cent. A few very low species also occur. Total cover values reach about 80 per cent. At the AFNP this community is characterized by a large number of species (Table 1): the shrubs or low trees *Acacia mellifera* subsp. *detinens* and *Pappea capensis,* which both reach high cover-abundance values here, the grasses *Eragrostis trichophora, Cenchrus ciliaris, Anthephora pubescens, Panicum maximum, Chloris virgata, Tragus berteronianus, Setaria verticillata* and *Rhynchelytrum repens,* and further by *Ocymum canum, Androcymbium* sp., *Berkheya spinosissima* var. *namaensis, Oxalis obliquaefolia* and *Lycium austrinum.* Some of these species, particularly the annuals, are widespread in the drier parts of southern Africa, and occur in a variety of habitats (cf. Leistner and Werger 1973; Werger 1973). Several species occurring in the *Eragrostis trichophora-Acacia mellifera* subsp. *detinens* Community are also important in other communities at the AFNP for example *Boscia foetida* subsp. *foetida, Hermannia spinosa, Asparagus denudatus, Rhus populifolia, Stipagrostis uniplumis, Forsskaolea candida, Aristida curvata* and *Enneapogon cenchroides* or *Schmidtia kalahariensis. Indigofera heterotricha* and *Sarcostemma viminale* may also be important in this community. This may indicate the importance of run-off water in this habitat, as both species are also important in the *Monechma spartioides* Subcommunity of the drainage lines on gneiss. Dense stands of *Stipagrostis uniplumis* and *Oropetium capense* sometimes grow at the fringe of this community and the gneiss domes.

In the southern Kalahari *Eragrostis trichophora* is associated with species that do not occur at the AFNP, and is typical of the crests of the red sand dunes (Leistner and Werger 1973).

9) *Antherothamnus pearsonii* Community

Gorges, between 1 m and 4 m deep and wide and sometimes more than 10 m long, occur occasionally in the gneiss outcrops. These gorges contain well-drained, grey-coloured, slightly humic, loamy sand with some gneiss gravel and represent relatively sheltered habitats as regards soil and air moisture, temperatures and wind. In these gorges an open shrub community, the *Antherothamnus pearsonii* Community is found. The shrubs are from 1 m to 4 m tall and cover about 10% to 15 per cent. The undergrowth of mainly dwarf shrubs but also grasses and herbs is mostly dense, covering between 15% and 50 per cent. Total cover values for this community vary from 40% to 80 per cent. The community occurs in its typical form in only few localities at Augrabies. Stands of a fragmentary nature can regularly be found at sheltered places with a deep sandy loam soil outside gorges of the type described above.

The community is characterized by the shrubs and dwarf shrubs *Antherothamnus pearsonii, Stachys burchelliana, Barleria lancifolia* and *Ozoroa namaensis,* which are virtually restricted to this habitat at the AFNP and can reach high cover values. Further species commonly encountered in the *Antherothamnus pearsonii* Community include *Hermannia minutiflora, Rhus populifolia, Stipagrostis uniplumis, Enneapogon scaber, Monechma spartioides, Forsskaolea candida* and *Aptosimum leucorrhizum* subsp. *junceum*

(Table 1). *Indigofera heterotricha* and *Triraphis ramossissima* may also be very abundant in this community. These species are important also in the *Monechma spartioides* Subcommunity of the drainage lines on gneiss, and the *Triraphis ramossissima* Subcommunity of the gneiss outcrops, respectively. This suggests that abundance of these species is indicative of strong changes in available moisture.

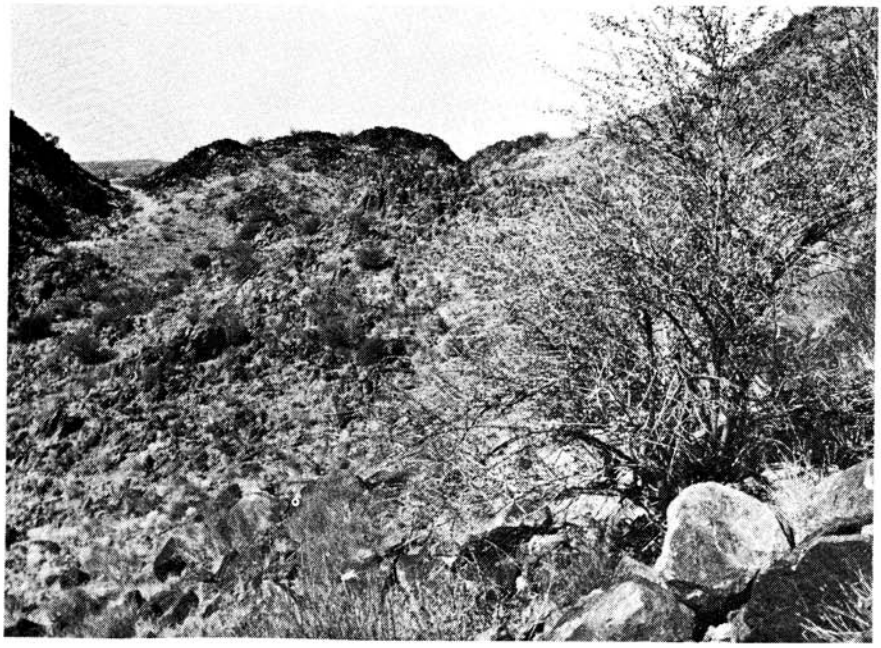

Fig. 18. *Commiphora gracilifrondosa* Community on black granulite hills at Augrabies. Shrub: *Adenolobis gariepina*.

10) *Commiphora gracilifrondosa* Community

The black granulite hills at the AFNP represent a habitat that strongly differs from the gneiss area. The mineralogical composition of the rock is different (Hugo 1969) and also the weathering, which again causes differences in landform. The slopes of the black granulite hills are generally steep and vary from 19° to more than 40 degrees. They are strewn with large boulders of 0,5 m and more in diameter as well as with smaller rock fragments (Fig. 18). The black weathered and "varnished" surfaces of the rocks are extremely hot when sun-baked.

Soil is mainly restricted to cracks and fissures between the rocks and boulders and to shallow drainage lines. The soil is sandy and gravelly and locally sudded with dung from rockdassies *Procavia capensis* which are very numerous in these black hills. The black granulite hills carry a distinct plant community, the *Commiphora gracilifrondosa* Community (Fig. 18). It is an open to extremely open community, but it can be somewhat denser along the larger drainage lines. In its typical constitution

total cover values vary from 5% to 15 per cent. Shrubs are 1 m to 3 m tall, never cover more than 5% and usually cover much less. Undergrowth of grasses and dwarf shrubs usually covers 5% to 10 per cent. At some places, most often near the top of a hill, the soil has been washed away between the boulders, leaving a loosely packed heap of large, black pieces of rock. Here the undergrowth is extremely sparse and the vegetation covers as little as 1 per cent. These represent only fragmentary stands of the community (Fig. 19).

Fig. 19. Fragmentary stand of *Commiphora gracilifrondosa* Community on top of ridge. Note loosely packed, bouldery substrate.

Both *Cleome angustifolia* subsp. *diandra* and *Euphorbia glanduligera* occur further north in the southern Kalahari, where they are restricted to calcrete riverbanks (Leistner and Werger 1973).

The *Commiphora gracilifrondosa* Community is characterized by the shrubs *Commiphora gracilifrondosa* and the forbs *Trichodesma africana, Abutilon pycnodon, Cleome angustifolia* subsp. *diandra, Euphorbia glanduligera* and perhaps *Sutera ramossissima* (Table 1). Species, occurring commonly in other communities, are also frequently found in this community: *Stipagrostis uniplumas, Enneapogon scaber, Monechma spartioides, Forsskaolea candida, Aristida curvata, Codon royeni,* and also *Triraphis ramossissima.* Some species, such as *Monechma spartioides* and *Enneapogon scaber* may be abundant where much soil has accumulated between large boulders. The moisture regime of these soil accumulations is favourable, because of increased run-off from such large boulders. Succulent plants are markedly absent from the *Commiphora gracilifrondosa* Community.

Two subcommunities of the *Commiphora gracilifrondsa* Community may be distinguished. These are correlated with the aspect of the slopes: (a) On

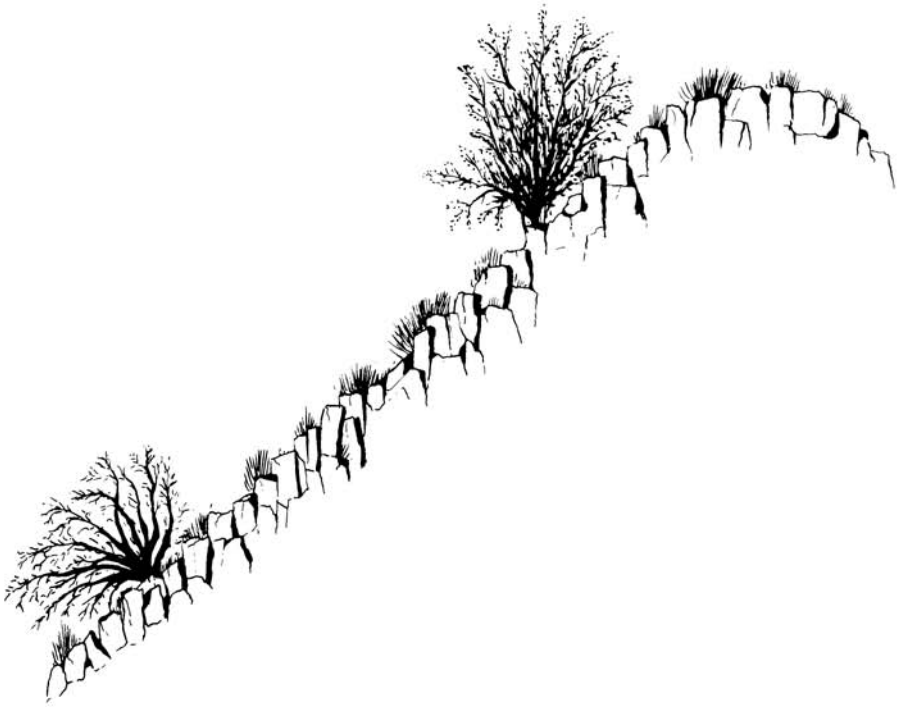

Fig. 20. Structure diagram of the *Adenolobis gariepina* Subcommunity (*Commiphora gracilifrondosa* Community), showing *Adenolobis gariepina* (upper shrub) and *Commiphora gracilifrondosa* (bottom shrub).

slopes with an aspect in the south-eastern sector the *Rhus populifolia* Subcommunity is found. These slopes are usually somewhat cooler than those on the north-western sector on which (b) the *Adenolobis gariepina* Subcommunity occurs (Fig. 18 and 20). The differences in microclimate between these aspects are apparently not such that there is a conspicuous difference in total cover values and structure of the sub-communities. There is, however, a marked difference in floristic composition (Table 1). The *Rhus populifolia* Subcommunity is differentiated from the *Adenolobis gariepina* Subcommunity by the occurrences of *Rhus populifolia* and *Hermannia minutiflora*. *Berkheya chamaepeuce* also characterizes the *Rhus populifolia* Subcommunity because of its constancy and the abundance in this subcommunity and *Commiphora gracilifrondosa* reaches somewhat higher cover-abundance values here. *Stipagrostis uniplumas* is not often found in this subcommunity. The *Adenolobis gariepina* Subcommunity is characterized by the shrubs. *A. gariepina,* which is usually conspicuous here, and *Sisyndite spartea,* as well as the forbs *Cleome oxyphylla* var. *oxyphylla* and *Hibiscus engleri*. *Enneapogon scaber* reaches high cover-abundance values.

The *Commiphora gracilifrondosa* Community also occurs further westward on dark, granulite outcrops, at least until the vicinity of Onseepkans and Poïadder. No relevés have been made there, however.

11) *Schotia afra* Community

The main drainage lines at the AFNP outside the Orange River Gorge are one to several metres deep. Wide canyons and their sides consist of bedrock or enormous boulders. The rock is mostly pink gneiss, but granulite also occurs locally. The cracks and fissures in the bedrock and between the boulders often contain some grey sand in which plants root. The bottoms of these drainage lines are made up of bedrock covered by white or pale yellow, loose sand, the depth of which varies from less than one centimetre to over one metre within very short distances. On the sides of such drainage lines a well-developed open shrub community, the *Schotia afra* Community grows. Large shrubs and sometimes low trees of *Schotia afra* var. *angustifolia* are up to 6 m tall and cover up to 60 per cent. Dwarf shrubs and grasses of varying height, usually covering up to 10% grow in between (Fig. 21 and 22). The community is

Fig. 21. *Schotia afra* Community on rocky banks of large drainage lines.

characterized by *Schotia afra* var. *angustifolia,* the most important species in this community, and by the grass *Triraphis ramossissima.* Few other species are frequent, for example *Stipagrostis uniplumis* and *Enneapogon scaber* but several other species may occur, mainly species typical for other contact communities, surrounding the narrow belts of the *Schotia afra* Community fringing the drainage lines.

In the deep gorge of the Orange River *Schotia afra* var. *angustifolia* locally also grows in open stands on cracked rock at about the high water mark (Fig. 23). No relevés have been made here.

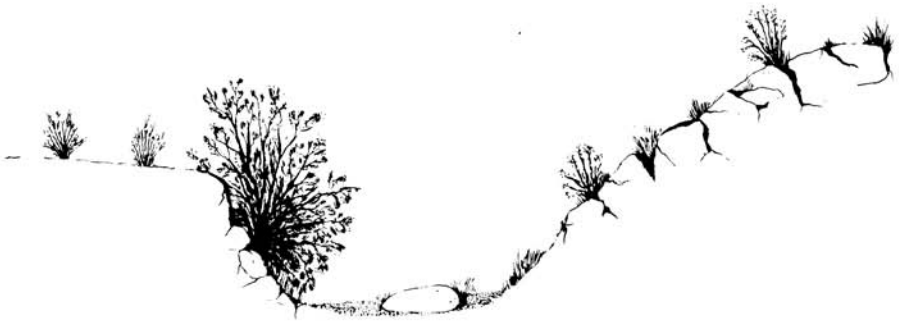

Fig. 22. Structure diagram showing sandy dry riverbed, with the *Schotia afra* Community on the steep rocky bank and the *Indigofera heterotricha* – *Zygophyllum suffruticosum* Community (*Triraphis ramossissima* Subcommunity) in cracks on the opposite broken rocky bank.

Fig. 23. Deep gorge of the Orange River below Augrabies Falls, with a loose stand of *Schotia afra* var. *angustifolia* along the mean high water line.

12) *Sisyndite spartea* Community

At a few places, where the bottom of a drainage line consists of strongly weathered gneiss rock, mostly as a zone of a few metres wide between the steep rocky sides and the loose, sandy bed, another open shrub community, the *Sisyndite spartea* Community occurs. The

weathered rocky substrate on which this community occurs is flooded for brief periods after every rainstorm that is large enough to cause run-off. The community is dominated and characterized by the zygophyllaceous shrub *Sisyndite spartea,* which is up to 2 m tall and covers up to 60% and sometimes even more. The undergrowth in this periodically flooded community is very sparse. Relevé 41 presents an example:

Relevé	41
size (m)	2 x 10
total cover (%)	60
Sisyndite spartea	4.2
Pappea capensis	+.2
Zygophyllum dregeanum	+.2
Blepharis mitrata	+.2
Stipagrostis uniplumis	+.2
Eragrostis porosa	+.2
Eragrostis annulata	+.2
Enneapogon brachystachyus	+.2
Schmidtia kalahariensis	+.2
Forsskaolea candida	+.2

13) *Stipagrostis namaquensis-Leucophrys mesocoma* Community

In some of the larger drainage lines coarse sand deposits of 1 m or more in thickness can accumulate. On these sandy "islands" in the dry streambeds, an open tall grass community, the *Stipagrostis namaquensis-Leucophrys mesocoma* Community, develops. *Stipagrostis namaquensis* is a tall shrubby grass and its dominance gives the community a physiognomy similar to the Stipagrostietum amabilis on the dune ridges in the southern Kalahari (Leistner and Werger 1973). Ecologically the two communities also have in common their occurrence on accumulations of coarse, loose sand. But whereas the Stipagrostietum amabilis occurs on aeolian sand, the present community occurs on alluvial deposits. The *Stipagrostis namaquensis-Leucophrys mesocoma* Community scores total cover values of about 20%, and the tallest grasses are up to 2 m high. Relevé 19 offers an example:

Relevé	19
size (m)	5 x 2
total cover (%)	20
Stipagrostis namaquensis	2.2
Leucophrys mesocoma	1.3
Stipagrostis ciliata	2.2
Stipagrostis uniplumis	+.2
Schmidtia kalahariensis	+.2
Dicoma capensis	+.2
Kohautia cynanchica	+.1

Indigofera argyrea	+.2
Pentzia annua	+.2
Berkheya spinossissima var. namaensis	+.2

Stipagrostis namaquensis is typical of coarse, sandy accumulations along drainage lines in the entire lower Orange River area. *Stipagrostis ciliata* also occurs abundantly in the southern Kalahari and on Kalahari sand in the Middle Orange River area. It is usually correlated with lime-rich sand (cf. Leistner and Werger 1973; Werger 1973).

14) *Cyperus marginatus – Cenchrus ciliaris* Community

The lowest-lying parts of the large drainage lines still contain water for a considerable period after a rain storm. The deep, coarse, loose sand that is deposited in the bed, and on which the *Stipagrostis namaquensis-Leucophrys mesocoma* Community is locally found, alternates in these low-lying parts with thin layers of fine, loamy sand deposited there shortly before water stops running in the drainage lines. Frequently an open community of herbs and graminoid plants, the *Cyperus marginatus-Cenchrus ciliaris* Community is encountered here. The community is mainly made up of annuals and seedlings of other rapidly germinating species, but the perennials *Cyperus marginatus* and *Cenchrus ciliaris,* which form tall, robust tussocks, are also characteristic. A few trees even sometimes occur in this community, e.g. *Euclea pseudebenus;* and some shrubs, such as *Ziziphus mucronata, Lycium austrinum, Rhus viminale* and *Maytenus linearis,* all of which are typical for the galery forest along the branches of the Orange River, where they can reach groundwater throughout the year. Occasionally a few larger specimens of *Acacia mellifera* subsp *detinens* can also be found in this community.
Relevés 15 and 18 offer examples:

Relevé	15	18
size (m)	3 x 5	8 x 5
total cover (%)	20	15
Cyperus marginatus	2.3	2.3
Cenchrus ciliaris	2.3	+.2
Kohautia cynanchica	+.1	+.1
Manulea schaeferi	+.1	+.1
Senecio arenarius	+.1	+.1
Geigeria ornativa	+.1	+.2
Vahlia capensis		1.2
Indigofera argyrea		+.2
Galenia secunda		+.2
Blumea gariepina		+.2
Dimorphotheca pluvialis	+.1	
Heliophila minima	+.1	
Diascia engleri	+.1	
Sutera tomentosa	+.1	

Arctotis leiocarpa	+.2	
Senecio sisymbrifolius	+.1	
Comptonanthus molluginoides	+.1	
Aptosimum leucorrhizum	+.1	
Berkheya spinossissima var. namaensis	+.1	+.2
Schmidtia kalahariensis	+.1	+.2
Eragrostis porosa	+.2	+.2
Eragrostis annulata		+.2
Giesekia africana		+.2
Stipagrostis uniplumis		+.2
Aristida congesta		+.2
Aristida curvata		+.2
Thesium laniculatum		+.2
Dicoma capensis		+.2
Mesembryanthemum magniflorum		+.1
Psilocaulon absimile		+.2
Hyperthelis salsoloides		+.2
Tragus berteronianus		+.2
Tribulus zeyheri		+.1
Euphorbia inaequilatera		+.1
Euclea pseudebenus		+.1
Ziziphus mucronata		+.2
Lycium austrinum		1.2
Rhus viminale		+.2
Maytenus linearis		+.2
Acacia mellifera subsp. detinens		1.2

Along gravel roads through AFNP another pioneer community of rapidly germinating annuals occurs. This vegetation exists only temporarily, because it is removed each time the roadscrapers are used. The vegetation consists mainly of grasses and of the slightly succulent annual *Zygophyllum simplex*. This latter species can form extensive mats resulting in high total cover values for this vegetation type. An example of this type of pioneer vegetation is shown in relevé 16:

Relevé	16
size (m)	1 x 4
total cover (%)	40
Zygophyllum simplex	3.4
Schmidtia kalahariensis	2.2
Stipagrostis uniplumis	+.2
Eragrostis porosa	+.2
Arctotis leiocarpa	+.1

15) *Ziziphus mucronata-Euclea pseudebenus* Community

Above the Augrabies Falls the Orange River is a braiding stream forming numerous small and large islands. Much alluvial fine sand and silt is deposited here. Between Upington and the AFNP this alluvium is irrigated with water from the Orange River and produces vegetables, fruits (grapes, peaches) and lucerne. Originally the alluvial substrate was covered with a riverine shrubland and forest, but this has largely been cleared.

At the AFNP in the section above the Falls, the riverine forest and shrubland is still well represented. The gallery forest along the river arms, the *Ziziphus mucronata-Euclea pseudebenus* Community, consists of three layers. The tree layer is 5 m to 9 m in height and usually covers 60% to 70 per cent. Sometimes the community is very open and the tree layer can cover as little as 20 per cent. The shrub layer is normally between 1 m–3 m high and covers 25% to 40 per cent. At places it can be much sparser, however. Cover of the undergrowth varies somewhat, but is often between 15% and 20 per cent. Total cover values for the community are usually between 80% and 90 per cent. There is often a mass of drift wood present in this community.

The *Ziziphus mucronata-Euclea pseudebenus* Community is characterized by many species (Table 2). In the tree layer these are *Ziziphus mucronata, Euclea pseudebenus, Maytenus linearis, Rhus viminalis, Acacia karroo* and *Tamarix usneoides*. In the shrub layer *Lycium austrinum, Diospyros lycioides* subsp. *lycioides, Maerua gilgii* and *Ehretia rigida* are typical, and in the undergrowth *Setaria verticillata, Asparagus laricinus, Zygophyllum microcarpum*, and a few other species may be important.

The community is best developed along the main tributaries of the Orange River, where flooding and subsequent deposition of alluvial material occurred most frequently before closing of the Hendrik Verwoerd Dam further upstream. These tributaries mostly hold water throughout the year and do not dry up in very dry years as sometimes occurs with the less important tributaries. Table 2 shows that there is a slight difference in vegetation composition and vegetation development of the gallery forests along the minor (relevés 79, 80, 78) and the major tributaries (relevés 39, 34, 40, 30) of the Orange River: *Euclea pseudebenus* and *Tamarix usneoides* seem to occur more along the major tributaries and *Zygophyllum microcarpum* and *Chenopodium olukondae* seem to be restricted to the gallery forests at these tributaries. On the other hand, *Asparagus laricinus* seems to be more abundant along the minor tributaries and several species seem to be restricted to them. To what extent these differences have syntzxonomical relevance must be cleared by further sampling.

There is sometimes a dense, narrow zone of grasses between the gallery forest and the streambed. *Dicanthium papillosum* and *Cenchrus ciliaris*, are particularly abundant in this zone, and to a far lesser extent *Schmidtia kalahariensis* and *Eragrostis echinochloidea*. *Agrostis lachnantha* or *Cyperus marginatus* may also occur at such sites.

Table 2

Ziziphus mucronata-Euclea pseudebenus Community

relevé	79	80	78	39	34	40	30
size (m)	10x10	10x20	10x10	8x10	5x10	10x10	10x10
total cover (%)	85	40	90	80	80	90	70
height tree layer (m)	5–8	5–6	6–9	5–7	5–7	6–9	5–7
cover tree layer (%)	65	20	50	60	70	80	70
cover shrub layer (%)	25	20	35	40	40	40	1
cover undergrowth (%)	3	4	15	15	20	15	35
Ziziphus mucronata	2	2	1	2	1	4	2
Euclea pseudebenus		+	+	3	2	3	2
Maytenus linearis	+	1	2	2	3	3	
Acacia karroo	1	+	+	+	+	1	
Rhus viminalis	3		3	+	1	2	
Tamarix usneoides	(+)	(+)			2	1	3
Lycium austrinum	2	2	2	2	3	3	1
Diospyros lycioides subsp. lycioides	1	+	+	+	1		
Maerua gilgii	+	+			+		
Setaria verticillata	1	+	2	2	2	2	3
Asparagus laricinus	2		2	+	+	+	+
Zygophyllum microcarpum				2	+	2	+
Chenopodium olukondae				+		+	+
Cenchrus ciliaris	+	+	1				
Ehretia rigida	+	+	+				
Eragrostis echinochloidea	+	+	+				
Amaranthus thunbergii			+	+			+
Galenia secunda			1	+			+
Loranthus olaeoides	+		+			+	
Pappea capensis		+	+				r
Dicanthium papillosum		+	+				
Panicum maximum	+		+				
Euclea undulata var. myrtina		+	+				
Senecio glutinosus						+	+
Atriplex semibaccata						+	+
Zygophyllum simplex					+	+	
Schmidtia kalahariensis		+	+				
Tribulus zeyheri		1					
Rhus lancea	+						
Combretum erythrophyllum	+						
Stipagrostis uniplumis		+					
Acacia mellifera subsp. detinens		+					
Pollichia campestris			+				
Mesembryanthemum magni-florus			+				
Salsola kali				+			
Monechma spartioides							+
Lycium arenicolum							+
Datura sp.							+
Lepidium desertorum							+
Chenopodium schraderanum							+
Trianthema triquetra					+		
Tragus berteronianus					+		

The *Ziziphus mucronata-Euclea pseudebenus* Community is floristically related to the Diospyrion lycioidis riverine communities described by Werger (1973) from the Upper Orange River. The community does not belong to the Diospyrion lycioidis, however, but probably to another, related alliance. Sampling the riverine forest in the section between Douglas and Augrabies as well as further downstream from Augrabies will clarify this problem.

The occurrences of *Combretum erythrophyllum* and *Rhus lancea* in relevé 79 are phytogeographically interesting since both species occur here at the AFNP in exclaves far away from their normal distribution area. Along the Upper Orange River these species are respectively absent and very rare (Werger 1973), but along the Vaal River they occur commonly in riverine forest. Their occurrences at the AFNP must therefore be ascribed to dispersal by water from diaspores, originating from the Vaal River area, that have managed to germinate at Augrabies. Merxmüller (1966–1972) mentions that only one record of *Combretum erythrophyllum* in South West Africa is available from Dinter who found a tree on the right hand bank of the Orange River at Gaidib in 1928. Obviously, this record must be interpreted in the same way as the occurrence at Augrabies Falls National Park.

Just north of the Orange River in the AFNP some large drainage lines locally form a wide system of temporary streambeds and sandy islands. These drainage lines drain mainly the area with the *Monechma australe-Acacia giraffae* Community on deep, coarse sand. On the islands, consisting of coarse, yellowish sand and gravel, a savanna vegetation dominated by *Zygophyllum microcarpum* and *Stipagrostis namaquensis* occurs. Stands of this vegetation are to a certain extent transitional between the *Monechma australe-Acacia erioloba* Community, the *Stipagrostis namaquensis-Leucophrys mesocoma* Community and the *Ziziphus mucronata-Euclea pseudebenus* Community. Vegetation dominated by *Zygophyllum microcarpum* and *Stipagrostis namaquensis* scores high total cover values, mainly because of the abundance of the shrubby grass *Stipagrostis namaquensis,* which is up to 2 m tall. Trees are up to 6 m high and cover less than 5 per cent. Undergrowth of small grasses and forbs is very sparse. An example of such a stand is shown in relevé 35:

Relevé	35
size (m)	10 x 10
total cover (%)	85
Acacia karroo	1.2
Acacia erioloba	+.1
Acacia mellifera subsp. detinens	+.2
Euclea pseudebenus	+.1
Lycium austrinum	1.2
Stipagrostis namaquensis	3.3
Zygophyllum microcarpum	3.3
Stipagrostis hochstetteriana var. secalina	+.2
Stipagrostis uniplumis	+.2

Setaria verticillata	+.3
Eragrostis porosa	+.2
Eragrostis annulata	+.2
Schmidtia kalahariensis	+.2
Geigeria ornativa	+.1
Hermannia stricta	r

16) *Lycium prunus-spinosa-Lycium austrinum* Community

In places the fine sand and silt deposits of the Orange River cover fairly wide areas. The gallery forest is never wider than about 100 m, however, and usually narrower. It is possible that away from the river tributaries the moisture regime in these deep, fine-grained soils changes to such an extent that tree growth is no longer possible. On these wide stretches of alluvial material an open shrub community dominated by *Lycium prunus-spinosa* occurs. Shrubs are 1 m to 1,5 m high with some emergents of *Lycium austrinum* up to 3 metres. The shrub layer covers about 20% to 25 per cent. The undergrowth is sparse and covers less than 10 per cent. Relevé 31 represents an example of the *Lycium prunus-spinosa-Lycium austrinum* Community:

Relevé	31
size (m)	5 x 10
Total cover (%)	25
Lycium prunus-spinosa	2.3
Lycium austrinum	1.2
Maerua gilgii	+.2
Zygophyllum microcarpum	+.2
Cyperus marginatus	+.3
Cenchrus ciliaris	1.2
Setaria verticillata	+.3
Eragrostis echinochloidea	+.2
Eragrostis porosa	+.2
Eragrostis annulata	+.2
Tragus berteronianus	+.2
Enneapogon brachystachyus	+.2
Aristida curvata	+.2
Schmidtia kalahariensis	+.2
Zygophyllum simplex	+.2
Geigeria ornativa	+.2
Trianthema triquetra subsp parviflora	+.2
Tribulus terrestris	+.2

The present *Lycium prunus-spinosa-Lycium austrinum* Community is florsitically not very closely related to the *Lycium prunus-spinosa* Community described by Werger (1973) from wide shallow drainage lines on

Ecca sandstones and shales in the Upper Orange River area between Hopetown and Petrusville. The relationship is virtually restricted to the dominance of *Lycium prunus-spinosa* in both communities.

17) *Ficus cordata* Community

Downstream of the Falls, the Orange River has a relatively narrow streambed in a deep, steepsided gorge. The water moves rapidly here, and sandy levees do not occur. The river is fringed by very large gneiss boulders with very little soil material in between. A sparse vegetation dominated and characterized by the tree *Ficus cordata* is encountered here. The trees may be up to 4 m or 5 m tall and grow individually or in clumps of a few individuals between the boulders. Under the trees a few other plants occur. Relevé 83 provides an example:

Relevé	83
size (m)	5 x 10
total cover (%)	3
Ficus cordata	1.2
Solanum coccineum	+.2
Trichodesma africana	+.2
Enneapogon scaber	+.2
Aristida curvata	+.2
Stipagrostis uniplumis	+.2
Schmidtia kalahariensis	+.2

Marloth (1908) already mentioned stands of *Ficus cordata* in similar habitats in the Moordenaars Karoo and Namaqualand. He provides figures on some giant individual trees.

Along rocky banks of tributaries of the Orange River with permanent water, or on small rocky outcrops in the middle of such river courses, one locally finds a few individuals of the loganiaceous shrub *Gomphostigma virgata*. The plants always grow in moist habitats. *G. virgata* is widespread in such habitats in southern Africa and in the less arid areas it may also be found occasionally on loamy banks of permanent streams. Small fringes of *Phragmites australis* also occur in places long the river tributaries.

On steadily slow flowing or stagnant water in some of the tributaries of the Orange River patches of the floating waterfern *Azolla filiculoides* are found. These patches almost certainly originate from small sidestreams flowing into the Upper Orange River in the vicinity of Bethulie, where *Azolla filiculoides* is common (Werger 1973).

Phytogeography, flora, life and growth forms

The Augrabies Falls National Park falls in the Karoo-Namib Region (Monod 1957; Volk 1966; White 1971; Werger 1973a). Judging from

its flora it clearly belongs to the Namaqualand Domain, although according to Monod's map its longitudinal and latitudinal position are such that it falls in the transition between this Domain and the Karoo and Namib Domains of the same Region.

The flora at the AFNP contains many species which are widespread* over most of the Karoo-Namib Region, such as *Enneapogon scaber, Eragrostis annulata, E. echinochloidea, E. porosa, Schmidtia kalahariensis, Stipagrostis obtusa, S. ciliata, S. uniplumis, Blumea gariepina, Dicoma capensis, Aptosimum leucorrhizum, Euphorbia glanduligera, Zygophyllum simplex, Phyllanthus maderaspatensis, Parkinsonia africana, Cleome angustifolia* subsp. *diandra, Leucosphaera bainsii, Salsola aphylla, Trianthema triquetra* subsp. *parviflora, Limeum aethiopicum, Phaeoptilum spinosum* and *Boerhavia repens.*

Several other species also occur widespread over the dry areas of the Karoo-Namib Region and are usually frequent there, but also occur outside this region in the Sudano-Zambezian Region. Examples are *Anthephora pubescens, Cenchrus ciliaris, Dicanthium papillosum, Eragrostis nindensis, Enneapogon brachystachyus, Oropetium capense, Tragus berteronianus, Asparagus denudatus, Barleria lancifolia, Acacia erioloba, Boscia albitrunca, Boscia foetida, Cadaba aphylla, Ficus cordata, Triraphis ramossissima* and *Acacia mellifera* subsp *detinens.*

Several species which are more restricted to the Namaqualand and Karoo Domains and are absent from the Namib Domain occur at the AFNP: *Barleria rigida, Blepharis mitrata, Monechma desertorum, Rhigozum trichotomum, Lycium prunus-spinosa, Euclea undulata* var. *myrtina, Hermannia spinosa, Nymania capensis, Indigofera alternans, Tetragonia arbuscula, Aizoon schellenbergii, Galenia secunda, Plinthus karooicus, Thesium laniculatum* and *Sericocoma avolans.*

Many species belong to the group restricted to the Namaqualand Domain and the Namib Domain, most often only the southern Namib. At the AFNP this group includes *Stipagrostis hochstetteriana* var. *secalina, Berkheya spinossissima, Osteospermum microcarpum, Rogeria longiflora, Sutera tomentosa, Codon royenii, Trichodesma africana, Chascanum gariepina, Orthanthera albida, Dyerophytum africanum, Euclea pseudebenus, Tamarix usneoides, Kissenia capensis, Abutilon pycnodon, Hibiscus elliottiae, Radyera urens, Hermannia minutiflora, H. stricta, Indigofera auricoma, I. heterotricha, Adenolobis gariepina, Parkinsonia africana, Cleome oxyphylla, Leucosphaera bainesii* and *Forsskaolea candida.* Several species mentioned so far belong to a transcontinental disjunct arid element. Literature on this phenomenon is extensive and it suffices here to refer to some recent reviews by De Winter (1974), Monod (1971) and Werger (1973b).

More or less restricted to the Namaqualand Domain are *Panicum arbusculum, Stipagrostis anomala, Berkheya chamaepeuce, Barleria lichtensteiniana, Curoria decidua, Stachys burchelliana, Euphorbia gariepina, E. gregaria, Aloe dichotoma, Zygophyllum dregeanum, Z. microcarpum, Z.*

* *Distributional data have been obtained from unpublished data of Mr. J.P.H. Acocks (cf. Werger 1973) and from Merxmüller (1966–72), De Winter (1965) and Volk (1966).*

suffruticosum, Indigofera argyrea, I. argyroides, Lotonis platycarpa and perhaps *Maytenus linearis, Euphorbia avasmontana* and *Heliophila minima.*

In the relevés made at the AFNP 175 species in 52 families have been recorded. This certainly does not represent the entire flora of the AFNP, as some rare species as well as some geophytes or annuals may not have been encountered in the relevés. It is therefore, not appropriate to use these figures to compare the floristic composition of the flora of the AFNP with the floristic composition of other areas on a percentage basis as described by Tolmachev (1971) and demonstrated for the southern Kalahari by Werger (1973a). It is nevertheless, interesting to see which families are the most important at Augrabies. By far the best represented is the Poaceae. This richness of grasses is probably favoured by the deep sandy habitats which are fairly well represented at Augrabies. After the Poaceae follow the Asteraceae and the Leguminosae which are of about equal importance. Next come the Aizoaceae (*s.l.*) with somewhat fewer species. Then four families of equal importance follow, namely the Scrophulariaceae, Zygophyllaceae, the Capparidaceae and the Acanthaceae and with just slightly lower scores, the Liliaceae and the Euphorbiaceae.

No detailed analysis of life and growth forms will be made here, but some remarkable features will be pointed out. In studying life forms the riverine forest should be left out of consideration, because it is azonal. In the other vegetation types chamaephytes, hemicryptophytes and therophytes are all of equal importance, scoring 22% each. Therophytes are very frequent in the group of species that is common to most communities. In arid areas it was often found that in general therophytes are usually less indicative of specific habitat factors than perennials (Batanouny and Abu El-Souod 1972; cf. Werger 1974). The importance of hemicryptophytes is to a large extent due to the relatively large number of grasses at Augrabies. Hemicryptophytic grasses make up nearly 14% of the flora. Chamaephytes are generally well represented in the Karoo-Namib Region. However, at the AFNP a small portion, namely 2,5% of the flora, is taken up by succulent chamaephytes whereas in the Western Cape Domain they make up a large percentage of the flora. At the AFNP species such as *Sarcocaulon patersonii* and *Senecio longiflorus* belong to this group. Other chamaephytes at the AFNP are microphyllous, sclerophyllous, mallacophyllous, or during most of the year aphyllous. Sometimes they have leaves with a combination of these features.

Of almost equal importance as the previous three life forms are the nanophanerophytes at Augrabies. They comprise 20% of the flora, but they certainly are more conspicuous in the landscape, and because of their abundance locally more important than other life forms. This 20% is made up of about 3,5% succulent nanophanerophytes, such as *Euphorbia gregaria, Sarcostemma viminale* and *Ceraria namaquensis,* and of 16,5% other nanophanerophytes. Some of these, like *Zygophyllum* species, possess slightly succulent leaves. Most nanophanerophytes are micro- or sclerophyllous, however, or possess leaves for only a short period each year.

Phanerophytes constitute 10% of the flora, of which only one, *Aloe dichotoma,* is succulent. The total percentage of succulent species comes to 6,5% at Augrabies. The remaining 4% of the flora are taken by geophytes with just over 3%, perennial lianas with less than 1%, and hemiparasites with less than 1 per cent.

Remarkable is the convergence in growth forms at the AFNP, mainly among the nanophanerophytes. There occur a number of species of entirely different families but sharing a very similar growth form. A striking example, the similarity between *Euphorbia gregaria, Sarcostemma viminale* and *Senecio longiflorus,* all forming glaucous, succulent, multibranched, erect nanophanerophytes. Also *Cadaba aphylla* looks rather similar, but has somewhat thinner branches. Very similar in appearance to *C. aphylla* are vigorous individuals of *Hermbstaedtia glauca* and some individuals of *Polygala leptophylla.* Less vigorous individuals of *Hermbstaedtia glauca* are more yellowish green to brown and look surprisingly similar to *Aptosimum leucorrhizum* subsp. *junceum* and *Monechma spartioides.* Another frequent growth form is a nanophanerophyte with tenuous, green, mostly leafless branches, expressed similarly by *Sisyndite spartea, Thesium laniculatum* and *Asparagus denudatus.*

Similar features of convergent evolution in plants in New Zealand and other areas have been pointed out by Went (1971), who suggests an explanation that is not readily acceptable. Mooney states that evidence is accumulating that for any given climate there is an optimal solar energy capture system, or an optimal form-behavioural strategy for carbon gain which are manifested by plant forms and physiological processes in those plants (Di Castri and Mooney 1973; Mooney 1974). Much experimental work is still necessary, however, to say anything substantial about this convergence in growth form among several unrelated plant species in a specific habitat.

Acknowledgements

We are indebted to the National Parks Board of Trustees for permission to undertake this survey.

REFERENCES

ACOCKS, J. P. H. 1953. Veld Types of South Africa. *Mem. bot. Surv. S. Afr.* 28:1–192.

ACOCKS, J. P. H. 1975. Veld Types of South Africa. 2nd Ed. *Mem. bot. Surv. S. Afr.* 40:1–128.

BATANOUNY, K. H. 1973. Soil properties as affected by topography in desert wadis. *Acta Bot. Acad. Sc. Hung.* 19:13–21.

BATANOUNY, K. H. and S. ABU EL-SOUOD. 1972. Ecological and phytosociological study of a sector in the Libyan Desert. *Vegetatio* 25:335–356.

BATANOUNY, K. H. and M. R. HILLI. 1973. Phytosociological study of Ghurfa Desert, Central Iraq. *Phytocoenologia* 1:223–249.

BATANOUNY, K. H. and M. Y. SHEIKH. 1972. Ecological observations along Baghdad-Huseiba Road, Western Desert, Irag. *Feddes Repert.* 83:245–263.

COETZEE, B. J. and M. J. A. WERGER. 1975. A west-east vegetation transect across Southern Africa near the Tropic of Capricorn. *Bothalia* 11:539–560.

DE WINTER, B. 1965. The South African Stipeae and Aristideae. *Bothalia* 8:199–404.

DE WINTER, B. 1974. Floristic relationships between the northern and southern arid areas in Africa. *Mitt. Bot. Staatssamml. München* 10:424–437.

DI CASTRI, F. and H. A. MOONEY. 1973. (Eds) *Mediterranean Type Ecosystems. Ecological Studies* 7. New York: Springer.

EDWARDS, D. 1974. Survey to determine the adequacy of existing conserved areas in relation to vegetation types. A preliminary report. *Koedoe* 17:3–38.

EDWARDS, D. and M. J. A. WERGER. 1972. Threatened vegetation and its conservation in South Africa. *In:* TÜXEN, R. (ed.): *Gefährdete Vegetation und ihre Erhaltung.* Int. Symp. Rinteln.

GAFF, D. F. 1971. Dessication-tolerant flowering plants in Southern Africa. *Science* 174:1033–1034.

GAFF, D. F. and R. P. ELLIS. 1974. Southern African grasses with foliage that revives after dehydration. *Bothalia* 11:305–308.

GLOVER, P. E., J. GLOVER and M. D. GWYNNE. 1962. Light rainfall and plant survival in East Africa. II. Dry grassland vegetation. *J. Ecol.* 50:199–206.

HOLDRIDGE, L. R., W. C. GRENKE, W. H. HATHEWAY, T. LIANG and J. A. TOSI. 1971. *Forest environments in tropical life zones. A pilot study.* Oxford: Pergamon Press.

HUGO, P. 1969. The pegmatites of the Kenhardt and Gordonia districts, Cape Province. *Mem. Geol. Surv. S. Afr.* 58:1–94.

LABUSCHAGNE, R. J. 1969. *Our national parks.* Pretoria: Nat. Parks Board.

LEISTNER, O. A. 1967. The plant ecology of the Southern Kalahari. *Mem. bot. Surv. S. Afr.* 38:1–172.

LEISTNER, O. A. and M. J. A. WERGER. 1973. Southern Kalahari phytosociology. *Vegetatio* 28:353–399.

MARLOTH, R. 1908. Das Kapland, insonderheit das Reich der Kapflora, das Waldgebiet und die Karroo, pflanzengeografisch dargestellt. *Wiss. Ergebn. Deutsch. Tiefsee-Exp. "Valdivia", 1898–1899.* Bd. II. T.3. Jena: Fischer.

MERXMÜLLER, H. (ed.) 1966–1972. *Prodomus einer Flora von Südwestafrika* 35 parts. Lehre: Cramer.

MONOD, T. 1957. Les grandes divisions chorologiques de l'Afrique. *C.S.A./C.C.T.A. Publ.* no. 24. London.

MONOD, T. 1971. Remarques sur les symmétries floristiques des zones

sèches nord et sud en Afrique. *Mitt. Bot. Staatssamml. München.* 10:375–423.
MOONEY, H. A. 1974. Plant forms in relation to environment. *In:* STRAIN, R. and W. D. BILLINGS. Eds.: *Vegetation and environment Handbook of vegetation science* 6:111–122. The Hague: Junk.
MORRIS, J. W. 1973. *Automatic classification and ecological profiles of South-Western Transvaal Highveld grassland.* Ph.D. dissertation Univ. Natal. Durban. Unpubl.
SCHULZE, B. R. 1947. The climate of South Africa according to the classifications of Köppen and Thornwaite. *S. Afr. Geogr. J.* 29:32–42.
SCHULZE, B. R. 1965. *Climate of South Africa. 8. General Survey.* Pretoria: Govt. Printer.
SPECHT, R. L. 1957. Dark Island heath (Ninety-Mile Plain, South Australia). IV. Soil moisture patterns produced by rainfall interception and stem-flow. *Austr. J. Bot.* 5:137–150.
TOLMACHEV, A. I. 1971. Über einige quantitative Wechselbeziehungen der Floren der Erde. *Feddes Repert.* 82:343–356.
TÜXEN, R. 1970. Pflanzensoziologie als synthetische Wissenschaft. *Meded. Landbouwhogeschool Wageningen.* 12:141–159.
VAN ZINDEREN BAKKER, E. M. and M. J. A. WERGER. 1974. Environment, vegetation and phytogeography of the high-altitude bogs of Lesotho. *Vegetatio* 29:37–49.
VOLK, O. H. 1966. Die Florengebiete von Südwesafrika. *J.S.W.A. Wissensch. Ges.* 20:25–58.
VOLK, O. H. and E. GEYGER. 1970. "Schaumböden" als Ursache der Vegetationslosigkeit in ariden Gebieten. *Z.f. Geomorph.* N.F. 14:79–95.
WALTER, H. and H. LIETH. 1960. *Klimadiagramm-Weltatlas.* Jena: Fischer.
WEATHER BUREAU. 1954. *Climate of South Africa. 1. Climate Statistics.* Pretoria: Govt. Printer.
WEATHER BUREAU. 1960. *Climate of South Africa. 6. Surface winds.* Pretoria: Govt. Printer.
WEATHER BUREAU. 1965. *Climate of South Africa. 9. Average monthly rainfall up to the end of 1960.* Pretoria: Govt. Printer.
WENT, F. W. 1971. Parallel evolution. *Taxon* 20:197–226.
WERGER, M. J. A. 1973. *Phytosociology of the Upper Orange River Valley, South Africa.* Pretoria: V & R Printers.
WERGER, M. J. A. 1973a. Notes on the phytographical affinities of the Southern Kalahari. *Bothalia* 11:177–180.
WERGER, M. J. A. 1973b. American and African arid disjunctions. *In:* BRANTJES, N. B. M. and M. F. LINSKENS. Eds.: *Pollination and dispersal.* Nijmegen: Univ. Fac. Science.
WERGER, M. J. A. 1974. On concepts and techniques applied in the Zürich-Montpellier method of vegetation survey. *Bothalia* 11:309–323.
WERGER, M. J. A. 1976. Applicability of Zürich-Montpellier methods in African tropical and subtropical rangelands. *In:* KRAUSE, W.

Ed.: Application to grassland husbandry. *Handbook of vegetation science*. The Hague: Junk (in press).

WERGER, M. J. A. and O. A. LEISTNER. 1976. Vegetationsdynamik in der südlichen Kalahari. *In:* SCHMIDT, W. Ed.: *Sukzessionsforschung*. Ber. Int. Symp. Rinteln. Lehre: Cramer.

WESTHOFF, V. and E. VAN DER MAAREL. 1973. The Braun-Blanquet approach. *In:* WHITTAKER, R. H. Ed.: Ordination and classification of vegetation. *Handbook of vegetation science*. The Hague: Junk.

WHITE, F. 1971. The taxonomic and ecological basis of chorology. *Mitt. Bot. Staatssamml. München*. 10:91–112.