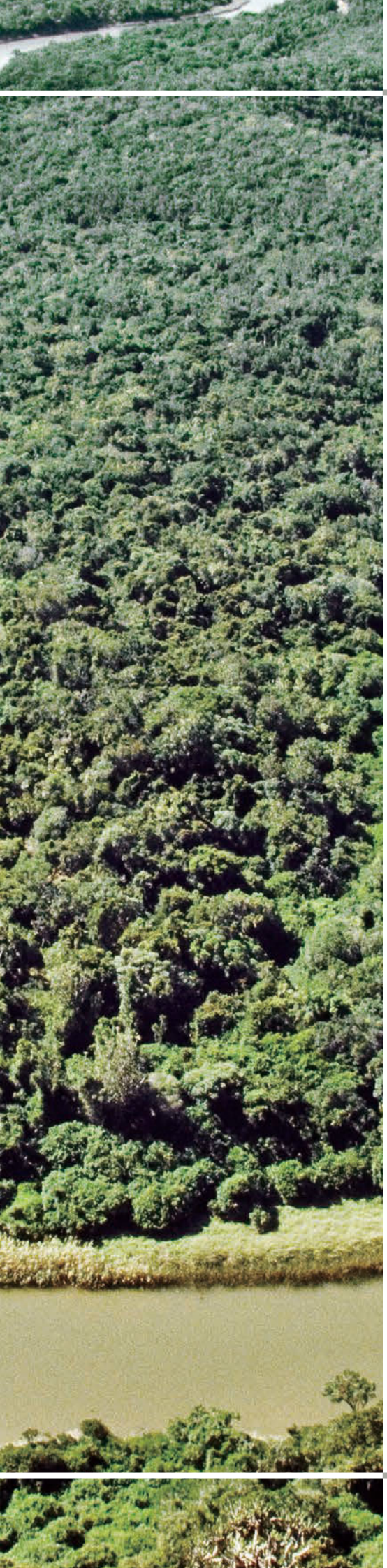

L. Mucina

Albany Thicket Biome 10

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1. Introduction: Delimitation and Global Perspective

Following the earlier work of Acocks (1953), the structurally unusual vegetation of the semi-arid river valleys of the eastern seaboard of South Africa was described as Valley Bushveld. This nomenclature probably followed the colloquial term used by the agriculturalists, mainly livestock farmers, who found it a largely impenetrable thicket which had to be 'opened-up' to allow access to domestic livestock (cattle and goats). According to Acocks, this comprised 'a semi-succulent thorny scrub 2–3 metres in height'.

Rutherford & Westfall (1986) classified the biomes of South Africa on the basis of dominant life-form combinations (Raunkiaer 1934, Cain 1950) and climatic features. Therefore, the areas now considered here to be the Albany Thicket Biome were classified by them as Savanna on the basis of the dominance of phanerophytes associated with, on average, hemicryptophyte co-dominance (Rutherford & Westfall 1986), although they acknowledged the existence of a variety of life-form combinations. This view continued in the work of Scholes (1997), who mapped the vegetation of the discussed region as a part of the broad-leaved Savanna. Following White & Moll (1978) and Cowling (1983), some evidence for its classification as a distinct structural and floristic unit was presented, and this provided justification for the later recognition of the Thicket Biome (Low & Rebelo 1996, 1998). Rutherford & Westfall (1986) noted that many parts of the areas classified here as Thicket Biome, namely Spekboomveld and the Fish River Scrub, Addo Bush and Sundays River Scrub forms of Valley Bushveld (Acocks 1988), had vegetation co-dominated by phanerophytes and chamaephytes. This corresponds to a 'missing biome' that they suggested may be recognised in the future. This concept is formally adopted here. Recent analyses, primarily within the STEP project (Cowling et al. 2003), have confirmed that the climatic uniqueness (Robertson & Palmer 2002) and peculiar vegetation structure resulting from a unique combination of constituent growth forms (Vlok & Euston-Brown 2002) as well as floristic diversity (including high regional endemism) justify its recognition as a biome.

The term 'Albany Thicket' is a concept recognised by the WWF (Olson et al. 2001, Burgess et al. 2004) where this vegetation type ('ecoregion') is listed as a part of the broader category (biome) 'mediterranean forests, woodlands, and scrubs', thus, as a part of the Cape Floristic Region—a misplacement that partly reflects the transitional nature of the biome. The same WWF categorisation does not recognise a global thicket biome. Various thicket formations in Africa, Madagascar, Asia, Australia and the Americas are spread over four different biomes. In Africa, patches of typical thicket are included in two other 'biomes': 'montane grasslands and shrublands' (e.g. Jos Plateau forest-grassland mosaic), and 'tropical and subtropical grasslands, savannas, and shrublands' (e.g. Somali *Acacia–Commiphora* bushlands and thickets). Worldwide, other thicket types are classified as 'tropical and subtropical dry broadleaf forests' (see Olson et al. 2001). In terms of vegetation structure and climate at least two other regions qualify as analogous to Albany Thicket. These include the thickets of the Chaco straddling the border areas between Argentina and Paraguay in South America (Lewis 1991, Cábido et al. 1992, 1994) and the Didiereaceae-rich semideciduous thickets (also called dry forests) of southern and southwestern Madagascar (Koechlin et al. 1974, Grubb 2003). Madagascar spiny thickets, largely equivalent in vegetation structure to southern Africa's Albany Thicket, are classified under 'deserts and xeric shrublands'.

Table 10.1 Major correspondence between vegetation units and STEP vegetation types (Vlok & Euston-Brown 2002). Those STEP units are listed which have at least 80% of their area within the vegetation units and do not necessarily constitute a high proportion of the vegetation unit (these proportions are given under the headings in the description of each unit). Only Gouritz Valley Thicket is (much) less than 80%.

Vegetation Units	STEP
AT 1 Southern Cape Valley Thicket	Gouritz Valley Thicket
AT 2 Gamka Thicket	Gamka Arid Spekboomveld Gamka Spekboom Thicket Oudtshoorn Karroid Thicket
AT 3 Groot Thicket	Baviaans Spekboom Thicket Baviaans Valley Thicket Bethelsdorp Bontveld Groot Arid Spekboomveld Kleinpoort Karroid Thicket
AT 4 Gamtoos Thicket	Gamtoos Arid Spekboomveld Gamtoos Bontveld Gamtoos Thicket Gamtoos Valley Thicket Kromme Forest Thicket Otterford Forest Thicket Vanstadens Forest Thicket
AT 5 Sundays Noorsveld	Sundays Noorsveld
AT 6 Sundays Thicket	Elands Forest Thicket Koedoeskloof Karroid Thicket Kremlin Grassland Thicket Motherwell Karroid Thicket Sundays Spekboom Thicket Sundays Spekboomveld Sundays Thicket Sundays Valley Thicket Zuurberg Fynbos Thicket
AT 7 Coega Bontveld	Grass Ridge Bontveld
AT 8 Kowie Thicket	Albany Spekboom Thicket Albany Spekboomveld Albany Thicket Albany Valley Thicket Ecca Bontveld Salem Karroid Thicket Shamwari Grassland Thicket Thorndale Forest Thicket
AT 9 Albany Coastal Belt	Geluk Grassland Thicket Hamburg Dune Thicket Kiwane Dune Thicket Nanaga Savanna Thicket Paterson Savanna Thicket Zuney Strandveld
AT10 Great Fish Noorsveld	Fish Noorsveld
AT11 Great Fish Thicket	Crossroads Grassland Thicket Doubledrift Karroid Thicket Fish Spekboom Thicket Fish Thicket Fish Valley Thicket Hartebeest Karroid Thicket
AT12 Buffels Thicket	Buffels Thicket Buffels Valley Thicket Kei Thicket Mountcoke Grassland Thicket
AT13 Eastern Cape Escarpment Thicket	Escarpment Thicket
AT14 Camdebo Escarpment Thicket	Escarpment Spekboom Thicket

Perhaps also the Somali-Masai thickets as described by White (1983), the so-called 'Vine Thickets' of Australian Queensland (Webb 1978) and succulent-rich thickets of northern Venezuela and Colombia (Matteuci 1987) could be viewed as part of the global subtropical succulent-rich thickets.

Thicket in the valleys from the other side of the Great Kei River to the Thukela River in KwaZulu-Natal are not recognised here as being part of the Albany Thicket Biome (the Great Kei River Valley does contain some mapped Albany Thicket). In fact, this is a gradual transition from the characteristic bimodal rainfall, with no seasonal period of pronounced drought of the Albany Thicket to the summer-rainfall areas with dry winters typical of the Savanna Biome. Also in terms of species affinities, an increasing number of typical savanna species occur along this gradient towards the northeast. Woody elements of strandveld units to the west, including parts of the west coast, are not regarded as part of the biome despite their recognition as thicket by some authorities (e.g. Cowling 1984). The current delimitation of the Albany Thicket Biome closely follows (in most parts) the set of core ('solid') thickets of STEP (Vlok & Euston-Brown 2002) (Table 10 1). Much of the area of STEP's mosaic thickets is not here included in this biome, although small parts of some of them are incorporated where the evidence for belonging to an adjacent biome (Forest, Fynbos, Savanna, Grassland, Nama-Karoo and Succulent Karoo) appeared unwarranted. Valley Bushveld and Spekboomveld (Acocks 1953) of the Eastern Cape are similar in structure to thickets found in the equatorial and tropical regions of Africa, and Addo Bush (Acocks 1953) is similar to certain thickets of the Arid Lowveld (Acocks 1953, 1988) in the Mpumalanga Lowveld, northern KwaZulu-Natal and parts of Swaziland. The Albany Thicket also has a unique phylogenetic and biogeographic origin and is transitional between Nama-Karoo and the subtropical regions of the eastern seaboard of southern Africa.

Rainfall can occur at any time of the year in Albany Thicket, which occurs in a climatic interface between an all-year rainfall zone in the west and a stronger summer-rainfall zone in the northeast (Schulze 1997). Thicket vegetation is considerably fragmented and displaced by renosterveld and fynbos in the winter-rainfall zone and by grasslands and savanna in the summer-rainfall zone (Vlok & Euston-Brown 2002). The climate in itself is not the primary selective force for this pattern, but rather the fire regimes that are determined by seasonal precipitation. Evidence for this lies in the occurrence of outliers of thicket vegetation in fire refugia in the winter- and summer-rainfall zones. Although it is tempting to think that thicket is also differentiated by occurring mostly on deep soils rich in nutrients, it is not limited to or restricted by any particular soil type (Vlok & Euston-Brown 2002). The clumping of the vegetation is another distinguishing feature and appears to be strongly facilitated by below-ground animal activity (termite mounds, active mole rat colonies, aardvark burrows, earthworm activity). The clumps show elevated levels of C, Ca, K, organic and moisture content when compared with the adjacent soils (Palmer et al. 1988).

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Figure 10.2 Spekboomveld dominated by *Portulacaria afra* (Didiereaceae) in the Ecca Pass (north of Grahamstown, Eastern Cape).

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Figure 10.3 *Euphorbia triangularis* (Euphorbiaceae) at road from Addo to Zuurberg Inn (Eastern Cape)—a flagship species of the Albany Thicket Biome.

2. Major Vegetation Patterns

Thicket, according to a dictionary definition, is a tangle or dense growth of shrubs or trees. This is a physiognomic or structural description of a type of vegetation that may be found in many geographical areas. The term 'Thicket' (uppercase 'T') refers to the Biome, whereas 'thicket' (lowercase 't') refers to a structural type of vegetation. Within several biomes there may be a wide variety of structural vegetation types found which would, through high densities of woody plants, qualify as 'thicket' (see for instance chapters on Fynbos and Savanna in this book).

The vegetation of the Albany Thicket Biome is described in general as a dense, woody, semisucculent and thorny vegetation type of an average height of 2–3 m (Acocks 1953, Everard 1987), relatively impenetrable in an unaltered condition. During his journey of 1776–1777, Paterson found this vegetation impenetrable except along elephant tracks (Dyer 1937). It comprises a broad spectrum of physiognomic types reflecting gradients in climate, geology, soil and herbivory. The Albany Thicket Biome consists of various major vegetation types, and the wide variety of plant communities, with varying structure and species composition, has posed a challenge for researchers attempting to describe it. Acocks (1953, 1988) recognised four vegetation types currently classified as thicket, namely Valley Bushveld, Noorsveld, Spekboomveld and False Karroid Broken Veld. His thicket also contains small patches of other vegetation types that are embedded within thicket, e.g. Coastal Forest and Thornveld, Alexandria Forest, etc. Acocks also subdivided Valley Bushveld into valley thicket, scrub and Addo Bush. Typical valley thicket may be tall or low and may be composed of different proportions of succulent and nonsucculent plants. Following Acocks (1953), Martin & Noel (1960) described this vegetation as a Succulent Woodland Formation, with two subformations, the taller 'sub-succulent woodland' and the 'low succulent scrub'. In an effort to contextualise the vegetation relative to its origin, White & Moll (1978) included it in their Tongaland-Pondoland Regional Mosaic, as it was part of the vegetation with strong tropical affinity. This affinity was attributed to the presence of genera such as *Acacia, Brachylaena, Carissa, Euclea, Grewia, Pappea, Ptaeroxylon, Rhoicissus* and *Ziziphus*, which were able to extend down the coast due to the influence of the warm Agulhas Current. This led to incorporating the notion of the subtropical origin of the flora into nomenclature. Cowling (1983) recognised the floristic uniqueness of the regional vegetation and coined the term Subtropical Transitional Thicket, which had two formations, the mesic 'Kaffrarian Thicket' and the xeric 'Kaffrarian Succulent Thicket'. In further floristic research in the Subtropical Transitional Thicket, Everard (1987) described the Albany region as comprising two formations, the 'Xeric Succulent Thicket' formation which could be distinguished from the 'Mesic Succulent Thicket' because of its higher proportion of succulents (29% as opposed to 24% for the Mesic Succulent Thicket) and lower proportion of woody taxa (39% as opposed to 48%). The floristic data collected by these researchers were further supplemented by local-scale research in the Great Fish River Valley (Palmer 1981, Palmer et al. 1988) where gradients in species composition and structure were described. These were further elaborated upon by Evans et al. (1997), providing landscape-scale descriptions of the vegetation units. They described Tall Succulent Thicket (TST), Medium Succulent Thicket (MST) and Short Succulent Thicket (SST) of the Great Fish River Valley (Evans et al. 1997). MST is dominated by the leaf succulent *Portulacaria afra*, which comprises the most extensive version of the thicket, synonymous with subsucculent woodland of Martin & Noel (1960). SST, characterised by the dominance of *Euphorbia x bothae*, is represented by our Great Fish Noorsveld and is structurally similar to our Sundays Noorsveld, being shorter in height (1–2 m) and having a lower standing biomass than the MST. The TST is associated with cooler, moister southern aspects, comprises taller emergent *Euphorbia* species, and has a greater standing biomass than either the MST or the SST. Noorsveld (Acocks 1953) is a uniform, 1–2 m high scrub dominated by *Euphorbia coerulescens*, known as *noors*. Spekboomveld is dominated by *Portulacaria afra* (*spek*: Dutch word meaning bacon), thus referring to the apparent delicacy of the plant. Other vegetation found in the Albany Thicket Biome includes mosaics of thicket clumps and grassland, and various secondary vegetation types, including grassland and thornveld. Vlok & Euston-Brown (2002) also point to examples of a gradient of plant species turnover within the biome from the Buffels to the Gamtoos Rivers.

There is a wide range of growth forms and a high diversity of plant species, including leaf and stem succulents (Figure 10.2 and 10.3), deciduous and semideciduous woody shrubs and dwarf shrubs, geophytes, annuals, grasses, and a high diversity of plant species (Cowling 1983). The understorey typically hosts a relatively high diversity of dwarf succulent shrubs and forbs (mainly Crassulaceae and Aizoaceae), many of which are locally endemic and rare (Cowling 1983, Johnson et al. 1999, Vlok & Euston-Brown 2002, Vlok et al. 2003). Perennial grasses are often prevalent inside the clumps, with *Panicum maximum, P. deustum* and numerous *Eragrostis* species being found. The wide range of growth forms and taxa in Albany Thicket is a reflection of the transitional nature of thicket vegetation, being an interface between various types of forest, sclerophyllous shrublands, karoo and grasslands (Cowling 1984, Palmer 1990, Everard 1991, Kerley et al. 1995, Vlok & Euston-Brown 2002). A distinct guild of spinescent woody plants occurs in certain types of thicket, that develop recurved branches once the plants are more than 1 m tall and continue to produce the recurved branches even when mature (*deurmekaarbossie*; Vlok & Euston-Brown 2002). This unusual growth pattern results in an impenetrable barricade of thorny branches, because adjacent plants become entwined as they mature. Seeds of all woody species of this guild are contained within edible fruits and are bird-dispersed. The initial establishment of the woody species of this guild with their spinescent, recurved branches is followed by the growth of vines (often poisonous, wind-dispersed species) within the bush clumps. These often spinescent lianas further become interwoven within the individual bush clumps, to form the impenetrable vegetation so typical of, for example, Sundays Thicket. Once the matrix of shrub, grass and herb species is well established, herbivores play an important role in maintaining growth form richness.

There are insufficient data to describe major patterns of alpha, beta and gamma diversity in thicket vegetation fully, but a local study (Birch et al. 1999) gives some indication of alpha diversity in this vegetation. Within the MST, the alpha diversity in the clumps is higher (approx. 28 taxa per plot, range 15–44) than outside the clumps (using data from Birch et al. 1999), but the changes in diversity between clumps are low (total number of species in 58 plots was 195). Clump diversity in SST is 25 taxa per plot. TST contains 30 taxa per 100 m^2 plot.

3. Ecology: Climate, Geology, Soils and Natural Processes

3.1 Climate

Albany Thicket is found in semi-arid areas of the Eastern and Western Cape, with 200–950 mm MAP (Vlok & Euston-Brown

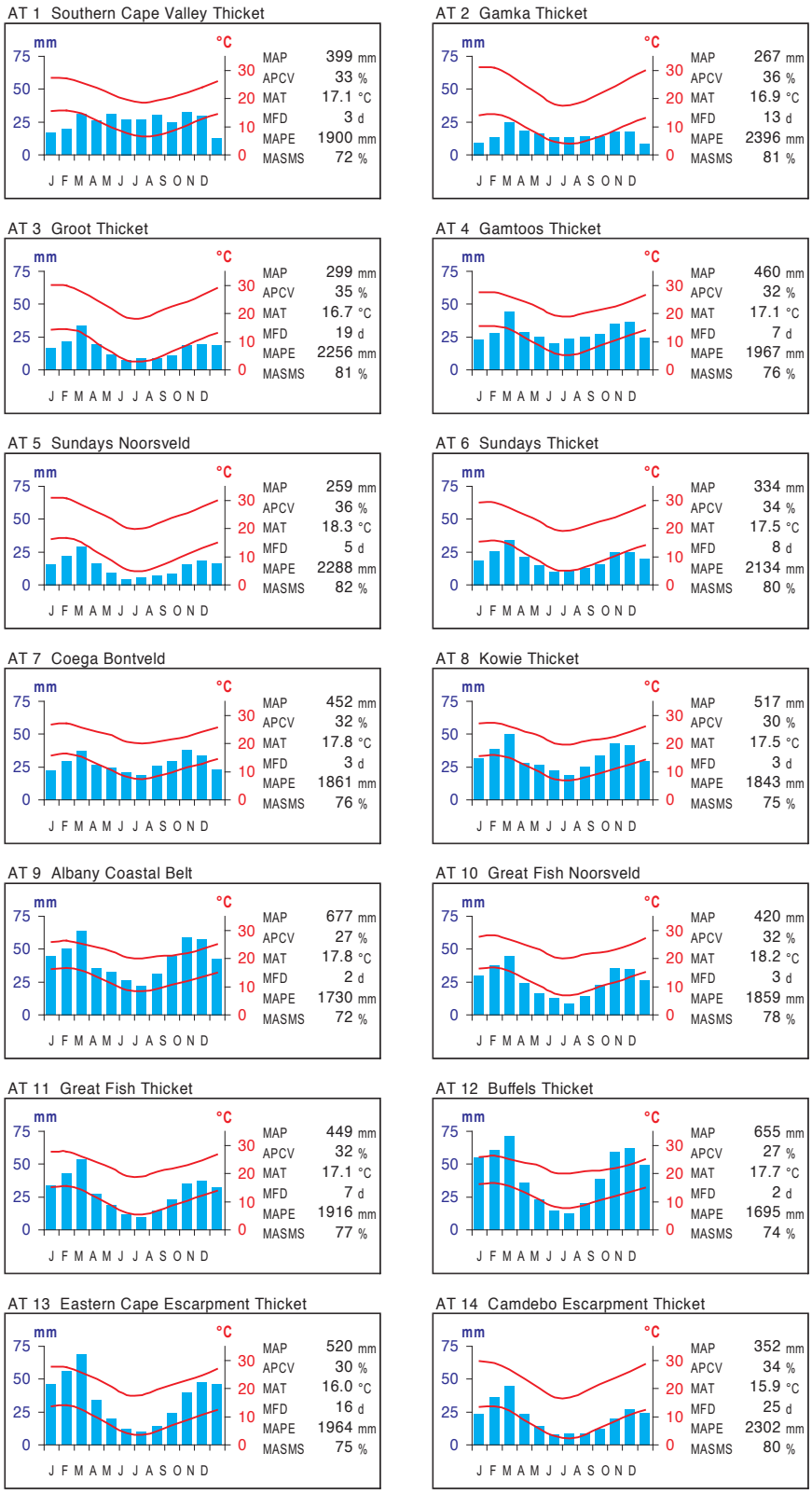

Figure 10.4 Climate diagrams of Albany Thicket Biome units. Blue bars show the median monthly precipitation. The upper and lower red lines show the mean daily maximum and minimum temperature respectively. MAP: Mean Annual Precipitation; APCV: Annual Precipitation Coefficient of Variation; MAT: Mean Annual 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).

2002; see also Figure 10.4). Two prevailing climate systems (all-year rainfall to the southwest and summer rainfall to the north-east) converge in the region, resulting in all-year rainfall, with spring and autumn maxima (Aucamp & Tainton 1984). All the Thicket vegetation units have nonseasonal rainfall, with optima in March and October or November. The increase in summer rainfall to the northeast corresponds with a change in vegetation towards grassland and thorn-tree savanna; the increase in winter rainfall to the southwest corresponds to a gradual replacement by fynbos. In these two zones interannual variations in climate, in combination with different fire regimes and substrate factors, may lead to temporal species turnover and changes in dominance between thicket species and those from adjoining biomes.

Rainfall is unreliable, with an average coefficient of variation of 25–36% (as low as 18% at the coast and along the escarpment, and as high as 40% in Gamka Thicket), and droughts of several months are common. There is a 25% chance of not receiving 80% of the mean rainfall in any given year (Aucamp & Tainton 1984). In addition to this unpredictable rainfall regime, the inland region experiences high temperatures in summer (exceeding 40˚C on occasion) and low temperatures with frost (0 to 64 days) in winter. The dominant plants in these inland regions reflect this harsh climate, with a high degree of succulence and sclerophylly. The larger shrubs and trees are deep-rooted, and plants with storage organs are common. Studies on primary productivity in thicket have shown that the life strategy in most species appears to be one of slow growth (Aucamp & Tainton 1984).

Thicket vegetation growing close to the coast experiences less extreme climatic variability due to the influence of the ocean. Coefficients of variation here are usually lower than 30% and the number of days of frost fewer than 10 per year. There also tends to be a higher annual rainfall, with the vegetation less succulent, and there is a lower degree of leaf sclerophylly and more predictable growth rates.

Vlok & Euston-Brown (2002) suggested that fog may be important even in arid thickets, with a high incidence of bark and ground lichens.

3.2 *Geology and Soils*

The dominant geological feature in the region occupied by the Albany Thicket Biome is the east-west trending Cape Fold Belt. These mountain ranges consist mostly of the folded strata of the Cape Supergroup, of which the sandstone and quartzite of the Table Mountain and Witteberg Groups (Ordovician to Silurian and Devonian, respectively) are biogeographically important (Gibbs

Russell & Robinson 1981) in that they typically support outlier populations of fynbos and renosterveld within a matrix of thicket. Early Karoo Supergroup sedimentary rocks, namely the Dwyka and Ecca Groups, are also folded in the northern margin of the Belt, where they overly the Cape Supergroup rocks. The main folding event took place around 250 mya. Another significant topographical feature is the escarpment which consists mostly of the fine-grained sediments of the Beaufort Group of the Karoo Supergroup. These rocks of Permian and Triassic age are also intruded by Jurassic Karoo Dolerite dykes and sills that formed in association with the break-up of the supercontinent Gondwana. This rifting of South America from Africa also resulted in the formation of half-graben structures within the Cape Fold Belt that formed the Cretaceous depositional basins for the Uitenhage Group sediments. This sequence includes Enon conglomerates as well as other finer-grained clastic sediments. During the Tertiary Period, times of relatively high sea level caused the peneplanation of large areas between the coast and the mountains. As the sea level dropped, the accelerated erosion resulted in the dissection of the plains by a series of large river valleys such as the Fish, Sundays and Gamtoos. It is these large valleys that gave rise to the name 'Valley Bushveld', as thicket vegetation is restricted to their slopes and floors. Recent deposits of shallow marine sandstones and coastal dunes are present along the coast in many parts as a result of more recent fluctuations in sea level.

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Figure 10.5 AT 6 Sundays Thicket: Spekboomveld (*Portulacaria afra*) with a herd of last Cape elephants (*Loxodonta africana*) browsing in the Greater Addo Elephant National Park (Eastern Cape).

The soils derived from these rocks vary considerably over a variety of scales, closely tracking the underlying geology and topography. The fine-textured rocks of the Karoo Supergroup typically give rise to deep, well-structured soils. A repeated catena pattern of shallow rocky soils on upper slopes and deep fine-textured soils in the valley floors is evident in the series of river valleys through the Eastern Cape. The more coarse-textured rocks of the Witteberg and Table Mountain Groups are typically found in sharply folded mountain systems, and the combination of steep slopes and the high percentage of quartz sand gives rise to coarse, unstructured soils that are shallow and nutrient-poor. Much of the fine-scale pattern in the vegetation is likely to be attributable to the interaction of climate and pedology (e.g. Palmer et al. 1988).

3.3 Natural Processes

Albany Thicket shows little annual fluctuation in its relatively high perennial cover or biomass, irrespective of the relatively high coefficient of variation in mean annual precipitation or with droughts that may last months or even years (Aucamp & Tainton 1984). This general resistance to drought probably involves several mechanisms such as below-ground storage organs, sclerophylly, CAM photosynthesis and succulence. Unlike other semi-arid ecosystems such as savannas and certain Mediterranean-type shrublands, intact Albany Thicket does not support a regular or widespread fire regime (Kerley et al. 1999a). The combination of the low availability of fuel and the high degree of succulence has largely excluded fire from Albany Thicket (Kerley et al. 1995). However, the occurrence of fire may be increasing in degraded areas due to the replacement of the nonflammable succulent component with a potentially flammable field layer (Vlok & Euston-Brown 2002).

Albany Thicket has historically supported a high diversity and density of indigenous herbivores, ranging in size from duiker to elephants (Skead 1989). Early accounts of the travellers and explorers in the region report high numbers of elephant (see references in Stuart-Hill 1992). The high nutrient status of the vegetation and proximity of many perennial rivers suggest that these large herbivores were permanent residents (Stuart-Hill 1992) and support the hypothesis that herbivory has played an important role in shaping vegetation and ecosystem properties (Kerley et al. 1999b). The impact of indigenous herbivory has been reflected in the evolution of the plant species, many of which are well defended against browsing (Everard 1987, Haschick 2002). Midgley (1991) and Stuart-Hill (1992) describe the potential impacts of large herbivores through herbivory, trampling and dunging, and suggest that large mammals were the primary patch disturbance agents in Albany Thicket prior to their extirpation in the 1800s.

Megaherbivores, such as elephants and rhinos, seem to be important in maintaining the structure of thicket vegetation (Stuart-Hill 1992), although they do impact on the diversity of the dwarf succulents (Johnson 1998, Johnson et al. 1999, Cowling & Kerley 2002). Stuart-Hill (1992) demonstrated the role that elephants play in maintaining vegetation structure and promoting asexual recruitment of *Portulacaria afra* in Albany Thicket (Figure 10.5). Elephants encourage coppicing in woody shrubs and promote the development of a skirt around *P. afra* plants. Sigwela (1999) and Sigwela et al. (2004) showed how significantly more seeds are dispersed by indigenous herbivores than by goats. There have been several previous studies that examine the impact of goats and indigenous megaherbivores on biodiversity and ecological processes. Most of the earlier work was done from an agricultural production perspective, where the vegetation was viewed primarily as a resource for browsing animals (Aucamp & Tainton 1984). There are two key vegetative traits that contribute to degradation of the Albany Thicket. Firstly, despite a high standing biomass, Albany Thicket has a low annual production, thus giving a false impression of the amount of forage available for animal production (Aucamp & Tainton 1984). Another is the very slow recovery periods of

the main forage species such as *P. afra*, which can take up to 18 months to recover from 50% defoliation by goats (Aucamp & Tainton 1984). Also, the feeding behaviour of goats, both as individuals and as herds, differs from that of indigenous herbivores (Danckwerts 1984, Stuart-Hill 1992). Goats are gregarious animals and tend to feed in groups around individual plants and vegetation patches, leading to very high localised impacts. They also damage the structure of bush clumps by browsing from the sides and exposing the interior to the forces of desiccating winds and erosion by water (Stuart-Hill 1992).

4. Origins and Biogeography

4.1 Origins of the Albany Thicket Biome

The Albany Thicket Biome is part of a poorly defined global Subtropical Thicket Biome, characterised by subtropical, semixeric conditions. Such conditions became globally important during the Eocene characterised by climate both colder and drier than the usual (Zachos et al. 2001). Hence one can expect that it was this period when most thicket plant lineages originated. In support of this hypothesis, Cowling et al. (2005) have shown that many plant groups characteristic of thicket vegetation (as well as associated insect taxa) are of Eocene age, although both older and more recent taxa currently represent important thicket components. This timing is confirmed by both palynological evidence (Boureau et al 1983, Salard-Cheboldaeff & Dejax 1991) and recent calibration attempts (Davies et al. 2004).

Ebenaceae, two clades of Celastraceae, Sapindaceae, Didiereaceae (currently including also *Portulacaria*) and Cotyledonoideae (Crassulaceae) can be reasonably listed as those families well represented in the Albany Thicket Biome which diversified most likely in the Eocene (Cowling et al. 2005). Generally, these are taxa endemic to, or most diverse in, semixeric African vegetation. Many other clades will probably be added to this list as more well-dated phylogenies become available.

Another set of taxa are likely to represent true Gondwanan relicts, and therefore are of Mesozoic age, although they may have adopted a semixerophytic habit only during the Eocene or later. These are the cycads of the genus *Encephalartos* as well as *Cussonia* (Araliaceae) and *Strelitzia* (Strelitziaceae; Figure 10.6), all having their closest relatives in South America, Madagascar and Australia.

Some of the succulents and geophytes are of more recent origin (Klak et al. 2004, Procheş et al. 2006), presumably dating back to the more pronounced mid- to late Tertiary aridification. These are groups that are generally centred in the arid southwest of southern Africa (Nama-Karoo and Succulent Karoo Biomes), but have clades typical of the Albany Thicket Biome, indicating a retrocolonisation of a semixeric environment from fully xeric conditions. Examples are several clades within Aizoaceae and within Asteraceae, specially the tribe Senecioneae (Cowling et al. 2005).

The geographic origins of Albany Thicket are poorly understood, and southern African fossil sites of relevant age are few. The fossil woods from Bogenfels (Namibia) indicate an assemblage more similar to present savanna or arid bushveld than to the Albany Thicket (Bamford 2000). Older sites, such as the pollen flora of Banke in Namaqualand (Cretaceous/Early Tertiary, Scholtz 1985) show no clear evidence of thicket elements. The Umzamba site in the Eastern Cape (of similar age) contains a variety of fossil woods, some belonging to the Euphorbiaceae, more likely typical of forest sites (Bamford 2000). The assemblages that can be quite clearly associated with the present-day Albany Thicket taxa come from other parts of the African continent, mainly from East Africa, such as the variety of woody plants of Ebenaceae, Celastraceae and Oleaceae occurring in Eocene to Miocene deposits from Ethiopia, Uganda and Egypt (Laudoueneix-Dupéron & Dupéron 1995). Recently, Schrire et al. (2005) have suggested that those plant forms characteristic of a global 'succulent biome' (covering also the parts of global Subtropical Thicket Biome) first appeared during the Eocene in the region of the Tethyan Ocean (the Mediterranean Sea being a remnant of the latter), in conjunction with the aridification that affected this region more drastically than others. This area is likely to have represented the cradle of the Fabaceae. An early branch that supports this hypothesis is the tribe Detarieae, which includes the southern African endemics *Schotia* and *Umtiza*. A northern origin is also supported by the Tertiary records of typical thicket genera such as *Ehretia* and *Rhoicissus* from Europe, where they are now extinct (Gottschling et al. 2002, Ingrouille et al. 2002). The above evidence may suggest that the Albany Thicket Biome may represent a relict formation with deep roots in the Eocene.

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Figure 10.6 *Strelitzia reginae* (Strelitziaceae)—a flagship beauty among South African plants (near Ecca Pass north of Grahamstown, Eastern Cape).

Currently, several centres of semixeric and xeric plant diversity can be distinguished on the African continent (including Madagascar), the most important being the Succulent Karoo Region, the thicket vegetation of the Eastern Cape, the KwaZulu-Natal/Limpopo high diversity zone, several smaller centres in East Africa, the Horn of Africa (including the Island of Socotra), the Mediterranean Basin, and southern and southwestern Madagascar. Three of these areas appear to have been most important in harbouring the earliest branches in various semixeric lineages, namely the Succulent Karoo Region, the Eastern Cape and

western Madagascar. Various groups appear to have colonised large parts of the continent having originated in one of these three areas. The southern African-Madagascan semixeric connection is particularly interesting, given that Madagascar has been separate from the African mainland since the Cretaceous. Nevertheless, the distance was never large enough to prevent multiple crossing events by wind-dispersed as well as bird-dispersed plants (Grubb 2003, Pell 2004). At the same time, temporary aridification events during the Tertiary (and recent ones associated with Pleistocene glaciations) may have facilitated exchange events between southern Africa and the Horn of Africa and consequently the entire Mediterranean region along an arid corridor, even in groups with limited dispersal abilities (see Axelrod & Raven 1978).

The floristic uniqueness of the Albany Thicket Biome, marked by a significant contingent of local endemics, suggests an uninterrupted existence in its current geographic distribution area. However, variations in size may have been great. The absence of endemic vertebrates—as would be expected given the relatively large area covered by the biome—strongly suggests that thicket vegetation suffered several constrictions in recent times, most likely associated with Pleistocene glacial cycles (see Cowling et al. 1999). Then the Albany patch may not have been much larger than other vegetation patches of similar composition growing under different climatic conditions in fire-free pockets along the eastern escarpment of southern Africa and the Great Rift Valley. The establishment of a relatively large nonseasonal rainfall and fire-protected area in the Eastern Cape may have allowed it to expand to its current extent.

Browser pressure and the unreliable arid climate of the region have probably been the driving forces in the evolution of Albany Thicket since the Last Glacial Maximum (LGM), 18 000 to 21 000 years BP (Palmer 1990). Yet, in the face of the impressive array of indigenous herbivores (not even considering arthropods), Albany Thicket appears to show little fluctuation (in recent decades) in standing biomass over short periods of time (Aucamp & Tainton 1984). This feature sets it apart from most of the other herbivore-driven systems, such as savannas (Scholes & Walker 1993) and grasslands (O'Connor & Bredenkamp 1997), where the herbivores (Owen-Smith & Danckwerts 1997), fire, and climate (Schulze 1997) are primary determinants of plant biomass. In Albany Thicket, indigenous herbivores do reduce plant biomass, but the overall patch structure is retained (Cowling & Kerley 2002). In spite of the widespread and varied defences employed by plants, and their apparent resistance to herbivory, the onset of domestic herbivory was the catalyst to degradation of the Albany Thicket ecosystems.

4.2 Biogeography

The Eastern Cape flora corresponds with the convergence of five of White's (1983) phytochoria (Cowling 1983, Cowling & Campbell 1983), namely the Cape Region, the Karoo-Namib Region (later subdivided; see chapter on Succulent Karoo in this book), the Maputaland-Pondoland Regional Mosaic, the Afromontane Region and the Kalahari-Highveld Regional Transition Zone. As a result, the flora has been described as complex and transitional and the convergence of these phytochoria in the Eastern Cape has led to a huge 'tension' zone (Cowling 1983). No less than 21 of 70 national Acocks (1953) Veld Types are represented in the Albany area, which constitutes the core of the Albany Thicket Biome. Subtropical Maputaland-Pondoland forests enter Albany Thicket from the northeast along the coast, penetrating up the river valleys after the establishment of warmer wetter conditions that followed the LGM (Palmer 1990). The succulent and dwarf shrublands of the Karoo-Namib phytochorion penetrated down the river valleys from the arid interior and graded into the forest and thicket. Afromontane (afrotemperate) forest elements are found from the sea level forests to the forest pockets in the interior mountains, possible refugia from the LGM. Cape fynbos elements are well represented on the infertile soils derived from the Cape Supergroup rocks (Cowling 1983). The relative distributions of these phytochoria are held in balance by environmental drivers such as climate and, more recently, land use. The result is a mosaic of plant communities with different or mixed chorological affinities (Cowling 1983).

The Albany Thicket is the Eastern Cape biome supporting the highest number of endemic taxa. It forms the core of the so-called Albany Centre of Endemism (Van Wyk & Smith 2001). Some authors (e.g. Gibbs Russell & Robinson 1981) consider the Albany region to have relatively low levels of endemism in comparison to the rich centres of endemism elsewhere in southern Africa. Many of the species in the Albany Thicket Biome are considered to have their centres of distribution elsewhere, and it has been suggested that the region does not have a strongly characterised flora (Gibbs Russell & Robinson 1981, Hoffman & Cowling 1991). However, endemism in this region is probably grossly under-estimated (Van Wyk & Smith 2001) and the region represents a centre of endemism for karroid succulents (Hoffman & Cowling 1991, Van Wyk & Smith 2001), most of which are restricted to the thicket vegetation in the region. High percentages of endemism are reported for the families Asclepiadaceae, Crassulaceae, Euphorbiaceae and for several families of the Asparagales (see Smith & Marx 1990). High numbers of local endemics are known to occur and Cowling & Hilton-Taylor (1994) report 51 Red Data taxa, 200 endemics and 2 000 taxa in the Albany hotspot, an area that corresponds broadly with the Albany Centre of Endemism (Van Wyk & Smith 2001). An analysis of threatened species in the Albany Centre of Endemism (Victor & Dold 2003), which includes the Albany Thicket, indicates that 180 (61%) of the species evaluated have a very narrow distribution range. This list does not include all endemic taxa, but is similar to the 200 endemics reported by Cowling & Hilton-Taylor (1994) and 205 by Lubke et al. (1986) that give an overall estimate of 10% endemism for the Albany Centre of Endemism. There are many more near-endemics (with about 90 listed in the descriptions of the vegetation types of the biome). Van Wyk & Smith (2001) report 365 endemic/near-endemic succulents in the Albany Centre of Endemism; inclusion of nonsucculents would expand this list considerably and indicates that 10% endemism is probably an under-estimate. Vlok & Euston-Brown (2002) provide a list of 322 out of 1 588 species (20%) in subtropical thicket that are endemic. The endemics of the region are a mixture of palaeoendemics and neoendemics, with few endemic genera and no endemic families (Van Wyk & Smith 2001).

5. Land Use History

Prior to the arrival of colonial settlers in the early 1800s the region was sparsely populated by humans. Most human activity was concentrated along the Sundays River Valley, the principal source of perennial water in the area. Early travellers described the area as an unbroken expanse of dense thicket north of Uitenhage (Skead 1989). Initially, domestic stock was restricted by the high densities of ticks (carrying the fatal heartwater disease) and difficultly of access for the stock associated with the very dense bush, and the limited perennial water (A. Rudman, personal communication). Later, the use of dips and boreholes allowed farmers to increase their stock densities and enter into

new areas of thicket. This trend resulted in the opening up of large areas of thicket. More recently, an increasing number of farmers are switching from stock to game farming (Smith & Wilson 2002) as reduced availability of forage and increased variability in forage production make stock farming less profitable and sustainable.

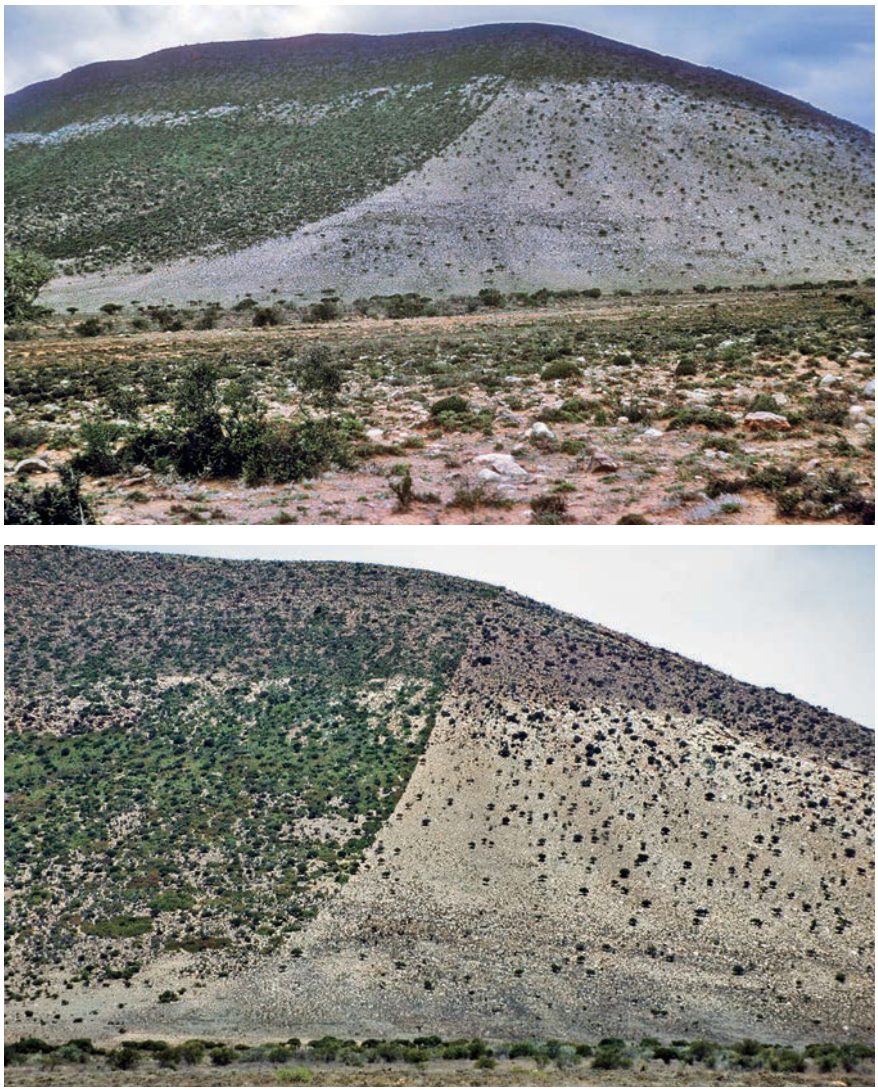
With the arrival of the first European settlers in the early 1800s, began the extirpation of megaherbivores (elephant and black rhino) and significant reductions in the populations of small (e.g. duiker) and medium-sized (e.g. bushbuck and kudu) herbivores (Kerley et al. 1999b). Since then, the high-quality forage available in intact Albany Thicket has been used to support extensive pastoralism. Goats were the most successful domestic species in the region since they were able to make use of the high biomass of browse. Despite its long history of herbivory, Albany Thicket has not displayed resilience to domestic herbivory and there is much evidence to show that commercial pastoralism has led to ecosystem-level degradation (Aucamp & Tainton 1984, Hoffman & Cowling 1990, Moolman & Cowling 1994, Kerley et al. 1999a, b). Approximately 92% (7 500 km^2) of Albany Thicket in the Eastern Cape has been degraded to some degree over the past 200 years (Lloyd et al. 2002). Much of this degradation occurred decades ago when there was little understanding of sustainable stocking levels in Albany Thicket. Anecdotal accounts suggest that government-recommended stocking rates during the 1950s were at least 20-fold those of today. Furthermore, it seems that some thicket farmers deliberately over-stocked goats to open up the dense bush, as much of the biomass was inaccessible to other stock, and high levels of tick-borne heartwater disease were associated with dense bush (A. Rudman, personal communication). Thus, the area is now dominated by grasses and ephemeral forbs, with remnant trees and pockets of thicket (Figure 10.7).

Considering that thicket has historically been exposed to a range of indigenous herbivores, from duiker to elephants, sometimes in very dense populations (Skead 1989), it is interesting to note why it collapses so rapidly in the face of domestic herbivory. The production potential of Albany Thicket is easily destroyed by domestic herbivory due to a combination of the feeding behaviour of goats (Stuart-Hill & Danckwerts 1988) and the slow growth rate of the plants (Aucamp & Tainton 1984). Stuart-Hill (1992) shows how goats feed into the sides of bush clumps, exposing the interior and reducing essential vegetative recruitment. In comparison, indigenous herbivores that browse from the top of the bush clumps, encourage vegetative recruitment. If damaged by over-utilisation, the woody component of the vegetation does not recover within management time frames (Stuart-Hill 1992). In comparison to other woody and herbaceous systems, such as savannas, removal of the woody component does not necessarily lead to a more productive grass understorey. The herbaceous layer is not a reliable source of forage, as its production closely tracks rainfall patterns (Stuart-Hill 1992).

6. Current Status, Threats and Actions

The current Albany Thicket vegetation is highly transformed and shows high levels of degradation (Lloyd et al. 2002, Palmer et al. 2004). Of the untransformed Thicket, only 11% is still in pristine condition and 60% is severely degraded (Lloyd et al. 2002). Approximately 7.3% has been transformed. The factors responsible for degradation and obliteration across the biome include cultivation in the moister regions, herbivory by livestock in the drier regions and urban settlement along the coast (Lloyd et al. 2002). The pressure on individual species, likewise, is high. Of the 126 species threatened with extinction in the Albany Centre of Endemism, the major threats, in decreasing order of importance, are illegal collecting, urban residential development, industrial development, alien plants, agriculture (including browsing/grazing), medicinal harvesting and forestry (Victor & Dold 2003).

Current land use pressure on thicket vegetation includes primarily urbanisation, agriculture and afforestation/alien trees



J.P.H. Acocks

L. Mucina

Figure 10.7 AT 3 Groot Thicket: Fence-line effect in the Spekboomveld near Willowmore (Eastern Cape), 13 km south of Beervlei Dam. To the right of fence small trees and shrubs of *Euclea undulata, Pappea capensis, Rhigozum obovatum* and *Lycium oxycarpum* are left. Photographed by J.P.H. Acocks in the 1950s (above top) and in 1998 (above). See also Acocks (1979, Figure 8).

(Cowling et al. 2003). Two urban areas constitute a significant pressure on surrounding vegetation, namely the Nelson Mandela Metropole (including Port Elizabeth) and environs and the corridor spanning Buffalo City (East London) and the Amathole range (Cowling et al. 2003). The Nelson Mandela Metropole is considered to constitute a significant urbanisation pressure on the surrounding landscape and therefore on biodiversity (Cowling et al. 2003). Coega is a specific nucleus of urban sprawl due to the development of the Industrial Development Zone that will result in the attraction of large populations of people to the surrounding areas. The Albany Thicket vegetation types from this node most at threat are Coega Bontveld and, to a lesser extent, Sundays Thicket. Further northeastwards, Buffalo City and its extensions towards Bisho constitute a threat to Buffels Thicket, but this vegetation is more widespread in areas removed from this threat.

A recent report detailing the effects of climate change on vegetation in South Africa (Rutherford et al. 1999, WWF 2001) did not treat the Albany Thicket as a separate biome. However, according to modelled climatic scenarios over the next 50 to 100 years, the area occupied by Thicket vegetation would undergo a major shift in climate, becoming warmer with fewer days when soil moisture and temperature are suitable for plant growth. Only the extreme western and eastern portions of the biome would be less affected. Fynbos would extend slightly eastwards, suggesting that bimodal climate conditions will also move eastwards shifting Albany Thicket in that direction. On the basis of this type of analysis, it is possible that there might be a significant loss in area of the Albany Thicket types that do not occur in the kind of habitat available in these eastern regions, for example steep-sided river valleys. Predictions are that approximately 20% of the area where *Portulacaria afra* is found, would become unsuitable for this species under modelled scenarios of climate change (Robertson & Palmer 2002). The worst-affected areas are likely to be the coastal region around Algoa Bay, almost at the core of the biome, as well as the Keiskamma River Valley and areas to the south of Graaff-Reinet (Robertson & Palmer 2002). Climate change effects are, however, more complex, and it is likely that changes in the variability of climate parameters will have as big an influence on the survival and distribution of species as changes in the mean values of parameters (O'Connor & Roux 1995).

A number of megaconservancy networks (MCNs) and expanded parks have been proposed or are in the process of being established within the biome, including the Fish-Kowie MCN, the Gqunube-Amathole MCN, the Kei MCN, the Gouritz-Little Karoo MCN, the Baviaanskloof MCN and the Addo-Camdebo MCN, many of which include existing reserves. Despite the formation of these new conservation areas, conservation of the variety of Thicket vegetation will not be achieved without the establishment of new protected areas that conserve unprotected types of Albany Thicket. One of the major conservation initiatives in the biome area is the expansion of the Addo Elephant National Park, which began in 1997 and is still under way, made possible by funds from the government (DEAT) and foreign donors (primarily the Global Environmental Fund). The park is currently 148 000 hectares in extent (December 2004) and will eventually cover 240 000 hectares to become South Africa's fourth largest National Park.

Large areas of Albany Thicket degraded by overgrazing and invasive alien plants require a substantial restoration effort for the achievement of both pattern and process conservation targets (Cowling et al. 2003). The Working for Water Programme may restore the function and biodiversity of the catchment through the systematic eradication of alien invasive plants. However, rehabilitation efforts to restore Albany Thicket vegetation are likely to be very labour-intensive and require long-term investment of resources (Todkill 2001). Much of the degraded thicket was *Portulacaria afra*-dominated and the re-establishment of this species is necessary to begin to restore the vegetation. However, this is costly and unlikely to be undertaken by private land owners. Due to the high carbon-storage ability of *Portulacaria afra*-dominated thicket (Lechmere-Oertel 2003), the opportunity exists to initiate restoration through the international carbon credit system (Cowling et al. 2003).

7. Further Research

The main focus of the research in the Albany Thicket Biome appears to have been on the agricultural potential of these areas and the contribution that Thicket may make towards animal production, both domestic (e.g. Aucamp 1976, 1979, Aucamp & Tainton 1984, Danckwerts 1984) and wild (e.g. Cowling & Kerley 2002), as well as on the influence of grazing and browsing on thicket structure and function (e.g. Lechmere-Oertel 2003). Two 'Valley Bushveld Symposia' (proceedings published in 1991 and 1996) generated much interest and data on the economic and conservation aspects of the Albany Thicket Biome.

Earlier studies (Dyer 1937, Story 1952, Acocks 1953, 1988, Archibald 1955, Lubke et al. 1986) were broad in nature, but provided a good first approximation of vegetation patterns. Some detailed studies have been undertaken, e.g. Cowling (1984), Everard (1987), Palmer (1988), Birch et al. (1999), Judd (2001), but most of these are concentrated in specific areas and have been undertaken at different levels of intensity. There is an urgent need for detailed floristic studies on the different vegetation units within the Albany Thicket Biome to provide baseline information on diversity, structure and species composition, as well as on the distribution of individual species and the relationship between the different parts of the Biome. Two major universities located in the region (the Nelson Mandela Metropolitan University in Port Elizabeth and the Rhodes University in Grahamstown) are the institutions that should take the lead to deal with these challenges.

Recently, the Subtropical Thicket Ecosystem Planning Project (STEP) was an important measure in identifying ecologically uniform areas on the basis of remote-sensed data and environmental parameters. The STEP (Cowling et al. 2003, Pierce et al. 2005) identified a number of research priorities of an ecological nature, including the need to identify dynamics within different Thicket types, how these dynamics compare in intact and degraded forms of Thicket, what the biological indicators of ecosystem health are in different Thicket types, what they mean and how they can be used in monitoring programmes, to what extent different Thicket types are dependent on herbivory by different guilds of indigenous herbivores for the maintenance of biodiversity and ecosystem health, and what processes are essential across all spatial and temporal scales for the long-term maintenance of Thicket biodiversity.

8. Descriptions of Vegetation Units

AT 1 Southern Cape Valley Thicket

Aloe Scrub (Muir 1929). VT 23 Valley Bushveld (44%), VT 46 Coastal Renosterbosveld (39%) (Acocks 1953). LR 63 South and South-west Coast Renosterveld (86%) (Low & Rebelo 1996, 1998). BHU 93 Gouritz Mesic Succulent Thicket (74%) (Cowling & Heijnis 2001). STEP Gouritz Valley Thicket (63%) (Vlok & Euston-Brown 2002).

Distribution Western Cape Province: The core of the distribution is in river valleys of the Goekoe River (between Riversdale and Still Bay) with the largest patch in the Gouritz River Valley (between Herbertsdale and the Gouritzmond) and is found in unmapped smaller patches of the Groot Brak and Klein Brak Rivers as well as the Kaaimans River (here at its easternmost limit). Towards the west this vegetation is found (unmapped) in valleys of the Duiwenhoek and Slang Rivers and reaches its westernmost limits of distribution in the Breede River Valley. Altitude 20–200 m.

Vegetation & Landscape Features Steep slopes of deeply incised valleys of rivers flowing mainly in a north-south direction and dissecting the Southern Cape coastal peneplain. Medium-sized to tall (3–5 m), dense thicket composed of sclerophyllous (often spinescent) evergreen shrubs (e.g. *Euclea, Grewia, Gymnosporia, Putterlickia, Rhus, Sideroxylon, Tarchonanthus*) as well as an important admixture of a microphyllous (partly ericoid) shrub element (*Athanasia*, *Elytropappus, Oedera, Stoebe*) and with a prominent (locally also dominant) succulent, rosulate tree, *Aloe ferox*. The low shrub layer contains a high proportion of succulent shrubs (*Aloe, Crassula, Euphorbia, Ruschia*). Grasses are abundant in some favoured grazing areas.

Geology & Soils Shallow, loamy-clayey soils (mostly Glenrosa and Mispah) derived from siltstone and shales of the Bokkeveld Group in the western part of the area, and Jurassic Enon conglomerates and other clastic sediments of the Uitenhage Group in the eastern part of the area. Where on hard Ordovician Table Mountain sandstone, only on the Aasvogelberg range—on rocky south-facing slopes with organic-rich soils (Rebelo et al. 1991). Fc land type predominates, while Ia is of lesser importance.

Climate Nonseasonal rainfall with several slight optima (in March, May, August, October), and with driest summer months December to February. MAP 400 mm, which ranges from about 340 mm in the west (Swellendam) to about 940 mm in the east (Wilderness). Frost is infrequent. MAT falls within warm-temperate range (17°C). Mean monthly maximum and minimum temperatures for the nearby Riversdale weather station are 37.5°C and 0.2°C for February and July, respectively and corresponding values on the coast for Mossel Bay (Cape St Blaize) are 29.6°C and 7.4°C for April and August, respectively. Also see climate diagram for AT 1 Southern Cape Valley Thicket (Figure 10.4).

Important Taxa Succulent Tree: *Aloe ferox* (d). Small Trees: *Acacia natalitia*, *Schotia afra* var. *afra*. Tall Shrubs: *Chrysanthemoides monilifera* (d), *Elytropappus rhinocerotis* (d), *Olea europaea* subsp. *africana* (d), *Carissa bispinosa* subsp. *bispinosa*, *Clausena anisata*, *Euclea undulata*, *Grewia occidentalis*, *Gymnosporia buxifolia*, *Putterlickia pyracantha*, *Rhus glauca*, *R. laevigata*, *R. longispina*, *R. lucida*, *Tarchonanthus camphoratus*. Low Shrubs: *Pteronia incana* (d), *Anthospermum aethiopicum*, *A. prostratum*, *Aspalathus globulosa*, *Asparagus capensis* var. *capensis*, *A. striatus*, *Athanasia pectinata*, *Felicia filifolia*, *Freylinia undulata*, *Galenia pubescens*, *Garuleum latifolium*, *Gnidia squarrosa*, *Lauridia tetragona*, *Leonotis leonurus*, *Oedera genistifolia*, *Otholobium hirtum*, *Pentzia incana*, *Polygala myrtifolia*, *P. scabra*, *Stoebe muirii*, *Sutera caerulea*. Succulent Shrubs: *Adromischus triflorus*, *Aloe maculata*, *Aptenia cordifolia*, *Cotyledon orbiculata* var. *orbiculata*, *C. papillaris*, *Crassula cultrata*, *Euphorbia burmannii*, *E. mauritanica*, *Lampranthus prominulus, Zygophyllum foetidum*. Woody Succulent Climbers: *Crassula perforata* (d), *Sarcostemma viminale*. Woody Climbers: *Asparagus africanus*, *A. racemosus*. Graminoids: *Ehrharta erecta* (d), *Cynodon dactylon*, *Ehrharta calycina*, *Festuca scabra*, *Karroochloa curva*, *Merxmuellera stricta*, *Panicum maximum*, *Stipa dregeana*. Herbaceous Climber: *Cynanchum obtusifolium*. Succulent Herbs: *Anacampseros telephiastrum*, *Carpobrotus edulis*, *C. muirii*, *Crassula muscosa*, *C. saxifraga*, *Senecio ficoides*. Geophytic Herbs: *Bulbine praemorsa*, *Cheilanthes hirta*, *C. multifida*, *Cyanella lutea*, *Hesperantha acuta*, *Mohria caffrorum*, *Nerine humilis*, *Oxalis bifurca* var. *angustiloba*, *O. obtusa*, *O. pes-caprae*. Herbs: *Arctotheca calendula*, *Berkheya heterophylla*, *Cineraria lobata*, *Cotula sororia*, *Erucastrum austroafricanum*, *Hypoestes aristata*, *Lepidium africanum*, *Lotononis calycina*, *Nemesia fruticans*, *Sebaea ramosissima*, *Sisymbrium capense*, *Stachys aethiopica*.

Biogeographically Important Taxa ([E]Eastern limit, [SE]Southeastern limit, [W]Western limit) Succulent Tree: *Aloe speciosa*[W]. Succulent Shrubs: *Aloe arborescens*[W], *Euphorbia mammillaris*[W], *Portulacaria afra*[W]. Tall Shrubs: *Azima tetracantha*[W], *Diospyros pallens*[SE]. Low Shrub: *Lyperia antirrhinoides*[E]. Succulent Climber: *Crassula lactea*[W]. Succulent Herb: *Gasteria carinata*[SE]. Herb: *Senecio muirii* (shared with AT 2 Gamka Thicket). Graminoid: *Pentaschistis triseta*[E].

Endemic Taxa Succulent Shrub: *Cotyledon eliseae*. Succulent Herbs: *Haworthia chloracantha*, *H. turgida* (all three varieties).

Conservation Vulnerable. Target 19%. Very little of unit conserved in Pauline Bohnen Nature Reserve (statutory) and in Langeberg-Oos Reserve (private). 35% transformed by cultivation. Erosion is variable—from very low to high. Near Albertinia the local *Aloe ferox* has become the subject of a local industry aimed at extracting substances for medicinal and cosmetic use.

Remark 1 This is the westernmost thicket type completely embedded within the matrix of the Fynbos Biome (with a minor border with the Succulent Karoo Biome in the upper Gouritz Valley). A number of taxa reach their westernmost limits of distribution here (see above), suggesting a (past) link to the Albany Thicket proper. At least two species (*Cotyledon papillaris* and *Senecio muirii*) are shared with Gamka Thicket. Not surprisingly, this thicket type contains the highest number of Fynbos elements of the whole Albany Thicket Biome.

Remark 2 The steep, rocky slopes, geomorphology and consequently poor soil development create environmental conditions very different from the surrounding renosterveld vegetation (Fynbos Biome) which typically covers the coastal plateaus of the Southern Cape. The habitats supporting this type of thicket are usually protected from fire that occurs in the neighbouring renosterveld. Grazing by domestic animals was (or in places still is) common.

References Muir (1929), Grobler & Marais (1967), Taylor (1970), Acocks (1988), Rebelo et al. (1991), Cowling & Heijnis (2001), Vlok & Euston-Brown (2002), Vlok et al. (2003).

AT 2 Gamka Thicket

VT 25 Succulent Mountain Scrub (Spekboomveld) (58%) (Acocks 1953). LR 8 Spekboom Succulent Thicket (47%), LR 58 Little Succulent Karoo (20%) (Low & Rebelo 1996, 1998). BHU 97 Spekboom Xeric Succulent Thicket (42%), BHU 89 Oudtshoorn Broken Veld (18%) (Cowling & Heijnis 2001). STEP Gamka Arid Spekboomveld (30%), STEP Kandelaars Karroid Thicket (17%), STEP Mons Ruber Fynbos Thicket (17%) (Vlok & Euston-Brown 2002).

Distribution Western and (marginally) Eastern Cape Provinces. Centred around Oudtshoorn in the basin of the Little Karoo between the Groot Swartberg Mountains in the north and the Outeniqua Mountains in the south, where it occurs on the lower mountain slopes and in some river valleys. It extends from the lower Gamka River Valley and the eastern lower flank of Rooiberg and through the Groot Swartberg Mountains (including the enclosed valley of 'The Hell'), for about 130 km eastwards on lower parts of ridges north of the Groot Swartberg

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Figure 10.8 AT 2 Gamka Thicket: Spekboomveld (*Portulacaria afra*) on steep northern slopes of the Huisrivier Pass between Calitzdorp and Ladismith in the Little Karoo (Western Cape).

as far as the Droëkloofberg Mountains (including the isolated ridges to the north that include Tierberg) and to the upper reaches of the Olifants River Valley south of the Groot Swartberg and north of the Kammanassie Mountains. Altitude varies from about 300–1 000 m.

Vegetation & Landscape Features Undulating to steep foothills and valleys dominated by a low succulent thicket, sometimes quite open. In its pristine condition dense stands of spekboom (*Portulacaria afra*) occur, often with *Euclea undulata*, *Gloveria integrifolia*, *Pappea capensis* and *Rhus glauca*. Shrubs are also abundant, stem- and leaf-succulents are often prominent, and the grass component is poorly developed, with *Cenchrus ciliaris, Ehrharta calycina, Eragrostis plana* and *Sporobolus fimbriatus* occasionally abundant after good rain.

Geology & Soils Mostly restricted to sites where relatively deep (>1 m) loamy-clayey soils occur on Enon Formation conglomerates (Jurassic), thus often deep beds of gravelly rocky soil. In the lower Gamka River Valley it occurs on Bokkeveld Group shales and north of the Swartberg Mountains it is found on arenites and shales of the Witteberg, Ecca or Bokkeveld Groups. Land types: mostly Ag (almost half of the area), followed by Ic, Ib and Fc.

Climate The driest of the thicket types, MAP ranges from about 105 mm on the plains north of the Swartberg to about 540 mm (extremes are 102–545 mm) on the south-facing mountain foothills. The rainfall is nonseasonal with slight optima in March and October/November and lowest rainfall in the summer months of December to February. Frost is fairly frequent. Mean monthly maximum and minimum temperatures for Oudtshoorn are 39.9°C and –0.4°C for February and July, respectively. See also climate diagram for AT 2 Gamka Thicket (Figure 10.4).

Important Taxa Succulent Trees: *Aloe ferox*, *A. speciosa*. Small Trees: *Acacia karroo*, *Pappea capensis*, *Schotia afra* var. *afra*. Tall Shrubs: *Cadaba aphylla*, *Carissa bispinosa* subsp. *bispinosa*, *Elytropappus rhinocerotis*, *Dodonaea viscosa* var. *angustifolia*, *Euclea undulata*, *Gymnosporia heterophylla*, *Melianthus comosus*, *Nymania capensis*, *Olea europaea* subsp. *africana*, *Putterlickia pyracantha*, *Rhigozum obovatum*, *Rhus glauca*, *R. lancea*, *R. lucida*. Succulent Shrubs: *Crassula cultrata* (d), *Euphorbia mauritanica* (d), *Portulacaria afra* (d), *Aloe microstigma*, *Cotyledon orbiculata* var. *orbiculata*, *C. papillaris*, *Crassula lanceolata*, *C. nudicaulis*, *C. ovata*, *C. rupestris* subsp. *commutata*, *C. tetragona* subsp. *acutifolia*, *Othonna carnosa*, *Pachypodium succulentum*, *Sceletium rigidum*, *Zygophyllum flexuosum, Z. foetidum*, *Z. fulvum*. Low Shrubs: *Garuleum latifolium* (d), *Pteronia incana* (d), *P. pallens* (d), *Aptosimum indivisum*, *Asparagus burchellii*, *A. mucronatus*, *A. striatus*, *Ballota africana*, *Chrysocoma ciliata*, *Eriocephalus africanus*, *Euryops brevipapposus*, *Felicia filifolia*, *F. muricata*, *Galenia africana*, *Gloveria integrifolia*, *Helichrysum zeyheri*, *Limeum aethiopicum*, *Lycium cinereum*, *L. oxycarpum*, *Monechma spartioides*, *Oedera squarrosa*, *Polygala myrtifolia*, *P. scabra*, *Tetragonia robusta* var. *psiloptera*, *Zygophyllum microphyllum*. Woody Succulent Climbers: *Pelargonium zonale*, *Sarcostemma viminale*. Semiparasitic Epiphytic Shrub: *Viscum rotundifolium*. Woody Climbers: *Asparagus racemosus*, *Cissampelos capensis*. Herbaceous Climbers: *Cynanchum ellipticum*, *Kedrostis capensis*. Graminoids: *Cynodon dactylon* (d), *C. incompletus* (d), *Ehrharta calycina* (d), *Eragrostis curvula* (d), *Aristida adscensionis*, *Cymbopogon prolixus*, *Digitaria argyrograpta*, *D. eriantha*, *Ehrharta erecta*, *Eragrostis obtusa*, *Fingerhuthia africana*, *Hyparrhenia poecilotricha*, *Stipagrostis ciliata* var. *capensis*. Succulent Herbs: *Crassula muscosa*, *Haworthia blackburniae* var. *blackburniae*. Geophytic Herbs: *Oxalis pes-caprae* (d), *Asplenium cordatum*, *Cheilanthes hirta*, *Chlorophytum crispum, Drimia intricata*. Herbs: *Arctotheca calendula*, *Chamaesyce inaequilatera*, *Cineraria platycarpa*, *Conyza scabrida*, *Emex australis*, *Hermannia pulverata*, *Lepidium africanum*, *Pulicaria scabra*, *Troglophyton capillaceum*.

Endemic Taxa Succulent Shrub: *Euphorbia gamkensis*. Geophytic Herbs: *Eriospermum rhizomatum*, *Lachenalia haarlemensis*.

Conservation Least threatened. Target 19%. About 9% statutorily conserved mainly in Groot Swartberg, Groenefontein and Gamkapoort Nature Reserves. About 4% transformed mainly by cultivation. The invasive alien, *Atriplex lindleyi*, is scattered in places. Erosion is very low to moderate. Fragmentation of the Gamka Thicket has occurred due to frequent fires that sweep down from the adjacent fynbos-clad mountains.

Remarks The vegetation has complex floristic and spatial links to Nama-Karoo and Succulent Karoo as well as to the Fynbos Biome vegetation demonstrated by the synonymy with a number of previously described vegetation units (see above). It is particularly in this area that Acocks (1953) characteristically positioned his Spekboomveld (thicket) in a vegetation sequence between the lower lying karoo and higher positioned renosterveld.

References Acocks (1953, 1988), Lloyd et al. (2002), Vlok & Euston-Brown (2002), Vlok et al. (2003), Cleaver et al. (2005).

AT 3 Groot Thicket

VT 25 Succulent Mountain Scrub (Spekboomveld) (43%), VT 26 Karroid Broken Veld (27%) (Acocks 1953). LR 8 Spekboom Succulent Thicket (33%), LR 54 Central Lower Nama Karoo (29%) (Low & Rebelo 1996, 1998). BHU 98 Willowmore Xeric Succulent Thicket (23%), BHU 92 Steytlerville Broken Veld (13%), BHU 73 Baviaanskloof Mountain Fynbos Complex (10%), BHU 99 Addo Xeric Succulent Thicket (9%) (Cowling & Heijnis 2001). STEP Groot Arid Spekboomveld (43%), STEP Baviaans Spekboom Thicket (21%) (Vlok & Euston-Brown 2002).

Distribution Eastern Cape Province: Lower slopes and ridges from Willowmore/Perdepoort in the west to the Klein Winterhoek/Zuurberg Mountains (northwest of Kirkwood) in the east including some narrow northern edges of the Baviaanskloof and Groot Winterhoek Mountains as well as the thicket of the central and upper Baviaanskloof (also narrow tributaries, for example, the Kouga River). Altitude ranges from about 200–1 100 m.

Vegetation & Landscape Features Moderate to steep slopes on the ridges of the mountain ranges dominated by a low succulent thicket, usually fairly dense and closed. Under favourable conditions spekboom (*Portulacaria afra*) is abundant amongst sometimes dense stands of other low woody shrubs. Stem- and leaf-succulents are present and may be prominent, and the grass component is usually poorly developed.

Geology & Soils Commonly found on steep slopes with relatively shallow, red, clayey and often rocky soils that are derived from a variety of parent materials, usually arenites and shales. Geological Groups include Table Mountain, Witteberg, Dwyka and Ecca. The dominant land types are Ib and Fc, followed by Ag and Fb.

Climate Subjected to summer droughts, but regular winter rain may decrease the impact of these droughts. MAP is relatively low, generally 250–450 mm; the rainfall is nonseasonal, with slight optima in March and November. The mean coefficient of variation in MAP is 35% for this vegetation unit; frost incidence varies from about 5 days of frost per annum in the east to around 65 days in the western parts. Mean monthly maximum and minimum temperatures for Willowmore are 37.7°C and –3.1°C for January and July, respectively, although there are smaller extremes in the east than the west. See also climate diagram for AT 3 Groot Thicket (Figure 10.4).

Important Taxa Succulent Trees: *Aloe ferox*, *Euphorbia tetragona*. Small Trees: *Acacia karroo*, *Boscia albitrunca*, *Cussonia spicata*, *Encephalartos lehmannii, Ozoroa mucronata*, *Pappea capensis*, *Schotia afra* var. *afra*, *Sideroxylon inerme*. Tall Shrubs: *Euclea undulata* (d), *Grewia robusta* (d), *Carissa bispinosa* subsp. *bispinosa*, *Dodonaea viscosa* var. *angustifolia*, *Elytropappus rhinocerotis*, *Gymnosporia polyacantha*, *Putterlickia pyracantha*, *Rhigozum obovatum*, *Rhus longispina*, *R. lucida*. Succulent Shrubs: *Crassula cultrata* (d), *C. ovata* (d), *C. rupestris* subsp. *commutata* (d), *Euphorbia ledienii* (d), *Portulacaria afra* (d), *Adromischus cristatus* var. *schonlandii*, *Cotyledon tomentosa* subsp. *tomentosa*, *Crassula tetragona* subsp. *robusta*, *Euphorbia mauritanica*, *E. polygona*, *Glotiphyllum oligocarpum, G. salmii, Pachypodium succulentum*, *Senecio junceus, Zygophyllum foetidum*. Low Shrubs: *Chrysocoma ciliata* (d), *Felicia muricata* (d), *Indigofera denudata* (d), *Aptosimum elongatum*, *Asparagus burchellii*, *A. mucronatus*, *A. subulatus*, *Eriocephalus africanus*, *E. capitellatus*, *E. ericoides*, *Euryops spathaceus, Felicia filifolia*, *Hermannia gracilis*, *Leucas capensis*, *Limeum aethiopicum* (d), *Lycium oxycarpum*, *Monechma spartioides*, *Pteronia adenocarpa*, *P. incana*, *Rosenia humilis*, *Selago albida*, *S. fruticosa*, *Solanum tomentosum*. Semiparasitic Epiphytic Shrub: *Viscum rotundifolium*. Woody Succulent Climbers: *Crassula perforata* (d), *Crassula pellucida* subsp. *marginalis*, *Sarcostemma viminale*. Woody Climbers: *Asparagus racemosus*, *Capparis sepiaria* var. *citrifolia*, *Cissampelos capensis*, *Rhoicissus digitata*. Graminoids: *Aristida adscensionis* (d), *A. congesta* (d), *Cynodon incompletus* (d), *Eragrostis obtusa* (d), *Setaria lindenbergiana* (d), *Tragus berteronianus* (d), *Cenchrus ciliaris*, *Cymbopogon pospischilii*, *Ehrharta calycina*, *Enneapogon desvauxii*, *Eragrostis curvula*, *Merxmuellera stricta*, *Sporobolus fimbriatus*. Succulent Herbs: *Crassula muscosa* (d), *C. orbicularis* (d), *Crassula expansa, Psilocaulon junceum*. Geophytic Herbs: *Asplenium cordatum, Boophone disticha, Moraea pallida*, *Sansevieria hyacinthoides*. Herbs: *Aizoon glinoides* (d), *Troglophyton capillaceum* (d), *Hermannia pulverata*, *Lepidium africanum*, *Pollichia campestris*, *Stachys aethiopica*.

Endemic Taxa Succulent Shrubs: *Aloe pictifolia*. Succulent Herbs: *Huernia brevirostris* subsp. *baviaana*, *H. echidnopsioides*, *Gasteria ellaphieae*, *G. glomerata*, *G. rawlinsonii*, *Haworthia glauca* var. *herrei*, *H. pungens*, *H. zantneriana* var. *minor*, *Stapelia kougabergensis*, *Tromotriche baylissii*, *T. longii*. Geophytic Herbs: *Albuca cremnophila, Bulbine cremnophila*.

Conservation Least threatened. Target 19%. About 11% statutorily conserved mainly in the Greater Addo Elephant National Park, Guerna Wilderness Area and Baviaanskloof Conservation Area. 3.5% conserved in addition in other reserves, for example in the Timbili Game Reserve and Brakkefontein Game Farm. Only about 1.5% transformed mainly through urbanisation and cultivation. Many parts have been opened up by overgrazing and poor management practices and fence-line contrasts along mountain slopes are fairly common, with thicket present on one side and absent on the other. Erosion is generally very low to moderate.

Remarks Although there are several species endemic to the Groot Thicket, many Albany Centre endemics are shared with the Kowie, Gamka, Gamtoos and Sundays Thicket vegetation units. The Thicket vegetation here thus consists of a combination of many of the thicket species that occur within the central portion of the Albany Thicket Biome. Despite having a common denominating content of thicket species, the Groot Thicket units have a unique combination of species and/or have local endemic species present in their mosaic units (Vlok & Euston-Brown 2002). Some of the species present in this unit (e.g. *Euphorbia polygona, E. tetragona, Ozoroa mucronata* and *Plumbago auriculata*) indicate a close affinity to more eastern portions of the Albany Valley Thicket.

References Acocks (1953, 1988), Lloyd et al. (2002), Vlok & Euston-Brown (2002), Vlok et al. (2003).

AT 4 Gamtoos Thicket

VT 70 False Macchia (42%), VT 23 Valley Bushveld (35%) (Acocks 1953). Valley Bushveld (35%), Mosaic of South Coast Renosterveld (12%), Mesic Grassy Fynbos (11%) (Moll & Bossi 1984). LR 54 Central Lower Nama Karoo (28%), LR 63 South and South-west Coast Renosterveld (22%) (Low & Rebelo 1996, 1998). BHU 92 Steytlerville Broken Veld (27%), BHU 21 Humansdorp Grassy Fynbos (20%), BHU 30 Kromme Fynbos/Renosterveld Mosaic (20%) (Cowling & Heijnis 2001). STEP Gamtoos Valley Thicket (38%), STEP Gamtoos Arid Spekboomveld (20%) (Vlok & Euston-Brown 2002).

Distribution Eastern Cape Province: Coastal basin of the Gamtoos River Valley, south of the Baviaanskloof Mountains and along some smaller river valleys such as that of the Kromme River. Also found north of the Baviaanskloof Mountains in more xeric conditions on some low ridges south and southeast of Steytlerville. Altitude 0–700 m.

Vegetation & Landscape Features On the low mountain slopes in steeply sloping areas and on low ridges. Tall, dense thicket, where both the trees and shrubs and the succulent component are well represented. Few distinct strata can be differentiated within much of the vegetation, as the lower and upper canopy species are intertwined, often together with a wide variety of liana species linking the understorey species with the canopy. Occurs mostly as a fragmented community with large, dense stands restricted to south- and southwest-facing slopes that are protected against fires. The structure of

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Figure 10.9 AT 4 Gamtoos Thicket: Nonsucculent face of Gamtoos Thicket on steep sandstone slopes of the Baviaanskloof River Valley (near Patensie, Eastern Cape).

the dense stands of Gamtoos Thicket is similar to that of the Sundays Thicket, but it differs in the dominant species.

Geology & Soils Mostly restricted to rocky, sandy-loamy soils derived from shale and sandstone of the Bokkeveld Group (Ceres and Tarka Subgroups) and Table Mountain Group (Nardouw Subgroup) as well as the Jurassic Enon conglomerates. Also found are fairly shallow clayey soils derived from the Gamtoos Group limestone, phyllite and arenite of the Kaan and Klein River Formations (Namibian Erathem). Fc land type covers half of the area, followed by Ae and Ib.

Climate Nonseasonal rainfall with slight optima in March and November. MAP ranges from about 180 mm in the northwest inland areas to 850 mm in the southeast coastal sites. The coefficient of variation in MAP is 32% for the unit, but varies from 22% at the coast to 38% inland. The mean daily maximum temperatures for January are 24°C at the coast and 31°C inland and the mean daily minimum temperatures for July are 3°C inland and 9°C at the coast. The incidence of frost is 7 days, but ranging widely from 3 days at the coast to more than 25 days of frost per year inland. See also climate diagram for AT 4 Gamtoos Thicket (Figure 10.4).

Important Taxa Succulent Trees: *Euphorbia triangularis* (d), *Aloe africana*, *A. speciosa*, *Euphorbia grandidens*. Small Trees: *Apodytes dimidiata*, *Canthium spinosum*, *Cussonia spicata*, *C. thyrsiflora*, *Maytenus undata*, *Pappea capensis*, *Ptaeroxylon obliquum*, *Schotia afra* var. *afra*, *Sideroxylon inerme*, *Vepris lanceolata*. Tall Shrubs: *Allophylus decipiens*, *Azima tetracantha*, *Carissa bispinosa* subsp. *bispinosa*, *Crotalaria capensis*, *Ehretia rigida*, *Elytropappus rhinocerotis*, *Euclea racemosa*, *E. undulata*, *Grewia occidentalis*, *Gymnosporia capitata*, *G. heterophylla*, *G. polyacantha*, *Hippobromus pauciflorus*, *Maerua cafra*, *Mystroxylon aethiopicum*, *Nylandtia spinosa*, *Olea europaea* subsp. *africana*, *Pterocelastrus tricuspidatus*, *Putterlickia pyracantha*, *Rhus glauca*, *R. incisa*, *R. longispina*, *R. lucida*, *R. pterota*, *R. refracta*, *Scolopia zeyheri*, *Scutia myrtina*. Low Shrubs: *Felicia muricata* (d), *Anthospermum aethiopicum*, *Asparagus striatus*, *Chaetacanthus setiger*, *Eriocephalus africanus*, *E. algoensis, E. spathaceus, Jamesbrittenia microphylla*, *Lauridia tetragona*, *Oedera genistifolia*, *Phyllanthus maderaspatensis*, *Pteronia incana*, *Senecio linifolius*. Succulent Shrubs: *Portulacaria afra* (d), *Exomis microphylla* var. *axyrioides*, *Cotyledon campanulata*, *C. orbiculata* var. *oblonga*, *C. tomentosa* subsp. *tomentosa*, *Crassula cultrata*, *Delosperma ecklonis*, *Euphorbia mauritanica*, *E. polygona*, *Glottiphyllum linguiforme*, *Senecio oxyodontus*, *Tylecodon striatus, Zygophyllum debile*. Semiparasitic Shrub: *Osyris compressa*. Semiparasitic Epiphytic Shrub: *Viscum rotundifolium.* Woody Climbers: *Capparis sepiaria* var. *citrifolia* (d), *Rhoicissus digitata* (d), *Asparagus aethiopicus*, *A. racemosus*, *Jasminum angulare*, *Plumbago auriculata*, *Rhoiacarpos capensis*. Woody Succulent Climber: *Sarcostemma viminale*. Herbaceous Climbers: *Cynanchum ellipticum*, *Senecio deltoideus*. Graminoids: *Ehrharta calycina* (d), *E. erecta* (d), *Panicum deustum* (d), *Setaria sphacelata* (d), *Aristida congesta*, *Cenchrus ciliaris*, *Cynodon dactylon*, *Digitaria natalensis*, *Enneapogon desvauxii*, *E. scoparius*, *Eragrostis obtusa*, *Eustachys paspaloides*, *Ficinia indica*, *F. nodosa*, *Heteropogon contortus*, *Karroochloa curva*, *Leptochloa fusca*, *Melica racemosa*, *Panicum maximum*, *P. stapfianum*, *Pycreus polystachyos* var. *laxiflorus*, *Sporobolus africanus*, *S. fimbriatus*, *Stipa dregeana*, *Themeda triandra*, *Tribolium hispidum*. Succulent Herbs: *Crassula expansa*, *C. muscosa*, *C. orbicularis*, *Plectranthus grandidentatus*, *P. madagascariensis, Senecio radicans*. Geophytic Herbs: *Asplenium cordatum*, *Bonatea speciosa* var. *antennifera*, *Bulbine alooides*, *B. frutescens*, *Chasmanthe aethiopica, Ornithogalum longibracteatum*, *Oxalis obtusa, Pelargonium pulverulentum, Sansevieria hyacinthoides*. Herbs: *Hypoestes aristata* (d), *Abutilon sonneratianum*, *Acalypha ecklonii*, *Blepharis integrifolia* var. *clarkei*, *Hibiscus pusillus*, *Indigastrum costatum* subsp. *macrum*, *Indigofera hedyantha*, *Peristrophe cernua*, *Stachys aethiopica*.

Endemic Taxa Small Tree: *Cussonia gamtoosensis*. Succulent Herbs: *Huernia bayeri*, *Gasteria pulchra*. Geophytic Herb: *Lachenalia latimerae.*

Conservation Least threatened. Target 19%. A total of 6% of this vegetation unit is protected in statutory conservation areas: Baviaanskloof Conservation Area, Guerna and Berg Plaatz Wilderness Areas as well as Stinkhoutsberg, Kabeljousrivier, Loerie Dam and Seekoeirivier Nature Reserves. Private conservation areas (Hankey Forest Reserve No. 1, Monteaux Game Ranch, Lombardini Game Farm, Kabeljous River Natural Heritage Site, and Kromme River Mouth, Eastcot and Loerie Dam Nature Reserves) also protect some patches of this vegetation type. Some 12% of Gamtoos Thicket has been altered by cultivation and 1% by urbanisation. The alien *Atriplex lindleyi* subsp. *inflata* has invaded many degraded arid thicket areas, especially on soils with a high clay content. Erosion is variable.

Remarks The structural characteristics and species present within the Gamtoos Thicket are intermediate between those of the Sundays River Thicket and Gouritz River Thicket (*sensu* Vlok & Euston-Brown 2002). However, the composition of the dominant species differs and there are several endemic species present in the Gamtoos Thicket, especially in the matrix vegeta-

tion, that only occur as fragmented clumps. The flora that occur along its boundaries is shared and has been enriched by the species typical of the adjacent units (Cowling 1983), e.g. Sundays Thicket. To a degree this is also true for the Baviaanskloof mountain zone, especially where the Gamtoos Thicket unit abuts the boundaries of the Groot Thicket units. Many species typical of both these major regions may co-occur along these overlapping areas, presenting rather diffuse patterns in species gradients (Vlok & Euston-Brown 2002).

References Acocks (1953, 1988), Cowling & Campbell (1983), Cowling (1984), Pierce & Cowling (1984), Everard (1987), Midgley & Cowling (1993), Vlok & Euston-Brown (2002), Vlok et al. (2003), Kamineth (2004).

AT 5 Sundays Noorsveld

VT 24 Noorsveld (72%) (Acocks 1953). LR 6 Xeric Succulent Thicket (84%) (Low & Rebelo 1996, 1998). STEP Sundays Noorsveld (100%) (Vlok & Euston-Brown 2002).

Distribution Eastern Cape Province: Mostly north of the Klein Winterhoek Mountains, centred around Waterford and the Darlington Dam and a smaller area from Jansenville westwards. Also some patches south of this mountain range west of Kirkwood in the Sundays River Valley. Altitude 100–600 m.

Vegetation & Landscape Features Flat lowlands where the vegetation is a dense, usually 1–2 m tall succulent thicket consisting of a mosaic of noors (*Euphorbia caerulescens*) and low karoo shrub vegetation (dominated by *Pentzia incana* and *Rhigozum obovatum*). Punctuated by solitary trees and shrub groups with *Pappea capensis, Euclea undulata, Rhus longispina* and *Gymnosporia polyacantha*.

Geology & Soils Shale, mudstones and sandstones of the Beaufort and Ecca Groups of the Karoo Supergroup in the north as well as of the Mesozoic Uitenhage Group in the south. Often heavy, clayey soils, but may be sandy and of Quaternary origin. The Fc land type overwhelmingly dominates.

Climate Nonseasonal rainfall with slight optima in March and November, but primarily in late summer. MAP ranges from about 210 mm in the west to 320 mm in the east. The incidence of frost is only 5 days, ranging from 3 to 13 days of frost per year. Mean daily maximum and minimum temperatures are 29–32°C and 4–6°C for January and July, respectively, and this is consistent across the distribution of the vegetation type. Mean monthly maximum and minimum temperatures for the Mentz Dam weather station are 41.4°C and –2.2°C for January and July, respectively. See also climate diagram for AT 5 Sundays Noorsveld (Figure 10.4).

Important Taxa Succulent Tree: *Aloe ferox* (d). Small Trees: *Pappea capensis* (d), *Acacia karroo*, *Boscia albitrunca*, *B. oleoides*, *Schotia afra* var. *afra*. Tall Shrubs: *Grewia robusta* (d), *Gymnosporia polyacantha* (d), *Azima tetracantha*, *Cadaba aphylla*, *Carissa bispinosa* subsp. *bispinosa*, *Diospyros austro-africana*, *Euclea undulata*, *Gymnosporia capitata*, *Nymania capensis*, *Putterlickia pyracantha*, *Rhus longispina*. Low Shrubs: *Blepharis capensis* (d), *Jamesbrittenia microphylla* (d), *Lycium cinereum* (d), *L. oxycarpum* (d), *Pentzia incana* (d), *Rhigozum obovatum* (d), *Aptosimum elongatum*, *Asparagus burchellii*, *A. crassicladus*, *A. striatus*, *A. suaveolens*, *A. subulatus*, *Barleria pungens*, *B. rigida*, *Chrysocoma ciliata*, *Eriocephalus ericoides*, *Felicia filifolia*, *F. muricata*, *Garuleum latifolium*, *Helichrysum rosum*, *H. zeyheri*, *Hermannia althaeoides*, *H. gracilis*, *Indigofera sessilifolia*, *Lantana rugosa*, *Leucas capensis*, *Lepidium africanum*, *Limeum aethiopicum*, *Monechma pseudopatulum*, *M. spartioides*, *Pelargonium aridum*, *Phyllanthus verrucosus*, *Phymaspermum parvifolium*, *Polygala seminuda*, *Rosenia humilis*, *Selago albida*, *S. fruticosa*, *S. triquetra*, *Solanum capense*, *S. tomentosum*. Succulent Shrubs: *Euphorbia caerulescens* (d), *Adromischus cristatus* var. *schonlandii*, *Aloe lineata*, *A. striata*, *Cotyledon orbiculata* var. *oblonga*, *C. velutina*, *C. woodii*, *Crassula corallina* subsp. *corallina*, *C. ovata*, *Delosperma frutescens*, *Drosanthemum lique*, *Euphorbia esculenta*, *E. mauritanica*, *E. pentagona*, *Mestoklema tuberosum*, *Pachypodium succulentum*, *Portulacaria afra*, *Trichodiadema barbatum*. Semiparasitic Shrub: *Thesium junceum*. Semiparasitic Epiphytic Shrubs: *Viscum continuum*, *V. obscurum*, *V. rotundifolium*. Woody Succulent Climber: *Sarcostemma viminale*. Woody Climbers: *Asparagus racemosus*, *Cissampelos capensis*, *Rhoicissus digitata*. Graminoids: *Aristida adscensionis* (d), *A. congesta* (d), *Cenchrus ciliaris* (d), *Cynodon incompletus* (d), *Ehrharta erecta* (d), *Eragrostis obtusa* (d), *Tragus berteronianus* (d), *Aristida barbicollis*, *A. diffusa*, *Chloris virgata*, *Cynodon dactylon*, *Digitaria argyrograpta*, *Ehrharta calycina*, *Enneapogon desvauxii*, *E. scoparius*, *Eragrostis chloromelas*, *E. curvula*, *E. lehmanniana*, *Fingerhuthia africana*, *Heteropogon contortus*, *Oropetium capense*, *Panicum coloratum*, *P. deustum*, *P. maximum*, *Setaria verticillata*, *Sporobolus fimbriatus*, *Tragus racemosus*. Herbaceous Climbers: *Cynanchum ellipticum*, *C. gerrardii*, *Cyphia sylvatica*, *Kedrostis capensis*, *K. nana*. Succulent Herbs: *Mesembryanthemum aitonis* (d), *C. muscosa*, *Gasteria maculata*, *Mesembryanthemum crystallinum*, *Senecio radicans*. Geophytic Herbs: *Drimia intricata* (d), *D. anomala*, *Ledebouria undulata*, *Moraea polystachya*, *Oxalis stellata*, *Sansevieria aethiopica, Tritonia laxifolia*. Herbs: *Aizoon glinoides* (d), *Gazania krebsiana* (d), *Lasiopogon glomerulatus* (d), *Lotononis leptoloba* (d), *Abutilon sonneratianum*, *Amaranthus thunbergii*, *Boerhavia diffusa*, *Chamaesyce inaequilatera*, *Cucumis myriocarpus*, *Hermannia cernua*, *H. comosa*, *H. pulverata*, *Hibiscus pusillus*, *Indigastrum costatum* subsp. *macrum*, *Indigofera disticha*,

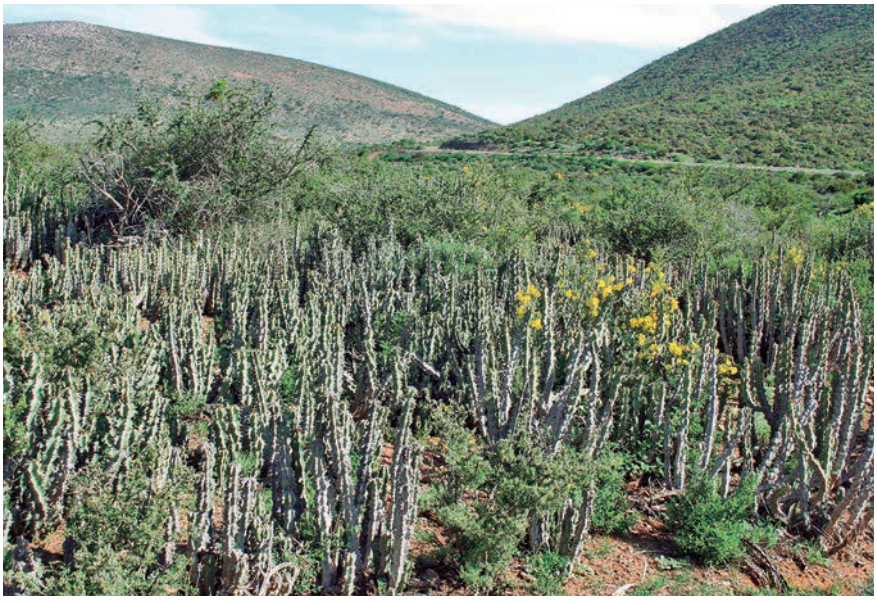

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Figure 10.10 AT 5 Sundays Noorsveld: Low succulent thicket with *Euphorbia caerulescens* (Euphorbiaceae) north of Wolwefontein on the road to Jansenville in the Sundays River basin (Eastern Cape).

Isoglossa ciliata, *Lactuca dregeana*, *L. desertorum*, *Lessertia pauciflora*, *Leysera tenella*, *Lotononis calycina*, *Peucedanum typicum*, *Tetragonia echinata*, *T. microptera*, *Tribulus terrestris*. Parasitic Herb: *Hydnora africana*.

Conservation Least threatened. Target 19%. Almost 15% statutorily conserved in Greater Addo Elephant National Park and some 3% in private game ranches (Kuzuko, Voetpadskloof, Koedoeskop, Schuilpatdop Game Farm, Goodhope). About 4% transformed with cultivation the primary factor. Erosion is moderate to very low.

References Acocks (1953, 1988), Van der Walt (1965), Hoffman (1989a, b), Hoffman & Cowling (1990), Du Toit & Blom (1995), Vlok & Euston-Brown (2002), Vlok et al. (2003).

AT 6 Sundays Thicket

VT 23 Valley Bushveld (42%), VT 24 Noorsveld (28%) (Acocks 1953). LR 6 Xeric Succulent Thicket (57%) (Low & Rebelo 1996, 1998). STEP Sundays Spekboomveld (55%) (Vlok & Euston-Brown 2002).

Distribution Eastern Cape Province: From the surrounds of Uitenhage and the northern edge of Port Elizabeth into the lower Sundays River Valley to east of Colchester and northwards to the base of the Zuurberg Mountains and stretching westwards north of the Groot Winterhoek Mountains to roughly the Kleinpoort longitude. Also an extensive area north of the Klein Winterhoek Mountains including much of the Jansenville District and parts of the far-southern Pearston District and far-western Somerset East District. Altitude 0–800 m.

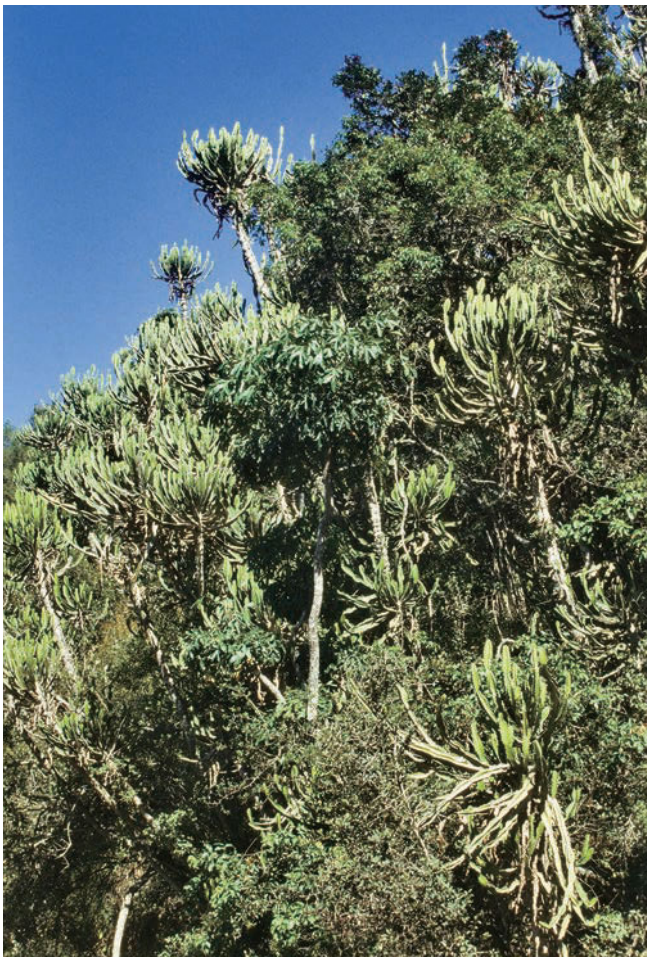

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Figure 10.11 AT 6 Sundays Thicket: Dense thicket with *Euphorbia triangularis* (Euphorbiaceae) and *Cussonia spicata* (Araliaceae) along road from Addo to Zuurberg Inn (Eastern Cape).

Vegetation & Landscape Features Undulating plains and low mountains and foothills covered with tall, dense thicket, where trees, shrubs and succulents are common, with many spinescent species. The transition between lower and upper canopies is obscured by the presence of a wide variety of lianas. The local dominance of *Portulacaria afra* increases and the relative abundance of woody species present decreases with increasing aridity. There is considerable structural heterogeneity within this vegetation unit.

Geology & Soils Mostly on deep (>1 m) red, loamy to clayey soils derived from the Sundays River and Kirkwood Formations (Mesozoic Uitenhage Group) in the south. In the Zuurberg Mountains, soils are more sandy and nutrient-poor and derived from the Bokkeveld and Witteberg Groups (Cape Supergroup). In the inland region of the Sundays River the soils are derived from Ecca Group shales and mudstones, and are heavy due to high clay content. Fc land type dominates the area, followed by Ae.

Climate Nonseasonal rainfall with slight optima in March and October/November. MAP ranges from about 190 mm in the northwest to 480 mm in the southeast on the coast near Port Elizabeth. The coefficient of variation in MAP is 29–38%, increasing with distance inland in a northwesterly direction. The incidence of frost is 8 days, but ranging widely from 3 days near the coast in the southeast to more than 24 days of frost per year in the more inland sites in the northwest. Mean monthly maximum and minimum temperatures for Jansenville are 41.3°C and –0.8°C for January and July, respectively, and corresponding values for Addo are 39.0°C and –0.3°C and for Uitenhage are 36.9°C and 1.3°C, both for February and July, respectively. See also climate diagram for AT 6 Sundays Thicket (Figure 10.4).

Important Taxa Succulent Trees: *Aloe africana* (d), *A. ferox*, *Euphorbia grandidens*. Small Trees: *Pappea capensis* (d), *Schotia afra* var. *afra* (d), *Acacia natalitia*, *Boscia albitrunca*, *Brachylaena ilicifolia*, *Cussonia spicata*, *Encephalartos lehmannii, Ptaeroxylon obliquum*, *Sideroxylon inerme*. Tall Shrubs: *Euclea undulata* (d), *Olea europaea* subsp. *africana* (d), *Azima tetracantha*, *Cadaba aphylla*, *Carissa bispinosa* subsp. *bispinosa*, *Diospyros pallens*, *Ehretia rigida*, *Grewia occidentalis*, *G. robusta*, *Gymnosporia buxifolia*, *G. capitata*, *G. polyacantha*, *Maerua cafra*, *Mystroxylon aethiopicum*, *Nymania capensis*, *Putterlickia pyracantha*, *Rhus incisa*, *R. longispina*, *Scutia myrtina*. Low Shrubs: *Pentzia globosa* (d), *Aptosimum elongatum*, *Asparagus burchellii*, *A. crassicladus*, *A. striatus*, *A. subulatus*, *Barleria obtusa*, *B. rigida*, *Blepharis capensis*, *Chascanum cuneifolium*, *Chrysocoma ciliata*, *Eriocephalus ericoides*, *Euryops algoensis*, *E. spathaceus, Felicia muricata*, *Garuleum latifolium*, *Hermannia althaeoides*, *Hibiscus aridus*, *Indigofera sessilifolia*, *Justicia orchioides*, *Lantana rugosa*, *Leucas capensis*, *Limeum aethiopicum*, *Lycium oxycarpum*, *Osteospermum imbricatum*, *Pteronia paniculata*, *Rhigozum obovatum*, *Rosenia humilis*, *Selago fruticosa*, *S. geniculata*, *Senecio linifolius*, *Solanum capense*, *S. tomentosum*. Succulent Shrubs: *Crassula ovata* (d), *Euphorbia caerulescens* (d), *E. ledienii* (d), *Portulacaria afra* (d), *Adromischus cristatus* var. *cristatus*, *A. sphenophyllus*, *Cotyledon campanulata*, *C. orbiculata* var. *oblonga*, *Crassula capitella* subsp. *capitella*, *C. capitella* subsp. *thyrsiflora*, *C. cotyledonis*, *C. cultrata*, *C. mesembryanthoides* subsp. *hispida*, *C. rogersii*, *Delosperma echinatum*, *D. uniflorum*, *Euphorbia mauritanica*, *Exomis microphylla*, *Kalanchoe rotundifolia*, *Lampranthus productus*, *Mestoklema tuberosum*, *Orbea pulchella*, *Pachypodium succulentum*, *Pelargonium carnosum*, *Psilocaulon articulatum, Zygophyllum foetidum*. Semiparasitic Shrub: *Osyris compressa*. Semiparasitic Epiphytic Shrubs: *Viscum crassulae*, *V. obscurum*, *V. rotundifolium*.

Woody Succulent Climbers: *Pelargonium peltatum* (d), *Crassula perforata*, *Cyphostemma quinatum*, *Sarcostemma viminale*. Woody Climbers: *Asparagus asparagoides*, *A. multiflorus*, *A. racemosus*, *A. volubilis*, *Behnia reticulata*, *Capparis sepiaria* var. *citrifolia*, *Cissampelos capensis*, *Plumbago auriculata*, *Rhoiacarpos capensis*, *Rhoicissus digitata*. Herbaceous Climbers: *Cynanchum ellipticum*, *Kedrostis capensis*. Graminoids: *Aristida adscensionis* (d), *A. congesta* (d), *Cynodon dactylon* (d), *C. incompletus* (d), *Eragrostis obtusa* (d), *Panicum maximum* (d), *Tragus berteronianus* (d), *Cenchrus ciliaris*, *Cyperus capensis*, *Digitaria argyrograpta*, *Ehrharta calycina*, *Enneapogon scoparius*, *Eragrostis curvula*, *Eustachys paspaloides*, *Heteropogon contortus*, *Panicum deustum*, *Sporobolus fimbriatus*, *Stipa dregeana*, *Themeda triandra*. Succulent Herbs: *Senecio radicans* (d), *Crassula expansa*, *C. spathulata*, *Gasteria bicolor, Sansevieria aethiopica*. Geophytic Herbs: *Bulbine frutescens* (d), *Drimia intricata* (d), *Sansevieria hyacinthoides* (d), *Cyanella lutea, Cyrtanthus loddigesianus*, *C. spiralis*, *Drimia anomala, Freesia corymbosa*, *Hypoxis argentea*, *Justicia cuneata* subsp. *cuneata*, *Moraea stricta*, *Oxalis smithiana*, *Spiloxene trifurcillata, Trachyandra affinis*, *Tritonia securigera*, *Tritonia strictifolia*, *Urginea altissima*. Herbs: *Abutilon sonneratianum*, *Aizoon glinoides*, *Arctotheca calendula*, *Chamaesyce inaequilatera*, *Commelina benghalensis*, *Cotula heterocarpa*, *Cyanotis speciosa*, *Cypselodontia eckloniana*, *Emex australis*, *Gazania krebsiana*, *Hibiscus pusillus*, *Hypoestes aristata*, *Indigastrum costatum* subsp. *macrum*, *Lepidium africanum*, *Lotononis glabra*, *Stachys aethiopica*.

Biogeographically Important Taxa ([S]Southern limit) Succulent Climber: *Ceropegia ampliata* var. *ampliata*[S]. Herbaceous Climber: *Fockea sinuata*[S]. Epiphytic Parasitic Herb: *Cuscuta bifurcata*. Geophytic Herb: *Pelargonium campestre*.

Endemic Taxa Small Tree: *Encephalartos horridus*. Succulent Shrubs: *Aloe bowiea*, *A. gracilis*, *Bergeranthus addoensis*, *Glottiphyllum grandiflorum*, *Orthopterum coegana*, *Ruschia aristata*, *Trichodiadema rupicola*. Succulent Climbers: *Aptenia haeckeliana*, *Ceropegia dubia*. Succulent Herbs: *Haworthia arachnoidea* var. *xiphiophylla*, *H. aristata*, *Huernia longii* subsp. *longii*. Geophytic Herbs: *Brachystelma cummingii*, *B. schoenlandianum*, *B. tabularium*, *Pelargonium ochroleucum*, *Strelitzia juncea*, *Tritonia dubia*. Herbs: *Arctotis hispidula*, *Argyrolobium crassifolium*, *Lessertia carnosa*, *Lotononis monophylla*, *Senecio scaposus* var. *addoensis*, *Wahlenbergia oocarpa*.

Conservation Least threatened. Target 19%. Protected statutorily in Greater Addo Elephant National Park, Groendal Wilderness Area as well as in Swartkops Valley and Springs Nature Reserves. Private conservation areas, especially game farms (Kuzuko, Koedoeskop, Schuilpatdop, Tregathlyn, Citruslandgoed, Voetpadskloof) and a couple of nature reserves contribute to conservation of this vegetation type as well. More than 6% already transformed (cultivated, urban development). Sundays Thicket has also been highly degraded through grazing by livestock (Hoffman & Cowling 1990, 1991, Lloyd et al. 2002, Lechmere-Oertel 2003). The degraded state resembles a secondary thornveld or grassland, dominated by invasive weedy species. In this state, most of the original thicket species are lost. Erosion is moderate to very low.

Remarks The considerable research interest in the Sundays Thicket unit is linked to the popular Addo National Park (now encompassing also the former Zuurberg National Park and a series of inland and coastal nature reserves forming the Greater Addo Elephant National Park)—the only locality in the Cape housing an extant population of elephant (*Loxodonta africana*) and an indigenous population of Cape buffalo (*Synceros caffer*).

References Archibald (1955), Pentzhorn & Olivier (1974), Pentzhorn et al. (1974), Aucamp (1976, 1979), Cowling (1983, 1984), Aucamp & Tainton (1984), Everard (1987), Hoffman (1989a, b), Hoffman & Cowling (1990, 1991), La Cock (1992), Stuart-Hill (1992), Midgley & Cowling (1993), Stuart-Hill & Aucamp (1993), Johnson (1998), Johnson et al. (1999), Kerley et al. (1999a, b), Sigwela (1999), Lombard et al. (2001), Todkill (2001), Cowling & Kerley (2002), Lloyd et al. (2002), Vlok & Euston-Brown (2002), Lechmere-Oertel (2003), Vlok et al. (2003), Sigwela et al. (2004).

AT 7 Coega Bontveld

VT 23 Valley Bushveld (87%) (Acocks 1953). Valley Bushveld (98%) (Moll & Bossi 1984). LR 7 Mesic Succulent Thicket (72%) (Low & Rebelo 1996, 1998). BHU 95 Sundays Mesic Succulent Thicket (70%) (Cowling & Heijnis 2001). STEP Grass Ridge Bontveld (100%) (Vlok & Euston-Brown 2002).

Distribution Eastern Cape Province: Northeast of Port Elizabeth just inland of Algoa Bay; mainly around Coega, but also in small patches in Addo (Zuurkop; Pentzhorn & Olivier 1974). Altitude 0–400 m.

Vegetation & Landscape Features On moderately undulating plains, where a mosaic of low thicket (2–3 m) built mainly of bush clumps occurs. Secondary open grassland occurs over wide stretches. This unit is often restricted to 'islands' in a matrix of typical valley thicket. The species present are a mixture of Fynbos, Grassland and Succulent Karoo elements.

Geology & Soils Outcrops of limestone (Nanaga Formation), and calcareous paleo-dune fields of the Cenozoic Algoa Group. The soils are shallow clay soils that are often lime-rich. Most of the area of this unit is primarily classified as the Fc land type, with Ae land type of minor importance.

Climate Nonseasonal rainfall with optima in March and October. MAP ranges from about 400 mm inland in the west to 550 mm in the east and closer to the coast. The coefficient of variation in MAP ranges between 30% and 32%. The incidence of frost is only 3 days, not varying across the range of the vegetation unit. Mean monthly maximum and minimum temperatures for the nearby Port Elizabeth are 32.1°C and 3.4°C for February and July, respectively. See also climate diagram for AT 7 Coega Bontveld (Figure 10.4).

Important Taxa Succulent Trees: *Aloe africana*, *A. ferox*. Small Trees: *Schotia afra* var. *afra*, *Sideroxylon inerme*. Tall Shrubs: *Euclea undulata* (d), *Carissa bispinosa* subsp. *bispinosa*, *Dovyalis caffra*, *Ehretia rigida*, *Euclea crispa*, *Gymnosporia capitata*, *Hippobromus pauciflorus*, *Maerua cafra*, *Mystroxylon aethiopicum*, *Pterocelastrus tricuspidatus*, *Putterlickia pyracantha*, *Rhus longispina*, *R. lucida*, *R. pyroides* var. *gracilis*, *Scutia myrtina*. Low Shrubs: *Helichrysum anomalum* (d), *Jamesbrittenia microphylla* (d), *Tephrosia capensis* var. *acutifolia* (d), *Acmadenia obtusata*, *Agathosma capensis*, *Asparagus falcatus*, *A. multiflorus*, *A. striatus*, *Blepharis capensis*, *Chaetacanthus setiger*, *Chascanum cuneifolium*, *Clutia daphnoides*, *Disparago ericoides*, *Felicia muricata*, *Hermannia althaeoides*, *H. flammea*, *H. holosericea*, *Lantana rugosa*, *Limeum aethiopicum*, *Lobostemon trigonus*, *Muraltia squarrosa*, *Osteospermum imbricatum*, *O. polygaloides*, *Passerina rubra*, *Wahlenbergia tenella*. Succulent Shrubs: *Crassula expansa* (d), *Ruschia hamata* (d), *Aloe arborescens*, *Carpobrotus edulis*, *Crassula capitella* subsp. *capitella*, *C. ericoides*, *C. perfoliata*, *C. perforata*, *C. tetragona* subsp. *robusta*. Semiparasitic Shrub: *Osyris compressa*. Woody Succulent Climbers: *Pelargonium peltatum*, *Sarcostemma viminale*. Woody Climbers: *Asparagus racemosus*, *Jasminum angulare*, *Rhoiacarpos capensis*, *Rhoicissus digitata*. Herbaceous Climber: *Kedrostis capensis*. Graminoids: *Aristida diffusa* (d), *Cynodon dactylon* (d), *C. incompletus* (d), *Eustachys paspaloides* (d), *Heteropogon contortus* (d), *Merxmuellera disticha* (d), *Panicum maximum* (d), *Setaria sphacelata* (d), *Stipa*

dregeana (d), *Themeda triandra* (d), *Cymbopogon marginatus*, *C. pospischilii*, *Digitaria argyrograpta*, *D. natalensis*, *Ehrharta calycina*, *E. erecta*, *Eragrostis capensis*, *E. curvula*, *E. obtusa*, *Helictotrichon capense*, *Melica racemosa*, *Panicum deustum*, *Pentaschistis pallida*, *Sporobolus ioclados*. Succulent Herbs: *Mesembryanthemum aitonis* (d), *C. muscosa*, Geophytic Herbs: *Sansevieria hyacinthoides* (d), *Bulbine favosa, B. inamarxiae*. *Moraea pallida*, *Oxalis smithiana*. Herbs: *Aizoon rigidum* (d), *Gazania krebsiana* (d), *Hypoestes aristata* (d), *Indigastrum costatum* subsp. *macrum* (d), *Senecio burchellii* (d), *Sutera campanulata* (d), *Arctotheca calendula*, *Berkheya heterophylla*, *Gazania jurineifolia*, *Hibiscus pusillus*, *Lotononis glabra*, *Monsonia emarginata*, *Scabiosa albanensis*.

Biogeographically Important Taxa ([E]Eastern limit, [W]Western limit) Graminoids: *Ficinia truncata*[E], *Tribolium uniolae*[W] (d). Herb: *Gibbaria scabra*[E].

Endemic Taxa Succulent Shrubs: *Euphorbia globosa*, *Rhombophyllum rhomboideum*. Low Shrub: *Anginon rugosum*. Geophytic Herb: *Ledebouria* sp. nov. *('coriacea'* S. Venter ined.).

Conservation Target 19%. A total of 10% of this vegetation unit is protected in the Greater Addo Elephant National Park and almost 4% in the private Grassridge Nature Reserve. Some 4% of Coega Bontveld has been altered by cultivation and 2% by urbanisation. The recent building of the traffic infrastructure around the new harbour near Port Elizabeth has encroached heavily into the area of the Coega Bontveld and the construction of an Industrial Development Zone in the area constitutes a serious threat to this vegetation type. Erosion is moderate to low.

Remarks There are areas in the Eastern Cape north and east of Grahamstown where calcrete resists weathering to form relatively flat landscapes surrounded by eroded valleys. The calcrete in these areas breaks down to form white clay that has been commercially harvested in the past for the production of crockery and pottery. The vegetation in all these areas is structurally and floristically similar to Coega Bontveld and they contain a number of taxa with Cape links, e.g. *Agathosma ovata*. There are also floristic links of Coega Bontveld to the local dune thicket vegetation.

References Acocks (1953, 1988), Pentzhorn & Olivier (1974), Vlok & Euston-Brown (2002), Vlok et al. (2003).

AT 8 Kowie Thicket

VT 23 Valley Bushveld (44%), VT 7 Eastern Province Thornveld (29%) (Acocks 1953). Valley Bushveld (93%) (Moll & Bossi 1984). LR 6 Xeric Succulent Thicket (25%), LR 16 Eastern Thorn Bushveld (24%), LR 5 Valley Thicket (21%) (Low & Rebelo 1996, 1998). STEP Albany Valley Thicket (38%), STEP Albany Thicket (31%) (Vlok & Euston-Brown 2002).

Distribution Eastern Cape Province: In the river valleys of the Bushmans, Kariega, Kowie, Kleinemonde and Kap Rivers from near the Great Fish River Mouth to Kenton-on-Sea, extending inland up these valleys past Grahamstown to just past Riebeeck East and Alicedale to north of the Zuurberg. Altitude 0–700 m.

Vegetation & Landscape Features On mainly steep and north-facing (dry) slopes. Tall thickets dominated by succulent euphorbias and aloes with a thick understorey composed of thorny shrubs, woody lianas (*Capparis, Secamone, Rhoicissus, Aloe*), and shrubby succulents (Crassulaceae, Asphodelaceae). Moister south-facing slopes support thorny thickets dominated by low evergreen trees (*Cussonia, Euclea, Hippobromus, Pappea, Ptaeroxylon, Schotia*) and shrubs (*Azima, Carissa, Gymnosporia, Putterlickia*) with fewer succulent shrubs and trees. The herbaceous layer is poorly developed.

Geology & Soils Clayey soils over Weltevrede and Lake Mentz (Darlington Dam) Formation sandstone and shale (Witteberg Group) and on Dwyka tillite (early Karoo) as well as Algoa Group calcareous sandstone in the south. Occurs on a wide variety of land types including Fc, Fa, Ae and Fb.

Climate Nonseasonal rainfall with optima in March and October/November. MAP ranges from around 340 mm in the west (north of the Zuurberg) to 650 mm in the east (at the coast near Port Alfred). The coefficient of variation in MAP is 30%, but varies from 27% at the coast to 34% inland. The incidence of frost is only 3 days, but ranges from 0 days at the coast to more than 17 days of frost per year inland. Mean monthly maximum and minimum temperatures for Bathurst are 35.0°C and 5.6°C for February and July, respectively. See also climate diagram for AT 8 Kowie Thicket (Figure 10.4).

Important Taxa Succulent Trees: *Euphorbia grandidens* (d), *E. tetragona* (d), *E. triangularis* (d), *Aloe africana*, *A. speciosa*. Small Trees: *Schotia afra* var. *afra* (d), *Acacia natalitia*, *Brachylaena ilicifolia*, *Commiphora harveyi*, *Cussonia spicata*, *Elaeodendron croceum*, *Encephalartos altensteinii*, *E. latifrons*, *E. trispinosus*, *Maytenus undata*, *Pappea capensis*, *Ptaeroxylon obliquum*, *Schotia latifolia*, *Sideroxylon inerme*. Tall Shrubs: *Azima tetracantha* (d), *Croton rivularis* (d), *Gymnosporia polyacantha* (d), *Scutia myrtina* (d), *Acokanthera oppositifolia*, *Allophylus decipiens*, *Calpurnia aurea*, *Carissa bispinosa* subsp. *bispinosa*, *Clausena anisata*, *Coddia rudis*, *Ehretia rigida*,

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Figure 10.12 AT 8 Kowie Thicket: Dense *Euphorbia triangularis*-dominated thicket on slopes facing the Settlers Dam in the Thomas Baines Nature Reserve (near Grahamstown, Eastern Cape).

Euclea undulata, *Flueggea verrucosa*, *Grewia occidentalis*, *Gymnosporia capitata*, *G. heterophylla*, *Hippobromus pauciflorus*, *Maerua cafra*, *Mystroxylon aethiopicum*, *Olea europaea* subsp. *africana*, *Putterlickia pyracantha*, *Rhus longispina*, *R. lucida*, *R. pyroides* var. *gracilis*, *R. refracta*, *Scolopia zeyheri*. Low Shrubs: *Asparagus striatus*, *A. subulatus*, *Chrysocoma ciliata*, *Galenia secunda*, *Hermannia althaeoides*, *Leonotis ocymifolia*, *Limeum aethiopicum*, *Pavonia praemorsa*, *Pelargonium odoratissimum*, *Polygala myrtifolia*, *Pteronia incana*, *Selago fruticosa*, *Senecio linifolius*, *Solanum rigescens*. Succulent Shrubs: *Aloe arborescens* (d), *Crassula cultrata* (d), *Portulacaria afra* (d), *Aptenia cordifolia*, *Bergeranthus scapiger*, *Cotyledon orbiculata* var. *oblonga*, *C. velutina*, *Crassula muscosa*, *C. tetragona* subsp. *acutifolia*, *Delosperma ecklonis*, *Euphorbia kraussiana*, *Exomis microphylla* var. *axyrioides*, *Kalanchoe rotundifolia*, *Mestoklema tuberosum*, *Senecio oxyodontus*. Semiparasitic Epiphytic Shrubs: *Viscum obscurum*, *V. rotundifolium*. Woody Succulent Climbers: *Pelargonium peltatum* (d), *Sarcostemma viminale* (d), *Aloe ciliaris*, *Crassula perforata*, *Senecio macroglossus*. Woody Climbers: *Capparis sepiaria* var. *citrifolia* (d), *Plumbago auriculata* (d), *Asparagus aethiopicus*, *A. multiflorus*, *A. racemosus*, *Dalechampia capensis*, *Ficus burttdavyi*, *Jasminum angulare*, *Rhoiacarpos capensis*, *Rhoicissus digitata*, *Secamone filiformis*. Herbaceous Climbers: *Acharia tragodes*, *Cynanchum ellipticum*, *Cyphia sylvatica*, *Didymodoxa caffra*, *Senecio deltoideus*. Graminoids: *Cynodon dactylon* (d), *C. incompletus* (d), *Cyperus albostriatus* (d), *Ehrharta erecta* (d), *Eragrostis curvula* (d), *Karroochloa curva* (d), *Panicum deustum* (d), *Setaria sphacelata* (d), *Sporobolus fimbriatus* (d), *Themeda triandra* (d), *Cyperus textilis*, *Eragrostis obtusa*, *Melica racemosa*, *Panicum maximum*. Megaherb: *Dracaena aletriformis*. Succulent Herbs: *Plectranthus grandidentatus* (d), *Crassula expansa, Gasteria bicolor*, *Plectranthus madagascariensis*, *P. verticillatus, Senecio radicans*. Geophytic Herbs: *Sansevieria aethiopica* (d), *S. hyacinthoides* (d), *Asplenium cordatum*, *Bulbine frutescens*, *Cheilanthes hirta*, *Strelitzia reginae, Veltheimia bracteata*. Herbs: *Achyranthes aspera* (d), *Commelina benghalensis* (d), *Hypoestes aristata* (d), *Leidesia procumbens* (d), *Abutilon sonneratianum*, *Centella asiatica*, *Commelina africana*, *Conyza scabrida*, *Ecbolium flanaganii*, *Emex australis*, *Lepidium africanum*, *Phyllopodium cuneifolium*, *Senecio burchellii*, *Sida ternata*, *Tetragonia microptera*, *Troglophyton capillaceum*.

Endemic Taxa Succulent Herb: *Faucaria nemorosa*. Geophytic Herb: *Albuca crudenii*. Herb: *Wahlenbergia kowiensis.*

Conservation Least threatened. Target 19%. A total of 5% of this vegetation unit is protected in various statutory reserves, including the Water's Meeting, Kowie, Cycad, Blaauwkrantz, Kap River Nature Reserves. A further 14% is conserved in private conservation areas such as game ranches (Shamwari, Emlanjeni, Amakhala, Fourie Safaris, Hunters Lodge, Elephant Park and Schotia Safaris) and in the Aylesbury Nature Reserve. Transformation 7%, mainly by cultivation. Erosion is moderate to very low.

Remarks This is bioclimatically the core of the Albany Thicket Biome and the major floristic node of the Albany Centre of Endemism. It is located adjacent to a wide variety of other vegetation types, including Zuurberg Quartzite Fynbos, Zuurberg Shale Fynbos, Southern Coastal Forest, Albany Coastal Belt, Albany Broken Veld, Great Fish Noorsveld and Eastern Cape Thornveld. This indicates the varying floristic influences on this vegetation and many species from different vegetation types may co-occur along these overlapping areas.

References Dyer (1937), Acocks (1953, 1988), Vlok & Euston-Brown (2002), Vlok et al. (2003), Kamineth (2004).

AT 9 Albany Coastal Belt

VT 1 Coastal Forest and Thornveld (29%), VT 2 Alexandria Forest (29%) (Acocks 1953). Valley Bushveld (73%) (Moll & Bossi 1984). LR 16 Eastern Thorn Bushveld (33%), LR 48 Coastal Grassland (21%) (Low & Rebelo 1996, 1998). STEP Berlin Savanna Thicket (22%), STEP Grahamstown Grassland Thicket (14%), STEP Hamburg Dune Thicket (11%), STEP Paterson Savanna Thicket (7%) (Vlok & Euston-Brown 2002).

Distribution Eastern Cape Province: Within 15 km (sometimes up to 30 km) of the Indian Ocean coastline, from Kei Mouth to the Sundays River, interrupted by many valleys. Altitude 10–400 m.

Vegetation & Landscape Features On the gently to moderately undulating landscapes and dissected hilltop slopes close to the coast, dominated by short grasslands punctuated by scattered bush clumps or solitary *Acacia natalitia* trees.

Geology & Soils The area covered by this unit is geologically complex and includes Beaufort Group mudstone and sandstone in the northeast, Nanaga Formation arenite and sand in the west and Bokkeveld, Witteberg and Ecca sandstone and shale in between, and a thin strip of Quaternary sand along the coast. The pure grasslands are limited to the Nanaga and Quaternary sands, whereas thornveld is prominent on the more finely textured soils derived from the Beaufort and Bokkeveld mudstone, arenite and shale. The most important land types include Db, Fa and Ae.

Climate In general the climate is ameliorated by the proximity to the coast. MAP ranges from 450 mm inland in the southwest to 900 mm in the northeast, and decreases slightly from the coast inland. The rainfall is nonseasonal with optima in March and October/November, but summer rainfall increases with distance northeastwards. The coefficient of variation in rainfall is 31% in the southwest inland areas, decreasing to 21% in the extreme northeasterly parts. There is a strong rainfall gradient across this unit, with higher rainfall further northeast, which influences species composition, with more subtropical elements up the coast and more drought-tolerant elements farther west. There is little variation in temperature from season to season and frost occurs on average for only 3 days a year in the inland sites and never at the coast. Mean monthly maximum and minimum temperatures for East London are 32.3°C and 5.3°C for March and July, respectively. See also climate diagram for AT 9 Albany Coastal Belt (Figure 10.4).

Important Taxa Tall Tree: *Erythrina caffra*. Succulent Tree: *Euphorbia triangularis*. Small Trees: *Acacia natalitia* (d), *Brachylaena elliptica*, *Canthium spinosum*, *Cussonia spicata*, *Ficus sur*, *Ochna arborea*, *Sideroxylon inerme*, *Zanthoxylum capense*. Tall Shrubs: *Clausena anisata*, *Clerodendrum glabrum*, *Coddia rudis*, *Croton rivularis*, *Diospyros villosa* var. *parvifolia*, *Grewia occidentalis*, *Gymnosporia heterophylla*, *Hippobromus pauciflorus*, *Mystroxylon aethiopicum*, *Pavetta lanceolata*, *Psydrax obovata*, *Pterocelastrus tricuspidatus*, *Rhus lucida*, *Scutia myrtina*, *Tarchonanthus camphoratus*, *Turraea obtusifolia*. Low Shrubs: *Rhynchosia ciliata* (d), *Carissa bispinosa* subsp. *bispinosa*, *Chaetacanthus setiger*, *Helichrysum asperum* var. *albidulum*, *Pelargonium alchemilloides*, *Phyllanthus maderaspatensis*, *Selago corymbosa*, *Senecio pterophorus*, *Tephrosia capensis* var. *acutifolia*. Semiparasitic Epiphytic Shrub: *Viscum obscurum*. Woody Succulent Climbers: *Crassula pellucida* subsp. *marginalis*, *Sarcostemma viminale*. Woody Climbers: *Asparagus aethiopicus*, *A. racemosus*, *Capparis sepiaria* var. *citrifolia*, *Clematis brachiata*, *Rhoiacarpos capensis*, *Rhoicissus digitata*, *R. tridentata*, *Secamone alpini*, *Tecoma capensis*. Herbaceous Climbers: *Rhynchosia caribaea*, *R. totta, Thunbergia capensis*, *Zehneria*

scabra. Graminoids: *Brachiaria serrata* (d), *Cynodon dactylon* (d), *Dactyloctenium australe* (d), *Digitaria natalensis* (d), *Ehrharta calycina* (d), *Eragrostis capensis* (d), *E. curvula* (d), *E. plana* (d), *Heteropogon contortus* (d), *Panicum deustum* (d), *P. maximum* (d), *Setaria sphacelata* (d), *Sporobolus africanus* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Cymbopogon marginatus*, *Ehrharta erecta*, *Elionurus muticus*, *Melica racemosa*, *Setaria megaphylla*, *Trachypogon spicatus*. Succulent Herb: *Plectranthus verticillatus* (d). Geophytic Herbs: *Cheilanthes hirta*, *Moraea pallida*, *Oxalis smithiana, Sansevieria hyacinthoides*, *Strelitzia reginae*. Herbs: *Chamaecrista mimosoides* (d), *Abutilon sonneratianum*, *Acalypha ecklonii*, *Centella asiatica*, *Commelina africana*, *C. benghalensis*, *Cynoglossum hispidum*, *Eriosema squarrosum*, *Lactuca inermis*, *Lobelia erinus*, *Monsonia emarginata*, *Phyllopodium cuneifolium*, *Senecio burchellii*, *Sonchus dregeanus*.

Endemic Taxa Succulent Shrub: *Bergeranthus concavus*. Succulent Herbs: *Brachystelma franksiae* var. *grandiflorum, Bulbine frutescens* var. nov. *('chalumnensis'* Baijnath ined.), *Faucaria subintegra*, *Haworthia coarctata* var. *tenuis*, *H. cooperi* var. *venusta*, *H. reinwardtii* var. *reinwardtii f. chalumnensis*, *Stapelia praetermissa* var. *luteola*, *S. praetermissa* var. *praetermissa*. Geophytic Herbs: *Bobartia gracilis, Apodolirion amyanum*, *Aspidoglossum flanaganii*, *Drimia chalumnensis*. Low Shrub: *Acmadenia kiwanensis*. Herb: *Monsonia galpinii.*

Conservation Least threatened. Target 19%. Only 1% of this vegetation unit is protected in 20 local-authority and provincial nature reserves as well as in the Greater Addo Elephant National Park (including Alexandria Coast Reserve West) as well as in number of private conservation areas. About 12% of the Albany Coastal Belt has recently been altered by cultivation, 1% by plantation forestry and 4% by urbanisation. According to land-cover data, at least 7% consists of degraded vegetation. It is difficult, however, to determine the proportion of the vegetation that is in a secondary state, since land-cover data do not distinguish between primary and secondary vegetation. Erosion is very low to moderate.

Remarks The seaboard region that contains this unit is a mosaic of a wide variety of structural vegetation types, ranging from grassland to forest. This variation reflects post-disturbance succession gradients as well as natural variation in geology, soil patterns and distribution of water in the landscape. The forests of the region have been mapped as different vegetation units (see Chapter on Forests in this book). Admittedly, this vegetation unit exemplifies a deviation from our mapping philosophy by featuring current-state rather than potential vegetation. We assume that the current vegetation mosaic so typical of the Albany Coastal Belt is a creation of man and the original (pre-settlement) vegetation was dominated by nonseasonal, dense thicket. The area of this unit was prime agricultural land which attracted early settlers who, presumably, cleared the dense thicket cloak for pastures.

References Acocks (1953, 1988), Judd (2001), Vlok & Euston-Brown (2002), Vlok et al. (2003).

AT 10 Great Fish Noorsveld

VT 23 Valley Bushveld (100%) (Acocks 1953). Valley Bushveld (94%) (Moll & Bossi 1984). LR 6 Xeric Succulent Thicket (84%) (Low & Rebelo 1996, 1998). STEP Fish Noorsveld (100%) (Vlok & Euston-Brown 2002).

Distribution Eastern Cape Province: One large patch surrounded mainly by Great Fish Thicket in the valley of the Great Fish River (north of Grahamstown) and spans a broad band from around Pigott's (Carlisle) Bridge in the west to around Committees Drift in the east, as well as unmapped patches in the Ecca Pass and its surroundings. Altitude 100–500 m.

Vegetation & Landscape Features Prevalent on plateaus and mildly sloping flanks of ridges supporting succulent thicket of low to medium height dominated by the local endemic *Euphorbia bothae* (a hybrid crowd) as well as other *Euphorbia* species intermixed with sclerophyllous bush clumps (*Euclea, Grewia, Gymnosporia, Putterlickia, Schotia*), groups of succulent shrubs (*Crassula, Cotyledon, Pelargonium*), patches of rhizomatous herbs (*Sansevieria hyacinthoides, Strelitzia reginae*) and accompanied by species-rich grass flora. *Portulacaria afra* is dominant on rocky outcrops.

Geology & Soil Mostly finely laminated clastic sediments of the Ecca Group (particularly the Fort Brown Formation) supporting skeletal shallow soils (Glenrosa and Mispah). Fc is the overwhelmingly dominant land type, Fb only of minor importance.

Climate Nonseasonal rainfall with optima in March and October/November. MAP ranges from about 360 mm to 500 mm, with the higher rainfall generally in the central parts. The incidence of frost is 3 days per annum, varying little across the range of the unit, except in the extreme eastern part where no frost occurs. Mean monthly maximum and minimum temperatures for Tyefu weather station are 39.6°C and 2.1°C for January and July, respectively. See also climate diagram for AT 10 Great Fish Noorsveld (Figure 10.4).

Important Taxa Succulent Trees: *Aloe africana*, *A. ferox*. Small Trees: *Schotia afra* var. *afra* (d), *Acacia natalitia*, *Boscia albitrunca*,

L. Mucina

Figure 10.13 AT 10 Great Fish Noorsveld: Stand of *Strelitzia reginae* (Strelitziaceae) in Noorsveld near Ecca Pass (north of Grahamstown, Eastern Cape). The low succulent is *Euphorbia x bothae,* an endemic taxon to this vegetation unit.

Cussonia spicata, *Pappea capensis*, *Ptaeroxylon obliquum*. Tall Shrubs: *Azima tetracantha* (d), *Grewia robusta* (d), *Brachylaena ilicifolia*, *Cadaba aphylla*, *Ehretia rigida*, *Euclea undulata*, *Gymnosporia capitata*, *Lantana rugosa*, *Rhigozum obovatum*. Low Shrubs: *Asparagus striatus*, *A. subulatus*, *Ballota africana*, *Becium burchellianum*, *Chrysocoma ciliata*, *Garuleum latifolium*, *Hermannia althaeoides*, *Indigofera sessilifolia*, *Jatropha capensis*, *Leucas capensis*, *Limeum aethiopicum*, *Phyllanthus maderaspatensis*, *Pteronia incana*, *Selago fruticosa*, *Senecio linifolius*, *S. pterophorus*, *Solanum tomentosum*. Succulent Shrubs: *Cotyledon orbiculata* var. *oblonga* (d), *Mestoklema tuberosum* (d), *Portulacaria afra* (d), *Crassula nudicaulis*, *C. tetragona* subsp. *acutifolia*, *Euphorbia mauritanica*, *E. pentagona*, *E. rectirama*, *Kalanchoe rotundifolia*, *Orthopterum waltoniae*, *Pachypodium succulentum*. Semiparasitic Shrub: *Thesium lineatum*. Semiparasitic Epiphytic Shrub: *Viscum rotundifolium.* Woody Succulent Climbers: *Crassula perforata*, *Cyphostemma quinatum*. Woody Climbers: *Asparagus racemosus* (d), *A. multiflorus*, *Rhoicissus digitata*. Graminoids: *Aristida congesta* (d), *Cynodon dactylon* (d), *Cyperus bellus* (d), *Digitaria argyrograpta* (d), *Panicum deustum* (d), *Paspalum distichum* (d), *Sporobolus fimbriatus* (d), *S. nitens* (d), *Tragus koelerioides* (d), *Chloris virgata*, *Cymbopogon pospischilii*, *Cynodon incompletus*, *Ehrharta erecta*, *Eragrostis chloromelas*, *E. curvula*, *E. lehmanniana*, *E. obtusa*, *Karroochloa curva*, *Leptochloa fusca*, *Microchloa caffra*, *Oropetium capense*, *Panicum coloratum*, *P. gilvum*, *P. maximum*, *P. stapfianum*, *Themeda triandra*. Succulent Herb: *Crassula expansa* (d), *C. muscosa*, *Mesembryanthemum aitonis*, *Senecio radicans*. Geophytic Herbs: *Sansevieria hyacinthoides* (d), *Strelitzia reginae* (d), *Bulbine asphodeloides*, *B. narcissifolia*, *Cyrtanthus smithiae*. Herbs: *Aizoon glinoides*, *Amellus strigosus* subsp. *pseudoscabridus*, *Atriplex suberecta*, *Commelina africana*, *Dolichos hastaeformis*, *Lepidium africanum*, *Pharnaceum dichotomum*, *Salvia stenophylla*.

Biogeographically Important Taxon Geophytic Herb: *Drimia acarophylla* (shared with Great Fish Thicket).

Endemic Taxon Succulent Shrub: *Euphorbia* x *bothae* (d).

Conservation Least threatened. Target 19%. Good examples of the Great Fish Noorsveld are conserved in a series of statutory nature reserves around and north of the Ecca Pass. A total of about 3% of the vegetation is in the Great Fish River Complex Nature Reserve, which includes the Andries Vosloo Nature Reserve. An additional 31% is conserved in several large-scale private reserves and game farms, mainly the Kwande Private Game Reserve. Great Fish Noorsveld has been relatively little transformed: only about 3% by cultivation. Erosion is moderate to high. This vegetation type contains the largest wild populations of the famous *Strelitzia reginae*—a flagship plant of South Africa.

References Palmer (1981), Palmer et al. (1988), Vlok & Euston-Brown (2002), Brink & Dold (2003), Vlok et al. (2003).

AT 11 Great Fish Thicket

VT 23 Valley Bushveld (38%), VT 37 False Karroid Broken Veld (30%) (Acocks 1953). LR 52 Eastern Mixed Nama Karoo (26%), LR 6 Xeric Succulent Thicket (19%), LR 16 Eastern Thorn Bushveld (17%) (Low & Rebelo 1996, 1998). STEP Fish Spekboom Thicket (42%), STEP Hartebeest Karroid Thicket (24%) (Vlok & Euston-Brown 2002).

Distribution Eastern Cape Province: Mainly in the lower Great Fish River and Keiskamma River Valleys (including the smaller intervening river valleys nearer the coast) extending up the Great Fish River Valley northwards to Cookhouse and into the southernmost part of the Cradock District. Extending up the Keiskamma River Valley as far as its confluence with the Tyume River. Also includes the lower reaches of the Koonap River and part of its upper reaches immediately north of Adelaide, as well as parts of the Kat River and Little Fish River Valleys. Altitude 0–1 000 m.

Vegetation & Landscape Features Steep slopes of deeply dissected rivers supporting short, medium and tall thicket types (Palmer 1981, Palmer et al. 1988, Evans et al. 1997), where both the woody trees and shrubs and the succulent component are well developed, with many spinescent shrubs. *Portulacaria afra* is locally dominant, decreasing in relative abundance and is replaced by *Euphorbia bothae* with increasing aridity. With increasing moisture status on southern aspects and in the riparian zone, *P. afra* is replaced by woody elements and tall emergent *Euphorbia tetragona* and *E. triangularis*. There is distinct clumping of the vegetation, which is linked to zoogenic mounds, formed principally by termites (*Microhodotermes viator*), earthworms (*Microchaetus*), mole rats (*Cryptomus hottentotus*) and aardvarks (*Orycteropus afer*)—these islands of concentrated nutrients and moisture have richer, deep soils and are often occupied by long-lived woody shrubs and trees such as *Pappea capensis* and *Boscia oleoides* and provide deep soils for endemic geophytes. The closed canopy of the *Portulacaria afra*-dominated thicket is another distinctive feature of parts of the Great Fish Thicket. There is high heterogeneity within this vegetation unit, which has been divided into nine distinct subtypes (Vlok & Euston-Brown 2002).

Geology & Soils Mostly on shallow (<1 m) clay soils (Glenrosa and Mispah) derived from the Adelaide and Estcourt Formations (Beaufort Group, Karoo Supergroup) mudstone and arenite. Half of the area falls within the Fc land type, with Fb the only other one of some importance.

Climate Nonseasonal rainfall with slight optima in March and October/November. MAP ranges from about 300 mm in the western inland areas to 600 mm in the eastern coastal areas. The coefficient of variation in MAP is 32%, but varies from 29% at the coast to 36% inland. The mean daily maximum temperatures for January are 26°C at the coast and 30°C inland and the mean daily minimum temperatures for July are 0°C inland and 9°C at the coast. The incidence of frost is 3 days, but ranging widely from 0 days at the coast to more than 60 days in the upper reaches of the river valley. See also climate diagram for AT 11 Great Fish Thicket (Figure 10.4).

Important Taxa Succulent Trees: *Euphorbia triangularis* (d), *Aloe ferox*, *Euphorbia tetragona*. Small Trees: *Pappea capensis* (d), *Acacia natalitia*, *Boscia albitrunca*, *Brachylaena ilicifolia*, *Cussonia spicata*, *Ozoroa mucronata*, *Ptaeroxylon obliquum*, *Schotia afra* var. *afra*, *Zanthoxylum capense*. Tall Shrubs: *Euclea undulata* (d), *Allophylus decipiens*, *Azima tetracantha*, *Carissa bispinosa* subsp. *bispinosa*, *Coddia rudis*, *Diospyros scabrida* var. *cordata*, *Ehretia rigida*, *Flueggea verrucosa*, *Grewia occidentalis*, *G. robusta*, *Gymnosporia capitata*, *G. heterophylla*, *Hippobromus pauciflorus*, *Mystroxylon aethiopicum*, *Olea europaea* subsp. *africana*, *Putterlickia pyracantha*, *Rhus incisa*, *R. refracta*, *Scolopia zeyheri*, *Scutia myrtina*. Low Shrubs: *Asparagus striatus* (d), *Chaetacanthus setiger* (d), *Chrysocoma ciliata* (d), *Asparagus subulatus*, *Felicia muricata*, *Hermannia althaeoides*, *Indigofera sessilifolia*, *Leucas capensis*, *Limeum aethiopicum*, *Lycium cinereum*, *Phyllanthus maderaspatensis*, *Selago fruticosa*. Succulent Shrubs: *Crassula cordata* (d), *C. ovata* (d), *Portulacaria afra* (d), *Aloe tenuior*, *Delosperma ecklonis*, *Kalanchoe rotundifolia*, *Mestoklema tuberosum*, *Tetradenia barberae*. Semiparasitic Epiphytic Shrub: *Viscum rotundifolium.* Woody Succulent Climbers: *Crassula perforata*,

A.I. Kamineth

Figure 10.14 AT 11 Great Fish Thicket: Valley slopes clad in dense succulent thicket in the Sam Knott Nature Reserve (near Grahamstown, Eastern Cape).

Cyphostemma quinatum, *Pelargonium peltatum*, *Sarcostemma viminale*. Woody Climbers: *Asparagus multiflorus*, *A. racemosus*, *Capparis sepiaria* var. *citrifolia*, *Jasminum angulare*, *Plumbago auriculata*, *Rhoicissus digitata*. Graminoids: *Aristida congesta* (d), *Cynodon incompletus* (d), *Digitaria eriantha* (d), *Ehrharta erecta* (d), *Eragrostis obtusa* (d), *Panicum deustum* (d), *P. maximum* (d), *P. stapfianum* (d), *Setaria sphacelata* (d), *Sporobolus fimbriatus* (d), *S. nitens* (d), *Themeda triandra* (d), *Tragus berteronianus* (d), *T. koelerioides* (d), *Cymbopogon pospischilii*, *Eragrostis chloromelas*, *E. curvula*, *Eustachys paspaloides*. Herbs: *Cyanotis speciosa* (d), *Hypoestes aristata* (d), *Salvia scabra* (d), *Abutilon sonneratianum*, *Aizoon glinoides*, *Hibiscus pusillus*, *Lepidium africanum*, *Sida ternata*. Succulent Herbs: *Crassula expansa* (d), *Senecio radicans*. Geophytic Herb: *Sansevieria hyacinthoides* (d).

Endemic Taxa Succulent Shrub: *Euphorbia cumulata*. Low Shrub: *Euryops gracilipes*. Succulent Herbs: *Haworthia angustifolia* var. *paucifolia*, *H. cummingii*, *H. cymbiformis* var. *incurvula*, *H. cymbiformis* var. *ramosa*. Herb: *Zaluzianskya vallispiscis.*

Conservation Least threatened. Target 19%. A total of 6% of this vegetation unit is protected in seven statutory reserves, especially in the Great Fish River Complex Nature Reserve and 4.5% in addition in at least nine private conservation areas. Great Fish Thicket has not been radically altered, only 3% by cultivation and 1% by urbanisation. Erosion is very variable, from high to low.

Remarks This is the easternmost vegetation unit assigned to the Albany Thicket Biome, except for Buffels Thicket that only occurs near the coast. The climate in these deep, wide river valleys is hotter and dryer than the surrounding countryside and the area covered by this vegetation unit may constitute an effective physical barrier to species migration in an east-west direction through this region. The vegetation unit also marks the transition between more concentrated summer rainfall and nonseasonal rainfall. The northeastern side of this vegetation unit is marked by the east-west-running Amathole-Winterberg mountain ranges (with its band of Eastern Cape Escarpment Thicket), further enhancing the barrier nature of this area.

References Acocks (1953, 1988), Palmer (1981), Cowling (1984), Everard (1987), Palmer et al. (1988), La Cock (1992), Stuart-Hill (1992), Stuart-Hill & Aucamp (1993), Evans et al. (1997), Lloyd et al. (2002), Vlok & Euston-Brown (2002), Vlok et al. (2003), Kamineth (2004).

AT 12 Buffels Thicket

VT 1 Coastal Forest and Thornveld (40%), VT 23 Valley Bushveld (39%) (Acocks 1953). LR 48 Coastal Grassland (31%), LR 5 Valley Thicket (30%) (Low & Rebelo 1996). STEP Mountcoke Grassland Thicket (45%), STEP Buffels Thicket (32%) (Vlok & Euston-Brown 2002).

Distribution Eastern Cape Province: In river valleys centred around East London, including the Tyolomnqa River, Buffalo River, Nahoon River, Gqunube River, Kwelera River and stretching between 40 and 50 km inland (including some areas around King William's Town and Komga), and a small area in the Great Kei River Valley between about 10 and 20 km from the coast. It also occurs in the valley bottom in Keiskammahoek north of Dimbaza. Altitude 0–700 m.

Vegetation & Landscape Features Steep slopes of river valleys in highly dissected hills and moderately undulating plains, where short, dense and tangled thicket stands reach up to 10 m. The dense thicket grades into more open, shorter thornveld at the edges of the valley slopes.

Geology & Soils Mudstones and sandstones derived from the Beaufort Group of the Karoo Supergroup as well as Jurassic Dolerite Suite intrusions. The shallow soils (Glenrosa and Mispah) derived from these rocks are fine-grained, nutrient-poor silts, but the presence of forests leads to the development of humus-rich, deep soils. Half of the area is classified as Fa land type, while Fb and Bd are of subordinate importance.

Climate Mild climate with few extremes, ameliorated by the close proximity of the Indian Ocean. Rainfall is 500–840 mm per year, and has a coefficient of variation of 22–29%, the higher coefficients occurring in the more inland, less steep sites. The rainfall occurs in spring and early to midsummer, but typically of the Eastern Cape it may occur at any time of the year. Mean monthly maximum and minimum temperatures for East London are 32.3°C and 5.3°C for March and July, respectively, with very little chance of frost. See also climate diagram for AT 12 Buffels Thicket (Figure 10.4).

Important Taxa Succulent Trees: *Euphorbia triangularis* (d), *Aloe ferox*, *Euphorbia grandidens*. Small Trees: *Acacia natalitia*, *Apodytes dimidiata*, *Brachylaena ilicifolia*, *Calodendrum capense*, *Canthium ciliatum*, *C. mundianum*, *Cussonia spicata*, *C. thyrsiflora*, *Dombeya tiliacea*, *Elaeodendron croceum*, *Eugenia zeyheri*, *Harpephyllum caffrum*, *Heteromorpha arborescens*, *Ochna arborea*, *Pappea capensis*, *Ptaeroxylon obliquum*, *Schotia afra* var. *afra*, *S. latifolia*, *Sideroxylon inerme*, *Trimeria trinervis*, *Vepris lanceolata*, *Zanthoxylum capense*, *Ziziphus mucronata*. Tall Shrubs: *Allophylus decipiens* (d), *Azima tetracantha* (d), *Scutia myrtina* (d), *Suregada africana* (d), *Acalypha glabrata*, *Acokanthera oppositifolia*, *Allophylus melanocarpus*, *Buddleja dysophylla*, *Carissa bispinosa* subsp. *bispinosa*, *Chaetacme aristata*, *Chrysanthemoides monilifera*, *Clerodendrum glabrum*, *Coddia rudis*, *Croton rivularis*, *Diospyros scabrida* var. *cordata*, *D. simii*, *D. villosa* var. *parvifolia*, *Ehretia rigida*, *Euclea natalensis*, *E. undulata*, *Grewia occidentalis*, *Gymnosporia buxifolia*, *G. heterophylla*, *G. nemorosa*, *Hippobromus pauciflorus*, *Maytenus acuminata*, *Mystroxylon aethiopicum*, *Olea*

europaea subsp. *africana*, *Pavetta lanceolata*, *Putterlickia pyracantha*, *P. verrucosa*, *Rhus gueinzii*, *R. lucida*, *Scolopia zeyheri*. Low Shrubs: *Pavonia praemorsa* (d), *Senecio pterophorus* (d), *Euphorbia kraussiana*, *Lauridia tetragona*, *Lippia javanica*, *Lycium cinereum*, *Rubus rigidus*, *Solanum rigescens*. Succulent Shrubs: *Aptenia cordifolia* (d), *Exomis microphylla* var. *axyrioides*, *Senecio oxyodontus*. Woody Succulent Climbers: *Cyphostemma quinatum*, *Sarcostemma viminale*. Woody Climbers: *Rhoicissus digitata* (d), *Asparagus aethiopicus*, *A. racemosus*, *Capparis sepiaria* var. *citrifolia*, *Dalbergia obovata*, *Jasminum angulare*, *Plumbago auriculata*, *Rhoicissus tomentosa*, *R. tridentata*, *Secamone alpini*, *Tecoma capensis*, *Uvaria caffra*. Graminoids: *Cynodon dactylon* (d), *Cyperus albostriatus* (d), *C. textilis* (d), *Digitaria argyrograpta* (d), *D. natalensis* (d), *Ehrharta erecta* (d), *Microchloa caffra* (d), *Panicum deustum* (d), *P. maximum* (d), *Schoenoxiphium sparteum* (d), *Setaria megaphylla* (d), *S. sphacelata* (d), *Paspalum dilatatum*. Herbaceous Climbers: *Senecio deltoideus* (d), *Coccinia quinqueloba*, *Cynanchum ellipticum*, *Helinus integrifolius*. Succulent Herbs: *Sansevieria hyacinthoides* (d), *Plectranthus grandidentatus*. Geophytic Herbs: *Moraea pallida*, *Ornithogalum longibracteatum*, *Cheilanthes hirta*. Herbs: *Commelina benghalensis* (d), *Conyza scabrida* (d), *Galopina circaeoides* (d), *Hypoestes aristata* (d), *Abutilon sonneratianum*, *Sida ternata.*

Endemic Taxon Woody Succulent Climber: *Ceropegia radicans* subsp. *smithii.*

Conservation Vulnerable. Target 19%. About 1% is protected in statutory reserves (Umtiza, Bridle Drift, Fort Pato, Nahoon, Bluebend, King William's Town Nature Reserves) and in addition 0.7% in private nature conservation areas. Transformation 21%, mainly by cultivation, urban and built up areas, and plantations. At least 15% consists of vegetation in a degraded state. Erosion very low to moderate.

References Acocks (1953, 1988), Low & Rebelo (1996), Vlok & Euston-Brown (2002), Vlok et al. (2003), Kamineth (2004).

AT 13 Eastern Cape Escarpment Thicket

VT 21 False Thornveld of Eastern Province (34%), VT 23 Valley Bushveld (20%) (Acocks 1953). LR 52 Eastern Mixed Nama Karoo (26%), LR 15 Subarid Thorn Bushveld (23%), LR 5 Valley Thicket (20%) (Low & Rebelo 1996, 1998). STEP Escarpment Thicket (74%) (Vlok & Euston-Brown 2002).

Distribution Eastern Cape Province: At the southern foot of the steep escarpment slopes of the Amathole, Winterberg and Swaershoek Mountains from the western flank of the Keiskammahoek District to just west of Somerset East as well as on the foothills of mountains and on hills in the mountainous regions centred within a radius of 25–35 km south and west of Cradock. Altitude 450–1 250 m.

Vegetation & Landscape Features Steeply sloping escarpment and mountain slopes, hills and lowlands of the region where it forms a medium high, semi-open to closed thicket dominated by *Olea europaea* subsp. *africana* and *Acacia natalitia* 3–7 m tall, grading into thornveld lower down and often into escarpment forest higher up the slopes.

Geology & Soils Mudstones and arenite of the Adelaide Subgroup of the Karoo Supergroup as well as Jurassic dolerite intrusions. The soils derived from these rocks are fine-grained, nutrient-poor silts or more nutrient-rich red clays. Soils are often shallow, on moderate to steep slopes and the surface rock cover is high. The major land types are Fc as well as Ib and Fb.

Climate Nonseasonal rainfall with optima in March and November, with February and March being the maximum months. MAP ranges from about 400–700 mm per annum on the southern side of the escarpment and from 310–400 mm per annum on the northern side around Cradock, increasing with elevation. The coefficient of variation in MAP is 25–35%, increasing with decreasing amounts of rainfall. The incidence of frost is 16 days, but ranging widely from fewer than 5 days to more than 35 days of frost per year, the areas with more frost occurring higher up the escarpment slopes where snow may occur in winter. Mean monthly maximum and minimum temperatures for Somerset East are 38.6°C and –1.0°C for January and July, respectively. See also climate diagram for AT 13 Eastern Cape Escarpment Thicket (Figure 10.4).

Important Taxa Succulent Trees: *Aloe ferox*, *Euphorbia tetragona*. Small Trees: *Acacia karroo* (d), *Cussonia spicata*. Tall Shrubs: *Olea europaea* subsp. *africana* (d), *Scutia myrtina* (d), *Buddleja auriculata*, *Euclea crispa*, *E. undulata*, *Grewia occidentalis*, *Gymnosporia heterophylla*, *Hippobromus pauciflorus*, *Leucosidea sericea*, *Myrsine africana*, *Rhus dentata*, *R. lucida*, *R. tomentosa*, *Scolopia zeyheri*. Low Shrubs: *Anthospermum rigidum* subsp. *pumilum*, *Argyrolobium collinum*, *Asparagus striatus*, *Chaetacanthus setiger*, *Felicia filifolia*, *F. muricata*, *Hermannia althaeoides*, *Lantana rugosa*, *Pelargonium alchemilloides*, *Phyllanthus maderaspatensis*, *Polygala fruticosa*, *Selago corymbosa*, *Solanum rigescens*. Succulent Shrubs: *Bergeranthus artus*, *Crassula obovata*. Semiparasitic Epiphytic Shrub: *Viscum rotundifolium*. Woody Climbers: *Asparagus aethiopicus*, *Plumbago auriculata*. Herbaceous Climber: *Senecio deltoideus* (d). Graminoids: *Aristida congesta* (d), *Cynodon incompletus* (d), *Ehrharta calycina* (d), *E. erecta* (d), *Eragrostis chloromelas* (d), *E. curvula* (d), *Panicum maximum* (d), *Sporobolus fimbriatus* (d), *Tragus berteronianus* (d), *Aristida diffusa*, *A. junciformis* subsp. *junciformis*, *Cymbopogon marginatus*, *C. pospischilii*, *Cynodon dactylon*, *Eragrostis obtusa*, *Heteropogon contortus*, *Melica decumbens*, *Panicum deustum*, *P. stapfianum*, *Sporobolus africanus*. Succulent Herbs: *Stapelia glabricaulis*. Geophytic Herbs: *Drimia uniflora* (d), *Bulbine asphodeloides*, *B. narcissifolia*, *Drimia intricata*. Herbs: *Cyanotis speciosa* (d), *Amaranthus praetermissus*, *Blepharis integrifolia* var. *clarkei*, *Commelina africana*, *Dianthus caespitosus*, *Gerbera piloselloides*, *Hibiscus aethiopicus*, *H. pusillus*, *Hypoestes aristata*, *Senecio retrorsus*, *Sida ternata*.

Conservation Target 19%. Eastern Cape Escarpment Thicket has been permanently altered, with 3% through cultivation and 1% through urbanisation. A total of 5% of this vegetation unit is statutorily conserved in local-authority nature reserves (Bosberg), provincial nature reserves (primarily the Mpofu Game Reserve and Bush Nek Outspan) and in the Mountain Zebra National Park. A further about 2% is protected in private conservation areas. Erosion is very variable, from very low to high.

Remarks Close floristic relationship and similar structure to AT 14 Camdebo Escarpment Thicket to the west and Gs 17 Tarkastad Montane Shrubland to the north, and also grades into the more mesic Buffels Thicket to the east.

References Acocks (1953, 1988), Vlok & Euston-Brown (2002), Vlok et al. (2003), Brown & Bezuidenhout (2005).

AT 14 Camdebo Escarpment Thicket

VT 37 False Karroid Broken Veld (41%), VT 25 Succulent Mountain Scrub (Spekboomveld) (33%) (Acocks 1953). LR 54 Central Lower Nama Karoo (41%), LR 5 Valley Thicket (40%) (Low & Rebelo 1996, 1998). STEP Escarpment Spekboomveld (41%), STEP Escarpment Valley Thicket (22%) (Vlok & Euston-Brown 2002).

L. Mucina

Figure 10.15 AT 14 Camdebo Escarpment Thicket: *Crassula arborescens* (Crassulaceae) in succulent thicket in the Rooiberg east of Aberdeen (Eastern Cape).

Distribution Eastern Cape Province: South-sloping face of the Great Escarpment, forming an arc from Bruintjieshoogte in the east via the Coetzeeberg Mountains and Graaff-Reinet (including Spandaukop and the isolated Rooiberg) to Kamdebooberg and Aberdeen in the west. Altitude varies from 570–1 600 m, with most of the area between 700–1 200 m.

Vegetation & Landscape Features Occurs on the rugged, broken and steeply sloping escarpment and mountain slopes of the region where it forms a 2–3 m tall, largely succulent thicket of *Portulacaria afra*-dominated clumps. Heavy browsing by goats reduces or eliminates *P. afra* and low trees (*Pappea capensis* and *Boscia oleoides*) remain.

Geology & Soil Sandstone and mudstone of the Permian Adelaide Subgroup (Beaufort Group), interrupted in places by dykes of Jurassic Karoo dolerites. Shallow skeletal soils (varying in depth from 20–30 cm) of Mispah form, with organically rich orthic A-horizon, moderately acidic. Land types are Ib and Fc on shallow substrates and Da duplex soils on dolerite dykes.

Climate Nonseasonal rainfall with optima in March and November and with February and March being the maximum months. MAP ranges from about 270–550 mm, increasing with elevation. The incidence of frost is 25 days, but ranging widely from fewer than 8 days to more than 40 days of frost per year, the areas with more frost occurring higher up the escarpment slopes where snow may occur in winter. Mean monthly maximum and minimum temperatures for Graaff-Reinet are 38.6°C and –0.3°C for January and July, respectively. See also climate diagram for AT 14 Camdebo Escarpment Thicket (Figure 10.4).

Important Taxa Succulent Tree: *Aloe ferox*. Small Trees: *Acacia karroo* (d), *Pappea capensis* (d), *Boscia albitrunca*, *B. oleoides*, *Cussonia paniculata*, *C. spicata*, *Maytenus undata*, *Schotia afra* var. *afra*. Tall Shrubs: *Euclea undulata* (d), *Gymnosporia polyacantha* (d), *Buddleja glomerata*, *Cadaba aphylla*, *Carissa bispinosa* subsp. *bispinosa*, *Diospyros lycioides*, *D. pallens*, *Ehretia rigida*, *Grewia robusta*, *Gymnosporia capitata*, *G. heterophylla, Olea europaea* subsp. *africana*, *Rhus longispina*, *R. lucida*. Low Shrubs: *Blepharis mitrata* (d), *Chrysocoma ciliata* (d), *Lycium schizocalyx* (d), *Pentzia incana* (d), *Rhigozum obovatum* (d), *Aptosimum elongatum*, *Asparagus burchellii*, *A. mucronatus*, *A. striatus*, *A. suaveolens*, *Blepharis capensis*, *B. villosa*, *Eriocephalus ericoides*, *Felicia filifolia*, *F. muricata*, *Garuleum latifolium*, *Helichrysum dregeanum*, *H. zeyheri*, *Hermannia filifolia*, *Indigofera sessilifolia*, *Lantana rugosa*, *Lycium oxycarpum*, *Macledium spinosum*, *Monechma spartioides*, *Pegolettia retrofracta*, *Peliostomum origanoides*, *Rosenia humilis*, *Solanum capense*, *Sutera halimifolia*. Succulent Shrubs: *Portulacaria afra* (d), *Crassula ovata*, *C. rogersii*, *Euphorbia mauritanica*, *E. obesa*, *Kleinia longiflora*, *Mestoklema tuberosum*, *Pachypodium succulentum*, *Trichodiadema barbatum*. Semiparasitic Epiphytic Shrub: *Viscum rotundifolium*. Woody Succulent Climber: *Sarcostemma viminale*. Woody Climbers: *Asparagus racemosus*, *Cissampelos capensis*, *Dioscorea elephantipes*, *Rhoicissus digitata*, *R. tridentata*. Graminoids: *Aristida adscensionis* (d), *A. congesta* (d), *Cenchrus ciliaris* (d), *Digitaria eriantha* (d), *Enneapogon desvauxii* (d), *Eragrostis lehmanniana* (d), *E. obtusa* (d), *Heteropogon contortus* (d), *Aristida diffusa*, *Cynodon incompletus*, *Enneapogon scoparius*, *Eragrostis chloromelas*, *E. curvula*, *Eustachys paspaloides*, *Fingerhuthia africana*, *Panicum maximum*, *Sporobolus fimbriatus*, *Themeda triandra*, *Tragus berteronianus*, *T. koelerioides*. Succulent Herb: *Mesembryanthemum aitonis*. Geophytic Herbs: *Boophone disticha*, *Drimia anomala*, *D. intricata, Moraea polystachya*. Herbs: *Abutilon sonneratianum*, *Aizoon glinoides*, *A. rigidum*, *Asplenium cordatum*, *Cheilanthes deltoidea*, *Gazania krebsiana*, *Hermannia coccocarpa*, *H. comosa*, *H. pulverata*, *Hibiscus pusillus*, *Lepidium africanum*, *Pollichia campestris*, *Troglophyton capillaceum*.

Endemic Taxa Succulent Shrubs: *Astroloba corrugata*, *Bergeranthus* sp. nov. (*'nanus'* A.P. Dold ined.), *Delosperma karrooicum*, *Trichodiadema olivaceum*. Succulent Herb: *Haworthia marumiana* var. *batesiana, Huernia kennedyana*. Geophytic Herbs: *Apodolirion bolusii*, *Dierama grandiflorum.*

Conservation Least threatened. Target 19%. About 5% of this vegetation unit is statutorily protected in the Karoo Nature Reserve and a further 15% in private conservation areas (Samara Private Game Reserve, Asanta Sana Game Reserve, Rupert Game Farm, Buchanon Game Farm, Hoeksfontein Game Farm and Glen Harry Game Reserve). Camdebo Escarpment Thicket has been transformed by only about 1%, through cultivation, but this vegetation has been subjected to degradation through grazing by domestic goats in many places. It is likely that it extended further down the slopes in recent history. Clear fence-line contrasts can be recognised both by satellite imagery and in the field (Lloyd et al. 2002). Erosion is moderate to high.

Remarks The dominance of *Portulacaria afra* is the main link of this unit with the Albany Thicket Biome, as earlier classified (Palmer 1988, 1991a, b). The overall floristic composition suggests rather that this is a marginal Nama-Karoo unit whose thicket structure can be ascribed to special regional habitat conditions, in particular geomorphology and associated microclimate. *P. afra* is a facultative C_3/CAM plant, and its distribution may be linked to CAM being activated following the extreme daily variation in temperature and moisture (Guralnick & Ting 1987) as often experienced on these south-facing slopes. The

distribution of *P. afra*, an important indicator of this thicket, has been modelled using a correlative modelling approach (Robertson & Palmer 2002).

References Acocks (1953, 1988), Palmer (1988, 1989, 1991a, b), Lloyd et al. (2002), Robertson & Palmer (2002), Vlok & Euston-Brown (2002), Vlok et al. (2003).

9. Credits

The Albany Thicket region was mapped using original sources, including contributions of D.B. Hoare (eastern and western parts) and A.R. Palmer (portion of western part); much of the latter was replaced by a detailed unpublished STEP map (Vlok & Euston-Brown 2002). The STEP source (counting more than 100 mapping units) was simplified by M.C. Rutherford and L. Mucina (for the main key see Table 10.1) and many of the more marginal (edge) STEP units were reconciled with other sources. The delimitation of the AT units was also influenced by the delimitation of AZa 6, Gs 18, Gs 16, SVs 6 and SVs 7 (all D.B. Hoare) as well as by placement of the forest patches (so-called Forest Biome forest map; see also Credits in the chapter on Forests). A.P. Dold contributed considerably to the species lists, Albany endemic species in particular. A.R. Palmer contributed to descriptions of units AT 2, 3, 11 and 14. D.B. Hoare contributed to the text of all mapping units except for AT 1. L. Mucina wrote AT 1 and contributed to the text of all other AT units. R.G. Lechmere-Oertel contributed to the text of AT 4 and 6; J.H.J. Vlok and D.I.W. Euston-Brown contributed to the text (list of species in particular) of AT 2 and 3.

The introductory text is the result of a joint effort by (in order of the volume of the contribution) D.B. Hoare (all major sections), A.R. Palmer (Sections 1, 2 and 3), R.G. Lechmere-Oertel (Sections 5 and 6), L. Mucina (sections 4.3 and 7) and Ş.M. Procheş (Section 4.1). The section 3.2 of the introductory text was shaped by A.R. Palmer and R.A. Ward. M.C. Rutherford considerably improved section 3.3. L.W. Powrie and M.C. Rutherford provided physico-geographical information extracted from various GIS sources for the descriptions and constructed the climate diagrams. The references were compiled and collated 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.

The STEP map and accompanying reports were kindly provided by the Terrestrial Ecology Unit, now of the Nelson Mandela Metropolitan University, Port Elizabeth (available at the website www.zoo.upe.ac.za/step). R.A. Ward corrected the geological terminology in the descriptions. Photographs were contributed by L. Mucina, D.B. Hoare, A.R. Palmer, Ş.M. Procheş and A.I. Kamineth.

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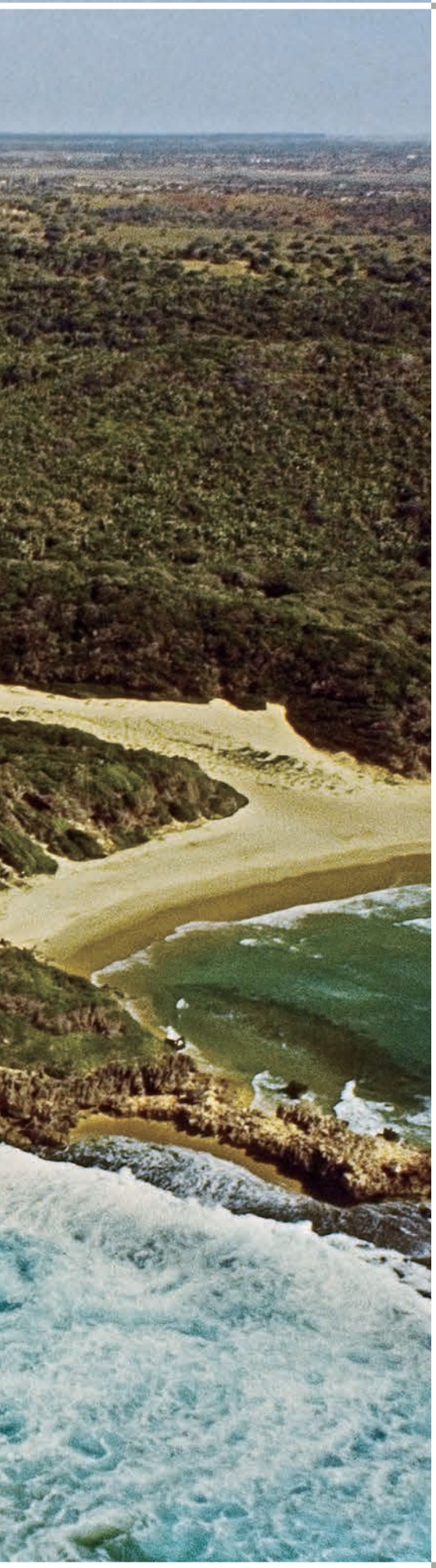

Indian Ocean Coastal Belt 11

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W.S. Matthews

1. Introduction

1.1 Position and Landscape Complexity

The region covers the seaboard in two provinces of South Africa—KwaZulu-Natal and the northern half of the Eastern Cape (in the latter part also known as the Wild Coast). This coastal belt in its subtropical facies extends also beyond the national borders into Mozambique as far as the Limpopo River mouth. It continues in strongly tropical facies further northwards into Tanzania, Kenya and southern Somalia (for approximate delimitation, consult Moll & White 1978: Figures 1 and 2). In South Africa it has been known as Coastal Belt (Bews 1920) or as Indian Ocean Coastal Belt (Moll & White 1978). It is the region, both for a biologist and a layman, where South Africa feels the breath of the Tropics the most.

The Indian Ocean Coastal Belt (IOCB) occurs as an almost 800 km long coastal strip between the South African border with Mozambique as far south as the mouth of the Great Kei River (near East London). It spans altitudes from 0–450 m (and higher up to 600 m in the Pondoland-Ugu Sandstone Coastal Sourveld). The landscapes of the IOCB are flat (Maputaland) or characterised by alternating rolling hills and deeply incised valleys (coastal stretch between Richards Bay and Port Edward in KwaZulu-Natal and then more markedly further south to Port St Johns as far as the Great Kei River mouth). Elevated plateaus and deep gorges are characteristic of the Pondoland coast and other regions with underlying sandstone geology. The belt is about 35 km wide at some places in the north (somewhat wider in the valley of the Thukela River), narrowing irregularly southwards to <20 km in parts of Pondoland to <10 km in several parts of the Wild Coast.

The region is very densely populated, with towns such as KwaNgwanase (Manguzi), St Lucia, Mtubatuba, KwaMbonami, Empangeni, Richards Bay, Stanger, Tongaat, Durban Metropolitan Area (Ethekwini), Umkomaas, Port Shepstone, Margate and Port Edward (all KwaZulu-Natal). Further south, in the Eastern Cape, densely populated rural areas are also found, for example in the Xhora District. Much of the KwaZulu-Natal coast (roughly between Stanger and Port Edward) has been turned into a 'South African Riviera'—an almost continuous chain of holiday settlements frequented by millions of tourists every year.

1.2 Biome Identity

Bews (1920: 383), in his classical paper on *The plant ecology of the coast belt of Natal* established that

'... both from the purely ecological and from the floristic standpoints... there are good reasons why the coast belt of Natal should be considered as part of a distinct subtropical region...'.

Later, some researchers would honour this proposition and would recognise the peculiarity of the KwaZulu-Natal (and to an extent also the Wild Coast) immediate seaboards as deserving special status in both ecological (Moll & White 1978; to an extent also Huntley 1984) and biogeographical (Van Wyk & Smith 2001, Heijnis 2004, Kirkwood 2004) terms. The overwhelmingly large extent of transformation of the coastal belt outside the existing strips and patches of embedded forest represents significant loss of evidence of its prior condition. This has led to a diversity of opinions on the broad-level classification of the vegetation of this coastal belt or its components (see Rutherford & Westfall 1986: Table 1 and Figure 4). Although the present work broadly follows Bews (1920) and Moll & White (1978) who assume a dominant forest cover interrupted by edaphically or hydrologically controlled areas of grassland, some others have assumed that at least a significant part of the belt had been an open to dense savanna vegetation, interspersed with many areas of forest and grassland. For example, Huntley (1984) mapped most of the IOCB as his Moist Savanna Biome type in which was embedded smaller but significant areas of his Lowland Forest unit. Rutherford & Westfall (1986) mapped the IOCB as part of their Savanna Biome explicitly on nonfloristic (only structural and climatic) criteria and followed a defined criterion at biome scale level which precluded the mapping of the small or narrow 'lowland forests'. They showed the rainfall seasonality of the IOCB as essentially summer rainfall tending towards even year rainfall near the northern coast. Despite the overriding floristic affinities of forest floras within the IOCB with the African East Coast to the north, the IOCB (the Pondoland-Ugu Sandstone Coastal Sourveld aside) also has some floristic links with savannas toward the northwest interior. Examples of elements straddling both Savanna and IOCB biomes include *Acacia ataxacantha*, *A. caffra*, *A. nilotica*, *A. robusta*, *Combretum molle*, *Erythrina lysistemon*, *Gardenia volkensii*, *Gymnosporia maranguensis*, *Heteropyxis natalensis*, *Ozoroa paniculosa*, *Sclerocarya birrea*, *Turraea obtusifolia* and *Vangueria infausta*. Acocks (1953) supported the notion that the whole IOCB (except the Pondoland Coastal Plateau Sourveld) 'was naturally some form of forest', but acknowledged that the 'veld today is a more or less open thornveld with numerous and extensive patches of forest'.

We argue that the reasons for considering the IOCB a biome in its own right lie in the combination of vegetation structure and combination of climatic characters which are different from the Savanna Biome. The 'tropical appearance of vegetation' (to cite the words of Bews 1920) is a result of a mixture of growth forms such as trees, lianas and epiphytes that dominate the zonal (forest) vegetation of the region, while grasses play only a subordinate role in the zonal vegetation itself. Grasses are, naturally, the structure-shaping growth form in azonal (or intrazonal) vegetation types such as hygrophilic grasslands and shallow-soil sourvelds, also found within IOCB. The presence of these azonal grasslands as well as extensive secondary grasslands led Low & Rebelo (1996, 1998) to classify a large portion of the IOCB as part of the Grassland Biome. The absence of an entirely rain-free dry period (so typically characterising the winter months in the Savanna Biome) and implied increased probability of winter rainfall is another feature distinguishing the IOCB from the Savanna. Although the rainfall of the IOCB is clearly higher in summer than in winter (Figure 1), along the Maputaland coast the winter half-year rainfall makes up as much as 40% of the total yearly precipitation. The overall high air-moisture saturation throughout the year gives the climate of the IOCB its strikingly tropical character, especially in summer.

Burgess et al. (2004) classify this region as part of the global 'Tropical Broadleaved Moist Forest' biome—a concept still much too broad as it would encompass not only the most (sub)tropical forests of the Indian Ocean seaboards (spanning East London and southern Somalia), but also afrotropical rainforests of Central and West Africa.

The biogeographical peculiarity of the IOCB (links to inland tropical regions of Central Africa) and regional concentration of endemic species, initiated an evolution of ideas spanning nearly 100 years (from Marloth 1907 to Van Wyk & Smith 2001). Marloth (1907) suggested 'South Eastern Coast Belt', which would incorporate not only the immediate coastal rims of the present KwaZulu-Natal and Transkei coast of the Eastern Cape, but also the deep hinterland. The 'Coast Belt' of Bews (1920) is a more conservative concept. In fact its extent is very close to

the mapped extent of the IOCB in this chapter. Acocks's (1953; see Acocks Map No. 4 in Acocks 1988) 'Forest and Scrubforest' basically copies the extent of the IOCB as it is depicted in our map. Acocks (1988) recognises the identity of the Coastal Belt in his Veld Type 1 called 'Coastal Forest and Thornveld'—a unit reaching beyond East London westwards as far as Keiskamma and incorporating most of the Maputaland coastal plains. The combination of Low & Rebelo's (1996, 1998) Vegetation Type 23 (Coastal Bushveld/Grassland, largely corresponding to the Acocks's Veld Type 1) and Vegetation Type 48 Coastal Grassland (incorporating the Acocks's Veld Type 3: Pondoland Coastal Plateau Sourveld) roughly corresponds to the IOCB as featured in this chapter. To date, Camp (1999a, b) has undertaken the most detailed climatic, geological and pedological delimitation of the Coastal Belt and classified it as his BRG 1 Moist Coast Forest, Thorn and Palm Veld. We follow (within the borders of the KwaZulu-Natal Province) this delimitation.

The World Wildlife Fund recognises five 'ecoregions' (Goldberg & Frank 2004, Heijnis 2004, Kirkwood 2004, Schipper & Burgess 2004a, b) within so-called 'Tropical and Subtropical Moist Broadleaf Forests' which straddle the Indian Ocean seaboards from the Jubba River in southern Somalia as far south as Port Elizabeth in South Africa. The southern part of the WWF ecoregion Maputaland Coastal Forest Mosaic (Kirkwood 2004) and KwaZulu-Natal-Cape Coastal Forest Mosaic (Heijnis 2004) overlap with the IOCB as defined in this chapter. The former unit is identical with our Maputaland Coastal Belt (with all imbedded intrazonal and azonal vegetation units), while the latter extends westwards beyond the limits of the southernmost vegetation unit within the IOCB (CB 5 Transkei Coastal Belt) and incorporates also the coastal belt between the Buffels River (East London) and Port Elizabeth. We consider the classification of the coastal belt of the Albany Thicket Biome into the KwaZulu-Natal-Cape Coastal Forest Mosaic as not justified. The latter portion of the coast has a warm-temperate character, carries climax vegetation (Albany Thickets), various coastal vegetation types on the adjacent seashore, strandveld (Vlok & Euston-Brown 2002, Vlok et al. 2003) as well as forest vegetation (Von Maltitz et al. 2003).

The IOCB is a climatically, ecologically and biogeographically peculiar region that deserves standing on its own at the level of biome within the scope of the South African vegetation. It is the southernmost, hence marginal, outlier of the East African Tropical Coastal Forest (Burgess et al. 1996, 1998, Burgess & Clarke 2000)—a member of the global Tropical and Subtropical Moist Forest Biome. As such it can be classified as the 'Subtropical Coastal Forest Biome'—an interesting geographical analogue of the 'Mata Atlântica', the subtropical coastal forest of the Atlantic seaboards of eastern Brazil (Hueck 1966), experiencing a fate very similar to the IOCB (Por 1992). The IOCB lost its natural 'forest face' due to intensive human influence dating since the Iron Age, but it demonstrates (under the climatic conditions of the current Holocene Interglacial) its clear tropical affinity.

The IOCB (or Subtropical Coastal Forest Biome) encompasses subtropical forest (Table 11.1) as zonal vegetation, accompanied by a series of intrazonal (edaphic grasslands) and azonal vegetation types. Within the latter, we count the azonal forest types (Northern Coastal Forest, Mangrove Forest, Swamp Forest, Lowveld Riverine Forest) and azonal nonforest vegetation units such as Subtropical Freshwater Wetland, Subtropical Dune Thicket and Subtropical Coastal Vegetation. For practical purposes we have singled out the forest vegetation (both zonal and azonal) of the IOCB and feature it, alongside other forest types, within Chapter 12. The nonforest vegetation is the subject of Chapters 13 and 14. The vegetation units in this particular chapter include the edaphic grassland units (Maputaland Wooded Grasslands, Pondoland-Ugu Sandstone Coastal Sourveld) as well as a series of 'Coastal Belts' (CB 1, 3, 5) which feature, similar to AT 9 Albany Coastal Belt (but unlike the rest of the units of the National Vegetation Map), current rather than potential vegetation patterns. We presume that most of the CB 1, 3 and 5 were formed by subtropical forests

Table 11.1 Indian Ocean Coastal Belt (corresponding to Subtropical Coastal Forest Biome) as a composite of zonal, intrazonal and azonal vegetation units. For the discussion on the concepts related to zonality, see Chapter 13 on 'Inland Azonal Vegetation'.

Vegetation Unit	Extent (km²)	Zonality status
FOz 7 Northern Coastal Forest [1,F]	467	zonal
FOz 8 Scarp Forest [4,F]	435	intrazonal (endemic)[6]
FOa 1 Lowveld Riverine Forest [F]	5	intrazonal/azonal[5]
FOa 2 Swamp Forest [F]	38	intrazonal/azonal[5]
FOa 3 Mangrove Forest [F]	33	intrazonal/azonal[5]
CB 4 Pondoland-Ugu Sandstone Coastal Sourveld	1297	intrazonal (endemic)[7]
CB 2 Maputaland Wooded Grassland	991	intrazonal (endemic)[7]
CB 1Maputaland Coastal Belt	4015	zonal[2]
CB 3 KwaZulu-Natal Coastal Belt	6293	zonal[2]
CB 5 Transkei Coastal Belt	1628	zonal[2]
AZe 3 Subtropical Estuarine Salt Marshes [C]	3	intrazonal/azonal[5]
AZs 3 Subtropical Dune Thicket [C]	20	intrazonal/azonal[5]
AZd 4 Subtropical Seashore Vegetation [C]	42	intrazonal/azonal[5]
AZf 6 Subtropical Freshwater Wetlands [A]	501	intrazonal/azonal[5]
AZa 7 Subtropical Alluvial Vegetation [A]	0[8]	intrazonal/azonal[5]
Freshwater Lakes[3]	91	not applicable
Coastal Lagoons[3]	465	not applicable

[1] incl. KwaZulu-Natal Coastal Forest and KwaZulu-Natal Dune Forest (Forest Types according to Von Maltitz et al. 2003)
[2] mapped as mosaic of primary (mainly edaphic) grassland, secondary grassland and succession thickets seral to the subtropical coastal forests (still found in patches and mapped as Northern Coastal Forest)
[3] not recognised as vegetation units (nonvegetated water bodies)
[4] incl. Pondoland Scarp Forest and Eastern Scarp Forest (Forest Types according to Von Maltitz et al. 2003)
[5] intrazonal on regional scale; azonal on continental scale
[6] endemism of this vegetation type relates to southern Africa (Scarp Forest occurs in Eastern Cape, KwaZulu-Natal and Mpumalanga, Swaziland, and possibly also in Mozambique)
[7] endemic to the Indian Ocean Coastal Belt
[8] none mapped in Indian Ocean Coastal Belt
[A] discussed in Chapter 13: Inland Azonal Vegetation
[C] discussed in Chapter 14: Coastal Vegetation
[F] discussed in Chapter 12: Afrotemperate, Subtropical and Azonal Forests

(see also the modelling study by Eeley et al. 1999), and possibly also by some more natural grassland. However, today these forests and natural grasslands have been replaced by a mosaic of secondary grasslands, seral thickets and bushveld or obliterated by agriculture and human settlements.

2. Ecology: Climate, Geology, Soils and Hydrology

2.1 Climate

The northern regions of the IOCB, close to the coast, have marginally nonseasonal (even) rainfall, with precipitation concentrated in summer. Richards Bay and St Lucia both have 41.6% of their annual mean rainfall in winter. There are approximately 14 rain days in June and July (Camp 1999b). The winter rains are associated with frontal systems from the south. Further south, the rainfall seasonality of the belt, also close to the sea, becomes clearly summer (Bailey 1979) in most places. The winter-rainfall proportion is 35.6% for Empangeni, 30.9% for Mount Edgecombe, 27.6% for Pinetown, 31.8% for Port Shepstone, 28.8% for Paddock, 32.7% for Cape Hermes Lighthouse (at Port St Johns) and 36.6% at Bashee Lighthouse (near the mouth of the Mbhashe River). The rainfall seasonality increases gradually inland towards neighbouring savanna vegetation types, for instance from about 33.6% on the border between Maputaland Coastal Belt and Zululand Thornveld (Riverview) and 26.7% on the border between KwaZulu-Natal Coastal Belt and Ngongoni Veld (Eshowe) to 28.0% (Mkuze) and 25.1% (Makatini Agr) well within savanna vegetation types. Strong summer-rainfall seasonality (<20% Bailey 1979) is only found in savanna types much further inland (e.g. in Thukela Valley Bushveld: Muden 19.3%). On the Transkei coast Cawe (1994) found that the proportion of winter rainfall is highest along the coastal belt closest to the sea; he refers to this as rainfall type D 'High rainfall with high winter rainfall' and he found this climate type to be confined to Acocks Veld Type 1.

In the KwaZulu-Natal part of the IOCB the mean annual rainfall ranges between 1 272 and 819 mm (Camp 1999b), while on the Eastern Cape coast the mean annual rainfall reaches 1 120 mm at Cape Hermes (Port St Johns) and 1 128 mm at Bashee Lighthouse (near the mouth of the Mbhashe River). The east-west gradient of annual precipitation is remarkably steep, especially in Maputaland, with around 1 200 mm on the coast, while about 60 km inland (Ndumo in the Savanna Biome) only about 60% of this amount occurs.

The mean annual temperature ranges relatively narrowly from about 22°C (in the north, near the Mozambique border) to 20.4°C at Mount Edgecombe (near Durban) to 19.9°C at Cape Hermes (Port St Johns) and to 19.1°C at the Bashee Lighthouse (near the mouth of the Mbhashe River). Summers are hot to very hot, while winters are mild, with hardly any frost (higher in the southernmost parts and then only mild).

Evaporation is roughly between 1 490 mm per annum on the South Coast (KwaZulu-Natal) and as high as 1 833 mm near Empangeni. Air humidity is high, especially along the coast in summer and may reach saturation point. Mean monthly relative humidity at 14:00 at Richards Bay varies from 72% in November to 59% in August. Moist summer heat may be a cause of discomfort, but it helps to maintain the temperature-sensitive and moisture-demanding tropical vegetation of the region—both indigenous as well as alien (crops and ornamental flora).

The region is under the combined influence of several wind systems (Bews 1920): rain-bearing southern and southwestern winds, eastern afternoon sea-breezes, and autumn anticyclonic föhns. The wind run was measured to be about 160 km per day in Empangeni. Cyclones originating over the Indian Ocean occasionally hit the region from the northeast, causing major climatic and hydrological havoc, for example the 1984 cyclone called Domoina.

The pronounced hot and damp tropical character of the climate of the IOCB in summer and its mild and slightly drier subtropical character in winter can be ascribed to several global and macroregional factors. Firstly, it is the unusual southbound shift of the Intertropical Convergence Zone in summer (Tyson 1986, Stokes et al. 1997). Secondly, it is the ameliorating influence of the warm Agulhas Current flowing close to the eastern coasts of South Africa. These factors control the deep intrusion of typical tropical biota on terra firma (terrestrial flora and fauna and associated biotic communities) on shore (global southernmost occurrence of mangroves) and offshore (global southernmost occurrence of corals: Ramsey 1994, Riegl 2003). Relative humidity of at least parts of the IOCB is remarkably similar to that in regions much further up the east coast of Africa within the tropics. For example, mean annual relative humidity for Durban is 79% (max. in February: 82% and min. in July: 73%) compared to 73% (max. in April: 82% and min. in October: 67%) for Dar-es-Salaam (Tanzania) and to 74% (max. in May: 79% and min. in February: 70%) for Mombasa (Kenya) (Müller 1982). Corresponding figures for relative humidity in Beira and especially Maputo (both in Mozambique) are considerably lower than for Durban.

2.2 Geology and Soils

The IOCB is geologically very heterogeneous, including Mokolian-age granites and gneisses that form the basement rocks for

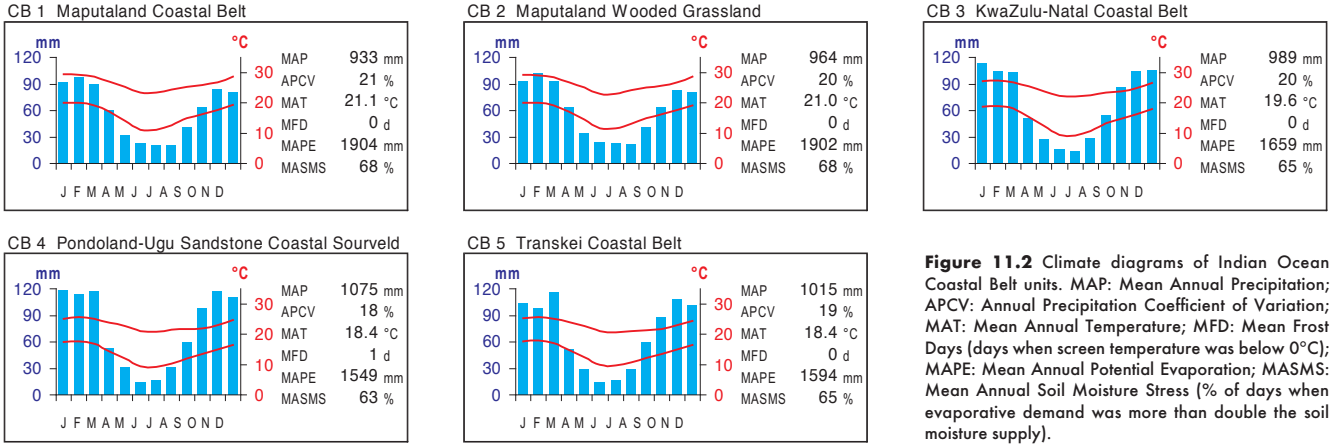

Figure 11.2 Climate diagrams of Indian Ocean Coastal Belt units. MAP: Mean Annual Precipitation; APCV: Annual Precipitation Coefficient of Variation; MAT: Mean Annual Temperature; MFD: Mean Frost Days (days when screen temperature was below 0°C); MAPE: Mean Annual Potential Evaporation; MASMS: Mean Annual Soil Moisture Stress (% of days when evaporative demand was more than double the soil moisture supply).

sedimentary deposits spanning almost the entire Phanerozoic, from Ordovician to Recent times, and representing all levels of softness and the large variety of physical and chemical traits. The most striking, and for the region most characteristic, rocks are sandstones of the Msikaba Formation and those of the Natal Group (Thomas et al. 1992) which support endemic vegetation types such as Pondoland Scarp Forests (*sensu* Von Maltitz et al. 2003)—part of FOz 5 Scarp Forest (see Chapter 12) and CB 4 Pondoland-Ugu Sandstone Coastal Sourveld. On the Pondoland Wild Coast these sandstones descend to sea level, where they form dramatic coastal cliffs ornamented by numerous spectacular waterfalls. In KwaZulu-Natal, most of this belt turns inland and continues in the form of geological islands at variable distance from the coast. The Msikaba Sandstones have a high quartz content (70%–96%), with potassium feldspar and small amounts of mica occurring as well (Hobday & Mathew 1974). They are stratigraphically linked to the Witteberg Group of the Cape Supergroup (both are of Devonian age). The Natal Group is, like the Peninsula Formation sandstones of the Table Mountain Group, Ordovician. Like the sandstones building the core of the Cape Fold Belt mountains, the soils developing over both Msikaba and Natal Sandstones are sandy, highly leached, acidic and mostly very shallow. Rock outcrops are very frequent and dramatic scarps, krantzes and deep canyons are the typical accompanying geomorphological feature of this geological landscape.

The sandstone belt (spanning Port St Johns and Port Edward) divides the remainder of the IOCB into two distinct parts. The northernmost region (Maputaland) is a broad coastal plain consisting of a variety of Cenozoic to Recent marine sediments, mainly of Berea and Muzi Formations. A system of dune cordons can be traced on this plain, marking past sea-level stillstands of various ages. The oldest dune cordon (Ndumo) is more than 25 my old and occurs outside the IOCB proper. The coastal plain itself is of Plio-Pleistocene age (3 mya to 10 000 yrs ago; Davis 1976, Botha 1997) and is covered by sandy deposits, forming a high dune cordon all along the coast. Between Richards Bay and Umlalazi these dunes cover the interesting Port Dunford Formation (Oschadleus et al. 1996), 70 000 years old. Dystric regosols (formed by well-drained and acidic sands) are formed on elevated slopes and crests of the dune cordons. Humic gleysols (wet, acidic sands with abnormal accumulation of organic matter) are found in depressions—habitats with a high water table (Matthews et al. 1999). The rest of the KwaZulu-Natal coastal belt is a geologically complicated mosaic of Karoo Supergroup clastic sediments, metamorphic rocks of the Namibian Erathem and Cenozoic to Recent sediments.

Most of the Transkei Coastal Belt is built of Karoo sediments, including sandstone and mudstone of the Adelaide Subgroup, shale, mudstone and sandstone of the Ecca Group as well as tillites of the Dwyka Group; Jurassic dolerite intrusions occur in places.

Right at the coast, sand dune cordons have been formed or are being formed—these are calcareous young Quaternary sands derived from rocks of Cretaceous and Cenozoic origin. The sand dunes are massive and very high, especially in Maputaland as well as on the Zululand coast. They become rare in the southern part of the IOBC, where they are concentrated into small pockets at river mouths cutting though the steep coasts of Transkei.

2.3 Hydrology

The vegetation patterns of the IOCB are the result of intricate palaeofloral history, climate, geology, and last, but not least, hydrology. There are a number of azonal (or intrazonal) vegetation types controlled by temporal or semipermanent flooding embedded within the IOCB (Table 1). These include freshwater wetlands, estuaries, coastal lakes, mangroves, riverine and swamp forests, described in separate chapters on Inland Azonal Vegetation, Coastal Vegetation and Forests.

Maputaland is a particularly water-rich environment with, for example, spectacular coastal lagoons such as Kosi Bay and St Lucia, big lakes (Lake Sibaya is the largest freshwater lake in South Africa; Wright et al. 2000) and extensive swamps (Muzi Swamp, swamps of the Mkuze floodplain north of the St Lucia lagoon). In many places the ground-water table is very high. It feeds the marshes and pans and is regularly replenished by rain. Sandy substrates result in considerable fluctuations in ground-water level (Matthews et al. 1999). The existence of some of the grassland types, including the enigmatic Maputaland Wooded Grasslands and other 'edaphic' grasslands embedded within the Maputaland Coastal Belt and KwaZulu-Natal Coastal Belt, is linked to dynamics of the ground-water table and temporary surface flooding (e.g. Matthews et al. 1999).

3. Biogeographical Patterns: Past and Present

3.1 Palaeo-ecological Patterns

According to Maud (in Tinley 1985: 43), at least the Maputaland region must have been submerged approximately 10 mya as witnessed by Miocene and Pliocene sediments reaching up to 300 m above present sea level. Mid- and Upper Pliocene were characterised by uplift and tilting of the southern African subcontinent, resulting in formerly submerged areas (or some parts of them) becoming dry land. However, the areas that we define as parts of the current IOCB were formed only much later—through a series of Pleistocene marine regressions.

It is clear that the climate in southern Africa underwent dramatic changes during the Pliocene and Pleistocene (past 5 my) marked by about 21 climatic cycles (each approximately 100 000 yrs long) of alternation of dry/cold and wet/warm climates (Deacon 1983, Tyson 1986, Deacon & Lancaster 1988). Undoubtedly these changes shaped the face of South African vegetation and are supposed to have had major impacts on the vegetation, especially on the extremes of macroclimatic gradients. There is only scanty palaeo-ecological (palynological) information on the vegetation of the IOCB during the Last Interglacial (approximately 130 000–40 000 BP). Studies of a lignite layer embedded in the Port Dunford Formation between Umlalazi Lagoon near Mtunzini and Richards Bay (Scott et al. 1992, Oschadleus et al. 1996) suggest existence of a complex of palustrine vegetation probably surrounded by coastal freshwater lakes, and forest vegetation in which *Podocarpus* (most likely *Afrocarpus falcatus*) might have been dominant. These papers hypothesised that the yellowwood forest developed here after formation of the peat (turning lignite) layer, coinciding with the deposition of sand with lower organic content. An abundance of *Podocarpus* pollen was found also in the sediments of the Lake Teza (near Mtubatuba)—around 3 400 yrs BP. *Podocarpus* contributed up to 20% of pollen found in the studied profile (Scott & Steenkamp 1996) deposited since the early Holocene. Scott & Steenkamp (1996) further imply that the *Podocarpus* pollen came from an 'original coastal woodland environment'. Unlike Port Dunford, in the surroundings of Lake Teza, *Podocarpus* was replaced by local swampy elements. Whatever the direction of the replacement, both studied localities suggest a spatial and temporal link between swamp vegetation and (presumably) *Podocarpus*-dominated

vegetation. Incidentally, it is the Swamp Forest, which supports (probably relictual) populations of afrotemperate tree elements such as *Apodytes dimidiata, Ilex mitis, Rapanea melanophloeos, Peddiea africana, Afrocarpus falcatus, Psychotria capensis* and *Scutia myrtina* (Wessels 1991). *Afrocarpus falcatus* occurs in the IOCB not only in the Scarp Forest (which shows a number of transitional traits between coastal and afrotemperate forests; see Chapter 12), but also in subtropical Coastal Forest (Lubbe 1997, Van Wyk & Smith 2001). Mazus (2000) added some more palynological data from the KwaZulu-Natal coastal peatlands and confirmed that *Podocarpus* has been abundant, especially in times when the regional climate during the Last Glacial was presumably wetter (70 000–34 000 BP and 14 000–5 000 BP). Botha et al. (1992) found *Podocarpus* pollen to be abundant in buried paleosols from cooler and wetter periods of the Late Pleistocene Hypothermal, but their locality is situated almost 1 000 m higher than the coastal peat deposits. Does the abundant occurrence (and dominance at the Port Dunford site) of *Podocarpus* in the pollen spectra mean (as argued for instance by Mazus 2000) that the coastal belt between Richards Bay and Umlalazi (and even further north as far as the Muzi Swamp) supported forests of afrotemperate nature? Not necessarily, as the tree species known today as 'afrotemperate' (including both genera *Podocarpus* and *Afrocarpus*) might rather be relicts of temporary migrations (or dispersal) from afromontane localities during wetter periods to palustrine coastal forests. The afrotemperate elements found within the IOCB today are exclusive to the Swamp Forests (Venter 1972, Lubbe 1997). These, as we know them today, '(sub)tropical' Swamp Forests might have acquired a more 'afrotemperate' face due to the increase of cover of *Podocarpus/Afrocarpus* in these habitats during cooler (but sufficiently wet) periods.

The vegetation landscapes of the IOCB, in concert with other biomes of southern Africa, underwent major changes as a response to a drop in temperature, reaching its minimum at about 18 000 yrs BP, at Late Glacial Maximum (LGM). This period is known to be not only cold (on average 5–6°C lower than today, Botha et al. 1992), but also drier—with precipitation as low as 40–70% of the present mean. The Indian Ocean seaboards of South Africa were much cooler and drier than today, owing also to the lower sea-surface temperatures (Van Zinderen Bakker 1982) and weaker and shallower Agulhas Current (Prell et al. 1980). Low precipitation and concentration of water in ice shields can cause a decrease of sea level by about 120 m. At the Indian Ocean seaboards, this resulted in reworking of the coastal dune cordons.

Following the LGM, climate ameliorated rather rapidly and wetter conditions re-established in the IOCB, sometimes between 17 000–15 000 BP (Tyson 1986). Along the time axis towards the present time, the temperature kept rising and around 7 000 BP it reached its alti-thermal (Tyson 1986, Deacon & Lancaster 1988, Partridge et al. 1990).

A new dune cordon was built and formed a corridor allowing (sub)tropical flora to migrate southwards together with the southward shift of the Intertropical Convergence Zone. It was supposedly during this period (between 15 000 to 7 000 BP) when the subtropical woody vegetation of the IOCB (as we know it today) staged its come-back or re-established here. In the process, the IOCB—the youngest biome in South Africa—was born.

3.2 Current Biogeographical Patterns

Biogeographically the IOCB region (and, unfortunately, also much of its deep hinterland) has been classified as Tongaland-Pondoland Regional Mosaic, spanning the coastal regions between Port Elizabeth and Xai Xai at the Limpopo River mouth in Mozambique and including regions such as the former Albany District, coastal hinterland as deep as Pietermaritzburg and Nongoma, most of Swaziland and the southern Lowveld (Moll & White 1978, White 1983). In a decisively altered version this region was redefined by Van Wyk (1994; see also Van Wyk & Smith 2001), setting the southernmost border at the Buffels River (albeit with reservations) and by including coastal plains of the Eastern Cape as far as Queenstown and piedmonts of the Southern Berg and further north all regions as far as the Low Drakensberg. Van Wyk (1994) renamed this unit to become the 'Maputaland-Pondoland Region', which is claimed to encompass two Centres of Endemism (CE), namely the Pondoland CE and Maputaland CE. Clarke (1998) reclassified the Maputaland CE by incorporating it into his Swahili-Maputaland Regional Transition Zone.

The extent of the Pondoland CE corresponds well with the core of our vegetation unit CB 4 Pondoland-Ugu Sandstone Coastal Sourveld. The Maputaland CE is heterogeneous in terms of vegetation (as well as in terms of age of incorporated vegetation units). It incorporates the CB 1 Maputaland Coastal Belt, CB 2 Maputaland Wooded Grasslands as well as part of the accompanying forest types (see Chapter 12) and azonal wetland and coastal vegetation. Unlike Van Wyk & Smith (2001), we do not recognise the Lebombo Mountains as part of the Maputaland CE.

The IOCB appears to be the youngest biome in our region and still two regional centres of endemism (Pondoland and Maputaland) coincide with the extent of the IOCB. How does this fit with the relatively 'recent' dramatic climatic (and palaeo-ecological) scenarios that led to formation of this new biome? We suggest that the explanation lies in the azonality (or intrazonality) of the habitats supporting endemic flora. The endemic-rich coastal sourveld is limited to special geology (sandstones of Msikaba Formation) supporting nutrient-stressed soils, and in a way simulating the geological and pedological conditions typical of the Fynbos (Van Wyk 1989, 1990a, 1994, Van Wyk & Smith 2001). The evolutionary old endemics of the Pondoland are concentrated either to scarp (and deep-gorge) forests, which undoubtedly must have undergone major shrinkage during the LGM (as well as during the much earlier Pleistocene glacials), but were able to recover from local, well-sheltered refugia. These forests, too, are confined largely to the same types of sandstones and to a lesser extent also to granites (Ongoye Forest near Empangeni). The endemics of Maputaland are largely neo-endemics—the infraspecific status of many of them suggests a very recent origin (Van Wyk & Smith 2001). Within the IOCB proper, they are almost exclusively found in azonal vegetation types, such as CB 2 Maputaland Wooded Grassland. The occurrence of palaeo-endemics in the region (such as *Helichrysopsis septentrionale* in wooded grasslands, *Encephalartos ferox* in coastal thicket and coastal forest, and palustrine palm *Raphia australis*) demonstrates the ability of these taxa to resist dramatic climate changes. Resilience of habitats such as wooded grasslands and swamps might have also played a role in preserving these old relics.

The nature of regional endemism in the IOCB and the major phytogeographic links are discussed in detail by Moll & White (1978). These authors have established that the flora of the IOCB contains Zanzibar-Inhambane, Zambezi, Afromontane, Upland, Cape/Afromontane, Karoo-Namib and Guineo-Congolian linking elements as well as a separate category of 'chorological and ecological transgressors' occurring in a wide range of vegetation types in southern Africa.

4. Present Status

Land use is primarily sugarcane farming (over 88% of the cultivated area; Camp 1999b) in the KwaZulu-Natal area of the biome and subsistence farming in the Eastern Cape. Subsistence farming areas from Port Shepstone in southern KwaZulu-Natal to the KwaZulu-Natal/Mozambique border are undergoing rapid development to small-scale sugarcane farming and small-scale commercial tree farming. This is resulting in the loss of vast areas of natural vegetation.

The coastline of KwaZulu-Natal south of St Lucia Estuary is highly developed, with only small isolated occurrences of natural vegetation. A considerable area of the Forest Biome is embedded within this geographical area. In contrast, the coastline of the Transkei is little transformed and there are many natural grassland patches outside formal nature reserves. The IOCB supports the highest human population concentrations on the eastern seaboard.

About 39% of the IOCB's geographical area has been transformed. However, there is a considerable range in the levels of transformation within and between vegetation types, with corresponding implications for meeting conservation targets for biodiversity. South of the KwaZulu-Natal/Eastern Cape border there remain extensive areas of natural vegetation and consequently conservation targets are likely to be attainable, but throughout the KwaZulu-Natal portion of the biome critically high levels of transformation make it very difficult to meet conservation targets.

Approximately 7% of the IOCB is formally protected in statutory reserves. However, this is disproportionately spread between the five vegetation units, one of them with less than 1% protected.

5. Threats to Natural Vegetation

Cultivation and afforestation are the greatest threats. Extensive areas, in many cases previously grazed on a subsistence basis, are undergoing rapid development to small-scale sugarcane farming and small-scale commercial tree farming. Outgrow projects of large companies coupled with large-scale government water supply schemes and other agricultural incentive schemes are promoting small-scale commercial farming in areas hitherto not available for these land uses.

Alien invasive plants are a major and growing threat. Replacement of natural plant communities to ones dominated by alien plants is prevalent throughout the geographical area of the biome and the vegetation units. *Chromolaena odorata* is the main problem plant. Severe loss of browsing and grazing for both domestic livestock and wildlife is commonplace. Where landowners can afford it, large amounts of money are often allocated to control of invasive plants. However, in poor areas infestation is usually so severe that little indigenous vegetation survives.

Extensive areas of subsistence farming often occur in underdeveloped areas between commercial agriculture. Grasslands are often burnt indiscriminately to the disadvantage of many natural plant communities and consequently of wildlife in general. This also tends to affect the ecological functioning of bush-clump and forest margins. Traditional hunting is sometimes the cause of such fires.

Urbanisation is rapidly expanding into the few natural areas remaining near the many development nodes. Some of the most prolific examples are to be seen at Richards Bay, Durban, Scottburgh, Port Shepstone and Margate.

The Pondoland coastal area faces the threat of dune mining and the construction of a new N2 toll road.

6. Action: Conservation and Management of Resources

In terms of the conditions of a World Heritage Site, the Greater St Lucia Wetland Park is run by a Wetlands Authority. The management of the wildlife has been delegated to the provincial nature conservation agency Ezemvelo KZN Wildlife. In addition, many natural areas of Maputaland are benefiting from the Lubombo Spatial Development Initiative. This applies mainly to the Savanna Biome west of the IOCB and is discussed in that chapter. It places much of the northern part of the IOCB in the fortunate position of being under well-developed, secure management structures.

Ezemvelo KZN Wildlife is mandated to attend to nature conservation needs throughout the KwaZulu-Natal part of the IOCB. The southern half of the coastal belt is, however, poorly provided for in terms of well-integrated land use planning. To this end, Ezemvelo KZN Wildlife has developed detailed conservation planning protocols based on systematic conservation planning approaches. This includes the modelling of irreplaceable areas. These are then embedded in the Municipal Spatial Development Frameworks. Other land use planning controls that are important for the conservation of natural vegetation include the Durban Metro Municipal Open Space System (D-MOSS).

In the Eastern Cape a project integrating conservation and development on the Wild Coast (most of the Transkei coastline and incorporating most of Pondoland), has been launched by the Eastern Cape Department of Economic, Environmental Affairs and Tourism and the Wilderness Foundation (*The Herald News* 29/7/2004). The project will build on the 1997 Spatial Development Initiative and is being modelled on the STEP Programme for the Thicket vegetation type. The Wild Coast Conservation and Development Project has initiated actions that include conservation assessment, strategic environmental assessment, an integrated land use plan that nests biodiversity conservation objectives into the regional sustainable development framework, a conservation strategy and action plan, participation in the Global Environmental Facility (GEF) funding proposals, and implementation programme for the Wild Coast in conjunction with the national Department of Environmental Affairs and Tourism. The long-term goal of the GEF project is: Representative system of protected areas in priority bioregions is established effectively, managed and contributes to sustainable development. The GEF project objective is: An effective network of protected areas is established on the Wild Coast and provides tested co-management models for replication. The possible creation of a Pondoland Park will form part of this planning.

7. Further Research Challenges

Maputaland became a focus of interest of geologists (Botha 1997, Maud & Botha 2000, Wright et al. 2000) as a prime example of evolution of coastal plains, of vegetation ecologists owing to interesting sources of palaeo-ecological data (Scott et al. 1992, Scott & Steenkamp 1996, Mazus 2000), of biogeographers because of the key importance of the Belt for southbound plant and animal migrations (White 1983, Lawes 1990) and of vegetation ecologists for the diversity of vegetation types reflecting intricate soil and hydrological patterns as well

as regional climatic gradients (Moll & White 1978, Moll 1978, 1980, Lubbe 1997). The Maputaland coast, and to some extent also southern stretches of the KwaZulu-Natal coast, with its mosaic of grasslands, thickets and coastal forests, faces human pressures ranging from over-development due to increasing tourism, urban sprawl to coastal mining. These pressures have generated considerable interest in biological research (Weisser 1978, 1987, Weisser & Marques 1979, Ward 1980). Our knowledge of floristic treasures of Pondoland is increasing (Van Wyk 1990b, Van Wyk & Smith 2001), and the region continues to yield new surprises, such as the discovery of a spectacular new *Clivia* species (Murray et al. 2004). There is still no comprehensive vegetation monograph for either the Pondoland coastal sourveld or of the famous Pondoland subtropical forests. Within the IOCB, the biota of the remainder of the Transkei coast is poorly known. More research in all aspects of ecology should be initiated here, especially in the light of the increased interest of developers targeting this coastal stretch.

8. Descriptions of Vegetation Units

CB 1 Maputaland Coastal Belt

VT 1 Coastal Forest and Thornveld (97%) (Acocks 1953). LR 23 Coastal Bushveld-Grassland (86%) (Low & Rebelo 1996). BRG 1 Moist Coast Forest Thorn & Palm Veld (59%) (Camp 1999a, b). Coast Grassveld p.p. & Palm Veld p.p. (Moll 1978, 1980).

Distribution KwaZulu-Natal Province (and continuing also in southern Mozambique): Up to 35 km broad strip along the coast of the Indian Ocean stretching from the Mozambique border in the north to Mtunzini in the south. Altitude varies from about 20–120 m.

Vegetation & Landscape Features Flat coastal plain originally probably densely forested in places with a wide range of interspersed nonforest plant communities including dry grasslands (which include palm veld where special conditions prevail), hygrophilous grasslands and thicket groups. Today the vegetation landscape is composed of pockets of various forest types (separated into different vegetation units), thicket, primary and secondary grasslands, extensive timber plantations and cane fields. The belt of the IOCB immediately inland (only a few kilometres wide) and parallel to the line of Northern Coastal Forest has a characteristic appearance of very irregular dunes with generally open vegetation and *Syzygium cordatum* dotted prominently on the dunes, with many irregular dune slacks interspersed. There is little to suggest that this part of the vegetation, e.g. between Lake Sibaya and Kosi Lake, is secondary. The peculiar CB 2 Maputaland Wooded Grassland—still another vegetation unit embedded within the geographical extent of the Maputaland Coastal Belt—is treated as a separate vegetation unit (see below).

Geology & Soils Up to about 18 000 yrs old Quaternary sediments of marine origin—mainly yellowish and argillaceous redistributed sands (Berea and Muzi Formations of the Maputaland Group, respectively). Soils nutritionally very poor and well leached, except in the interdune depressions where organic-rich soils are sometimes found. The dominant land types include Hb and Ha, with some contribution of Db land type.

Climate Weak rainfall seasonality near the coast tending toward summer rainfall towards the interior. Relatively high precipitation attaining annual values up to 1 200 mm in coastal localities, decreasing rapidly to the interior. High humidity and temperature. Mean maximum and minimum monthly temperature for Lake St Lucia Research Centre are 35.3°C and 5.5°C (for January and June, respectively). No incidence of frost. See also climate diagram for CB 1 Maputaland Coastal Belt (Figure 11.2).

Important Taxa Low Shrubs: *Agathisanthemum bojeri* (d), *Helichrysum kraussii* (d), *Tephrosia longipes*. Small Trees & Tall Shrubs: *Syzygium cordatum* (d), *Acacia natalitia*, *Annona senegalensis*, *Apodytes dimidiata*, *Bridelia cathartica*, *Canthium inerme*, *Chrysanthemoides monilifera* subsp. *rotundata*, *Euclea natalensis* subsp. *natalensis*, *Ficus burtt-davyi*, *Kraussia floribunda*, *Phoenix reclinata*, *Rhus natalensis*, *Sclerocroton integerrimum*, *Strychnos spinosa*. Woody Climbers: *Abrus precatorius* subsp. *africanus*, *Smilax anceps*. Herbs: *Achyranthes aspera*, *Centella asiatica*, *Chamaecrista plumosa*, *Hermbstaedtia odorata* var. *aurantiaca*, *Vernonia centaureoides*, *V. oligocephala*. Graminoids: *Diheteropogon amplectens* (d), *Eragrostis sclerantha* (d), *Ischaemum fasciculatum* (d), *Themeda triandra* (d), *Urelytrum agropyroides* (d), *Aristida stipitata* subsp. *graciliflora*, *Cymbopogon pospischilii*, *Elionurus muticus*, *Eragrostis inamoena*, *E. lappula*, *Sporobolus subulatus*, *Trachypogon spicatus*, *Trichoneura grandiglumis*, *Tristachya leucothrix*.

Biogeographically Important Taxa ([C]Coastal belt element, [F]Generic fynbos element, [ILP]Isolated lowland populations, [M]Maputaland endemic, [N]Northern distribution limit, [S]Southern distribution limit) Geoxylic Suffrutex: *Diospyros galpinii*[S]. Low Shrubs: *Indigofera williamsonii*[C], *Rhus kwazuluana*[M], *Stylosanthes fruticosa*[S]. Small Trees & Tall Shrubs: *Hyphaene coriacea*[S] (d), *Ozoroa obovata*[S], *Rhus nebulosa*[C], *Synaptolepis kirkii*[M]. Woody Climber: *Dalbergia obovata*[C]. Herbs: *Helichrysopsis septentrionale*[M], *Helichrysum tongense*[C], *H. cymosum* subsp. *cymosum*[N], *Nidorella tongensis*[M], *Senecio ngoyanus*[C], *Vernonia natalensis*[ILP]. Megaherb: *Strelitzia nicolai*[C] (d). Succulent Herb: *Orbea longidens*[M]. Semiparasitic Herb: *Striga junodii*[S]. Graminoid: *Monocymbium ceresiiforme*[ILP].

L. Mucina

Figure 11.3 CB 1 Maputaland Coastal Belt: Seasonally wet grasslands of the Palm Veld (with *Hyphaene coriacea*) near KaNgwanase in Maputaland, northern KwaZulu-Natal.

Endemic Taxa ([F]Generic fynbos element) Herbs: *Helichrysum adenocarpum* subsp. *ammophilum*, *Vahlia capensis* subsp. *vulgaris* var. *longifolia*. Geophytic Herbs: *Asclepias gordon-grayae*, *Kniphofia leucocephala*, *Raphionacme lucens*. Graminoid: *Restio zuluensis*[F] (d).

Conservation Vulnerable. Target 25%. 15% statutorily conserved in the Greater St Lucia Wetland Park as well as in Sileza, Enseleni and Amathikulu Nature Reserves. More than 30% transformed for plantations and cultivation and by urban sprawl. Aliens include scattered populations of *Chromolaena odorata* and *Lantana camara*. Erosion is mostly very low. This vegetation type has a relatively high number of plant taxa at the southernmost and northernmost limits of their distribution range—the occurrence of widely disjunct or outlier populations increases the conservation value of this vegetation type.

Remark 1 The primary grasslands of interdune depressions and seasonally waterlogged bottomlands of the Maputaland were classified by Matthews et al. (1999) as the *Eragrostis lappula–Helichrysopsis septentrionalis* and *Ischaemum fasciculatum–Eragrostis inamoena* hygrophilous grasslands, and by Lubbe (1997) as *Ischaemum fasciculatum–Centella asiatica* hygrophilous grassland. Like the Maputaland Wooded Grasslands, these primary grasslands are home to a number of Maputaland endemics such as the enigmatic *Restio zuluensis* and *Helichrysopsis septentrionale*.

Remark 2 Most of the Maputaland Coastal Belt is agricultural land and very little of this unit remains in a natural state in the South African part of Maputaland. A much larger area of well-preserved coastal belt is found in Mozambique.

References Venter (1972), Moll (1972, 1978, 1980), Moll & White (1978), Weisser (1978, 1987), Weisser & Marques (1979), Lubbe (1997), Camp (1999a, b), Matthews et al. (1999), Smith (2001), Van Wyk & Smith (2001).

CB 2 Maputaland Wooded Grassland

VT 1 Coastal Forest and Thornveld (100%) (Acocks 1953). LR 23 Coastal Bushveld–Grassland (98%) (Low & Rebelo 1996). BRG 1 Moist Coast Forest Thorn & Palm Veld (61%) (Camp 1999a, b). Incl. *Themedo–Salacietum* Myre (1964).

Distribution KwaZulu-Natal Province and southern Mozambique: In South Africa from the Mozambique border near KwaNgwanase southwards to Sileza, Sibaya, Mseleni, Mbazwana, Sodwana Bay, Ozabeni, eastern and western shores of Lake St Lucia, KwaMbonambi and as far south as near Richards Bay. Altitude varies from about 20–120 m.

Vegetation & Landscape Features Generally flat landscape of the Maputaland coastal plain supporting coastal sandy grasslands rich in geoxylic suffrutices, dwarf shrubs, small trees and very rich herbaceous flora. Excluded from this unit are the many interdune depression wetlands and hygrophilous grasslands neighbouring the wooded grasslands.

Geology & Soils Quaternary redistributed sand supporting yellowish redistributed sands of the Berea Formation (Maputaland Group). These are dystric regosols building dune crests, slopes and relatively high-lying level plains. Water table found at depth 1.6–2.0 m below surface (and slightly deeper) in average rainfall years. Ha is the overwhelmingly dominant land type, followed by Hb land type.

Climate Approximately the same as for the CB 1 Maputaland Coastal Belt (both units form an intricate regional mosaic). See also climate diagram for CB 2 Maputaland Wooded Grassland (Figure 11.2).

Important Taxa ([#]Suffrutex form) Geoxylic Suffrutices: *Parinari curatellifolia* (d), *Salacia kraussii* (d), *Ancylobotrys petersiana*, *Diospyros galpinii*, *Eugenia capensis*[#], *Syzygium cordatum*[#]. Graminoids: *Diheteropogon amplectens* (d), *Themeda triandra* (d), *Aristida stipitata* subsp. *graciliflora*, *Bewsia biflora*, *Cyperus obtusiflorus*, *C. tenax*, *Digitaria natalensis*, *Eustachya paspaloides*, *Setaria sphacelata*, *Sporobolus fimbriatus*, *S. subulatus*, *Urelytrum agropyroides*. Herb: *Chamaecrista plumosa*. *Geophytic Herb: Cyrtanthus galpinii*. Low Shrubs: *Helichrysum kraussii* (d), *Agathisanthemum bojeri*, *Crotalaria monteiroi* var. *monteiroi*. Small Trees & Tall Shrubs: *Acridocarpus natalitius* var. *linearifolius*, *Dichrostachys cinerea* subsp. *nyassana*, *Diospyros lycioides* subsp. *sericea*, *Hyphaene coriacea*, *Terminalia sericea*.

Biogeographically Important Taxa ([C]Coastal belt element, [M]Maputaland endemic, [S]Southern distribution limit) Geoxylic Suffrutices: *Eugenia albanensis*[C], *Gymnosporia markwardii*[M]; Graminoids: *Abildgaardia hygrophila*[C], *Cyperus natalensis*[C]. Herbs: *Helichrysopsis septentrionale*[M]; *Oxygonum robustum*[M], *Tricliceras mossambicense*[M]. Tall Shrub: *Grewia microthyrsa*[S]. Woody Climbers: *Albertisia delagoensis*[S], *Cissampelos hirta*[S].

Endemic Taxa ([#]Suffrutex form) Geoxylic Suffrutices: *Ochna* sp. nov., *Syzygium cordatum*[#]. Succulent Herb: *Aloe* sp. nov. (*Strey 5100 PRE*). Geophytic Herb: *Brachystelma vahrmeijeri*.

Conservation Endangered. Target 25%. About 17% statutorily conserved mainly in the Greater St Lucia Wetland Park. Some 46% transformed mostly for plantations and partly for cultivated land. The southern half of the area is not protected and it is here that over 90% of the extent of the vegetation type has been transformed—mostly to pulpwood timber plantations, cane fields and informal settlements. Aliens include scattered populations of *Chromolaena odorata* and *Lantana camara*.

W.S. Matthews

Figure 11.4 CB 2 Maputaland Wooded Grassland: Wooded grassland in Maputaland (northern KwaZulu-Natal) with prominent (silvery leaves) undescribed species of geoxylic suffrutex (*Ozoroa* sp. nov.).

Remarks This type is an example of the famous 'underground forests of Africa' (White 1976) characterised by plants with sometimes enormous underground woody parts connecting apparently separate dwarf shrubs or even with only tufts of leaves above ground. This growth form is called a geoxylic suffrutex (dwarf woody plant with annual or short-lived above-ground woody shoots sprouting from massive underground 'stem') (White 1976, Matthews et al. 1999, Van Wyk & Smith 2001). Some of the taxa occur naturally only as geoxylic suffrutices, while in some, generally more widely distributed taxa (incl. *Eugenia capensis, Syzygium cordatum*) suffrutex forms occur in these habitats. Several hypotheses have been suggested to explain the existence of this enigmatic vegetation type as well as the peculiar concentration of the geoxylic suffrutices. Fire-resistance and adaptation to high groundwater tables have been proposed most often (see White 1976, Matthews et al. 1999), but none of these (and other) explanations have been accompanied by conclusive evidence. Species with the geoxylic suffrutex form are also found within many open and well-wooded savanna types including some with sandy substrate where there is commonly a higher investment in below-ground organs.

References Myre (1964, 1971), White (1976, 1983), Moll (1978, 1980), Moll & White (1978), Van Wyk (1994, 1996), Lubbe (1997), Mathews et al. (1999), Smith (2001), Van Wyk & Smith (2001), Felton (2002).

CB 3 KwaZulu-Natal Coastal Belt

VT 1 Coastal Forest and Thornveld (81%) (Acocks 1953). LR 23 Coastal Bushveld–Grassland (62%) (Low & Rebelo 1996). BRG 1 Moist Coast Forest Thorn & Palm Veld (89%) (Camp 1999a, b).

Distribution KwaZulu-Natal Province: Long and in places broad coastal strip along the KwaZulu-Natal coast, from near Mtunzini in the north, via Durban to Margate and just short of Port Edward in the south. Altitude ranges from about 20–450 m.

Vegetation & Landscape Features Highly dissected undulating coastal plains which presumably used to be covered to a great extent with various types of subtropical coastal forest (the remnants of one of which are described in Chapter 12 as Northern Coastal Forest). Some primary grassland dominated by *Themeda triandra* still occurs in hilly, high-rainfall areas where pressure from natural fire and grazing regimes prevailed. At present the KwaZulu-Natal Coastal Belt is affected by an intricate mosaic of very extensive sugarcane fields, timber plantations and coastal holiday resorts, with interspersed secondary *Aristida* grasslands, thickets and patches of coastal thornveld.

Geology & Soils Ordovician Natal Group sandstone, Dwyka tillite, Ecca shale and Mapumulo gneiss (Mokolian) dominate the landscapes of the KwaZulu-Natal Coastal Belt. Weathering of old dunes has produced the red sand, called the Berea Red Sand, in places. The soils supported by the above-mentioned rocks are shallow over hard sandstones and deeper over younger, softer rocks. Fa land type dominates the area, while Ab land type is only of minor importance.

Climate Summer rainfall, but with some rainfall also in winter. High air humidity. No incidence of frost. Mean maximum and minimum monthly temperatures for Durban (airport) are 32.6°C and 5.8C and for Port Shepstone 30.6°C and 8.8°C (both for January and July, respectively). See also climate diagram for CB 3 KwaZulu-Natal Coastal Belt (Figure 11.2).

Important Taxa Graminoids: *Aristida junciformis* subsp. *galpinii* (d), *Digitaria eriantha* (d), *Panicum maximum* (d), *Themeda triandra* (d), *Alloteropsis semialata* subsp. *eckloniana*, *Cymbopogon caesius*, *C. nardus*, *Eragrostis curvula*, *Eulalia villosa*, *Hyparrhenia filipendula*, *Melinis repens*. Herbs: *Berkheya speciosa* subsp. *speciosa* (d), *Cyanotis speciosa* (d), *Senecio glaberrimus* (d), *Alepidea longifolia*, *Centella glabrata*, *Cephalaria oblongifolia*, *Chamaecrista mimosoides*, *Conostomium natalense*, *Crotalaria lanceolata*, *Dissotis canescens*, *Eriosema squarrosum*, *Gerbera ambigua*, *Hebenstretia comosa*, *Helichrysum cymosum* subsp. *cymosum*, *H. pallidum*, *Hibiscus pedunculatus*, *Hybanthus capensis*, *Indigofera hilaris*, *Pentanisia prunelloides* subsp. *latifolia*, *Senecio albanensis*, *S. bupleuroides*, *S. coronatus*, *S. rhyncholaenus*, *Sisyranthus imberbis*, *Stachys aethiopica*, *S. nigricans*, *Vernonia galpinii*, *V. oligocephala*. Geophytic Herbs: *Bulbine asphodeloides*, *Disa polygonoides*, *Hypoxis filiformis*, *Ledebouria floribunda*, *Pachycarpus asperifolius*, *Schizocarphus nervosus*, *Tritonia disticha*. Low Shrubs: *Clutia pulchella*, *Gnidia kraussiana*, *Phyllanthus glaucophyllus*, *Tephrosia polystachya*. Woody Climbers: *Abrus laevigatus*, *Asparagus racemosus*, *Smilax anceps*. Small Trees & Tall Shrubs: *Bridelia micrantha* (d), *Phoenix reclinata* (d), *Syzygium cordatum* (d), *Acacia natalitia*, *Albizia adianthifolia*, *Antidesma venosum*.

Biogeographically Important Taxa ([C]Coastal belt element, [S]Southern distribution limit) Graminoids: *Cyperus natalensis*[C], *Eragrostis lappula*[S]. Herbs: *Helichrysum longifolium*[C], *Selago tarachodes*[C], *Senecio dregeanus*[C], *Sphenostylis angustifolia*[S]. Geophytic Herbs: *Kniphofia gracilis*[C], *K. littoralis*[C], *K. rooperi*[C], *Pachystigma venosum*[S], *Zeuxine africana*[S]. Low Shrubs: *Helichrysum kraussii*[S] (d), *Agathisanthemum bojeri*[S], *Desmodium dregeanum*[C]. Megaherb: *Strelitzia nicolai*[C] (d). Geoxylic Suffrutices: *Ancylobotrys petersiana*[S], *Eugenia albanensis*[C], *Salacia kraussii*[S]. Small Trees & Tall Shrubs: *Anastrabe integerrima*[C] (d), *Acacia nilotica* subsp. *kraussiana*[S].

Endemic Taxa Herb: *Vernonia africana* (extinct). Geophytic Herb: *Kniphofia pauciflora*. Low Shrub: *Barleria natalensis* (extinct).

Conservation Endangered. Target 25%. Only very small part statutorily conserved in Ngoye, Mbumbazi and Vernon Crookes

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Figure 11.5 CB 3 KwaZulu-Natal Coastal Belt: Complex of primary species-rich grasslands and subtropical forests in Vernon Crookes Nature Reserve near Umzinto, KwaZulu-Natal.

Nature Reserves. About 50% transformed for cultivation, by urban sprawl and for road-building. Aliens include *Chromolaena odorata, Lantana camara, Melia azedarach* and *Solanum mauritianum*. Erosion is low and moderate.

References Edwards (1967), Moll & White (1978), Ward (1980), Roberts (1993), Camp (1999a, b), Heijnis (2004), Van der Linden et al. (2005).

CB 4 Pondoland-Ugu Sandstone Coastal Sourveld

VT 1 Coastal Forest and Thornveld (53%) (Acocks 1953). LR 48 Coastal Grassland (38%), LR 42 Moist Upland Grassland (28%) (Low & Rebelo 1996). BRG 1 Moist Coast Forest Thorn & Palm Veld p.p. Camp (1999a, b).

Distribution Eastern Cape and KwaZulu-Natal Provinces: Elevated coastal sandstone plateaus from Port St Johns on the Pondoland coast (Eastern Cape) to the vicinity of Port Shepstone (Ugu District, KwaZulu-Natal), incl. the sourveld of the well-known Oribi Gorge. Altitude ranges from about 0–600 m.

Vegetation & Landscape Features Coastal peneplains and partly undulating hills with flat table-lands and very steep slopes of river gorges. These sites support natural, species-rich grassland punctuated with scattered low shrubs or small trees (sometimes with bush clumps, especially in small gullies). Rocky outcrops and krantzes are common and dramatic sea-cliffs occur. Proteaceous trees (*Protea, Faurea*) can be locally common where conditions allow. Although less important here, the geoxylic suffrutex growth form (so typical of CB 2 Maputaland Wooded Grassland), is also represented in this sourveld.

Geology & Soils This unit is strictly delimited by its geology—it is built of hard, white, coarse-grained, siliceous quartz arenites (sandstones) of the Msikaba Formation of the Devonian Period (Thomas et al. 1992) giving rise to shallow, nutrient-poor (highly leached), skeletal, acidic sandy soils. Almost 80% of the area is classified as Fa land type, followed by Aa land type (10%).

Climate Summer rainfall with some rain in winter. No or very infrequent incidence of frost. Mean maximum and minimum monthly temperatures at Paddock (near Oribi Gorge in the north) are 32.2°C and 5.8°C (for January and July, respectively). The corresponding values for Cape Hermes Lighthouse (Port St Johns, in the south) are 29.5°C and 9.6°C for the same months. See also climate diagram for CB 4 Pondoland-Ugu Sandstone Coastal Sourveld (Figure 11.2).

Important Taxa Graminoids: *Alloteropsis semialata* subsp. *eckloniana* (d), *Aristida junciformis* subsp. *galpinii* (d), *Cymbopogon nardus* (d), *Themeda triandra* (d), *Tristachya leucothrix* (d), *Cyperus rupestris*, *Diheteropogon amplectens*, *Elionurus muticus*, *Eragrostis capensis*, *E. plana*, *Eulalia villosa*, *Heteropogon contortus*, *Panicum natalense*, *Trachypogon spicatus*. Herbs: *Chaetacanthus burchellii* (d), *Cyanotis speciosa* (d), *Helichrysum allioides* (d), *H. appendiculatum* (d), *H. krebsianum* (d), *H. spiralepis* (d), *Pentanisia angustifolia* (d), *Rhynchosia totta* (d), *Tephrosia macropoda* (d), *Berkheya speciosa* subsp. *speciosa*, *Cephalaria oblongifolia*, *Chamaecrista mimosoides*, *Eriosema salignum*, *Euphorbia ericoides*, *Helichrysum adenocarpum* subsp. *adenocarpum*, *H. aureum* var. *monocephalum*, *H. herbaceum*, *H. nudifolium* var. *pilosellum*, *H. pallidum*, *Indigofera hilaris*, *Pentanisia prunelloides* subsp. *latifolia*, *Pimpinella caffra*, *Vernonia capensis*. Geophytic Herbs: *Brachystelma tenellum*, *Eriospermum mackenii*. Low Shrubs: *Athrixia phylicoides*, *E. natalensis*, *E. natalitia*, *Gnidia anthylloides*, *G. kraussiana*, *G. nodiflora*, *Leonotis intermedia*, *Polygala hottentotta*. Small Trees & Tall Shrubs: *Euryops brevipapposus, Syzygium cordatum*. Semiparasitic Shrubs: *Thesium acutissimum*, *T. cupressoides*.

Biogeographically Important Taxa ([C]Coastal belt element, [E]Eastern isolated occurrence, [F]Generic fynbos element, [N]Northern distribution limit, [S]Southern distribution limit) Geoxylic Suffutex: *Gymnosporia vanwykii*[C]. Graminoids: *Loudetia simplex*[S] (d), *Calopsis paniculata*[F], *Tetraria robusta*[EF]. Herbs: *Helichrysum auriceps*[S], *H. natalitium*[S], *H. pannosum*[S], *Senecio dregeanus*[S], *S. rhyncholaenus*[S], *Berkheya insignis*[S], *Eriosema acuminatum*[C], *Helichrysum acutatum*[S], *H. longifolium*[C], *Peucedanum natalense*[C], *Roella glomerata*[F,C]. Geophytic Herbs: *Stenoglottis woodii*[S], *Asclepias patens*[C], *Disperis woodii*[C], *Kniphofia rooperi*[C]. Low Shrubs: *Senecio medley-woodii*[S], *Gnidia woodii*[S] (d), *Agathosma ovata*[F], *Erica aspalathifolia*[C], *Gnidia coriacea*[N], *Muraltia lancifolia*[F], *Pseudarthria hookeri*[F,S], *Relhania pungens*[F], *Stangeria eriopus*[C], *Syncolostemon rotundifolius*[C]. Geoxylic Suffutex: *Eriosemopsis subanisophylla*[S]. Small Trees & Tall Shrubs: *Faurea saligna*[S] (d), *Protea roupelliae* subsp. *roupelliae*[F] (d), *Encephalartos caffer*[N], *Loxostylis alata*[F], *Polygala gazensis* (isolated populations; also Inyanga), *Protea caffra* subsp. *caffra*[F], *P. simplex*[F], *Sclerocroton integerrimum*[S].

Endemic Taxa ([F]Generic fynbos element) Graminoid: *Fimbristylis variegata*. Herbs: *Eriosema umtamvunense*, *Geranium sparsiflorum*, *Lotononis bachmanniana*, *Selago peduncularis*, *Senecio erubescens* var. *incisus*, Geophytic Herbs: *Brachystelma australe*, *B. kerzneri*, *Watsonia inclinata*[F], *W. mtamvunae*[F]. Geoxylic Suffrutex: *Rhus acocksii*. Low Shrubs: *Leucadendron spissifolium* subsp. *natalense*[F] (d), *L. spissifolium* subsp. *oribinum*[F] (d), *Acalypha* sp. nov. (*Scott-Shaw 636 NU*), *Anthospermum streyi*, *Erica abbottii*, *E. cubica* var. *natalensis*[F], *Eriosema dregei*, *E. latifolium*, *E. luteopetalum*, *Euryops leiocarpus, Gnidia triplinervis*, *Leucadendron pondoense*[F], *Leucospermum innovans*[F], *Raspalia trigyna*[F], *Struthiola pondoensis*[F], *Syncolostemon ramulosus*, *Tephrosia bachmannii*. Tall Shrub: *Tephrosia pondoensis*.

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Figure 11.6 CB 4 Pondoland-Ugu Sandstone Coastal Sourveld: Pondoland sourveld on the edge of the Umtamvuna Gorge (near Port Edward, KwaZulu-Natal) with scattered trees of *Protea roupelliae* subsp. *roupelliae*. The dominant grasses are *Aristida junciformis* and *Loudetia simplex*.

Conservation Vulnerable (one of the top six vegetation units with the highest level of overall vulnerability in South Africa). Target 25%. Only about 7% statutorily conserved in the Mkambati Wildlife Reserve & Marine Sanctuary, and Umtamvuna, Mbumbazi and Oribi Gorge Nature Reserves. About 29% transformed for cultivation and plantations or by urban sprawl. In the Eastern Cape the land use is mostly subsistence farming. Erosion is very low and low.

L. Mucina

Figure 11.7 CB 5 Transkei Coastal Belt: Coastal grasslands and subtropical dune thickets near Umgazi River Mouth on the Transkei Coast (Eastern Cape Province).

Remark 1 The sandstone geology links Pondoland to other 'sourvelds' of South Africa. Pondoland forms the lowest step along a staircase of nutrient-poor geologies, comprising further the early Palaeozoic Natal Sandstones of the KwaZulu-Natal Midlands and the Late Triassic Clarens Sandstones of the Drakensberg (see also Van Wyk 1994). The occurrence of *Protea roupelliae, P. simplex*, *P. welwitschii, Erica natalitia*, *Helichrysum herbaceum, H. krebsianum, H. pannosum*, *Senecio rhyncholaenus* and *Schizoglossum atropurpureum* subsp. *virens* is indicative of this link. Pondoland is a crossroads of old migration routes and perhaps also a migration cul-de-sac (Van Wyk 1990a) of some of them. It shows not only a clear Drakensberg link, but also clear biogeographical (and geological) relationships to the Capensis through the occurrence of genera such as *Agathosma, Aristea, Athrixia, Calopsis, Cliffortia, Erica, Euryops, Leucadendron, Leucospermum, Loxostylis*, *Muraltia, Phylica, Podalyria, Prionium*, *Protea, Pseudoscolopia, Raspalia* (the only representative of the family Bruniaceae outside Capensis), *Restio*, *Relhania, Roella, Struthiola, Tetraria* and *Watsonia*. Some of these disjunctions occur at the species level (!): *Calopsis paniculata, Cliffortia odorata, Helichrysum diffusum, Loxostylis alata, Prionium serratum, Pseudoscolopia polyantha* and *Restio triticeus* (Midgley 1986, Carbutt & Edward 2001).

Remark 2 Slight depressions on the coastal plateau and rock pools on rocky outcrops support another suite of local endemics or biogeographically important taxa linked to hygromorphic soils. These include *Kniphofia rooperi, Podalyria velutina, Psoralea abbottii, Utricularia sandersonii, Watsonia bachmannii* and *W. pondoensis*.

References Moll & White (1978), Midgley (1986), Shackleton (1989, 1992), Shackleton (1990), Van Wyk (1990a, b), Shackleton et al. (1991), Abbott (1993), Shackleton & Shackleton (1994), Le Roux (1995), Glen (1996), Camp (1999a, b), Scott-Shaw (1999), Abbott et al. (2000), Carbutt & Edwards (2001), Van Wyk & Smith (2001).

CB 5 Transkei Coastal Belt

VT 1 Coastal Forest and Thornveld (84%) (Acocks 1953). LR 48 Coastal Grassland (37%), LR 23 Coastal Bushveld–Grassland (21%) (Low & Rebelo 1996).

Distribution Eastern Cape Province: Narrow coastal strip along the Wild Coast of Transkei and the Indian Ocean seaboards between Port St Johns (Egossa Interval) as far as the vicinity of the Great Kei River in the south. Altitude ranges from about 20–450 m.

Vegetation & Landscape Features The Transkei Coastal Belt is highly dissected, hilly coastal country with alternating steep slopes of low-reach river valleys and coastal ridges, sometimes broad enough to form small plains. A mosaic of grassland vegetation on the higher lying areas and characteristically on hill tops and upper hill slopes, alternating with bush clumps and small forests (considered as part of the vegetation unit FOz 5 Scarp Forest) is the major vegetation feature of the region. Most of the grasslands are undoubtedly secondary (result of forest clearing for cattle grazing). At the seaward border this vegetation mosaic is fringed by an interrupted belt of coastal dune thicket (considered as part of AZs 3 Subtropical Dune Thicket) and vegetation of young coastal habitats (dunes and beaches).

Geology & Soils Most of the area is built of Karoo Supergroup sediments including sandstone and mudstone of the Adelaide Subgroup, shale, mudstone and sandstone of the Ecca Group as well as tillite of the Dwyka group. Intrusions of Jurassic Karoo Dolerite Suite occur in places. The dominating soil forms are Glenrosa and Mispah. Fa land type dominates the area.

Climate Summer rainfall with some rain in winter (with up to 36.6% rainfall in winter at Bashee Lighthouse). No incidence of frost. Bashee Lighthouse recording a mean minimum temperature of 7.7°C in July. See also climate diagram for CB 5 Transkei Coastal Belt (Figure 11.2).

Important Taxa Graminoids: *Aristida junciformis* subsp. *galpinii* (d), *Stenotaphrum secundatum* (d), *Abildgaardia ovata*, *Cynodon dactylon*, *Dactyloctenium aegyptium*, *Ehrharta erecta* var. *erecta*, *Setaria plicatilis*, *S. sphacelata*, *Sporobolus africanus*. Herb: *Ipomoea cairica*. Geophytic Herb: *Bonatea speciosa* var. *antennifera*. Low Shrubs: *Anisodontea scabrosa*, *Passerina rigida*. Succulent Herb: *Crassula multicava* subsp. *multicava*. Small Trees & Tall Shrubs: *Acacia natalitia*, *Cestrum laevigatum*, *Grewia occidentalis* var. *occidentalis*. Succulent Tree: *Aloe ferox*.

Biogeographically Important Taxa (all coastal belt elements) Herb: *Stachys comosa*. Geophytic Herbs: *Asclepias patens*, *Strelitzia reginae*. Geoxylic Suffrutex: *Gymnosporia vanwykii*. Low Shrub: *Pavetta revoluta*.

Conservation Vulnerable. Target 25%. Only about 1% statutorily conserved, for example in Dwesa-Cwebe Wildlife Reserve & Marine Sanctuary, Silaka Wildlife Reserve and Hluleka Wildlife Reserve & Marine Sanctuary. About 20% transformed mainly for cultivation. Erosion is low and moderate.

Remarks The nonforest vegetation of the Transkei Coastal Belt is one of the most poorly studied vegetation types in the country.

References Acocks (1953, 1988), Moll & White (1978), Hoffman (1983).

9. Credits

The delimitation of the IOCB is based on K.G.T. Camp's map of Bioresource Groups for KwaZulu-Natal (Camp 1999a) within the borders of KwaZulu-Natal and on analysis based on interpretation of satellite-image data by D.B. Hoare in the Eastern Cape Province. The borders between CB 1 and CB 3 follow, to a great extent, the Camp's (1999a) map, but have been modified by C.R. Scott-Shaw and L. Mucina. The concept of CB 2 was jointly defined by W.S. Matthews, C.R. Scott-Shaw and L. Mucina, partly using the sources by Smith (2001) and Felton (2002). The concept of CB 3 resulted from fusion, as suggested by L. Mucina, and C.R. Scott-Shaw, of several units defined by Camp (1999a). The extent of CB 1 and CB 2 was partly defined also by mapping of the wetlands in Maputaland by M.C. Rutherford and L.W. Powrie. The extent of all IOCB vegetation units was also modified by the extent of the forest patches (see Chapter 12 for Credits).

The descriptions of CB 1 to CB 4 were a joint effort by L. Mucina and C.R. Scott Shaw; W.S. Matthews contributed to descriptions of CB 1 and CB 2; L. Mucina wrote the description of CB 5. The species lists were created by L. Mucina, C.R. Scott-Shaw and W.S. Matthews (the last-named for the Maputaland units). The introductory text was written by L. Mucina (sections 1 to 3), while C.R. Scott-Shaw contributed sections 4 to 7 of the introductory text. M.C. Rutherford contributed to sections 1 and 2 of the introductory text as well as to the climate and conservation sections of the vegetation unit descriptions. Table 11.1 was created jointly by L. Mucina, M.C. Rutherford and L.W. Powrie. The last-mentioned two authors also provided all climate diagrams. L. Mucina (with help of C.R. Scott-Shaw) collated the list of references. The photographs were contributed by W.S. Matthews 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.

Ezemvelo KZN Wildlife kindly provided data on the extent of CB 2 as well as forest patches imbedded within the IOCB (Ezemvelo KZN Wildlife 2004. Metadatabase file: KwaZulu-Natal Forest Types, Dataset ID 550. Ezemvelo KZN Wildlife Scientific Services Branch, Pietermaritzburg). The wetlands were mapped using selected data from the National Land Cover 2000 project as well as digitising by L.W. Powrie from topographic maps of a number of wetlands in the Maputaland region. P.S. Goodman contributed valuable comments and C. Oellerman assisted C.R. Scott-Shaw with GIS work. R.A. Ward kindly corrected the geological terminology.

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'Die dag as die Bos tot niet is, is julle soos miere waarvan die nes uitmekaargeskop is. Al verskil is dat miere weer kan nes maak, maar julle kan nie weer die Bos maak nie. Het jy al gaan sit en uitreken hoeveel byle in hierdie bos kap? Hoeveel hande aan die grootword is om nóg te kap?'

from D. Matthee, 1984. Kringe in 'n bos. Tafelberg, Cape Town. p. 140

L. Mucina

Afrotemperate, Subtropical and Azonal Forests

12

Ladislav Mucina and Coert J. Geldenhuys

with contributions by

Michael C. Rutherford, Leslie W. Powrie, Mervyn C. Lötter, Graham P. von Maltitz, Doug I.W. Euston-Brown, Wayne S. Matthews, Linda Dobson and Bruce McKenzie

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List of Vegetation Units

Figure 12.1 Typical moist form of indigenous warm-temperate forest (FOz 1 Southern Afrotemperate Forest) with tree fern *Cyathea capensis* (Diepwalle, Knysna, Western Cape).

1. Introduction

Indigenous forest in South Africa is defined as 'a generally multilayered vegetation unit dominated by trees (largely evergreen or semi-deciduous), whose combined strata have overlapping crowns (i.e. the crown cover is 75% or more), and where graminoids in the herbaceous stratum (if present) are generally rare' (Bailey et al. 1999, Shackleton et al. 1999). Stand height ranges from high forest over 30 m to scrub forest with a height of just over 3 m. All indigenous forest of southern Africa is evergreen. Besides the obviously distinctive structure, the forests differ from the surrounding vegetation (fynbos, succulent thicket, grassland, savanna) by a large specific set of flora.

Forests occur scattered along the eastern and southern margins (Great Escarpment, mountain ranges and coastal lowlands) of South Africa, from the Soutpansberg in the north (inland, 22° 40′ S) and Maputaland in the east (coast, 27° S) to the Cape Peninsula in the west (34° S) (Figures 12.2 and 12.3). Typically they occur as a series of scattered small to very small patches (<10 ha), and most forests are smaller than 100 ha in size (Cooper 1985, Geldenhuys 1991, Midgley et al. 1997). In Mpumalanga the average forest patch size is 29 ha (Lötter et al. 2002). Most of the forest realm is an archipelago of forest islands imbedded within large-scale patches of biomes such as Fynbos, Albany Thicket, Grassland and Savanna. Today these patches form scarce, but typical elements of the Subtropical Coastal Forest Biome along the subtropical seaboards of the Indian Ocean. Only few larger forest complexes can be recognised in South Africa, and these are widely separated. The largest single forest (25 706 ha) is found in the surrounds of Knysna in the south; it forms part of a still larger complex of 60 560 ha at about 34° S, spanning 22° to 24° 30′ E (Geldenhuys 1991). The Amathole forest complex (Eastern Cape) covers 40 550 ha between latitudes 32° S and 33° S, and longitudes 26° E and 27° 30′ E (Thompson 1991). In the Pirie-Isidenge-Kubusie area there is a single patch larger than 8 000 ha (Phillipson 1987). In KwaZulu-Natal the Dukuduku Forest is the largest one (3 500 ha) (Cooper 1985). The Woodbush-De Hoek Forest (6 626 ha) is the largest forest patch along the Northern Escarpment (Scheepers 1978, Cooper 1985). Smaller and isolated, still significant forests occur in the regions between the larger forest complexes around Knysna, in the Amathole Mountains, in KwaZulu-Natal (both coastal and montane forests), and along the Northern Escarpment in Mpumalanga and Limpopo Provinces (Cooper 1985, Anonymous 1987, Von Breitenbach 1990, Geldenhuys 1991, Cooper & Swart 1992, Everard & Hardy 1993, Geldenhuys & Venter 2002).

The recent floristic-biogeographic classification of the indigenous forests of South Africa (Von Maltitz et al. 2003; further developed by L. Mucina, unpublished data) recognises 26 Forest Types grouped into 8 zonal groups and 1 azonal group. Table 12.1 features the correspondence between this detailed classification scheme and the system of vegetation units adopted here (see below). The vegetation units (as well as underlying Forest Types) were derived on the basis of real quadrate data, whereby the floristic composition, biogeographic relationship as well as climate, substrate and water dynamics

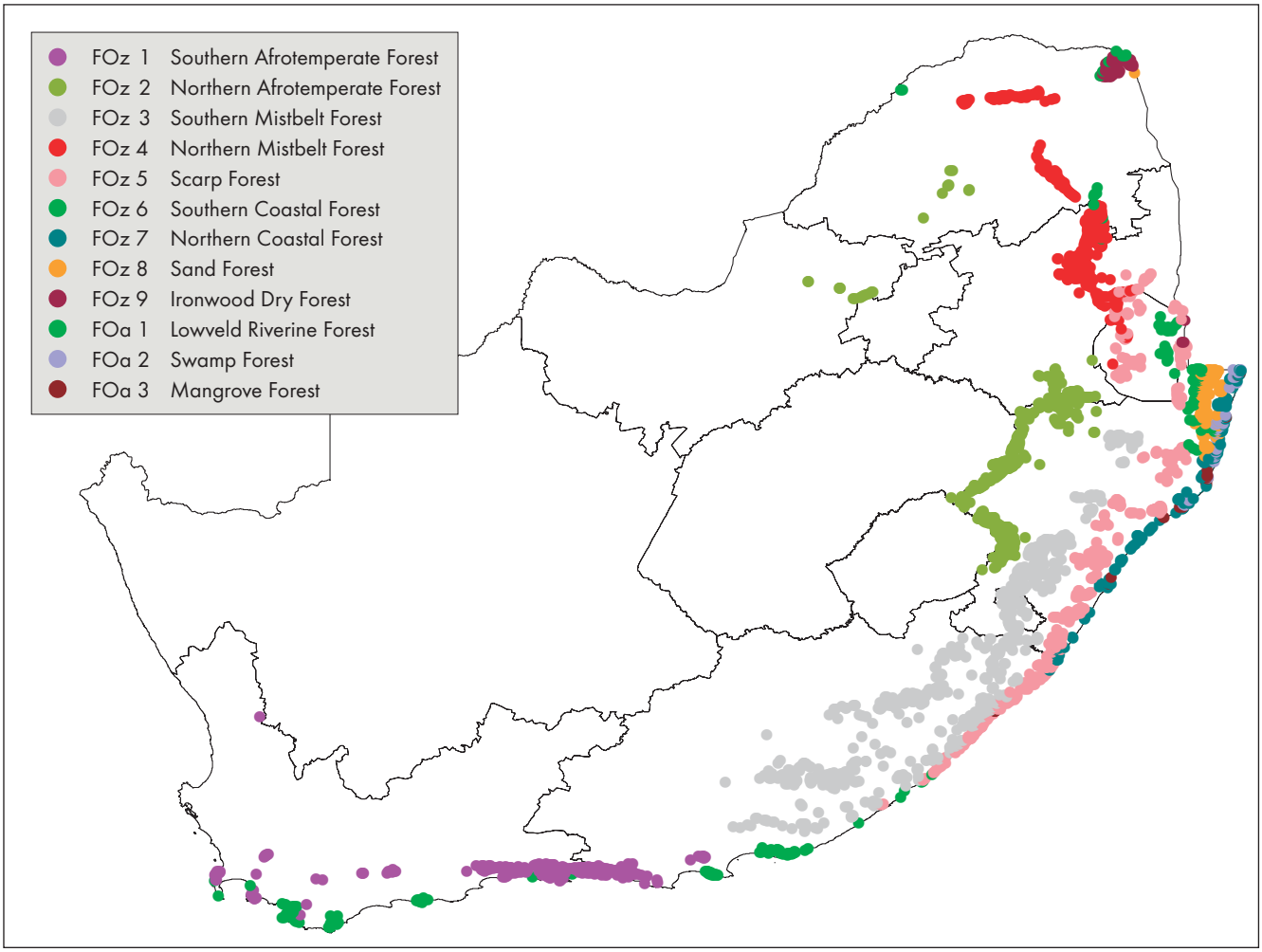

Figure 12.2 Distribution of the mapped vegetation units of the indigenous forests in South Africa and Swaziland.

Table 12.1 Crosswalk between the vegetation units adopted in this study and the National Forest Type Classification (modified after Von Maltitz et al. 2003; *not in the latter source). Zonality, intrazonality and azonality status is given for each forest type. The notion 'Savanna/Grassland' indicates that the particular forest type straddles the ecotone of both biomes.

Vegetation Units	National Forest Classification		Biome	Zonality
FOz 1 Southern Afrotemperate Forest	I	**Southern Afrotemperate Forest Group**		
	I1	Western Cape Talus Forest	Fynbos	intrazonal
	I2	Western Cape Afrotemperate Forest	Fynbos	intrazonal
	I3	Southern Cape Afrotemperate Forest	Afrotemperate Forest Biome	zonal
FOz 2 Northern Afrotemperate Forest	II	**Northern Afrotemperate Forest Group**		
	II1	Marekele Afromontane Forest	Savanna/Grassland	intrazonal
	II2	Northern Highveld Forest	Savanna/Grassland	intrazonal
	II3	Drakensberg Montane Forest	Grassland	intrazonal
	II4	Low Escarpment Mistbelt Forest	Grassland	intrazonal
FOz 3 Southern Mistbelt Forest	III	**Southern Mistbelt Forest Group**		
	III1	Eastern Mistbelt Forest	Grassland	intrazonal
	III2	Transkei Mistbelt Forest	Grassland	intrazonal
	III3	Amathole Mistbelt Forest	Grassland	intrazonal
FOz 4 Northern Mistbelt Forest	IV	**Northern Mistbelt Forest Group**		
	IV1	Northern Mistbelt Forest	Savanna/Grassland	intrazonal
	IV2	Mpumalanga Mistbelt Forest	Savanna/Grassland	intrazonal
FOz 5 Scarp Forest	V	**Scarp Forest Group**		
	V1	Eastern Scarp Forest	Savanna	intrazonal
	V2	Pondoland Scarp Forest	Indian Ocean Coastal Belt	zonal
	V3	Transkei Coastal Scarp Forest	Indian Ocean Coastal Belt	zonal
FOz 6 Southern Coastal Forest	VI	**Northern Coastal Forest Group**		
	VI1	Eastern Cape Dune Forest	Albany Thicket Biome	intrazonal
	VI2	Albany Coastal Forest	Albany Thicket Biome	intrazonal
	VI3	Western Cape Milkwood Forest	Fynbos	intrazonal
FOz 7 Northern Coastal Forest	VII	**Southern Coastal Forest Group**		
	VII1	KwaZulu-Natal Coastal Forest	Indian Ocean Coastal Belt	zonal
	VII2	KwaZulu-Natal Dune Forest	Indian Ocean Coastal Belt	zonal
FOz 8 Sand Forest	VIII	**Tropical Dry Forest Group***		
	VIII1	Licuati Sand Forest	Savanna	intrazonal
	VIII2	Nwambyia Sand Forest*	Savanna	intrazonal
FOz 9 Ironwood Dry Forest	VIII3	Ironwood Dry Forest*	Savanna	intrazonal
FOa 1 Lowveld Riverine Forest	A1	Lowveld Riverine Forest	Savanna	azonal
FOa 2 Swamp Forest	A2	Swamp Forest	Indian Ocean Coastal Belt	azonal
FOa 3 Mangrove Forest	A3	Mangrove Forest	Indian Ocean Coastal Belt	azonal

were taken into consideration. Details on the procedures of the classification of the indigenous forests into Forest Types, which led to the conceptualisation of the vegetation units in this study, are given by Mucina & Geldenhuys (2002).

Owing to the fragmented distribution of forests, the concept of zonality (as defined by Walter 1976) can be applied to forests only to a limited extent. The notion of a 'zone' relates (by definition) to biome (see Mucina 2000 for a definition). In the past the indigenous forests of South Africa were classified broadly into either two biomes, such as Afromontane forests and Coastal Belt forests (e.g. Huntley 1984) or just as a single biome (Forest Biome) as in Rutherford & Westfall (1986) and later in Low & Rebelo (1996). The latter notion was apparently motivated by purely structural rather than climatic-structural or floristic-biogeographic criteria.

In the case of the afromontane (White 1978) or more appropriately 'afrotemperate' (see Meadows & Linder 1989, 1993) forests, only one Forest Type would qualify as a part of a biome in its own right. It is the Forest Type I3: Southern Cape Afrotemperate Forests, which comprises the only forest area (the Knysna-Tsitsikamma Forest complex) of a biome dimension (Rutherford & Westfall 1986). Here these forests descend to sea level at 34° S latitude, providing a mirror image to the distribution pattern of warm-temperate forests of the northern hemisphere (Klötzli 1988) to such forests in Eastern Asia (e.g. Ohsawa 1993) and southwestern United States (Christensen 1988, Fujiwara & Box 1994, Haeupler 1994). The rest of the afrotemperate 'forest archipelago' in southern Africa should be seen as 'wreckage' of a warm-temperate biome occupying a narrow but probably formerly continuous belt along the steps of the Escarpment. These forests are imbedded (surrounded) by various temperate biomes such as Fynbos and Grassland or straddle ecotones between the Grassland and Savanna Biomes.

The evolutionary young Coastal Subtropical Forest Biome, known also as Indian Ocean Coastal Belt (Bews 1920, Moll & White 1978 and Huntley 1984) was probably dominated by a subtropical forest, of which only fragments classified as Forest Type VII1 KwaZulu-Natal Coastal Forests and VII2 KwaZulu-Natal Dune Forests remain. The other forest types rich in subtropical elements (the remainder of the Forest Group VI; Von Maltitz et al. 2003) are intrazonal—hence forming specific vegetation units embedded within (and unique to) well-defined vegetation zones (Table 12.1). Within South Africa the azonal Swamp Forests and Mangrove Forests (both of pronouncedly tropical character and distribution) are limited to the zone of the Indian Ocean Coastal Belt.

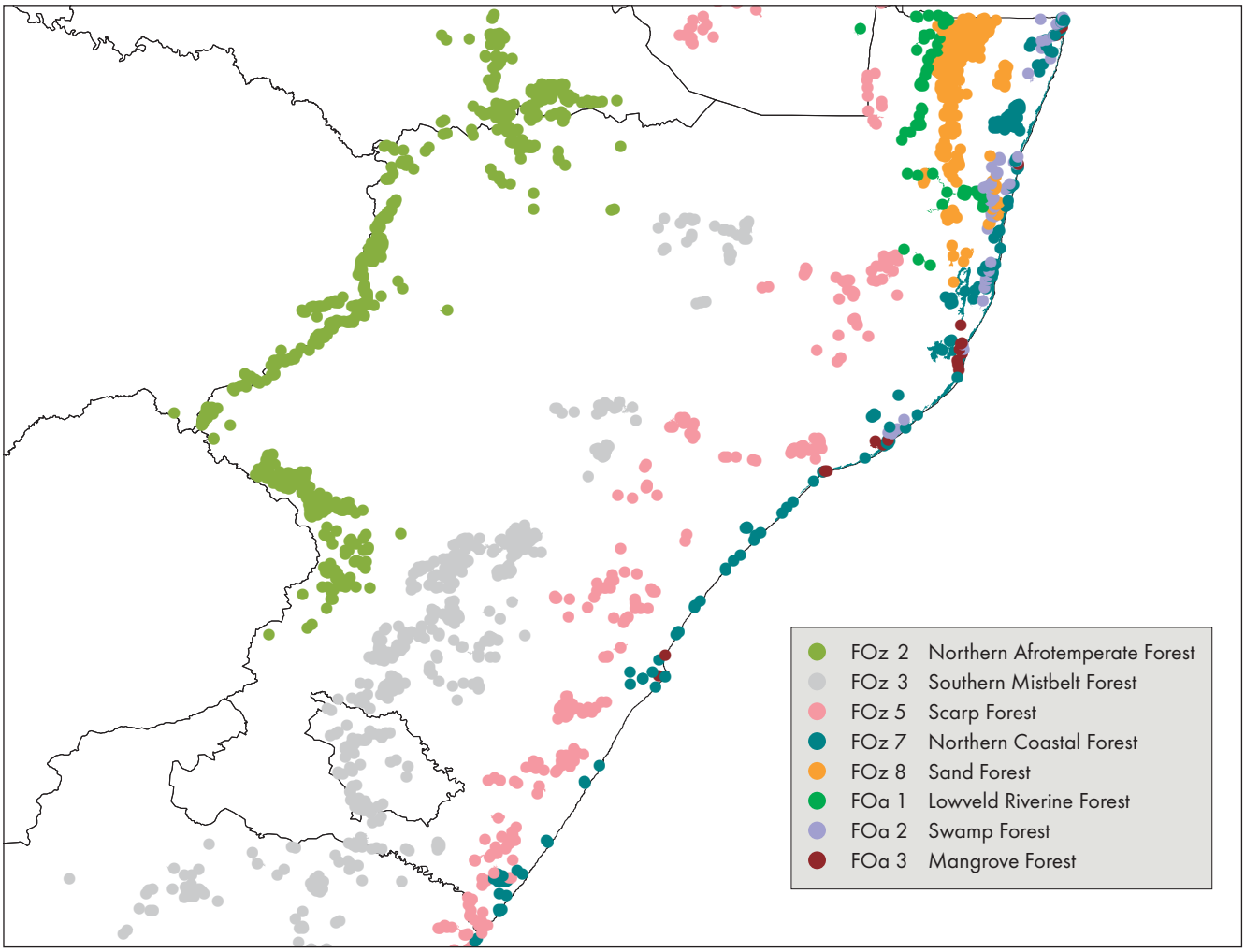

Figure 12.3 Distribution of the mapped vegetation units of the indigenous forests in KwaZulu-Natal.

The marginal (albeit very interesting owing to high concentration of tropical elements and endemic species) group of dry forests (represented by two vegetation units: Sand Forest and Ironwood Dry Forest) occur imbedded within seasonally dry and hot types of Lowveld (Maputaland and northern Kruger National Park).

There are three clearly hydrologic-edaphic azonal forest types typical of habitats controlled by specific hydrological regimes:

- LowveldRiverine Forest (gallery forest that fringes rivers in subtropical regions of South Africa and neighbouring countries).
- Swamp Forest (forest showing evolutionary and ecological links to tropical swamp forests of central Africa).
- Mangrove Forest (specific intertidal forests of subtropical and tropical coasts, reaching the southernmost distribution along the Indian Ocean coast of South Africa).

At least 7% of the country is a potential habitat owing to the favourable combination of climate and substrate suitable for forest growth. Still, forests cover just more than 3 000 km^2 or 0.1% of the land surface of South Africa (Huntley 1984, Cooper 1985, Rutherford & Westfall 1986, Anonymous 1987, Geldenhuys 2000a). This estimate varies depending on the criteria (minimum forest size mapped of 50 ha, 30 ha or 1 ha) and mapping method (use of satellite imagery or aerial photographs).

2. Current Biogeographic Patterns

In very general terms, the zonal forests in South Africa show floristic and palaeo-biogeographic links to two main African forest zones (Chapman & White 1970, White 1983, Timberlake & Shaw 1994), namely the afrotemperate forests and the coastal forests. The former is part of the Afromontane Region which also occurs outside South Africa further north in Zimbabwe, Malawi and along the East African mountain ranges, reaching as far north as Ethiopia and westwards to Cameroon and northern Angola. The coastal forests form part of the Tongaland-Pondoland Regional Mosaic with some forest elements shared with the adjacent Zanzibar-Inhambane Regional Mosaic (*sensu* White 1983). The former region has also recently been recognised as a Centre of Endemism (Van Wyk & Smith 2001), although one should reconsider joining Maputaland and Pondoland into one Centre because of the different geological and evolutionary ages of the two regions and their floras.

Taxa shared between forests show at least three patterns (Geldenhuys 1992a). Firstly, forest patches share many more of their species with neighbouring forest patches to their north and east than with those occurring to their south and west. This indicates the erosion of species diversity from the two tropical source areas—both mountains and coastal regions of East Africa—towards the South African distribution area of afrotemperate as well as subtropical forests (McKenzie 1978, Tinley 1985, Cawe 1986, Geldenhuys 1992b). For example, 206 of the 470 species found in the southern Cape forests (consider-

ing all growth forms) reach their geographical distribution limit here (Geldenhuys 1992b). Of these, 158 species reached their western limit and only 23 species reached their eastern limit in the area of the southern Cape forests. Secondly, forests share many more species with their nearest neighbouring forests than with forests further away. Thirdly, the afrotemperate forests (including those occurring in mountains close to the coast in the southwest of the country) share relatively fewer species with the forests of the subtropical coastal areas (Geldenhuys 1992a). Canopy trees and ferns have the lowest proportions of unique species, whereas these proportions are >40% for the shrubs, geophytes and forbs.

Reconstruction of the relic temperate flora of the small, isolated forests of the inland mountains of the southern Cape showed the changes in species composition that may have happened as a result of forest contraction and expansion due to landscape and climatic changes (Geldenhuys 1997a). The less isolated forests had been enriched from the large forest complex on the coast along specific migration routes and during specific waves of forest expansion. The distribution ranges of taxa of the southern Cape forests were used to establish generalised tracks of the flora in order to test hypotheses about the speciation and development of the forest floras (Geldenhuys 1994a). The results indicated that the ecological characteristics of species of each geographical species group reflected the environmental conditions and disturbance regimes that prevailed in each source area. The southern Cape forest flora was therefore considered to be composed of the following elements:

- Species adapted to a narrow, cool, humid afromontane area.
- Species of a transition zone between the montane zone and the humid, warm, subtropical coastal areas.
- Species adapted to more frequent and extreme droughts and drier conditions of the lowlands between the coast and mountains.
- Species adapted to the southern temperate cool, moist mountain areas.
- Species adapted to frequent grassland and shrubland fires on the forest margin.
- Local endemic species.

The present patterns of composition of the different forests (within either afrotemperate or coastal regions) suggest that their high degree of similarity may have been established before major fragmentation of the forests since the late Miocene—the time period which experienced increasing aridity (Geldenhuys 1992a). During this period of fragmentation, forests and forest biota survived in areas now considered as dispersal corridors. The number of dispersal corridors (mountain chains, escarpments, river valleys, coastal dune systems) meeting in a particular forest is probably one of the strongest variables determining the number of woody plants in a forest (Geldenhuys 1992a, 1997a).

3. Diversity Patterns

Geldenhuys (1992a) listed 1 438 plant species that had been recorded for 14 forests or forest complexes representing the geographical range of the mixed evergreen forests in South Africa. These included 155 families and 661 genera. The forests covered only 0.08% of the area and 7.1% of the vascular species, but had a relatively rich 0.58 species per km^2. Gibbs Russell (1987) indicated a ratio of 0.0079 plant species per km^2 overall for southern Africa, with 20 227 indigenous vascular taxa. Only fynbos exceeded the forest value with 1.36 species per km^2 (7 316 species). The third richest biome was grassland with 0.25 species per km^2 (3 788 species).

Plant species richness remains relatively constant along the tropical-temperate gradient of southern Africa, except for the southwestern extreme (Geldenhuys & MacDevette 1989, Geldenhuys 1992a). KwaZulu-Natal Coastal Forests and Pondoland Scarp Forests with a large proportion of endemic plants (Van Wyk & Smith 2001) have the highest number of woody species (254 and 338 species respectively). The Western Cape Afrotemperate Forests (from the Cape Peninsula to Swellendam) and the Drakensberg Montane Forests have the lowest number (48 and 78 species respectively). The number of both woody and herbaceous species of isolated forests and forest complexes increases with area of the forest (Geldenhuys 1992a). However, woody species richness is more strongly correlated with the proximity to other forests and the number of available dispersal corridors (mountain range, escarpment, river, coastal dune system).

The ratio of woody to herbaceous plant species varies greatly between individual forests (Geldenhuys 1992a). In general, coastal forests have a ratio in excess of 60%, whereas in montane forests the ratio varies between 39% and 53%.

Species richness varies more within a forest than between forests (Geldenhuys & MacDevette 1989). Montane forests, in general, have fewer species than lowland, coastal and dune forests, both in KwaZulu-Natal and the southern Cape. Furthermore, drier (or warmer?) forests are richer in species than wetter (or cooler?) forests. The different growth forms also show clear patterns amongst the different forest types. Species turnover of woody plants from montane to lowland forests increases more sharply than for herbaceous plants. Fern species richness experiences decline, and richness of vines, graminoids, geophytes and forbs increases from the montane to the coastal forests. The species richness of epiphytes is the highest in less disturbed and mature forests, especially in the mistbelt and subtropical forests.

4. Palaeo-ecological Patterns: Role of Climate and Fire

The remarkable variability of extant forests in southern Africa and their generally patchy (archipelago-like) dispersal over landscapes of several biomes are indicative of their relictual character. We discuss the role of two major probable agents that shaped the current and past forest patterns—climate and fire.

Geldenhuys (1994b) suggested that not only environmental factors (rainfall and substrate) determine the potential limits of forest distribution but that actual pattern of forests and their boundary shapes are to a large extent (particularly in hilly and mountainous areas) determined by the fire pattern. This pattern, in turn, is determined by the interaction between the prevailing winds during dry periods and terrain physiography. Gusty, hot, desiccating northwesterly föhn-like berg winds are common during autumn and winter (Tyson 1964, 1986). Berg wind direction is locally changed by barriers, such as the mountain ridges to the windward (northern) side of the forests. The wind direction is channelled through valleys running from the mountains, and its flow direction is determined by the position and form of the barriers (see Figure 12.4). Lightning and human-induced fires (Deacon et al. 1983) are exacerbated by the berg winds. The fires burn with higher frequency in zones in the landscape where forest is absent (fire pathway), fragmenting the forests along the fire pathways. Forest persists in the

topographic or wind shadow areas (also called fire refugia).

The borders between forests and surrounding fire-prone ecosystems (FPE; *sensu* Bond et al. 2003b), including Fynbos, Grassland and Savanna, are characteristically sharp. Geldenhuys' (1994b) hypothesis addresses this phenomenon convincingly in regions of frequent berg winds and under current climatic conditions (Figure 12.4 and 12.5). Persistence of the large number of forest patches scattered over vast areas of southern Africa and the existence of sharp forest limits outside the regions of berg-wind influence demand additional, alternative explanations. Increased inflamability due to long-lasting (unusual) droughts and unnatural high-frequency of man-made fires in coastal grasslands may alter forest limits (Figure 12.6). Sharp change in substrate properties, such as observed on the border between boulder screes on steep slopes in deep kloofs (supporting afrotemperate forest) and the surrounding fire-driven fynbos (Figure 12.7), may be seen as another important factor for survival of forest patches in a FPE landscape.

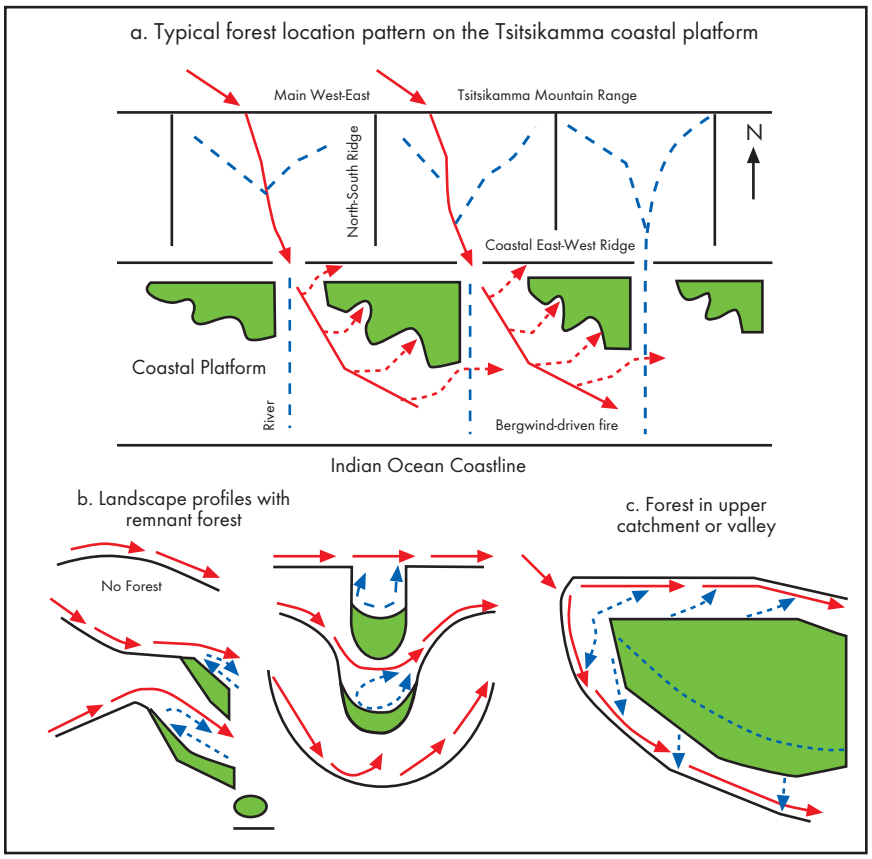

Figure 12.4 Schematic view of hypothetical airflow across and around topographic barriers to show the persistence of forest in wind-shadow areas in relation to wind-driven fires (adapted from Geldenhuys 1994a; courtesy of Blackwell Science Publishing).

Fire does not normally play a role in ecosystem dynamics of forest patches, except at the fringes (Bailey et al. 1999). However, Geldenhuys (1993e) collected charcoal from the litter and feeding root zone of many seemingly mature forest stands throughout the southern Cape. The charcoal resulted from fires caused by lightning (Geldenhuys et al. 1994), spotting during berg winds or by honey collectors. In principle, the South African forests (in particular the afrotemperate ones) as we know them today are non-flamable by nature. A study by Van Wilgen et al. (1990) has shown that the reasons for fire-resistance of forests can also be found in vegetation structure (spatial compartmenting of fuel) and physico-chemical properties of the fuel with high moisture and low fat content in the leaves. For various causes of and response of forests and species to fire inside forests, we refer to papers by Edwards (1984), Granger (1984), Pammenter et al. (1985), Lübbe (1990a) and Geldenhuys et al. (2002).

From a palaeo-ecological perspective, fire must have played a major role in shaping the extent of forests in our region since the formation of the fire-prone ecosystems (late Miocene-Pliocene; see chapters on Grassland and Savanna in this book). Subtropical and warm-temperate evergreen forests covered the largest part of Africa until the Great Escarpment was formed and separated the moist coastal belt from the arid interior (Deacon 1983, Deacon et al. 1983). Increasing aridity (combined with prolonged dry seasons) developed, and increased fire frequency contributed to the expansion of fire-adapted woodlands, shrublands and grasslands. The relictual nature of the forests within the grasslands and woodlands has been attributed to the destructive activities of man during the relatively recent past, i.e. over the last 100 to 300 years (e.g. Acocks 1953, White 1983). However, as argued by Deacon et al. (1983) and Meadows & Linder (1989, 1993), patterns of forest distribution were to a far greater extent determined by climatic (see Eeley et al. 1999) and landscape changes.

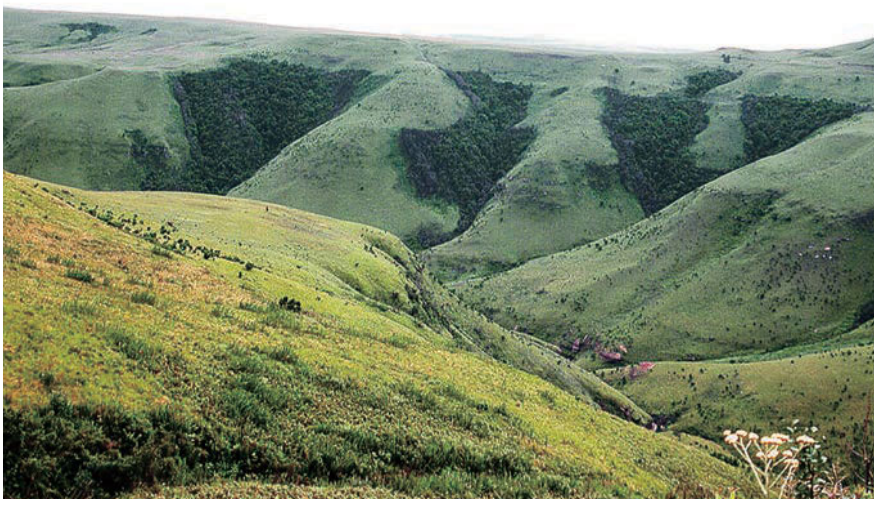
C. J. Geldenhuys

Figure 12.5 Patches of Drakensberg montane forests (FOz 2 Northern Afrotemperate Forest) in fire-protected kloofs in the Cathedral Peak area (uKhahlamba-Drakensberg Park, KwaZulu-Natal). The fire-exposed ridges are devoid of forest (see also Figure 12.4).

Scholtz (1986) demonstrated from palynological and charcoal studies that large climatic changes occurred in the south-

W.S. Matthews

Figure 12.6 Scorched edges of a dune forest (FOz 7 Northern Coastal Forest) neighbouring onto coastal grassland in Maputaland (northeastern KwaZulu-Natal).

ern Cape over the last 60 000 years. Since the cold and dry Last Glacial Maximum, the most mesic period (with forest expansion) was between 14 000 and 12 000 BP. This was followed by a hot, dry period (with forest regression) until the climatic optimum period fostered forest spread during the period 4 000 to 2 500 BP. Another period of warm, dry summers followed, accompanied by forest regression. However, the climate since about 1 400 BP is considered to have been similar to the present and supported another boost of the forest spread.

Hypotheses addressing the past and present distribution of forests (in particular the age of forests and their persistence on a site) must consider the origins and dynamics of the surrounding FPEs. A study of West et al. (2000), using oil-carbon isotope methods, revealed that C_4 plants (hence grasslands) earlier dominated the site that is today covered by Hluhluwe Forest—a member of the endemic-rich vegetation unit FOz 5 Scarp Forest. Incidentally, the Hluhluwe Forest itself houses *Albizia suluensis*, a very restricted local endemic. West et al.'s study concluded that grasslands were precursors to the forest vegetation in the region because of the observed shift from a also C_3- to C_4-dominated ecosystem with increasing soil depth. This fact, however, does not preclude a possibility of existence of this forest on the site in pre-Pliocene times. Its extent might have undergone reduction (or even obliteration in the study site). The Hluhluwe Forest could have regenerated from close-by patches, still leaving a C_3–C_4 transition signal behind. Simulation studies (Bond et al. 2003a, b) predicted a shift from C_4- to C_3-ecosystems, due to increase of woody biomass, under exclusion of fire. Considering the long-term dynamics of forests (and FPEs surrounding them), a new element of ecological thinking appears —the interaction of CO_2 ambient concentration and fire (Bond et al. 2003a). Paleoclimatology presumes that during LGM (21 000 to 18 000 ya) and implicitly during all glacial maxima of the other 20+ glaciation cycles during the Pleistocene (and possibly beyond into Pliocene), the forest cover was sparse. During the LGM low CO_2 levels (180 ppm) have promoted C_4-dominated grasslands. A simulation study by Bond et al. (2003b) argues, that by current (human-forced) levels of CO_2 of 360 ppm, the grassland ecosystems with precipitation above 650 mm would develop towards fire-sensitive forest, if fire was excluded. Also the mesic fynbos would then turn into forest under the simulated conditions. Experiments addressing success of establishment of forest precursors in fynbos (Manders 1990, Manders & Richardson 1992) lend this idea strong support. Rebelo et al. (see Chapter on Fynbos in this book: FFg 3 Peninsula Granite Fynbos) argue that changes in fire-management allowed forest to take over much of the area formerly covered with granite fynbos over a short period of only several decades. In the Soutpansberg, and along the Northern Escarpment, the exclusion of fire changed some grasslands to forests through woodlands serving as an intermediary step (Geldenhuys & Venter 2002).

Despite mounting evidence for the role of climate and fire in shaping the current patterns of forest cover, the influence of man cannot be denied. Climatically favourable Holocene and human-enforced increases of temperature result in expansion of the forest cover. Still some potentially forest-rich regions (see Chapter on Indian Ocean Coastal Belt in this book) show only very fragmented and scanty forest cover. We argue that these regions, comprising mainly the coastal belts of KwaZulu-Natal and the north-eastern Eastern Cape have experienced heavy forest clearing in the past. The Iron Age farmers migrating southwards along the

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Figure 12.7 Patch of afrotemperate forests on scree (Table Mountain Group sandstone) in Leopard's Kloof in the Harold Porter National Botanical Garden (Betty's Bay, Western Cape).

broad coastal belt settled in high density in preferred sites at least over the last 1400 years. Forest and scrub forest have been continuously cleared for pastures and exploited for timber, plant foods and medicines during this period (Feely 1980, 1987), but also recovered in many places in the same areas (Von Maltitz et al. 1996).

5. Ecology

5.1 *Climate*

Forest is limited to regions with high water availability. This is mostly determined by high rainfall, though riverine and kloof forests exist outside the normal rainfall envelopes associated with forests—here the groundwater, flood water and shelter phenomenon (deep gorges with low solar irradiation, hence lower evaporation and evapo-transpiration) play a role. Hence, the water availability to forest vegetation is a function of amount of precipitation (rainfall and mist), evapo-transpiration, availability of groundwater and, in addition, soil structure and seasonality of precipitation.

Forest persists in areas with mean annual rainfall >525 mm with strong winter rainfall and >725 mm with strong summer rainfall (Rutherford & Westfall 1986, Geldenhuys 1991). Rutherford & Westfall (1986) have suggested that a summer aridity index may be a better predictor of forest distribution than rainfall per se. They have shown that forests grow under lower rainfall conditions in winter-rainfall areas than in summer-rainfall areas. The basic climatic characteristics of the forest vegetation units are depicted in the climate diagrams featured in Figure 12.8.

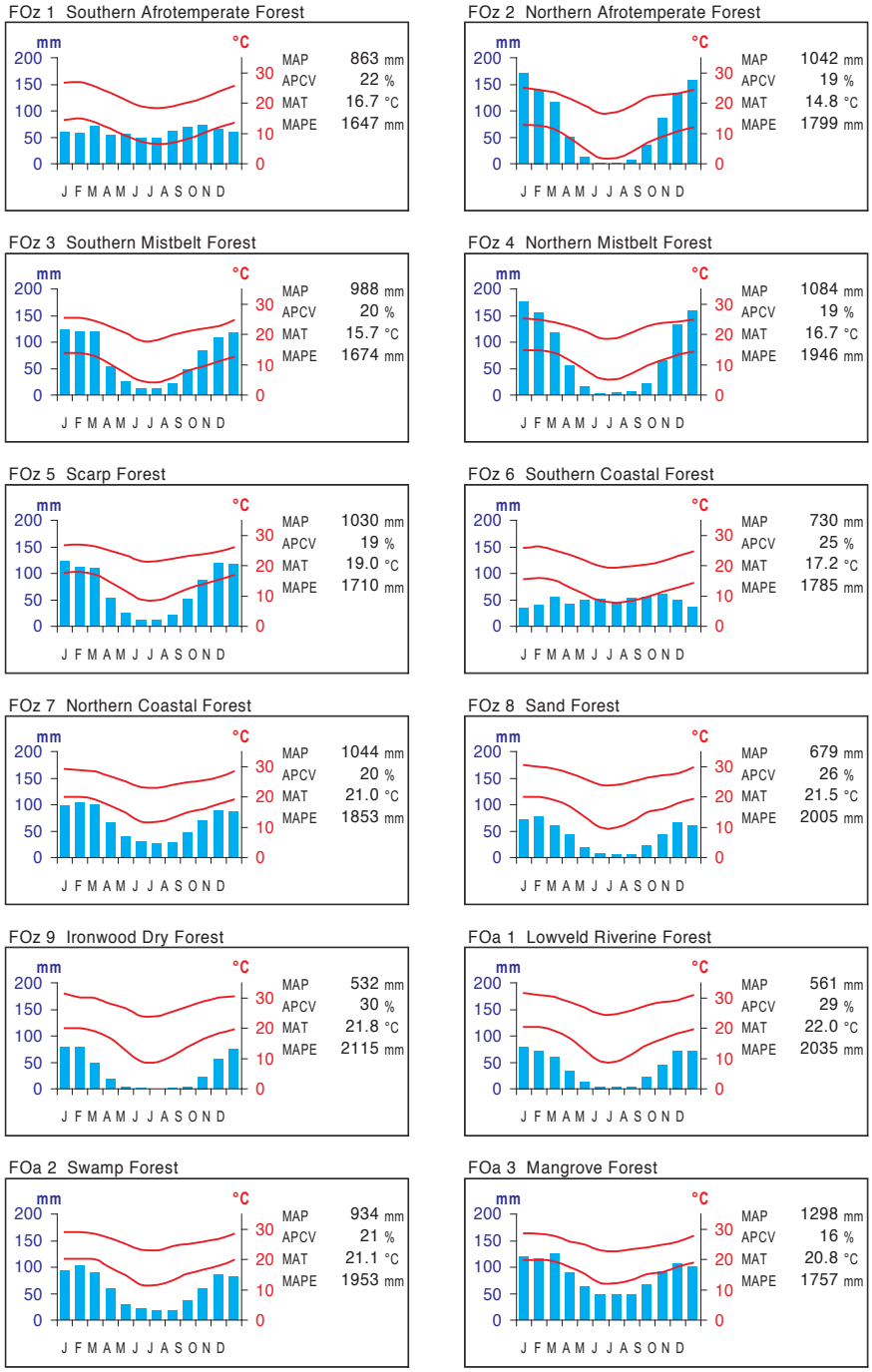


Figure 12.8 Climate diagrams of afrotemperate, subtropical and azonal forest units. Blue bars show the median monthly precipitation. The upper and lower red lines show the mean daily maximum and minimum temperature respectively. MAP: Mean Annual Precipitation; APCV: Annual Precipitation Coefficient of Variation; MAT: Mean Annual Temperature; MAPE: Mean Annual Potential Evaporation.

Mist precipitation along the Great Escarpment and some exposed mountain ranges supplements the rainfall considerably. Forests are, however, also found along rivers and in protected kloofs (gorges) in areas of lower rainfall (Von Maltitz et al. 2003). In the drier inland areas, mountains provide important sites for development of forest, e.g. the southern slopes of the Soutpansberg (Geldenhuys & Murray 1993) and sheltered valleys in the southwestern Cape (McKenzie 1978, Masson 1990, Geldenhuys 1997a).

Most areas covered in forest are linked to orographic precipitation. These mountainous areas show steep gradients in precipitation and localised rain shadows. Spatial patterns of total precipitation do not show a clear correlation with forest type distribution. Most afforested areas of the country show local gradients in rainfall. The following conclusions were drawn from an analysis of rainfall envelopes for the indigenous forests:

- Azonal types, and especially riverine forest, occur in areas of lower rainfall than are typical for forests.
- The areas of highest rainfall are found in the Mpumalanga and Soutpansberg areas.
- The Alexandria (Albany) forests have lower rainfall than most forest types.
- The southern Cape forests have a mix of rainfall, with some areas receiving low rainfall (Geldenhuys 1991 indicated a range from 500 mm near Great Brak River to 1 200 mm in Jonkersberg, Diepwalle and Storms River).

Two discernible gradients exist in seasonality of precipitation. There is a trend from west to east following the coastline from the Western Cape coast with winter rainfall to all-year rainfall in the Knysna region. Most of the remaining coast to the east has predominantly summer rainfall, though the northern KwaZulu-Natal coast also receives rainfall all year. From Port Elizabeth eastwards there is a gradient from the coast inland of increasingly greater summer dominance of rainfall.

A number of factors influence temperature within forests. Temperature decreases with both latitude and altitude. Proximity to the coast has a moderating influence on temperature and tends to reduce the range in temperature extremes. Maximum temperature is most extreme on the KwaZulu-Natal north coast where mean maximums for the hottest month are in the region of 30°C and mean annual temperature is 22°C. Temperature decreases southwestwards along the coast to a mean maximum of 25°C for the hottest month in the afrotemperate forests of the Knysna area. Inland areas tend to be cooler, especially in the mistbelt and high mountains of KwaZulu-Natal. The inland Eastern Cape region has higher maximum temperatures than other inland forests.

The coastal influence moderates minimum temperature in the coastal region. Along the coast there is a decrease in temperature from the northern Zululand coast through to the George-Knysna area. Inland minimum temperatures decline rapidly from the coast towards the mountains as altitude increases. There is also a discernible decrease in temperature with latitude.

Persistence and recovery of forests are also linked to microclimate created by the forest patches themselves. A mixed evergreen forest is a layered community and always has a continuous tree layer, with or without shrub and/or herbaceous layers (Geldenhuys et al. 1988a). The layering and the closed forest canopy buffer the outer macroclimate to create a more equable internal microclimate (Geldenhuys 1993a). In relation to conditions above the canopy, the temperature in the shrub layer is lower, the humidity is higher and the wind speed is considerably lower to almost nonexistent, even during berg wind conditions. Large gaps created in the canopy during road construction or careless timber harvesting have two major effects on the plants growing in and around such gaps. Below-canopy plants are exposed to the more extreme conditions prevailing outside the canopy. Many of them cannot adapt to the changed conditions, and die. Wind blowing over the relatively smooth, undulating forest canopy becomes turbulent within the gap and uproots the trees on the side of the gap from which the wind blows (Geldenhuys et al. 1988b).

Vegetation of a natural forest edge has an effect on the microclimate of the forest interior similar to that of the closed forest canopy. A natural forest edge consists of plants of various growth forms and sizes that close the gaps between the mature trees. It usually forms what is known as a soft edge, which gradually decreases in height and increases in foliage density away from the mature forest. This transitional area, or ecotone, also has a higher biodiversity than either the forest or the outside vegetation, because it includes elements of both. Creation of a hard forest edge, such as during removal of the forest edge vegetation or cutting of a clearing in the forest, exposes the forest interior to penetration by the hot, dry and gusty winds, and even fires, to the detriment of the less hardy plant species that grow there.

5.2 Geology and Soils

The substrates supporting forests include a wide range of geological formations: quartzitic sandstone, mudstone, shale, schist, Enon conglomerate, dolerites, dolomite, granite-gneiss and aeolian sands (Geldenhuys 2000a). The derived soils vary in depth, water-holding capacity and nutrient status.

The high rainfall in areas supporting forests has major effects on forest soils. It causes waterlogged conditions in clayey soils and leaches the soluble nutrients deeper into the soil. The result is that the trees develop very shallow root systems. In the southern Cape forests, in general, the root system of a tree has a maximum depth immediately beneath the bole and decreases further away from the tree where the roots are confined to the top 30 cm of the soil (Kotze & Geldenhuys 1992). Large individual trees of *Afrocarpus falcatus* have roots of more than 20 cm in diameter appearing above the soil surface and extending horizontally for distances in excess of 40 m away from the bole. A dense mat of fine, feeder roots concentrates in the upper 10 cm of the soil. The waterlogged conditions inhibit penetration of roots deeper into the soil, where they would suffocate from lack of oxygen. The main function of the feeder roots is to absorb nutrients from decomposing litter in the upper part of the soil profile. Disturbance of the root and litter layers will have significant negative effects on forest nutrition, and this will, in turn, adversely affect forest regeneration and recovery. The trees are also particularly sensitive to poor soil aeration caused by standing water resulting from disturbance of the natural drainage patterns and from soil compaction (Geldenhuys et al. 1988b, Lübbe & Mostert 1991). Naturally, the trees, shrubs and many herbs of the riverine, swamp and mangrove forests have developed a number of adaptations to cope with anaerobic conditions in waterlogged soils.

6. Forest Dynamics

Forest stand dynamics are determined by a number of important processes inside the forests, such as natural disturbance and gap dynamics, litter fall and a closed nutrient cycling, characteristic fruit and seed types and associated regeneration processes, and plant-animal interactions.

6.1 Gap Dynamics

The forest interior is subject to regular small-scale disturbances causing gaps of 0.005 to 0.5 ha (Geldenhuys & Maliepaard 1983, Midgley et al. 1995). Lightning may cause a fire or merely kill a small group of trees (Geldenhuys et al. 1994). Some trees, such as *Ocotea bullata*, can recover from such strikes by resprouting, whereas others (e.g. *Rapanea melanophloeos*) can be easily killed. Hail events occur very infrequently, but still they can cause major damage by defoliation of whole stands. Winds cause the breakage of large branches or occasionally uproot a single tree, or at the most a small group of trees. Large windfalls occur very infrequently in the southern Cape and other forests along the escarpment. In northern KwaZulu-Natal tropical cyclones occasionally flatten large parts of the coastal and riverine forests. However, most trees die standing and singly from old age or some form of disease or stress (Geldenhuys & Maliepaard 1983, Midgley et al. 1995). Van Daalen & Shugart (1989) applied an individual-tree gap model aimed at simulating succession dynamics on a site in the Outeniqua Forest (near Knysna) using demographic parameters for 28 woody plant species.

Severe droughts affect the forests from time to time. In 1983 the leaves of most evergreen trees in some Eastern Cape forests died on the trees (Geldenhuys 1993b). The leaves of the evergreen *Buxus macowanii* remained green throughout the

drought, but many plants died shortly afterwards when they were totally defoliated by larvae of a moth species, which appeared in large numbers after the first rains.

6.2 Litter Fall and Nutrient Cycling

The high nutrient content in the surface layers of the soil is maintained through the fall of litter—leaves, twigs, bark, flowers and fruit—as well as through the death of forest microbes and animals (Geldenhuys & Theron 1994). Contrary to the general (perhaps eurocentric) perception that leaves fall in autumn, leaf fall in the South African indigenous forests occurs throughout the year, but with a definite peak in midsummer (December and January). During this time the rainfall is high (except in the west), but the trees experience a physiological drought because of the high temperatures and associated high loss of water due to transpiration. The total litter fall in forests in the southern Cape amounts to 3 000–4 500 kg. $ha^{-1}.yr^{-1}$ (Geldenhuys & Theron 1994), but it may reach values up to 10 000 $kg.ha^{-1}.yr^{-1}$ in the high-rainfall areas of the Limpopo Province (Geldenhuys et al. 1984). The total amount of litter increases with increasing total mass of living material (biomass) of the forest, which is well correlated with rainfall. The litter, with the leaf component forming about 80%, decomposes relatively quickly. However, the decomposition in the warm-temperate forests proceeds at a much slower pace than in warm, moist tropical rainforests. The rate of decomposition of the litter is about two years for a moist forest, and four years for a dry forest, resulting in a gradual build-up of litter on the forest floor (Geldenhuys & Theron 1994).

Forests can also grow on nutrient-poor or shallow soils, provided that the moisture is sufficient and disturbance is minimised, so that the nutrient cycle can develop. It is a slow process and one that requires the recovery and increase of the nutrient status in the upper layers of the soil.

6.3 Dispersal Syndromes and Animal-plant Interactions

The suite of dispersal syndromes in the southern Cape indigenous forests are considered (Geldenhuys 1993c) to be similar to those of the closed, mixed tropical-subtropical forest as described by Hall & Swaine (1981). They include:

- 34% Species with small, dry seeds dispersed by gravity or ballistic mechanisms.
- 24% Species with small seeds either from fleshy fruits or with a fleshy aril from drier fruits, dispersed by frugivores.
- 18% Species with spores or dust-like seed for dispersal by wind.
- 8% Species with fleshy fruits with large seeds, dispersed by larger frugivores.
- 8% Species with small seed with a pappus or wool for wind dispersal.
- 4% Species with larger dry seeds from capsules, cones or nuts, dispersed by mechanical means.
- 3% Species with seed with attachments for accidental dispersal by mammals.

The representation of propagule type also varies across growth forms (Phillips 1931, Geldenhuys 1993c). Fleshy propagules, especially of small size, predominate in tree species. Large fleshy propagules are more important in canopy than in sub-canopy trees. Large dry propagules are more common than small dry ones in both canopy and sub-canopy trees. Very few tree species have true wind-dispersed seeds. A few trees have very small seeds that can drift in the wind over short distances. Woody shrubs usually have small, fleshy propagules and soft shrubs mostly small, dry ones. Lianas have either fleshy (64%) or wind-dispersed (36%) propagules, whereas vines have dry (64%), mostly wind-dispersed (53%) propagules. The other categories occur in the geophytes, graminoids, epiphytes, ferns and other forbs. Fruit type and seed dispersal agent are important in the seedling germination and population demography of many forest species (Geldenhuys 1996a).

Forests are home to many animal species—they use them for shelter, breeding and forage. Animals act both as disturbance and regeneration agents. Most of the mammals and a large proportion of the birds found in South African forests are not confined to the forest habitat and have wide distribution ranges (Geldenhuys & MacDevette 1989). Many of the forest-dependent birds migrate to forests at lower altitudes during winter.

Bird species richness is relatively low in forest areas and shows a decline from north to south like plant species do (Koen & Crowe 1987). For example, moving southwards from the Eastern Cape, 54 species have been recorded in Dwesa Forest, 43 in Alexandria Forest, 35 in Diepwalle Forest near Knysna, and only 15 in forest patches of the Cape Peninsula (Cody 1983).

Forest mammals generally occur solitarily or in small groups, are shy and many are nocturnal. Mammals are particularly important in forest dynamics in browsing of young plants and coppice re-growth (Lübbe 1990b), in seed predation (Geldenhuys 1993d, Koen 1991) and seed dispersal (Koen 1983, Geldenhuys 1993d, 1996a). Birds are important in pollination and seed dispersal (Koen 1988, 1992, Geldenhuys 1996a).

7. Status of Indigenous Forests of South Africa

Ownership determines the type and quality of forest management and possible impacts on the vegetation (Phillips 1963, Cooper 1985, Cawe 1986, McKenzie 1988, Geldenhuys 1991, Cooper & Swart 1992). Most of the forests are surrounded by areas of high population density (Geldenhuys 1999a). Some forests occur in areas surrounded by developed affluent societies. In such areas, the people strive to satisfy higher-order needs, such as high-quality furniture and crafts, recreation and ecotourism, and biodiversity conservation. In general the forests expand, with a small impact from development (roads, power lines, dams, housing complexes). Other forests occur in areas surrounded by poor developing rural communities. In such areas, traditional subsistence practices are used to satisfy the livelihood needs, such as building material, fuel wood, food and medicine, and other household goods. The actions are poverty-driven because people lack alternative income-generating activities. Such activities often lead to forest degradation. The challenge is to move the living standards of the rural poor towards higher income-generating levels of society.

The national and provincial governments and statutory bodies manage and control a very large proportion of the forests (and the largest forests), and only a small portion is privately owned or on communal land (Cooper 1985, Geldenhuys & MacDevette 1989, Geldenhuys 1991). Conserved forests in South Africa range from forests in private and tribal ownership that are in good condition, to forests in conservancies and natural heritage sites, through to forests in nature reserves and

wilderness areas proclaimed under the Forest Act. There are many forests outside the proclaimed areas that are well conserved but with insecure conservation status. Geldenhuys & MacDevette (1989) defined conserved forests as those in the custody of government authorities, including the National Parks Board (currently South African National Parks) and city councils. The forest types and forest complexes in southern Africa are generally well conserved (Geldenhuys & MacDevette 1989, Von Maltitz et al. 2003). However, various sources still exert pressure on these forests (McKenzie 1988, Geldenhuys & MacDevette 1989, Von Maltitz et al. 2003):

- Growing human needs in rural tribal areas (uncontrolled use of forest resources for construction, crafts and traditional medicine, and forest clearing).
- High-intensity farming interests (causing the clearing of scrub forest and riverine forest for agriculture).
- Economic pressures (causing uncontrolled exploitation, grazing and burning of forests on farms).
- Mining of forested dunes along the coast.
- Development of infrastructure (roads, power lines, dams), township and resort developments.

8. Threats to Indigenous Forests of South Africa

With the settlement of the Europeans in southern Africa since 1652, large-diameter trees of selected species were harvested for building and furniture timber and for railway sleepers (King 1938, 1941, Phillips 1963, McKenzie et al. 1977, Scheepers 1978, Cawe 1986). However, the forests of South Africa have played a role over a much longer period in the welfare of society that is disproportionately greater than their small extent and low potential for commercial exploitation. McKenzie (1988) recognised many direct uses and indirect values of the South African forests. A review showed that 365 of the 568 tree and shrub species recorded from 14 forest complexes throughout South Africa (Geldenhuys 1992a) were utilised for a wide range of direct uses (Table 12.2; Geldenhuys 1999a). A recent survey of 21 villages for forest resource accounting in the Eastern Cape Province (with many forests in poor rural areas) showed much informal commercial and subsistence use of the forests (Hassan & Haveman 1997). A total of 140 tree and shrub species were recorded, some more widely and generally used than others, but not all were indigenous species. The uses include a variety of poles (mainly for construction), firewood, crafts (from timber and non-timber species), binding and weaving, food sources (vegetables, fruits and bush meat), and traditional medicine (bark, roots and other sources). Poverty of rural people and their inability to afford alternative commodities cause a continuous use of products from the forests and increased forest clearing to grow crops to support their families.

Fuel wood represents the highest volume of forest products used by rural people (Basson 1987) and the resulting pressure is particularly severe where the forests are not surrounded by woodland, plantations or woodlots of introduced species (McKenzie 1988). *Acacia natalitia* (formerly included in *A. karroo*: see Coates Palgrave 2002), a pioneer species in many forest areas along the coast, is an important firewood species (Hassan & Haveman 1997, Van Eck et al. 1997). Climbers, leaves, leaf petioles and tree bark are sources of binding materials (Cunningham & Gwala 1986). Use of wood for building varies with building style and availability of materials, and a variety of species have been recorded (Johnson 1982, 1983, Cunningham 1985, McKenzie 1988, Van Eck et al. 1997, Obiri 2002, Obiri et al. 2002). Traditional medicines are important to rural communities for medical, psychosomatic and economic reasons (McKenzie 1988). Urbanisation of rural people has generated a local and countrywide multimillion Rand annual trade between rural source areas and urban markets and shops (Cunningham 1986, Williams et al. 1997, Mander 1998). This trade has increased the pressure on the forests in the rural areas and on specific species such as *Rapanea melanophloeos, Curtisia dentata, Prunus africana* and *Ocotea bullata* in the Umzimkhulu District in the Eastern Cape (Geldenhuys 2002, 2004).

Coastal Forests and Dune Forests experience significant current utilisation pressures with the potential to increase. These forests have more species bearing fleshy fruits (a primary source of vitamin C), whereas Sand Forest has the highest diversity of fruit-bearing species (Cunningham 1985, McKenzie 1988, Van Eck et al. 1997). Several home crafts are based on sources from the forest (McKenzie 1988). Various palms, reeds and climbers are used, mainly for baskets and mats, for example *Flagellaria guineensis* (Cawe & Ntloko 1997), and the pioneer tree *Millettia grandis* is used in woodcarving (Obiri & Lawes 1997). Around Port St Johns (Eastern Cape coast) people directly employed in craftwork earn an annual income of over US$0.2 million (Obiri & Lawes 1997). Fronds (leaves) of the fern *Rumohra adiantiformis* are used extensively in the florist trade, both locally and abroad. Since 1981 the development of the export market for the fern has developed into a lucrative local industry (Milton 1987a, b,

Table 12.2 Number of tree and shrub species in the South African forests that have been or are still used traditionally and/or commercially (Geldenhuys 1999a). C: Canopy trees; SC: Sub-canopy trees; S: Shrubs.

Category	Use	C	SC	S
Timber	Furniture	43	13	-
	Construction	40	26	6
	Poles	15	22	6
	Fuelwood	18	25	4
	Ornamental	45	42	18
Traditional medicine (by plant part used)	Leaves	10	22	15
	Fruit	2	5	2
	Bark	34	34	4
	Roots	10	17	13
	Other	18	16	13
Food (by plant part used)	Leaves	-	3	3
	Fruit	29	38	29
	Roots	2	-	2
	Other	2	2	-
Crafts (from other than timber)	Basket	-	2	3
	Weaving	1	-	-
	Binding	2	7	6
	Other (including dyes)	6	12	2
Other uses	Horticulture	83	100	93
	Floristic	-	2	-
	Other	15	10	12
Total in forests		**109**	**185**	**274**
Total used		**102**	**143**	**120**

Geldenhuys & Van der Merwe 1988, 1994, Geldenhuys 1994c). During 1994/1995, 2.2 million fronds were harvested from the forest over a total area of 15 000 ha and sold for a value of almost US$125 000.

9. Action: Conservation and Utilisation

The initial colonial timber exploitation and destruction of forests was followed by forest protection since 1939 and the development of sustainable forest management systems (King 1938, Phillips 1963, Geldenhuys 1980). Today timber and other minor but important forest products are utilised conservatively from ecologically suitable but small areas of State Forest. Two large forest complexes, the southern Cape and Amathole forests, are mainly state-controlled and managed under a formal multiple-use system, with close monitoring to ensure sustainable use (Phillips 1931, Laughton 1937, McKenzie 1988, Seydack et al. 1990, Geldenhuys 1994c, 1996b, Seydack 1995, Vermeulen 2000). Scientific and multiple-use management principles were developed in the southern Cape forests and are applied through five management classes (production 19.8%; protection 55.8%, nature reserves 23%, recreation 0.4% and research 1.1%) in order to sustain utilisation of forest products, recreation and conservation. Furniture timber is currently provided mainly from the relatively large southern Cape forests where this industry has an annual turnover of >15 million Rand and employs about 650 people, and from the Amathole forests. Today commercial plantations of pines, eucalypts and wattles, covering >1.4 million ha, provide in the structural timber needs of the region.

Commercial forestry plantations of pines, eucalypts, acacias and other species have been established in the grasslands and shrublands surrounding the forests, but rarely in areas cleared of evergreen forest. Interestingly enough, besides the obvious negative effect of establishment of forest plantations on biodiversity of grasslands and fynbos (see Chapter on Grassland in this book), there are also positive sides to such silviculture practices: the plantations aid the rehabilitation of the forests, and expansion in places, reduce pressure on the forests for timber, fibre and firewood needs, and protect forest margins against frequent fires (Geldenhuys et al. 1986). Commercial timber plantations currently cover an area of about 1 487 million ha, comprising 53.2% pines of various species, 39.2% eucalypts of various species and 7.6% acacias (mainly *Acacia mearnsii*) and other species (Forestry SA 2002). Several good indigenous timber species can grow fast outside the forest if planted in suitable sites and managed appropriately (Lübbe & Geldenhuys 1991, Geldenhuys & Von dem Bussche 1997), and several of these species establish naturally under nurse stands of, for example, pines, eucalypts and acacias (Van Wyk et al. 1995, Geldenhuys 1996c, 1997b, Geldenhuys & Delvaux 2002).

The establishment of pure stands of indigenous tree species through planting was practised for many years, but this proved to be a very expensive process. A more acceptable and cost-effective approach was developed. Recent studies show that tree plantings catalyse or nurse the establishment of natural forest species to restore forest biodiversity and productivity (Geldenhuys et al. 1986, Parrotta 1995, Geldenhuys 1996c, 1997b, Parrotta et al. 1997). It is based on the concept that if fire is controlled in the landscape (urban development, crop production, commercial plantations), the areas in the former fire pathways (Figure 12.4) grow back to trees: firstly by alien invader species. They are intolerant of shade, cannot establish under their own canopy, but shade-tolerant forest species become established in the understorey (Geldenhuys 1994d, 1996c, 1997b, Geldenhuys & Delvaux 2002).

Careful manipulation of the invader stand through selective thinning where forest species start to establish, facilitates stronger growth of the established indigenous species and establishment of more species (Geldenhuys et al. 1986). Eventually the invader plant stand can be converted to re-growth forest. Similarly, plantation stands can be converted to forest (Van Wyk et al. 1995). This can also be done with natural stands of indigenous forest pioneer species such as *Acacia karroo* (as well as *Acacia kosiensis* and *A. natalitia,* formerly included within *A. karroo*; see Coates Palgrave 2002), *Trema orientalis*, *Virgilia divaricata* and other useful, fast-growing indigenous tree species such as *Afrocarpus falcatus, Millettia grandis, Ptaeroxylon obliquum, Prunus africana, Rapanea melanophloeos* etc. (Van Wyk et al. 1995, Geldenhuys & Delvaux 2002). Nurse stands of indigenous species can also be planted to develop useful, mixed forest stands in degraded forest gaps or forest margins (but outside the fire zones) to restore forest (Geldenhuys & Von dem Bussche 1997, Geldenhuys & Delvaux 2002).

Facilitation of forest re-establishment and recovery, using stands of planted trees, provides the basis for combining forest rehabilitation and production of the plants used by rural communities for their daily livelihood (Geldenhuys 1999b). Selected, traditionally used forest species grow faster in mixed-species stands, add value to products harvested from the planted stands through small businesses, reduce the pressure on forests through socio-economic upliftment of poor rural communities, and restore forest. Restoration actions are successful only if they are economically viable or if they provide in the daily needs of rural communities. In particular (1) they need to resolve the conflicts between resource users and resource managers and (2) there must be an improved, diversified and productive commercial use of the natural resources.

The actions must contribute to improved productivity of degraded land (such as through growth of leguminous trees and agrobiological improvement of degraded soil). They must ensure sustainable resource management.

In some areas, deforestation is continuing at an alarming rate, primarily for maize cultivation, to provide in the daily food needs of the very poor people. Cutting trees for construction poles and firewood is a secondary cause of forest degradation, but considered essential as the rural people have no money to buy such products. This degradation of the forest causes the loss of other sources of income such as woodcrafts and the basket industry. The Eastern Cape Resource Accounting Survey (Hassan & Haveman 1997) indicated a number of wrong perceptions on both sides that relate partly to the real meaning of sustainability and partly to the true dependence of the poor rural communities on the forests for their daily livelihood. This accentuates the need for implementation of joint resource management strategies in the rural areas to resolve the conflicts and to ensure sustainable resource use and socio-economic development.

Development of sustainable resource use from forest involves a process within which the resource managers (often the authorities) and the resource users must (Geldenhuys 2000b):

- Define the products to be used.
- Make an inventory of resource availability and match this with the resource needs.
- Determine the rate of production.
- Make assumptions on aspects not known.
- Set management objectives and guidelines.
- Implement management.

- Monitor.
- Re-evaluate and adapt management.

Resource use should be approached from a business development perspective to focus the attention on critical issues related to market demand, whether it is other rural communities, sophisticated industries (furniture, florist greenery, medicine) or conservation.

Development of small businesses in rural areas, based on sustainable use of forests, is a new approach in South Africa to deal with illegal resource use practices. It was developed with implementation of the harvesting of *Rumohra* fern for the florist industry in a commercial forestry and farming environment (Geldenhuys 1994c). The approach was further advanced with the harvesting of bark for traditional medicine in a rural environment (Geldenhuys 2002, 2004), but also in other areas such as vine harvesting for basket-making (Venter 2000). Businesses in rural areas, based on the use of forest species, could be developed as an approach to improve management of forests for the benefit of rural communities.

Forests play an increasingly important role in providing for the recreation and aesthetics of the growing urban and industrial societies of southern Africa. Many picnic sites, viewpoints, camping sites, forest walks and hiking trails in forests offer unique experiences (Levy 1987, Van Dijk 1987). The care taken with the management of recreation sites has contributed to forest recovery in several areas.

Forests also have cultural importance as burial sites (Netshiungani et al. 1981, McKenzie 1988). Undisturbed forest and wooded copses persist around major grave sites in many parts of South Africa because of the acknowledged importance of the role that ancestral spirits play in daily life and the value of ensuring them peace.

10. Further Research

The recently completed National Forest Type Classification (Von Maltitz et al. 2003) has brought together most of the existing information and knowledge of the natural forests in the different parts of South Africa. Forest inventory data exist for many areas (see Von Maltitz et al. 2003), but the data are not always in a form that would facilitate sustainable resource use, or provide knowledge of the conservation status of important species. What is needed are data on the population demography of the key ecological and economic species, i.e. data on the numbers of a species in all age or size categories. This would indicate what the important species would require for recruitment, establishment and for growth to maturity. There is a considerable amount of data on the recruitment, growth and mortality of forest stands and species (Geldenhuys 1997c, 1998, 2000c), which, after detailed analysis and interpretation, would shed light on the problems of forest dynamics. Prediction of forest dynamics will also require much improved understanding of competitive relationships of forest plants, mutualisms and ecosystem-level functions, including nutrient cycling.

Traditionally, trees and shrubs were the subject of forest research, grossly neglecting the non-woody component. It is becoming increasingly clear (Mucina & Geldenhuys 2002) that this situation is untenable, especially in the light of conservation needs and sustainable use of non-woody forest components. Biodiversity studies in forests are also hampered by our ignorance (or negligence) of epiphytes, herbs and grasses in forest environments. There are many taxonomic and biogeographic surprises out there.

The small and fragmented forests are unlikely to support long-term resource removal, in areas subject to frequent harvesting, that is sustainable (Adie & Goodman 2000). Appropriate utilisation guidelines have to be researched and compiled to enable the long-term utilisation of forest products, such as bark, that is not destructive and would also not change the species composition of the forest or impact on forest integrity.

Management of natural forest has to integrate the knowledge of forest types, the relationship between forest composition and site conditions, the development stage of the vegetation (stand dynamics), the rates of recruitment, growth and mortality, disturbance and recovery processes. For some areas, knowledge and understanding of the forest is advanced (Seydack et al. 1990, Geldenhuys 1996b), but for others it is seriously lacking.

11. Descriptions of Vegetation Units

Zonal & Intrazonal Units

FOz 1 Southern Afrotemperate Forest

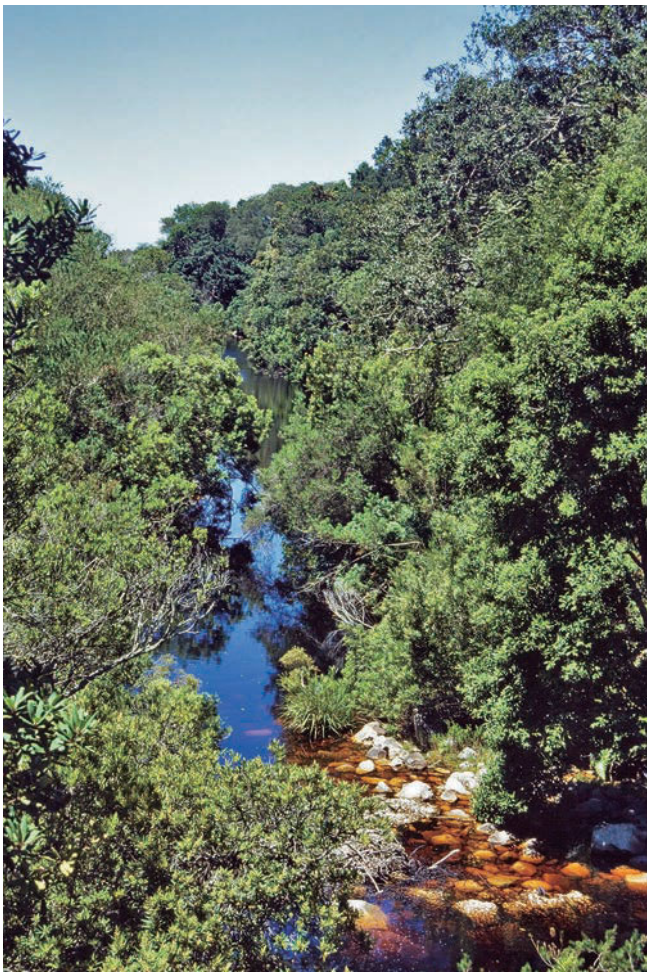
Knysna Forests (Acocks 1988). Southern Cape Forests (Phillipson & Russell 1988, Geldenhuys 1993e). Afrotemperate Forests p.p. (Low & Rebelo 1996). Knysna-Tsitsikamma Forests, Swellendam Area Forests, Cape Peninsula Forests and South-western Cape Forests (Bailey et al. 1999). Western Cape Talus Forest, Western Cape Afrotemperate Forest and Southern Cape Afrotemperate Forest (Von Maltitz et al. 2003).

Distribution Western Cape, Eastern Cape and also (only few patches) in Northern Cape Provinces: The largest complex is found in the southern Cape along the narrow coastal strip (250 km long) between Humansdorp in the east and Mossel Bay (Knysna-Tsitsikamma forest region)—here occurring on sheltered seaward slopes, plateaux and coastal scarps. The easternmost outlier forest patches occur near Port Elizabeth, while westwards floristically impoverished forms of these forests occur along the feet of south- and east-facing slopes and in deep kloofs and ravines of the Cape Fold Belt mountains as far as the Cape Peninsula in the west. The northernmost localities are near Vanrhynsdorp Pass and in the Matsikamma Mountains. At altitudes ranging from about 10 m (Tsitsikamma region) to 600 m (most of patches), with notable outliers occurring as high as 1 060 m.

Vegetation & Landscape Features Tall, multilayered afrotemperate forests dominated by yellowwoods (*Afrocarpus falcatus* and *Podocarpus latifolius*), *Ocotea bullata, Olea capensis* subsp. *macrocarpa, Pterocelastrus tricuspidatus, Platylophus trifoliatus* etc. In scree and deep-gorge habitats *Cunonia capensis, Heeria argentea, Metrosideros angustifolia, Podocarpus elongatus* and *Rapanea melanophloeos* predominate. The shrub understorey and herb layers are well developed, especially in mesic and wet habitats.

Geology & Soils Soils varying from shallow (and skeletal) Mispah, Glenrosa and Houwhoek forms to sandy humic Fernwood form, derived from Table Mountain Group sandstones and shales of the Cape Supergroup and partly also from Cape Granite.

Important Taxa Tall Trees: *Afrocarpus falcatus* (d), *Cunonia capensis* (d), *Curtisia dentata* (d), *Nuxia floribunda* (d), *Ocotea bullata* (d), *Olinia ventosa* (d), *Podocarpus elongatus* (d), *P. latifolius* (d), *Pterocelastrus tricuspidatus* (d), *Rapanea melanophloeos* (d), *Ilex mitis*, *Olea capensis* subsp. *macrocarpa*. Small Trees. *Canthium inerme* (d), *Cassine peragua* (d), *Diospyros*



L. Mucina

Figure 12.9 FOz 1 Southern Afrotemperate Forest: Riparian forest with prominent *Cunonia capensis*, *Olinia ventosa* and *Platylophus trifoliatus* in the Disa Kloof, Harold Porter National Botanical Garden near Betty's Bay (Western Cape).

L. Mucina

Figure 12.10 FOz 1 Southern Afrotemperate Forest: Dense warm-temperate forests near Nature's Valley (Western Cape) featuring a dense population of endemic *Strelitzia alba* (Strelitziaceae).

whyteana. Tree Fern: *Cyathea capensis* (d). Herbaceous Climber: *Cissampelos torulosa*. Epithytic Herb: *Angraecum pusillum*. Tall Shrubs: *Burchellia bubalina* (d), *Trichocladus crinitus* (d), *Sparrmannia africana*.Geophytic Herbs: *Blechnum capense* (d), *B. tabulare* (d), *Dietes iridioides* (d), *Rumohra adiantiformis* (d), *Todea barbara* (d), *Oxalis incarnata*. Graminoid: *Oplismenus hirtellus* (d).

Biogeographically Important Taxa ([C]Endemic of Capensis, [W]Western distribution limit) Tall Trees: *Brabejum stellatifolium*[C], *Ochna arborea* var. *arborea*[W]. Small Trees: *Gonioma kamassi*[W] (d), *Heeria argentea*[C] (d), *Metrosideros angustifolia*[C] (d), *Allophylus decipiens*[W], *Brachylaena neriifolia*[C], *Cassine schinoides*[C], *Lachnostylis hirta*[C], *Virgilia divaricata*[C]. Woody Climber: *Asparagus scandens*[C]. Epiphytic Herb: *Mystacidium capense*[W]. Tall Shrub: *Laurophyllus capensis*[C]. Herb: *Gerbera cordata*[W], *Streptocarpus rexii*[W]. Geophytic Herbs: *Liparis capensis*[C]. Graminoids: *Ischyrolepis subverticillata*[C], *Schoenoxiphium lanceum*[C].

Endemic Taxa Tall Tree: *Platylophus trifoliatus* (d). Small Trees: *Apodytes geldenhuysii*, *Cryptocarya angustifolia*, *Virgilia oroboides* subsp. *ferruginea*, *V. oroboides* subsp. *oroboides*. Megaherb: *Strelitzia alba* (d). Geophytic Herbs: *Amauropelta knysnaensis*, *Clivia mirabilis*, *Freesia sparrmannii*, *Polystichum incongruum*.Graminoid: *Schoenoxiphium altum.*

Conservation Least threatened. Target 34%. More than half of the extent of these forests enjoy statutory conservation in the proposed Garden Route National Park (including Tsitsikamma and Wilderness National Parks, several nature reserves and a number of otherwise protected forests formerly under DWAF jurisdiction), Table Mountain National Park, and many nature reserves managed by CapeNature in the Western Cape Province (including Cederberg Wilderness Area, Kogelberg Biosphere Reserve, Boosmansbos Wilderness Area, nature reserves of Jonkershoek, Assegaaibos, Limietberg, Hottentots Holland, Riviersonderend, Marloth, Outeniqua, Swartberg etc.); small portions are also protected in the Oorlogskloof Nature Reserve (Northern Cape) and in the Groendal Wilderness Area and Loerie Nature Reserve (Eastern Cape). Number of privately owned nature reserves in both Western and Eastern Cape also protect some patches of this forest. Unknown portion of the original area (only about 300 ha in the southern Cape; see Geldenhuys 1991) has been transformed for plantations.

Remarks Southern Afrotemperate Forests are species-poorer than those of the mistbelt, but they still support some woody (palaeo)endemic elements such as *Cunonia capensis*, *Cryptocarya angustifolia, Heeria argentea*, *Metrosideros angustifolia*, *Platylophus trifoliatus*, *Podocarpus latifolius* and *Afrocarpus falcatus.*

References Phillips (1931), Laughton (1937), Taylor (1955, 1996), Von Breitenbach (1974), Campbell & Moll (1977), McKenzie et al. (1977), McKenzie (1978), Geldenhuys (1982, 1987, 1992a, 1993c, e, 1994b, 1997a), Hanekom et al. (1989), Masson & McKenzie (1989), Masson (1990), McKenzie et al. (1990), Vermeulen (1995), Von Maltitz et al. (2003), Geldenhuys & Mucina (2006).

FOz 2 Northern Afrotemperate Forest

Mountain *Podocarpus* Forest (Edwards 1967). Kloof Forest (Coetzee 1974). Afromontane *Podocarpus* Forest (Cooper 1985). Highland Sourveld p.p. (Acocks 1988). Montane *Podocarpus* Forests (Everard 1992). Marekele Afromontane Forest, Northern Highveld Forest, Drakensberg Montane Forest and Low Escarpment Mistbelt Forest (Von Maltitz et al. 2003).

Distribution Free State, KwaZulu-Natal, Mpumalanga, North-West, Gauteng and Limpopo Provinces (as well as Lesotho): Restricted to mountain kloofs and low ridges (Strydpoortberg, Waterberg, Pilanesberg, Witwatersrand, Magaliesberg, Suikerbosrand, Sekhukhuneland) interrupting the relatively flat northern highveld. This group also comprises forests found in kloofs along the northern and eastern flanks of the Drakensberg and those found on the slopes and scarps of the Low Escarpment between Van Reenen's Pass and Pongola Bush near Piet Retief. The westernmost localities of these forests are found in the Koranaberg (close to Thaba 'Nchu). The remnants of forests rich in afrotemperate elements in Lesotho might also be classified within this vegetation unit. Most patches occur at altitudes between 1 450 and 1 900 m, with outliers as low as 1 100 m and around 2 000 m.

Vegetation & Landscape Features Low (in the Low Escarpment region with canopy reaching up to 20 m), relatively species-poor forests of afromontane origin and some of them still showing clear afromontane character. Found as small patches in kloofs and on sub-ridge scarps at high altitudes (1 500–1 900 m). Canopy dominated usually by *Podocarpus latifolius*, *Olinia emarginata*, *Halleria lucida*, *Scolopia mundii* and rarely also by *Widdringtonia nodiflora*, in drier facies also by *Pittosporum viridiflorum*, *Celtis africana, Mimusops zeyheri, Nuxia congesta* and *Combretum erythrophyllum*. *Xymalos monospora* sometimes dominate patches of species-poor mistbelt forests of northern KwaZulu-Natal.

Geology & Soils Shallow acidic soils over sandstones of the Karoo Supergroup, quartzites and rarely also volcanic rocks of Ventersdorp Supergroup and intrusive diabases of Pretoria Igneous Complex.

Important Taxa Tall Trees: *Celtis africana* (d), *Halleria lucida* (d), *Olinia emarginata* (d), *Pittosporum viridiflorum* (d), *Podocarpus latifolius* (d), *Rothmannia capensis* (d), *Scolopia mundii* (d), *Afrocarpus falcatus*, *Buddleja saligna*, *Dais cotinifolia*, *Ilex mitis*. Small Trees: *Acalypha glabrata* (d), *Buddleja salviifolia* (d), *Calpurnia aurea* (d), *Combretum erythrophyllum* (d), *Diospyros lycioides* subsp. *guerkei* (d), *D. whyteana* (d), *Euclea crispa* subsp. *crispa* (d), *Widdringtonia nodiflora* (d), *Bowkeria verticillata*, *Canthium ciliatum*, *Leucosidea sericea*, *Scolopia flanaganii*. Woody Climber: *Cassinopsis ilicifolia* (d). Tall Shrubs: *Myrsine africana* (d), *Cliffortia nitidula*. Soft Shrubs: *Isoglossa grantii* (d), *Hypoestes aristata*, *Plectranthus fruticosus*. Herbs: *Plectranthus grallatus* (d), *P. hereroensis* (d), *Peperomia retusa*, *Streptocarpus haygarthii*, *S. pusillus*. Geophytic Herbs: *Blechnum attenuatum* (d), *Asplenium aethiopicum*, *Polystichum luctuosum*. Graminoids: *Carex spicato-paniculata* (d), *Oplismenus hirtellus* (d), *Cyperus albostriatus*, *Schoenoxiphium lehmannii*, *Thamnocalamus tessellatus.*

Endemic Taxa Tall Tree: *Scolopia oreophila*. Small Tree: *Maytenus albata*. Tall Shrub: *Sparrmannia ricinocarpa*. Herb: *Streptocarpus polyanthus* subsp. *dracomontanus.*

Conservation Least threatened. Target 31%. About 30% statutorily conserved in uKhahlamba Drakensberg Park, Phongola Bush, Vryheid Mountain, Poccolan/Robinson's Bush, Ngome and Ncandu Nature Reserves, Magaliesberg Nature Area, Merville Ridge, Paardeplaats, Rustenburg, Suikerbosrand Nature Reserves, Marekele National Park and Pilanesberg Game Reserve. Some private nature reserves (e.g. Mooibron, Mhlongamvula, Tafelkop, Oudehoutdraai, Oshoek and Ossewakop) protect some patches too. Occasional hot fires encroaching from the surrounding savanna woodlands, uncontrolled timber extraction, medicinal-plant harvesting, and grazing in forest can be viewed as the current major threats (Von Maltitz et al. 2003).

Remarks In the northern highveld, these forest patches are either imbedded within Savanna Biome or straddle an ecotone between sourveld grassland and subtropical savanna of the Central Bushveld. This group of forests is a 'high-altitude' analogue to 'high-latitude' afrotemperate forests of the southern and western Cape. The major unifying trait of the two groups of forests mentioned above is impoverished floristic composition when compared to Northern Mistbelt Forest and Southern Mistbelt Forest (both also of afrotemperate character).

References Roberts (1961), Van Vuuren (1961), Killick (1963), Van Vuuren & Van der Schijff (1970), Van Zinderen Bakker (1971, 1973), Coetzee (1974, 1975), Van der Meulen (1978, 1979), Bredenkamp & Theron (1978, 1980), Westfall (1981), Cooper (1985), Westfall et al. (1985), Everard (1986), Behr & Bredenkamp (1988), Du Preez & Bredenkamp (1991), Du Preez et al. (1991), Smit et al. (1993), Hill (1996), Eckhardt et al. (1997), Ellery et al. (2001), Siebert (2001), Van Staden (2002), Siebert et al. (2003), Von Maltitz et al. (2003), Van Staden & Bredenkamp (2005, 2006), Geldenhuys & Mucina (2006).

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Figure 12.11 FOz 2 Northern Afrotemperate Forest: Kloof forests with *Podocarpus latifolius* above Thendele Camp in uKhahlamba-Drakensberg Park near Bergville, KwaZulu-Natal.

FOz 3 Southern Mistbelt Forest

Mist Belt Mixed *Podocarpus* Forests (Edwards 1967). Transkei and Natal Montane Forests p.p. & Eastern Cape Montane Forests (Phillipson & Russell 1988). High Altitude Afrotemperate Forests, Middle Altitude Afrotemperate Forests, Mistbelt Afrotemperate Forests, Moist Afrotemperate Forests (Cawe 1996, Cawe & McKenzie 1989). Afromontane Forests p.p. (Low & Rebelo 1996). Amathole Forest Complex (Bailey et al. 1999). Eastern Mistbelt Forest, Transkei Mistbelt Forest and Amatole Mistbelt Forest (Von Maltitz et al. 2003).

Distribution KwaZulu-Natal and Eastern Cape Provinces: Forest patches varying in size, occurring in fire-shadow habitats on south- and southeast-facing slopes and located along the Great Escarpment, spanning a large area from Somerset East, the Amathole Mountains, scarps of Transkei to the KwaZulu-Natal Midlands as far east as Ulundi. In KwaZulu-Natal these forests are found in a wide band sandwiched between the Drakensberg Montane Forests and Northern KwaZulu-Natal Mistbelt Forests at higher altitudes and Eastern Scarp Forests at lower altitudes. Belts of forest patches belonging to this vegetation unit occur in the Baviaanskloof Mountains, Zuurberg Mountains and in the region spanning Grahamstown and King William's Town. Found at altitudes spanning 850–1 600 m (most patches between 1 000 and 1 400 m).

Vegetation & Landscape Features On the Great Escarpment (Amathole, Transkei Escarpment) and in the KwaZulu-Natal Midlands these forests are tall (15–20 m tall) and multilayered (having two layers of trees, a dense shrubby understorey and a well-developed herb layer). The forests found on low-altitude scarps are low (in places having the character of a scrub forest), and although less structured into different tree layers, they are still species-rich. The tall forests show a mix of coarse-grained, canopy gap/disturbance-driven dynamics and fine-grained, regeneration characteristics. The Amathole mistbelt forests are dominated by emergent trees of *Afrocarpus falcatus* and a range of deciduous and semi-deciduous species such as *Celtis africana*, *Calodendrum capense*, *Vepris lanceolata* and *Zanthoxylum davyi*. Further east (Transkei, KwaZulu-Natal Midlands) *Podocarpus henkelii* becomes prominent in the canopy layer. Deciduous elements play an important role.

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Figure 12.12 FOz 3 Southern Mistbelt Forest: Patch of Amathole Mistbelt Forest in the Zuurberg (Eastern Cape).

Geology & Soils Some of the soils are deep, loamy and with high nutrient status, developed on weathered dolerite intrusions or mudstones, shales and sandstones of the Karoo Supergroup (on Great Escarpment). The soils supporting forests of low-lying scarps are shallower as they developed on quartzitic Witteberg Sandstones or sandstones of the Karoo Supergroup.

Important Taxa Tall Trees: *Afrocarpus falcatus* (d), *Apodytes dimidiata* subsp. *dimidiata* (d), *Celtis africana* (d), *Chionanthus foveolatus* subsp. *foveolatus* (d), *C. peglerae* (d), *Cunonia capensis* (d), *Curtisia dentata* (d), *Kiggelaria africana* (d), *Olea capensis* subsp. *macrocarpa* (d), *Podocarpus henkelii* (d), *P. latifolius* (d), *Protorhus longifolia* (d), *Ptaeroxylon obliquum* (d), *Rapanea melanophloeos* (d), *Rhus chirindensis* (d), *Scolopia mundii* (d), *S. zeyheri* (d), *Vepris lanceolata* (d), *Xymalos monospora* (d), *Combretum kraussii*, *Elaeodendron croceum*, *E. zeyheri*, *Halleria lucida*, *Mimusops obovata*, *Ochna arborea* var. *arborea*, *Ocotea bullata*, *Pleurostylia capensis*, *Psydrax obovata* subsp. *elliptica*, *Zanthoxylum davyi*. Small Trees: *Canthium ciliatum* (d), *C. inerme* (d), *Cassipourea flanaganii* (d), *Clausena anisata* (d), *Eugenia capensis* (d), *Gymnosporia buxifolia* (d), *Maerua racemulosa* (d), *Ochna serrulata* (d), *Scutia myrtina* (d), *Trichocladus ellipticus* (d), *Trimeria grandifolia* (d), *Allophylus dregeanus*, *Diospyros whyteana*, *Mystroxylon aethiopicum*, *Rinorea angustifolia*. Tall Shrubs: *Burchellia bubalina* (d), *Carissa bispinosa* subsp. *zambesiensis* (d), *Grewia occidentalis* (d), *Calodendrum capense*, *Diospyros scabrida* var. *cordata, Hyperacanthus amoenus*, *Maesa alnifolia*. Low Shrub: *Azima tetracantha* (d). Soft Shrubs: *Hypoestes aristata* (d), *Isoglossa woodii* (d). Herbs: *Streptocarpus daviesii*, *S. haygarthii*, *S. pentherianus*, *S. polyanthus* subsp. *comptonii*, *S. polyanthus* subsp. *polyanthus*. Geophytic Herbs: *Dietes iridioides* (d), *Dryopteris inaequalis* (d), *Polystichum pungens* (d). Graminoid: *Oplismenus hirtellus* (d).

Endemic Taxa Tall Shrub: *Eugenia zuluensis* (d). Herbs: *Plectranthus elegantulus*, *P. rehmannii*, *Pyrrosia africana*, *Streptocarpus bolusii*, *S. candidus*, *S. fanniniae*, *S. silvaticus*.

Conservation Least threatened. Target 30%. Some 8% statutorily conserved (including forests under DWAF jurisdiction) in the Eastern Cape encompassing the Bosberg Nature Reserve, Greater Addo Elephant National Park as well as Hogsback, Kologha, Isidenge, Kubusi, Katberg and Nabakyu State Forests. In KwaZulu-Natal these forests are statutorily protected in Impendle, Igxalingenwa, Karkloof and Qudeni Nature Reserves. Several private reserves protect smaller patches. About 5% has been transformed for plantations. Invasive aliens include *Solanum mauritianum*, *Rubus* species and several *Acacia* and *Eucalyptus* species. Uncontrolled harvesting of timber, poles and firewood, overexploitation of non-timber forest products and mismanagement of fire and burning regimes in surrounding grasslands are considered as current major threats (Von Maltitz et al. 2003).

Remarks All mistbelt forests are species-rich afrotemperate forests containing an important share of subtropical floral elements.

Podocarpus henkelii is a near-endemic species for this vegetation unit, as it marginally occurs in the Northern Afrotemperate Forests as well.

References Story (1952), Edwards (1967), Moll (1976), Cooper (1985), Cawe (1986, 1996), Phillipson (1987), Cawe & McKenzie (1989), Everard (1992), Geldenhuys (1992a), Everard & Hardy (1993), Everard et al. (1995), Geldenhuys & Rathogwa (1997), Von Maltitz et al. (2003), Geldenhuys & Mucina (2006).

FOz 4 Northern Mistbelt Forest

Soutpansberg Forests & Transvaal Drakensberg Escarpment Forests (Cooper 1985). Transvaal Forests (Phillipson & Russell 1988). Afromontane Forest p.p. (Low & Rebelo 1996). Northern Mistbelt Forest and Mpumalanga Mistbelt Forest (Von Maltitz et al. 2003). Limpopo Mistbelt Forests (Geldenhuys & Mucina 2005).

Distribution Limpopo and Mpumalanga Provinces as well as in Swaziland: Occurring along the Soutpansberg from Blouberg in the northwest to the Samandou Plateau in the northeast and further southwards (along the Northern Escarpment) from Abel Erasmus Pass (Olifants River) to the surroundings of Badplaas and Barberton. In northern Swaziland in fire refugia and cooler sheltered areas along a north-south trending lowveld/highveld transition. Most of the patches occur in an altitudinal belt spanning 1 050 to1 650 m.

Vegetation & Landscape Features Tall, evergreen afrotemperate mistbelt forests occurring primarily in east-facing fire refugia such as subridge scarps and moist sheltered kloofs where they form small, fragmented patches. The most common canopy trees include *Xymalos monospora*, *Podocarpus latifolius*, *Combretum kraussii*, *Cryptocarya transvaalensis Schefflera umbellifera*, *Syzygium gerrardii*, *Olea capensis* subsp. *macrocarpa*, *Psydrax obovata* subsp. *elliptica*, *Pterocelastrus galpinii*. In the understorey *Psychotria zombamontana*, *Canthium kuntzeanum*, *Gymnosporia harveyana, Peddiea africana*, *Pavetta inandensis*, *Mackaya bella*, *Sclerochiton harveyanus* etc. are found. The herb layer supports a number of dominating Acanthaceae (*Isoglossa*), Lamiaceae (*Plectranthus*, *Stachys*) and Rubiaceae (*Galopina*) herbs and so called 'soft shrubs', geophytic herbs and ferns (*Asplenium, Dryopteris, Polystichum*). Of lianas and climbers *Dalbergia armata*, *Combretum edwardsii*, *Jasminum abyssinicum, Rhoicissus rhomboidea* and *Keetia gueinzii* are the most conspicuous vines, as is the scandent grass *Prosphytochloa prehensilis*.

Geology & Soils Highly weathered, clayey soils mainly of Avalon and Hutton soil forms, derived from shales (Pretoria Group), quartzite (Black Reef Formation), dolomite (Chuniespoort Group), granite (Nelspruit Basement) and diabase (Mokolian intrusives).

Important Taxa Tall Trees: *Brachylaena transvaalensis* (d), *Combretum kraussii* (d), *Curtisia dentata* (d), *Drypetes gerrardii* (d), *Kiggelaria africana* (d), *Ocotea kenyensis* (d), *Olea capensis* subsp. *macrocarpa* (d), *Podocarpus latifolius* (d), *Psydrax obovata* subsp. *elliptica* (d), *Rhus chirindensis* (d), *Schefflera umbellifera* (d), *Syzygium gerrardii* (d), *Xymalos monospora* (d), *Aphloia theiformis*, *Chionanthus battiscombei*, *C. foveolatus* subsp. *major*, *Maytenus acuminata*, *Pterocelastrus galpinii*, *Rapanea melanophloeos*, *Rothmannia capensis*, *Trichilia dregeana*. Small Trees: *Cassipourea malosana* (d), *Oxyanthus speciosus* subsp. *gerrardii* (d), *Englerophytum magalismontanum*, *Gymnosporia harveyana*, *Mackaya bella*, *Ochna arborea* var. *oconnorii*, *Peddiea africana*, *Rinorea angustifolia*. Woody Climbers: *Acacia ataxacantha* (d), *Keetia gueinzii* (d), *Rhoicissus rhomboidea* (d), *Bauhinia galpinii*, *Dalbergia armata*. Climbing Graminoid: *Prosphytochloa prehensilis* (d). Tall Shrubs: *Psychotria capensis* (d), *Canthium kuntzeanum*, *Carissa bispinosa* subsp. *zambesiensis*, *Pavetta kotzei*, *Sclerochiton harveyanus*. Soft Shrubs: *Galopina circaeoides*, *Hypoestes triflora*. Herbs: *Begonia sonderiana*, *Plectranthus rubropunctatus*, *P. tetragonus*, *Streptocarpus meyeri*, *S. pentherianus*. Geophytic Herbs: *Dietes iridioides* (d), *Asplenium aethiopicum*, *A. boltonii*, *A. splendens*, *Crocosmia aurea*, *Dryopteris inaequalis*, *Elaphoglossum acrostichoides*, *Polypodium polypodioides* subsp. *ecklonii*, *Polystichum macleae*, *Pteris catoptera*. Graminoids: *Carex spicato-paniculata* (d), *Cyperus albostriatus* (d), *Oplismenus hirtellus* (d).

Biogeographically Important Taxa ([S]Southern distribution limit, [B]Endemic of Barberton Centre) Tall Tree: *Anthocleista grandiflora*[S], *Faurea galpinii*. Tall Shrubs: *Psychotria zombamontana*[S] (d), *Coptosperma rhodesiacum*[S]. Soft Shrub: *Duvernoia adhatodoides*[B]. Megaherbs: *Ensete ventricosum*[S], *Strelitzia caudata*[S]. Herbs: *Plectranthus swynnertonii*[S], *Sphaerocionium capillare*[S].

Endemic Taxa Tall Trees: *Cryptocarya transvaalensis* (d), *Ochna gamostigmata*. Small Trees: *Dombeya pulchra*, *Heteropyxis canescens*. Epiphytic Herb: *Mystacidium brayboniae*. Tall Shrub: *Pavetta barbertonensis* (d). Herbs: *Streptocarpus davyi*, *S. fenestra-dei*, *S. micranthus*, *S. parviflorus*, *S. roseo-albus*, *S. wilmsii.* Geophytic Herb: *Clivia caulescens* (d).

Conservation Least threatened. Target 30%. About 10% statutorily conserved in Blyde River Canyon, Lekgalameetse, Songimvelo, Makobulaan, Malalotja, Nelshoogte, Barberton, Starvation Creek Nature Reserves. More than 25% enjoys pro-

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Figure 12.13 FOz 4 Northern Mistbelt Forest: Stand of tree fern *Cyathea capensis* on the edge of mistbelt forest in a shady gully below the escarpment near Graskop (Mpumalanga).

tection in privately owned nature reserves, including for instance Wolkberg Wilderness Area, In-De-Diepte, Sudwala, Mac Mac, Buffelskloof, Mount Sheba etc. Aliens such as *Solanum mauritianum, Caesalpinia decapetala, Acacia mearnsii* and *Lantana camara* can be locally of concern. Encroaching subsistence agriculture, firewood collection in communal areas, and selective harvesting of bark are viewed as serious threats (Von Maltitz et al. 2003). Below the escarpment between Mariepskop and Graskop, the natural forest has expanded into former grassland areas due to the protection of the timber plantations against fire (when comparing the current forest areas with aerial photographs of the 1930s, before the establishment of the plantations) (Grossman 2005).

Remarks These forests border on sourveld grasslands on their upper boundary, whereas they often border on bushveld on their lower boundary. The Northern Mistbelt Forests are typically species rich, containing a mixture of afrotemperate elements and species of subtropical provenience, indicating a floristic (and possibly also biogeographic-evolutionary) link of these forests to the Scarp Forests. This phenomenon is clearly observed along the Northern Escarpment below God's Window and Marieskop, and in the Barberton region (Morgenthal & Cilliers 1999).

References Van der Schijff & Schoonraad (1971), Scheepers (1978), Deall et al. (1989), Von Breitenbach (1990), Matthews et al. (1992), Geldenhuys & Murray (1993), Geldenhuys & Pieterse (1993), Masson (1994), Morgenthal & Cilliers (1999), Stalmans et al. (1999), Geldenhuys & Venter (2002), Von Maltitz et al. (2003), Lötter & Beck (2004), Geldenhuys & Mucina (2006).

FOz 5 Scarp Forest

Semi-Coast Forest (Edwards 1967). Tongaland-Pondoland Undifferentiated Forest p.p. (White 1983). Coast Scarp Forest (Cooper 1985). Pondoland Coastal Plateau Sourveld p.p. & Transitional Coastal Forest (Acocks 1988). Natal and Transkei Coastal Forests p.p. (Phillipson & Russell 1988). Ngoye Group Forests p.p. (MacDevette et al. 1989). Pondoland Coast Forest & South Coast Forest (Cooper & Swart 1992). Moist Subtropical Forest (Cawe 1996). Coastal Forest p.p. (Low & Rebelo 1996). Eastern Scarp Forest, Pondoland Scarp Forest and Transkei Coastal Scarp Forest (Von Maltitz et al. 2003).

Distribution Eastern Cape, KwaZulu-Natal and Mpumalanga Provinces as well as in Swaziland (and possibly also in Mozambique): An archipelago of scattered patches (some of them large, such as Ongoye) spanning southern Mpumalanga (Crocodile River Gorge), the southern part of Lebombo Mountains (KwaZulu-Natal) and reaching nearly as far as Kei River Mouth on the Transkei coast. Patches of this forest lie as far as 140 km inland (Mpumalanga), but extend increasingly closer to the sea in a southward direction—in Pondoland, and southern Transkei they occur at the coast or in deep gorges, often associated with krantzes, scarps and coastal platforms. Most of the patches occur at low altitudes between 50 and 600 m.

Vegetation & Landscape Features Tall (15–25 m), species-rich and structurally diverse, multilayered forests, with well-developed canopy and understorey tree layers, but a poorly developed herb layer. Buttressed stems are common in the Scarp Forest. The most conspicuous trees are *Buxus macowanii*, *B. natalensis*, *Drypetes gerrardii*, *Englerophytum natalense*, *Harpephyllum caffrum*, *Heywoodia lucens*, *Memecylon natalense*, *Millettia grandis*, *Oricia bachmannii*, *Philenoptera sutherlandii*, *Rinorea angustifolia*, *Rothmannia globosa* and *Umtiza listeriana*.

Geology & Soils Natal Sandstone outcrops (Msikaba Group Sandstones in Pondoland) as well as syenitic granite, rhyolite of the Jozini Formation of the Lebombo Group (Karoo Supergroup) and other Karoo sedimentary rocks; supporting nutrient poor, leached and shallow soils.

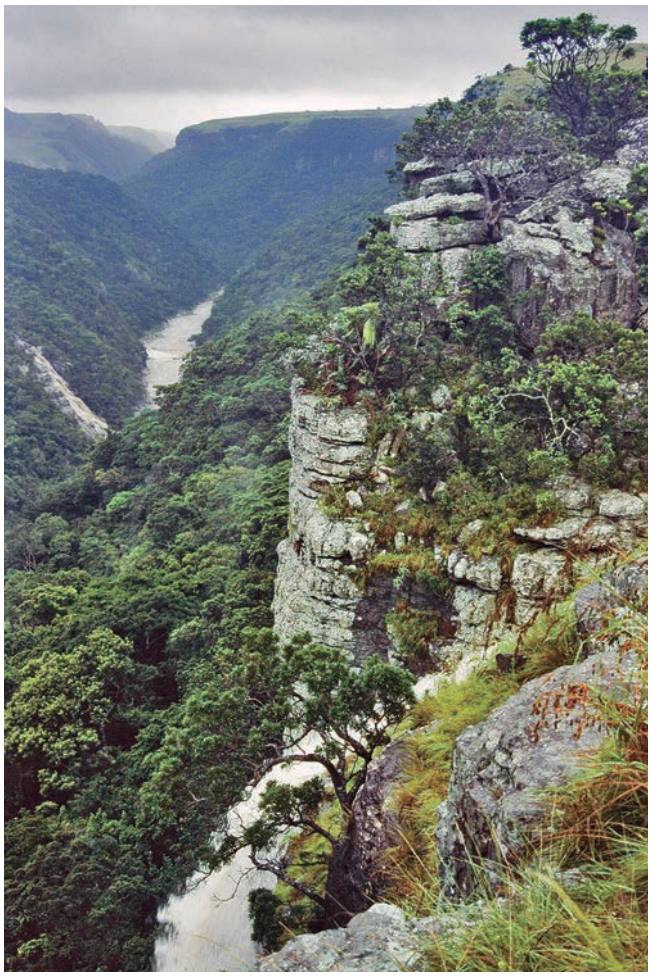

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Figure 12.14 FOz 5 Scarp Forest: Endemic-rich subtropical scarp forests on Msikaba sandstones in the gorge of the Umtamvuna River near Port Edward (southern KwaZulu-Natal).

Important Taxa Tall Trees: *Buxus natalensis* (d), *Drypetes gerrardii* (d), *Englerophytum natalense* (d), *Harpephyllum caffrum* (d), *Heywoodia lucens* (d), *Rothmannia globosa* (d), *Commiphora harveyi*, *C. woodii*, *Drypetes arguta*, *Manilkara discolor*, *Nectaropetalum capense*, *Nuxia congesta*, *Olinia emarginata*, *Ptaeroxylon obliquum*, *Pterocelastrus tricuspidatus*, *Vitellariopsis marginata*. Small Trees: *Buxus macowanii* (d), *Rinorea angustifolia* (d), *Dombeya cymosa*, *Encephalartos natalensis*, *E. villosus*, *Ochna natalitia*, *Strychnos henningsii*, *S. mitis*. Herbaceous Climbers: *Flagellaria guineensis, Thunbergia alata*. Tall Shrubs: *Memecylon natalense* (d), *Eugenia natalitia*. Low Shrub: *Stangeria eriopus*. Soft Shrub: *Piper capense*. Herbs: *Begonia dregei*, *B. homonyma*, *Streptocarpus grandis*, *S. johannis.* Geophytic Herb: *Clivia miniata*.

Biogeographically Important Taxon Tall Shrub: *Pseudoscolopia polyantha* (disjunct populations also in Capensis in AZa 1 Fynbos Riparian Vegetation).

Endemic Taxa Tall Trees: *Millettia grandis* (d), *Oricia bachmannii* (d), *Philenoptera sutherlandii* (d), *Umtiza listeriana* (d), *Celtis mildbraedii*, *Colubrina nicholsonii*, *Cryptocarya myrtifolia*, *C. wyliei*, *Dahlgrenodendron natalense*, *Jubaeopsis caffra*, *Manilkara nicholsonii*, *Maytenus oleosa*, *Pseudosalacia streyi*, *Rinorea domatiosa*. Small Trees: *Alberta magna*, *Albizia suluensis*, *Apodytes abbottii*, *Canthium vanwykii*, *Encephalartos woodii* (extinct in the wild), *Gerrardanthus tomentosus*, *Rhynchocalyx lawsonioides*, *Tarchonanthus trilobus* var. *trilobus*. Woody Climber: *Podranea ricasoliana* (d). Epiphytic Herb: *Bolusiella*

maudiae. Epiphytic Shrub: *Dermatobotrys saundersii*. Epiphytic Parasitic Shrubs: *Actinanthella wyliei*, *Helixanthera woodii*. Tall Shrubs: *Eugenia simii*, *E. verdoorniae*, *Gymnosporia bachmannii*, *Justicia bolusii*, *J. petiolaris* subsp. *bowiei*, *Oxyanthus pyriformis*, *Putterlickia retrospinosa*. Soft Shrubs: *Heterosamara galpinii*, *Metarungia galpinii*. Herbs: *Impatiens flanaganiae*, *Plectranthus oribiensis*, *P. praetermissus*, *Streptocarpus fasciatus*, *S. kentaniensis*, *S. lupatanus*, *S. porphyrostachys*, *S. primulifolius* subsp. *formosus*. Geophytic Herbs: *Clivia robusta* (d), *C. gardenii*. Succulent Herbs: *Plectranthus ernstii*, *P. hilliardiae* subsp. *australis*, *P. hilliardiae* subsp. *hilliardiae*, *P. oertendahlii*, *P. saccatus* var. *longitubus.*

Conservation Least threatened in protected areas, but exposed to over-exploitation elsewhere. Target 40%. More than 20% statutorily conserved in Umtiza and Manubi Nature Reserves, Dwesa-Cwebe Wildlife Reserve & Marine Sanctuary, Hluleka, Mount Thesiger, Umkambati, Umtamvuna, Oribi Gorge, Vernon Crookes, Krantzkloof, Nkandla, Ongoye, Dlinza, Entumeni, Ghost Mountain and Hlatikulu (Gwalinweni) Nature Reserves as well as in Hluhluwe-iMfolozi Park. Still most of the approximately 70 smaller scarp forests between Durban and Umtamvuna are not protected. Proclamation of the planned Pondoland National Park is expected to improve the conservation status of these unique forests along the Wild Coast. Smaller patches of the northern scarp forests are protected in the Barberton area, in southern Kruger National Park and in some Swaziland nature reserves. Almost 5% has been transformed for cultivation or plantations. Aliens such as *Chromolaena odorata, Solanum mauritianum, Melia azedarach, Lantana camara* and *Litsea sebifera* are of concern locally. Collapse of traditional authorities in both Eastern Cape (especially in Transkei and in KwaZulu) has led to uncontrolled use of forests formerly protected under the authority of headmen and chiefs. Bark stripping, muthi collection, deadwood extraction, and land-claims may become other major sources of threat to the existence of some forest patches (Von Maltitz et al. 2003). *Dahlgrenodendron natalense* and *Metarungia galpinii* are listed as endangered. *Encephalartos ngoyanus*, *Eugenia simii*, *Jubaeopsis caffra* and *Rhynchocalyx lawsonioides* are vulnerable. *Encephalartos woodii* (formerly found only in the Ongoye Forest) is extinct in the wild, and survives in about five individuals in various living botanical collections.

Remarks Biogeographically (and from the point of view of biodiversity) this is probably the most valuable forest in South Africa housing many endemic species, six endemic genera and one endemic family (Rhynchocalycaceae) of trees and relict occurrences of small populations of *Encephalartos,* suggesting that this vegetation unit is biogeographically ancient. The endemism in the herbaceous understorey is also high, particularly in the genera *Plectranthus* and *Streptocarpus*. The Pondoland Scarp Forest is a core vegetation unit of the Pondoland Centre of Endemism as defined by Van Wyk & Smith (2001).

References Huntley (1965), Van Wyk (1981, 1989), Nicholson (1982), Whateley & Porter (1983), Cooper (1985), Acocks (1988), MacDevette et al. (1989), Cawe (1990, 1996), Cooper & Swart (1992), Van Wyk & Everard (1993a, b), Everard et al. (1995), Glen (1996), Jacobs (1996), Van Wyk & Smith (2001), Von Maltitz et al. (2003), Geldenhuys & Mucina (2006).

FOz 6 Southern Coastal Forest

Coastal Forest (Taylor 1961, Knight 1989). Coastal Dune Bush (Comins 1962). Alexandria Forest (Phillipson & Russell 1978). Alexandria Forest p.p. (Acocks 1988). Mature Dune Forests (Burns 1986, Burns & Raal 1993). Coastal Forest p.p. (Low & Rebelo 1996). Eastern Cape Dune Forest, Albany Coastal Forest and Western Cape Milkwood Forest (Von Maltitz et al. 2003).

Distribution Eastern Cape and Western Cape Provinces: Coastal plains between Alexandria and Van Stadens River canyon (west of Port Elizabeth) and on coastal dunes of the Eastern Cape. Also found at low altitudes (close to the sea) in deeply incised river valleys in the Albany District surrounded by subtropical succulent thickets. The westernmost forest type of this group is the Western Cape Milkwood Forest found as an interrupted belt of patches stretching along the southern seaboard between Nature's Valley (Plettenberg Bay) and Llandudno (Cape Town). At low altitudes between 20 and 340 m (most patches).

Vegetation & Landscape Features Generally low forests dominated by *Celtis africana*, *Sideroxylon inerme*, *Mimusops caffra* and *Dovyalis rotundifolia*. In the eastern regions of the distribution area, having well-developed low-tree and shrub (*Brachylaena discolor*, *Strychnos decussata*, *Euclea natalensis*, *Dracaena aletriformis* etc.) as well as herb (*Isoglossa woodii*, *Hypoestes aristata*, *Laportea grossa*, *Oxalis pes-caprae*) layers, becoming increasingly floristically and structurally impoverished in a westward direction.

Geology & Soils Well-drained sandy soils of coastal (dune) origin over sedimentary rocks of Alexandria and Nanaga Formations of the Algoa Group. Loamy skeletal soils are supported by the Bokkeveld Group sediments, while deep, nutrient-rich sandy soils over aeolinite or limestone of Bredasdorp Group. The patches situated deeper inland (such as those in Albany region) are found at colluvial valley-bottom sediments derived from Karoo Supergroup shales.

Important Taxa Tall Trees: *Celtis africana* (d), *Ficus burkei* (d), *Mimusops caffra* (d), *Nuxia congesta* (d), *Rhus chirindensis* (d), *Schotia latifolia* (d), *Sideroxylon inerme* (d), *Vepris lanceolata* (d), *Afrocarpus falcatus*. Small Trees: *Allophylus natalensis* (d), *Brachylaena discolor* subsp. *discolor* (d), *Diospyros natalensis* (d), *Euclea natalensis* (d), *E. racemosa* (d), *Gymnosporia buxifolia* (d),

L. Mucina

Figure 12.15 FOz 6 Southern Coastal Forest: Remnants of milkwood (*Sideroxylon inerme*) dune forests in Gordon's Bay (Western Cape).

Maytenus undata (d), *Mystroxylon aethiopicum* (d), *Strychnos decussata* (d), *Trichocladus ellipticus* (d), *Atalaya capensis*, *Brachylaena ilicifolia*, *Encephalartos altensteinii*. Succulent Tree: *Euphorbia grandidens*. Woody Climbers: *Behnia reticulata* (d), *Rhoicissus tomentosa* (d), *Tecoma capensis*. Succulent Woody Climber: *Aloe ciliaris*. Herbaceous Climbers: *Cissampelos torulosa*, *Cynanchum obtusifolium*. Tall Shrubs: *Carissa bispinosa* subsp. *bispinosa* (d), *Hyperacanthus amoenus* (d), *Maytenus lucida*, *Olea exasperata, Rhus glauca*. Low Shrub: *Phyllanthus heterophyllus*. Soft Shrubs: *Euphorbia kraussiana* (d), *Hypoestes aristata* (d), *Isoglossa woodii* (d). Megaherbs: *Dracaena aletriformis* (d). Herb: *Laportea grossa* (d). Geophytic Herb: *Oxalis pes-caprae* (d). Succulent Herbs: *Sansevieria hyacinthoides* (d). Graminoids: *Cyperus albostriatus* (d), *Ehrharta erecta* (d), *Oplismenus hirtellus* (d).

Biogeographically Important Taxa (Southern distribution limit) Tall Tree: *Erythrina caffra* (d). Small Trees: *Dovyalis rotundifolia* (d), *Deinbollia oblongifolia*.

Endemic Taxon Small Tree: *Sterculia alexandri*.

Conservation Least threatened. Target: 40%. More than half of the area of these forests is under statutory conservation since the frontal dune cordons along the Eastern Cape coast fall largely on state-owned land. The Eastern Cape Dune Forests (*sensu* Von Maltitz et al. 2003) are relatively well-preserved by Eastern Cape government authorities in Cape Morgan, Bosbokstrand, Cape Henderson, Kwelera, Three Sisters, Joan Muirhead and Woody Cape Nature Reserves; the latter is now part of the Greater Addo Elephant National Park. The Albany Coastal Forests are protected in the Greater Addo Elephant National Park (including the extensive Alexandria Forest), Waters Meeting, Kap River, Thomas Baines, Peddlar's Bush, The Island and Maitland River Nature Reserves. The Western Cape Milkwood Forests (*sensu* Von Maltitz et al. 2003) are well preserved in Goukamma Nature Reserve and Wilderness National Park (now incorporated into the Garden Route National Park), De Hoop, De Mond and Walker Bay Nature Reserves. A number of private reserves protect patches of the Southern Coastal Forests both in the Eastern Cape and Western Cape. About 6% has been transformed mainly for cultivation or by urbanisation. Invasion by woody aliens such as *Acacia cyclops, A. saligna* and *Casuarina equisetifolia* are a serious concern especially on the dunes. The most serious threat to these forests is posed by coastal development, accidental fires, and in the Eastern Cape also by mining of heavy minerals from the coastal dunes (Von Maltitz et al. 2003). *Encephalartos altensteinii,* occurring in the Eastern Cape, is listed as vulnerable.

Remarks Southern Coastal Forests can be viewed as an impoverished form of Northern Coastal Forests. They show features of interesting biogeographic and floristic transitions between forests of subtropical and afrotemperate provenience and character (see also Phillipson & Russell 1978).

References Taylor (1961), Phillipson & Russell (1978), Burns (1986), Acocks (1988), Cowling et al. (1988), Lubke & Strong (1988), Knight (1989), McKenzie et al. (1990), Cooper & Swart (1992), Von Maltitz et al. (2003), Geldenhuys & Mucina (2006).

FOz 7 Northern Coastal Forest

Coast Forest & Psammophilous Bush (Bews 1920). Coastal Dune Forest & Coast Lowland Forest (Edwards 1967). Dune Forest & Undifferentiated Lowland Forest (Moll & White 1978). Tongaland-Pondoland Undifferentiated Forest p.p. (White 1983). Typical Coastal-belt Forest (Acocks 1988). Typical Coast Lowland Forest (Bartholomew 1989). Mozambique Coastal Plain Forest (MacDevette et al. 1989). Dune Forest (Cooper & Swart 1992). KwaZulu-Natal Coastal Forest and KwaZulu-Natal Dune Forest (Von Maltitz et al. 2003).

L. Mucina

Figure 12.16 FOz 7 Northern Coastal Forest: Interior of a scarp forest with *Strelitzia nicolai* in the Vernon Crookes Nature Reserve near Scottburgh (KwaZulu-Natal).

Distribution KwaZulu-Natal and (to a very small extent) Eastern Cape Province: Especially along the seaboards of Indian Ocean of KwaZulu-Natal Province and particularly well-developed in Maputaland. Few patches of the dune forest also occur on the Wild Coast of Transkei (Eastern Cape Province). Beyond South Africa these forests occur throughout the Mozambican seaboard as far as southern Tanzania. At low altitudes, from about 10 to 150 m.

Vegetation & Landscape Features Species-rich, tall/medium-height subtropical coastal forests occur on coastal (rolling) plains and stabilised coastal dunes. Forests of the coastal plains are dominated by *Drypetes natalensis*, *Englerophytum natalense*, *Albizia adianthifolia*, *Diospyros inhacaensis* etc. The low-tree and shrubby understoreys are species-rich and comprise many taxa of (sub)tropical provenience. On dunes, these forests have well-developed tree, shrub and herb layers. *Mimusops caffra*, *Sideroxylon inerme*, *Dovyalis longispina*, *Acacia kosiensis* and *Psydrax obovata* subsp. *obovata* are the most common constituents of the tree layer. *Brachylaena discolor* var. *discolor*, *Chrysanthemoides monilifera* subsp. *rotundata*, *Carissa bispinosa* subsp. *bispinosa*, *Euclea natalensis*, *E. racemosa*, *Eugenia capensis*, *Gymnosporia nemorosa*, *Kraussia floribunda*, *Peddiea africana*, *Strelitzia nicolai* and *Dracaena aletriformis* are frequent in the understorey. The herb layer usually contains by *Asystasia gangetica*, *Isoglossa woodii*, *Microsorum scolopendria*, *Zamioculcas zamiifolia* and *Oplismenus hirtellus*. Herbaceous

vines and woody climbers (*Acacia kraussiana*, *Artabotrys monteiroae*, *Dalbergia armata*, *Landolphia kirkii*, *Monanthotaxis caffra*, *Rhoicissus tomentosa*, *Rhus nebulosa*, *Scutia myrtina*, *Uvaria caffra*, *Gloriosa superba* etc.) are important structural determinants in these forests.

Geology & Soils Well-developed sandy-loamy soils on sedimentary rocks of the Karoo Supergroup and Jurassic intrusive dolerites (in places) as well as on Holocene marine sediments. Forming stabilised sandy dune systems, mostly younger than 10 000 years and still in the process of sedimentation.

Important Taxa Tall Trees: *Albizia adianthifolia* (d), *Drypetes reticulata* (d), *Mimusops caffra* (d), *Psydrax obovata* subsp. *obovata* (d), *Sideroxylon inerme* (d), *Trichilia emetica*, *Vepris lanceolata*. Small Trees: *Brachylaena discolor* subsp. *discolor* (d), *Buxus natalensis* (d), *Cavacoa aurea* (d), *Englerophytum natalense* (d), *Erythroxylum emarginatum* (d), *Eugenia capensis* (d), *Gymnosporia nemorosa* (d), *Kraussia floribunda* (d), *Peddiea africana* (d), *Rhus nebulosa* (d), *Strychnos henningsii* (d), *Acokanthera oblongifolia*, *Callichilia orientalis*, *Deinbollia oblongifolia*, *Dovyalis rhamnoides*, *Euclea natalensis*, *E. racemosa*, *Scutia myrtina*, *Strychnos decussata*, *Tapura fischeri*, *Teclea gerrardii*, *Turraea floribunda*, *Xylotheca kraussiana*. Woody Climbers: *Acacia kraussiana* (d), *Rhoicissus tomentosa* (d), *Dalbergia armata*, *Monanthotaxis caffra*, *Uvaria caffra*. Herbaceous Climber: *Gloriosa superba*. Tall Shrubs: *Carissa bispinosa* subsp. *bispinosa*, *Hyperacanthus amoenus*, *Putterlickia verrucosa*. Low Shrub: *Chrysanthemoides monilifera* subsp. *rotundata*. Soft Shrub: *Isoglossa woodii* (d). Megaherbs: *Dracaena aletriformis* (d), *Strelitzia nicolai* (d). Herbs: *Achyranthes aspera* (d), *Asystasia gangetica* (d), *Laportea peduncularis* (d). Geophytic Herb: *Microsorum scolopendria* (d). Graminoids: *Cyperus albostriatus* (d), *Oplismenus hirtellus* (d).

Biogeographically Important Taxa ([M]Maputaland endemic, [S]Southern distribution limit) Tall Trees: *Celtis gomphophylla*[S] (d), *Chrysophyllum viridifolium*[S] (d), *Diospyros inhacaensis*[S] (d), *Drypetes natalensis*[S] (d), *Cola natalensis*[S], *Inhambanella henriquesii*[S], *Manilkara concolor*[S]. Small Trees: *Coffea racemosa*[S] (d), *Dovyalis longispina*[S] (d), *Artabotrys monteiroae*[S], *Encephalartos ferox*[M], *Erythrococca berberidea*[S], *Pancovia golungensis*[S]. Tall Shrubs: *Haplocoelum foliolosum* subsp. *mombasense*[S], *Landolphia kirkii*[S].

Endemic Taxon Small Tree: *Acacia kosiensis* (d).

Conservation Least threatened in general, but still under threat on coastal dunes of KwaZulu-Natal (due to mining). Target 43%. About 68% statutorily conserved in Manguzi, Greater St Lucia Wetland Park, Maphelana, Dukuduku, Sodwana Bay, Richards Bay, Umlalazi, Enseleni, Amathigulu, Harold Johnson, Hawaan, Umhlanga Lagoon, Kenneth Stainbank, Impisini, Skyline, Frederika, Mpenjati Nature Reserves, mostly under Ezemvelo KZN Wildlife magement. The original extent of these forests has been diminished by agriculture (mainly sugar cane and fruit gardens), timber plantations, urban sprawl and tourism-oriented development on the KwaZulu-Natal coast. The current threats count (besides the ongoing coastal development pressures) also illegal clearing of the forest and turning it into lots for small-scale agriculture (Von Maltitz et al. 2003). Coastal dunes are being prospected and exploited for heavy metals—some companies are, however, actively engaged in dune forest regeneration programmes (Van Aarde & Wassenaar 1999). These subtropical forests are sensitive to alien plant invasion, and invaders such as *Chromolaena odorata*, species of *Pereskia* and *Acacia* are posing serious threats. Maputaland endemic *Encephalartos ferox* is listed as vulnerable.

Remarks However, many tropical species reach their southern distribution here. Von Maltitz et al. (2003) classified these forests into two Forest Types, namely the KwaZulu-Natal Coastal Forests (plains) and KwaZulu-Natal Dune Forests. The Manguzi Forest (near KaNgwanase in Maputaland) and some forest in the False Bay area of St Lucia show transitional features towards Sand Forest (Kirkwood & Midgley 1999).

References Bews (1920), Breen (1971), Venter (1976), Wager (1976), Weisser (1978, 1980, 1987), Ward (1980), MacDevette (1987, 1989, 1993), MacDevette & Gordon (1989a, b), MacDevette & MacDevette (1989), MacDevette et al. (1989), Cooper & Swart (1992), Weisser et al. (1992), Van Wyk & Everard (1992), Van Wyk et al. (1996), Von Maltitz et al. (1996, 2003), Lubbe (1997), Kirkwood & Midgley (1999), Van Aarde & Wassenaar (1999), Geldenhuys & Mucina (2006).

FOz 8 Sand Forest

Licuati Forest (Myre 1964). *Baphia massaiensis–Guibourtia conjugata* thicket (Van Rooyen et al. 1981). Tropical Dry Forests (MacDevette et al. 1989). Sand Forest (Low & Rebelo 1996). Licuati Sand Forest (Von Maltitz et al. 2003).

Distribution KwaZulu-Natal Province and Mozambique: Occurring in a broad and highly fragmented belt in South Africa from False Bay Park (Greater St Lucia Wetland Park) in the south to the national border with Mozambique (Tembe Elephant Park and Ndumo Game Reserve). The main distribution of this forest is in Maputaland, where still reasonably extensive patches of this forest can be encountered. Special thicket communities, floristically very close to the Maputaland sand forest, are found in the northern part of the Kruger National Park—here imbedded within Nwambyia and Pumbe sandvelds. At low altitudes between 20 and 160 m, with about half of the area between 100 and 120 m.

Vegetation & Landscape Features Dense thickets of 5–6 m ('short forest' of Matthews et al. 2001) up to tall forests

W.S. Matthews

Figure 12.17 FOz 8 Sand Forest: Aerial view of patches of sand forest in Maputaland (KwaZulu-Natal) surrounded by short savanna grasslands.

with the canopy reaching 15 m ('tall forest' of Matthews et al. 2001), with well-developed shrub layer and very poorly developed ground layer. The dominant trees are *Cleistanthus schlechteri*, *Dialium schlechteri* and emergent *Newtonia hildebrandtii* in Maputaland, whereas *Baphia massaiensis* subsp. *obovata*, *Cleistanthus schlechteri* and *Guibourtia conjugata* are most conspicuous in the tree layer in the Nwambyia and Pumbe regions. The shrub layer is dominated by *Croton pseudopulchellus*, *Cola greenwayi*, *Pteleopsis myrtifolia*, *Psydrax locuples*, *Drypetes arguta* and the woody climber *Uvaria lucida*. The most conspicuous graminoid in the herb layer is *Eragrostis moggii*. Epiphytic orchids and lichens festoon the tall trees.

Geology & Soils Grey to orange-brown (Maputaland), and dull brown/red-brown (Kruger National Park), deep arenosols and dystric (strongly leached) regosols; soils contain very little clay and are acidic. In Maputaland these soils develop on ancient (up to 3 myr old; Ndumo Hill cordon is up 5 myr old) mega-dune systems (crests, slopes and rarely also inter-dune depressions) of the Maputaland and Zululand Groups.

Important Taxa ([M]In South Africa only in Maputaland, [K]Only in northern Kruger National Park) Tall Trees: *Balanites maughamii* (d), *Cleistanthus schlechteri* (d), *Cola greenwayi*[M] (d), *Dialium schlechteri*[M] (d), *Drypetes arguta*[M] (d), *Guibourtia conjugata*[K] (d), *Newtonia hildebrandtii* (d), *Pteleopsis myrtifolia* (d), *Drypetes mossambicensis*[K], *D. natalensis*[M], *Lagynias lasiantha*, *Lannea antiscorbutica*[M], *Pterocarpus lucens* subsp. *antunesii*[K], *Suregada zanzibariensis*[M], *Xeroderris stuhlmannii*[K]. Small Trees: *Baphia massaiensis* subsp. *obovata*[K] (d), *Hymenocardia ulmoides* (d), *Wrightia natalensis* (d), *Alchornea laxiflora*[K], *Brachylaena huillensis*, *Callichilia orientalis*[M], *Cassipourea mossambicensis*[M], *Cavacoa aurea*[M], *Coffea racemosa*[M], *Dalbergia nitidula*[K], *Heinsia crinita*[K], *Hexalobus monopetalus*[K], *Hugonia orientalis*[K], *Markhamia zanzibarica*[K], *Monodora junodii* var. *junodii*, *Strychnos madagascariensis*, *Toddaliopsis bremekampii*, *Xylotheca kraussiana*. Woody Climbers: *Uvaria lucida* (d), *Prionostemma delagoensis* var. *delagoensis*[M], *Sclerochiton apiculatus*[M], *Uvaria gracilipes*[K]. Tall Shrubs: *Croton pseudopulchellus* (d), *C. steenkampianus* (d), *Canthium setiflorum* subsp. *setiflorum*, *Coptosperma zygoon*[K], *Erythrococca menyharthii*[K], *Haplocoelum foliolosum* subsp. *mombasense*[M], *Pavetta catophylla*. Low Shrubs: *Tricalysia junodii* var. *junodii*, *Warneckea sousae*. Herb: *Aneilema arenicola*[M]. Succulent Herb: *Crassula maputensis*[M]. Graminoids: *Eragrostis moggii*[M] (d), *Panicum laticomum*.

Endemic Taxa ([M]In South Africa only in Maputaland, [K]Only in northern Kruger National Park) Tall Tree: *Erythrophleum lasianthum*[M]. Small Trees: *Monodora junodii* var. *macrantha*[K], *Oxyanthus latifolius*[M]. Woody Climbers: *Combretum celastroides* subsp. *orientale*, *Schlechterina mitostemmatoides*[M], *Strophanthus luteolus*[M]. Tall Shrubs: *Gymnosporia oxycarpa*[K], *G. pubescens*, *Psydrax fragrantissima*[M], *Tricalysia delagoensis*[M]. Low Shrubs: *Leptactina delagoensis* subsp. *delagoensis*, *Salacia leptoclada*[M]. Geophytic Herb: *Bonatea lamprophylla*[M]. Graminoid: *Brachychloa schiemanniana*[M].

Conservation Critically endangered due to its vulnerability and economic pressure. Target 100%. Some 42% statutorily conserved in Tembe Elephant Park, Sileza Nature Reserve, Ndumo and Mkhuze Game Reserves, Greater St Lucia Wetland Park, Kruger National Park and in private Phinda Resource Reserve. An unknown portion was lost through clearing for subsistence agriculture and grazing. Uncontrolled extraction of wood for fuel and woodcraft is a problem as is the high density of elephants in Tembe Elephant Park—the best preserved portion of the sand forest in South Africa.

Remarks This forest houses a large number of local Maputaland endemics (Matthews et al. 1999, 2001) and forms the core of the Maputaland Regional Centre of Endemism (Van Wyk & Smith 2001). Many other tropical elements have their southernmost distribution here and/or are found in South Africa exclusively here (Van Wyk & Smith 2001, Schmidt et al. 2002).

References Myre (1964), De Moor et al. (1977), Moll (1978), Van Rooyen (1978), Van Rooyen et al. (1981), Gertenbach (1983), Kirkwood & Midgley (1999), Matthews et al. (1999, 2001), Van Wyk & Smith (2001), Schmidt et al. (2002), Von Maltitz et al. (2003), Gaugris et al. (2004), Geldenhuys & Mucina (2006).

FOz 9 Ironwood Dry Forest

Androstachys johnsonii–Croton pseudopulchellus dry forest (Van Rooyen et al. 1981).

Distribution Limpopo Province: Northern part of the Kruger National Park in the Lebombo Mountains as well as in the surroundings of Punda Maria. Possibly also found in the Soutpansberg. Found at most mapped patches at altitudes between 280 and 580 m.

Vegetation & Landscape Features On moderate to steep mountain slopes (up to 22°), forming dense forests (sometimes called 'thicket') dominated by Lebombo Ironwood (*Androstachys johnsonii*), which may build a closed canopy reaching up to 10 m. *Croton pseudopulchellus* attains high densities in the understorey. The adjacent bushveld communities are often sharply demarcated from the forest (Van Rooyen et al. 1981).

Geology & Soil fine to medium-textured (dark red-brown to brown-red) sand to sandy- loamy soil derived from Soutpansberg Group sandstone and quartzite, Karoo Supergroup sandstone as well as Lebombo Group rhyolites and the Cretaceous Malvernia Formation sandstones. Rocks cover 60% of the surface and soil depth ranges from 100–250 mm. pH of soil spans 4.8–8.3 and there is a moderate concentration of soluble salts or the soil is strongly leached in places (Van Rooyen et al. 1981).

Important Taxa (*Also occurring in FOz 8 Sand Forest) Tall Trees: *Androstachys johnsonii* (d), *Entandrophragma caudatum**. Small Trees: *Alchornea laxiflora**, *Boscia albitrunca*, *Cassia abbreviata* subsp. *beareana*, *Commiphora tenuipetiolata*, *Croton gratissimus*, *Euphorbia espinosa*, *Hymenodictyon parvifolium*, *Monodora junodii* var. *junodii**, *Pouzolzia mixta*, *Vitex ferruginea**. Succulent Tree: *Euphorbia confinalis*. Woody Climbers: *Combretum paniculatum*, *Strophanthus kombe**. Herbaceous Climber: *Ipomoea magnusiana*. Tall Shrubs: *Croton pseudopulchellus** (d), *C. madandensis*, *Dombeya kirkii*, *Phyllanthus reticulatus*. Low Shrubs: *Asparagus setaceus*, *Hibiscus micranthus*, *Phyllanthus pinnatus*. Herbs: *Achyranthes aspera* (d), *Commelina benghalensis* (d), *Selaginella dregei* (d), *Blainvillea gayana*, *Blepharis maderaspatensis*, *Celosia trigyna*, *Cleome monophylla*, *Corchorus longipedunculatus*, *Monechma debile*, *Pupalia lappacea*, *Spermacoce senensis*, *Triumfetta pentandra*, *Xerophyta equisetoides*, *X. humilis*. Geophytic Herbs: *Cheilanthes viridis*, *Pellaea calomelanos*. Graminoids: *Aristida congesta* (d), *Panicum maximum* (d), *Brachiaria deflexa*, *Danthoniopsis pruinosa*, *Digitaria eriantha*, *Enteropogon macrostachyus*, *Leptocarydion vulpiastrum*, *Setaria pumila*, *S. sagittifolia*, *Sporobolus panicoides.*

Endemic Taxon Tall Shrub: *Pavetta tshikondeni*.

Conservation Target 100%. About 78% (of the mapped patches) statutorily conserved in Kruger National Park and Mlawula Nature Reserve. Only a very small portion has been transformed.

Remarks Despite early recognition of this vegetation as 'dry forest' (Van Rooyen 1978, Van Rooyen et al. 1981), forest managers have, surprisingly, persisted in considering it a 'thicket' form of savanna. The Punda Maria ironwood forests are more mesic than those of the Lebombo (Gertenbach 1983). More extensive and still taller forest stands of this vegetation type can be found in neighbouring Mozambique and southern Zimbabwe. Due to lack of data we have not mapped this forest type in the Soutpansberg range.

References Van Wyk (1973), Van Rooyen (1978), Van Rooyen et al. (1981), Coetzee (1983), Gertenbach (1983), Von Maltitz et al. (2003), Geldenhuys & Mucina (2006).

Azonal Units

FOa 1 Lowveld Riverine Forest

Gallery Forest (*sensu auct.*). Fringing Forest (Moll & White 1978). Riverine Forest (Cooper 1985). Lowveld Riverine Forest (Von Maltitz et al. 2003).

Distribution KwaZulu-Natal, Mpumalanga and Limpopo Provinces (as well as in Swaziland and other countries neighbouring on South Africa): Broad river alluvia of Zululand (Hluhluwe, middle reaches of Phongolo), Maputaland (Mkuze, lower reaches of Phongolo, Usutu) and numerous rivers draining the northern provinces of South Africa (Limpopo, Luvuvhu, Phongolo, Shingwedzi, Letaba, Olifants, Timbavati, Sabie, Crocodile). At low altitudes, from about 20 to 320 m.

Vegetation & Landscape Features Tall forests fringing larger rivers (gallery forests) and water pans. When dominated by *Ficus sycomorus* or *Diospyros mespiliformis* (alluvial sediments along major rivers), these forests are dense and tall, structured into several tree layers and with a well-developed dense shrub layer.

Geology, Soils & Hydrology Recent alluvial deposits with deep, fine-textured soils (e.g. Dundee soil form). Subject to frequent flooding and occasionally to very heavy flood spells.

Important Taxa Tall Trees: *Acacia robusta* subsp. *clavigera* (d), *Breonadia salicina* (d), *Diospyros mespiliformis* (d), *Faidherbia albida* (d), *Ficus sycomorus* (d), *Kigelia africana* (d), *Berchemia discolor*, *Combretum erythrophyllum*, *C. imberbe*, *Ekebergia capensis*, *Philenoptera violacea*, *Rauvolfia caffra*, *Spirostachys africana*, *Syzygium guineense*, *Trichilia emetica*, *Xanthocercis zambesiaca*. Small Trees: *Combretum hereroense*, *Croton megalobotrys*, *Hyphaene coriacea*, *Nuxia oppositifolia*, *Phoenix reclinata*, *Vernonia colorata*. Tall Shrubs: *Abutilon angulatum*, *Acacia schweinfurthii*, *Ficus capreifolia*. Soft Shrub: *Hypoestes aristata*. Herb: *Achyranthes aspera* (d). Graminoids: *Digitaria eriantha* (d), *Panicum maximum* (d), *Echinochloa pyramidalis*, *Eriochloa meyeriana*, *Panicum coloratum*, *Phragmites mauritianus*, *Setaria incrassata*, *S. sphacelata*, *Sporobolus consimilis*.

Conservation Critically endangered. Target 100%. Half statutorily conserved in Kruger and Mapungubwe National Parks, Greater St Lucia Wetland Park, Ndumo and Mkhuze Game Reserves (here the Fig Forest is one of the prime examples), Mlawula and Blyde River Canyon National Park in South Africa, Royal Hlane Game Sanctuary in Swaziland as well as in a number of private game and nature reserves east and south of the Kruger National Park, Selati Game Reserve, Limpopo Valley Wildlife Utilisation Area etc. Unknown portion has been irreversibly transformed by clearing for cultivation. Aliens such as *Melia azedarach, Lantana camara, Psidium guajava, Chromolaena odorata, Caesalpinia decapetala* are serious invaders in places. Agricultural malpractices upstream, building of dams and excessive water extraction for agriculture and mining as well as local exploitation for timber and non-timber forest products are serious threats to this vegetation (Von Maltitz et al. 2003).

Remarks Low (as compared to forests) riparian thickets found along rivers in Lowveld and Central Bushveld feature as part of the AZa 7 Subtropical Alluvial Vegetation.

References De Moor et al. (1977), Moll (1978), Van Rooyen (1978), Van Rooyen et al. (1981), Gertenbach (1983), Whateley & Porter (1983), Cooper (1985), Bredenkamp & Deutschländer (1995), Von Maltitz et al. (2003), Geldenhuys & Mucina (2006).

FOa 2 Swamp Forest

Hygrophilous Bush, Waterboom Associes & *Barringtonia* Associes (Bews 1920). Hygrophilous Forest (Weisser 1978). Swamp Forest (Von Maltitz et al. 2003).

Distribution KwaZulu-Natal and Eastern Cape Provinces: In pockets and narrow ribbons extending in a narrow belt along the Indian Ocean coast from Maputaland as far south as Port Grosvenor in Pondoland. Swamp Forests reach lower latitudes than Mangrove Forests, which suggests that they are climatically more limited than the mangroves. At low altitude, mainly between 20 and 60 m.

Vegetation & Landscape Features 12–15 m tall forests with two main strata (canopy and shrub layers). The dominating trees include *Ficus trichopoda*, *Barringtonia racemosa*, *Casearia gladiiformis*, *Cassipourea gummiflua*, *Syzygium cordatum*, *Phoenix reclinata* and *Raphia australis*. Understorey is poorly developed. Some ferns such as *Microsorum punctatum* and *Nephrolepis biserrata* are of importance and orchids (*Eulophia horsfallii*) occur frequently.

Geology, Soils & Hydrology Very fine, muddy, waterlogged soil, with organic humus, a peat-like layer and anoxic conditions. The St Lucia swamp forests are

L. Mucina

Figure 12.18 FOa 1 Lowveld Riverine Forest: Riparian forests with *Acacia gerrardii* on the Crocodile River near Lephalale (Limpopo Province).

found on sand, sandy loam or loamy sand with a moderate to high status (7–17%) of organic matter. The soil is acidic, pH range 2.5–6 (mean 3–4.5), and calcium and magnesium concentrations can be high. Impeded drainage and poor aeration characterise soil forms such as Sterkspruit, Valsrivier and Katspruit (Nyalazi area) or Fernwood and Champagne (Eastern Shores State Forest in the St Lucia area). Water is acidic to alkaline and mineral-rich with high calcium, magnesium and conductivity values. Water tables were found to fluctuate from the surface to a depth of 600 mm (Wessels 1991b).

J.C. Manning

Figure 12.19 FOa 2 Swamp Forest: *Scadoxus multiflorus* subsp. *katherinae* (Amaryllidaceae) flowering in the understorey of swamp forest near Munster on the KwaZulu-Natal south coast.

Important Taxa Tall Trees: *Barringtonia racemosa* (d), *Ficus trichopoda* (d), *Macaranga capensis* (d), *Rauvolfia caffra* (d), *Schefflera umbellifera* (d), *Shirakiopsis elliptica* (d), *Syzygium cordatum* (d), *Ficus lutea*. Small Trees: *Allophylus dregeanus* (d), *Bridelia micrantha* (d), *Cassipourea gummiflua* (d), *Morella serrata* (d), *Phoenix reclinata* (d), *Sclerocroton integerrimum*. Woody Climber: *Adenopodia spicata*. Herbaceous Climbers: *Stenochlaena tenuifolia* (d), *Ipomoea indica*, *I. mauritiana*. Tall Shrubs: *Burchellia bubalina* (d), *Psychotria capensis* (d), *Tarenna pavettoides* subsp. *pavettoides* (d), *Hibiscus tiliaceus* (d). Geophytic Herbs: *Eulophia horsfallii* (d), *Microsorum punctatum* (d), *Nephrolepis biserrata* (d). Graminoid: *Scleria angusta* (d).

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Figure 12.20 FOa 2 Swamp Forest: Interior of a swamp forest with *Ficus trichopoda* near Mtunzini (KwaZulu-Natal).

Biogeographically Important Taxa (all at southern distribution limit) Tall Trees: *Voacanga thouarsii* (d), *Scolopia stolzii*. Tall Shrub: *Ficus verruculosa*. Megaherb: *Dracaena mannii*.

Endemic Taxon Tall Tree: *Raphia australis* (d).

Conservation Critically endangered. Target 100%. Some 66% statutorily conserved in Greater St Lucia Wetland Park, Maphelana, Dududuku, Raphia Palms and Umlalazi Nature Reserves. Unknown portion has been already transformed either for plantations or by illegal clearing for making fruit and vegetable gardens. Especially the swamp forests in the Kosi Bay area are disappearing with alarming speed. *Chromolaena odorata, Lantana camara* and *Pereskia* species are common invaders in disturbed swamp forests. Change in local hydro-geological conditions poses another serious threat to this fragile forest ecosystem (Von Maltitz et al. 2003).

Remarks Swamp Forests have a strong tropical link and reach their southernmost distribution limit in South Africa. The endemic *Raphia australis* is limited to Maputaland and forms an intriguing forest in the Kosi Bay lagoon system. It also forms a planted grove in Mtunzini (KwaZulu-Natal).

References Bews (1920), Moll (1972), Venter (1972, 1976), Moll & White (1978), Weisser (1978, 1987), Ward (1980), Weisser & Ward (1982), Wessels (1991a, b), Weisser et al. (1992), Lubbe (1997), Von Maltitz et al. (2003), Geldenhuys & Mucina (2006).

FOa 3 Mangrove Forest

Distribution KwaZulu-Natal and Eastern Cape Provinces: Coastal lagoons and estuaries of Transkei as far south as Kobonqaba Estuary—the highest latitude with extant mangroves in the world (Moll & Werger 1978, Ward & Bunyard 1992) as far north as KwaZulu-Natal/Mozambique border (Kosi Bay estuary) and beyond to Mozambique and further northwards to tropical East Africa. At very low altitudes around sea level.

Vegetation & Landscape Features Species-poor and often monospecific, low and dense forests of mangroves (and fring-

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Figure 12.21 FOa 3 Mangrove Forest: Interior of *Avicennia marina* mangrove in St Lucia Estuary with tracks of a hippo (*Hippopotamus amphibius*).

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Figure 12.22 FOa 3 Mangrove Forest: *Avicennia marina* shrub on the edge of a mangrove forest in Umlalazi Nature Reserve near Mtunzini (KwaZulu-Natal).

ing thickets of *Hibiscus tiliaceus* and *Acrostichum aureum*) in tidal zones of coastal lagoons and estuaries.

Geology, Soils & Hydrology Mangroves occur between mean sea level and mean high-water spring tide level in sheltered estuaries on tidal flats built by recent sediments caused by accretion of river-borne sediments, to which material brought in from the sea with the rising tide is added; the soils are poorly drained, saline, anoxic, fine-grained and rich in organic content (coming from decomposing plant debris).

Important Taxa Small Trees: *Avicennia marina* (d), *Bruguiera gymnorrhiza* (d), *Ceriops tagal*, *Lumnitzera racemosa*, *Rhizophora mucronata*, *Xylocarpus granatum*. Tall Shrub: *Hibiscus tiliaceus* (d). Geophytic Herb: *Acrostichum aureum* (d).

Conservation Critically endangered. Target 100%. About 72% statutorily conserved in Greater St Lucia Wetland Park, Richards Bay, Beachwood Mangroves and Umlalazi Nature Reserves. Much of the original extent of mangrove was lost in South Africa through harbour development (Richards Bay and Durban), clearing for development (Durban) or they became degraded through unfavourable agricultural practices upstream of the rivers feeding into the estuaries.

Remarks Mangrove Forests are imbedded within the Indian Ocean Coastal Belt (see also Chapter 11) where they are found to form a vegetation complex with AZe 3 Subtropical Estuarine Salt Marshes. According to Moll & Werger (1978), the South African mangroves belong to the group of 'East Coast Mangroves' (referring to eastern coasts of Africa).

References Berjak et al. (1995), Moll & Werger (1978), Ward (1980), Ward & Steinke (1982), Ward et al. (1986), Weisser (1987), MacDevette et al. (1989), Cooper & Swart (1992), Ward & Bunyard (1992), Roberts (1993), Steinke (1995), Colloty et al. (2002), Von Maltitz et al. (2003), Geldenhuys & Mucina (2006).

12. Credits

The text of descriptions of all units was provided by L. Mucina. The species lists were compiled by L. Mucina and C.J. Geldenhuys (extracted from so far unpublished report by Von Maltitz et al. 2003, wherein the species lists were also created by the senior authors of this chapter). C.J. Geldenhuys wrote the extensive introductory text to the chapter (sections 1 to 10) to which L. Mucina contributed several additions (especially to section 4). L. Mucina has further contributed to the delimitation of several forest patches in the Western Cape, Eastern Cape, KwaZulu-Natal and Free State Provinces. C.J. Geldenhuys selected the quotation on the opening page. G.P. von Maltitz contributed to this chapter by providing unpublished material, leading to formulation of the sections on Conservation in the descriptions of vegetation units. M.C. Lötter and L. Dobson have contributed to improvement of the mapped forest coverage in Mpumalanga and in Swaziland, respectively. M.C. Lötter and W.S. Matthews

have contributed to the descriptions of FOz 4 and FOz 8, respectively, and provided further valuable comments on other parts of the text and the mapped forest coverage. D.I.W. Euston-Brown contributed an unpublished coverage of milkwood forests in the Overberg region (FOz 6) and B. McKenzie helped mapping forest patches in the Western Cape (FOz 1). M.C. Rutherford and L.W. Powrie have provided environmental data used in the descriptions of the vegetation units. M.C. Rutherford was also instrumental in conceptual issues concerning units FOz 1, FOz 2 and FOa 1 as well as shaping the final appearance of the forest patches on the map. L.W. Powrie and L. Mucina jointly produced Figures 12.2 and 12.3. M.C Rutherford and L.W. Powrie supplied climate diagrams (Figure 12.8). M. Rouget and others within the Directorate of Biodiversity Programmes, Policy and Planning of SANBI provided the quantitative information for each vegetation unit on various conservation issues.

The original Forest Biome Project Map (Anonymous 1987) was provided by the CSIR, Pretoria through the project on classification of indigenous forests (see Von Maltitz et al. 2003 for a public-domain report). In KwaZulu-Natal this coverage was replaced by new data which resulted from a forest mapping project steered by Ezemvelo KZN Wildlife. In Mpumalanga a part of the original Forest Biome Project Map was replaced by coverage featured in an unpublished report by Emery et al. (2002). We express our gratitude to DWAF, CSIR, Ezemvelo KZN Wildlife and Mpumalanga Parks Board for providing these sources. J.E. Burrows kindly commented on FOz 4 and suggested corrections to the species list. W.S. Matthews and J.C. Manning contributed some photographs. R.A. Ward kindly collated the geological terminology. J. Gilliatt redrew Figure 12.4.

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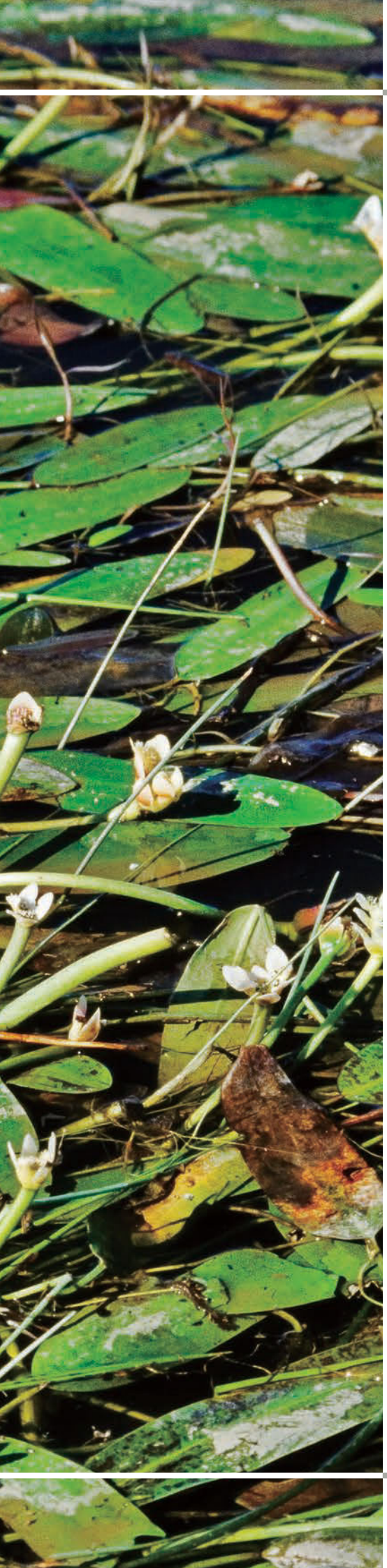

Inland Azonal Vegetation 13

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with contributions by

Jacques Gerber, Hugo Bezuidenhout, Erwin J.J. Sieben, Sarel S. Cilliers, P. Johann du Preez, John C. Manning, David B. Hoare, Charles Boucher, Anthony G. Rebelo, George J. Bredenkamp and Frances Siebert

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L. Mucina

1. Introduction: Concepts Related to Zonality of Vegetation

Water, salt and processes linked to concentration of both are the major controls of the creation, maintenance and development of peculiar habitats. Habitats, formed in and around flowing and stagnant freshwater bodies experience waterlogging (seasonal or permanent) and flooding (regular, irregular or catastrophic), leading to formation of special soil forms. Habitats with high levels of salt concentration form a highly stressed environment for most plants and often markedly affect the composition of plant communities. Invariably, both waterlogged and salt-laden habitats appear as 'special', deviating strongly from the typical surrounding zonal vegetation. They are considered to be of azonal character.

Azonal vegetation has long been an orphan of vegetation mapping in South Africa and overseas. Its enormous complexity is usually little known, and its limited extent (small size of patches) poses a challenge to mapping at scales smaller than 1:50 000.

In countries such as South Africa, where broad-scale vegetation complexes (or in other words vegetation on supra-habitat level) have always been the major focus, the concept of azonality remained largely unknown, denied or at best recognised but unexplored. A notable exception is the study of Campbell (1985) on classification of mountain fynbos of the Cape. He used the term 'azonality' explicitly to recognise various groups of communities within his 'Restioid Fynbos'. Azonal Restioid Fynbos according to Campbell (1985) is limited owing to waterlogging or to excessive drainage or as a consequence of a combination of these two habitat conditions. In his ground-breaking monograph on vegetation of the upper Orange (Gariep) River Valley, Werger (1980), who was instrumental in importing European ways of doing vegetation science to South Africa, speaks about 'minor communities', obviously referring to those of azonal nature. Mention of only these two sources does not necessarily imply that other students of South African vegetation did not sample azonal vegetation. However, they came short of defining the relationship of such vegetation to zonal vegetation patterns, neglected the question of intrazonality and, most importantly, failed to feature azonal (and intrazonal) vegetation on vegetation maps of the country. Admittedly, this was also due to the physical limitation imposed by the small scale of the maps (1:1 500 000 in Acocks 1953 and 1:1 850 000 in Low & Rebelo 1996) concomitant with the then more limited state of knowledge of the spatial variation of vegetation in South Africa. There was an attempt at continued adherence to the practice of not mixing different spatial scales on the same map. It is one of the major purposes of the National Vegetation Map to give the azonal vegetation of the region (with its 23 inland and 11 coastal azonal vegetation units) desired coverage for the first time.

All concepts related to zonality of vegetation go back to the fundamental work of Heinrich Walter. In simple terms, he used the term *zonal* to refer to the vegetation typical of climatic zones. Such vegetation forms an integrated part of biomes (for recent definitions see Mucina 2000 and the Chapter on Biomes and Bioregions in this book) or, more precisely, of 'zonobiomes' in Walter's terminology (Walter 1964, 1973, Walter & Box 1976, Walter & Breckle 1991). Hence, it is a complex of macroclimate characteristics, which exert control over structure and dynamics of the zonal vegetation. The typical soils occurring within such (climate-defined) zones are also considered zonal. The zonal vegetation can occur as *extrazonal* in specialised habitats outside the climatic zones (where this kind of vegetation is considered to be of zonal nature).

In *azonal* vegetation *sensu lato*, on the other hand, special substrate (special soil types or bedrocks) and/or hydrogeological conditions (waterlogging, flooding, tidal influence) exert an overriding influence on floristic composition, structure and dynamics over macroclimate. (Vegetation of heavily disturbed and man-made habitats, termed anthropogenic, synanthropic, ruderal or agrestal, falls within this broadly conceived concept of azonality as well.) If such vegetation occurs exclusively within a climatic (and vegetation or biome) zone, then it is considered to be *intrazonal*. Where such vegetation occurs irrespective of climatic and vegetation zones, we use the term *azonal* vegetation *sensu stricto*.

An example of typical zonal vegetation would be proteoid sandstone fynbos, granite asteraceous renosterveld etc. occurring within the zone called the Fynbos Biome. Hence vegetation units such as FFs 9 Peninsula Sandstone Fynbos, FFg 2 Boland Granite Fynbos, FRs 9 Swartland Shale Renosterveld and the like are considered as zonal. The vegetation units such as AZf 2 Cape Vernal Pools or AZi 9 Cape Inland Salt Pans are typical intrazonal units. Structure and dynamics of both are determined by either waterlogging or accumulation of salt (hence by special hydrogeological or pedological conditions), and equally importantly—both embedded within the zone of the Fynbos Biome and experiencing similar climatic traits of that particular climatic-vegetation zone. AZf 6 Subtropical Freshwater Wetlands, on the other hand, occur across the zones of the Savanna Biome, Indian Ocean Coastal Belt and Albany Thicket Biome, and hence qualify as an azonal unit in the narrow sense (Table 13.1). The climate diagrams of the particular regions where the azonal vegetation units have been mapped (Figure 13.2) reflect the patterns of intrazonality (where the form of the climate diagram follows the basic patterns of the surrounding zone) as well as azonality (characterised by a lack of distinct pattern due to a pooling effect).

Although the concept of azonality did receive some marginal attention in South African vegetation-ecological literature in the past, the concept of intrazonality is entirely new to it. Undeniably, it is also a rather controversial issue as it is scale dependent, requiring definition of the system of zones. Therefore, for practical reasons we refrain from an attempt to distinguish clearly between intrazonal and azonal (*sensu stricto*) units. Because the concepts of azonal (*sensu lato*) units as defined in our map and in this chapter are narrowly defined both in habitat and regional terms, most of those units are actually intrazonal (Table 13.1).

We are well aware of the fact that the same concepts (azonality and intrazonality) can be applied to the forest vegetation. We have decided to feature both zonal and azonal forest vegetation within one chapter for conventional and practical purposes.

Table 13.1 Spatial link between the inland azonal vegetation units and surrounding biome, with reference to the zonality status of the units. IOCB: Indian Ocean Coastal Belt.

Vegetation Unit	Biome	Zonality
Freshwater Wetlands		
AZf 1 Cape Lowland Freshwater Wetlands	Fynbos	intrazonal
AZf 2 Cape Vernal Pools	Fynbos	intrazonal
AZf 3 Eastern Temperate Freshwater Wetlands	Grassland	intrazonal
AZf 4 Drakensberg Wetlands	Grassland	intrazonal
AZf 5 Lesotho Mires	Grassland	intrazonal
AZf 6 Subtropical Freshwater Wetlands	Savanna; Albany Thicket; IOCB	azonal
Alluvial Vegetation		
AZa 1 Fynbos Riparian Vegetation	Fynbos	intrazonal
AZa 2 Cape Lowland Alluvial Vegetation	Fynbos	intrazonal
AZa 3 Lower Gariep Alluvial Vegetation	Succulent Karoo	intrazonal
AZa 4 Upper Gariep Alluvial Vegetation	Grassland	intrazonal
AZa 5 Highveld Alluvial Vegetation	Grassland	intrazonal
AZa 6 Albany Alluvial Vegetation	Albany Thicket	intrazonal
AZa 7 Subtropical Alluvial Vegetation	Savanna; IOCB	azonal
Inland Saline Vegetation		
AZi 1 Namaqualand Riviere	Succulent Karoo	intrazonal
AZi 2 Namaqualand Salt Pans	Succulent Karoo	intrazonal
AZi 3 Southern Kalahari Mekgacha	Savanna	intrazonal
AZi 4 Southern Kalahari Salt Pans	Savanna	intrazonal
AZi 5 Bushmanland Vloere	Nama-Karoo	intrazonal
AZi 6 Southern Karoo Riviere	Nama-Karoo	intrazonal
AZi 7 Tanqua Wash Riviere	Succulent Karoo	intrazonal
AZi 8 Muscadel Riviere	Succulent Karoo	intrazonal
AZi 9 Cape Inland Salt Pans	Fynbos	intrazonal
AZi 10 Highveld Salt Pans	Grassland; Nama-Karoo	azonal
AZi 11 Subtropical Salt Pans	Savanna	intrazonal

2. Typology of Inland Azonal Vegetation in South Africa

Water, in conjunction with geology, soil, topography and climate, is responsible for the creation of remarkably many types of habitats. Water chemistry, temperature (and temporary changes in both) together with the amount of water (depth of water column), timing of occurrence (regular tides or irregular floods) and speed of its movement (discharge, flow and stagnation) are the major factors shaping the ecology of biotic communities occupying such habitats.

Noble & Hemens (1978) coined the first habitat-level system for southern African wetlands. Their original scheme has been modified (adding new categories and hierarchies to the system) in later publications (Breen & Begg 1989, Rogers 1995 and recently also Sieben et al. 2004; see Rogers 1997 for a comprehensive account). A simple vegetation/habitat system (from a pan-African point of view) was also suggested by Denny (1993). The habitat-level system adopted by the Ramsar Convention in Recommendation C.4.7 (Rev) of 199 (see also Cowan 1995c) is comprehensive and also includes categories of coastal wetlands, but does not yet enjoy broad general acceptance in South Africa.

On (sub)continental level there were several attempts to classify the surface of South(ern) Africa into wetland zones. Harrison (1959) attempted to subdivide the territory of South Africa, Lesotho and Swaziland into 13 'hydrobiological regions' based on types of rivers. Allanson et al. (1990) introduced a limnological system comprising five categories, such as Subtropical Coastal Peneplain, Southeastern Coastal Plain and Elevated Plateau, Australomontane, Temperate Acid Waters of the Western Cape and finally Arid West. Rogers (1995) suggested a system based on several 'determinants' such as topography (prevailing criterion), hydrology and nutrient regime to arrive at four broad groups, based on the 'broad morphology of the country' further subdivided into 26 regions. The latest attempt was made within a pan-African background when Thieme et al. (2005) suggested the subdivision of the region comprising South Africa, Lesotho and Swaziland into seven 'ecoregions' (representing four bioregions), such as 37-Drakensberg-Maloti Highlands, 36-Amatolo-Winterberg Highlands, 73-Southern Temperate Highveld, 77-Zambezian Lowland, 33-Cape Fold, 91-Southern Kalahari and 93-Western Orange. The classification and delineation into bioregions and ecoregions primarily followed fish distribution data.

Our classification approach follows multilayered criteria, the macro-ecological one (character of azonality and combination of azonality-driving ecological factors such as water and salt content) being the most important. According to this criterion, we distinguish, firstly, freshwater wetlands (along stagnant or slow-flowing waters) as different from, secondly, alluvial vegetation fringing water courses and undergoing dynamic change due to a periodic flood regime. The third class—the 'inland azonal vegetation'—comprises vegetation accompanying salt-laden intermittent rivers and salt pans. High concentration of salt in the environment (either soil or water or both) is the major ecological determinant of this vegetation complex. Further subdivision within these three categories follows biogeographical (hence floristic and floral-evolutionary) criteria and reflects the link between the azonal vegetation unit and its corresponding 'matrix' zonal vegetation (Table 13.1). A comparison of the spatial extent of the zonal and azonal vegetation identified only four units as truly azonal, hence occurring within more than one biome—three subtropical units and Highveld Salt Pans. The other vegetation units are intrazonal. The vegetation units recognised in this chapter can be classified with high certainty into four Rogers's (1995) regions (Table 13.2), with the notable exception of our subtropical units (AZf 6, AZa 7 and AZi 11) shared by three of the four broad groups; the subtropical wetland units naturally do not occur in the fourth group—the 'Mountain Wetlands'.

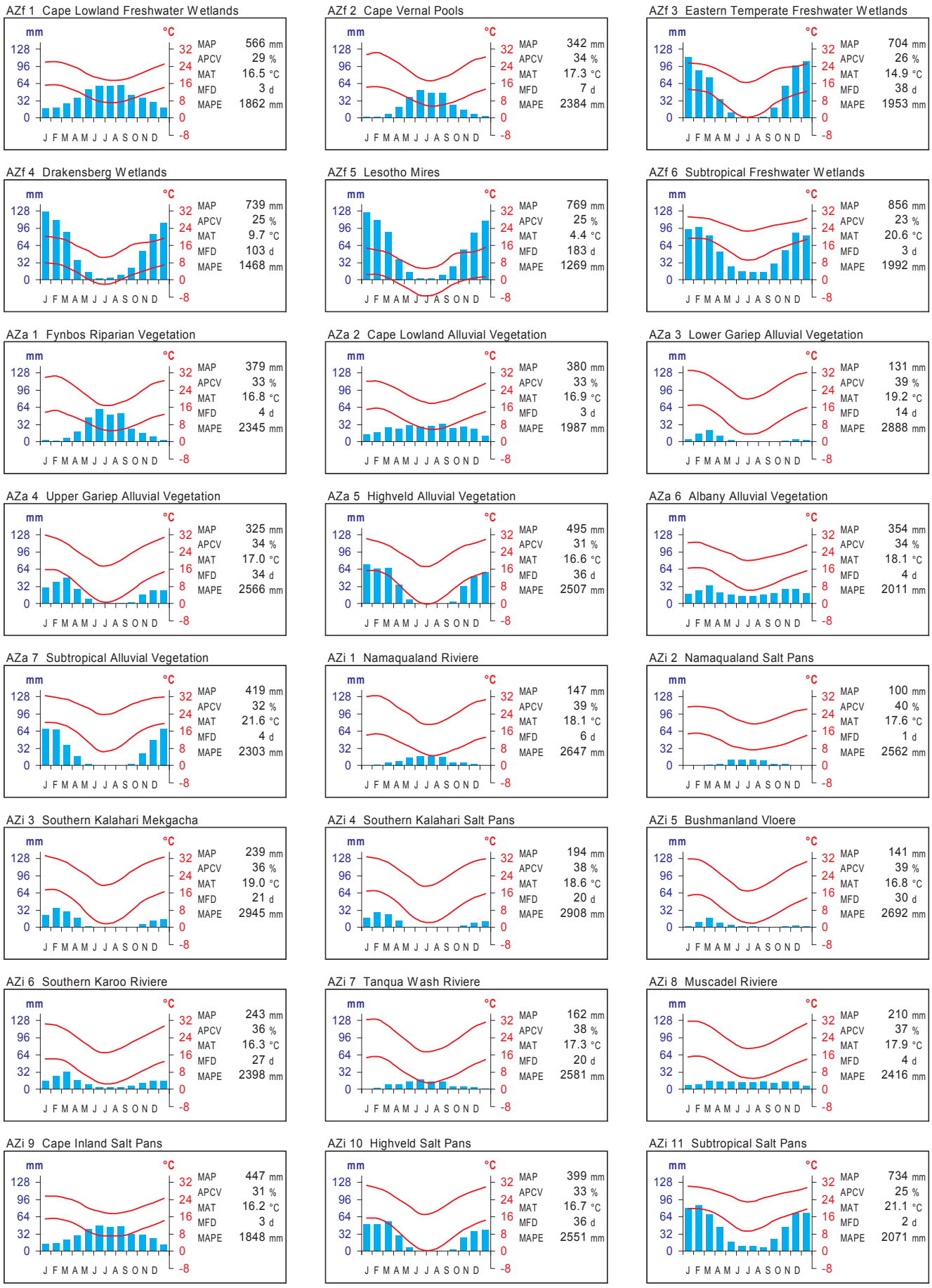

Figure 13.2 Climate diagrams of Inland Azonal Vegetation units. Blue bars show the median monthly precipitation. The upper and lower red lines show the mean daily maximum and minimum temperature respectively. MAP: Mean Annual Precipitation; APCV: Annual Precipitation Coefficient of Variation; MAT: Mean Annual Temperature; MFD: Mean Frost Days (days when screen temperature was below 0°C); MAPE: Mean Annual Potential Evaporation.

Table 13.2 Correspondence between the Wetland Regions of Cowan (1995c) coded as C, S, M and P and the vegetation units as described in this Chapter (for the codes see the List of Vegetation Units) and combined into three groups, namely FW (Freshwater Wetlands), AV (Alluvial Vegetation) and ISV (Inland Saline Vegetation). The units given in bold are shared between Wetland Regions C, S and P, while the other units show exclusive links to a wetland region. N: data do not apply.

		FW	AV	ISV
C	Coastal plain wetlands	**AZf 6**	**AZa 7**	**AZi 11**
S	Coastal slope & rimland	**AZf 6**	**AZa 7**	**AZi 11**
		AZf 1	AZa 2	AZi 1
		AZf 2	AZa 3	AZi 2
			AZa 6	AZi 9
				AZi 6
				AZi 7
				AZi 8
M	Mountain wetlands	AZf 4	AZa 1	N
		AZf 5		
P	Plateau wetlands	**AZf 6**	**AZa 7**	**AZi 11**
		AZf 3	AZa 4	AZi 3
			AZa 5	AZi 4
				AZi 5
				AZi 10

3. Freshwater Wetlands, Alluvial and Inland Saline Vegetation

In this chapter we address the inland segment of the wetlands of southern Africa. Here we feature and classify (in floristic-biogeographical terms) the wetland vegetation of all freshwater wetlands (including vleis, marshes, mires, lakes, alluvia) and vegetation of land-locked salt-laden habitats (including salt pans and river channels of intermittent rivers in arid and semi-arid regions).

3.1 Freshwater Wetlands

Freshwater wetlands form a system of archipelagos of small and highly fragmented patches, embedded within all mainland biomes of South Africa. They are particularly common landscape features in regions with mean annual precipitation exceeding 500–600 mm (Figure 13.3). The floristic composition in the freshwater habitats underwent a series of ecological and evolutionary filters linking the azonal vegetation with its background zonal vegetation. The classification of the freshwater wetlands into vegetation units as applied in our map reflects this link very closely (Table 13.1).

The typical freshwater wetlands are vleis, which form in the catchment areas of highveld streams (spruits), where a sufficiently shallow gradient permits the soils to remain wet without being eroded by flowing water. Many of these vleis on the highveld are peat forming, especially where the dominant species is the reed *Phragmites australis*. Rietvlei in Gauteng is a prime example of a wetland with peat deposits sufficiently large to be suitable for mining. The perimeter around stagnant water bodies (lakes, banks of dams) as well as the 'Floodplain Vleis' of Noble & Hemens (1978; see also Rogers 1995) is here classified as part of Freshwater Wetlands as well. Many pans, especially on the precipitation-rich eastern and northeastern highveld are also considered freshwater wetland habitats. A very significant pan field is that of the Lake Chrissie region in Mpumalanga where over 250 pans occur—remnants of a fossil riverine system. The surrounding landscape is also very uniformly flat with an underlying layer of marine-deposited sandstone that forms the bed of many of the pans. These freshwater pans can be classified as Open Pans, Reed Pans, and Grass Pans (according to Rogers 1997; see also Geldenhuys 1982 for the definitions of these concepts), depending on vegetation cover and its composition. The narrow alluvia of highveld streams are also tentatively classified as part of the Freshwater Wetland category due to notable floristic similarity to the vlei vegetation.

The high-altitude wetlands of the Lesotho Highlands (with a small portion belonging to South Africa) enjoy particular status within southern African wetlands. They have been called 'bogs' (e.g. Van Zinderen Bakker 1955, Jacot Guillarmod 1962, Van Zinderen Bakker & Werger 1974), 'mires' (Backéus 1988) or 'flushes' and 'cushion bogs' (Thompson & Hamilton 1983), and they are characterised by the formation of peat—a phenomenon typical of precipitation-rich and cold climates (Gore 1983). These wetlands develop into depressions, and on slightly inclined slopes they are fed by rain water as well as lateral flow of water released from the peat layer down-slope. Hence, according to the hydrological classification (see for instance Walter 1968) they should be considered to be ombro-soligenous mires (influenced by rain water as well as water seeping through the soil). The water is eutrophic since the underlying basalt is rich in calcium, potassium and phosphorus and has a pH of about 8. The mires develop, in an oligotrophic direction (Van Zinderen Bakker & Werger 1974), under extreme precipitation conditions

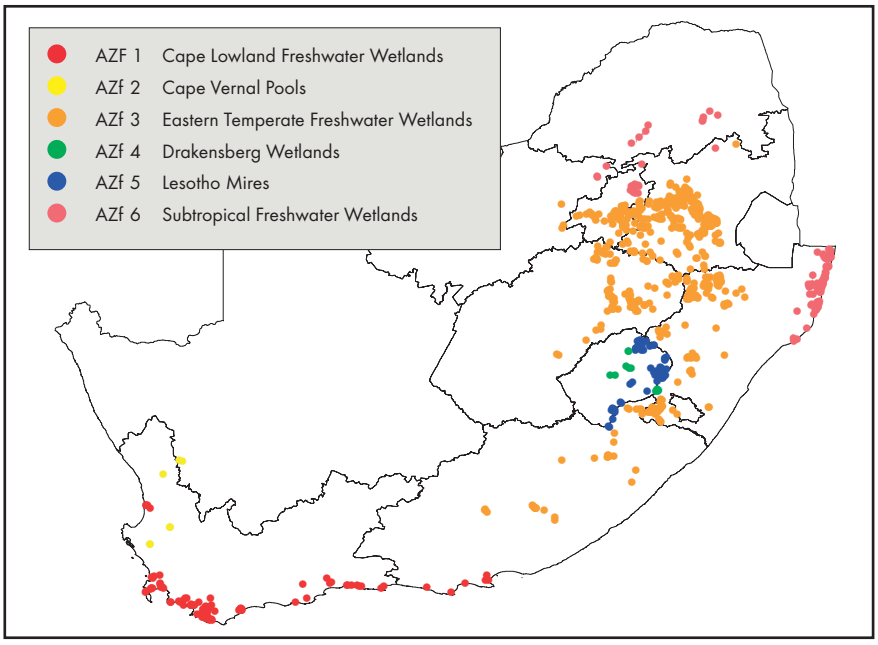

Figure 13.3 Position of patches of vegetation units featuring freshwater wetlands (AZf group) in South Africa, Lesotho and Swaziland.

leading to flushing of bases from the mineral-rich peat. Moist or so-called head-valley 'sponges' should not be included in the mire category since they do not show a marked rise in the peat layer. Formation of thufurs (small hummocks) and tarns (small water pools) are typical geomorphological and hydrological features of the Lesotho mires. The origin of the thufurs is still not fully understood, but uneven freezing/snowing patterns might be an obvious cause (see Van Zinderen Bakker & Werger 1974 for a review of the problem and Thompson & Hamilton 1983 for some comparative ideas). The high-altitude bogs and mires of southern Africa have a long evolutionary history and as evolutionary laboratories and museums, they house a high number of relicts of the past afromontane flora migrations and they also became a cradle of neo-endemism.

Peat layers are also formed in wetlands on the highest summit plateaus of the mountains in the southwestern Cape (Kruger 1979, Sieben et al. 2004). These are rain-fed and acidic and in the Cape they also receive a considerable amount of fog precipitation, also with some in summer (Marloth 1907). In summer these small peatlands experience seasonal drought (or at least considerable decrease in water content). Formation of typical raised bogs (purely ombrogenous mires) has not yet been observed.

All of the different freshwater wetland types as listed above can contain permanent water bodies qualifying as natural lakes (Allanson 1979, 1981, Hart 1995; Figure 13.4). The shallow fringes of these lakes support a variety of so-called macrophytic aquatic vegetation composed of various life forms adapted to life on the lake bottom, free-floating within a water column or floating on the surface of the water. These habitats are considered (also in accordance with the definition of a wetland of the Ramsar Convention) as wetlands, although we have not always mapped them.

The freshwater wetlands found outside the centres of regional endemism (Van Wyk & Smith 2001), and especially at low altitudes, show certain uniformity in terms of dominants and house a number of species of subcosmopolitan distribution. In regions known for their high endemism (Capensis, Drakensberg), their contribution to the scores of endemism is considerable (e.g. Drakensberg Wetlands, Cape Vernal Pools, Fynbos Riparian Vegetation and unmapped freshwater wetlands in the mountainous regions of the Fynbos Biome).

L. Mucina

Figure 13.4 Island Lake (Onder-Langvlei) near Wilderness on the Garden Route (Western Cape)—an example of a coastal freshwater lake separated from the sea by a high cordon of dunes.

3.2 Alluvial Vegetation

Southern Africa is a dry land, and it has been so since about the mid-Tertiary. Still, water has long been a major landscape-shaping factor. Tributaries of major perennial river systems, of which the Orange, Thukela and Limpopo are the most important water courses draining South Africa, Lesotho and Swaziland. There are many smaller ones dissecting the sloping face of the subescarpment regions of Namaqualand (e.g. Buffels), the southwestern and southern Cape (e.g. Berg, Breede, Gouritz) and the broad coastal slopes of the Eastern Cape (e.g. Gamtoos, Great Fish, Kei) and KwaZulu-Natal (e.g. Phongolo).

The systems of permanent and intermittent rivers of southern Africa, as we know them today, represent a snapshot in history of the evolution of our landscapes. Continental uplift and climate change events (and associated changing precipitation and through-flow patterns) have always driven the dynamics of formation, alteration and obliteration of riverine systems. The development of the Orange River basin (Wellington 1958, Dingle & Hendey 1984, De Wit 1999, Goudie 2005) has demonstrated beyond doubt that, since dryness became a dominant feature of the climate of our planet, the changes in the major riverine systems draining arid and semi-arid regions of southern Africa have been extensive.

All the extant perennial as well as intermittent rivers are accompanied by systems of alluvial terraces suited to support a special category of wetlands characterised by flooding and associated disturbance. Alluvium is usually defined as a place where sediments carried by a river are deposited. Typically, alluvia are flat terraces built of assorted sedimentary material, and regularly accompany the middle (partly) and lower (prevalently) reaches of slow-flowing rivers. Because the volume of water carried by rivers might change seasonally, the build-up of the alluvia follows these cyclic changes. The alluvia undergo frequent rebuilding by erosion of old or adding of new material, depending on the mobility of the river. As a river changes its direction or might cut deeper into the surrounding landscape, new systems of alluvial terraces are built, older ones are eroded away or abandoned in places where the influence of flooding has ceased. In general, typical alluvia are habitat complexes where sedimentation (hence habitat-creating) processes prevail over erosion (destructive) processes. The riverbanks of rapidly flowing, montane rivers, sometimes with rapids, along the upper river reaches with steep gradients can also develop alluvia. This happens especially in places where the valley carrying the river becomes broader or where gradients become less pronounced. There are several differences between these alluvia and those along the middle and lower reaches of a river. The mountain river alluvia are usually built of coarse sedimentary material including large boulders and gravel, they have a low nutrient status and they are exceedingly prone to extensive damage (and obliteration) by unpredictable catastrophic floods.

Alluvia support habitat complexes emerging as a result of the interplay of several ecological factors such as temporary and spatial sedimentation-to-erosion rates, water sediment load, water chemistry and nutrient content, frequency and

duration of flooding, soil texture and soil nutrient status, just to mention the most important ones. It has been shown (Van Coller 1993, Van Coller et al. 1997, 2000) that vegetation populating the alluvia is primarily structured by environmental gradients reflecting the habitat differences in the vertical (above), lateral (away from) and longitudinal (along) dimensions of the river channel. The elevation above the macrochannel explains the main variation in vegetation pattern, with processes of flooding frequency and water availability as major determinants of the vegetation cover on the alluvia (Van Coller et al. 2000). The latter authors further demonstrate that patchiness factors (such as presence of well-developed alluvial bars and quality of bedrock) also play an important role as vegetation-structuring processes.

The diversity of the alluvial habitats is considerable, which is reflected in diversified pertinent geomorphological and hydrological terminology. Ecologists have also coined several sets of terms describing alluvial habitats especially in relation to occurrence (and frequency) of flooding. Kopecký's (1969) typology of riverbank habitats is based on three criteria, namely (1) the vertical division of the riverbanks into riparian and subriparian zones, (2) range of the water level fluctuation, and (3) intensity of wave action or speed of flow. The amplitude of the fluctuation in water level defines either a stenosauletic type of riverbank (when the difference between maximum and minimum levels does not exceed 0.6 m) or a eurysauletic type (where water level fluctuates more than 1 m). Four 'ecotopes' (= habitats) can be distinguished within the stenosauletic type of riverbanks, depending on the duration of floods: the submerse ecotope is permanently flooded, the demerse ecotope is exposed only briefly during dry periods, the semi-emerse ecotope is usually dry as a rule, but flooded during shallow flood periods, and finally the emerse ecotope is the zone inundated only during high floods. An unpublished system by Boucher & Tlale (1999a; see also Sieben 2003) is in principle very similar to the one described above and involves three basic zones, namely Aquatic, Wet Bank (with Lower and Upper Zones) and Dry Bank (with Lower Dynamic, Shrub/Tree, and Back Dynamic zones).

Frequently flooded lower banks are usually populated by transient herblands made up of short-lived, nutrient-demanding flora. Reeds occupy beds forming on banks of very slow-flowing rivers or are found in still backwaters. Patches of flooded grasslands are usually found on both low and middle terraces, while riparian thickets usually occur on high terraces experiencing only occasional disturbance events resulting from floods. Permanent (or semipermanent) alluvial lakes or backwaters can form within extensive alluvial complexes. They may diminish in size and expose broad bands of clayey banks in regions characterised by seasonal rainfall. The actual water bodies in this habitat complex, including the backwater (pan) lakes, oxbows as well as slow-flowing river channels, may support macrophytic vegetation (*sensu* Hejný 1960)—true aquatic vegetation built of plants floating on the water surface or dwelling within the water column. These patterns hold for most of the perennial river systems and occur in modified form also on alluvial complexes accompanying intermittent rivers. The narrow mountain alluvia can support herblands, restiolands and sedgelands consisting of disturbance-resistant clonal plants. They also support thickets such as those constituted by endemic shrubs in Capensis and *Leucosidea sericea* in the Drakensberg.

The alluvial vegetation shows many common floristic and ecological features across the biomes of southern Africa (Figure 13.5), resulting from selection of plant functional types that respond well to high water supply, occasional (and sometimes heavy) disturbance and extraordinarily high nutrient status (especially in the case of lower alluvia). Disturbance, both natural and man-induced, in these habitats creates a set of conditions allow-

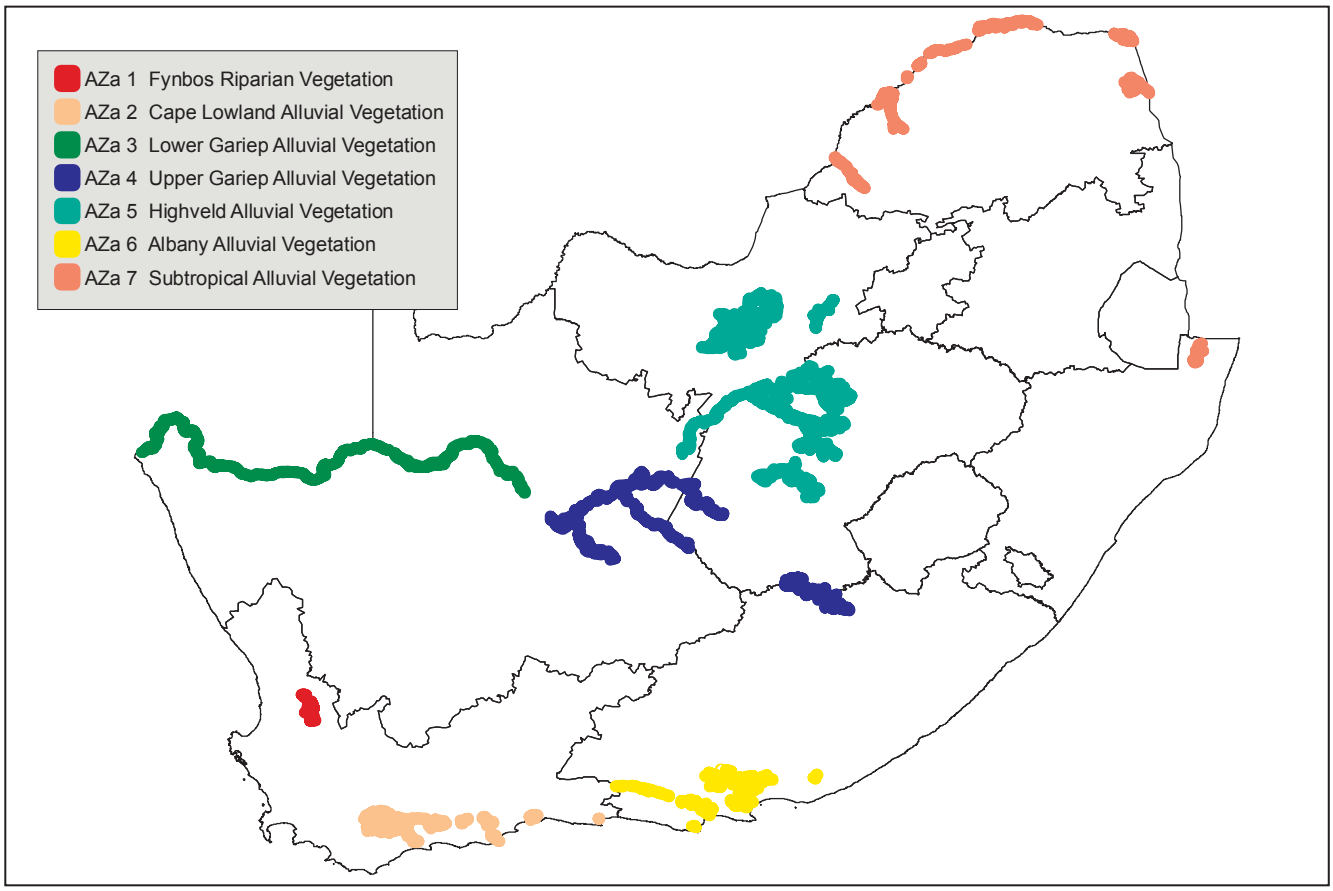

Figure 13.5 Position of patches of vegetation units featuring alluvial (and riparian) wetlands (AZa group) in South Africa.

ing and fostering the rapid spread of highly responsive native, ruderal flora. Alluvia also serve as important corridors for linear invasions by alien flora (e.g. Duvenhage 1993, Pyšek & Prach 1994; see also Macdonald et al. 1986).

3.3 *Inland Saline Vegetation*

The salt-laden habitats found inland, hence outside the immediate influence of the sea, are diverse in character and origin. Still they do share several basic ecological features, such as a high concentration of salt soil and water. The salinity originates either from a salt-bearing substrate or from mineral-rich groundwater aquifers, typically those located close to the soil surface, or from other forms of water that seep to the surface and deposit salt after evaporation. Inland saline habitats are found in regions that experience a prolonged dry period.

The most prominent inland saline habitats are those in and around salt pans (Allan et al. 1995), also called 'closed drainage salt pans' (Rogers 1995) and 'vloere' or 'kolk' by the local population in Bushmanland (the latter also called 'Karoo salt flats' by Rogers 1995). The term 'endorheic' is often used for these pans and refers to the closed nature (no outlet) of the drainage system of the pans. The size of the salt pans can range from very small to very large (such as Grootvloer in Bushmanland). Typically, they are filled with fine clayey sediments with a high salt content (pH of soil regularly exceeding values of 8). Most of them are dry for most of the year, while only some carry water (subject to large water-column fluctuations) all year round. The central, flat part of many pans is usually devoid of vegetation, and typical vegetation zonation patterns may form at the edges of the pan floor and on the banks of the pan.

Marshall & Harmse's (1992) review of the knowledge on the origin and formation of pans revealed the complexity of this interesting natural phenomenon. The authors concluded that there are three basic integrated mechanisms of pan initiation involving (a) suitable substratum (easily weathering rocks such as those of Karoo Supergroup sediments), (b) disrupted drainage (induced either by tectonic or climate-change processes), and (c) geological structure (including the presence of dolerite sills, fracture intersections and volcanism). Deflation and the concentration of animals around pans (to drink and wallow) may play an enhancing role in the formation of the pans. The concentrated occurrence of inland salt pans coincides with ancient (usually Tertiary) river systems, for example those of the northern and western Free State (Grobler et al. 1988) or the Orange (Gariep) River (Wellington 1958). Because of the conserving properties of high salt concentrations, the pan sediments preserve pollen and other remains of organisms, which are used as an important source of palaeoecological information (e.g. Scott & Brink 1992, Partridge & Scott 2000).

The most extensive salt pan systems in South Africa are found in Bushmanland, the northeastern Free State and in the adjacent regions of the North-West Province. The name of the region is derived from the salt pans of the Kalahari (Figure 13.6).

The salt pans along the Atlantic seaboard of the West Coast are of marine origin. These pans used to be coastal lagoons and as they became fully severed from the sea, they turned into salt pans (Rocher Pan near Velddrif, salt pans near Darling and Cape Town). The pans of Namaqualand as well as those of the Agulhas Plain and of the plains bordering the Indian Ocean further east (near Albertinia in the Western Cape, Uitenhage and Despatch in the Eastern Cape) are remnants of Pleistocene marine transgressions.

In the Overberg region (typically made up of salt-laden Bokkeveld Shales), and to a small extent also in other regions

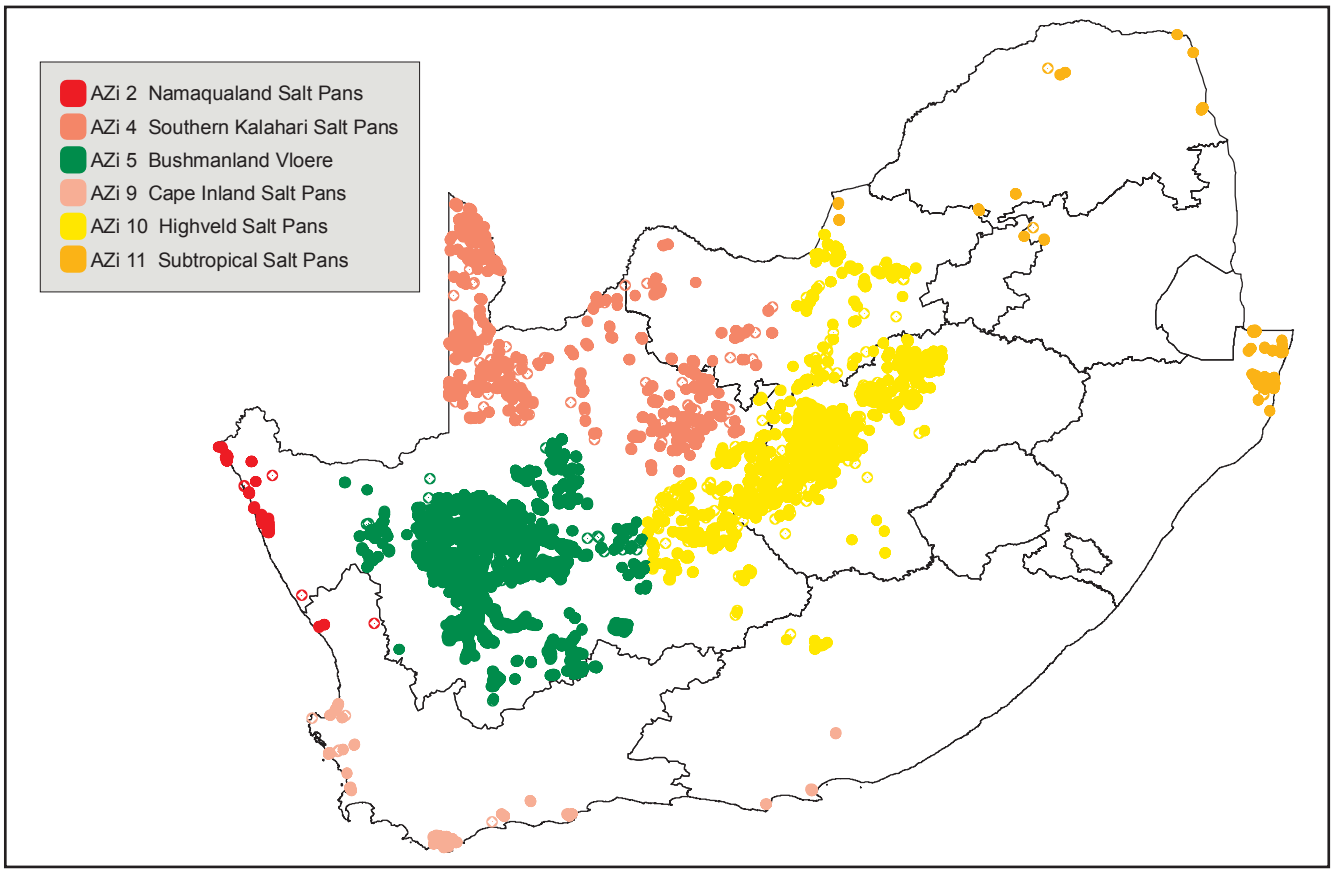

Figure 13.6 Position of patches of inland salt-pan vegetation units (part of AZi group) in South Africa.

consisting of shales of different origin (around Worcester and Malmesbury), inland saline vegetation is limited to erosion scars and to narrow alluvia collecting salty, clayey, shale-derived sediments. Quite extensive salt alluvia and flats are especially found in the vicinity of Bredasdorp, Napier and Swellendam.

Salt pans in the subtropical regions of South Africa and Swaziland are another, special wetland category. They are well known to both South Africans and tourists for excellent game viewing in the parks and nature reserves of the Lowveld and the Central Bushveld, especially in the dry season (summer), when some of them still carry some water or turn into muddy pools (Figure 13.7). These natural pans are usually either remnants of dysfunctional drainage systems or are formed in drainage lines of intermittent rivers. They are seldom formed in deflated depressions, sealed with clayey sediments and perpetuated (and extended) by animals visiting the water pools emerging from them from time to time. Only one of these pans is known to be of impact (meteorite) origin—Soutpan in the Tswaing Crater, north of Pretoria. The most extensive subtropical pans are those of the Ndumo Game Reserve (Nyamiti and Banzi) and other pans of the same riverine (Phongolo) system in Maputaland, and the pans in the Lowveld (Kruger National Park). The subtropical pans in South Africa provide habitats for tropical hygrophytes and hydrophytes at the southern limits of their distribution (Cook 2004) and are of enormous conservation importance for maintenance of populations of megaherbivores (Figure 13.8) and water birds.

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Figure 13.8 Lowveld pans are important habitat of large herbivores: young hippo (*Hippopotamus amphibius*) in an artificial pan filled with alien *Pistia stratiotes* (Araceae) near Lower Sabie Rest Camp in the eastern Kruger National Park.

Azonal vegetation is also found on the bottom and on slopes of hardpan (mainly calcrete, sometimes also ferricrete and silcrete) edges of dry riverbeds criss-crossing the driest parts of South Africa (Figure 13.9). The drainage channels of intermittent rivers, called 'waadi' in Arabic-speaking countries or 'riverwash' in America, are a typical feature of semidesert and desert landscapes of southern Africa. In the Kalahari they are called 'mekgacha' (plural); in Namibia, Walter (1985) adopted the Afrikaans term 'riviere' (plural) for them.

The mekgacha and riviere are dry most of the year. In fact, they may stay dry for many consecutive years. They very seldom are in flood and then only for a short time, immediately after heavy (often unexpected) rains and are usually not able to carry the flood surges far. Water typically recedes very quickly (sometimes within hours) and disappears into the sandy riverbeds, where it can persist in the soil column (as capillary water) or form small aquifers. Erosion and sedimentation cycles redistribute not only water-borne soil particles, larger rock debris or dead plant material, but also seeds and entire mats of creeping grasses. This natural plant propagation material provides the foundation for a new vegetation cover on the dried bottom of the intermittent rivers after the waters have receded and soil particles have settled.

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Figure 13.7 Nyamiti Pan in Ndumo Game Reserve (Maputaland, KwaZulu-Natal). *Cynodon dactylon* sward covers the proximal pan bank, while *Acacia xanthophloea* (fever tree) dominates the opposite upper bank of the pan.

The drainage lines of the intermittent rivers are often associated with outcrops of hardpan (mainly calcrete), which supplies (through erosion and in times of flood surges or through seeps in the calcrete riverbanks) high levels of calcium in the soil. High evaporation pressure leads to salt accumulation on the surface (also on the dry bottom of intermittent rivers). It is therefore not surprising that the vegetation of dry river bottoms is of halophytic character.

The drainage systems of (semi)desert intermittent rivers are probably very old as the events leading to dramatic change of the course are rare.

The classification of vegetation units related to salt-laden habitats of intermittent rivers follows the same principles as for salt pans—the position of the respective vegetation unit in relation to the surrounding biome (Figure 13.10).

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Figure 13.9 Valley-bound view of the subescarpment plains of the Knersvlakte below the Vanrhyns Pass (on the border between Northern and Western Cape) with tributaries of drainage lines carrying intermittent water courses fringed by *Acacia karroo* thickets.

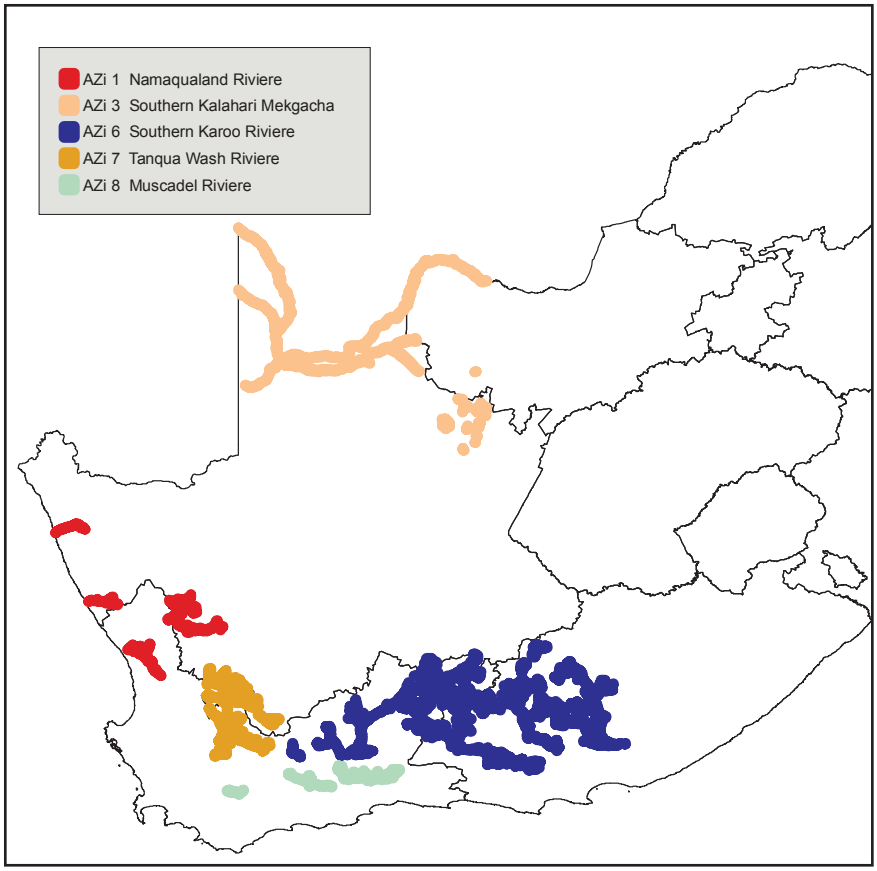

Figure 13.10 Position of patches of vegetation units (part of AZi group) featuring vegetation of intermittent rivers and associated habitats in South Africa.

4. Caveats: Neglected Azonal Vegetation

Much of the Freshwater Wetlands escaped mapping at this stage due to their small extent and lack of data. We admit that the major caveats are in the coverage of Freshwater Wetlands of the Cape Fold Mountains, Highveld, Drakensberg (and adjacent parts of the Great Escarpment) and KwaZulu-Natal and Eastern Cape coastal forelands. We still lack proper data on the extent of alluvia of the Cape forelands, Highveld, Central Bushveld, Lowveld and KwaZulu-Natal and the Eastern Cape coastal belt (and deep inland coastal forelands). The mapping of the extent of units such as AZf 4 Drakensberg Wetlands, AZa 1 Fynbos Riparian Vegetation and AZa 2 Cape Lowland Alluvial Vegetation is in its infancy.

The recognition of Freshwater Wetlands embedded within the Fynbos Biome (especially fynbos shrubland units—see chapter on Fynbos in this book) is the major challenge for future vegetation mapping. These wetlands encompass a plethora of habitats classified by Sieben et al. (2004) into four major habitat complexes, namely slope seepages, valley seepages, high-altitude fens (called 'acid fens' by Rogers 1997), and restio marshlands (Figure 13.11). Apart from several notable exceptions (such as restio marshlands near Rawsonville in the Breede River Valley and temporary wetlands of the Agulhas Plains), these habitats are small and mainly mappable only at scales below 1:50 000 (see Boucher 1978). Like its surrounding zonal vegetation, the Fynbos Freshwater Wetlands show high levels of endemism and regional distinctness resulting from high beta diversity across the coenoclines of freshwater fynbos communities. Classification of such a highly fragmented archipelago of habitats and associated vegetation showing high levels of distinctive species composition, remains an exciting challenge.

Despite the high diversity of azonal vegetation types featured in this chapter, the list is far from complete. We admit to have disregarded a number of very specific vegetation types—potential subjects for more detailed future mapping exercises. We believe that all these small-scale vegetation units can be mapped at scales spanning 1:5 000 to 1:50 000. Among those, we wish to mention:

(a) Vegetation of inland cliff faces and crevices, rock ledges and sheets

Inland cliffs create a plethora of microhabitats supporting specific vegetation reflecting geology, soil-trapping (and erosion) processes, duration and intensity of insulation (a function of aspects and shading by surrounding landscape features), presence of trickling or seeping water, disturbance by animals and several other ecological factors. They are found on steep slopes along the Cape Fold Mountains and Great Escarpment as well as deep gorges (Figure 13.12) cutting the table landscapes of southern Africa. Poor accessibility (hence protection from grazing pressure), low levels of competition and often relative habitat stability over millennia (and possibly even longer) are prerequisites for the presence of relict and endemic

flora. Brief accounts of this kind of community are scattered in reports of the Nama-Karoo Biome (Werger & Coetzee 1977, pp. 19, 20) and the Grassland Biome (e.g. Hilliard & Burtt 1987, pp. 54–56, Siebert et al. 2003). Unlike in the northern hemisphere, in South Africa research on the flora and vegetation of rocky habitats is in its infancy (Van Jaarsveld & Van Wyk 2000, 2003). Given the basic geometry of plain-surface mapping, the depiction of the vegetation of near vertical cliffs on such maps might be a challenge, even at a scale of 1:5 000.

(b) Vegetation of rock overhangs and cave openings

Cave openings and rock overhangs are a very special habitat characterised by steep gradients, low moisture (due to shelter effect) and often a high nutrient-status of the soil due to frequent visits by both humans and animals seeking shelter. Because of the slow rates of rock weathering, these shelters remain for tens to hundreds of thousands of years, hence long enough to allow evolution of specific flora. Herbs such as *Crassula densa* (Werger & Coetzee 1977, p. 20), *C. umbraticola*, *Cynoglossum spelaeum*, *Juncus mollifolius* (endemic to the Drakensberg), *Lappula squarrosa*, *Malva verticillata*, *Nemesia rupicola*, *Parietaria micrantha* and *Troglophyton capillaceum* (all cited by Hilliard & Burtt 1987, pp. 60, 61) and shade-tolerant ferns *(Adiantum capillus-veneris*, *A. poiretii*, *Asplenium trichomanes*, *Blechnum australe*, *Cheilanthes hirta*, *Cystopteris fragilis*, *Mohria caffrorum*, *Woodsia montevidensis* var. *burgessiana* etc.) have been reported from the rock overhangs.

(c) Vegetation of ephemeral freshwater wetlands of (semi-)arid regions

Ephemeral wetlands in semidesert and desert regions usually form in close proximity of (temporary) springs or on banks of temporary streams. Some of the plants are ephemeral annual herbs, while others may survive the dry period by means of bulbs and corms in the soil until their habitat is soaked the next time. For instance, extensive granite-derived coarse-sand seeps emerge in high-rainfall years in central Namaqualand, showing a rich display of bulbous flora well adapted to this habitat. To an extent these habitats simulate synecological conditions of AZf 2 Cape Vernal Pools. Short-lived wetland species such as *Cotula coronopifolia* and *C. nigellifolia*, and bulbous plants such as *Androcymbium dregeanum*, *Bulbine latifolia* var. *latifolia* (Figure 13.13), *Oxalis namaquana* and *Romulea pearsonii* are floral gems typical of these ephemeral wetlands.

(d) Vegetation of temporary rock pools

Temporary rock pools (Figure 13.14 and 13.15) are a quite common small-scale habitat, supporting fascinating assemblages of plants and animals. They come alive during the rainy season and are especially encountered in depressions on the surface of rock sheets and outcrops of granite and gneiss (Cape granite plutons, Namaqualand, Richtersveld, Augrabies Falls; e.g. Werger & Coetzee 1977, p. 21) as well as sandstone and quartzite (Cape Fold Mountains, the Karoo Escarpment and Drakensberg; e.g. Hilliard & Burtt 1987, pp. 39, 40). Typical species sharing the short-lived water pools with fairy shrimps are *Aponogeton desertorum, A. stuhlmannii, Crassula aphylla*, *C. elatinoides* (endemic to the top of Table Mountain), *C. inanis*, *C. natans*, *C. vaillantii*, very rare *Isoetes stellenbossiensis*, *I. stephanseniae* (both in the Cape), *I. toximontana* (endemic to Gifberg), *I. transvaalensis* and *I. welwitschii* (both occurring in the eastern part of the country), *Limosella africana*, *L. grandiflora*, *L. inflata, Lindernia conferta*, *L. pulchella* and *L. wilmsii* etc. The temporary rock pools found in winter-rainfall regions are of particular interest due to high levels of endemism.

The major reason why these specific vegetation complexes (indeed deserving status as mapping entities) are not featured on our map is their extremely small size and patchy occurrence. We believe that they will receive proper attention in local classifications and microscale mapping studies as in the past (Boucher 1972, 1978).

5. Conservation Challenges: Status, Threats and Action

Conservation and restoration of wetlands (including riverine vegetation and rivers) in southern Africa have been the subject of a number of reports, proceedings, chapters and books (e.g. Noble & Hemens 1978, Denny 1985, O'Keeffe 1986, Begg 1990, Dallas & Day 1993, Davies et al. 1993, Cowan 1995c, Thieme et al. 2005; see also reports of the Water Research Commission, website: http://www.wrc.org.za). In this work we want to highlight only briefly sev eral issues directly pertinent to conservation and the wise use of wetland vegetation.

5.1 Value of Wetlands

Water is one of the essential preconditions of life. It is a renewable resource, but the 'renewability' has its limits and has to be addressed in countries experiencing water shortages. South Africa is a dry land (at least most of the area for most of the year) and therefore the water availability, its spatial and temporal distribution and, last but not least, its quality, are of national strategic importance. Vegetation occupying wet (albeit often only temporarily) areas carries important information about parameters such as water quantity, position and status of the groundwater table and aquifers, chemical composition of water and sources of pollution.

Wetlands are home to many rare plant species, including ecological specialists and relicts of past migration patterns. To an extent wetlands are both evolutionary museums and laboratories. In the light of their high biological value as a habitat for resident and migratory waterfowl, the international conservation community has recognised the role of some wetlands as crucial. The Convention for Conservation of Wetlands (also known as the Ramsar Convention; see Cowan 1995a, b, 1999) declared in 1971, has so far recognised 16 wetland areas (most of them freshwater ones) in South Africa as members of the Ramsar wetland network. Tourism is a major industry in South Africa and depends largely on wildlife conservation as its major attraction. Therefore protection of spectacular water-dwelling wildlife such as crocodile, hippo, otter and water birds is not only a matter of conservation in its own right or the evolutionary responsibility of mankind, but has become an important economic factor.

5.2 Threats to Wetlands

The principle threats to wetlands include the conversion of a wetland from one form to another (changing the status of the wetland) and reduction in size, often resulting in the total demise of the wetland habitat.

Conversion usually involves the erection of structures within the wetland, typically dams. Impounding causes changes in the functioning of the wetland by reducing the flow of water downstream while increasing the inundation period and/or depth of inundation. These interventions initiate changes in the structure of biota populating the wetland. Excessive water pollution results in shifts from oligotrophic (usually very diverse habitats

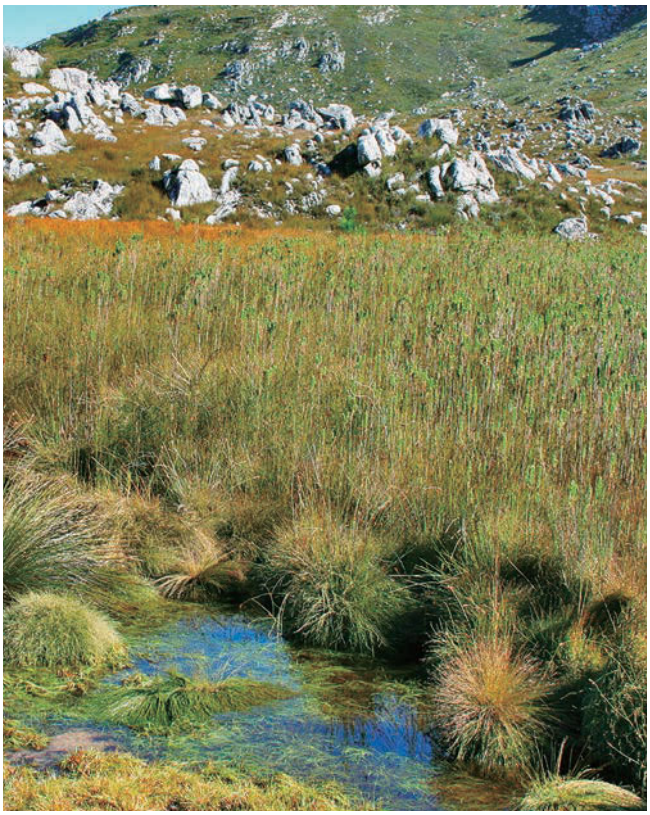

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Figure 13.11 Restio marshland (mire) below Landdroskop in the Hottentots Holland Mountains. The dominant plants are *Ursinia caledonica*, various species of *Elegia* and *Anthochortus crinalis*.

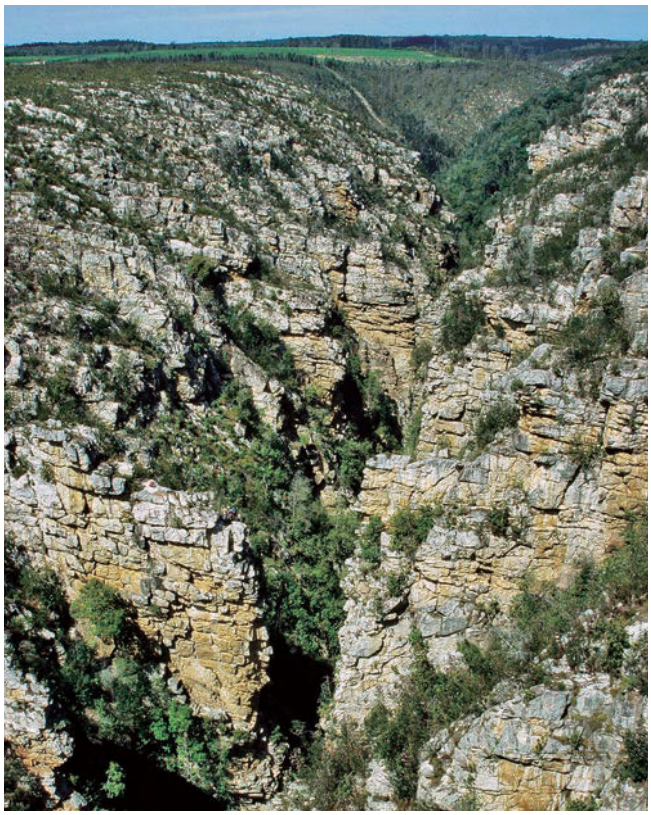

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Figure 13.12 Complex of steep cliffs, rock ledges, deep cracks and fissures housing fragments of fynbos vegetation and specific chasmophytic (cremnophilous) vegetation in the Storms River gorge (west of Humansdorp, Eastern Cape).

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Figure 13.13 *Bulbinella latifolia* subsp. *latifolia* (Asphodelaceae) in a temporary vlei overgrown by alien *Populus*, south of Grootvlei near Nieuwoudtville (Northern Cape).

L. Mucina

Figure 13.14 Temporary mini-wetland–a rock pool in Nardouw sandstone on the Bokkeveld Plateau (near Nieuwoudtville, Northern Cape) with *Crassula aquatica*.

of high conservation value) to eutrophic wetlands, often dominated by single ubiquitous species choked by algal blooms.

Drainage of a wetland involves both diversion of water away from the wetland, as well as the extraction of water from the wetland itself via drains. This results in changes in the species composition from wetland species to a habitat dominated by purely terrestrial species, as well as changes in the soils from typically anaerobic to aerobic. In urban areas, housing developments are a specific problem. Occasionally this is due to ignorance, but often a developer will deliberately set out to destroy a wetland should it be present on a development site. Urban wetlands, especially, are subject to increased water runoff from hard surfaces. Although the total volume may be similar, the water flows faster into and through the wetland, resulting in increased erosion. A common source of headcuts, where erosion gullies form in the wetland, is the construction of culverts permitting roads to cross wetlands. The bottom of these culverts are often much lower than the surface of the wetland, resulting in erosion.

The main pollution threats to wetlands are petrochemical spills, unprocessed or semiprocessed sewage, fertiliser and pesticide runoff, and dumping, both of garbage and rubble. Petrochemical spills are toxic to most organisms, including the vegetation, of a wetland. These are often due to indiscriminate disposal of lubrication oils into storm-water drains, as well as from runoff from roads. The dumping of sewage is usually due to blockages and bursts in sewage pipes discharging organic wastes into wetlands. This results in the increase in the *Escherichia coli* count as well as an increase in organic matter, phosphates and nitrates in the system. Sewage processing plants usually discharge treated water into wetland systems. Although the dissolved organic solids may have been removed from this water, it is usually high in phosphates and nitrates. Surplus of fertilisers and especially pesticides used in the agricultural industry usually end up in wetlands via surface runoff or infiltration into the water table. Phosphates and nitrates form the bulk of agricultural fertilisers. Wetlands are often perceived as wasted space, and as such are used as unofficial dumpsites for household and garden refuse as well as rubble from construction sites.

Many of the species declared as alien invasive weeds are wetland species. These species have varying effects on wetlands, from the displacement of indigenous species to unduly high extraction of water from wetlands and rivers. For instance, Le Maitre et al. (2000) estimated that the total incremental water use of invading alien plants attained 3 300 million m^3 of water per year—an equivalent to about 75% of the virgin MAR of the Vaal River system. Alien infestation is often exacerbated by nitrate and phosphate pollution. Some species such as *Eichhornia crassipes* increase the evaporation from water bodies and alter the nutrient and oxygen levels of the water. Much attention has been devoted to controlling this species (for extensive literature on *Eichhornia crassipes* see Gopal 1987 for a global review, and Thompson et al. 1985 and O'Keeffe 1986 for references relevant to Africa). Still more research and management effort (despite the very successful Working for Water Programme launched in 1996) is needed to understand and to bring these invaders under control.

Some fast developing regions of South Africa sometimes experience water shortages during dry periods, leading to the implementation of water-saving measures. Because of the lack of surface water, new sources are being investigated, natural underground reservoirs in particular. Water extraction from aquifers such as those in sandstones of the Cape Fold Mountains is being considered. However, care must be exercised as uncontrolled and scientifically ill-funded extractions can easily lead to the demise of fynbos seeps, which support hundreds of local endemics.

5.3 Sustainable Use and Restoration of Wetlands

Wetlands have long been sources of vital resources for human populations, water being the most important commodity. Apart from supplying water, wetlands have other major roles in a healthy functioning landscape, for instance in matter and nutrient cycling, source of food for grazing animals, protein for humans (wild fowl, fish) or material for building shelters. A wise farmer knows that his springs and vleis can be used in a sustainable way only when the carrying capacity is not superseded. Reed beds can recover easily if harvesting is done wisely according to sustainable scenarios (e.g. McKean 2001, Van Rooyen et al. 2004).

Legal conservation of extant well-preserved wetlands is in place in many parts of South Africa, but more extensive measures are called for. First and foremost, development of extant wetlands must be halted. Uses of wetlands that might lead to conversion from one form such as a vlei, to another, such as an impoundment, should be abandoned. It is not too late for many altered wetlands and rehabilitation is possible.

6. Research Challenges

Obvious economic interests made water and water biota the focus of a number of research groups and organisations such as the Water Research Commission (established in terms of the Water Research Act—Act 34 of 1971), South African Institute for Aquatic Biodiversity at the Rhodes University in Grahamstown (a national research facility of National Research Foundation), the Freshwater Research Unit at the Department of Zoology, University of Cape Town, the Centre for Environmental Management of the University of KwaZulu-Natal in Durban, the Centre for Water in the Environment at the University of the Witwatersrand and hydrogeology and hydrochemistry research at the Department of Earth Sciences of the University of the Western Cape. However, our understanding of variability and biodiversity of wetlands (and saline habitats), and the functioning of wetlands in regional and continental nutrient-energy cycling context is calling for more research.

The long list of references at the end of this chapter (see also Thompson et al. 1985 and Rogers 1997) may suggest that vegetation of inland wetlands as well as vegetation of salt-laden habitats has received much attention in South Africa, Lesotho and Swaziland. However, most of the published academic research on wetlands in South Africa (and neighbouring countries) is fragmented by focusing on small areas or by giving the wetlands only marginal attention in studies devoted to zonal vegetation such as grassland and savanna. An integrated and comprehensive picture of the distribution and variability of the wetlands is still outstanding. Effective conservation (see above) of the wetlands and saline habitats is very much dependent on knowing the scale of variability (biodiversity) of these special and vulnerable habitats. We do have some management tools, such as regional classification systems, and now also floristic-biogeographical systems at hand (presented in this chapter), but a comprehensive habitat classification system for wetlands remains lacking (see also lament by Rogers 1997). Our classification is a large-scale one and intuitive, although based on meta-analysis of available information, including extensive and well-defined data sets. More rigorous data treatment is neces-

sary. Vegetation ecological research and conservation practice in the northern hemisphere has identified the floristically based approach as very effective in identifying patterns (classification of wetland plant communities, identification of indicators of environmental change). A classification system of habitats (including wetlands) adopted in the European Union Habitat Directive (see Rodwell et al. 2002 for analysis of relations of this document to existing habitat databases) has become a powerful tool for nature land managers and conservationists.

The relative simplicity of wetland habitat in terms of only a few dominating environmental gradients, relatively easily predictable pattern formation and low species diversity, but high plant-functional group diversity make wetlands an ideal model for testing theories of community assembly at a small scale.

7. Descriptions of Vegetation Units

Freshwater Wetlands

AZf 1 Cape Lowland Freshwater Wetlands

Including *Phragmites*, *Scirpus* or *Typha* Reed Beds (Boucher 1978). *Aponogeton–Sporobolus* Community & *Potamogeton–Aponogeton* Vlei Community (Campbell et al. 1980). Submerged Aquatic Communities, Emergent and Wetland Communities & *Tetragonia decumbens–Senecio halimifolius* Moist Dune Community (O'Callaghan 1990a).

Distribution Western Cape Province: Freshwater inland vleis, edges of water bodies, such as Verlorenvlei (West Coast), De Hoop Vlei, Cape Flats vleis, Papenkuils Wetland, some vleis of the Agulhas Plains and Wilderness Lake System (between George and Knysna). This azonal unit is embedded within various types of renosterveld (especially those on shale) and the alluvial fynbos of the Fynbos Biome. Altitude ranges from close to sea level to mainly 400 m.

Vegetation & Landscape Features Flats and landscape depressions with extensive tall reeds of *Phragmites australis* and *Typha capensis*, temporarily or permanently flooded restiolands, sedgelands and rush-beds as well as macrophytic vegetation embedded in permanent water bodies.

Geology, Soil & Hydrology Substrate built of fine sandy, silty and clayey soils over young Quaternary sediments, largely derived from weathering Cape Supergroup shales and Cape granites as well as Table Mountain sandstones. They fill depressions and accompany broad alluvia of lowland rivers. The major source of water is either permanent (banks of permanent lakes) or temporary (hence either of riverine origin or result of high winter precipitation). In places (especially due to salt leaching from Malmesbury Group shales), these wetlands can acquire a brackish character.

Climate Seasonal winter rainfall (West Coast) to nonseasonal (South Coast) climate regime, but still characterised by general prevalence of winter rainfall. MAP ranges between 175 and 845 mm. Characterised by typical warm-temperate regime with MAT spanning 16.0–17.6°C. Incidence of frost is infrequent. See also climate diagram for AZf 1 Cape Lowland Freshwater Wetlands (Figure 13.2).

Important Taxa ([B]Brackish habitats): **Marshes** Low Shrub: *Senecio halimifolius*. Graminoids: *Paspalum vaginatum* (d), *Diplachne fusca*, *Juncus rigidus*[B], *Pennisetum macrourum*, *P. thunbergii*, *Polypogon monspeliensis*[B], *Stenotaphrum secundatum*[B]. Herbs: *Berula erecta* subsp. *thunbergii* (d), *Falkia repens* (d), *Chironia decumbens, Conyza pinnatifida, Epilobium hirsutum*, *Persicaria decipiens, Samolus valerandi*. Geophytic Herbs: *Triglochin bulbosa*[B] complex, *T. striata*[B]. Succulent Herb: *Sarcocornia natalensis* agg.[B] (d). **Reed & sedge beds** Megagraminoids: *Bolboschoenus maritimus*[B] (d), *Phragmites australis* (d), *Typha capensis* (d), *Cladium mariscus* subsp. *jamaicense*, *Cyperus thunbergii*. Graminoids: *Ficinia nodosa* (d), *Juncus kraussii* subsp. *kraussii*[B] (d), *Carex clavata, Cyperus denudatus*, *C. sphaerospermus*, *C. textilis*, *Pycreus nitidus*. Low Shrub: *Plecostachys serpyllifolia* (d). Geophytic Herb: *Zantedeschia aethiopica* (d). **Water bodies** Aquatic Herbs: *Myriophyllum spicatum* (d), *Nymphaea nouchali* var. *caerulea* (d), *Aponogeton junceus*, *Ceratophyllum demersum*, *Nymphoides indica* subsp. *occidentalis*, *N. thunbergiana*, *Potamogeton pectinatus*, *Ruppia cirrhosa*[B], *R. maritima*[B], *Zannichellia palustris*. Macroalgae: *Chara globularis*, *Lamprothamnium papulosum*[B], *Nitella dregeana*.

Endemic Taxa **Marshes** Low Shrubs: *Passerina paludosa*. **Water bodies** Aquatic Herbs: *Aponogeton angustifolius* (d), *A. distachyos* (d), *Cotula myriophylloides*.

Conservation Target 24%. Some 14% statutorily conserved in the Cape Peninsula and Agulhas National Parks as well as in the proposed Garden Route National Park, Rondevlei and Zandvlei Bird Sanctuaries as well as in Botrivier, De Hoop, Doringrivier, Salmonsdam, Verlorenvlei and Walker Bay Nature Reserves. De Hoop Vlei, Verlorenvlei and Wilderness Lakes (formerly within

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Figure 13.15 AZf 1 Cape Lowland Freshwater Wetlands: *Wachendorfia thyrsiflora* (Haemodoraceae) in a *Typha capensis* reed bed on the edge of a small dam in the Helderberg Nature Reserve (Somerset West, Western Cape).

the Wilderness National Park) enjoy Ramsar site status. More than 2% is also protected in private nature reserves such as Rietvlei, Oude Bosch, Groothagelkraal, Kleyn Kloof, Sandies Glen and Vergaderingskop. More than 15% has been transformed to cultivated land, plantations and urban areas. The vegetation of these wetlands is prone to invasion by alien shrubs (*Acacia saligna*, *A. longifolia*, *A. mearnsii*), herbs (*Apium inundatum*) and grasses such as *Pennisetum clandestinum* (kikuyu grass) and *Paspalum dilatatum*.

Remarks Unlike marshes and seeps dominated by endemic elements of the Capensis (preliminarily included within particular vegetation units of the Fynbos Biome), this vegetation has a (sub)cosmopolitan character indicated by the occurrence of a number of species with worldwide distribution in analogous habitats.

References Marloth (1908), Adamson (1929), Stephens (1929), Phillips (1931), Liversidge (1955), Martin (1960a, b), Middlemiss (1960), Taylor (1969), Andrag (1970), Van der Merwe (1976), Boucher & Jarman (1977), Van der Merwe (1977b), Linder (1978), Noble & Hemens (1978), Lamprecht (1979), Weisser (1979), Campbell et al. (1980), Howard-Williams (1980b), Howard-Williams & Liptrot (1980), Jacot Guillarmod (1982), Weisser & Howard-Williams (1982), Allanson & Whitfield (1983), Hall (1985), Boucher (1987, 1996b, 1999a, b, c), O'Callaghan (1990b), Weisser et al. (1992), Boucher & Rode (1995), Privett (1998), http://www.ngo.grida.no/soesa/nsoer/resource/wetland/sa_ramsar.htm.

AZf 2 Cape Vernal Pools

Distribution Western and Northern Cape Provinces: Cape Peninsula, Cape Flats and West Coast (especially between Hopefield and Piketberg) as far north as the surrounds of Vanrhynsdorp and Nieuwoudtville. This azonal unit is embedded within some shale renosterveld and sand fynbos units of the Fynbos Biome. Altitude ranging from 50–850 m.

Vegetation & Landscape Features The vegetation is distinctly zoned, with fringing species that occupy waterlogged soils surrounding the pools plus specialised aquatics that are rooted in the mud but often have floating stems or leaves. The zone of fringing species which grow in water up to 2 cm deep, comprises a band up to 2 m wide of various small annuals, typically species of *Crassula* (e.g. *C. vaillantii*, *C. natans*) and of *Cotula* (e.g. *C. coronopifolia*) along with several small geophytes, such as species of *Trachyandra*. The small aquatic *Limosella* with floating leaves is also found in this zone. Later in the season as the margins dry out, larger bulbs such as *Ornithogalum thyrsoides* predominate. The specialised aquatics grow in waters deeper than 2 cm although seldom more than 10 cm and typically include a combination of one or two species with floating stems, such as *Oxalis natans*, *O. disticha* or *Cadiscus aquaticus* plus one or two geophytes, especially *Romulea aquatica*, *R. multisulcata*, *Onixotis stricta* and *Lachenalia bachmannii*.

Geology, Soil & Hydrology Vernal pools form either on fine clays or silts overlying some impermeable layer and are thus largely restricted to Malmesbury Group shales (Namibian Erathem) and sometimes on the coastal sands derived from sandstones of the Table Mountain Group. They vary in dimension, but are mostly between 20 and 100 m in diameter. The pools are highly seasonal, filling up from May and beginning to dry out in October. The water level rarely exceeds 10 cm at the deepest point and they become completely dry in summer.

Climate Found exclusively in regions characterised by winter-rainfall (MAP range 163–430 mm). Climate is warm-temperate with MAT ranging between 16.4°C and 17.2°C. See also climate diagram for AZf 2 Cape Vernal Pools (Figure 13.2).

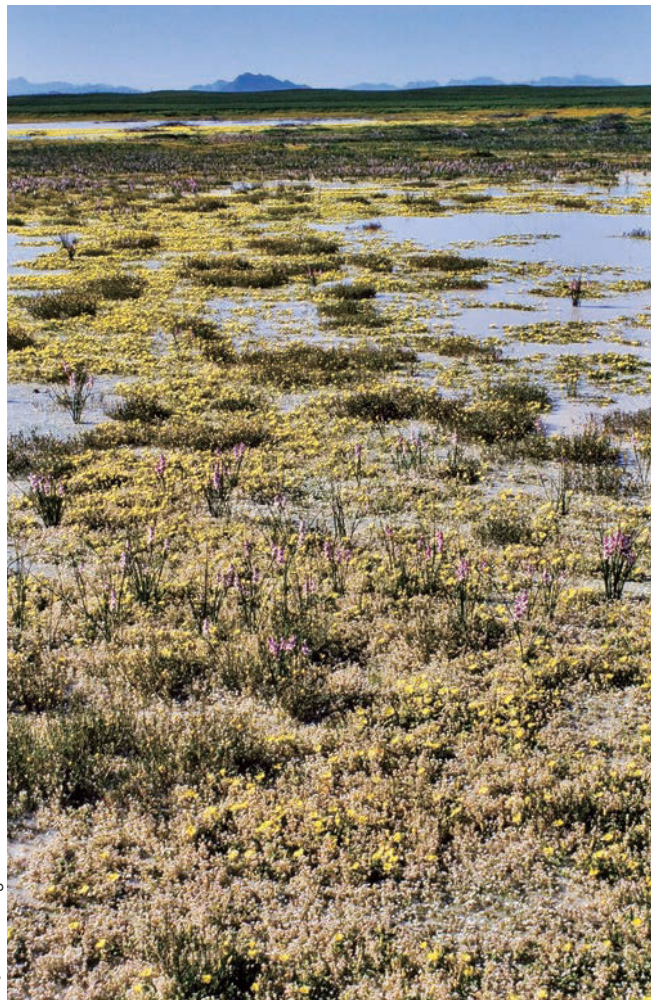
Important Taxa Herbs: *Cotula coronopifolia* (d), *Arctotheca forbesiana*, *Felicia tenella*, *Hesperantha falcata*, *Wimmerella secunda*. Geophytic Herbs: *Onixotis stricta* (d), *Ornithogalum thyrsoides* (d), *Geissorhiza aspera*, *G. juncea*, *Lachenalia aloides* var. *aloides*, *L. orchioides*, *Micranthus alopecuroides, M. plantagineus*, *Romulea rosea, R. tabularis*, *Sparaxis bulbifera*, *Spiloxene aquatica*, *Triglochin bulbosa*, *Zantedeschia aethiopica*. Succulent Herbs: *Crassula aphylla, C. decumbens*, *C. expansa, C. natans*, *C. vaillantii*. Aquatic Herb: *Limosella grandiflora*. Graminoids: *Diplachne fusca* (d), *Stenotaphrum secundatum* (d), *Cyperus tenellus*, *Isolepis diabolica*, *Schoenus nigricans, Scirpus cernuus*.

Biogeographically Important Taxon Herb: *Pilularia americana* (continental disjunction).

Endemic Taxa Graminoids: *Isoetes capensis*, *I. stellenbossiensis*, *I. stephansenii*. Herbs: *Cadiscus aquaticus* (d), *Arctotheca marginata, Cotula vulgaris*, *Marsilea schelpeana*. Geophytic Herbs: *Lachenalia bachmannii*, *Oxalis disticha*, *O. natans*, *Romulea aquatica*, *R. multisulcata*.

Conservation Critically endangered through especially cultivation and none so far conserved in statutory conservation areas. Target 24%.

Remark 1 The seasonal (vernal) pools (called 'Smaller Cyperaceae Zone' by Muir 1929, p. 70) used to be a common sight on the Cape Flats and Stellenbosch Flats in the past. Only remnants are encountered today (e.g. Campbell et al. 1980: Edith Stephens



J.C. Manning

Figure 13.16 AZf 2 Cape Vernal Pools: A flooded vernal pool near Hopefield (West Coast) with rare and endemic *Cadiscus aquaticus*, *Romulea* species and *Onixotis stricta*.

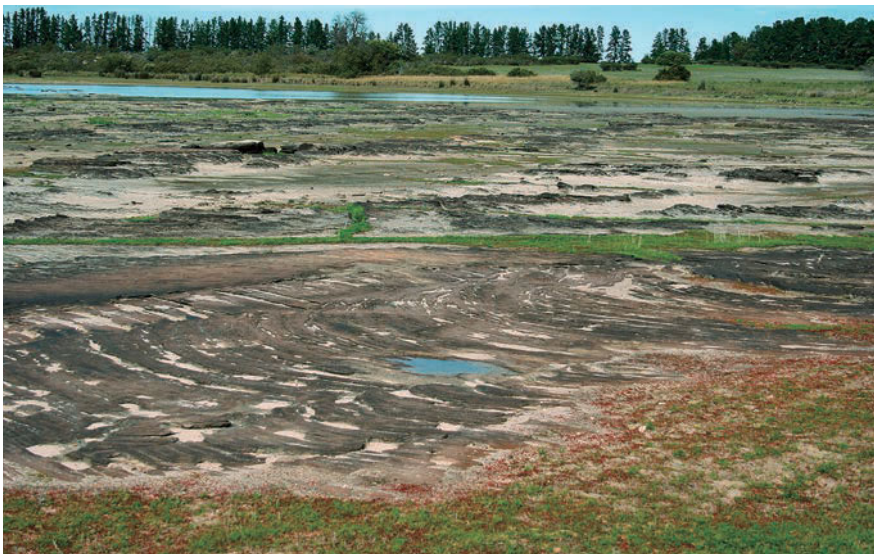


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Figure 13.17 AZf 2 Cape Vernal Pools: Temporary pools on hard Nardouw sandstones on the top of the Bokkeveld Plateau (Farm Meulsteen near Nieuwoudtville, Northern Cape). The vegetation is dominated by annual *Crassula aphylla* and *Cotula coronopifolia*.

Flora Reserve) and apparently many endemic taxa (tiny ephemerals or bulbous ephemeroids) supported by this special habitat are either under critical threat or have not been encountered again for a long time. A very specialised seasonal-pool habitat is formed on granite boulders and sheets (around Stellenbosch, Paarl, Darling, Langebaan and Saldanha).

Remark 2 Most of the small seasonal pools are not featured on our map due to lack of proper coverage and difficulties with featuring this vegetation unit at large (country-wide) mapping scales.

References Duthie (1929), Muir (1929), Taylor (1972), Noble & Hemens (1978), Campbell et al. (1980), Boucher (1987), Cook (2004).

AZf 3 Eastern Temperate Freshwater Wetlands

Distribution Northern Cape, Eastern Cape, Free State, North-West, Gauteng, Mpumalanga and KwaZulu-Natal Provinces as well as in neighbouring Lesotho and Swaziland: Around water bodies with stagnant water (lakes, pans, periodically flooded vleis, edges of calmly flowing rivers) and embedded within the Grassland Biome. Altitude ranging from 750–2 000 m.

Vegetation & Landscape Features Flat landscape or shallow depressions filled with (temporary) water bodies supporting zoned systems of aquatic and hygrophilous vegetation of temporarily flooded grasslands and ephemeral herblands.

Geology, Soil & Hydrology Found on younger Pleistocene to recent sediments overlying fine-grained sedimentary rocks of the Karoo Supergroup (on sediments of both Ecca and Beaufort Groups due to the large extent of the area of occurrence) as well as of the much older dolomites of the Malmani Subgroup of the Transvaal Supergroup in the northwest. Especially the areas built by Karoo Supergroup sediments are associated with the occurrence of Jurassic Karoo dolerite dykes having a profound influence on run-off. Soils are peaty (Champagne soil form) to vertic (Rensberg soil form). The vleis form where flow of water is impeded by impermeable soils and/or by erosion resistant features, such as dolerite intrusions. Many vleis and pans of this type of freshwater wetlands are inundated and/or saturated only during the summer rainfall season, and for some months after this into the middle of the dry winter season, but they may remain saturated all year round. Surface water inundation may be present at any point while the wetland is saturated and some plant species will be present only under inundated conditions, or under permanently saturated conditions. The presence of standing water should not be taken as a sign of permanent wet conditions.

Climate Exclusively summer-rainfall region (MAP range 421–915 mm). Cool-temperate pattern with MAT ranging between 12.6°C and 16.7°C. Due to high elevation, frost is a frequent phenomenon. See also the summary climate diagram for AZf 3 Eastern Temperate Freshwater Wetlands (Figure 13.2).

Important Taxa **Marshes** Megagraminoid: *Cyperus congestus* (d). Graminoids: *Agrostis lachnantha* (d), *Carex acutiformis* (d), *Eleocharis palustris* (d), *Eragrostis plana* (d), *E. planiculmis* (d), *Fuirena pubescens* (d), *Helictotrichon turgidulum* (d), *Hemarthria altissima* (d), *Imperata cylindrica* (d), *Leersia hexandra* (d), *Paspalum dilatatum* (d), *P. urvillei* (d), *Pennisetum thunbergii* (d), *Schoenoplectus decipiens* (d), *Scleria dieterlenii* (d), *Setaria sphacelata* (d), *Andropogon appendiculatus*, *A. eucomus*, *Aristida aequiglumis*, *Ascolepis capensis, Carex austro-africana*, *C. schlechteri*, *Cyperus cyperoides*, *C. distans*, *C. longus*, *C. marginatus*, *Echinochloa holubii*, *Eragrostis micrantha*, *Ficinia acuminata*, *Fimbristylis complanata*, *F. ferruginea*, *Hyparrhenia dregeana*, *H. quarrei, Ischaemum fasciculatum*, *Kyllinga erecta*, *Panicum schinzii*, *Pennisetum sphacelatum*, *Pycreus macranthus*, *P. nitidus*, *Setaria pallide-fusca*, *Xyris gerrardii*. Herbs: *Centella asiatica* (d), *Ranunculus multifidus* (d), *Berkheya radula*, *B. speciosa*, *Berula erecta* subsp. *thunbergii*, *Centella coriacea*, *Chironia palustris*, *Equisetum ramosissimum*, *Falckia oblonga*,

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Figure 13.18 AZf 3 Eastern Temperate Freshwater Wetlands: Small wetland sedge bed surrounded by sub-escarpment grassland in Transkei (Eastern Cape).

Haplocarpha lyrata, Helichrysum difficile, *H. dregeanum*, *H. mundtii*, *Hydrocotyle sibthorpioides, H. verticillata*, *Lindernia conferta*, *Lobelia angolensis, L. flaccida*, *Mentha aquatica*, *Monopsis decipiens*, *Pulicaria scabra*, *Pycnostachys reticulata*, *Rorippa fluviatilis* var. *fluviatilis*, *Rumex lanceolatus*, *Senecio inornatus*, *S. microglossus*, *Sium repandum*, *Thelypteris confluens*, *Wahlenbergia banksiana*. Geophytic Herbs: *Cordylogyne globosa*, *Crinum bulbispermum*, *Gladiolus papilio*, *Kniphofia ensifolia*, *K. fluviatilis*, *K. linearifolia*, *Neobolusia tysonii, Nerine gibsonii* (only in Eastern Cape), *Satyrium hallackii* subsp. *hallackii*. **Reed & sedge beds** Megagraminoids: *Phragmites australis* (d), *Schoenoplectus corymbosus* (d), *Typha capensis* (d), *Cyperus immensus*. Graminoid: *Carex cernua*. **Water bodies** Aquatic Herbs: *Aponogeton junceus*, *Ceratophyllum demersum*, *Lagarosiphon major*, *L. muscoides*, *Marsilea capensis*, *Myriophyllum spicatum, Nymphaea lotus*, *N. nouchali* var. *caerulea*, *Nymphoides thunbergiana*, *Potamogeton thunbergii*. Carnivorous Herb: *Utricularia inflexa*. Herb: *Marsilea farinosa* subsp. *farinosa*.

Biogeographically Important Taxon (Highveld endemic) Herb: *Rorippa fluviatilis* var. *caledonica*.

Endemic Taxa **Marshes** Geophytic Herbs: *Disa zuluensis, Kniphofia flammula* (northern KwaZulu-Natal), *Nerine platypetala*. Succulent Herb: *Crassula tuberella*.

Conservation Target 24%. About 5% statutorily conserved in the Blesbokspruit (a Ramsar site), Hogsback, Marievale, Olifantsvlei, Seekoeivlei (a Ramsar site), Wakkerstroom Wetland, Umgeni Vlei, Umvoti Vlei and Pamula Park Nature Reserves. It is also protected in private nature reserves such as the Korsman Bird Sanctuary and Langfontein. Some 15% has been transformed to cultivated land, urban areas or plantations. In places intensive grazing and use of lakes and freshwater pans as drinking pools for cattle or sheep cause major damage to the wetland vegetation. The following aliens are encountered in this type of wetland: *Bidens bidentata*, *Cirsium vulgare*, *Conyza bonariensis*, *Oenothera rosea*, *Physalis viscosa*, *Plantago lanceolata*, *Rumex crispus*, *Sesbania punicea*, *Schkuhria pinnata*, *Stenotaphrum secundatum* (native on South African coast, alien on highveld), *Trifolium pratense*, *Verbena bonariensis*, *V. brasiliensis*, *Xanthium strumarium*, etc.

Remarks Vegetation patterning in the form of concentric belts ('rings') is often found in pans. Pan size and depth may be a factor limiting vegetation, as large water bodies with shallow water may experience wave action. This limits the presence of species with floating leaves as well as some submerged and marginal macrophytes. The situation is more complex in vleis as these often have variable microtopography and soil types within a single wetland. It is possible for seasonally inundated zones to occur embedded inside the permanently inundated zone of a vlei, if this zone is present.

References Downing (1966, 1968, 1970), Noble & Hemens (1978), Müller (1986), Allan (1987), Begg & Carser (1988, 1989), Behr & Bredenkamp (1988), Breytenbach (1991), Fuls et al. (1992), Breen et al. (1993), Breytenbach et al. (1993), Eckhardt (1993), Eckhardt et al. (1993a, c), Smit et al. (1993a, 1995, 1997), Bredenkamp et al. (1994), Coetzee et al. (1994a, b), Malan (1997), Cilliers et al. (1998), Kotze & O'Connor (2000), Perkins et al. (2000), Van Wyk et al. (2000), Dingaan et al. (2001), Siebert et al. (2002), Malan (2003).

AZf 4 Drakensberg Wetlands

Including 'Wetlands below escarpment' (Hilliard & Burtt 1987).

Distribution Free State, KwaZulu-Natal, Eastern Cape and Mpumalanga Provinces as well as in Lesotho: Wetlands (vleis and lakes) on broad ridges and narrow alluvia of slow- and fast-flowing mountain streams in deeply incised valleys. Found from the Stormberg Plateau through the highlands of the Eastern Cape, KwaZulu-Natal and Lesotho (Drakensberg range). Outliers occur also on top of tafelbergs such as Korannaberg, Thaba Nchu and Platberg. Scattered along the Low Escarpment (between Van Reenen's Pass and Piet Retief) and then along the Northern Escarpment. The northernmost patch of this wetland type has thus far been identified on the summit plateau of the Leolo Mountains in Sekhukhuneland. Embedded within the high-altitude Grassland Biome found at altitudes roughly spanning 1 800–2 500 m.

Vegetation & Landscape Features Vleis (sometimes with open water bodies such as tarns) and fringes of mountain streams, supporting tall herb vegetation and shrubby vegetation of medium height (reaching thicket density in places) along upper reaches of mountain streams. Characteristic feature of the Drakensberg Wetlands is the frequent occurrence of terrestrial orchids and species of *Kniphofia* and *Geranium*.

Geology, Soil & Hydrology Geological substrate is formed by the uppermost (youngest) part of the Karoo Supergroup. Jurassic basalts and dolerites of the Drakensberg Group as well as sandstones and mudstones of the Clarens and Elliot Formations (both Triassic) forming the Eastern Escarpment. These bedrocks support heavy, clayey soils (e.g. Champagne, Arcadia, Katspruit soil forms) often with high humus content. The water bodies are either stagnant (or slow-flowing) and fed either from springs or slope seeps or to an extent also from abundant rainfall and snowfall (especially in the Eastern Cape). Here we have also included vegetation along fast-flowing mountain streams in sandy gravel and stony (in places built of large boulders) ravines with only very narrow alluvia—the habitats along the fast-flowing streams can suffer extensive erosion, especially during heavy-rainfall and stormy local weather situations in summer. Some water bodies freeze in winter.

Climate Seasonal, summer-rainfall regime with maximum precipitation in December–February (MAP range 543 mm on

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Figure 13.19 AZf 4 Drakensberg Wetlands: Riparian vegetation (with dominant *Leucosidea sericea*) along a stream in a Tšehlanyane gorge in northern Lesotho.

Stormberg Plateau, up to 1 247 mm on upper uKhahlamba). Especially on the Southern Berg, part of this precipitation occurs in the form of snow. Sudden melting of the snow cover on the surrounding high-altitude grasslands may have a profound (albeit short-term) influence on stream flow and may subsequently cause erosion of the river channels. The temperature regime is cold-temperate with MAT spanning 9.6°C (Lesotho Plateau) to 13.1°C (Senqu Valley). See also regional climate diagram for AZf 4 Drakensberg Wetlands (Figure 13.2).

Important Taxa **Drainage-line grasslands & herblands** Tree Fern: *Cyathea dregei* (d). Megagraminoid: *Miscanthus junceus* (d). Graminoids: *Cyperus congestus* (d), *Merxmuellera macowanii* (d), *Cyperus keniensis*, *C. marginatus, C. usitatus, Hyparrhenia quarrei, Pycreus mundii*. Herbs: *Peltocalathos baurii* (d), *Epilobium salignum*, *Geranium wakkerstroomianum*, *Nasturtium officinale*. Geophytic Herbs: *Gunnera perpensa* (d), *Galtonia candicans*, *G. princeps*, *Littonia modesta*, *Neobolusia tysonii, Sandersonia aurantiaca*. **Drainage-line shrublands** Tall Shrubs: *Buddleja salviifolia* (d), *Cliffortia linearifolia* (d), *Leucosidea sericea* (d), *Cliffortia nitidula*, *Phygelius aequalis*. Low Shrubs: *Cliffortia filicauloides*, *Erica oatesii*, *Senecio subrubriflorus*. Herbs: *Denekia capensis*, *Persicaria meisneriana*, *Salvia aurita*. **Marshes & seeps** Graminoids: *Carex acutiformis* (d), *C. austro-africana* (d), *Fuirena pubescens* (d), *Ascolepis capensis, Carex cognata*, *Carpha filifolia*, *Helictotrichon turgidulum, Juncus oxycarpus*, *Kyllinga pauciflora, Rhynchospora brownii*, *Schoenoxiphium burttii*, *Scirpus ficinioides*, *Xyris capensis*, *X. gerrardii*. Herbs: *Ranunculus meyeri* (d), *R. multifidus* (d), *Epilobium capense*, *Eriocaulon hydrophilum*, *Pycnostachys reticulata*, *Rumex lanceolatus*, *Senecio serratuloides*. Geophytic Herbs: *Dierama pauciflorum*, *Drimia sphaerocephala*, *Kniphofia albescens*, *K. fluviatilis*, *K. linearifolia*, *K. northiae*, *K. triangularis*, *Moraea ardesiaca*, *M. trifida*, *Nerine angustifolia, N. gibsonii* (only in Eastern Cape), *Satyrium hallackii* subsp. *hallackii*, *S. trinerve*, *Schizoglossum nitidum*, *Zantedeschia albomaculata*. **Streams** Graminoid: *Isolepis fluitans*. Aquatic Herb: *Hydrophilus rattrayi*. **Tarns** Aquatic Herbs: *Limosella africana*, *L. inflata*. Carnivorous Herb: *Utricularia prehensilis*. Succulent Herb: *Crassula natans*. Graminoids: *Juncus dregeanus*, *J. punctorius*. Herbs: *Lindernia bolusii*, *L. conferta*.

Biogeographically Important Taxa (all Drakensberg endemic): **Drainage-line grasslands & herblands** Herb: *Geranium pulchrum*. Geophytic Herb: *Anemone fanninii*. **Marshes** Herbs: *Cotula paludosa*, *Felicia uliginosa*, *Gnaphalium limicola*. Geophytic Herb: *Wurmbea elatior*.

Endemic Taxa **Drainage-line shrublands** Herbs: *Afrotysonia africana*, *A. glochidiata*, *Felicia drakensbergensis, Lepidium basuticum*, *Sebaea pleurostigmatosa*, *Senecio kalingenwae*. **Marshes & seeps** Graminoid: *Isolepis pellocolea*. Herb: *Helichrysum ephelos*. Geophytic Herbs: *Disa scullyi*, *Kniphofia albomontana*, *K. evansii*.

Conservation Target 24%, but already almost perhaps more than 50% conserved in statutory protection areas such as the uKhahlamba Drakensberg Park (a Ramsar site), and Sehlabathebe and Tšehlanyane National Parks and Bokong Nature Reserve (all Lesotho). Only about 2–3% has been transformed for cultivation. Invasive aliens do not play any important role.

Remarks This unit has not been mapped in its full extent due to a lack of data, particularly for riparian shrubland, which deserves recognition as a vegetation unit in its own right (as an analogue to the AZa 1 Fynbos Riparian Vegetation). Important patches of the riparian thickets occur along many Drakensberg (including many deeply incised river valleys in Lesotho), Amathole and possibly also Stormberg mountain streams. In the Low Drakensberg area similar vegetation was found to occur in places even below 1 800 m (Smit et al. 1995). Due to lack of data we did not map the patches of this wetland along the Eastern Escarpment and adjacent mountain ranges (see Burgoyne 1995, Burgoyne et al. 2000).

References Bews (1917), Jacot Guillarmod (1964, 1969, 1972), Nanni (1972), Smith (1972), Killick (1978a, b), Noble & Hemens (1978), Potgieter (1982), Deall (1985), Hilliard & Burtt (1987), Begg & Carser (1989), Deall et al. (1989), Killick & Holcroft (1990), Du Preez (1991), Du Preez & Bredenkamp (1991), Matthews (1991), Matthews et al. (1992), Smit et al. (1993b, 1995), Burgoyne (1995), Dely et al. (1995), Eckhardt et al. (1996), Eckhardt (1998), Burgoyne et al. (2000), Siebert et al. (2002), http://www.ngo.grida.no/soesa/nsoer/resource/wetland/sa_ramsar.htm.

AZf 5 Lesotho Mires

Distribution Lesotho and to a very small extent also South Africa (KwaZulu-Natal Province): Lesotho Plateau and adjacent mountain ranges—wetlands (locally, in Sesotho, called 'mokhoabo') embedded within grassland units Gd 10 Drakensberg Afroalpine Heathland and upper parts of Gd 8 Lesotho Highland Basalt Grassland. Altitude ranging from 2 500–3 400 m.

Vegetation & Landscape Features Depressions and slight slopes on the high-altitude plateau. Low grass-herb mire complexes with turf and tussock grassland patches and herblands built of low creeping herbs as well as luxurious moss cover in places. Small lakes (tarns) support aquatic vegetation covering tarn bottoms where shallow water column allows deep penetration of light.

M. Polaki

Figure 13.20 AZf 5 Lesotho Mires: Complex of low-altitude mires on Thaba Putsoa in western Lesotho.

Geology, Soil & Hydrology Peat (organic soils) functioning as sponge in summer and freezing in winter over basaltic lava flows of the Jurassic Drakensberg Group (top of the Karoo Supergroup). Eutrophic water rich in CaO, K_2O and P_2O_3 with pH about 8 (Stockley 1947 *sec.* Van Zinderen Bakker & Werger 1974), changing in an oligotrophic direction, with ultimate values between pH 4 and 5. Most of the pH (H_2O) measurements of soils by Backéus (1988) in the Thaba-Putsoa range were below 5.

Climate Seasonal, summer-rainfall regime with MAP 1 500 mm, much of it in the form of snow. Very cold, high-altitude climate (MAT 4.0–9.6°C); according to Van Zinderen Bakker & Werger (1974) the maximum temperatures in summer do not exceed 16°C, while the nightly minimum temperature at soil level is below freezing point throughout the year. See also climate diagram for AZf 5 Lesotho Mires (Figure 13.2).

Important Taxa **Mires** Semiparasitic Shrub: *Thesium nigrum*. Graminoids: *Agrostis bergiana* var. *bergiana* (d), *Carex cognata* (d), *Isolepis costata* (d), *Kyllinga erecta* (d), *Scirpus ficinioides* (d), *Agrostis lachnantha*, *Bulbostylis densa*, *Juncus dregeanus*, *Koeleria capensis*, *Luzula africana*, *Pennisetum thunbergii*. Herbs: *Athrixia fontana* (d), *Haplocarpha nervosa* (d), *Ranunculus meyeri* (d), *Alchemilla woodii*, *Anagallis huttonii*, *Cerastium capense*, *Cineraria lyrata*, *Cotula hispida*, *Eriocaulon sonderianum*, *Lobelia flaccida*, *Ranunculus multifidus*, *Rorippa microphylla*, *Sebaea leiostyla*, *Senecio macrocephalus*, *S. polyodon* var. *subglaber*, *Trifolium burchellianum*. Geophytic Herbs: *Ornithogalum paludosum*, *Oxalis obliquifolia*, *Rhodohypoxis milloides*, *Wurmbea kraussii*. Carnivorous Herb: *Utricularia livida*. **Tarns** Succulent Herbs: *Crassula inanis* (d), *C. natans* (d). Aquatic Herbs: *Lagarosiphon muscoides* (d), *Limosella longiflora* (d), *L. maior* (d), *Aponogeton junceus*, *Limosella africana*, *L. vesiculosa*.

Biogeographically Important Taxa (all Drakensberg endemic): **Mires** Low Shrubs: *Erica frigida*, *Inulanthera thodei*. Graminoids: *Agrostis subulifolia*, *Carex monotropa*, *Fuirena tenuis*, *Schoenoxiphium filiforme*. Herbs: *Senecio cryptolanatus* (d), *Alepidea pusilla*, *Cotula paludosa*, *Felicia uliginosa*, *Helichrysum bellum*. Geophytic Herbs: *Rhodohypoxis deflexa*, *R. rubella*, *Saniella verna*, *Wurmbea elatior*. Succulent Herb: *Crassula gemmifera*. **Tarns** Aquatic Herb: *Limosella inflata*.

Endemic Taxa **Mires** Semiparasitic Shrub: *Thesium nationae*. Graminoids: *Isolepis angelica* (d), *Colpodium hedbergii*. Herbs: *Helichrysum flanaganii*, *Sebaea marlothii*. Geophytic Herbs: *Kniphofia caulescens* (d), *Hesperantha crocopsis*, *Romulea luteoflora* var. *sanisensis*. **Tarns** Aquatic Herb: *Aponogeton ranunculiflorus* (d).

Conservation Target 24%. Only about 4% statutorily conserved in the Malekgonyane (Ongeluksnek) Wildlife Reserve and uKhahlamba Drakensberg Park (a Ramsar site) and in the Bokong Nature Reserve (Lesotho). Grazing (and even burning) can be seen as a serious threat to this unique and fragile vegetation type.

References Bews (1917), Van Zinderen Bakker (1955, 1965), Jacot Guillarmod (1961, 1962, 1963, 1964, 1968, 1971, 1972), Van Zinderen Bakker & Werger (1974), Killick (1978a, b), Backéus (1988), Schwabe (1989, 1995), Du Preez (1991), Du Preez & Bredenkamp (1991), Lesotho Government, National Environment Secretariat (2000), Day (2005a), http://www.ngo.grida.no/soesa/nsoer/resource/wetland/sa_ramsar.htm.

AZf 6 Subtropical Freshwater Wetlands

Distribution KwaZulu-Natal, Mpumalanga, Gauteng, North-West, Limpopo and Eastern Cape Provinces as well as in Swaziland: Wetlands embedded within the Albany Thicket Biome, the Coastal Belt from Transkei as far as Maputaland as well as those of Lowveld and the Central Bushveld regions. Altitude ranging from 0–1 400 m.

Vegetation & Landscape Features Flat topography supporting low beds dominated by reeds, sedges and rushes, waterlogged meadows dominated by grasses. Found typically along edges of often seasonal pools in aeolian depressions as well as fringing alluvial backwater pans or artificial dams.

Geology, Soil & Hydrology Waterlogged, clayey soils of Champagne and Arcadia forms, containing certain levels of decaying organic matter, especially in very productive reed beds. These wetlands are underlain mostly by Cenozoic alluvium, less so by Karoo Supergroup volcanic rocks and sediments, as well as by the Cretaceous (and younger coastal) sediments of the Zululand and Maputaland Groups. Waterlogged habitats with water regularly forming columns of variable depth. The highest water levels are found in summer, during periods of maximum seasonal rainfall.

Climate Mainly seasonal, summer rainfall (Lowveld and Central Bushveld), and to a lesser extent also nonseasonal (Albany region and the Eastern Cape and KwaZulu-Natal coastal belts) climate characterised by high precipitation. MAP spanning 454 mm (Makhado) to 963 mm (Maputaland). Subtropical and tropical temperature regimes are prevalent in winter and summer, respectively. MAT ranging from 18.0°C (Central Bushveld) to 22.0°C (Makatini Flats). Occurrence of frost is limited to southernmost localities. See also climate diagram for AZf 6 Subtropical Freshwater Wetlands (Figure 13.2).

W.S. Matthews

Figure 13.21 AZf 6 Subtropical Freshwater Wetlands: Muzi Swamp in an interdune depression at the edge of the Tembe Elephant Park on the Mozambique border (northern KwaZulu-Natal). The reed beds of *Phragmites mauritianus* dominant in the swamp are surrounded by broad-leaved savanna of the SVl 18 Tembe Sandy Bushveld.

Important Taxa **Marshes** Small Trees: *Hyphaene coriacea* (d), *Phoenix reclinata* (d). Graminoids: *Chloris virgata* (d), *Cynodon dactylon* (d), *Cyperus articulatus* (d), *Dactyloctenium aegyptium* (d), *Diplachne fusca* (d), *Echinochloa pyramidalis* (d), *Fimbristylis obtusifolia* (d), *Hemarthria altissima* (d), *Imperata cylindrica* (d), *Ischaemum arcuatum* (d), *Leersia hexandra* (d), *Pycreus mundii* (d), *Sporobolus nitens* (d), *S. smutsii* (d), *Urochloa stolonifera* (d), *Bolboschoenus glaucus, Courtoisia cyperoides*, *Cyperus alopecuroides*, *C. pectinatus*, *Digitaria natalensis*, *Echinochloa stagnina*, *Eragrostis chapelieri, E. lappula, Eriochloa meyeriana*, *Fimbristylis bisumbellata*, *Fuirena ecklonii*, *Oxycaryum cubense*, *Paspalidium obtusifolium*, *Paspalum commersonii*, *Pycreus pelophilus*, *P. polystachyos*, *Scleria poiformis*, *Sporobolus consimilis*. Herbs: *Pentodon pentandrus* (d), *Persicaria senegalensis* (d), *Burmannia madagascariensis, Centella coriacea*, *Commelina diffusa, Convolvulus mauritanicus*, *Desmodium dregeanum*, *Eclipta prostrata, Epaltes gariepina*, *Eriocaulon abyssinicum*, *Ethulia conyzoides*, *Glinus lotoides*, *Hydrocotyle ranunculoides, Ludwigia adscendens* subsp. *diffusa*, *L. leptocarpa*, *L. octovalvis*, *L. palustris*, *Neptunia oleracea*, *Persicaria attenuata* subsp. *africana, P. hystricula*, *Rorippa madagascariensis*, *Sium repandum*, *Vahlia capensis*. Geophytic Herbs: *Eulophia angolensis*, *Zeuxine africana*. Succulent Herb: *Salicornia pachystachya*. Semiparasitic Herb: *Buchnera longespicata*. Aquatic Herbs: *Bergia salaria*, *Lagarosiphon crispus*. **Lakes & ponds** Graminoid: *Eleocharis dulcis* (forming rafts). Aquatic Herbs: *Azolla pinnata* var. *africana* (d), *Ceratophyllum demersum* (d), *Lemna minor* (d), *Nymphaea nouchali* var. *caerulea* (d), *Pistia stratiotes* (d), *Wolffia arrhiza* (d), *Aponogeton desertorum, A. natalensis, A. rehmannii, Ceratophyllum muricatum*, *Marsilea macrocarpa*, *Najas marina* subsp. *delilei*, *N. pectinata*, *Nymphoides indica* subsp. *occidentalis*, *N. rautanenii*, *Ottelia exserta*, *Potamogeton crispus*, *P. pectinatus*, *P. schweinfurthii*, *Spirodela polyrhiza*, *S. punctata, Trapa natans* var. *bispinosa*. Carnivorous Herbs: *Utricularia gibba* subsp. *exoleta*, *U. inflexa*, *U. subulata*. Geophytic Herb: *Crinum paludosum*. **Reed & sedge beds** Megagraminoids: *Cladium mariscus* subsp. *jamaicense* (d), *Cyperus papyrus* (d), *Phragmites australis* (d), *P. mauritianus* (d), *Schoenoplectus corymbosus* (d), *S. scirpoideus* (d), *Typha capensis* (d). Graminoids: *Cyperus fastigiatus* (d), *C. difformis*, *C. digitatus, C. latifolius*, *C. sexangularis*, *Fuirena ciliaris*.

L. Mucina

Figure 13.22 AZf 6 Subtropical Freshwater Wetlands: Pan wetland in the Kruger National Park infested by *Pistia stratiotes* (Araceae), with a crocodile (*Crocodilus niloticus*) basking after a meal on the opposite side of the lake.

Biogeographically Important Taxa (all southernmost distribution limit) **Streambanks** Herb: *Floscopa glomerata, Ipomoea aquatica.* Geophytic Herb: *Bolbitis heudelotii*. **Lakes & ponds** Aquatic Herbs: *Brasenia schreberi*, *Ceratopteris cornuta, Wolffia globosa, Wolffiella welwitschii*. Herbs: *Hygrophila schulli, Limnophyton obtusifolius, Marsilea apposita, M. coromandelina, M. minuta*, *M. villifolia*. **Reed & sedge beds** Graminoids: *Cyperus dives, C. procerus, C. prolifer.*

Endemic Taxa **Marshes** Graminoid: *Cyperus sensilis* (embedded within Indian Ocean Coastal Belt of KwaZulu-Natal). **Lakes & ponds** Geophytic Herbs: *Crinum campanulatum* (Albany region). Aquatic Herbs: *Isoetes wormaldii* (Albany region), *Wolffiella denticulata* (Maputaland).

Conservation Least threatened. Target 24%. Some 40–50% is statutorily conserved in the Greater St Lucia Wetland Park (including Ramsar sites such as St Lucia System, Kosi Bay System and Lake Sibaya), Kruger National Park, Ndumo Game Reserve, Tembe Elephant Park as well as in Nhlabane, Nylsvley (a Ramsar site), Mkombo, Sileza and Richards Bay Nature Reserves. A further 10% enjoys protection in a number of private game farms and other reserves in the Limpopo, Mpumalanga and KwaZulu-Natal Provinces. So far only about 4% has been transformed (largely for cultivation), but the pressure of local grazing and urban sprawl will result in the demise of many subtropical freshwater habitats. Disturbance leads to invasion by alien plants such as *Lantana camara*, *Chromolaena discolor* and *Melia azedarach* (on the edges of wetlands) and aquatic weeds such as *Eichhornia crassipes*, *Pistia stratiotes* and *Salvinia molesta* (in water bodies).

References Dyer (1937), Edwards (1967), Musil (1972), Venter (1972), Musil et al. (1973), Theron (1973), Noble & Hemens (1978), Howard-Williams (1979, 1980a), Furness & Breen (1980), Heeg et al. (1980), Rogers (1980, 1984), Furness (1981), Gertenbach (1983), Tinley (1985), Goodman (1987a, b), Tarboton (1987), Begg & Carser (1988, 1989), Breen et al. (1993), Brown & Bredenkamp (1994), Barnes et al. (2002), Hattingh & Matthews (2003), http://www.ngo.grida.no/soesa/nsoer/resource/wetland/sa_ramsar.htm.

Alluvial Vegetation

Aza 1 Fynbos Riparian Vegetation

Including *Brabejum–Rhus* Riverine Scrub (Boucher 1978). *Elegia capensis–Miscanthus capensis* Scrub & *Calopsis paniculata–Cliffortia strobilifera* Scrub (Cleaver et al. 2005).

Distribution Western Cape and (partly) Eastern Cape Provinces: Vegetation of narrow belts of alluvial thickets and accompanying palmiet (*Prionium serratum*) vegetation along upper stretches of the rivers draining mountain fynbos. Altitude from near sea level to 1 300 m.

Vegetation & Landscape Features Narrow, flat or slightly sloping alluvial flats supporting a complex of reed beds dominated by tall palmiet (*Prionium serratum*) and restios (*Calopsis*, *Cannomois*, *Elegia*, *Ischyrolepis* and *Rhodocoma*), low shrublands with moisture-loving species of *Berzelia*, *Cliffortia*, *Helichrysum* etc. With tall riparian thickets of *Metrosideros angustifolia* and *Brachylaena neriifolia* in places.

L. Mucina

Figure 13.23 AZa 1 Fynbos Riparian Vegetation: Boulders along a narrow alluvium of a mountain stream in the Hottentots Holland Nature Reserve near Grabouw, with palmiet (*Prionium serratum*) in the river channel and *Brachylaena neriifolia* (Asteraceae) and *Ischyrolepis subverticillata* (Restionaceae) on the river terrace.

Geology, Soil & Hydrology Alluvial sandy or silty soils over Quaternary sediments, largely derived from weathering of Table Mountain sandstone, Cape Supergroup shale and Cape Granite. The streams are fed mainly during the winter-rainfall season and later through seeps carrying acidic water rich in organic compounds (tannins) and with a characteristic brownish colour (locally called 'tea-water'). Large streams carry water all year round, while some smaller streams can turn into a series of disconnected pools in the upper reaches in summer. Even in relatively small streams flooding can be quite violent, with strong flows especially in narrow gorges. Many trees and shrubs are adapted to uprooting or heavy damage by spates. The heavy erosion also results in a soil-poor substrate and plant cover is often very patchy, located in small depressions with some soil development or between boulders.

Climate Similar to the climate of the surrounding mountains (see climate diagrams for mesic types of fynbos such as those of the FFs and FFh groups; see the chapter on Fynbos in this book), although the presence of a river influences the microclimate of the valley considerably, making it cooler, moister and better sheltered from wind. The most detailed study on the climate in a river valley (Jonkershoek) was published by Wicht et al. (1969). (See also climate diagram in Figure 13.2.)

Important Taxa ([C]Endemic to Capensis, [P]Sharing with Pondoland) Small Trees: *Brabejum stellatifolium*[C] (d), *Brachylaena neriifolia*[C] (d), *Cunonia capensis*[C] (d), *Kiggelaria africana*, *Pseudoscolopia polyantha*[P], *Widdringtonia nodiflora*. Tall Shrubs: *Berzelia lanuginosa*[C] (d), *Cliffortia strobilifera* (d), *Metrosideros angustifolia*[C] (d), *Psoralea pinnata*[C] (d), *Berzelia squarrosa*[C], *Cassine schinoides*[C], *Cliffortia atrata*[C], *Diospyros glabra*[C], *Erica caffra*, *Freylinia lanceolata, Halleria elliptica*[C], *Maytenus oleoides, Podalyria calyptrata*[C], *Psoralea aphylla*[C]. Low Shrubs: *Helichrysum cymosum*, *H. helianthemifolium*[C], *Penaea cneorum*[C], *Pseudobaeckea africana*[C]. Semiparasitic Shrub: *Osyris compressa* (d). Woody Climber: *Asparagus scandens*. Megagraminoids: *Prionium serratum*[P] (d), *Calopsis paniculata* (d), *Ischyrolepis subverticillata*[C] (d), *Cannomois virgata*[C], *Ehrharta rehmannii, Elegia capensis*[C], *Merxmuellera cincta, Miscanthus capensis, Rhodocoma capensis*[C]. Graminoids: *Ficinia brevifolia* (d), *Isolepis digitata*[C], *Juncus capensis*, *Pentaschistis curvifolia*, *P. pallida*, *Tetraria cuspidata*. Herbs: *Grammatotheca bergiana*[P], *Persicaria decipiens*. Geophytic Herbs: *Wachendorfia thyrsiflora*[C] (d), *Blechnum punctulatum*, *Disa tripetaloides*[P], *Osmunda regalis*, *Pteridium aquilinum*, *Todea barbata*. Carnivorous Herbs: *Drosera capensis*[C], *Utricularia bisquamata*.

Endemic Taxa Tall Shrub: *Ixianthes retzioides*. Low Shrub: *Metalasia riparia*. Herb: *Pelargonium pseudoglutinosum*. Graminoid: *Isolepis digitata* (d; aquatic). Moss: *Wardia hygrometrica* (aquatic; representative of monotypic endemic family).

Conservation Due to a very extensive system of nature reserves and wilderness areas administered by CapeNature, Eastern Cape Nature Conservation Service and partly also by South African National Parks (especially in the southern Cape), many patches of this vegetation type are well protected. This vegetation is, however, prone to infestation by alien woody plants such as *Acacia mearnsii*.

Remark 1 Due to the small scale as well as lack of data, the current mapping coverage of the unit on the national vegetation map is only a rough indication of its occurrence (few patches in the Cederberg area). The riparian thickets and accompanying palmiet reeds occur regularly along the fynbos mountain streams in many of the Cape Fold Mountains (from the Bokkeveld Plateau as far as Van Stadens Mountains near Port Elizabeth), and we hope they will receive proper attention in future. Many important species of riparian scrub vegetation do not occur east of Mossel Bay.

Remark 2 This vegetation unit bears floristic (and partly also ecological) similarity to the Western Cape Talus Forest (subtype: Western Cape Riverine Forests) of Von Maltitz et al. (2003) and Geldenhuys & Mucina (2006)—well-developed riparian forests along several rivers of the Cape Fold Mountains.

References Marloth (1908), Rycroft (1953), Harrison & Elsworth (1958), Martin & Noel (1960), Grobler (1964), Harrison (1964), Wicht et al. (1969), Boucher (1972, 1978, 1987, 1994, 1996a, 1999a, b), Werger et al. (1972a, b), Kruger (1974, 1979), Campbell (1975), Acocks (1976), Linder (1976), Le Roux (1977), Priday (1977), Van Zyl (1977), Parkman (1978), Taylor (1978), Seydack & Home (1980), McDonald (1985, 1988), Van Wilgen & Kruger (1985), Sieben (2003), Cleaver et al. (2005).

AZa 2 Cape Lowland Alluvial Vegetation

Riparian vegetation p.p. (Boucher 1978).

Distribution Western Cape Province: Vegetation of broad alluvia of middle and lower stretches of rivers of the Western Cape such as the upper Olifants, Berg, Eerste, Lourens, Palmiet, Bot, Klein, Breede, Goekoe, Gouritz, Hartebeeskuil, Klein Brak, Groot Brak, Keurbooms and a number of small tributaries of the above-mentioned water courses. Altitude ranging from 20–300 m.

L. Mucina

Figure 13.24 AZa 2 Cape Lowland Alluvial Vegetation: Bottom of temporary water course feeding into Verlorenvlei Lake, with *Phragmites australis* reed bed near Redelinghuys (Western Cape).

Vegetation & Landscape Features Flat landscape with slow-flowing (in place meandering) lowland rivers fringed on banks by extensive tall reeds dominated by *Phragmites australis* and *Typha capensis* as well as by flooded grasslands and herblands and tall riparian thickets (gallery forests) with *Salix mucronata* subsp. *capensis* on the river terraces.

Geology, Soil & Hydrology Alluvial fine sandy, silty and clayey soils over Quaternary sediments, largely derived from weathering of Table Mountain sandstone, Bokkeveld Group shales and Cape Granite (specifically the George Batholith). The streams are fed mainly during the winter-rainfall season. An important factor on the flood regime are the numerous dams built for water storage, which can simulate features of a natural flood regime by means of several quick releases of water from the reservoir.

Climate Identical to the climate of the surrounding lowland vegetation, and due to the large geographical span of the scattered patches of this vegetation unit, it typically encompasses winter rainfall as well as transitional winter-summer rainfall in both facies (with prevalence of either). The local MAP spans 320 mm (Breede River Valley) to 700 (Garden Route) while the MAT spans 15.9°C (Overberg) to 17.2°C (Garden Route). See also climate diagram for AZa 2 Cape Lowland Alluvial Vegetation (Figure 13.2).

Important Taxa ([C]Endemic to Capensis, [P]Sharing with Pondoland) **Riparian thickets** Small Trees: *Salix mucronata* subsp. *mucronata* (d), *Virgilia divaricata*[C], *Podocarpus elongatus*[C]. Tall Shrubs: *Buddleja saligna, B. salviifolia*, *Cliffortia strobilifera*, *Freylinia lanceolata*, *Rhus angustifolia*. Low Shrubs: *Cliffortia odorata* (d), *Senecio halimifolius* (d), *Cliffortia ferruginea*[C]. **Flooded grasslands & herblands** Tall Shrub: *Melianthus major* (d). Megagraminoids: *Prionium serratum*[P] (d), *Calopsis paniculata*, *Cyperus thunbergii*. Graminoids: *Cynodon dactylon* (d), *Cyperus congestus, C. denudatus*, *C. textilis*, *Eragrostis sarmentosa*, *Ficinia distans*, *Fuirena hirsuta*, *Hemarthria altissima*, *Isolepis cernua*, *I. prolifera*, *Juncus capensis*, *J. lomatophyllus*, *Leersia hexandra*, *Merxmuellera cincta*, *Paspalum distichum*, *Pennisetum macrourum*. Herbs: *Conyza scabrida*, *Helichrysum helianthemifolium*[C], *Laurembergia repens, Persicaria decipiens*. Geophytic Herbs: *Wachendorfia thyrsiflora*[C] (d), *Triglochin bulbosa* complex, *Watsonia galpinii*[C], *Zantedeschia aethiopica*. **Open water** Aquatic Herb: *Myriophyllum spicatum*.

Endemic Taxon **Riparian thickets** Small Tree: *Salix mucronata* subsp. *hirsuta* (d; only Olifants River and maybe Berg River catchments; see Jordaan 2005).

Conservation Critically endangered. Target 31%, but so far only about 1% statutorily (Bontebok National Park, Verlorenvlei (a Ramsar site), Broomvlei, Marloth Nature Reserves) or privately (Wadrif) conserved. Some 72% of the area has been transformed for cultivation, urban development and road building. Disturbance and alien infestation are very common in this type. Among the most vigorous woody alien invaders are *Acacia saligna*, *A. mearnsii* and *A. longifolia* as well as *Alnus glutinosa*, *Quercus robur*, *Salix babylonica* and *Sesbania punicea*. The high nutrient status of alluvial soils attracts fast-growing herbaceous alien weeds such as *Xanthium* species, *Sonchus oleraceus*, *Rumex crispus*, *Stellaria media* etc. as well as garden escapes such as *Tropaeolum majus*, *Tradescantia fluminensis*, *Pennisetum clandestinum* (kikuyu grass), *Colocasia esculenta* and *Lupinus angustifolius* (see for instance Duvenhage 1993 and Ahmed 1995).

References Duthie (1929), Muir (1929), Stephens (1929), Harrison & Elsworth (1958), Harrison (1964), Grobler & Marais (1967), Acocks (1976), Boucher (1978, 1987, 1996a, b, 1997), Noble & Hemens (1978), Rebelo et al. (1991), Duvenhage (1993), Ahmed (1995), Sieben (2003), http://www.ngo.grida.no/soesa/nsoer/resource/wetland/sa_ramsar.htm.

AZa 3 Lower Gariep Alluvial Vegetation

Distribution Northern Cape Province: Broad alluvium (floodplains and islands) of the Orange (Gariep) River between Groblershoop and the mouth into the Atlantic Ocean at Oranjemund (Namibia). This river stretch is embedded within Desert (Oranjemund to roughly Pofadder) and Nama-Karoo (further upstream as far as Groblershoop). Altitude ranging from 0–1 000 m.

Vegetation & Landscape Features Flat alluvial terraces and riverine islands supporting a complex of riparian thickets (dominated by *Ziziphus mucronata*, *Euclea pseudebenus* and *Tamarix usneoides*), reed beds with *Phragmites australis* as well as flooded grasslands and herblands populating sand banks and terraces within and along the river.

Geology, Soil & Hydrology Recent alluvial deposits of the Orange River supporting soil forms such as Dundee and Oakleaf. The river cuts through a great variety of Precambrian metamorphic rocks. Ia land type. Subject to floods, especially in summer, caused by high precipitation on the highveld.

Climate Region with very arid (desert) to subarid (semidesert) climate and erratic, unimodal (winter-rainfall) regime in the extreme west (near the Orange River mouth) to bimodal, equinoctial with major peak in March and less pronounced peak in November in the extreme east (near Upington). MAP 40–150 mm and MAT between 15.4°C (Alexander Bay) and 20.5°C (Upington). See also climate diagram for AZa 3 Lower Gariep Alluvial Vegetation (Figure 13.2).

L. Mucina

Figure 13.25 AZa 3 Lower Gariep Alluvial Vegetation: Alluvial grasslands with *Cynodon dactylon* and riparian thickets with *Tamarix usneoides* on rocky banks of the Orange River at Grasdrif (Richtersveld National Park).

These river stretches are surrounded by vegetation units of broad transitional regions between the dry facies of the Savanna and Grassland and northern regions of the Nama-Karoo Biome. Altitude ranging from 1 000–1 500 m.

Vegetation & Landscape Features Flat alluvial terraces supporting complex of riparian thickets (gallery forests) dominated by native *Acacia karroo* and *Diospyros lycioides*, flooded grasslands, reed beds and ephemeral herblands populating mainly sand banks within the river and on its banks.

Geology, Soil & Hydrology Recent alluvial deposits underlain mostly by Karoo Supergroup sediments and tillites, supporting soils typical of Ia group land types. Subject to flooding, especially in summer.

Climate Bimodal (equinoctial) climate with a major peak in March and with a lesser peak in November–December. The overall MAP is 325 mm (range 230–600 mm for Prieska and Wepener, respectively). MAT for the entire area averages 17°C (range 19.3–15.4°C for Prieska and Aliwal North, respectively). See also climate diagram for AZa 4 Upper Gariep Alluvial Vegetation (Figure 13.2).

Important Taxa **Riparian thickets** Small Trees: *Acacia karroo* (d), *Euclea pseudebenus* (d), *Salix mucronata* subsp. *mucronata* (d), *Schotia afra* var. *angustifolia* (d), *Ziziphus mucronata* (d), *Acacia erioloba*, *Combretum erythrophyllum*, *Ficus cordata*, *Maerua gilgii*, *Prosopis glandulosa* var. *glandulosa*, *Rhus lancea*. Tall Shrubs: *Gymnosporia linearis* (d), *Tamarix usneoides* (d), *Ehretia rigida*, *Euclea undulata*, *Sisyndite spartea*. Low Shrub: *Asparagus laricinus*. Woody Climber: *Asparagus retrofractus*. Succulent Shrub: *Lycium bosciifolium*. Herb: *Chenopodium olukondae*. **Reed beds** Megagraminoid: *Phragmites australis* (d). **Flooded grasslands & herblands** Low Shrubs: *Tetragonia schenckii* (d), *Litogyne gariepina*. Graminoids: *Cynodon dactylon* (d), *Setaria verticillata* (d), *Cenchrus ciliaris*, *Cyperus laevigatus*, *Eragrostis echinochloidea*, *Leucophrys mesocoma*, *Polypogon monspeliensis*, *Stipagrostis namaquensis*. Herbs: *Amaranthus praetermissus*, *Coronopus integrifolius*, *Frankenia pulverulenta*, *Gnaphalium confine, Pseudognaphalium luteo-album*.

Conservation Endangered. Target 31%. About 6% statutorily conserved in the Richtersveld and Augrabies Falls National Parks. Some 50% transformed for agricultural purposes (vegetables and grapes) or alluvial diamond mining. *Prosopis* species, *Nicotiana glauca* and *Argemone ochroleuca* can invade the alluvia in places.

References Acocks (1976), Werger & Coetzee (1977), Werger & Ellenbroek (1978), Werger (1980), Bezuidenhout (1996), Bezuidenhout & Jardine (2001), Jürgens (2004).

AZa 4 Upper Gariep Alluvial Vegetation

Including Riverine Communities (*Diospyros lycioides*) (Werger 1980).

Distribution Free State and Northern Cape Provinces: Broad alluvia of the Orange River, lower Caledon as well as lower stretches of the Vaal, Riet and Modder Rivers as far as Groblershoop.

Important Taxa **Riparian thickets** Small Trees: *Acacia karroo* (d), *Celtis africana* (d), *Salix mucronata* subsp. *mucronata* (d). Tall Shrubs: *Diospyros lycioides* (d), *Melianthus comosus* (d), *Rhus pyroides*. Low Shrubs: *Asparagus setaceus*, *A. suaveolens*. Woody Climber: *Clematis brachiata*. Succulent Shrubs: *Lycium arenicola*, *L. hirsutum*. Herb: *Rubia cordifolia*. **Flooded grasslands & herblands** Graminoid: *Melica decumbens* (d). Herbs: *Cineraria dregeana*, *C. lobata*.

Conservation Vulnerable. Target 31%. Only about 3% statutorily conserved in Tussen Die Riviere, Gariep Dam and Oviston Nature Reserves. More than 20% transformed for cultivation

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Figure 13.26 AZa 4 Upper Gariep Alluvial Vegetation: Riparian thickets with dominant *Acacia karroo* and *Diospyros lycioides* fringing the banks of the Orange River near Colesberg.

(vegetables, grapes) and building of dams. Exotic woody species such as *Salix babylonica*, *Eucalyptus camaldulensis*, *E. sideroxylon*, *Prosopis* and *Populus* species have become common dominants in patches of heavily disturbed alluvial vegetation.

References Werger (1973, 1980), Acocks (1976), Werger & Ellenbroek (1978), Du Preez (1991), Du Preez & Bredenkamp (1991).

AZa 5 Highveld Alluvial Vegetation

Distribution Free State, North-West, Mpumalanga and Gauteng Provinces as well as in Lesotho and Swaziland: Alluvial drainage lines and floodplains along rivers embedded within the Grassland Biome and marginal (eastern) units of the Kalahari (Savanna Biome), such as along upper Riet, Harts, upper Modder, upper Caledon, Vet, Sand, Vals, Wilge, Mooi, middle and upper Vaal Rivers etc. and their numerous tributaries. Altitude ranging from 1 000–1 500 m.

Vegetation & Landscape Features Flat topography supporting riparian thickets mostly dominated by *Acacia karroo*, accompanied by seasonally flooded grasslands and disturbed herblands often dominated by alien plants.

Geology, Soil & Hydrology Deep sandy to clayey (but mostly coarse sand) alluvial soils developed over Quaternary alluvial (fluviatile) sediments. Oakleaf, Dundee, Shortlands, Glenrosa and Mispah soil forms were identified in the Vaal River floodplain (Bezuidenhout 1994). The rivers are perennial, often in flood in summer. Erosion of banks and deposition of new fine soil on alluvium can be of considerable extent. Some smaller anastomosing channels of major rivers can dry out in winter.

Climate Seasonal, mainly summer rainfall. Precipitation in the western part of the highveld is erratic (MAP 300–400 mm), increasing sharply towards the east and north (up to 600 mm in places). The overall MAP is almost 500 mm (range 373 mm at the western distribution limit and 593 mm at the northern distribution limit near Carletonville). Typical continental thermal regime, showing subtropical features is typical of the summer season (daily temperature often surpassing 35°C), while cold-temperate features (such as frequent frost) prevail in winter. See also climate diagram for AZa 5 Highveld Alluvial Vegetation (Figure 13.2).

Important Taxa **Riparian thickets** Small Trees: *Acacia karroo* (d), *Salix mucronata* subsp. *mucronata* (d), *S. mucronata* subsp. *woodii* (d, within subescarpment grasslands of KwaZulu-Natal), *Ziziphus mucronata* (d), *Celtis africana*, *Rhus lancea*. Tall Shrubs: *Gymnosporia buxifolia* (d), *Rhus pyroides* (d), *Diospyros lycioides*, *Ehretia rigida*, *Grewia flava*. Low Shrubs: *Asparagus laricinus* (d), *A. suaveolens* (d). Woody Climber: *Clematis brachiata*. Succulent Shrub: *Lycium hirsutum* (d). Graminoids: *Setaria verticillata* (d), *Panicum maximum*. Herb: *Pollichia campestris*. **Reed beds** Megagraminoid: *Phragmites australis* (d). **Flooded grasslands & herblands** Low Shrubs: *Gomphocarpus fruticosus* (d), *Felicia muricata*. Succulent Shrub: *Salsola rabieana*. Graminoids: *Agrostis lachnantha* (d), *Andropogon eucomus* (d), *Chloris virgata* (d), *Cynodon dactylon* (d), *Eragrostis plana* (d), *Hemarthria altissima* (d), *Imperata cylindrica* (d), *Ischaemum fasciculatum* (d), *Miscanthus junceus* (d), *Paspalum distichum* (d), *Andropogon appendiculatus*, *Brachiaria marlothii, Cyperus denudatus*, *C. longus*, *Echinochloa holubii*, *Eragrostis obtusa*, *E. porosa*, *Fimbristylis ferruginea, Panicum coloratum*, *Pycreus mundii*, *Sporobolus africanus*, *S. fimbriatus*, *Themeda triandra*, *Urochloa panicoides*. Herbs: *Persicaria lapathifolia* (d), *Alternanthera sessilis*, *Barleria macrostegia*, *Corchorus asplenifolius*, *Equisetum ramosissimum*, *Galium capense*, *Hibiscus pusillus*, *Lobelia angolensis, Nidorella resedifolia*, *Persicaria amphibia, P. hystricula*, *Pseudognaphalium oligandrum*, *Pulicaria scabra, Rorippa fluviatilis* var. *fluviatilis*, *Senecio inornatus*, *Stachys hyssopoides*, *Vahlia capensis*. Geophytic Herbs: *Crinum bulbispermum*, *Haplocarpha lyrata*. **Open water** Aquatic Herb: *Myriophyllum spicatum*.

Conservation Least threatened. Target 31%. Nearly 10% statutorily conserved in the Barberspan (a Ramsar site), Bloemhof Dam, Christiana, Faan Meintjes, Sandveld, Schoonspruit, Soetdoring and Wolwespruit Nature Reserves. More than a quarter has been transformed for cultivation and by building of dams (Bloemhof, Erfenis, Krugersdrif, Mockes and Vaalharts Dams). The highveld alluvia are prone to invasion by a number of weeds, obviously encouraged by the high nutrient status of soils and ample water supply. Woody plants such as *Salix babylonica*, *Schinus molle*, *Melia azedarach*, *Celtis sinensis*, *Morus alba*, *Populus* x *canescens*, *Nicotiana glauca* and *N. longiflora* and forbs such as *Argemone ochroleuca*, *Chenopodium strictum*, *Conyza canadensis*, *Datura stramonium*, *Melilotus alba*, *Oenothera indecora*, *Paspalum dilatatum*, *P. urvillei*, *Pennisetum clandestinum*, *Tagetes minuta*, *Verbena bonariensis*, *Xanthium strumarium* agg. and *Zinnia peruviana* (see Cilliers et al. 1998, Malan et al. 2001a, b, L. Mucina, unpublished data) often dominate either the riverine thickets or grasslands or form ruderal communities in disturbed habitats. The undergrowth of the alluvial riparian thickets and the accompanying grasslands suffer from heavy overgrazing in many places.

Remark Many patches of this vegetation escaped our mapping efforts due to a lack of proper geographical coverage.

References Acocks (1976), Roussouw (1983), Müller (1986), Bezuidenhout (1988, 1994), Bredenkamp et al. (1989), Bredenkamp & Bezuidenhout (1990), Du Preez & Venter (1990), Kooij et al. (1990a, b), Du Preez (1991), Du Preez & Bredenkamp (1991), Eckhardt et al. (1993b, 1996), Bezuidenhout et al. (1994), Bredenkamp et al. (1994), Hoare (1997), Cilliers et al. (1998), Eckhardt (1998), Malan (1998), Boucher & Tlale (1999a, b), Hoare & Bredenkamp (1999), Myburgh (2000, 2001), Van Wyk et al. (2000), Dingaan et al. (2001), Malan et al. (2001a, b), Myburgh & Bredenkamp (2004), http://www.ngo.grida.no/soesa/nsoer/resource/wetland/sa_ramsar.htm.

AZa 6 Albany Alluvial Vegetation

Including Stream-bank Bush (Story 1952). Riverine Bush (Martin & Noel 1960). Baviaans Doringveld, Gamtoos Doringveld & Sundays Doringveld (Vlok & Euston-Brown 2002, Vlok et al. 2003).

Distribution Eastern Cape Province: Between East London and Cape St Francis on wide floodplains (usually close to the coast where the topography becomes flatter) of the large rivers such as the Sundays, Zwartkops, Coega, Gamtoos, Baviaanskloof, Great Fish River etc. This alluvial unit is embedded within the Albany Thicket Biome. Altitude ranging from 20–1 000 m.

Vegetation & Landscape Features Two major types of vegetation pattern are observed in these zones, namely riverine thicket and thornveld (*Acacia natalitia*). The riverine thicket tends to occur in the narrow floodplain zones in regions close to the coast or further inland, whereas the thornveld occurs on the wide floodplains further inland.

Geology, Soil & Hydrology Underlain by Jurassic-Cretaceous sediments of the Uitenhage Group. The alluvial zones (recent alluvial deposits of various textures, but usually with high clay content) can become flooded following the west-east passage of frontal systems in autumn and winter or during intensive local storms in summer. Ia land type.

Climate Characterised by undifferentiated, year-round precipitation regime, with only two slight peaks in March and November.

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Figure 13.27 AZa 6 Albany Alluvial Vegetation: *Acacia natalitia* thickets fringing the Great Fish River in the former Double Drift Nature Reserve near Fort Beaufort (Eastern Cape).

The overall MAP is 350 mm (range 300–717 mm). Warm-temperate climate (overall MAT 18°C; range 15.7–18.3°C). The river valleys are often hotter than the surrounding landscape (due to exposed steep slopes), whereas riverine zones closer to the coast enjoy an ameliorated climate due to its proximity to the sea. See also climate diagram for AZa 6 Albany Alluvial Vegetation (Figure 13.2).

Important Taxa ([B]Brackish habitats): **Riparian thickets** Small Trees: *Acacia natalitia* (d), *Salix mucronata* subsp. *mucronata* (d), *Schotia afra* var. *afra* (d), *Acacia caffra*, *Rhus longispina*. Succulent Trees: *Aloe africana*, *A. ferox*. Tall Shrubs: *Azima tetracantha*, *Cadaba aphylla*. Low Shrubs: *Pentzia incana* (d), *Asparagus striatus*, *A. suaveolens*, *Carissa haematocarpa*. Succulent Shrubs: *Amphiglossa callunoides*, *Lycium cinereum*. Graminoids: *Sporobolus nitens* (d), *Digitaria eriantha*, *Eragrostis curvula*, *E. obtusa*. **Reed beds** Megagraminoids: *Cyperus papyrus* (d), *Phragmites australis* (d). **Flooded grasslands & herblands** Succulent Shrubs: *Cotyledon campanulata*[B], *Glottiphyllum longum*[B], *Malephora lutea*[B], *M. uitenhagensis*[B]. Semiparasitic Shrub: *Thesium junceum*[B]. Succulent Herbs: *Haworthia sordida* var. *sordida*[B], *Orbea pulchella*[B]. Herb: *Rorippa fluviatilis* var. *fluviatilis*. Graminoid: *Cynodon dactylon*[B] (d).

Conservation Endangered. Target 31%. Only about 6% statutorily conserved in the Greater Addo Elephant National Park, Baviaanskloof Wilderness Area, Loerie Dam, Springs, Swartkops Valley and Yellowwoods Nature Reserves and the Double Drift Reserve Complex. About 2% enjoys protection in eight private conservation areas. More than half of the area has been transformed for cultivation, urban development, road building and plantations. Alien invaders include *Acacia saligna*, *Nerium oleander* and *Eucalyptus* species.

Remarks Vlok & Euston-Brown (2002) consider this vegetation as important temporary habitats and migration corridors for larger herbivores such as elephant (in the past), rhinoceros, eland and kudu.

References Story (1952), Martin & Noel (1960), Jessop & Jacot Guillarmod (1969), Jacot Guillarmod (1973), Acocks (1976), Cowling & McKenzie (1979), Vlok & Euston-Brown (2002), Vlok et al. (2003).

AZa 7 Subtropical Alluvial Vegetation

Including Riverine Bush (Comins 1962). *Salvadora angustifolia* Floodplains (Gertenbach 1983).

Distribution Limpopo, Mpumalanga and KwaZulu-Natal Provinces and in Swaziland: Broad river alluvia and around some river-fed pans in the subtropical regions of eastern South Africa, in particular in the Lowveld, Central Bushveld and in northern KwaZulu-Natal. The most important alluvia include the Limpopo, Luvubu, Olifants, Sabie, Crocodile, Phongolo, Usutu and Mkuze Rivers. This unit is fully embedded within the Savanna Biome. Altitude ranging from 0–1 000 m.

Vegetation & Landscape Features Flat alluvial riverine terraces supporting an intricate complex of macrophytic vegetation (channel of flowing rivers and river-fed pans), marginal reed belts (in sheltered oxbows and along very slow-flowing water courses) as well as extensive flooded grasslands, ephemeral herblands and riverine thickets.

Geology, Soil & Hydrology Recent alluvial deposits with deep fine-structured sandy to loamy soils (Dundee, Estcourt, Valsrivier, Sterkspruit, Oakleaf forms), waterlogged as it is often exposed to floods (especially during the rainy summer season). Salt often

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Figure 13.28 AZa 7 Subtropical Alluvial Vegetation: Complex of reed beds (*Phragmites mauritanicus*) and alluvial shrublands along the White Mfolozi River (Hluhluwe-iMfolozi Park, KwaZulu-Natal).

accumulates in the alluvial soils (due to strong evaporation). Ia land type.

Climate Subtropical, seasonal summer-rainfall climate with broad range of temperature (19.3°C in western Central Bushveld and 22.0°C in Mopane) and precipitation (MAP 311–672 mm for Limpopo Valley and Maputaland, respectively) due to large latitudinal and longitudinal ranges. See also climate diagram for AZa 7 Subtropical Alluvial Vegetation (Figure 13.2).

Important Taxa **Riparian thickets** Small Trees: *Acacia natalitia* (d), *A. robusta* (d), *Boscia foetida* subsp. *rehmanniana* (d), *Combretum erythrophyllum* (d), *Phoenix reclinata* (d), *Salix mucronata* subsp. *woodii* (d), *Ziziphus mucronata* (d), *Acacia luederitzii*, *A. nebrownii*, *A. nigrescens*, *A. tortilis*, *A. xanthophloea*, *Colophospermum mopane*, *Combretum hereroense*, *Philenoptera violacea*, *Pseudoscolopia polyantha* (Pondoland, sharing with Capensis). Tall Shrubs: *Salvadora angustifolia* (d), *Commiphora glandulosa*, *C. pyracanthoides*, *Euclea divinorum*, *Grewia bicolor*, *Gymnosporia senegalensis*. Low Shrubs: *Justicia flava*, *Ocimum canum*. Graminoids: *Eragrostis trichophora* (d), *Panicum maximum* (d), *Setaria incrassata* (d), *Sporobolus ioclados* (d), *Chloris virgata*, *Dactyloctenium aegyptium*, *Enneapogon cenchroides*, *Urochloa mosambicensis*. Herbs: *Commelina benghalensis* (d), *Abutilon austro-africanum*, *Acalypha indica*, *Achyranthes aspera*, *Boerhavia erecta*, *Commicarpus fallacissimus*, *Cucumis zeyheri*, *Heliotropium ovalifolium*, *Lobelia angolensis, Oxygonum sinuatum*, *Pupalia lappacea*, *Ruellia patula*. Geophytic Herb: *Crinum moorei*. Succulent Herb: *Portulaca quadrifida*. **Reed beds** Megagraminoids: *Phragmites australis* (d), *P. mauritianus* (d), *Prionium serratum* (only along few rapids in Pondoland). **Flooded grasslands & herblands** Megagraminoid: *Cyperus immensus*. Graminoids: *Cynodon dactylon* (d), *Cyperus articulatus* (d), *Echinochloa pyramidalis* (d), *Urochloa mosambicensis* (d), *Bolboschoenus glaucus, Chloris mossambicensis*, *C. virgata*, *Cyperus corymbosus*, *C. difformis*, *C. distans*, *C. fastigiatus*, *C. sexangularis*, *Dactyloctenium aegyptium*, *Hemarthria altissima*, *Ischaemum afrum*, *Paspalidium obtusifolium*, *Setaria sphacelata*, *Sporobolus consimilis*, *S. fimbriatus*. Herbs: *Alternanthera sessilis*, *Amaranthus praetermissus*, *Grammatotheca bergiana* (Pondoland), *Marsilea ephippiocarpa, Scutellaria racemosa*. Geophytic Herb: *Trachyandra saltii*. Aquatic Herbs: *Ceratophyllum muricatum*, *Ottelia exserta*.

Endemic Taxon **Flooded grasslands & herblands** Herb: *Crotalaria mollii*.

Conservation Target 31%. Large patches are statutorily conserved in the Kruger and Mapungubwe National Parks, Vemre and D'nyala Nature Reserves, Ndumo Game Reserve and Greater St Lucia Wetland Park (Mkhuze Game Reserve) as well as in a number of private reserves fringing the western borders of the Kruger National Park and the Limpopo River. The Ndumo Game Reserve and Greater St Lucia Wetland Park are Ramsar sites. Much of the area has been transformed for cultivation, urban development and road building. Alien woody species commonly occurring in this vegetation types include *Melia azedarach*, *Chromolaena discolor* and the like.

Remark 1 The vegetation of the Lowveld alluvia is found in a complex of Subtropical Riverine Forests (gallery forests), and both are usually embedded within various bushveld types of the Savanna Biome. The major distinction between this type of alluvial vegetation and other alluvia is the presence and importance of subtropical and tropical floristic elements and the pronouncedly subtropical climate. One of the best researched subtropical alluvial systems in South Africa is the Nylsvlei east of the Modimolle–Mookgophong line, especially in the Nylsvlei Nature Reserve (Coetzee et al. 1976).

Remark 2 The current mapping coverage of Subtropical Alluvial Vegetation reflects our current poor knowledge and the lack of data from all around the Central Bushveld as well as Lowveld regions.

References Comins (1962), Edwards (1967), Musil (1972), Musil et al. (1973), Theron (1973), Acocks (1976), Coetzee et al. (1976), De Moor et al. (1977), Noble & Hemens (1978), Furness & Breen (1980), Heeg et al. (1980), Rogers (1980, 1984), Furness (1981), Gertenbach (1983), Goodman (1987a, b), Begg & Carser (1988, 1989), Breen et al. (1993), Brown & Bredenkamp (1994), Bredenkamp & Deutschländer (1995), Brown et al. (1995, 1996, 1997), Breebaart & Deutschländer (1997), Kotschy et al. (2000), Barnes et al. (2002), Götze (2002), Götze et al. (2003), O'Keeffe & Rogers (2003).

Inland Saline Vegetation

AZi 1 Namaqualand Riviere

Distribution Northern and Western Cape Provinces: Along dry riverbeds throughout Namaqualand, but especially the Buffels, Bitter, Spoeg, Groen, Sout, Doring Rivers and lower reaches of the Olifants River. Within this unit we also classify alluvia of intermittent rivers of the Hantam region. Altitude ranging from 0–800 m.

Vegetation & Landscape Features Complex of alluvial shrubland (*Suaeda fruticosa*, *Zygophyllum morgsana*, *Ballota africana* and *Didelta spinosa*) and patches of tussock graminoids occupying riverbeds and banks of intermittent rivers. In places low thickets of *Acacia karroo* and *Tamarix usneoides* can be encountered.

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Figure 13.29 AZi 1 Namaqualand Riviere: Broad sandy-loamy alluvium of the Varsch River northwest of Vanrhynsdorp, with *Acacia karroo* (yellow-flowered shrub) and species of *Salsola* and *Galenia* (low greyish shrubs).

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Figure 13.30 AZi 1 Namaqualand Riviere: Salty bottom of intermittent semidesert river on the Knersvlakte with *Sarcocornia terminalis* (endemic Chenopodiaceae), *Galenia africana* and salt-loving *Limonium dregeanum* (Plumbaginaceae, dark green tussocks).

Geology, Soil & Hydrology Alluvial sandy soils on Quaternary fluviatile sediments that overlie Namibian-age sediments and Mokolian gneisses. Seasonally wet (late winter). The riverbed sometimes carries torrential flood waters. In summer, patches of crystallised salt film may cover the soil surface in slight, clayey depressions.

Climate Arid, seasonal climate with MAP around 150 mm (with 100 mm on the coast and 250 mm on the Hantam Plateau). Most of the erratic rainfall occurs between June and August. Hot summers (marked by extremely high evapotranspiration) and cool winters, with fairly frequent frost. MAT 18.1°C (range 15.7°C for Hantam Plateau and 18.5°C for Knersvlakte). See also climate diagram for AZi 1 Namaqualand Riviere (Figure 13.2).

Important Taxa **Riparian thickets** Small Tree: *Acacia karroo* (d). Tall Shrubs: *Melianthus pectinatus*, *Rhus burchellii*, *Tamarix usneoides*. Low Shrub: *Ballota africana* (d). Semiparasitic Epiphytic Shrub: *Viscum capense*. **Dry river bottoms** Tall Shrub: *Lebeckia sericea*. Low Shrubs: *Galenia africana* (d), *Gomphocarpus fruticosus* (d), *Hermannia disermifolia*, *Jamesbrittenia fruticosa*, *Salvia dentata*. Succulent Shrubs: *Suaeda fruticosa* (d), *Zygophyllum morgsana* (d), *Atriplex cinerea* subsp. *bolusii*, *Didelta carnosa* var. *carnosa*, *Lycium horridum*, *Salsola tuberculata*, *Tetragonia fruticosa*, *T. pillansii*, *Zygophyllum retrofractum*. Herbaceous Climber: *Didymodoxa capensis*. Graminoids: *Cynodon dactylon* (d), *Odyssea paucinervis* (d), *Cyperus marginatus*, *Diplachne fusca*, *Ehrharta longiflora*, *Isolepis antarctica*, *Scirpus nodosus*. Herbs: *Limonium dregeanum* (d), *Arctotheca calendula*, *Cotula coronopifolia*, *Galium tomentosum*. Geophytic Herb: *Crinum variabile*. Succulent Herbs: *Conicosia elongata*, *Mesembryanthemum guerichianum*.

Endemic Taxon **Dry river bottoms** Succulent Shrub: *Sarcocornia terminalis* (d).

Conservation Least threatened. Target 24%. Only very small portion statutorily protected in nature reserves (Lutzville). Almost 20% transformed for cultivation (vineyards along the entire lower reaches of the Olifants River) or by building of dams (Driekoppies Dam). Exotic shrubs *Nicotiana glauca* and *Prosopis* species are often found in riverbeds. The latter is probably the most important woody invader species found in Namaqualand. In some years invasive indigenous *Gomphocarpus fruticosus* may appear in abundance in the alluvia, while in other years it would disappear completely. Another invasive indigenous species is *Galenia africana* which can be dominant along some of the water courses, especially in the south.

Reference Boucher (2003).

AZi 2 Namaqualand Salt Pans

Distribution Northern and Western Cape Provinces: Smaller and larger areas along the coastal plains of Namaqualand, including Sonnekwa, Hondevlei (both southeast of Kleinzee), Bloupan, Dryerspan, Karaspan (north of Kleinzee) and Soutpan (southeast of Port Nolloth). The cut-off supratidal terraces of the Olifants River mouth qualify as salt pans as well. Altitude ranging from 0–250 m.

Vegetation & Landscape Features Flat surfaces of depressions, mostly without vegetation and only occasionally covered with sparse, highly salt-tolerant succulent shrubs (*Salsola*, *Malephora*). The highest vegetation cover has been found in the salt pan at the Olifants River mouth, where the succulent shrubs *Salsola*, *Psilocaulon* and *Sarcocornia* are dominant.

Geology, Soil & Hydrology Large depressions (pans) of marine origin (remnants of former larger marine transgression-forming coastal lagoons) with white to grey silt and clay soils, seasonally moist. These pans are formed on the Cenozoic alluvium, sand and calcrete that were deposited over Mokolian-age schists and gneisses as well as metavolcanics and metasediments of Namibian age. Namaqualand salt pans are nearly permanently dry (only seldom intermittent pools of standing water are found in the lowest depressions) and especially in the Kleinzee area they disappear and are buried under layers of wind-borne sand.

Climate Arid, erratic seasonal rainfall of which most falls between May and August. Overall MAP 100 mm, ranging from 45 mm at Alexander Bay to 126 mm on the Knersvlakte below the Bokkeveld Escarpment. Along the Richtersveld coast the lack of rainfall is partly compensated by more frequent coastal winter fog. Hot summers (accompanied by high evapotranspiration rates) alternate with cool winters. MAT ranging from 17.6°C, with narrow range of 17.3–18.6°C. See also climate diagram for AZi 2 Namaqualand Salt Pans (Figure 13.2).

Important Taxa Succulent Shrubs: *Salsola aphylla* (d), *Sarcocornia mossiana* agg. (d), *Atriplex cinerea* subsp. *bolusii*. Succulent Herbs: *Mesembryanthemum guerichianum*, *Salicornia meyeriana*. Graminoids: *Juncus rigidus* (d), *Sporobolus virginicus*.

Biogeographically Important Taxa ([NQ]Namaqualand endemic, [G]Gariep endemic, [W]West Coast endemic): Low Shrub: *Frankenia pomonensis*[G]. Succulent Shrub: *Lycium tetrandrum*[W]. Herbs: *Malephora purpureo-crocea*[NQ] (d), *Limonium equi-*

setinum[W]. Succulent Herb: *Psilocaulon dinteri*[W]. Graminoid: *Schoenoplectus scirpoides*.

Conservation Least threatened. Target 24%. None conserved in statutory conservation areas. Only small portion transformed (road building).

Remarks The Namaqualand pans are superficially (physiognomy, ecology) very similar to those of Bushmanland such as Verneukpan and other 'vloere', but they differ in terms of origin (marine versus fluviatile) and also in constituent flora. The salt pan at the Olifants River mouth is an example of an 'inland' pan in *stadio nascendi*—some supratidal terraces of the original estuarine salt marsh are becoming isolated from any influence of the tidal regime, forming an isolated saline system resulting in a pan.

References Bornman (2002), Bornman et al. (2002, 2004).

AZi 3 Southern Kalahari Mekgacha

Distribution Northern Cape and North-West Provinces: Valleys (including beds and adjacent slopes) of the intermittent rivers draining the dry savanna south of the Bakalahari Schwelle (broad interfluve at 1 000–1 100 m altitude) in the South African part of the Kalahari region. The major mekgacha of the region include the Nossob, Auob, Molopo and Kuruman Rivers. A more extensive (endorheic) system of mekgacha is found north of the Bakalahari Schwelle in central Botswana. Altitude ranging from 850 m to mainly 1 100 m, with a few occurrences as high as 1 500 m.

Vegetation & Landscape Features Sparse, patchy grasslands, sedgelands and low herblands dominated by C_4 grasses (*Panicum*, *Eragrostis*, *Enneapogon*, *Tragus*, *Chloris*, *Cenchrus*) on the bottom of (mostly) dry riverbeds. Low shrublands in places with patches of taller shrubland (with *Schotia afra*) on the banks of the rivers. Relatively tall *Acacia erioloba* trees can form a dominant belt along some of the rivers, for example the middle and lower reaches of the Kuruman River. In some other rivers the taller trees are scattered.

Geology, Soil & Hydrology The river channels are embedded within prevalently sandy Kalahari sediments that cover the Precambrian metamorphic crust of the area. The substrate of the dry riverbeds are silty, sandy and rocky, poorly drained and rich in nutrients though the ionic composition of the soils in particular rivers show considerable differences. The banks of the dry rivers can cut deep into duricrust (calcrete or silcrete and various transitions between these end-members, and in places also ferricretes), sometimes vertical bluffs (steep cliffs) of a few metres high may develop (Werger 1978, Thomas & Shaw 1991). The mekgacha may stay without any water for a very long time and floods (sometimes of considerable magnitude) occur only in response to dramatic short-term precipitation events, for example the Nossob was in flood in 1806, 1963 and 1987 and the Auob was in flood in 1973, 1974 and 2000 (Thomas & Shaw 1991; H. Bezuidenhout, personal communication). Some of the rivers such as the Kuruman must experience effective subsurface flow of water judging from the near-continuous belt of trees.

Climate Subarid region with seasonal, summer-rainfall regime with a slight shift of the major peak towards late summer (February–March). Overall MAP 240 mm (ranging from 180 mm at southwestern boundary to as much as 420 mm further north). High thermic continentality is obvious from the extreme differences between the mean daily maximum and minimum temperatures in January and July: 34°C and 1°C, respectively, great daily temperature differences (sometimes reaching amplitude between 25°C and 30°C, especially in transitional climatic periods) as well as the fairly frequent occurrence of frost. The overall MAT of 19°C (range 17.5–19.1°C) is indicative of a subtropical climate, classified in the Köppen's system as BWKw' in its southernmost regions and as BWhw further north (Coetzee & Werger 1975, Schultze & McGee 1978, Werger 1978). See also climate diagram for AZi 3 Southern Kalahari Mekgacha (Figure 13.2).

Important Taxa **Dry river bottoms** Tall Shrubs: *Lebeckia linearifolia* (d), *Sisyndite spartea* (d), *Deverra denudata* subsp. *aphylla*. Herbs: *Amaranthus dinteri* subsp. *dinteri*, *A. praetermissus*, *A. schinzianus*, *Boerhavia repens*, *Chamaesyce inaequilatera*, *Cucumis africanus*, *Geigeria ornativa*, *G. pectidea*, *Heliotropium lineare*, *Indigofera alternans*, *I. argyroides*, *Kohautia cynanchica*, *Lotononis platycarpa*, *Osteospermum muricatum*, *Platycarpha carlinoides*, *Radyera urens*, *Stachys spathulata*, *Tribulus terrestris*. Succulent Herb: *Zygophyllum simplex* (d). Graminoids: *Cenchrus ciliaris* (d), *Chloris virgata* (d), *Enneapogon desvauxii* (d), *Eragrostis annulata* (d), *E. bicolor* (d), *Odyssea paucinervis* (d), *Panicum coloratum* (d), *Eragrostis porosa*, *Panicum impeditum*, *Sporobolus nervosus*. **Rocky slopes of river canals** Tall Tree: *Acacia erioloba* (d). Low Shrubs: *Aptosimum lineare*, *Pechuel-Loeschea leubnitziae*. Graminoids: *Setaria verticillata* (d), *Enneapogon scaber*, *Oropetium capense*, *Stipagrostis uniplumis*, *Tragus racemosus*. Herb: *Dicoma capensis*.

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Figure 13.31 AZi 3 Southern Kalahari Mekgacha: Dry Nossob River in the Kgalagadi Transfrontier Park against the backdrop of sparsely vegetated dunes in neighbouring Botswana. For springbok (*Antidorcas marsupialis*) and other hoofed as well as carnivorous wildlife the open landscape of the intermittent rivers is a favourite grazing, resting and hunting ground.

Conservation Least threatened. Target 24%. Already 18% statutorily conserved in the Kgalagadi Transfrontier Park and Molopo Nature Reserve. About 2% has been transformed by road building. The

mekgacha are under strong utilisation pressure, both from wildlife (to graze and for salt licks) and domestic animals (grazing, browsing and animal penning). Alien woody *Prosopis* species occur as invasive plants in places.

Remark 1 The term 'mekgacha' (singular 'mokgacha') is of Setswana origin and means 'dry (river) valley'. Mekgacha are considered to be remnants of an ancient extensive riverine system of the 'Kalahari River', which drained the Kalahari Basin and used the current lower Orange River channel from Kakamas downstream. In the early Tertiary, the Kalahari River captured the upper parts of the Karoo River (draining the inland plateau of southern Africa into the southern Atlantic Ocean at the current mouth of the Olifants River on the West Coast and with the present offshore submarine Cape Canyon as outlet) as a result of accelerated uplift of the southern and eastern subcontinental margins ca. 100 to 80 mya (De Wit 1999, Goudie 2005). The flow of the Kalahari River system was interrupted by the dry periods of the Eocene-Miocene transition and further decimated during Plio-Pleistocene dry periods.

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Figure 13.32 AZi 4 Southern Kalahari Salt Pans: A salt pan in the northern Kgalagadi Transfrontier Park near a dry riverbed of the Nossob, surrounded by shrubby savanna with *Rhigozum trichotomum* (Bignoniaceae) and *Schmidtia kalahariensis* (Poaceae) dominant.

Remark 2 The Southern Kalahari Mekgacha differ from the Bushmanland Vloere and Southern Karoo Riviere in climatic, geological (origin) and floristic terms. The Bushmanland pans (vloere) are distinguished by an increased occurrence of shrubby elements (especially *Salsola* and similar karoo dwarf shrubs), while the Southern Karoo Riviere have well-developed tall-shrub structures fringing the riverbeds but lack the *Acacia erioloba* of the Mekgacha.

Remark 3 Some of the longer rivers in the region, especially the Molopo, have a generally progressive reduction in larger woody plant cover in a downstream direction due to reduced penetration of water flow with increasing distance into the more arid regions.

References Leistner (1967), Leistner & Werger (1973), Werger & Leistner (1975), Werger & Coetzee (1977), Noble & Hemens (1978), Werger (1978), Thomas & Shaw (1991), De Wit (1999), Smit (2000), Malan (2003), Goudie (2005).

AZi 4 Southern Kalahari Salt Pans

Distribution Northern Cape and North-West Provinces and neighbouring Kalahari regions of Botswana and Namibia: System of endorheic, closed depressions (pans) in the southern Kalahari as defined by Thomas & Shaw (1991) south of the Bakalahari Schwelle. The largest concentrations of such pans in South Africa are found near Groot-Mier in western Gordonia. Altitude ranging from 800–1 500 m.

Vegetation & Landscape Features Low grasslands on pan bottoms (these often devoid of vegetation) often dominated by *Sporobolus* species, with a mixture of dwarf shrubs. The low shrubland dominated by *Lycium* and/or *Rhigozum* usually forms the outer belt in the salt-pan zonation systems.

Geology, Soil & Hydrology Most of the pans formed on the sandy sediments of the Cenozoic Kalahari Group; in the southeast some formed on the dolomites of the Campbell Group (Vaalian-age Griqualand West Supergroup) and in the west some formed on diamictites of the Dwyka Group (Karoo Supergroup). Extensive pan-like areas occur locally in slightly higher-lying portions of dry riverbeds (mekgacha), where they are isolated from the river course by a raised, compact calcareous sand formation—the pan-like alluvium consists of sandy loam and a fairly high content of calcium and phosphate (Leistner & Werger 1973, Werger 1978). The pan soils consist of white (washed) sand in shallow pans ('sand pans'), rocky soils on calcrete outcrops and most typically of clays and sandy clays very rich in Na, K, Mg and are characterised by high a pH, reaching values of 9. The pan bottoms are exposed for most of the year and carry shallow pools for a short time only after very good rains (March–April).

Climate For the climate account of this unit see AZi 3 Southern Kalahari Mekgacha, sharing basically the same region in South Africa. See also climate diagram for AZi 4 Southern Kalahari Salt Pans (Figure 13.2).

Important Taxa Succulent Shrubs: *Zygophyllum tenue* (d), *Salsola scopiformis*. Herbs: *Hirpicium gazanioides*, *Tribulus terrestris*. Succulent Herb: *Trianthema triquetra* subsp. *parvifolia*. Graminoids: *Enneapogon desvauxii* (d), *Eragrostis truncata* (d), *Sporobolus coromandelianus* (d), *S. rangei* (d), *Panicum impeditum*.

Conservation Least threatened. Target 24%. About 8% statutorily conserved in the Kgalagadi Transfrontier Park. The vegetation of the pans is subject to natural degradation/regeneration cycles controlled by concentration of grazing animals (antelopes in particular).

References Leistner (1967), Leistner & Werger (1973), Werger & Leistner (1975), Werger & Coetzee (1977), Noble & Hemens (1978), Werger (1978), Lancaster (1986), Skarpe (1986), Thomas & Shaw (1991), Bezuidenhout (1995), Smit (2000).

AZi 5 Bushmanland Vloere

Distribution Northern Cape Province: Vloere (salt pans) of the central Bushmanland Basin as well as the broad riverbeds of the intermittent Sak River (functioning as temporary connection between some of the pans) as well as its numerous ancient (today dysfunctional) tributaries. The patches of this vegetation unit are embedded especially within NKb 6 Bushmanland Basin

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Figure 13.33 AZi 5 Bushmanland Vloere: Shrubland with dominant *Rhigozum trichotomum* (Bignoniaceae) in a 'vloer' near Brandvlei in central Bushmanland (Northern Cape). The yellow-flowered plant is the annual *Gazania lichtensteinii* (Asteraceae).

Shrubland and NKb 3 Bushmanland Arid Grassland and to a lesser extent also within NKb 4, NKu 1, NKu 2 as well as marginal Succulent Karoo units summarised within the bioregion of Trans-Escarpment Succulent Karoo. Altitude 850–1 450 m.

Vegetation & Landscape Features Flat and very even surfaces of pans and broad bottoms of intermittent rivers. The centre of a pan (or the river drainage channel itself) is usually devoid of vegetation; loosely patterned scrub dominated by *Rhigozum trichotomum* and various species of *Salsola* and *Lycium*, with a mixture of nonsucculent dwarf shrubs of Nama-Karoo relationship. In places loose thickets of *Parkinsonia africana*, *Lebeckia linearifolia* and *Acacia karroo* can be found.

Geology, Soil & Hydrology Endorheic pans and alluvia of associated intermittent rivers filled with silty and clayey alluvial deposits with a high content of concentrated salt (sodic soils), supported by Ecca Group shales and Dwyka diamictites (Karoo Supergroup). Watkeys (1999) found that in the pan of Brandvlei, the orthic A horizon is underlain by a soft carbonate subsoil and the soils of the alluvial terraces of the Sak River are deep (more than 1 000 mm), stratified and weakly structured and calcareous. Ia land type. Erosion in some places can be considerable, especially after unpredictable heavy thunderstorms leading to sudden swelling of the Sak River. The pans can be filled in wet summers and in autumn.

Climate Arid, seasonal climate with bimodal (equinoctial) precipitation regime—two peaks, one in March and another in November. Overall MAP 141 mm (range 91 mm in western Bushmanland to 306 mm at northern edges of the Roggeveld). Overall MAT 16.8°C (range 17.4°C in northern Bushmanland to 14.5°C on northern edge of the Roggeveld). The region where the Bushmanland Vloere occur, is known for thermic extremes, both long-term (mean daily temperature in January approaching 32°C and in July only several degrees above zero) and short-term (daily temperature amplitude around 25°C). Frequent occurrence of frost is also indicative of the high thermic continentality of the region. See also climate diagram for AZi 5 Bushmanland Vloere (Figure 13.2).

Important Taxa Tall Shrubs: *Parkinsonia africana*, *Xerocladia viridiramis*. Low Shrubs: *Rhigozum trichotomum* (d), *Aizoon schellenbergii*, *Asparagus glaucus*, *Eriocephalus decussatus*, *E. spinescens*, *Pegolettia retrofracta*. Succulent Shrubs: *Salsola aphylla* (d), *S. glabrescens* (d), *S. rabieana* (d), *Lycium pumilum*, *Salsola gemmifera*. Herbs: *Amaranthus dinteri* subsp. *dinteri*, *Lotononis minima*. Geophytic Herb: *Crinum variabile*. Graminoids: *Stipagrostis ciliata* (d), *S. obtusa* (d), *Sporobolus nervosus*, *Stipagrostis namaquensis*.

Conservation Least threatened. Target 24%. None conserved in statutory conservation areas. About 2% transformed for cultivation or building of dams (Vanwyksvlei Dam). Alien *Prosopis* occurs as scattered in some vloere and dry riverbeds. Several of the pans are mined for salt production.

Remark 1 We have refrained from distinguishing pans and the channels of intermittent rivers (unlike in Namaqualand, Kalahari and Highveld regions) as different major habitat complexes, hence different vegetation units deserving independent status. The pans (vloere) and the intermittent rivers of Bushmanland are closely related in terms of origin, geology and the floristic composition of the vegetation they support and they merge into each other at many localities, making the separation virtually impossible. The extensive pan and river system of Bushmanland is a remnant of the ancient Karoo River and later Palaeo-Orange River which have been draining the centre of the region since the Late Cretaceous (for development of these riverine systems see Dingle & Hendey 1984, De Wit 1999 and Goudie 2005). An important role in (trans)formation of the Bushmanland riverine system was played by the Koa River, which drained the area (then covered by dense tropical forest) from Miocene to Late Quaternary (Pleistocene). The Koa River left its traces through a series of pans spanning Commisioner's Pan located west of Brandvlei and Bosluis se Pan found south of Aggeneys as well as through a broad valley filled with deep red sands in the present-day Koa Valley in northern Bushmanland (see also NKb 4 Bushmanland Sandy Grassland).

Remark 2 A reliable floristic characterisation of this unit is not feasible at this stage due to the pending taxonomic revision of the South African representatives of the genus *Salsola*, one of the most important generic components of vegetation of Bushmanland. The vegetation of the AZi 5 Bushmanland Vloere remains of the least studied in the country.

References Acocks (1953), Noble & Hemens (1978), Le Roux et al. (1985), Day (2005b).

AZi 6 Southern Karoo Riviere

Including Mesic Riparian Bush & Xeric Riparian Bush (Van der Walt 1980). Riparian Thicket (Palmer 1991). *Lycium cinereum-Salsola aphylla* Shrubland & *Acacia karroo-Stipagrostis namaquensis* Riparian Woodland (Rubin & Palmer 1996). *Becium burchellianum-Acacia karroo* Woodland (Brown & Bezuidenhout 2000).

Distribution Western and Eastern Cape Provinces: Alluvia of the Buffels, Bloed, Dwyka, Gamka, Sout, Kariega, and Sundays Rivers and their tributaries), east of Laingsburg as far west as Graaff-Reinet and Jansenville. This vegetation unit is embedded within the Koedoesberge-Moordenaars Karoo, Prince Albert Succulent Karoo, Gamka Karoo, Eastern Lower Karoo, and southern parts of the Eastern Upper Karoo as well as some

parts of the Albany Thicket Biome south of Cradock. Altitude ranging from 250–1 550 m.

Vegetation & Landscape Features Narrow riverine flats supporting a complex of *Acacia karroo* or *Tamarix usneoides* thickets (up to 5 m tall), and fringed by tall *Salsola*-dominated shrubland (up to 1.5 m high), especially on heavier (and salt-laden) soils on very broad alluvia. In sandy drainage lines *Stipagrostis namaquensis* may occasionally also dominate. Mesic thicket forms in the far eastern part of this region (see Van der Walt 1980: Table 4) may also contain *Leucosidea sericea*, *Rhamnus prinoides* and *Ehrharta erecta.*

Geology, Soil & Hydrology Recent sandy-clayey alluvial deposits rich in salt occurring on mudrocks and sandstones of the Adelaide Subgroup (Beaufort Group of the Karoo Supergroup) that support soils typical of Ia land type. Torrential convectional rains in summer cause sudden flood surges which remodel the riverbed and adjacent alluvium.

Climate Transitional, bimodal (equinoctial) rainfall patterns with peaks in March (major) and November (minor). Climate is subarid on the whole, with overall MAP of 243 mm (range from 165 mm in the Gamka Karoo basin to 430 mm in the vicinity of Bedford). Overall warm-temperate regime, with MAT of 16.3°C, ranging from 14.6°C (Upper Karoo) to 18.3°C (upper reaches of Sundays River). Frost occurs frequently in winter. See also climate diagram for AZi 6 Southern Karoo Riviere (Figure 13.2).

Important Taxa **Riparian thickets** Small Trees: *Acacia karroo* (d), *Rhus lancea* (d). Tall Shrubs: *Diospyros lycioides* (d), *Tamarix usneoides* (d), *Cadaba aphylla*, *Euclea undulata*, *Grewia robusta*, *Gymnosporia buxifolia*, *Melianthus comosus*. Low Shrub: *Asparagus striatus*. Succulent Shrubs: *Lycium cinereum* (d), *Amphiglossa callunoides*, *Lycium hirsutum*, *L. oxycarpum*. **Rocky slopes of river canals** Graminoid: *Stipagrostis namaquensis* (d). **Alluvial shrublands & herblands** Low Shrubs: *Ballota africana*, *Bassia salsoloides*, *Carissa haematocarpa*, *Pentzia incana*. Succulent Shrubs: *Malephora uitenhagensis* (d), *Salsola aphylla* (d), *S. arborea* (d), *Drosanthemum lique*, *Salsola geminiflora*, *S. gemmifera*. Graminoids: *Cynodon incompletus* (d), *Cenchrus ciliaris*, *Cyperus marginatus*. **Reed beds** Megagraminoid: *Phragmites australis* (d).

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Figure 13.34 AZi 6 Southern Karoo Riviere: *Acacia karroo* thickets on valley alluvium below the Molteno Pass near Beaufort West (Western Cape).

Endemic Taxon **Alluvial shrublands & herblands** Graminoid: *Isolepis expallescens*.

Conservation Least threatened. Target 24%. Only about 1.5% statutorily conserved in the Karoo National Park as well as in the Aberdeen, Bosberg, Commando Drift, Gamkapoort and Karoo Nature Reserves and in about 10 private reserves, mainly set up for game farming. Some 12% transformed for cultivation and building of dams, including Beaufort West, Beervlei, De Hoop, Floriskraal, Kommandodrift, Lake Arthur, Leeu-Gamka, Mentz and Vanryneveldspas Dams. Frequent disturbance (floods, concentrated grazing pressure), and associated input of nutrients, increase vulnerability of these habitats to invasion of alien woody species such as *Agave americana*, *Opuntia* species, *Prosopis* species, *Salix babylonica* and *Schinus molle*, and forbs including *Atriplex eardleyae*, *A. lindleyi* subsp. *inflata*, *Cirsium vulgare*, *Salsola kali* and *Schkuhria pinnata.*

Remark 1 Due to the lingering taxonomic problems, the identity of South African species of *Salsola* sect. *Caroxylon* cited in various papers (see below), should be approached with caution.

Remark 2 Plants of drainage lines may be resistant to damage by hail storms. At the Tierberg Karoo Research site, 36 of the 44 species in drainage lines were undamaged after a hail storm, with the remaining species only slightly damaged (Milton & Collins 1989). This contrasted with much higher levels of damage to plants of the surrounding habitats (flats and heuweltjies).

References Acocks (1979), Van der Walt (1980), Palmer (1988, 1989, 1991), Milton (1990), Rubin & Palmer (1996), Brown & Bezuidenhout (2000).

AZi 7 Tanqua Wash Riviere

Distribution Western Cape and (to a smaller extent) Northern Cape Provinces: Alluvia of the Tankwa and Doring Rivers and sheet-wash plains of their less important tributaries embedded within SKv 5 Tanqua Karoo. Altitude ranging from 300–1 000 m.

Vegetation & Landscape Features Deeply incised valleys (sometimes several hundred metres broad) of intermittent rivers supporting a mosaic of succulent shrublands with *Salsola* and *Lycium* alternating with *Acacia karroo* gallery thickets. The broad sheet-wash plains support sparse vegetation of various *Salsola* species, often building phytogenic hillocks interrupting the monotonous barren face of a sheet wash. Occasional rainfalls in early winter result in localised displays of annuals and early flowering geophytes along washes.

Geology, Soil & Hydrology Broad Quaternary alluvial floors and drainage lines filled with recent sediments mostly from eroded Karoo Supergroup sediments. Sodic loamy to sandy soils (Ia land type) are predominantly supported by sediments of the Ecca and Dwyka Groups of the Karoo Supergroup. In the west, rocks of the Devonian Bokkeveld Group (Cape Supergroup) and

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Figure 13.35 AZi 7 Tanqua Wash Riviere: Riparian thickets dominated by *Acacia karroo* and *Salsola arborea* with fringing alluvial gannabosveld along the Tankwa River.

in the east, the Permian Adelaide Subgroup (Karoo Supergroup) also support these soils. The run-off in these habitats is very low and spread over large areas.

Climate Region characterised by arid to hyperarid climate, with MAP ranging between 100 mm and 170 mm (lowest long-term average is 72.3 mm for Elandsvlei on the Tankwa River). Overall MAP 162 mm, mainly falling in autumn and winter. Mean daily maximum and minimum temperatures are 32.5°C and 3.0°C for January and July, respectively. Overall MAT is slightly higher than 17°C. Due to basin macrotopography the occurrence of frost is fairly frequent. See also climate diagrams for AZi 7 Tanqua Wash Riviere (Figure 13.2) and SKv 5 Tanqua Karoo (Figure 5.65 in Chapter on Succulent Karoo in this book).

Important Taxa **Riparian thickets** Small Tree: *Acacia karroo* (d). **Alluvial shrublands & herblands** Low Shrub: *Galenia africana*. Succulent Shrubs: *Lycium cinereum* (d), *Malephora luteola*, *Salsola arborea*, *Sarcocornia mossiana* agg. Geophytic Herbs: *Moraea speciosa*, *Tritonia florentiae*. Graminoids: *Cladoraphis spinosa*, *Stipagrostis obtusa*. **Sheet washes** Succulent Shrubs: *Augea capensis*, *Salsola aphylla*. Herbs: *Euryops annuus*, *Gazania lichtensteinii*, *Osteospermum pinnatum*, *Ursinia nana*.

Endemic Taxa **Alluvial shrublands & herblands** Herbs: *Limonium* sp. nov. (*Mucina 310104/1* STEU). **Sheet washes** Succulent Shrub: *Salsola ceresica* (d).

Conservation Least threatened. Target 19%. About 13% statutorily conserved in the Tankwa National Park and in some private reserves (Inverdoorn, Jakkalsfontein, Uintjieskraal, Groote Kapelsfontein, Vaalkloof). About 3% already transformed for cultivation or dam building (Oudebaaskraal Dam and Swartkop se Dam). Alien *Atriplex lindleyi* subsp. *inflata* and *Prosopis* species can become frequent in places.

Remarks We acknowledge that this unit is of heterogeneous character at present and the ecological and floristic relationship between the *Acacia karroo*-dominated riparian vegetation on the one hand and the *Salsola*-dominated sheet-wash vegetation on the other, deserves re-evaluation in the light of new data still to be collected.

Reference Rubin (1998).

AZi 8 Muscadel Riviere

Distribution Western Cape Province: River alluvia of the lower Breede River (between Worcester and Bonnievale) as well as those embedded within the western Little Karoo (Montagu area) and eastern Little Karoo (the rivers draining the basin around Oudtshoorn). Altitude 150–600 m.

Vegetation & Landscape Features Flat, in places very broad alluvia originally supporting a complex of riverine thickets dominated by *Acacia karroo* and accompanying succulent gannabos (*Salsola* species) and low vygie shrublands. Today the typical landscape view of these alluvia is dominated by extensive vineyards and orchards, with a narrow alley of alien woody species (*Eucalyptus* species, *Salix babylonica*) fringing the riverbanks.

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Figure 13.36 AZi 7 Tanqua Wash Riviere: Gannabos (*Salsola ceresica*) on sparsely vegetated sheet wash-plain in the desert-like western part of Tankwa National Park (Western Cape).

Geology, Soil & Hydrology Recent sandy and clayey alluvial (riverine) sediments mostly derived from the clastic sediments of the Jurassic-Cretaceous Uitenhage Group supporting soils typical of Ia land type. These alluvial habitats frequently suffer from devastating floods occurring especially with the first cold western frontal systems bringing torrential rain to the Cape (such as recently in 1981, 2002, 2004 and 2005).

Climate The regional climate diagram for this unit suggests almost evenly spread precipitation. However, winter rainfall prevails in the western part of the region and becomes nonseasonal towards the eastern limits of the distribution of this vegetation type (eastern Little Karoo). MAP is low (210 mm; range 220 mm in the rainshadow of the Langeberg to

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Figure 13.37 AZi 8 Muscadel Riviere: Alluvial thicket (with dominant *Acacia karroo*) at the bottom of the Huis River in the Huisrivier Pass west of Calitzdorp. Part of the alluvium has been cleared for agriculture.

368 mm in the Breede River Valley) due to the rainshadow effect from the surrounding mountain ranges of the Cape Fold Belt. The region is characterised by relatively high MAT (17.9°C; range 16.0°C in Breede River Valley to 17.2°C near Willowmore) and particularly hot summers (with temperatures reaching above 40°C (especially in Worcester). See also climate diagram for AZi 8 Muscadel Riviere (Figure 13.2).

Important Taxa **Riparian thickets** Trees: *Acacia karroo* (d), *Salix mucronata* subsp. *mucronata* (d), *Rhus lancea*. **Alluvial shrublands & herblands** Tall Shrubs: *Cliffortia strobilifera, Melianthus comosus*, *Tamarix usneoides*. Low Shrubs: *Galenia africana* (d), *Pentzia incana* (d), *Atriplex vestita* var. *appendiculata*, *Chrysanthemoides incana*, *Polygala virgata* var. *virgata*, *Pteronia oblanceolata*. Succulent Shrubs: *Malephora luteola* (d), *Salsola aphylla* (d), *S. arborea* (d), *Bassia salsoloides, Lycium arenicola*, *Suaeda fruticosa, Zygophyllum sessilifolium*. Herb: *Berkheya spinosa*. Succulent Herb: *Psilocaulon junceum*. Graminoids: *Ehrharta calycina*, *E. delicatula*. **Reed beds** Megagraminoids: *Phragmites australis* (d), *Typha capensis* (d).

Endemic Taxon **Alluvial shrublands & herblands** Herb: *Pelargonium citronellum*.

Conservation Endangered. Target 16%. Small patches of this vegetation are protected in the Vrolijkheid Nature Reserve near McGregor (Van der Merwe 1977a) and Kammanassie Nature Reserve (Cleaver et al. 2005) as well as on private land (Greylands, Die Poort). More than 60% already transformed for cultivation (vineyards, orchards) or road building. Aliens *Arundo donax*, *Atriplex lindleyi* subsp. *inflata*, *Chenopodium* species, *Datura* species, *Prosopis glandulosa*, *Ricinus communis*, *Schinus molle*, *Tamarix chinensis* and *T. ramosissima* cause local infestations.

Remark 1 The classification of the '*Calpurnia intrusa-Rhus pallens* Woodland' by Cleaver et al. (2005) described from streambanks of the Vermaaks River (Kammanassie Mountains, eastern Little Karoo) from altitudes 543–675 m remains only tentative. Two communities described within this woodland show transitional character between riparian thickets of the Muscadel Riviere on the one hand and eastern facies of Cape thickets (see chapter on the Fynbos Biome in this book) on the other.

Remark 2 The name of this unit celebrates the marvellous sweet fortified wines (mainly muscadel, but also local port wine) made from grapes grown on the alluvial soils of the summer-hot Robertson Karoo and Little Karoo.

References Joubert (1968), Van der Merwe (1977a), Vlok (2002), Cleaver et al. (2005).

AZi 9 Cape Inland Salt Pans

Distribution Western and Eastern Cape (to smaller extent) Provinces: Jakkalsrivier Valley between Graafwater and Lambert's Bay, Rocher Pan and other pans near Dwarskersbos (near Velddrif), Soutpan near Yzerfontein, Rondevlei, Paardevlei, Noordhoek (all near Cape Town), salt vleis of the Agulhas Plain, Zoutpan and several other smaller salt pans in the Albertinia region (Zoutpan, Melkhoutfontein, Vogelvlei). We also include saline habitats near Worcester and an extensive system of saline alluvia, saline floodplain flats (Karsrivier) and slope saline scars scattered around the Overberg region (e.g. the vicinity of Napier, Bredasdorp, Stormsvlei and Swellendam). These pans occur

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Figure 13.38 AZi 9 Cape Inland Salt Pans: A salt pan on the Agulhas Plain (Overberg region, Western Cape) housing sparse population of an undescribed species of *Salicornia* (Chenopodiaceae) and local endemic *Limonium kraussianum* (Plumbaginaceae).

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Figure 13.39 AZi 9 Cape Inland Salt Pans: Small-scale hypersaline pans near Yzerfontein on the Cape West Coast. Vegetation is dominated by *Sarcocornia natalensis* var. *affinis*, *Suaeda inflata*, *Plantago crassifolia* complex, *Frankenia repens*, *Salicornia meyeriana*, *Sporobolus virginicus* and *Limonium equisetinum*.

Polypogon monspeliensis, *Prionanthium pholiuroides*, *Tribolium hispidum*.

Endemic Taxa Succulent Shrubs: *Disphyma dunsdonii* (d), *Drosanthemum salicola*, *Lampranthus salicola*. Herbs: *Dymondia margaretae* (d), *Limonium anthericoides*. Succulent Herb: *Dorotheanthus clavatus*. Aquatic Herb: *Pseudalthenia aschersoniana*.

Conservation Vulnerable. Target 24%. Some 20% statutorily conserved in the Agulhas and West Coast National Parks as well as in the Soetendalsvlei and Rocherpan Nature Reserves. Furthermore, almost 3% enjoys protection on private land (Rietvlei, Rhenosterkop). More than 20% has been transformed for cultivated land, mines (in the past some of the pans near Albertinia were exposed to salt mining; Muir 1929) or by urban sprawl. Alien (Australian) herbaceous *Atriplex* species show invasive behaviour in places.

References Muir (1929), Noble & Hemens (1978), Van Rooyen (1981), Olivier (1983), Gray (1997), Harding et al. (2000).

as far east as the broader surrounds of the Nelson Mandela Metropole (Soutpan near Dispatch and smaller pans near Uitenhage, Port Elizabeth and Addo). Altitude ranging from 0–150 m, with few isolated pans at around 500 m.

Vegetation & Landscape Features Small depressions dominated by low succulent scrub composed of creeping chenopods and salt-tolerant herbs and grasses. The saline Overberg alluvia are dominated by a low succulent shrub, *Sarcocornia mossiana*.

Geology, Soil & Hydrology Originally, most of the saline pans were coastal lagoons but they became dry after having been cut off from the sea—they may become temporarily flooded by winter rains and remain mostly dry in summer. Some of the smaller salt pans along the coast might have originated through deflation processes on easy-eroding coastal calcrete. The pans in the Overberg region are mostly on Bokkeveld Group shales as well as the much younger sandstone and limestone of the Bredasdorp Group nearer the coast. The saline alluvia of some Overberg rivers were formed by sediments that originated from erosion scars of salt-bearing Bokkeveld shale.

Climate The occurrence of Cape inland salt pans spans typical winter-rainfall (West Coast) and transitional (winter-summer) rainfall regions (Port Elizabeth and Grahamstown areas). MAP ranges from 278 mm (Langebaan) to 627 mm (Humansdorp), while the range of MAT is less pronounced: 15.9°C for the Overberg to 17.5°C for the Sundays River Valley. The ocean has an ameliorating effect on temperature patterns in hot, dry summers. See also climate diagram for AZi 9 Cape Inland Salt Pans (Figure 13.2).

Important Taxa Low Shrubs: *Morella cordifolia*, *Orphium frutescens*, *Senecio halimifolius*. Succulent Shrubs: *Sarcocornia capensis* (d), *S. mossiana* complex (d), *Atriplex cinerea* subsp. *bolusii*, *Lycium cinereum*, *Sarcocornia pillansii*, *Suaeda inflata*. Herbs: *Frankenia repens* (d), *Limonium equisetinum* (d), *L. kraussianum* (d), *Chironia baccifera*, *C. decumbens*, *C. tetragona*. Succulent Herbs: *Malephora luteola* (d), *Plantago crassifolia* complex (d), *Sarcocornia natalensis* (d), *Halopeplis amplexicaulis*. Graminoids: *Chondropetalum microcarpum* (d), *C. nudum* (d), *Sporobolus virginicus* (d), *Elegia verreauxii*, *Ficinia lateralis*, *F. ramosissima*,

AZi 10 Highveld Salt Pans

Distribution Northern Cape, Eastern Cape, North-West, Free State and Gauteng Provinces: Pans scattered on broad Grassland/Karoo and Grassland/Savanna interface roughly between Mafikeng/Koster in the north and Britstown/Middelburg in the south. The highest concentrations of pans are found around Dealesville, Bultfontein, Wesselsbron, Delareyville and Petrusburg. The average size of the playas in the western Free State is 0.2 km^2, with a number of the largest ones (e.g. Florisbad Pan and Annaspan) measuring several kilometres across (Goudie & Thomas 1985). Altitude ranging from 1 000–1 600 m.

Vegetation & Landscape Features Depressions in plateau landscape containing temporary (and less frequently also permanent) water bodies. Central parts of the pans often seasonally inundated and sometimes with floating macrophyte vegetation or the vegetation cover develops on drained bottoms of the pans and forms typical concentric zonation patterns. On the pan edges open to sparse grassy dwarf shrubland may develop, especially when the pan is under heavy grazing pressure.

Geology, Soil & Hydrology The bottoms of the pans are usually formed by shales of the Ecca Group giving rise to vertic clays. The environment of the pans undergoes dramatic changes from freshwater systems during the wet season to saline systems as the dry season progresses and evaporation intensifies. Wind erosion is of particular significance during the dry season, when the playa basin is dry and marginal vegetation is short and sparse (Allan et al. 1995). Dense dust can reach several thousand metres into the air under such windy conditions.

Climate These salt pans occur in arid and semi-arid elevated regions of the Highveld, receiving less than 500 mm rain per year. Overall MAP 400 mm (range from 275 mm in the Upper Karoo to 654 mm in Gauteng). Characterised by thunderstorms leading to high water run-off and low soil absorption. The climate pattern spans bimodal (equinoctial) to typically summer-rainfall in the northeastern regions. The overall MAT of 16.7°C (range 14.3°C near Aliwal North to 18.3°C near Mafikeng). Frequent incidence of frost corresponds to high thermic

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Figure 13.40 AZi 10 Highveld Salt Pans: Salt pan at Hutchinson (Northern Cape).

continentality. See also climate diagram for AZi 10 Highveld Salt Pans (Figure 13.2).

Important Taxa Low Shrubs: *Atriplex vestita*, *Felicia filifolia*, *F. muricata*, *Nenax microphylla*, *Nestlera conferta*, *Pentzia globosa*, *P. incana*. Succulent Shrubs: *Salsola glabrescens* (d), *Lycium cinereum*, *Malephora herrei, Suaeda fruticosa*, *Titanopsis hugo-schlechteri*. Megagraminoids: *Cyperus congestus*, *Phragmites australis*, *Typha latifolia*. Graminoids: *Chloris virgata* (d), *Cynodon dactylon* (d), *C. transvaalensis* (d), *Cyperus laevigatus* (d), *C. marginatus* (d), *Diplachne fusca* (d), *Eragrostis bicolor* (d), *E. chloromelas* (d), *E. plana* (d), *Hemarthria altissima* (d), *Juncus rigidus* (d), *Panicum coloratum* (d), *P. laevifolium* (d), *P. schinzii* (d), *Setaria incrassata* (d), *Andropogon eucomus*, *Aristida adscensionis*, *Brachiaria marlothii*, *Cyperus longus*, *C. rigidifolius*, *Echinochloa holubii*, *Eleocharis palustris*, *Enneapogon desvauxii*, *Eragrostis curvula*, *E. micrantha*, *E. obtusa*, *E. stapfii*, *Fuirena coerulescens*, *F. pubescens*, *Juncus exsertus*, *Scirpoides dioecus*, *Sporobolus albicans*, *S. fimbriatus*, *S. ioclados*, *S. tenellus*, *Tragus berteronianus*, *T. racemosus*. Herbs: *Alternanthera sessilis*, *Amaranthus praetermissus*, *Aponogeton rehmannii, Atriplex suberecta*, *Chenopodium mucronatum*, *Gnaphalium declinatum*, *Mollugo cerviana*, *Phyla nodiflora*, *Platycarpha parvifolia*, *Pterodiscus speciosus*, *Senecio reptans*. Succulent Herb: *Zygophyllum simplex*.

Biogeographically Important Taxon (Highveld endemic) Herb: *Rorippa fluviatilis* var. *caledonica*.

Endemic Taxon Herb: *Gnaphalium simii*.

Conservation Target 24%. Only very small portion statutorily conserved in the Vaalbos National Park and in the Bloemhof Dam, Soetdoring, Willem Pretorius, Barberspan (a Ramsar site) and S.A. Lombard Nature Reserves. About 4% has been transformed so far, but threats by agriculture, road building, mining and urbanisation are still increasing. Alien plants such as *Atriplex semibaccata*, *Conyza albida*, *Flaveria bidentis*, *Salsola kali*, *Schkuhria pinnata*, *Sonchus oleraceus*, *Spergularia rubra*, *Tagetes minuta*, *Verbena brasiliensis* and *Xanthium* species (Cilliers & Bredenkamp 2003, Janecke et al. 2003) have been recorded in the vegetation of these salt pans.

Remark 1 In the northeastern regions of the NKu 4 Eastern Upper Karoo (e.g. along the upper Orange River Valley between Aliwal North and Petrusville, in the broad area of Middelburg, Rosmead, Hanover and Colesberg) eroding calcrete outcrops in wide pan-like depressions form an interesting microhabitat. It is characterised by shallow, white, powdery and highly alkaline soils (Werger 1980 measured pH values above 8) usually supporting dominants similar to those of true salt pans, including *Salsola glabrescens*, *Zygophyllum incrustatum*, *Eragrostis truncata*, *Sporobolus* species and *Pentzia globosa* as well as some odd vygies such as *Trichodiadema pomeridianum*, *Titanopsis schwantesii* and *Delosperma 'ornatulum'* (Werger 1980, p. 77).

Remark 2 The vegetation of the Highveld Salt Pans differs greatly from that of other pan types (Namaqualand Salt Pans, Bushmanland Vloere, Southern Kalahari Salt Pans and Cape Inland Salt Pans) mainly due to the dominance of cyperoids.

Remark 3 Geldenhuys (1982) distinguished the six pan types based on the presence of emergent vegetation—bare, sedge, scrub, mixed grass, closed, and open *Leptochloa* playas.

References Noble & Hemens (1978), Werger (1980), Seaman (1987), Kooij et al. (1990b), Seaman et al. (1991), Breen et al. (1993), Allan et al. (1995), Bezuidenhout (1995), Malan (1998), Janecke (2002), Cilliers & Bredenkamp (2003), Janecke et al. (2003).

AZi 11 Subtropical Salt Pans

Distribution Limpopo, Mpumalanga and KwaZulu-Natal Provinces and in Swaziland: Pans in the subtropical regions of eastern southern Africa, in particular in the Lowveld, Maputaland and northern KwaZulu-Natal. Altitude ranging from 0–1 400 m.

Vegetation & Landscape Features Shallow depressions, often found on old alluvial terraces of rivers, surrounded by zones of bank reeds or low herblands and in more perennial pans also filled with a dense carpet of macrophytic floating vegetation.

Geology, Soil & Hydrology The pans occur on Cenozoic alluvium, sand and calcrete, but also significantly on sediments of the Cretaceous Zululand Group. Large perennial-water pans are found in the alluvia of the Phongolo and Usutu Rivers. During the drier winter period, the water may recede below ground and salt may precipitate on the banks (this especially in the case of small zoogenic pans in the Kruger National Park), the water in the pans consequently becoming brackish and even saline. The salinity of water of some other pans (such as the Nyamithi Pan in the Ndumo Game Reserve) is attributed to leaching of salt from Cretaceous sediments of marine origin (Hattingh & Matthews 2003).

Climate Seasonal, summer-rainfall regime with MAP ranging from 311 mm in the Limpopo Valley to 964 mm in Maputaland. Subtropical temperature regime with MAT ranging from 18.0°C in the Central Bushveld to 22.0°C in Maputaland), with very infrequent incidence of frost (only in marginal areas of contact with the Grassland Biome in the Central Bushveld). See also climate diagram for AZi 11 Subtropical Salt Pans (Figure 13.2).

Important Taxa **Drained pan bottoms** Graminoids: *Cynodon dactylon* (d), *Diplachne eleusine* (d), *Eragrostis rotifer* (d), *Chloris virgata*, *Cyperus indecorus*. Herbs: *Isoetes schweinfurthii, Persicaria senegalensis*. **Pan edges** Megagraminoid: *Phragmites mauritianus* (d). Graminoids: *Digitaria didactyla*, *Echinochloa pyramida-*

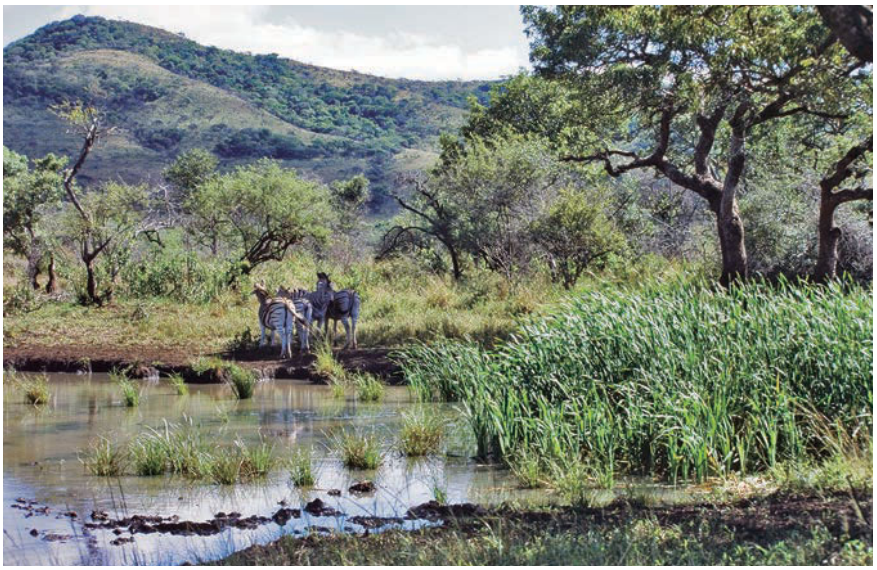

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Figure 13.41 AZi 11 Subtropical Salt Pans: A pan near Masinda Camp in the Hluhluwe-iMfolozi Park with a reed bed of *Typha capensis* and resting zebra (*Equus burchellii*).

lis, *Paspalum vaginatum*, *Sporobolus smutsii*. Herbs: *Eclipta prostrata, Marsilea ephippiocarpa, Persicaria hystricula*, *Syngonanthus wahlbergii*. **Pan lakes** Herb: *Ludwigia stolonifera* (d). Aquatic Herbs: *Azolla pinnata* var. *africana* (d), *Ceratophyllum demersum* (d), *Nymphaea nouchali* var. *caerulea* (d), *Potamogeton crispus* (d), *Trapa natans* var. *bispinosa* (d), *Wolffia arrhiza* (d), *Monochoria africana*, *Najas pectinata*, *Nymphaea lotus*. Carnivorous Herb: *Utricularia inflexa* (d).

Endemic Taxon **Pan edges** Aquatic Herb: *Marsilea fenestrata*.

Conservation Least threatened. More than 40% (well over the target of 24%) statutorily conserved in the Greater St Lucia Wetland Park, Ndumo Game Reserve (both Ramsar sites), Kruger National Park as well as in the private Zoutpan Nature Reserve. About 11% has been transformed for mines, cultivation and plantations. Aliens *Cardiospermum halicacabum* and *Argemone ochroleuca* invade edges of some of the pans. Alien floating *Pistia stratiotes* and *Nymphaea lotus* are dominant in some Lowveld pans when filled with water.

Remark 1 Subtropical salt pans have always served as an important source of water (and salt) for ungulates abundant in the Savanna Biome. In winter wild animals teem around the water 'holes' (often natural pans with residual water from the summer), a spectacle attracting thousands of local and overseas tourists.

Remark 2 At least one salt pan has been recognised as a result of a meteorite impact that resulted in a crater, the floor of which later developed into a temporary flooded salt pan. This is the Tswaing Crater (formerly Pretoria Salt Pan) 40 km north of Pretoria and it is 200 000 years old.

References Musil et al. (1973), De Moor et al. (1977), Noble & Hemens (1978), Goodman (1981), Gertenbach (1983), Begg & Carser (1988, 1989), Schmidt (1992), Schmidt et al. (1993), Breebaart & Deutschländer (1997).

8. Credits

The concept of the classification of the inland azonal vegetation units was formulated by L. Mucina with assistance of M.C. Rutherford and L.W. Powrie. These authors have also prepared the first-approach map of the units using land-cover, satellite imagery and digitised topographic maps featuring lakes, pans and major wetlands. Many of the azonal vegetation patches were classified after extensive field work. The Namaqualand salt pans were mapped by A. le Roux, while parts of the coverage for alluvial and freshwater wetlands of the Capensis were provided by A.G. Rebelo, C. Boucher (both within the Fynbos Biome) and J.C. Manning (vernal pools).

The introductory text was written by L. Mucina, with contributions by J. Gerber (Section 5). L. Mucina wrote descriptions of all vegetation units as first author except for AZi 1 and 2, where he assisted A. le Roux. The following colleagues co-authored several descriptions: M.C. Rutherford (AZi 3, 5 and 6), G.J. Bredenkamp (AZa 5 and AZi 10), P.J. du Preez (AZa 4 and AZi 10), J.C. Manning (AZf 2 and AZi 7), E.J.J. Sieben (AZa 1 and 2), H. Bezuidenhout (AZa 3), S.S. Cilliers (AZi 10), J. Gerber (AZf 3), D.B. Hoare (AZa 6) and F. Siebert (AZa 7). The species lists were compiled by L. Mucina with the technical help of L.W. Powrie. The data for the Conservation sections of the descriptions were compiled by L.W. Powrie and the sections on Geology, Soil & Hydrology were corrected by R.A. Ward. 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.

The climate diagrams were prepared by M.C. Rutherford and L.W. Powrie. Most of the photographs were provided by L. Mucina except for those kindly contributed by W.S. Matthews, M.C. Lötter and J.C. Manning. L. Scott, J. Grobbelaar, K. Kobisi, M. Polaki and J.R.U. Wilson provided some less accessible literature sources. C.R. Scott-Shaw and P.S. Goodman provided valuable comments on parts of the text.

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