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A PHYTOSOCIOLOGICAL AND PHYTOGEOGRAPHICAL STUDY OF AUGRABIES FALLS NATIONAL PARK, REPUBLIC OF SOUTH AFRICA

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Abstract – An outline of the physiography and climate of the Augrabies Falls National Park is given. The plant communities occurring in the Park are described and their ecology is briefly discussed. A brief discussion on the phytogeography of the area, and on the flora and growth forms is added.

Introduction

The Augrabies Falls National Park (AFNP), Republic of South Africa (RSA), straddles the Orange River approximately 380 km inland from Alexander Bay where the river reaches the west coast of southern Africa. The Park falls in the Namaqualand Broken Veld (Acocks 1953)**, where the Orange River flows through the extensive arid plain of Bushmanland and Namaqualand. The vegetation is of a Karroid desert type, with a large number of succulents. Scattered *Aloe dichotoma* trees and particular convergences of xeromorphic forms in unrelated plant taxa are characteristic.

Like most Veld Types the Namaqualand Broken Veld is varied and

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** *In the new edition of his map Veld Types of South Africa, Acocks has drawn the boundary between the Orange River Broken Veld and the Namaqualand Broken Veld further westward. Augrabies Falls National Park now falls entirely in the Orange River Broken Veld (Acocks 1975).*

the vegetation and landscape at the AFNP differs considerably from that in the Hester Malan Wild Flower Reserve, at present the only other permanently conserved portion of Namaqualand Broken Veld. The total area of this Veld Type is 28 459 km² or 2,5% of the RSA and the areas covered by the AFNP and the Hester Malan Wild Flower Reserve near Springbok are 5 400 ha and 5 200 ha respectively (Edwards 1974). Edwards (*loc. cit.*) points out that, of the poorly conserved South African Veld Types, the lack of conservation in the arid areas is particularly significant; yet these Karoo and Karroid Bushveld Types of vegetation, with the False Karoo Types, cover about 35% of the country and are renowned as botanically unique. Moreover, the conversion of large tracts of these arid areas into nature reserves appears to be a valid and economic form of land use compared with the profits that can be made in farming these areas (Edwards and Werger 1972).

The AFNP is administered by the National Parks Board of Trustees and is a strong tourist attraction, particularly because of the spectacular Augrabies Falls and Orange River Gorge (Fig. 1) but also on account of its wild life, vegetation and unusual scenery (Labuschagne 1969).

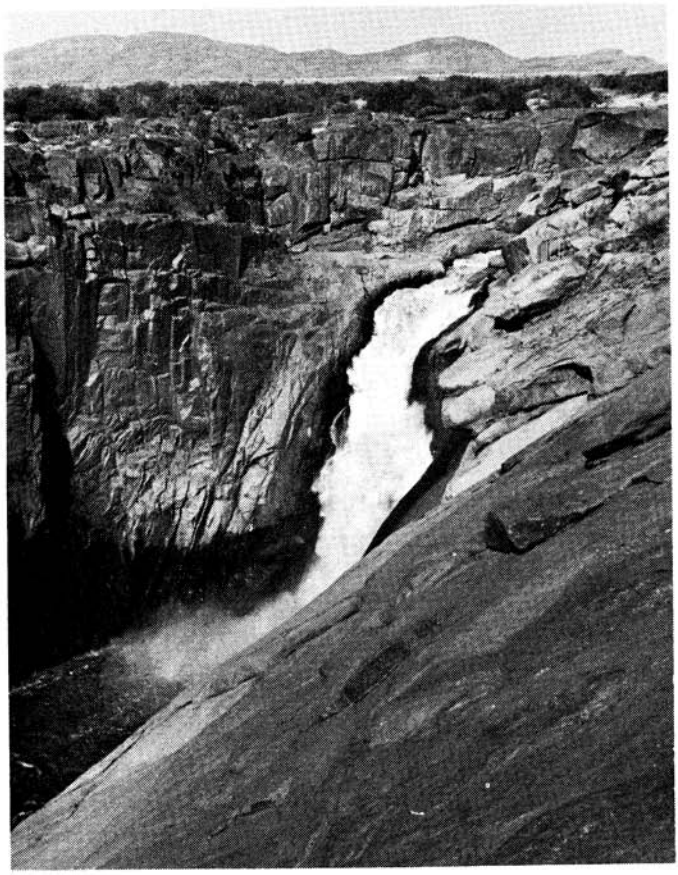

Fig. 1. Augrabies Falls in the Orange River.

The present survey formed part of the South African National Programme for Environmental Sciences' project to inventorize plant communities in permanently conserved areas at a semi-detailed level (Edwards 1974). For this purpose the Botanical Research Institute adopted the Braun-Blanquet Method of sampling and classification, described by Werger (1973, 1974) and Westhoff and Van der Maarel (1973).

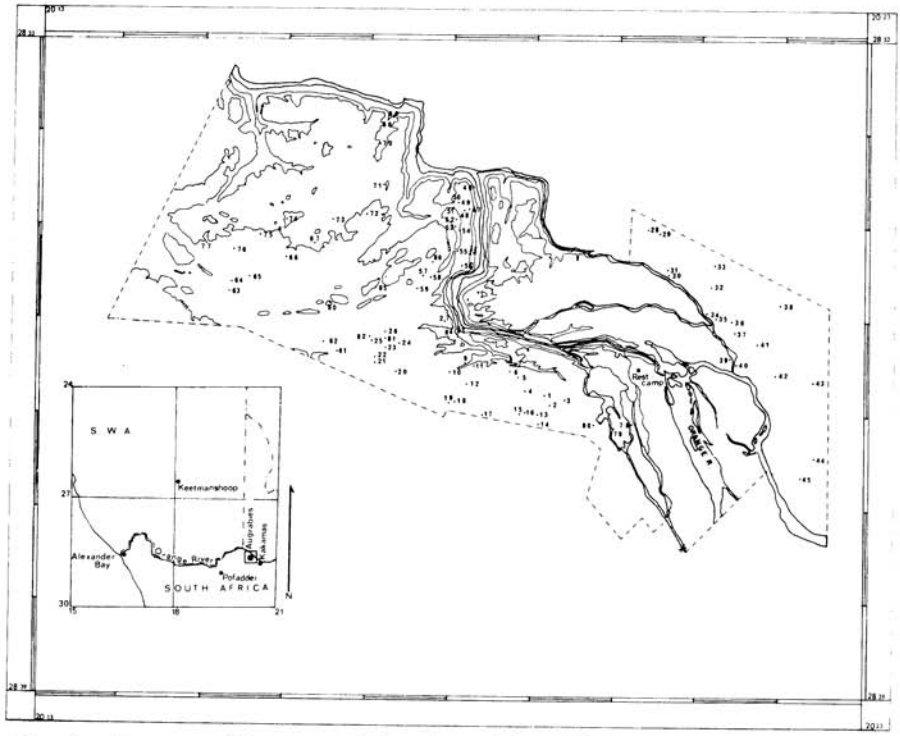

Fig. 2. Topographic map of the Augrabies Falls National Park showing positions of relevés. Contours are in 200 feet intervals.

Physiography

The physiography of the AFNP and surroundings is described by Hugo (1969) in his report of a survey undertaken in view of the beryl bearing pegmatites occurring in these parts of the country. The following account is based on his report.

The Park is situated on the vast Bushmanland peneplain and is drained by the Orange River (Fig. 2) which is normally a perennial stream. Between Kakamas and the Augrabies Falls, a distance of approximately 35 km, the river flows through a wide, flat, cultivated valley. From the 146 m high falls it flows in a deep, narrow, almost 100 km long gorge. The main incision of the peneplain to form the Orange River Gorge and the evolution of the Augrabies Falls are correlated with a continental uplift during the late Tertiary. Geological formations in the Park (Fig. 3) are reconstituted sedimentary rocks of the Kaaien

Series, Kheis System and are part of the Archaean Complex. These sediments have undergone large-scale metamorphism, which changed them into crystaline gneiss and granulite.

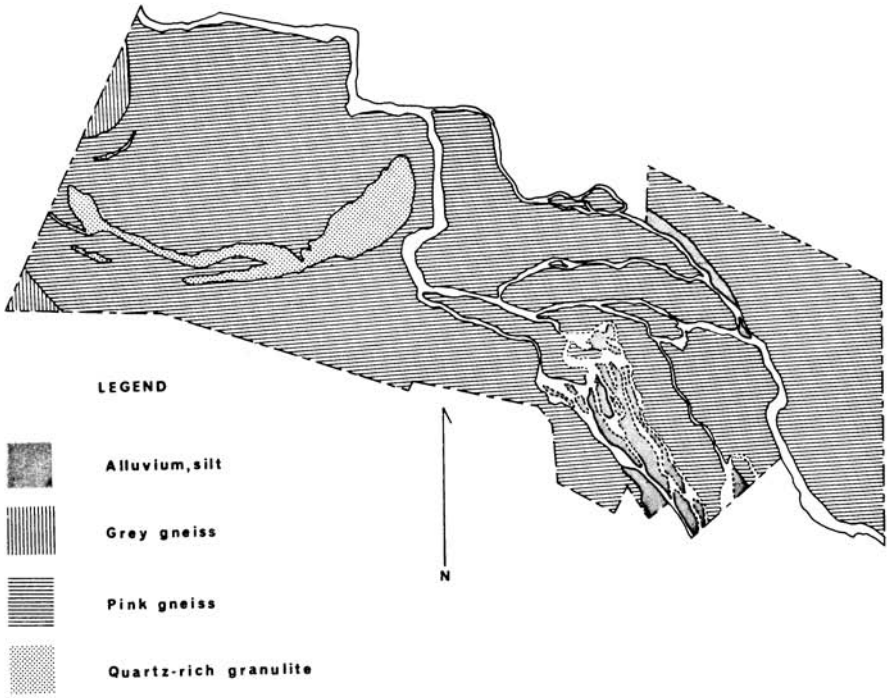

Fig. 3. Geological map of the Augrabies Falls National Park (after Hugo 1969).

Most of the Park is composed of red biotite granite gneiss, which is one of three types of granite gneiss called Pink Gneiss and has a typical orange brown colour on weathered surfaces. When weathered this rock forms large rounded domes. These are scattered in a landscape with otherwise very low relief and are characteristic of the scenery in the park (Figs. 4 and 17). The Pink Gneiss looks like a typical igneous rock and also resembles granite mineralogically and in chemical composition. The main constituents are quartz, microline and albite-oligoclase, with subsidiary iron ore (magnetite and hematite) and biotite. Heavy residues contain fluorspar, apatite, sericite, xircon and tourmaline. The flats in the Pink Gneiss area are gently undulating. Drainage channels are sandy, gravelly and dry and are mostly very shallow (Fig. 11); or sometimes deeper with rocky sides and broad beds (Fig. 21). Soils of the convex run-off areas are shallow litholitic with a porous "Schaumboden" structure typical of arid areas (Fig. 5) (cf. Volk and Geyger 1970). This structure renders the soil particularly dry and unsuitable for seed germination. At the AFNP this soil consists of a thin, compact crust of about 1 mm to 2 mm thick, followed by the layer with the foam structure of about 5 mm to 10 mm thick.

Fig. 4. Large rounded dome, called "Moon Rock", at Augrabies. In foreground pink gneiss outcrops with *Indigofera heterotricha-Zygophyllum suffruticosum* Community (*Triraphis ramossissima* Subcommunity).

Fig. 5. Porous "Schaumboden" at Augrabies.

A range of steep rocky hills in the western portion of the Park is formed by dark-weathering Quartz-rich Granulite (Figs. 3, 18, 19). This rock is invariably white on fresh surfaces, but on weathering becomes black. It consists of quartz, microcline and oligoclase.

A fairly large flat sandy area occurs north and west of the black hills, between these hills and the strongly dissected sides of the Orange River Gorge. The sand is yellowish white, suggesting that it is water washed. The sand flats are unerlain by Pink Gneiss. Recent river terrace gravel and alluvium consisting of silt and fine sand occurs along the Orange River. The alluvium also forms large islands in the River (Fig. 3).

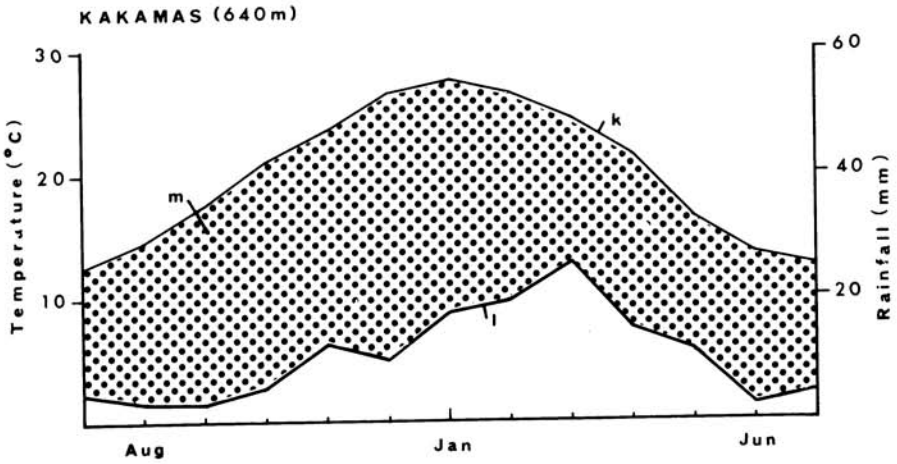

Fig. 6. Climate diagram of Kakamas, 25 km east of Augrabies Falls National Park. k = mean monthly temperature curve; l = mean monthly precipitation curve; m = dry season.

Climate

The climate according to Köppen's System is a cold desert, but with the mean temperature of the hottest month exceeding 18° C and with the height of the rainy season in March (autumn). This is designated BWkw' (Schulze 1947). As shown in Fig. 6, the climate is arid throughout the year in terms of Walter and Lieth's (1960) definition. In the Thornthwaite Classification System the area is classified as EB'd falling in the most arid type of Humidity Province (E), in a sub-province with moisture deficiency in all seasons (d) and a meso-thermal Temperature Efficiency Province (B') (Schulze 1947). In the Holdridge Life Zone system (Holdridge, Grenke, Hatheway, Liang and Tosi 1971) the area falls into the perarid subtropical desert scrub life zone.

Insolation

Total solar radiation at Keetmanshoop (Fig. 2) is largely direct and is between 300 and 350 cal/cm²/day in June and 700–750 cal/cm²/day in December (Schulze 1965). The periods of sunshine, judging from the

Pofadder weather station (Fig. 2), is between 80% and 90% of the astronomically possible, throughout the year.

Temperature

The annual range of mean temperatures at the Kakamas weather station (Fig. 2) over the period 1922–1935 was from 12,5° C in July to 27,3° C in January (Fig. 6; Weather Bureau 1954). The mean maximum temperature for January, the hottest month, is 41,3° C. The mean maximum temperature for any month exceeds 27° C. The lowest mean monthly minimum temperature is -2,0° C for July. Diurnal variation in temperature is also large. The difference between mean daily maximum and minimum temperatures for any month is at least 16° C and up to 19° C. Absolute maximum and minimum temperatures measured at Kakamas are 43,3° C and -4,7° C respectively.

Wind

Wind speeds are mostly less than 40 km/h but in January occasional stronger winds blow from the south and in July stronger winds blow from the north and south (Weather Bureau 1960).

Rainfall

The average annual rainfall at Kakamas is 129 mm and single heavy showers can account for as much as this (Schulze 1965; Weather Bureau 1965). Showers of more than 10 mm occur on less than five out of the average number of 20 rainy days per annum. Hail seldom occurs. The average monthly rainfall for the period June to October varies from 2 mm–6 mm, with on the average one rainy day per month (Fig. 6). The average monthly rainfall figures for November to May are between 10 mm and 26 mm and the number of rainy days per month, two to four. The highest average is in March.

Humidity

Mean monthly relative humidity at 14h00 SAST is lowest, between 10% and 20%, during September to January and highest, between 30% and 40%, in June (Schulze 1965). Evaporation figures are high, with the annual averages of 2 700 mm and 3 800 mm measured with a Symons pan and a Class 'A' pan respectively.

Methods

The phytosociological analysis according to the Braun-Blanquet procedures requires sampling of homogeneous plots of an adequate size (Werger 1973, 1974). In arid vegetation such as at the AFNP, the selection of homogeneous sites large enough for sampling is somewhat more difficult than in more closed vegetation types. This is particularly the case when sampling vegetation types like the *Indigofera heterotricha-Zygophyllum suffruticosum* Community. Available moisture is the most important factor determining plant life in an arid area like the AFNP and owing to this, minor changes in relief and soil depth cause major differences in the vegetation. However, the depth of the soil at a particular spot is often directly related to the topography of the immediate vicinity and the pattern of run-off. At the AFNP one finds in the gneiss area an irregular pattern of rocky outcrops, of which some are smooth and others have pockets or deep fissures, some are convex and others concave alternated by slightly concave or convex flats, funnels and drainage channels, and smaller or deeper fissures filled with sand or a more silty soil type. This pattern effects a mosaic of patches with different moisture regimes, and causes again a mosaic of different types of phytocoenoses (Batanouny, 1973; Batanouny and Sheikh 1972; Batanouny and Abu El-Souod 1972; Batanouny and Hilli 1973; Werger and Leistner 1976; Werger 1973). Some of these spots are too small to carry a floristically fully developed phytocoenosis, while others are intermediate in moisture regime between that of a rocky outcrop and that of a slightly loamy flat, and carry an intermediate type of vegetation. Therefore, not all samples taken and shown in Table 1 are typically representative of the communities in which they are placed. Some samples are floristically poorly developed and others are to some extent intermediate between two communities. Contrary to some authors, however, (e.g. Tüxen 1970; cf. Werger 1973, 1974) the present authors prefer to list all samples in the tables. Although this makes some noda in the tables slightly less distinct, it has the advantage of showing more fully the variation in vegetation types occurring at the AFNP (cf. Werger 1976).

Although most of the communities described probably will prove to have the rank of association and subassociation no attempt has been made in the present study at a formal hierarchial classification. This can be undertaken when the ranges of the constituent species are more fully analysed phytosociologically (cf. Werger 1974).

At the time of sampling the vegetation at the AFNP was in an excellent condition, due to favourable rains in the preceeding weeks. Therefore, all species were recorded, although during the tabulation phase, emphasis was put on perennials as they are more reliably recorded in arid areas than annuals and geophytes. Furthermore, in arid areas perennials are often regarded to be better indicators of specific habitat factors than ephemerals (Werger 1974).

Comparison of the occurrences of *Schmidtia kalahariensis* and

Enneapogon cenchroides in Table 1 will reveal that these species show an almost perfect mutually exclusive pattern. This is based only on misidentifications, however. During the field work individuals of *Schmidtia kalahariensis* have frequently been misidentified as *Enneapogon cenchroides*. This latter species also occurs at the AFNP, but to a lesser extent than shown in Table 1. The mistake could not be corrected anymore. Since both species, also outside the AFNP, have not shown to be indicative of specific environmental factors, and in fact occur in many widely different habitats, the present mistake is not thought to be crucial.

Plant communities

The plant communities are described on the basis of 86 relevés, of which the localities are shown in Fig. 2, and additional observations on some communities occurring on very restricted areas.

Fig. 7. "Moon Rock" with *Ceraria namaquensis* Community.

1) *Ceraria namaquensis* Community

The smooth, pink gneiss domes, of which the largest one at the AFNP is called "Moon Rock", are largely bare (Fig. 4). Only in limited areas does one find open stands dominated by *Ceraria namaquensis*, which can be up to 2 m tall. *Ceraria namaquensis* Community (Table 1) usually has total cover values of less than 5% and forms a pioneer vegetation of which the plants root in narrow cracks in the rock and in very shallow

soil deposists in and around these cracks (Fig. 7 & 8). The community is exposed to long periods of extreme drought, owing to its habitat. It is characterized by the odd-looking, portulacaceous, succulent shrub *C. namaquensis,* which is always the most abundant, and the grass *Panicum arbusculum* forming open tufts. As soon as the cracks become somewhat wider, or the soil deposits around the cracks somewhat deeper, other species start to occur, indicating a successional tendency towards the other communities described below (cf. Table 1). Most frequent among these species are the grasses of general occurrence *Enneapogon scaber, Stipagrostis uniplumis* and *Schmidtia kalahariensis* and the dwarf shrubs *Indigofera heterotricha, Hermannia spinosa* and *Monechma spartioides.*

The *Ceraria namaquensis* Community also occurs infrequently on bare rocky outcrops of rather strongly weathered gneiss with no dome shape. These localities are always on slopes where run-off starts immediately when it starts raining. Total cover values are higher here, namely up to 25% which is mainly due to a larger richness in species. At one restricted spot at the AFNP *C. namaquensis* occurs abundantly in another community, the *Enneapogon scaber-Euphorbia gregaria* Community described below. At this particular spot the quartzitic substrate which is typical of that community, is thin and directly underlain by pink gneiss.

Four hundred kilometres further west, in the Richtersveld, where the Atlantic fogs constitute an important climatological factor, on quartzite rock with very little soil, *C. namaquensis* occurs locally abundant in stands with many other succulent species, mainly Aizoaceae.

2) *Crassula densa* Community

In places, protected from the sun and dry winds by overhanging rocks, one sometimes finds another pioneer community in fissures in the rock containing very little soil: the *Crassula densa* Community. This habitat is relatively mesic. Relevé 84, which gives an example, was made in a rock fissure with a slope angle varying between 30° and 90° and a southern aspect.

Relevé	84
size (m)	2 x 0,05
total cover (%)	35
Crassula densa	2.3
Pellaea deltoidea	2.2
Senecio sisymbrifolia	+.1
Oxalis sp.	+.1
Forsskaolea candida	+.1
Liliaceae	+.1
Lichens (on rock, not on soil)	2

3) *Limosella capensis* Community

In the bare gneiss outcrops numerous small pockets occur with a diameter of 0,7 m or less. They are sometimes filled with rain water and a shallow soil layer at the bottom. Some pockets contain water for several weeks, and in these small pools a temporary waterplant community consisting of numerous individuals of *Limosella capensis* may develop. This species is very widespread in pools in southern Africa (Van Zinderen Bakker and Werger 1974).

Fig. 8. Structure diagram of a transect through gneiss domes with: the *Ceraria namaquensis* Community on the left where plants grow in tiny cracks with very shallow soil deposits; the *Eragrostis trichophora – Acacia mellifera* subsp. *detinens* Community in the deep-sandy depression between the domes; and the *Triraphis ramosissima* Subcommunity of the *Indigofera heterotricha – Zygophylla suffruticosum* Community, in large cracks of the broken gneiss dome.

4) *Indigofera heterotricha-Zygophyllum suffruticosum* Community

Wide stretches of the AFNP and its vicinities carry the *Indigofera heterotricha-Zygophyllum suffruticosum* Community (Table 1). This is the open community of the rocky outcrops of the Pink Gneiss, its shallow sandy drainage lines, and the slightly curved, rocky plains where a shallow top soil covers the gneiss substrate (Figs. 8–13).

The community is always open, usually covering less than 15%, but along the shallow drainage lines the more favourable water regime allows a slightly denser growth, with total cover percentages of about 35. This vegetation consists mainly of xeromorfic shrubs and dwarfshrubs with a sparse layer of grasses, which are physiologically active only during a short period immediately following the rains. Small trees, like *Pappea capensis, Boscia albitrunca, B. foetida* subsp. *foetida,* and *Aloe dichotoma,* sometimes also occur. Apart from *Indigofera heterotricha* and *Zygophyllum suffruticosum,* the community is characterized by the spiny shrubs and dwarfshrubs *Acacia mellifera* subsp. *detinens, Blepharis mitrata* and *Hermannia stricta,* the succulents *Sarcostemma viminalis, Euphorbia rhombifolia, Aloe dichotoma,* and *Sacocaulon pattersonii,* which is also spiny. Also characteristic are the shrubs and dwarfshrubs *Limeum dinteri,*

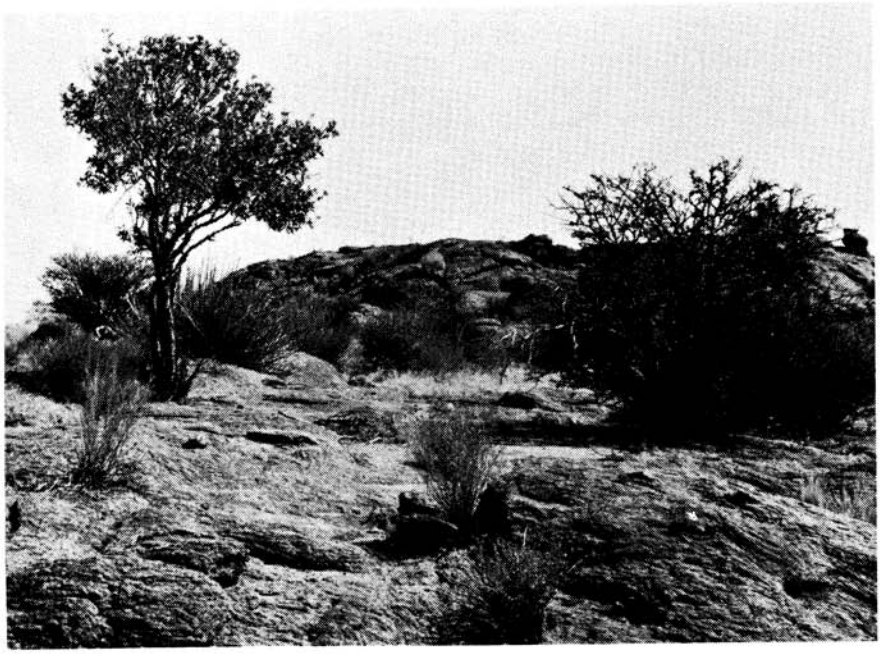

Fig. 9. *Triraphis ramossissima* Subcommunity of *Indigofera heterotricha-Zygophyllum suffruticosum* Community of pink gneiss outcrops. Tree: *Pappea capensis;* shrub: *Acacia mellifera* subsp. *detinens;* dwarfshrubs mainly *Monechma spartioides* and *Euphorbia gregaria.*

Sericocoma avolans, Polygala leptophylla, Boscia foetida subsp. *foetida, B. albitrunca* and *Rhynchosia totta,* the grasses *Aristida congesta* subsp. *barbicollis* and *Stipagrostis anomala,* which are both widespread in the arid regions of southern Africa, and possibly the geophyte *Androcymbium* sp. A large number of other species are found in the *Indigofera heterotricha-Zygophyllum suffruticosum* Community (Table 1), of which some of the most important or most constant are *Stipagrostis uniplumis, Enneapogon scaber, Monechma spartioides, Euphorbia gregaria, Aptosimum spinescens* and *Zygophyllum dregeanum.* The physiognomy of this community, is largely determined by *Euphorbia gregaria, Monechma spartioides, Acacia mellifera* subsp. *detinens, Stipagrostis uniplumis, Enneapogon scaber* and the two name-giving species.

Three subcommunities of the *Indigofera heterotricha-Zygophyllum suffruticosum* Community have been distinguished at the AFNP:

(a) The subcommunity with *Triraphis ramossissima* occurs on the gneiss outcrops, where soil is virtually lacking (Fig. 8). The gneiss forms strangely weathered, rounded boulders and pillars, or sometimes less irregularly dissected shields or ridges. Debris and soil, offering possi-

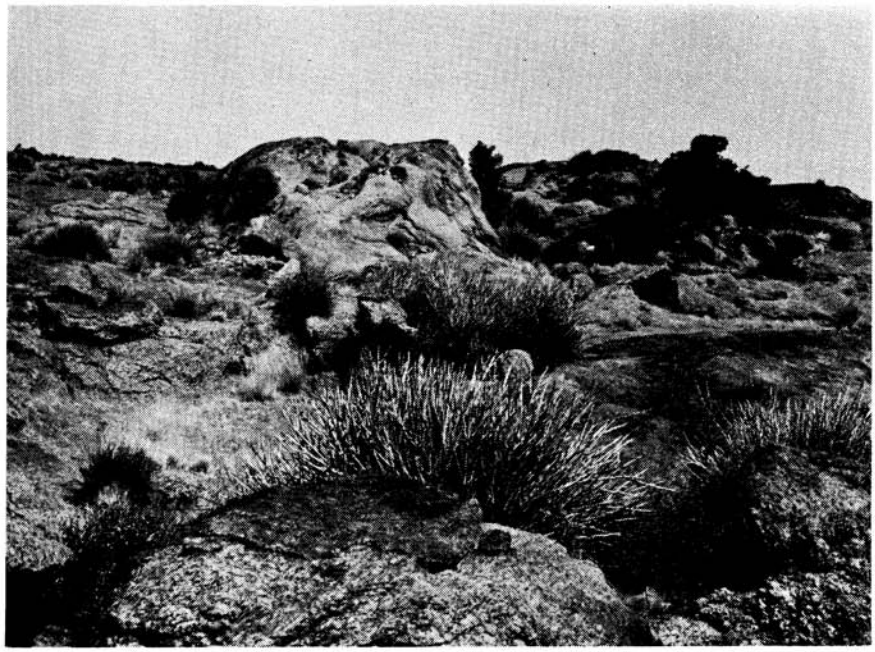

Fig. 10. *Triraphis ramossissima* Subcommunity of *Indigofera heterotricha-Zygophyllum suffruticosum* Community with *Euphorbia gregaria*.

bilities for plant growth have accumulated only in cracks and fairly deep pockets (Figs. 8–10). Consequently the Subcommunity with *Triraphis ramossissima* is extremely open, with total cover values of usually 10% or less. It represents a pioneer stage with respect to the two other subcommunities of this *Indigofera heterotricha-Zygophyllum suffruticosum* Community. When further weathering and erosion create a substrate with more soil and thus more possiblities for plant growth, one of the other two subcommunities can develop. The *Triraphis ramossissima* Subcommunity is floristically the poorest subcommunity of the three. This also will have its causes in the limited possiblities for plant growth offered by the habitat. Low trees and large shrubs do not occur.

The absence or rarity of several species common in the other two subcommunities is typical for the *Triraphis ramossissima* Subcommunity. Such species appear to be, for example, *Acacia mellifera* subsp. *detinens, Zygophyllum suffruticosum, Blepharis mitrata, Sericocoma avolans, Boscia foetida* subsp. *foetida, Limeum aethiopicum, Hermannia spinosa, Aptosimum spinescens* and *Asparagus denudatus* (Table 1). This subcommunity is also typified against the other two subcommunities by the occurrence of *Triraphis ramossissima* and *Anthephora pubescens,* while *Euphorbia gregaria* and *Forsskaolea candida* are more constant in this subcommunity.

Fig. 11. *Indigofera heterotricha – Zygophyllum suffruticosum* Community. *Zygophyllum dregeanum* Subcommunity on slightly convex, almost bare sites with "Schaumboden". *Monechma spartioides* Subcommunity in drainage channels, showing *Acacia mellifera* subsp. *detinens* and *Euphorbia gregaria*.

Fig. 12. Structure diagram of the *Indigofera heterotricha – Zygophyllum suffruticosum* Community: the *Monechma spartioides* Subcommunity occurs in the slight depressions of drainage lines and the *Zygophyllum dregeanum* Subcommunity occurs on convex areas with "Schaumboden".

(b) Along the drainage channels in the gneiss outcrops and through the slightly curved flats, where the gneiss is covered by a thin, rocky top soil, the Subcommunity with a high cover of *Monechma spartioides* is found. Owing to the much better moisture conditions along these drainage lines, this subcommunity is less open than the *Triraphis ramossissima* Subcommunity and reaches total cover values of 35% and sometimes even more. *Monechma spartioides* Subcommunity by no means

constitutes a closed vegetation type, however, but consists of a fairly open growth of mainly shrubs and dwarf shrubs and a few low trees up to 4 m tall, in narrow ribbons following the "banks" of the drainage lines. Whereas the drainage lines themselves are usually on bare bedrock, or only locally have shallow accumulations of loose, washed sand and rock debris, there is some soil accumulation on their "banks". During rains and shortly afterwards, this soil can store some moisture, which makes the slightly more luxurious shrubby growth of this *Monechma spartioides* Subcommunity as compared to the other subcommunities, possible (Figs. 11–13).

Fig. 13. *Monechma spartioides* Subcommunity of *Indigofera heterotricha – Zygophyllum suffruticosum* Community on pink gneiss covered by thin, rocky soil. Tree: *Aloe dichotoma;* shrubs: *Acacia mellifera* subsp. *detinens.*

There is a slight tendency to clump-forming in this subcommunity in the sense that under drainage channels, one often finds a concentration of the smaller shrubs and dwarf shrubs. Outside the canopies of the larger shrubs enough smaller shrubs and dwarf shrubs still occur, however, to give a picture of evenly spread canopy cover in a stand of this subcommunity. The reasons for this tendency to clump-forming must be sought in the first place in larger canopies collecting and concentrating precipitation moisture, which results in a local increase of water; secondly, temperature, evaporation and humidity deficiency will be less extreme under those canopies, which favour the general moisture regime (Specht 1957; Glover, Glover and Gwynne 1962;Werger and Leistner 1976). The *Monechma spartioides* Subcommunity is characterized

Fig. 14. *Enneapogon scaber – Euphorbia gregaria* Community on fairly deep, rocky soil. Both name-giving species are clearly visible.

boulders but also of granulite and gneiss about 0,1 m to 0,2 m in diameter. It is a sandy loam which apparently has a larger water capacity than most other soils in the Augrabies area. This slope with its fairly well-drained soil carries a succulent shrub savanna vegetation, the *Enneapogon scaber-Euphorbia gregaria* Community. This community reaches total cover values of 30% to 40% being higher than most of the other vegetation types of Augrabies. The round, succulent shrubs of *Euphorbia gregaria* are particularly abundant in this community, and determine its physiognomy together with numerous white tufts of the grass *Enneapogon scaber* (Fig. 14). Neither species are restricted to this community in the AFNP, but reach here characteristically high cover-abundance values. The *Enneapogon scaber-Euphorbia gregaria* Community is further characterized by the grass *Eragrostis nindensis,* which has dessication-tolerant foliage (Gaff and Ellis 1974), the annuals *Chascanum gariepina* and *Osteospermum amplectens,* and the forbs *Tephrosia dregeana, Phyllanthus maderaspatentis* and *Oxalis* sp. All these species are restricted to this community at Augrabies. The annual *Cleome angustifolia* subsp. *diandra* is constant in this community, but also occurs in the *Commiphora gracilifrondosa* Community of the black granulite hills. *Lotononis platycarpha* var. *abyssinica* and *Rhigozum trichotomum* appear to be more constant in this community than in the other communities in which they occur.

In addition to the succulent shrubs of *Euphorbia gregaria,* the grassy component is well represented. These are all grasses which have a short physiologically active period just following the rains, but they remain as bleached tufts during the dry season, so that total cover values remain relatively high.

The *Enneapogon scaber-Euphorbia gregaria* Community has a number of species in common with some of the other communities at the AFNP (Table 1). Apart from the above-named ones, some of the most important of these species are the dwarf shrub *Monechma spartioides* and the grasses *Stipagrostis uniplumis* and *Aristida curvata.* Table 1 suggests that the *Enneapogon scaber-Euphorbia gregaria* Community, the *Indigofera heterotricha-Zygophyllum suffruticosum* Community and the *Ceraria namaquensis* Community together belong to a higher vegetation unit, presumably of the level of an alliance. Further research in a wider area may confirm this Table picture.

Further down the Orange River, particularly in the vicinity of Onseepkans, a vegetation type in which *Euphorbia gregaria* and *Aloe dichotoma* are co-dominant, occurs over wide stretches on sandy soil. The suffrutescent *Stipagrostis brevifolia* as well as *Stipagrostis uniplumis* and the dwarf shrubs *Rhigozum trichotomum* are also important in this vegetation type.

In the southern part of South West Africa, particularly on the Huib plateau, *Euphorbia gregaria* is dominant over wide stretches of rocky desert landscape (Coetzee and Werger 1975). These areas have not been described phytosociologically, however, and the exact relationships between these *Euphorbia gregaria*-dominated vegetation types and the *Enneapogon scaber-Euphorbia gregaria* Community at the AFNP are not yet clear.

6) *Stipagrostis hochstetteriana* var. *secalina* Community

West of the black granulite hills there is a plain of about 1,5 km across, which is made up of a thick layer of washed, coarse, loose, white sand, intersected by a few shallow drainage lines. The vegetation on this sandy plain is an open savanna, entirely dominated by *Stipagrostis hochstetteriana* var. *secalina* (Fig. 15). This grass, which is about 0,75 m high grows very luxuriantly in this habitat, and is restricted to it at the AFNP – hence the name *Stipagrostis hochstetteriana* var. *secalina* Community. Total cover values in this vegetation type are about 30%, and these values are mainly made up by the name-giving grass. Here and there shrubs emerge from the field layer, the most frequent ones being *Euphorbia gregaria, Cadaba aphylla* and *Nymania capensis,* but *Parkinsonia africana, Phaeoptilum spinosum, Boscia foetida* subsp. *foetida, Sisyndite spartea, Acacia mellifera* subsp. *detinens* and *Motinia caryophyllacea* also occur. These shrubs are mainly between 1 m and 2,5 m tall. Apart from *Stipagrostis hochstetteriana* var. *secalina* the following species are typical for and restricted to this community at the AFNP: *Kohautia cynanchica, Ptycholobium biflorum, Parkinsonia africana* and *Cadaba aphylla* (Table 1). The community is relatively poor in spe-

cies, and except for some of the abovementioned species, only *Stipagrostis uniplumis, Monechma spartioides* and *Schmidtia kalahariensis* are frequently encountered.

The drainage lines through this savanna vegetation often carry a fragmentary form of the *Zygophyllum dregeanum* Subcommunity of the *Indigofera heterotricha-Zygophyllum suffruticosum* Community, when they are shallow and contain sandy loam. Relevé 67 was made near such a drainage line and contains some of the species typical for that community. The larger drainage lines are rocky, however, and carry on their banks the *Schotia afra* Community which will be described below.

Fig. 15. *Stipagrostis hochstetteriana* var. *secalina* Community on plain of washed, white sand.

7) *Monechma australe-Acacia erioloba* Community

North of the Orange River in the Melkbosrand area another plain about 0,5 km across and consisting of deep, coarse sand occurs. Although the sand also seems to be washed, it is not as white as the sand of the *Stipagrostis hochstetteriana* var. *secalina* savanna, but it still has a yellow colouring due to the coating of ferric oxide on the sand grains (cf. Leistner and Werger 1973). The sand is also slightly more compact here than west of the black granulite hills. Drainage lines are virtually absent from the sandy plain, and the occasional rainwater apparently immediately infiltrates the soil. Ground squirrels *Xerus inauris,* are very active in this habitat, judging from numerous burrows found.

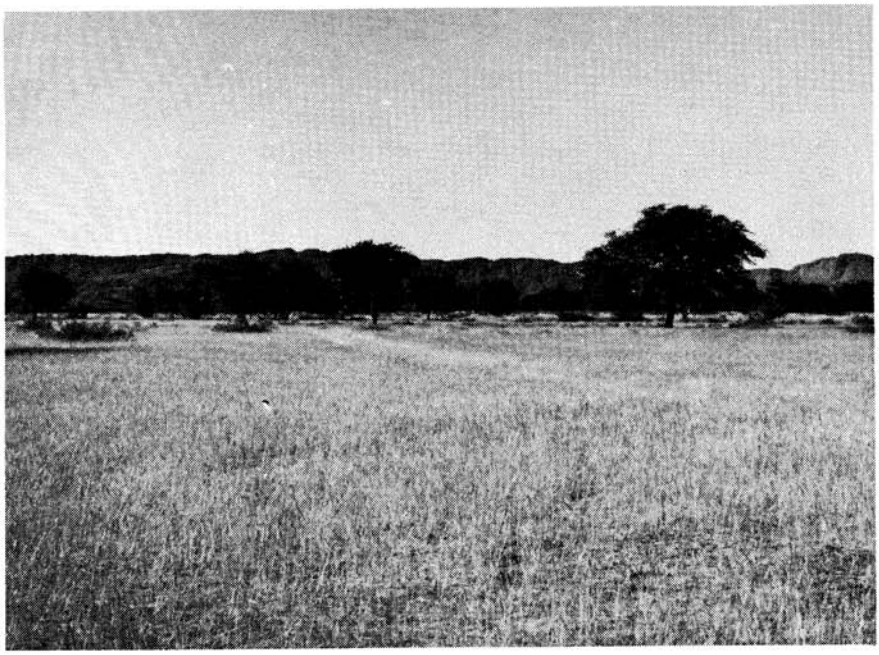

Fig. 16. *Monechma australe – Acacia erioloba* savanna on plain of yellow sand; northern side of Augrabies Falls National Park.

Another savanna community, the *Monechma australe-Acacia erioloba* Community (Fig. 16), of which relevé 36 is an example occurs in this habitat:

Relevé	36
size (m)	10 x 10
total cover (%)	60
Acacia erioloba	1.1
Monechma australe	2.2
Zygophyllum microcarpum	1.2
Schmidtia kalahariensis	4.2
Zygophyllum simplex	+.2
Eragrostis annulata	1.2
Aristida congesta	+.2
Eragrostis cf. pilosa	+.2

The physiognomy of this savanna community is mainly determined by the trees of *Acacia erioloba,* which are 5 m to 7 m high and cover about 3%, together with the annual grass *Schmidtia kalahariensis.* The dwarf shrubs *Monechma australe* and *Zygophyllum microcarpum* do not emerge from the fieldlayer, which is about 0,6 m high. Except for the dwarf shrubs the fieldlayer consists entirely of annual pioneer species. It is possible that heavy grazing and trampling by goats and donkeys prior to the

proclamation of the national park have caused the reduction of the field-layer to this pioneer stage, and that the present state is maintained by the numerous ground squirrels.

Eragrostis cf. *pilosa* is mainly confined to the areas shaded by *Acacia erioloba,* a widespread southern African species, typical of Kalahari sand. However, in the southern Kalahari it does not occur in the same habitat as *Monechma australe,* which there is restricted to compact, limy substrates (Leistner and Werger 1973).

8) *Eragrostis trichophora-Acacia mellifera* subsp. *detinens* Community

Another deep sandy habitat is encountered in the depressions between large gneiss domes (Fig. 8). Here all the eroded material is deposited mainly with the strong run-off from the domes after a shower. The coarse, sandy material has a favourable water storage capacity, and because of the run-off the soil is always humid in its deeper reaches. The vegetation in these depressions is luxuriant as compared to the surroundings (Fig. 17), and is called the *Eragrostis trichophora-Acacia mellifera*

Fig. 17. *Eragrostis trichophora – Acacia mellifera* subsp. *detinens* Community on deep sandy soil in depression between gneiss domes carrying *Ceraria namaquensis* Community.

subsp. *detinens* Community. It is a savanna vegetation with tall shrubs up to 4 m high and covering up to 20 per cent. There is also a lower shrub and dwarf shrub layer interwoven with a fieldlayer of grasses, forbs and dwarf shrubs up to 1,5 m in height and together covering 75% to 80 per