the valleys, with a well-developed herb layer. Bushveld of valleys and dry northern aspects usually dense, like thicket, with a herb layer comprising many short-lived perennials. Dry habitats contain a number of species with xerophytic adaptations, such as succulence and underground storage organs. Both man-made and natural erosion dongas occur on footslopes of clays rich in heavy metals.

Geology & Soils Rocks mainly ultramafic intrusives of the lower, critical and main zones of the eastern Rustenberg Layered Suite of the Bushveld Igneous Complex (Vaalian). Three sub-suites (zones), namely Croydon, Dwars River and Dsjate consist mainly of norite, pyroxenite, anorthosite and gabbro, and are characterised by localised intrusions of magnetite, diorite, dunite, bronzitite and harzburgite. Soils are predominantly shallow, rocky and clayey. Glenrosa and Mispah soil forms are common, with lime present in low-lying areas. Rocky areas without soil are common on steep slopes. The Dwars River Valley is characterised by prismacutanic horizons with melanitic structured diagnostic horizons. Around Steelpoort red apedal, freely drained soils occur and these deeper soils include Hutton, Bonheim and Steendal soil forms. Land types mainly Ib, Ae, Ic and Fb.

Climate Summer rainfall with very dry winters. MAP about 500–700 mm, but local topography influences rainfall patterns over short distances. Frost fairly infrequent. Daily temperatures vary considerably at different localities, with highest temperatures in lower-lying areas and lowest temperatures on southern aspects of mountains. See also climate diagram for SVcb 28 Sekhukhune Mountain Bushveld.

Important Taxa Tall Tree: *Acacia nigrescens*. Small Trees: *Acacia senegal* var. *leiorhachis* (d), *Combretum apiculatum*

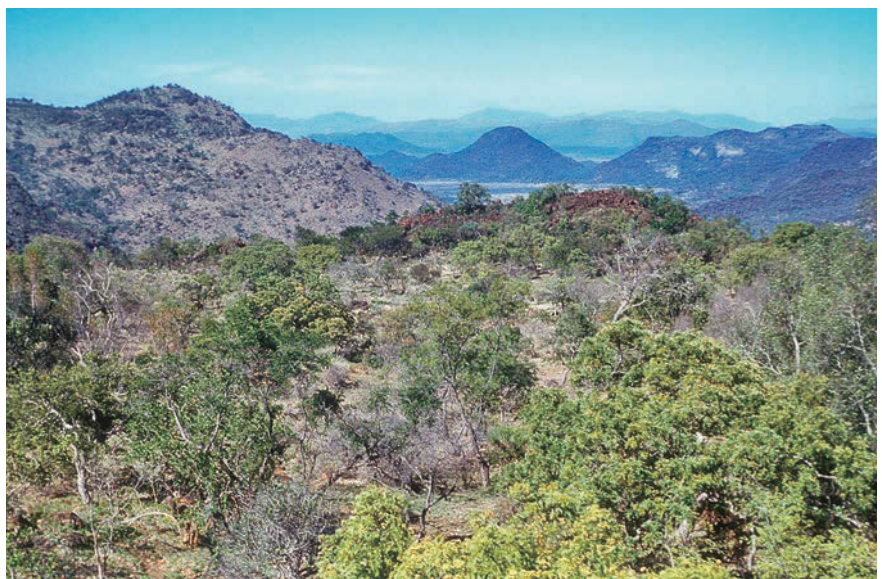


Figure 9.35 SVcb 28 Sekhukhune Mountain Bushveld: Moderately open bushveld on upper slopes of the Leolo Mountains, Sekhukhune District, Limpopo Province.

(d), *Kirkia wilmsii* (d), *Terminalia prunioides* (d), *Vitex obovata* subsp. *wilmsii* (d), *Ziziphus mucronata* (d), *Bolusanthus speciosus*, *Boscia albitrunca*, *Brachylaena ilicifolia*, *Combretum molle*, *Commiphora mollis*, *Croton gratissimus*, *Cussonia transvaalensis*, *Hippobromus pauciflorus*, *Ozoroa sphaerocarpa*, *Pappea capensis*, *Schotia latifolia*, *Sterculia rogersii*. Succulent Tree: *Aloe marlothii* subsp. *marlothii*. Tall Shrubs: *Dichrostachys cinerea* (d), *Euclea crispa* subsp. *crispa* (d), *Combretum hereroense*, *Euclea linearis*, *Pavetta zeyheri*, *Tinnea rhodesiana*, *Triaspis glaucophylla*. Low Shrubs: *Elephantorrhiza praetermissa* (d), *Grewia vernicosa* (d), *Asparagus intricatus*, *Barleria saxatilis*, *B. senensis*, *Clerodendrum ternatum*, *Commiphora africana*, *Hermannia glanduligera*, *Indigofera lydenburgensis*, *Jatropha latifolia* var. *angustata*, *Melhania prostrata*, *Phyllanthus glaucophyllus*, *Psidium punctulata*, *Rhus keetii*, *Rhynchosia komatiensis*. Succulent Shrubs: *Aloe castanea* (d), *A. cryptopoda* (d). Woody Climbers: *Clematis brachiata* (d), *Rhoicissus tridentata* (d), *Acacia ataxacantha*. Woody Succulent Climber: *Sarcostemma viminalis*. Graminoids: *Aristida canescens* (d), *Heteropogon contortus* (d), *Panicum maximum* (d), *Setaria lindenberghiana* (d), *Themeda triandra* (d), *Aristida transvaalensis*, *Cymbopogon pospischilii*, *Diheteropogon amplexans*, *Enneapogon scoparius*, *Loudetia simplex*, *Panicum deustum*, *Setaria sphacelata*. Herbs: *Berkheya insignis* (d), *Commelina africana* (d), *Cyphostemma woodii*, *Kyphocarpa angustifolia*, *Senecio latifolius*. Geophytic Herbs: *Hypoxis rigidula*, *Sansevieria hyacinthoides*. Succulent Herb: *Huernia stapelioides*.

Biogeographically Important Taxa

(^NNorthern Sourveld endemic, ^{CB}Central Bushveld endemic, ^{SK}Sekhukhune endemic, ^ZLink to Zimbabwe) Small Tree: *Lydenburgia cassinoides*^{SK}. Tall Shrub: *Rhus sekhukhuniensis*^{SK}. Low Shrubs: *Euclea sekhukhuniensis*^{SK}, *Petalidium oblongifolium*^{CB}, *Plectranthus venter*^Z, *Rhus batophylla*^{SK}. Woody Climbers: *Asparagus sekukuniensis*^{SK}, *Rhoicissus sekhukhuniensis*^{SK}. Geophytic Herbs: *Chlorophytum cyperaceum*^{SK}, *Raphionacme chimanimaniana*^Z.

Endemic Taxa Small Tree: *Acacia ormo-carpoides*. Succulent Tree: *Euphorbia sekukuniensis*. Soft Shrub: *Plectranthus porcatus*.

Conservation Least threatened. Target 24%. None conserved in statutory conservation areas, but 0.4% conserved in Potlake Nature Reserve. Nearly 15% transformed, mainly by cultivation and urban built-up. Erosion is at moderate to high levels, with donga formation in places. An increasing area along the Dwaars River Subsite is under pressure from mining activities and its associated urbanisation (Siebert et al. 2002d). *Melia azedarach* is currently the most aggressive alien invader.

Remarks This mountain bushveld is part of the Sekhukhuneland CE (Van Wyk & Smith 2001), more specifically the Steelpoort Subcentre. This vegetation unit is not heavily disturbed or degraded and its vast range of habitat still harbours high plant diversity with many endemics, many of which still await formal descrip-

tion (Siebert et al. 2001). It is related to SVcb 27 Sekhukhune Plains Bushveld, SVcb 7 Norite Koppies Bushveld and SVcb 26 Ohrigstad Mountain Bushveld in terms of floristic diversity, species richness and vegetation structure (Siebert et al. 2002b, c).

References Siebert (2001), Siebert et al. (2001, 2002a, b, c, d, 2003b), Van Wyk & Smith (2001).

Mopane

SVmp 1 Musina Mopane Bushveld

VT 15 Mopani Veld (80%) (Acocks 1953). LR 10 Mopane Bushveld (69%) (Low & Rebelo 1996).

Distribution Limpopo Province: Undulating plains from around Baines Drift and Alldays in the west, remaining north of the Soutpansberg and south of the Limpopo River (but also occurring to the north in Zimbabwe), through Musina and Tshipise to Malongavlake, Masisi and Banyini Pan in the east. Altitude about 300 m (in the eastern Limpopo Valley) to 800 m.

Vegetation & Landscape Features Undulating to very irregular plains, with some hills. In the western section, open woodland to moderately closed shrubveld dominated by *Colophospermum mopane* on clayey bottomlands and *Combretum apiculatum* on hills. In the eastern section on basalt, moderately closed to

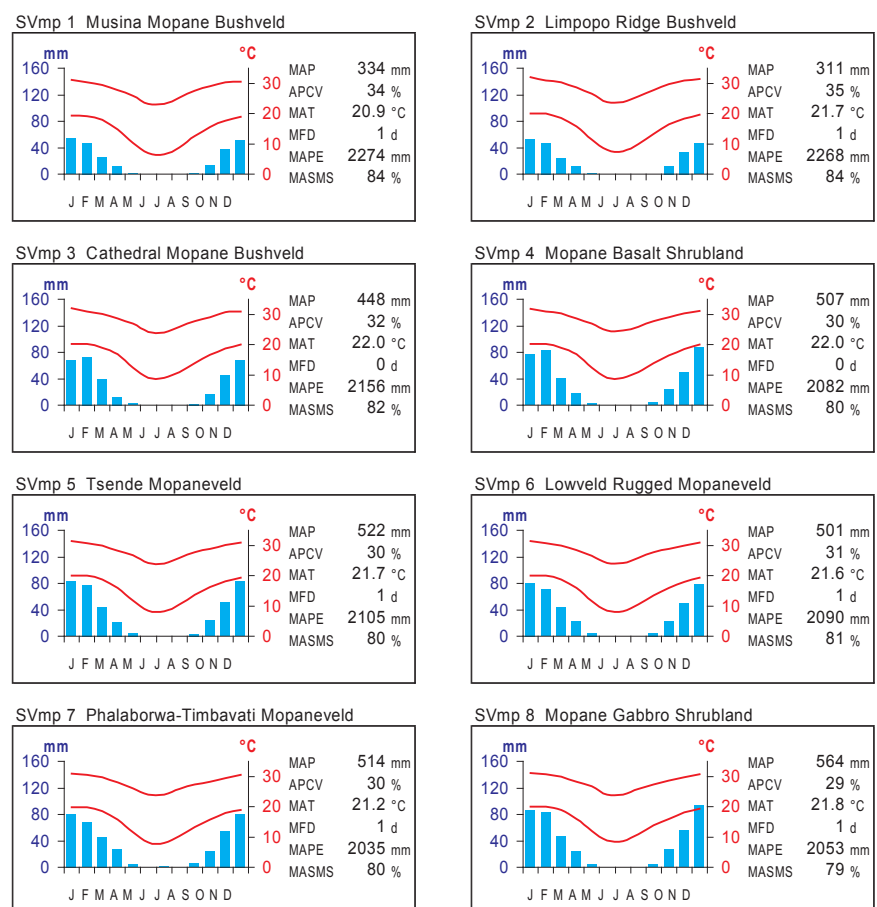


Figure 9.36 Climate diagrams of Mopane Bioregion units. Blue bars show the median monthly precipitation. The upper and lower red lines show the mean daily maximum and minimum temperature respectively. MAP: Mean Annual Precipitation; APCV: Annual Precipitation Coefficient of Variation; MAT: Mean Annual Temperature; MFD: Mean Frost Days (days when screen temperature was below 0°C); MAPE: Mean Annual Potential Evaporation; MASMS: Mean Annual Soil Moisture Stress (% of days when evaporative demand was more than double the soil moisture supply).



Figure 9.37 SVmp 1 Musina Mopane Bushveld: Bushveld dominated by *Colophospermum mopane* in the Honnet Nature Reserve near Tshipise (Musina District, Limpopo Province).

open shrubveld is dominated by *Colophospermum mopane* and *Terminalia prunioides*. On areas with deep sandy soils, moderately open savanna dominated by *Colophospermum mopane*, *T. sericea*, *Grewia flava* and *Combretum apiculatum*. Field layer well developed (especially on the basalt), open during the dry season; the herbaceous layer is poorly developed in areas with dense cover of *Colophospermum mopane* shrubs, for example, north of Alldays bordering the Limpopo floodplain.

Geology & Soils Most of the area is underlain by the Archaean Beit Bridge Complex, except where it is covered by much younger Karoo sandstones and basalts. The Beit Bridge Complex consists of gneisses and metasediments and is structurally very complex. Variable soils from deep red/brown clays, moderately deep, dark, heavy clays to deep, freely drained sandy soils to shallower types including skeletal Glenrosa and Mispah soil forms. Land types mainly Ae, Ah, Fc and Db.

Climate Summer rainfall with very dry winters including the shoulder months of May and September. MAP about 300–400 mm. Generally frost-free unit. Mean monthly maximum and minimum temperatures for Macuville-Agr (northwest of Musina) 39.9°C and 0.9°C for November and June, respectively. See also climate diagram for SVmp 1 Musina Mopane Bushveld.

Important Taxa Tall Trees: *Acacia nigrescens*, *Adansonia digitata*, *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Colophospermum mopane* (d), *Combretum apiculatum* (d), *Acacia senegal* var. *leiorhachis*, *A. tortilis* subsp. *heteracantha*, *Boscia albitrunca*, *B. foetida* subsp. *rehmanniana*, *Commiphora glandulosa*, *C. tenuipetiolata*, *C. viminea*, *Sterculia rogersii*, *Terminalia prunioides*, *T. sericea*, *Ximenia americana*. Tall Shrubs: *Grewia flava* (d), *Sesamothamnus lugardii* (d), *Commiphora pyracanthoides*, *Gardenia volkensii*, *Grewia bicolor*, *Maerua parvifolia*, *Rhigozum zambesiaceum*, *Tephrosia polystachya*. Low Shrubs: *Acalypha indica*, *Aptosimum lineare*, *Barleria senensis*, *Dicoma tomentosa*, *Felicia clavipilosa* subsp. *transvaalensis*, *Gossypium herbaceum* subsp. *africanum*, *Hermannia glanduligera*, *Neuracanthus africanus*, *Pechuel-Loeschea leubnitziae*, *Ptychobium contortum*, *Seddera suffruticosa*. Succulent Shrub: *Hoodia currorii* subsp. *lugardii*. Herbaceous Climber: *Momordica balsamina*. Graminoids: *Schmidtia pappophoroides* (d), *Aristida adscensionis*, *A. congesta*, *Bothriochloa insculpta*, *Brachiaria deflexa*,

Cenchrus ciliaris, *Digitaria eriantha* subsp. *eriantha*, *Enneapogon cenchroides*, *Eragrostis lehmanniana*, *E. pallens*, *Fingerhuthia africana*, *Heteropogon contortus*, *Sporobolus nitens*, *Stipagrostis hirtigluma* subsp. *patula*, *S. uniplumis*, *Tetrapogon tenellus*, *Urochloa mosambicensis*. Herbs: *Acrotome inflata*, *Becium filamentosum*, *Harpagophytum procumbens* subsp. *transvaalense*, *Heliotropium steudneri*, *Hermbstaedtia odorata*, *Oxygonum delagoense*. Succulent Herbs: *Stapelia gettliffei*, *S. kwebensis*.

Conservation Least threatened. Target 19%. Only 2% statutorily conserved mainly in the Mapungubwe National Park as well as in Nwanedi and Honnet Nature Reserves. Additionally, about 1% conserved in the Baobab Tree Reserve. Roughly 3% transformed, mainly by cultivation. Erosion is high to moderate.

Remarks The unit is the most diverse mopaneveld type in South Africa. The Musina region has the highest species

richness—also relative to *Colophospermum mopane*-dominated areas in Namibia and the Save River Valley in Zimbabwe (F. Siebert et al. 2003). The relationship of this unit with the adjacent and often fragmented parts of SVmp 2 Limpopo Ridge Bushveld is spatially complex. It is very dependent on scale and has not been fully captured on the map.

References Louw (1970), O'Connor (1992), Dekker & Van Rooyen (1995), Visser et al. (1996), Du Plessis (2001), Götze (2002), Straub (2002), Jordaan et al. (2004).

SVmp 2 Limpopo Ridge Bushveld

VT 15 Mopani Veld (82%) (Acocks 1953). LR 10 Mopane Bushveld (81%) (Low & Rebelo 1996).

Distribution Limpopo Province: On hills and ridges, such as Madiapala in the lower Mogalakwena River basin in the west through a cluster of hills in the Pontdrif area including Poortjieberg and Tsolwe, eastwards including Mapungubwe Mountain in the Mapungubwe National Park through to the hills and ridges in the vicinity of the Limpopo River further downstream (for example Ha-Tshansi at Musina, Ha-Dowe and Maremani). Also including hills and ridges well away from the river north of the Soutpansberg and generally east of the Sand River (e.g. Tshitangai, Bloukop and Ha-Manenzhe) through to some rugged areas in the far northern Kruger National Park. Altitude from about 300 m in the east to 700 m, with the top of a few hills in the west at around 1 000 m.

Vegetation & Landscape Features Extremely irregular plains with ridges and hills. Moderately open savanna with poorly developed ground layer. Umbrella-shape canopied *Kirkia acuminata* is prominent on some ridge skylines with the often enormous *Adansonia digitata* on shallow calcareous gravel; the shrub *Catophractes alexandri* is dominant on calc-silicate soils. These are particularly striking landscapes with rock walls and passages within areas of sandstone of the Clarens Formation (e.g. within the Mapungubwe National Park).

Geology & Soils Mostly rocks of the Beit Bridge Complex (Swazian Erathem) as well as sediments (including sandstones of the Clarens Formation) and basalt (particularly in the east) of



Figure 9.38 SVmp 2 Limpopo Ridge Bushveld: *Kirkia acuminata* trees on a rocky hillside at 560 m on Leokwe Hill in Mapungubwe National Park.

the Karoo Supergroup. Shallow gravel and sand (Glenrosa and Mispah soil forms) to calcareous clayey soil. Land types mainly Fc, Fb and Ib.

Climate Summer rainfall with very dry winters including the shoulder months of May and September. MAP about 300–400 mm. Generally a frost-free area. See also climate diagram for SVmp 2 Limpopo Ridge Bushveld.

Important Taxa Tall Trees: *Adansonia digitata* (d), *Acacia nigrescens*, *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Colophospermum mopane* (d), *Commiphora glandulosa* (d), *C. tenuipetiolata* (d), *Terminalia prunioides* (d), *Acacia senegal* var. *leiorhachis*, *A. tortilis* subsp. *heteracantha*, *Boscia albitrunca*, *Combretum apiculatum*, *C. imberbe*, *Commiphora mollis*, *Ficus abutilifolia*, *F. tettensis*, *Kirkia acuminata*, *Sterculia rogersii*, *Ximenia americana*. Tall Shrubs: *Catophractes alexandri*, *Commiphora pyracanthoides*, *Gardenia resiniflua*, *Grewia bicolor*, *G. villosa*, *Hibiscus calyphyllus*, *H. micranthus*. Low Shrubs: *Barleria affinis*, *Blepharis diversispina*, *Neuracanthus africanus*, *Plinthus rehmannii*, *Ptychlobium contortum*. Woody Climber: *Cissus cornifolia*. Graminoids: *Aristida adscensionis*, *A. stipitata* subsp. *graciliflora*, *Digitaria eriantha* subsp. *eriantha*, *Enneapogon cenchroides*, *Panicum maximum*, *Schmidtia papophoroides*, *Stipagrostis uniplumis*. Succulent Herb: *Tavaresia barklyi*.

Endemic Taxa Low Shrub: *Pavonia dentata*. Herb: *Cleome oxyphylla* var. *robusta*.

Conservation Least threatened. Target 19%. Some 18% statutorily conserved, mainly in the Kruger and Mapungubwe National Parks. An additional 2% conserved in the Baobab Tree Reserve (thus together attaining the target). Only about 1% is transformed, mainly for cultivation and mining.

Remark The correspondence of this vegetation unit with the landscape units of Gertenbach (1983b) and of others below that occur within the Kruger National Park, is given in Table 9.1.

References Louw (1970), Van Rooyen (1978), Gertenbach (1983b), O'Connor (1992), Dekker & Van Rooyen (1995), Visser et al. (1996), Du Plessis (2001), Götze (2002), Straub (2002), Jordaan et al. (2004).

SVmp 3 Cathedral Mopane Bushveld

VT 15 Mopani Veld (59%) (Acocks 1953). LR 10 Mopane Bushveld (80%) (Low & Rebelo 1996). KNP 15 *Colophospermum mopane* Forest (99%) (Gertenbach 1983b).

Distribution Limpopo Province: Mapped as a limited area in the Kruger National Park on the flats east of Punda Maria Gate from around Dzundwini Mountain to Gumbandebvu Hills. Also extends northwards in the upper Madzaringwe River Valley and in the Shilahlandonga River Valley to the east. Altitude 350–500 m.

Vegetation & Landscape Features

A high, moderately closed tree savanna overwhelmingly dominated by *Colophospermum mopane* 10–15 m tall, often with some shrubs (e.g. *Euclea divinorum*) 2–3 m tall in the understorey, and a sparse herbaceous layer. The upper canopy is seldom closed. Vegetation of this unit occurs on flats and gentle slopes.

Geology & Soils Sandstone and shale of the Karoo Supergroup are most important, with sandstone, basalt and tuff of the



Figure 9.39 SVmp 3 Cathedral Mopane Bushveld : Tall *Colophospermum mopane* trees outside the mapped unit and associated with the drainage area of the Kolope River in Mapungubwe National Park.

Table 9.1 Correspondence within the Kruger National Park between vegetation types and landscapes (Gertenbach 1983b), with landscapes in decreasing order of area within a vegetation type.

Vegetation Units	Landscapes
SVmp 2 Limpopo Ridge Bushveld	KNP 25 <i>Adansonia digitata</i> / <i>Colophospermum mopane</i> Rugged Veld
	KNP 26 <i>Colophospermum mopane</i> Shrubveld on Calcrete
SVmp 3 Cathedral Mopane Bushveld	KNP 15 <i>Colophospermum mopane</i> Forest
SVmp 4 Mopane Basalt Shrubland	KNP 23 <i>Colophospermum mopane</i> Shrubveld on Basalt
	KNP 22 <i>Combretum</i> / <i>Colophospermum mopane</i> Rugged Veld
SVmp 5 Tsende Mopaneveld	KNP 11 Tsende Sandveld
	KNP 12 <i>Colophospermum mopane</i> / <i>Acacia nigrescens</i> Savanna
	KNP 9 <i>Colophospermum mopane</i> Woodland / Savanna on Basic Soils
	KNP 27 Mixed <i>Combretum</i> / <i>Colophospermum mopane</i> Woodland
SVmp 6 Lowveld Rugged Mopaneveld	KNP 10 Letaba River Rugged Veld
	KNP 7 Olifants River Rugged Veld
SVmp 7 Phalaborwa-Timbavati Mopaneveld	KNP 6 <i>Combretum</i> / <i>Colophospermum mopane</i> Woodland of Timbavati-area
	KNP 8 Phalaborwa Sandveld
SVmp 8 Mopane Gabbro Shrubland	KNP 24 <i>Colophospermum mopane</i> Shrubveld on Gabbro
SVI 1 Makuleke Sandy Bushveld	KNP 34 Punda Maria Sandveld on Waterberg Sandstone
	KNP 16 Punda Maria Sandveld on Cave Sandstone
	KNP 33 <i>Pterocarpus rotundifolius</i> / <i>Combretum collinum</i> Woodland
SVI 2 Nwambyia-Pumbe Sandy Bushveld	KNP 32 Nwambia Sandveld
	KNP 30 Pumbe Sandveld
SVI 3 Granite Lowveld	KNP 5 Mixed <i>Combretum</i> / <i>Terminalia sericea</i> Woodland
	KNP 4 Thickets of the Sabie & Crocodile River
	KNP 3 <i>Combretum collinum</i> / <i>Combretum zeyheri</i> Woodland
SVI 4 Delagoa Lowveld	KNP 13 <i>Acacia welwitschii</i> Thickets on Karoo Sediments
SVI 5 Tshokwane-Hlane Basalt Lowveld	KNP 17 <i>Sclerocarya birrea</i> subsp. <i>caffra</i> / <i>Acacia nigrescens</i> Savanna
	KNP 18 Dwarf <i>Acacia nigrescens</i> Savanna
	KNP 21 <i>Combretum</i> / <i>Acacia nigrescens</i> Rugged Veld
	KNP 20 Bangu Rugged Veld
	KNP 14 Kumana Sandveld
SVI 6 Gabbro Grassy Bushveld	KNP 19 Thornveld on Gabbro
SVI 10 Pretoriuskop Sour Bushveld	KNP 1 Lowveld Sour Bushveld of Pretoriuskop
SVI 11 Malelane Mountain Bushveld	KNP 2 Malelane Mountain Bushveld
SVI 15 Northern Lebombo Bushveld	KNP 29 Lebombo South
	KNP 31 Lebombo North

Soutpansberg Group (Mokolian Erathem) also significant. Soils are often deep, with high sodium content. Prisma cutanic and/or pedocutanic diagnostic horizons are often dominant. Land types mainly Dc, Fc and Ca.

Climate Summer rainfall with very dry winters. MAP about 400–500 mm. Generally a frost-free area. See also climate diagram for SVmp 3 Cathedral Mopane Bushveld.

Important Taxa Tall Trees: *Colophospermum mopane* (d), *Acacia nigrescens*. Small Trees: *Combretum imberbe*, *Spirostachys africana*, *Ximenia americana*. Tall Shrubs: *Euclea divinorum* (d), *Combretum hereroense*, *Grewia bicolor*, *Hibiscus micranthus*, *Maerua parvifolia*. Low Shrub: *Neuracanthus africanus*. Graminoids: *Enneapogon cenchroides* (d), *Enteropogon macrostachyus* (d), *Aristida congesta*, *Panicum maximum*,

Schmidtia pappophoroides. Herbs: *Amaranthus thunbergii*, *Seddera capensis*.

Conservation Least threatened. Target 19%. Entirely statutorily conserved in the Kruger National Park. Erosion is low to moderate.

Remarks Forms of this structural type occur unmapped in a number of small areas north of the Soutpansberg, usually forming bands along less major water courses, allied to that on some alluvial soils close to larger streams and rivers (e.g. stretches of the Tsende River north of the Letaba River). The unit is related to the SVI 4 Delagoa Lowveld in moister areas further south.

References Van Rooyen (1978), Van Rooyen et al. (1981b), Gertenbach (1983b).

SVmp 4 Mopane Basalt Shrubland

VT 15 Mopani Veld (90%) (Acocks 1953). LR 9 Mopane Shrubveld (74%) (Low & Rebelo 1996). KNP 23 *Colophospermum mopane* shrubveld on basalt (71%) (Gertenbach 1983b).

Distribution Limpopo and Mpumalanga Provinces: Mainly occurs in a large belt on the plains in the Kruger National Park from around Kloppefontein in the north, southwards and east of the Lebombo Mountain range through the Shingwedzi and Letaba Rest Camp areas to the vicinity of Olifants and Roodewal Rest Camps in the south. Altitude about 200–450 m.

Vegetation & Landscape Features Mainly plains and slightly undulating plains with medium-low (1–2 m) shrubs dominated overwhelmingly by multistemmed *Colophospermum mopane*. Tree forms of mopane are rare. Grass layer is well developed. Vegetation consists of three main variations depending on topographical position (Gertenbach 1983b): (1) lower, middle and footslopes, (2) middle slopes and convex uplands on usually deeper soils, and (3) concave terrain with soils with very high clay content. The unit includes some bottomlands and parts of the Lebombo pediment with a slightly increased proportion of other woody plant species.

Geology & Soils The area is built almost entirely by basalts (tholeiitic and picritic) of the Letaba Formation (Lebombo Group, Karoo Supergroup). Soils are often deep and have a high clay content with a dark colour in the lower positions, becoming red on the higher middle slopes. Land types mainly Ea, with some Ia and Fb.

Climate Summer rainfall with very dry winters. MAP about 400–600 mm. Generally a frost-free area. Mean monthly maximum and minimum temperatures for Shingwedzi 40.8°C and 2.4°C for November and June, respectively. See also climate diagram for SVmp 4 Mopane Basalt Shrubland.

Important Taxa Tall Trees: *Acacia nigrescens*, *Philenoptera violacea*, *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Acacia exuvalis*, *A. tortilis* subsp. *heteracantha*, *Combretum apiculatum*, *C. imberbe*, *Commiphora glandulosa*, *C. mollis*, *Dalbergia melanoxylon*, *Kirkia acuminata*, *Terminalia phanerophlebia*, *T. prunioides*. Tall Shrubs: *Colophospermum mopane* (d), *Combretum hereroense*, *Flueggea virosa*, *Grewia bicolor*, *Hibiscus calyphyl-*

lus, *H. micranthus*, *Maerua parvifolia*, *Tephrosia polystachya*. Low Shrubs: *Clerodendrum ternatum*, *Dicoma tomentosa*, *Neuracanthus africanus*. Woody Climber: *Combretum mossambicense*. Herbaceous Climber: *Rhynchosia totta*. Graminoids: *Aristida congesta*, *Bothriochloa radicans*, *Cenchrus ciliaris*, *Enneapogon cenchroides*, *Fingerhuthia africana*, *Heteropogon contortus*, *Panicum maximum*, *Schmidtia pappophoroides*, *Setaria incrassata*, *Themeda triandra*, *Urochloa mosambicensis*. Herbs: *Heliotropium steudneri*, *Leucas glabrata*, *Phyllanthus asperulatus*. Geophytic Herb: *Sansevieria hyacinthoides*.

Conservation Least threatened. Target 19%, but 100% already statutorily conserved in the Kruger National Park.

Remark The contrast along the interface between the low mopane shrubs of this unit and the very tall mopane trees of the neighbouring SVmp 3 Cathedral Mopane Bushveld is striking.

References Van Rooyen (1978), Gertenbach & Potgieter (1979), Van Rooyen et al. (1981b), Gertenbach (1983a, b), Fraser et al. (1987).

SVmp 5 Tsende Mopaneveld

VT 15 Mopani Veld (77%) (Acocks 1953). LR 10 Mopane Bushveld (92%) (Low & Rebelo 1996).

Distribution Limpopo Province: The main block occurs on undulating terrain west of the basalt plains from the Mphongolo River and Sirheni Bushveld Camp area in the north, southwards across the Shingwedzi River and extending slightly outside the Kruger National Park to include areas near to Malamulele and Mahlathi, through the upper Tsende River catchment area to around Mopani Camp in the south. Another belt occurs further south from the area around the Hans Merensky Nature Reserve in the west to the vicinity of Letaba Rest Camp in the east. It is also mapped as a narrow irregular strip immediately to the east of the basalt plains as far south as the Shingwedzi River area. Altitude about 300–550 m.

Vegetation & Landscape Features Slightly undulating plains with medium-high shrubby savanna, with some trees and dense ground layer dominated by *Colophospermum mopane*, but with the ratio of *C. mopane* to *Combretum apiculatum* decreasing somewhat on the less clayey soils of the uplands. In the northwestern parts the tree cover is greater and, together with the southern and northeastern outliers of the unit, these flatter landscapes include several trees such as *Acacia nigrescens* in addition to the dominant *Colophospermum mopane*.

Geology & Soils Three quarters of the area is underlain by potassium-poor, quartz-feldspar rocks of the Goudplaats Gneiss Basement. The northeastern part of the area lies on Letaba basalts of the Karoo Supergroup. Typically clayey soils occur, but with less than 15% clay in the A-horizon on the upland positions. Generally deeper clayey soils are found on the flats; the northeastern outlier area has more sandy soils—weathered products of basalt and Quaternary sand and gravel.

Climate Summer rainfall with very dry winters. MAP about 450–650 mm. Generally a frost-free area. See also climate diagram for SVmp 5 Tsende Mopaneveld.



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Figure 9.40 SVmp 4 Mopane Basalt Shrubland: Open shrubland dominated by *Colophospermum mopane*, approximately 14 km northeast of Mopani Rest Camp, Kruger National Park.



Figure 9.41 SVmp 5 Tsende Mopaneveld: Aerial view of the Tsende Mopaneveld on the right in strong contrast to the far less wooded Mopane Basalt Shrubland on the left. North of Mopani Rest Camp, Kruger National Park.

Important Taxa Tall Trees: *Acacia nigrescens*, *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Colophospermum mopane* (d), *Combretum apiculatum* (d), *Acacia gerrardii*, *A. tortilis* subsp. *heteracantha*, *Albizia harveyi*, *Bridelia mollis*, *Cassia abbreviata* subsp. *beareana*, *Combretum imberbe*, *C. zeyheri*, *Dalbergia melanoxylon*, *Peltophorum africanum*, *Philenoptera violacea*, *Terminalia sericea*. Tall Shrubs: *Combretum hereroense*, *Dichrostachys cinerea*, *Euclea divinorum*, *Grewia bicolor*, *G. monticola*, *Strychnos madagascariensis*, *Tephrosia polystachya*. Low Shrubs: *Clerodendrum ternatum*, *Indigofera schimperi*, *Melhaniea forbesii*. Woody Climbers: *Cissus cornifolia*, *Combretum mossambicense*. Graminoids: *Bothriochloa radicans* (d), *Digitaria eriantha* subsp. *pentzii* (d), *Heteropogon contortus* (d), *Panicum maximum* (d), *Themeda triandra* (d), *Cymbopogon pospischilii*, *Enneapogon cenchroides*, *Eragrostis rigidior*, *E. superba*, *Panicum coloratum*, *Perotis patens*, *Pogonarthria squarrosa*, *Schmidtia pappophoroides*, *Urochloa mosambicensis*. Herbs: *Blepharis integrifolia*, *Ceratotheca triloba*, *Chamaecrista absus*, *Corchorus asplenifolius*, *Evolvulus alsinoides*, *Heliotropium steudneri*.

Conservation Least threatened. Target 19%. Some 63% statutorily conserved, almost all in the Kruger National Park, with some patches in the Hans Merensky Nature Reserve. About a further 5% is conserved in private reserves, mainly in the Groot-Letaba Wildreservaat. Some 12% of the area has been transformed, mainly through cultivation and some settlement development outside the Kruger National Park.

Remark In most of the main (northern) block of this unit, pans are very common (Gertenbach 1983b).

References Gertenbach (1983a, b), Fraser et al. (1987).

SVmp 6 Lowveld Rugged Mopaneveld

VT 11 Arid Lowveld (55%) (Acocks 1953). LR 10 Mopane Bushveld (87%) (Low & Rebelo 1996).

Distribution Limpopo and Mpumalanga Provinces: Broken veld from the area southeast of Giyani in the west to Shimuwini and Boulders Camps in the east as well as the rugged area of the Olifants River Valley south of Phalaborwa, from Grietjiesberg in the west to the Maveni River tributary in the east. Altitude 250–550 m.

Vegetation & Landscape Features Slightly to extremely irregular plains with sometimes steep slopes and a number of prominent hills. The area around the Olifants River has more dissected and steeper slopes than the northern part of this unit. Usually dense shrubs with occasional trees and a sparse ground layer. Woody plants can become particularly dense where fire is excluded by very rocky terrain, such as in the vicinity of the Olifants River. Vegetation is more open in the northeastern parts of this unit outside the Kruger National Park.

Geology & Soils The Goudplaats Gneiss and Makhutswi Gneiss underlie most of this area, with a smaller contribution from the ultramafic metavolcanics (rocks rich in chlorite, amphibole, talc and serpentine) and metasediments of the Giyani Greenstone Belt (all Swazian Erathem). Soils are red-yellow apedal, freely drained, but also shallow and stony, especially in the east. Soil forms are mainly Hutton, Mispah and Glenrosa. Land types Ae, Fb and Fa.

Climate Summer rainfall with very dry winters. MAP about 400–600 mm. Generally a frost-free area, but frost sometimes occurs in the low-lying areas. See also climate diagram for SVmp 6 Lowveld Rugged Mopaneveld.

Important Taxa Tall Trees: *Acacia nigrescens*, *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Colophospermum mopane* (d), *Combretum apiculatum* (d), *Terminalia prunioides* (d), *Acacia exuvialis*, *A. nilotica*, *Boscia albitrunca*, *Commiphora mollis*, *Dalbergia melanoxylon*. Tall Shrubs: *Combretum hereroense*, *Dichrostachys cinerea*, *Grewia bicolor*, *G. villosa*, *Rhigozum zambesiaceum*. Low Shrubs: *Commiphora africana*, *Melhaniea forbesii*, *M. rehmannii*, *Solanum panduriforme*. Graminoids: *Aristida congesta* (d), *Enneapogon cenchroides* (d), *Melinis repens* (d), *Sporobolus panicoides* (d), *Bothriochloa radicans*, *Digitaria eriantha* subsp. *pentzii*, *Fingerhuthia africana*, *Panicum maximum*. Herbs: *Crabbea velutina*, *Heliotropium steudneri*, *Hemizygia elliottii*, *Hibiscus sidiformis*, *Phyllanthus asperulatus*, *Xerophyta retinervis*.

Conservation Least threatened. Target 19%. Some 34% statutorily conserved, almost all in the Kruger National Park. At least an additional 5% conserved in private reserves, such as Klaserie, Letaba Ranch and Selati Game Reserve. About 20% already transformed mainly by cultivation and some urban and built-up areas. This vegetation occurring outside the conserved areas is under pressure from high-density rural human population and associated urban sprawl and agricultural activities. Some areas experience moderate erosion.

Remark The southern part of this unit in the Kruger National Park contains a number of tree species that are relatively

scarce elsewhere in the park, e.g. *Kirkia wilmsii* and *Hexalobus monopetalus*.

References Gertenbach (1983a, b).

SVmp 7 Phalaborwa-Timbavati Mopaneveld

VT 11 Arid Lowveld (68%) (Acocks 1953). LR 10 Mopane Bushveld (77%) (Low & Rebelo 1996).

Distribution Limpopo and Mpumalanga Provinces: Occurs in a band about 40 km west and east of Phalaborwa and also occurs south of the Olifants River on the boundary between the Timbavati Game Reserve and the Kruger National Park including parts of the Umbabat and Klaserie Nature Reserves. Altitude 300–600 m.

Vegetation & Landscape Features Open tree savanna on undulating plains with the sandy uplands dominated by *Combretum apiculatum*, *Terminalia sericea* and *Colophospermum mopane* trees, with *T. sericea* disappearing and *Combretum apiculatum* becoming less common in the clayey bottomlands, and being replaced by trees such as *Acacia nigrescens* and increased dominance of *Colophospermum mopane*. The field layer is usually well developed. A feature of the northern section of this unit is the large number of termite mounds on the uplands.

Geology & Soils Quartz-feldspar rocks of the Makhutswi Gneiss (Swazian) dominate this area, except in the northwest where they are intruded by the Lekkersmaak Granite (Randian). Sandy soils (usually less than 10% clay in the A-horizon) on the uplands (e.g. Clovelly soil form) and clay soils in the bottomlands (e.g. Valsrivier and Sterkspruit soil forms). The dominant land type mapped is mainly Fb.

Climate Summer rainfall with very dry winters. MAP about 400–600 mm. Generally frost-free. Mean monthly maximum and minimum temperatures for Phalaborwa 38.4°C and 5.7°C for January and July, respectively. See also climate diagram for SVmp 7 Phalaborwa-Timbavati Mopaneveld.

Important Taxa Tall Trees: *Acacia nigrescens*, *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Colophospermum mopane* (d), *Combretum apiculatum* (d), *Terminalia sericea* (d), *Acacia exualis*, *A. tortilis* subsp. *heteracantha*, *Albizia harveyi*, *Cassia*

abbreviata subsp. *beareana*, *Combretum zeyheri*, *Dalbergia melanoxylon*, *Ozoroa engleri*, *Peltophorum africanum*, *Pseudolachnostylis maprouneifolia*. Tall Shrubs: *Combretum hereroense*, *Euclea divinorum*, *Grewia bicolor*, *Maerua parvifolia*, *Strychnos madagascariensis*, *Tephrosia polystachya*. Low Shrubs: *Clerodendrum ternatum*, *Commiphora africana*, *Hermannia glanduligera*, *Melhaniea forbesii*. Woody Climber: *Cissus cornifolia*. Graminoids: *Digitaria eriantha* subsp. *pentzii* (d), *Eragrostis rigidior* (d), *Pogonarthria squarrosa* (d), *Andropogon gayanus*, *Aristida congesta*, *Brachiaria nigropedata*, *Melinis repens*, *Panicum maximum*, *Perotis patens*, *Schmidtia pappophoroides*, *Themeda triandra*. Herbs: *Evolvulus alsinoides*, *Heliotropium steudneri*, *Hemizygia elliottii*, *Ipomoea magnusiana*, *Kohautia virgata*.

Conservation Least threatened. Target 19%. Some 38% statutorily conserved in the Kruger National Park, with a similar proportion in the private Selati Game Reserve and Umbabat, Timbavati, Klaserie Nature Reserves. About 5% has been transformed, mainly by development of human settlements as well as by mining.

Remark This unit contains the most southerly populations of *Colophospermum mopane* in South Africa.

References Gertenbach (1983a, b).

SVmp 8 Mopane Gabbro Shrubland

VT 15 Mopani Veld (85%) (Acocks 1953). LR 10 Mopane Bushveld (95%) (Low & Rebelo 1996). KNP 24 *Colophospermum mopane* shrubveld on gabbro (98%) (Gertenbach 1983b).

Distribution Limpopo and Mpumalanga Provinces: Occurs in narrow, irregular and disjunct belts from the Phoda Hills near Bateleur Bushveld Camp in the north, southwards in the vicinity of the Stapelkop Dam and Shimuwini Bushveld Camp, to the Shilawuri Hill area. Also further south in the vicinity of the Shisakashanghondo Dam. Altitude 300–460 m.

Vegetation & Landscape Features Slightly irregular to slightly undulating landscape with numerous outcrops of gabbro. Mainly a low shrub layer with two main structural variations both dominated by *Colophospermum mopane*: a shrubveld with practically no trees and a shrubveld with a few larger shrubs and trees, including *C. mopane* and *Acacia nigrescens*. Species diversity is the highest in the latter variation. The ground layer of both variations is dense.

Geology & Soils The basement rocks of the general area are the Swazian Goudplaats and Makhutswi gneisses. These are intruded by sinuous dykes of Timbavati gabbro that are most significant in this shrubland. Soils are dark, with relatively high clay content. Vertisols occur in areas with concave topography and lithosols on the outcrops. Main soil forms are Milkwood, Mayo, Bonheim and Swartland. Main land types Fa, Ah, Ae, Fb and Ea.

Climate Summer rainfall with very dry winters. MAP about 450–650 mm. Generally a frost-free area. See also climate diagram for SVmp 8 Mopane Gabbro Shrubland.



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Figure 9.42 SVmp 7 Phalaborwa-Timbavati Mopaneveld: Savanna plains dominated by *Colophospermum mopane* and *Combretum apiculatum* in the Shivulani Kop area of the Kruger National Park, northeast of Phalaborwa.

Important Taxa Tall Tree: *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Acacia exuvialis*, *A. tortilis* subsp. *heteracantha*, *Albizia harveyi*, *Combretum imberbe*, *Dalbergia melanoxylon*. Tall Shrubs: *Colophospermum mopane* (d), *Dichrostachys cinerea*, *Grewia bicolor*, *Tephrosia polystachya*. Low Shrubs: *Commiphora africana*, *Phyllanthus pentandrus*. Woody Climber: *Cissus cornifolia*. Graminoids: *Fingerhuthia africana* (d), *Heteropogon contortus* (d), *Panicum coloratum* (d), *Schmidtia pappophoroides* (d), *Bothriochloa radicans*, *Themeda triandra*, *Urochloa mosambicensis*. Herbs: *Chamaesyce neopolycnemoides*, *Corbichonia decumbens*, *Heliotropium steudneri*.

Conservation Least threatened. Target 19%. Virtually untransformed and about 99% statutorily conserved in the Kruger National Park and the remainder conserved in the private Umbabat Nature Reserve. Erosion is low to very low.

Remarks The vegetation structure is similar to much of that of the SVmp 4 Mopane Basalt Shrubland. The mapped unit follows Gertenbach's (1983b) boundaries. More recent geology maps show the gabbro to be narrower and less continuous than mapped.

References Gertenbach (1978, 1983a, b).



Figure 9.44 SVI 1 Makuleke Sandy Bushveld: Moderately dense bushveld on sandstone ridge east of Mutale, Limpopo Province.

exposed in this area (the Wyllie's Poort, Fundudzi and Nzhelele Formations). Some Karoo Supergroup rocks are also present (Clarens and Letaba Formations). Most of the area has deep sands to shallow sandy lithosols. A few limited areas with heavier soil, particularly in the B-horizon, occur near the western boundary of the Kruger National Park.

Climate Summer rainfall with very dry winters. MAP about 300–700 mm. Generally a frost-free region, except possibly for higher elevations. Mean monthly maximum and minimum temperatures for Punda Maria 39.7°C and 8.5°C for December and July, respectively. See also climate diagram for SVI 1 Makuleke Sandy Bushveld.

Important Taxa Small Trees: *Burkea africana* (d), *Kirkia acuminata* (d), *Pseudolachnostylis maprouneifolia* (d), *Terminalia sericea* (d), *Azelia quanzensis*, *Bridelia mollis*, *Combretum apiculatum*, *C. collinum* subsp. *gazense*, *C. zeyheri*, *Croton gratissimus*, *Ficus abutilifolia*, *F. ingens*, *Guibourtia conjugata*, *Hymenocardia ulmoides*, *Lannea schweinfurthii* var. *stuhlmannii*, *Ochna pulchra*, *Ozoroa obovata* var. *elliptica*, *Peltophorum africanum*, *Phyllanthus reticulatus*, *Pterocarpus rotundifolius*, *Stadmannia oppositifolia* subsp. *rhodesica*. Tall Shrubs: *Pteleopsis myrtifolia* (d), *Alchornea laxiflora*, *Boscia angustifolia* var. *corymbosa*, *Dichrostachys cinerea*, *Diospyros lycioides* subsp. *sericea*, *Diplorhynchus condylocarpon*, *Grewia hexamita*, *Gymnosporia mossambicensis*, *Hexalobus monopetalus*, *Monodora junodii* var. *junodii*, *Senna petersiana*, *Steganotaenia araliacea*, *Strychnos madagascariensis*, *Tricalysia junodii*. Low Shrubs: *Agathisanthemum bojeri*, *Hermannia glanduligera*, *Pavetta harborii*. Woody Climbers: *Artabotrys brachypetalus*, *Bauhinia galpinii*, *Cissus cornifolia*, *Rhoicissus revoli*. Herbaceous Climbers: *Merremia tridentata*, *Rhynchosia totta*. Graminoids: *Andropogon gayanus* (d), *Digitaria eriantha* subsp. *pentzii* (d), *Panicum maximum* (d), *Aristida mollissima* subsp. *argentea*, *A. stipitata* subsp. *graciliflora*, *Brachiaria serrata*, *Bulbostylis hispidula*, *Coleochloa setifera*, *Perotis patens*, *Pogonarthria squarrosa*, *Setaria incrassata*, *Tetrapogon tenellus*, *Tricholaena monachne*. Herbs: *Vahlia capensis* subsp. *vulgaris*, *Vernonia fastigiata*. Geophytic Herb: *Drimis altissima*.

Lowveld

SVI 1 Makuleke Sandy Bushveld

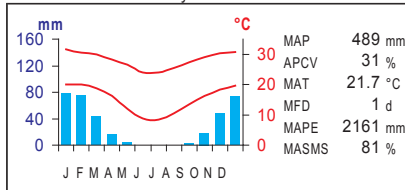
VT 9 Lowveld Sour Bushveld (34%), VT 15 Mopani Veld (21%) (Acocks 1953). LR 21 Sour Lowveld Bushveld (40%), LR 10 Mopane Bushveld (28%) (Low & Rebelo 1996).

Distribution Limpopo and (very slightly into) Mpumalanga Provinces: Flats and hills east of the Soutpansberg, south of Klein Tshipise and Masisi, along the valleys of the Mutale River and mid- to lower Levuvhu River; the Maseya Sandveld and Punda Maria areas of the northern Kruger National Park and as few isolated patches in the park, for example Dzundwini Mountain in the north and a narrow sandstone belt sandwiched between the granite and the basalt reaching the Timbavati Picnic Area in the south. Altitude 300–700 m.

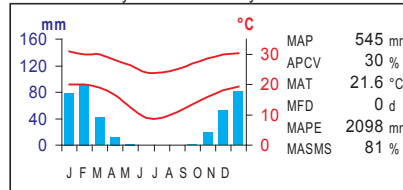
Vegetation & Landscape Features Variable landscapes from low mountains, slightly to extremely irregular plains to hills. A tree savanna (or tall shrub in places) occurs on the deep sands with trees such as *Terminalia sericea*, *Burkea africana*, *Guibourtia conjugata* and *Peltophorum africana* and a moderate to dense ground layer containing, for example, *Andropogon gayanus* and *Digitaria eriantha*. On stony soils the tree savanna includes *Kirkia acuminata*, *Croton gratissimus*, *Combretum apiculatum* and *Diplorhynchus condylocarpon* while the ground layer includes dominant *Digitaria eriantha*, *Panicum maximum* and *Pogonarthria squarrosa*.

Geology & Soils The Soutpansberg Group of sandstones with lesser amounts of conglomerate, shale and basalt is mostly

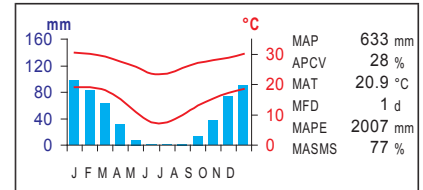
SVI 1 Makuleke Sandy Bushveld



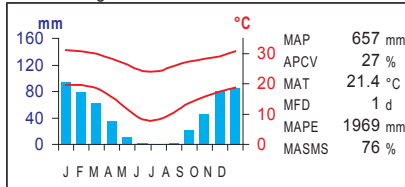
SVI 2 Nwambyia-Pumbe Sandy Bushveld



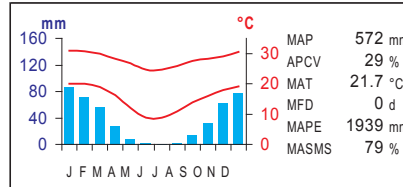
SVI 3 Granite Lowveld



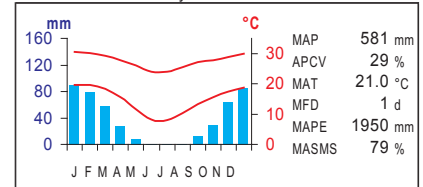
SVI 4 Delagoa Lowveld



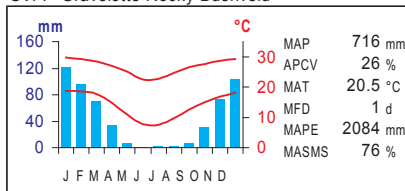
SVI 5 Tshokwane-Hlane Basalt Lowveld



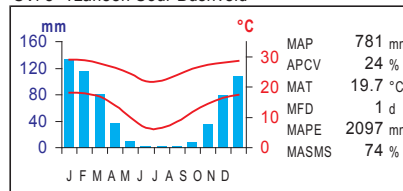
SVI 6 Gabbro Grassy Bushveld



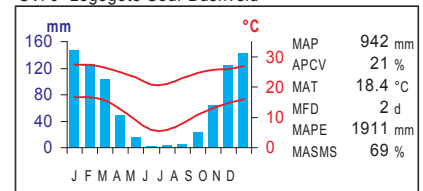
SVI 7 Gravelotte Rocky Bushveld



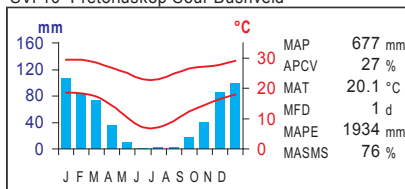
SVI 8 Tzaneen Sour Bushveld



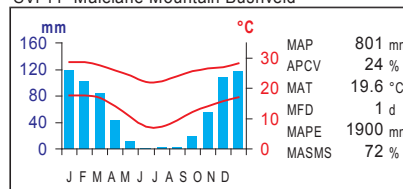
SVI 9 Legogote Sour Bushveld



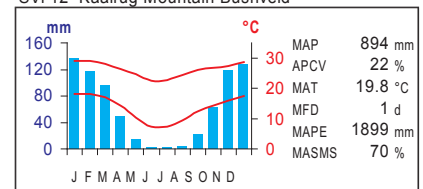
SVI 10 Pretoriuskop Sour Bushveld



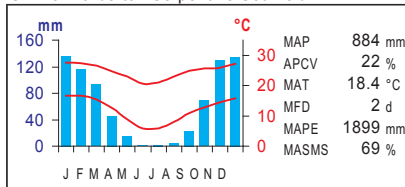
SVI 11 Malelane Mountain Bushveld



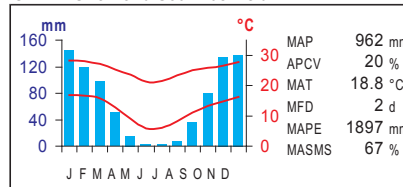
SVI 12 Kaalrug Mountain Bushveld



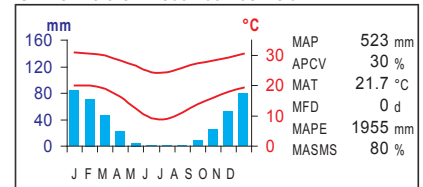
SVI 13 Barberton Serpentine Sourveld



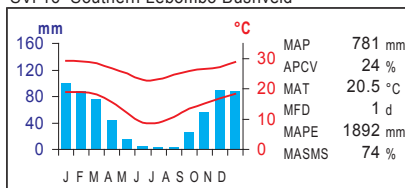
SVI 14 Swaziland Sour Bushveld



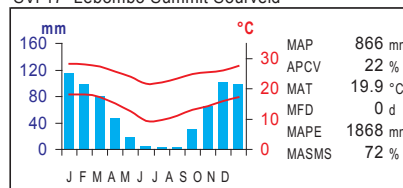
SVI 15 Northern Lebombo Bushveld



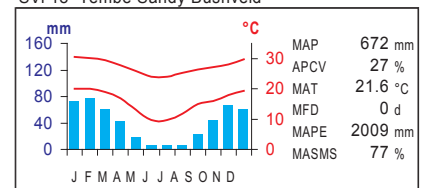
SVI 16 Southern Lebombo Bushveld



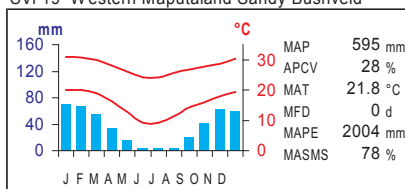
SVI 17 Lebombo Summit Sourveld



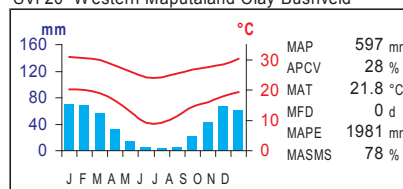
SVI 18 Tembe Sandy Bushveld



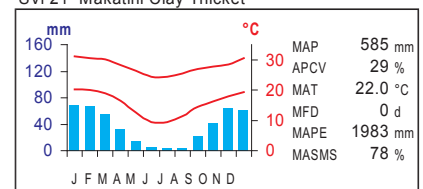
SVI 19 Western Maputaland Sandy Bushveld



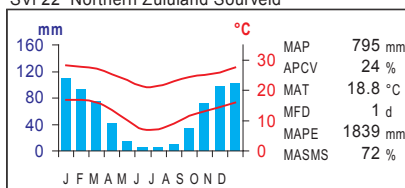
SVI 20 Western Maputaland Clay Bushveld



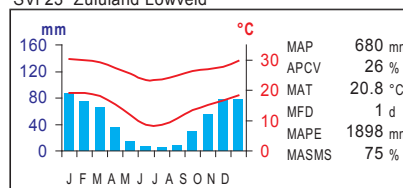
SVI 21 Makatini Clay Thicket



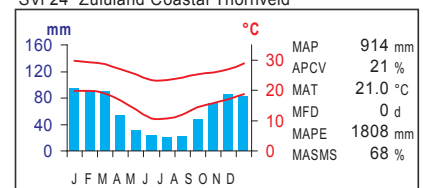
SVI 22 Northern Zululand Sourveld



SVI 23 Zululand Lowveld



SVI 24 Zululand Coastal Thornveld



Biogeographically Important Taxon (Southern distribution limit) Small Tree: *Holarrhena pubescens*.

Endemic Taxa Succulent Shrub: *Euphorbia rowlandii*. Herb: *Ceratotheca saxicola*.

Conservation Vulnerable. Target 19%. About 32% statutorily conserved in the Kruger National Park. Roughly 27% has been transformed, mostly through cultivation. Erosion is moderate to high in places.

Remarks At least two areas of this unit have heavier soil with a clayey B-horizon, and occur on flat to undulating terrain near the western boundary of the Kruger National Park. Despite their heavier soil and that these areas are completely surrounded by vegetation which is overwhelmingly dominated by *Colophospermum mopane*, remarkably few individuals of mopane penetrate these areas. These patches correspond to the *Pterocarpus rotundifolius/Combretum collinum* Woodland of Gertenbach (1983b).

References Van Rooyen (1978), Van Rooyen et al. (1981a), Gertenbach (1983b).



Figure 9.45 SVI 2 Nwambyia-Pumbe Sandy Bushveld: Open to closed broad-leaved woodland, largely occurring on sandy soils with *Strychnos* species, *Crossopteryx febrifuga* and *Xeroderris stuhlmannii* south of Nwambyia, Kruger National Park.

SVI 2 Nwambyia-Pumbe Sandy Bushveld

VT 15 Mopani Veld (81%) (Acocks 1953). LR 10 Mopane Bushveld (55%) (Low & Rebelo 1996). KNP 32 Nwambia Sandveld (84%) (Gertenbach 1983b).

Distribution Limpopo and Mpumalanga Provinces: Flats well to the east of Punda Maria on the border with Mozambique (the Nwambyia part of this unit). A small patch further south, also on the eastern border, in the vicinity of the Pumbe Guard Post northeast of Satara. Altitude 350–550 m.

Vegetation & Landscape Features Flats with several small pans embedded. Conspicuous is the absence of well-defined drainage channels. Moderately open tall shrubland with few trees. The Nwambyia part consists mainly of *Xeroderris stuhlmannii*–*Combretum apiculatum* tree savanna and *Terminalia sericea*–*Pogonarthria squarrosa* tree savanna (Van Rooyen 1978), both with field layers better developed than that of the FOz 8 Sand Forest patch embedded in it. The second variation has many floristic links with SVI 1 Makuleke Sandy Bushveld.

Geology & Soils The Cretaceous Malvern Formation conglomerate and overlying sandstone form deep yellow to red Quaternary sands of the Hutton and Clovelly soil forms (apedal, freely drained, dystrophic and mesotrophic). The Pumbe part also includes some shallow lithosols (Mispah and Glenrosa soil forms). Land types mainly Ac and Fb.

Climate Summer rainfall with dry winters. MAP about 450–650 mm. Generally a frost-free region. See also climate diagram for SVI 2 Nwambyia-Pumbe Sandy Bushveld.

Important Taxa Tall Trees: *Sclerocarya birrea* subsp. *caffra* (d), *Acacia nigrescens*, *Adansonia digitata*, *Philenoptera violacea*. Small Trees: *Baphia massaiensis* (d), *Combretum apiculatum* (d), *C. zeyheri* (d), *Terminalia sericea* (d), *Azelia quanzensis*, *Balanites maughanii*, *Boscia albitrunca*, *Cassia abbreviata* subsp. *beareana*, *Combretum collinum* subsp. *taborense*, *C. molle*, *Crossopteryx febrifuga*, *Dalbergia melanoxylon*, *Lannea schweinfurthii* var. *stuhlmannii*, *Ozoroa engleri*, *Ptaeroxylon obliquum*, *Spirostachys africana*, *Vangueria infausta*. Tall Shrubs: *Grewia microthyrsa* (d), *Pteleopsis myrtifolia* (d), *Tephrosia polystachya* (d), *Vitex ferruginea* (d), *Alchornea laxiflora*, *Dichrostachys cinerea*, *Grewia bicolor*, *G. monticola*, *Phyllanthus parvulus*, *Strychnos madagascariensis*. Low Shrubs: *Agathisanthemum bojeri*, *Aptosimum lineare*, *Melhania forbesii*, *Monechma debile*, *Pavetta catophylla*. Woody Climbers: *Cissus cornifolia*, *Combretum mossambicense*, *Rhynchosia resinosa*. Herbaceous Climber: *Merremia tridentata* (d). Graminoids: *Aristida stipitata* subsp. *graciliflora* (d), *Brachiaria nigropedata* (d), *Digitaria eriantha* subsp. *eriantha* (d), *Eragrostis pallens* (d), *Panicum maximum* (d), *Schmidtia pappophoroides* (d), *Aristida congesta*, *Cymbopogon pospischilii*, *Enneapogon cenchroides*, *Eragrostis superba*, *Heteropogon contortus*, *Perotis patens*, *Pogonarthria squarrosa*, *Tricholaena monachne*, *Urochloa mosambicensis*. Herbs: *Vigna unguiculata* (d), *Coptosperma zygoon*, *Euphorbia tettensis*, *Commelina africana*, *C. erecta*, *Heliotropium steudneri*, *Indigofera filipes*, *I. vicioides*, *Kohautia virgata*.

Biogeographically Important Taxa (Southern distribution limit) Small Trees: *Xeroderris stuhlmannii* (d), *Xylia torreana* (d). Woody Climber: *Hugonia orientalis* (d).

Conservation Least threatened. Target 19%. All statutorily conserved in the Kruger National Park.

Remark This vegetation unit is well represented in Mozambique and extends only as far as 10 km into South Africa.

References Van Rooyen (1978), Van Rooyen et al. (1981a), Gertenbach (1983b).

Figure 9.43 Climate diagrams of Lowveld Bioregion units. Blue bars show the median monthly precipitation. The upper and lower red lines show the mean daily maximum and minimum temperature respectively. MAP: Mean Annual Precipitation; APCV: Annual Precipitation Coefficient of Variation; MAT: Mean Annual Temperature; MFD: Mean Frost Days (days when screen temperature was below 0°C); MAPE: Mean Annual Potential Evaporation; MASMS: Mean Annual Soil Moisture Stress (% of days when evaporative demand was more than double the soil moisture supply).

SVI 3 Granite Lowveld

VT 11 Arid Lowveld (40%), VT 10 Lowveld (38%) (Acocks 1953). LR 19 Mixed Lowveld Bushveld (61%) (Low & Rebelo 1996).

Distribution Limpopo and Mpumalanga Provinces, Swaziland and marginally also KwaZulu-Natal: A north-south belt on the plains east of the escarpment from Thohoyandou in the north, interrupted in the Bolobedu area, continued in the Bitavi area, with an eastward extension on the plains around the Murchison Range and southwards to Abel Erasmus Pass, Mica and Hoedspruit areas to the area east of Bushbuckridge. Substantial parts are found in the Kruger National Park spanning areas east of Orpen Camp southwards through Skukuza and Mkuhlu, including undulating terrain west of Skukuza to the basin of the Mbyamiti River. It continues further southward to the Hectorspruit area with a narrow westward extension up the Crocodile River Valley past Malelane, Kaapmuiden and the Kaap River Valley, entering Swaziland between Jeppe's Reef in the west and the Komati River in the east, through to the area between Manzini and Siphofaneni, including the Grand Valley, narrowing irregularly and marginally entering KwaZulu-Natal near Pongola. Altitude 250–700 m.

Vegetation & Landscape Features Tall shrubland with few trees to moderately dense low woodland on the deep sandy uplands with *Terminalia sericea*, *Combretum zeyheri* and *C. apiculatum* and ground layer including *Pogonarthria squarrosa*, *Tricholaena monachne* and *Eragrostis rigidior*. Dense thicket to open savanna in the bottomlands with *Acacia nigrescens*, *Dichrostachys cinerea*, *Grewia bicolor* in the woody layer. The dense herbaceous layer contains the dominant *Digitaria eriantha*, *Panicum maximum* and *Aristida congesta* on fine-textured soils, while brackish bottomlands support *Sporobolus nitens*, *Urochloa mosambicensis* and *Chloris virgata*. At seep lines, where convex topography changes to concave, a dense fringe of *Terminalia sericea* occurs, with *Eragrostis gummiflua* in the undergrowth.

Geology & Soils From north to south, the Swazian Goudplaats Gneiss, Makhutswi Gneiss and Nelspruit Suite (granite gneiss and migmatite), and further south still, the younger Mpuluzi Granite

(Randian) form the major basement geology of the area. Archaean granite and gneiss weather into sandy soils in the uplands and clayey soils with high sodium content in the lowlands.

Climate Summer rainfall with dry winters. MAP from about 450 mm on the eastern flats to about 900 mm near the escarpment in the west. In a north-south direction, MAP of the unit appears to peak in Swaziland. Generally a frost-free region. Mean monthly maximum and minimum temperatures for Skukuza 39.5°C and –0.1°C for January and June, respectively. Corresponding values for Hoedspruit 38.0°C and 3.7°C for January and July, respectively. See also climate diagram for SVI 3 Granite Lowveld.

Important Taxa Tall Trees: *Acacia nigrescens* (d), *Sclerocarya birrea* subsp. *caffra* (d). Small Trees: *Acacia nilotica* (d), *Albizia harveyi* (d), *Combretum apiculatum* (d), *C. imberbe* (d), *C. zeyheri* (d), *Ficus stuhlmannii* (d), *Peltophorum africanum* (d), *Pterocarpus rotundifolius* (d), *Terminalia sericea* (d), *Acacia exuvialis*, *A. gerrardii*, *Bolusanthus speciosus*, *Cassia abbreviata* subsp. *beareana*, *Combretum collinum* subsp. *suluense*, *Dalbergia melanoxylon*, *Gymnosporia glaucophylla*, *Lannea schweinfurthii* var. *stuhlmannii*, *Pavetta schumanniana*, *Plectroniella armata*, *Terminalia prunioides*. Tall Shrubs: *Combretum hereroense* (d), *Dichrostachys cinerea* (d), *Euclea divinorum* (d), *Strychnos madagascariensis* (d), *Gardenia volkensii*, *Hibiscus micranthus*, *Tephrosia polystachya*. Low Shrubs: *Abutilon austro-africanum*, *Agathisanthemum bojeri*, *Aptosimum lineare*, *Barleria elegans*, *Clerodendrum ternatum*, *Commiphora africana*, *Gossypium herbaceum* subsp. *africanum*, *Pavonia burchellii*. Woody Climber: *Sphegamnocarpus pruriens* subsp. *pruriens*. Herbaceous Climber: *Rhynchosia totta*. Graminoids: *Brachiaria nigropedata* (d), *Digitaria eriantha* subsp. *eriantha* (d), *Eragrostis rigidior* (d), *Melinis repens* (d), *Panicum maximum* (d), *Pogonarthria squarrosa* (d), *Aristida congesta*, *Bulbostylis hispidula*, *Chloris mossambicensis*, *Enneapogon cenchroides*, *Heteropogon contortus*, *Leptochloa eleusine*, *Perotis patens*, *Schmidtia pappophoroides*, *Sehima galpinii*, *Tricholaena monachne*, *Urochloa mosambicensis*. Herbs: *Achyranthes aspera*, *Aspilia mossambicensis*, *Becium filamentosum*, *Chamaecrista absus*, *Commelina benghalensis*, *C. erecta*, *Cucumis africanus*, *Evolvulus alsinoides*, *Heliotropium strigosum*, *Hermbstaedtia odorata*, *Hibiscus praeteritus*, *Indigofera filipes*, *I. sanguinea*, *Kohautia virgata*, *Kyphocarpa angustifolia*, *Leucas glabrata*, *Ocimum gratissimum*, *Phyllanthus maderaspatensis*, *Pupalia lappacea*, *Vahlia capensis* subsp. *vulgaris*, *Waltheria indica*. Succulent Herbs: *Orbea rogersii*, *Stapelia leendertziae*.

Conservation Vulnerable. Target 19%. Some 17% statutorily conserved in the Kruger National Park. About the same amount conserved in private reserves mainly the Selati, Klaserie, Timbavati, Mala Mala, Sabi Sand and Manyeleti Reserves. More than 20% already transformed, mainly by cultivation and by settlement development. Erosion is very low to moderate.

Remark Further research may reveal a need to differentiate the northern from the southern parts of this unit.

References Bredenkamp (1982, 1985, 1986a, 1987), Bredenkamp et al. (1983, 1993), Coetzee (1983), Gertenbach (1983b), Bredenkamp & Theron (1985, 1988, 1990, 1991), Witkowski & O'Connor (1996).



H.C. Eckhardt

Figure 9.46 SVI 3 Granite Lowveld: Moderately open savanna dominated by *Sclerocarya birrea*, *Combretum apiculatum* and *C. zeyheri* south of Skukuza, Kruger National Park.



Figure 9.47 SVI 4 Delagoa Lowveld: Heavily utilised area surrounded by *Acacia welwitschii* tending towards thickets southwest of Satara, Kruger National Park.

SVI 4 Delagoa Lowveld

VT 10 Lowveld (87%) (Acocks 1953). LR 19 Mixed Lowveld Bushveld (59%) (Low & Rebelo 1996).

Distribution Mpumalanga Province, Swaziland and marginally into KwaZulu-Natal Province: A narrow strip on plains immediately east of the SVI 3 Granite Lowveld from the Nsemani River west of Satara in the Kruger National Park southwards to immediately west of Lower Sabie Camp to the Pomba Guard Post west of Crocodile Bridge Camp to the Strydom Block in the south. Also a band in Swaziland from Mhlume in the north to Onverwacht Border Post in the south, extending marginally into KwaZulu-Natal at Pongola. Altitude 150–450 m.

Vegetation & Landscape Features Dense tree or tall shrub layer dominated by *Acacia welwitschii*, often forming thickets. Herb layer has in addition to grass species a wide variety of forbs. Areas are often heavily grazed which sometimes drastically reduces the grass cover.

Geology & Soils Karoo Supergroup shale and lesser sandstone layers are punctuated by sheets and dykes of Jurassic dolerite. Soils (Sterkspruit, Swartland and Estcourt soil forms) are rich in sodium and very susceptible to erosion. Land types include Dc and Ea.

Climate Summer rainfall with dry winters. MAP about 450–850 mm. Generally a frost-free region. See also climate diagram for SVI 4 Delagoa Lowveld.

Important Taxa Small Trees: *Acacia senegal* var. *rostrata* (d), *A. welwitschii* subsp. *delagoensis* (d), *Albizia petersiana* (d), *Schotia capitata* (d), *Spirostachys africana* (d), *Pappea capensis*. Tall Shrubs: *Euclea divinorum* (d), *Maerua parvifolia* (d), *Boscia mossambicensis*, *Dichrostachys cinerea*, *Ehretia rigida* subsp. *rigida*, *Flueggea virosa*, *Grewia bicolor*, *Rhus gueinzii*. Low Shrubs: *Abutilon austroafricanum*, *Justicia flava*, *Zanthoxylum*

humile. Woody Climbers: *Cordia ovalis* (d), *Capparis tomentosa*. Graminoids: *Chloris virgata* (d), *Panicum coloratum* (d), *P. maximum* (d), *Sporobolus nitens* (d), *Aristida congesta*, *Chloris roxburghiana*, *Dactyloctenium aegyptium*, *Tragus berteronianus*. Herbs: *Blepharis integrifolia*, *Kyphocarpa angustifolia*, *Ruellia patula*. Succulent Herb: *Aloe parvibracteata*.

Conservation Vulnerable. Target 19%. About 18% statutorily conserved in the Kruger National Park. Some 33% transformed, almost all by cultivation.

References Coetzee (1983), Gertenbach (1983b).

SVI 5 Tshokwane-Hlane Basalt Lowveld

VT 11 Arid Lowveld (56%) (Acocks 1953). LR 20 Sweet Lowveld Bushveld (69%) (Low & Rebelo 1996).

Distribution Mpumalanga Province and Swaziland (and very slightly into Limpopo Province): On plains immediately west of the Lebombo Mountains from Balule and Satara Camps in Kruger National Park in the north, through Tshokwane, Lower Sabie and Crocodile Bridge Camps, Komatipoort to around Ngwenyeni in the south. In Swaziland it occurs from Vuvulane Settlement in the north, through Hlane Game Sanctuary to a point in the south approximately halfway between Siteki and Big Bend. Altitude 180–400 m.

Vegetation & Landscape Features Usually fairly flat plains with open tree savanna, often dominated by tall *Sclerocarya birrea* and *Acacia nigrescens* with a moderately developed shrub layer and a dense herbaceous layer. On some sloping areas with shallower soils, trees are stunted (e.g. *A. nigrescens*).

Geology & Soils The Letaba Formation basalts of the Karoo Supergroup in this area give rise to black, brown or red clayey soils, usually not more than 1 m deep. Vertisols, such as the Arcadia soil form, occur in low-lying areas and concave plains. Land types mainly Ea with some Dc.



Figure 9.48 SVI 5 Tshokwane-Hlane Basalt Lowveld: Deciduous closed woodland occurring on clay flats with *Acacia gerrardii*, *A. tortilis*, *Combretum hereroense* and *C. imberbe* looking over the Nwanetsi River, Kruger National Park.

Climate Summer rainfall with dry winters. MAP about 400–800 mm in the southernmost part in Swaziland. Mean monthly maximum and minimum temperatures for Satara (in the north of the unit) 40.2°C and 4.2°C for January and June, respectively. See also climate diagram for SVI 5 Tshokwane-Hlane Basalt Lowveld.

Important Taxa Tall Trees: *Acacia nigrescens* (d), *Sclerocarya birrea* subsp. *caffra* (d), *Philenoptera violacea*. Small Trees: *Acacia borleae*, *A. gerrardii*, *A. nilotica*, *A. tortilis* subsp. *heteracantha*, *Albizia harveyi*, *Combretum hereroense*, *C. imberbe*, *Lannea schweinfurthii* var. *stuhlmannii*, *Peltophorum africanum*, *Pterocarpus rotundifolius*. Tall Shrubs: *Dichrostachys cinerea*, *Grewia bicolor*, *Gymnosporia maranguensis*, *Rhus gueinzii*. Low Shrubs: *Acalypha segetalis*, *Dicoma tomentosa*, *Hermannia glanduligera*, *Justicia flava*, *J. protracta* subsp. *protracta*, *Seddera suffruticosa*, *Tragia dioica*. Herbaceous Climber: *Commicarpus plumbagineus*. Graminoids: *Bothriochloa radicans* (d), *Digitaria eriantha* subsp. *eriantha* (d), *Panicum coloratum* (d), *P. maximum* (d), *Themeda triandra* (d), *Urochloa mosambicensis* (d), *Aristida congesta*, *Cenchrus ciliaris*, *Eragrostis superba*, *Heteropogon contortus*. Herbs: *Chamaecrista mimosoides*, *Gisekia africana*, *Thunbergia dregeana*. Succulent Herbs: *Aloe zebrina*, *Orbea paradoxa*, *O. rogersii*.

Endemic Taxon Low Shrub: *Boscia foetida* subsp. *minima*.

Conservation Least threatened. Target 19%. About 64% statutorily conserved mainly in the Kruger National Park, but also in the Mlawula Nature Reserve. In addition, over 3% conserved mainly in the Hlane Game Sanctuary. About 17% transformed, almost all by cultivation.

Remarks Different parts of this unit can show different rates of change over years, including some parts with very little change (Coetzee et al. 1977). Mapped as part of this unit is the small area (3% of the unit) east of Kumana waterhole, south of Satara (Kumana Sandveld of Gertenbach 1983b), which is on sandstone, but contains dolerite intrusions with clayey soil as well as some surface shales with sodium-saturated soil.

References Coetzee et al. (1977), Gertenbach & Potgieter (1978), Coetzee (1983), Gertenbach (1983b).

SVI 6 Gabbro Grassy Bushveld

VT 11 Arid Lowveld (60%) (Acocks 1953). LR 20 Sweet Lowveld Bushveld (52%) (Low & Rebelo 1996). KNP 19 Thornveld on gabbro (96%) (Gertenbach 1983b).

Distribution Mpumalanga Province: Flats and hills mainly in the Kruger National Park in isolated patches from Orpen Camp in the north, southwards including Rooigras Vlake (northeast of Skukuza) and some areas stretching from north of Pretoriuskop to around Afsaal in the south. Altitude 200–550 m.

Vegetation & Landscape Features Open savanna with a dense grass cover (with dominants including *Themeda triandra*) with a few scattered trees and shrubs. Sparser grass cover is encountered on shallow soils.



Figure 9.49 SVI 6 Gabbro Grassy Bushveld: Very open low grassy savanna with *Acacia nigrescens* and *Albizia harveyi* near Skipberg southeast of Pretoriuskop, Kruger National Park.

Geology & Soils The distribution of this bushveld closely follows the sinuous intrusions of the Timbavati gabbro (Mokolian Erathem). The unit is also mapped on surrounding potassic granite and gneiss of Archaean basement and the gneiss and migmatite of the Nelspruit Suite (also Archaean). Dark vertic clay soils (20–50% clay) often swell and shrink. Loose rock is often present on the surface. Some shallow lithosols occur in places. Where gabbro is in contact with the adjacent granite, a mixed soil sometimes develops with a gabbro-derived A-horizon overlying a granite-derived B-horizon. Land types mainly Fb and Dc.

Climate Summer rainfall with dry winters. MAP about 500–650 mm. Generally a frost-free region. See also climate diagram for SVI 6 Gabbro Grassy Bushveld.

Important Taxa Tall Trees: *Acacia nigrescens* (d), *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Acacia tortilis* subsp. *heteracantha*, *Bolusanthus speciosus*, *Dalbergia melanoxylon*, *Lannea schweinfurthii* var. *stuhlmannii*, *Ziziphus mucronata*. Tall Shrubs: *Flueggea virosa*, *Grewia bicolor*, *Ormocarpum trichocarpum*, *Tephrosia polystachya*. Low Shrubs: *Abutilon austro-africanum*, *Seddera suffruticosa*, *Sida rhombifolia*. Graminoids: *Chloris virgata* (d), *Ischaemum afrum* (d), *Setaria incrassata* (d), *Themeda triandra* (d), *Bothriochloa radicans*, *Cenchrus ciliaris*, *Cymbopogon pospischilii*, *Digitaria eriantha* subsp. *eriantha*, *Enneapogon cenchroides*, *Eragrostis superba*, *Panicum maximum*, *Schmidtia pappophoroides*, *Sorghum versicolor*, *Sporobolus nitens*, *Urochloa mosambicensis*. Herbs: *Heliotropium steudneri*, *Ipomoea crassipes*, *Kyphocarpa angustifolia*. Succulent Herb: *Aloe zebrina*.

Conservation Least threatened. Target 19%. Altogether 96% statutorily conserved in the Kruger National Park and the remainder is conserved in private reserves (Timbavati and Manyeleti). Very little transformed and erosion is low.

Remarks The mapped unit follows Gertenbach's (1983b) boundaries. More recent geology maps show the gabbro to be narrower than mapped. A few areas of gabbro just outside the southern Kruger National Park have not been depicted on our map.

References Gertenbach (1978, 1983b), Bredenkamp & Deutschländer (1994, 1995).

SVI 7 Gravelotte Rocky Bushveld

VT 11 Arid Lowveld (59%) (Acocks 1953). LR 19 Mixed Lowveld Bushveld (58%) (Low & Rebelo 1996).

Distribution Limpopo Province: The Murchison Range in the Gravelotte area including surrounding mountains and hills including Ga-Mashishimale north of Mica and Seribana, and extending northwards towards Thohoyandou as isolated hills including Mangombe and Sionwe. Altitude 450–950 m (with the highest peaks reaching 1 025 m).

Vegetation & Landscape Features Open deciduous to semi-deciduous woodland on rocky slopes and inselbergs, contrasting strongly with the surrounding plains.

Geology & Soils The varied geology is largely composed of schist and amphibolite of the Gravelotte and Giyani Groups, with a few quartzitic and granitic hills. Miscellaneous, often shallow, soils with Glenrosa and Mispah forms common. Land types mainly Ib, Fa, Ae and Fb.

Climate Summer rainfall with dry winters. MAP about 500 mm in the east to about 900 mm in the west, with the higher rainfall on the higher mountains. Frost very infrequent. See also climate diagram for SVI 7 Gravelotte Rocky Bushveld.

Important Taxa Tall Tree: *Pterocarpus angolensis*. Small Trees: *Acacia caffra* (d), *Croton gratissimus* (d), *Cussonia natalensis* (d), *Ficus tettensis* (d), *Kirkia acuminata* (d), *Berchemia zeyheri*, *Bridelia mollis*, *Combretum apiculatum*, *C. molle*, *Dombeya rotundifolia*, *Englerophytum magalismontanum*, *Faurea saligna*, *Ficus abutilifolia*, *F. burkei*, *Heteropyxis natalensis*, *Ochna natalitia*, *Pavetta schumanniana*, *Rhus leptodictya*, *Schrebera alata* (woodland form), *Sterculia rogersii*, *Vangueria infausta*. Succulent Tree: *Euphorbia cooperi*. Tall Shrubs: *Steganotaenia araliacea* (d), *Coptosperma supra-axillare*, *Hexalobus monopetalus*, *Mundulea sericea*, *Pouzolzia mixta*, *Psydrax livida*. Low Shrubs: *Barleria affinis*, *B. lancifolia*, *B. saxatilis*, *Psiadia punctulata*. Woody Climbers: *Cocculus hirsutus*, *Sphedamnocarpus pruriens* subsp. *pruriens*. Graminoids: *Brachiaria serrata* (d), *Panicum maximum* (d), *Andropogon schirensis*, *Brachiaria nigropedata*, *Cymbopogon caesius*, *Eustachys paspaloides*, *Heteropogon contortus*, *Loudetia simplex*, *Setaria sphacelata*. Herb: *Vernonia natalensis*. Succulent Herb: *Stapelia gigantea*.

Endemic Taxon Small Tree: *Encephalartos dyerianus*.

Conservation Least threatened. Target 19%. None conserved in statutory conservation areas. Some 7% conserved in a small proportion of the area in the northern part of the Selati Game Reserve. Conservation of this unit is promoted due to the land use of game and cattle ranching and due to its low agronomic potential. About 15% transformed, mainly by cultivation and some development of settlements. Erosion is very low to moderate.

Reference M.C. Lötter & J.E. Burrows (unpublished data).

SVI 8 Tzaneen Sour Bushveld

VT 9 Lowveld Sour Bushveld (80%) (Acocks 1953). LR 21 Sour Lowveld Bushveld (59%) (Low & Rebelo 1996).

Distribution Limpopo Province: A band extending along the footslopes and hills of the northeastern escarpment, from the Soutpansberg Mountains in the north via Tzaneen and narrowing to the Abel Erasmus Pass area in the south. Altitude 600–1 000 m and higher in places.

Vegetation & Landscape Features Deciduous, tall open bushveld (parkland) with a well-developed, tall grass layer, occurring on low to high mountains with undulating plains mainly at the base of, and on the lower to middle slopes of the northeastern escarpment.

Geology & Soils The potassium-poor gneisses of the Goudplaats gneiss (Swazian Erathem) and an Archaean granite dyke underlie most of this area. Shales and quartzite of the Wolkberg Group are present, but not common. Soils are Mispah, Glenrosa or Hutton forms, shallow to deep, sandy or gravelly and well-drained. Land types Fa, Ab, Ae and Ia.

Climate Summer rainfall with dry winters. MAP from about 550 mm on the footslopes of the escarpment in the east to about 1 000 mm, where it borders grassland at higher altitudes to the west. Frost infrequent, but occasional at higher altitude. Mean monthly maximum and minimum temperatures for Tzaneen 36.4°C and 3.9°C for January and June, respectively. Corresponding values for Levubu-Agr 36.4°C and 5.7°C for October and July, respectively. See also climate diagram for SVI 8 Tzaneen Sour Bushveld.

Important Taxa Tall Trees: *Pterocarpus angolensis*, *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Acacia polyacantha* (d), *Albizia versicolor* (d), *Ficus sansibarica* (d), *Parinari curatellifolia* (d), *Piliostigma thonningii* (d), *Pterocarpus rotundifolius* (d), *Trichilia emetica* (d), *Acacia davyi*, *A. sieberiana* var. *woodii*, *Antidesma venosum*, *Catha edulis*, *Faurea rochetiana*, *F. saligna*, *Ficus*



Figure 9.50 SVI 8 Tzaneen Sour Bushveld: The legendary Modjadji 'Forest' housing thousands of old specimens of *Encephalartos transvenosus*, protected by Her Majesty the Rain Queen of the Bo-Lobedu people near Ga-Modjadji, northeast of Tzaneen.

burkei, *F. petersii*, *Heteropyxis natalensis*, *Peltophorum africanum*, *Terminalia sericea*, *Vernonia colorata*. Tall Shrubs: *Olea europaea* subsp. *africana*, *Pseudarthria hookeri* var. *hookeri*, *Rhus pentheri*, *Triumfetta pilosa* var. *tomentosa*. Low Shrubs: *Agathisanthemum bojeri*, *Barleria elegans*, *Dicliptera clinopodia*, *Flemingia grahamiana*, *Indigofera filipes*, *Polygala producta*. Woody Climbers: *Bauhinia galpinii*, *Pterolobium stellatum*. Graminoids: *Cymbopogon caesius* (d), *C. nardus* (d), *Hyparrhenia cymbaria* (d), *H. poecilotricha* (d), *Hyperthelia dissoluta* (d), *Alloteropsis semialata* subsp. *semialata*, *Andropogon schirensis*, *Bothriochloa bladhii*, *Monocymbium ceresiiforme*, *Paspalum scrobiculatum*, *Schizachyrium sanguineum*, *Themeda triandra*. Herb: *Waltheria indica*.

W.L. McClelland



Figure 9.51 SVI 9 Legogote Sour Bushveld: A particularly open form of this type, namely Short Sparse Woodland with scattered Short Thicket (sensu Edwards 1983), extensively represented on crests and slopes. Dominant trees include *Acacia sieberiana*, *A. davyi*, *Dichrostachys cinerea* and *Rhus pyroides* with grasses *Hyperthelia dissoluta*, *Hyparrhenia* species, and shorter grass species such as *Themeda triandra* and *Loudetia simplex*. On the Farm Dingwell southwest of White River.

Conservation Endangered. Target 19%. Only a little over 1% statutorily conserved, almost all in the Lekgalameetse Nature Reserve, and about 2% conserved in private reserves such as the Selati Game Reserve and Wolkberg (Serala) Wilderness Area. About 41% transformed mainly by cultivation (29%) and plantations (9%).

The higher-lying parts of this unit have been heavily afforested with tree plantations while the lower-lying areas are under agricultural and horticultural crops. Scattered alien plants include *Solanum mauritianum*, *Melia azedarach* and *Caesalpinia decapetala*. The subtropical climate is conducive to the spread of *Chromolaena odorata*, *Lantana camara* and *Psidium guajava*. Erosion is very variable—from very low to high in some areas.

Remarks This unit has several subtropical elements such as *Acacia polyacantha* and *Trichilia emetica*. It is very similar to SVI 9 Legogote Sour Bushveld, but the latter has a cooler climate and different floristic elements. At places on the footslopes, this vegetation becomes very dense and is transitional to forest in kloofs on the eastern slopes of the Drakensberg. *A. ataxacantha* and *Trema orientalis* are prominent pioneer species here. This unit is also rich in fig species.

References Scheepers (1977), Acocks (1988), Stalmans (1990).

SVI 9 Legogote Sour Bushveld

VT 9 Lowveld Sour Bushveld (56%) (Acocks 1953). LR 21 Sour Lowveld Bushveld (90%) (Low & Rebelo 1996).

Distribution Mpumalanga and Limpopo Provinces: Lower eastern slopes and hills of the northeastern escarpment from Mariepskop in the north through White River to the Nelspruit area extending westwards up the valleys of the Crocodile, Elands and Houtbosloop Rivers and terminating in the south in the Barberton area. Altitude 600–1 000 m and higher in places.

Vegetation & Landscape Features Gently to moderately sloping upper pediment slopes with dense woodland including many medium to large shrubs often dominated by *Parinari curatellifolia* and *Bauhinia galpinii* with *Hyperthelia dissoluta* and *Panicum maximum* in the undergrowth. Short thicket dominated by *Acacia ataxacantha* occurs on less rocky sites. Exposed granite outcrops have low vegetation cover, typically

with *Englerophytum magalismontanum*, *Aloe petricola* and *Myrothamnus flabellifolia*.

Geology & Soils Most of the area is underlain by gneiss and migmatite of the Nelspruit Suite, but the southern part occurs on the potassium-poor rocks of the Kaap Valley Tonalite (both Swazian Erathem). The westernmost parts of the distribution are found in Pretoria Group shale and quartzite (Vaalian). Archaean granite plains with granite inselbergs and large granite boulders also occur. Soils are of Mispah, Glenrosa and Hutton forms, shallow to deep, sandy or gravelly and well drained. Diabase intrusions are common, giving rise to Hutton soils. Land types Ab, Fa and Ae.

Climate Summer rainfall with dry winters. MAP from about 700 mm on the footslopes of the escarpment in the east to about 1 150 mm where it borders on grassland at higher altitude to the west. Frost infrequent to occasional at higher altitudes. Mean monthly maximum and minimum temperatures for Nelspruit 35.7°C and 1.6°C for October and July, respectively. Corresponding values for Barberton-Agr 36.0°C and 0.8°C for October and June, respectively. Both weather stations lie at the eastern edge of the unit at lower altitude. See also climate diagram for SVI 9 Legogote Sour Bushveld.

Important Taxa Tall Trees: *Pterocarpus angolensis* (d), *Sclerocarya birrea* subsp. *caffra* (d). Small Trees: *Acacia davyi* (d), *A. sieberiana* var. *woodii* (d), *Combretum zeyheri* (d), *Erythrina latissima* (d), *Parinari curatellifolia* (d), *Terminalia sericea* (d), *Trichilia emetica* (d), *Vernonia amygdalina* (d), *Acacia caffra*, *Antidesma venosum*, *Erythroxylum emarginatum*, *Faurea rochetiana*, *F. saligna*, *Ficus burkei*, *F. glumosa*, *F. ingens*, *F. petersii*, *Heteropyxis natalensis*, *Peltophorum africanum*, *Piliostigma thonningii*, *Pterocarpus rotundifolius*, *Schotia brachypetala*. Succulent Tree: *Euphorbia ingens*. Tall Shrubs: *Diospyros lycioides* subsp. *sericea*, *Erythroxylum delagoense*, *Olea europaea* subsp. *africana*, *Pachystigma macrocalyx*, *Pseudarthria hookeri* var. *hookeri*, *Rhus pentheri*. Low Shrubs: *Diospyros galpinii* (d), *Flemingia grahamiana* (d), *Agathisanthemum bojeri*, *Eriosema psoraleoides*, *Gymnosporia heterophylla*, *Hemizygia punctata*,

Indigofera filipes, *Myrothamnus flabel-lifolius*, *Rhus rogersii*. Succulent Shrubs: *Aloe petricola*, *Euphorbia vandermerwei*, *Huernia kirkii*. Woody Climbers: *Acacia ataxacantha* (d), *Bauhinia galpinii* (d), *Helinus integrifolius*, *Sphedamnocarpus pruriens* subsp. *pruriens*. Graminoids: *Bothriochloa bladhii* (d), *Cymbopogon caesius* (d), *C. nardus* (d), *Hyparrhenia cymbaria* (d), *H. poecilotricha* (d), *Hyperthelia dissoluta* (d), *Panicum maximum* (d), *Andropogon schirensis*, *Paspalum scrobiculatum*, *Schizachyrium sanguineum*. Herbs: *Gerbera ambigua*, *G. viridifolia*, *Hemizygia persimilis*, *Hibiscus sidiformis*, *Ocimum gratissimum*, *Waltheria indica*. Succulent herbs: *Orbea carnosia* subsp. *carnosia*, *Stapelia gigantea*. Geophytic Herbs: *Gladiolus hollandii*, *Hypoxis rigidula*.



Figure 9.52 SVI 10 Pretoriuskop Sour Bushveld: Typical savanna dominated mainly by *Terminalia sericea* with *Pterocarpus angolensis* north of Pretoriuskop, Kruger National Park.

Endemic Taxon Succulent Herb: *Aloe simii*.

Conservation Endangered. Target 19%. About 2% statutorily conserved mainly in the Bosbokrand and Barberton Nature Reserves; at least a further 2% is conserved in private reserves including the Mbesan and Kaapsehoop Reserves and Mondri Cycad Reserve. It has been greatly transformed (50%), mainly by plantations and also by cultivated areas and urban development. Scattered alien plants include *Lantana camara*, *Psidium guajava* and *Solanum mauritianum*. Erosion is very low to moderate.

Remark At places on the footslopes this vegetation becomes very dense and is transitional to forest in kloofs on the eastern slopes of the escarpment.

References Van der Schijff & Schoonraad (1971), Deall (1985), Acocks (1988), Deall et al. (1989).

SVI 10 Pretoriuskop Sour Bushveld

VT 10 Lowveld (94%) (Acocks 1953). LR 21 Sour Lowveld Bushveld (78%) (Low & Rebelo 1996).

Distribution Mpumalanga Province: From around Hazyview and Pretoriuskop Camp in the southwestern part of the Kruger National Park to the Malekutu area. Also in the Crocodile Estates area between Nelspruit and Crocodile Gorge. Altitude 400–700 m.

Vegetation & Landscape Features Mainly uplands with open tree savanna dominated by *Terminalia sericea* and *Dichrostachys cinerea* with relatively few low shrubs, grassy layer dense and dominated by sour grasses such as *Hyperthelia dissoluta*, *Elionurus muticus* and *Hyparrhenia hirta*. Grass composition changes somewhat on the midslopes, and in the narrow bottomlands dominant species include *Acacia nilotica*, *A. gerrardii* and *A. tortilis*, *Digitaria eriantha*, *Eragrostis superba* and *Aristida congesta*.

Geology & Soils Granite and gneiss of the Nelspruit Suite weathering to a shallow, leached, red to yellow-brown sand to sandy loam of the Glenrosa, Hutton and Clovelly forms. Land types Ae, Ab, Ba and Fb.

Climate Summer rainfall and dry winters. MAP about 550–800 mm. Frost infrequent. Mean monthly maximum and minimum temperatures for Pretoriuskop are 37.3°C and 5.2°C for

October and July, respectively. See also climate diagram for SVI 10 Pretoriuskop Sour Bushveld.

Important Taxa Tall Tree: *Sclerocarya birrea* subsp. *cafra* (d). Small Trees: *Combretum apiculatum* (d), *C. zeyheri* (d), *Peltophorum africanum* (d), *Piliostigma thonningii* (d), *Terminalia sericea* (d), *Antidesma venosum*, *Combretum collinum* subsp. *gazense*, *C. molle*, *Ficus petersii*, *Parinari curatellifolia*, *Pterocarpus angolensis*, *Ximenia caffra*. Tall Shrubs: *Dichrostachys cinerea* (d), *Gymnosporia senegalensis* (d), *Strychnos madagascariensis* (d), *Grewia bicolor*, *G. monticola*, *Strychnos spinosa*, *Turraea nilotica*. Low Shrubs: *Agathisanthemum bojeri*, *Aptosimum lineare*, *Barleria obtusa*, *Gymnosporia glaucophylla*, *Melhanie rehmannii*, *Sida chrysantha*. Succulent Shrub: *Aloe petricola*. Woody climber: *Bauhinia galpinii*. Graminoids: *Aristida congesta* (d), *Digitaria eriantha* subsp. *eriantha* (d), *Elionurus muticus* (d), *Eragrostis rigidior* (d), *Heteropogon contortus* (d), *Hyparrhenia hirta* (d), *Hyperthelia dissoluta* (d), *Panicum coloratum* (d), *Pogonarthria squarrosa* (d), *Bothriochloa radicans*, *Diheteropogon amplexens*, *Eragrostis atrovirens*, *E. lappula*, *Hyparrhenia filipendula*, *Melinis repens*, *Perotis patens*, *Setaria sphacelata*, *Urochloa mosambicensis*. Herbs: *Chamaecrista mimosoides*, *Tricliceras glanduliferum*.

Conservation Least threatened. Target 19%. Some 40% statutorily conserved in the Kruger National Park. A very small area is also conserved in the private Mthethomusha Nature Reserve. About 16% transformed by cultivation and by development of settlements. Alien plants include *Opuntia stricta*, *Lantana camara* and *Psidium guajava*. Erosion is very low to moderate.

Remark This vegetation is related to the SVI 9 Legogote Sour Bushveld, but is drier.

Reference Gertenbach (1983b).

SVI 11 Malelane Mountain Bushveld

VT 10 Lowveld (80%) (Acocks 1953). LR 21 Sour Lowveld Bushveld (75%) (Low & Rebelo 1996).

Distribution Mpumalanga Province: High-lying area north of Malelane and Kaapmuiden including Berg-en-Dal Rest Camp area as far north as the area of the hill Sithongwane in the

Kruger National Park. Also includes the Krokodilpoortberge both north and south of the Crocodile Gorge. Altitude from 400 to over 1 000 m in places.

Vegetation & Landscape Features Open savanna on mountains and higher-lying slopes, with an open to dense, short mountain bushveld on rocky outcrops and lower-lying areas. Altitude and aspect are important in determining species composition in this mountainous terrain.

Geology & Soils Granite and gneiss, mostly of the Nelspruit Suite, forming hills with large boulders, with shallow, coarse, sandy lithosols, largely comprised of Glenrosa or Mispah soil types. Land types Fa, Fb and Ib.

Climate Summer rainfall with dry winters. MAP about 600–1 100 mm, increasing with altitude. Mountain tops experience occasional mist. Frost infrequent to occasional at higher altitudes. See also climate diagram for SVI 11 Malelane Mountain Bushveld.

Important Taxa Low-lying closed savanna: Tall Tree: *Pterocarpus angolensis* (d). Small Trees: *Acacia caffra* (d), *A. davyi* (d), *Combretum molle* (d), *Dombeya rotundifolia* (d), *Faurea saligna* (d), *Heteropyxis natalensis* (d), *Kirkia wilmsii* (d), *Sterculia murex* (d), *Acacia swazica*, *Combretum collinum* subsp. *suluense*, *C. zeyheri*, *Englerophytum magalis-montanum*, *Ficus abutilifolia*, *Maytenus undata* (woodland form), *Mimusops zeyheri*, *Pterocarpus rotundifolius*, *Rhus leptodictya*, *Terminalia sericea*, *Vitex obovata* subsp. *wilmsii*. Succulent Tree: *Euphorbia cooperi*. Tall Shrubs: *Acalypha glabrata*, *Croton madandensis*, *Diospyros lycioides* subsp. *sericea*, *Grewia monticola*, *Olea europaea* subsp. *africana*, *Strychnos spinosa*. Low Shrubs: *Barleria rotundifolia*, *Orthosiphon labiatus*, *Polygala producta*. Succulent Shrub: *Aloe spicata*. Woody Climbers: *Bauhinia galpinii*, *Dalbergia armata*, *Pterolobium stellatum*. Woody Succulent Climber: *Senecio pleistocephalus*. Herbaceous Climbers: *Coccinia rehmannii*, *Rhynchosia caribaea*. Graminoids: *Bothriochloa radicans* (d), *Enneapogon scoparius* (d), *Eragrostis rigidior* (d), *Eustachys paspaloides*, *Heteropogon contortus*, *Themeda triandra*, *Tristachya leucothrix*, *Urochloa mosambicensis*. Geophytic Herb: *Drimia altissima*. Succulent Herb: *Plectranthus cylindraceus*. Epiphytic Succulent Herb: *Ansellia africana*. **High-lying open savanna:** Small Trees: *Acacia davyi* (d), *Combretum molle* (d), *Heteropyxis natalensis* (d), *Hippobromus pauciflorus* (d), *Sterculia murex* (d), *Acacia*

natalitia, *Bersama lucens*, *Combretum kraussii*, *Cussonia spicata*, *Ekebergia capensis*, *Faurea rochetiana*, *Ficus ingens*, *Pavetta edentula*, *Rhus leptodictya*, *Vitex obovata* subsp. *wilmsii*. Tall Shrubs: *Olea capensis* subsp. *enervis* (d), *Canthium inerme*, *Rhus pentheri*, *Vernonia myriantha*. Low Shrubs: *Flemingia grahamiana* (d), *Helichrysum kraussii* (d), *Acalypha villicaulis*, *Asparagus virgatus*, *Diospyros galpinii*, *Helichrysum lepidissimum*, *Polygala producta*, *Tenrhynea phyllifolia*, *Vernonia crataegifolia*. Succulent Shrub: *Aloe spicata*. Woody Climber: *Dalbergia armata*. Graminoids: *Bothriochloa radicans* (d), *Enneapogon scoparius* (d), *Eragrostis rigidior* (d), *Andropogon eucomus*, *Eustachys paspaloides*, *Heteropogon contortus*, *Panicum natalense*, *Themeda triandra*, *Tristachya leucothrix*, *Urochloa mosambicensis*. Herbs: *Becium obovatum*, *Indigofera sanguinea*. Geophytic Herb: *Drimia altissima*. Succulent Herb: *Stapelia gigantea*. Epiphytic Succulent Herb: *Ansellia africana*.

Conservation Least threatened. Target 24%. About 39% statutorily conserved in the Kruger National Park and a further 6% conserved in the Mthethomusha Nature Reserve. At least 4% transformed, mainly by cultivation and urban and built-up areas. Scattered alien plants include *Lantana camara*, *Jacaranda mimosifolia*, *Melia azedarach*, *Solanum mauritanum*, *Sesbania punicea*, *Ricinus communis* and *Psidium guajava*. Erosion is generally very low to low.

Remarks This mountainous unit is similar to the SVI 9 Legogote Sour Bushveld, but which has a wetter and cooler climate. Two broad groups of plant communities are recognised, namely the high-lying open savannas and the low-lying closed savannas. The transition between these two community complexes is at an altitude of about 700 m.

Reference Gertenbach (1983b).

SVI 12 Kaalrug Mountain Bushveld

VT 10 Lowveld (73%) (Acocks 1953). LR 21 Sour Lowveld Bushveld (79%) (Low & Rebelo 1996).

Distribution Mpumalanga Province and slightly into Swaziland: Mountain slopes and hills from Barberton in the west continuing eastwards south of the Kaaps River and lower Crocodile River. Also including the lower slopes of Three Sisters and Kaalrug to the area of One Tree Hill and Wilson's Kop in the east. Altitude 350–950 m.

Vegetation & Landscape Features Open to dense, short mountain savanna or thickets, with a more dense grassy layer at higher altitudes. Often steep or very broken mountain slopes at altitudes lower than the Gm 17 Barberton Montane Grassland.

Geology & Soils Rocky mountains of schists, gneiss, shale and quartzite of the Figtree, Moodies, and Onverwacht Groups of the Barberton Greenstone Belt. Also basaltic lava including the granodiorite of the Salisburykop Pluton. Soils shallow, mainly Glenrosa and Mispah forms, with some areas of vertic, melanic clays along lowest edges. Land types Fb, Fa and Ea.

Climate Summer rainfall with dry winters. MAP from about 650 mm on the footslopes of the mountains to about



H.C. Eckhardt

Figure 9.53 SVI 11 Malelane Mountain Bushveld: General view of here moderately open bushveld near Berg-en-Dal Rest Camp, Kruger National Park.



M.C. Lötter

Figure 9.54 SVI 12 Kaalrug Mountain Bushveld. Rocky bushveld with *Olea europaea* subsp. *africana* and *Ficus sur* with some alien *Eucalyptus* species in the centre on Colombo Ranch mine east-northeast of Barberton.

1 200 mm where it borders grassland at higher altitudes. Frost infrequent to occasional at higher altitudes. See also climate diagram for SVI 12 Kaalrug Mountain Bushveld.

Important Taxa Small Trees: *Pavetta edentula* (d), *Sclerocroton integerrimus* (d), *Margaritaria discoidea*, *Tabernaemontana elegans*. Succulent Tree: *Euphorbia triangularis*. Tall Shrubs: *Combretum padoides* (d), *Diplorhynchus condylocarpon*, *Galpinia transvaalica*, *Maerua rosmarinoides*, *Monanthotaxis caffra*, *Olea europaea* subsp. *africana*. Low Shrubs: *Orthosiphon serratus*, *Pavetta gracilifolia*, *Ruttya ovata*. Succulent Shrub: *Euphorbia transvaalensis*. Soft Shrub: *Metarungia longistrobis*. Woody Climbers: *Combretum woodii* (d), *Caesalpinia rostrata*. Graminoids: *Bothriochloa radicans* (d), *Digitaria eriantha* subsp. *eriantha* (d), *Eragrostis rigidior* (d), *Eustachys paspaloides* (d), *Enneapogon scoparius*, *Heteropogon contortus*, *Panicum maximum*, *Schmidtia pappophoroides*, *Themeda triandra*. Herbs: *Senecio venosus*, *Vernonia natalensis*, *Waltheria indica*. Geophytic Herb: *Cyrtanthus galpinii*. Succulent Herb: *Plectranthus neochilus*.

Endemic Taxa Succulent Shrub: *Euphorbia complexa*. Geophytic Herb: *Ledebouria cremnophila*.

Conservation Least threatened. Target 24%. Some 16% statutorily conserved, almost all in Mountainlands Nature Reserve. A further 9% conserved in the private reserves of Cwantalala and Boondocks. About 12% transformed, mainly by cultivation and plantations. Erosion is generally very low.

Remarks This is a mesic mountain bushveld with some relationships to the mountain grassland, though woody species are most dominant. FOz 8 Scarp Forest patches occur in protected kloofs.

References Bredenkamp & Matthews (1991), De Frey (1999), Van Wyk & Smith (2001).

SVI 13 Barberton Serpentine Sourveld

VT 10 Lowveld (46%), VT 9 Lowveld Sour Bushveld (32%) (Acocks 1953). LR 21 Sour Lowveld Bushveld (86%) (Low & Rebelo 1996).

Distribution Mpumalanga Province: Occurs in fragmented patches on the exposed ultramafic substrates in a triangular region extending from Malelane in the east, to Badplaas,

Barberton and eastern Swaziland in the south and to west of Nelspruit in the north. Altitude 350–1 400 m.

Vegetation & Landscape Features

Often hilly, but very varied terrain. The southern ultramafic outcrops support herbaceous grasslands with stunted woody vegetation with more woody vegetation apparent within the lower-lying Noordkaap area and towards Malelane.

Geology & Soils Soils derived from ultramafic lavas (including komatiites and serpentinites), predominantly of the Onverwacht Group of the Barberton Supergroup (Barberton Greenstone Belt). The ultramafic geology gives rise to soils with unusually high magnesium:calcium ratios. These soils are associated with high concentrations of heavy metals such as Ni and Cr, which are generally toxic to most plants. Land types mostly Fa and Fb.

Climate Summer rainfall with dry winters. MAP about 600–1 150 mm. Frost infrequent. See also climate diagram for SVI 13 Barberton Serpentine Sourveld.

Important Taxa Small Trees: *Acacia caffra*, *A. davyi*, *Faurea rochetiana*, *Pavetta edentula*. Succulent Tree: *Aloe marlothii* subsp. *marlothii* (d). Tall Shrubs: *Erythroxylum delagoense*, *Tephrosia elongata*. Low Shrubs: *Gnidia caffra* (d), *G. sericocephala*, *Helichrysum kraussii*, *Jamesbrittenia grandiflora*, *Jatropha latifolia* var. *latifolia*, *Pearsonia sessilifolia*, *Rhus rogersii*, *Thunbergia atriplicifolia*. Herbaceous Climbers: *Rhynchosia minima*, *R. totta*. Graminoids: *Loudetia simplex* (d), *Themeda triandra* (d), *Andropogon schirensis*, *Bewisia biflora*, *Cymbopogon caesius*, *Diheteropogon amplexans*, *Eragrostis capensis*, *E. racemosa*, *Heteropogon contortus*, *Panicum natalense*. Herbs: *Helichrysum nudifolium* var. *pilosellum*, *Hemizygia persimilis*, *Rabdosiella calycina*, *Rhynchosia monophylla*, *Senecio coronatus*, *S. venosus*, *Vernonia natalensis*, *V. sutherlandii*. Geophytic Herb: *Cheilanthes involuta*.

Biogeographically Important Taxon (Link to Pondoland) Low Shrub: *Rhus pondoensis* (d).

Endemic Taxa Small Tree: *Protea curvata*. Low Shrubs: *Ozoroa barbertonensis*, *Rhus pygmaea*, *Sclerochiton triacanthus*. Succulent Shrub: *Aloe thorncroftii*. Herbs: *Berkheya coddii* (d), *B. zeyheri* subsp. *rehmannii* var. *rogersiana* (d), *Asystasia subbiflora*, *Berkheya nivea*, *Cyphia bolusii*, *Dicoma swazilandica*, *Inezia speciosa*. Geophytic Herbs: *Brachystelma dyeri*, *Gladiolus serpenticola*.

Conservation Vulnerable. Target 24%. Almost 6% statutorily conserved in the Songimvelo and Barberton Nature Reserves, amongst others. Almost 2% conserved in addition in private reserves including Queensriver and Boondocks. More than one quarter of the area has been transformed, mainly by plantations and cultivation.

Remarks Species richness on some serpentine sites is only slightly lower than that of surrounding areas, but on other serpentine sites the species richness is higher than that of the surrounding vegetation (S. Williamson, unpublished data). This higher species richness is probably due to the heterogeneous nature of these outcrops in terms of altitude, slope and soil conditions. In addition, this vegetation unit is very rich in endemics that have evolved as edaphic specialists. It has been suggested

that these plants could originally have colonised these areas with unfavourable soil conditions as a refuge from competition. There are 31 edaphic specialists known from this vegetation unit at present, of which 10 are still to be described.

References Morrey et al. (1989, 1992), Balkwill et al. (1997), Smith et al. (2001), S. Williamson (unpublished data).

SVI 14 Swaziland Sour Bushveld

VT 9 Lowveld Sour Bushveld (57%) (Acocks 1953). LR 43 North-eastern Mountain Grassland (73%) (Low & Rebelo 1996).

Distribution Mpumalanga Province, Swaziland and marginally into KwaZulu-Natal: From Badplaas, Tjakastad east to Piggs Peak area in the north, southwards through valleys around Manzini and slopes around the Grand Valley, and some isolated mountain outcrops in the lowveld plains, for example the Nkambeni Hills and Bulungu Mountains. Altitude 400–1 100 m.

Vegetation & Landscape Features Open to closed, medium to tall tree layer with closed well-developed grass layer. Very hilly with moderate to steep slopes, positioned at higher altitudes than the adjacent SVI 3 Granite Lowveld to the east.

Geology & Soils Grey soils derived mostly from Randian granites (Mpuluzi and Mswati) and Swazian granites and gneisses (Usutu Suite and Ngwane gneiss). The area reaches to the Onverwacht Group of the Barberton Greenstone Belt in the far north. Soils are dark, very clayey, of the Sterkspruit, Valsrivier, Swartland soil forms. Land types were unclassified in Swaziland, but elsewhere they are mainly Fa, Fb and Ae.

Climate Summer rainfall with dry winters. MAP about 700–1 350 mm. Frost infrequent to occasional at higher altitudes. See also climate diagram for SVI 14 Swaziland Sour Bushveld.

Important Taxa Tall Tree: *Philenoptera violacea*. Small Trees: *Acacia davyi* (d), *A. natalitia* (d), *A. sieberiana* var. *woodii* (d), *A. tortilis* subsp. *heteracantha* (d), *A. gerrardii*, *Combretum molle*, *C. zeyheri*, *Englerophytum magalismontanum*, *Faurea rochetiana*, *F. saligna*, *Pavetta edentula*, *Vangueria madagascariensis*, *Vitex obovata* subsp. *obovata*, *Ziziphus mucronata*. Succulent Tree: *Aloe marlothii* subsp. *marlothii*. Tall Shrubs: *Dichrostachys cinerea* (d), *Calpurnia glabrata*, *Cliffortia strobilifera*, *Crotalaria*

monteiroi, *Elaeodendron transvaalense*, *Heteromorpha arborescens* var. *abyssinica*, *Rhus pallens*, *R. pentheri*, *Tricalysia lanceolata*. Low Shrubs: *Barleria obtusa*, *Crossandra fruticulosa*, *Gnidia splendens*, *Gymnosporia heterophylla*, *Jatropha latifolia* var. *angustata*, *J. latifolia* var. *swazica*, *Justicia flava*, *Passerina filiformis*, *Rhus grandidens*. Woody Climbers: *Helinus integrifolius*, *Putterlickia verrucosa*. Graminoids: *Panicum maximum* (d), *Themeda triandra* (d), *Enteropogon monostachyus*, *Sporobolus fimbriatus*, *S. nitens*. Herbs: *Becium obovatum*, *Gerbera viridifolia*, *Helichrysum miconiifolium*, *Hemizygia pretoriae* subsp. *pretoriae*, *Nidorella auriculata*. Geophytic Herbs: *Eulophia petersii*, *Hypoxis rigidula*.

Biogeographically Important Taxa (^{KZN}Northern KwaZulu-Natal endemic, ^NNorthern Sourveld endemic) Low Shrub: *Hemizygia gerrardii*^{KZN}. Geophytic Herb: *Haemanthus paucifolius*^N.

Endemic Taxa Geophytic Herbs: *Drimiopsis pusilla*, *D. reillejana*.

Conservation Vulnerable. Target 19%. About 6% statutorily conserved in mainly the Songimvelo, Ithala and Malalotja Nature Reserves, and a further 0.5% conserved in the Mlilwane Game Sanctuary in Swaziland. Some 21% has been transformed by cultivation and plantations.

Remark In this savanna vegetation unit with the highest MAP, *Philenoptera violacea* is not as restricted to water courses in contrast to its generally close association with water course areas in the drier vegetation units of the Lowveld and Mopane Bioregions.

References Coetzee & Nel (1978), De Frey (1999), Stalmans et al. (1999), Stalmans (2002).

SVI 15 Northern Lebombo Bushveld

VT 11 Arid Lowveld (45%), VT 15 Mopani Veld (27%) (Acocks 1953). LR 13 Lebombo Arid Mountain Bushveld (56%) (Low & Rebelo 1996). KNP 29 Lebombo South (58%) (Gertenbach 1983b).

Distribution Mpumalanga and Limpopo Provinces: Lebombo Mountains south of the Shingwedzi River to the Komatiipoort area, including ridge points such as Nhlangueni. The mountain range forms a natural frontier between Mozambique and South Africa (Kruger National Park). Much of the eastern slopes are in Mozambique. Altitude 200–450 m.

Vegetation & Landscape Features Open bushveld dominated by Combretaceae on rocky slopes and ridges of a linear range of hills reaching about 100 m (and higher in places) above its surrounding basalt plains towards the west. Tree succulents such as *Euphorbia confinalis* and *E. cooperi* are typical on steep, stony slopes.

Geology & Soils Rhyolite of the Jozini Formation and lesser basalt of the Letaba Formation, both of the Lebombo Group (Karoo Supergroup) as well as dykes of granophyre (Jurassic) form ridges with stony, shallow lithosols with very frequent rocky outcrops. Soils are shallow (Mispah) as well as deeper (Swartland and Glenrosa). Land types Fb and Ea.



M.C. Lötter

Figure 9.55 SVI 14 Swaziland Sour Bushveld: Woodland with *Acacia gerrardii*, *A. karroo* and *Euclea schimperi* in Ithala Game Reserve, KwaZulu-Natal.



H.C. Eckhardt

Figure 9.56 SVI 15 Northern Lebombo Bushveld: Short savanna with *Lannea schweinfurthii* and *Combretum apiculatum* northeast of Letaba Rest Camp, Kruger National Park.

Climate Summer rainfall with dry winters. MAP about 350–750 mm. Incidence of fog in river gorges in the Lebombo Mountains supposedly contributes extensively to moisture availability to plants in these areas. Generally a frost-free area. Temperature on the western mountainside can become very high. See also climate diagram for SVI 15 Northern Lebombo Bushveld.

Important Taxa Tall Tree: *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Combretum apiculatum* (d), *Acacia erubescens*, *A. exuvialis*, *Albizia harveyi*, *Boscia albitrunca*, *Combretum molle*, *Commiphora mollis*, *Croton gratissimus*, *Kirkia acuminata*, *Lannea schweinfurthii* var. *stuhlmannii*, *Manilkara mochisia*, *Newtonia hildebrandtii* var. *hildebrandtii*, *Ozoroa engleri*, *Pappea capensis*, *Sterculia rogersii*, *Strychnos decussata*, *Terminalia sericea*, *Ximenia caffra*. Succulent Trees: *Euphorbia confinalis* (d), *E. cooperi*. Tall Shrubs: *Dichrostachys cinerea* (d), *Croton madandensis*, *Flueggea virosa*, *Grewia bicolor*, *Karomia speciosa*. Low Shrubs: *Barleria affinis*, *Commiphora africana*, *Pavetta catophylla*, *Tragia dioica*, *Tricalysia junodii*. Succulent Shrubs: *Aloe chabaudii*, *A. spicata*, *Kalanchoe rotundifolia*. Woody Climbers: *Adenia digitata*, *A. spinosa*, *Capparis sepiaria*, *Cardiospermum halicacabum*, *Cissus rotundifolia*, *Helinus integrifolius*. Herbaceous Climber: *Cyphostemma subciliatum*. Graminoids: *Aristida congesta* (d), *Digitaria eriantha* subsp. *eriantha* (d), *Enneapogon cenchroides* (d), *Heteropogon contortus* (d), *Panicum maximum* (d), *Andropogon gayanus*, *Bothriochloa radicans*, *Brachiaria nigropedata*, *B. xantholeuca*, *Cymbosetaria sagittifolia*, *Panicum deustum*, *Pogonarthria squarrosa*, *Schmidtia pappophoroides*, *Themeda triandra*. Herbs: *Achyranthes aspera*, *Cleome maculata*, *Crabbea velutina*, *Heliotropium steudneri*. Geophytic Herbs: *Actinopterys radiata*, *Pellaea calomelanos*, *P. viridis*, *Sansevieria pearsonii*.

L.W. Powrie

Conservation Least threatened. Target 24%. All statutorily conserved in the Kruger National Park and there has been virtually no transformation.

Remark There are *Androstachys johnsonii* 'thickets' embedded within this savanna unit (relate to the FOz 9 Ironwood Dry Forest further north).

References Van Rooyen (1978), Coetzee (1983), Gertenbach (1983b).

SVI 16 Southern Lebombo Bushveld

VT 10 Lowveld (62%) (Acocks 1953). LR 13 Lebombo Arid Mountain Bushveld (69%) (Low & Rebelo 1996).

Distribution Mpumalanga and KwaZulu-Natal Provinces and Swaziland: From Komatipoort, widening southwards into Swaziland, including the Mbuluzi River Gorge, through Siteki and across the Isuthu River Gorge into KwaZulu-Natal,

extending east of Mkuze and terminating about 10 km north of Hluhluwe in the south. The high-altitude sourvelds are excluded and are SVI 17 Lebombo Summit Sourveld. Relatively small parts of this unit extend into Mozambique, mainly at the northern end. Altitude 100–600 m. Small patches are unmapped between the Mkuze and Msunduzi Rivers.

Vegetation & Landscape Features Open bushveld with dominant *Acacia* and *Combretum* species. *Themeda triandra* is the dominant grass on undisturbed sites. On very shallow soils (e.g. slopes of deep gorges or exposed ridges) with *Aloe marlothii*, *Euphorbia confinalis* and thickets of *Olea europaea* subsp. *africana* and *Combretum woodii*. Dry slopes may be dominated by *Androstachys johnsonii* in the northern parts.

Geology & Soils Shallow lithosols developing over rhyolites of the Jozini Formation, Lebombo Group (Karoo). Soils shal-



Figure 9.57 SVI 16 Southern Lebombo Bushveld: Dense bushveld with *Mundulea sericea*, *Dichrostachys cinerea* and *Peltophorum africanum* at an altitude of 355 m near Ubombo, north-east of Mkuze town, KwaZulu-Natal.

low Glenrosa and Mispah forms. Land types are unclassified in Swaziland and in South Africa the dominant land type is Fb.

Climate Summer rainfall with very little rain in winter. MAP about 550–1 000 mm. Frost very infrequent. See also climate diagram for SVI 16 Southern Lebombo Bushveld.

Important Taxa Tall Trees: *Acacia burkei* (Lebombo form), *A. nigrescens*. Small Trees: *Acacia davyi*, *A. gerrardii*, *Atalaya alata*, *Bridelia cathartica*, *Combretum apiculatum*, *C. molle*, *Commiphora harveyi*, *Croton gratissimus*, *Encephalartos lebomboensis*, *Erythroxylum emarginatum*, *Manilkara concolor*, *Peltophorum africanum*, *Pterocarpus rotundifolius*, *Strychnos gerrardii*, *Teclea gerrardii*, *Turraea floribunda*, *Vepris reflexa*, *Vitex obovata* subsp. *obovata*. Succulent Trees: *Euphorbia confinalis* (d), *Aloe marlothii* subsp. *marlothii*, *Euphorbia cooperi*, *E. tirucalli*. Tall Shrubs: *Diospyros dichrophylla* (d), *Cassipourea mossambicensis*, *Coptosperma supra-axillare*, *Dichrostachys cinerea*, *Euclea schimperii*, *Galpinia transvaalica*, *Hibiscus micranthus*, *Karomia speciosa*, *Maerua rosmarinoides*, *Olax dissitiflora*, *Olea europaea* subsp. *africana*, *Pouzolzia mixta*, *Rhus gueinzii*. Low Shrubs: *Barleria saxatilis*, *Jatropha variifolia*, *Mundulea sericea*, *Polygala producta*. Succulent Shrubs: *Aloe spicata* (d), *A. vanbalenii* (d), *A. chabaudii*, *Euphorbia knuthii* subsp. *knuthii*. Soft Shrub: *Metarungia longistrobis*. Woody Climbers: *Asparagus buchananii*, *Cissus quadrangularis*, *Combretum woodii*, *Pristimera longipetiolata*, *Sphedamnocarpus pruriens* subsp. *pruriens*. Herbaceous Climber: *Coccinia rehmannii*. Graminoids: *Brachiaria xantholeuca*, *Digitaria eriantha* subsp. *eriantha*, *Enneapogon cenchroides*, *Panicum deustum*, *P. maximum*, *Themeda triandra*, *Trachypogon spicatus*. Herbs: *Hibiscus meyeri* subsp. *meyeri*, *H. pedunculatus*, *Pupalia lappacea*. Geophytic Herbs: *Cheilanthes hirta*, *Gladiolus hollandii*, *Pellaea calomelanos*, *Sansevieria hyacinthoides*. Succulent Herbs: *Aloe parvibracteata*, *Stapelia unicornis*. Epiphytic Geophytic Herb: *Acampe pachyglossa*. Epiphytic Succulent Herb: *Ansellia africana*.

Biogeographically Important Taxa (^{KZN}Northern KwaZulu-Natal endemic, ^LLebombo endemic) Geophytic Herb: *Pachycarpus lebomboensis*^L. Succulent Herb: *Gasteria batesiana* var. *batesiana*^{KZN}.

Endemic Taxa Small Trees: *Encephalartos aplanatus*, *E. senticosus*. Succulent Tree: *Euphorbia keithii*. Epiphytic Geophytic Herb: *Polystachya zuluensis*.

Conservation Least threatened. Target 24%. Some 10% statutorily conserved in the Mlawula Nature Reserve, Greater St Lucia Wetland Park, Mananga Cycad Colony as well as in the Ubombo Mountain and Phongolapoort Nature Reserves. A further 1% is conserved in the private Masibekela Wetland. About 9% of the area has been transformed, mainly by cultivation.

Remarks Some of the prehistory of mankind has been revealed in the Lebombo Mountains. The border cave is the site of one of the world's earliest records of *Homo sapiens* (100 000–200 000 BP). This unit is part of the Maputaland CE as defined by Van Wyk & Smith (2001).

References Moll (1978), Smith (2001), Van Wyk & Smith (2001).

SVI 17 Lebombo Summit Sourveld

VT 6 Zululand Thornveld (88%) (Acocks 1953). LR 13 Lebombo Arid Mountain Bushveld (85%) (Low & Rebelo 1996). BRG 15 Moist Lowland Tall Grassveld (83%) (Camp 1999c). Lebombo Grassland (Smith 2001).

Distribution KwaZulu-Natal Province with small parts in Mpumalanga Province and Swaziland: Localised high points

on the crest of the Lebombo Mountains from Mbuzini (Mpumalanga) in the north to the Ubombo area immediately north of Mkuze River Gorge in the south. Also occurs in Mozambique in a very limited area north of Namaacha. Altitude mostly from above 600 to 803 m at the summit of Mananga Mountain.

Vegetation & Landscape Features Ridge plateaus and adjacent slightly sloping flanks covered with open, tall, sour, wiry grasslands, often dotted with low bushes and solitary savanna trees.

Geology & Soils Shallow soils of Glenrosa and Mispah forms over Jozini Formation rhyolite lavas (Karoo Supergroup). Heavier soils have developed over dolerite in places. Rocky outcrops are typical. Land types mainly Fa, Ea and Ib.

Climate Summer rainfall with little rain in winter. MAP about 600–1 050 mm. Generally frost-free. See also climate diagram for SVI 17 Lebombo Summit Sourveld.

Important Taxa Small Trees: *Acacia caffra*, *Encephalartos ngoyanus*. Tall Shrubs: *Diospyros dichrophylla*, *Gnidia caffra*, *Grewia monticola*. Low Shrubs: *Crossandra greenstockii*, *Diospyros galpinii*, *D. lycioides* subsp. *nitens*, *Phyllanthus glaucophyllus*, *Polygala producta*, *Ruellia cordata*, *Senecio medley-woodii*. Semiparasitic Shrub: *Thesium jeanae*. Graminoids: *Andropogon gayanus* (d), *Elionurus muticus* (d), *Heteropogon contortus* (d), *Themeda triandra* (d), *Brachiaria serrata*, *Cymbopogon caesius*, *Hyparrhenia filipendula*, *Hyperthelia dissoluta*, *Schizachyrium sanguineum*, *Tristachya leucothrix*. Herbs: *Argyrolobium adscendens*, *Berkheya insignis*, *Blepharis integrifolia*, *Crabbea hirsuta*, *Gazania krebsiana* subsp. *serrulata*, *Gerbera ambigua*, *Helichrysum nudifolium* var. *pilosellum*, *H. rugulosum*, *Indigofera sanguinea*, *Lepidagathis scabra*, *Vernonia oligocephala*, *Zornia capensis*. Succulent Herb: *Australluma ubomboensis*. Geophytic Herb: *Hypoxis hemerocallidea*.

Biogeographically Important Taxon (Lebombo endemic) Geophytic Herb: *Pachycarpus lebomboensis*.

Endemic Taxa Herb: *Cyphostemma barbosae*. Succulent Herb: *Orbea ubomboensis*.

Conservation One of the most endangered vegetation types in KwaZulu-Natal due to alien plant (*Lantana camara*) encroachment, heavy livestock grazing and expanding cultivation. Target 24%. About 4% is statutorily conserved in the Mananga Cycad Colony, Ubombo Mountain, Phongolapoort and Hlatikulu Nature Reserves. Very small portion also conserved in the private Masibekela Wetland Reserve. At least 41% already transformed, almost all by cultivation. Rural settlements are concentrated in these areas. Heavy utilisation and population density may have contributed to the open and less wooded aspect of this vegetation unit. Erosion is very low due to the hard substrate.

Remark Culturally important Gwaliweni Forest (classified as part of FOz 5 Scarp Forest) borders on this vegetation unit.

References Camp (1999c), Smith (2001), Van Wyk & Smith (2001).

SVI 18 Tembe Sandy Bushveld

VT 1 Coastal Forest and Thornveld (56%) (Acocks 1953). LR 22 Subhumid Lowveld Bushveld (77%) (Low & Rebelo 1996). BRG 23 Sandy Bush & Palm Veld (99%) (Camp 1999e).

Distribution KwaZulu-Natal Province: Part of the Maputaland lowveld, east of the Pongola River. Strip of land between the Mozambique border and the Tembe Elephant Park in the north extending south as far as the surrounds of the confluence of



W.S. Matthews

Figure 9.58 SVI 18 Tembe Sandy Bushveld: An aerial view of the *Terminalia sericea*-dominated sandy bushveld in Tembe Elephant Park in Maputaland.

the Mkuze and Msunduzi Rivers. Sandwiched between the SVI 20 Western Maputaland Clay Bushveld in the west and CB 1 Maputaland Coastal Belt in the east. Isolated patch found east of the town of Hluhluwe. Altitude 40–140 m.

Vegetation & Landscape Features Extensive flat plains to slightly undulating in places with open to closed woodland with canopy 5–10 m tall, dominated by leguminous woody species and *Terminalia sericea*, with species-rich shrub layer and grassy undergrowth (*Panicum*, *Perotis*, *Urelytrum agropyroides*, *Hyperthelia dissoluta* and *Diheteropogon* species).

Geology & Soils System of old (5–3 million years) and younger (125 000 years) grey regic to reddish redistributed sand dunes of marine origin. Nutritionally the sandy soils are very poor and well leached. In some depressions, duplex soils can be found. Land type mainly Ha, with some Ae, Ah and Hb also occurring.

Climate Summer rainfall with some rain in winter. MAP about 550–800 mm. Mist of the warm Indian Ocean contributes to precipitation. No incidence of frost. See also climate diagram for SVI 18 Tembe Sandy Bushveld.

Important Taxa Tall Trees: *Acacia burkei*, *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Terminalia sericea* (d), *Azelia quanzensis*, *Albizia adianthifolia*, *A. versicolor*, *Clauseria anisata*, *Combretum molle*, *Diospyros inhacaensis*, *Ozoroa engleri*, *O. obovata* var. *elliptica*, *Spirostachys africana*, *Tabernaemontana elegans*, *Vepris lanceolata*, *Zanthoxylum capense*. Tall Shrubs: *Strychnos madagascariensis* (d), *Cordia rudis*, *Crotalaria monteiri*, *Dichrostachys cinerea*, *Euclea natalensis*, *Gardenia volkensii*, *Grewia caffra*, *Monanthes caffra*, *Rhus gueinzii*, *Strychnos spinosa*. Low Shrubs: *Corchorus junodii*, *Indigofera inhambanensis*. Woody Climber: *Landolphia kirkii*. Herbaceous Climber: *Cissampelos hirta*. Graminoids: *Panicum maximum* (d), *Aristida stipitata* subsp. *graciliflora*, *Digitaria eriantha* subsp. *eriantha*, *Diheteropogon amplexans*, *Eragrostis moggii*, *Hyperthelia dissoluta*, *Perotis patens*, *Pogonarthria squarrosa*, *Urelytrum agropyroides*. Herb: *Oxygonum delagoense*. Succulent Herb: *Aloe parvibracteata*. Semiparasitic Herb: *Striga junodii*.

Biogeographically Important Taxa (Maputaland endemics) Small Tree: *Dialium schlechteri*. Tall Shrubs: *Cussonia arenicola*, *Lagynias monteiri*, *Synaptolepis kirkii*, *Tarenna junodii*.

Low Shrub: *Rhus kwazuluana*. Succulent Shrub: *Aloe marlothii* subsp. *orientalis*. Woody Climbers: *Acridocarpus natalitius* var. *linearifolius*, *Albertisia delagoensis*, *Prionostemma delagoensis* var. *delagoensis*. Herbs: *Aneilema arenicola*, *Pelargonium tongaense*. Geophytic Herbs: *Aspidoglossum delagoense*, *Crinum acaule*. Succulent Herb: *Crassula maputensis*.

Endemic Taxa Low Shrub: *Pavetta vanwykiana*. Herb: *Cleome bororensis*.

Conservation Least threatened. Target 19%. Some 17% statutorily conserved, almost all in the Tembe Elephant Park. The Manqakulane people have established the Tshanini Game Reserve south of Tembe. About 8% has been transformed mainly by cultivation. Erosion is very low.

Remarks The origin of the name relates to the Tembe people living in the area and the Tembe Elephant Park located in the north of this unit in South Africa. The

unit extends to the Maputaland part of southern Mozambique. This bushveld unit surrounds most of the Licuati Sand Forests (see Von Maltitz et al. 2003).

References Moll (1978), Camp (1999e), Matthews et al. (2001), Gaugris et al. (2004).

SVI 19 Western Maputaland Sandy Bushveld

VT 10 Lowveld (90%) (Acocks 1953). Red Sand Bushveld (Moll 1980). LR 26 Natal Lowveld Bushveld (99%) (Low & Rebelo 1996). BRG 22 Lowveld (85%) (Camp 1999e).

Distribution KwaZulu-Natal Province: Isolated patches on the coastal plain in the Maputaland region east of the Lebombo Mountains from the Ndumo Game Reserve on the Mozambique border in the north to the Mkhuzi Game Reserve (now part of Greater St Lucia Wetland Park) in the south. Altitude 40–180 m.

Vegetation & Landscape Features Comprised of mixed, but mainly simple-leaved, short (5–10 m) bushlands, woodlands and wooded grasslands. Occurring on the mid- and lower midslopes of ancient coastal dune cordons on gently undulating terrain. Extreme variations include open-canopy *Terminalia sericea* sandveld on deeper yellow to orange sands, through to *Combretum molle*-dominated woodlands on the deep red mesotrophic sands.

Geology & Soils Underlying geology comprises the innermost (most westerly) carbonate-rich sandy dune cordon and siltstones formed in the shallow marine and near-coastal environment of the Cenozoic Maputaland and the Mesozoic Zululand Groups. This cordon is poorly preserved with generally well-developed soil profiles which are commonly red to orange. Soils comprise ferruginous arenosols of the Clovelly and Hutton forms. These are well-drained mesotrophic soils with a low clay content (5–14%). Land types typically Ae and Ah.

Climate Summer rainfall with dry winters. MAP about 500–700 mm. Mean daily maximum and minimum temperatures for Mkhuzi Game Reserve 32.5°C and 11.7°C for January and July, respectively. Mean monthly maximum and minimum temperatures for Ndumo Game Reserve 40.1°C and 6.2°C for January



P.C. Rutherford

Figure 9.59 SVI 19 Western Maputaland Sandy Bushveld: Moderately dense savanna dominated by *Terminalia sericea* on a sandy slope in Ndumo Game Reserve, KwaZulu-Natal.

and July, respectively. Mean annual evaporation (A-pan) 2 100 mm for Mkhuze Game Reserve. No incidence of frost. See also climate diagram for SVI 19 Western Maputaland Sandy Bushveld.

Important Taxa Tall Tree: *Acacia burkei*. Small Trees: *Combretum molle* (d), *Terminalia sericea* (d), *Balanites maughamii*, *Bolusanthus speciosus*, *Boscia albitrunca*, *Commiphora neglecta*, *Ziziphus mucronata*. Tall Shrubs: *Brachylaena discolor*, *Carissa tetramera*, *Catunaregam obovata*, *Euclea natalensis*, *Gardenia volkensii*, *Grewia bicolor*, *G. caffra*, *Mundulea sericea*, *Pteleopsis myrtifolia*, *Rhus gueinzii*, *Strychnos madagascariensis*, *S. spinosa*, *Vitex ferruginea*. Low Shrubs: *Helichrysum athrixifolium*, *Melhaniea forbesii*, *Solanum panduriforme*. Graminoids: *Dactyloctenium australe* (d), *Sporobolus fimbriatus* (d), *Aristida congesta*, *Eragrostis ciliaris*, *E. pallens*, *Panicum maximum*, *Perotis patens*, *Tragus berteronianus*. Geophytic Herb: *Drimia altissima*.

Biogeographically Important Taxa (Maputaland endemics) Tall Shrub: *Tarenna junodii*. Woody Climber: *Acridocarpus natalitius* var. *linearifolius*. Herb: *Helichrysopsis septentrionale*.

Endemic Taxon Succulent Herb: *Plectranthus psammophilus*.

Conservation Least threatened. Target 19%. Some 18% statutorily conserved, mainly in the Greater St Lucia Wetland Park (Mkhuze) and Ndumo Game Reserve. Very little (2%) transformed, mainly by cultivation. Erosion is low to moderate.

Remark The sandy patches of this unit are usually elevated above much of the surrounding clay flats.

References De Moor et al. (1977), Moll (1978), Goodman (1990), Camp (1999e).

SVI 20 Western Maputaland Clay Bushveld

L. Mucina

VT 10 Lowveld (75%) (Acocks 1953). Mixed Bushveld p.p. (Moll 1978). LR 26 Natal Lowveld Bushveld (74%) (Low & Rebelo 1996). BRG 22 Lowveld (88%) (Camp 1999e).



Figure 9.60 SVI 20 Western Maputaland Clay Bushveld: Typical umbrella thorn (*Acacia tortilis*) in open savanna in the Mkhuze Game Reserve portion of the Greater St Lucia Wetland Park.

Distribution KwaZulu-Natal Province: Maputaland region immediately east of the Lebombo Mountains, eastwards to the western edge of the SVI 18 Tembe Sandy Bushveld. From the Ndumo Game Reserve on the Mozambique border, through the Makatini Flats south to Mkhuze Game Reserve, with a narrower extension to just east of the town Hluhluwe. Altitude 20–200 m.

Vegetation & Landscape Features Comprises a mixed but mainly compound leaved short (5–10 m) woodlands and wooded grasslands. It occurs on the crests, upper and midslopes of gently undulating terrain. This vegetation unit is dissected by two large alluvial floodplains associated with the Mkuze and Phongolo Rivers. FOa 1 Lowveld Riverine Forest and woodland dominate these alluvial soils and numerous small floodplains associated with smaller streams.

Geology & Soils Underlying geology comprises Cretaceous shallow-marine and coastal sediments, siltstones and conglomerates of the Zululand Group and minor rhyolites of the Jozini Formation (Karoo Supergroup). Dominant or zonal soils of this vegetation unit are latosols comprising red sandy clay loam to red clay soils (Hutton, Bainsvlei and Shortlands soil forms) and nonduplex brown calcimorphic soils comprising yellow-brown sandy clay, sandy loam to sandy clay loams (Valsrivier and Avalon soil forms). These are generally fertile soils, characterised by a moderate to high clay content (20–60%) in the A-horizon. Land types Ea, Ae, Dc, Ia and Db.

Climate Rainfall occurs in summer with dry winters. MAP about 500–750 mm. No incidence of frost. Mean monthly maximum and minimum temperatures for Makatini-Agr 39.5°C and 3.1°C for January and July, respectively. See also climate diagram for SVI 20 Western Maputaland Clay Bushveld.

Important Taxa Tall Tree: *Acacia nigrescens* (d). Small Trees: *Acacia nilotica* (d), *A. tortilis* subsp. *heteracantha* (d), *Bolusanthus speciosus* (d), *Acacia gerrardii*, *A. grandicornuta*, *A. luederitzii* var. *retinens*, *A. senegal* var. *rostrata*, *Spirostachys africana*, *Ziziphus mucronata*. Tall Shrubs: *Dichrostachys cinerea*

(d), *Gymnosporia senegalensis* (d), *Azima tetraacantha*, *Cadaba natalensis*, *Carissa bispinosa* subsp. *bispinosa*, *C. tetramera*, *Ehretia rigida* subsp. *rigida*, *Euclea divinorum*, *Galpinia transvaalica*, *Grewia caffra*, *Salvadora angustifolia*. Low Shrubs: *Abutilon austro-africanum*, *Dicliptera clinopodia*, *Maerua edulis*. Graminoids: *Bothriochloa insculpta* (d), *Dactyloctenium australe* (d), *Panicum maximum* (d), *Themeda triandra* (d), *Aristida congesta*, *Digitaria didactyla*, *D. eriantha* subsp. *eriantha*, *Eragrostis rigidior*, *E. superba*, *Panicum coloratum*, *Sehima galpinii*, *Sporobolus fimbriatus*, *S. nitens*, *Urochloa mosambicensis*. Herbs: *Asystasia gangetica*, *Chascanum hederaceum*, *Crossandra greenstockii*, *Hibiscus pusillus*.

Conservation Vulnerable. Target 19%. About 11% statutorily conserved in the Greater St Lucia Wetland Park (Mkhuze) and Ndumo Game Reserve. A significant proportion (34%) has been transformed—almost all by cultivation. Alien plant infestations are locally severe and include *Opuntia* species.

References De Moor et al. (1977), Moll (1978), Goodman (1990), Camp (1999e).

SVI 21 Makatini Clay Thicket

VT 10 Lowveld (63%) (Acocks 1953). LR 26 Natal Lowveld Bushveld (95%) (Low & Rebelo 1996). BRG 22 Lowveld (92%) (Camp 1999e).

Distribution KwaZulu-Natal Province: A number of patches in the Maputaland region, primarily east of the Lebombo Mountains, from Ndumo Game Reserve on the Mozambique border through the Makatini Flats south to just east of the town Hluhluwe. Mostly embedded as varying sized patches within the SVI 20 Western Maputaland Clay Bushveld, where it occurs in bottomland positions. Small unmapped fragments of Makatini Clay Thicket occur west of the Lebombo Mountains, embedded within the SVI 23 Zululand Lowveld. Altitude 40–140 m.

Vegetation & Landscape Features Comprises a mixed, but mainly simple-leaved short bushland and thicket with emergent trees up to 10 m and a generally dense dominant shrub layer 1–4 m tall. It occurs on the lower slopes and bottomland areas of gently undulating terrain. Small clay-bottom, endorheic pans occur commonly at low points in the terrain.

Geology & Soils Underlying geology comprises mostly Cretaceous sandstones, siltstones and conglomerates of the

Zululand Group (Mzinene and Makatini Formations). Dominant soils are vertic or melanic clays and clay loams of the Rensburg, Arcadia and Bonheim forms. They are characterised by being poorly drained, with calcium carbonate concretions on the surface or in the A-horizon. Land types mainly Ea and Dc with some Ae and Db.

Climate Rainfall occurs in summer with dry winters. MAP about 500–750 mm. No incidence of frost. See also climate diagram for SVI 21 Makatini Clay Thicket.

Important Taxa Small Trees: *Acacia luederitzii* var. *retinens* (d), *A. grandicornuta*, *A. nilotica*, *Albizia anthelmintica*, *Berchemia zeyheri*, *Ozoroa engleri*, *Schotia capitata*, *Sideroxylon inerme*, *Spirostachys africana*. Tall Shrubs: *Euclea divinorum* (d), *Croton menyharthii*, *Ehretia rigida* subsp. *rigida*, *Erythroxylum delagoense*, *Euclea schimperi*, *Lycium acutifolium*, *Rhus gueinzii*. Low Shrubs: *Barleria elegans*, *Ecobolium glabratum*, *Solanum capense*. Succulent Shrub: *Euphorbia grandicornis*. Graminoids: *Bothriochloa insculpta*, *Chloris mossambicensis*, *Dactyloctenium australe*, *Enteropogon monostachyus*, *Panicum deustum*, *P. maximum*, *Sporobolus nitens*. Herbs: *Blepharis integrifolia*, *Centema subfusca*. Succulent Herb: *Orbea paradoxa*.

Endemic Taxon Geophytic Herb: *Raphionacme elsana*.

Conservation Least threatened. Target 19%. Some 42% statutorily conserved in the Greater St Lucia Wetland Park (Mkhuze) and Ndumo Game Reserve. About 7% already transformed, mainly by cultivation.

References De Moor et al. (1977), Moll (1978), Goodman (1990), Camp (1999e).

SVI 22 Northern Zululand Sourveld

VT 10 Lowveld (31%), VT 6 Zululand Thornveld (24%) (Acocks 1953). LR 26 Natal Lowveld Bushveld (32%), LR 25 Natal Central Bushveld (24%) (Low & Rebelo 1996). BRG 20 Dry Zululand Thornveld (34%), BRG 16 Dry Lowland Tall Grassveld (29%) (Camp 1999c).

Distribution KwaZulu-Natal Province and Swaziland: From the Lusthof area in Swaziland southwards with scattered patches in northern Zululand in the surrounds of Hlomohlomo, east of Louwsburg, Nongoma and the vicinity of Ulundi including Nkandla. In the Hluhluwe-iMfolozi Park it occurs at highest altitudes in the park. Altitude mainly 450–900 m.

Vegetation & Landscape Features The dominant structural vegetation type is wooded grassland, in places pure sour grasslands and rarely also dense bushveld thickets. Terrain is mainly low, undulating mountains, sometimes highly dissected, and also some moderately undulating plains and hills.

Geology & Soils Well-drained and shallow soil forms (Glenrosa and Mispah forms) derived from various lithologies; predominantly, Dwyka Group diamictites, but also shale, siltstone and sandstone from the Madzaringwe and Pietermaritzburg Formations, all of the Karoo Supergroup. Archaean granite and gneiss are also significant. Land types mainly Fb and Fa, with some Ac.

Climate Summer rainfall with a little rain in winter. MAP about 600–1 050 mm



P.S. Goodman

Figure 9.61 SVI 21 Makatini Clay Thicket: *Acacia luederitzii* var. *retinens* – *Euclea divinorum* Thicket with emergent *Berchemia zeyheri* on melanic bottomland clay soils of the Makatini Flats, southern Maputaland, KwaZulu-Natal.



Figure 9.62 SVI 22 Northern Zululand Sourveld: Heavily utilised communal farming area north of Nongoma, KwaZulu-Natal.

reaching a maximum, for example, in the region northwest of Nongoma, towards the mistbelt Ngome Forest. Frost very infrequent to occasional. See also climate diagram for SVI 22 Northern Zululand Sourveld.

Important Taxa Small Trees: *Acacia sieberiana* var. *woodii* (d), *A. natalitia*, *A. nilotica*, *A. tortilis* subsp. *heteracantha*, *Plectroniella armata*. Tall Shrubs: *Gardenia volkensii*, *Gnidia caffra*, *G. kraussiana*. Low Shrubs: *Agathisanthemum bojeri*, *Chaetacanthus burchellii*, *Crossandra fruticulosa*, *C. greenstockii*, *Diospyros galpinii*, *Phyllanthus glaucophyllus*, *Ruellia cordata*, *Syncolostemon argenteus*, *Tetraselago natalensis*. Succulent Shrub: *Aloe vanbalenii*. Woody Climber: *Cryptolepis oblongifolia*. Herbaceous Climber: *Cyphostemma schlechteri*. Graminoids: *Eragrostis curvula* (d), *Hyparrhenia hirta* (d), *Microchloa caffra* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Alloteropsis semialata* subsp. *semialata*, *Digitaria argyrograptia*, *D. tricholaenoides*, *Diheteropogon amplexans*, *Elionurus muticus*, *Loudetia simplex*, *Trachypogon spicatus*. Herbs: *Alepidea longifolia*, *Argyrobolium adscendens*, *Aster bakerianus*, *Berkheya speciosa*, *Chascanum hederaceum*, *Crabbea hirsuta*, *Gazania krebsiana* subsp. *serrulata*, *Gerbera ambigua*, *Helichrysum mixtum*, *H. nudifolium* var. *pilosellum*, *Hemizygia pretoriae* subsp. *pretoriae*, *Hermannia*

grandistipula, *Hypericum aethiopicum*, *Lichtensteinia interrupta*, *Pimpinella caffra*, *Senecio glaberrimus*, *S. latifolius*, *Stachys nigricans*, *Vernonia galpinii*, *V. oligocephala*. Geophytic Herbs: *Hypoxis hemerocallidea*, *Pachycarpus concolor*. Succulent Herbs: *Aloe minima*, *A. parvibracteata*, *Senecio oxyriifolius*. Geoxylic Suffrutex: *Salacia kraussii*.

Conservation Vulnerable. Target 19%. Only 4% statutorily conserved, mainly in the Hluhluwe-iMfolozi Park and Ithala Game Reserve. Some 22% already transformed, mainly by cultivation and plantations. Erosion is generally moderate to high.

Remark Northern Zululand Sourveld can be seen as a northern extension of the SVs 4 Ngongoni Veld.

Reference Camp (1999c).

SVI 23 Zululand Lowveld

VT 10 Lowveld (71%) (Acocks 1953). LR 26 Natal Lowveld Bushveld (49%), LR 20 Sweet Lowveld Bushveld (12%) (Low & Rebelo 1996). BRG 22 Lowveld (63%) (Camp 1999e).

Distribution KwaZulu-Natal Province, Swaziland and Mpumalanga Province: Main extent from around Big Bend south to Mkuze, Hluhluwe, Ulundi to just north of the Ongoye Forest. An isolated patch is found on the Swaziland-Mpumalanga border. Altitude about 50–450 m.

Vegetation & Landscape Features Extensive flat or only slightly undulating landscapes supporting complex of various bushveld units ranging from dense thickets of *Dichrostachys cinerea* and *Acacia* species, through park-like savanna with flat-topped *A. tortilis* to tree-dominated woodland with broad-leaved open bushveld with *Sclerocarya birrea* subsp. *caffra* and *A. nigrescens*. Tall grassveld types with sparsely scattered solitary trees and shrubs form a mosaic with the typical savanna thornveld, bushveld and thicket patches.

Geology & Soils Black-clay soils and duplex soils derived from a distinct variety of clastic sediments of the Dwyka, Ecca, Beaufort and igneous rocks of the Lebombo Groups (all of the Karoo Supergroup). Also well-drained soil forms occur especially on stony slopes. Land types Fb and Ea, with some Db and Dc.



Figure 9.63 SVI 23 Zululand Lowveld: Extensive areas covered by bushveld of this unit at lower altitudes and with SVI 22 Northern Zululand Sourveld visible at higher altitudes in the Hluhluwe-iMfolozi Game Park (Hluhluwe section) in KwaZulu-Natal. Patches of FOz 5 Scarp Forest are visible in the sub-summit positions of the ridges in the background.

Climate Summer rainfall with some rain in winter. MAP about 500–900 mm (highest in the southeast). Generally a frost-free area. Mean monthly maximum and minimum temperatures for Mpila Camp (Hluhluwe-iMfolozi Park) 38.5°C and 7.8°C for February and June, respectively. See also climate diagram for SVI 23 Zululand Lowveld.

Important Taxa Tall Trees: *Acacia burkei* (d), *A. nigrescens* (d), *Sclerocarya birrea* subsp. *caffra* (d). Small Trees: *Acacia tortilis* subsp. *heteracantha* (d), *A. gerrardii*, *A. natalitia*, *A. nilotica*, *A. senegal* var. *rostrata*, *A. welwitschii* subsp. *welwitschii*, *Boscia albitrunca*, *Combretum apiculatum*, *C. molle*, *Ozoroa paniculosa*, *Phoenix reclinata*, *Schotia brachypetala*, *Spirostachys africana*, *Teclea gerrardii*, *Ziziphus mucronata*. Succulent Trees: *Aloe marlothii* subsp. *marlothii*, *Euphorbia grandidens*, *E. ingens*. Tall Shrubs: *Dichrostachys cinerea* (d), *Euclea divinorum* (d), *Coptosperma supra-axillare*, *Crotalaria monteiroi*, *Euclea crispa* subsp. *crispa*, *E. schimperi*, *Galpinia transvaalica*, *Gardenia volkensii*, *Gymnosporia maranguensis*, *G. senegalensis*, *Jatropha zeyheri*, *Lycium acutifolium*, *Olea europaea* subsp. *africana*, *Tarchonanthus parvicapitulatus*, *Tephrosia polystachya*, *Triumfetta pilosa* var. *tomentosa*. Low Shrubs: *Barleria obtusa*, *Crossandra greenstockii*, *Felicia muricata*, *Gymnosporia heterophylla*, *Indigofera trita* subsp. *subulata*, *Justicia flava*, *J. protracta* subsp. *protracta*, *Melhania didyma*, *Orthosiphon serratus*, *Pearsonia sessilifolia*, *Ruellia cordata*, *Sida serratifolia*, *Tetraselago natalensis*. Succulent Shrubs: *Euphorbia grandicornis*, *E. trichadenia*, *E. vandermerwei*. Soft Shrub: *Pavonia columella*. Herbaceous Climber: *Fockea angustifolia*. Graminoids: *Dactyloctenium australe* (d), *Enteropogon monostachyus* (d), *Eragrostis capensis* (d), *E. curvula* (d), *E. racemosa* (d), *Heteropogon contortus* (d), *Panicum maximum* (d), *Sporobolus pyramidalis* (d), *Themeda triandra* (d), *Aristida bipartita*, *A. congesta*, *Bothriochloa insculpta*, *Chloris mossambicensis*, *Cymbopogon caesius*, *Digitaria natalensis*, *Leptochloa eleusine*, *Panicum deustum*, *Schizachyrium sanguineum*, *Setaria incrassata*, *Sporobolus nitens*, *Trachypogon spicatus*, *Tristachya leucothrix*. Herbs: *Acrotome hispida*, *Argyrobolium rupestre*, *Aspilia mossambicensis*, *Chamaecrista biensis*, *C. mimosoides*, *Corchorus asplenifolius*, *Felicia mossamedensis*, *Gerbera ambigua*, *Helichrysum rugulosum*, *Hibiscus pusillus*, *Kohautia virgata*, *Lotononis eriantha*, *Senecio latifolius*, *Stachys aethiopica*, *Tragia meyeriana*, *Vernonia capensis*. Succulent Herb: *Aloe parvibracteata*.

Biogeographically Important Taxa Small Tree: *Acacia theronii* (Broadly disjunct distribution). Tall Shrub: *Lycium shawii* (Southern distribution limit).

Conservation Vulnerable. Target 19%. Some 11% statutorily conserved mainly in the Hluhluwe-iMfolozi Park and Phongolapoort Nature Reserve. Almost 1% is protected in the private Masibekela Wetland. Much of the area between Magudu, Mkuze and Nongoma is managed as private game farms and lodges. About 26% of the area has been transformed, mostly by cultivation. Erosion is variable from low to high.

Remark Most of the Hluhluwe-iMfolozi Park is covered by tall grassveld and thornveld of this vegetation unit.

References Ward (1962), Downing (1972, 1980), Macdonald (1980, 1981), Watson & Macdonald (1983), Whateley & Porter (1983), Camp (1999e).

SVI 24 Zululand Coastal Thornveld

VT 1 Coastal Forest and Thornveld (71%) (Acocks 1953). LR 23 Coastal Bushveld-Grassland (94%) (Low & Rebelo 1996). BRG 1 Moist Coast Forest Thorn & Palm Veld (100%) (Camp 1999a).

Distribution KwaZulu-Natal Province: Immediately west of Mtubatuba (in the north) and Empangeni (in the south) bisected by the iMfolozi River, extending westwards for 10–20 km. Altitude 40–300 m.

Vegetation & Landscape Features Gently rolling landscapes supporting wooded grassland dominated by *Themeda triandra*. The bush clumps are a strong feature and are more numerous on deeper soils, with *Phoenix reclinata* and *Gymnosporia senegalensis* usually dominant. These plant communities are species-rich relative to the surrounding vegetation units. They grade into dense *Acacia* woodland on dry slopes and riverine bushland thickets and FOa 1 Lowveld Riverine Forest in valley bottoms.

Geology & Soils The area is situated almost entirely on Letaba Formation basalts of the Karoo Supergroup. Soils are mainly black with a high (35–55%) clay content and depth in the range 200–300 mm. Land types mainly Ea with some Fb and Dc.

Climate Summer rainfall but also some in winter (each winter month receiving about 20 mm, which is greater than that of any of the other savanna vegetation units for this period). MAP about 800–1 050 mm, generally higher towards the coast. Frost very infrequent. See also climate diagram for SVI 24 Zululand Coastal Thornveld.

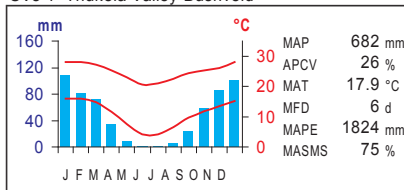
Important Taxa Small Trees: *Acacia natalitia*, *A. nilotica*, *Phoenix reclinata*. Succulent Trees: *Euphorbia tirucalli* (d), *E. ingens*. Tall Shrubs: *Diospyros lycioides* subsp. *sericea* (d), *Euclea divinorum* (d), *Gymnosporia senegalensis* (d), *Abutilon angulatum*, *Clutia abyssinica*, *Euclea schimperi*, *Gymnosporia buxifolia*. Low Shrubs: *Acalypha peduncularis*, *Clutia cordata*, *Sida cordifolia*, *S. dregei*, *Thunbergia atriplicifolia*. Herbaceous Climbers: *Rhynchosia minima*, *R. totta*. Graminoids: *Eragrostis capensis* (d), *Panicum maximum* (d), *Sporobolus pyramidalis* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Aristida congesta*, *Eragrostis curvula*, *E. racemosa*, *Heteropogon contortus*, *Hyparrhenia hirta*, *Schizachyrium sanguineum*, *Setaria sphacelata*, *Trachypogon spicatus*. Herbs: *Berkheya setifera*, *B. speciosa*, *Centella asiatica*, *Eriosema cordatum*, *E. distinctum*, *Gerbera viridifolia*, *Helichrysum nudifolium* var. *pilosellum*, *Hypericum aethiopicum*, *Indigofera hiliaris*, *I. sanguinea*, *Pentanisia prunelloides*, *Ruellia patula*, *Senecio erubescens*, *S. inornatus*, *Spermacoce natalensis*, *Vernonia oligocephala*, *Vigna unguiculata*. Geophytic Herbs: *Hypoxis rigidula*, *Pelargonium luridum*.

Conservation Endangered. Target 19%. None of the area is protected in statutory conservation areas. Highly transformed (58%), mostly by cultivation. This is high-potential agricultural land, which is already been much transformed to sugar cane. Most of the area is communal land. Large areas close to towns (e.g. Mtubatuba) are becoming an urban sprawl. Very little of the natural plant communities remains intact. Heavy grazing has depleted the grasslands and wood harvesting has depleted the bush clumps, reducing them to only the resistant and less useful species. Stunted forms of many of the woody species (e.g. *Euclea*, *Diospyros*, *Gymnosporia*, *Maytenus*) invade the grasslands in many places. Currently it is rare to find a site still with its natural plant composition. *Themeda triandra*, a 'decreaser species', has declined to critically low levels. Alien plant invasions are a threat, with *Chromolaena odorata* being the most problematic. Erosion low to moderate.

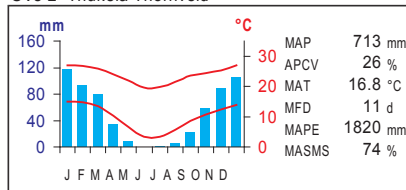
Remarks Owen Sithole (Cwaka) Agricultural College is a large estate containing SVI 24 Zululand Coastal Thornveld. A distinction from neighbouring SVI 23 Zululand Lowveld is that the latter is often tree-dominated woodland with tall grassveld.

References Camp (1999a), Van der Linden et al. (2005).

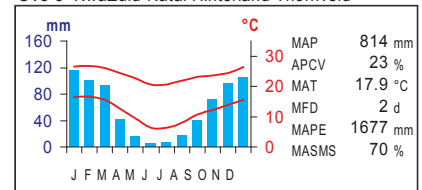
SVs 1 Thukela Valley Bushveld



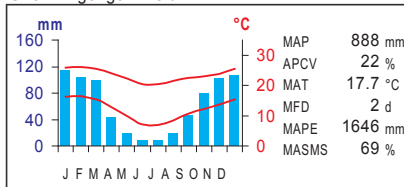
SVs 2 Thukela Thornveld



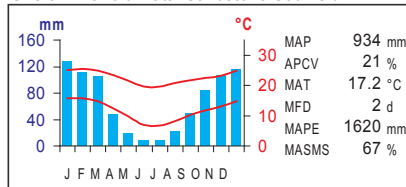
SVs 3 KwaZulu-Natal Hinterland Thornveld



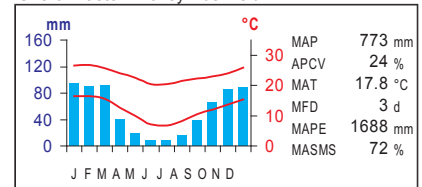
SVs 4 Ngongoni Veld



SVs 5 KwaZulu-Natal Sandstone Sourveld



SVs 6 Eastern Valley Bushveld



SVs 7 Bhisho Thornveld

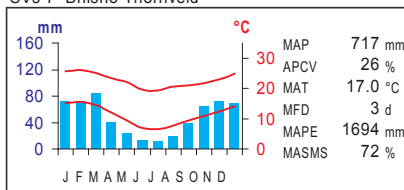


Figure 9.64 Climate diagrams of Sub-Escarpment Savanna Bioregion units. Blue bars show the median monthly precipitation. The upper and lower red lines show the mean daily maximum and minimum temperature respectively. MAP: Mean Annual Precipitation; APCV: Annual Precipitation Coefficient of Variation; MAT: Mean Annual Temperature; MFD: Mean Frost Days (days when screen temperature was below 0°C); MAPE: Mean Annual Potential Evaporation; MASMS: Mean Annual Soil Moisture Stress (% of days when evaporative demand was more than double the soil moisture supply).

Sub-Escarpment Savanna

SVs 1 Thukela Valley Bushveld

VT 23 Valley Bushveld (85%) (Acocks 1953). E 6.3C Semi-deciduous Bush (*Acacia-Boscia-Olea-Schotia* Scrub) (38%), E 6.4C Interior *Acacia* karroo-*A. nilotica* Thorn Veld (33%) (Edwards 1967). LR 5 Valley Thicket (59%) (Low & Rebelo 1996). BRG 21 Valley Bushveld (99%) (Camp 1999e).

Distribution KwaZulu-Natal Province: Central Thukela River basin upstream of Jameson's Drift, past Tugela Ferry to about 20 km southeast of Ladysmith. Also in valleys of several major tributaries, such as the lower Mooi, Bushmans, Buffels and Sundays Rivers. Altitude about 350–1 000 m.

Vegetation & Landscape Features Often rocky rugged slopes and terraces mainly with deciduous trees of short to medium height (and many large shrubs) including *Acacia tortilis*,

A. nilotica and *A. natalitia* and prominent evergreen species such as *Olea europaea* subsp. *africana*, *Boscia albitrunca* and *Euclea crispa* in places. Succulent plants, mainly species of *Euphorbia* and *Aloe* occur on shallow and eroded soils. Relatively limited areas are dominated by succulents such as *E. tirucalli* (some hill-sides south of the Thukela) and *E. ingens* on steep slopes, but also commonly on the valley floor.

Geology & Soils Shallow soils of Mispah and Glenrosa forms on the slopes, while in valley bottoms, pockets of deep alluvial soils as well as calcareous, duplex soils are found. The major geological formations are sediments of Ecga Group (Karoo Supergroup) and in the eastern part also Archaean granites. Land types mainly Fc and Fb, with some Ae and Ea.

Climate Summer rainfall with dry winters. MAP about 500–850 mm. Frost fairly infrequent and usually on valley bottoms. Mean monthly maximum and minimum temperatures for Mudén 36.7°C and 0.2°C and for Weenen 38.1°C and –4.4°C both for December and June, respectively. See also climate diagram for SVs 1 Thukela Valley Bushveld.

Important Taxa Tall Tree: *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Combretum apiculatum* (d), *Spirostachys africana* (d), *Acacia tortilis* subsp. *heteracantha*, *Berchemia zeyheri*, *Boscia albitrunca*, *Combretum molle*, *Cussonia spicata*, *Pappia capensis*, *Schotia brachypetala*. Succulent Trees: *Aloe marlothii* subsp. *marlothii* (d), *Euphorbia grandidens* (d), *E. tirucalli* (d), *E. ingens*, *E. triangularis*. Tall Shrubs: *Coddia rudis* (d), *Dichrostachys cinerea* (d), *Euclea crispa* subsp. *crispa*, *E. schimperi*, *Gymnosporia buxifolia*, *Heteromorpha arborescens* var. *abyssinica*, *Olea europaea* subsp. *africana*, *Rhus pentheri*, *Vitex rehmannii*. Low Shrubs: *Barleria obtusa*, *Gymnosporia glaucophylla*. Soft Shrubs: *Hypoestes aristata* (d), *Peristrophe cernua*. Succulent Shrub:



B. Forbes

Figure 9.65 SVs 1 Thukela Valley Bushveld: Degraded Thukela Valley Bushveld near Mudén showing encroachment by *Euphorbia pseudocactus* and *Blepharis natalensis*.

Huernia hystrix subsp. *hystrix*. Woody Climbers: *Asparagus falcatus*, *Jasminum multipartitum*. Woody Succulent Climber: *Sarcostemma viminalis*. Graminoids: *Heteropogon contortus* (d), *Melinis repens* (d), *Panicum maximum* (d), *Themeda triandra* (d), *Aristida congesta*, *A. diffusa*, *Cymbopogon pospischilii*, *Eragrostis chloromelas*, *E. curvula*, *Panicum deustum*, *Urochloa mosambicensis*. Succulent Herbs: *Aloe mudenensis*, *Bulbine narcissifolia*, *Duvalia polita*, *Orbea woodii*.

Biogeographically Important Taxa (Thukela Basin endemics) Small Tree: *Vitellariopsis dispar*. Succulent Herbs: *Aloe prinslooii*, *Orbea woodii*.

Endemic Taxa Small Tree: *Encephalartos cerinus*. Tall Shrub: *Gymnosporia macrocarpa*. Low Shrubs: *Blepharis natalensis* (d), *Barleria argillicola*. Succulent Shrub: *Euphorbia pseudocactus* (d). Succulent Herb: *Gasteria tukhelensis*. Succulent Herbaceous Climber: *Ceropegia cynniflora*.

Conservation Least threatened. Target 25%. Statutorily conserved (less than 200 ha) in the Weenen Game Reserve. This vegetation unit has undergone considerable degradation over almost its entire area. In the many eroded areas, prolonged continuous overgrazing has led to the complete destruction of the grass cover. Often the only ground cover is found under *Acacia tortilis* trees where their root systems retain soil, the trees act as nutrient pumps and provide shade (Camp 1999e). Erosion very variable, ranging from very low to very high. Alien plants include the widely scattered *Opuntia imbricata*.

Remarks Very steep and exposed (well-insolated and dry) rocky habitats support succulent flora including, for example, *Aloe rupestris* and *A. mudenensis*. In the last four decades there has been a substantial increase in woody plant cover, mainly *Acacia tortilis*, at altitudes roughly below 1 000 m in the Weenen/Muden area and possibly related to reduced incidence of fire (Hoffman & O'Connor 1999).

References West (1951), Edwards (1967), Camp (1999e).

SVs 2 Thukela Thornveld

VT 23 Valley Bushveld (58%) (Acocks 1953). E 6.4C Interior *Acacia karoo*–*A. nilotica* Thorn Veld (61%) (Edwards 1967). LR 25 Natal Central Bushveld (55%) (Low & Rebelo 1996). BRG 18 Mixed Thornveld (98%) (Camp 1999d).



Figure 9.66 SVs 2 Thukela Thornveld: Open thornveld in the Weenen Game Reserve northeast of Estcourt. *Acacia natalitia* is the prominent tree in the foreground and *A. sieberiana* in the middle distance.

Distribution KwaZulu-Natal Province: Upper Thukela River basin fringing the SVs 1 Thukela Valley Bushveld on its upper border in a series of discontinuous patches. Largest area east of Estcourt–Colenso and including Ladysmith. Also some outliers on slopes south of Dundee. Altitude 900–1 300 m.

Vegetation & Landscape Features The dominant landscape features are valley slopes to undulating hills. Vegetation is *Acacia*-dominated bushveld of variable density (ranging from wooded grassland to dense thickets) with dense grassy undergrowth.

Geology & Soils Broad variety of soils ranging from vertisols and solodised solonchaks to transitional fersiallitic soils (Edwards 1967) developing over Karoo Supergroup sediments of the Beaufort and Ecca Groups). Heavy soils are developed over Jurassic dolerite intrusions forming koppies and sills. Land types Fb, Fa, Db, Ea, Fc and Dc.

Climate Summer rainfall with dry summers. MAP about 550–850 mm. Frost fairly infrequent, occurring mainly on the flats. Mean monthly maximum and minimum temperatures for Ladysmith 36.1°C and –3.6°C for January and July, respectively. Corresponding values for Estcourt–TNK 34.5°C and –2.3°C for January and June, respectively. See also climate diagram for SVs 2 Thukela Thornveld.

Important Taxa Small Trees: *Acacia natalitia* (d), *A. nilotica* (d), *A. sieberiana* var. *woodii*, *A. tortilis* subsp. *heteracantha*, *Allophylus melanocarpus*, *Boscia albitrunca*, *Clausena anisata*, *Cussonia spicata*, *Dais cotinifolia*, *Ziziphus mucronata*. Tall Shrubs: *Coddia rudis* (d), *Buddleja saligna*, *Clerodendrum glaberrimum*, *Euclea crispa* subsp. *crispa*, *Heteromorpha arborescens* var. *abyssinica*, *Hibiscus calyphyllus*, *Lippia javanica*, *Pachystigma macrocalyx*, *Rhus pentheri*, *R. rehmanniana*. Low Shrubs: *Barleria obtusa*, *Justicia flava*. Soft Shrub: *Peristrophe cernua*. Woody Succulent Climber: *Senecio brachypodus*. Graminoids: *Eragrostis curvula* (d), *Hyparrhenia hirta* (d), *Melinis repens* (d), *Panicum maximum* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Aristida congesta*, *Digitaria eriantha* subsp. *eriantha*, *Elionurus muticus*, *Eragrostis chloromelas*, *E. superba*, *Heteropogon contortus*, *Setaria sphacelata*, *Sporobolus pyramidalis*. Herb: *Osteospermum muricatum*. Geophytic Herb: *Sansevieria hyacinthoides*. Succulent Herb: *Aloe mudenensis*.

Biogeographically Important Taxa (Thukela Basin endemics) Small Tree: *Vitellariopsis dispar*. Succulent Herbs: *Aloe prinslooii*, *Orbea woodii*.

Endemic Taxon Small Tree: *Encephalartos msinganus*.

Conservation Least threatened. Target 25%. Statutorily conserved (less than 1 500 ha) in Weenen Game Reserve and Isandlwana Nature Reserve. About 5% already transformed, mainly by cultivation. Erosion somewhat less than in SVs 1 Thukela Valley Bushveld.

Remarks Edwards (1967), echoed by Camp (1999d), claims that an estimated 60% of the thornveld invaded the region this century by an outward migration (encroachment) of *Acacia* species from Thukela River Valley vegetation into presumed original *Themeda*–*Hyparrhenia* grasslands, but neither of the cited sources provided conclusive evidence to support this suggestion. However, in the last four decades there has been a substantial increase in woody plant cover,

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mainly *A. karroo*, at altitudes roughly above 1 000 m in the Weenen/Muden area and possibly related to reduced incidence of fire (Hoffman & O'Connor 1999).

References West (1951), Edwards (1967), Camp (1999d), Breebaart et al. (2001).

SVs 3 KwaZulu-Natal Hinterland Thornveld

VT 5 Ngongoni Veld (41%), VT 23 Valley Bushveld (32%) (Acocks 1953). LR 5 Valley Thicket (46%), LR 24 Coast-Hinterland Bushveld (36%) (Low & Rebelo 1996). BRG 17 Coast Hinterland Thornveld (97%) (Camp 1999d).

Distribution KwaZulu-Natal Province: Patches, scattered immediately above SVs 6 Eastern Valley Bushveld, at altitudes 450–900 m in river valleys of mainly the Mpisi (in the Thukela River catchment), Mvoti, Umgeni (below the Howick Falls), Mlazi, and Lufafa (vicinity of Ixopo) and Mtungwane (tributaries of the Mkomazi).

Vegetation & Landscape Features Vegetation is open thornveld dominated by *Acacia* species on undulating plains found on upper margins of river valleys.

Geology & Soils Shallow sandy soils (Glenrosa and Mispah forms) developing over Ordovician Natal Group sandstones and compact, clayey soils on Dwyka diamictites (Karoo Supergroup) as well as on layered quartz-feldspar metasediments (Mapumulo Group, Mokolian) and granites of the Oribi Gorge Suite (also Mokolian). Land types mainly Fa and Fb with some Ca, Bd and Ac.

Climate Summer rainfall pattern, with some rain in winter. MAP about 650–1 000 mm. Frost infrequent. Mean monthly maximum and minimum temperatures for Pietermaritzburg 37.2°C and –1.8°C for January and June, respectively. See also climate diagram for SVs 3 KwaZulu-Natal Hinterland Thornveld.

Important Taxa Tall Tree: *Acacia robusta*. Small Trees: *Acacia natalitia* (d), *A. nilotica* (d), *Combretum molle* (d), *Ziziphus mucronata* (d), *Brachylaena elliptica*, *Cussonia spicata*, *Erythrina latissima*. Succulent Trees: *Aloe marlothii* subsp. *marlothii*, *Euphorbia ingens*. Tall Shrubs: *Calpurnia aurea*, *Coddia rudis*, *Diospyros dichrophylla*, *Ehretia rigida* subsp. *rigida*, *Grewia occidentalis*, *Gymnosporia buxifolia*, *Hibiscus calyphyllus*, *Rhus pentheri*. Low Shrubs: *Barleria obtusa*, *Chaetacanthus setiger*, *Crossandra greenstockii*, *Justicia flava*. Soft Shrub: *Hypoestes aristata* (d). Woody Climbers: *Jasminum breviflorum*, *Putterlickia verrucosa*, *Tecoma capensis*. Woody Succulent Climber: *Sarcostemma viminalis*. Graminoids: *Aristida junciformis* subsp. *junciformis* (d), *Eragrostis curvula* (d), *Hyparrhenia hirta* (d), *Melinis nerviglumis* (d), *Themeda triandra* (d), *Cymbopogon nardus*, *Eragrostis capensis*, *E. chloromelas*, *E. racemosa*, *E. superba*, *Heteropogon contortus*, *Panicum maximum*, *Sporobolus fibriatus*, *S. pyramidalis*, *Tristachya leucothrix*. Herbs: *Commelina africana*, *Ruellia patula*. Geophytic Herb: *Sansevieria hyacinthoides*.

Biogeographically Important Taxon (Southern distribution limit) Low Shrub: *Barleria elegans*.

Endemic Taxon Succulent Herb: *Aloe pruinosa*.

Conservation Vulnerable. Target 25%. None conserved in statutory conservation areas. Some 22% already transformed by cultivation and some urban or built-up areas. Erosion is low to very low, with some areas of moderate erosion.

Remark 1 Camp (1999e) suggested that his 'Coast Hinterland Thornveld' (identical with this vegetation unit) was originally *Acacia sieberiana* wooded grassland, and woodland before major disturbance occurred, but evidence is largely lacking.

Remark 2 This vegetation unit can be distinguished from SVs 2 Thukela Thornveld by higher floristic richness and a different vegetation structure (scrub and clump character). These differences are linked by Camp (1999d) to milder climatic conditions with less frequent, lighter and localised frosts in this unit.

Remark 3 One of the most prominent woody components of this unit identified in earlier literature sources as *Acacia karroo* Hayne appears to be *A. natalitia* E.Mey. (Coates Palgrave 2002, p. 291).

Reference Camp (1999d).

SVs 4 Ngongoni Veld

VT 5 Ngongoni Veld (59%) (Acocks 1953). LR 24 Coast-Hinterland Bushveld (38%), LR 42 Moist Upland Grassland (24%) (Low & Rebelo 1996). BRG 3 Moist Coast Hinterland Ngongoni Veld (44%), BRG 4 Dry Coast Hinterland Ngongoni Veld (26%) (Camp 1999a).

Distribution KwaZulu-Natal and Eastern Cape Provinces: From Melmoth in the north to near Libode in the former Transkei (including Eshowe, New Hanover, Camperdown, Eston, Richmond, Dumisa, Harding, Lusikisiki and the Libode area). Altitude 400–900 m.

Vegetation & Landscape Features Dense, tall grassland overwhelmingly dominated by unpalatable, wiry Ngongoni grass (*Aristida junciformis*), with this monodominance associated with low species diversity. Wooded areas (thornveld) are found in valleys at lower altitudes, where this vegetation unit



Figure 9.67 SVs 4 Ngongoni Veld: Species-rich grasslands dominated by *Aristida junciformis* grazed by large indigenous grazers such as impala (*Aepyceros melampus*) and Burchell's zebra (*Equus burchellii*) in the Vernon Crookes Nature Reserve near Scottburgh, southern KwaZulu-Natal.

grades into SVs 3 KwaZulu-Natal Hinterland Thornveld and SVs 7 Bhisho Thornveld. Termitaria support bush clumps with *Acacia* species, *Cussonia spicata*, *Ziziphus mucronata*, *Coddia rudis*, *Ehretia rigida* etc.

Geology & Soils Acid, leached, heavy soils are derived from Karoo Supergroup sediments (including significant Dwyka tillites) and intrusive Karoo dolerites. Also Glenrosa and Mispah soils occur. Land types Fa, Ab, Ac and Aa.

Climate Summer rainfall with some rain in winter. MAP about 700–1 100 mm. Some valleys are sheltered and may show weak rainshadow effects. Frost infrequent, occurring mainly where cold air becomes trapped in valleys. Mean monthly maximum and minimum temperatures for Melmoth 37.0°C and 4.9°C for October and July, respectively. Corresponding values for New Hanover 38.2°C and –0.2°C for January and June, respectively. See also climate diagram for SVs 4 Ngongoni Veld.

Important Taxa Small Trees: *Acacia natalitia*, *A. nilotica*, *A. sieberiana* var. *woodii*. Low Shrubs: *Agathisanthemum bojeri*, *Euryops laxus*, *Gnidia anthylloides*. Graminoids: *Aristida junciformis* subsp. *junciformis* (d), *Bothriochloa insculpta*, *Eragrostis curvula*, *Hyparrhenia hirta*, *Panicum maximum*, *Paspalum scrobiculatum*, *Sporobolus africanus*, *S. pyramidalis*, *Themeda triandra*. Herbs: *Chamaecrista mimosoides*, *Conostomium natalense*, *Gerbera ambigua*, *Helichrysum allioides*, *Hermannia grandistipula*, *Pentanisia prunelloides*, *Selago tarachodes*, *Senecio exuberans*, *Vernonia galpinii*. Geophytic Herbs: *Hypoxis argentea*, *Watsonia densiflora*. Succulent Herb: *Aloe minima*.

Conservation Vulnerable. Target 25%. Only less than 1% of the unit is statutorily conserved in the Ophathe and Vernon Crookes Nature Reserves. Some 39% has been transformed for cultivation, plantations and urban development.

Remarks Within KwaZulu-Natal, this vegetation unit comprises mainly Camp's (1999a) BRG 3 and BRG 4, representing wet and dry forms of Ngongoni veld, respectively. His distinction is based on MAP of 800 mm, which is assumed to have significant agricultural importance (see Camp 2001). Major floristic differences have yet to be shown. Camp (1999a), in accordance with Acocks (1953), considers the Ngongoni Veld to be secondary.

References Killick (1958), Moll (1976), Camp (1999a, 2001).

SVs 5 KwaZulu-Natal Sandstone Sourveld

VT 5 Ngongoni Veld (55%) (Acocks 1953). LR 24 Coast-Hinterland Bushveld (50%) (Low & Rebelo 1996). BRG 3 Moist Coast Hinterland Ngongoni Veld (49%), BRG 5 Moist Midlands Mistbelt (49%) (Camp 1999a, b).

Distribution KwaZulu-Natal Province: Elevated coastal inland sandstone plateaus from Mapumulo near Kranskop in the north to St Faiths near Port Shepstone in the south (including Noodsberg, Hillcrest, Kloof, Table Mountain, Inanda, Stony Hill, Umbumbulu, Mid-Illovo, Dumisa, Highflats). Altitude 500–1 100 m.

Vegetation & Landscape Features Short, species-rich grassland with scattered low shrubs and geoxylic suffrutices. Proteaceae trees and shrubs (*Protea*,

Leucospermum, *Faurea*) can be locally common. The dominating landscape features are flat (or rolling) plateau tops and steep slopes commonly forming table mountains.

Geology & Soils Ordovician Natal Group sandstones carry shallow, nutrient-poor, skeletal, sandy soils freely drained and including Glenrosa and Mispah forms. Land types Fa, Ac, Aa and Bb.

Climate Summer rainfall with some rain in winter. MAP about 700–1 200 mm. Mist common and important in providing additional moisture. Frost very infrequent. Mean monthly maximum and minimum temperatures for Hillcrest 35.0°C and 4.2°C and for Mid-Illovo 35.8°C and 4.7°C both for October and June/July, respectively. Corresponding values for Dalton 35.6°C and 0.9°C for October and July, respectively. See also climate diagram for SVs 5 KwaZulu-Natal Sandstone Sourveld.

Important Taxa Small Trees: *Protea caffra* (d), *P. roupelliae* subsp. *roupelliae* (d). Tall Shrubs: *Aspalathus chortophila*, *Gnidia kraussiana*, *Pachystigma macrocalyx*. Low Shrubs: *Acalypha glandulifolia*, *Agathisanthemum bojeri*, *Erica cubica* var. *cubica*, *E. natalitia*, *Protea simplex*, *P. welwitschii* subsp. *welwitschii*, *Rhus grandidens*, *Senecio medley-woodii*, *Tetraselago natalensis*, *Thunbergia atriplicifolia*, *Turraea pulchella*. Graminoids: *Aristida junciformis* subsp. *junciformis* (d), *Heteropogon contortus* (d), *Themeda triandra* (d), *Trachypogon spicatus* (d), *Tristachya leucothrix* (d), *Andropogon schirensis*, *Cymbopogon nardus*, *Digitaria diagonalis*, *D. natalensis*, *Diheteropogon amplexans*, *Elionurus muticus*, *Eragrostis plana*, *E. racemosa*, *Eulalia villosa*, *Hyparrhenia hirta*, *Monocymbium ceresiiforme*. Herbs: *Aster bakerianus*, *Cyanotis speciosa*, *Dianthus zeyheri*, *Helichrysum allioides*, *Selago tarachodes*, *Senecio dregeanus*, *Zaluzianskya pilosa*. Geophytic Herbs: *Aspidoglossum ovalifolium*, *Brachystelma perditum*, *B. pygmaeum* subsp. *flavidum*, *B. tenellum*, *Eriospermum mackenii*, *Watsonia densiflora*. Succulent Herbs: *Aloe minima*, *Senecio oxyriifolius*.

Biogeographically Important Taxa ^MMidlands endemic, ^PLink to Pondoland, ^FFynbos generic element, ^SSouthern distribution limit) Low Shrubs: *Agathosma ovata*^F, *Erica aspalathifolia*^P, *Eriosemopsis subanisophylla*^P, *Gnidia woodii*^P,



Figure 9.68 SVs 5 KwaZulu-Natal Sandstone Sourveld: Short grassland with the range-restricted *Gladiolus inandensis* in the Vernon Crookes Nature Reserve.

Leucospermum gerrardii^F, *Muraltia lancifolia*^{PF}, *Stangeria eriopus*^P, *Syncolostemon parviflorus*^P. Herbs: *Agathisanthemum chlorophyllum*^P, *Callilepis leptophylla*^S, *Helichrysum acutatum*^P, *H. griseum*^P, *H. pannosum*^P. Geophytic Herbs: *Dierama pallidum*^M, *D. pumilum*^M, *Disperis woodii*^P, *Gladiolus inandensis*^P. Succulent Herbs: *Bulbine inflata*^S, *Crassula multicava* subsp. *floribunda*^P. Geoxylic Suffrutex: *Rhus rudatisii*^P.

Endemic Taxa Low Shrubs: *Helichrysum woodii*, *Tephrosia inandensis*. Succulent Herbaceous Climber: *Crassula inandensis*. Herbs: *Eriosema populifolium* subsp. *populifolium*, *E. rossii*, *Phymaspermum pinnatifidum*. Geophytic Herbs: *Brachystelma modestum*, *B. natalense*, *B. pulchellum*, *Cynorkis compacta*, *Gladiolus cruentus*, *Hesperantha gracilis*.

Conservation Endangered. Target 25%. Only 0.2% statutorily conserved in the Krantzklouf and Vernon Crookes Nature Reserves. Some 68% transformed for cultivation, plantations, urban development or road building. This highly transformed vegetation type is a prime agricultural area with mainly sugar cane and timber plantations. The urban sprawl of the Ethekwini (Durban) Metropolitan Area and densely populated subsistence farming areas account for most of the remainder. Apart from the critically little conserved areas (only several hundred hectares), most remaining areas are subjected to high levels of grazing and frequent fire not conducive to the recruitment of seedlings of many of the shrubs and herbs. Erosion is low to very low.

Remark 1 This vegetation unit shares a number of endemic species with CB 4 Pondoland-Ugu Sandstone Coastal Sourveld.

Remark 2 Biome affiliation of this unit is borderline and it could also be considered a candidate for the Grassland Biome.

References Killick (1958), Camp (1999a, b), Scott-Shaw (1999).

SVs 6 Eastern Valley Bushveld

VT 23 Valley Bushveld (56%) (Acocks 1953). LR 5 Valley Thicket (58%) (Low & Rebelo 1996).

Distribution KwaZulu-Natal and Eastern Cape Provinces: Deeply incised valleys of rivers including the lower reaches of the Thukela, Mvoti, Mgeni, Mlazi, Mkhomazi, Mzimkulu, Mzimkulwana, Mtamvuna, Mtentu, Msikaba, Mzimvubu (and

its several tributaries), Mthatha, Mbhashe, Shixini, Qhorha and Great Kei. Very seldom extending to the coast. Altitude 100–1 000 m.

Vegetation & Landscape Features Semideciduous savanna woodlands in a mosaic with thickets, often succulent and dominated by species of *Euphorbia* and *Aloe*. Most of the river valleys run along a northwest-southeast axis which results in unequal distribution of rainfall on respective north-facing and south-facing slopes since the rain-bearing winds blow from the south. The steep north-facing slopes are sheltered from the rain and also receive greater amounts of insolation adding to xerophilous conditions on these slopes.

Geology & Soils The area is underlain by the sediments of the Karoo Supergroup with the mudstones and lesser sandstones of the Adelaide and Tarkastad Subgroups (Beaufort Group) dominant, and some Ecca Group shale. Dominant land type Fa.

Climate Summer rainfall with some rain in winter. MAP about 550–1 000 mm. Frost infrequent. Mean monthly maximum and minimum temperatures for Nagle Dam 36.9°C and 4.0°C for December and June, respectively. See also climate diagram for SVs 6 Eastern Valley Bushveld.

Important Taxa Tall Trees: *Acacia robusta*, *Sclerocarya birrea* subsp. *caffra*. Small Trees: *Acacia natalitia* (d), *A. nilotica* (d), *Combretum molle* (d), *Spirostachys africana* (d), *Acacia tortilis* subsp. *heteracantha*, *Berchemia zeyheri*, *Boscia albitrunca*, *Brachylaena elliptica*, *Cussonia spicata*, *Dombeya rotundifolia*, *Encephalartos natalensis*, *E. villosus*, *Hippobromus pauciflorus*, *Schotia brachypetala*, *Ziziphus mucronata*. Succulent Trees: *Euphorbia tirucalli* (d), *Aloe marlothii* subsp. *marlothii*, *A. rupestris*, *Euphorbia ingens*, *E. triangularis*. Tall Shrubs: *Dichrostachys cinerea* (d), *Calpurnia aurea*, *Coddia rudis*, *Ehretia rigida* subsp. *rigida*, *Euclea crispa* subsp. *crispa*, *Grewia occidentalis*, *Olea europaea* subsp. *africana*. Succulent Shrubs: *Aloe arborescens*, *Euphorbia grandicornis*, *Kleinia fulgens*. Soft Shrubs: *Hypoestes aristata*, *Peristrophe cernua*. Woody Climber: *Acacia brevispica* subsp. *dregeana*. Herbaceous Climber: *Ischnolepis natalensis*. Graminoids: *Aristida congesta* (d), *Eragrostis curvula* (d), *Hyparrhenia hirta* (d), *Melinis repens* (d), *Panicum maximum* (d), *Themeda triandra* (d), *Cymbopogon pospischilii*, *Eragrostis superba*, *Heteropogon contortus*, *Panicum deustum*, *Sporobolus fimbriatus*, *S. pyramidalis*, *Tristachya leucothrix*, *Urochloa mosambicensis*. Herbs: *Achyrantes aspera*, *Hibiscus pedunculatus*. Geophytic Herb: *Sansevieria hyacinthoides*.

Endemic Taxa Tall Shrub: *Bauhinia natalensis*. Succulent Herb: *Huernia pendula*.

Conservation Least threatened. Target 25%. Only 0.8% statutorily conserved, mainly in the Luchaba Wildlife Reserve; small patches also conserved in the Oribi Gorge Nature Reserve. Some 15% transformed mainly by cultivation. Alien plant invasions are a serious threat, with *Chromolaena odorata*, *Lantana camara* and *Caesalpinia decapetala* being most problematic.

Remarks This unit (together with the SVs 1 Thukela Valley Bushveld) corresponds closely to Acocks's (1953) 'Northern Variation of the Valley Bushveld' from the Great Kei River Valley northwards. He viewed this area as transitional to



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Figure 9.69 SVs 6 Eastern Valley Bushveld: Moderately dense bushveld between Mpisi River and Emabhobhane Drift on the lower Thukela River with *Ehretia rigida*, *Boscia albitrunca*, *Croton pseudopulchellus* (grey shrubs), *Euphorbia grandicornis* and *Aloe marlothii*.

the Lowveld, particularly that part from the Umkomaas River Valley northwards. Its northern variation (i.e. from the Kei northwards) is more open than its southern variation (the latter is a part of the Albany Thicket Biome) and includes 'more grass, fewer succulents and more species of definitely tropical nature'. Examples of species of this unit that extend southwards from at least the lowveld savanna of Mpumalanga, or from savanna elsewhere at this northern latitude are *Acacia nilotica*, *Euphorbia ingens*, *Spirostachys africana* and *Vitex rehmannii* (extending southwards as far as the Umkomaas River Valley), *Combretum molle* and *Dichrostachys cinerea* (extending further south to around the southern border of KwaZulu-Natal), and *A. robusta*, *Dalbergia obovata*, *Dombeya cymosa*, *E. tirucalli* and *Vangueria infausta* (extending to the vicinity of the Great Kei River Valley or enter the easternmost extremity of the Albany Thicket Biome). In contrast to the thicket vegetation found in valleys south of the Great Kei River, Vlok & Euston-Brown (2002) found that most of the Kei Valley does not have extensive stands of thicket and that thicket only occurs as small clumps, usually on north-facing slopes in a matrix of savanna. Despite considerable disturbance to the vegetation here, they stated that there was no direct evidence that thicket did occur in more extensive stands in recent times. Only over a short length along the lower Great Kei River does true Albany Thicket Biome occur (mapped as part of AT 12 Buffels Thicket; see chapter on Albany Thicket in this book).

References Edwards (1967), Morris (1967, 1969), Grunow & Morris (1969), Perkins (1997), Perkins et al. (1999).

SVs 7 Bhisho Thornveld

VT 7 Eastern Province Thornveld (37%), VT 23 Valley Bushveld (23%) (Acocks 1953). LR 16 Eastern Thorn Bushveld (50%) (Low & Rebelo 1996).

Distribution Eastern Cape Province: From near Mthatha in a band parallel to but inland of the coast to north of East London, turning to run along the southern side of the Amathole Mountains as far as Fort Beaufort. Also on dissected hills and low mountains around Grahamstown, especially to the southwest, and in a few fragments in valleys northeast of the Amathole Mountains. Altitude mostly 200–700 m.

Vegetation & Landscape Features On undulating to moderately steep slopes, sometimes in shallow, incised drainage valleys. Open savanna characterised by small trees of *Acacia natalitia* with a short to medium, dense, sour grassy understorey, usually dominated by *Themeda triandra* when in good condition. A diversity of other woody species also occur, often increasing under conditions of overgrazing.

Geology & Soils Mudstone with subordinate sandstone of the Adelaide Subgroup (Beaufort Group, Karoo Supergroup) underlies most of the area and is intruded by Karoo dolerite dykes and sills. The substrate is primarily loamy soils, but there is significant variability. The area was classified into a variety of land types, with Fa and Fb dominant.

Climate Summer rainfall with some rain in winter. MAP from about 500 mm in the west to more than 900 mm in the east.



Figure 9.70 SVs 7 Bhisho Thornveld: Thornveld dominated by *Acacia natalitia* near Butterworth, Transkei, Eastern Cape.

The coefficient of variation in MAP is approximately 25%, but varies from about 20% at the coast to about 30% on the inland and western parts. Frost infrequent. The mean daily maximum temperatures for January 25°C in the east and 28°C in the west and the mean daily minimum temperatures for July 3°C inland and 9°C at the coast. Mean monthly maximum and minimum temperatures for King William's Town 37.0°C and –1.6°C for February and June, respectively. See also climate diagram for SVs 7 Bhisho Thornveld.

Important Taxa Small Tree: *Acacia natalitia* (d). Tall Shrub: *Tephrosia capensis*. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum*, *Chrysocoma ciliata*, *Felicia muricata*. Graminoids: *Eragrostis plana* (d), *Heteropogon contortus* (d), *Hyparrhenia hirta* (d), *Sporobolus africanus* (d), *Themeda triandra* (d), *Aristida junciformis* subsp. *junciformis*, *Bulbostylis humilis*, *Cynodon dactylon*, *Digitaria diagonalis*, *D. eriantha* subsp. *eriantha*, *Elionurus muticus*, *Eragrostis capensis*, *E. chloromelas*, *E. curvula*, *Kyllinga alata*, *Microchloa caffra*, *Paspalum dilatatum*, *Schoenoxiphium sparteum*. Herbs: *Centella asiatica*, *Commelina africana*, *Gazania linearis*, *Gerbera ambigua*, *Helichrysum miconiifolium*, *H. nudifolium* var. *pilosellum*, *H. rugulosum*, *Senecio retrorsus*, *Spermacoce natalensis*, *Wahlenbergia stellarioides*, *Zornia capensis*. Geophytic Herbs: *Hypoxis argentea*, *Moraea polystachya*, *Pellaea calomelanos*.

Conservation Least threatened. Target 25%. Only 0.2% statutorily conserved in the Doubledrift and Thomas Baines Nature Reserves. About 2% conserved in private reserves such as Shamwari Game Reserve, Rockdale Game Ranch and Fourie Safaris Game Farm. Some 20% already transformed for cultivation, urban development or plantations. Erosion is very low to moderate.

Remarks Due to the wide distribution of this unit, it incorporates a wide variety of environmental conditions. It borders on a number of other units and species from different vegetation types may co-occur along overlapping areas. Most similar to and forms a gradient to Gs 18 Bedford Dry Grassland in the west. Fire and grazing regimes appear to be key determinants of this vegetation unit, although soil characteristics are also important. *Acacia natalitia*, the main woody species of the SVs 7 Bhisho Thornveld, tends to occur in habitats with high soil moisture balance.

Reference Acocks (1988).

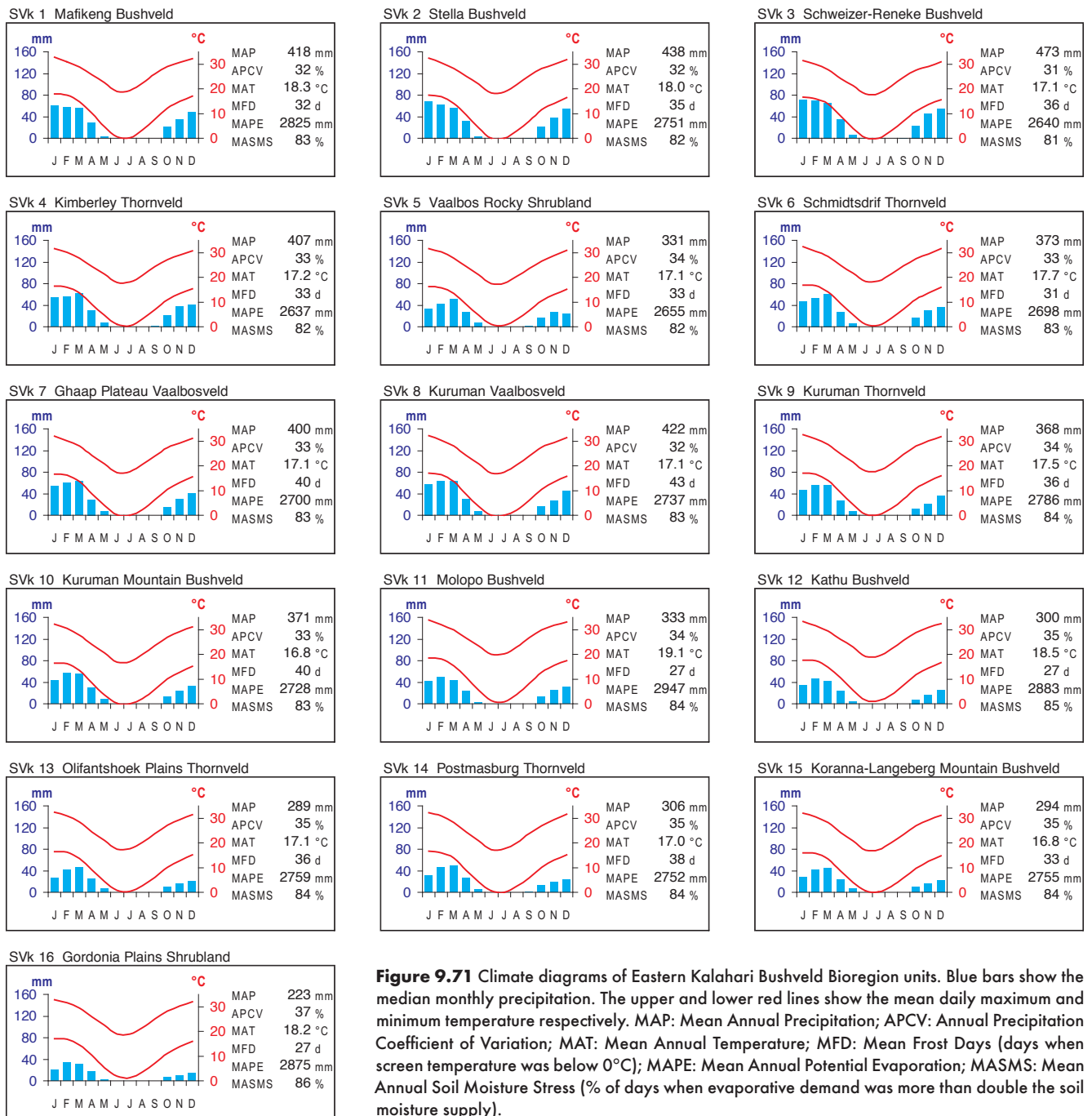


Figure 9.71 Climate diagrams of Eastern Kalahari Bushveld Bioregion units. Blue bars show the median monthly precipitation. The upper and lower red lines show the mean daily maximum and minimum temperature respectively. MAP: Mean Annual Precipitation; APCV: Annual Precipitation Coefficient of Variation; MAT: Mean Annual Temperature; MFD: Mean Frost Days (days when screen temperature was below 0°C); MAPE: Mean Annual Potential Evaporation; MASMS: Mean Annual Soil Moisture Stress (% of days when evaporative demand was more than double the soil moisture supply).

Eastern Kalahari Bushveld

SVk 1 Mafikeng Bushveld

VT 16 Kalahari Thornveld and Shrub Bushveld (76%) (Acoccks 1953). LR 30 Kalahari Plains Thorn Bushveld (80%) (Low & Rebelo 1996).

Distribution North-West Province: West of Mafikeng and south of the Botswana border westwards to around Vergeleë, southwards to Piet Plessis and Setlagole. Altitude 1 100–1 400 m.

Vegetation & Landscape Features Well developed tree and shrub layers, dense stands of *Terminalia sericea*, *Acacia luederitzii* and *A. erioloba* in certain areas. Shrubs include *A. karroo*, *A. hebeculata* and *A. mellifera*, *Dichrostachys cinerea*, *Grewia flava*, *G. retinervis*, *Rhus tenuinervis* and *Ziziphus mucronata*. Grass layer is also well developed.

Geology & Soils Aeolian Kalahari sand of Tertiary to Recent age on flat sandy plains, soils deep (>1.2 m). Clovelly and Hutton soil forms. Land types Ah, Ai and Ae.

Climate Summer rainfall with very dry winters. MAP from about 350 mm in the west to about 520 mm in the east. Frost frequent in winter. Mean monthly maximum and minimum temperatures for Mmabatho 35.6°C and –1.8°C for November and June, respectively. See also climate diagram for SVk 1 Mafikeng Bushveld.

Important Taxa Tall Tree: *Acacia erioloba* (d). Small Trees: *Acacia karroo* (d), *A. mellifera* subsp. *detinens* (d), *Terminalia sericea* (d), *Ziziphus mucronata* (d). Tall Shrubs: *Dichrostachys cinerea* (d), *Grewia flava* (d), *Rhus tenuinervis* (d), *Diospyros austro-africana*, *Ehretia rigida* subsp. *rigida*, *Rhigozum obovatum*, *Tarchonanthus camphoratus*. Low Shrubs: *Acacia hebe-*



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Figure 9.72 SVk 1 Mafikeng Bushveld: Open savanna dominated by *Ziziphus mucronata*, *Grewia flava* and *Acacia erioloba* on Wildebeesthoorn between Vergelegeë and Setlagole in the Vryburg District, North-West Province.

clada subsp. *hebeclada* (d), *Grewia retinervis* (d), *Aptosimum procumbens*, *Felicia muricata*, *Gnidia polycephala*, *Helichrysum zeyheri*, *Hoffmannseggia burchellii*, *Lantana rugosa*, *Talinum arnotii*. Geoxylic Suffrutex: *Elephantorrhiza elephantina*. Succulent Shrub: *Lycium cinereum*. Woody Climber: *Asparagus africanus*. Graminoids: *Antheophora pubescens* (d), *Cymbopogon pospischilii* (d), *Digitaria eriantha* subsp. *eriantha* (d), *Eragrostis lehmanniana* (d), *E. pallens* (d), *Schmidtia pappophoroides* (d), *Stipagrostis uniplumis* (d), *Aristida congesta*, *A. meridionalis*, *A. mollissima* subsp. *argentea*, *A. stipitata* subsp. *stipitata*, *Brachiaria nigropedata*, *B. serrata*, *Cynodon dactylon*, *Digitaria argyrograptia*, *Eragrostis superba*, *E. trichophora*, *Melinis repens*, *Tragus racemosus*, *Urochloa panicoides*. Herbs: *Barleria macrostegia*, *Erlangea misera*, *Harpagophytum procumbens* subsp. *procumbens*, *Hermannia tomentosa*, *Hermbstaedtia odorata*, *Indigofera daleoides*, *Limeum fenestratum*, *Nidorella resedifolia*, *Oxygonum dregeanum* subsp. *canescens* var. *canescens*, *Senna italica* subsp. *arachoides*. Geophytic Herb: *Ledebouria marginata*.

Biogeographically Important Taxa (Kalahari endemics) Small Tree: *Acacia luederitzii* var. *luederitzii* (d). Graminoid: *Panicum kalaharensis*.

Conservation Vulnerable. Target 16%. None conserved in statutory conservation areas but very small area conserved in the Mmabatho Recreation Area. About 25% already transformed, mainly for cultivation and urban development. Erosion is very low.

Reference Smit (2000).

SVk 2 Stella Bushveld

VT 16 Kalahari Thornveld and Shrub Bushveld (92%) (Acocks 1953). LR 33 Kalahari Plateau Bushveld (73%) (Low & Rebelo 1996).

Distribution North-West Province: North of Vryburg around Stella westwards to Louwna and eastwards to about 20

km west of Delareyville. Altitude 1 250–1 400 m.

Vegetation & Landscape Features

Plains to sometimes slightly undulating plains with open tree and shrub layers and trees *Acacia erioloba* and *A. tortilis* and shrubs *A. hebeclada*, *Dichrostachys cinerea*, *Grewia flava* and *Tarchonanthus camphoratus*.

Geology & Soils Andesitic lavas of the Allanridge Formation of the Ventersdorp Supergroup, sometimes covered with silcrete or calcrete of the Kalahari Group, on flat to hilly plains. Sandy soils 0.1–0.9 m deep, various soil forms. Land types Bc and Ae, with a little Ah.

Climate Summer rainfall with very dry winters. MAP about 400–480 mm. Frost frequent in winter. See also climate diagram for SVk 2 Stella Bushveld.

Important Taxa Tall Tree: *Acacia erioloba* (d). Small Trees: *Acacia tortilis* subsp.

heteracantha (d), *A. caffra*, *A. karroo*, *Rhus lancea*. Tall Shrubs: *Dichrostachys cinerea* (d), *Grewia flava* (d), *Tarchonanthus camphoratus* (d), *Asparagus laricinus*, *Diospyros lycioides* subsp. *lycioides*, *D. pallens*, *Ehretia rigida* subsp. *rigida*. Low Shrubs: *Acacia hebeclada* subsp. *hebeclada* (d), *Chrysocoma ciliata* (d), *Helichrysum zeyheri*, *Pentzia viridis*, *Solanum supinum*. Succulent Shrub: *Hertia pallens*. Woody Climber: *Asparagus africanus*. Herbaceous Climber: *Rhynchosia confusa*. Graminoids: *Cenchrus ciliaris* (d), *Cymbopogon pospischilii* (d), *Eragrostis rigidior* (d), *Panicum coloratum* (d), *Themeda triandra* (d), *Aristida congesta*, *Cynodon dactylon*, *Eragrostis lehmanniana*, *E. obtusa*, *E. superba*, *Pogonarthria squarrosa*, *Sporobolus fimbriatus*, *Tragus racemosus*. Herbs: *Barleria macrostegia*, *Dicoma capensis*, *Hibiscus pusillus*, *Indigofera alternans*, *I. daleoides*, *Lippia scaberrima*, *Osteospermum muricatum*, *Tripteris aghillana*. Geophytic Herb: *Babiana hypogaea*.

Conservation Vulnerable. Target 16%. None conserved in statutory conservation areas. Some 21% transformed, almost all by cultivation. Erosion is very low.

Reference Smit (2000).



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Figure 9.73 SVk 2 Stella Bushveld: Open savanna on plains with *Acacia erioloba*, *Tarchonanthus camphoratus*, *A. hebeclada* and *Eragrostis lehmanniana* var. *lehmanniana* on Klipfontein between Vryburg and Ganyesa, North-West Province.



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Figure 9.74 SVk 3 Schweizer-Reneke Bushveld: Open shrubland dominated by *Acacia hebeclada* and *Tarchonanthus camphoratus* with some *A. karroo* trees on Nieuwjaarsfontein west of Schweizer-Reneke, North-West Province.

SVk 3 Schweizer-Reneke Bushveld

VT 16 Kalahari Thornveld and Shrub Bushveld (89%) (Acocks 1953). LR 32 Kimberley Thorn Bushveld (88%) (Low & Rebelo 1996).

Distribution North-West Province: Schweizer-Reneke area in the east to Amalia in the west and from the farming areas of around Broedersput in the north to Never Mind (Christiana District) in the south. Altitude 1 250–1 400 m.

Vegetation & Landscape Features Plains, slightly undulating plains and some hills, supporting open woodland with a fairly dense shrub layer, with trees *Acacia erioloba*, *A. karroo*, *A. tortilis*, *Rhus lancea* and shrubs *A. hebeclada*, *Diospyros lycioides*, *Grewia flava*, *Tarchonanthus camphoratus*.

Geology & Soils Andesitic lavas of the Allanridge Formation of the Ventersdorp Supergroup, sometimes covered with silcrete or calcrete of the Kalahari Group. Deep (0.9–1.2 m) sandy soils, with Hutton and Clovelly the dominant soil forms. Land types Ah and Ae and some Bc.

Climate Rainfall in summer with very dry winters. MAP about 440–520 mm. Frost frequent in winter. See also climate diagram for SVk 3 Schweizer-Reneke Bushveld.

Important Taxa Tall Tree: *Acacia erioloba* (d). Small Trees: *Acacia karroo* (d), *A. tortilis* subsp. *heteracantha* (d), *Rhus lancea* (d). Tall Shrubs: *Asparagus laricinus* (d), *Diospyros lycioides* subsp. *lycioides* (d), *Grewia flava* (d), *Tarchonanthus camphoratus* (d), *Diospyros pallens*, *Ehretia rigida* subsp. *rigida*, *Gymnosporia buxifolia*, *Rhus tridactyla*. Low Shrubs: *Acacia hebeclada* subsp. *hebeclada* (d), *Aptosimum decumbens*, *Chrysocoma ciliata*, *Gnidia polycephala*, *Pentzia viridis*. Woody Climber: *Asparagus africanus*. Graminoids: *Antheophora pubescens* (d), *Digitaria eriantha* subsp. *eriantha* (d), *Heteropogon contortus* (d), *Stipagrostis uniplumis* (d), *Themeda triandra* (d), *Aristida congesta*, *A. stipitata* subsp. *spicata*, *Chloris virgata*, *Cynodon*

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Figure 9.75 SVk 4 Kimberley Thornveld: Open savanna dominated by *Acacia erioloba* and *A. mellifera* on Kloksfontein south-southwest of Kimberley.

dactylon, *Eragrostis biflora*, *E. rigidior*, *E. superba*, *E. trichophora*, *Sporobolus fimbriatus*. Herbs: *Barleria macrostegia*, *Hermannia tomentosa*, *Hibiscus pusillus*, *Indigofera daleoides*, *Lippia scaberrima*, *Osteospermum muricatum*, *Pollichia campestris*, *Rhynchosia adenodes*. Geophytic Herbs: *Dipcadi papillatum*, *Nerine laticoma*.

Conservation Endangered. Target 16%. None conserved in statutory conservation areas. Largely (42%) transformed, almost all by cultivation. Erosion is very low.

Reference Smit (2000).

SVk 4 Kimberley Thornveld

VT 16 Kalahari Thornveld and Shrub Bushveld (50%) (Acocks 1953). LR 32 Kimberley Thorn Bushveld (74%) (Low & Rebelo 1996).

Distribution North-West, Free State and Northern Cape Provinces: Most of the Kimberley, Hartswater, Bloemhof and Hoopstad Districts as well as substantial parts of the Warrenton, Christiana, Taung, Boshof and to some extent the Barkly West Districts. Also includes pediment areas in the Herbert and Jacobsdal Districts. Altitude 1 050–1 400 m.

Vegetation & Landscape Features Plains often slightly irregular with well-developed tree layer with *Acacia erioloba*, *A. tortilis*, *A. karroo* and *Boscia albitrunca* and well-developed shrub layer with occasional dense stands of *Tarchonanthus camphoratus* and *A. mellifera*. Grass layer open with much uncovered soil.

Geology & Soils Andesitic lavas of the Allanridge Formation in the north and west and fine-grained sediments of the Karoo Supergroup in the south and east. Deep (0.6–1.2 m) sandy to loamy soils of the Hutton soil form (Ae and Ah land types) on slightly undulating sandy plains.

Climate Summer and autumn rainfall and very dry winters. MAP from about 300 mm in the southwest to about 500 mm in the northeast. Frost frequent in winter. Mean monthly maximum and minimum temperatures for Kimberley 37.5°C and –4.1°C for January and July, respectively. Corresponding values for

Vaalharts-Agr 37.4°C and –3.9°C, respectively. See also climate diagram for SVk 4 Kimberley Thornveld.

Important Taxa Tall Tree: *Acacia erioloba* (d). Small Trees: *Acacia karroo* (d), *A. mellifera* subsp. *detinens* (d), *A. tortilis* subsp. *heteracantha* (d), *Rhus lancea*. Tall Shrubs: *Tarchonanthus camphoratus* (d), *Diospyros pallens*, *Ehretia rigida* subsp. *rigida*, *Euclea crispa* subsp. *ovata*, *Grewia flava*, *Lycium arenicola*, *L. hirsutum*, *Rhus tridactyla*. Low Shrubs: *Acacia hebeclada* subsp. *hebeclada* (d), *Anthospermum rigidum* subsp. *pumilum*, *Helichrysum zeyheri*, *Hermannia comosa*, *Lycium pilifolium*, *Melolobium microphyllum*, *Pavonia burchellii*, *Peliostomum leucorrhizum*, *Plinthus sericeus*, *Wahlenbergia nodosa*. Succulent Shrubs: *Aloe here-roensis* var. *hereroensis*, *Lycium cinereum*. Graminoids: *Eragrostis lehmanniana* (d), *Aristida canescens*, *A. congesta*, *A. mollissima* subsp. *argentea*, *Cymbopogon pospischilii*, *Digitaria argyrograptia*, *D. eriantha* subsp. *eriantha*, *Enneapogon cenchroides*, *E. scoparius*, *Eragrostis rigidior*, *Heteropogon contortus*, *Themeda triandra*. Herbs: *Barleria macrostegia*, *Dicoma schinzii*, *Harpagophytum procumbens* subsp. *procumbens*, *Helichrysum cerastioides*, *Hermbstaedtia odorata*, *Hibiscus marlothianus*, *Jamesbrittenia aurantiaca*, *Lippia scaberrima*, *Osteospermum muricatum*, *Vahlia capensis* subsp. *vulgaris*. Succulent Herbs: *Aloe grandidentata*, *Piранthus decipiens*.

Biogeographically Important Taxa (^{GW}Griqualand West endemic, ^KKalahari endemic) Low Shrub: *Blepharis marginata*^{GW}. Succulent Shrub: *Euphorbia bergii*^{GW}. Graminoid: *Panicum kalaharensis*^K. Herbs: *Helichrysum arenicola*^K, *Neuradopsis bechuanaensis*^K. Succulent Herbs: *Lithops aucampiae* subsp. *aucampiae*^{GW}, *Tridentea marientalensis* subsp. *marientalensis*^K.

Conservation Least threatened. Target 16%. Only 2% statutorily conserved in Vaalbos National Park as well as in Sandveld, Bloemhof Dam and S.A. Lombard Nature Reserves. Some 18% already transformed, mostly by cultivation. Erosion is very low. Area is mostly used for cattle farming or game ranching. Overgrazing leads to encroachment of *Acacia mellifera* subsp. *detinens*.

References Bezuidenhout (1994, 1995), Smit (2000).

SVk 5 Vaalbos Rocky Shrubland

VT 17 Kalahari Thornveld invaded by Karoo (31%), VT 40 False Orange River Broken Veld (21%) (Acocks 1953). LR 32 Kimberley Thorn Bushveld (44%), LR 51 Orange River Nama Karoo (36%) (Low & Rebelo 1996).

Distribution Northern Cape and Free State Provinces: Extends along solitary hills and scattered ridges east of the confluence of the Orange and Vaal Rivers, mainly in the Kimberley and Herbert Districts and west of a line bounded by the western Free State towns of Luckhoff, Petrusburg, Dealesville, Bultfontein and Hertzogville. Altitude 1 000–1 400 m.

Vegetation & Landscape Features Slopes and elevated hills and ridges within plains of mainly SVk 4 Kimberley Thornveld, also in the vicinity of NKu 3 Northern Upper Karoo. Evergreen shrub communities dominated by *Tarchonanthus camphoratus*, *Olea europaea* subsp. *africana*, *Euclea crispa*, *Diospyros lycioi-*



Figure 9.76 SVk 5 Vaalbos Rocky Shrubland: Open shrubland dominated here by *Tarchonanthus camphoratus*, *Acacia tortilis* and *Lycium* species on a rocky hillside on The Grange, north-east of Hopetown, Northern Cape Province.

des, *Rhus burchellii* and *Buddleja saligna*. Sheltered, cool sites include trees such as *R. lancea*, *Celtis africana* and *Ziziphus mucronata*. On the footslopes of the dolerite hills, where calcareous soils occur, shrubs and small trees of *Acacia tortilis* and *Z. mucronata* can be dominant.

Geology & Soils A highly fragmented area on Ecca and Dwyka Group sediments and Karoo dolerites as well as on Ventersdorp Supergroup lavas (Allanridge Formation). Extensive dolerite sills which form ridges, and plateaus and slopes of koppies and small escarpments mark the erosion terraces. These dolerite sills cover alternating layers of mudstone and sandstone of sedimentary origin. The lb land type is typical of these rock- and boulder-covered slopes. Prominent soil forms are the stony Mispah and gravel-rich Glenrosa forms derived from Jurassic dolerite, calcareous soils cover the lowlands (Kimberley and Plooyburg forms).

Climate Summer and autumn rainfall with very dry winters. MAP about 250–450 mm. Frost frequent in winter, especially on bottomlands. Mean monthly maximum and minimum temperatures for Douglas 39.7°C and –4.6°C for January and July, respectively. See also climate diagram for SVk 5 Vaalbos Rocky Shrubland.

Important Taxa Small Trees: *Boscia albitrunca*, *Cussonia paniculata*, *Rhus lancea*. Tall Shrubs: *Euclea crispa* subsp. *crispa* (d), *Olea europaea* subsp. *africana* (d), *Tarchonanthus camphoratus* (d), *Ziziphus mucronata* (d), *Buddleja saligna*, *Cadaba aphylla*, *Diospyros austro-africana*, *D. lycioides* subsp. *lycioides*, *Ehretia rigida* subsp. *rigida*, *Gymnosporia polyacantha*, *Rhigozum obovatum*, *Rhus burchellii*. Low Shrubs: *Asparagus suaveolens*, *Hermannia comosa*, *Lantana rugosa*, *Lycium pilifolium*, *Pentzia globosa*, *Rhus ciliata*. Succulent Shrubs: *Cotyledon orbiculata* var. *orbiculata*, *Crassula nudicaulis*, *Kalanchoe paniculata*, *Lycium cinereum*. Graminoids: *Aristida adscensionis*, *A. congesta*, *Digitaria eriantha* subsp. *eriantha*, *Elionurus muticus*, *Enneapogon scoparius*, *Eragrostis lehmanniana*, *E. obtusa*, *Eustachys paspaloides*, *Fingerhuthia africana*, *Heteropogon contortus*, *Hyparrhenia hirta*, *Stipagrostis uniplumis*, *Themeda triandra*. Herbs: *Chascanum pinnatifidum*, *Harpagophytum procumbens* subsp. *procumbens*, *Hibiscus pusillus*. Geophytic Herbs: *Albuca setosa*, *Cheilanthes eckloniana*, *Haemanthus humilis* subsp. *humilis*, *Pellaea calomelanos*. Succulent Herbs: *Aloe grandidentata*, *Stapelia grandiflora*.

Conservation Least threatened. Target 16%. Less than 2% statutorily conserved in the Vaalbos National Park. Only about 2% already transformed.

Remarks Although similar topography and geology to that of koppies in the broad surrounds of Bloemfontein (Gh 4 Besemkaree Koppies Shrubland and Gh 7 Winburg Grassy Shrubland) in the Grassland Biome, the vegetation of this unit differs considerably in species composition through the occurrence of more arid elements.

References Malan et al. (1998, 2001), Müller (2002).

SVk 6 Schmidtsdrif Thornveld

VT 16 Kalahari Thornveld and Shrub Bushveld (56%) (Acocks 1953). LR 32 Kimberley Thorn Bushveld (89%) (Low & Rebelo 1996).

Distribution Northern Cape, Free State and North-West Provinces: Footslopes and midslopes to the southeast and below the Ghaap Plateau from around Douglas in the southwest via Schmidtsdrif towards Taung in the northeast. A small less typical section is found east of the Ghaap Plateau from Warrenton towards Hertzogville. Altitude 1 000–1 350 m.

Vegetation & Landscape Features Mostly a closed shrubby thornveld dominated by *Acacia mellifera* and *A. tortilis*. Apart from grasses, bulbous and annual herbaceous plant species are also prominent. The vegetation is sometimes very disturbed due to overgrazing by goats and other browsers.

Geology & Soils Most significant are the Dwyka diamictites and Ecca shales of the Karoo Supergroup. Shale and dolomite of the Schmidtsdrif Subgroup (Griqualand West Supergroup) are also present. Surface limestone occurs sporadically. Well-drained, shallow (<0.3 m), stony soil with large angular rocks on the soil surface. A soil-rock complex with Mispah soil form. Land types mainly Ae and Dc.

Climate Summer and autumn rainfall with very dry winters. MAP from about 250 mm in the southwest to about 450 mm in the northeast. Frost frequent in winter. See also climate diagram for SVk 6 Schmidtsdrif Thornveld.

Important Taxa Small Trees: *Acacia mellifera* subsp. *detinens* (d), *A. tortilis* subsp. *heteracantha* (d), *Ficus cordata*, *Ziziphus mucronata*. Tall Shrubs: *Tarchonanthus camphoratus* (d), *Grewia flava*. Low Shrubs: *Aptosimum albomarginatum* (d), *Barleria rigida* (d), *Monechma incanum* (d), *Pentzia incana* (d), *Hermannia affinis*, *H. comosa*, *Ptychlobium biflorum*, *Zygophyllum pubescens*. Semiparasitic Shrub: *Thesium lineatum*. Graminoids: *Aristida meridionalis* (d), *Enneapogon cenchroides* (d), *Eragrostis lehmanniana* (d), *E. obtusa* (d), *Enneapogon desvauxii*. Herbs: *Lepidium bonariense* (d), *Amaranthus praetermissus*, *Heliotropium ciliatum*, *Indigastrum parviflorum*, *Osteospermum muricatum*, *Seddera capensis*, *Stachys hyssopoides*.

Biogeographically Important Taxa (Griqualand West endemics) Low Shrub: *Blepharis marginata*. Succulent Shrub: *Prepodesma orpenii* (endemic genus).

Conservation Least threatened. Target 16%. Only 0.2% statutorily conserved

in the Vaalbos National Park. Some 13% already transformed, mainly by cultivation. Erosion is very low to low. Of alien plant taxa, *Prosopis* deserves attention.

References Gubb (1980), Crowe et al. (1981), Bezuidenhout (1994), Smit (2000).

SVk 7 Ghaap Plateau Vaalbosveld

VT 16 Kalahari Thornveld and Shrub Bushveld (74%) (Acocks 1953). LR 33 Kalahari Plateau Bushveld (86%) (Low & Rebelo 1996).

Distribution Northern Cape and North-West Provinces: Flat plateau from around Campbell in the south, east of Danielskuil through Reivilo to around Vryburg in the north. Altitude 1 100–1 500 m.

Vegetation & Landscape Features Flat plateau with well-developed shrub layer with *Tarchonanthus camphoratus* and *Acacia karroo*. Open tree layer has *Olea europaea* subsp. *africana*, *A. tortilis*, *Ziziphus mucronata* and *Rhus lancea*. *Olea* is more important in the southern parts of the unit, while *A. tortilis*, *A. hebeclada* and *A. mellifera* are more important in the north and part of the west of the unit. Much of the south-central part of this unit has remarkably low cover of *Acacia* species for an arid savanna and is dominated by the nonthorny *T. camphoratus*, *R. lancea* and *O. europaea* subsp. *africana*.

Geology & Soils Surface limestone of Tertiary to Recent age, and dolomite and chert of the Campbell Group (Griqualand West Supergroup, Vaalian Erathem) support shallow soils (0.1–0.25 m) of Mispah and Hutton soil forms. Land types mainly Fc with some Ae and Ag.

Climate Summer and autumn rainfall with very dry winters. MAP from about 300 mm in the southwest to about 500 mm in the northeast. Frost frequent to very frequent in winter. Mean monthly maximum and minimum temperatures for Koopmansfontein 36.3°C and –7.5°C for January and July, respectively. Corresponding values for Armoedsvlakte (near Vryburg) 36.6°C and –5.5°C for December and July, respectively. See also climate diagram for SVk 7 Ghaap Plateau Vaalbosveld.

Important Taxa Tall Tree: *Acacia erioloba*. Small Trees: *Acacia mellifera* subsp. *detinens* (d), *Rhus lancea* (d), *Acacia karroo*, *A. tortilis* subsp. *heteracantha*, *Boscia albitrunca*. Tall Shrubs: *Olea*



Figure 9.77 SVk 7 Ghaap Plateau Vaalbosveld: Open savanna dominated by *Tarchonanthus camphoratus* and *Olea europaea* subsp. *africana* between Papkuil and Campbell, Northern Cape Province.

europaea subsp. *africana* (d), *Rhigozum trichotomum* (d), *Tarchonanthus camphoratus* (d), *Ziziphus mucronata* (d), *Diospyros austro-africana*, *D. pallens*, *Ehretia rigida* subsp. *rigida*, *Euclea crispa* subsp. *ovata*, *Grewia flava*, *Gymnosporia buxifolia*, *Lessertia frutescens*, *Rhus tridactyla*. Low Shrubs: *Acacia hebeclada* subsp. *hebeclada* (d), *Aptosimum procumbens*, *Chrysocoma ciliata*, *Helichrysum zeyheri*, *Hermannia comosa*, *Lantana rugosa*, *Leucas capensis*, *Melolobium microphyllum*, *Peliostomum leucorrhizum*, *Pentzia globosa*, *P. viridis*, *Zygophyllum pubescens*. Succulent Shrubs: *Hertia pallens*, *Lycium cinereum*. Semiparasitic Shrub: *Thesium hystrix*. Woody Climber: *Asparagus africanus*. Graminoids: *Antheophora pubescens* (d), *Cenchrus ciliaris* (d), *Digitaria eriantha* subsp. *eriantha* (d), *Enneapogon scoparius* (d), *Eragrostis lehmanniana* (d), *Schmidtia pappophoroides* (d), *Themeda triandra* (d), *Aristida adscensionis*, *A. congesta*, *A. diffusa*, *Cymbopogon pospischilii*, *Enneapogon cenchroides*, *E. desvauxii*, *Eragrostis echinochloidea*, *E. obtusa*, *E. rigidior*, *E. superba*, *Fingerhuthia africana*, *Heteropogon contortus*, *Sporobolus fimbriatus*, *Stipagrostis uniplumis*, *Tragus racemosus*. Herbs: *Barleria macrostegia*, *Geigeria filifolia*, *G. ornativa*, *Gisekia africana*, *Helichrysum cerastioides*, *Heliotropium ciliatum*, *Hermbsaedia odorata*, *Hibiscus marlothianus*, *H. pusillus*, *Jamesbrittenia aurantiaca*, *Limeum fenestratum*, *Lippia scaberrima*, *Selago densiflora*, *Vahlia capensis* subsp. *vulgaris*. Succulent Herb: *Aloe grandidentata*.

Biogeographically Important Taxa (^{GW}Griqualand West endemic, ^KKalahari endemic, ^DBroadly disjunct distribution) Tall Shrubs: *Lebeckia macrantha*^{GW}, *Nuxia gracilis*^D. Low Shrubs: *Blepharis marginata*^{GW}, *Putterlickia saxatilis*^{GW}, *Tarchonanthus obovatus*^{GW}. Succulent Shrubs: *Euphorbia wilmaniae*^{GW}, *Prepodesma orpenii*^{GW} (endemic genus). Graminoids: *Digitaria polyphylla*^{GW}, *Panicum kalaharensis*^K. Herbs: *Corchorus pinatipartitus*^{GW}, *Helichrysum arenicola*^K. Succulent Herb: *Orbea knobelii*^K.

Endemic Taxon Herb: *Rennera stellata*.

Conservation Least threatened. Target 16%. None conserved in statutory conservation areas. Only about 1% already transformed. Erosion is very low.

Reference Smit (2000).

SVk 8 Kuruman Vaalbosveld

VT 16 Kalahari Thornveld and Shrub Bushveld (100%) (Acocks 1953). LR 33 Kalahari Plateau Bushveld (74%) (Low & Rebelo 1996).

Distribution North-West and Northern Cape Provinces: East of Kuruman to Lykso, south of Bendell towards Good Hope. Altitude 1 300–1 500 m.

Vegetation & Landscape Features Open tree layer characterised by *Acacia erioloba*, *A. karroo*, *Rhus lancea* and *Ziziphus mucronata*. Shrub layer poorly developed, with *Grewia flava* and *Tarchonanthus camphoratus* and grass layer open, with much bare soil in places.

Geology & Soils Carbonates and chert of the Vaalian Griqualand West Supergroup and Kalahari sediments form flat,



Figure 9.78 SVk 8 Kuruman Vaalbosveld: Open savanna dominated by *Tarchonanthus camphoratus* and *Rhus lancea* with a mix of grasses including *Themeda triandra* near Lykso, between Kuruman and Vryburg, North-West Province.

rocky, sandy plains with shallow (0.1–0.6 m) red aeolian sands, stony and underlain by rock. Dominant land types Ae and Fc, with Hutton, Clovelly and Mispah soil forms common.

Climate Summer and autumn rainfall with very dry winters. MAP about 350–450 mm. Frost very frequent in winter. See also climate diagram for SVk 8 Kuruman Vaalbosveld.

Important Taxa Tall Tree: *Acacia erioloba* (d). Small Trees: *Acacia karroo* (d), *Ziziphus mucronata* (d), *Rhus lancea*. Tall Shrubs: *Tarchonanthus camphoratus* (d), *Cadaba aphylla*, *Diospyros austro-africana*, *D. lycioides* subsp. *lycioides*, *Grewia flava*, *Gymnosporia buxifolia*. Low Shrubs: *Amphiglossa triflora*, *Anthospermum rigidum* subsp. *pumilum*, *A. rigidum* subsp. *rigidum*, *Helichrysum zeyheri*. Geoxylic Suffrutex: *Elephantorrhiza elephantina*. Succulent Shrub: *Ebracteola wilmaniae*. Herbaceous Climber: *Rhynchosia holosericea*. Graminoids: *Antheophora pubescens* (d), *Aristida meridionalis* (d), *Eragrostis lehmanniana* (d), *Stipagrostis uniplumis* (d), *Aristida stipitata* subsp. *spicata*, *Cymbopogon caesius*, *Digitaria eriantha* subsp. *eriantha*, *Fingerhuthia africana*, *Pogonarthria squarrosa*, *Schmidtia pappophoroides*, *Themeda triandra*, *Tragus koelerioides*. Herbs: *Acrotome inflata*, *Dicoma schinzii*, *Geigeria ornativa*, *Heliotropium strigosum*, *Stachys spathulata*, *Tripteris aghillana*.

Biogeographically Important Taxon (Kalahari endemic) Graminoid: *Antheophora argentea*.

Conservation Least threatened. Target 16%. None conserved in statutory conservation areas. Erosion is very low.

Remark In the dolomite area, sinkholes may be filled with wind-blown sand and occupied by conspicuous dense clumps of *Acacia erioloba*.

Reference Smit (2000).

SVk 9 Kuruman Thornveld

VT 16 Kalahari Thornveld and Shrub Bushveld (98%) (Acocks 1953). LR 30 Kalahari Plains Thorn Bushveld (67%) (Low & Rebelo 1996).

Distribution North-West and Northern Cape Provinces: On flats from the vicinity of Postmasburg and Danielskuil (here west of the Kuruman Hills) in the south extending via Kuruman to Tsineng and Dewar in the north. Altitude 1 100–1 500 m.

Vegetation & Landscape Features Flat rocky plains and some sloping hills with very well-developed, closed shrub layer and well-developed open tree stratum consisting of *Acacia erioloba*.

Geology & Soils Some Campbell Group dolomite and chert and mostly younger, superficial Kalahari Group sediments, with red wind-blown (0.3–1.2 m deep) sand. Locally, rocky pavements are formed in places. Most important land types Ae, Ai, Ag and Ah, with Hutton soil form.

Climate Summer and autumn rainfall with very dry winters. MAP about 300–450 mm. Frost frequent in winter. Mean monthly maximum and minimum temperatures for Kuruman 35.9°C and –3.3°C for January and June, respectively. See also climate diagram for SVk 9 Kuruman Thornveld.

Important Taxa Tall Tree: *Acacia erioloba* (d). Small Trees: *Acacia mellifera* subsp. *detinens* (d), *Boscia albitrunca* (d). Tall Shrubs: *Grewia flava* (d), *Lycium hirsutum* (d), *Tarchonanthus camphoratus* (d), *Gymnosporia buxifolia*. Low Shrubs: *Acacia hebeclada* subsp. *hebeclada* (d), *Monechma divaricatum* (d), *Gnidia polycephala*, *Helichrysum zeyheri*, *Hermannia comosa*, *Pentzia calcarea*, *Plinthus sericeus*. Geoxylic Suffrutex: *Elephantorrhiza elephantina*. Graminoids: *Aristida meridionalis* (d), *A. stipitata* subsp. *stipitata* (d), *Eragrostis lehmanniana* (d), *E. echinochloidea*, *Melinis repens*. Herbs: *Dicoma schinzii*, *Gisekia africana*, *Harpagophytum procumbens* subsp. *procumbens*, *Indigofera daleoides*, *Limeum fenestratum*, *Nolletia ciliaris*, *Seddera capensis*, *Tripteris aghillana*, *Vahlia capensis* subsp. *vulgaris*.

Biogeographically Important Taxa ^{GW}Griqualand West endemic, ^KKalahari endemic, ^SSouthernmost distribution in interior of southern Africa) Small Trees: *Acacia luederitzii* var. *luederitzii*^K, *Terminalia sericea*^S. Tall Shrub: *Acacia haematoxylon*^K. Low Shrub: *Blepharis marginata*^{GW}. Graminoid: *Digitaria polyphylla*^{GW}. Herb: *Corchorus pinnatipartitus*^{GW}.

Endemic Taxon Herb: *Gnaphalium englerianum*.

Conservation Least threatened. Target 16%. None conserved in statutory conservation areas. Only 2% already transformed. Erosion is very low.

Remark Disturbed areas north of Kuruman are characterised by *Aristida adscensionis*, *A. congesta*, *Enneapogon scoparius*, *Geigeria ornativa*, *Melhania rehmanii*, *Rhigozum trichotomum*

and *Sericorema remotiflora* and the absence of *Acacia erioloba*, *A. haematoxylon* and *Grewia flava*.

Reference Smit (2000).

SVk 10 Kuruman Mountain Bushveld

VT 16 Kalahari Thornveld and Shrub Bushveld (64%) (Acoks 1953). LR 31 Kalahari Mountain Bushveld (57%) (Low & Rebelo 1996).

Distribution Northern Cape and North-West Provinces: From the Asbestos Mountains southwest and northwest of Griekwastad, along the Kuruman Hills north of Danielskuil, passing west of Kuruman town and re-emerging as isolated hills, i.e. Makhubung and the hills around Pomfret in the north. Altitude 1 100–1 800 m.

Vegetation & Landscape Features Rolling hills with generally gentle to moderate slopes and hill pediment areas with an open shrubveld with *Lebeckia macrantha* prominent in places. Grass layer is well developed.

Geology & Soils The Kuruman and Asbestos Hills consist of banded iron formation, with jaspilite, chert and riebeckite-asbestos of the Asbestos Hills Subgroup of the Griqualand West Supergroup (Vaalian). Most common land type Ib, followed by Ae, Ic and Ag. Soils are shallow sandy soils, of the Hutton form.

Climate Summer and autumn rainfall with very dry winters. MAP about 250–500 mm. Frost frequent in winter. The unit corresponds in part to cluster 17 of the 27 in the physio-climatic classification of South Africa's woodland areas with summer rainfall (Fairbanks 2000). See also climate diagram for SVk 10 Kuruman Mountain Bushveld.

Important Taxa Small Tree: *Rhus lancea*. Tall Shrubs: *Diospyros austro-africana*, *Euclea crispa* subsp. *crispa*, *E. undulata*, *Olea europaea* subsp. *africana*, *Rhus pyroides* var. *pyroides*, *R. tri-dactyla*, *Tarchonanthus camphoratus*, *Tephrosia longipes*. Low Shrubs: *Rhus ciliata* (d), *Amphiglossa triflora*, *Anthospermum rigidum* subsp. *pumilum*, *Gomphocarpus fruticosus* subsp. *fruticosus*, *Helichrysum zeyheri*, *Lantana rugosa*, *Wahlenbergia nodosa*. Succulent Shrubs: *Ebracteola wilmaniae*, *Hertia pal-lens*. Herbaceous Climber: *Rhynchosia totta*. Graminoids:

Andropogon chinensis (d), *A. schi-rensis* (d), *Antheaphora pubescens* (d), *Aristida congesta* (d), *Digitaria eriantha* subsp. *eriantha* (d), *Themeda triandra* (d), *Triraphis andropogonoides* (d), *Aristida diffusa*, *Brachiaria nigropedata*, *Bulbostylis burchellii*, *Cymbopogon caesius*, *Diheteropogon amplexans*, *Elionurus muticus*, *Eragrostis chloromelas*, *E. nindensis*, *Eustachys paspaloides*, *Heteropogon contortus*, *Melinis repens*, *Schizachyrium sanguineum*, *Trichoneura grandiglumis*. Herbs: *Dicoma anomala*, *D. schinzii*, *Geigeria ornativa*, *Helichrysum cerastioides*, *Heliotropium strigosum*, *Hibiscus marlothianus*, *Kohautia cynanchica*, *Kyphocarpa angustifolia*. Geophytic Herbs: *Boophone disticha*, *Pellaea calomelanos*.

Biogeographically Important Taxa (Griqualand West endemics) Tall Shrub: *Lebeckia macrantha* (d). Low Shrubs: *Justicia puberula*, *Tarchonanthus obo-*



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Figure 9.79 SVk 9 Kuruman Thornveld: *Acacia erioloba* trees and the overwhelmingly dominant shrub *Tarchonanthus camphoratus* immediately south of Kuruman at an altitude of 1 415 m.



Figure 9.80 SVk 10 Kuruman Mountain Bushveld: Open low bushveld with the usually leafless *Lebeckia macrantha* clearly visible at an altitude of approximately 1 680 m near Bretby between Danielskuil and Kuruman.

vatus. Succulent Shrub: *Euphorbia wilmaniae*. Graminoid: *Digitaria polyphylla*. Herb: *Sutera griquensis*.

Endemic Taxon Succulent Shrub: *Euphorbia planiceps*.

Conservation Least threatened. Target 16%. None conserved in statutory conservation areas. Very little transformed. Erosion is very low to low. Some parts in the north are heavily utilised for grazing.

Remarks Many species in this unit are widely distributed to the northeast of the subcontinent and reach their southwestern limit in this unit (e.g. *Andropogon schirensis*). There are distinct floristic differences with the relatively nearby and parallel mountains of the SVk 15 Koranna-Langeberg Mountain Bushveld. For example, *Croton gratissimus* is common in the last mentioned unit but rare in Kuruman Mountain Bushveld. *Lebeckia macrantha* shows just the reverse distributional pattern between these units. A very low form (<0.5 m) of *Acacia hebeclada* is common in the north on Makhubung hill, north of Heuningvlei.

References Smit (2000), Van Wyk & Smith (2001).

SVk 11 Molopo Bushveld

VT 16 Kalahari Thornveld and Shrub Bushveld (100%) (Acocks 1953). LR 30 Kalahari Plains Thorn Bushveld (100%) (Low & Rebelo 1996).

Distribution North-West and Northern Cape Provinces: In the Molopo area from Bray and Werda in the north on the border with Botswana, southwards through Morokweng and Tosca in the east and Vorstershoop to McCarthy'srus and Eldorado in the west to Bendell in the south. Altitude 1 000–1 300 m.

Vegetation & Landscape Features

Open woodland to a closed shrubland with the trees *Acacia erioloba* and *Boscia albitrunca* and shrubs *Lycium cinereum*,

L. hirsutum and *Rhigozum trichotomum*. Grass layer is well developed in parts of the northeast, but usually fairly open.

Geology & Soils Red aeolian sand of Recent age with surface calcrete and silcrete. Soils are deep (>1.2 m) and sandy (Hutton and Clovelly soil forms). Land types mainly Ah with a little Fc.

Climate Summer and autumn rainfall with very dry winters. MAP about 250–400 mm. Frost frequent in winter. See also climate diagram for SVk 11 Molopo Bushveld.

Important Taxa Tall Tree: *Acacia erioloba* (d). Small Trees: *Boscia albitrunca* (d), *Terminalia sericea* (d), *Acacia mellifera* subsp. *detinens*. Tall Shrubs: *Lycium hirsutum* (d), *Rhigozum trichotomum* (d), *Grewia flava*, *Lycium villosum*, *Rhus burchellii*. Low Shrubs: *Acacia hebeclada* subsp. *hebeclada*, *Aptosimum albomarginatum*, *A. marlothii*, *Eriocephalus ericoides*, *Monechma divaricatum*, *M. incanum*. Geoxylic Suffrutex: *Elephantorrhiza elephantina*. Herbaceous Climber: *Momordica balsamina*. Graminoids: *Aristida meridionalis* (d), *A. stipitata* subsp. *spicata* (d), *Cenchrus ciliaris* (d), *Eragrostis lehmanniana* (d), *Aristida congesta*, *Eragrostis biflora*, *E. pallens*, *E. rigidior*, *Pogonarthria squarrosa*, *Schmidtia kalahariensis*, *S. pappophoroides*, *Stipagrostis ciliata*, *S. uniplumis*. Herbs: *Acanthosicyos naudinianus*, *Acrotome angustifolia*, *A. inflata*, *Dicoma schinzii*, *Geigeria ornativa*, *Helichrysum cerastioides*, *Hermannia tomentosa*, *Hermbstaedtia fleckii*, *H. linearis*, *Limeum arenicolum*, *L. fenestratum*, *L. viscosum*, *Lotononis platycarpa*, *Senna italica* subsp. *arachoides*, *Sericorema remotiflora*, *Tephrosia purpurea* subsp. *leptostachya*, *Tribulus terrestris*.

Biogeographically Important Taxa (Kalahari endemics) Small Tree: *Acacia luederitzii* var. *luederitzii*. Tall Shrub: *Acacia haematoxylon*. Graminoids: *Antheophora argentea*, *Megaloprotachne albescens*, *Panicum kalaharensis*.



Figure 9.81 SVk 11 Molopo Bushveld: Plains with *Terminalia sericea*, *Boscia albitrunca*, *Acacia erioloba*, *Grewia flava*, *Stipagrostis uniplumis* and *Tribulus zeyheri* subsp. *zeyheri* on Mahakane southwest of Pomfret, Vryburg District in the North-West Province.

Conservation Least threatened. Target 16%. Only 1% statutorily conserved in the Molopo Nature Reserve. More than 1% already transformed. In the Morokweng, Konke and Ewbank regions, intense utilisation has led to encroachment of *Geigeria ornativa*, *Tribulus terrestris* and *Acacia mellifera*, while much *A. erioloba* has been destroyed by fire-wood collection. Erosion is very low.

Remark An extensive unit with increasing diversity of savanna plant species towards the north and northeast.

Reference Smit (2000).

SVk 12 Kathu Bushveld

VT 16 Kalahari Thornveld and Shrub Bushveld (100%) (Acocks 1953). LR 30 Kalahari Plains Thorn Bushveld (86%) (Low & Rebelo 1996).

Distribution Northern Cape Province: Plains from Kathu and Dibeng in the south, through Hotazel, vicinity of Frylinckspan to the Botswana border roughly between Van Zylsrus and McCarthysrus. Altitude 960–1 300 m.

Vegetation & Landscape Features Medium-tall tree layer with *Acacia erioloba* in places, but mostly open and including *Boscia albitrunca* as the prominent trees. Shrub layer generally most important with, for example, *A. mellifera*, *Diospyros lycioides* and *Lycium hirsutum*. Grass layer is variable in cover.

Geology & Soils Aeolian red sand and surface calcrete, deep (>1.2 m) sandy soils of Hutton and Clovelly soil forms. Land types mainly Ah and Ae, with some Ag.

Climate Summer and autumn rainfall with very dry winters. MAP about 220–380 mm. Frost frequent in winter. Mean monthly maximum and minimum temperatures for Sishen 37.0°C and –2.2°C for December and July, respectively. See also climate diagram for SVk 12 Kathu Bushveld.

Important Taxa Tall Tree: *Acacia erioloba* (d). Small Trees: *Acacia mellifera* subsp. *detinens* (d), *Boscia albitrunca* (d), *Terminalia sericea*. Tall Shrubs: *Diospyros lycioides* subsp. *lycioides* (d), *Dichrostachys cinerea*, *Grewia flava*, *Gymnosporia buxifolia*,

Rhigozum brevispinosum. Low Shrubs: *Aptosimum decumbens*, *Grewia retinervis*, *Nolletia arenosa*, *Sida cordifolia*, *Tragia dioica*. Graminoids: *Aristida meridionalis* (d), *Brachiaria nigropedata* (d), *Centropodia glauca* (d), *Eragrostis lehmanniana* (d), *Schmidtia pappophoroides* (d), *Stipagrostis ciliata* (d), *Aristida congesta*, *Eragrostis biflora*, *E. chloromelas*, *E. heteromera*, *E. pallens*, *Melinis repens*, *Schmidtia kalahariensis*, *Stipagrostis uniplumis*, *Tragus berteronianus*. Herbs: *Acrotome inflata*, *Erlangea misera*, *Gisekia africana*, *Heliotropium ciliatum*, *Hermbsaedia fleckii*, *H. odorata*, *Limeum fenestratum*, *L. viscosum*, *Lotononis platycarpa*, *Senna italica* subsp. *arachoides*, *Tribulus terrestris*.

Biogeographically Important Taxa (Kalahari endemics) Small Tree: *Acacia luederitzii* var. *luederitzii*. Graminoids: *Antheophora argentea*, *Megaloprotachne albescens*, *Panicum kalaharensis*. Herb: *Neuradopsis bechuanensis*.

Conservation Least threatened. Target 16%. None conserved in statutory conservation areas. More than 1% already transformed, including the iron ore mining locality at Sishen, one of the biggest open-cast mines in the world. Erosion is very low.

Remark One of the most strikingly dominant areas of fairly tall *Acacia erioloba* is centred on the town of Kathu, which was built around many of these trees.

Reference Smit (2000).

SVk 13 Olifantshoek Plains Thornveld

VT 17 Kalahari Thornveld invaded by Karoo (49%), VT 16 Kalahari Thornveld and Shrub Bushveld (48%) (Acocks 1953). LR 31 Kalahari Mountain Bushveld (62%) (Low & Rebelo 1996).

Distribution Northern Cape Province: Plains including most of the pediment areas of the Korannaberg, Langeberg and Asbestos Mountains as well as those of some ridges to the west of the Langeberg. From the vicinity of Sonstraal in the north, past Olifantshoek to areas north of Niekerkshoop between Volop and Griekwastad in the south. Also from Griekwastad northwards to the flats west of the Lime Acres area. Altitude 1 000–1 500 m.

Vegetation & Landscape Features A very wide and diverse unit on plains with usually open tree and shrub layers with, for example, *Acacia luederitzii*, *Boscia albitrunca* and *Rhus tenuinervis* and with a usually sparse grass layer.

Geology & Soils Red aeolian sand of Tertiary to Recent age (Kalahari Group) with silcrete and calcrete and some andesitic and basaltic lava of the Griqualand West Supergroup. Hutton soil forms, deeper than 1.2 m, on the overwhelmingly dominant Ae and to a far lesser extent Ah land types.

Climate Summer and autumn rainfall with very dry winters. MAP about 200–350 mm in the east. Frost frequent in winter. See also climate diagram for SVk 13 Olifantshoek Plains Thornveld.

Important Taxa Tall Tree: *Acacia erioloba*. Small Trees: *Boscia albitrunca* (d), *Acacia mellifera* subsp. *detinens*, *Terminalia sericea*. Tall Shrubs: *Lessertia*



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Figure 9.82 SVk 12 Kathu Bushveld: Open savanna dominated by *Acacia erioloba*, *A. mellifera* and *Grewia flava* with low cover of *Stipagrostis ciliata* against the red sand east of Oupos, in the Kuruman District north of Kathu.



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Figure 9.83 SVk 13 Olifantshoek Plains Thornveld: Very open shrubland with *Boscia albitrunca*, *Acacia luederitzii*, *Schmidtia pappophoroides* and *S. kalahariensis* in the western part of this unit.

frutescens, *Lycium hirsutum*, *Rhigozum obovatum*, *Rhus tri-dactyla*, *Tarchonanthus camphoratus*. Low Shrubs: *Aptosimum procumbens*, *Grewia retinervis*, *Hoffmannseggia burchellii*, *Lycium pilifolium*, *Solanum tomentosum*. Succulent Shrubs: *Lycium cinereum*, *Talinum cafferum*. Graminoids: *Schmidtia pappophoroides* (d), *Stipagrostis uniplumis* (d), *Aristida congesta*, *Brachiaria serrata*, *Digitaria eriantha* subsp. *eriantha*, *Melinis repens*. Herbs: *Acanthosicyos naudinianus*, *Gisekia pharnacioides*, *Hermannia tomentosa*, *Ipomoea magnusiana*, *Oxygonum delagoense*, *Pollichia campestris*, *Tephrosia purpurea* subsp. *leptostachya*. Succulent Herb: *Piaranthus decipiens*. Geoxylic Suffrutex: *Elephantorrhiza elephantina*.

Biogeographically Important Taxa (^{GW}Griqualand West endemic, ^KKalahari endemic) Small Tree: *Acacia luederitzii* var. *luederitzii*^K (d). Tall Shrub: *Lebeckia macrantha*^{GW}. Low Shrubs: *Hermannia burchellii*^K, *Justicia puberula*^{GW}, *Putterlickia saxatilis*^{GW}, *Tarchonanthus obovatus*^{GW}. Graminoid: *Antheophora argentea*^K. Herb: *Sutera griquensis*^{GW}.

Endemic Taxon Low Shrub: *Amphiglossa tecta*.

Conservation Least threatened. Target 16%. Only 0.3% statutorily conserved in the Witsand Nature Reserve. Only about 1% of the area has been transformed and erosion is very low.

Reference Smit (2000).

SVk 14 Postmasburg Thornveld

VT 17 Kalahari Thornveld invaded by Karoo (57%) (Acocks 1953). LR 31 Kalahari Mountain Bushveld (64%) (Low & Rebelo 1996).

Distribution Northern Cape Province: Limited area around Postmasburg along the short valley of the Groenwaterspruit to the northeast and southwest, west to Bermolli and around Heuningkrans. Altitude 1 180–1 440 m.

Vegetation & Landscape Features Flats surrounded by mountains supporting open, shrubby thornveld characterised by a dense shrub layer and often lacking a tree layer; the grass layer is very sparse. Shrubs are generally low and with a karoid affinity.

Geology & Soils Red aeolian sand of the Kalahari Group overlying the volcanics and sediments of the Griqualand West Supergroup that outcrop in places. Deep soils are of the Hutton form. Dominant land type Ag.

Climate Summer and autumn rainfall with very dry winters. MAP about 250–350 mm. Frost frequent in winter. See also climate diagram for SVk 14 Postmasburg Thornveld.

Important Taxa Tall Tree: *Acacia erioloba* (d). Small Trees: *Acacia karroo* (d), *A. tortilis* subsp. *heteracantha* (d), *Rhus lancea* (d), *Ziziphus mucronata* (d). Tall Shrubs: *Rhus tri-dactyla* (d), *Diospyros lycioides* subsp. *lycioides*, *Ehretia rigida* subsp. *rigida*, *Grewia flava*, *Tarchonanthus camphoratus*. Low Shrubs: *Acacia hebeclada* subsp. *hebeclada* (d), *Felicia muricata*, *Gomphocarpus fruticosus* subsp. *fruticosus*, *Lantana rugosa*, *Melolobium microphyllum*, *Sutera halimifolia*. Succulent Shrubs: *Kalanchoe rotundifolia*, *Lycium cinereum*. Graminoids: *Digitaria eriantha* subsp. *eriantha* (d), *Enneapogon scoparius* (d), *Eragrostis lehmanniana* (d), *Aristida adscensionis*, *A. congesta*, *A. diffusa*, *Eragrostis superba*, *Heteropogon contortus*, *Melinis repens*, *Schmidtia pappophoroides*, *Stipagrostis uniplumis*. Herbs: *Dicoma anomala*, *Geigeria filifolia*, *G. ornativa*, *Hibiscus pusillus*, *Jamesbrittenia aurantiaca*, *Selago densiflora*, *Tripteris aghillana*. Geophytic Herb: *Boophone disticha*.

Biogeographically Important Taxa (Griqualand West endemics) Succulent Shrub: *Euphorbia bergii*. Graminoid: *Digitaria polyphylla*.

Conservation Least threatened. Target 16%. None of the unit is conserved in statutory conservation areas, but very little has been transformed. Erosion is very low.

Remark In contrast to eastern parts of the unit, *Tarchonanthus camphoratus* is conspicuously absent in the western parts.

Reference Smit (2000).

SVk 15 Koranna-Langeberg Mountain Bushveld

VT 16 Kalahari Thornveld and Shrub Bushveld (91%) (Acocks 1953). LR 31 Kalahari Mountain Bushveld (67%) (Low & Rebelo 1996).

Distribution Northern Cape Province: From the Tswalu Kalahari Reserve at the northern tip of the Korannaberg southwards in the form of multiple ridges to the Langeberg west of Olifantshoek and southwards along the Langeberg and some parallel ridges, to ridges in the vicinity of Volop. Also some ridges to the west of the Langeberg. Altitude 1 000–1 836 m at highest point.

Vegetation & Landscape Features Rugged mountains and steep slopes in parts of the Korannaberg but with few cliffs in the Langeberg to the south. Generally supporting open shrubland with moderately open grass cover. *Croton gratissimus* common in places, becoming particularly diminutive south of the Langeberg.



Figure 9.84 SVk 15 Koranna-Langeberg Mountain Bushveld: Shrubland on rocky slope with *Croton gratissimus* and *Tarchonanthus camphoratus* shrubs close to Olifantshoek, Northern Cape Province.

Geology & Soils The geology of the Korannaberg and Langeberg Mountains consists of quartzite, greywacke and lenses of hematite of the Olifantshoek Supergroup (Mokolian Erathem). The soils consist of very rocky, shallow sands. Land types mainly Ic, with some Ae.

Climate Summer and autumn rainfall with very dry winters. MAP about 180–380 mm. Frost frequent in winter. See also climate diagram for SVk 15 Koranna-Langeberg Mountain Bushveld.

Important Taxa Small Trees: *Acacia mellifera* subsp. *detinens* (d), *Boscia albitrunca*, *Ficus cordata*, *Maytenus undata*. Tall Shrubs: *Ehretia rigida* subsp. *rigida*, *Euclea undulata*, *Grewia flava*, *Hibiscus micranthus*, *Rhigozum obovatum*, *Rhus burchellii*, *Tarchonanthus camphoratus*, *Tephrosia longipes*. Low Shrubs: *Croton gratissimus* (d), *Artemisia afra*, *Felicia muricata*, *Indigofera polioties*, *Jamesbrittenia albiflora*, *Leucas capensis*, *Lophiocarpus polystachyus*, *Melhania prostrata*, *Nolletia arenosa*, *Pegolettia retrofracta*, *Psiadia punctulata*. Succulent Shrubs: *Aloe hereroensis* var. *hereroensis*, *Euphorbia avasmontana*, *E. rectirama*. Semiparasitic Shrub: *Thesium hystrix*. Woody Climber: *Putterlickia pyracantha*. Woody Succulent Climber: *Sarcostemma viminale* (d). Graminoids: *Aristida diffusa* (d), *Eragrostis curvula* (d), *Brachiaria nigropedata*, *Cenchrus ciliaris*, *Digitaria eriantha* subsp. *eriantha*, *Heteropogon contortus*, *Stipagrostis uniplumis*. Herb: *Ceratotheca triloba*. Geophytic Herbs: *Boophone disticha*, *Cheilanthes hirta*, *Pellaea calomelanos*, *Sansevieria aethiopica*.

Biogeographically Important Taxa (Griqualand West endemics) Low Shrub: *Justicia puberula*. Graminoid: *Digitaria polyphylla*.

Conservation Least threatened. Target 16%. None conserved in statutory conservation areas but partly conserved in private reserves such as the Tswalu

Kalahari Reserve. Virtually none of the area is transformed. Erosion is very low.

Remark This unit forms the first, almost unbroken, mountain barrier to the east of the Kalahari on the Gordonia plains.

References Smit (2000), Van Wyk & Smith (2001).

SVk 16 Gordonia Plains Shrubland

VT 16 Kalahari Thornveld and Shrub Bushveld (100%) (Acocks 1953). LR 28 Shrubby Kalahari Dune Bushveld (81%) (Low & Rebelo 1996).

Distribution Northern Cape Province: Broad north-south band on flats west of the Korannaberg and Langeberg Mountains (and of their western pediment) and east of the main Kalahari duneveld area (for example at Pearson's Hunt). From Van Zylsrus in the north to south-west of Witsand in the south. Also as a number of isolated patches embedded

in the duneveld area between the Auob and Nossob Rivers in the Kgalagadi Transfrontier Park as well as the valley containing Groot and Klein Mier south of the park. Altitude 900–1 250 m.

Vegetation & Landscape Features Plains with open grassland with occasional shrubs *Rhigozum trichotomum* and *Grewia flava*, sometimes including *Acacia haematoxylon* and scattered individuals of *A. erioloba*. The area has virtually no dunes.

Geology & Soils Aeolian sand, underlain by calcrete of the Kalahari Group, deep, loose, sandy soils of the Namib soil form on the flat plains. Land types mainly Ah and Af with a little Ae.

Climate Summer and autumn rainfall with very dry winters. MAP about 180–280 mm. Frost frequent in winter. See also climate diagram for SVk 16 Gordonia Plains Shrubland.

Important Taxa Tall Tree: *Acacia erioloba* (d). Small Tree: *Acacia mellifera* subsp. *detinens*. Tall Shrubs: *Grewia flava* (d), *Rhigozum trichotomum* (d). Low Shrubs: *Jatropha erythro-*



Figure 9.85 SVk 16 Gordonia Plains Shrubland: Open shrubland dominated by *Rhigozum trichotomum* and *Aristida meridionalis* with a solitary *Acacia haematoxylon* tree on Goedemoed between Olifantshoek and Upington.

poda, *Plinthus sericeus*, *Requienia sphaerosperma*. Geoxyllic Suffrutex: *Elephantorrhiza elephantina*. Semiparasitic Shrub: *Thesium lineatum*. Herbaceous Climber: *Merremia tridentata*. Graminoids: *Aristida meridionalis* (d), *Centropodia glauca* (d), *Eragrostis lehmanniana* (d), *Schmidtia kalahariensis* (d), *Brachiaria glomerata*, *Bulbostylis hispidula*, *Eragrostis pallens*, *Stipagrostis uniplumis*. Herbs: *Acanthosicyos naudinianus*, *Cucumis africanus*, *Dicoma capensis*, *Harpagophytum procumbens* subsp. *procumbens*, *Heliotropium ciliatum*, *Hermannia tomentosa*, *Ipomoea hackeliana*, *Limeum argute-carinatum*, *Oxygonum dregeanum* subsp. *canescens* var. *canescens*, *Senna italica* subsp. *arachoides*, *Sericorema remotiflora*.

Biogeographically Important Taxa (Kalahari endemics) Tall Shrub: *Acacia haematoxylon*. Low Shrub: *Hermannia burchellii*. Graminoid: *Antheophora argentea*.

Conservation Least threatened. Target 16%. Some 9% statutorily conserved in the Kgalagadi Transfrontier Park. Very little of the area is transformed and erosion is very low.

References Leistner (1967), Leistner & Werger (1973), Werger & Leistner (1975), Werger (1978b), Lubbinge (1998).

Kalahari Duneveld

SVkd 1 Gordonia Duneveld

VT 16 Kalahari Thornveld and Shrub Bushveld (91%) (Acocks 1953). LR 28 Shrubby Kalahari Dune Bushveld (65%) (Low & Rebelo 1996).

Distribution Northern Cape Province: Areas with dunes comprising the largest part of the South African side of the Kgalagadi Transfrontier Park. South of the Molopo River border with Botswana (west of Van Zylsrus), interleaving with NKb 5 Kalahari Karroid Shrubland in the west (south of Rietfontein to the Orange River area) and in the south (around Upington and north of Groblershoop). Also occurs as a number of loose dune cordons south of the Orange River near Keimoes and between Upington and Putsonderwater. Eastern boundary is found at the longitude of Pearson's Hunt, but with outliers near Niekerkshoop in the southeast and Floradora in the northeast. Altitude 800–1 200 m.



Figure 9.86 SVkd 1 Gordonia Duneveld: Sparse dune shrubland with *Acacia haematoxylon* (the silvery bush on the slopes) and *Stipagrostis amabilis* (the grass on the dune ridge) in the valley of the Auob River in the Kgalagadi Transfrontier Park.

Vegetation & Landscape Features Parallel dunes about 3–8 m above the plains. Open shrubland with ridges of grassland dominated by *Stipagrostis amabilis* on the dune crests and *Acacia haematoxylon* on the dune slopes, also with *A. mellifera* on lower slopes and *Rhigozum trichotomum* in the interdune straaten.

Geology & Soils Aeolian sand underlain by superficial silcretes and calcretes of the Cenozoic Kalahari Group. Fixed parallel sand dunes, with Af land type almost exclusively.

Climate Summer and autumn rainfall with very dry winters. MAP about 120–260 mm. Frost fairly frequent to frequent in winter. Mean monthly maximum and minimum temperatures for Vrouenspan 41.5°C and –4.0°C for December and July, respectively. See also climate diagram for SVkd 1 Gordonia Duneveld.

Important Taxa Small Tree: *Acacia mellifera* subsp. *detinens* (d). Tall Shrubs: *Grewia flava* (d), *Rhigozum trichotomum* (d). Low Shrubs: *Aptosimum albomarginatum*, *Monechma incanum*, *Requienia sphaerosperma*. Succulent Shrubs: *Lycium bosciifolium*, *L. pumilum*, *Talinum cafferum*. Graminoids: *Schmidtia kalahariensis* (d), *Brachiaria glomerata*, *Bulbostylis hispidula*, *Centropodia glauca*, *Eragrostis lehmanniana*, *Stipagrostis ciliata*, *S. obtusa*, *S. uniplumis*. Herbs: *Hermbstaedtia fleckii* (d), *Acanthosicyos naudinianus*, *Hermannia tomentosa*, *Limeum arenicolum*, *L. argute-carinatum*, *Oxygonum dregeanum* subsp. *canescens* var. *canescens*, *Sericorema remotiflora*, *Sesamum triphyllum*, *Tribulus zeyheri*.

Biogeographically Important Taxa (Kalahari endemics) Tall Shrub: *Acacia haematoxylon* (d). Graminoids: *Stipagrostis amabilis* (d), *Antheophora argentea*, *Megaloptachne albenscens*. Herbs: *Helichrysum arenicola*, *Kohautia ramosissima*, *Neuradopsis austro-africana*.

Conservation Least threatened. Target 16%. Some 14% statutorily conserved in the Kgalagadi Transfrontier Park. Very little transformed. Generally low erosion, but some areas with spectacular destabilisation of normally vegetated dunes (through local overstocking) favoured by photographers. Erosion is normally very low.

Remarks The unit extends into Namibia to a large extent (Leistner 1967) and very little into Botswana. Only degenerates into semimobile dunes, where heavily disturbed through intense grazing pressure.

References Leistner (1967), Bothma & De Graaff (1973), Leistner & Werger (1973), Werger & Leistner (1975), Werger (1978b), Skarpe (1986), Lubbinge (1998).

SVkd 2 Gordonia Kameeldoring Bushveld

VT 16 Kalahari Thornveld and Shrub Bushveld (100%) (Acocks 1953). LR 28 Shrubby Kalahari Dune Bushveld (82%) (Low & Rebelo 1996).

Distribution Northern Cape Province: Duneveld along the northern side of the Auob River from Mata Mata to about Gembokplein, and western side of the Nossob River from about Kaspersdraai to St John's Dam in the Kgalagadi Transfrontier Park. A few isolated occurrences between the Auob and Nossob

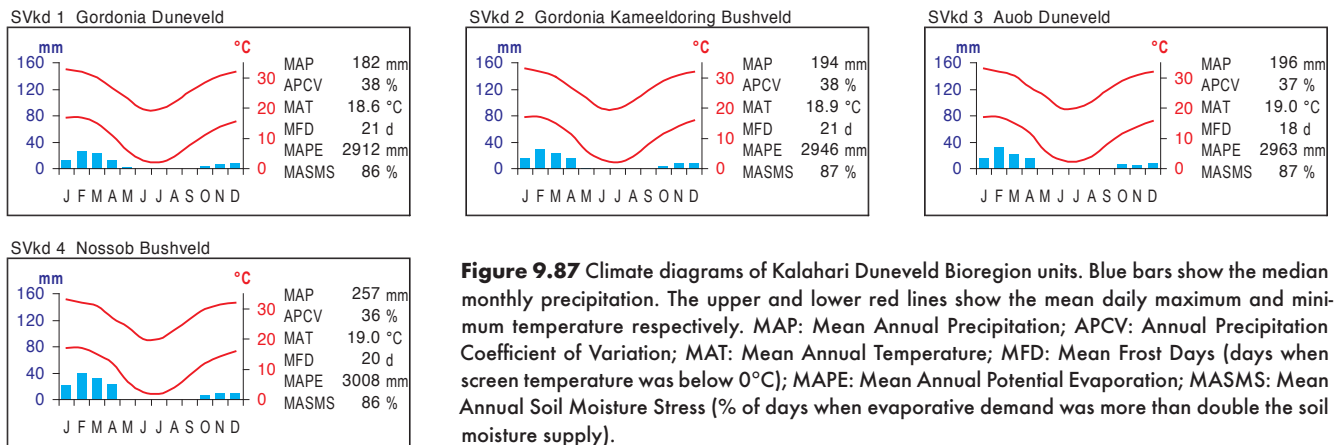


Figure 9.87 Climate diagrams of Kalahari Duneveld Bioregion units. Blue bars show the median monthly precipitation. The upper and lower red lines show the mean daily maximum and minimum temperature respectively. MAP: Mean Annual Precipitation; APCV: Annual Precipitation Coefficient of Variation; MAT: Mean Annual Temperature; MFD: Mean Frost Days (days when screen temperature was below 0°C); MAPE: Mean Annual Potential Evaporation; MASMS: Mean Annual Soil Moisture Stress (% of days when evaporative demand was more than double the soil moisture supply).

Rivers such as around Seven Pans. Also found in marginal area south of the Kuruman River near Eensaam Kasteel. Altitude 920–1 040 m.

Vegetation & Landscape Features On the dune slopes and dune straten with well-developed tree layer, dominated by *Acacia erioloba* and *Boscia albitrunca* and shrub layer with *A. haematoxylon*, *A. mellifera* and *Rhigozum trichotomum*. Grass layer is very scanty.

Geology & Soils Aeolian undulating sand dunes underlain by calcrete, deep, loose, sandy soil of the Namib soil form. Land type Af.

Climate Summer and autumn rainfall with very dry winters. MAP about 150–250 mm. Frost fairly frequent to frequent in winter. Mean monthly maximum and minimum temperatures for Mata Mata are 40.0°C and –6.8°C for December and June, respectively. See also climate diagram for SVkd 2 Gordonia Kameeldoring Bushveld.

Important Taxa Tall Tree: *Acacia erioloba* (d). Small Trees: *Acacia mellifera* subsp. *detinens* (d), *Boscia albitrunca* (d). Tall Shrubs: *Rhigozum trichotomum* (d), *Ehretia rigida* subsp. *rigida*, *Grewia flava*, *Lycium villosum*, *Rhus tenuinervis*. Low Shrubs: *Aptosimum albomarginatum*, *Jatropha erythropoda*, *Plinthus*

sericeus, *Requienia sphaerosperma*. Graminoids: *Aristida meridionalis* (d), *Centropodia glauca* (d), *Eragrostis lehmanniana* (d), *Schmidtia kalahariensis* (d), *Stipagrostis ciliata* (d), *Brachiaria glomerata*, *Stipagrostis obtusa*, *S. uniplumis*. Herbs: *Acanthosicyos naudinianus*, *Hermannia tomentosa*, *Limeum arenicolum*, *Senna italica* subsp. *arachoides*, *Tribulus zeyheri*.

Biogeographically Important Taxa (Kalahari endemics) Tall Shrub: *Acacia haematoxylon* (d). Succulent Herbs: *Orbea knobellii*, *Tridentea marientalensis* subsp. *marientalensis*.

Conservation Least threatened. Target 16%. Some 38% statutorily conserved in the Kgalagadi Transfrontier Park. Very little transformed and showing generally little surface erosion.

References Leistner (1967), Leistner & Werger (1973), Werger & Leistner (1975), Lubbinge (1998).

SVkd 3 Auob Duneveld

VT 16 Kalahari Thornveld and Shrub Bushveld (100%) (Acocks 1953). LR 28 Shrubby Kalahari Dune Bushveld (99%) (Low & Rebelo 1996).

Distribution Northern Cape Province: Belt of duneveld south of the Auob River from Mata Mata to Twee Rivieren within the Kgalagadi Transfrontier Park as well as in the northern Mier area. Found also in the area between the Auob and Nossob Rivers near their confluence as well as small areas around the confluences of the Nossob, Molopo and Kuruman Rivers. Altitude 880–1 040 m.

Vegetation & Landscape Features

Open shrubland with low shrub layer dominated by *Acacia haematoxylon*, *A. mellifera* and *Rhigozum trichotomum*. Trees of *A. erioloba* and *Boscia albitrunca* are widely scattered and grass layer is scanty.

Geology & Soils Deep aeolian sand forming undulating dunes, with outcrops of calcrete, Namib soil form. Shallow soils on calcrete outcrops often with Clovelly soil form. Land type Af.

Climate Summer and autumn rainfall with very dry winters. MAP about 150–250 mm. Frost fairly frequent to frequent



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Figure 9.88 SVkd 2 Gordonia Kameeldoring Bushveld: Interdune sandy area dominated by *Acacia erioloba* and, in the foreground, *Rhigozum trichotomum* between Nu-Quap and Craig Lockhardt about 5 km from the bed of the Auob River in the Kgalagadi Transfrontier Park, Northern Cape Province.



Figure 9.89 SVkd 3 Auob Duneveld: Open shrubland with *Boscia albitrunca* and *Stipagrostis amabilis* in the foreground on the crest of a dune near Kielie Krankie, Kgalagadi Transfrontier Park, Northern Cape.

in winter. Mean monthly maximum and minimum temperatures for Twee Rivieren 40.6°C and –6.0°C for December and July, respectively. See also climate diagram for SVkd 3 Auob Duneveld.

Important Taxa Tall Tree: *Acacia erioloba*. Small Trees: *Acacia mellifera* subsp. *detinens* (d), *Boscia albitrunca*. Tall Shrubs: *Rhigozum trichotomum* (d), *Grewia flava*. Low Shrub: *Requienia sphaerosperma*. Graminoids: *Schmidtia kalahariensis* (d), *Stipagrostis ciliata* (d), *S. uniplumis* (d), *Brachiaria glomerata*, *Bulbostylis hispidula*, *Centropodia glauca*, *Eragrostis tri-chophora*. Herbs: *Acanthosicyos naudinianus*, *Acrotome angustifolia*, *Hermannia tomentosa*, *Limeum arenicolum*, *Sesamum triphyllum*.

Biogeographically Important Taxa (Kalahari endemics) Tall Shrub: *Acacia haematoxylon* (d). Low Shrub: *Hermannia burchellii*. Graminoid: *Stipagrostis amabilis* (d).

Conservation Least threatened. Target 16%. Some 57% statutorily conserved in the Kgalagadi Transfrontier Park. Erosion is very low.

References Leistner (1967), Leistner & Werger (1973), Werger & Leistner (1975), Lubbinge (1998).

SVkd 4 Nossob Bushveld

VT 16 Kalahari Thornveld and Shrub Bushveld (95%) (Acocks 1953). LR 27 Thorny Kalahari Dune Bushveld (83%) (Low & Rebelo 1996).

Distribution Northern Cape Province: Strip of duneveld west of the Nossob River from Nossob Camp area to Union's End as well as some patches (for example in the vicinity of the waterpoint of Dankbaar) in the far northern parts of the Kgalagadi Transfrontier Park. Altitude 980–1 120 m.

Vegetation & Landscape Features Open bushveld on plains, with relatively tall (for the southern Kalahari) tree layer



Figure 9.90 SVkd 4 Nossob Bushveld: *Albizia anthelmintica* trees with *Acacia mellifera* shrubs on a large dune between Union's End and Gharagab in the Kgalagadi Transfrontier Park, Northern Cape.

with *Acacia erioloba*, *A. luederitzii* and *Boscia albitrunca* and grass layer with higher cover than towards the south.

Geology & Soils Aeolian sand of the Kalahari forming undulating dunes. Soil of the Namib soil form. Dominant land type Af.

Climate Summer and autumn rainfall with very dry winters. MAP about 200–300 mm. Frost fairly frequent to frequent in winter. Mean monthly maximum and minimum temperatures for Nossob Rest Camp 39.9°C and –6.2°C for December and July, respectively. See also climate diagram for SVkd 4 Nossob Bushveld.

Important Taxa Tall Tree: *Acacia erioloba* (d). Small Trees: *Boscia albitrunca* (d), *Acacia mellifera* subsp. *detinens*. Tall Shrubs: *Grewia flava*, *Rhus tenuinervis*. Low Shrub: *Plinthus sericeus*. Graminoids: *Schmidtia kalahariensis* (d), *Stipagrostis uniplumis* (d), *Centropodia glauca*, *Eragrostis biflora*. Herbs: *Hermstaedtia fleckii* (d), *Acanthosicyos naudinianus*, *Pollichia campestris*.

Biogeographically Important Taxa (^KKalahari endemic, ^DSouthwestern distribution limit in South Africa) Small Trees: *Acacia luederitzii* var. *luederitzii*^K (d), *Albizia anthelmintica*^D. Herb: *Neuradopsis austro-africana*^K.

Conservation Least threatened. Target 16%. All of the unit is statutorily conserved in the Kgalagadi Transfrontier Park and remains virtually untransformed. Erosion is very low.

Remark This is the southernmost part of the unit, which is more widely distributed in the neighbouring Botswana and Namibia.

References Leistner & Werger (1973), Werger & Leistner (1975), Van Rooyen et al. (1990), Lubbinge (1998).

8. Credits

Most of the introductory sections were written by M.C. Rutherford (sections 1, 2.1 (main part), 3.2, 3.3, 4, 5 & 6), with 2.2 by R.A. Ward, 2.3 by F. Ellis, 3.1 by L. Scott and the climate systems part of 2.1 by L. Mucina.

The mapping concepts within the Kalahari bioregions (SVk and SVkd) are based on original mapping by J.H.L. Smit, J.-W. Lubbinge and N. van Rooyen. The detailed legend of the original map was simplified by M.C. Rutherford and L. Mucina after consultation with G.J. Bredenkamp, J.H.L. Smit and H. Bezuidenhout. The southernmost parts of the units within SVk were mapped by M.C. Rutherford, L. Mucina, H. Bezuidenhout and P.J. du Preez.

The areas of the Central Bushveld, Mopane and Lowveld Bioregions were originally mapped for the project by G.J. Bredenkamp, assisted by W.H. de Frey and R.A.J. Robesson (both GIS) using concepts of G.J. Bredenkamp. Later, some of the original concepts in Mpumalanga, southern parts of Limpopo Province, Gauteng and eastern North-West Province were modified by M.C. Lötter (assisted by J.E. Burrows and S. Williamson). These changes included introduction of new units (SVcb 6 (with D.B. Hoare), 12, 14, 16, 25, 26 & SVI 7 & 13). Other new units that were introduced were SVcb 10 by D.B. Hoare, SVcb 22 by M.C. Rutherford and L. Mucina (with shape and position supplied by E. van Wyk), SVcb 24 by P.J.D. Winter and SVI 7 by M.C. Rutherford, L. Mucina and P.J.D. Winter. The sand vegetation of the northern lowveld was split into SVI 1 & 2 by L. Mucina, M.C. Lötter and M.C. Rutherford. The boundaries of most of the earlier mapped units were substantially revised (but with relatively little change to the remaining eight units, namely SVcb 5, 8, 9, 21, 23, SVmp 4, SVI 4 & SVI 15) by M.C. Lötter in many areas as well as by D.B. Hoare in Gauteng, M.C. Rutherford, especially in North-West and Limpopo Provinces, and R.J. Scholes on the Blouberg in Limpopo Province. In the Mopane Bioregion, all units, except SVmp 4, were subdivided and boundaries revised by F. Siebert & M.C. Rutherford.

The current mapping concepts covering the eastern areas of the Lowveld are rooted in Gertenbach's (1983b) 'landscapes', which have been simplified for the purpose of our map by M.C. Rutherford, L. Mucina, M.C. Lötter and F. Siebert, also in consultation with N. Zambatis and H.C. Eckhardt (both who provided the original GIS coverage of Gertenbach's landscapes and discussed the conceptual issues regarding the mapping units). The savanna mapping units of Swaziland were originally derived from an unpublished map of Swaziland by L. Dobson after reconciling the units with those across the border with South Africa. This reconciliation as well as the modification of the boundaries of these entities was done by M.C. Lötter, M.C. Rutherford and L. Mucina. The savanna units recognised for KwaZulu-Natal are the result of co-operation between K.G.T. Camp, R.G. Bennett (GIS), L. Mucina, M.C. Rutherford, C.R. Scott-Shaw, P.S. Goodman, C. Oellermann (GIS) and W.S. Matthews (in Maputaland). The boundaries were derived from the original BRGs (and lower units as defined in the map of Camp (1999a, b, c, d, e), after a series of fusions and some splitting of the original Camp's BRGs. An unpublished map by Smith (2001) was put at our disposal by Ezemvelo KZN Wildlife and was used in part for the spatial definition of some units in Maputaland. The coverage of some subescarpment (SVs) units in the Eastern Cape comes from an original contribution of D.B. Hoare, modified by M.C. Rutherford and L. Mucina, also based on information from Vlok & Euston-Brown (2002).

All Geographical Information Systems (GIS) changes on the map not specifically attributed by name above were made by

L.W. Powrie. He also collated and managed all GIS changes to the map.

M.C. Rutherford contributed the descriptions of SVcb 2, 5, 9 & SVI 6 (all with G.J. Bredenkamp), SVcb 4 (with G.J. Bredenkamp and L. Mucina), of SVcb 17 & 19 (both with G.J. Bredenkamp and B.J. Henning), of SVcb 18, 20 & 23 (all with G.J. Bredenkamp and T.H. Mostert), of SVI 1 (with L. Mucina and G.J. Bredenkamp), SVI 3 (with G.J. Bredenkamp and C.E. Venter), SVI 8 & 9 (with M.C. Lötter and J.E. Burrows), SVk 7, 10, 12, 15, 16 & SVkd 1 (all with J.H.L. Smit).

M.C. Lötter contributed the descriptions of SVcb 1, 3 & 12 (all with T.H. Mostert, G.J. Bredenkamp and M.C. Rutherford), of SVcb 6, 13 & 14 (all with M.C. Rutherford), of SVcb 15 (with M.C. Rutherford, G.J. Bredenkamp and B.J. Henning), of SVcb 16 (with M.C. Rutherford, L. Mucina and G.J. Bredenkamp), of SVcb 25 & SVI 7 (both with M.C. Rutherford and J.E. Burrows), of SVcb 26 (with M.C. Rutherford, J.E. Burrows and P.J.D. Winter), of SVI 5 (with M.C. Rutherford, G.J. Bredenkamp, C.E. Venter and F. Siebert), of SVI 10, 11 & 12 (all with M.C. Rutherford, J.E. Burrows and E. Schmidt), of SVI 13 (with S. Williamson and M.C. Rutherford) and of SVI 4 & 14 (with M.C. Rutherford, G.J. Bredenkamp and C.E. Venter).

L. Mucina contributed the descriptions of SVcb 22 (with M.C. Rutherford and P.J.H. Hurter), of SVI 2 (with M.C. Lötter and M.C. Rutherford), of SVI 15 (with M.C. Rutherford), of SVI 16 (with W.S. Matthews, M.C. Lötter, J.E. Burrows, E. Schmidt, C.R. Scott-Shaw and M.C. Rutherford), of SVI 17 (with M.C. Rutherford and C.R. Scott-Shaw), of SVI 18 (with W.S. Matthews and M.C. Rutherford), of SVI 22 & 23 (both with C.R. Scott-Shaw and M.C. Rutherford), of SVI 24 (with C.R. Scott-Shaw), of SVs 1–3 (with K.G.T. Camp and M.C. Rutherford), of SVs 4 (with K.G.T. Camp, D.B. Hoare and M.C. Rutherford) and SVs 6 (with D.B. Hoare, K.G.T. Camp and M.C. Rutherford).

J.H.L. Smit contributed the descriptions of SVk 1–4 (with G.J. Bredenkamp and M.C. Rutherford), and of SVk 8, 9, 11, 13, 14 & SVkd 2 & 3 (all with M.C. Rutherford). F. Siebert contributed the descriptions of SVmp 1–8 (all with M.C. Rutherford). P.S. Goodman contributed the descriptions of SVI 19–21 (with M.C. Rutherford). D.B. Hoare contributed the descriptions of SVs 7 and SVcb 7 (with M.C. Rutherford) and SVcb 10. T.H. Mostert contributed the descriptions of SVcb 8 (with G.J. Bredenkamp and M.C. Rutherford), of SVcb 21 (with M.C. Rutherford and G.J. Bredenkamp). S.J. Siebert contributed the descriptions of SVcb 27 & 28 (both with F. Siebert, M.C. Lötter and M.C. Rutherford). G.J. Bredenkamp contributed the description of SVcb 11 (with M.C. Rutherford). P.J.D. Winter contributed the description of SVcb 24 (with M.C. Rutherford). C.R. Scott-Shaw contributed the description of SVs 5 (with L. Mucina and M.C. Rutherford). H. Bezuidenhout contributed the description of SVk 6. P.J. du Preez contributed the description of SVk 5 (with L. Mucina and M.C. Rutherford).

Assignment of growth forms of species listed was done by L. Mucina. Most references were sourced by M.C. Rutherford and L. Mucina.

M. Rouget, and others within the Directorate of Biodiversity Programmes, Policy & Planning of SANBI, provided quantitative information for each vegetation unit on conservation status and targets, areas currently conserved and areas transformed. Data for the climate diagrams of each vegetation unit were taken or derived from the work of R.E. Schulze.

The photographs were contributed mainly by M.C. Rutherford, L. Mucina, H.C. Eckhardt, M.C. Lötter and L.W. Powrie, with other contributions from W.L. McClelland, the late J.P.H. Acocks,

F. Bronkhorst, R. de la Harpe, B. Forbes, H.F. Glen, D.B. Hoare, W.S. Matthews, D. Mucina, P.C. Rutherford, C.R. Scott-Shaw, P.S. Goodman and E. van Wyk.

The concept (content and presentation) of climate diagrams was derived by M.C. Rutherford and all diagrams were prepared by L.W. Powrie based on information from Schulze (1997a).

Further we thank A. Grobler for supplying a map of the northern KNP and Mopane Bioregion, T. Rutherford for assistance with typing and checking the references and proofreading, and H. Parenzee for assistance with proofreading, as well as any other persons whom we may have inadvertently omitted.

Other data sources used are given in the general acknowledgements in the introduction chapter of this book.

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