THE ECOLOGY AND MANAGEMENT

OF RIEMVASMAAK'S

NATURAL RESOURCES

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BOTANICAL
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Report on a baseline ecological survey conducted in Riemvasmaak, Northern Cape, South Africa between 16-29 January, 1995, and an outline of a proposed monitoring programme for the region.

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July 1995

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This project was initiated and funded by FARM Africa.

FOOD AND AGRICULTURAL RESEARCH MANAGEMENT

FARM Africa's role and work

"FARM Africa, a registered charity set up in 1985, is committed to helping the small farmers and herders of Africa to help themselves. FARM Africa believes that these are the people who can contribute most towards breaking the cycle of famine and bring hope and new prosperity to neglected marginal communities. In partnership with the people, FARM's projects pioneer new strategies and techniques in crop and animal husbandry to produce more food and crops, including forestry, in a sustainable way that does not damage the environment. FARM's projects are long-term initiatives which may extend up to 10-15 years.

By increasing and spreading knowledge of better farming practices to resourceful but neglected agriculturalists, FARM helps Africans reap a richer harvest from their land. Wherever possible FARM works with or through other development groups and African governments, providing technical expertise, training and other inputs. FARM strives to influence agricultural development policy at national and international levels.

FARM is the recognised development charity of the United Kingdom's agricultural industry, and provides a channel through which supporters can give direct assistance to the hard-pressed people of Africa. It has a thriving supporters' network - the Friends of FARM in the UK, Kenya and South Africa. FARM has expanded rapidly and has planned, and now runs in partnership with farming communities, seven projects in Ethiopia, Kenya, Tanzania and South Africa. Two more projects are in the planning phase."

(From FARM Africa's 1994/1995 Review).

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PLATE 1.1. National Botanical Institute members of the survey team and authors of this report: Clockwise from upper left: Barry Jagger, Dan Sonnenberg, Jeanne Hurford and Timm Hoffman

PREFACE

During the last five years South Africans have witnessed dramatic political and social changes and genuine attempts are currently being made to redress some of the injustices which occurred during decades of minority government rule. One of the worst of these injustices was the removal and re-location of entire communities as part of a large-scale, social engineering programme which accompanied the South African government's apartheid legislation from 1948 onwards. This programme of ethnic cleansing or "black spot removal" profoundly affected the lives of millions of South Africans.

One such group was a small community of about 1 500 people living an agrarian existence in one of the most arid parts of the country in an area known as Riemvasmaak. Boasting a diverse ethnic heritage the Riemvasmakers colonized this approximately 75 000 ha region immediately north of the Orange River towards the end of the last century and during the first few decades of this century. It was a peaceful and religious community which managed its natural resources effectively, provided schools for the education of its children and which also enjoyed good relationships with its neighbours. However, as part of a well-orchestrated "black spot removal" programme, the South African government forcibly relocated some of the Riemvasmakers during 1973 and 1974. Those with an historical Xhosa ethnicity were moved to the Ciskei in South Africa in 1973 while those with Nama and Damara heritage were moved, against their wishes, to northern Namibia in 1974. A number of Riemvasmakers classified as "Coloured" were dispersed in and around the greater Orange River environment at the same time. Tremendous subsequent hardships ensued for the majority of Riemvasmakers in their adopted lands including livestock losses and debilitating poverty.[1]

Following their exodus in 1974, Riemvasmaak was used by the South African Defence Force (now known as the South African National Defence Force but referred to as the SADF throughout this document) and other military establishments as a troop-training and arms-testing facility. However, in anticipation of the changes sweeping the country in the early 1990's a group of Riemvasmakers began to initiate procedures for re-claiming their land. After an intensive struggle in which a number of individuals comprising the Riemvasmaak Coordinating Committee, the Surplus People Project (SPP) and the Legal Resources Centre (LRC) played pivotal roles it was agreed by the Commission on Land Allocation in December 1993 that the people who were forcibly removed from Riemvasmaak should return.

But what was there to return to and how would the Riemvasmaak community rebuild their livelihoods? The national as well as the regional economic, social and agricultural environment has changed considerably since 1974. Which agricultural enterprises should be developed or supported, where would the necessary capital be

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[1] Although elaborated upon in the report which follows, a more detailed account of the history of Riemvasmaak, the brutal nature of the forced removal, their period in the "wilderness" and the community's claim to the land is contained in Smith & Bozalek (1993) and in the Riemvasmaak Coordinating Committee's "Submission to the Commission on Land Allocation on behalf of the community of Riemvasmaak" (SPP & LRC, 1993). Other aspects, especially the landuse history of the region are dealt with in more detail elsewhere in this report.

found and who would assist the Riemvasmakers in their attempts to rebuild their lives?

FARM Africa has an extensive and growing experience in agricultural development programmes in Africa and it is to this organization that the Riemvasmaak Trust Committee has turned to provide assistance with the planning of the agricultural development of the region. Planning, however, requires an extensive knowledge of the region's natural resources and its potential. Responsible and sustainable development programmes also require the measurement of a variety of indicators with which to assess the effectiveness or otherwise of the programme. In order to fulfill its task of developing the agricultural base of Riemvasmaak, FARM Africa, in turn, has requested assistance from the National Botanical Institute (NBI), an organization with expertise in the ecology and management of southern Africa's arid and semi-arid zones.

This report of the National Botanical Institute has six main objectives:

a. To synthesize available ecological information about the area including all available plant and animal checklists;
b. To conduct a baseline survey of the region and to describe the landscape as it existed in January 1995;
c. To assess landscape "condition" in the context of the environmental and landuse history of the region;
d. To assess the landscape's potential and livestock carrying capacity;
e. To describe landuse practices in "Old Riemvasmaak";
f. To outline a monitoring programme for Riemvasmaak.

Firstly, numerous unpublished reports and plant and animal checklists have emerged concerning the Riemvasmaak environment and our first task, therefore, was to synthesize available information pertaining to the physical and biotic environment of the region. Where applicable we have tried to redraw the key figures and redraft important technical data from other sources so as to make them more accessible to a broader, non-specialist audience.

Secondly, a survey of the region was conducted by the authors of this report between January 16-29, 1995. This document serves as a useful vehicle to summarize the main findings of the survey which describes the condition of the landscape after 20 years without livestock. It was important that the survey be conducted in January, before the return of the Riemvasmakers with their stock from January to June 1995. In a sense, the survey describes the Riemvasmaak environment at "time zero" and future changes can now be interpreted according to this benchmark period.

Thirdly, a detailed knowledge of the past often helps in the planning for the future. This report, therefore, also emphasizes the environmental and landuse history of the region. An analysis of long-term rainfall records, aerial and ground photographs and the re-sampling of key plant survey sites has helped us to develop a more complete understanding of the changing Riemvasmaak ecological environment over time and to assess its current ecological "condition". Interviews with a number of livestock farmers has also helped considerably in our understanding of landscape condition in "Old Riemvasmaak".

Fourthly, many Riemvasmakers possess a keen interest in livestock and wish to farm either on a full- or part-time basis. However, FARM Africa, and indeed many other planning agencies, need to know something about the ecological potential and livestock carrying capacity of the region in order to make important decisions concerning future development projects. We address this thorny carrying capacity issue in our report and draw on the historical testimony of a number of Riemvasmakers to describe the grazing practices and fluctuations in stock numbers which existed in “Old Riemvasmaak”.

Finally, in order for the livestock owners and crop farmers of Riemvasmaak to make decisions about their agricultural enterprises in the future they will need to keep track of environmental and economic conditions. Therefore, FARM Africa explicitly wanted this report to advise on the development of a monitoring programme for the region.

The National Botanical Institute’s team has been acutely aware throughout this survey that although the Riemvasmakers have been away from their land for 20 years, many retain an impressive knowledge of the region’s natural resources. Because of this we have tried, wherever possible, not only to extract relevant information from key informants but also to feed back to interested members and especially the livestock owners, knowledge that we have gained during the course of our survey. In this way we have also been able to assess the accuracy of our information and data. To this end we met with available Riemvasmakers on the 16 January to discuss our survey intentions. It was suggested at this meeting that we take along a local guide and for three days we enjoyed the expert guidance, advice and warm company of Mr Willem Vass. The last day of our survey was concluded with a brief report-back and discussion of our observations and preliminary findings.

Between February and April 1995 the survey data were analyzed and prepared for presentation. A further trip was made to the region by the senior author of this report together with Dr David Catling of FARM Africa from May 2-6 1995. A more detailed three-hour report-back session was arranged for the morning of the 4 May 1995. Highlights of this report, including the long-term rainfall record, stocking rates, water resources, the *Prosopis* problem and aspects of the monitoring programme were discussed with about 40 Riemvasmakers, most of whom were livestock owners. Further discussions were conducted in smaller groups for the next two days and important details of these fruitful exchanges have been incorporated into the text, figures and tables of this report.

A seminar, attended by about 40 academics was also held in the University of Cape Town’s Botany Department on 17 May 1995. The frank and sometimes hostile responses to some of the issues raised in this report, especially those concerning carrying capacity estimates, have been considered in the relevant sections of this report.

Finally, our relationship to this project has changed considerably during the last 6 months. While we do “advise” on certain key aspects of the agricultural development programme for the region we would now rather like to emphasize our role as interpreters and advocates of especially the aspirations of the livestock owners of Riemvasmaak. Only a small amount of their extensive knowledge and management expertise has been captured in this report. We would advise that far more effort in the future be spent on simply listening to the history and aspirations of the Riemvasmakers themselves before any far-reaching decisions are taken on crucial aspects such as stocking rates and grazing systems. Without an extensive and inclusive consultation process there is little doubt in our minds that even the most elaborate and expensive development programmes will ultimately fail. Authoritarian grazing “rules” if not developed and agreed to by the livestock owners themselves will meet with determined resistance. Also, the success of other constructive development programmes will ultimately be jeopardized.

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July 21, 1995

ACKNOWLEDGEMENTS

Many individuals and organizations have helped in this project. Firstly, we would like to acknowledge the contribution of the Riemvasmaak community itself. Not only have they supplied a great deal of the information contained in this report but they have also directed much of our line of investigation. Although we mention throughout the text, the names of individuals who have helped with specific aspects of our study, we would like to highlight the assistance we have received from Mr Freddy Bosman Snr, Mr Freddy Bosman Jnr, Mrs Rita Maasdorp, Mr Pieter Malgas, Mr James Mapanka and especially Mr Willem Vass. The frank and constructive response of all the livestock farmers to our report-back session on 4 May 1995 is also much appreciated.

The National Parks Board assisted us in a number of ways during our baseline survey. Dr Anthony Hall Martin, Dr Hugo Bezuidenhout, Dr Michael Knight and especially Mr Barry Hopgood, the Augrabies Falls National Park Game Warden, are thanked for their help.

This report would not have been possible without the supportive encouragement of Dr David Catling, the FARM Africa representative who has been intimately involved with the agricultural development initiatives at Riemvasmaak. Together with Dr Dick Sandford, who suggested the need for the survey and monitoring programme, we have received nothing but constructive assistance. Mr David Makin-Taylor has also provided helpful comment on a number of issues.

Ms Sue Power and Ms Glenda Glover of the Surplus People Project have made their very valuable resource files available to us and have provided us with a great deal of historical information concerning Riemvasmaak. Together with Mr Henk Smith of the Legal Resources Centre, the Surplus People Project was pivotal in the struggle for the return of the land to the Riemvasmakers. These people willingly shared their insights of the region and wealth of experience with us.

We have benefited from the botanical expertise of many of our colleagues at the National Botanical Institute. In particular we would like to mention the Compton Herbarium staff: Dr John Rourke, Mr Koos Roux and Dr Deidre Paterson-Jones. Other colleagues, including Dr George Davis, Dave Macdonald, Guy Midgley, Dr Mike O'Callaghan, Les Powrie and Dr Mike Rutherford helped with interpretation and analysis of key aspects of the data. An afternoon in the University of Cape Town, Botany Department's "Bear Pit" discussing aspects of this report with Professor William Bond, Dr Peter Linder, Dr Jeremy Midgley, Dr Willie Stock and others has sharpened our thinking considerably.

Other colleagues who have provided information include Professor Noel van Rooyen of the University of Pretoria, Dr Kevin Balkwill of Wits University, Dr Dave Richardson from the University of Cape Town and Tanya Anderson of the McGregor Museum in Kimberley. Carl Stoltsz of the Plant Protection Research Institute provided information and helpful advice on the *Prosopis* problem at Riemvasmaak.

Dr Mariane Tredoux of the Geology Department at the University of Cape Town helped to simplify Riemvasmaak's complex geology for us.

The archaeological work mentioned in the report has benefited from the advice of Professor Andy Smith of the University of Cape Town and Mr Peter Beaumont of the MacGregor Museum.

The South African National Defence Force, and especially Captain Willie van der Merwe, have been most cooperative in providing access to their files on Riemvasmaak. They have also sent us a great deal of ecological information collected during their tenure of the region from 1974-1993.

Ms Rachel Wynberg of the Environmental Evaluation Unit has also provided us with assistance especially regarding the development of the monitoring programme for the region.

We would also like to acknowledge the support of the National Botanical Institute and the Department of Environment Affairs and Tourism.

Finally, decisions taken at the household level appear critical for any enterprise whether it be ecological research or livestock farming. In the light of this, the senior author would like to acknowledge the generous support and encouragement that his wife Carolyn has provided throughout this project.

EXECUTIVE SUMMARY

- This report of the National Botanical Institute has six main objectives: We synthesize available ecological information about the area including all available plant and animal checklists; conduct a baseline survey of the region and describe the landscape as it existed in January 1995; assess landscape "condition" in the context of the environmental and landuse history of the region; assess the landscape's potential and livestock carrying capacity; describe landuse practices in "Old Riemvasmaak"; finally, we outline a monitoring programme for Riemvasmaak.
- The report has four chapters and 10 Appendices.

CHAPTER 1: THE BASELINE SURVEY

- This first chapter describes the baseline survey conducted in Riemvasmaak between 15-29 January 1995.
- Riemvasmaak is 74 563 ha in extent. It is situated in the Northern Cape province and borders on the Orange River in the south and Namibia in the west. Commercial farmland occurs to the north and northeast of Riemvasmaak while the National Parks Board owns adjoining land in the east and leases 4 270 ha of Riemvasmaak land from the Riemvasmaak Trust in the southeast;
- A map of local place names including those of veeposte (stockposts) shows the wealth of knowledge which still exists within members of the Riemvasmaak community regarding the ecology and management of the landscape;
- The geology of the region is tightly coupled to the landforms of the region and is comprised of 3 main geological groups: the Namaqualand Mobile Belt sediments and intrusive rocks; the Nama sediments comprising the plateau; the more recent Kalahari and Quaternary sands;
- Numerous pegmatites exist in the region and form the basis for the mining industry that existed in the region in the past. The six main pegmatites that have been exploited in the past are described;
- The results of an analysis of 12 soil samples is presented and a description of the Molopo alluvial fan that has been earmarked for cropland development is included based on the results of previous research in the area;
- The mean annual rainfall for the region is 125 $mm.yr^{-1}$ with a coefficient of variation of 59 per cent. Mean annual rainfall increases only marginally from west to east but slightly more from the Orange River basin (75 $mm.yr^{-1}$) to the northern borders of Riemvasmaak (145 $mm.yr^{-1}$).
- Long-term rainfall data for the period 1918-1994 is presented for two rainfall stations situated close to Riemvasmaak and indicate large fluctuations in annual rainfall totals. In some years, less than 25 mm was recorded while for 1976 more than 350 mm was measured. This very high rainfall period, from 1972-1976 coincided with the period when the Riemvasmakers were removed from the region in 1973/74;
- The Molopo River catchment area is the largest of the four main catchment areas which decrease in size from the Bak, Kourop and Orange River catchments respectively. The water points, including boreholes, dug wells, fountains, natural

springs as well as the Riemvasmaak Hot Spring are mapped and details of each water point is synthesized from previous reports. Only three of the twenty water points sampled by Toens (1994) contained potable water;

- A lengthy description of the methodology used in the baseline survey is presented to enable future workers to re-sample the area. Our itinerary is presented in Appendix 1. We adopt a landscape approach and couple photographs with our sample plots. 29 photostations provide the basis of our vegetation and landform classification analysis. Details of the photostations and the main view (photograph) used at each photostation are provided in Appendix 8;
- With the assistance of aerial photographs, five main landforms are mapped: the Plateau (26 % of the area); Rocky slopes (25 %); Rocky footslopes and rocky pediments (34 %); Sandy pediments (14 %); and River beds (1.4 %) with inselbergs forming a sixth rather minor unit;
- The general composition and dominant species associated with each landform are presented in Appendix 2 and described in the text. A checklist comprising 443 plant species is contained in Appendix 3. None of the species are listed as Endangered or Vulnerable in the Red Data book. A stylized diagram shows *Euphorbia gregaria* dominating the plateau and rocky slope environments with *Acacia mellifera* and *Stipagrostis* spp. common on the sandy pediments. Three variations of the River beds, differing in their species composition are proposed;
- An analysis of the size class distributions of three important range species (*Acacia mellifera*, *Acacia erioloba* and *Schotia afra*) shows that there has been much recruitment in all three species in the last twenty years and these species have "benefited" greatly from the absence of domestic stock. The widespread recruitment of these species may also be closely linked to the high rainfall period between 1972-1976;
- The widespread distribution of the alien leguminous shrub *Prosopis* spp. is highlighted. Because of its potential threat to the production potential as well as to the hydrology of the region we recommend its immediate eradication from the open range and the release of seed-eating weevils to reduce the further spread of the species in Riemvasmaak;
- A preliminary checklist of reptiles and amphibians comprising 11 frogs, 2 tortoises, 1 turtle, 19 snakes and 35 lizard species is shown in Appendix 4. Three Peripheral and one Rare species are listed while no Endangered or Vulnerable Red Data book species were identified;
- 192 bird species have been recorded in and around Riemvasmaak and the checklist is shown in Appendix 5. The Red Data book status of three species is listed as Vulnerable, while a further 2 species are listed as Rare. The status of 3 species is unknown (Indeterminate) but is also probably Rare;
- We observed 72 birds during the course of the survey and their abundance at this time is listed;
- A checklist of 51 mammal species for the Riemvasmaak and Augrabies Falls National Park regions is presented in Appendix 6 of which one species (the black rhinoceros) is Endangered, 2 are Vulnerable, 2 are Rare and one is listed as Indeterminate in the South African Red Data book for mammals;
- We observed 12 mammal species in the field during our survey and their abundance and locality as well as that of domestic livestock is also shown in

Appendix 6. The most common wild ungulate was the klipspringer and 89 individuals were recorded;

- 474 goats, 20 sheep, 12 head of cattle; 3 horses and 24 donkeys were seen by the survey team;
- The results of a helicopter survey conducted by the National Parks Board are presented in Appendix 7 and show that for Riemvasmaak in March there were 31 gemsbok, 64 kudu, 26 springbok, 5 steenbok and 7 klipspringer although the abundance of the last species was clearly underestimated;
- The grazing environment of Riemvasmaak is described. Firstly, we suggest that based on our understanding of the composition, structure and abundance of important forage species, the vegetation of Riemvasmaak is in an "excellent" condition. It has benefited greatly from the 20 years without domestic livestock and this view is corroborated by the testimony of the Riemvasmakers who have returned to the region. However, the sandy pediments in the east, that were used by the military for their mechanized infantry manouvres appear heavily disturbed;
- The range potential and carrying capacity of Riemvasmaak are calculated from standard agricultural models which have historically been applied to commercial farms. Recognizing their limitations in a communal land context we nonetheless show that the relationship between long-term annual rainfall data and stocking rate indicates that about 60 ha will be needed to support one Large Stock Unit (LSU) at Riemvasmaak. This sums to 1 243 LSU's (1 130 mature cows or 7 312 Boer goats) for the area. If the 4 270 ha currently leased to the National Parks Board is excluded from the calculation then the recommended carrying capacity drops to 1 172 LSU's (1 065 head of cattle or 6 894 goats);
- Using standard methods for estimating carrying capacity we show that, of all the landforms it is the undisturbed sandy pediments and dry river beds (i.e. the bottomlands) that are able to support the most number of animals;
- If the carrying capacity and size of each landform is included in the calculation of carrying capacity for Riemvasmaak then only 1 028 LSU's (935 cattle or 6 047 goats) can be supported on the available range. These values are in agreement with stock numbers that were censused in 1960/61 at the height of a severe drought but three times lower than the Riemvasmakers themselves claimed they possessed in "Old Riemvasmaak". We explore this apparent contradiction in Chapter 2;
- The economic analysis of the livestock industry presented by the Department of Agriculture and based on a commercial farming enterprise shows that the gross income from the livestock industry at Riemvasmaak could amount to R684 000 per year. If costs of 60 % are subtracted from this total then a profit of R273 600 or R60-80 per ewe results
- We conclude this chapter by recommending (a) that the wide interest shown by the Riemvasmakers in owning stock be understood and accepted by all involved in the area; (b) that the general aridity of the region cannot accommodate all interested livestock farmers and the allocation of grazing resources to full-time and part-time farmers is going to be problematic; (c) consensus must be reached amongst livestock farmers concerning stock numbers; (d) no one magic number (e.g. 60 ha/LSU) should dominate the debate as stock numbers should probably track environmental conditions; (e) the establishment of an elected, respected and

influential “stock committee” or similar such institution will probably be the key to the success of the livestock industry’s future.

CHAPTER 2: LANDUSE HISTORY

- This chapter presents an archaeological and historical landuse continuum for the region summarized in a general chronology from pre-history to the present;
- Prior to the ancestors of the present inhabitants of Riemvasmaak settling in the area the Orange River itself was home to a mixed group of Khoikhoi pastoralists and San hunter-gatherer-fishers;
- By all accounts the area carried abundant game although domestic livestock probably didn’t graze away from the river itself;
- The results of an archaeological survey conducted by the SADF during their term of tenure are presented and show a wealth of archaeological artefacts in the region;
- We recommend that there is an urgent need to have the region comprehensively surveyed by an experienced archaeologist especially those areas that have been earmarked for cropland development near the Molopo River mouth. The archaeological history could form an important part of the ecotourism potential of the region;
- A brief history and chronology of the settlement of Riemvasmaak is provided which suggests that the ancestors of the majority of the current inhabitants of Riemvasmaak arrived in the area from many different regions in southern Africa from about the 1870’s onwards;
- A discussion of the landuse practices in “Old Riemvasmaak” begins with an analysis of the stock numbers owned by Riemvasmakers in 1960/61, 1973/74 and in 1994. Problems with each of the data sets are described. The data show that stock numbers have changed from a low of 974 LSU’s in 1960/61 to a high of 3593 LSU’s in 1973/74. In 1994 the Riemvasmaak farmers in exile possessed 1302 LSU’s.
- Differences in the composition of the herds associated with each village in “Old Riemvasmaak” (?1973/74) suggest that goats were preferred by livestock owners at or near the river while sheep became common in the herds of farmers living away from the river. Donkeys were only abundant in the herds around the Mission Station while cattle numbers were never high;
- Who owned livestock in “Old Riemvasmaak”? Our analysis shows that only 8 of the 318 household heads censused in 1960/61 gave their occupation as “veeboer”. The majority of household heads worked as farm workers on the numerous islands of the Orange River. However, it was this group of people who possessed the majority of animals at Riemvasmaak even though each person only owned about 6 goats;
- Local testimony of a number of farmers at Riemvasmaak was used to reconstruct key aspects of the land tenure and grazing management practices in the years before 1973/74;
- The functioning of the Mr Jacob Booysen as the Hoofman in the land allocation and grazing management system of “Old Riemvasmaak” is outlined. His role and that of the “voormanne” who helped him govern the region from 1934 until his death in 1972 was integral to the entire landuse system of the area;

- No internal limits appear to have been placed on stock numbers although the state introduced a "head tax" as well as set maximum stock numbers (50 goats, 5 cows, 4 donkeys) to discourage too many animals on the range. Although transgressors were severely punished in the 1940's it is unclear whether the law was enforced in later years. Oral testimony suggests that as many as 800 goats were owned by a single farmer during the 1950's;
- The most important resting system applied was that which set aside large areas of Riemvasmaak, always the productive bottomlands, for the exclusive use of large bulk grazers such as cattle and donkeys. Sheep and goats were not allowed to graze in these "spaarveld" areas without the permission of the Hoofman and then only during a drought;
- Livestock owners from different parts of Riemvasmaak employed different strategies to deal with the severe droughts which ravaged the area. Those living in and around the Riemvasmaak Mission Station made use of the Orange River while livestock owners living in Deksel and Bok se Puts made use of veeposte (stock posts) where perennial springs were available;
- The marketing of livestock was non-existent in some areas and the livestock owners were severely exploited by local speculators;
- Conflicts between livestock owners appeared to have been few and far between. During the mid-1960's, however, conflict over grazing resources in one area is outlined and the central role that Mr Booysen apparently played in resolving this conflict is described;
- The results of a re-survey of John Acocks' sample sites which he visited in 1952 is presented in the text and in Appendix 10. One of the sites exists within the communal land of Riemvasmaak while the other borders the reserve on the south east. Both of the sites show a large decrease in diversity between the two time periods although the site in Riemvasmaak itself appears to have "lost" fewer species than the site in the commercial farmland. It is difficult to explain the changes that we observed at these two sites although overgrazing by domestic livestock is the hypothesis we favour most. Three matched photographs illustrate the nature of the changes that we have measured at these sites;
- The impact of the 8 South African Infantry Training Unit, Armscor and the South African Airforce on the vegetation of Riemvasmaak is describes and a map of their activities presented;
- Finally, we use our understanding of the historical landuse practices to comment on the future. We suggest that the Orange River environment could form an integral part of the livestock industry in Riemvasmaak but that one of the greatest challenges faced by FARM Africa lies in the incorporation of the part-time farmers into the livestock industry. We suggest that any new institution which has a role in the management of the livestock industry in Riemvasmaak should be aware of the region's livestock management history.

CHAPTER 3: A PROPOSED MONITORING PROGRAMME

- There is a general paucity of advice on how to develop a monitoring programme, especially for communal lands;
- We suggest a number of elements that should be considered. The first relates the need of the programme. Who needs it and who stands to benefit?

- Next, we explore the aims of the programme and propose the following objectives: "*The purpose of the monitoring programme is to provide the Riemvasmaak community with sufficient knowledge about the state of their environment (including climate, vegetation, stock condition, crop yields and market forces) at any one time so that informed decisions can be made by all Riemvasmakers, from household to village to community level, about their various agricultural enterprises*";
- Six main variables or indicators of change are suggested: Climate (rainfall, temperature), Water (quantity & quality), Vegetation "condition" (using matched photographs, key species abundances and demonstration plots) , Livestock (movements, births and deaths and market trends), Croplands and Community health.
- The location, sampling intensity and frequency, and type of measurement that will be required as well as the proposed responsible person(s) involved are also discussed;
- Pitfalls regarding data analysis and interpretation are highlighted and the use of participatory methods to present the results of the programme are emphasized;
- A preliminary budget is provided which suggests that capital equipment expenditure would amount to R51 000 while annual running costs will be about R40 000 including the salary of a Monitoring Warden drawn from the local community;
- The role of the Monitoring Warden will be crucial to the success of the programme. This individual would see to the day to day running of the programme and could also act as an important link with the Agricultural Extension Services facilitating technology transfer if and when needed by the communal farmers
- The selection and training of a Monitoring Warden should commence as soon as possible and the necessary infrastructure be developed between August and December 1995. By the beginning of 1996 the monitoring programme could begin.

CHAPTER 4: BIBLIOGRAPHY OF RIEMVASMAAK LITERATURE

- 24 articles which deal specifically with the history and agricultural potential of Riemvasmaak are listed;
- Details of 26 press clippings relating to community life, the removal, resettlement and the present are provided;
- Finally, reference to the general scientific and popular literature as well as numerous unpublished reports which deal with the history and natural resources of Gordonia district, the Kalahari ecosystem and the greater Orange River environment is given. This list comprises 95 articles.

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PLATE 1.12. David Catling of FARM Africa providing scale for the recruitment of a cohort of *Acacia erioloba* saplings near Gyam/Vaalputs (see Fig 1.17, site 24).

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PLATE 2.4. Matched photograph pair at photostation 25 taken from the same camera position as in Plate 2.3 but looking north along the "priest's road winding down the hill." Photographers and dates are the same as for Plate 2.3 (Acocks #5564). (See text for a discussion of the changes).

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PLATE 2.6. Sandy pediment near Gyam/Vaalputs. The dominance of the landscape by *Rhigozum trichotomum* suggests that heavy disturbance of the environment has occurred in the past. This may possibly be related to the mechanized infantry manoeuvres or arms-testing exercises carried out during the SADF's tenure of the region.

[PHOTOGRAPHS OF PHOTOSTATIONS 1-29 ARE ALSO SHOWN IN APPENDIX 8]

Chapter 1 : THE BASELINE SURVEY

1.1 INTRODUCTION

Agricultural development programmes require a comprehensive knowledge of the region's natural resources. Information about the geological, climatic, ecological and agricultural environment is essential if the full potential of an area is to be developed. There is already a considerable body of literature pertaining to Riemvasmaak and the general surrounds of Gordonia (see bibliography). However, much of it is unpublished and exists in difficult-to-locate internal reports. One of our first tasks, therefore, was to synthesize this information in one document and to develop a broad overview of the region's environmental resources and potential.

In addition to this synthesis we have also reported on the results of a baseline survey conducted in mid to late January 1995. An itinerary of this expedition is provided in Appendix 1. A description of major landforms within Riemvasmaak and their associated vegetation is summarized in this chapter. Also, the abundance of key forage species is analyzed and the potential danger posed by the invasive alien genus, *Prosopis*, is discussed. The difficult and contentious debate around veld "condition", range potential and carrying capacity is addressed in this chapter and we conclude with a discussion of the economic potential of the proposed livestock industry at Riemvasmaak.

1.2 LOCATION, SETTLEMENTS AND INFRASTRUCTURE

Riemvasmaak is located in the Northern Cape province of the Republic of South Africa (Fig. 1.1). It lies between 28° 13' and 28° 32' S and between 20° 00' and 20° 25' E. Riemvasmaak is 74 562.8124 ha in extent (Van Zyl & Van Zyl, 1994). It is bordered in the west by Namibia and in the north by the privately-owned, commercial farms of Aries, Narougas and Enna. Similarly, a number of commercial farms including Waterval and Omdraai form the eastern boundary of the reserve. The perennial waters of the Orange River form the southern border of Riemvasmaak. On the southern banks of the river itself the table grape-producing farms of Zeekoeisteek and Blouputs occur. The southeastern border is comprised of the Augrabies Falls National Park, a tourist and conservation enterprise owned and administered by the National Parks Board. Part of Riemvasmaak itself is also currently leased to the National Parks Board as part of an agreement with the Riemvasmaak Trust. This region, of about 4 270 ha, forms the extreme southeastern section of Riemvasmaak. It has become known as "Bokvasmaak" or the "Melkbosrandgebied" and is bordered in the south by the Orange River and in the north by the low ridge marked as |Haodaos in Fig. 1.2. A number of farmers, who lived in the settlements in this area prior to their removal in 1974, are unhappy with the fact that they are denied access to this land. An acrimonious protest has recently developed over the lease agreement.

A number of fairly widely-dispersed permanent settlements occurred in "Old Riemvasmaak" the largest of which remains the Riemvasmaak Mission Station itself (Fig. 1.1). Historically, Bok se Puts, Deksel and Xubuxnab were the next largest villages and are all located near permanent water supplies within the Bak, Kourop and Orange River valleys respectively. In the southeastern part of Riemvasmaak, in the region now leased to the National Parks Board, the small but permanent settlements of Wabrand and Melkbosrand were situated. Two smaller settlements, probably better described as homesteads, existed in the northeastern parts of Riemvasmaak. These are

Gyam/Vaalputs and Perdepoort. There were no permanent settlements on the plateau, presumably because there is no permanent water in this environment.

A rudimentary road network exists within Riemvasmaak. However, for much of the region it has degenerated to such an extent that it is only negotiable by means of an off-road vehicle or donkey cart (see Hawkins *et al* 1994).

Some of the place names shown on the 1:50 000 topographic maps published by the Chief Director of Surveys and Mapping are not recognized by the Riemvasmakers. For example, Riemvasmaakkop is known locally as Groot Rooiberg or Kai |nabab, while Donkieboud is better known as Donkiemond. There are also errors of location. For example, Twakputs did not exist along the banks of the Orange River but according to local testimony was located further inland.

To clarify some of these inaccuracies and to develop a better understanding of the names and locations of settlements, physiographic features and stock posts (veeposte) an informal workshop was held on the 5 May 1995. Mr Hans April, Mr Dawid Isaacs, Mr James Mapanka, Mr Pieter Malgas, Mr April Silwer, Mr Jan Silwer and Mr Gys Simon assisted in the identification and pronunciation of key place names in "Old Riemvasmaak." Ms Claudia Simon who learnt to read and write Damara at school acted as the scribe.

The place names are shown in Fig. 1.2 and described in Table 1.1. This clearly only scratches the surface of the wealth of nomenclatural information that exists for the region. None of the people who helped in the identification of place names had knowledge of the whole of Riemvasmaak. Some parts of the reserve were poorly known and because of this, some inaccuracies and omissions have undoubtedly occurred. We suggest that a group of the older members of the community be taken around the region with the express purpose of establishing the boundaries and more accurate locations and terminology of the key features in Riemvasmaak. As discussed in Chapter 2 this has important implications in understanding the grazing strategies employed in "Old Riemvasmaak".

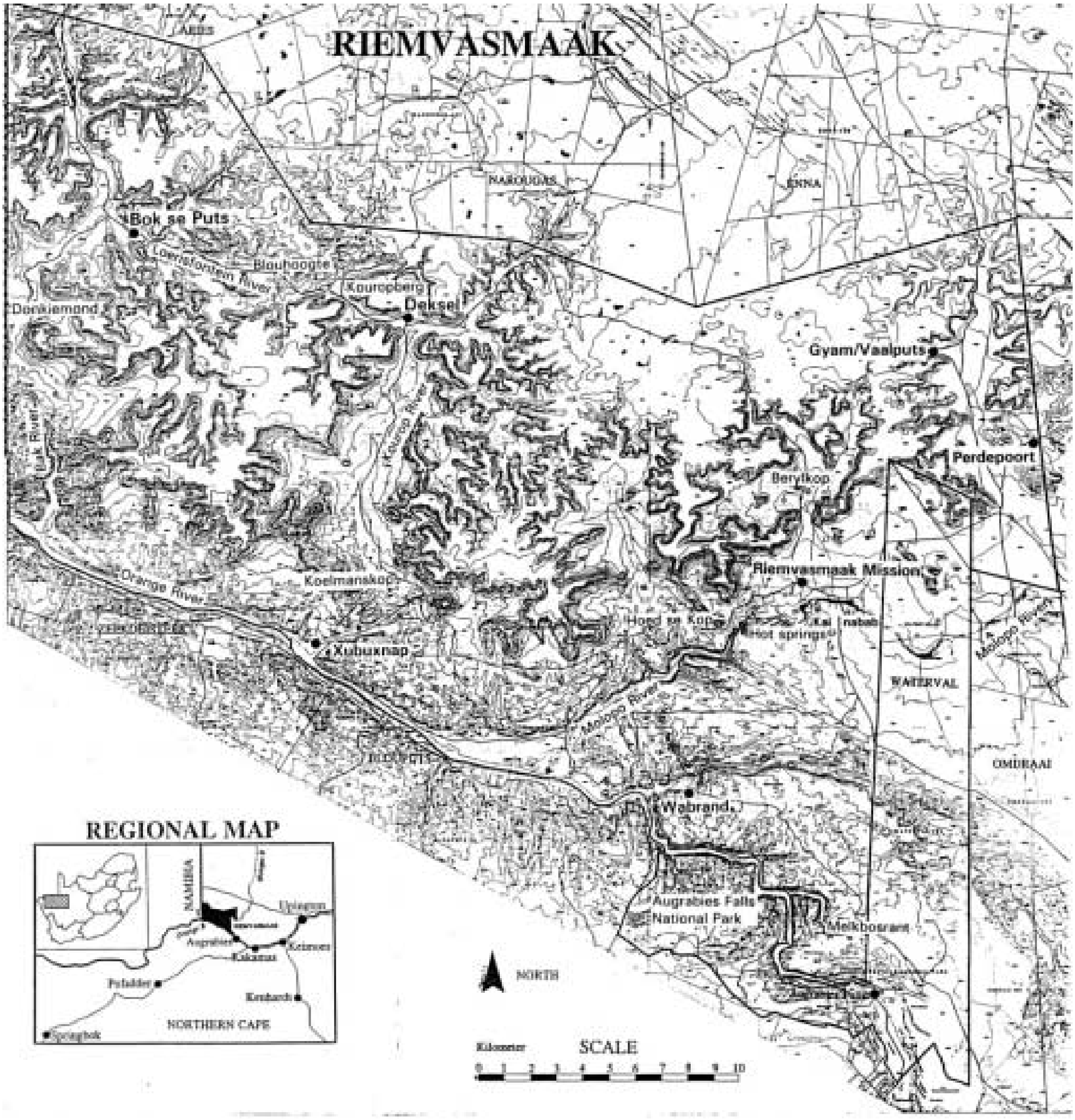


Fig. 1.1. Location, settlements, infrastructure, place names and general topography of Riemvasmaak derived from a composite of 1:50 000 topographical maps: 2820 AC, 2820 AD, 2820 CA, 2820 CB.

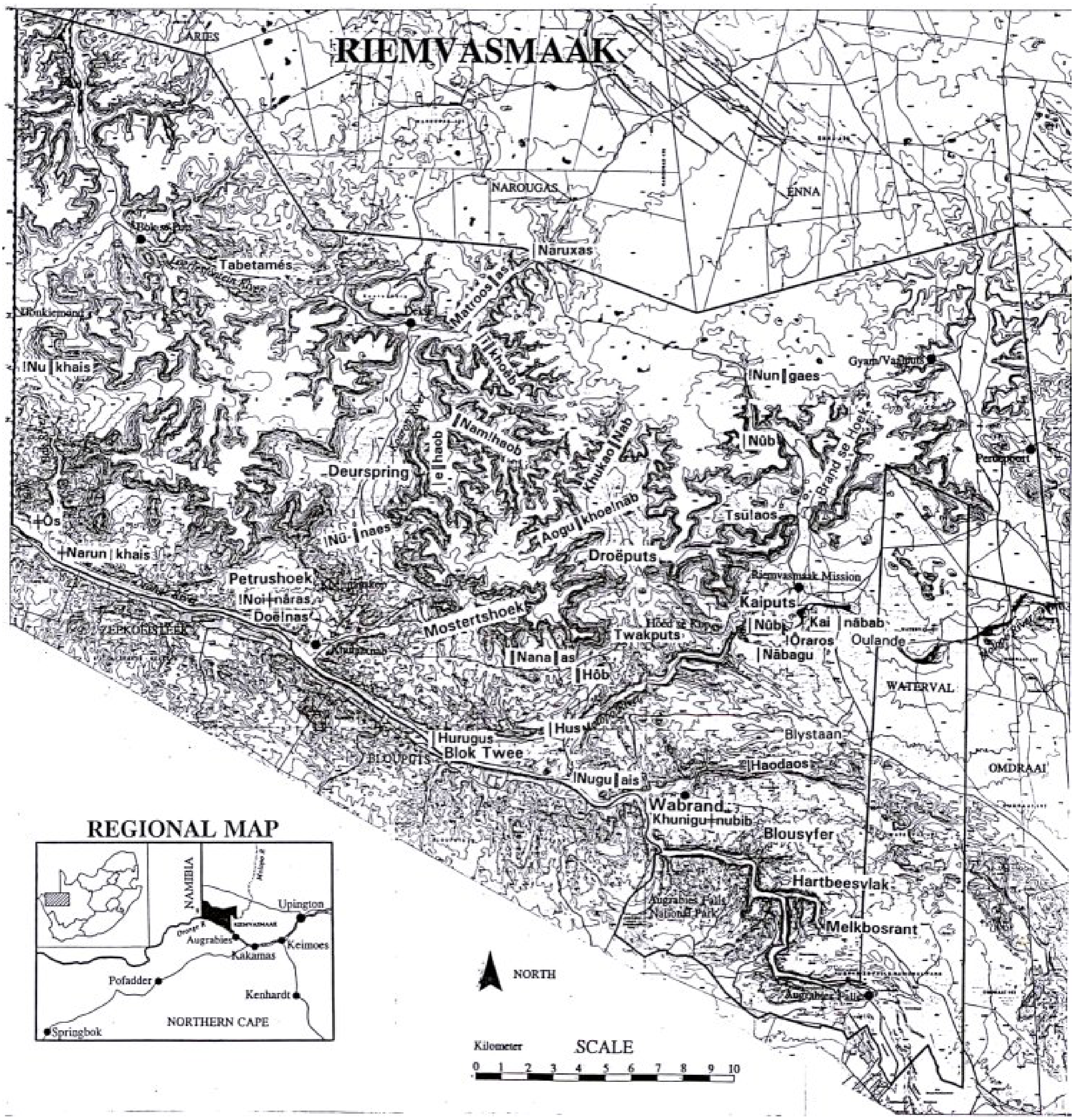


Fig. 1.2. Place names in "Old Riemvasmaak" including those of topographic features, settlements and veeposte. Table 1.1 provides a translation and interpretation of many of the names shown.

Table 1.1. Damara and Nama place names and their meanings in "Old Riemvasmaak". Afrikaans place names are not listed here but are shown in Fig. 1.2.

Name	Remarks
Kai ǀnabab	Also known as "Groot Rooiberg", (from Kai = groot or big) and called "Riemvasmaakkop" on 1:50 000 topographical maps.
!Ôraros	"Vlaketjie" (little flat land or depression).
ǀNabagu	"Rooies" (reddish or red ?region).
Tsu!aos	Also known as Sagtehoek.
ǀNûb	Meaning unknown.
!Nunǁgaes	"Sandgat" (sand hole or well perhaps).
Kaivlei	"Grootvlei" (large vlei or marsh).
ǀNaruxas	"Vol biesies" (full of reeds - probably *Mariscus marginatus*).
Matroosǁas	Someone's surname-Matroos, and from "ǁas" = kloof or narrow valley or ravine.
ǀiǁkhoêb	"Maanhaarjakkals se plek" (place of the aardwolf, *Proteles cristatus*).
Tabetamés	"Abwikaboom" (*Tamarix usneoides* tree).
ǂNudaob	"Ver pad" (long or far road. From "daob" = pad or road). Located somewhere north of Bok se Puts.
!Nuǁkhais	"Swartbevolkings tradisionele dans" (black community's traditional dance from "ǁkhais" = traditional dance).
!Nu-ǁnaes	Also known as "Wildehondsekloof" (wild dog's kloof).
!Noiǂnâras	!Noi (boom) kraal (kraal made out of !Noi (*Acacia mellifera*).
Doë!nas	"Iets soos 'n intrek" (something like a hauling in, gathering or settlement).
ǂÔs	"Spreekword" (a saying or proverb).
ǂNarunǀkhais	"Houtstomp is nie daar nie" ("the tree stump isn't there").
ǁNanaǁas	Also known as Kameeldoringhoek.
ǁHôb	Meaning unknown.
Khukaoǁ Nab	Also known as Skaaphoringkloof.
Aoguǁkhoe!nab	"Waar die manne lê" ("where the men lie" - casualties from the German war.
ǁNam!haob	"Waterbank" (water ridge).
ǀeǁhaob	"Erdmanshoek" (from "erdman" = ground squirrel).
Twakputs	Also known as ǂNus!nâb.
ǀHus	Means fountain.
!Nuguǁais	Meaning unknown.
ǀHurugus	"Hy is vergeet" ("he (or maybe "it") is forgotten") - also known as "Blok Twee".
Khuniguǂnubib	More commonly known as Wabrand.
!Haodaos	"Bankpad" (ridge road).

1.3 THE PHYSICAL ENVIRONMENT

1.3.1 Geology

A clear interpretation of the geology of Riemvasmaak is crucial for an understanding of the various landforms of the region since they exist largely as a direct consequence of the geological environment.

Although fairly complex in detail (Fig. 1.3, Table 1.2) (see also Von Backstrom, 1967; Gerringer & Botha, 1975) the geology of the region is easily understood when collapsed into its main lithological groups (Fig. 1.4) which together span a tremendous age range.

The oldest group of rocks is represented by the basement material of the Namaqualand Mobile Belt which dates to about 1.1 billion years. These are sedimentary, volcanic and intrusive rocks. Following the collision of the original continental material or Kaapvaal craton with other major blocks to the north of it (e.g. the Zimbabwe craton) an unstable region called a mobile belt or geosyncline was created. The sedimentary and volcanic rocks of the Koronnaland sequence and Hartbees River complex were deposited within this region at the time and the intrusive rocks of the Keimoes and Eendhoorn suites are also related to this collisional event. Subsequent erosion over millions of years has exposed both the basement gneisses and other material of the Namaqualand Mobile Belt. This material forms much of the rocky pediments at the base of mountains in the region.

An unrelated and substantially more recent event (from 550 million years ago) has been the laying down, within a shallow sea environment of the Nama Group of sediments. It is this sedimentary grey and red-brown quartzite, shale and conglomerate which comprises the plateau and steep rocky slopes of Riemvasmaak.

The Kalahari group of sandy alluvial depositions occurred relatively recently during the Quaternary. It is these wind- and water-transported materials which comprise the sandy pediments and sandy dry river beds below the plateau today.

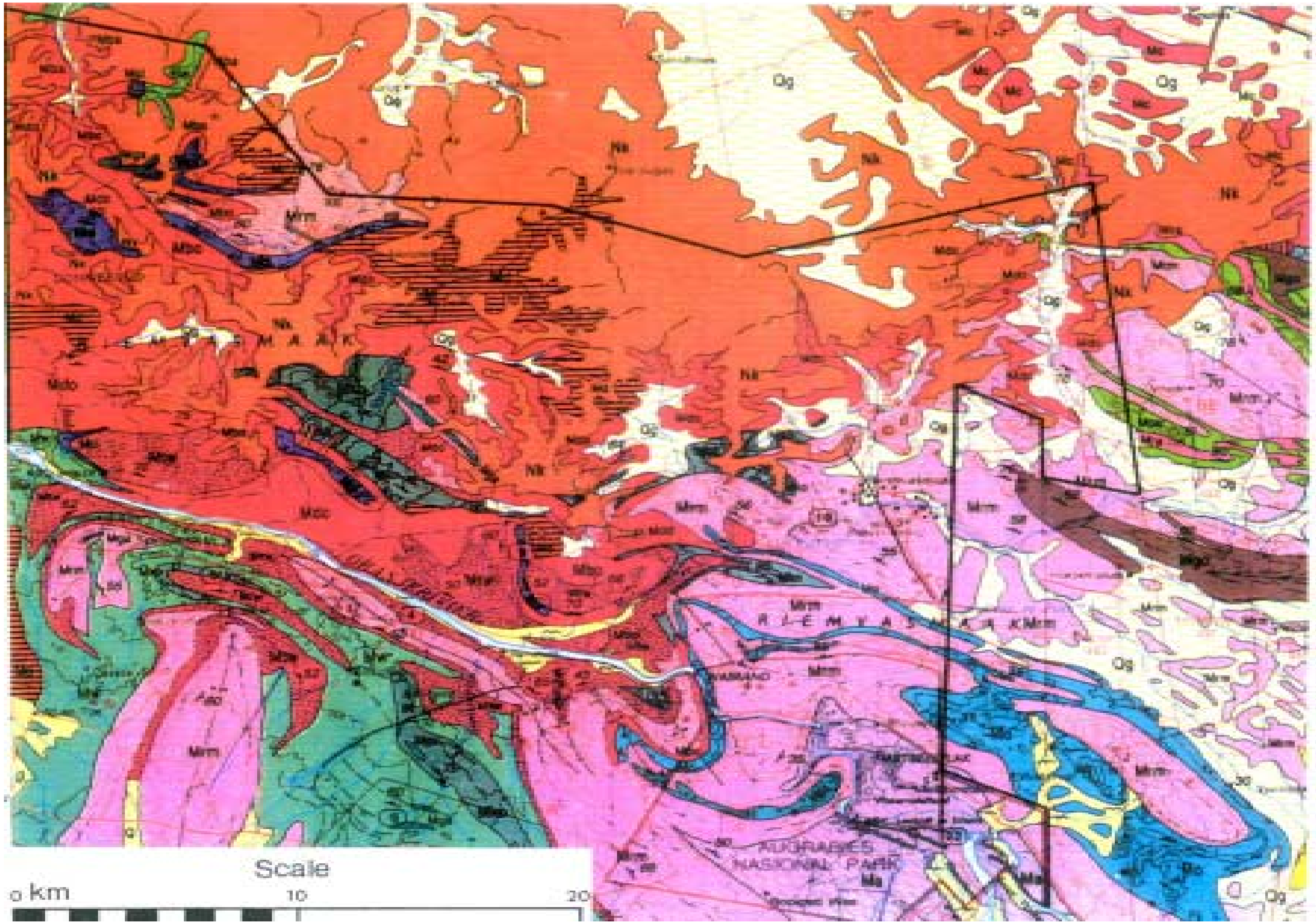


Fig. 1.3. The geology of Riemvasmaak enlarged from the 1:250 000 Geological Series 2820 Upington map (Moen, 1988).

TABLE 1.2. The geology and lithology of Riemvasmaak (after Moen, 1988).

MAP SYMBOL	SEQUENCE/ COMPLEX	GROUP/SUITE	FORMATION	LITHOLOGY
		Kalahari group sandy alluvium		
Q		Kalahari group		Sandy alluvium
Qg		Kalahari group	Gordonia	Red-brown, wind-blown sand and dunes
		Nama group sediments		
Nk		Nama group	Kuibis	Grey and red-brown quartzite, shale, conglomerate
		Namaqualand Mobile Belt - Sedimentary and volcanic rocks		
Mgo			Goedehoop	Quartzite, sericitic and/or feldspathic in places
Mra	Korannaland sequence	Biesjepoort group	Rautenback se kop	Fine-grained, pink-weathering gneiss
Mpu			Puntsit	Quartz-rich and mafic calc-silcate rocks with lenses of wollastonite and marble
Mo			Omdraai	Leucocratic quartz-microcline gneiss, amphibole gneiss, quartzite
Mcl			Collinskop	Kinzigite
Mbo	Hartbees River complex	Koelmanskop metamorphic suite	Bok-se-puts	Yellow-weathering gneiss with quart-rich and pelitic zones
Mko			Kourop Migmatite	Migmatitic leucogneiss and biotite gneiss, garnetiferous in places; amphibole gneiss
Mw			Witwater Gneiss	White, garnetiferous mica-poor gneiss, pegmatitic in places
Mtw			Twakputs Gneiss	Mega blastic, garnetiferous biotite gneiss
		Namaqualand Mobile Belt - Intrusive rocks		
Mc		Keimoes Suite	Cnydas Subsuite	Unfoliated, equigranular granites, with tormaline nodules in places
Mdo			Donkieboud Granite Gneiss	Biotite rich granite gneiss, garnetiferous and/or megacrystic in places
Mba		Eendhoorn Suite	Bak River Granite Gneiss	Biotite-rich, garnetiferous granite gneiss
Md			Daberas Granodiorite	Charnockitic granodiorite
Mga		-	-	Undifferentiated basic rocks (metagabbro, diabase, etc)
Ma		-	Augrabies Gneiss	Grey to red-brown granite gneiss
Mrm		-	Riemvasmaak Gneiss	Pink-weathering granite gneiss with a granular or augen texture

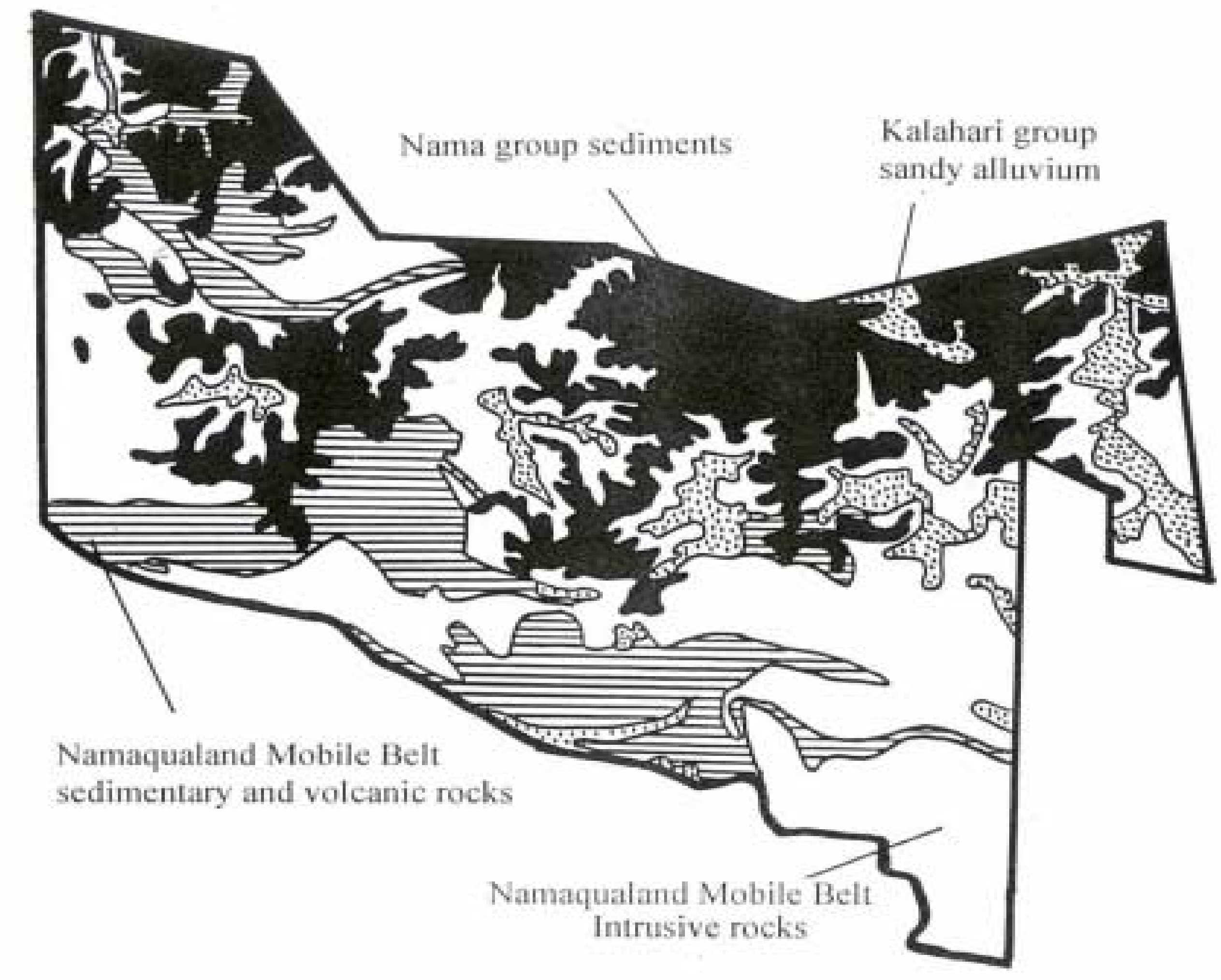


Fig. 1.4. Major geological groups comprising the Riemvasmaak environment.

1.3.2 Mining

This section is drawn directly from the work contained in the South African Defence Force report (SADF, 1990) and except for a few minor editorial changes and the exclusion of a number of figures it is reproduced in its entirety. Where applicable, additional material drawn from Toens' (1994) brief synopsis is included. This information is extracted "from the study of certain unpublished reports, most of which are not generally available" (Toens, 1994). Important early sources of information concerning the mining potential are contained in Gerringer & Bothas's (1975) excellent description of the pegmatite-granite association in Riemvasmaak . Three maps, providing an accurate location and description of each pegmatite field, are also contained in their article. Von Backstrom (1967) presents important details of the pegmatite minerals, including their composition, history of extraction and potential for further exploitation. Although we provide some additional references in our bibliography, a comprehensive survey of the geological and mining literature by a skilled consultant is needed.

The pegmatite belt of the Northern Cape

Pegmatites occur mainly as relatively sporadic deposits that are connected with granitic intrusive activity. The pegmatites in the northwestern Cape occur along a fairly continuous belt approximately 25 km wide and 250 km long, and is estimated to contain in excess of 50 000 pegmatites of various sizes.

The pegmatites, ranging from homogenous to inhomogenous types, are found in the area west of Upington. They are concentrated in distinct areas and seven such fields have been recognized by Gerringer & Botha (1975). The pegmatites have been divided into groups according to their main economical mineralisation. Four different types, namely, rare earth bearing, beryl bearing, andalusite bearing and tourmaline bearing pegmatites have been recognized. Riemvasmaak itself displays a wealth of pegmatite intrusions, including some of the most renowned Rare earth and beryl bearing pegmatites in the country

A close association exists between the mineralisation and distribution of the pegmatites and the various granitic occurrences in the area. Gerringer & Botha (1975) have shown that the Rare earth bearing pegmatites are associated with the Central Massif of the Bakriver granite, the beryl bearing pegmatites are associated with the Southern Massif of the Bakriver granite. The andalusite bearing pegmatites are related to the Kouropriver granite and the tourmaline rich types are associated with the younger granites of the Cnydas complex.

Several of the pegmatites in the area have been economically exploited in the past, but only in small quantities. The mining of pegmatites has mostly been done by nomadic prospectors who move from one pegmatite to another. The large scale exploitation of pegmatitic mineralisation is hampered by the general lack of geological information pertaining to the size of the pegmatites and the extent of mineralisation.

Economically exploited pegmatites in Riemvasmaak.

The Bakriver pegmatite

This pegmatite is situated on the eastern slope of the Bakriver valley about 9 km south of Bok se Puts. It is approximately 30 m long and between 10 m and 30 m wide. It forms an irregular body with a discordant off-shoot. The body exhibits a complicated structural relationship with the enclosing country rock.

The pegmatite has three distinct zones: a border zone, a wall zone and a core with the mineralisation occurring in the wall zone. Between 1952 and 1959 the pegmatite was prospected for gadolinite and allanite, producing several tons. The pegmatite is now largely worked out. Toens (1994) states that "....approximately 75 tons of radioactive materail (was) produced in the Bakriver pegmatite containing 0.07 % uranium oxide."

The Murasie pegmatite

At Murasie, five thin tabular parallel pegmatites dip 40 degrees south and form a low hill 9 km south of Bok se Puts. A prospecting pit 500 m reveals a well-developed zonal structure consisting of a quartz core, a perthitic intermediate zone and a wall zone of graphic granite consisting of quart, plagioclase and biotite.

The Rare earth minerals are concentrated in the intermediate zone. Allanite and gadolinite generally occur as small anhedral lumps close to the contact with the wall zone and a few tons of the se minerals have been mined.

The Japie pegmatite

This pegmatite lies 5 km northeast of the confluence of the Orange and Bak rivers, on the southern slope of a steep hill. The east-west trending body dips vertically and plunges east. It is 80 m long and between 10 m and 20 m wide. A creek has cut its way across the western part of the body and exposed the internal structure. The central and largest part of the pegmatite is the quartzitic core surrounded by a perthitic shell.

On the northern side of the body considerable quantities of ?ergusonite was allegedly recovered from pockets of biotite, quartz and perthite lying close to the core. The pegmatite was prospected for Rare earth minerals from 1956 to 1958, producing seven tons of gadolinite.

The Mosterthoek pegmatite

This pegmatite is situated approximately 10 km west of the Riemvasmaak Mission Station. It forms a concordant lenticular dyke 1 000 m long and 7 m to 30 m wide. The pegmatite consists of a quartz-perthite core in contact with a zone consisting of albite, cleavlandite, quartz, muscovite, beryl, schorl and columbite tantalite. Some of the beryl crystals from this pegmatite measure in excess of one meter in length.

According to local prospectors (and Toens, 1994), more that 225 tons of beryl have been produced (see also Von Backstrom, 1967).

The Kourop pegmatite

This pegmatite forms the crest of a steep hill 5 km east of the confluence of the Kourop and Orange Rivers. The pegmatite is a dyke-like body 200 m long and 6 m to 12 m wide. It strikes northwest and dips slightly to the northeast. The pegmatite consists of a border zone and wall zone and a core, which contains radial clusters of andalusite. Elluvial lumps of andalusite in excess of 12 kg can be found in the rubble of the old diggings. No information pertaining to the amount of andalusite produced could be found.

The Riemvasmaak pegmatite

This pegmatite is exposed 3 km north of the Riemvasmaak Mission Station. It is 60 m long and 3 m wide and lies on the steep slopes of the spur jutting out from the hill on which the northwestern beacon of the farm Waterval is located.

Rare earth minerals, mainly gadolinite, have replaced microcline perthite close to and along the contacts with the core.

Approximately 140 kg of gadolinite was produced during 1945 from a small mineralized portion of the pegmatite estimated to contain 0.1 % Rare earth minerals (see also Toens, 1994).

Other economical deposits in the area

Approximately 1.5.km south of Bok se Puts lies the locality of an old Rose Quartz mine. The colour of Rose Quartz is due to the presence of manganese. Although Rose Quartz is common and widespread it is nearly always cloudy and cracked so that clear pieces are scarce. The same mine evidently also produced some smoky quartz, which is a colourless to black variety of quartz. The colour is due to irradiation or due to heat.

On the farm Aries, forming the northwestern border of the area, baryte deposits have been found in addition to a gypsum deposit constituting approximately 22 million tons of 67 % gypsum. The deposit is presently (i.e. 1990) being mined by Blue Circle Mines.

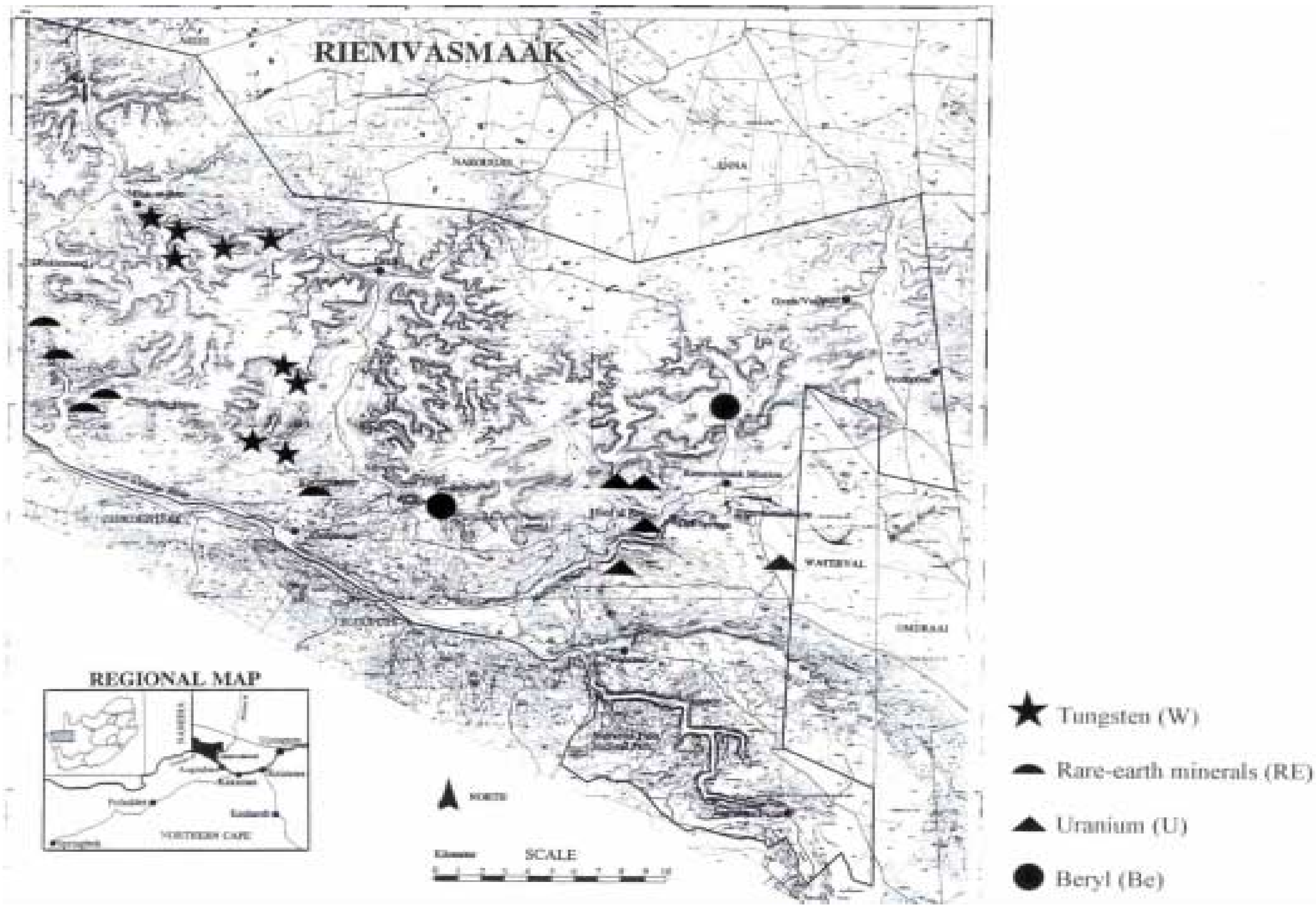

RIEMVASMAAK
REGIONAL MAP
NORTHERN CAPE
NORTH
SCALE
Tungsten (W)
Rare-earth minerals (RE)
Uranium (U)
Beryl (Be)

Fig. 1.5. Occurrence of minerals at Riemvasmaak. (See also Von Backstrom (1967) for a more detailed account of mining operations in the area).

1.3.3 Soils

No detailed soil survey of the whole of Riemvasmaak has as yet been undertaken. However, because the Molopo alluvial fan (see photostation 12 for a view of the region) has been ear-marked as a potential crop irrigation site it has been thoroughly investigated by Van Niekerk (1994) who provides a soil unit map of the alluvial fan and a detailed physical and chemical analysis of each unit. Because of its importance to the agricultural development of the region, the soil unit map (Fig. 1.6) and brief description of the soil units is included in this report (Table 1.3).

In addition to Van Niekerk's (1994) soil analysis we also collected and analyzed 12 soil samples from a range of landforms in Riemvasmaak and present the data in Table 1.4. We discuss salient features of the soil data set in our description of the vegetation associated with landforms (Section 1.4.1.3).

TABLE 1.3. A description of soil units on the Molopo alluvial fan indicating their geomorphological position, dominant soil form, map symbol (see Fig. 1.6) and their irrigation potential (L = Low; M-L = Moderate to Low; M = Moderate; M-H = Moderate to High). Information for this table has been compiled from data in Van Niekerk (1994).

NAME	DESCRIPTION	SOIL FORM	MAP SYMBOL	IRRIGATION POTENTIAL
Lower Orange River terrace	• Young, alluvial, deep, fine sand deposits	Dundee	Du1	M
	• Uniform, very deep, fine sand deposits	Namib	Nb1	M-H
Higher Orange River terraces	• Shallow to very deep, wind redistributed, fine sandy alluvium	Namib	Nb2	M
	• Very stony, bouldery area	Namib	Nb3	M
Alluvial fans	• Gently sloping alluvial fan with deep gravelly coarse sand	Dundee	Du2	M
Very low Molopo River terrace	• Recent, gravelly soarse sand alluvium	Dundee	Du3	L
Higher Molopo River terrace	• Recent,deep, gravelly coarse sand alluvium	Dundee	Du4	M-L
	• Deep, calcareous gravelly, coarse sand to gravelly loamy coarse sand	Dundee/ Augrabies	Du5	M-H
Gently sloping pediment slopes	• Deep, calcareous, very gravelly loamy coarse sand	Augrabies	Ag1	M-H
	• Non-calcareous gravelly coarse sand	Dundee/ Clovelly	Du6	M-H
Narrow, north-aspect pediment	• Aeolian fine sand and coarse alluvium	Dundee	Du7	M
Sloping, eroded, upper pediment slopes	• Deep, calcareous, gravelly loamy coarse sand	Augrabies	Ag2	M-H
Moderately deep to shallow soils	• Occur as narrow bands on the upper pediments	Augrabies	Ag3	M-H
Lower pediment slope alluvium	• Fine sand to loamy fine sand alluvium	Dundee	Du8	M-H
Stony, older terrace remnants	• Gravel, stones and boulders in a calcareous coarse sand to loamy coarse sand	Dundee	Du9	M-L

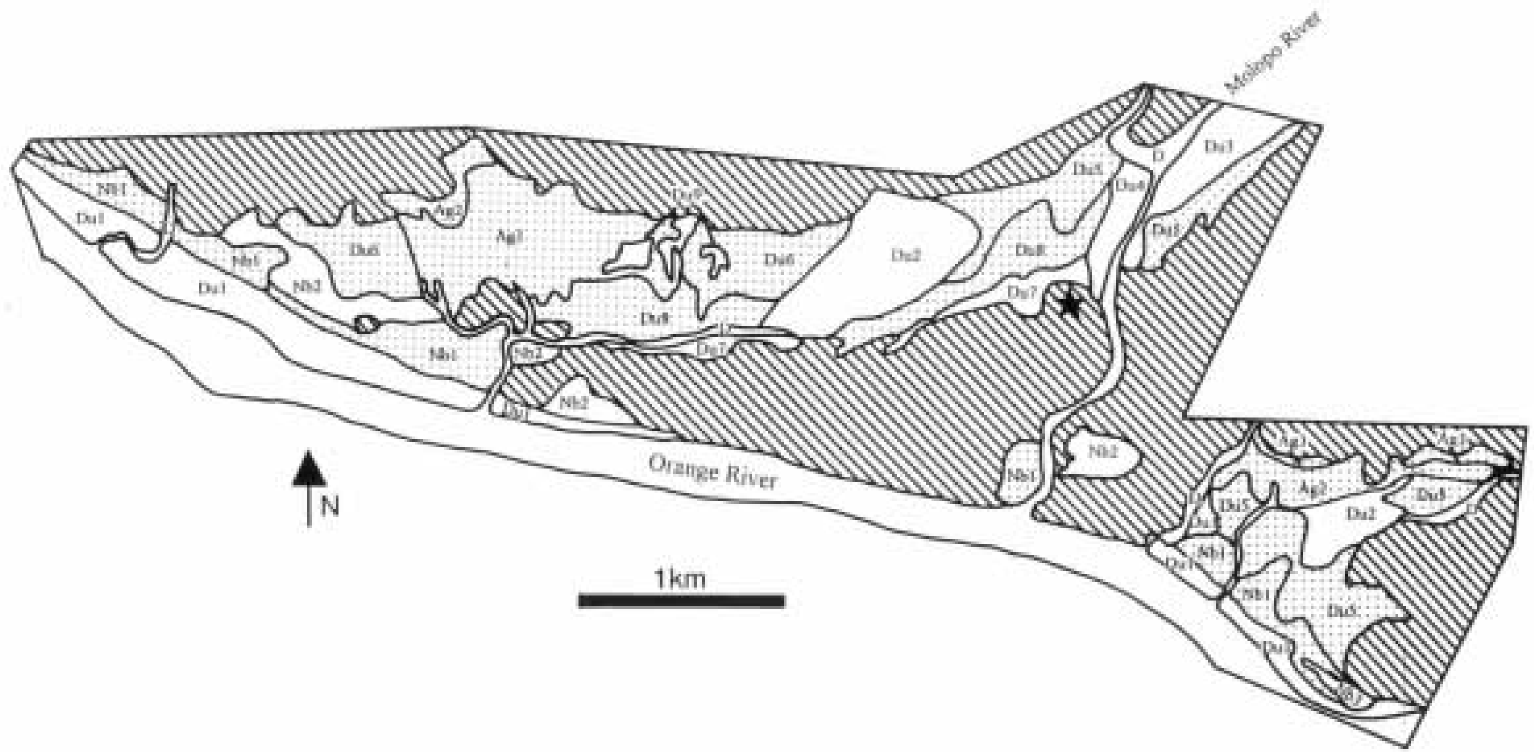


Fig. 1.6. Soil unit map of the Molopo alluvial fan (redrawn from Van Niekerk (1994)) showing the distribution of regions with moderate to high irrigation potential (dots) and those with moderate, moderate to low and low irrigation potential (left blank). Rocky, mountainous terrain is indicated by diagonal lines; D = drainage line of Orange River, Molopo River or smaller tributaries of these two rivers. Soil unit map symbols are those used in Table 1.3 where details of the soil units are presented. Star indicates position of photostation 12.

TABLE 1.4. Results of an analysis of soil samples from 12 sites in Riemvasmaak. Number refers to the photostation number (see Appendix 8) and the letter refers to the landform wherein the soil sample was taken. Landform abbreviations are Rf = rocky footslope, Sp = Sandy pediment, Pl = Plateau, Pa = Pan on plateau, Rb = River bed. The soils are all loamy sands except for 5c which is a sandy clay loam.

VARIABLE	SOIL SAMPLE											
Number	2e	2f	5a	5c	7a	7c	8a	9a	11b	12a2	18a	18b
Landform	Rf	Sp	Pl	Pa	Sp	Sp	Sp	Sp	Rb	Rb	Sp	Sp
Colour	BR	LT R BR	RD	RD	LT R BR	LT R BR	BR	BR	BR	BR	RD	RD
% Coarse sand	22.1	24.5	20.7	26.7	22.5	19.0	20.5	24.5	19.8	20.4	26.0	24.1
% Medium sand	18.9	20.7	18.0	6.9	20.7	16.7	16.7	18.9	16.0	16.7	20.7	22.0
% Fine sand	49.0	46.8	55.3	38.4	50.8	54.3	54.8	50.6	58.2	56.9	43.3	43.9
% Silt	4.0	4.0	2.0	12.0	2.0	4.0	4.0	2.0	2.0	2.0	4.0	4.0
% Clay	6.0	4.0	4.0	16.0	4.0	6.0	4.0	4.0	4.0	4.0	6.0	6.0
pH	8.1	7.0	4.6	6.4	7.6	6.2	6.5	6.5	5.7	7.2	6.3	6.7
Resistance (ohm)	417	2500	1667	833	200	2500	3333	2000	3731	1190	3846	308
P (mg/kg)	307	158	31	230	165	94	142	155	100	98	59	157
Ca (mg/kg)	4264	486	362	1216	1192	474	611	646	382	838	211	355
Mg (mg/kg)	221	62	134	187	59	108	78	92	85	51	71	75
K (mg/kg)	335	116	163	419	129	96	106	111	108	90	53	107
Na (mg/kg)	115	52	55	61	52	58	53	52	52	75	51	273
T-Value [meq%]	24.45	3.46	4.03	8.94	6.99	3.75	4.19	4.49	3.19	5.16	1.99	3.85
% Ca	87.0	70.1	44.9	67.8	85.1	63.0	72.7	71.8	59.7	81.1	52.8	46.0
% Mg	7.4	14.8	27.4	17.2	6.9	23.7	15.3	16.9	21.9	8.1	29.3	16.0
% K	3.5	8.6	10.4	12.0	4.7	6.5	6.5	6.3	8.7	4.5	6.8	7.1
% Na	2.0	6.5	5.9	3.0	3.2	6.7	5.5	5.0	7.1	6.3	11.1	30.8
% Base saturation	100	100	89	100	100	100	100	100	97	100	100	100
Cu (mg/kg)	0.8	0.5	0.8	2.1	1.0	0.5	0.5	0.7	0.5	0.7	0.4	0.6
Mn (mg/kg)	37.0	57	37.0	187	45.0	43.0	45.0	53	41.0	42.0	31.0	49.0
Zn (mg/kg)	1.3	0.7	0.8	2.0	0.6	1.0	0.6	0.5	0.7	0.5	0.7	0.9

1.3.4 Climate

Werger & Coetzee (1977) provide an excellent introduction to the climate of the Augrabies Falls National Park including descriptions of the solar radiation, temperature, wind, rainfall and ralative humidity.

With a mean annual rainfall figure of 124.4 mm (std. dev. = 73.47 mm) there are few places in South Africa as arid as Riemvasmaak (Fig. 1.7). Although highly unpredictable (coefficient of mean annual rainfall = 59.06 %) long-term records indicate that rainfall is greatest between February and April with a distinct peak in March. The mean annual temperature is 21.6 °C and although the mean daily maximum temperature for January - the warmest month is 37.4 °C, summer temperatures frequently exceed 40 °C. When considered on a monthly basis, at no time during the year does water availability exceed evaporative demand and a state of permanent drought therefore exists.

The spatial variation, between 75-155 $mm.yr^{-1}$ in Riemvasmaak's annual rainfall totals (Fig. 1.8), suggests that only small gradients in moisture availability exist. Rainfall increases only slightly from west to east reflecting the more general regional trend for an increase in mean annual rainfall totals in more eastern parts of the Northern Cape. The most pronounced trend within Riemvasmaak itself, however, is for an increase northwards away from the lower elevations of the Orange River channel onto the higher-lying plateau environment. The modelled data indicate that places along the Orange River receive between 75-85 $mm.yr^{-1}$ but that this increases to between 135-145 $mm.yr^{-1}$ on the plateau north of the Riemvasmaak Mission Station.

The long-term rainfall records for Augrabies village and Geelkop, about 50 km east of Augrabies (Fig. 1.9, Fig. 1.10), show that the region is characterised by periods of alternating low and high rainfall which have been interpreted by some researchers as pseudocycles (Tyson, 1988).

The general pattern in rainfall for the region during the last 65 years may be interpreted as follows. There appears to have been a general aridification of the region from 1918-1933 with only 4 years showing any significant increase above the long-term mean annual amounts (Fig. 1.9, Fig. 1.10). Between 1934 and 1941, however, a series of generally higher rainfall years followed. From 1942 right up until 1948 (for Augrabies village at least) mean annual totals were very low. The early 1950's are characterised by large fluctuations in annual totals but from 1956 to the end of 1966 there was a clear decrease in rainfall totals. From 1967 in Augrabies but a little later in Geelkop, an unparalleled and sustained increase in annual rainfall occurred. These "wet" conditions were to last until 1977 in Augrabies and have been followed by one of the most extended dry spells on record which continues to the present. The significance of the wet 1970's which coincidentally occurred at the very beginning of the SADF's tenure has important implications for the recruitment of key tree species such as *Acacia erioloba* and *Schotia afra* and will be discussed in more detail later.

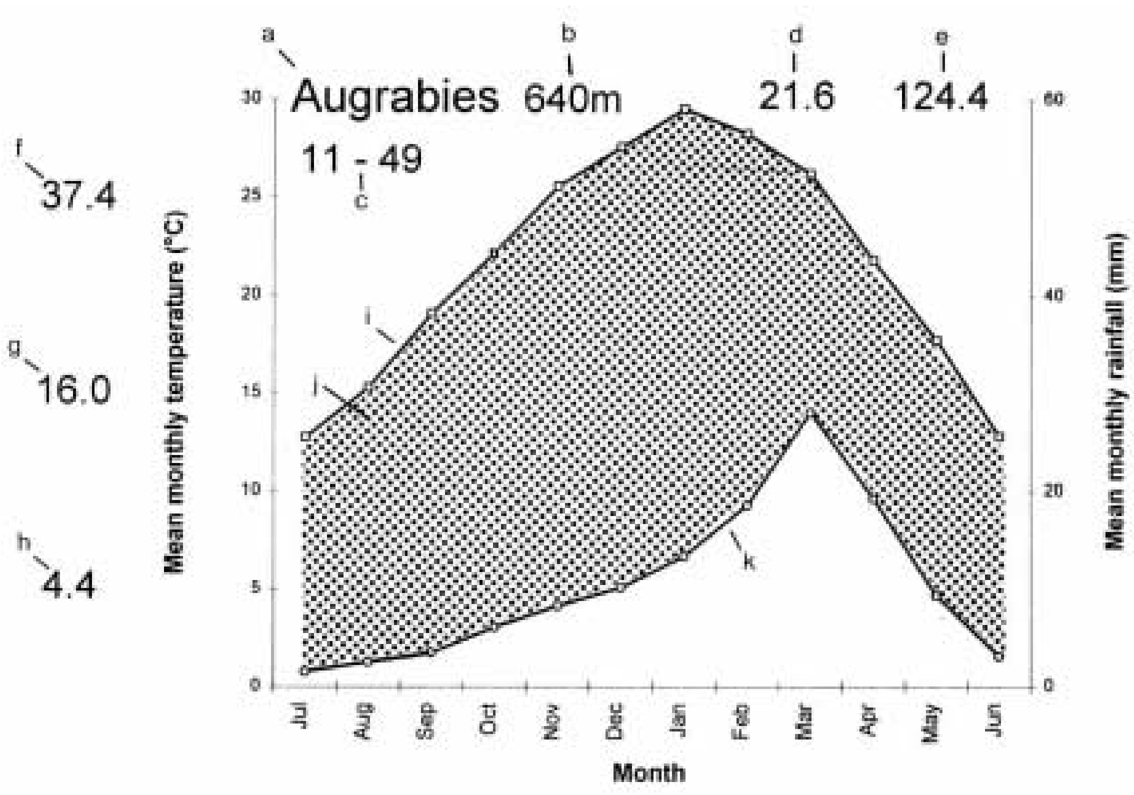


Fig. 1.7. Walter-Leith climate diagram for Augrabies close to the south eastern boundary of Riemvasmaak. a = climate station: [rainfall data are taken for the period 1946-1994 from Augrabies village (station number 0281760 1) (28°40'S 20°26'E) while temperature data are for the period 1984-1994 and are from Augrabies Water Falls (station number 0281606 0) (28°36'S 20°21'E) some 14 km northwest of Augrabies village]; b= height above sea level (Augrabies village = 640 m; Augrabies Water Falls = 626 m); c = duration of observation in years (the first figure indicates temperature, the second, precipitation); d = mean annual temperature; e = mean annual precipitation; f= mean daily maximum temperature of the warmest month; g = mean daily temperature variations; h = mean daily minimum temperature of the coldest month; i = curve of mean monthly temperature; j = relative period of drought; k = curve of mean monthly precipitation.

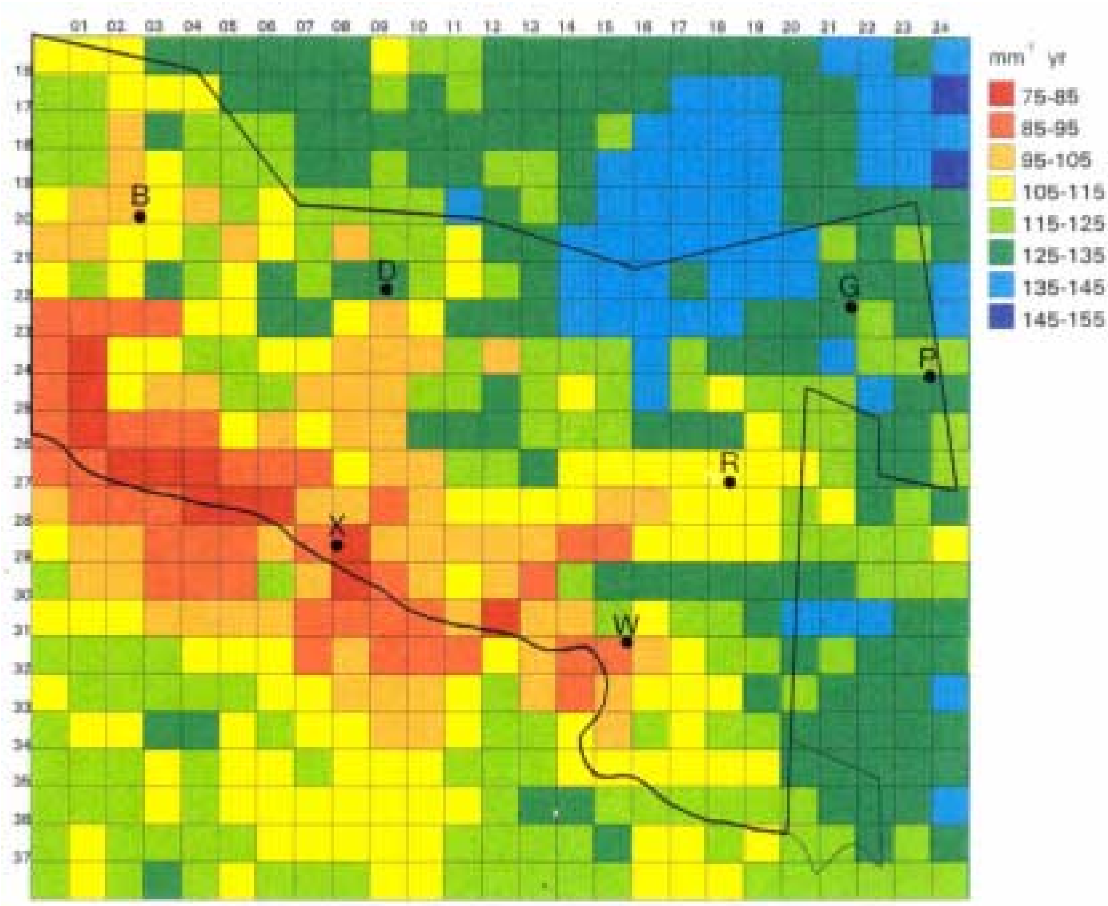
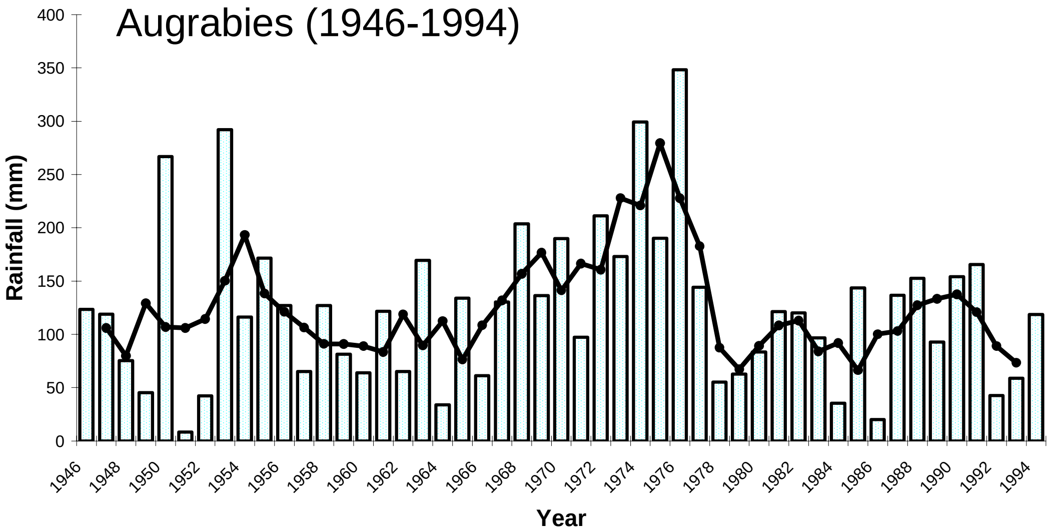


Fig. 1.8. Mean annual rainfall for Riemvasmaak and surrounding areas calculated from CCWR (1994) modeled data.



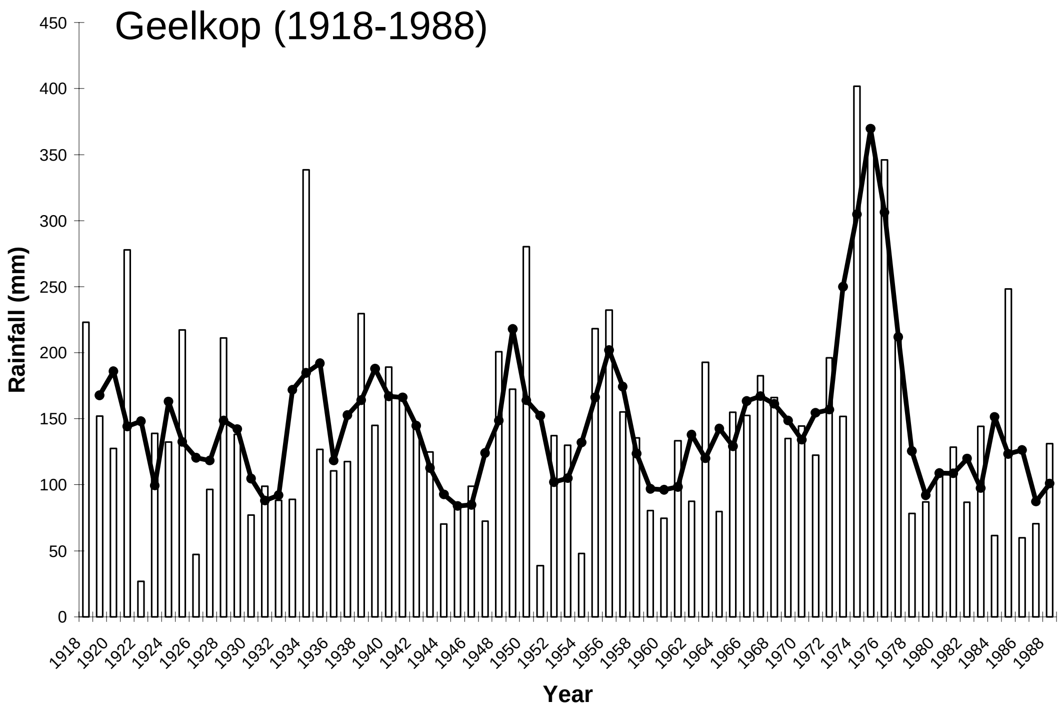
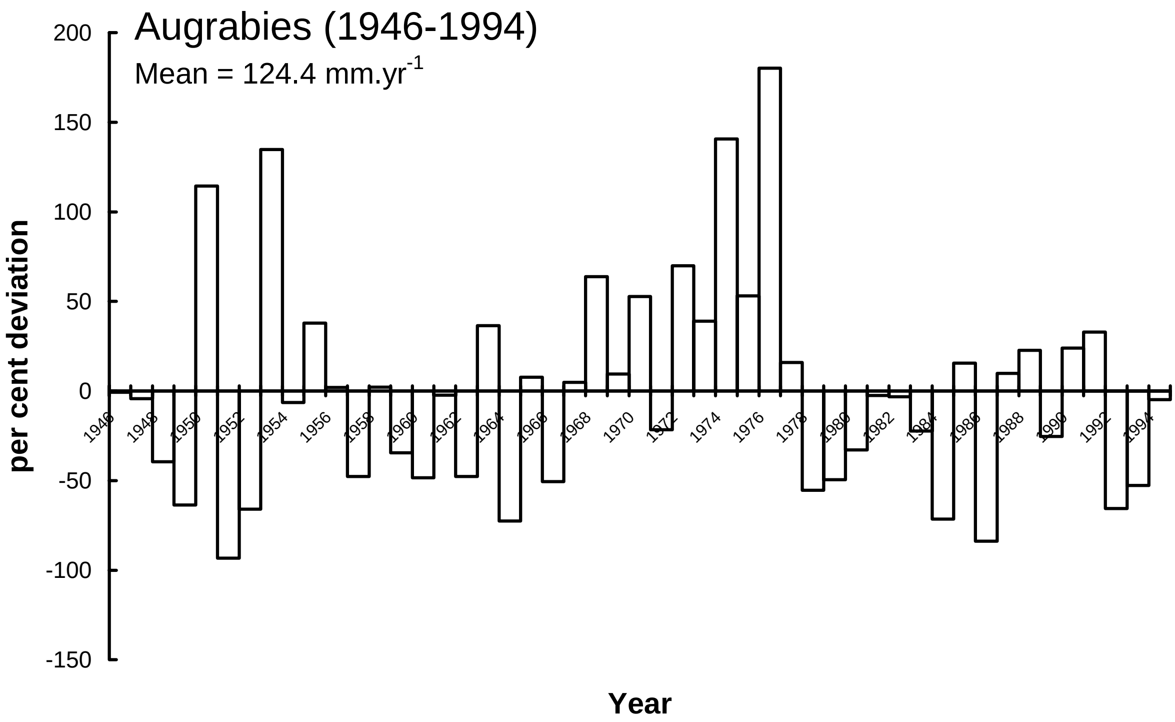


Fig. 1.9. Total annual rainfall (histograms) and three-year running mean (solid line) for Augrabies village (station number 0281760 1) (28°40'S, 20°26'E) for the period 1946-1994 and for Geelkop (station number 0283098 3) (28°38's, 21°04'E) for the period 1918-1988.



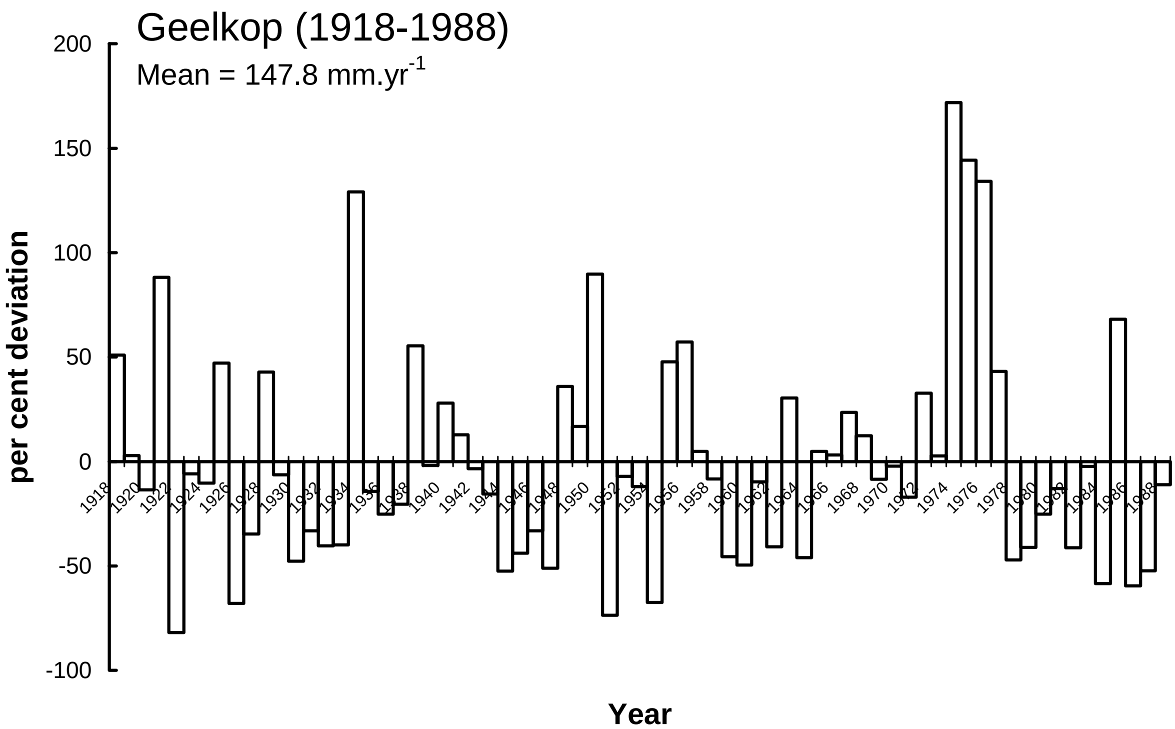


Fig. 1.10 Percent deviation from mean long-term rainfall at Augrabies village (station number 0281760 1) (28°40'S, 20°26'E) for the period 1946-1994 and at Geelkop (station number 0283098 3) (28°38's, 21°04'E) for the period 1918-1988.

1.3.5 Hydrology and water sources

Four river systems occur in Riemvasmaak (Fig. 1.11; Table 1.5) and the general direction of drainage is from north to south although the Molopo River channel itself runs slightly transverse to this pattern

The Bak River drains the western portion of Riemvasmaak and is the second largest catchment within the region. The central portions of the reserve are drained by the marginally smaller Kourop River. The eastern parts are drained by the Molopo River and its tributaries forming the largest catchment in Riemvasmaak. Three small subcatchments of the Orange River occur between each of the Bak, Kourop and Molopo Rivers.

TABLE 1.5. The % cover and area (ha) of each river catchment in Riemvasmaak.

No.	Catchment	Area	
		%	ha
1	Bak River	23.4	17 433
2	Kourop River	23.3	17 369
3	Molopo River	36.0	26 898
4	Orange River	17.3	12 863
(4a)	(Orange River)	(4.8)	(3 579)
(4b)	(Orange River)	(5.0)	(3 700)
(4c)	(Orange River)	(7.5)	(5 584)
	Total	100.0	74 563

Over the years a number of boreholes and dug wells or “putte” have been established while the location of a number of natural springs and water holes are still remembered by local people. Upon the request of FARM Africa, P D Toens and Associates - a consulting geological and geohydrological enterprise - investigated the water sources of Riemvasmaak. This study (Toens, 1994) was conducted in August 1994 and together with information contained in the SADF report (SADF,1990) has been synthesised into a more user-friendly format in Fig. 1.12 and Table 1.6. The most crucial finding of Toens (1994) was that only three of the twenty water points sampled contained potable water (numbers 5, 6 & 20). The remaining sources had excessive levels of either fluoride or nitrates or were too saline for healthy human consumption. These findings are in stark contrast to the views expressed by the Riemvasmaak community who during a workshop in May 1994 (Isaacs & Phillips, 1994) described many of their water sources as "vars" (fresh).

Fig. 1.11. Catchment areas of the four main river systems in Riemvasmaak: 1 = Bak River; 2 = Kourop River; 3 = Molopo River; 4 = Orange River.

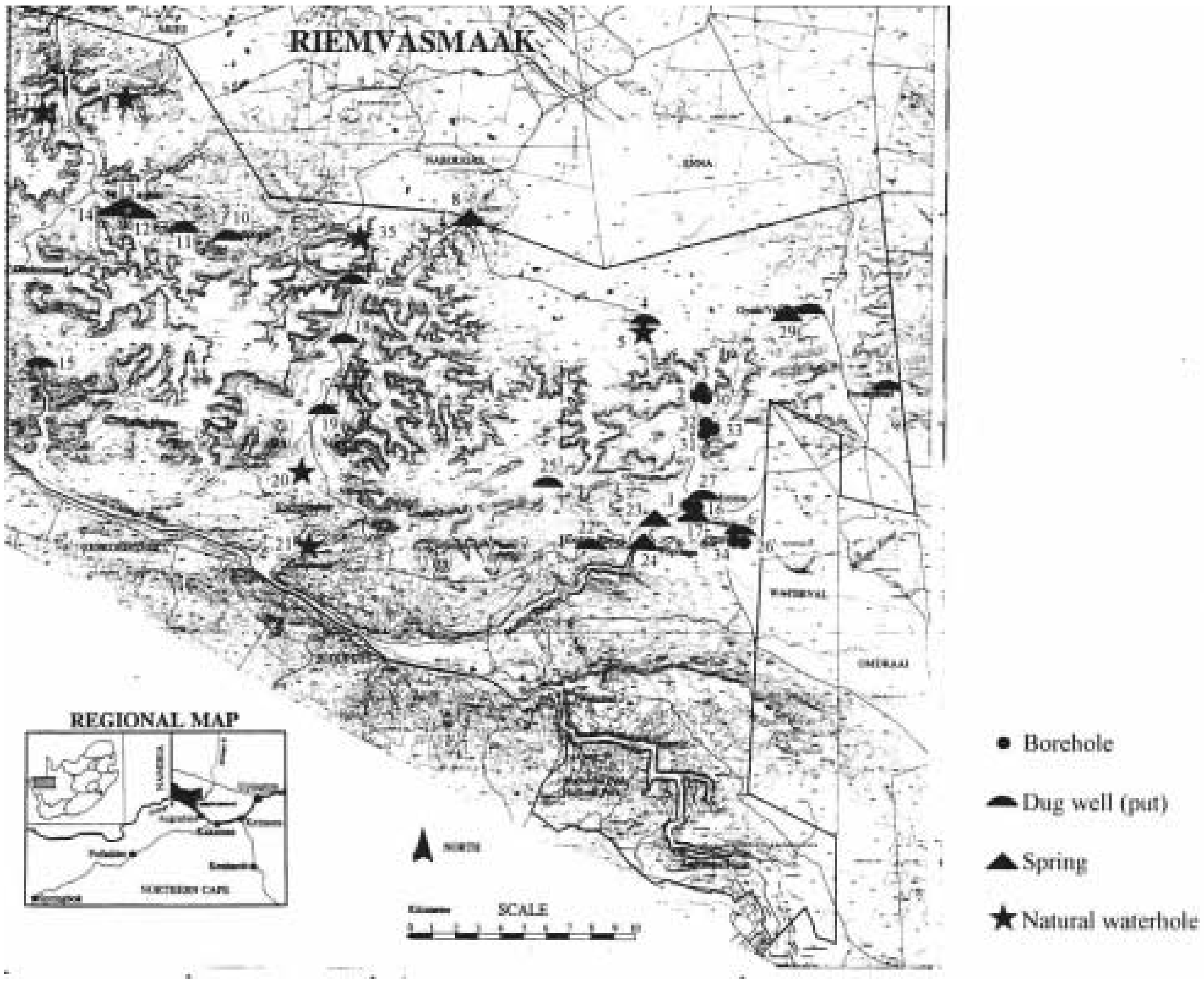


Fig. 1.12. Location of different water sources in Riemvasmaak. Numbers refer to those in Table 1.6.

Table 1.6. Water quality and other characteristics of water sources (boreholes, dug wells (= put), springs (= fonteine) and natural waterholes) in Riemvasmaak.

No.	Toens (1994) No.	SADF (1990) No.	Description	Water level (m)	Depth (m)	Conductivity (mS/m) Acc. limit = 70 Max. limit = 300	Fluoride (mg/l) Acc. limit = 1.00 Max. limit = 1.50	Nitrate (mg/l) Acc. limit = 6.00 Max. limit = 10.00	Remarks
1	RIEM 1	B1	Production borehole	12.5	17.3	185	5.00	26.40	Diesel-driven monopump (at Mission Station). Yield (according to locals) = 0.93 l/s. Adjacent to septic tank
2	RIEM 2/ G38354	-	Production borehole	27.2	80.0	114	3.40	4.03	Drilled by Water Affairs. Pump and pipeline removed. Situated in riverbed. Yield = 4.0 l/s
3	RIEM 3/ G38355	-	Borehole	26.9	81.0	116	3.21	<0.01	Borehole in riverbed. Dead animal in borehole Yield = 0.33 l/s
4	RIEM 4	P4	Dug well	4.0	-	126	3.80	3.10	Well dries up during periods of drought
5	RIEM 5	N1	Natural waterhole	-	-	31	0.76	<0.01	Seasonal
6	RIEM 6	P3	Dug well	2.9	6.95	77	0.87	3.13	A perennial well on the bank of the Molopo R.
7	RIEM 7	P1	Duwell	-	-	-	-	-	Well dry
8	RIEM 8	F4	Spring	-	-	-	-	-	Seasonal spring
9	RIEM 9	P6	Dug well	-	-	-	-	-	On a fault. Well dry
10	RIEM 10	-	Dug well	-	-	-	-	-	Well in Loeriesfontein river. Silted up
11	RIEM 11	P7	Dug well	1.2	-	160	5.00	0.44	Well in Loeriesfontein river - dry
12	RIEM 12	P8	Dug well	-	-	-	-	-	On a fault alongside the river. Well silted up
13	RIEM 13	-	Dug well	-	-	-	-	-	On a fault - silted up
14	RIEM 14	B3	Dug well	-	-	-	-	-	Well collapsed - windmill dismantled
15	RIEM 15	?P9	Dug well	-	-	1160	10.00	0.15	Well situated on riverbank
16	RIEM 16	-	Borehole	-	-	-	-	-	Vandalised
17	RIEM 17	-	Dug well	14.3	-	350	5.50	32.72	Windmill dismantled
18	RIEM 18	-	Dug well	5.15	-	760	15.50	1.80	On a fault
19	RIEM 19	P5	Dug well	5.0	10.0	850	5.50	0.66	In foliated biotite schist
20	RIEM 20	N3	Seepage in river bed	-	-	56	0.38	<0.01	Perennial
21	RIEM 21	-	Seepage in river bed	-	-	310	2.80	0.14	Perennial
22	RIEM 22	F3	Dug well	-	-	-	-	-	Well on riverbank. Completely silted up
23	RIEM 23	-	Spring	-	-	380	4.70	28.14	Situated on a fracture

24	RIEM 24	F2	Spring	-	-	475	4.60	2.97	Hot spring (35-40°C). On a fault, flow = 3-5 l/s
25	RIEM 25	B2	Dug well	7.5	10.0	640	3.90	37.44	Windmill in working order
26	T34100	-	Borehole	12.3	-	215	6.30	11.24	Windmill dismantled
27	T34002	-	Dug well	10.8	-	465	10.20	26.91	Well next to school at Mission
28	T34004	P2	Dug well	*(11.5)*	*(15.0)*	-	-	-	Dry well situated on basic dyke
29	T34005	F1	Spring	-	-	-	-	-	Dry silted up
30	G38357	-	Borehole	26.7	69.0	155	4.10	19.21	Srilled by Water Affairs. Yield = 4 l/s
31	G38351	-	Borehole	-	80.0	-	-	-	Silted up. Yield <0.14 l/s
32	G38352	-	Borehole	-	-	-	-	-	Silted up. Dry
33	G39390	-	Borehole	-	-	-	-	-	Dry
34	G38359	-	Borehole	5.79-	-	190	7.10	4.31	Windmill in working order. Yield = 0.5 l/s
35	-	N2	Natural waterhole	-	-	-	-	-	
36	-	N4	Natural waterhole	-	-	-	-	-	
37	-	N5	Natural waterhole	-	-	-	-	-	

Hot spring

This section has been taken directly from the SADF report (1990).

The Riemvasmaak thermal spring is the only natural source of perennial water away from the course of the Orange River. The temperature of the water issuing from the spring was measured by von Backstrom (1962), at 2 p.m. on 11 May, 1957 at 38.3 °C. The spring therefore falls under the class of Hot Springs (37-50 °C) according to Kent (1949). The spring is estimated to yield approximately 1800 litres/hr (von Backstrom, 1962).

The point of emergence of the spring is not associated with any clearly definable geological feature such as faults or joints.

The spring is near the foot of the dissected escarpment formed by the rocks of the Nama system to the northwest, resulting in a rapid fall of country from the northwest to the southeast, accentuated by the presence of the Molopo River canyon. The final difference in elevation between the thermal spring and the edge of the plateau is greater than 335 m. In the area main joints strike predominantly N 25 - 28 E, N 60 -65 W and N 73 - 83 E. Perhaps the strike of the canyon in the area, (N 35 E) is significant. The canyon could thus have formed along one of the main joint directions in the area and the spring could therefore have issued from a principle joint in the Pink Gneiss, which has subsequently been covered by superficial material forming the bed of the Molopo River.

The thermal water appears to be of meteoric (rainfall) origin, having percolated to sufficient depth along suitable fractures and joints in order to achieve the high temperature. Von Backstrom (1962) has shown that the depth of the origin of the thermal water must be considerable greater than that of the elevation difference depicted.

1.4 THE BIOTIC ENVIRONMENT

1.4.1 Vegetation

1.4.1.1 General methodology

The chief aim of the expedition in January 1995 was to conduct a baseline survey of the region. Not only does such an exercise help to familiarise development and research agencies with the general environment, but, more importantly, it also forms the springboard from which a monitoring programme can be launched (Chapter 3). We sought to classify the Riemvasmaak environment into landforms; to describe the vegetation (in terms of species composition and cover) associated with each landform; to assess the overall "condition" of the vegetation and how it has changed in the last few decades; and to provide some indication of the carrying capacity of each landform. In addition, one of our aims was to establish an extensive set of baseline photographs, widespread throughout Riemvasmaak, which can be used in future matched photographic studies of the region.

Matched photography remains a powerful tool for assessing vegetation change, particularly so in semi-arid and arid environments. It has been used very successfully in the United States of America. For example, Rogers *et al* (1984) document over 450 studies which incorporate matched photographic techniques in their overall assessment of vegetation change. In southern Africa, Shantz & Turner (1958) and Hoffman & Cowling (1990) provide examples of matched photographic studies to assess dryland degradation of the Karoo and arid savanna regions.

One of the important strengths of using matched photography in communal areas is that no scientific expertise is required to compare the images from two time periods. There is no analytical or statistical manipulation of the raw data and the images can be understood by people who may not have had access to an advanced education but who nonetheless have an intelligent ecological and historical knowledge of their own landscape.

In developing our general methodology for this survey we have used many of the techniques and tools employed traditionally by the Zurich-Montpellier school of vegetation survey (Werger, 1972). However, there are a number of important differences. Firstly, we have tried to link our photographic documentation of the region directly with our sampling strategy. As outlined above and shown in Appendix 2 and Appendix 8, this adds a valuable monitoring component to the study. We believe that our methods will enable future workers and local farmers to assess accurately the changes in the Riemvasmaak environment with the aid of the photographs and detailed vegetation descriptions. Secondly, we have adopted a landscape focus, describing the vegetation associated with key landforms rather than only with the identification and description of important plant communities (Werger & Coetzee, 1977). Because of this our sample "plot" sizes were usually two to three orders of magnitude larger than is usually the case in standard phytosociological analyses (e.g. Werger & Coetzee, 1977). We think that this "scaling up" is important for a number of reasons not least of which is the fact that it is at this level of scale that farmers interpret and manage their landscapes. Farmers talk of "koppies", "vlaktes" and "riviere" and divide their landscape into these components. It has been our experience that they do not identify plant communities in the way that vegetation scientists have traditionally done and that these plant community units have little value in day to day communal as well as commercial farm managment activities.

Another reason for us to adopt a landscape approach is that we were required to produce a “range map” of the region and provide some idea of the utilization potential of each region. In the very short time available to us to complete our field work, we thought that a focus on the composition and potential of different landscape elements would be the most appropriate method to use.

Site selection

We decided that while as much of the region should be covered as possible there should also be some focus to our sampling strategy. Since the road network links individual villages within Riemvasmaak, we decided to locate our photostations and survey sites in and around major settlements with due care to cover as many landforms as possible. Our photostations were also selected for their aesthetic appeal and panoramic views and the wide open valleys within all the river catchments lent themselves to such documentation. The location of the photostations is shown in Fig. 1.13.

A high position on a hill or rocky slope, overlooking the study site was usually sought and a camera position selected. Time did not permit us to sample the entire landscape and so once the panorama was evident before us we selected one image within the panorama to sample intensively. Criteria for selection usually incorporated aspects of the view's diversity of landforms, its representativeness of the local environments, aesthetic quality and potential as a site from which future landscape changes can be assessed.

Photographic documentation

Although photographic details are recorded in Appendix 8 some information about the equipment used is necessary here. All photographs were taken on a sturdy tripod (*Bogen 3001*) with camera heights ranging from 138.5 cm to 160 cm. Four cameras were used at each photostation. Once an image had been selected for detailed analysis a Mamiya 645, medium format camera with a standard 80 mm lens and black-and-white Ilford FP4 Plus 120 mm film (ASA 125) was used to capture the image. Due care was taken to record the camera height, photographic details (f-stop, shutter speed) and exact time of photograph. The camera position was also recorded with a Sony PYXIS Global Positioning System, marked on a 1:50 000 topographic map and the direction of the field of view of the "main image" recorded by means of a standard compass. After this image was captured the field of view was swivelled 30° left, 60° left and so on until that part of the panorama to the left of the main image was photographed. Then the procedure was repeated 30° right, 60° right and so on, for the panorama to the right of the main image. With the aid of a built-in tripod spirit level, appropriate care was taken at each position to ensure that the camera remained horizontal at all times.

The second camera used was a 135 mm Minolta X-300s with a standard 50 mm Minolta lens loaded with black-and-white Ilford FP4 Plus film (ASA 125). The same procedure, outline above, was repeated with this camera after which one member of the team moved to a location a few hundred metres from the camera position and

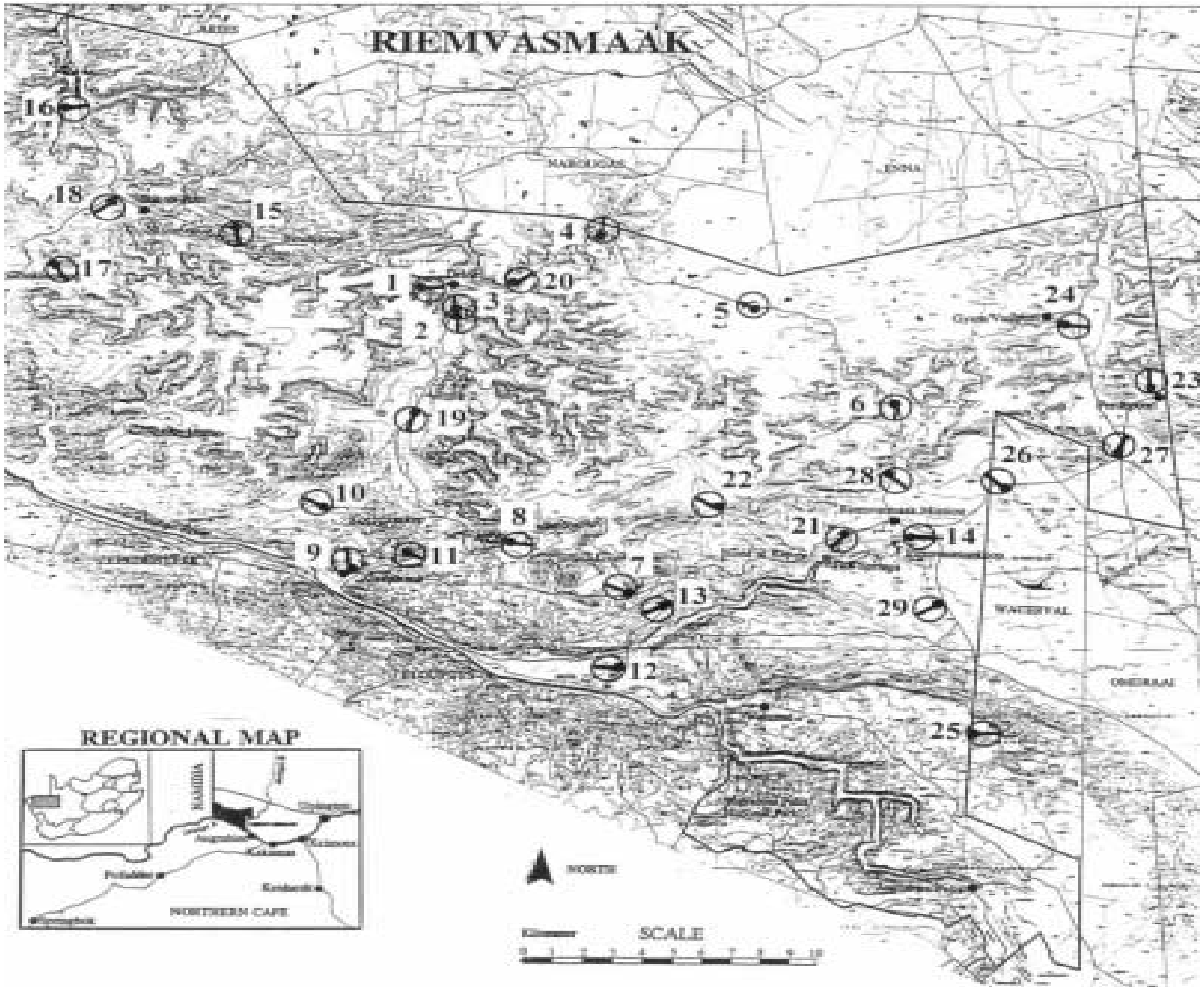


Fig. 1.13 Location of 29 photo stations in Riemvasmaak. Large circles show the general area covered by the images, small dot indicates approximate position of photostation and line indicates the direction of the "main" photograph and sample area.

photographed the photostation with the Minolta X-300s. This image will help future investigators to relocate the exact position of each photostation.

A third camera, a 135 mm Minolta X-70 with a 35-200 zoom lens with (Fujichrome ASA 100) colour slide film was also used to record the main image only.

Finally, a cheap Polaroid camera was used to record the main image so that an immediate record of the site to be sampled was available. The spot directly below the camera position was marked with a metal dropper which, because of the rockiness of the terrain, usually had to be supported within a small rock cairn.

It is our intention to place a copy of this report, together with a set of 7"X5" prints and a set of negetatives of either the medium or 35 mm format with a reputable archival institution such as the South African Library. In doing so it is our hope that this record of the Riemvasmaak environment will be accessible to future generations.

Vegetation analysis

Once the photographs were taken with all four cameras, the main image captured on the Polaroid film was classified by consensus within the survey team into its different landscape elements such as rocky slopes, sandy pediments, dry river beds and so on. These different elements were marked with a permanent pen, numbered (a-f) on the Polaroid image and briefly described from the camera position (Appendix 8).

With the Polaroid image as our guide we walked from the camera position "into" the main image sampling each element (e.g. rocky footslope, rocky pediment, dry river bed, etc) in detail as we moved through the landscape. Sampling consisted of identifying each plant species we encountered and assigning, by consensus within the survey team, a percentage cover value for that species within a particular landscape element. Unknown plant species were collected and later identified in the Compton Herbarium at Kirstenbosch, Cape Town where voucher specimens have been deposited.

The different landscape elements effectively formed our plots or "sites" and ranged in size from less than one ha in rare instances to hundreds of hectares. Generally the sites were between 10-100 ha in size (Appendix 8).

These data collected from each landscape element formed the basis of our vegetation and landform classification. A two-way matrix of species-by-sites was constructed and subjected to standard two-way indicator species (TWINSPAN) (Hill, 1979) classification procedures. The resultant dendrogram was refined by means of a manual adjustment of sites (Appendix 2; Appendix 8).

1.4.1.2 Landform classification

The classification procedure outlined above sorted sites into major landform categories (Appendix 2). Although we assigned each site to a particular landscape element in the field our categories and classification was refined with the aid of the TWINSPAN analysis. Once these basic landform units were established a composite image of about 40, 1:30 000 aerial photographs of the region was created (Job No. 771, Series 1-9, June 1976). This composite was used to classify the Riemvasmaak environment into its component landforms and to map the elements onto the 1:50 000 topographic maps for the region. These topographic maps were photo-reduced and the area of each landform determined using a standard cut-and-weigh method.

Five main landforms are recognised in Riemvasmaak (Fig. 1.14, Table 1.7), with a sixth one - inselbergs - covering only a very small part of the landsurface area of the region. The different landforms are closely associated with the major geological groups of the region.

The plateau is comprised almost exclusively of Nama group sediments and covers about a quarter of the region (Fig. 1.14, Table 1.7). A surprisingly high proportion of Riemvasmaak, also about 25 %, is comprised of the rocky slopes which fringe the plateau. The largest landform is that of the rocky footslopes, toeslopes and rocky pediments which cover slightly more than a third of the area in Riemvasmaak. They represent a diverse set of environments formed within the extremely complex geological mosaic of the Namaqualand Mobile Belt. There is some indication from our analysis that the very broken topography which exists below the escarpment represents a landform distinct from the rocky pediments in the upper reaches of the Kourop River, Bak River and the Molopo River. However, too few sites were located in this environment to adequately assess this.

The sandy pediments occur largely as a result of the recent alluvial and aeolian sandy deposits within the broad river valleys of the region. Plant species composition appears to change between sandy pediments west of the Riemvasmaak Mission Station and those in the more eastern parts. This will be discussed in more detail later.

Finally, the dry river beds which bisect the river valleys cover only 1.4% of the region. They contribute a disproportionate amount to the biomass and production potential of the landscape and are key landscape elements in the ecology and management of Riemvasmaak. Narrow rocky river beds, wide and saline river beds and wide and sandy river beds are recognised as important variations in our analysis (Appendix 2; Appendix 8; Fig. 1.15)

TABLE 1.7. The % cover and area (ha) of each land form in Riemvasmaak.

Land form	Area	
	%	ha
Plateau	25.6	19 121
Rocky slopes	25.0	18 615
Rocky footslopes & rocky pediments	33.9	25 285
Sandy pediments	14.1	10 496
River beds	1.4	1 046
Total	100.0	74 563

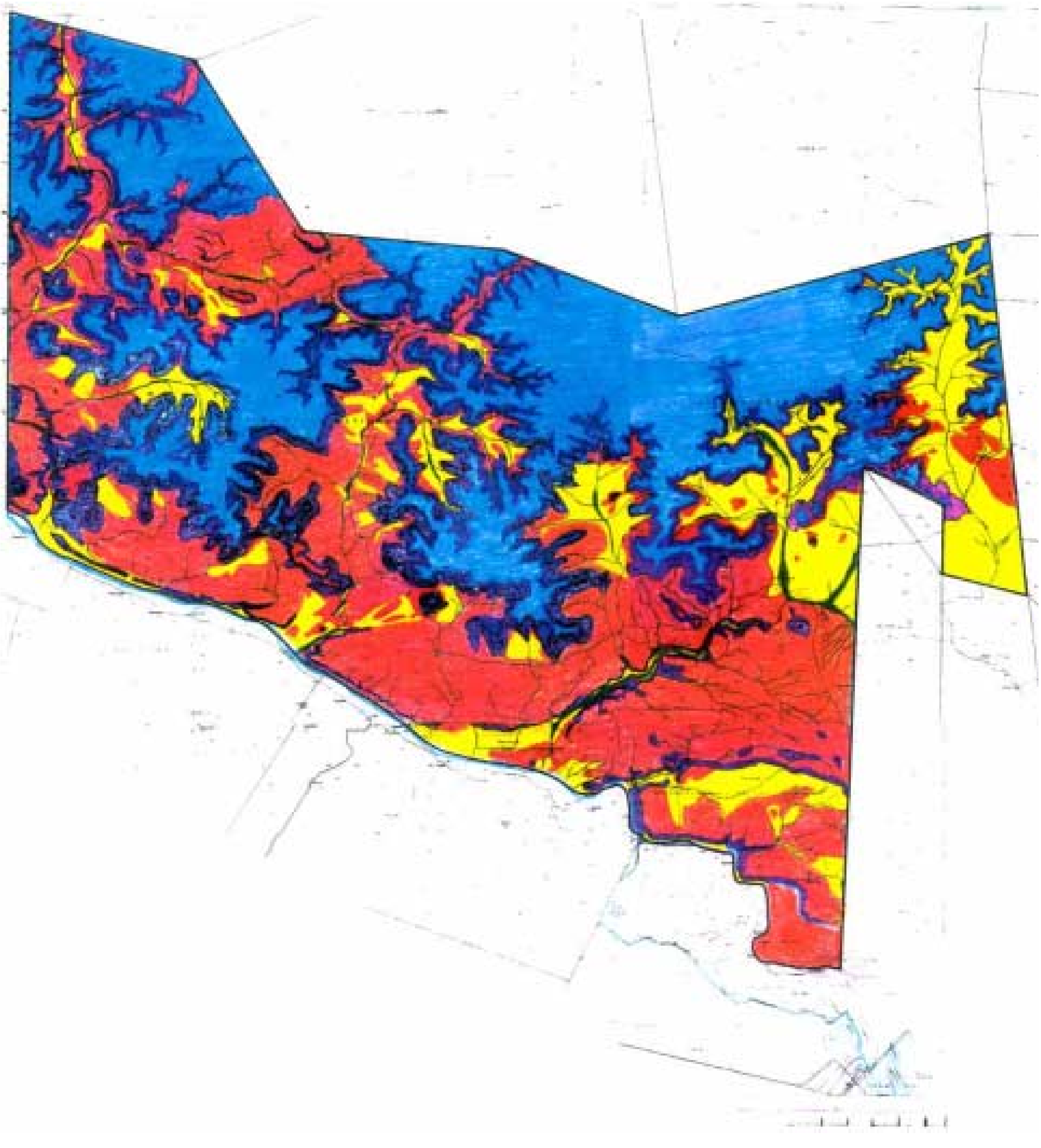


Fig. 1.14. Major landforms in Riemvasmaak: blue = Plateau; purple = Steep slopes; red = Rocky footslopes, rocky toeslopes and rocky pediments; yellow = Sandy pediments; green = River beds.

1.4.1.3 Vegetation associated with landforms

The matrix of species (listed alphabetically) and sites (grouped into the major landforms in Riemvasmaak) is presented in Appendix 2. A checklist of the 159 plants identified during this study and those in the general Riemvasmaak environment, comprising a total of 443 species, is shown in Appendix 3. A highly stylised description of the main species and growth forms associated with different landscape elements is also shown in Fig. 1.15. We discuss below the composition and structure of the vegetation associated with each landform and recommend that Werger & Coetzee's (1977) excellent phytosociological treatment of the plant communities of the Augrabies Falls National Park be consulted for additional information on the vegetation of the region.

Plateau

The plateau is a flat and featureless plain comprised of acidic red loamy sands with an abundance of large (10-15 cm) rounded or angular rocks covering the surface. Because of its apparent uniformity and difficulty of access we only sampled one region of the plateau (Photostation 5; see Fig. 1.13). The vegetation of the plateau is dominated by *Euphorbia gregaria*, and to a lesser extent by the very similar-looking *Sarcostemma viminale* and by *Monechma spartioides* (Appendix 2). *Boscia foetida* and *Petalidium lucens* are other common shrubs while the most abundant grasses include *Panicum arbusculum*, *Enneapogon scaber* and *Stipagrostis uniplumis*. In places, isolated *Aloe dichotoma* individuals rise above the succulent shrubland.

To the north of Riemvasmaak in particular, the plateau environment is characterised by a series of depressions or pans ranging from tens of meters to kilometers in length or breadth (Fig. 1.1). The pans themselves (Site 5c) possess soils with high clay contents (Table 1.4) and have a very sparse vegetation dominated by the leaf-succulent halophytes *Zygophyllum retrofractum* and *Salsola aphylla*. Other common species include the two disturbance-related species: *Aptosimum spinescens* and *Geigaria ornativa*.

On the sandy fringes of the pan a distinctive flora occurs. It is similar to the vegetation of the sandy pediments east of Riemvasmaak and is dominated by *Parkinsonia africana*, *Stipagrostis uniplumis* and *Monechma spartioides*.

From discussions with members of the Riemvasmaak community there is some indication that the pans become seasonally inundated with water enabling the plateau environment to be utilized by stock farmers for extended periods during high rainfall events. Although not adequately documented, individual pans appear to have their own names (e.g. Keivlei) suggesting that they may have formed an important part of the grazing and strategies employed in "Old Riemvasmaak".

Rocky slopes, footslopes, toeslopes and rocky pediments

The Nama sediments of the plateau are deeply dissected in places and an escarpment, running haphazardly from west to east, dominates the Riemvasmaak skyline. Although there are many similarities, our analysis suggests that two variations of this landform may occur. The rocky slopes, footslopes, toeslopes and rocky pediments associated, either directly with the Nama sediments or those of the upper reaches of the Bak and Kourop Rivers, may support a vegetation distinct from the pediments associated with the Namaqualand Mobile Belt sediments and granites below the escarpment (i.e. roughly south of the Riemvasmaak Mission Station) (Appendix 2; Plates 1.3, 1.4; 1.5). Dominant species common to both these rocky pediments include *Acacia mellifera*, *Euphorbia gregaria*, *Monechma spartioides* and *Stipagrostis uniplumis* with the dominance of *E. gregaria* being a distinctive feature of both variations. However, some of the rocky slopes and pediments of the upper reaches of the Bak and Kourop River valleys possess a number of interesting local dominants including the aphyllous shrub *Calicorema capitata*, the grass *Stipagrostis hochstetteriana* and the annual *Zygophyllum simplex*. Similarly, some of the unique features of the vegetation below the escarpment include the occurrence of *Schotia afra*, paraticularly along drainage lines, *Enneapogon scaber, Aptosimum spinescens* and especially *Hermannia spinosa* which appears to be widespread in this region only.

Inselbergs

Although forming an insignificant percentage of the land cover, a number of inselbergs arise from the rocky or sandy pediments within the river valleys (Appendix 8, Photostation 15). Probably because of their different geological composition, the vegetation appears to differ markedly between different inselbergs (Appendix 2). For example, *Enneapogon scaber* is dominant on some but *Panicum arbusculum*, *Stipagrostis uniplumis* or *Triraphis ramosissima* is the dominant grass on others. Similarly, any one of a number of shrubs such as *Rhigozum trichotomum*, *Adenolobus gariepensis*, *Boscia foetida* or *Sisyndite spartea* may be common. In general, vegetation cover was usually very sparse on the rocky slopes of the inselbergs.

Sandy pediments

The sandy pediments associated with the wide valleys in Riemvasmaak are comprised of recent alluvial or aeolian material (Plate 1.6). Based on our analysis of the vegetation we divide this landform into those occurring west of the Riemvasmaak Mission Station and those occurring east of this settlement. Both, however, share common dominants such as *Acacia mellifera*, *Monechma spartioides* and *Stipagrostis uniplumis*. In the west, vegetation cover is generally higher and species such as *Boscia foetida*, *Sisyndite spartea*, *Stipagrostis hochstetteriana* and *Zygophyllum simplex* are generally co-dominants. In the east, the dominance or wide-spread occurrence of species such as *Rhigozum trichotomum*, *Lycium cinereum*, *Geigaria ornativa* and *Sesamum capense* suggests that these pediments have been subjected to higher levels of disturbance in the recent past than those west of Riemvasmaak.

Although the main body of the Kalahari dune fields ends a few km north of Riemvasmaak, a few isolated pockets of Kalahari sands occur, usually adjacent to the sandy pediments (Plate 1.10). *Stipagrostis ciliata* and *Schmidtia kalahariensis* are usually associated with these red sands.

River beds

We recognize three main variations of the dry river beds in Riemvasmaak (Fig. 1.15). In the upper reaches of the Bak and Kourop rivers and the tributaries of the Molopo River, large round boulders are exposed at the surface. The narrow and rocky river channels here are dominated by *Acacia mellifera*, *Cyperus marginatus*, *Monechma spartioides*, *Cenchrus ciliaris*, *Stipagrostis uniplumis* and especially by *Schotia afra* (Appendix 2, Plate 1.9). It is in these habitats that most of the recruitment of *Schotia afra* and *Pappea capensis* was observed.

Where wide and sandy river beds occur there are two main forms. Those which are dominated by *Euclea pseudebenus* and *Tamarix usneoides* (Plate 1.8) may be relatively saline. In places, such as below the Hot Springs in the Molopo River, *T. usneoides* form impenetrable thickets. More commonly, however, the wide and sandy river beds contain very little *T. usneoides*, if any, and are characterised by large *Acacia erioloba* individuals, by *Stipagrostis namaquensis* tussocks and by the occurrence of a range of other species such as *Acacia mellifera*, *Phaeoptilum spinosum*, *Sisyndite spartea* and *Rhigozum trichotomum* (Plate 1.7).

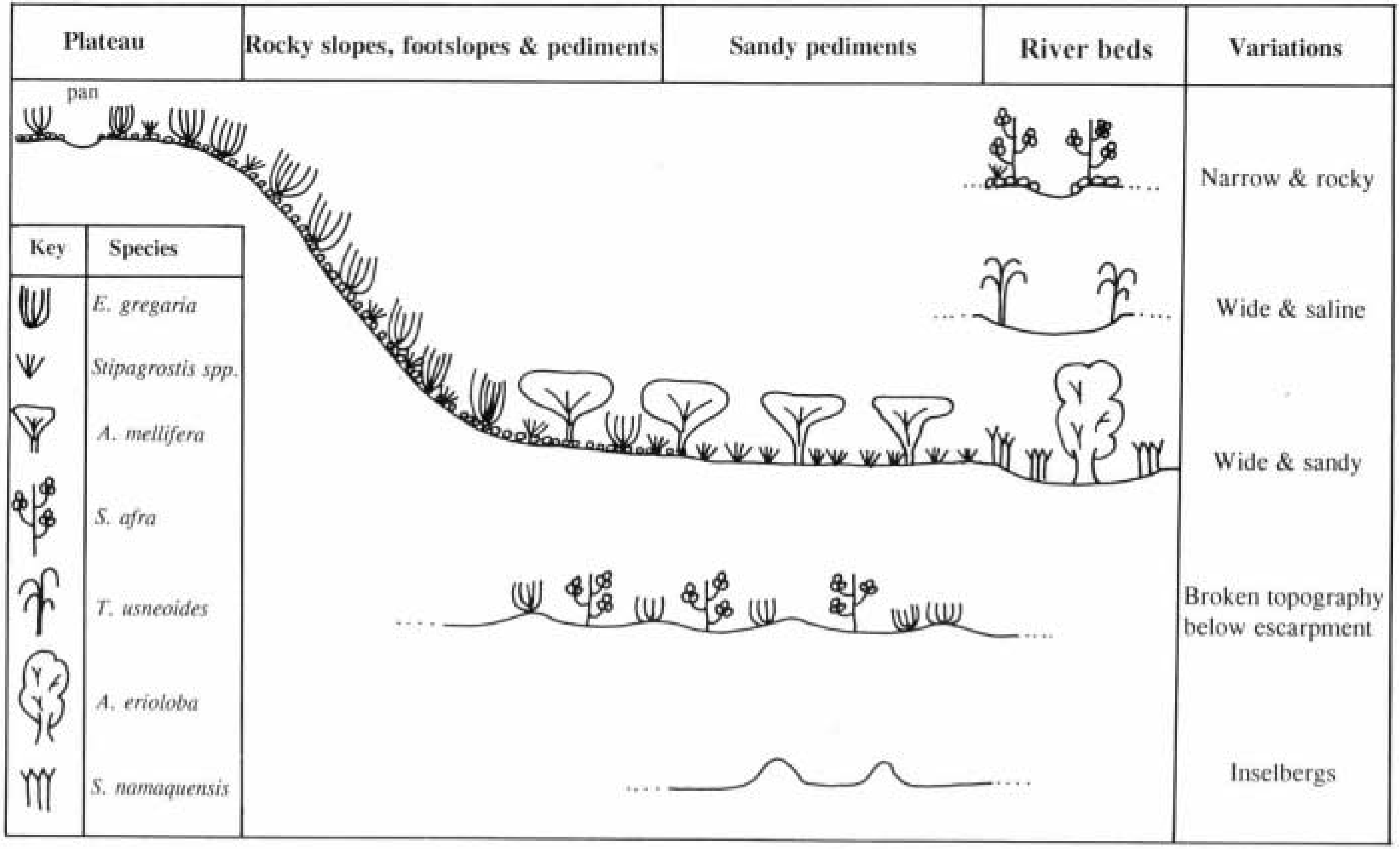


Fig. 1.15. Generalized view of vegetation associated with different landforms in Riemvasmaak.

PLATE 1.2. Flat, stony landscape of the plateau between Riemvasmaak Mission Station and Deksel. The landscape is dominated by *Euphorbia gregaria* with a number of species including *Monechma spartioides*, *Boscia foetida*, *Panicum arbusculum* and *Sarcostemma viminale* as common elements. The pan in the mid-ground depression is obscurred by a fringe of 2-3 m high *Parkinsonia africana* trees. Part of panorama of photostation 5.

PLATE 1.3. Steep rocky slopes below the plateau dominated by *Euphorbia gregaria*, *Stipagrostis uniplumis* and *Monechma spartioides*. The witgatboom (*Boscia albitrunca*) which dominates the right foreground is frequently associated with the rocky slope environments.

PLATE 1.4. Rocky pediment below the Kouropberg about 1km south of Deksel. The vegetation is dominated by *Euphorbia gregaria*, *Acacia mellifera*, *Monechma spartioides* and *Stipagrostis uniplumis*.

PLATE 1.5. Broken topography and rocky pediment below the plateau near the Molopo gorge about 2 km southwest of the Riemvasmaak Mission Station. The vegetation is dominated by *Euphorbia gregaria* and *Stipagrostis uniplumis* on the interfluves and by *Schotia afra* in the narrow and rocky river valleys.

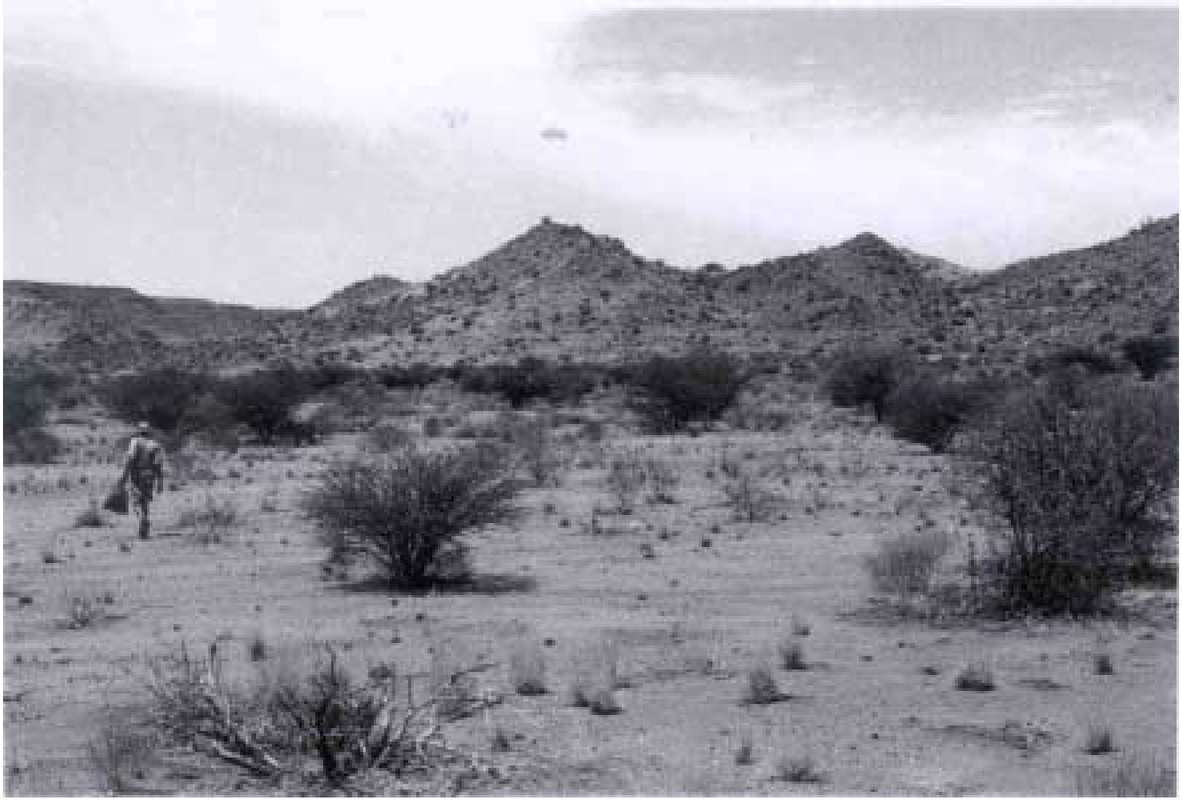


PLATE 1.6. Sandy pediment 5 km north of the Riemvasmaak Mission Station dominated by *Acacia mellifera*, *Stipagrostis uniplumis* and *Rhigozum trichotomum*. This photo represents site 6a of photostation 6. It is also the site where *Acacia mellifera* size classes were measured (see Fig. 1.16)

PLATE 1.7. Wide and sandy river bed about 4.5 km north of the Riemvasmaak Mission Station dominated by *Stipagrostis namaquensis* in the foreground and *Acacia erioloba* in the distance. This photo represents site 6b of photostation 6.

PLATE 1.8. Wide and saline river bed near the confluence of the Molopo and Orange Rivers close to photostation 12. The vegetation is dominated by *Tamarix usneoides*, *Euclea pseudebenus* and *Acacia mellifera*.

PLATE 1.9. Narrow and rocky river bed about 8 km north of Riemvasmaak Mission Station at the point where the road ascends the plateau. The vegetation is dominated by *Schotia afra*, *Acacia mellifera* and *Cyperus marginatus*.

PLATE 1.10. An isolated pocket of Kalahari sand little more than 500 m^2 dominated by *Stipagrostis ciliata* and *Rhigozum trichotomum* (foreground) and *Euphorbia gregaria* (mid-ground).

1.4.1.4 Size class distributions of key species

Because one of our objectives was to assess the "condition" of the vegetation we sampled the size classes of three key species (*Acacia mellifera*, *Acacia erioloba* and *Schotia afra*) at a few widely-dispersed sites. This was done in the following way. Two recorders, with two, 2 m long ranging rods each walked along a transect measuring the heights of every individual of the species of interest within the transect. One member of the survey team recorded the measurements and, walking along a central line, kept the transect focused on a pre-determined direction and distance. Transect lengths varied for each analysis but were usually 20 m wide. The area convered by each transect is indicated in the appropriate figure legends. For *Acacia erioloba* we also recorded the mortalities of all individuals as well as the presence and absence of pods.

Acacia mellifera

Our analysis of one population of *Acacia mellifera* occurring on a sandy pediment at photostation 6 shows that much recruitment of this species has occurred in recent years (Fig. 1.16). In other parts of the Northern Cape and Namibia where higher rainfall occurs (e.g. near Kimberley) the active recruitment and "thickening-up" of dense stands of this species considerably reduces the grazing potential of the region. In these regions the species is considered invasive and the Swarthaak problem remains the focus of considerable research activity (Joubert, 1962; Fugle, 1990). Reasons for the species' increase are usually given as changing fire regimes and overgrazing by domestic stock.

We have included this analysis of *A. mellifera* in our report to suggest that future arguments which may use the size class distributions of this species to support statements about the degradation of the Riemvasmaak environment as a result of livestock grazing should be carefully constructed. The patterns evident in this analysis of a single population (Fig. 1.16) were further supported by our general observations of there being many young *A. mellifera* individuals throughout the region. In the absence of livestock grazing during the last 20 years at Riemvasmaak this species appears to have actively recruited young individuals into the population. However, the timing of this recruitment and age of the smaller individuals is crucial. We show in Chapter 2 that this general area was used by the South African Defence Force as one of three main training grounds for their military activities. From 1988 onwards 8 SAI became mechanized and manouvres in the region included the use of heavy military vehicles such as Ratels. Whether they rode over the area where our transect is located is not clear but it is possible that the recruitment of the small size classes of *A. mellifera*, observed by us, may be in response to these disturbance events.

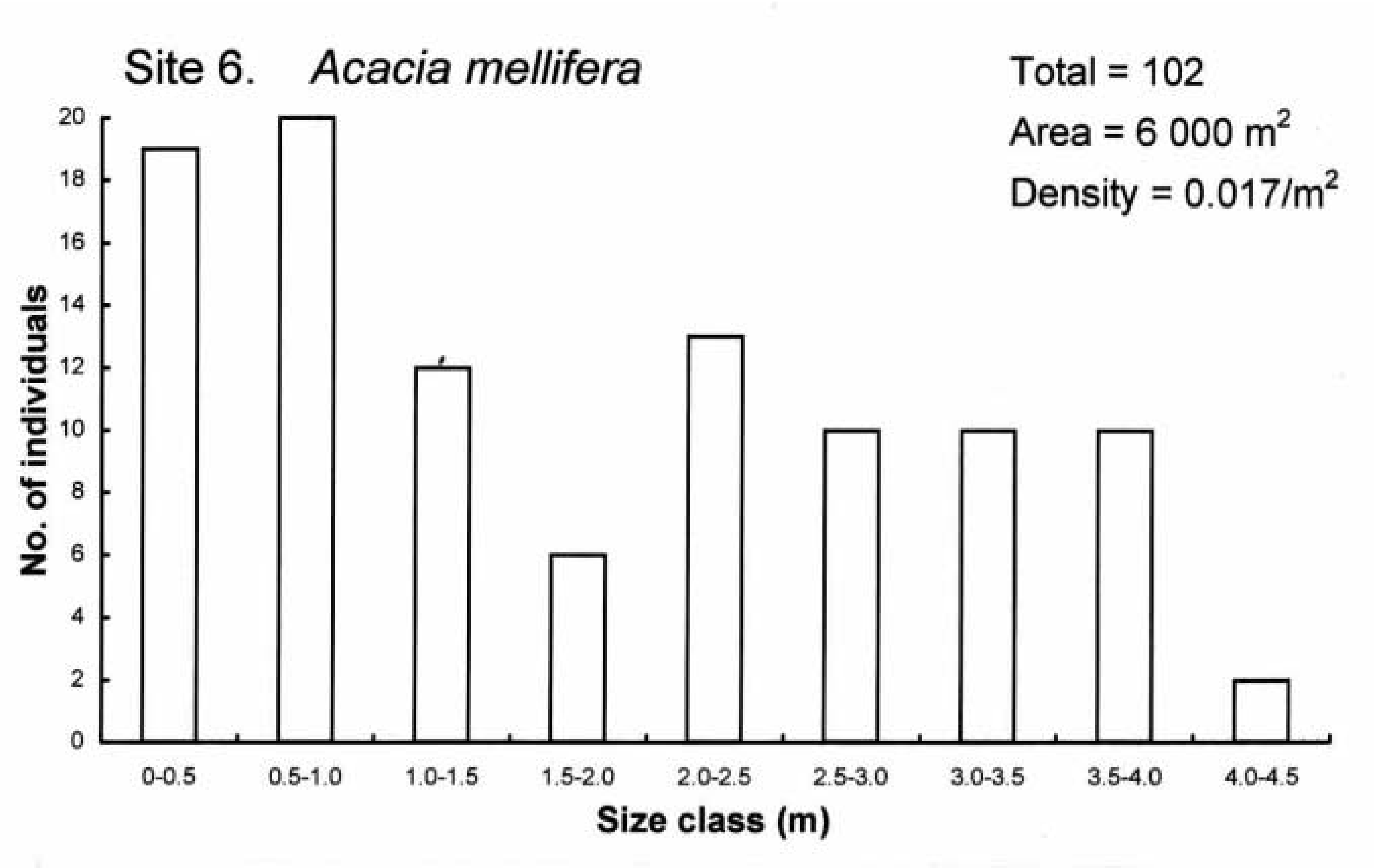


Fig. 1.16. Size class distributions of a population of *Acacia mellifera* on a sandy pediment at photostation 6.

Acacia erioloba

Since camelthorn is such a valuable forage and firewood species in Riemvasmaak we assessed the size class distributions of six widely-dispersed populations (Fig. 1.17). While the patterns varied considerably between populations all showed a healthy recruitment of small (i.e. young) individuals. However, the absence of very small individuals in the 0-0.5 m size class at two sites (photostations 14ii and 24) as well as the mortality of individuals within the smallest size classes at a number of sites (e.g. at photostations 3 and 24) suggests that recruitment conditions have not been favourable throughout the region during the last few years.

We suggest that the very high rainfall conditions which prevailed in the region during the early to mid- 1970's (Fig. 1.9, Fig. 1.10) as well as the absence of grazing, coincident with these favourable growing conditions, may be responsible for the "healthy" population structure which exist in the region at present.

Discussion around the sustainable use of this species so that the favourable population structure is maintained should be initiated within the Riemvasmaak community. Decisions about the harvesting and grazing of immature individuals should be taken as a matter of urgency.

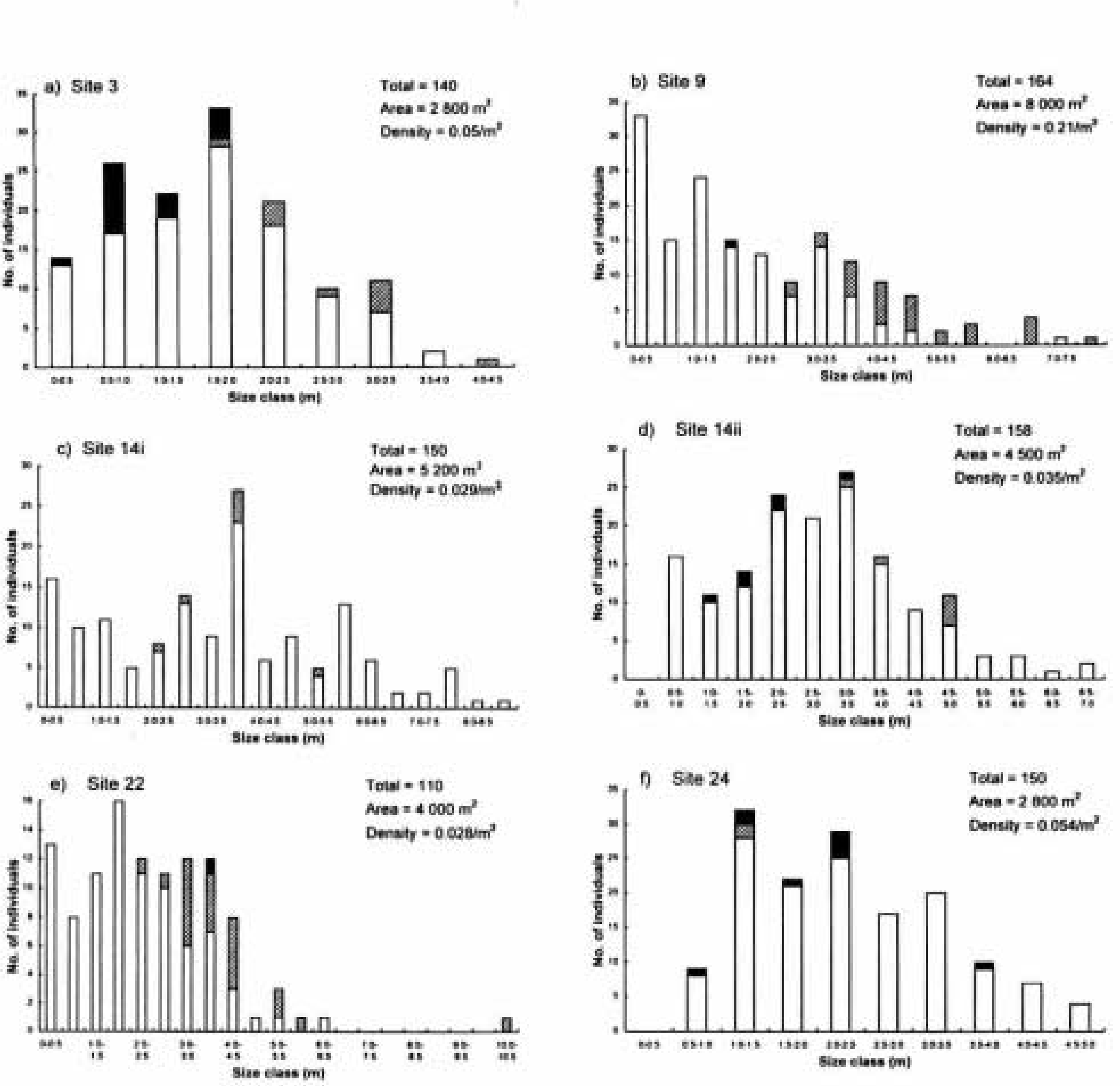


Fig. 1.17. Size class distributions of *Acacia erioloba* populations recorded at six different photostations in Riemvasmaak. Filled sections indicate dead individuals while hashed sections show the number of individuals in a size class which had one or more pods.

PLATE 1.11. Recruitment of *Acacia erioloba* saplings at old kraal sites near Deksel. The 2 m tall ranging rod in left midground marks the deep dung deposits of an old kraal while Jeanne points to a 1.6 m tall *Schotia afra* sapling. Note the dominance of mature *Acacia erioloba* trees in the river course in the right background (see Fig. 1.17, site 3).

PLATE 1.12. David Catling of FARM Africa providing scale for the recruitment of a cohort of *Acacia erioloba* saplings near Gyam/Vaalputs (see Fig 1.17, site 24).

Schotia afra

While this species is not one of the most valuable forage or firewood species in Riemvasmaak it is nonetheless one of the most dominant species especially within the narrow rocky river beds of the region. Furthermore, the general absence of any seedlings of this species throughout its distribution in the semi-arid Karoo is a frequent talking point of South African arid zone ecologists. With nearly a decade of field experience in the arid regions of southern Africa the senior author of this report has seen only two seedlings of *Schotia afra* in other regions of the Nama- and Succulent Karoo biomes and in the arid subtropical thicket/Valley Bushveld vegetation of the eastern Cape.

We were, therefore, intrigued to discover an abundance of *Schotia afra* seedlings in Riemvasmaak and we recorded the size class distributions of one exceptionally dense concentration of *S. afra* seedlings within the river bed at photostation 4 (Fig. 1.12).

The data indicate two peaks in the size class distributions. Firstly, a mature group of individuals from about 3 - 5.5 m was recorded along the river banks. Secondly, within the river course itself we recorded a second peak in the size class structure centred on individuals between 0.5 - 1.5.m. The senior author has some horticultural experience of the relative growth rates of this species and, as is the case for *Acacia erioloba*, we suggest that its recruitment may have been related to the exceptional rainfall conditions which prevailed in the region between 1974-1976 and that the bimodal structure reflects this period.

For the sake of completeness we should point out that the fairly regular sitings of *Pappea capensis* seedlings also surprised us as these are extremely rare in other Karoo environments.

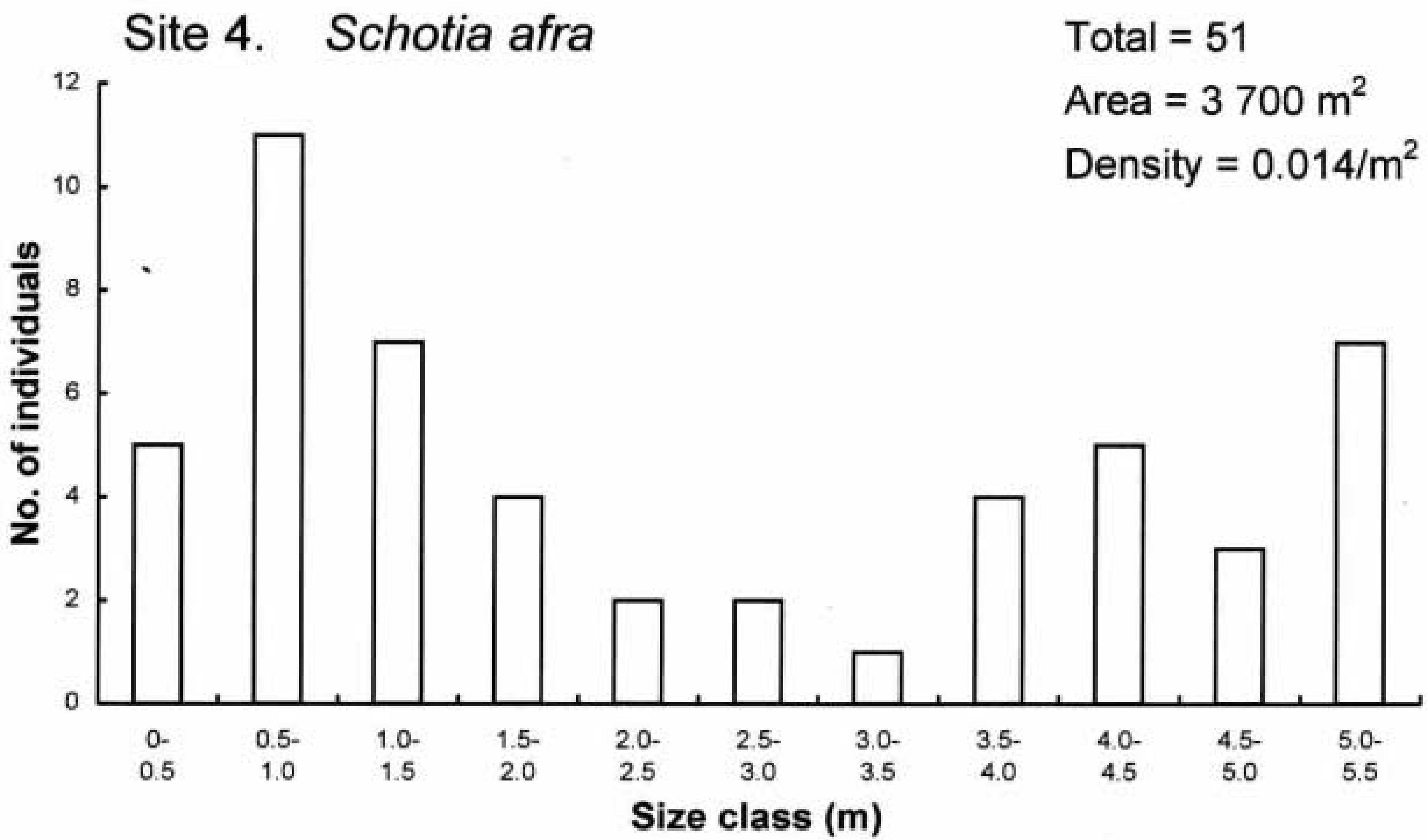


Fig. 1.18. Size class distributions of a population of *Schotia afra* in a rocky river bed at photostation 4.

1.4.1.5 Alien plant control

Of all the invasive alien species in South Africa's arid zone none poses as great a threat to the region's agricultural productivity as does the genus *Prosopis*. Six different species have been introduced to this country since 1879 (Poynton, 1990) and today the genus covers about 200 000 ha of some of the most productive parts of the arid interior of South Africa (Fig 1. 19) (Harding & Bate, 1991). The potential for further invasion is great with an additional one million ha potentially at risk (Harding & Bate, 1991).

Three main species are implicated (Table 1.8). The least invasive of these is *Prosopis chilensis* which forms large, single-stemmed ornamental trees (Poynton, 1990). *P. glandulosus* var *torreyana*, *P. velutina* and the numerous hybrid swarms associated with these three species, however, form dense multi-stemmed thickets.

Prosopis spp. present an important threat to the production potential of Riemvasmaak. The most dense stands of the genus are usually associated with the most productive landforms in South Africa's arid zones, i.e. the dry river beds and sandy pediments. When heavily infested, these landforms become inaccessible to livestock which may also suffer terribly from injuries sustained if individual animals become entangled in the spiny thickets. An additional, seldom considered problem associated with dense infestations, is the impact of these species on the hydrology of a region. *Prosopis* spp. are "extravagant" and wasteful water users and dense thickets could lower the water table and thereby reduce water availability in the dug wells associated with the dry river beds (Harding, 1988).

The rate of infestation of *Prosopis* spp. is dramatic. In other arid areas of South Africa, some 200 km to the east of Riemvasmaak in the agricultural districts of De Aar and Britstown, farmers have recorded a 400 % increase in *Prosopis* spp infestations between 1974 and 1991 (Anonymous, 1990). This dramatic increase in the species complex during the last 20 years is a wide-spread phenomenon apparently linked to the large and widespread rainfall events of the early and mid-1970's (Macdonald, 1985; Henderson, 1991). Infestations seem to occur in "steps" related to rainfall and as Macdonald indicated in 1985, the *Prosopis* problem is a "bomb" ready to explode with the next set of above-average rainfall events.

Just north of Riemvasmaak, slightly higher up the Molopo River, *Prosopis* is a serious pest. For example, during his survey of areas in north of the Orange River in 1989, Henderson (1991) noted that "the most extensive stands of *Prosopis* spp were located along the Molopo River....They were not confined to the river bed of the Molopo but in places had invaded dune valleys and the lower slopes of dunes." Henderson (1991) concludes that "All watercourses [in the northwestern Cape] are potentially at risk from invasion by *Prosopis* spp and it is predicted that without drastic control measures dense infestations could develop along large stretches of the Molopo and Kuruman Rivers....seed washed down to the very arid uncultivated lower reaches of the [Molopo] river....could also result in infestations of *Prosopis* spp"

What is the occurrence of the species at Riemvasmaak? Our survey results indicate that *Prosopis* spp are widespread throughout Riemvasmaak but still in relatively low numbers (Fig 1.19, Table 1.9). We did not however, sample along the Orange River. Mature trees which were probably planted for shade at the large settlements (e.g. around the Riemvasmaak Mission Station and Deksel) still exist around these habitations but are also found now as isolated trees in the general landscape. A number of seedlings were also observed although no dense stands were recorded anywhere during our survey.

To date, control of the dense thickets in South Africa has been either by mechanical or chemical means or through the release of host-specific, seed-eating insects. Mechanical and chemical clearing, however, is a costly affair (Harding, 1987) with the added requirement of repeated treatments to prevent re-infestation. Recent recommendations have suggested a thinning of dense stands both to save on costs associated with clear-felling and to render these thickets utilizable once more as pods and leaf production increases as the canopy becomes more open.

An additional, slightly more long-term solution has been a biocontrol experiment centered on the release of a few of *Prosopis* spp natural pests, i.e. host-specific seed-eating weevils imported from North America. Host-specificity trials have been carried out in South Africa over two years and 70 potential hosts, including *Acacia erioloba*, have been screened (Zimmerman & de Beer, 1992). Two biocontrol agents, viz. *Algarobius prosopis* and *Neltumius arisonensis* are currently being released to control the seed output of *Prosopis* spp in the arid zones of South Africa (Stoltsz, 1994).

Despite the potential dangers that *Prosopis* spp thickets pose for the agricultural productivity of Riemvasmaak, the genus also possesses many potential uses. Besides the fuel and construction materials derived from the species, the pods of this legume are very nutritious with high protein and fat contents (Harding, 1987). They can provide an excellent stock feed and trials suggest that if broken down by a hammer mill, the seed and pod material can make up to 40 % of the food intake of sheep. Yields from mature trees can be 90-140 kg in a single season (Harding, 1987).

In an agrarian community which will remain dependent on the region's natural resources for construction materials, fuel and forage for their livestock for some time to come, decisions to eradicate the species should be carefully considered.

Recommendations

After consultation with Mr Carl Stoltsz of the Plant Protection Research Institute (see also Harding & Bate, 1991) and after careful consideration of the evidence above, we suggest that the risks of *Prosopis* spp infestations are simply too great for us to propose anything other that their complete eradication from the veld of Riemvasmaak. If mono-specific *Prosopis* spp thickets were to dominate the dry river beds and sandy pediments, the impact on the carrying capacity and hydrology of the region would be catastrophic.

We recommend that the eradication be accomplished in two ways. Firstly, large trees which occur away from major settlements should be cut and used for firewood and construction materials. There should also be an active seedling removal programme and farmers and herders should be encouraged to remove any seedlings that they come across in the veld. When we spoke to the live-stock owners of Riemvasmaak on 4 May 1995, they appeared generally unfamiliar with the species. A broader education or awareness programme may be necessary to inform people of the threat that this species poses to their livelihoods.

Those mature individuals that already exist as shade trees should be identified by a competent systematist with experience in *Prosopis* taxonomy. We recommend that those individuals that are not *P. chilensis* but represent individuals of the *P.*

glandulosus var *torreyana/P. velutina* complex should be replaced by non-invasive tree species.

The second way to deal with this problem is to release the two biocontrol agents onto the mature trees around the Riemvasmaak Mission Station and at other localities where sufficient numbers of trees exist. These host-specific insect populations will ensure that seed production will be reduced although there will probably always be an input of *Prosopis* spp seeds into Riemvasmaak from the heavily-infested surrounding areas.

Finally, we recommend that the dynamics of this species complex should be carefully monitored and appropriate steps taken if infestations appear.

TABLE 1.9. Size class distributions of *Prosopis glandulosus* individuals seen at photo stations (see Fig. 1.13) in Riemvasmaak.

Size class (m)	Photo station number								Total
	2	9	12	14	16	22	24	26	
0-0.5									0
0.5-1.0				3	2				5
1.0-1.5									0
1.5-2.0									0
2.0-2.5			1		1			1	3
2.5-3.0				3					3
3.0-3.5									0
3.5-4.0							1		1
4.0-4.5						4			4
4.5-5.0									0
5.0-5.5	1					1			2
5.5-6.0		1				2			3
6.0-6.5						2			2
6.5-7.0						2			2
Total	1	1	1	6	3	11	1	1	25

TABLE 1.8. Characteristics of the three species of *Prosopis* that occur in the arid zones of southern Africa (information from Harding, (1987); Poynton, (1990)).

Species	Place of origin	Year introduced	Growth form	Preferred habitat	Pod production	Pod quality	Invasive potential
P. chilensis	South America	1894	Shapely, single-stemmed tree	Deep alluvial soils, high water tables	Low/ none	High	Low/none
P. glandulosus var *torreyana*	S.W. USA, N. Mexico	1880	Single to multi-stemmed tree or spiny shrub	Periodically inundated river courses	High	Medium	Very high
P. velutina	S.W. USA, N. Mexico	early 1900's	Multi-stemmed shrub	Dry stony slopes	High	Medium	Very high
Hybrids	-	-	Usually a multi-stemmed shrub	Variable	Often high	Medium-high	Very high

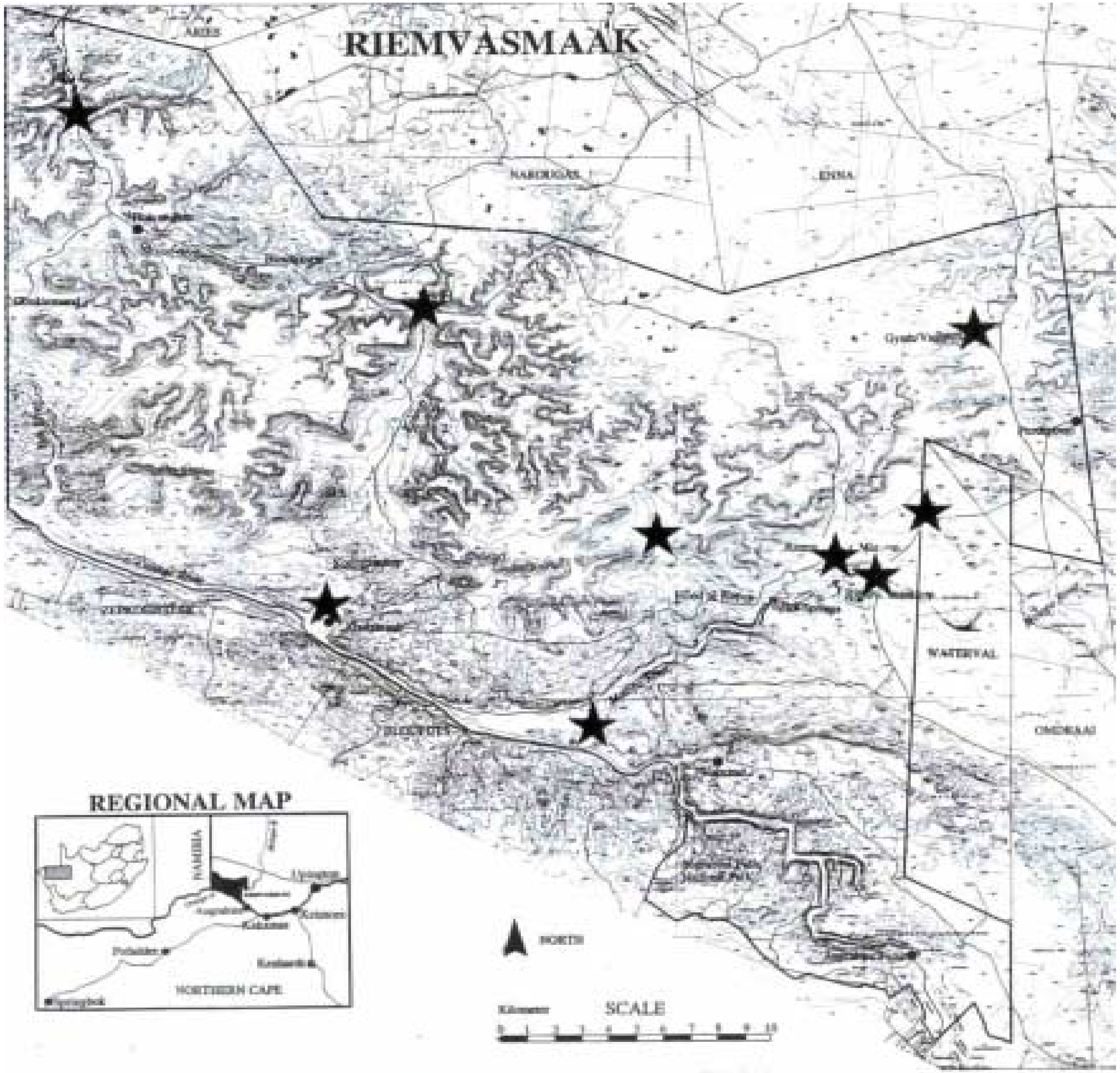


Fig. 1.19. Location of *Prosopis glandulosus* populations observed between 16-31 January 1995 at Riemvasmaak.

PLATE 1.13. Mr Willem Vass standing in front of a single large *Prosopis glandulosus* individual near Xubuxnap. The large trees in left and right background are all *Acacia erioloba* individuals while the saplings in the foreground are all *Acacia mellifera* individuals.

1.4.2 Reptiles and amphibians

The checklist of reptiles and amphibians, shown in Appendix 4, is drawn from standard herpetological field guides of the southern African subregion (Passmore & Carruthers, 1979; Branch, 1988), from the list compiled for the Augrabies Falls National Park (see Appendix 4) and from the list in the SADF (1990) report. It comprises 11 frogs, 2 tortoises, 1 turtle, 19 snakes and 35 lizards.

There were important discrepancies between some of the lizard and snake species noted in the Augrabies Falls National Park checklist and the distribution maps listed in Branch (1988) (e.g. *Lygodactylus capensis, Homoroselaps lacteus)*). As none of the survey team is competent to judge the relative merits of the respective lists and distribution maps we have included all species. There are thus undoubtedly many inaccuracies in our checklist.

The use of common names for lizards and snakes also proved to be problematic. We have used Branch (1988) for all English common names but since he does not list Afrikaans common names we have relied on the Augrabies Falls National Park checklist for these. However, in some instances either no Afrikaans common name was available to us or the Afrikaans common name given in the Augrabies Falls National Park checklist was a direct translation of an English common name which differed from that in Branch (1988). Therefore, rather than confuse the literature with additional names we have simply left the column blank.

Although none of the survey team has any herpetological experience we were especially keen to note the occurrence of tortoises and it is of interest that none were recorded during our survey.

1.4.3 Birds

A checklist of birds for the Riemvasmaak area is shown in Appendix 5 and comprises 192 species. This list is a combination of three separate checklists. Firstly, we combine the list of birds recorded for the Augrabies Falls National Park (AFNP, n.d.) with that of the South African Defence Force (SADF, 1990) (see Appendix 5). This latter list is for the Riemvasmaak area only. We also list and mark with an asterisk (*) the birds seen during our casual observations in the two week period (17-29 January, 1995) during which our ecological survey was carried out. These latter observations were incidental and this checklist was not one of the main aims of the survey. However, we feel it is a reasonably accurate account of what was present at Riemvasmaak at the time. Descriptors of abundance (rare, common etc.), when listed at all, are based on the duration of this study only and therefore do not refer to the actual status of the bird at Riemvasmaak. The duration spent at a particular site influenced the number of species seen as well as the abundance of each species. Skulking species (e.g. Cape Reed Warbler, Cape Robin) are listed as rare whereas they may well be common. The Augrabies Falls National Park (AFNP, n.d.) and SADF (1990) checklists are worth consulting independently as they provide additional information on the species' habitat preference, status (i.e. whether resident, migrant, vagrant etc.), Red Data category and months when present in the area.

During our survey we noted 72 species or 37.5 % of the total number of species on the checklist.

1.4.4 Mammals

The mammals for the Riemvasmaak region are shown in Appendix 6. This list has been compiled from Rautenbach et al (1979) for the Augrabies Falls National Park and surrounding areas, from AFNP (n.d. - an updated list for the Augrabies Falls National Park) and from the SADF (1990) report. It comprises 51 species.

Besides this checklist synthesis, we also recorded the type, number and locality of any mammals seen during the course of our baseline survey. By so doing, it is hoped that changes in abundance, accredited to human disturbance, will be detected in future surveys of the area.

We began recording mammals on the 17th January and ended on the 29th January, 1995. To record the abundance of mammal species, a grid system was compiled for the Riemvasmaak area at the start of the survey. This grid consisted of squares divided into latitude and longitude of 1' x 1' (approximately 1.5 km x 1.5 km). Mammal species, together with numbers of individuals seen (and appropriate care taken not to record the same individual twice) were recorded on this grid system at the time of observation. Maps were subsequently produced using a Geographical Information System. These maps do not reflect actual distribution since not all areas of Riemvasmaak were surveyed. However, they do reflect the presence and abundance of mammals in those areas which are likely to be subjected to heaviest human disturbance, i.e. the areas of importance for future monitoring programmes.

In total we saw 12 mammal species or 23.5 % of those listed for the area. The majority of our observations were of conspicuous, diurnal mammal species. Klipspringers and dassies were by far the most abundant mammals recorded by us. The 89 klipspringer that we saw are of special interest as the National Parks Board helicopter survey of Riemvasmaak conducted on 10 March 1995 (see Appendix 7) yielded only 7 individuals. This cryptic species is difficult to see from the air and a ground survey of the region is probably the best method to use in determining the abundance of this species.

We used the same method to list the number and location of goat, sheep, cattle, horses and donkeys seen during our survey and discuss these data later.

Finally, in Appenidix 7 we present data on the abundance of mammal species censused during helicopter surveys undertaken by the National Parks Board in Riemvasmaak in March 1995 and in “Bokvasmaak”, the area leased by the National Parks Board from the Riemvasmaak Trust. Details of the methods used during these surveys may be obtained from Dr Mike Knight at National Parks Board, Scientific Services Department, PO Box 110040, Hadison Park, Kimberley, [Tel: 0531-25488, Fax: 0531-34543]. It should be noted that when the South African Defence Force vacated the area in 1994, the National Parks Board caught and removed 21 Gemsbok, 10 Kudu and 4 Ostrich in a game capture excercise (Barry Hopgood, personal communication, 2 February 1995).

1.5 THE GRAZING ENVIRONMENT

1.5.1 Veld "condition"

The current composition and structure of the vegetation at Riemvasmaak, as well as the relative abundance or rarity of different species is a function of two main influences. Firstly, climatic factors such as soils, rainfall and temperature exert an important influence on the vegetation of arid lands. We have shown in previous sections of this chapter how the Riemvasmaak landscape is structured, which species dominate under specific environmental conditions and what some of the possible influences of large rainfall events might have been on the dymanics of key species in the region during the last two decades. Landuse history, however, also has a profound influence on the vegetation of any region and a comprehensive history of landuse practices in Riemvasmaak from pre-colonial times to the end of 1994 is described in Chapter 2.

So, based on our experience, what is the current state of the Riemvasmaak environment and which factor - climate or humans - exerts the most important control on the vegetation of this arid land? This discussion forms part of a much broader debate currently evolving in the ecological and grazing science literature (Behnke *et al*, 1993; Scoones, 1995).

Firstly, how does one measure veld "condition"? Usually, long-term data, including matched photography, fence-line contrast studies or an analysis of the population dynamics of key forage species are used. Since we did not have access to a comprehensive historical photographic collection and historical environmental data for the region are generally absent we have assessed Riemvasmaak's veld condition using our estimates of the composition, structure and abundance of important forage species.

Despite the low rainfall that the region has experienced in the last few years (Fig. 1.9; Fig. 1.10) we considered the veld in Riemvasmaak generally to be in an excellent condition. This subjective assessment is based on the fact that:

(a) The cover of perennial plant species, especially grass cover, was generally good (see Appendix 2 and Table 1.10) and we seldom encountered large bare patches which are usually indicative of degraded arid lands;

(b) The vegetation was usually diverse with a mix of growth forms including trees, shrubs, perennial grasses and annuals. There appeared not to be a dominance of annual species as is usually the case in degraded arid lands and important perennial, palatable forage species such as *Limeum aethiopicum*, *Monechma spartioides*, *Hermannia* spp., and a number of legumes and many palatable grasses were regularly encountered in the mix of plant species;

(c) There was a noticeable lack of a distinct browse line on important tree species such as *Acacia erioloba*, *Boscia albitrunca*, *Pappea capensis* and the physical structure of other forage species, especially some of the shrubs such as *Limeum* spp., *Monechma* spp. and palatable grasses (*Cenchrus ciliaris*, *Stipagrostis ciliata*, *Stipagrostis hochstetteriana*) suggested "healthy" plants, capable of flowering and contributing to the seed pool;

(d) The population structure, inferred from size class distributions of the dominant tree and shrub species suggested that active recruitment of new individuals had occurred in the recent past and that the populations of important forage species comprised a mix of individuals of different ages;

(e) The few fence-line contrast studies that we conducted at photostations 4, 25 and 26 and our general observations of the vegetation surrounding Riemvasmaak all indicated that the Riemvasmaak environment supported vegetation with a greater cover and more diverse mix of species;
(f) Except for a few erosion scars running parallel with the roads in some places there was no evidence of widespread and active gulley, rill or wind erosion;
(g) Without exception, the returning Riemvasmakers all stated that vegetation cover and the abundance of important species such as *Acacia erioloba* and *Acacia mellifera* had increased considerably in their absence and that the veld looked to be in an excellent condition.

Although we have suggested that the Riemvasmaak landscape is in an excellent condition a few qualifications of this general statement are required. It is also important that we assess the impact of the South African Defence Force's tenure on the region.

The eastern parts of the area, particularly on the sandy pediments east of the Mission Station, around Perdepoort and around Gyam/Vaalputs, appear to have been subjected to fairly extensive recent disturbance. This is reflected in the low cover of plants in general and dominance by classic disturbance species such as *Rhigozum trichotum* and by annuals (see Plate 2.6). Since the South African Defence Force used these areas for their militarized infantry exercises (see Chapter 2) it is likely that much of what we measured and observed may be related to this period. However, without a thorough account of the condition of the landscape at the time of their occupation it would appear illogical to place all of the responsibility for the current state of the veld in this area at the door of the SADF. The imact of several decades of livestock farming on the vegetation of the sandy pediments of the eastern parts of Riemvasmaak may also be partly responsible for current landscape condition.

Besides the ubiquitous presence of military debris and the shattered ruins of old homesteads, schools and churches we could find little direct evidence of the impact that the South African Defence Force's tenure might have had on the rest of the Riemvasmaak landscape. Here and there we noticed clear signs of bomb craters and we suspect that the more remote parts of the plateau might have been more severely impacted since these regions were used as target areas for Air Force bombing practice (Chapter 2). However, we suggest that except for a few localized regions, covering perhaps less than 15 % of the area of Riemvasmak, the impact of the South African Defence Force on the Riemvasmaak landscape has been slight. Indeed, the absence of large numbers of domestic livestock during their period of tenure appears to have had important benefits for key forage species such as *Acacia erioloba*, *Pappea capensis*, *Limeum aethiopicum*, *Monechma spartioides* and many of the palatable grasses listed in Appendix 2. In addition, the SADF also initiated an effective programme of clearing the alien plant, *Nicotiana glauca* (Wild tobacco/Wildetabak) from the river courses where it was apparently an important invasive element (SADF, 1990). We did not observe any populations of wild tobacco during our survey in Riemvasmaak.

Given the discussion above, which factor - humans or climate - appears most important in determining the condition of Riemvasmaak's vegetation? This debate is critical since an influential body of range scientists with an impressive experience of conditions in sub-saharan Africa has recently challenged long-held views of grazing systems and the impact of livestock on arid communal rangelands (see Sandford, 1983; Behnke *et al*, 1993: Scoones, 1995). Many of these scientists emphasize climatic controls of rangeland productivity and composition and suggest that livestock numbers in communal rangelands are seldom able to reach the sort of levels that are destructive to the vegetation and healthy functioning of the environment. Currently South African models of arid rangeland dynamics suggest that, while climate plays a pivotal role (Roux, 1966; Milton & Hoffman, 1994), the impact of livestock grazing over decades also has an important influence in changing the composition of the veld (O'Connor & Roux, 1995).

Our study has suggested that the Riemvasmaak environment has benefitted greatly from the twenty year "rest" that it has received from domestic livestock grazing. Wild ungulates such as kudu, gemsbok and klipspringer have been present in the area but in low numbers and their impact appears to have been neglible. Clearly, the preservationists are not incorrect in saying that arid land ecosystem "health" and veld "condition" are well served if left alone to the forces of nature.

What should be kept in mind, however, is the fact the Riemvasmaak environment was utilized and grazed for several decades by communal farmers and their livestock prior to their removal in 1974. If the Riemvasmaak environment has been able to "recover" to the extent that it has, then the obvious question to ask is "Does livestock grazing really have such an impact in the long-term?" Of course the full impact of any landuse practice such as livestock grazing can never be completely known, but despite its historical treatment prior to 1974, today the Riemvasmaak environment appears little influenced by these landuse practices (but see the discussion in Chapter 2 on the re-sampling of one of John Acocks' sites - our photostation 21).

Unfortunately this whole debate is confounded by the fact that the removal of domestic livestock coincided almost exactly with a period of unprecedented high rainfall. Would the landscape have responded in the same way if domestic livestock had remained in Riemvasmaak? We think not but can can only suggest that a well designed and on-going monitoring programme as outlined in Chapter 3 will be the best way to understand the relative influence of climate and grazing on the Riemvasmaak environment.

1.5.2 Range potential and carrying capacity

"*...there is no method whereby any technician can go into a new country and measure anything which will automatically give him the grazing capacity*" (Stoddart, 1960 in Bartels *et al*, 1993)

"*Let us admit the problems with the carrying capacity concept in sub-Saharan Africa, and stop trying to apply it*." (Bartels *et al*, 1993)

The assessment of the carrying capacity for an area is notoriously difficult. This is particularly so for arid and semi-arid regions managed under communal tenure. Recent opinions even suggest that under many African circumstances the exercise may be pointless.

While acknowledging the emerging debate around the theme we also feel that it is important to provide an estimate of the carrying capacity of the region calculated using the most recent, and standard agricultural methods available. By doing this we hope to provide some material around which the Riemvasmaak farmers can formulate their own ideas about carrying capacity concepts and to provide a broader context for management decisions. It also enables more fruitful interaction with neighbouring commercial farmers and with the Department of Agriculture extension services if some knowledge of the recommended carrying capacities is available.

For the semi-arid and arid Karoo environments of South Africa the recommended carrying capacities for commercial farms are correlated with long-term rainfall records (Van Den Berg, 1975; Dean & Macdonald, 1994; Fig. 1.20). For arid Riemvasmaak this means that the departmental recommendation translates to a value of about 60 ha/LSU (Fouche, 1994). Large Stock Unit equivalents are presented in Appendix 9 and by using these tables the number of animals of any particular species within any herd structure for any size farm can be calculated. In fact, in chapter 2 we have used this table and general method to assess the stock levels present in "Old Riemvasmaak". 60 ha/LSU translates to about 1 243 LSU's for Riemvasmaak which in turn is 1 130 mature cows or 7 312 mature Boer goats. Strictly speaking, the area currently leased to the National Parks Board should not be included in the calculation as it is unlikely that livestock will be grazing there in the immediate future. When this land of 4 270 ha with the ability to support about 71 LSU's (65 mature cows or 418 Boer goats) is excluded a total of about 1 172 LSU's for the remaining grazing lands of Riemvasmaak results. This translates to a total of either 1 065 mature cows or 6 894 mature Boer goats if the recommendations of the Department of Agriculture are to be applied. The economic implications of these stocking rates are discussed later.

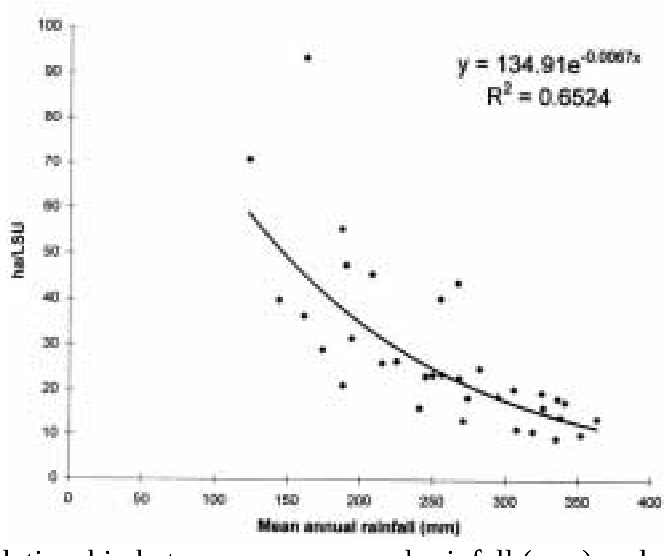


Fig. 1.20. The relationship between mean annual rainfall (mm) and actual stocking rate (ha/Large Stock Unit equivalent) on commercial farms between the period 1971-1981 for 34 magisterial districts in the arid savanna, central karoo and succulent karoo regions of South Africa. The exponential relationship is significant at $p < 0.0001$. Data are derived from Dean & Macdonald (1994).

Locally, there have been two recent refinements to these general carrying capacity recommendations both of which have emanated from workers within the South African Department of Agriculture's Grootfontein Agricultural Development Institute situated in the eastern Karoo in Middelburg, some 570 km southeast of Riemvasmaak. These are the Ecological Index Method (EIM) (Vorster, 1982) and more recently, the Grazing Index Method (GIM) (Botha *et al*, 1993). Both methods are aimed at adjusting the carrying capacity value of a camp, farm or region depending on an objective assessment of range condition, based on standard measurements of species composition and cover. Both the EIM and GIM use some benchmark value against which individual sites, camps or farms are assessed and carrying capacity recommendations subsequently adjusted. This benchmark value incorporates the rainfall/carrying capacity relationship discussed above, the economic performance of monitored marker groups under different carrying capacities as well as the experience of researchers and farmers, all of which operate within the ranch or commercial livestock model. An accurate assessment of carrying capacities for communal rangelands in the semi-arid and arid Karoo has not received any attention in the southern African literature.

We used the Grazing Index Method (Botha *et al*, 1993) in our assessment of the carrying capacity of the different landforms within Riemvasmaak. Firstly, we assigned a Grazing Index Value to every species that we recorded during our survey. These values range from 1-10 with “valuable” species scoring higher that less valuable species (see Appendix 2) and are based on the following five criteria (Botha *et al*, 1993):

(a) The ability of the species to produce forage;
(b) The value of the forage during both the growing and dormant seasons;
(c) The degree of spinescence and relative ease with which the species can be grazed;
(d) The perenniality or longevity of species with long-lived perennials scoring higher than annuals;
(e) The ability of the plant to protect the soil against surface erosion.

We used the values for 75 of the 165 species in our checklist that are contained in the unpublished booklet of Grazing Index Values for Karoo species compiled by Botha *et al* (1995). Three of the values were later modified as conservators with experience of the vegetation of the region and Riemvasmaak farmers disagreed with the values assigned to these species in Botha *et al* (1995). These values either under- or over-estimated the local expression of the grazing value of the species. The GIV was increased from 2.9 to 6.0 for *Acacia mellifera*, from 3.7 to 4.5 for *Diospyros lycioides* and decreased from 2.0 to 1.5 for *Tamarix usneoides*. For species that were not listed in Botha *et al* (1995) Grazing Index Vaues were assigned by us in consultation with Dr Hugo Bezuidenhout, a range and wildlife ecologist with the National Parks Board who has extensive experience of the vegetation and grazing value of individual species.

For each site (e.g. 5a, 4d1, 13b etc.) the Grazing Index Value for each species was multiplied by the percentage cover score for that species at that site. The summation of these values reflects the Grazing Index Score for the site. The mean Grazing Index Score and percentage cover for each landform and a mean value for Riemvasmaak was then calculated (Table 1.10).

TABLE 1.10. Mean percentage cover (± std. dev.) and mean Grazing Index Score ((± std. dev.) for 96 sites encompassing different landforms and their variations at Riemvasmaak.

Landform	n	Cover (%)		Grazing Index Score	
		Mean	Std. dev.	Mean	Std. dev.
Plateau	**2**	**32.5**	**10.6**	**101.2**	**66.0**
Rocky slopes, footslopes, and pediments	**36**	**22.9**	**9.4**	**96.7**	**50.0**
- *Rocky slopes, footslopes,and pediments*	*(26)*	*(24.5)*	*(9.9)*	*(101.8)*	*(56.8)*
- *Broken topography below escarpment*	*(10)*	*(18.5)*	*(5.3)*	*(83.7)*	*(31.1)*
Inselbergs	**5**	**11.4**	**3.5**	**47.1**	**17.6**
Sandy pediments	**23**	**29.8**	**16.8**	**145.1**	**59.3**
- *West of Riemvasmaak*	*(13)*	*(37.3)*	*(18.7)*	*(184.7)*	*(97.0)*
- *East of Riemvasmaak*	*(10)*	*(20.0)*	*(5.8)*	*(93.7)*	*(41.8)*
River channels	**30**	**36.4**	**18.5**	**142.8**	**69.5**
- *Narrow and rocky*	*(6)*	*(44.2)*	*(15.0)*	*(200.7)*	*(86.4)*
- *Wide and saline*	*(5)*	*(54.0)*	*(26..1)*	*(118.4)*	*(55.3)*
- *Wide and sandy*	*(19)*	*(29.3)*	*(13.4)*	*(131.0)*	*(60.0)*
Mean[1]		**27.0**	**15.0**	**120.6**	**72.5**

[1] includes data for main landforms only.

Based on these calculations, it is evident that the Grazing Index Score is highest for the sandy pediments and river channels (with the exception of those dominated by *Tamarix usneoides*). The plateau and rocky pediments had Grazing Index Scores below the overall mean with the few inselbergs that we sampled possessing very low Grazing Index Scores.

Knowledge of the Grazing Index Score for a particular landform has only enabled us to rank the relative value of each landform. In the absence of benchmark sites for the region it is not possible to use this method to arrive at an objective stocking rate for the region. However, in order to assign stock numbers to the Grazing Index Score and to calculate a relative carrying capacity for each landform we made the mean value of 120.6 for the region equal to the recommended stocking rate of 60 ha/LSU. The number of Large Stock Units for each landform was then calculated by the following formula:

No. LSU's = 120.6/GIS x 60 ha/LSU.

This provided a total number of Large Stock Units for the 74 563 ha reserve of 1 084 LSU which is equivalent to 985 head of cattle or 6 376 mature Boer goats (Table 1.11). If the 4 270 ha leased to the National Parks Board, comprised predominantly of rocky pediments, are subtracted from the calculation, then the total number of LSU’s drops to 1 028. This is about 935 head of cattle or 6 047 mature Boer goats.

TABLE 1.11. Number of cattle or large stock units (LSU) able to be accommodated within different landforms at Riemvasmaak assuming a mean Grazing Index Score (GIS) for the 74 563 ha reserve of 120.6 equivalent to the recommended stocking rate of 60 ha/LSU.

Landform	Grazing Index Score	ha/LSU[1]	Area of landform ha	No. of LSU’s
Plateau	101.2	71.5	19 121	267
Rocky slopes, footslopes & pediments	96.7	74.8	43 890	586
Sandy pediments	145.1	49.9	10 496	210
River channels	142.8	50.7	1 046	21
Total			74 563	1 084

[1] (=120.6/GIS x 60 ha/LSU)

When these numbers were presented, on 5 May 1995, to a group of about 45 Riemvasmakers, some of whom were farmers, they made two comments. Firsly, they felt that it was too early to start talking about carrying capacities with the expressed intention of setting limits to stock numbers. All people who owned stock had not returned and before rules, set by outside agencies were applied, the people at the meeting felt that they needed to settle in and bring those animals which they had in their possession back to Riemvasmaak.

But who will bring animals back to Riemvasmaak? Some record of the stock holdings of Riemvasmakers in the Ciskei, Khorixas and elsewhere was made between March and July 1994 by the Surplus People Project (SPP). Of the 207 household heads for whom data were available, 102 or roughly half, possessed at least one animal. Of these 102 household heads, 18 or roughly 18 % stated that they were stock farmers. The rest of the household heads who owned animals, did not state explicitly that they were stock farmers, preferring to write their occupation as “labourer”, “manager” or “pensioner”. Thus, despite the harsh conditions under which the Riemvasmakers have been living for the last two decades many have retained an interest in stock while working in other occupations. This pattern will more than likely continue in the future. As is the case in many communal systems people do not have to invest exclusively in stock farming to make a living and will probably continue to seek alternative livelihoods while retaining a small number of animals under the care of relatives, friends, or recognized stock farmers in the region.

How many animals are expected to return? The total number of animals listed by the 102 household heads who owned stock during SPP's March-July 1994 census was: 3 818 goats; 1 244 sheep; 252 cattle; 25 horses and 219 donkeys. Applying the conversion factors for mature animals listed in Appendix 9 this sums to a grand total of 1 302 LSU's. This value exceeds the recommended stocking rate, based on a "straight" 60 ha/LSU for the 74 563 ha region (giving 1 243 LSU's) by about 5 percent. If the "Bokvasmaak " region leased to the National Parks Board is excluded, then the number of returning animals will exceed the recommended stocking rate (1 172 LSU's) by about 11%. If the calculations derived in Table 1.11 are used as a guide then the returning herds will exceed the estimated carrying capacity of the landscape by between 20 % and 27 % depending on whether the land leased to the National Parks Board is included or excluded from the calculation. A crucial factor that is difficult to predict is the number of animals that have been either added or subtracted in the 12 months since July 1994. It is also not known whether the Riemvasmakers will augment these herds with the animals of relatives, friends or even entrepreneurs from Namibia or those living in neighbouring settlements such as Kakamas or Marchand.

The second comment that the Riemvasmaak farmers made was that the recomended stocking rates of 60 ha/LSU (or 1 000 LSU's for the area) was far too conservative. They felt that they have had up to three times that number in the past. Indeed, data from Isaacs and Phillips (1994) supports this contention although these high numbers have been questioned by some members of the Riemvasmaak community. Clearly stock owners in Riemvasmaak did not maintain their herds at these high levels all the time and the numbers reported in Isaacs and Philips (1994) may merely be a product of the good rainfall conditions that occurred in the early 1970's. A stock census undertaken in Riemvasmaak in 1960 or 1961, during poor conditions, indicates that only 970 LSU's were kept by a total of 319 household heads. A more detailed account of historical stocking rates and grazing strategies employed by the communal stock farmers in "Old" Riemvasmaak is presented in Chapter 2.

1.5.3 Economic potential of the livestock industry

Using assumptions applicable to a commercial farming situation, Fouche (1994) has calculated the economic potential of the livestock enterprise in Riemvasmaak. He suggests firstly that an area of only about 60 000 ha can realistically be farmed in Riemvasmaak given the area leased to the National Parks Board and the areas that are inaccessible to livestock (e.g. very steep slopes). With a carrying capacity of 60 ha/LSU it follows that 60 000 ha divided by 60 ha/LSU provides for about 1 000 Large Stock Units in Riemvasmaak or (according to Fouche's (1994) calculations but not according to the conversion factors in Appendix 9) about 4 500 Dorper ewes or 5 000 Boerbok ewes.

Usually within a commercial farming enterprise the following calculations apply. Firstly, 20 % of the older ewes (900 individuals) in the flock are sold every year. Secondly, if a 100 % lambing success rate occurs then 4 500 new additions are added to the flock every year. Thirdly, about 20 % (900 individuals) of these new additions are kept as replacements for the older ewes leaving a stock of 3 600 lambs that can be marketed.

The total income from the meat and pelts amounts to R684 000 broken up as follows:

3 600 lambs @ ± R150 per lamb[1]	=	R 540 000
900 ewes @ ± R160 per ewe	=	R 144 000
TOTAL INCOME		R 684 000

[1] Local famers (see Nel, 1994) suggest that a value of R120-R130 for lambs and ewes is probably a more accurate estimate of the market price.

Costs are normally set at 60 % of Gross Income or R410 400. This leaves a profit of R273 600 or R60-80 per ewe. If 20 families with equal herd sizes share these profits then each family will earn R13 680 per year or R1 140 per month. If 100 families with equal herd sizes share these profits then each family will earn only R2 736 per year or R228 per month from the sale of their livestock.

Clearly not all farmers will have the same size herds and there is going to be a large difference in the herd sizes between full-time and part-time farmers. Also, the stocking rate determinations and the economic viability assessments outlined above completely ignore the dynamic herding strategies and social arrangements evident in most communal rangelands. Although we have outlined many of the standard range management techniques in our discussion of carrying capacity and the economic potential of the livestock industry we are fully aware of the weaknesses and dangers of applying a commercial ranch model to a communal rangeland environment. At this stage, however, we simply do not have alternative models to apply especially not to a region where it is unclear as to how exactly the communal grazing and marketing systems will be developed and applied.

Conclusions

Recognizing the importance of the livestock industry for many Riemvasmakers and the difficulty of the task which faces them in developing this region we conclude that:

(a) Planners, government officials, development agencies, Riemvasmaak Trust committee members, National Parks Board personnel and indeed all who are connected with the development of Riemvasmaak should accept that probably at least half of the returning household heads are going to want initially to keep at least some animals on the veld. Many economic, cultural and social aspects of their lives appear intimately connected to livestock ownership. This fact cannot be ignored, wished away or simply dismissed as unacceptable;

(b) Riemvasmaak is an extremely arid land and is neither large enough nor productive enough to enable all those interested in owning livestock to make a living from livestock alone. There will always be a wide range of interest in the industry with some farmers possessing large herds and others retaining only a few animals. Enormous difficulties lie ahead in apportioning grazing resources in an equitable manner;

(c) All discussions around stock numbers should be undertaken with great awareness. The issue is an extremely sensitive one within the Riemvasmaak community particularly when viewed in its proper historical context where stock numbers were set and controlled by unpopular outside agencies;

(d) Consensus around stock numbers and the control of numbers must be reached within the community either via an open forum which meets regularly or within an elected and functioning stock committee. Unless carrying capacities are set by the Riemvasmaak farmers themselves there is little chance of controlling or enforcing stock numbers in this rugged terrain;

(e) No one “magic” number (e.g. 60 ha/LSU) should be imposed for all environmental conditions. Clearly, during favourable years stock numbers should be allowed to track vegetation condition and during drought years stock numbers should be reduced. This suggests that relatively sophisticated grazing and marketing strategies need to be developed for the effective functioning of the region as a whole;

(f) The monitoring programme (see Chapter 3) should form the basis within which decisions around stock numbers are taken. Reliable data concerning rainfall patterns, veld condition and resource-related stock mortalities are crucial if informed decisions are to be made;

(g) The key to the management of Riemvasmaak’s livestock industry lies in the creation and development of an effective institution such as a stock committee with the mandate to act and make decisions around a wide range of stock issues including grazing systems, stock numbers, watering points, vetinary services and marketing strategies. It is vital that this body be established as soon as possible. Without it, we predict a dismal future for both the livestock industry as well as the general ecology of Riemvasmaak.

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Chapter 2 : LANDUSE HISTORY

2.1 INTRODUCTION

A knowledge of the past helps us to understand the present and plan for the future. This is particularly relevant for the agricultural development of Riemvasmaak since many of the livestock owners are keen to return to the same general landuse practices that were in place before their removal in 1973. But what were these practices and how did the people of Riemvasmaak survive in these arid and drought-prone environments?

To understand these and other questions we present an archaeological and historical landuse continuum which focuses on the landuse practices employed by the diverse set of human communities that have made the broader Riemvasmaak and Middle Orange River environment their home over the last few millennia. We advocate that the rich archaeological heritage of the region must be preserved in the development plans for the region. Next we summarize briefly the settlement history of the current inhabitants of the region i.e. the "Riemvasmakers", and discuss the main elements of their livestock management systems that were in place in the middle part of this century. A series of interviews with senior members of the community explore the stock movement and drought avoidance strategies that were used in "Old Riemvasmaak". Changes in stock numbers between 1960 and 1974 provide insight into the dynamic nature of the Riemvasmaak environment. By re-sampling a few sites in the region some insight is gained into the changes in the vegetation that have taken place in the last 40 years. We also discuss details of the way in which the South African Defence Force used the land between 1973-1994 . Finally, based on this historical understanding of landuse practices in the region, we explore some of the intervention possibilities that FARM Africa could pursue in the development of the agricultural potential of Riemvasmaak. A general chronology of key events in the history of Riemvasmaak is presented in Table 2.1.

TABLE 2.1. General chronology of key historical events relating to land tenure, management and landuse practices in Riemvasmaak and the broader Middle Orange River environment (taken in part from Smith & Bozalek, 1993).

DATE	COMMENTS
Pre-history	Hunter-gatherer-fishers living along the Orange River corridor and the hinterland. After 2 000 BP joined and largely displaced by herders
1770's	First European travelers visit the region
1868-9 & 1878-9	Korana and northern border wars along the Orange River
?1870's-1900	Damara, Nama, Herero, Coloured and other groups of herders settle in Riemvasmaak where Khoikhoi pastoralists and San hunter-gatherers had lived or perhaps were still living
1885	Bechuanaland Protectorate declared and British Bechuanaland Colony (incorporating the area now known as Riemvasmaak) proclaimed
1895	British Bechuanaland Colony incorporated into the Cape Colony
1904-06	German-Herero war in Namibia
1923	Riemvasmaak land set aside for Blacks
1930	Roman Catholic school established at Riemvasmaak
1936	Development Trust and Land Act promulgated and Riemvasmaak vesting in the South African Development Trust
1947	Independent mission station established at Riemvasmaak with outstations with schools and chapels at Melkbosrand, Bok se Puts and Omdraai. Clinic opened
1957	Regulations applicable to Native Trust land applied to Riemvasmaak
1973	First group of Riemvasmakers (from Xubuxnab) moved off the land and sent to the Ciskei
Feb 1974	Rest of Riemvasmakers dispersed to Namibia and other locations
1974	South African Defence Force assumes responsibility for the region.
1981	Proclamation 257 purportedly amending the list of scheduled land in terms of the 1913 Act and excising Riemvasmaak land therefrom
1982	Proclamation 44 declaring the Bokvasmaak area as part of the Augrabies Falls National Park
June 1988	SADF and National Parks Board develop Riemvasmaak contractual park agreement
1990	Declaration of the extension of the boundary of the Augrabies Falls National Park
1991	Correction Notice regarding the extension of the boundaries of the Augrabies Falls National Park
1993	Successful land claim application
Jan - May 1995	Riemvasmakers from Ciskei, Namibia and other localities resettled at Riemvasmaak

2.2 THE ARCHAEOLOGICAL AND HISTORICAL RECORD

Anatomically-modern humans have been in southern Africa for the last 100 000 years and many Earlier Stone Age hunter-gatherer-fisher sites are located in and adjacent to the greater Orange River Environment (Deacon, 1986). Khoikhoi pastoralists arrived in southern Africa much later, around 2 000 years B.P. (Before Present), and according to one hypotheses (Elphick, 1985) used the Orange River as a main dispersal corridor to Namibia and Namaqualand. The first European travelers to the Augrabies region in the 1770's (e.g. Wikar, Gordon - see Raper & Boucher, 1988) describe communities of both San hunter-gatherer-fishers and Khoikhoi pastoralists living in small villages both above and below the Augrabies Falls.

Some of these communities kept domestic animals including cattle, sheep and goats but all lived at least partly on the bountiful game that frequented the luxuriant Orange River corridor. During the course of his travels up the river in October 1779, Robert Jacob Gordon describes a spectacular variety and abundance of especially large mammals in the area (Raper & Boucher, 1988, Smith, 1995a). In one particularly idyllic description of the teeming wildlife in the region he provides a window on a world that is unimaginable in relation to the relative sterility of the Orange River environment today. Gordon writes (Cullinan, 1992) (pp. 105-106): "....below the Great Waterfall Aukoerebis in the Orange or Garieb River in the country of the Einiquas....[in fact very close to the confluence of the Orange and Molopo Rivers].... I saw the most beautiful and singular sight in all my journeys, seeing, all at one glance through a semi-circle: twelve giraffes, about fifty elephants, 5 rhinoceros, a flock of 20 ostriches, a herd of 13 kudu, and one great herd of zebra. Saw hippopotamus in the river below, swimming and playing together." Throughout the next few weeks, Gordon describes numerous encounters with elephants, rhinoceros, hippopotamus and many other animals. Black rhinoceros, in particular were often described and killed by Gordon during his travels in this region. From his description of the many pit traps dug by indigenous people living along the river, rhinoceros were, together with hippopotamus, a frequent source of protein and fat for these people.

Both herders and San hunter-gatherer-fishers lived along the river; not always in harmony and often as part of complex mixed economies that could change quite quickly depending on local and even regional events such as drought, cattle raids or even war - the "cycle of fortune" described by Smith (1995b). Beaumont *et al* (1995) have proposed that despite an extensive overlap, the Orange River corridor and the hinterland were partitioned between these two separate economies. When present at the river it appears that the hunter-gatherers had to fit between the interstices of the dominant herder economies which occupied the more productive Orange River environment itself. In their model, hunting and gathering occurred mostly away from the river while herding was more or less confined to the river corridor itself. This proposal describing pre-colonial land use practices is crucial in that it suggests that prior to the arrival of the Riemvasmakers, the region away from the Orange River did not have a history of domestic livestock grazing pressure. Instead, a diverse mixture of mostly browsing animals (giraffe, kudu, rhinoceros) existed there with grazers such as buffalo, hippopotamus and later cattle frequenting the riverine areas.

Morris & Beaumont (1991) and Beaumont *et al* (1995) summarize the range and context of archeological sites in the Middle Orange River region and its environs (including a site at "Bokvasmaak") while the SADF (1990) report provides a detailed (albeit preliminary) account of archaeological sites in Riemvasmaak itself (see later).

The poorly investigated Kourop and Molopo alluvial fans in particular possess rich collections of archaeological material and sites. These relatively undisturbed flood plains are some of the few areas along the middle reaches of the Orange River that have not been ploughed and irrigated. Many thousands of invaluable archaeological sites have probably been lost forever in the last few decades because of the recent agricultural development of these alluvial fans on commercially owned farms that fringe the Orange River. The value of archaeological artefacts situated within the Molopo alluvial fan should be emphasized and we suggest that a thorough survey of the region be done before any agricultural work commences on the Molopo. This is not to suggest that archaeological sites should prevent or retard the agricultural development of Riemvasmaak. On the contrary this is a marvelous opportunity to integrate the potential ecotourism value of such sites within a more general development programme for the region. In addition, the Riemvasmaak community will be afforded considerable prestige if they conserve these rare sites when neighbouring commercial farms throughout the region have long since destroyed them. Besides, a number of the archaeological sites may represent ancient settlements or burial grounds of the ancestors of some of the Riemvasmakers. We suggest that an experienced archaeologist be contracted as a matter of urgency to investigate, firstly the Molopo alluvial fan, and later the other areas earmarked for cropland development.

The SADF (1990) report devotes considerable discussion to the archaeological material at Riemvasmaak and is produced in detail here (Table 2.2; Fig. 2.1). Their findings are based on three archaeological surveys conducted between July 1988 and August 1989 which focused on specific areas within Riemvasmaak. It is clear from this preliminary survey that Riemvasmaak possesses a rich and valuable archaeological heritage that must be considered in the development of the full potential of the region.

TABLE 2.2. List of site numbers and description of archaeological sites in Riemvasmaak (from SADF (1990)). Abbreviations are: ESA = Earlier Stone Age, MSA = Middle Stone Age, LSA = Later Stone Age, OES = Ostrich Egg Shell.

NUMBER	DESCRIPTION	NOTES
2820AC: 1	Stone Age	ESA
2820AC: 2	Stone Age	ESA, MSA?, LSA
2820AC: 3	Stone Age	ESA, MSA
2820AC: 4	Pastoralist	Ceramic LSA
2820AC: 5	Stone Age	ESA (not located in SADF, 1990)
2820AC: 6	Stone Age	ESA (not located in SADF, 1990)
2820AC: 7	Pastoralist	Stone artefacts, pottery, OES, LSA
2820AC: 8	Stone Age	Five San graves
2820AC: 9	Pastoralist	Stone artefacts, ceramic, charcoal, slag, LSA
2820AC: 10	Pastoralist	Charcoal, slag
2820AC: 11	Stone Age	Two San graves
2820AC: 12	Pastoralist	Stone artefacts, bone, OES, OES beads, grindstone, slag, LSA
2820AC: 13	Pastoralist	Pottery
2820AC: 14	Pastoralist	Stone artefacts, pottery, bone (fish), charcoal LSA
2820AC: 15	Stone Age	Two San graves
2820AC: 16	Pastoralist	Stone artefacts, pottery, OES beads, bone (fish), charcoal, LSA
2820AC: 17	Pastoralist	Stone artefacts, pottery, OES beads, bone, charcoal, LSA
2820AC: 18	Pastoralist	Pottery scatter, few amorphous quartz pieces
2820AC: 19	Pastoralist	Ceramic LSA
2820AD: 1	Stone Age	Indeterminate
2820AD: 2	Stone Age	MSA
2820AD: 3	Stone Age	ESA
2820AD: 4	Stone Age	ESA
2820AD: 5	Stone Age	Scatter of quartzite flakes, cores and end scraper LSA
2820AD: 6	Stone Age	MSA, LSA
2820AD: 7	Stone Age	Scatter of quartz flakes LSA
2820AD: 8	Stone Age	LSA
2820AD: 9	Stone Age	ESA
2820AD: 10	Stone Age	Two quartzite flakes and small core. Indeterminate
2820AD: 11	Stone Age	MSA, LSA
2820AD: 12	Stone Age	ESA
2820AD: 13	Stone Age	ESA, MSA
2820AD: 14	Stone Age	ESA
2820AD: 15	Stone Age	ESA, MSA, LSA
2820AD: 16	Pastoralist	Ceramic LSA
2820AD: 17	Stone Age	ESA
2820AD: 18	Stone Age	ESA
2820AD: 19	Stone Age	LSA?
2820AD: 20	Stone Age	ESA
2820AD: 21	Stone Age	LSA
2820AD: 22	Stone Age	ESA, MSA, LSA?
2820AD: 23	Stone Age	ESA handaxe and MSA blade, plus cores and flakes
2820AD: 24	Stone Age	One quartzite flake and two quartzite cores
2820CA: 1	Stone Age	Large cores and flakes, blade and blade core found MSA
2820CA: 2	Stone Age	MSA
2820CA: 3	Stone Age	Isolated cores and flakes MSA
2820CA: 4	Stone Age	Scatter of large & small quartzite cores and flakes

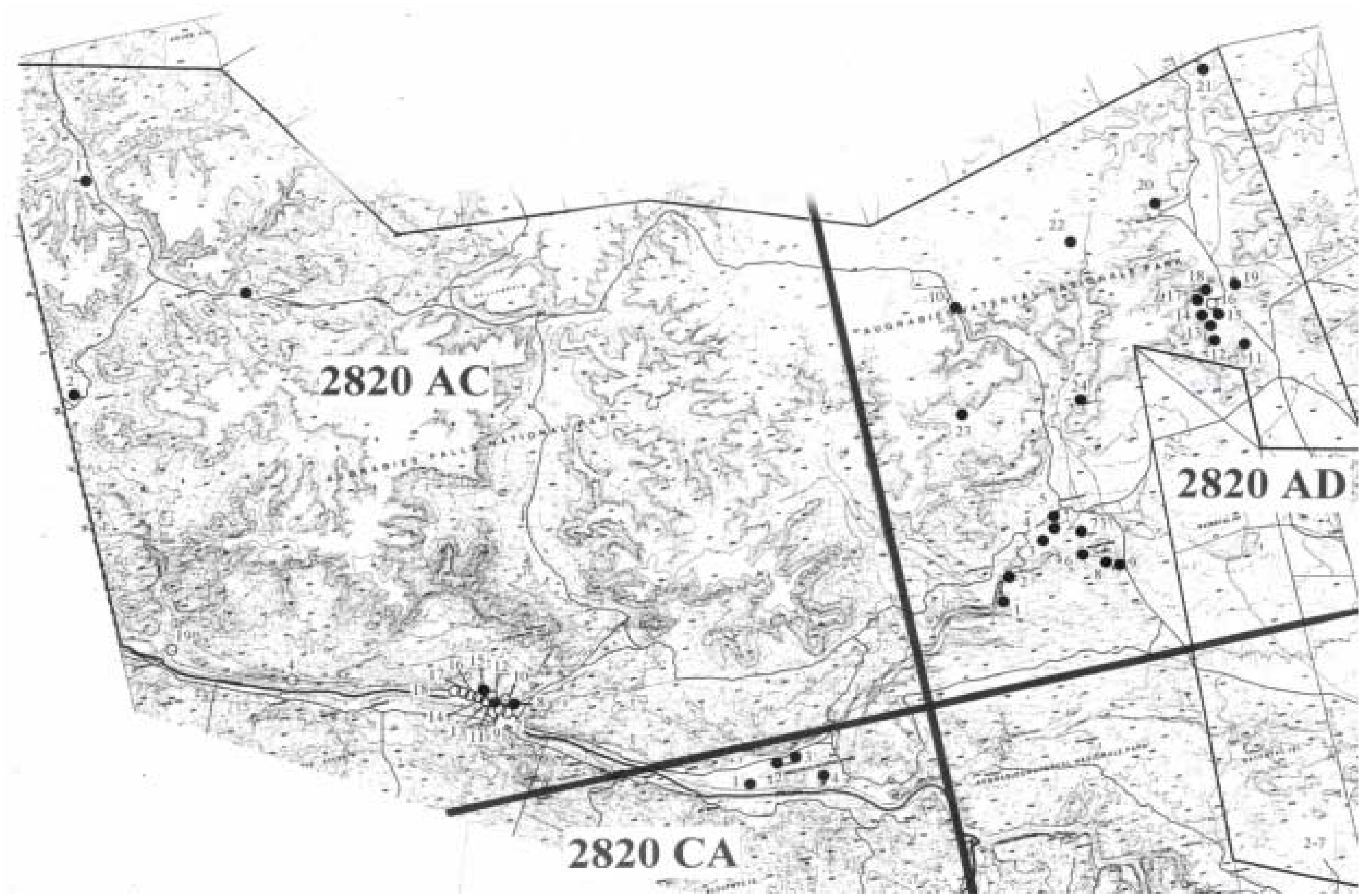

Fig. 2.1. Location of Stone Age (dots) and Pastoralist (circles) archaeological sites in Riemvasmaak as indicated in the preliminary survey data in the South African Defence Force (1990) report. The absence of archaeological sites in places such as the upper Kourop River Valley and lower Bak River simply means that these areas have not been surveyed. See Table 2.2 for a description of the sites.

2.3 SETTLEMENT AT RIEMVASMAAK

The expansion of the settler frontier in South Africa during the 18th and 19th centuries was to have far-reaching implications for southern Namibia and the northern Cape as a range of displaced and indigenous ethnic groups contested grazing and hunting lands in these regions (Strauss, 1979). It is within the context of this extremely complex and dynamic mix of ethnicities and cultures that the origins of the Riemvasmaak community should be sought. Smith & Bozalek (1993) provide an excellent general history of the settlement of Riemvasmaak with a focus on the legal aspects of the claim. This history suggests that around the 1870's or perhaps a little later, a number of families of Nama, Damara and Herero origin trekked from southern Namibia to the Riemvasmaak area and were joined by "Coloured" pastoralists and Xhosa-speakers from south of the Orange River (see Anderson 1987 for a history of the Xhosa of the northern Cape up to 1879). What is not clear is the ethnicity of the people who were already present in the region at this time and who also form part of the region's history (Nurse & Jenkins, 1978). Even Father Zaby's account (Zaby, 1982) focuses on the Damara founders since his interviews in the 1970's were with the Riemvasmakers who were re-located to Namibia.

Zaby (1982) suggests that Dawid Dawids, born in 1840 and also referred to as "Koning Dawid", is regarded as the "actual founder of Riemvasmaak". Oral testimony suggests that he settled in the region now known as Riemvasmaak "at the turn of the century". While he left for a brief period during the First World War he settled permanently in Riemvasmaak in 1923 with an enlarged group of four other families numbering perhaps "30 armed men with families, wagons, large and small stock" (see Zaby, 1982). A detailed account of the relationships between descendants of these founder Damara families is provided by Zaby (1982) and should be consulted by anyone interested in the full details of the history of settlement of Riemvasmaak.

The arrival of other groups of people has not been clearly documented. Oral testimony of Mr Vass suggests that his family, who claim a Xhosa heritage, arrived in Riemvasmaak in 1939 (Plate 2.2). His own father was born in Lady Frere (see Smith & Bozalek 1993, Annexure R) and Mr Vass remembers trekking from Van Wyksvlei to Kenhardt to the Buchuberg to Koross and then to Riemvasmaak where they settled in 1939. At the time Mr Vass suggests that at Xubuxnap there were lots of people living there who were working on the mine at Koelmanskop and that the place "het iets soos 'n lokasie" gelyk. Like so many other Riemvasmakers it appears that before coming to the area Mr Vass' own father worked as a labourer on white farms in parts of the northern Cape acquiring livestock as part-payment for service. Once large numbers of animals had been accumulated, however, their owners were forced to keep trekking since they effectively didn't have the "rights" to any grazing land in the northern Cape. Because Riemvasmaak provided these farmers with legitimate grazing rights they settled in the region if permission to stay was granted by the Headman, Jacob Booysen and if grazing fees were paid to the local magistrate.

Although the history of arrival and origins of the complex mix of people comprising the Riemvasmakers remains poorly known, the 1960 census provides an interesting account of the racial composition of the community at the time. As dubious as some of the classification procedures may have been, of the 318 "Household Heads" censused in 1960, 38.9% were classified as Damara, 22.9% as "Hotnot" (which is perhaps a reference to


PLATE 2.1. Unmarked grave sites south of Deksel in the Kourop River valley.

PLATE 2.2. Mr Willem Vass at Xubuxnap sitting on the ruins of his father's oxwagon that was brought to the area in 1939.

people with Korana or Einiqua Khoikhoi heritage (Zaby, 1982)), 14.7% as Xhosa, 13.5% as Coloured and 9.4% as other (including Herero, 4.4% and Tswana, 3.4%). The total population at Riemvasmaak, suggested by the census data, was 1 540 people. Of the 318 household heads 210 or 66.0% were born in Riemvasmaak while many of the rest stated that they came originally from areas within the Keimoes/Kakamas/Upington region. These census data suggest that all racial groups enjoyed a long history in the region as there are records of "coloured", Damara, "Hotnot" and even one record of a person classified as Zulu having been born in Riemvasmaak in the late 1880's and early 1890's. The mean length of time that the household heads had been living in Riemvasmaak is given as 32.3 years although many of these household heads were young adults who had been born in Riemvasmaak, had lived there all there life, and perhaps whose parents were already deceased.

2.4 LANDUSE PRACTICES IN "OLD RIEMVASMAAK"

2.4.1 Stock numbers

Knowledge of the size and composition of herds at different times provides important insights into the rangeland dynamics, management practices and agricultural potential of an area. But how reliable are stock number estimates especially when collected by different institutions whose reason for asking about the number of animals differs widely?

TABLE 2.3. Number of domestic livestock and their Large Stock Unit (LSU) equivalents in Riemvasmaak in 1960 (unpublished census data), in "Old Riemvasmaak" probably around 1973/74 (see Isaacs & Phillips, 1994) and held by Riemvasmakers in exile in 1994 before their return to Riemvasmaak (unpublished records, Surplus People Project). LSU conversion factors are for adult animals (see Appendix 9, Table 2.4).

Livestock Type	1960		1973/74		1994	
	Number	**LSU**	Number	**LSU**	Number	**LSU**
Goats	3 183	**541**	8 700	**1 479**	3 818	**649**
Sheep	660	**112**	3 450	**587**	1 244	**211**
Cattle	56	**62**	560	**616**	252	**277**
Donkeys	334	**217**	1 340	**871**	216	**140**
Horses	10	**10**	40	**40**	25	**25**
Mules	32	**32**	-	**-**	-	**-**
TOTAL	4 275	**974**	14 090	**3 593**	5 555	**1 302**

In Table 2.3 we document the number of livestock owned by people within the Riemvasmaak community at three different time periods. The first set of data reflect an undated but official government census of the region which we located in the files of the Surplus People Project. Based on the birthdates of known individuals listed in the census we suggest that the records are for 1960 or perhaps 1961. Since individuals were allegedly taxed on the number of animals in their possession it is possible that this census underestimates the actual number of animals in Riemvasmaak at the time, although, as we suggest later is may not have been that easy to provide false information.

The second set of data for stock numbers was collected in 1994 at a Participatory Rural Appraisal workshop organized by FARM Africa in Upington in May 1994 (Isaaks & Phillips, 1994). Not all of the livestock owners who were removed from Riemvasmaak in 1973/74 were present at this 1994 workshop. Some individuals could not be contacted, couldn't make the event or in some cases were deceased. The values listed in Table 2.3 for 1973/74 are those given by the 27 members of the "Blue Group" at the workshop and must therefore reflect estimates of the size of many livestock owners herds. It is clear from the nature of the numbers too (e.g. 8 700, 560, etc.) that these are estimates and not actual numbers.

There are a few reasons why these 1973/74 values should be treated with caution. Firstly, it is not clear as to the exact date reflected in these values. Are these stock numbers in "Old Riemvasmaak" the numbers that livestock owners possessed when they were moved from the area or do they reflect a general value for an unspecified time period? Secondly, and perhaps the most important reason why these 1973/74 values should be questioned, is that the 27 members of the "Blue Group" were asked to report, not only on the stock numbers which they possessed, but also on those which were owned by friends and relatives not present in the group or at the May 1994 workshop. While it was our experience that all of the livestock owners in "Old Riemvasmaak" that we spoke to possessed a remarkable historical knowledge of their herds for almost any time period from 1930 to the present in some cases, inaccuracies may have developed when estimates for other livestock owners were being made. Individual farmers may find reason to enhance the wealth of that of family members or friends or of Riemvasmaak as a whole by supplying inflated values, or they may simply not have known the actual number of animals. A third reason to treat the 1973/74 data with caution is that livestock owners know the concern that most official agencies have towards livestock numbers. By presenting higher numbers than were actually present, a case is immediately made for disregarding "official" values since the impression is then given that people survived successfully in the landscape with these high numbers of animals. When the discrepancy between official carrying capacity estimates and the stock numbers for 1973/74 was presented by the senior author of this report to the group of about 40 Riemvasmakers, most of whom were livestock owners, on 4 May 1995 their immediate response was to reject the official estimate as too low. However, the most vociferous objection came from the younger urbanized members of the community who did not own livestock but who understood very well the political importance of this issue.

Finally, the third set of data in Table 2.3 were collected by Surplus People Project field workers with a rich experience of taking oral testimony from rural communities. A questionnaire was used to record the number of animals possessed by individuals. Of all the data it is probably the 1994 estimates that are the most accurate although livestock owners may have hoped to increase their herd sizes before returning to Riemvasmaak and presented these projected values instead.

One other factor needs to be considered in Table 2.3. We have used LSU conversion factors for mature animals only. When appropriate age classes structures for each livestock type (David Makin-Taylor, personal communication) are included in the analysis we found that the values in Table 2.3 overestimated actual LSU equivalents by about 10 %.

Assuming that the data in Table 2.3 are a reasonably accurate reflection of stock numbers owned by Riemvasmakers then it is clear that these numbers have fluctuated with time. During the dry years of the late 1950's and 1960 stock numbers were low but increased dramatically with the high rainfall years of the early 1970's. Oral histories testify to the hardships endured by the livestock owners in Namibia and in the Ciskei and stock numbers in 1994 were relatively low compared to the 1973/74 estimates and only slightly higher than those of 1960. If the 1960 data are an accurate reflection of how many animals were present at Riemvasmaak then it is interesting that the total number of animals was well below, in fact only 75 % of the stocking rate currently suggested by the Department of Agriculture for the region (i.e. 60 ha/LSU or 1 243 LSU's, see Chapter 1).

Goats have always been the dominant livestock type and account for between 62-74 % of all the animals during the three time periods (Table 2.3). The proportion of sheep has been remarkably constant making up between 16-24 % of the total herd. Cattle (1-5 %) and donkey (4-10 %) populations have always been a relatively minor component of the herds although their value increases when considered in terms of Large Stock Unit equivalents.

Data collected during the PRA workshop in 1994 (Isaaks & Phillips, 1994) also makes it possible to enquire whether different villages in "Old Riemvasmaak" had different concentrations of different livestock types (Table 2.4). It is clear that areas around the Riemvasmaak Mission Station itself appeared to have supported a far greater proportion of donkeys than other villages. For all the other villages, donkeys comprise between 1 and 10 % of the animal numbers but around the mission station nearly 30 % of the total number of animals was made up of donkeys. This high number may have arisen because of the need for transport from the more densely populated mission centre to neighbouring towns such as Kakamas and Marchand where many of the Riemvasmakers earned a living as short-term contract labourers (Table 2.5).

Other differences between the villages are that those closer to the Orange River (Blousyfer, Wabrand & Melbosrand; Blok 1 & 2; Xubuxnab) kept proportionately more goats in their herds (78-82 %) than villages in the hinterland (mean of only 50 %). Sheep were favoured more by farmers in the Gyam/Vaalputs area and those living in Deurspring, Deksel and Bok se Puts than livestock owners elsewhere. Cattle never comprised more than 11 % of the village herd and proportionately more cattle were kept at Riemvasmaak and in the villages of Blousyfer, Wabrand and Melkbosrand than anywhere else. Whether these differences in herd composition reflect different environmental conditions or cultural preferences is unclear. The general pattern, however, suggests that goats were preferred by livestock owners at or near the river while sheep became common in the herds of farmers living away from the river. Donkeys were only abundant in the herds around the mission station while cattle numbers never reached high values. This exercise should be repeated for the 1960 census data once the household heads have been assigned to villages.

TABLE 2.4. Number and per cent (in brackets) of the total number of livestock in and around different settlements in "Old Riemvasmaak" as reported by the "Blue Group" in the PRA workshop held on 19 May 1994 (data in Isaacs & Phillips, 1994). LSU conversion factors are for adult animals (see Appendix 9).

SETTLEMENT	NO. & *(%)* OF EACH LIVESTOCK TYPE					TOTAL	
	GOATS	SHEEP	CATTLE	DONKEYS	HORSES	NUMBER	LSU's
Riemvasmaak Mission Station	1 000 *(37)*	600 *(22)*	300 *(11)*	800 *(30)*	-	2 700	**1 122**
Gyam/Vaalputs	600 *(39)*	900 *(58)*	20 *(1)*	20 *(1)*	-	1 540	**290**
Perdepoort	500 *(68)*	200 *(27)*	20 *(3)*	20 *(3)*	-	740	**154**
Blousyfer, Wabrand & Melkbosrand	1 500 *(82)*	200 *(11)*	20 *(11)*	100 *(5)*	10 *(0.5)*	1 830	**386**
Blok 1 & 2	1 600 *(82)*	150 *(8)*	50 *(3)*	150 *(8)*	-	1 950	**451**
Xubuxnap	1 600 *(78)*	200 *(10)*	50 *(2)*	200 *(10)*	-	2 050	**491**
Deurspring, Deksel & Bok se Puts	1 900 *(58)*	1 200 *(37)*	100 *(3)*	50 *(2)*	30 *(1)*	3 280	**700**
TOTAL NUMBER	8 700 *(62)*	3 450 *(24)*	560 *(4)*	1 340 *(10)*	40 *(0.2)*	14 090	
LSU CONVERSION FACTOR	0.17	0.17	1.10	0.65	1.00		
TOTAL LSU's	**1 479** *(41)*	**587** *(16)*	**616** *(17)*	**871** *(24)*	**40** *(1)*		**3 593**

TABLE 2.5. Mean number of livestock (± std. dev.) owned by 318 household heads censused in 1960/61 according to their occupation listed in the census records. Mean values for the number of horses and mules owned by different occupation groups were never above 1.6 animals and usually below 0.3 and these livestock categories have therefore been excluded from this table. LSU values include horses and mules and use conversion factors for mature animals (Appendix 9).

OCCUPATION	No.	% OWNING LIVESTOCK	MEAN No. (± STD. DEV) OF ANIMALS				MEAN No. OF LSU's	TOTAL No. OF LSU's
			CATTLE	SHEEP	GOATS	DONKEYS		
Hoofman & Onder Hoofman	2	100	**1.0**±1.4	**19.0**±15.6	**42.5**±38.9	**4.0**±0	**14**	**28**
Livestock farmers ("Veeboere")	8	100	**2.4**±2.7	**22.6**±36.1	**85.6**±64.6	**4.8**±2.1	**26**	**206**
Labourers - employed locally								
• Farm workers on "island"	176	42.6	**0.1**±0.4	**0.3**±2.1	**6.0**±14.1	**0.7**±1.7	**2**	**309**
• Mine, road, railway workers, etc.	41	53.7	**0.2**±0.8	**3.4**±12.5	**13.1**±32.3	**1.8**±3.2	**4**	**177**
• Shearers	4	100	**0**	**9.5**±1.0	**17.5**±2.1	**0**	**5**	**18**
• Shepherds	10	90.0	**0**	**19.4**±38.1	**13.6**±13.9	**0.8**±1.7	**6**	**66**
Migrant labourers								
• Various (clerks, municipal, etc.)	21	52.4	**0**	**0.4**±1.2	**7.5**±9.7	**0**	**1**	**28**
• Shepherds	5	80.0	**0**	**0**	**25.2**±23.8	**1.8**±1.8	**6**	**27**
Pensioners	43	53.5	**0.2**±1.5	**0.2**±1.5	**5.6**±10.8	**1.3**±2.0	**2**	**92**
Unspecified, Disabled, Unemployed	8	75.0	**0.1**±0.4	**0**	**11.3**±11.4	**1.0**±2.1	**3**	**22**

2.4.2 Land tenure and grazing management

> "*The land all along the Orange River is being very rapidly developed and many European farmers are already settled there, and their numbers will steadily increase in the next few years. A large number of native labourers will be required by them for certain periods of the year, e.g., when ploughing and harvesting operations are in progress. These labourers will not be permanently employed and must of necessity have an area available where their families could reside and the few head of stock, they may be possessed of, may graze.*" (Letter from the Magistrate's Office in Upington to the Secretary for Mines and Industries suggesting that the land now called Riemvasmaak be "made available for native occupation". Dated 8 November 1932.)

One of the first questions that will need to be asked of any grazing strategy is "Who will own livestock and thus have a stake in the process"? Ownership is obviously a dynamic process and will also take some time to sort itself out amongst members of the community who will return to Riemvasmaak. Whether stock ownership profiles that existed in "Old Riemvasmaak" will be emulated in the future is impossible to predict but knowledge of these profiles provides a baseline against which development objectives can be judged.

The stock census data for 1960/61 have been used to create a stock ownership profile for the community by grouping the 318 Riemvasmaak household heads censused into their respective occupations and recording the number of livestock owned by each member of the group (Table 2.5). From these data the following key points arise:

- Only 8 (i.e. 2.5 %) of household heads listed their occupation as "veeboer"; all the rest derived their income working as labourers outside of Riemvasmaak, especially on the numerous islands of the Orange River (thus fulfilling to the letter the prediction made by the Magistrate's office in 1932 outlined in the quotation above);
- While *bona fide* "veeboere" possessed more livestock on average than other occupations, the number of animals owned by the veeboere, as a proportion of the total number of animals on Riemvasmaak land, was less than 22 %. The vast majority of animals were owned by household heads who worked outside of Riemvasmaak itself but who kept relatively low numbers of livestock in the care of family and friends;
- In almost all occupations, at least half of the household heads possessed at least one animal emphasizing the tremendous interest that existed in keeping stock;
- Goats were the preferred animal in all occupations, except for local shepherds who kept more sheep than goats.

The work on the islands provided crucial employment for the community at Riemvasmaak and was also very tightly coupled to the livestock industry. The work was very labour intensive and the hours long involving a variety of skills such as ploughing, leading water, clearing trees (e.g. *Acacia erioloba*) for new irrigation lands, shepherding, shearing and crop harvesting. Many of the labourers would work as share-croppers in the Kakamas/Marchand area harvesting commercial farm cash crops such as corn, beans, peas, lentils and cotton. Verbal contract agreements would usually be reached between the labourer and farmer in which payment for the harvest would be part cash, maybe one third of the going weekly wage of about R2-50 in the 1960's, and the rest would be payment in kind i.e. a share of the harvest measured in terms of sacks of mielies or beans. These sacks were then often brought back to Riemvasmaak for domestic consumption or if there was a surplus they were used as payment for livestock at the going rate of one sack of mielies for one goat. In this way goat herds could be enlarged fairly quickly emphasizing the importance of outside employment to Riemvasmaak's livestock industry.

In what follows we address a series of land tenure and management questions relating to "Old Riemvasmaak". This evidence was collected during January and between 4-5 May 1995 in the course of 3 main interviews with members of the Riemvasmaak community. Mr Willem Vass, Mr Pieter Malgas, Mr Abrahaam Adams and Mr Petrus Basson and his son are thanked for their valuable contributions in this regard. Additional material concerning historical landuse practices was found in the files of the Surplus People Project and has been incorporated where applicable.

What institutional arrangements existed in "Old Riemvasmaak" to manage the livestock industry?

"Koning" Dawid Dawids died in 1940 aged 100 years. For many years he had acted as the leader of the community. Although this date has not been confirmed, it appears that in 1934, 6 years before Mr Dawid Dawids' death, Mr Jacob Booysen was appointed as the Hoofman or Headman of Riemvasmaak by the local magistrate. His appointment was to last for 38 years until his death in 1972 at the age of 82 years. His long and respected tenure as Hoofman was a key factor in the successful management of a wide range of affairs at Riemvasmaak including that of the communal grazing system.

Mr Jacob Booysen apparently relied heavily on a group of regional committees in each of the outlying villages to act as his "eyes and ears". This group of "voormanne" (see Annexure L in Submission to the Commission on Land Allocation) met regularly to discuss livestock and grazing management matters and, if necessary, Mr Booysen would travel to the outlying stations to see for himself the conditions at these centres. In what appear to have been open community meetings at which the Onderlandros presided, matters relating to land tenure and veld management were discussed. The minutes of one such meeting held on 23 October 1958 are invaluable in that they suggest a fairly consultative process in which a number of people voice their opinions on a range of matters. At this meeting which probably lasted for three or four hours ending at 12.30 pm, there were 22 men, 10 women and Mr Booysen. Although the Onderlandros is not listed as being present it is likely that he wrote the minutes as there is some reference to legal jargon that is unlikely to have come from Mr Booysen who apparently could not read or write.

How were grazing lands and watering points allocated?

New comers to the Riemvasmaak Native Reserve had to ask permission from the Hoofman to settle. Failure to do so meant certain expulsion from the area and the minutes of the meeting in 1958 in fact, deal with a transgression of this protocol and the subsequent legal expulsion of a perpetrator who had been squatting in Riemvasmaak for more than a year.

It appears also that once permission was granted to settle in an area then it was necessary to remain in the allotted area or at least permission had to be granted to set up permanent abode elsewhere. Again the minutes of the October meeting provide some insight in stating: "Jacob Booyse (sic) kla dat ['n persoon van die gemeentskap] getrek het van die woonplek aanhom uitgewys gedurende 1956 en tans woon in die gemeentskaplike weiveld op Kameelkloof met sy huisgesin. Niemand anders woon in die weiveld nie. Vee raak weg. Die plek waar hy nou staan is nie die plek wat aan hom uitgewys is op 26/7/1956 nie".

This item is interesting for a number of reasons not least of which is the fact that a chief concern on Mr Booysen's is that this person has chosen "community grazing land" on which to settle and has thus meddled with the grazing system that exists in the area. It is difficult to understand what this "community grazing land" is but it could be a reference to ‖ana‖as, (also called Kameeldoringkloof) which was an area used most commonly as a veepos during drought years.

In the 1930's and 1940's, however, oral testimony indicates a high degree of mobility and "trekking" from one region within Riemvasmaak to another. Reasons for moving were varied and included to seek better grazing lands, to avoid drought, to escape stock diseases and to move closer to the schools established in a number of the outlying villages so that their children could attend school. In 1966 the primary schools at Deksel and Bok se Puts were closed by the state because Riemvasmaak was a Native (i.e. Bantu) Reserve and the school teachers was funded out of a Department of "Coloured" Affairs budget. With the removal of the teachers the schools could no longer function and people with children of school-going age then moved to the Mission Station itself because the independent Roman Catholic school was not similarly affected. It is unclear whether permission to move was sought during the earlier years and in the 1960's. Also, a distinction should be made between moving temporarily during drought years to veeposte and better grazing lands and shifting one's permanent place of abode.

What limits were places on stock numbers?

All evidence suggests that there was never any attempt by Mr Booysen or his committee to limit the stock numbers of individual farmers. However, from about 1940 onwards there were attempts on the part of the administration to do just that in Riemvasmaak: "Die wet het gesê ons mag net 50 bokke (or 25 sheep, 25 goats) en vyf bees, vier donkies aanhou en jy mag nie meer as dit hou nie". To discourage people keeping more animals a "kop belasting" of £2 per animal per year was required. Failure to pay meant imprisonment. In fact, Mr Petrus Basson's father died in an Upington jail in 1948 after being arrested, together with a number of other

Riemvasmakers ("hele klomp") for falling behind in his kop belasting payments. Stock numbers were apparently checked by surprise visits by the (?state) veterinarian and it was not easy to hoodwink the authorities about animals numbers.

It is not clear whether both the stock quotas as well as the stock tax were enforced throughout the period from the 1940's to 1974. Certainly, there were many livestock owners who either ignored the state quotas or who could afford to pay the tax. The census records of 1960 and oral testimony indicate many livestock owners who possessed far in excess of the 50 goats allowed. In fact, some estimates for the 1950's are for individual herds of over 800 goats and it is interesting that some of the people interviewed indicated that "ons het oorgeboer".

<u>What resting systems were in place</u>?

The most important resting system developed by the Riemvasmakers was the concept of "spaarveld" - literally "spare rangeland". Each outlying settlement had its own designated spaarveld in which only bulk grazers such as cows, donkies, horses and mules could graze. These areas were always the bottom lands, including the sandy pediments and dry river beds. In 1958, for the land around the Mission Station, the spaarveld areas were: Brand se Hoek, Sandhoek, and Onkais se hoek. At Deksel, Deurspring (photostation 19) and Oshoek were designated spaarveld areas while Loeriesfontein se vlak (we suspect at photostation 15) catered for the needs of the Bok se Puts community. At Gyam/Vaalputs the area now called Perdepoort (photostation 23) was kept for the exclusive use of cattle while the Xubuxnap farmers used the Mostertshoek (photostation 8) valley as spaarveld. The areas set aside as spaarveld in the Wabrand, Blousyfer, Melbosrant as well as the Blok Twee regions have not been determined.

Goats and sheep were not allowed into these areas except under drought conditions and then only after discussion with Mr Booysen and the committee and with the Hoofman's permission. The minutes of the 1958 meeting state that one of the local farmers at the meeting requested that the spaarveld for his area be opened up because it was so dry while this motion was opposed by another farmer. Mr Booysen ruled that the spaarveld would remain closed for the time being. Any transgressions would result in the trespassing animals being impounded and a fee charged for their release. This system was initiated in 1946 and the money was initially used for the creation of a loan fund. By 1958 the fund had grown to £50 and had been changed to a burial fund.

The reason why the spaarveld was kept for the use of cattle only was that they were unable to climb the steep slopes of the escarpment in search of grazing while the goats were quite at home in these rocky environments. There is a story that one of the farmers who owned cattle constructed a pathway from the valley bottom to the plateau. To do this he had to move, by hand, many thousands of rocks so that his animals could more easily negotiate the very broken terrain on their way to the grassy plain on the plateau.

<u>How did Riemvasmakers cope with drought</u>?

It appears that livestock owners in "Old Riemvasmaak" had many ways of dealing with the frequent droughts in the region. Firstly, during wet years, their herds would graze fairly close to the homesteads following similar daily paths. As key forage species became heavily grazed the livestock owners would note from the veld, as well as from their livestock condition, that they should alter their grazing pattern and select another local region, perhaps even another kloof in which to graze their herds. As the drought period deepened so the spaarveld became open and they would utilize these regions for awhile. If the droughts persisted then livestock owners were forced to graze their herds further and further away from their settlements going higher and higher up the rocky slopes each day even up to the plateau in search of grazing. Finally, during really bad years livestock owners would move with their herds to outlying veeposte until conditions improved.

It appears that farmers from different parts of Riemvasmaak employed different strategies during the very protracted drought periods. Those farmers with livestock living in and around the Mission Station would "sak groot rivier toe" during these periods and graze their herds along the banks and on the numerous islands of the Orange River. Once conditions improved, usually after a few months, they would return to their homesteads in and around the Mission Station. For farmers around Deksel, however, they used veeposte at a well or put at Narougas (photostation 4). Nobody owned the veeposte and nobody directed individual farmers where to go. One testimony suggests that individuals knew or "had a feeling" of how many people each veepos could sustain and based on the knowledge of how many people were already occupying the veepos decided in what direction to move.

<u>How were livestock marketed</u>?

Two views have emerged with regard to the marketing of livestock in "Old Riemvasmaak" which may relate to the relative distances to markets. Firstly, testimony from a farmer living in Xubuxnap at the time (Annexure K2, Submission to the Commission on Land Allocation) suggests animals were sold at auctions and that the farmers in this area "...het plekke soos Marchand en Kakamas voorsien met slag diere". Xubuxnap is just across the Orange River and with the aid of a sturdy pont it would have been easy to transport slaughter animals across the river and take them the short distance to the local markets.

However, the farmers living further inland away from the main markets at places like Deksel and at the Mission Station itself report an entirely different history. These farmers indicate that their animals were sold to speculators (mostly one or two neighbouring white farmers) for "'n appel en 'n ei". One person suggested that three pounds for a mature animal ('n kraaklid kapater) was an excellent price at the time and that sometimes tobacco was exchanged for one or more animals. Many of the poorest members of the community lived from day to day and were happy to receive very low cash offers for their animals.

How were conflicts over land tenure and grazing rights resolved?

From all accounts there were very few conflicts relating to these issues in "Old Riemvasmaak". One testimony states that there was an excellent understanding between individual farmers and that: "...ons het nooit die ander man uitgestoot nie...om te sê 'Jou goed is te veel en jy kan nie hierso in die area al die grond plat maak.' Nee. ...by die groot ou Damaras daar was nie so 'n ding nie. Hulle het altyd saam gewerk en dit was klaar gewees".

This idyllic view is not the whole story however, and we relate one situation where the leadership skill and respect of the Hoofman, Mr Booysen played a crucial role in settling a dispute concerning someone moving into an area with large numbers of animals and overgrazing the area. .

1966 was a very dry year especially coming as it did so soon after the record low rainfall year of 1964. The entire region was drought-stricken. Because of the conditions away from the Orange River, one farmer with his and his extended family's very large flock of karakul sheep (swartskaap) moved from one end of Riemvasmaak to the other in search of better grazing. This extra pressure that was now placed on the veld meant that the vegetation very quickly became overgrazed (uitgetrap) and the original inhabitants of the area were forced to move. Some individuals moved to the veeposte at !Xob and ǁanaǁas while at least one of livestock farmers left Riemvasmaak altogether ("sommer aangetrek en nie weer teruggekom nie"). Mr Jacob Booysen was approached to settle the dispute ("ons het almal opgestaan") and the initial transgressor was told to return to his original grazing lands.

Prior to 1966 it appears no control on stock movement existed and the need for tighter control at this time may be related to the drought as well as to the enclosure of neighbouring commercial farms by wire fencing from the early 1950's onwards. Fencing prevented the Riemvasmakers from grazing their herds on these traditional grazing lands and restricted their movements within the borders of the declared "Native Reserve" for the first time.

2.4.3 Vegetation change since 1952: Acocks revisited

In chapter 1 we have assessed the "condition" of the vegetation within the current landscape after 20 years of military activity in the area. In the section which follows we expand on the analysis and in Appendix 10 we present the results of a survey of two sample sites of renowned South African botanist John Acocks' (1911-1979). He traveled in the Riemvasmaak area in May 1952 and listed the vegetation of two areas which now correspond to our photostations 21 and 25 (see Appendix 8).

At photostation 21 we were interested to know what the impact of communal grazing may have been between 1952-1974 as well as the subsequent 20 year "rest" period. In particular we were interested in the impact of landuse on species composition and cover of key forage species. This site is only a few kilometres from the Mission Station itself and is also just above the Molopo Gorge close to a number of important dug wells and springs in the area. It is likely to have been heavily utilized by the communal farmers of the area. Since 1974 the area around photostation 21 has not been grazed by small stock but klipspingers and other ungulates may well have used the area.

Photostation 25 is located on a commercial farm forming the eastern border with Riemvasmaak. This farm has only recently been sold to the National Parks Board (NPB). Although open to black rhinoceros for the last two years (i.e. since January 1993) the area is not utilized much by these animals (Barry Hopgood, personal communication). There are indications that this particular area of the farm was very heavily stocked once the decision to sell the land to the NPB had been made. We were interested to measure the changes that had occurred in the vegetation in the intervening 43 years following a period of commercial farming. Three of Acocks' photographs, taken at photostation 25 in May 1952, and forming a discontinuous panorama, were also re-photographed by us to provide additional information concerning vegetation changes in the area. Plate 2.3 is taken looking west into the Wabrand area of Riemvasmaak while Plate 2.4 and Plate 2.5 are looking north and east respectively and show changes in the vegetation and landscapes of the neighbouring commercial farm, Waterval.

One of the difficulties we faced in re-sampling Acocks' sites is that he didn't indicate precisely where he walked when compiling his species list. Unpublished sources suggest that he covered a very large area, walking for perhaps 2-4 km, sampling every possible habitat in the general locality until he no longer found new species to add to his list. His knowledge of plant species and ability to recognize them from the smallest of scraps was legendary. Although we attempted to emulate Acocks' general methodology by covering a very large area in our sampling strategy we recognize with hindsight that we could have worked further and spent longer than the three hours that we did spend sampling at each site. However, with two field workers covering 2-3 km each in searching for plants to add to the list, a total of 6 person-hours were spent at each of the sites. Regional climatic conditions had also been extremely dry when we sampled and the grass inflorescences, in particular were seldom present. Although we feel confident that we all possessed a good working knowledge of the flora of the region after nearly 10 days of collecting in the area, the dry condition of some of the species often made accurate identification very difficult.

One other difficulty in re-sampling Acocks' sites is that he had, over the years, developed a unique method of assessing the abundance of different species in the landscape, complete with its own notation. While it has been well described in Acocks (1988) it is, nonetheless, difficult to implement with accuracy in the field. We assigned, by consensus, Acocks abundance classes to the species that we observed at these re-sampled sites.

TABLE 2.6. Comparison of changes between Acocks' May 1952 sample data and that of the National Botanical Institute's (NBI) Jan 1995 survey team at two Photostations in Riemvasmaak (see also Appendix 10)..

COMPARISON	PHOTOSTATION NUMBER	
	21	25
Total number of species in Acocks sample	70	131
Number of species found only in Acocks sample	42	87
Total number of species in NBI sample	50	63
Number of species found only in NBI sample	22	19
Number of species present in both samples (i.e.shared species)	28	44
Total number of different species recorded at photostation	92	150
Number of grass species in Acocks sample	17	27
Number of grass species in NBI sample	8	12
Number of shared species whose abundance class value has stayed the same between 1952-1995	10	16
Number of shared species which have shown a decrease by one or more abundance classes	8	22
Mean decrease	4.6	4.0
Number of shared species which have shown an increase by one or more abundance class	10	6
Mean increase	3.3	1.3

Changes at Photostation 21.

Only 28 of the 50 species found by us were also recorded by Acocks at this site (Table 2.6). His total species list is also considerably larger than ours and 42 of the species in his checklist (or 45.6 % of the total species complement at this site) were not found by the NBI survey team. However, 22 "new" species were recorded by us and not by Acocks in 1952.

Some of the most important differences in the species abundance values that are evident between the two time periods are (see Appendix 10):

- A decrease in both the number and cover of most grass species including *Aristida* spp., *Danthoniopsis ramosa*, *Enneapogon desvauxii*, *Eragrostis* spp., *Melinis repens*, and *Stipagrostis anomela*, although the abundance of some grass species didn't change and that of *Stipagrostis uniplumis* and *Triraphis ramosissima* even increased significantly;
- A decrease in the abundance of many perennial dwarf shrubs such as *Aptosimum marlothii*, *Hermannia spinosa*; *Indigofera pungens*; but an increase in others (e.g.

Indigofera heterotricha, and the very palatable dwarf shrub, *Limeum aethiopicum*). Interestingly, the abundance of some of the dominant shrubs in the region, *Monechma spartioides*, *Sisyndite spartea* haven't changed;
- A significant decrease in the abundance of *Euphorbia gregaria*;
- The absence of any geophytes (e.g. *Dipcadi glaucum*) in the 1995 sample;
- A drop in abundance of herbaceous species such as *Forsskaola candida*, *Lotononis crumanina*, and the toxic *Tribulis cristatus* although the herbaceous *Cleome oxyphylla* was fairly frequent in 1995;
- An increase in the abundance of some large shrubs and trees such as *Acacia mellifera*; *Schotia afra*.

The changes that are outlined above are difficult to interpret. When Acocks sampled the vegetation in 1952 he was not entering a pristine landscape. As indicated in earlier sections it had probably already been grazed by domestic stock for at least two and possibly up to five decades prior to 1952. In fact, in the only reference to the condition of the vegetation, Acocks notes: "In bed of Molopo (very t.-o [notation for "tramped out"]), *Sisyndite spartea* is F (eaten down) with much *Zygophyllum microcarpum* and some *Aristida namaquensis* (eaten down) & of course *Acacia giraffae*".

The presence of a number of herbaceous species and geophytes in Acocks' sample also suggests that he may have sampled during a wetter period than the NBI survey team. In these arid environments a small rainfall event of only 10 mm a few weeks before the survey can make an enormous difference to the germination and growth of a wide range of species.

We conclude that the overall loss of species in the landscape is alarming but we would like to sample the site again after good rains have fallen in the area before drawing more definite conclusions about the degree of degradation and long-term effect of the historical landuse practices at this site.

Changes at Photostation 25.

Differences in the vegetation between 1952 and 1995 are far more dramatic for photostation 25 than photostation 21 (Table 2.6). 87 species (or 58 % of the total species complement at this site) were not recorded in the 1995 survey with only 19 (or 12.6 % of the total species number) being recorded as "new" additions to the checklist. Less than a third (44 or 29.3 %) of the species were shared between the two time periods.

The most important points to note are (see Table 2.6 and Appendix 10):
- An almost complete crash in the grass component in which many species such as *Chloris virgata*, *Eragrostis lehmanniana*, *E. porosa* have changed from being abundant to rare or even absent in the landscape;
- The loss of a broad spectrum of dwarf shrubs that were once abundant, common or frequent on either the upper or lower slopes in the region;
- An important reduction in the abundance of *Euphorbia gregaria* and other succulents in the landscape (e.g. *Sarcostemma viminale*);

- A slight increase or no change in many of the dominant trees (e.g. *Acacia mellifera*, *Boscia albitrunca*, *Euclea undulata*, *Schotia afra*.

Some of the differences that can be measured between the two time periods may relate to climatic conditions in the months preceding the different surveys. The presence, often in abundance, of a number of geophytes (e.g. *Eriospermum* sp.), herbaceous species (e.g. *Forsskaolea candida*) and members of the Cyperaceae (e.g. *Bulbostylis volubilis*), suggests that Acocks sampled this landscape soon after a fairly wet period. Despite this obvious climate effect, however, there is little doubt that something fairly dramatic has occurred in this landscape since 1952. The matched photographs (Plates 2.3, 2,4, 2.5) illustrate this point more clearly in that they show a marked reduction in vegetation cover on the pediments below the rocky ridges. Most of this reduction is caused by the mortality of *Euphorbia gregaria* and we noticed many dead skeletons of this and other succulent species (e.g. *Aloe dichotoma*) in the region. We noticed large-scale sheet erosion of the bottomlands for the first time at this site characterized by a number of shrub species “standing on root-stilts” about 30 cm above the soil surface and it appeared that much of the pediment had been either washed or blown away.

We are unable to explain adequately the changes that we have measured at this site but suggest a number of competing hypotheses that could account for these differences.

Hypothesis 1: Differences between the two time periods are simply a function of rainfall patterns. The prolonged drought in the area that has lasted for nearly a decade may have been extreme in this specific locality and local aridification has caused the differences in the vegetation in the two time periods. Whether these changes are permanent or can be switched on and off by good and poor rainfall cycles is not clear. It is possible that following good rains in the area many of the species listed by Acocks in 1952 will germinate from long-lived seed banks and return to dominate the landscape once more. One bit of evidence supporting this “climate hypothesis” is the fact that the matched photograph (Plate 2.3) looking west into the Riemvasmaak area has reportedly been protected from domestic livestock grazing since 1974, yet it too shows a large change in the abundance of species on the sandy and rocky pediments.

Hypothesis 2: Differences between the two time periods have been caused by human factors such as over-grazing. These changes indicate a permanent reduction in the production potential of the land since the soil and geomorphological environment has been altered. This degradation may have been caused:

- either by domestic livestock overgrazing the range;
- or by the impact of the rhinoceros population which has fed in the area since 1993.

While the hypothesis which suggests that overgrazing by domestic livestock is responsible for the clear degradation of the site is currently the one we favour most, an ongoing monitoring programme will help to eliminate some of the other competing hypotheses.

PLATE 2.3. Matched photograph pair at photostation 25 taken about 7 km east of Wabrand looking west towards the Orange River. The top photograph was taken by John Acocks (#5563) on 22 May 1952 while the lower image was taken on 27 January 1995 (see text for a discussion of the major changes in the landscape).

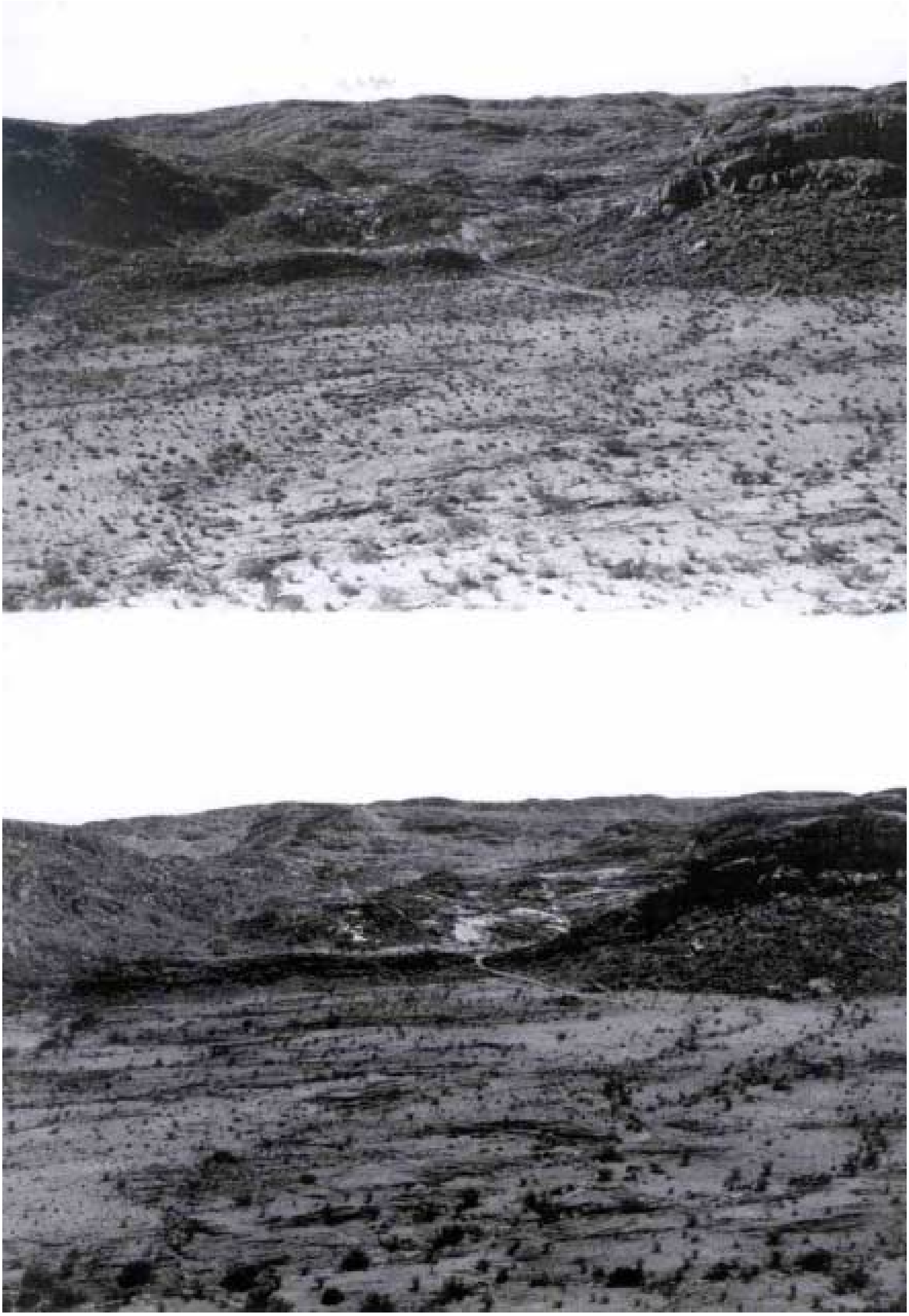

PLATE 2.4. Matched photograph pair at photostation 25 taken from the same camera position as in Plate 2.3 but looking north along the "priest's road winding down the hill." Photographers and dates are the same as for Plate 2.3 (Acocks #5564). (See text for a discussion of the changes).

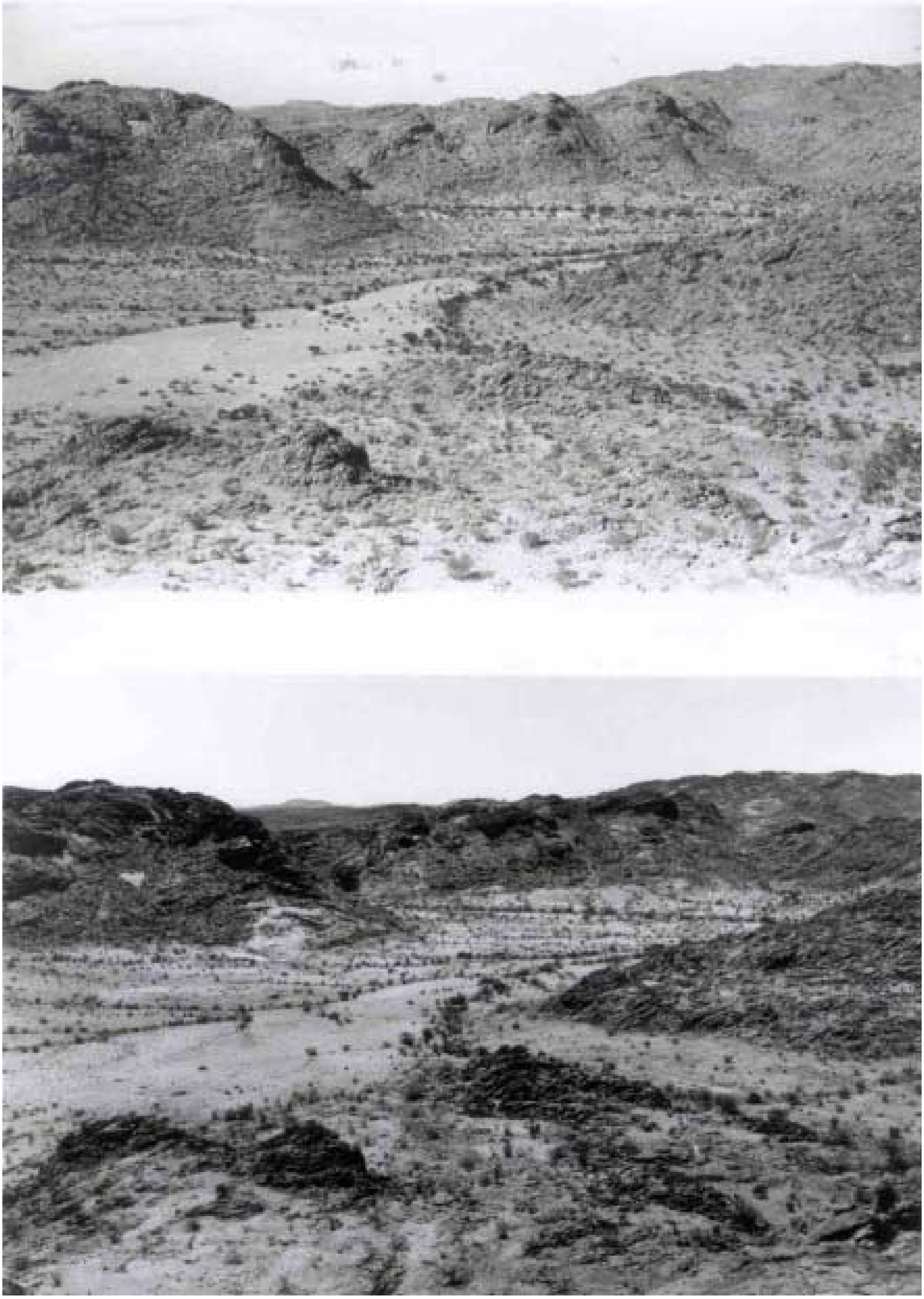

PLATE 2.5. Matched photograph pair of photostation 25 taken from the same camera position and by the same photographers as indicated in Plate 2.3 but looking east (Acocks #5565). (See text for a detailed discussion of the changes in the images).

2.5 MILITARY OCCUPATION: THE LAST 20 YEARS

The main South African Defence Force base was at the Riemvasmaak Mission Station from where the training activities of three main sections of the military were co-ordinated. These three sections were: 8 South African Infantry Training Unit; Armscor; and the South African Airforce. Their respective impacts are discussed separately in the SADF (1990) report and we paraphrase and provide some interpretation of this account.

2.5.1 8 South African Infantry Training Unit

Three main areas were used for troop training by the 8 SAI Infantry Training Unit which together account for about 6 % of the land area of Riemvasmaak. The first was the broad valley north of the Riemvasmaak Mission Station incorporating Brand se Hoek, Tsu!aos and |Nûb (Fig. 1.2, Fig 2.2). The second was the region northeast of the mission station bordering on the farm Waterval. Between 1974 and 1988 these regions were used mainly for basic and advanced infantry troop training but from 1988 onwards 8 SAI became mechanized. This meant the inclusion of heavy military vehicles such as Samils and Ratels in the manoeuvres as well as the use of 12.7 mm and 20 mm ammunition. The SADF (1990) report is explicit in listing the areas in these two regions where disturbance was greatest. The report states that both Ratels and Samils only used the region in the “A-Valley” which was “west of A-base” (marked “a” in Fig. 2.2) while the use of Ratels in training exercises also occurred in the region “east of C-base” (marked “c” in Fig. 2.2).

The third main area used by 8 SAI for troop training was the broad sandy pediment in the Gyam/Vaalputs region (Fig. 2.2). It appears that the entire valley was used for manoeuvres and the SADF (1990) report highlights the impact of these activities on the vegetation, soils and roads within this region. It concludes that most of the Gyam/Vaalputs area has been moderately (“redelik”) disturbed. Our findings outlined in chapter 1 confirm this conclusion where the presence of many disturbance-related perennial and annual plants suggests a landscape that has been disturbed in the recent past (Plate 2.7). In places we suggest that this disturbance is more that “moderate” but the long-term implications for the healthy functioning of the landscape are unclear.

Two other activities of 8 SAI have implications for the landuse history of the region. Firstly, an area south of Groot Rooiberg (Riemvasmaakkop) was used as a mortar range. While we saw evidence of much military debris in the area it did not appear as if the region had been severely disturbed. Secondly, a driver’s training area was also established south west of Groot Rooiberg. We did not visit this area but surmise that it would have been severely disturbed by the impact of heavy vehicles.

2.5.2 Armscor

The Gyam/Vaalputs area was also use by Armscor for the testing of newly-developed vehicles, armaments and ammunition (Fig. 2.2). Long-range artillery equipment was also tested by firing from Gyam/Vaalputs across to targets at

Donkiemond, 35 km to the west and a few kms east of the Namibian border. While there was evidence of a few bomb craters and much military debris at Donkiemond we did not observe a severely disturbed landscape, as a result of Armscor's activities, in this region. Armscor also tested vehicles and vehicular equipment at the Driver Training area southeast of the mission station.

2.5.3 South African Airforce

Although about 30 000 ha within Riemvasmaak was set aside for the testing of newly developed equipment by the South African Airforce probably only a small part of this area was disturbed by their activities. Several glass-fibre models and scrap motor vehicles were positioned in target areas within the Loeriesfontein and Kourop Valleys as well as the plateau areas west and east of the Kourop River valley (Fig. 2.2). Airforce vehicles apparently did not operate in the region and the SADF report suggests that the impact of the airforce's activities was slight ("klein van skaal"). Except for the craters caused by exploding bombs in a few of the areas that we sampled we
found no evidence to reject this general view. However, we could not reach many of the more inhospitable plateau environments used by the airforce and we cannot comment on their impact in these regions.

Details of military manoeuvres at Riemvasmaak in 1989 are shown in Table 2.7. Activities prior to this are not listed in the SADF report. In 1989 activities occurred in short intensive spells from a few days up to four weeks at a time totaling about 4½ months or slightly more than a third of the year.

TABLE 2.7. Dates in 1989 and kind of activities carried out by three military organizations using Riemvasmaak as a training facility.

UNIT & DATE	DAYS	COMMENTS
8 SAI Training Unit		
Apr 10-26	17	Basic training: 450 troops
May 1-28	28	Section commanders training: 160 troops
Jun 12-30	19	General training: 530 troops, 50 Ratels
Jul 17-28	12	General training: 530 troops, 50 Ratels
Armscor		
Feb 8-20	13	Direct shelling, Engine and tyre testing
May 1-5	5	Engine and tyre testing
Oct 30 - Nov 2	4	Direct and long-range artillery
South African Airforce		
Apr 10-21	12	-
May 5-20	16	-
Jun 12-23	12	-
TOTAL DAYS	138	

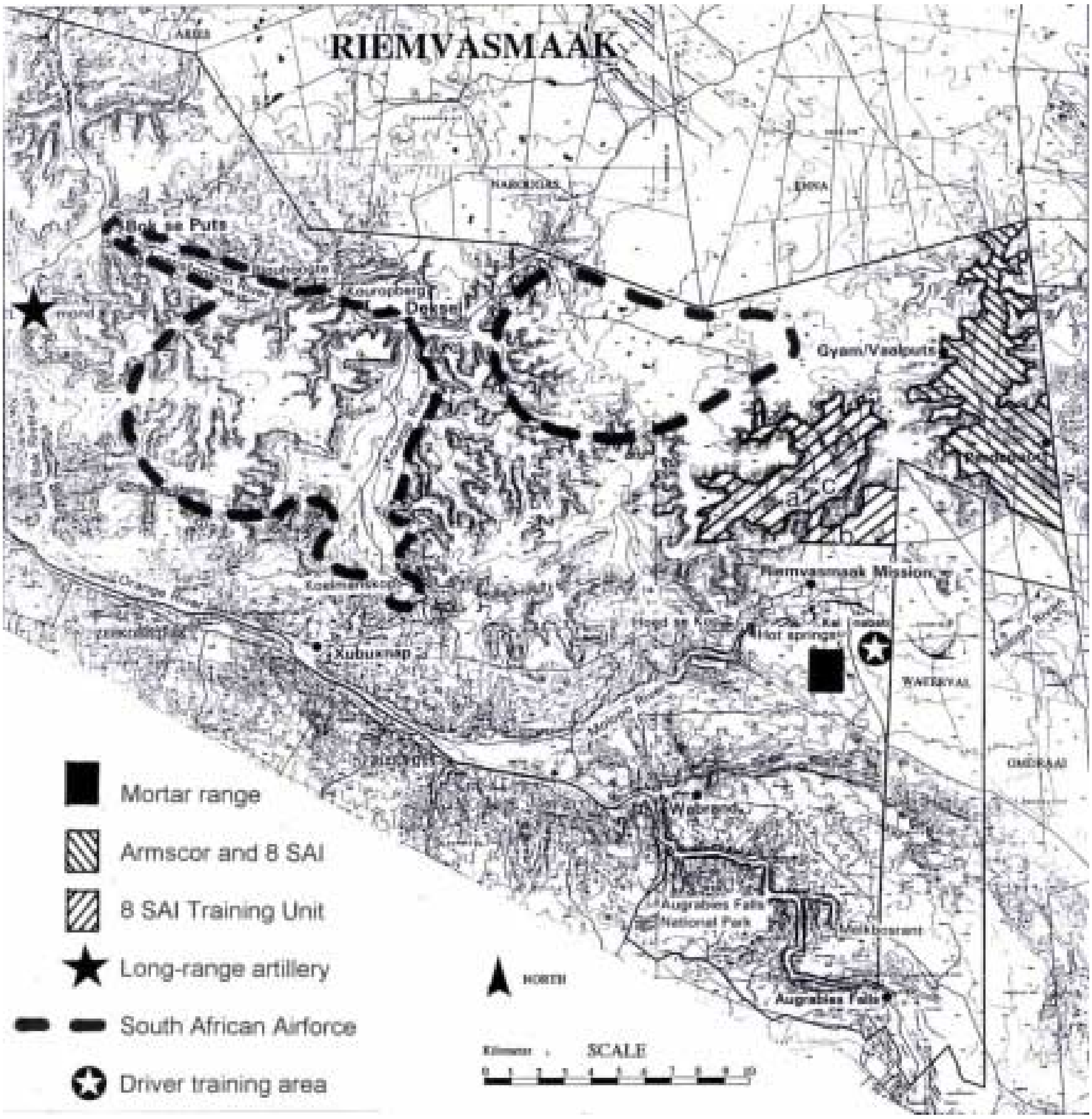

Figure 2.2. The distribution of different types of military activity during the South African Defence Force's tenure of Riemvasmaak between 1974-1994.

PLATE 2.6. Sandy pediment near Gyam/Vaalputs. The dominance of the landscape by *Rhigozum trichotomum* suggests that heavy disturbance of the environment has occurred in the past. This may possibly be related to the mechanized infantry manoeuvres or arms-testing exercises carried out during the SADF's tenure of the region.

2.6 THE FUTURE

A number of important issues have emerged in our rather superficial treatment of historical landuse practices in Riemvasmaak which can be used in the future development of the livestock industry. Firstly, Riemvasmaak is too small to be able to move livestock very large distance and it is unlikely that the region will be increased in size. Although local testimony suggests a more patchy landscape in Riemvasmaak relative to the rangelands around Khorixas, in Namibia, the situation is nothing like in the communal rangelands of many sub-saharan countries where animals are able to trek over very large distances to make use of the variable rainfall regime (see chapters in Behnke *et al* 1993). In Riemvasmaak, climatic gradients are shallow and a severe drought will probably extend over the entire region. The land area is small in comparison with what is required for a productive and extensive small stock industry with the ability to support an economically viable community paying for all of the essential services that will be provided for them.

The Orange River environment is a huge boon to the development of any range management system. They are few arid areas that can boast a major river on their doorstep and although some of the stock farmers used to move to the river during extreme drought years, it seems not to have been developed to its full potential. By building on the historical landuse practices it will be possible to cater for drought years and poor seasons by providing a permanent fodder bank of cultivated pastures along the river itself. Tenure of these croplands will be a crucial issue, however, and communally-owned and managed cropland areas may be the answer. The full economic, social and cultural implications of and potential interactions between the livestock and crop industries need to be carefully understood.

The development of an effective marketing strategy will be an important contribution to the livestock industry. Knowledge of when to buy and sell and developing access to local markets will assist Riemvasmaak farmers greatly.

Goats are likely to be the preferred animal in Riemvasmaak and a stud herd to improve drought tolerance could be implemented. Not all of the livestock farmers have lived a subsistence existence while in exile and even if they have many are fully aware of the value of selection.

The greatest challenge faced by the development programmes will be in the incorporation of the part-time farmers into the grazing and livestock management systems. It is possible that many of the people returning the region will want to keep some livestock while earning their major source of income from jobs maintained outside Riemvasmaak itself. In the past it was this group of people who collectively possessed the majority of animals. How can their needs and aspirations be accommodated?

Finally, the importance of the management structures in “Old Riemvasmaak” cannot be underestimated. Although the Hoofman was appointed and not elected he appears to have illicited great respect from the majority of people in Riemvasmaak. Decisions on such important issues as settlement rights and seasonal grazing strategies were based on consultation and sometimes even after inspection of local conditions. An elected stock committee faced with similar responsibilities should build on this history of “Old Riemvasmaak”.

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Chapter 3 : THE DEVELOPMENT OF A MONITORING PROGRAMME FOR RIEMVASMAAK

"*Monitoring is the process by which we keep the characteristics of the environment in view. It provides the essential data on how systems are changing and how fast. It provides the essential feed-back loops to management, so that we can adjust what we are doing and get the best out of the system*." (Spellerberg, 1991).

"....counsel on how to plan a monitoring study seems not to exist." (Mentis & Walker, 1989).

3.1 INTRODUCTION

To plan effectively, both in the short-term (i.e. daily to seasonal time horizons), medium-term (i.e. annual) and long-term (i.e.decadal) requires a sound understanding of any resource base. This includes knowledge of not only the fluctuations in the natural components such as the rainfall and vegetation upon which an agricultural industry is ultimately based but also incorporates knowledge of market fashions, trends and cycles.

But how is it possible to keep track of fluctuations in these resources and markets? More importantly, how can this knowledge be used by individual farmers and communities to make decisions about their day to day farming operations so that their activities are both profitable and sustainable in the long-term?

Answers to these questions form part of the broad and developing field of monitoring, defined rather formally by Goldsmith (1991a) (pg. 2) as the "intermittent (regular or irregular) surveillance carried out in order to ascertain the extent of compliance with a predetermined standard or the degree of deviation from an expected norm" and described less formally by Spellerberg (1991) in the quotation at the start of this chapter. Spellerberg (1991) in particular, emphasizes that monitoring is an integral part of management and that it should not to be conducted simply for the sake of monitoring.

One problem, as Mentis & Walker (1989) point out, however, is that there is little guidance to draw from in the development of a monitoring programme. Although this position has been somewhat alleviated by the publication of two recent text books on the theme (Goldsmith, 1991a; Spellerberg, 1991), and a number of unpublished reports (e.g. Anonymous, 1990), details of site-specific monitoring programmes are seldom available. Where details are provided they often describe programmes established for conservation-orientated problems where one or a few rare, endangered or threatened plant and animal species are at risk from habitat destruction or other human impacts (e.g. Goldsmith, 1991b). Examples of monitoring programmes developed specifically for the sustainable development of arid, communally-managed rangelands are lacking.

This chapter is an attempt to redress this imbalance. We have drawn on the key principles outlined in the literature above as well as on the results of our baseline survey and collective monitoring experience in the semi-arid and arid rangelands of southern Africa to propose a preliminary structure for a monitoring programme for Riemvasmaak. Although the main aspects of the monitoring programme were discussed with the livestock owners on 4 May 1995, we emphasize that it requires considerable additional discussion before further steps for its implementation can be taken.

3.2 KEY ELEMENTS OF A MONITORING PROGRAMME

All monitoring programmes emphasize a sequential arrangement of key elements in their structure (Usher, 1991). These steps and related questions usually incorporate one or more of the following:

Need: Who wants or needs the monitoring programme?
Purpose: What is the aim of the programme?
Methods: What methods will be used to achieve the aim?
Analysis: How will the data be analyzed and presented?
Equipment: What equipment and infrastructure are needed?
Training: Who will undertake the monitoring?
Initiation: When will monitoring begin?
Operation: How will the decisions be made?

Termination: When will the monitoring programme end?

3.3 NEED

The first step in any monitoring programme, but particularly in a rural development situation where community support is crucial for its success, is to clarify who it is who wants the programme, who will be supporting it in terms of financial and personpower costs and who stands to benefit from it?

Who wants the programme? For Riemvasmaak, it is clear that much of the early initiative to develop a monitoring programme has thus far come from FARM Africa. This is line with their commitment to sustainable development in the region. What would it benefit them or the community which they are committed to assist, if agricultural development were conducted at the expense of the environment and if it were non-sustainable in the short-, medium- or long-term?

What is not entirely clear, to date, is the full interest that the Riemvasmakers themselves have in the programme. It was encouraging to note, however, that during the report-back on 4 May 1995 the livestock owners perceived a need for a monitoring programme and indicated their support for its development and intended use. As will be discussed later, this includes providing input into raw data collection such as stock numbers and vegetation condition assessment as well as involvement in all decision-making processes. Without their support and active control of the monitoring process and associated management decisions there is little hope of the monitoring programme achieving anything beyond a rather superficial and patchy scientific assessment of the condition of the natural resource base. Tracking the state of the region's resources is not the same as managing the resources. A fully integrated monitoring programme should aim to be part of the broad agricultural management strategy of the Riemvasmaak environment.

Who will provide the financial and personpower costs for the programme? Clarity on these details is essential. At this stage it seems reasonable to assume that various state and non-governmental development and agricultural agencies, possibly co-ordinated by FARM Africa, will provide the initial financial support for the programme. If significant benefits are perceived to arise from the programme, then the feasibility and interest of the Riemvasmaak agricultural community assisting with the financial costs will need to be addressed at some stage. Personpower costs are likely to be borne firstly by limited voluntary contributions by the farmers when supplying, for example, details of stock mortalities or births and in making decisions about management options. Secondly, the need for a full-time Monitoring Warden will be discussed later but he or she together with specialist consultants will probably provide the bulk of the personpower costs of the programme.

Who stands to benefit from the monitoring programme? For it to succeed, unequivocal benefits, derived directly from information drawn from the programme, must be evident to all farmers within Riemvasmaak, irrespective of economic or social status. Benefits must also be evident at different scales from individual households to the entire community.

3.4 PURPOSE

Before any monitoring programme is initiated the objectives need to be clearly stated (Usher, 1991). These should be formulated by all parties who have an interest in the programme. Such objectives should include statements about the environmental quality or state of the environment at any one time so that Riemvasmakers, from household to village to community level can make informed decisions about how best to manage their animal and rangeland resources.

Without being prescriptive we suggest the following as a starting point for the development of a set of objectives for the monitoring programme:

> "*The purpose of the monitoring programme is to provide the Riemvasmaak community with sufficient knowledge about the state of their environment (including climate, vegetation, stock condition, crop yields and market forces) at any one time so that informed decisions can be made by all Riemvasmakers, from household to village to community level, about their various agricultural enterprises*."

3.5 METHODS

The choice of methods should be directly related to the objectives of the monitoring programme since they provide the means for achieving them. Three main concerns about the choice of methods arise. Firstly, a baseline survey should be conducted to provide an initial interpretation of the environment. Secondly, appropriate variables or indicators of change need to be selected. Thirdly, the intensity (how many measurements are needed in order to say something statistically meaningful about the variable's behaviour within the reserve?); the spatial arrangement or measurement grid (i.e. where will what be measured?); and the frequency (how often must something be measured in order to capture the change in a parameter?) must be established for each variable. Each one of these concerns is shown in Table 3.1 and discussed in more detail below.

Table 3.1. Key variables that could be monitored at Riemvasmaak with some indication of their sampling intensity, location and frequency, the type of measurement and units needed and the individual(s) or agency responsible for the task.

Variable	Sampling intensity	Sample location	Sampling frequency	Type of measurement & units	Responsible individual(s)/agency
1. CLIMATE					
- Rainfall	4-6 rain gauges	At each main settlement	Daily, synthesized monthly	Rainfall amount (mm)	Designated recorders, Monitoring Warden
- Temperature	1 higher order station	Riemvasmaak Mission St.	Daily, synthesized monthly	Maximum/minimum temperature (°C)	Monitoring Warden
2. WATER					
- Quantity	5-10 permanently monitored water sources	At major wells, fountains and boreholes	Initially monthly, later seasonally	Depth ((m); rate (l/s)	Monitoring Warden
- Quality	5-10 permanently monitored water sources	At major wells, fountains and boreholes	Initially monthly, later seasonally	Various (e.g. Conductivity (mS/m); Fluoride (mg/l), Nitrates (mg/l))	Monitoring Warden and outside agency
3. VEGETATION					
- Matched photos	29 permanently-marked photo stations	Widespread, concentrated around settlements	Every 5-10 years	Species and growth form composition and % cover	Ecologist, Monitoring Warden
- Key species abundance	Replicated samples of 4-6 key species	Widespread	Annually	Abundance (No., % cover), height (m); seed production, condition, etc.	Ecologist, Monitoring Warden
- Demonstration plots	3 replicates in 5 localities (= 15 plots)	Riemvasmaak Mission St., Deksel, Bok se Puts, Xubuxnap; Perdepoort	Annually	Species composition (No.), abundance (No., % cover)	Ecologist, Monitoring Warden
4. LIVESTOCK					
- Census, births & deaths	All livestock owners	All settlements	Annually	No. of animals, herd structure, deaths, births	Livestock owners, Monitoring Warden
- Markets	Local and national indices	As contained in agricultural reports	Monthly	Meat, pelt, wool prices (R/c)	Monitoring Warden
5. CROPLANDS	All crop farmers	All croplands	Seasonally	Area planted, crop yields (kg/ha)	Monitoring Warden
6. COMMUNITY HEALTH	As many cases of selected ailments as possible	All settlements	Ad hoc, but synthesized annually	No. of cases	Medical practitioners, Monitoring Warden

A baseline survey provides invaluable assistance when planning the monitoring programme in detail. Firstly, it synthesizes information (maps, aerial photographs, literature) about the region and makes this available to all involved in the development of the monitoring programme. Planning requires knowledge about a region and the more that is available for synthesis and discussion the better.

A reasonably thorough and photographically-documented ecological survey of the region, as contained in the earlier sections of this report, also provides important information about the state of the environment at the start of the programme. In the case of Riemvasmaak, which has experienced 20 years without domestic livestock, the detailed survey describes an environment as "pristine" as there has been, probably since the late 19th century.

A baseline survey also identifies the key resources within the region. This not only suggests which variables may be the important ones to select for observation and measurement but also provides information about the spatial and temporal intensity necessary for the monitoring process.

The choice of parameters to be measured is a crucial part of any monitoring programme. Indeed, inappropriate selection would invalidate the process completely. However, if chosen correctly, these parameters should reflect the "pulse" of the environment. They should indicate the state and condition of key resources and knowledge about these parameters should precipitate decisions about the agricultural enterprises of the region.

A distinction is generally made between parameters that measure changes in processes (e.g. decomposition, productivity, succession, etc.) and those that measure changes in variables (e.g. biomass, percentage cover, composition, species diversity, population size class distributions, etc.) (Spellerberg, 1991). We suggest that the initial emphasis should be on the measurement of changes in five main groups of variables and if key processes emerge, that could provide additional insight into the state of the environment, then they should be incorporated later.

For an effective monitoring programme we suggest that information about the following five main groups of variables is needed (see Table 3.1):

Climate
Water
Vegetation
Livestock
Croplands
Community health

3.5.1 Climate

Riemvasmaak is an arid region and the amount of rainfall over any one period is critical for the region's agricultural productivity. It is also important that the spatial pattern of rainfall is understood so that decisions about, for example, livestock movements and concentrations can be made at both a village and reserve level. Although the rainfall gradients suggested in Fig. 1.8 indicate a slight increase in annual rainfall from north to south and from west to east there will undoubtedly be enormous variation within and between years.

To keep track of the amount of rain falling on Riemvasmaak it is suggested that a series of standard rain gauges be erected at each of the main settlements such as Bok se Puts, Deksel, Xubuxnab, Riemvasmaak Mission Station, Perdepoort, and possibly also one on the plateau close to one of the larger settlements. It is also suggested that since the Riemvasmaak Mission Station is likely to represent the administrative centre of the reserve that a higher order weather station, which would record at least maximum and minimum temperatures, would be useful. The Weather Bureau should be consulted about the most cost-effective instrumentation. In addition, instruction about how to collect the data will need to be provided. Ideally, the outlying rainfall stations would be handled by designated villagers and synthesized by the Monitoring Warden who would also be responsible for the higher order weather station at the Riemvasmaak Mission Station itself (Table 3.1). (The rationale for the Monitoring Warden and his or her terms of reference will be discussed later under the section which deals with Training).

3.5.2 Water

Both the quantity and quality of the water must be monitored on a regular basis. Changes in both of these variables could impact severely on livestock condition which in turn could have far-reaching implications for individual farmers and villages

Fig. 1.12 suggests the location of water sources within Riemvasmaak. Those sources used most frequently by the greatest number of people and livestock should be selected and monitored initially on a monthly basis. This could change to a seasonal (three-monthly) or even annual periodicity once initial patterns have been established. Both water depth and an assortment of tests which assess water quality (e.g. salinity, fluoride and nitrates) should be measured. This task should be conducted by the Monitoring Warden who will be able to measure water depth and collect the samples before sending them off for analysis by an outside agency such as the Council for Scientific and Industrial Research (CSIR).

3.5.3 Vegetation

A permanent record of the landscape and vegetation has been captured by the ground photographs taken during the baseline survey and this record is described in Appendix 2 and Appendix 8. Twenty-nine photostations spread throughout Riemvasmaak, incorporating some 150 different images, provide adequate photographic documentation of the region. These images can be used every five to ten years as part of a long-term, matched photography monitoring programme that has been used so successfully in many arid regions (e.g. Hastings & Turner, 1965; Bahre, 1991), including southern Africa (Hoffman & Cowling, 1990), to assess landscape change over decades. More frequent analysis of these photographs will not be cost-effective at this level of scale where the identification of gross changes is documented. It is suggested that an ecologist skilled in the methodology and with a knowledge of the region be used for the task. This person should be assisted by the Monitoring Warden.

Finer-scale tracking of changes in the vegetation and an assessment of the seasonal impact of livestock on the resource should be conducted differently. We suggest two approaches that might be useful.

Firstly, the state of key forage species should be assessed annually. These species should be selected in consultation with the farmers but would probably include one or some of the following species: *Acacia mellifera*, *Acacia erioloba*, *Pappea capensis*, *Schotia afra*, *Prosopis* spp, *Limeum aethiopicum*, *Monechma* spp. and an assortment of grasses, succulents and herbaceous species. Individuals and populations of these species should be marked and their abundance, height (where applicable), phenology, reproductive behaviour, and general condition noted annually, during the same season each year.

Secondly, replicated demonstration plots, of probably 10 x 10 m each should be constructed at a number of localities within Riemvasmaak. These should be fenced off to serve as ungrazed controls. They should be matched with adjacent grazed plots. If possible, matched sites inside and outside the area which will be leased to the National Parks Board and grazed by black rhino should be established. Suitable matched plots on adjacent commercial farms should also be erected. Measurements of species composition and abundance should be made annually, initially by a field ecologist together with the Monitoring Warden, and later by the Monitoring Warden operating alone. Problems of autocorrelation should be considered in the experimental design (Spellerberg, 1991; Usher, 1991). The demonstration plots could also form part of the discussion material around which grazing management workshops can be based.

3.5.4 Livestock

Goats, sheep and to a lesser extent cattle and donkeys are likely to form, at least in the initial stages, the backbone of the agricultural industry in Riemvasmaak. Birth and death rates should be monitored at least once a year to keep track of herd sizes within households and villages. The quality (e.g. mass gain, incidence of specific diseases) of individuals and herds could also be monitored regularly. This information could feed directly to any veterinary intervention that may be needed by livestock owners. It is important that stock numbers are determined for all farmers from all the villages every year so that an accurate annual census is returned for the reserve. Stock losses due to predators should also be recorded.

The monitoring programme will be directly dependent on the individual farmers for this information. Although discussion around stock numbers remains problematic, honest reporting is essential if the objectives of the monitoring programme are to be achieved. The intention of an annual census must be raised with all members of the community at the start of the monitoring programme. This must be done not only to determine the value and purpose of collecting the data but also to gauge support for the exercise.

The collation of stock census data should form one of the major tasks of the proposed Monitoring Warden who will, however, ultimately be dependent on the goodwill of the farmers of the region for accurate information.

In addition to the task of keeping track of stock numbers it is important that the monitoring programme maintains a good record of stock movements and concentrations. For a variety of reasons, not least of which is water availability, some areas will be favoured more than others. The location of and duration that veeposte or stockposts are occupied is likely to vary considerably depending on seasonal and annual climatic conditions. An effective and adaptive range management programme can only develop if a sound knowledge of stock movement patterns and their concentrations is available. Without this information it will also be impossible to ascribe changes in the ecological resource base to climate or landuse practices and to understand how these two important ecosystem driving variables interact.

Another task of the Monitoring Warden will be to keep track of local and national agricultural market indices including such items as meat, pelt and wool prices and any other traded products deemed of interest to the farming community of Riemvasmaak. These indices should be extracted from relevant agricultural journals and reports and a permanent subscription to these sources of information is essential.

3.5.5 Croplands

Although it will take some time before the region's potential croplands are fully developed the location, area and yields of these lands should be recorded annually. More detailed information concerning development costs, input costs (e.g. fertilizer) and labour costs can be monitored as the different enterprises gain momentum. Again it is suggested that the Monitoring Warden be given the responsibility for developing this focus in addition to assessing trends in local and national market forces for individual products.

3.5.6 Community health

A viable agricultural industry is only possible if the human community in Riemvasmaak is also healthy. Statistics of key ailments which may be influenced by the ecological (e.g. water quality) and agricultural (e.g. stock disease) resource base should be kept. A positive and reciprocal working relationship between the Monitoring Warden and health practitioners of the region, including midwives, herbalists, doctors, traditional healers, and nurses should be developed as a key objective of the monitoring programme. Medical consultants with an experience of the primary health care issues in the region should also be consulted at the start of the programme in an attempt to better understand the links between agriculture and community health.

3.6 ANALYSIS, INTERPRETATION AND PRESENTATION

Once the data have been collected the question arises as to how this information will be analysed, interpreted and presented to the community in a format that is palatable to a variety of educational and literacy levels.

Firstly, with regard to analysis, each variable will have to be assessed separately. The choice of analytical tools, however, will vary depending on the spatial and temporal nature of the data. Inter-regional and inter-time period comparisons will probably be the most effective way of tracking the resource base so as to discern more clearly the impact of different agricultural practices on the land.

It is important that, where applicable, statistically-valid experimental designs are constructed to ensure that unequivocal interpretations of the data are possible. There is nothing worse than having to discard data collected from months of field work because of excessive pseudoreplication or autocorrelation or some other statistical flaw that could have been corrected at the outset. The general monitoring programme design should be discussed with an experienced statistician before its implementation.

Once the data have been analyzed a further problem arises as to the interpretation of the results. How will it be possible to distinguish between trends, cycles or simply noise in the data-set? More importantly, how will the causes of change be explained and how much faith will one be able to place in the predictions suggested by the patterns of change? We suggest that a more accurate interpretation of the patterns will be facilitated by a thorough analysis of historical trends and cycles. In this regard we suggest that the process begun in Chapter 2, concerning landuse history, be strengthened. A more detailed analysis of rainfall records, early traveller's notes and old photographs will provide a broader framework within which to interpret the general ecology and observed patterns of change. Also, changes in district stock records, shifts in animal types in relation to rainfall patterns and agricultural economies will provide a more comprehensive framework for understanding the landuse history of the region. Economic and survival strategies which have an historical precedent may augment the decision-making process. Announcing the need for such work at the numerous academic institutions in South Africa may attract the required focus from qualified environmental historians who are often keen to work in an applied context.

The presentation of the data poses interesting challenges for a community with as wide an array of education and literacy levels as in Riemvasmaak. Recently, however, there has been an upsurge in Participatory Rural Appraisal (PTA) methodologies (Chambers, 1992) which could be used very effectively to convey the patterns evident in the monitoring data sets to all interested parties. We suggest that the presentation be conducted as frequently as needed or requested but at least once a year a workshop be held to discuss the details of the previous year's monitoring results. It is important that any irregularities between the community's perception of events and the data set itself be resolved at such a meeting.

3.7 CAPITAL EQUIPMENT & INFRASTRUCTURAL COSTS

Table 3.2 suggests some of the capital equipment and running expenses that will be required to develop and operate the monitoring programme. Tentative costing is also provided although the final amounts will depend greatly on choices about type of rainfall gauge, vehicle purchase (whether off-road motor cycle or 4x4 vehicle), salary scales for the Monitoring Warden, and so on. In addition, the monitoring programme may also require the services of specialist consultants and this also needs to be considered within the running expense budget.

TABLE 3.2. Capital equipment and some of the running costs associated with the monitoring programme.

ITEM	QUANTITY	VARIABLE MEASURED OR REASON	PROVISIONAL COST	TOTAL AMOUNT
CAPITAL EQUIPMENT				
Rain gauges	4-6	Rainfall	@ ca. R100 ea.	R600
Higher order weather station	1	Rainfall, temperature	@ ca. R5 000	R5 000
Tape measures, metre sticks, ranging rods etc.	Various	Water quantity, vegetation	@ R400	R400
Demonstration plots (poles, droppers, concrete, fencing, transport etc.)	15	Vegetation	@ R1 000 ea.	R15 000
Off-road vehicle	1	Transportation	R30 000	R30 000
			SUB-TOTAL	R51 000
ANNUAL RUNNING COSTS				
Salary (depending on qualification, experience and training)	1	Monitoring Warden	R30 000	R30 000
Off-road motor vehicle	1	Petrol, service & repairs	@R6 000	R6 000
Water analysis	100	Water quality	@R20 ea.	R2 000
Vials	100	Water quality	@ R200 for 100	R200
Agricultural magazine/report subscription	5	Livestock/crop markets	@ R150 ea.	R750
Stationery & sundry expenses	-	-	@ R500	R500
			SUB-TOTAL	R39 450

3.8 TRAINING

An extensive and on-going training programme of all participants will be required before initiation of the monitoring programme. For example, all rainfall recorders will have to become familiar with the methods of recording accurate rainfall totals and the safe storage of records. Similarly, livestock owners will have to be encouraged to keep detailed stock records, particularly of disease, death and predation.

The person most crucial for the success of the programme, however, is undoubtedly the Monitoring Warden. This individual should come from the Riemvasmaak community and should be employed on a full-time basis. A salary commensurate with the individual's education and aspirations will have to be negotiated. Suitable applicants should be educated and should possess at least a Matric school leaver's certificate or higher. He or she should also have some basic knowledge of the sciences and an interest in agriculture and community development is essential.

The basic tasks of the Monitoring Warden are listed in Table 3.1. These could also include a broader educational focus, particularly in the school environment where this individual's knowledge and expertise can be incorporated into school curricula and standing interpretative displays.

The further training of the Monitoring Warden should be considered very carefully. Firstly, a productive working relationship with the local Agricultural Extension service should develop. If necessary the Monitoring Warden should attend short courses provided by the Department of Agriculture and other institutions so that technological innovations developed within the broader agricultural environment are returned to the community and made available for discussion. A close association with the National Parks Board should also be encouraged and additional responsibilities which deal with the ecotourism potential of the region could also form part of the candidate's portfolio. However, the task of monitoring the large number of variables will be an onerous one and dilution of the Monitoring Warden's effort in this regard should be watched.

3.9 PROGRAMME INITIATION

In one sense, the monitoring programme has already been initiated with the completion of the baseline survey. The day to day running of the programme, however, can only begin once the objectives have been established and once the numerous issues outlined above have been discussed with the Riemvasmaak community. It is suggested that the programme be built sequentially but that a start be made with the establishment of the rainfall monitoring grid as soon as possible.

Of major importance is the selection and training of the Monitoring Warden. Selection should occur as soon as possible and training should take place during the rest of 1995.
The weather station should be purchased during the course of 1995 and should be fully operational by the start of 1996. Further discussions with the Riemvasmaak community should also take place around when different variables should be recorded. For example, should livestock censuses start and end; in December each year or should these be more closely associated with lambing seasons? Similarly, should the annual vegetation assessment be undertaken during spring each year or should this be done at the end of the rainy season in April or May of each year?

3.10 OPERATION

Responsibility for the day to day operation of the programme will ultimately rest with the Monitoring Warden. However, data should regularly be made available for workshop discussions and decision-making sessions. The most appropriate time to hold these sessions will need to be discussed. It is important, however, that all people are involved in decisions taken at the appropriate level. The focus of the monitoring programme should be on the adaptive management of agricultural enterprises within Riemvasmaak.

The value of the monitoring programme will itself need to be assessed by the stock farmers and other role players. Particular interest should be shown in analysing the "returns" to investments. Does an outlay on veterinary drugs result in lower mortality of animals, or does a new water point result in less grazing pressure overall or does it merely increase the area of grazing-induced degradation?

3.11 TERMINATION

Once the objectives of the programme have been met it should be terminated. However, financial and logistic constraints may also influence the decision to terminate the monitoring programme. Smaller-scale operations should therefore, be considered as alternative solutions to the proposal outlined above.

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Chapter 4 : BIBLIOGRAPHY OF LITERATURE PERTAINING TO RIEMVASMAAK AND SURROUNDING AREAS WITHIN THE DISTRICT OF GORDONIA, NORTHERN CAPE

This bibliography consists of three parts. Firstly, we list the mostly unpublished literature concerning Riemvasmaak, its agricultural resources and potential. Much of this material can be obtained from the FARM Africa office which is currently at the University of the Western Cape. Numerous small memoranda are also available from this source.

Secondly, we list the newspaper articles that have dealt with Riemvasmaak. This list has been compiled from that in Smith & Bozalek (1993). We retain the broad subject headings provided by these authors. A few additional sources, which we located in the comprehensive files of the Surplus People Project , are also included. This list is not exhaustive as we have missed a number of press articles concerning the resettlement programme that has occurred during the first six months of 1995. For some articles we could only find the title - the source and date was unknown.

Thirdly, we include some of the many scientific and popular articles that concern the general ecology, geology, archaeology and history of Riemvasmaak and the broader surrounds within the Gordonia district and Kalahari environments. The composition, structure and dynamics of Riemvasmaak's natural resources are best understood in the context of its regional environment . It is our hope that this list of references will help in developing a fuller understanding of the ecological, agricultural and economic potential of the region. The references have been extracted from the bibliography of over 7 000 southern African arid zone references compiled by the senior author of this report and available on diskette (see Hoffman, 1994). We have been very selective in our choice of articles and there are many ecological articles for the Kalahari environment, especially the Kalahari Gemsbok National Park, that we have not included.

Finally, we suggest that anyone interested in seeking additional information on Riemvasmaak, especially smaller articles, minutes of meetings, archival documentation and so on, should contact the Cape Town offices of FARM Africa, the Surplus People Project (SPP) and the Legal Resources Centre. There is a wealth of additional material and personnel to consult at these institutions. SPP, in particular, have a comprehensive file on the archival material, from the national and various local archives around the country, that deals specifically with the history of Riemvasmaak.

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Appendix 1: The itinerary of the ecological survey team between 16-30 January, 1995.

We include below details of our movements during our survey of Riemvasmaak to assist teams who may re-sample the area at some future date. Additional information concerning photostation location, length of time spent at each location and details of what was photographed and sampled may be found in Fig. 1.13 and Appendix 8. Place names used are those in Fig. 1.1 and Fig. 1.2.

Supporting four people who are constantly on the move, in mid-summer in the inhospitable Riemvasmaak terrain resulted in considerable logistic problems with regard to petrol, vehicle repairs (e.g. flat tyres), food and especially water. We were forced to return to Augrabies Falls National Park at least every third evening to replenish our water, food and petrol supplies and to affect any equipment repairs that might have been necessary. In addition, this opportunity was taken to develop the film exposed during the previous few days in the field.

DAY 1: (Monday, 16th). Travelled from Cape Town to Augrabies Falls National Park. Logistic arrangements and vehicle hire from the National Parks Board finalised.

DAY 2: (Tuesday, 17th). Met members of the Riemvasmaak community who had arrived from Welcomewood in the Ciskei a few days before. Outlined details of our intended survey with them and arranged to have Mr Willem Vass accompany us later in the week. Familiarised ourselves with the area in and around the Mission Station, Perdepoort, Gyam/Vaalputs and Droëputs with the assistance of Barry Hopgood and a team of rangers from the National Parks Board. Travelled to Deksel, took photographs and sampled at photostation 1 in the late afternoon.

DAY 3: (Wednesday, 18th). Photostations 2 and 3 near Deksel finished in the morning. Size class distribution transect of *Acacia erioloba* at Deksel completed (see Fig. 1,.17, "Site 3"; Plate 1.11). Drove to photostation 4 which was photographed and sampled in the late afternoon. Slept near photostation 4.

DAY 4: (Thursday, 19th). Drove onto the plateau, sampled and photographed photostation 5 then travelled back to the Riemvasmaak Mission Station completing photostation 6 along the way. Size class distribution of *Acacia mellifera* completed at photostation 6 (Fig. 1.16). Returned to the Augrabies Falls National Park.

DAY 5: (Friday, 20th). Drove to Riemvasmaak, and collected Mr Willem Vass before heading to photostation 7 which was completed in the morning. Photostation 8 sampled and photographed in the afternoon and drove to Xubuxnap where we spent the night. Mr Vass was interviewed concerning his and his family's history in the region and his knowledge of management systems used in "Old Riemvasmaak".

DAY 6: (Saturday, 21st). Photostation 9 completed in the morning together with an *Acacia erioloba* size class distribution transect (Fig. 1.17 "Site 9). Photostation 10 at Petrushoek was sampled in the late morning and then we travelled back to Xubuxnap.

Photostation 11, in the lower reaches of the Kourop River, was finished in the early afternoon before heading towards the Molopo River mouth via ‖Nana‖as, ‖Hôb and |Hus. Camped on a ridge about 1 km from the Molopo/Orange River confluence. Mr Vass was interviewed in the evening with regard to his knowledge of livestock and human uses of key plant species.

DAY 7: (Sunday, 22nd). Photostation 12 completed in the morning together with a trip up the Molopo River to assess density of *Tamarix usneoides* thickets in and along the banks of the river. Travelled back to Riemvasmaak Mission Station and photographed and sampled photostation 13 along the way. Dropped off Mr Willem Vass at the Mission Station and photographed, but did not sample, photostation 14 at the base of Groot Rooiberg. Returned to the Augrabies Falls National Park.

DAY 8: (Monday, 23rd). Travelled to Riemvasmaak. Headed towards Bok se Puts via Deksel stopping at photostation 4 to do a size class distribution transect of *Schotia afra* in the rocky river bed (Fig. 1.18). Drove to photostation 15 in the Loeriesfontein River which we finished in the late morning and then travelled up the Bak River to photograph and sample at photostation 16. Travelled south down the Bak River in the late afternoon to Donkiemond where we spent the night.

DAY 9: (Tuesday, 24th). Completed photostation 17 at Donkiemond in the morning. Returned to Bok se Puts where we photographed and sampled photostation 18. Met and interviewed Mr Johannes Andreas at a dug well in the Loeriesfontein River. Drove to Deksel and down the Kourop River to photostation 19 which we completed in the afternoon. Returned to Deksel and finished photostation 20 in the late afternoon. Travelled over the plateau, past the Riemvasmaak Mission Station to the Hot Spring in the Molopo Gorge which we reached after 9 pm.

DAY 10: (Wednesday, 25th). Completed photostation 21 in the morning, a re-survey of one of John Acocks sites for the region. Drove past Hoed se Kop to photograph and sample photostation 22 at Droëputs in the early afternoon. Did size class distribution transects of *Acacia erioloba* (Fig. 1.17, ":Site 22") and *Prosopis glandulosus* (Table 1.9). Travelled to Augrabies Falls National Park. Met with FARM Africa representative, Dr David Catling in the evening and outlined our progress in the field.

DAY 11: (Thursday, 26th). Travelled with David to Riemvasmaak Mission Station where we reported back to the Riemvasmakers on aspects of the work that we had completed to date. Drove to Perdepoort where we demonstrated to David the methodology we were using and completed photostation 23. Ad hoc notes concerning key forage species taken from Mr Johannes Langans, a stock farmer, working in the Perdepoort area with Mr Niels Farmer. Drove to Photostation 24 and photographed this site near Gyam/Vaalputs. Conducted size class distribution transect for *Acacia erioloba* at this site (Fig. 1.17, "Site 24", Plate 1.12). Returned to Augrabies Falls National Park.

DAY 12: (Friday, 27th). Together with Mr Barry Hopgood of the National Parks Board we entered "Bokvasmaak" - the area of land leased to the National Parks Board south of a low ridge called |Haodaos containing the old settlements of Wabrand and

Melkbosrant (Fig. 1.2). Found and re-photographed three of John Acocks photographs all taken from the same location and re-sampled his site No. 1648. Together with Barry we discussed and assessed the impact of rhino on vegetation at this photostation. Returned to Augrabies Falls National Park in the late afternoon.

DAY 13: (Saturday, 28th). Drove to Riemvasmaak and completed two size class distribution transects of *Acacia erioloba* in the morning (Fig. 1.17, “Site 14i” & “Site 14ii”). Also sampled the vegetation for photostation 14 which had been photographed on Sunday 22 January. Drove to photostation 26 and completed this site in the late morning. Interviewed Mr Piet Neus who works for the owner of the neighbouring farm “Waterval” about the landuse history of the farm. Drove the few kms to photostation 27 which we photographed and sampled in the early afternoon. Decided to photograph and sample at photostation 28 in the late afternoon. Returned to Riemvasmaak Mission Station where we reported back to members of the Riemvasmaak community and later spent part of the evening socialising with them.

DAY 14: (Sunday, 29th). Completed photostation 29 and returned to Augrabies Falls National Park to pack up and prepare for journey back to Cape Town.

DAY 15: (Monday, 30th). Travelled from Augrabies Falls National Park to Cape Town.

Appendix 3: Checklist of plants in Riemvasmaak and the Augrabies Falls National Park compiled from data from this survey (*) and from AFNP (n.d.)[1], Werger & Coetzee (1977)[2] , SADF (1990)[3] and from Acocks' checklists of two sites in Riemvasmaak[4]. The total area covered by this checklist is 74 563 ha (Riemvasmaak) and 5 400 ha (Augrabies Falls National Park) giving a total of 79 963 ha. Taxonomic nomenclature follows Arnold & De Wet (1993)[5]. Common names for grass species are taken from Gibbs Russell *et al* (1991)[6] when listed. Other common family and species names are from the AFNP checklist, from Smith (1966)[7], Le Roux & Schelpe (1981)[8], Le Roux *et al* (1994)[9], Shearing & Van Heerden (1994)[10] and from names given to us by Riemvasmakers during informal discussions. No Endangered or Vulnerable Red Data Book species are evident in this checklist.

FAMILY AND SPECIES	COMMON NAMES
BRYOPHYTA	**MOSSES & LIVERWORTS**
BRYACEAE	Moss family
Bryum apiculatum	
AYTONIACEAE	Liverwort family/Lewermosfamilie
Plagiochasma rupestre	
RICCIACEAE	Liverwort family/Lewermosfamilie
Riccia atropurpurea	
Riccia cavernosa	
Riccia okahandjana	
Riccia trichocarpa	
PTERIDOPHYTA	**FERNS & FERN ALLIES**
ADIANTACEAE	
Cheilanthes deltoidea	Fern/Varing
ASPLENIACEAE	
Ceterach cordatum	Resurrection fern/Opstandingsvaring
AZOLLACEAE	Aquatic fern family/Watervaringfamilie
Azolla filiculoides	
SPERMATOPHYTA	**SEED-BEARING PLANTS**
ANGIOSPERMAE	**FLOWERING PLANTS**
MONOCOTYLEDONAE	
AMARYLLIDACEAE	Daffodil family
Crinum bulbispermum	Orange river lilly/Oranjerivierlelie
Nerine filifolia	

	Nerine gaberonensis	
	ASPARAGACEAE	Asparagus family/Aspersiefamilie
*	Protasparagus africanus	Katdoring
	Protasparagus cooperi	
	Protasparagus denudatus	
	Protasparagus laricinus	
	Protasparagus pearsoni	
*	Protasparagus retrofractus	Katdoring
*	Protasparagus sp.	
	Protasparagus suaveolens	Wild asparagus/Katdoring
	ASPHODELACEAE	Aloe family/Aalwynfamilie
	Aloe claviflora	Kraalaalwyn, Kanonaalwyn
*	Aloe dichotoma	Quiver tree/Kokerboom
	Aloe hereroensis	Sandaalwyn
*	Aloe gariepensis	
	Chlorophytum undulatum	
	Haworthia transluscens	
	COLCHICACEAE	
	Ornithoglossum viride	Poison onion/Cape- or Karoo slangkop
	Ornithoglossum vulgare	
	CYPERACEAE	Sedge family/Biesiefamilie
	Bulbostylis hispidula	
*	Cyperus marginatus	Matjiesgoed
	Scirpus sp.	Biesie
	DRACAENACEAE	
	Sansevieria aethiopica	Bowstring hemp/Wildewortel
	ERIOSPERMACEAE	
	Eriospermum sp.	
	HYACINTHACEAE	Chinkerinchee family/Tjienkerintjeefamilie
	Bowiea volubilis	Knolklimop
*	Dipcadi gracillimum	Oumasegroottoon
	Dipcadi glaucum	Poison onion/Slangkop, Groenlelie
	Ornithogalum suaveolens	Geelviooltjie
	Ornithogalum unifolium	Chinkerinchees/Tjienkerintjee
	Schizobasis intricata	Volstruiskos
	IRIDACEAE	Iris family/Irisfamilie
	Babiana tritonioides	
	Gladiolus sp.	
	Lapeirousia plicata	
	POACEAE	Grass family/Grasfamilie

	Anthephora pubescens	Wool grass/Borseltjiegras
	Anthephora ramosa	Vertakte borseltjiegrass
	Aristida adscensionis	Annual bristle grass/Steekgras
*	Aristida congesta	Katstertsteekgras
	Aristida engleri	Engler’s bristle grass/Bristle three-awn
	Botriochloa bladhii	Purple plume grass/Blouklosgras
*	Cenchrus ciliaris	Buffelsgras
	Chloris virgata	Feathered chloris/Klossiegras
	Danthoniopsis ramosa	
	Diandrochloa namaquensis	
*	Dicanthium annulatum	Blue grama/Vlei finger grass
	Digitaria ciliaris	Tropical finger grass
	Digitaria eriantha	Common finger grass
	Echinochloa colona	Jungle rice
*	Enneapogon cenchroides	Nine-awned grass/Suurgras
	Enneapogon desvauxii	Wonder grass/Kalkgras
*	Enneapogon scaber	Klipgras
	Eragrostis annulata	Soetgras
*	Eragrostis aspera	Grootpluimeragrostis
	Eragrostis biflora	
	Eragrostis brizantha	Kwaggagras
	Eragrostis cylindriflora	
	Eragrostis echinochloidea	Tick grass/Bosluisgras
	Eragrostis homomalla	Reengrassie
*	Eragrostis lehmanniana	Lehmannn’s love grass/Knietjiesgras
	Eragrostis nindensis	Agtdaepluimgras
	Eragrostis cf. pilosa	Reëngrassie
	Eragrostis planiculmis	Besemeragrostis
	Eragrostis porosa	Besembiesie
	Eragrostis rotifer	Reëngrassie
	Eragrostis tef	Teff
	Eragrostis trichophora	Blousaadgras
	Eragrostis virescens	Chilean love grass
	Eragrostis viscosa	Sticky love grass
	Hermarthria altissima	Red swamp grass/Rooikweek
*	Heteropogon contortus	Tanglehead/Pylgras, Assegaaigras
*	Leucophrys mesocoma	Withaargras
	Melinis repens	Natal red top
*	Odyssea paucinervis	Prickly brack grass/Steekriet
	Oropetium capense	Dwarf grass/Haasgras
*	Panicum arbusculum	Struikpanicum
	Panicum maximum	Guinea grass/Blousaad soetgras
*	Panicum sp.	
	Paspalum distichum	Couch paspalum/Bankrotkweek
	Pennisetum setaceum	Fountain grass/Pronkgras
	Polypogon monspeliensis	Brakgras
*	Schmidtia kalahariensis	Kalaharigras
*	Setaria appendiculata	Klitsgras
*	Setaria verticillata	Bur bristle grass/Klitssetaria, Klitsgras

*	Sporobolus iocladus	Pan dropseed
*	Stipagrostis anomela	Torro-boesmangras
*	Stipagrostis ciliata	Tall bushman grass/Langbeenboesmangras
*	Stipagrostis hochstetteriana	Spike or rye bushman grass
*	Stipagrostis namaquensis	River bushman grass/Steekrietboesmangras
*	Stipagrostis obtusa	Kortbeenboesmangras
*	Stipagrostis uniplumis	Silky bushman gass/Blinkaarboesmangras
	Tragus berteronianus	Small carrot-seed grass/Kousklits
*	Triraphis ramossisima	Berggras

DICOTYLEDONAE

	ACANTHACEAE	Black-eyed susan family
*	Acanthopsis disperma	Verneukhalfmensie
	Acanthopsis hoffmannseggiana	Disseldoring
*	Baleria secunda	
*	Barleria lichtensteiniana	Rolvarkie, Klapperbossie
*	Barleria rigida	Scorpion thistle/Skerpioendissel
*	Blepharis furcata	
	Blepharis mitrata	Klapperbossie
*	Justicia sp.	
	Monechma divaricatum	Wild lucerne/Wildelusern
*	Monechma genistifolium	
*	Monechma incanum	Bloubossie, Blouskaapbossie, Netvetbossie
*	Monechma spartioides	Besembos/Maklikbreekbossie
*	Petalidium lucens	Kudubos
	Petalidium oblongifolium	
*	Petalidium spinescens	

	AIZOACEAE	Brakbos family/Brakbosfamilie
*	Aizoon asbestinum	
	Aizoon glinoides	
	Aizoon schellenbergii	Skaapbossie
	Coelanthum grandiflorum	
*	Corbichonia decumbens	
*	Galenia africana	Kraalbos
	Galenia sarcophylla	Vanwyksbrak, Joubertsbrakbossie
*	Galenia secunda	Vanwyksbossie
	Gisekia africana	
*	Gisekia pharnaceoides	
*	Hypertelis salsoloides	Braksuring, Skaapsuring, Haassuring
*	Limeum aethiopicum	Koggelmandervoetkaroo
*	Limeum cristatus	
	Limeum deserticolum	
	Limeum dineri	
	Limeum fenestratum	
*	Limeum myosotis	Klosaarbossie
	Limeum sulcatum	Klosaarbossie
	Limeum viscosuum	

*	Limeum sp.	
	Mollugo cerviana	
*	Plinthus arenarius	
*	Tetragonia arbuscula	Grootrooilootganna, Klappiesbrak
*	Tetragonia sp.	
	Trianthema parvifolia	
	Trianthema triquetra	Rooivygie
	AMARANTHACEAE	Amaranth family/Misbrediefamilie
	Amaranthus praetermissus	
	Amaranthus thunbergii	Pigweed/Misbredie, Sprinkaanbossie
*	Calicorema capitata	Vaalbossie
	Kyphocarpa angustifolia	
	Leucosphaera bainesii	Perdebossie
*	Sericocoma avolans	Katstert
	Sericorema remotiflora	
	ANACARDIACEAE	Mango family/Mangofamilie
	Ozoroa concolor	
*	Ozoroa crassinervia	
	Ozoroa namaensis	Nama resin tree/Namaharpuisboom
	Rhus lancea	Kareeboom
*	Rhus pendulina	Witkaree
*	Rhus populifolia	Rosyntjieboom
	ASCLEPIADACEAE	Milkweed family/Melkbosfamilie
*	Hoodia sp.	-ghaap
*	Microloma incanum	Bokhoring
	Microloma sasgittatum	Bokhoring
*	Pergularia daemia	
*	Sarcostemma viminale	Melktou, Spantou
	ASTERACEAE	Daisy or sunflower family/Madeliefiefamilie
	Amellus epaleaceus	
*	Arctotis fenuosa	
	Arctotis leiocarpa	Gousblom
	Berkheya canescens	
	Berkheya chamaepeuce	
*	Berkheya spinosissima	
	Blumea cafra	
*	Blumea gariepina	
	Chrysocoma ciliata	Bitterbos
	Conyza bonariensis	
	Dicoma capensis	Koorsbossie, Karmedik
	Didelta spinosa	Perdebossie, t’arda
	Dimorphotheca polyptera	Jakkalsblom
	Gazania lichtensteinii	Botterblom, Gousblom, Kougoed
	Geigaria filifolia	Vermeerbossie
*	Geigaria ornativa	Vermeerbossie

*	Geigaria pectidea	Vermeerbossie
	Geigaria vigintisquamea	
	Gorteria corymbosa	
	Helichrysum argyrosphaerum	
	Helichrysum herniarioides	
	Helichrysum tomentosulum	
	Ifloga molluginoides	
*	Kleinia longiflora	Sjambokbossie
	Leysera tenella	Vaalteebossie
	Myxopappus acutilobus	
*	Nidorella resedifolia	
	Nolletia gariepina	
	Oncosiphon piluliferum	
	Osteospermum amplectens	Bietou, Dassiegousblom
	Osteospermum breviradiatum	Lemoenbossie
*	Osteospermum microcarpum	Boegoebossie
	Othonna floribunda	
*	Pentzia argentea	
	Pentzia pinnatisecta	
	Pentzia quinquefida	Beesbossie
	Pentzia spinescens	
	Platycarpha carlinoides	
*	Pteronia sp.	
*	Rosenia sp.	
	Senecio arenarius	Hongerblom
	Senecio consanguineus	
	Senecio flavus	
	Senecio inaequidens	Canary weed/Geelopslag
	Senecio niveus	
	Senecio sisymbrifolius	
	Sonchus oleraceus	Milk thistle/Melkdissel
	Verbesina encelioides	Wildesonneblom
	BIGNONIACEAE	Bignonia, honeysuckle family
*	Rhigozum trichotomum	Driedoring
	BORAGINACEAE	Forget-me-not family/Vergeet-my-nie familie
*	Ehretia rigida	Cape lilac/Deurmekaarbos
*	Trichodesma africanum	
	BRASSICACEAE	Cabbage or mustard family/Koolfamilie
	Capsella bursa-pastoris	Shepherd’s purse/Geldbeursie
	Coronopus integrifolius	Peperbossie
	Heliophila deserticola	
	Heliophila minima	
	Heliophila seselifolia	
	Heliophila trifurca	Naeltjiesbossie
	Lepidium africanum	Bird seed, Pepper cress/Kanariesaadgras
	Lepidium desertorum	Peperbossie

	Sisymbrium capense	Cape mustard/Strandmostert
	BURSERACEAE	Commiphora family (Frankincense and Myrrh)
*	Commiphora gracilifrondosa	Karee corkwood/Karee kannniedood
	CAMPANULACEAE	Bellflower family/Klokkiefamilie
	Wahlenbergia prostrata	
	CAPPARACEAE	Caper family
*	Boscia albitrunca	Shepherd's tree/Witgatboom
*	Boscia foetida	Stinkbos/knoudoring/ ! noemie
*	Cadaba aphylla	Blackstorm/Swartstorm
*	Cleome angustifolia	
	Cleome foliosa	
	Cleome kalachariensis	
*	Cleome oxyphylla	Peultjiebos
	Cleome paxii	
	Cleome semitetrandra	
*	Maerua gilgii	
	CARYOPHYLLACEAE	Carnation family
*	Montinia caryophyllacea	
	CELASTRACEAE	Spike thorn family/Pendoring familie
	Maytenus heterophylla	Common spike thorn/Gewonependoring
	Maytenus linearis	Narrow-leaved spikethorn/Smalblaarpendoring
*	Putterlickia pyracantha	Wolwedoring
	CHENOPODIACEAE	Sugar Beet, Beetroot and Spinach family
	Atriplex semibaccata	Creeping saltbush/Australiesebrakbossie
	Chenopodium album	White goose-foot/Gansvoet
	Chenopodium ambrosioides	Wormseed goose-foot/Galsiektebossie
	Chenopodium olukonde	
	Chenopodium schraderianum	Schrader goose-foot/Vlooibossie
*	Lophiocarpus polystachyus	Sandaarbossie
*	Salsola aphylla	Lye bush/Brakganna
	Salsola arborea	Beesganna
	Salsola barbata	
	Salsola kali	Russian thistle, tumbleweed/Tolbos, rolbos
	Salsola tuberculata	Blomkoolganna
	Suaeda fruticosa	Inkbush/Inkbos
	COMBRETACEAE	Combretum family
	Combretum erythrophyllum	Bushveldwillow/Bosveldwilg
	CONVOLVULACEAE	Morning glory family/Purperwindefamilie
	Convolvulus sagittatus	Klimop, Bobbejaantou
	CRASSULACEAE	Crassula family/Plakkiefamilie

	Cotyledon orbiculata	Pig’s ear/Plakkie
	Crassula ausensis	
	Crassula elegans	
	Crassula sericea	Vaalplakkie
	CUCURBITACEAE	Pumpkin family/Pampoenfamilie
	Coccinea rehmannii	
	Cucumis africanus	Bitter apple/Bitterappel, Doringkomkommertjie
	Cucumis meeusei	
*	Cucumis sagittatus	
	EBENACEAE	Ebony family/Ebbehoutfamilie
*	Diospyros acocksii	
*	Diospyros lycioides	Star apple/Swartbas
*	Euclea pseudebenus	Black ebony/Swartebbehout, Sabbiboom
*	Euclea undulata	Ghwarriebos
	EUPHORBIACEAE	Euphorbia or spurge family/Naboomfamilie
	Chamaesyce glanduligera	
	Chamaesyce inaequilatera	
*	Euphorbia avosmontana	Boesmangifboom
	Euphorbia brachiata	Bloumelkbos, soetmelkbos
	Euphorbia decussata	Kareemoerbos
	Euphorbia gariepina	
*	Euphorbia gregaria	Melkbos, Aggenysmelkbos
	Euphorbia mauritanica	Melkbos
	Euphorbia peplus	Milkweed/Gifbossie
*	Euphorbia rhombifolia	
	Euphorbia spartaria	
	Euphorbia spinea	
	Phyllanthus burchellii	
	Phyllanthus maderaspatensis	Skilpadbossie
	FABACEAE	Pea family/Ertjiefamilie
	Acacia davyi	Paper-bark thorn/Papierdoring
*	Acacia erioloba	Camel thorn/Kameeldoring
	Acacia haematoxylon	Red ebony/Rooiebbehout
*	Acacia karroo	Karoo thorn/Karoo doringboom
*	Acacia mellifera	Swarthaak/ !Noi
*	Adenolobus garipensis	Butterfly leaf/Peultjiebos, Bloubeesklou
	Bauhinia bowkeri	Kei white bauhinia/Keibeesklou
*	Crotalaria virgultalis	
	Cullen obtusifolia	Blue clover/Blouklawer
	Cyamopsis serrata	
	Indigofera alternans	Skaap-ertjie
	Indigofera argyraea	Oogseerbossie
	Indigofera argyroides	
	Indigofera disjuncta	
*	Indigofera heterotricha	

*	Indigofera pungens	Drieblaarbos
*	Indigofera sp.	
*	Indigofera spinescens	
*	Lebeckia sericea	Vaalertjiebos, bloufluitjiesbos, t'aibie
	Lebeckia spinescens	Sandganna, !Gom
	Lotononis crumanina	
	Lotononis platycarpa	
	Lotononis rabenaviana	
	Melilotus alba	Bokhara clover/Bokhaargras
	Melilotus indica	Bitterklawer
	Melolobium candicans	Heuningbossie
*	Parkinsonia africana	Lemoendoringboom
	Piliostigma thonningii	Picture-frame tree/Kameelspoor
*	Prosopis glandulosus	Mesquite/Suidwesdoring
	Prosopis velutina	Velvet mesquite/Fluweelboontjie
*	Ptycholobium biflorum	
*	Rhynchosia longiflora	
	Rhynchosia totta	
*	Schotia afra	‖amiboom/Karooboerboen
*	Sutherlandia frutescens	Cancer bush/Jantjiebarend, Kankerbos
*	Tephrosia dregeana	
	Tephrosia linearis	
	Trigonella hamosa	Wildeklawer
	FRANKENIACEAE	
	Frankenia pulverulenta	
	GENTIANACEAE	Gentian family
	Sebaea pentandra	
	GERANIACEAE	Perlargonium family/Pelargoniumfamilie
	Monsonia luederitziana	
	Monsonia parvifolia	Dysentery herb/Disenteriekruid
*	Monsonia umbellata	Wilderabassam
	Sarcocaulon crassicaule	
*	Sarcocaulon pattersonii	Bushman's candle/Boesmanskers
	Sarcocaulon salmoniflorum	
	HYDROPHYLLACEAE	
	Codon schenckii	
*	Codon royeni	Soetdoringbos, Suikerkelk
	ILLECEBRACEAE	Pollichia family/Pollichiafamilie
	Pollichia campestris	Waxberry/Aarbossie, Teesuiker
	LAMIACEAE	Mint family/Kruisementfamilie
	Lamium amplexicaule	
*	Ocimum canum	Transvaal basil/Transvaal basielkruid
	Stachys burchelliana	Wildesalie

	LOASACEAE	Helicopter tree or Blazing star family
	Kissenia capensis	Helikopterboompie
	LOGANIACEAE	Wild elder family/Wildevlierfamilie
	Gomphostigma virgatum	Water sprite/Besembossie
	LORANTHACEAE	Mistletoe family/Voëlentfamilie
*	Tapinanthus oleifolius	Mistletoe, lighted matches/Voëlentf
	LYTHRACEAE	Pride-of-India family
	Nesaea drummondii	
	MALVACEAE	Hibiscus family/Hibiskusfamilie
	Abutilon angulatum	
*	Abutilon pycnodon	
*	Hibiscus elliottiae	
	Hibiscus engleri	
	Hibiscus fleckii	
	Malva parviflora	Bread-and-cheese/Brood-en-botter, Kiesieblaar
	Sida ovata	
	MELIACEAE	Mahogany family/Seringfamilie
	Nymania capensis	Chinese lanterns/Klapperbos
	MENISPERMACEAE	Curare family
*	Antizoma miersiana	
	MESEMBRYANTHEMACEAE	Mesembryanthemum or Vygie family
	Aridaria sp.	
*	Mesembryanthemum crystallinum	Ice plant/Brakslaai
	Mesembryanthemum perlatum	Fig marigolds/Vyebossie
	Psilocaulon absimile	Asbos
	Psilocaulon inconstrictum	
	Ruschia cyanthiformis	
	Ruschia griquensis	
*	Ruschia sp.	
	Sphalmanthus olivaceus	
	MONTINIACEAE	
	Montinia caryophyllacea	Pepper bush/Peperbossie, t'iena
	MORACEAE	Fig family/Vyfamilie
	Ficus cordata	Namaqua fig/Namakwavy
	Ficus ingens	Wildevyboom
	NEURADACEAE	
	Grielum humifusum	Pietsnot, duikerwortel, t'koeibee

	NYCTAGINACEAE	Bougainvilleas or Four o'clock family
	Boerhavia repens	
*	Phaeoptilum spinosum	Brosdoring/Bloudoringbos
	ONAGRACEAE	Evening primrose family/Aandblomfamilie
	Oenothera indecora	
	OXALIDACEAE	Sorrel family/Suringfamilie
	Oxalis cf. corniculata	Wood sorrel/Ranksuring
	Oxalis obliquifolia	
	PAPAVERACEAE	Poppy family/Papawerfamilie
	Argemone ochroleuca	Mexican poppy/Bloudissel
	PASSIFLORACEAE	Passion flowers and Granadillas
	Adenia repanda	
	PEDALIACEAE	Sesame family/Sesaam familie
	Rogeria longiflora	Djirrie witblom
*	Sesamum capense	Aprilbaadjie
	PERIPLOCACEAE	Khadi-root family/Khadiwortelfamilie
*	Curroria decidua	
	PLUMBAGINACEAE	Plumbago or Sea lavender family
*	Dyerophytum africanum	
	POLYGALACEAE	Milkwort family/Bloukappiefamilie
	Nylandtia spinosa	Tortoise berry/Duinebessie, Skilpadbessie
*	Polygala leptophylla	Skaapertjie
	POLYGONACEAE	Buckwheat family/Bokwietfamilie
	Emex australis	Devil's thorn/Breëblaardubbeltjie
	Oxygonum delagoense	
	Persicaria serrulata	
	PORTULACACEAE	Purslane family/Spekboomfamilie
	Anacampseros albissima	Moerbossie
*	Ceraria namaquensis	Hottentotsriem
	Portulaca oleracea	Purslane/Porselein, Varkkos
	RHAMNACEAE	Buffalo-thorn family/Blinkblaarfamilie
*	Ziziphus mucronata	Buffalo-thorn/Wag-'n-bietjie
	RUBIACEAE	Coffee, Gardenia and Quinine family
	Kohautia caespitosa	
	Kohautia cynanchica	Aandblom

	SANTALACEAE	Sandalwood family/Sandelhoutfamilie
	Thesium lacinulatum	
*	Thesium lineatum	Witstorm
	SAPINDACEAE	Litchi family/Lietsjiefamilie
*	Pappea capensis	Wild plum/Pruimboom
	SCROPHULARIACEAE	Snapdragon family/Leeubekkiefamilie
	Antherothamnus pearsonii	
*	Aptosimum albomarginatum	
	Aptosimum lineare	
	Aptosimum marlothii	Koffiepit
*	Aptosimum spinescens	Rolvarkie, Doringviooltjie
	Diascia engleri	
	Freylinia lanceolata	Honey bells
	Limosella grandiflora	Blouwaterblommejie
	Manulea gariepina	
	Manulea schaeferi	
*	Peliostomum leucorrhizum	Veld violet/Karooviooltjie, Springbokbossie
	Sutera adpressa	
*	Sutera ramosissima	
	Sutera tomentosa	Tongblaar
	SELAGINACEAE	
	Hebenstretia parviflora	
	Walafrida densiflora	
	SOLANACEAE	Tomato and potato family
	Datura stramonium	Thornapple/Malpitte, Stinkblaar
	Lycium afrum	Kraaldoring, Slangbessie
	Lycium bosciifolium	
*	Lycium cinereum	Wolwedoring
	Lycium oxycarpum	Honey-thorn/Kriedoring, Wolwedoring
*	Lycium prunus-spinosa	Bloukareedoring
*	Lycium sp.	
	Solanum burchellii	Slangappel
*	Solanum capense	Nightshade/Bitterappel
*	Solanum catombelense	Slangbessie
	Solanum coccineum	Kleingrysbitterappeltjie
*	Solanum gifbergense	
	Solanum nigrum	Black nightshade/Galbessie, Nastergal
*	Solanum pseudocapsicum	
	Solanum rigescens	Wildelemoentjie
	Solanum sisymbrifoliuum	Doringtomatie
	Solanum tomentosum	Slangappelbos
	Solanum villosum	Woody nightshade
	STERCULIACEAE	Cacao family/Kakaofamilie
	Hermannia bicolor	

	Hermannia minutiflora	Gannabos
	Hermannia modesta	
	Hermannia pulchella	Verfbossie, Bergpleisterbos
	Hermannia solaniflora	
*	Hermannia spinosa	Steekbossie
*	Hermannia stricta	Rooi-opslag
*	Hermannia tomentosa	
	Hermannia vestita	Swaelbossie
	Melhania didyma	
	TAMARICACEAE	Tamarisk family
*	Tamarix usneoides	Tamarisk/Abiekwaboom, Dabbieboom
	THYMELAEACEAE	Fibre-bark family/Veselbasfamilie
	Gnidia polycephala	
	TILIACEAE	Linden and basswoods/Rosyntjiebosfamilie
	Grewia flava	Wild currant/Wilderosyntjie
	URTICACEAE	Nettle family/Brandnetelfamilie
*	Forsskaolea candida	Kwaaibul
	VAHLIACEAE	
*	Vahlia capensis	
	VERBENACEAE	Teak and Verbena family
*	Plexipus garipensis	
*	Plexipus pumilis	
	VISCACEAE	Mistltoe family/Voëlent familie
	Viscum rotundifolium	Mistletoe/Voëlent
	ZYGOPHYLLACEAE	Devil-thorn family/Dubbeltjiefamilie
*	Augea capensis	Bobbejankos, Volstruisganna
*	Sisyndite spartea	Desert broom/Woestynbesem
	Tribulis cristatus	
*	Tribulis pterophorus	Duiviedoring
*	Tribulis terrestris	Common dubbeltjie/Dubbeltjie, duifiedoring
	Tribulis zeyheri	Dubbeltjie
	Zygophyllum dregeanum	Skilpadbossie
*	Zygophyllum gilfillani	Spekbos
*	Zygophyllum microcarpum	Sandhaarpuis, Ouooibos
	Zygophyllum microphyllum	Inkbos
*	Zygophyllum simplex	Brakkies
*	Zygophyllum suffruticosum	Spekbos

[1] Augrabies Falls National Park (n.d.). *A preliminary plant species list of the Augrabies Falls National Park with English and Afrikaans common names*. Unpublished checklist, Augrabies Falls National Park. Compiled by H Bezuidenhout, P C Zietsman & T Peyper.

[2] Werger M J A & Coetzee B J 1977. A phytosociological and phytogeographical study of Augrabies Falls National Park, Republic of South Africa. *Koedoe* 20, 11-51. (This study appears to have been done entirely outside of the Riemvasmaak area but its checklist has been included because it provides a fairly comprehensive coverage of the riverine vegetation. The survey was done in 1977 at a time when the vegetation was "in an excellent condition, due to favourable rains in the preceding weeks" and the addition of annual species missed in our survey in January 1995 adds considerably to the checklist).

[3] South African Defence Force 1990. Voorlopige plantspesieslys vir Riemvasmaak. Aanhangsel J. In (ed.) P Scogings, *Military-Ecological Management* P*lan for Riemvasmaak.* Environmental Services, Chief of the South African Defence Force, Department of Logistics, Pretoria.

[4] John Acocks sampled two sites (No.'s 1647 & 1648). One is located within Riemvasmaak and the other immediately adjacent to Riemvasmaak on the farm "Waterval". We relocated his sites and they have become our photostations 21 and 25 respectively. His plant lists are comprehensive and added 37 species to this checklist.

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[10] Shearing D & Van Heerden K 1994. *Karoo*. South African Wildflower Guide 6. Botanical Society of South Africa & National Botanical Institute, Cape Town.

Appendix 4: List of amphibians and reptiles at Riemvasmaak and surrounding areas compiled from a checklist for the Augrabies Falls National Park (AFNP, n.d.), from a checklist in SADF (1990) and from distribution maps in Passmore (1979) [amphibians] and Branch (1988) [reptiles]. Scientific nomenclature and English common names follow Passmore & Carruthers (1979) and Branch (1988a) for amphibians and reptiles respectively. Afrikaans common names, where available are taken from AFNP (n.d.). and from Boycott & Bourquin (1988) for the tortoise fauna. Red Data Book status is according to Branch (1988b) and only three species are listed as Peripheral (P) with a subspecies of *Naja nigricollis* (*N. nigricollis woodii*) also listed as Rare.

ORDER, FAMILY & SPECIES	ENGLISH COMMON NAME	AFRIKAANS COMMON NAME
CLASS: **AMPHIBIA**		
ORDER: **ANURA** (Frogs)		
FAMILY: PIPIDAE		
Xenopus laevis	Common Clawed Frog	Platanna
FAMILY: BUFONIDAE		
Bufo gariepensis	Karoo Toad	Karoo skurwepadda
B. gutturalis	Common or Guttural Toad	Gewone skurwepadda
B. garmani	Olive Toad	Gevlekte skurwepadda
B. rangeri	Raucous Toad	Lawaaierige skurwepadda
FAMILY: MICROHYLIDAE		
Breviceps adspersus	Common Rain Frog	Gewone blaasop
Phrynomerus annectens	Marbled Rubber Frog	Rooirubberpadda
FAMILY: RANIDAE		
Cacosternum boettgeri	Common Caco	Blikslanertjie
Rana angolensis	Common River Frog	Gewone rivierpadda
R. grayi	Clicking River Frog	Grey se rivierpadda
Tomopterna cryptotis	Tremelo Sand Frog	Gestreepte sandpadda
CLASS: **REPTILIA** (Reptiles)		
ORDER: **CHELONIA** (Chelonians)		
FAMILY: TESTUDINIDAE (Land Tortoises)		
Geochelone pardalis	Leopard tortoise	Bergskilpad
Psammobates tentorius verroxii	Bushmanland Tent tortoise	Boesmanland-tentskilpad
FAMILY: PELOMEDUSIDAE (Side-necked Terrapins)		
Pelomedusa subrufa	Cape Terrapin	Gewone waterskilpad
ORDER: **SQUAMATA** (Scaled Reptiles)		
SUB-ORDER SERPENTES		
FAMILY: TYPHLOPIDAE (Blind Snakes)		
Typhlops schinzi (P)	Beaked Blind Snake	Haakneus blindeslang

FAMILY: LEPTOTYPHLOPIDAE (Thread Snakes)		
Leptotyphlops occidentalis (P)	Western Thread Snake	-
FAMILY: COLUBRIDAE (Typical Snakes)		
Lamprophis fuliginosus	Brown House Snake	Bruin huisslang
Pseudaspis cana	Mole Snake	Molslang
Prosymna frontalis	South-western Shovel-snout	Suidwes graafneusslang
Dipsina multimaculata	Dwarf Beaked Snake	-
Psammophis notostictus	Karoo Sand Snake	-
P. leightoni	Fork-marked Sand Snake	Vurkmerk sandslang
Homoroselaps lacteus	Spotted Harlequin Snake	-
Xenocalamus bicolor	Bicoloured Quill-snouted Snake	-
Dasypeltis scabra	Common Egg Eater	Eiervreter
Telescopus beetzii	Namib Tiger Snake	Beetz se tierslang
T. semiannulatus	Eastern Tiger Snake	-
FAMILY: ELAPIDAE (Cobras, Mambas and their relatives)		
Aspidelaps lubricus	Coral Snake	Koraalslang
Naja nivea	Cape Cobra	Kaapse geelslang
N. nigricollis	Black-necked Spitting Cobra	-
FAMILY: VIPERIDAE (Adders & Vipers)		
Bitis arietans	Puff Adder	Pofadder
B. caudalis	Horned Adder	Horingadder
B. xeropaga (P)	Desert Mountain Adder	Woestynbergadder
SUB-ORDER AMPHISBAENIA FAMILY: AMPHISBAENIDAE (Worm Lizards)		
Monopeltis capensis	Cape Spade-snouted Worm Lizard	-
Zygaspis quadrifrons	Kalahari Round-headed Worm Lizard	-
SUB-ORDER SAURIA (Lizards) FAMILY: SCINIDAE (Skinks)		
Acontias lineatus	Striped Legless Skink	-
Mabuya capensis	Cape Skink	Kaapse gladdeakkedis
M. occidentalis	Western Three-striped Skink	Westelike driestreepakkedis
M. spilogaster	Kalahari Tree Skink	-
M. striata	Striped Skink	-
M. sulcata	Western Rock Skink	-
M. variegata	Variegated Skink	Gespikkelde gladdeakkedis
Typhlosaurus gariepensis	Gariep Blind Legless Skink	-
FAMILY: LACERTIDAE (Old World Lizards)		
Meroles suborbitalis	Spotted Desert Lizard	-
Nucras tessellata	Striped Sandveld Lizard	Gestreepte sandveldakkedis
Pedioplanis lineoocellata	Spotted Sand Lizard	-
P. namaquensis	Namaqua Sand Lizard	Namakwa sandakkedis
P. undata	Western Sand Lizard	Westelike sandakkedis
FAMILY: CORDYLIDAE (Plated & Girdled Lizards)		

Cordylosaurus subtessellatus	Dwarf Plated Lizard	-
Cordylus polyzonus	Karoo Girdled Lizard	Karoo-skurwejantjie
Platysaurus capensis	Cape Flat Lizard	-
FAMILY: VARINIDAE		
(Monitors)		
Varanus exanthematicus	Rock or White-throated Monitor	Veldlikkewaan
V. niloticus	Water Monitor	Waterlikkewaan
FAMILY: AGAMIDAE		
(Agamas)		
Agama aculeata	Ground Agama	-
A. anchietae	Anchieta's Agama	Anchieta se stekelkoggelmander
A. atra	Southern Rock Agama	-
FAMILY: GEKKONIDAE		
(Typical Geckos)		
Chondrodactylus angulifer	Giant Ground Gecko	Groot grondgeitjie
Colopus wahlbergii	Kalahari Ground Gecko	Kalahari grondgeitjie
Lygodactylus bradfieldi	Bradfield's Dwarf Gecko	-
Lygodactylus capensis	Cape Dwarf Gecko	-
Pachydactylus bibronii	Bibron's Gecko	Bibron se diktoongeitjie
P. capensis	Cape Gecko	-
P. laevigatus	Button-scaled Gecko	Gewone knopieskubgeitjie
P. mariquensis	Marico Gecko	-
P. rugosus	Rough-scaled Gecko	-
P. serval	Western Spotted Gecko	-
P. weberi	Weber's Gecko	Weber se geitjie
Ptenopus garrulus	Common Barking Gecko	-

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Appendix 5: List of birds recorded for the Augrabies Falls National Park (AFNP, n.d.), recorded at Riemvasmaak by the South African Defence Force (SADF, 1990) and those marked with an asterisk (*) were recorded at Riemvasmaak between 17 - 29 January 1995 by the survey team. Species which we saw during our survey and which may well respond to increasing human disturbance are highlighted. Numbers are Roberts' numbers (Maclean, 1993). Decriptors of abundance between 17-29 January, 1995 only are: rare - seen once; uncommon - seen less than 10 times; common - seen 10 - 50 times on most days; very common - seen every day and in excess of 50 individuals per day. Categories and Red Data Book status (after Brooke, 1984) of species in the checklist are (V) = Vulnerable; R = Rare; (I) = Indeterminate.

1. Ostrich/Volstruis (*Struthio camelus*) - SADF (1990) checklist only. The National Parks Board removed 4 individuals when the South African Defence Force's term of tenure expired in 1993/94 (Barry Hopgood, personal communication).
55. Whitebreasted Cormorant/Witborsduiker (*Phalacrocorax carbo*).
58. Reed Cormorant/Rietduiker (*Phalacrocorax africanus*).
60. Darter/Slanghalsvoël (*Anhinga melanogaster*).
62. Grey Heron/Bloureier (*Ardea cinerea*).
63. Blackheaded Heron/Swartkopreier (*Ardea melanocephala*).
*64. **Goliath heron/Reuse-reier** (*Ardea goliath*) - rare; restricted to the Orange River (Molopo mouth).
67. Little Egret/ Kleinwitreier (*Egretta garzetta*).
71. Cattle Egret/Veereier (*Bubulcus ibis*). SADF (1990) checklist only.
78. Little Bittern/Woudapie (*Ixobrychus minutus*).
81. Hamerkop/Hamerkop (*Scopus umbretta*).
83. White Stork/Witooievaar (*Ciconia ciconia*).
84. Black Stork/Grootswartooievaar (*Ciconia nigra*). **(I), probably (R)**
85. Abdim's Stork/Kleinswartooievaar (*Ciconia abdimii*).
94. Hadeda Ibis/Hadeda (*Bostrychia hagedash*).
95. African Spoonbill/Lepelaar (Platalea alba).
*102. Egyptian Goose/Kolgans (*Alopochen aegyptiacus*) - uncommon; restricted to the Orange River (Molopo mouth).
103. South African Shelduck/Kopereend (*Tadorna cana*).
104. Yellowbilled Duck/Geelbekeend (*Anas undulata*).
105. African Black Duck/Swarteend (*Anas sparsa*).
106. Cape Teal/Teeleend (*Anas capensis*).
108. Redbilled Teal/Rooibekeend (*Anas erythrorhyncha*)
113. Southern Pochard/Bruineend (*Netta erythrophthalma*). SADF (1990) checklist only.
116. Spurwinged Goose/Wildemakou (*Plectropterus gambensis*).
118. Secretarybird/Sekretarisvoël (*Sagittarius serpentarius*). SADF (1990) checklist only.
126. Yellowbilled Kite/Geelbekwou (*Milvus migrans*).
127. Blackshouldered Kite/Blouvalk (*Elanus caeruleus*)

*131. **Black Eagle/Witkruisarend** (*Aquila verreauxii*)- uncommon; seen 5 times (including three juveniles) widespread throughout the region with a pair at a nest east of Deksel near photostation 4 .

136. Booted Eagle/Dwergarend (*Hieraaetus pennatus*).

140. Martial Eagle/Breëkoparend (*Polemaetus bellicosus*). **(V)**

*143. **Blackbreasted Snake Eagle/Swartbosslangarend** (*Circaetus pectoralis*) - rare; recorded flying above the central plateau.

*148. **African Fish Eagle/Visarend** (*Haliaeetus vocifer*) - rare; restricted to the Orange River. Pair seen with a nest at Xubuxnab. A species likely to suffer from agricultural development along the banks of the Orange River. The developed southern side of the river has in places, had most of its riverine vegetation removed.

149. Steppe Buzzard/Bruinjakkalsvoël (Buteo buteo).

*152. Jackal buzzard/Rooiborsjakkalsvoël (*Buteo rufofuscus*)- rare; recorded once at photostation 9.

*162. **Pale Chanting Goshawk/Bleeksingvalk** (*Melierax canorus*) - uncommon;

169. Gymnogene/Kaalwangvalk (*Polyboroides typus*).

171. Peregrine Falcon/Swerfvalk (*Falco peregrinus*). **(R)**

172. Lanner Falcon/Edelvalk (*Falco biarmicus*).

178. Rednecked Falcon/Rooinekvalk (*Falco chicquera*). **(R)**

*181. Rock Kestrel/Rooivalk (*Falco tinnunculus*) - rare; recorded once near photostation 29.

182. Greater Kestrel/Grootrooivalk (*Falco rupicoloides*).

186. Pygmy Falcon/Dwergvalk (*Polihierax semitorquatus*).

195. Cape Francolin/Kaapse Fisant (*Francolinus capensis*).

199. Swainson's Francolin/Bosveldfisant (*Francolinus swainsonii*).

200. Common Quail/Afrikaanse Kwartel (*Coturnix coturnix*).

203. Helmeted Guineafowl/Gewone Tarentaal (*Numida meleagris*).

213. Black Crake/Swartriethaan (*Amaurornis flavirostris*).

226. Moorhen/Waterhoender (*Gallinula chloropus*).

228. Redknobbed Coot/Bleshoender (*Fulica cristata*).

230. Kori Bustard/Gompou (*Ardeotis kori*). **(V)**

232. Ludwig's Bustard/Ludwigse Pou (*Neotis ludwigii*). **(V)**

*235. **Karoo Korhaan/Vaalkorhaan** (*Eupodotis vigorsii*) - uncommon; recorded on the plateau and near photostation 29.

239. Black Korhaan/Swartkorhaan (*Eupodotis afra*). SADF (1990) checklist only.

*249. Threebanded Plover/Driebandstrandkiewiet (*Charadrius tricollaris*) - rare; recorded once along the Orange River.

*258. Blacksmith Plover/Bontkiewiet (*Vanellus armatus*) - uncommon; recorded along the Orange River.

264. Common Sandpiper/Gewone Ruiter (*Actitis hypoleucos*).

266. Wood Sandpiper/Bosruiter (*Tringa glareola*).

*270. Greenshank/Groenpootruiter (*Tringa nebularia*) - rare; recorded along the Orange River (Molopo River mouth).

295. Blackwinged Stilt/Rooipootelsie (*Himantopus himantopus*). SADF (1990) checklist only.

*297. Spotted Dikkop/Dikkop (*Burhinus capensis*) - uncommon; heard calling at dusk along the Orange River (Molopo River mouth).

298. Water Dikkop/Waterdikkop (*Burhinus vermiculatus*).

301. Doublebanded Courser/Dubbelbanddrawwertjie (*Smutsornis africanus*). SADF (1990) checklist only.

*344. Namaqua Sandgrouse/Kelkiewyn (*Pterocles namaqua*) - common; seen flying early in the morning en route to or from a drinking source. In small groups to fairly large flocks of up to about 100 birds.

347. Doublebanded Sandgrouse/Dubbelbandsandpatrys (*Pterocles bicinctus*).

348. Feral Pidgeon/Tuinduif (*Columba livia*). SADF (1990) checklist only.

*349. Rock Pigeon/Kransduif (*Columba guinea*) - common; widespread where suitable habitat (gorges, cliffs) occurs.

352. Redeyed Dove/Grootringduif (*Streptopelia semitorquata*).

*354. Cape Turtle Dove/Gewone Tortelduif (*Streptopelia capicola*) - very common; widespread throughout the region.

*355. Laughing Dove/Rooiborsduifie (*Streptopelia senegalensis*) - very common; widespread throughout the region.

*356. Namaqua Dove/Namakwaduifie (*Oena capensis*) - common; widespread throughout the region.

*367. Rosyfaced Lovebird/Rooiwangparkiet (*Agapornis roseicollis*) - uncommon; recorded at Riemvasmaak Mission Station, Perdepoort and Donkiemond. Seen drinking from the water tower at the mission station. **(I), probably (R)**

*386. Diederik Cuckoo/Diederikkie (*Chrysococcyx caprius*) - rare; heard calling once along the Molopo River near its confluence with the Orange River. Presumably restricted by the availability of suitable hosts (weavers and bishops) which occur more commonly along the Orange river.

392. Barn Owl/Nonnetjie-uil (*Tyto alba*).

401. Spotted Eagle Owl/Gevlekte Ooruil (*Bubo africanus*).

402. Giant Eagle Owl/Reuse Ooruil (*Bubo lacteus*).

*406. Rufouscheeked Nightjar/Rooiwangnaguil (*Caprimulgus rufigena*) - uncommon; heard calling (Xubuxnab, Molopo River) and seen prior to a lightning storm along the Molopo River. the local rainbird according to Mr Willem Vass.

410. Pennantwinged Nightjar/Wimpelvlerknaguil (*Macrodipteryx vexillaria*).

*412. Black Swift/Swartwindswael (*Apus barbatus*)- common; widespread throughout the region; especially conspicuous when hawking insects after rain storms.

413. Bradfield's Swift/Muiskleurwindswael (*Apus bradfieldii*).

415. Whiterumped Swift/Witkruiswindswael (*Apus caffer*).

*417. Little Swift/Kleinwindswael (*Apus affinis*) - common; widespread throughout the region.

*418. Alpine Swift/Witpenswindswael (*Apus melba*) - uncommon; recorded after rain storm at photostation 8. Very distinctive.

424. Speckled Mousebird/Gevlekte Muisvoël (*Colius striatus*).

*425. Whitebacked Mousebird/Witkruismuisvoël (*Colius coliusi*) - rare; recorded once north of the Riemvasmaak Mission Station.

*426. Redfaced Mousebird/Rooiwangmuisvoël (*Urocolius indicus*) - rare; recorded once along the Molopo River close to its confluence with the Orange River.

428. Pied Kingfisher/Bontvisvanger (*Ceryle rudis*).

429. Giant Kingfisher/Reuse Visvanger (*Megaceryle maxima*).
431. Malachite Kingfisher/Kuifkopvisvanger (*Alcedo cristata*).
*438. European Bee-eater/Europese Byvreter (*Merops apiaster*) - rare; heard calling above the Molopo River near its confluence with the Orange River.
440. Bluecheeked Bee-eater/Blouwangbyvreter (*Merops persicus*).
444. Little Bee-eater/Kleinbyvreter (*Merops pusillus*).
*445. Swallowtailed Bee-eater/Swaelstertbyvreter (*Merops hirundineus*) - rare; a flock recorded in the Molopo River bed near its confluence with the Orange River.
449. Purple Roller/Groottroupant (*Coracias naevia*).
451. Hoopoe/Hoephoep (*Upupa epops*).
*454. Scimitarbilled Woodhoopoe/Swartbekkakelaar (*Rhinopomastus cyanomelas*) - uncommon; recorded twice in *Acacia erioloba* woodland.
459. Southern Yellowbilled Hornbill/Suidelike Geelbekneushoringvoël (*Tockus leucomelas*).
*465. Pied Barbet/Bonthoutkapper (*Tricholaema leucomelas*) - common; widespread throughout the region in a variety of habitats.
474. Greater Honeyguide/Grootheuningwyser (*Indicator indicator*).
476. Lesser Honeyguide/Kleinheuningwyser (*Indicator minor*).
483. Goldentailed Woodpecker/Goudstertspeg (*Campethera abingoni*).
486. Cardinal Woodpecker/Kardinaalspeg (*Dendropicos fuscescens*).
*498. Sabota Lark/Sabotalewerik (*Mirafra sabota*) - uncommon; recorded in the lowlands beneath the central plateau.
*500. Longbilled Lark/Langbeklewerik (*Mirafra curvirostris*) - uncommon; recorded throughout the region.
*502. Karoo Lark/Karoolewerik (*Mirafra albescens*) - rare; one record for the plateau.
506. Spikeheeled Lark/Vlaktelewerik (*Chersomanes albofasciata*).
516. Greybacked Finchlark/Grysruglewerik (*Eremopterix verticalis*).
517. Blackeared Finchlark/Swartoorlewerik (*Eremopterix australis*).
*518. European Swallow/Europese Swael (*Hirundo rustica*) - uncommon; recorded at Xubuxnab and at the mouth of the Molopo River.
520. Whitethroated Swallow/Witkeelswael (*Hirundo albigularis*).
523. Pearlbreasted Swallow/Pêrelborsswael (*Hirundo dimidiata*).
526. Greater Striped Swallow/Grootstreepswael (*Hirundo cucullata*).
*529. Rock Martin/Kranswael (*Hirundo fuligula*) - common; the commonest swallow, recorded widely throughout the region.
530. House Martin/Huisswael (*Delichon urbica*). ?Record doubtful. **(I)**
*533. Brownthroated Martin/Afrikaanse Oewerswael (*Riparia paludicola*) - uncommon; recorded at Xubuxnab and at the mouth of the Molopo River.
534. Banded Martin/Gebande Oewerswael (*Riparia cincta*).
*541. Forktailed Drongo/Mikstertbyvanger (*Dicrurus adsimilis*) - rare; recorded once from the Riemvasmaak Mission Station.
551. Southern Grey Tit/Piet-tjou-tjou-grysmees (*Parus afer*).
*552. Ashy Tit/Acaciagrysmees (*Parus cinerascens*) - rare; recorded at photostation 4 along a rocky river course.
557. Cape Penduline Tit/Kaapse Kapokvoël (*Anthoscopus minutus*). SADF (1990) checklist only.

558. Grey Penduline Tit/Gryskapokvoël (*Anthoscopus caroli*).
*567. Redeyed Bulbul/Rooioogtiptol (*Pycnonotus nigricans*) - uncommon; recorded widely in a variety of habitats.
577. Olive Thrush/Olyflyster (*Turdus olivaceus*).
580. Groundscraper Thrush/Gevlekte Lyster (*Turdus litsitsirupa*).
583. Shorttoed Rock Thrush/Korttoonkliplyster (*Monticola brevipes*). SADF (1990) checklist only.
*586. Mountain Chat/Bergwagter (*Oenanthe monticola*) - common; recorded widely and not necessarily in association with mountains.
587. Capped Wheatear/Hoëveldskaapwagter (*Oenanthe pileata*).
*589. Familiar Chat/Gewone Spekvreter (*Cercomela familiaris*) - rare; a pair recorded at photostation 5 on the plateau.
590. Tractrac Chat/Woestynspekvreter (*Cercomela tractrac*).
592. Karoo Chat/Karoospekvreter (*Cercomela schlegelii*).
593. Mocking Chat/Dassievoël (*Thamnoclaea cinnamomeiventris*).
*595. Anteating Chat/Swartpiek (*Myrmecocichla formicivora*) - rare; recorded once on the plateau.
*601. Cape Robin/Gewone Janfrederik (*Cossypha caffra*) - rare; recorded only along the Orange River (Molopo River mouth).
*614. Karoo Robin/Slangverklikker (*Erythropygia coryphaeus*) - uncommon; recorded sparsely throughout the region.
615. Kalahari Robin/Kalahariwipstert (*Erythropygia paena*).
*621. Titbabbler/Bosveldtjeriktik (*Parisoma subcaeruleum*) - uncommon; seen in wide valleys.
631. African Marsh Warbler/Kleinrietsanger (*Acrocephalus baeticatus*).
634. European Sedge Warbler/Europese Vleisanger (*Acrocephalus schoenobaenus*).
*635. Cape Reed Warbler/Kaapse Rietsanger (*Acrocephalus gracilirostris*) - rare; heard calling from a reedbed at the Molopo River mouth.
*651. Longbilled Crombec/Bosveldstompstert (*Sylveitta rufescens*) - uncommon; recorded only from *Acacia erioloba* woodlands.
653. Yellowbellied Eremomela/Geelpensbossanger (*Eremomela icteropygialis*).
660. Cinnamonbreasted Warbler/Kaneelborssanger (*Euryptila subcinnamomea*).
664. Fantailed Cisticola/Landeryklopkloppie (*Cisticola juncidis*).
*669. Greybacked Cisticola/Grysrugtinktinkie (*Cisticola subruficapilla*) - uncommon; recorded on the plateau and along the Molopo gorge.
677. Levaillant's Cisticola/Vleitinktinkie (*Cisticola tinniens*).
*685. Blackchested Prinia/Swartbandlangstertjie (*Prinia flavicans*) - very common; widely recorded throughout the region.
687. Namaqua Warbler/Namakwalangstertjie (*Phragmacia substriata*).
*688. Rufouseared Warbler/Rooioorlangstertjie (*Malcorus pectoralis*) - uncommon; recorded on the plateau and on Kalahari sand near Gyam/Vaalputs.
689. Spotted Flycatcher/Europese Vlieëvanger (*Muscicapa striata*)
695. Marico Flycatcher/Maricovlieëvanger (*Melaenornis mariquensis*).
*697. Chat Flycatcher/Grootvlieëvanger (*Melaenornis infuscatus*) - rare; recorded on the plateau.
701. Chinspot Batis/Witliesbosbontrokkie (*Batis molitor*).
*703. Pririt Batis/Priritbosbontrokkie (*Batis pririt*) - common; widespread; seen and heard calling frequently, often in the heat of the day.
706. Fairy Flycatcher/Feevlieëvanger (*Stenostira scita*).

711. African Pied Wagtail/Bontkwikkie (*Motacilla aguimp*).
*713. Cape Wagtail/Gewone Kwikkie (*Motacilla capensis*) - rare; recorded only along the Orange River.
716. Grassveld Pipit/Gewone Koester (*Anthus cinnamomeus*).
717. Longbilled Pipit/Nicholsonse Koester (*Anthus similis*).
719. Buffy Pipit/Vaalkoester (*Anthus vaalensis*). SADF (1990) checklist only.
*732. Fiscal Shrike/Fiskaallaksman (*Lanius collaris*) - uncommon; recorded widely in the region. A species often associated with humans.
733. Redbacked Shrike/Rooiruglaksman (*Lanius collurio*).
*741. Brubru/Bontroklaksman (*Nilaus afer*) - rare; heard calling from *Acacia erioloba* woodland in the Molopo River alluvial fan.
*746. Bokmakierie/Bokmakierie (*Telophorus zeylonus*)- common; widely recorded throughout the region.
748. Orangebreasted Bush Shrike/Oranjeborsboslaksman (*Telophorus sulfureopectus*).
759. Pied Starling/Witgatspreeu (*Spreo bicolor*).
*760. Wattled Starling/Lelspreeu (*Creatophora cinerea*) - uncommon; recorded in small flocks throughout the region except the plateau.
764. Glossy Starling/Kleinglansspreeu (*Lamprotornis nitens*).
769. Redwinged Starling/Rooivlerkspreeu (*Onychognathus morio*).
*770. Palewinged Starling/Bleekvlerkspreeu (*Onychognathus nabouroup*) - common; occurs most frequently on rocky koppies, along gorges and on cliff faces.
783. Lesser Doublecollared Sunbird/Klein-roobandsuikerbekkie (*Nectarinia chalybea*).
*788. Dusky Sunbird/Namakwasuikerbekkie (*Nectarinia fusca*) - very common; recorded throughout the region.
796. Cape White-eye/Kaapse Glasogie (*Zosterops pallidus*).
*799. Whitebrowed Sparrowweaver/Koringvoël (*Plocepasser mahali*) - rare; recorded with nests in *Acacia erioloba* woodland near the confluence of the Molopo and Orange rivers.
*800. Sociable Weaver/Versamelvoël (*Philetairus socius*) - common; nesting confined to *Acacia erioloba* trees.
*801. House Sparrow/Huismossie (*Passer domesticus*) - uncommon; recorded only at the Riemvasmaak Mission.
802. Great Sparrow/Grootmossie (*Passer motitensis*).
*803. Cape Sparrow/Gewone Mossie (*Passer melanurus*) - common; recorded throughout the region.
804. Greyheaded Sparrow/Gryskopmossie (*Passer diffusus*)
805. Yellowthroated Sparrow/Geelvlekmossie (*Petronia superciliaris*).
806. Scalyfeathered Finch/Baardmannetjie (*Sporopipes squamifrons*).
*814. Masked Weaver/Swartkeelgeelvink (*Ploceus velatus*) - uncommon; recorded at the Riemvasmaak Mission Station and along the Orange River.
821. Redbilled Quelea/Rooibekkwelea (*Quelea quelea*).
*824. Red Bishop/Rooivink (*Euplectes orix*) - rare; recorded along the Orange River (Molopo River mouth)
842. Redbilled Firefinch/Rooibekvuurvinkie (*Lagonosticta senegala*)
*846. Common Waxbill/Rooibeksysie (*Estrilda astrild*) - rare; recorded at Xubuxnab along the Orange River.

860. Pintailed Whydah/Koninggrooibekkie (*Vidua macroura*).
864. Black Widowfinch/Gewone Blouvinkie (*Vidua funera*)
870. Blackthroated Canary/Bergkanarie (*Serinus atrogularis*)
*876. Blackheaded Canary/Swarkopkanarie (*Serinus alario*) - rare; a pair recorded once at the Riemvasmaak Mission Station.
*878. Yellow Canary/Geelkanarie (*Serinus flaviventris*) - uncommon; recorded at the Riemvasmaak Mission Station and in *Acacia erioloba* woodland along the Molopo River.
*879. Whitethroated Canary/Witkeelkanarie (*Serinus albogularius*) - uncommon; recorded on the plateau and near the Molopo River mouth.
*885. Cape Bunting/Rooivlerkstreepkoppie (*Emberiza capensis*) - rare; pair recorded at photostation 4 along a rocky river course.
*887. Larklike Bunting/Vaalstreepkoppie (*Emberiza impetuani*) - very common; recorded everyday, everywhere. The most common bird in Riemvasmaak during the survey.

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Appendix 6: Checklist of mamals for Riemvasmaak and surrounding areas compiled from Rautenbauch *et al* (1979), AFNP (n.d.) and SADF (1990). Nomenclature follows Skinner and Smithers (1990). Red Data Book status according to Smithers (1986): E = Endangered; V = Vulnerable; R = Rare; I = Indeterminate.

No.	**ORDER**, FAMILY & *Species*	ENGLISH COMMON NAME	AFRIKAANS COMMON NAME
	INSECTIVORA (Shrews, hedgehogs, golden moles)		
	SORICIDAE (Shrews)		
10	*Crocidura cyanea*	Reddish-grey musk shrew	Rooigrysskeerbek
	MACROSCLELIDEA (Elephant shrews)		
	MACROSCELIDIDAE		
36	*Elephantulus rupestris*	Smith's rock elephant-shrew	Smith se klipklaasneus
	CHIROPTERA (Bats)		
	PTEROPODIDAE (Fruit-eating bats)		
45	*Eidolon helvum*	Straw-coloured fruit bat	Geelvrugtevlermuis
	MOLOSSIDAE (Free-tailed bats)		
52	*Sauromys petrophilus*	Flat-headed free-tailed bat	Platkoplosstert vlermuis
	RHINOLOPHIDAE (Horseshoe bats)		
102	*Rhinolophus clivosus*	Geoffroy's horshoe bat	Geoffroy's se saalneusvlermuis
106	*R. capensis*	Cape horshoe bat	Kaapse saalneusvlermuis
	PRIMATES (Bushbabies, baboons, monkeys)		
	CERCOPITHECIDAE (Baboons & monkeys)		
117	*Papio ursinus*	Chacma baboon	Kaapse bobbejaan
119	*Cercopithecus aethiops*	Vervet monkey	Blouaap
	LAGOMORPHA (Hares, rock rabbits, rabbits)		
	LEPORIDAE		
123	*Lepus saxitilis*	Scrub hare	Kolhaas
124	*Pronolagus rupestris*	Smith's red rock	Smith se

		rabbit	rooiklipkonyn
	RODENTIA (The rodents) HYSTRICIDAE (Porcupines)		
134	*Hystrix afrcaeaustralis*	Cape porcupine	Kaapse ystervark
	PEDETIDAE (Springhaas)		
135	*Pedetes capensis*	Springhaas	Springhaas
	GLIRIDAE (Doormice)		
136	*Graphiurus ocularis*	Spectacled doormouse	Gemsbokmuis
	SCIURIDAE (Squirrels)		
140	*Xerus inauris*	Cape ground squirrel	Waaierstert grondeekhoring
	PETROMURIDAE (Dassie rat)		
149	*Petromus typicus*	Dassie rat	Dassierot
	MURIDAE (Rats & mice)		
150	*Parotomys brantsii*	Brant's whistling rat	Brant se fluitrot
151	*P. littledalei*	Littledale's whistling rat	Littledale se fluitrot
163	*Rhabdomys pumilio*	Striped mouse	Streepmuis
174A	*Mastomys coucha*	Multimammate mouse	Vaalveldmuis
177	*Thallomys paedulcus*	Tree rat	Boomrot
177A	*T. nigricauda*	Black-tailed tree rat	Swartstertboomrot
179	*Aethomys namaquensis*	Namaqua rock mouse	Namakwalandse klipmuis
185	*Desmodillus auricularis*	Short-tailed gerbil	Kortstertnagmuis
186	*Gerbillurus paeba*	Hairy-footed gerbil	Haarpoortnagmuis
188	*G. vallinus*	Brush-tailed hairy-footed gerbil	Borselsterthaarpoort nagmuis
190	*Tatera leucogaster*	Bushveld gerbil	Bosveldse nagmuis
196	*Saccostomus campestris*	Pouched mouse	Wangsakmuis
206	*Petromyscus collinus* (I)	Pygmy rock mouse	Dwergklipmuis
	CARNIVORA PROTELIDAE (Aardwolf)		
244	*Proteles cristatus* (R)	Aardwolf	Aardwolf
	FELIDAE (Cats)		
248	*Panthera pardus* (R)	Leopard	Luiperd
250	*Felis caracal*	Caracal	Rooikat
251	*F. libyca* (V)	African wild cat	Vaalboskat
	CANIDAE (Foxes, wild		

	dog, jackal)		
255	*Otocyon megalotis*	Bat-eared fox	Bakoorvos
259	*Canis mesomelas*	Black-backed jackal	Rooijakkals
	MUSTELIDAE (Otters, polecats, weasels, honey badger)		
260	*Aonyx capensis*	Cape clawless otter	Groototter
264	*Ictonyx striatus*	Striped polecat	Stinkmuishond
	VIVERRIDAE (Mongoose, civers, genets, suricate)		
267	*Genetta genetta*	Small-spotted genet	Kleinkolmuskejaatkat
272	*Cynictis penicillata*	Yellow mongoose	Witkwasmuishond
274	*Galerella sangiunea*	Slender mongoose	Swartkwasmuishond
275	*G. pulverulenta*	Small grey mongoose	Klein grysmuishond
278	*Atilax paludinosus*	Water mongoose	Kommetjiegat muishond
	TUBULIDENTATA ORYCTEROPODIDAE (Aardvark)		
288	*Orycteropus afer* (V)	Aardvark	Aardvark
	HYRACOIDEA PROCAVIIDAE (Dassies)		
290	*Procavia capensis*	Rock dassie	Klipdas
	PERISSODACTYLA (Odd-toed ungulates) RHINOCEROTIDAE (Rhinoceros)		
296	*Diceros bicornis* (E) (Re-introduced to "Bokvasmaak")	Black rhinoceros	Swartrenoster
	ARTIODACTYLA (Even-toed ungulates) BOVIDAE (The antelopes & buffalo)		
313	*Sylvicapra grimmia*	Common duiker	Gewone duiker
314	*Antidorcas marsupialis*	Springbok	Springbok
315	*Oreotragus oreotragus*	Klipspringer	Klipspringer
318	*Raphicerus campestris*	Steenbok	Steenbok
327	*Oryx gazella*	Gemsbok	Gemsbok
329	*Tragelaphus strepsiceros*	Kudu	Koedoe
333	*Taurotragus oryx*	Eland	Eland

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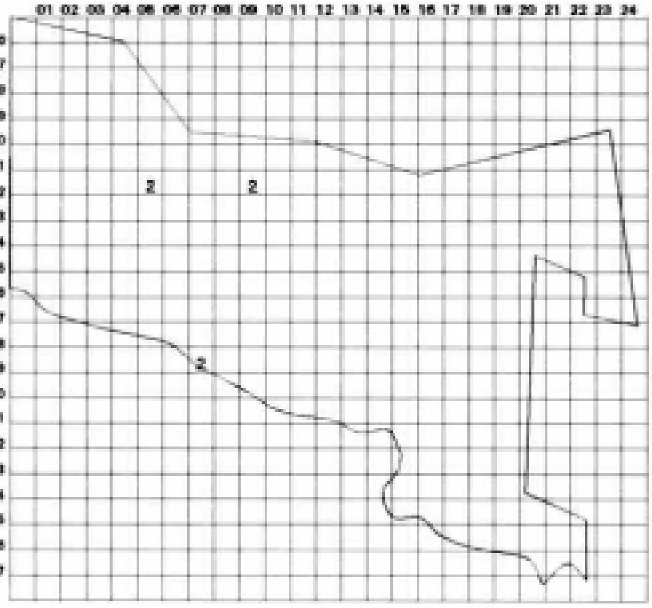
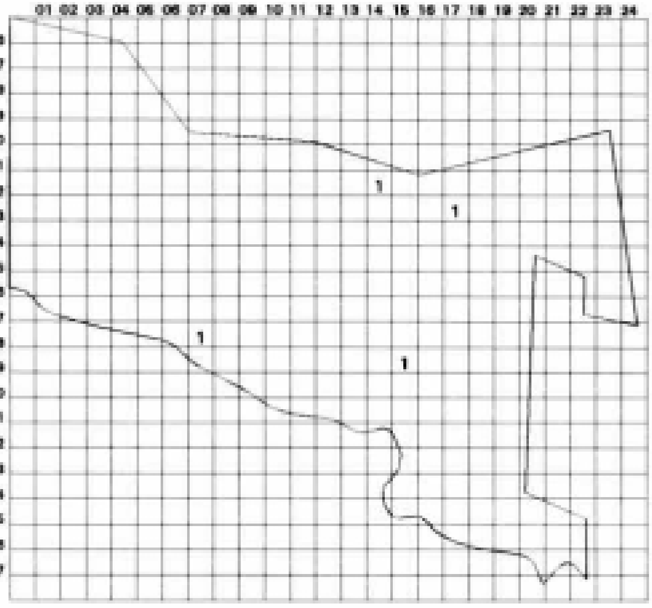
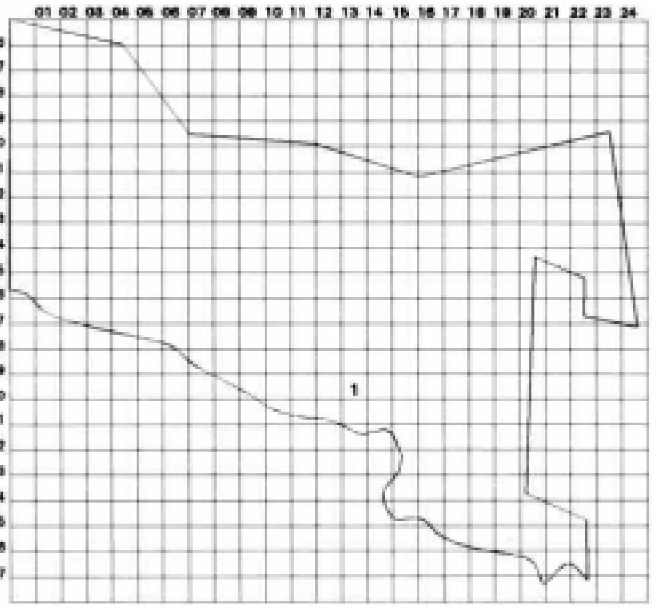
The type, number and locality of the 12 mammal species that we observed in Riemvasmaak between 17-29 January, 1995. (See chapter 1, Section 1.4.4 for details of methods).



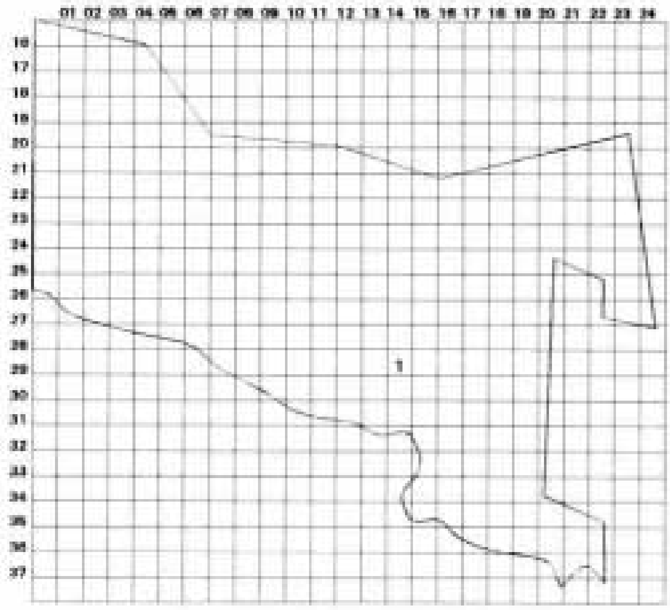
(117) Chacma baboon
Papio ursinus
Three recordings each of two individuals. Culling pressure from farmers may cause a decline in abundance of this species.



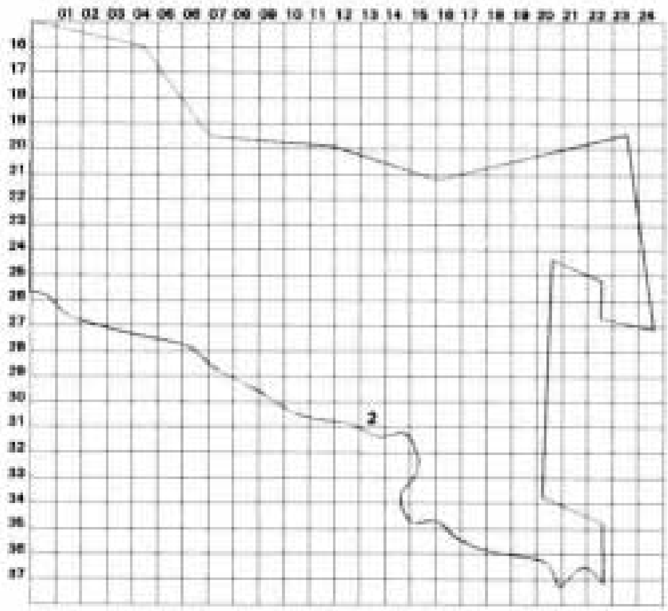
(140) Ground squirrel
Xerus inaurus
Four widely spaced recordings of this species, each of a solitary individual.



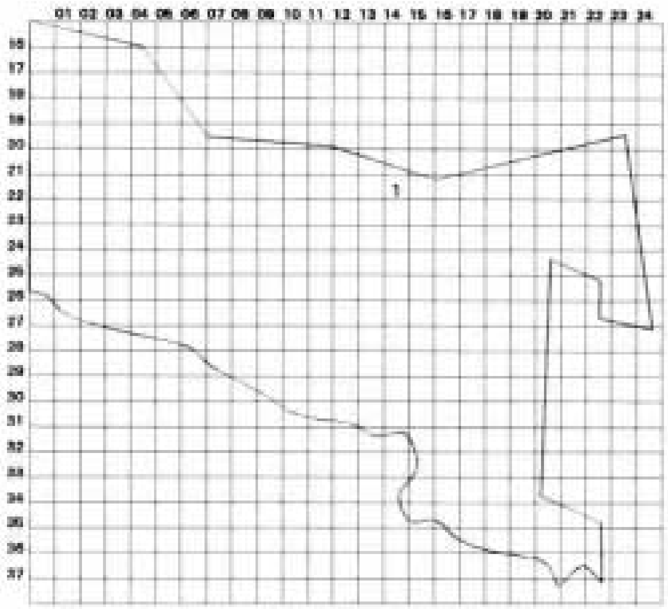
(163) Striped mouse
Rhabdomys pumilio
Seen once during the survey, near the Orange-Molopo river confluence.



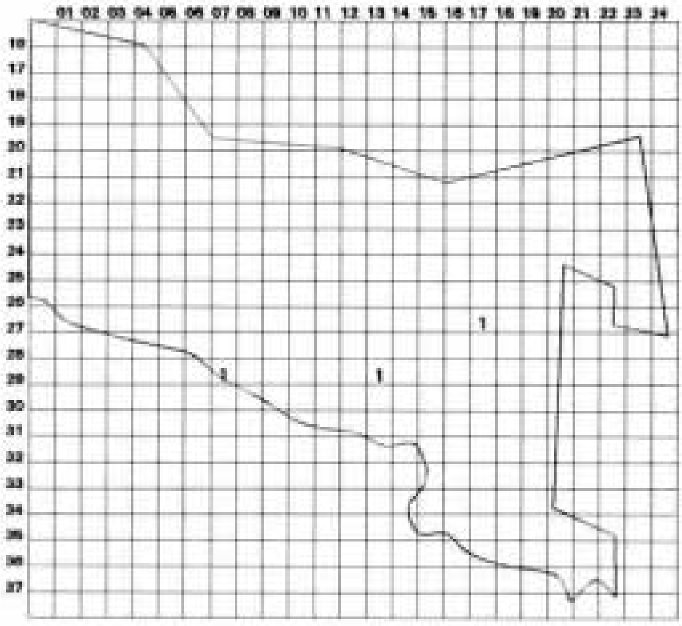
(251) African wild cat
Felis lybica
One individual seen twice, inhabiting a rocky outcrop on the road close to the mouth of the Molopo river.



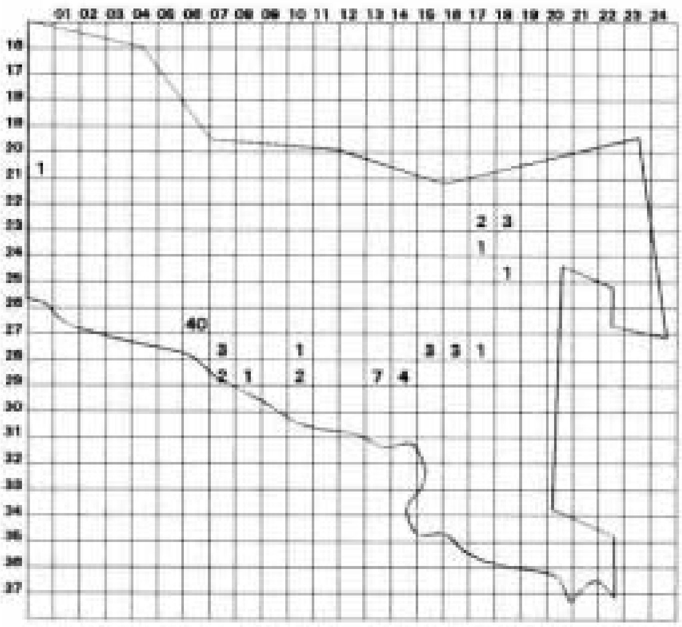
(259) Black-backed jackal
Canis mesomelas
Two individuals heard calling at night close to the Orange-Molopo river confluence. Conflict may arise between farmers and jackals owing to domestic stock being hunted by this species.



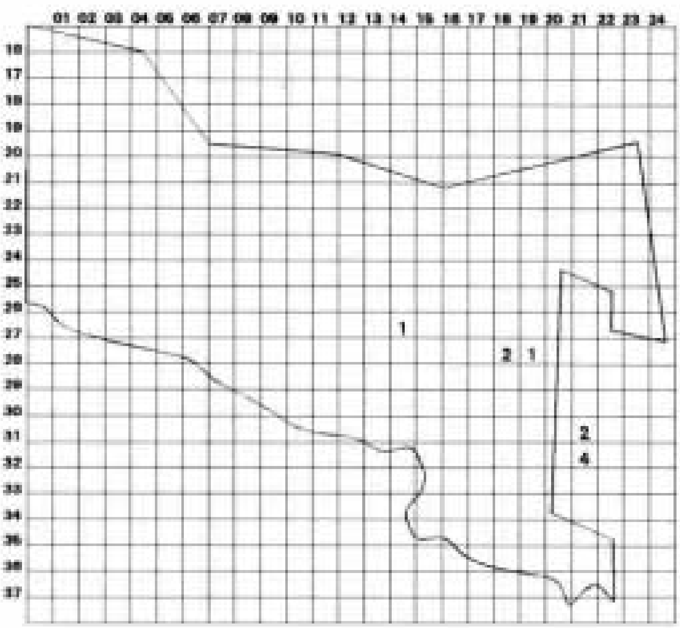
(272) Yellow mongoose
Cynictis penicillata
One individual spotted on the open central plateau on the road to Deksel.



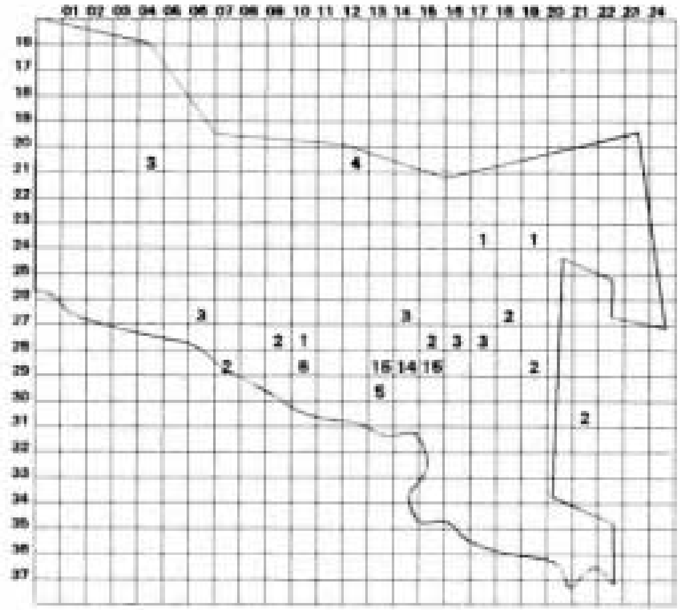
(275) Small grey mongoose
Galerella pulverulenta
Three recordings, each of one individual. All recordings were made on the road between the Riemvasmaak mission station to the Molopo river mouth.



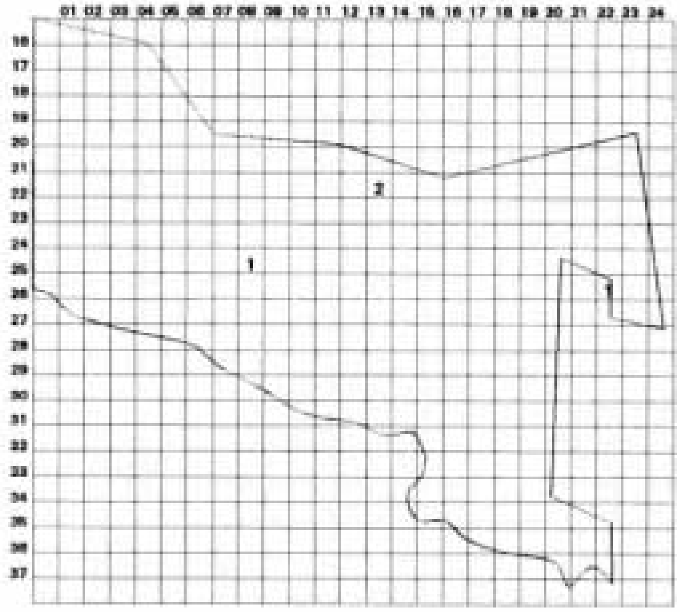
(290) Rock dassie
Procavia capensis
This species is widespread and common in the area, inhabiting rocky crevices.



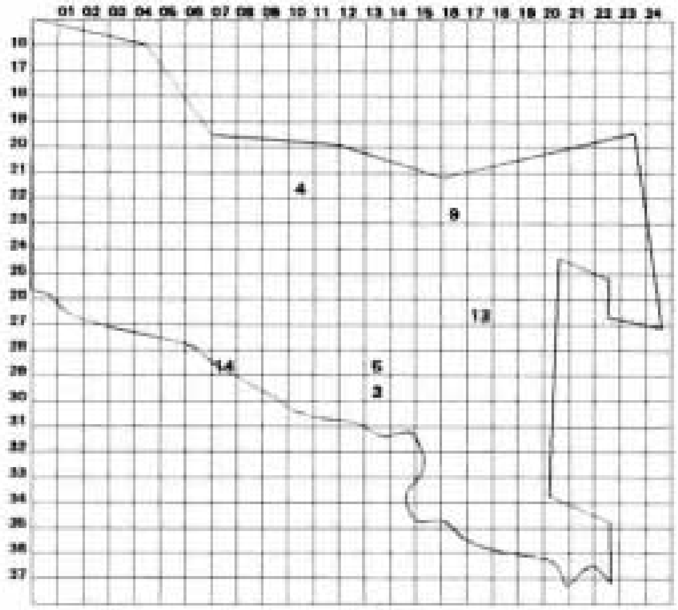
(314) Springbok
Antidorcas marsupialis
A small herd seen on the central open plateau (ideal habitat for this species). Only four other individuals seen in the Riemvasmaak settlement area and a further six individuals in the Waterval area. This species may be affected by human activity, since it is commonly hunted.



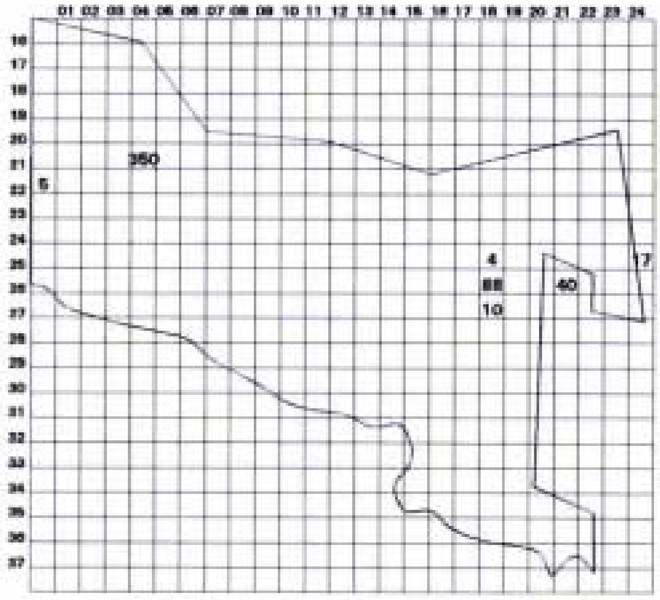
(315) Klipspringer
Oreotragus oreotragus
This species is widespread and common in the area, several sightings being recorded each day. They were usually seen in pairs or small family groups of 3 individuals. This species is very susceptible to human disturbance. Evidence of hunting of this species is already to be found, and domestic dogs may also intefere with this species.



(318) Steenbok
Raphicerus campestris
Four individuals recorded during the survey. In the face of disturbance, this species is able to become nocturnal (Smithers, 1983).

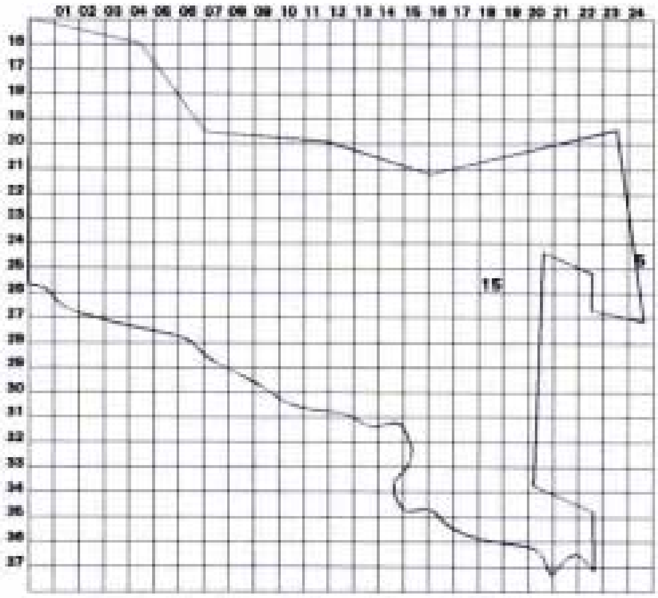


(329) Kudu
Tragelaphus strepsiceros
Fairly widespread in the area with seven recordings of this species, mostly occuring in herds (largest herd of 13 individuals). This species is a favourite hunting species and may therefore be affected by human activity, although it has been reported to be resilient in the face of heavy hunting (Smithers, 1983).



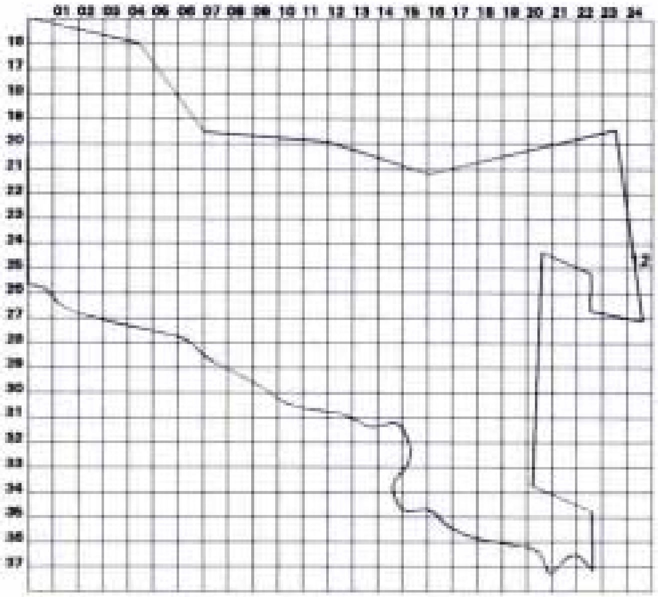
Goat

Three concentrations of goats were recorded. These were (1) Bok se Puts (355 individuals); (2) In and around and just north of the Riemvasmaak Mission Station (102 individuals) and (3) Perdepoort (17 individuals). The total for Riemvasmaak was **474**. Most had been present since November 1994). Another 40 goats were recorded from the adjacent farm Waterval.



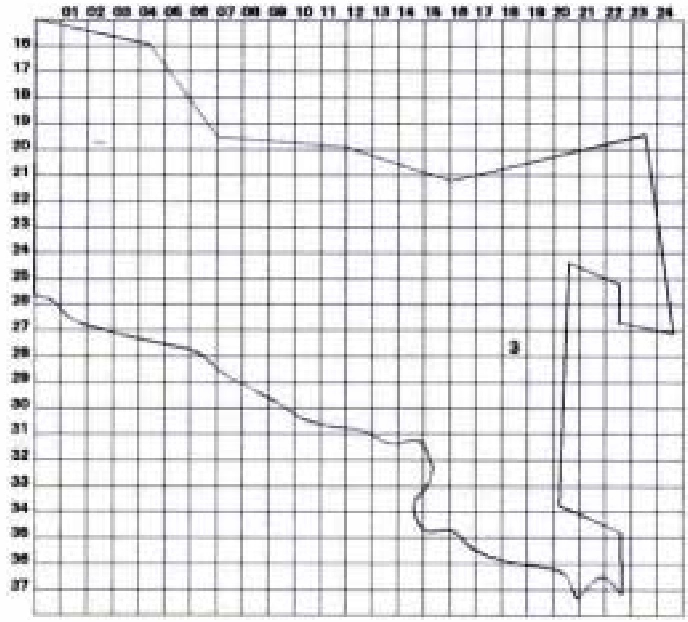
Sheep

Twenty sheep were recorded from two localities: North of Riemvasmaak (15 individuals) and Perdepoort (5 individuals).



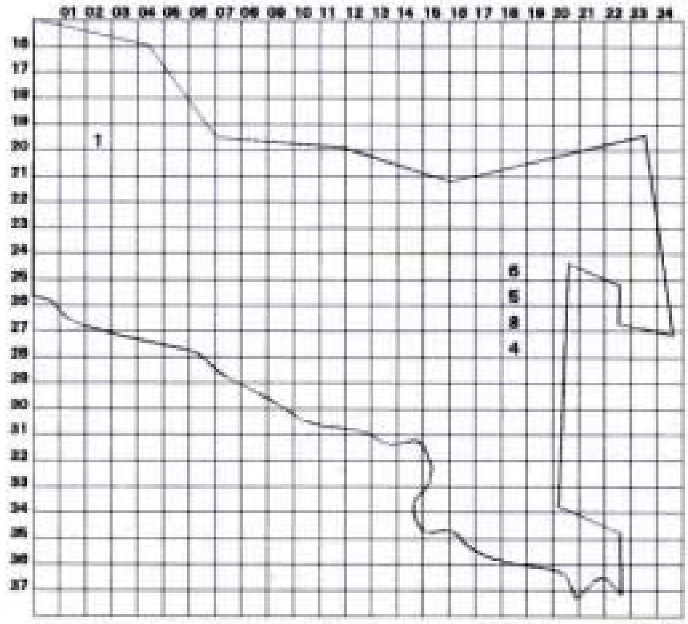
Cattle

Twelve individuals were recorded from Perdepoort.



Horse

Three horses were recorded close to the Riemvasmaak settlement.



Donkey

One donkey was used for donkey-cart transport in Bok se Puts. A further 23 individuals were recorded from in around the Riemvasmaak settlement.

Appendix 7: List of mammal species and their abundances determined by the National Parks Board during helicopter surveys in "Bokvasmaak"[a] and Riemvasmaak in March 1995. Calves <1 yr are listed in parentheses, except rhino calves which are assumed to be < 2yrs. Data are compiled from Knight (1995a, 1995b) who should be consulted for details of methodology.

LOCATION	SPECIES							
	Black rhino	Giraffe	Eland	Gems bok	Kudu	Spring bok	Steen bok	Klip springer
"**Bokvasmaak**"	5(2)	9(1)	8	20(2)	2	81	-	11
Riemvasmaak								
Plateau	0	0	0	18	27	0	1	1
Bak River	0	0	0	0	2	0	0	0
Orange & Lower Kourop Rivers	0	0	0	0	6	0	0	0
Kourop River	0	0	0	0	0	0	0	4
Lower Molopo River	0	0	0	0	3	0	0	1
Upper Molopo River	0	0	0	0	5	0	0	0
"Wildevallei"/Droëputs	0	0	0	13	16	26	0	0
Gyam/Vaalputs	0	0	0	0	5	0	4	1
TOTAL FOR RIEMVASMAAK	0	0	0	31	64	26	5	7[b]
GRAND TOTAL	7	10	8	53	66	107	5	18

[a] "Bokvasmaak" refers to that part of Riemvasmaak leased to the National Parks Board on the north bank of the Orange River but it also includes a small area of the farm Waterval (see Anonymous, 1991 in bibliography).

[b] We observed 89 Klipspringers during the course of our ground survey in Riemvasmaak. The National Parks Board helicopter census provides a significant underestimate of this cryptic species.

REFERENCES

KNIGHT M H 1995a. Helicopter survey of Augrabies Falls National Park, March 1995. Unpublished internal report. National Parks Board, Kimberley. 3pp.

KNIGHT M H 1995b. Helicopter survey of Riemvasmaak, March 1985. Unpublished internal report. National Parks Board, Kimberley. 2pp.

Appendix 8: Description of photostations in Riemvasmaak with information about their location (see also Fig. 1.13), direction of focus, camera height, date and time of exposure and the landforms within the main field of view that were identified and sampled during January 1995. The photograph of the main field of view at each photostation follows the table.

No.	NAME	LOCATION	GRID REFERENCE	DEGREES	HEIGHT (cm)	DATE	TIME	LANDFORMS IDENTIFIED & SAMPLED
1	DEKSEL WEST	ca. 1 km W of Deksel, looking E to Kouropberg	S 28 21 36.5 E 20 08 47.3	90° E	155.5	17/1/95	18h20	1a Rocky pediment 1b Narrow & rocky river bed
2	UPPER KOUROP VALLEY	1.25 km S of Deksel, looking down Kourop River Valley; a few hundred metres east of the road	S 28 22 36.7 E 20 09 22.0	212° SSW	160	18/1/95	08h18	2a Rocky footslope 2b Rocky pediment 2c Narrow & rocky river bed[a] 2d Rocky pediment 2e Rocky pediment 2f Sandy pediment
3	DEKSEL SOUTH	1.2 km S of Deksel, looking N to Kouropberg, ca. 50 paces N of location for photostation 2	S 28 22 15.1 E 20 09 22.7	8° N	157	18/1/95	08h42	3a Rocky footslope 3b Wide & saline river bed 3c Rocky pediment 3d Rocky pediment
4	NARUXAS	ca. 5.4 km ENE of Deksel, looking NE to farm Naruxas (Narougas) as road turns to ascend plateau	S 28 20 16.4 E 20 12 21.2	40° NE	146	18/1/95	17h39	4a Rocky footslope 4b Narrow & rocky river bed 4c Narrow & rocky river bed 4d1 Rocky pediment 4d2 Rocky pediment 4e1 Rocky hillslope 4e2 Rocky hillslope
5	PLATEAU	On top of the plateau, just E of a large pan, 50 paces south of road	S 28 22 09.1 E 20 15 51.2	250° WSW	159	19/1/95	08h15	5a Plateau 5b Sandy pediment 5c Pan
6	BERYLKOP	5.05 km N of Riemvasmaak Mission Station, just W of	S 28 24 14.8 E 20 18 35.8	180° S	?ca. 145	19/1/95	11h08	6a Sandy pediment 6b Wide & sandy river bed

		road						
7	‖ANA‖AS	9.35 SW from Riemvasmaak Mission Station, ca. 200 N of road	S 28 28 40.4 E 20 13 02.3	324° NW	149	20/1/95	09h33	7a Sandy pediment 7b Wide & sandy river bed 7c Sandy pediment
8	MOSTERTSHOEK	5.6 km ENE of Xubuxnap, ca. 750 m N of road	S 28 27 34.5 E 20 10 32.8	99° E	158	20/1/95	15h32	8a Sandy pediment 8b Wide & sandy river bed 8c Rocky pediment 8d Rocky toeslope
9	XUBUXNAB	Just above old settlement at Xubuxnap	S 28 28 37.0 E 20 07 44.4	18° NNE	152.5	21/1/95	08h10	9a Sandy pediment 9b Inselberg 9c Inselberg
10	PETRUSHOEK	2.1 km NW of top of Koelmanskop, just above 650 m contour.	S 28 26 45.4 E 20 0.6 39.1	296° WNW	153	21/1/95	11h16	10a Rocky footslope 10b Rocky pediment 10c Sandy pediment
11	LOWER KOUROP VALLEY	2.2 km NE of Xubuxnap, on hillsope ca. 200 NE of road	S 28 27 49.9 E 20 08 25.2	134° SE	160	21/1/95	16h03	11a Sandy pediment 11b Wide & sandy river bed 11c Inselberg
12	MOLOPO FAN	On top of high point 514 m; 1.1 km N of where the Molopo River enters the Orange River	S 28 30 26.8 E 20 12 57.1	290° WNW	141	22/1/95	07h42	12a1 Wide & sandy river bed 12a2 Wide & sandy river bed 12b Wide & sandy river bed 12e1 Wide & saline river bed[b] 12e2 Wide & saline river bed
13	DESCENT TO MOLOPO RIVER	Just above where road turns sharp corner	S 28 28 56.7 E 20 13 47.9	254° WSW	154	22/1/95	12h26	13a Rocky pediment, below escarpment 13b Rocky pediment, below escarpment
14	RIEMVASMAAK MISSION EAST	1 km SE of Riemvasmaak Mission Station	S 28 27 22.6 E 20 18 59.7	104° ESE	153	22/1/95	16h11	14a Wide & saline river bed 14b Sandy pediment 14c Sandy pediment
15	LOERIESFONTEIN RIVER	2.9 km ESE of Bok se Puts, 200 m N of road	S 28 21 03.1 E 20 05 12.1	224° SW	153	23/1/95	11h44	15a Sandy pediment 15b Rocky footslope 15c Inselberg
16	UPPER BAK RIVER	5.3 km NNE of Bok se Puts, 500 m W of road	S 28 17 25.1 E 20 01 21.2	104° ESE	151	23/1/95	16h20	16a Rocky pediment 16b Wide & sandy river bed

								16c1 ?Rocky pediment overlain by Kalahari sand 16c2 Rocky footslope 16d Narrow & rocky river bed 16e Rocky footslope
17	DONKIEMOND	950 m E of road	S 28 21 06.3 E 20 00 59.9	180° S	152.5	24/1/95	08h32	17a Sandy pediment 17b Rocky toeslope
18	NEAR BOK SE PUTS	950 m W of Bok se Puts, ca. 600 SW of road	S 28 19 29.1 E 20 02 20.1	258° WSW	157.5	24/1/95	10h19	18a Sandy pediment 18b Sandy pediment 18c Rocky pediment 18d Wide & sandy river bed
19	DEURSPRING	5.6 km S of Deksel, on top of low koppie, 200 m E of road	S 28 24 28.0 E 20 08 37.6	246° WSW	154	24/1/95	15h31	19a Sandy pediment 19b Wide & saline river bed
20	DEKSEL EAST	2.05 km E of Deksel, 100 m above road	S 28 21 26.2 E 20 10 42.4	80° ENE	153.5	24/1/95	18h08	20a Rocky pediment 20b Narrow & rocky river bed
21	ABOVE MOLOPO GORGE	1.9 km SW of the Mission Station	S 28 26 51.1 E 20 17 03.4	215° SW	158.5	25/1/95	07h52	21a Rocky pediment, below escarpment
22	DROËPUTS	6 km W of the Mission Station, or ca. 3.5 km NW of high point 759 m on Hoed se Kop	S 28 26 44.5 E 20 14 55.5	317° NW	143	25/1/95	11h55	22a Rocky footslope, below escarpment 22b Wide & sandy river bed 22c Sandy pediment 22d Wide & sandy river bed 22e Rocky pediment
23	PERDEPOORT	ca. 400 m N of the the settlement at Perdepoort	S 28 23 57.7 E 20 23 52.9	26° NNE	150.5	26/1/95	09h54	23a Wide & sandy river bed 23b Sandy pediment 23c Sandy pediment 23d Inselberg
24	GYAM/VAALPUTS	600 m SE of old homestead at Gyam/Vaalputs	S 28 22 27.3 E 20 21 57.6	126° SE	138.5	26/1/95	14h12	24a Sandy pediment 24b Wide & sandy river bed 24c Sandy pediment 24d Wide & sandy river bed (Kalahari dunes)
25	WATERVAL SOUTH	Just east of the Waterval boundary, 7.25 km east of	S 28 32 03.6 E 20 20 13.3	70° ENE	138	27/1/95	10h34	25a Rocky pediment, below escarpment 25b Rocky footslope, below escarpment

		Wabrand						
26	WATERVAL NORTH	550 m E of boundary between Waterval and Riemvasmaak	S 28 26 13.1 E 20 20 48.9	330° NNW	150	28/1/95	12h34	26a Wide & sandy river bed 26b Wide & sandy river bed
27	PERDEPOORT - GYAM/VAALPUTS CROSSROADS	1.3 km NE of where road enters Riemvasmaak again from Waterval	S 28 25 28.5 E 20 23 09.7	30° NNE	147.5	28/1/95	15h53	27a Sandy pediment 27b Wide & sandy river bed 27c Wide & sandy river bed
28	RIEMVASMAAK MISSION NORTH	1.95 km NNE of Riemvasmaak Mission Station, 100 m W of road	S 28 26 03.0 E 20 18 24.8	170° S	152	28/1/95	17h49	28a Rocky footslope, below escarpment 28b Sandy pediment 28c Wide & sandy river bed
29	BLYSTAAN	3.7 km SE of the Mission Station, 300 m W of the road	S 28 28 58.2 E 20 19 23.9	278° W	156	29/1/95	08h42	29a Rocky pediment, below escarpment 29b Rocky pediment, below escarpment 29c Rocky pediment, below escarpment

[a] Our landform classification has proven problematic in a few cases, such as 2c, in the Kourop River valley. This is clearly a wide and sandy river bed but the river banks are rocky and are dominated by plants that are more typically represented in narrow and rocky river beds.

[b] Both 12e1 and 12e2 are of the Molopo River bed itself which is more densely vegetated. 12e1 is of the lower reaches while 12e2 is a sample of the upper reaches of the MolopoRiver above |Hus in Fig. 1.2.

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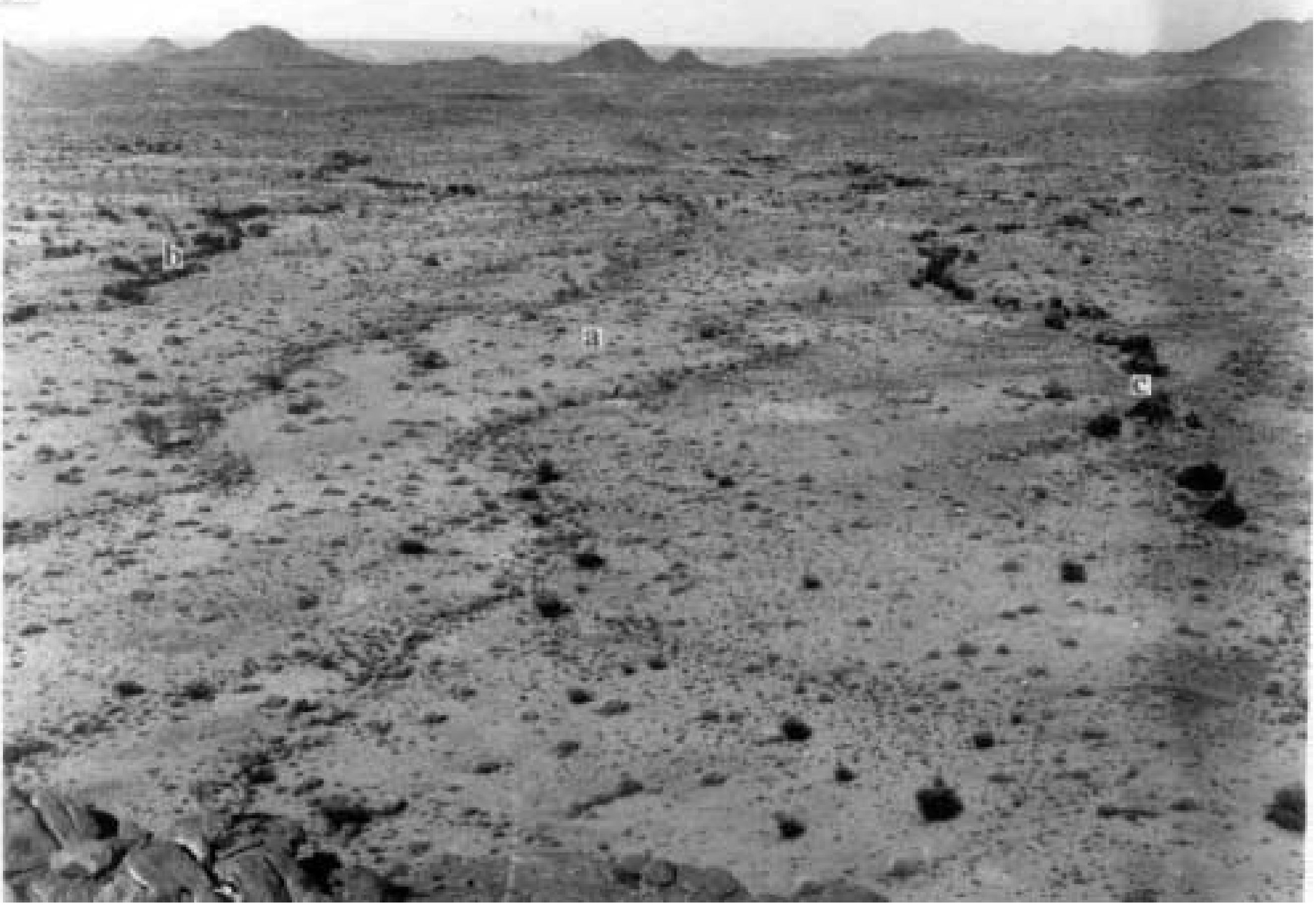

Appendix 9: Large stock unit (LSU) equivalents of grazing animals. Compiled from Table 2 in Anonymous (1984).

Kind of animal	Sex and phase of production	Number of LSU's equivalent to one animal
Cattle	Calf, unweaned	0.50
	Young animal, unshed	0.75
	Female or ox, 2-tooth & older	1.10
	Bull, 2-tooth and older	1.50
Woolled sheep	Lamb, unweaned	0.05
	Young sheep, unshed	0.12
	Sheep, 2-tooth and older	0.14
	Ram, 2-tooth and older	0.19
Dual-purpose sheep	Lamb, unweaned	0.08
	Young sheep, unshed	0.15
	Sheep, 2-tooth and older	0.17
	Ram, 2-tooth and older	0.25
Mutton sheep	Lamb, unweaned	0.05
	Young sheep, unshed	0.13
	Sheep, 2-tooth and older	0.15
	Ram, 2-tooth and older	0.23
Karakul sheep	Lamb, unweaned	0.05
	Young sheep, unshed	0.13
	Sheep, 2-tooth and older	0.14
	Ram, 2-tooth and older	0.20
Boer goats	Lamb, unweaned	0.08
	Young goat, unshed	0.15
	Goat, 2-tooth and older	0.17
	Ram, 2-tooth and older	0.22
Angora goats	Lamb, unweaned	0.04
	Young goat, unshed	0.09
	Goat, 2-tooth and older	0.11
	Ram, 2-tooth and older	0.15
Shetland ponies	Foal, unweaned	0.15
	Young animal, unshed	0.30
	Animal with 2 permanent incisors & older	0.40
Large ponies & donkies	Foal, unweaned	0.25
	Young animal, unshed	0.50
	Animal with 2 permanent incisors & older	0.65
Light horses & mules	Foal, unweaned	0.30
	Young animal, unshed	0.60

	Animal with 2 permanent incisors & older	1.00
Medium draft horses	Foal, unweaned	0.25
	Young animal, unshed	0.50
	Mare with 2 permanent incisors & older	1.20
	Stallion or gelding with 2 permanent incisors & older	1.30
Heavy draft horses	Foal, unweaned	0.50
	Young animal, unshed	1.00
	Animal with 2 permanent incisors & older	1.50
	Stallion or gelding with 2 permanent incisors & older	1.60
Ostriches	Chick	0.12
	Young bird	0.26
	Mature bird	0.37
Elephants	Calf, unweaned	1.00
	Weaned and older	4.00
Giraffe	Calf, unweaned	0.75
	Weaned and older	1.50
Eland	Calf, unweaned	0.50
	Female animal, weaned and older	1.00
	Male animal, weaned and older	1.30
Buffalo	Calf, unweaned	0.50
	Female animal, weaned and older	1.00
	Male animal, weaned and older	1.20
Zebra	Foal, unweaned	0.50
	Weaned and older	0.70
Kudu	Calf, unweaned	0.20
	Female animal, weaned and older	0.40
	Male animal, weaned and older	0.50

ANONYMOUS 1984. Conservation of Agricultural Resources Act, 1983 (Act 43 of 1983). *Government Gazette* 227(9238), 25 May, 1984.

Appendix 10: Checklist and abundance classes of plant species collected by John Acocks in May 1952 at two localities in and adjacent to Riemvasmaak and re-surveyed by the National Botanical Institute's survey team in January 1995 (see Appendix 8 for photostation details). Taxonomic nomenclature is the same as for Appendix 3. Abundance classes are detailed in Acocks (1988): ab = abundant; c = common; f = frequent; ff = fairly frequent; o = occasional; r = rare. l = local; ll = very local. A capital letter for an abuncance class indicates that a species is conspicuous in the landscape. + and - indicate more or less; ↓↑ are lower and upper slopes respectively, ^{e} = rocky krantz; ^{N} = North slope; ^{s} = on shallow soil; T = under tree; t = under shrub; ^{W} = river banks; ^{w} = dry water course.

Researcher(s)	Acocks	NBI	Acocks	NBI
Date	21/5/52	25/1/95	22/5/95	27/1/95
Site or photostation No.	1647	21	1648	25

SPECIES	ABUNDANCE CLASS			
Abutilon angulatum			F-↑	
Abutilon pycnodon		o		o-
Acacia erioloba	r	r		
Acacia mellifera	r	ff+	O+↓^{s}	FF-↓^{s}
Adenia repanda			r^{s}	
Adenolobus gariepensis	oR	oR	R	
Aizoon asbestinum	r+		ff↓	
Aizoon schellenbergii			ff+↓	
Aloe dichotoma	R		R	R
Amaranthus praetermissus	r		r	
Anthephora ramosa	r		ff.llf	
Antherothamnus pearsonii			FF-^{s}	
Aptosimum lineare			f↓	
Aptosimum marlothii	llf		lff	
Aptosimum spinescens		o-		o
Aridaria sp.			r	
Aristida adscensionis	ff		c	
Aristida engleri	ff		ff.lF+	
Aristida congesta				r

Barleria rigida	o	o	o↓	r↓
Berkheya canescens	o			
Berkheya spinosissima			o	r
Blepharis acaulis			ff	
Blepharis furcata		r		o
Boerhaavia sp.			r↑	
Boscia albitrunca	R	R+	r+	o-
Boscia foetida		o	r+	r
Bowiea volubilis	f[e]			
Bulbostylis hispidula			llab	
Cadaba aphylla		r	r	r+
Cenchrus ciliaris				R
Ceraria namaquensis	o		o.FF+[N]	FF
Ceterach cordatum			r[es]	
Chamaesyce inaequilatera			r	
Cheilanthes deltoidea			ff[e]	
Chloris virgata			llab↓[s]	
Cleome oxyphylla		ff	r↑	o-
Cleome angustifolia				r
Coccinea rehmannii			ct	
Codon royeni	o	r	ff	lo
Commiphora oblanceolata (?=gracilifrondosa)			R+	
Commiphora gracilifrondosa		o		o-
Corbichonia decumbens		r		
Crassula ausensis			o[es]	
Cucumis saggitatus			o↑	
Curoria decidua		r+	o	
Cyperus sp.			llc↓[W]	
Danthoniopsis ramosa	ff[e]			
Diandrochloa namaquensis			llo↓[W]	
Digitaria sp.			ff.llf	
Dipcadi glaucum	o		r	
Dyerophytum africanum	r	o	o-	r
Ehretia rigida			r	
Enneapogon cenchroides	o	o+	ff	o
Enneapogon desvauxii	ff		f	
Enneapogon scaber	f	f	c	c
Eragrostis annulata	ff		lc	
Eragrostis biflora			r[es]	
Eragrostis lehmanniana			llab↓[W]	r
Eragrostis nindensis			r↓	

Eragrostis planiculmis			llab↓[W]	
Eragrostis porosa	lf		lab	
Eragrostis rotifer			llC↓[W]	
Eriospermum sp.			llab↓[W]	
Euclea undulata			r[s]	o-
Euphorbia avosmontana			lR+[N]	r
Euphorbia decussata (?=rhombifolia)	o		o	
Euphorbia gregaria	FF+	o	O.FF+↓	O-↓
Euphorbia rhombifolia		o-		f-
Ficus ingens			vr[s]	
Forsskaolea candida	c[e]	o-	ab↑	
Geigaria filifolia			lf↓	
Geigaria vigintisquamea			f	
Gisekia pharnaceoides	f			
Gladiolus sp.			r	
Grewia flava	r			
Helichrysum tomentosulum			r↑	
Hermannia spinosa	ff	o+	f-↓	
Hermannia stricta		o+	r↓	r
Hermannia vestitia	r		ff↑	
Hibiscus elliottiae		r	ff	
Hibiscus fleckii	r		ff↑	
Hoodia sp.			r	
Indigofera heterotricha	o	ff	ff	o
Indigofera pungens	F-	o		
Kissenia capensis	r		o↓[W]	
Lepturella capensis[1]	ff			
Leucosphaera bainesii	o		lff↓	
Limeum aethiopicum	r	o+	o↓	r
Limeum myosotis	ff+	ff+	ff	r
Lophiocarpus polystachys				r
Lotononis crumanina	ff			
Lotononis platicarpa			o↓	
Lycium cinereum			r.o+[s]	
Lycium oxycarpum	r			
Lycium prunis-spinosa				o-
Maerua gilgii			r	
Maytenus heterophylla			r↑	
Melhania didyma			o↑	
Melhania genistifolium				
Melinis repens	ff		ff	
Microloma incanum		r	r	r+

Mollugo cerviana			lc	
Monechma genistifolium		r	o↓	o
Monechma spartioides	ff+	ff+	F-↓	o
Montinia caryophyllacea	r		r+	
Nolletia gariepina			o[e]	
Nymannia capensis	r		r	
Oldenlandia filifolia	r		o	
Ornithogalum sp.			r	
Ornithoglossum viride	o			
Osteospermum microcarpum			o	
Ozoroa concolor (?=crassinervia)			R	
Ozoroa crassinervia				R
Panicum arbusculum		o+		r
Panicum sp. (?scopelophilum = ?arbusculum)	o		ff	
Pappea capensis	R+	R	R[w]	R[w]
Peliostomum leucorrhizum	r	o	ff-	lo
Pentzia argentea			r[e]	
Petalidium oblongifolium	F-		ff↓[W]	
Phyllanthus burchellii			o[e]	
Pollichia campestris			r[e]	
Polygala leptophylla	o			
Portulaca oleracea			r	
Protasparagus cooperi	r			
Protasparagus retrofractus				r
Protasparagus suaveolens (?=retrofractus)			r[s]	
Pteronia sp.				r
Putterlickia pyracantha				r
Rhigozum trichotomum	o	o	o↓	o
Rhus populifolia	r	r	O-	r
Rhyncosia longiflora	ot	r+	ot	r
Rogeria longiflora	lf[e]		ff↑	
Salsola aphylla		r		o
Salsola tuberculata			r	
Sarcocaulon sp.			r↓	r
Sarcostemma viminale			lff↓	
Schotia afra	O	ff+	O	O
Schmidtia kalahariensis			r	
Scirpus sp.			llab↓[W]	
Senecio longiflora			r	r
Senecio sisymbrifolius	f[e]		f[e]	
Sericocoma avolans	o	o	ff-	r

Sesamum capense		r	r	r
Setaria appendiculata	o+		o	r
Setaria verticillata			llabT	
Sisyndite spartea	F	F		
Solanum capense	r		o	o-
Solanum catombelense			r	r
Stachys burchelliana			ff↑	
Stipagrostis anomela	lf	r	lf↓	
Stipagrostis ciliata		r	llf↓	llff-
Stipagrostis obtusa		o	lf↓	o
Stipagrostis hochstetteriana				o
Stipagrostis namaquensis				
Stipagrostis uniplumis	ff	f	F.lC-	F.lC-
Sutera ramosissima			ff-^{e}	
Sutera tomentosa	r		r	
Tephrosia dregeana		r	o	
Tetragonia arbuscula	r		rt↓	r
Thesium lineatum			r	r
Trianthema parvifolia			o	
Tribulis cristatus	f			
Tribulis terrestris		o		r
Trichodesma africanum			lc^{e}	r
Triraphis ramosissima	r	o+		o
Zygophyllum dregeanum			o↓	
Zygophyllum gilfillani	r			
Zygophyllym simplex		r+		
Zygophyllym suffruticosum			lf↓	lf
TOTAL NO. OF SPECIES	70	50	131	63

[1] *Lepturella capensis* is not listed in Arnold & De Wet (1993).

REFERENCES

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