THE INFLUENCE OF MOUNTAIN CATCHMENT AREA CONTROL MEASURES ON LAND MANAGEMENT IN THE GROOT-WINTERHOEK AREA OF THE WESTERN-CAPE : ECOLOGICAL, ECONOMIC AND SOCIAL IMPLICATIONS

by

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ABSTRACT

This study is about conservation of water source areas.

The study area comprises the Groot Winterhoek Mountain Catchment Area, as proclaimed in terms of the Mountain Catchment Areas Act (No. 63 of 1970) and the associated State Forest. Physical attributes and location of the area in the western-Cape are described on the basis of published work, unpublished Departmental records and a field survey.

Published works and archival material were consulted to determine probable pre-European settlement land use and post-settlement land use up to the present time. Questionnaires and field surveys were used to determine current land use and the effect of past and present use on study area ecosystems. Serious degradation appears to have occurred only over the last 70 to 80 years.

Questionnaires and personal interviews provided material for the discussion of attitudes toward Government control in mountain catchments and its social and economic implications.

Finally, a procedure for deciding optimum land use in mountain catchments, including a flexible land classification system and a decision model that accommodates both quantifiable and non-quantifiable factors is proposed and demonstrated.

OPSOMMING

Die studie handel oor bewaring van water bron-gebiede.

Dit is uitgevoer in die Groot-Winterhoek Bergopvanggebied, soos geproklameer in terme van die Wet op Bergopvanggebiede (Nr. 63 van 1970) en die aangrensende Staatsbos. Die fisiese eienskappe en ligging van die studiegebied in die Wes-Kaap word beskryf op grond van gepubliseerde inligting, ongepubliseerde Departementele rekords en ´n veldopname.

Gepubliseerde stukke en argiefmateriaal is nagegaan om waarskynlike voor-setllar grondgebruik asook na-setlaar grondgebruik tot op hede vas te stel. Vraeboë en veldopnames is gebruik om huidige grondgebruik te bepaal asook die uitwerking van vorige en huidige gebruik op die ekostelsels van die gebied. Dit wil voorkom of ernstige agteruitgang beperk was tot die laaste 70 tot 80 jaar.

Die gesindheid teenoor Staatsbeheer in bergopvanggebied en die sosiale en ekonomiese implikasies daarvan is deur vraeboë en persoonlike onderhoude bepaal en word bespreek.

Ten laaste word ´n prosedure vir besluitneming oor optimale grondgebruik in bergopvanggebiede voorgestel en gedemonstreer. Die prosedure sluit in ´n besluitnemingsmodel wat beide kwantifiseerbare en nie-kwantifiseerbare faktore akkommodeer.

1. INTRODUCTION

1.1 Conservation is defined as wise use. The aim of this study is to promote the conservation of two essential and finite natural resources; water and land.

1.2 In an address delivered before the Standing Committee for Forestry of the Southern African Regional Committee for the Conservation and Utilization of the Soil (SARCCUS) in September 1969, the late Dr. C.L. Wicht made the following statements: "Forestry is an applied science developed by man to improve his environment - directly or indirectly - and ensure his well-being".

"The role of forestry in human environment can best be appreciated if we apply to forest the original meaning of the word. It is derived from the Latin Foris, meaning `outside´ and forestis in the Latin of the middle ages meant an area lying outside the boundary of the village or park and not fenced in. Originally forest therefore referred to all uncultivated or untended land, ..." (Wicht, 1969). In the same paper he listed five basic principles that should be considered when framing a national forest policy. The first was: "Sufficient land must be reserved for forestry to protect climate, soil and water supplies, to yield recreational, scientific, aesthetic and other accessory benefits, and to produce supplies of wood to meet expected demands".

1.3 South African forestry legislation, from the first Forest Act (Act No. 28), promulgated by the Cape Colonial Government in 1888, indicates that Professor Wicht's approach was in fact a traditional one. Apart from making provision for protecting and supplementing timber resources the Act enabled the Governor to "protect any portion of a Crown Forest or private forest for the maintenance of water supplies", and so on, "or in the interests of public health". Furthermore, all forest produce enjoyed protection and, by definition, forest produce included all wild flora and fauna (Forest Act No. 28 of 1888 in Wicht and Kruger, 1973). It is interesting to speculate that even at that early date the vital role of nature oriented outdoor recreation in maintaining public health was appreciated.

1.4 In the early 1900's there was still considerable debate about the advantages and disadvantages of afforestation as a device for climatic amelioration and water conservation. In spite of Ebermayer's categorical statement that "... there is no doubt that forests are the greatest consumers of water on the face of the earth ... and of all forms of vegetation, closed canopy forest is that which dries out the earth most" (Ebermayer, 1881 in Wicht and Kruger, loc cit). C.C. Robertson, the Conservator of Forests of the Orange Free State wrote in 1908 that "There is no more important problem before South Africa than that of water conservation, and afforestation will prove one of the most efficient as it is the most natural means towards this end". (Robertson 1908 in Wicht and Kruger, loc. cit.), and C.D.H. Braine, an engineer in the Transvaal Department of Irrigation wrote "Afforestation is of vital importance for maintaining the permanence of streams ..." (Braine, 1908 in Wicht and Kruger, loc. cit.). A little over 20 years later the Drought Investigation Commission appointed by the Union Government in 1923 commented in its report that: "much of the veld that is currently used for grazing and must be burnt frequently for this purpose, would be more profitably used for growing trees ..." (Wicht and Kruger, loc. cit.). The Commission also reported that afforestation with the right species would help to regulate the flow of the Country′s rivers (op. cit.). In the early 1930′s many were still convinced that either natural or artificial forest was the best protective cover for mountain catchment areas. It is interesting to note that in the first decade of this century members of the Mountain Club were given free pine seed by the Cape colonial Department of Forestry and encouraged to sow it in the mountains (Hutchins, 1906). It is of course now common knowledge that plantations of exotic trees reduce streamflow relative to natural vegetation types such as grassland or fynbos (van der Zel and Kruger, 1975; van Wyk, 1977; Bosch, 1981). The legal requirement introduced in an amendment to the Forest Act in 1972, that landowners obtain formal permission before planting timber trees on a commercial scale, is largely aimed at controlling afforestation in catchment areas.

1.5 In the mid to late 1930's extensive areas of mountain land were purchased by the Government for the conservation of water sources and natural vegetation. These areas were added to the already considerable estate entrusted to the Department of Forestry for control and management. In its report to the Soil Conservation Board, an interdepartmental committee set up to investigate and report upon conservation of mountain catchments recommended, among other things, that "The ideal solution would be for the State ... to acquire control of all mountain catchment land", (Ross et al, 1961). While not explicitly stated, it is clear that many regarded outright purchase or expropriation to be the best, if not the only way to acquire control of the mountain catchments and proceeded accordingly. However, the Mountain Catchment Areas Act, No. 63 of 1970, enables the Government to proclaim any land to be a Mountain Catchment Area and thereafter to exercise control over land use and land management within the proclaimed area. Control of mountain catchments can therefore be acquired by the State without the need to purchase or expropriate property.

1.6 Government policy for State Forest mountain catchments is clear. It is based upon the principle of multiple use, with water and nature conservation as primary management objectives. Nature oriented outdoor recreation opportunities are provided wherever this form of land use is clearly compatible with the primary objectives. While afforestation is retained as a management option on all State Forest lands other than those portions that have been proclaimed Nature Reserves or Wilderness Areas in terms of the Forest Act, the proportion of the total State Forest area afforested or recorded as available for afforestation is small (18,3%; 1981/82 Departmental Annual Report) whereas the proportion with special conservation status is growing (0,2% in 1971 to 18,9% in 1981; Departmental Annual Reports).

1.7 Government policy concerning important mountain catchments in private ownership can also be regarded as clear, but the action taken to implement the policy, including proclamation of Mountain Catchment Areas in terms of Act 63 of 1970, is not always understood by the land owners and others involved.

1.8 In 1961 an interdepartmental committee recommended that the headwaters of the Vier-en-Twintig-Riviere, in the Groot Winterhoek mountain area north of Tulbagh and east of Porterville in the Western Cape, should be reserved and protected for water production and that farming in the area concerned should be discontinued (Correspondence on Departmental files). Steps were taken to implement the recommendations and the farms in the area were either purchased after negotiation or expropriated where negotiation failed or was considered impracticable, as in the case the estate of a deceased person. Both former land owners and members of the remaining farming community of that general area voiced dissatisfaction with the arguments put forward to support the action taken and expressed doubt about the need to stop all farming. The question of what effect the farming activities were having, or might have, on either the quantity or quality of the area's water resources was raised (Correspondence of Departmental files and pers. com.).

1.9 It is generally agreed that an owner's right to free and unrestricted use of his mountain property should only be curtailed if his use is actually or potentially causing unacceptable degradation, such as soil erosion, or significant changes to the seasonality, quantity or quality of the water resource. This implies, for example, that a farmer should be free to convert any natural ecosystem on his property to an artificial system provided that the conditions required to ensure sound water conservation are met. However, lack of knowledge of the effect of manipulating or converting natural mountain ecosystems on hydrological processes, and hence on water yields, and lack of trained personnel to staff an effective catchment advisory and control unit, make it essential for the State to adopt a conservative approach when dealing with the conservation of so vital a natural resource. The Government has a responsibility to ensure that the Nation's water resources are conserved and it must be expected to do this to the best of its ability. Water resources are finite and the commodity is becoming increasingly scarce relative to demand; but land is also a finite resource that is coming under ever increasing pressure from competitive uses. The Government can therefore be expected to work towards ensuring optimum land use, in mountain catchments no less than anywhere else. Multiple land use is an obviously attractive goal but the identity of the elements of the multiple use matrix is by no means obvious.

1.10 The study which is the subject of this report, was undertaken in an attempt to find answers to questions posed about mountain catchments and their control, to determine the ecological, social and economic implications of State control of mountain catchment land use, to assess actual and potential impact of various forms of land use on the study area and to suggest a method of deciding upon an optimum land use pattern.

1.11 There are four distinct parts to the study, which was conducted in the proclaimed Groot Winterhoek Mountain Catchment Area of the Western Cape and the associated State Forest, which includes the headwaters of the Vier-en-twintig-Riviere. The first part deals with the physical attributes of the area; the second concerns past and present land use and the effects of that use on the physical and other attributes of the area; the third is an enquiry into and discussion of social and economic questions relevant to the use of the study area and the steps taken by the Government to protect the catchment and the fourth part comprises the investigation and testing of a method for deciding upon optimum land use in mountain catchments. This includes a flexible land classification system and a decision aid model that accommodates both quantifiable and non-quantifiable factors.

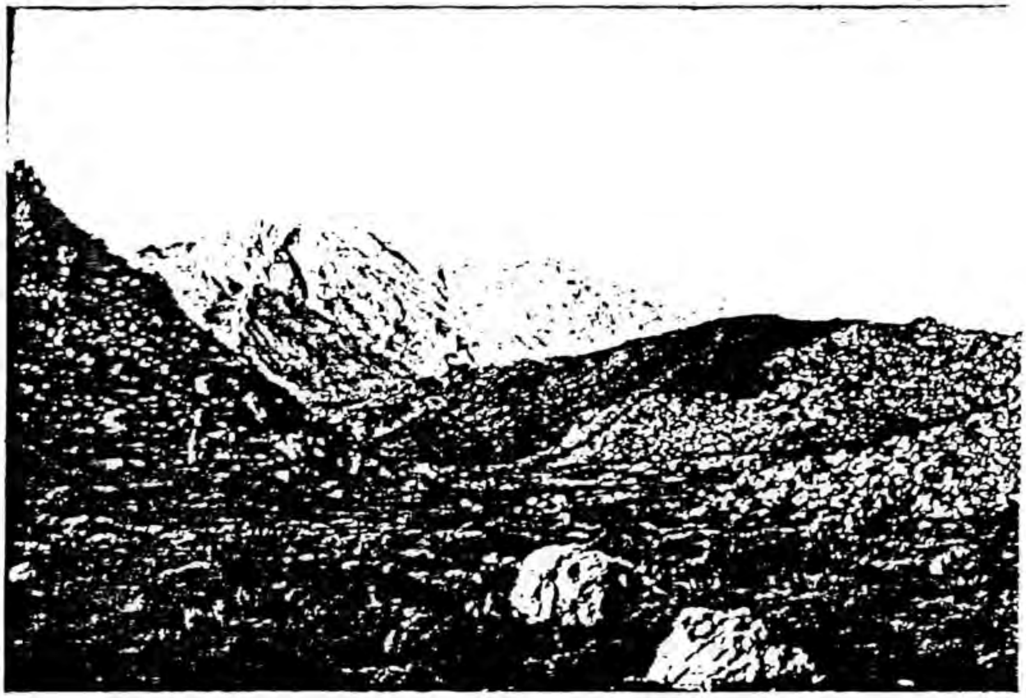


PHOTO 1

Groot Winterhoek Peak in the heart of the study area.

2. DESCRIPTION OF THE STUDY AREA

2.1 Location (Map 1)

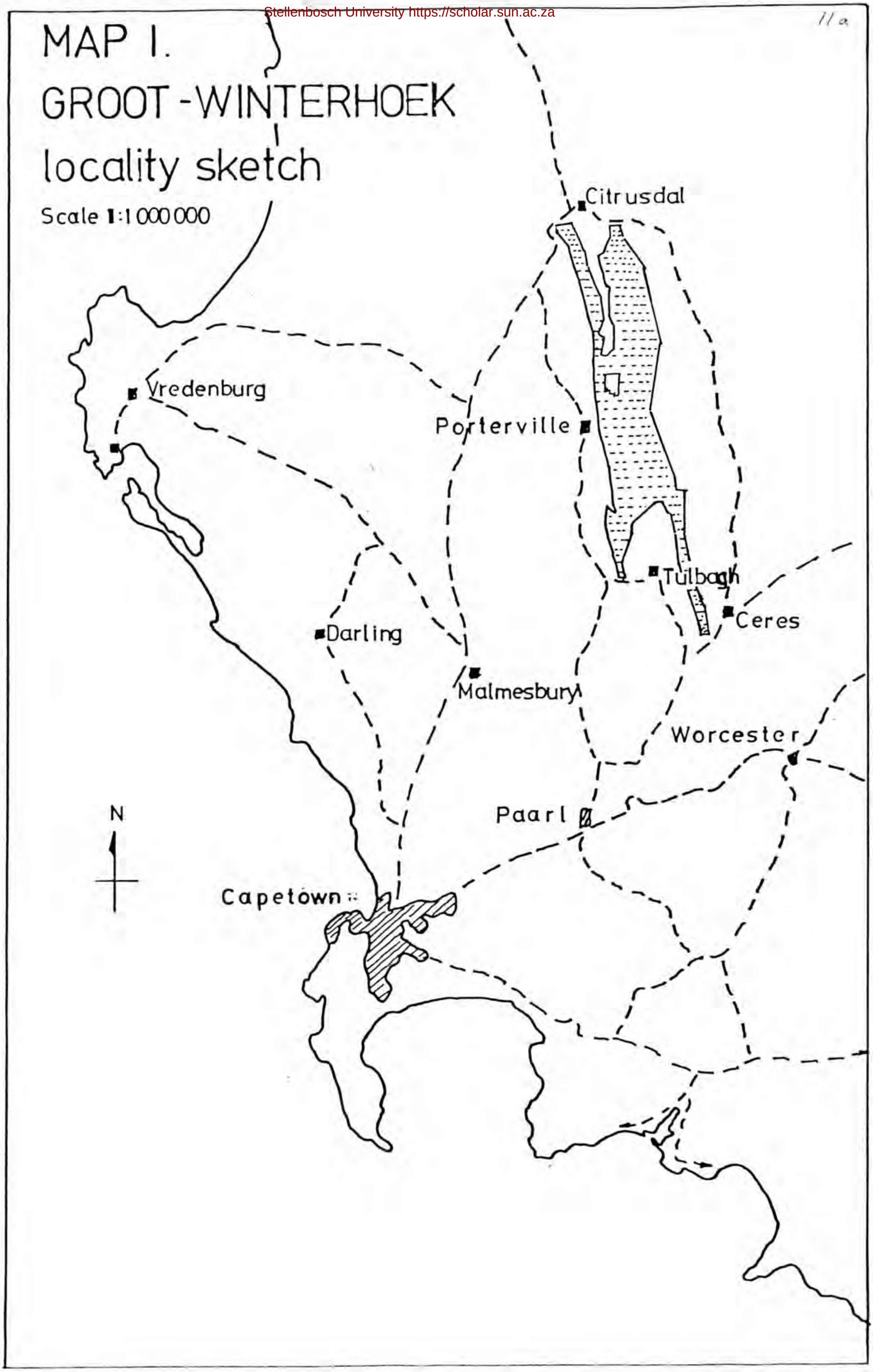
2.1.1 The study area is located in the south-western Cape Province of the Republic of South Africa between approximately 32 35′ and 33 25′ south latitude and 18 55′ and 19 16′ east longitude. It comprises the Groot-Winterhoek mountain catchment management area which in turn comprises all State Forest within the area and the area of non-State Forest, including both private and State owned land, proclaimed in terms of the Mountain Catchment Areas Act (Act Number 63 of 1970).

2.2 Land ownership status (Map 2)

2.2.1 Map 2 indicates land ownership status and Table 1 gives approximate areas per ownership class.

2.3 Centres of development and communications (Map 3)

2.3.1 Map 3 illustrates the position of the area in relation to the Cape Town - Atlantis - Vredenburg-Saldanha development axis and to other relevant centres of development in the south-western Cape Province (Page, 1973).


MAP I.
GROOT-WINTERHOEK
locality sketch
Scale 1:1000000
Citrusdal
Vredenburg
Porterville
Tulbagh
Ceres
Darling
Malmesbury
Worcester
Paarl
Capetown
N

MAP 2

GROOT WINTERHOEK Mountain Catchment

Scale 1:250 000

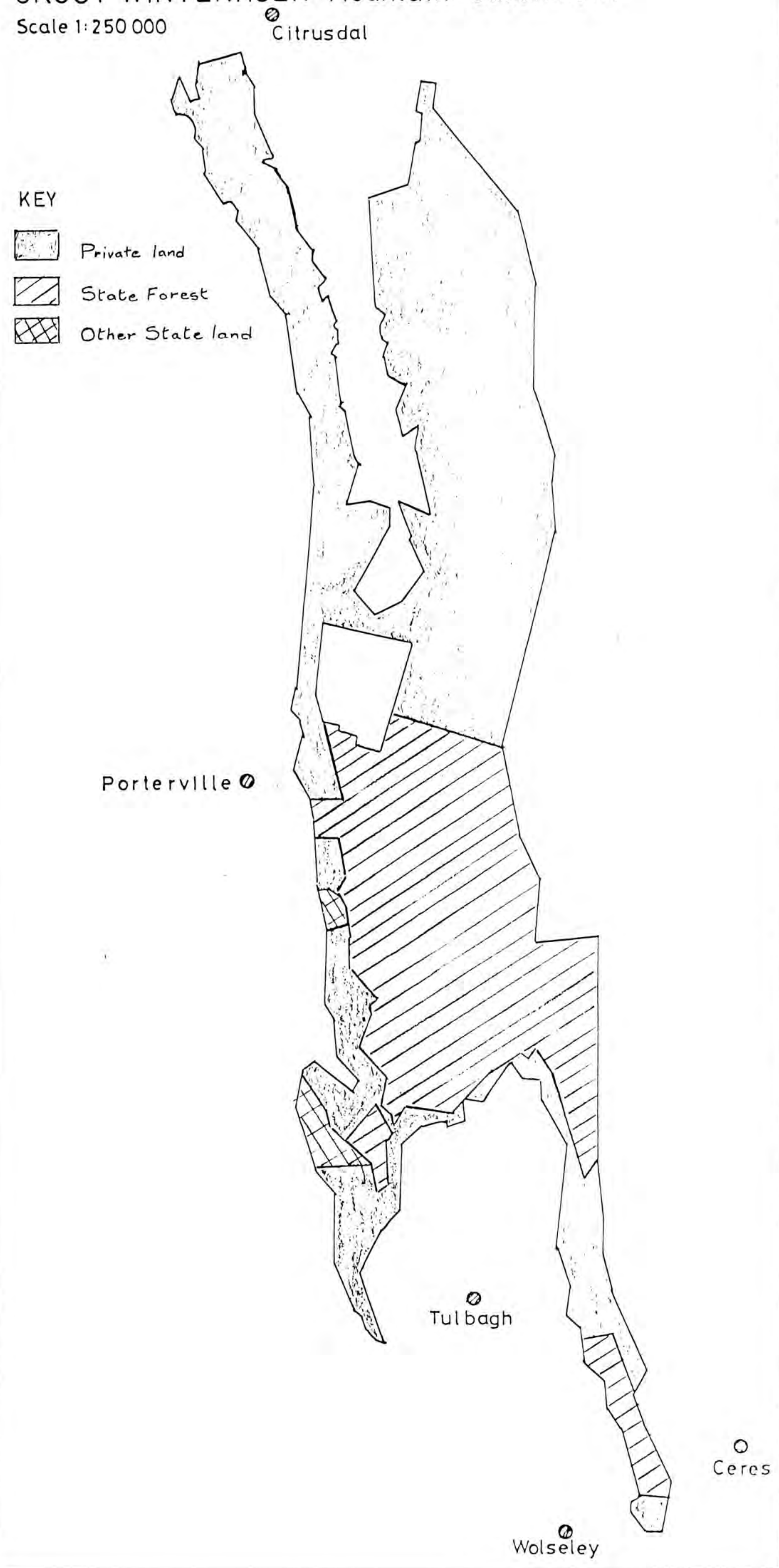
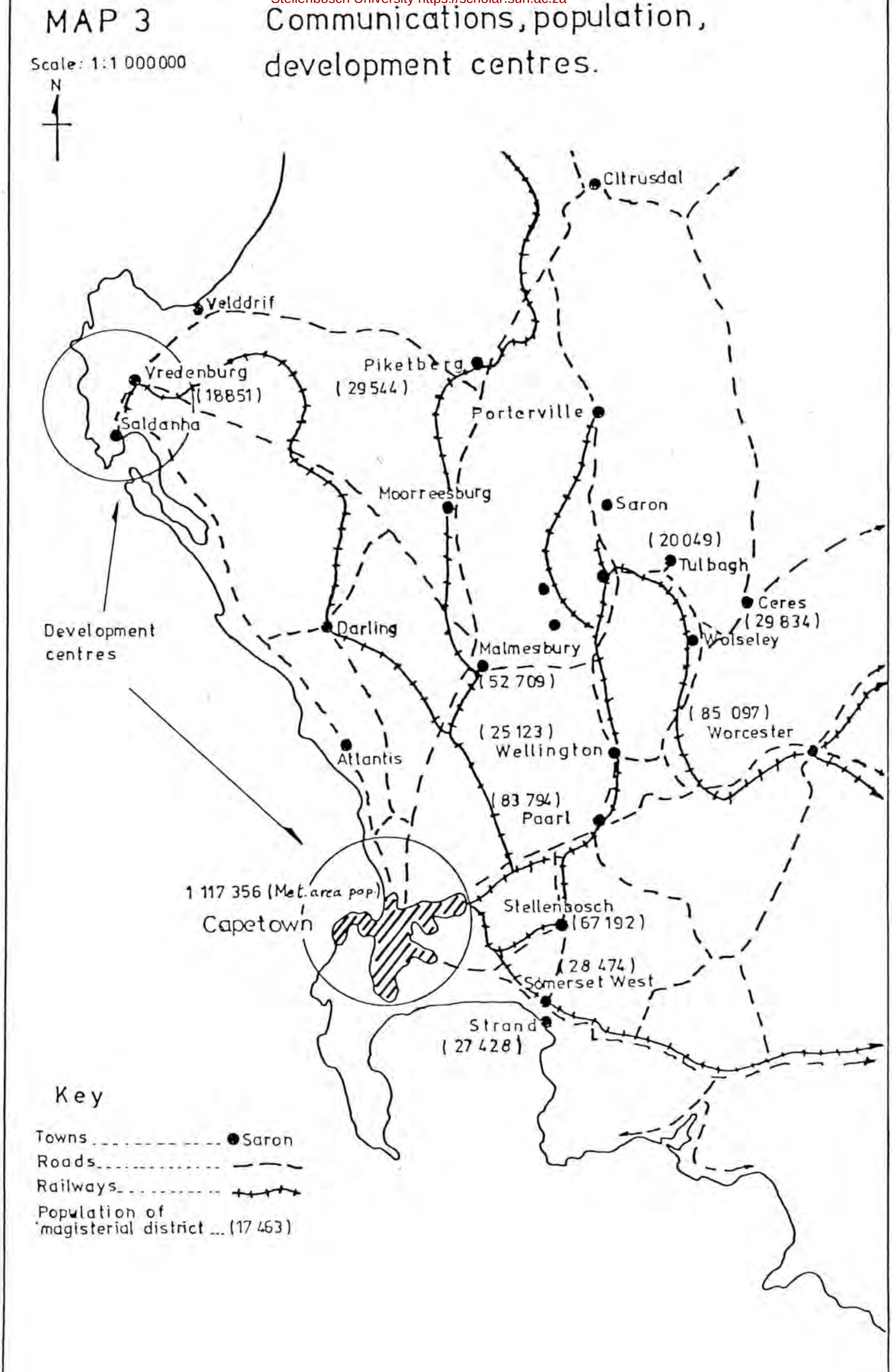


TABLE 1:

Land ownership status of Groot Winterhoek Mountain Catchment Area and associated State Forest

Ownership class	Approximate Area (Ha)
State Forest	30 608
Other State Land	921 - (Saron, Dept. of Coloured Affairs)
	233 - (Dept. of Prisons, Voorberg Prison)
Private land	49 665
Total	81 427


MAP 3
Communications, population, development centres.
Scale: 1:1 000 000
N
Citrusdal
Velddrif
Vredenburg
(18851)
Saldanha
Piketberg
(29 544)
Porterville
Moorreesburg
Saron
(20 049)
Tulbagh
Ceres
(29 834)
Wolseley
Darling
Malmesbury
(52 709)
Development centres
(85 097)
Worcester
(25 123)
Wellington
Atlantis
(83 794)
Paarl
1 117 356 (Met. area pop.)
Capetown
Stellenbosch
(67 192)
(28 474)
Somerset West
Strand
(27 428)
Key
Towns .... Saron
Roads ....
Railways ....
Population of magisterial district ... (17 463)

2.3.2 The village of Porterville may be regarded as the gateway to the heart of the area and Table 2a lists some important distances by road from Porterville. Table 2b presents distances from Groot Winterhoek Forest Station to some localities within the study area.

2.3.3 Table 3 presents some relevant population statistics and population distribution is illustrated in Map 3.

2.4 Geology (Map 4)

2.4.1 The following short description follows Rust (1967), Visser and Schoch (1973) and Visser et al (1981).

2.4.2 Formations of the Table Mountain group predominate and are represented by the following, in order of deposition:

(1) quartzitic sandstone and conglomerate of the Piekenier formation, dating from the late Cambrian or early Ordovician period some 500 million years B.P.;

(2) reddish brown shale, sandy shale and siltstone of the Graafwater formation, deposited in the Ordovician period;

(3) quartzitic sandstone with minor shale and conglomerate lenses of the Peninsular formation, deposited over a period

TABLE 2a:

Approximate road distance from Porterville to the following places (km):

Cape Town	:	139
Saldanha/Vredenburg	:	118
Ceres	:	82
Gouda	:	37
Malmesbury	:	75
Paarl/Wellington	:	91
Piketberg	:	26
Stellenbosch	:	120
Tulbagh	:	50
Groot Winterhoek Forest Station	:	36
Berghof Farm	:	30
Perdevlei Farm	:	50
Groot Kliphuis Farm	:	44
Agterdam Farm	:	49
Wletevrede/Driebosch Farms	:	45
De Tronk (Groot Winterhoek) Farm	:	48

TABLE 2b:

Approximate road distances from Groot Winterhoek Forest Station to the following places (km):

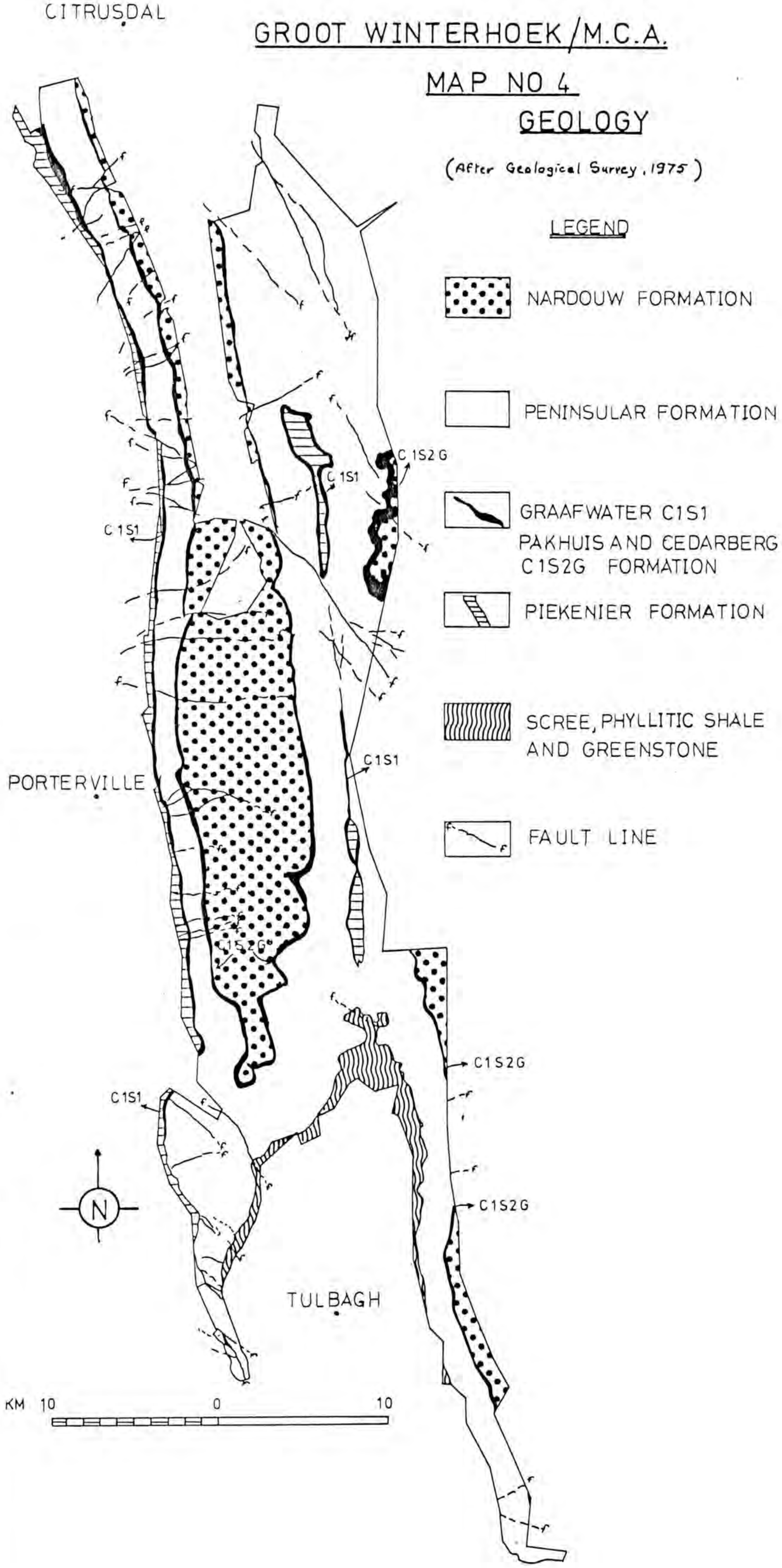
Berghof	:	6
Perdevlei	:	20
Groot Kliphuis	:	14
Agterdam	:	19
Weltevrede/Driebosch	:	15
De Tronk	:	18

TABLE 3:

Population data

AREA	TOTAL POPULATION
Lower Berg River planning region	126 857 (1970)
Cape Metropolitan Area (planning region 39)	1 610 100 (1975)
TOWNS	
Gouda	721 (1970)
Malmesbury	9 466 (1970)
Piketberg	3 601 (1970)
Porterville	2 946 (1970)
Saldanha	4 916 (1970)
Tulbagh	1 912 (1970)
Vredenburg	6 096 (1970)
Wolseley	2 688 (1970)

(Sources of data. 1970 figures after Page, 1973
1975 figures after Anon, 1977)


CITRUSDAL
GROOT WINTERHOEK/M.C.A.
MAP NO 4
GEOLOGY
(After Geological Survey, 1975)
LEGEND
NARDOUW FORMATION
PENINSULAR FORMATION
GRAAFWATER C1S1
PAKHUIS AND CEDARBERG
C1S2G FORMATION
PIEKENIER FORMATION
SCREE, PHYLLITIC SHALE
AND GREENSTONE
FAULT LINE
C1S2G
C1S1
PORTERVILLE
TULBAGH
N
KM 10
0
10

extending from about the middle Ordovician to well into the Silurian period;

(4) shale, arenaceous shale, tillite, grit and conglomerate of the Pakhuis and Cedarberg formations, which give rise to the so-called shale band, laid down about half way through the Silurian period, and

(5) quartzitic sandstone, with thin shale and conglomerate lenses of the Nardouw formation, deposited toward the end of the Silurian to the beginning of the Devonian period about 400 million years B.P.

2.4.3 Below these formations lie the well known Malmesbury shales on the soils of which the wheat of the Swartland is produced, and above are the Bokkeveld shales that produce the soils supporting the highly productive deciduous fruit orchards of the Koue Bokkeveld and Elgin.

2.4.4 It will be demonstrated in a later section that the two predominantly shale formations in the Table Mountain group, namely the Graafwater and the Cedarberg formations, were and still are important in determining land use in the area under consideration.

2.5 Topography

2.5.1 The area is typical of south-western Cape folded sandstone mountain ranges, rising suddenly and steeply from the coastal plain to a series of uneven plateaux and then to higher ridges of peaks. The chain lies more or less parallel to the western coastline and between the coastal plain and the plains of the Koue Bokkeveld plateau and Ceres valley. The mountain terrain is deeply incised by young fast flowing streams which drain the catchment. Strike orientation of the sedimentary rock layers and the numerous faults both parallel to and across the grain determine the principal drainage patterns, which in turn are useful indicators of both geology and topography (Kuska and Lamarra, 1973). The drainage patterns range from scalariform to dendritic. Near horizontal-lying Nardouw layers give rise to a typical rhombic pattern (Fig. 1).

2.5.2 Sandy often poorly drained flats and corridors alternate with steep rubble and boulder strewn slopes below sheer rock scarps and peaks. Loose, unstable rubble slopes and talus fans are a feature of the topography.

2.5.3 Also typical are the so-called shale bands which run the full length of the area north-south giving rise to easily recognisable softer, less rocky strips in an otherwise very rugged landscape (Photos 2 and 3).

FIGURE 1

Drainage patterns

Drainage Patterns

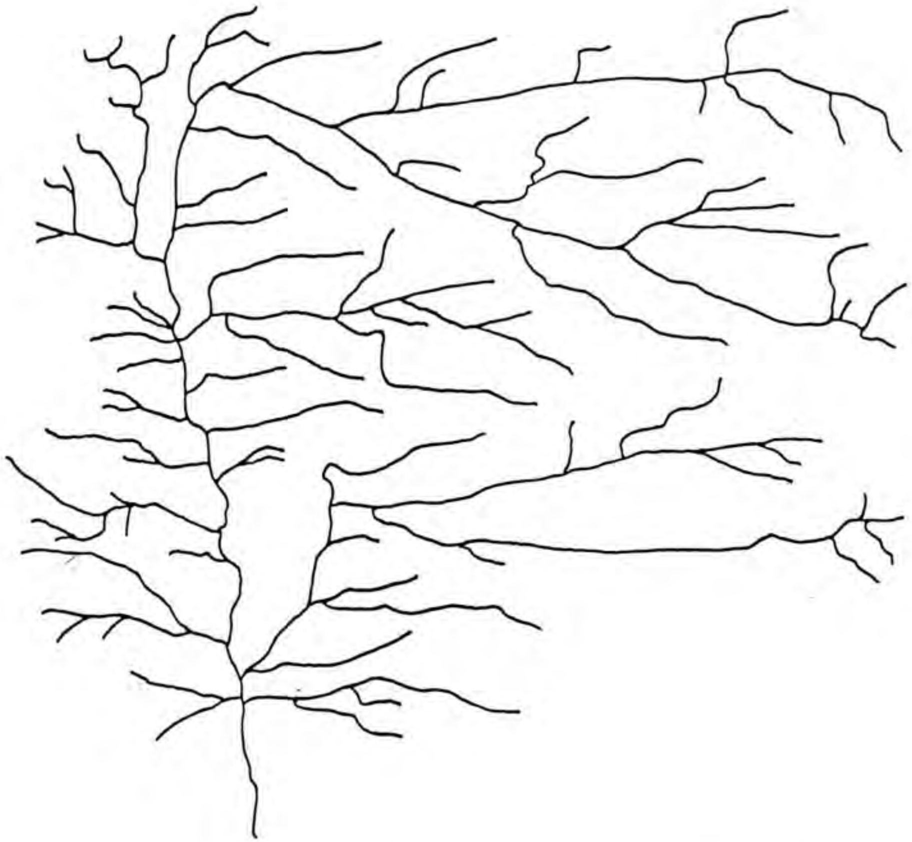


Fig. 1a

Rhombic pattern of near-horizontal Nardouw layers. Streams run in narrow, shallow to deep cracks or ravines or through seasonally water-logged flats eg. Groot-Kliphuis R.

Drainage Patterns

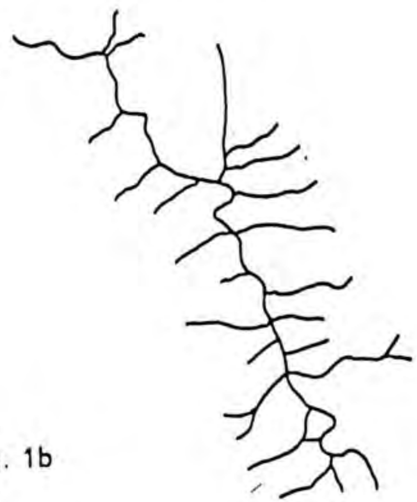


Fig. 1b

Scalariform pattern

severely folded layers

deeply incised steep sided valleys

eg. Oudsterivier

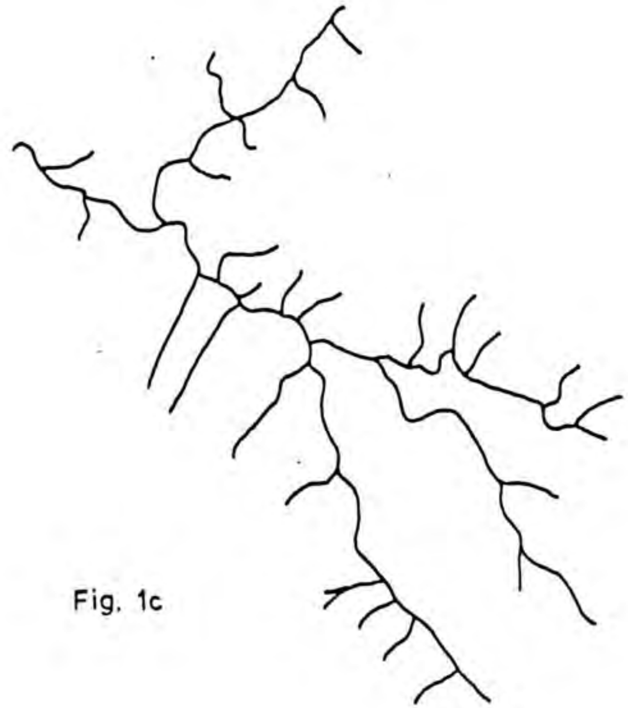


Fig. 1c

Scalariform - dendritic pattern

heavily folded layers

steep-sided valleys

eg. Teerivier

Drainage Patterns

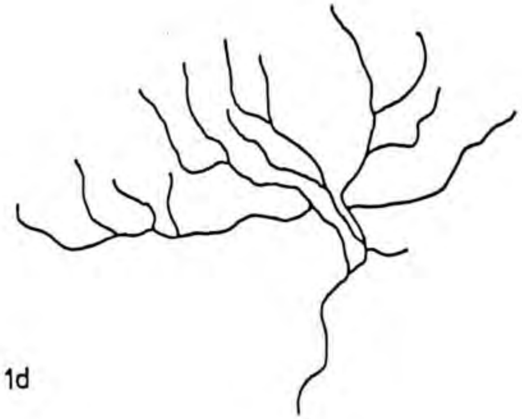


Fig. 1d

<u>Dense dendritic pattern</u> of steep

upper slopes

steeply dipping layers (±50°)

steep-sided, narrow valleys and ravines

eg. Upper Sneeugat R.

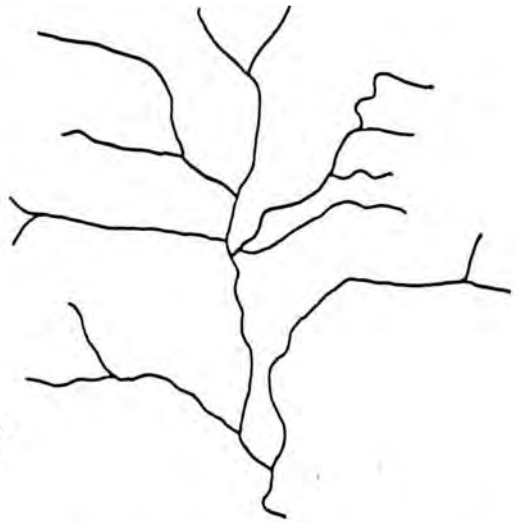


Fig. 1e

<u>More open dendritic pattern</u> of

sandflats

streams run in shallower depressions

eg. Zuurvlakte tributary of Groot-Kliphuis R.

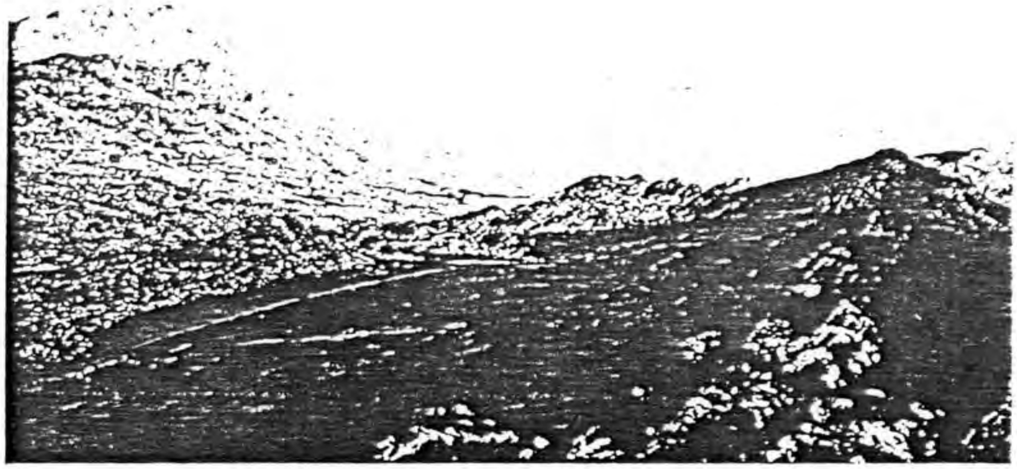


PHOTO 2

Voorberg shale band

PHOTO 3

Solderberg shale band (Stock camp ruin centre left)

2.5.4 Altitude varies from about 137 metres above mean sea level on the coastal plain near Porterville to 2077 metres a.m.s.l. at the beacon on Groot Winterhoek Peak. Some other peak altitudes are: the Voorberg approximately 1145 metres a.m.s.l.; the Groen approximately 1668 metres a.m.s.l.; Klein Winterhoek Peak approximately 1955 metres a.m.s.l.; Drosterberg approximately 1734 metres a.m.s.l., and Eureka Peak approximately 1987 metres a.m.s.l.

2.5.5 The nature of the topography renders access to and movement within the area difficult. As will be discussed later, this influenced land use and settlement patterns in historic times and probably in prehistoric times as well.

2.6 Soils (McVicar et al, 1974)

2.6.1 Shallow skeletal soils (Mispah form) and structureless sands (Fernwood, Houwhoek, Lamotte and Dundee forms) of low fertility predominate. Where the sandstone beds lie at a near horizontal dip angle deeper sands accumulate in places. Drainage is often poor on such sites and marshes or seasonal bogs may develop. This is most likely to occur where the sand is underlain by an impervious layer of material such as shale. Soils on these sites are extremely acid with a high organic content (Champagne form) giving rise to "brown" water in the streams.

2.6.2 Shale lenses in the Peninsula and Nardouw formations and shales and mudstones of the Graafwater and Cedarberg formations give rise to soils with somewhat better properties for agriculture, that is, better moisture retention and nutrient status (Clovelly and Hutton forms). However even the shale derived mountain soils are relatively poor by agricultural standards. Some data from soil analyses are presented in Appendix 8, and a selection of profiles are illustrated in photos 4 to 10.

2.6.3 Being relatively poor in nutrients, sandy and porous in texture with little or no organic content the soils of the very limited arable area are far from ideal for irrigation. Some 40 percent more water per unit of yield may be required on these soils as compared with the heavier and more fertile valley soils derived from Malmesbury or Bokkeveld shales (Verslag van die kommissie van ondersoek insake wateraangeleenthede 1970). Not only do the sandy soils require more frequent irrigation but they also require more frequent applications of fertilizers to maintain productivity (Local farmers, pers. com.).

2.7 Climate (Figure 2; Tables 4 and 5)

2.7.1 As there are no weather stations within the study area, the following account of climatic conditions is based upon information obtained from farmers, extrapolation from weather stations adjacent to the area and inference from vegetation growth patterns.

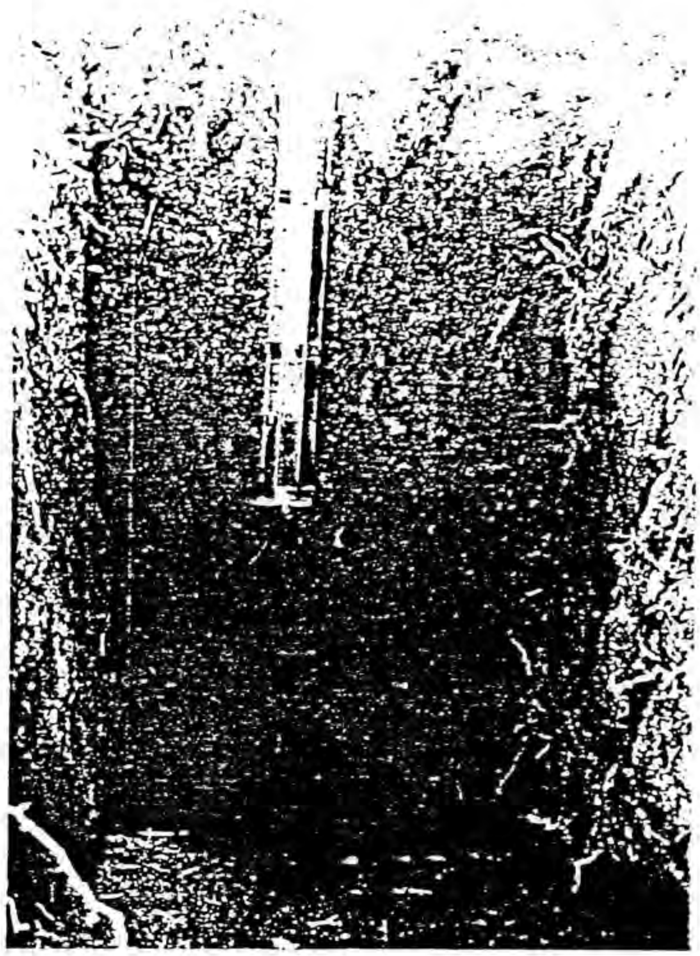


PHOTO 4

Soil pit 1.

Profile description.

0 - 60 cm plus : loose course pale to dark grey sand.

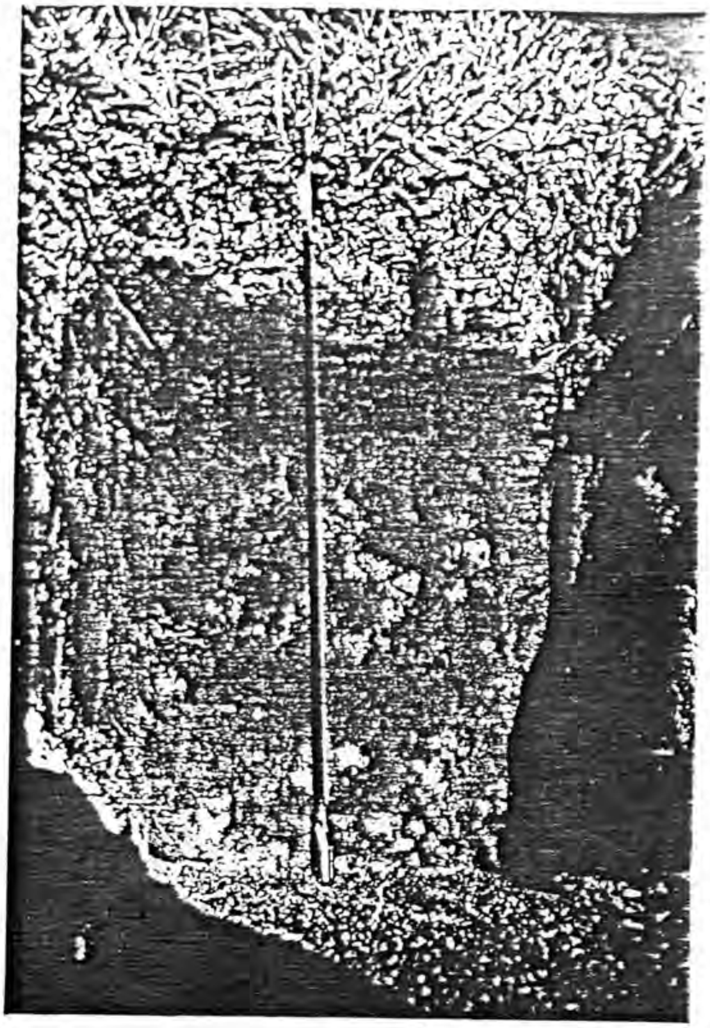


PHOTO 5

Soil pit 2.

Profile description.

0 - 11 cm : 10 YR, 4/4; loose course grey-buff sand.
11 - 22 cm : 10 YR, 5/4; compact course yellow-buff sand
22 - 55 cm plus : 10 YR, 6/6; somewhat loose yellow sand with light grey-buff and some dark grey mottling.

PHOTO 6

Soil pit 3.

Profile description.

0 - 11 cm	: 10 YR, 4/3;	loose course grey-buff sand.
11 - 18 cm	: 10 YR, 4/4;	compact course grey-buff sand.
18 - 64 cm plus:	10 YR, 5/8;	more or less compacted course yellow-buff to yellow sand; red mottling increasing with depth and becoming gravelly (course sand aggregates cemented with iron oxides) sand grains also reddish stained.

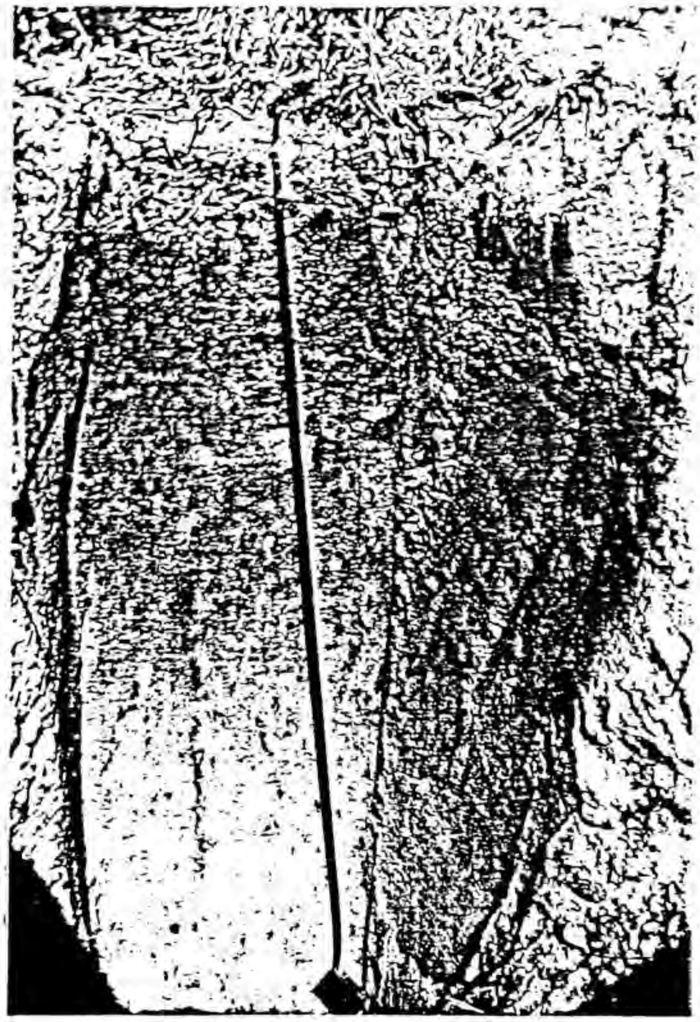


PHOTO 7

Soil pit 4.

Profile description.

0 - 20 cm	: 10 YR, 3/3;	course grey-buff sand.
20 - 37 cm	: 10 YR, 5/3;	course grey-buff sand with increasing amount of paler grey, yellow and darker grey mottling.
37 - 78 cm plus	: 10 YR, 7/6;	course pale yellow sand with dark grey mottling and some reddish mottling in lowest portion of profile.

No part of the profile was compacted.

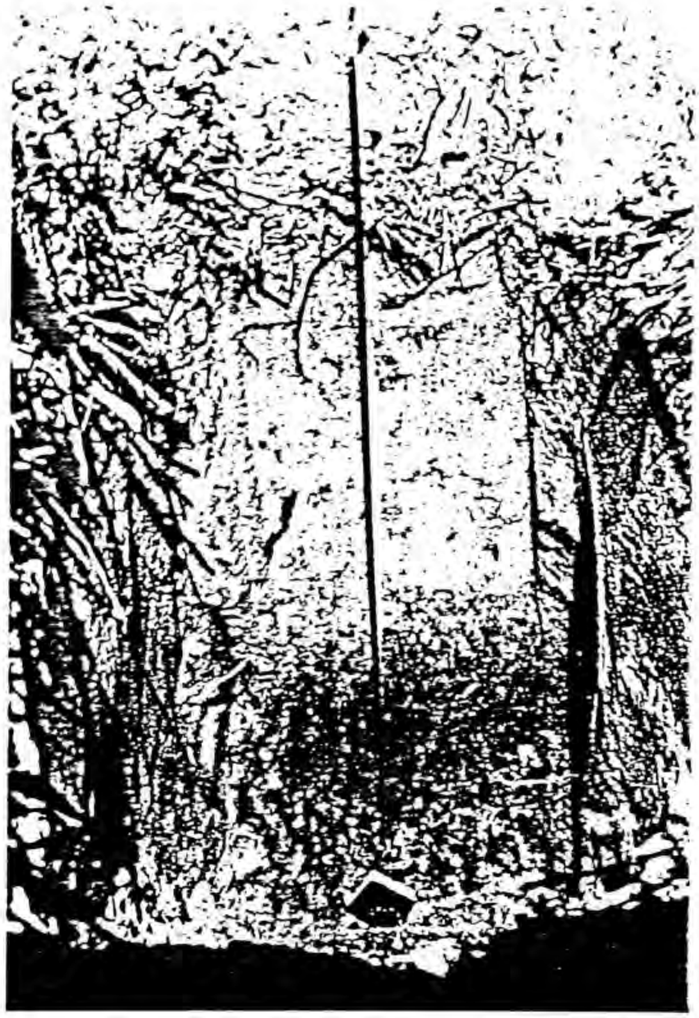


PHOTO 8

Soil pit 5.

Profile description.

0 - 6 cm	:	10 YR, 5/1;	loose course grey sand with mat of michorrhizal pine roots.
6 - 17 cm	:	loose course	grey sand, main pine rooting zone.
17 - 52 cm	:	loose course	brown-grey sand with grey mottling.
52 - 64 cm	:	10 YR, 4/3;	somewhat finer and slightly more compact brown-buff sand with much dark grey and brown mottling.
64 cm plus	:	10 YR, 5/3;	becoming paler with depth with grey and light brown mottling.

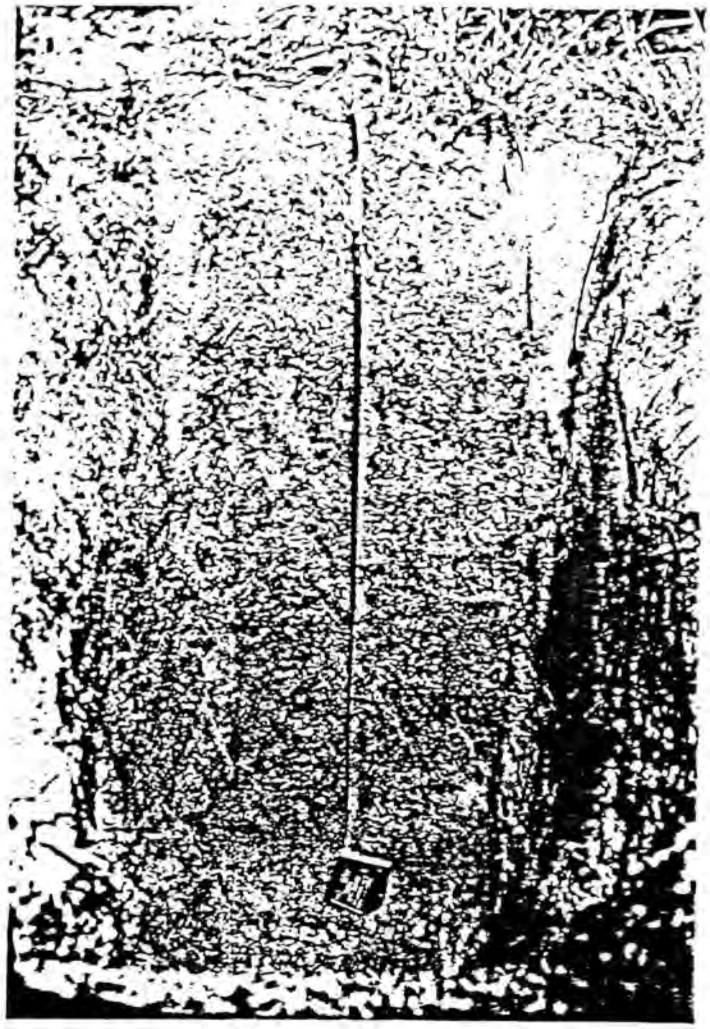


PHOTO 9

Soil pit 6.

Profile description.

0 - 16 cm	:	10 YR, 5/2;	loose course grey sand.
16 - 60 cm plus	:	10 YR, 5/4;	loose course yellow-buff sand, becoming courser with depth, ending in quartz gravel and pebbles

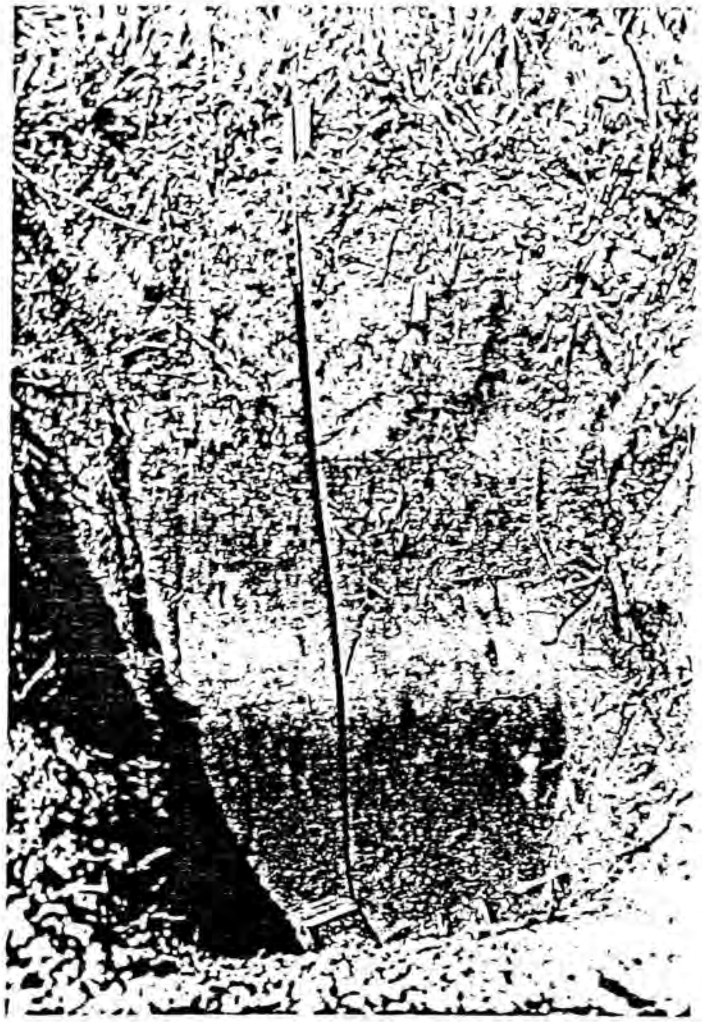


PHOTO 10

Soil pit 7.

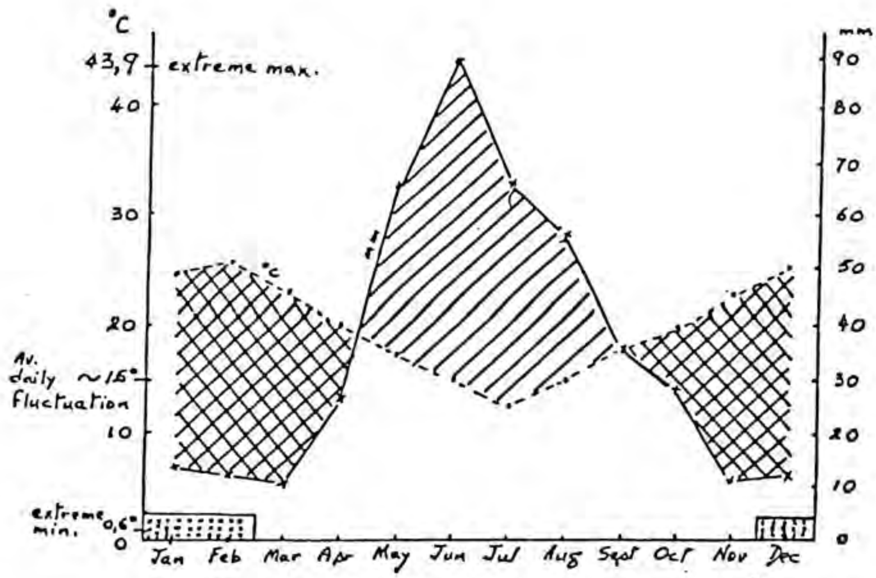
Profile description.

0 - 10 cm	: 10 YR, 4/1;	loose, medium course grey sand.
10 - 22 cm	: 10 YR, 5/2;	more compact medium course grey-buff sand.
22 - 35 cm	: 10 YR, 5/2;	somewhat more compacted course grey-buff sand with some "body", some yellowish mottling.
35 - 43 cm	: 10 YR, 5/3;	pale whitish-buff loose course sand with some reddish mottling.
43 - 54 cm	: 10 YR, 3/4;	more compact course brown-buff sand.
54 cm plus	: 10 YR, 4/4;	course sand becoming paler and more buff and looser with depth.

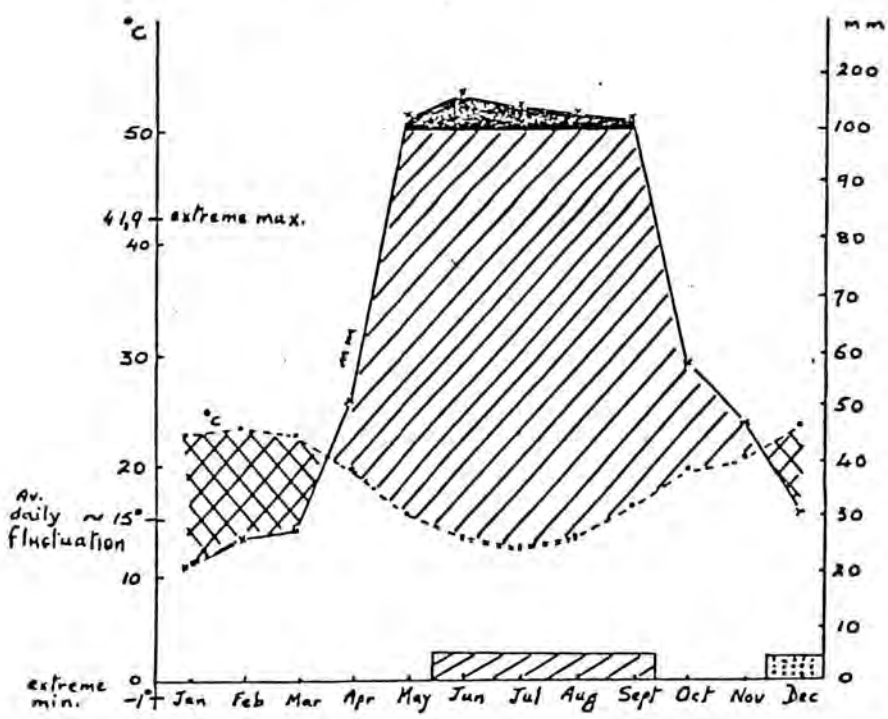
FIGURE 2

Walter Diagrams for Groot Winterhoek Mountain Catchment Area.

2.1 Porterville; altitude 137 m a.m.s.l.



2.2 Mountain catchment plateau above Porterville; altitude ± 800 m a.m.s.l. (estimated data).



Months with an absolute minimum temperature of 0°C or less.

Months with an absolute maximum temperature of 40°C or more.

'ABLE 4: RAINFALL

verage monthly rainfall (mm) up to 1960 (From Weather Bureau report WB29 of 1965)

lt. m)	STATION	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
.37	Porterville	14,4	12,0	10,8	26,3	66,2	88,6	66,4	56,5	36,5	28,1	11,4	12,1	429,3
.20	Saron	14,0	13,8	17,7	51,8	105,3	84,1	75,8	73,4	71,9	55,6	16,8	19,2	599,4
.51	Mont Pellier	11,9	16,3	15,3	44,2	79,1	88,8	71,8	74,6	57,9	37,5	27,3	13,5	538,2
84	Inkruip	20,6	45,7	27,2	50,5	110,0	111,8	127,8	127,8	112,8	56,6	46,0	30,2	867,0
30 approx.)	(1) Rock haven 1970-1976	24	17	17	80	149	140	150	138	68	64	50	66	947
30 approx.)	(1) Phoenix Rock 1972-1976	17	19	27	94	167	183	161	122	84	79	59	94	1107

lote: (1) These data were obtained from the respective farmers.

TABLE 5: TEMPERATURE °C (at Porterville)

(1934-1942) (After Weather Bureau report WB29 of 1965)

Month	Mean of daily max.	Mean of monthly max.	Extreme daily max.	Year	Mean of daily min.	Mean of monthly min.	Extreme daily min.	Year	Mean of monthly max. + min
Jan.	31,5	37,9	40,6	1942	15,7	10,4	7,6	1936	24,2
Feb.	31,8	38,7	40,6	1940	16,2	11,4	8,3	1936	25,1
March	29,9	36,7	38,5	1936	14,6	10,4	8,9	1935	23,6
April	26,1	35,7	37,2	1937	10,4	5,9	2,2	1937	20,8
May	21,5	29,3	32,2	1937	8,1	5,0	2,8	1941	17,2
June	19,7	26,7	28,9	1939	6,6	3,2	1,7	1940	15,0
July	17,8	25,9	28,9	1940	5,3	2,0	0,6	1942	14,0
Aug.	19,2	27,6	33,9	1940	6,5	2,3	1,7	1940	15,0
Sept.	20,7	31,8	34,4	1939	7,7	3,2	2,2	1941	17,5
Oct.	24,4	34,4	38,3	1940	9,8	5,0	3,7	1936	19,7
Nov.	28,3	36,9	38,6	1935	13,2	7,8	6,1	1936	22,4
Dec.	30,3	39,3	43,9	1941	15,1	10,8	8,3	1936	25,1
Year	25,1	-	43,9	1941	10,8	-	0,6	1942	-

2.7.2 The area falls within the Mediterranean-type climatic zone with cold wet winters and hot dry summers. Eighty four percent of total rain falls in the period first of April to 31st October on 80,5 per cent of the rain days. Rain normally follows in the wake of a cold front, approaching from the north--west accompanied by winds of varying strength. Thunder storms with lightning activity may occur, particularly in spring and autumn. These storms, which may bring hail, are more frequent to the east toward the Koue Bokkeveld than in the study area. Terrain above 900 to 1300 metres in altitude receives appreciable amounts of fog and mist precipitation throughout the year but especially during summer months because of low level cloud (orographic) induced by the strong prevailing south-easterly winds of that season. There appears to be a rainfall gradient with decreasing precipitation from west to east, although this is not particularly obvious within the study area. The increase in total precipitation with altitude is however noticeable and there are indications that the altitudinal contours at approximately 900, 1300 and 1600 metres above mean sea level may be significant for some plant species and communities. The two most common cloud base altitudes are approximately 900 metres (usually in winter) and 1300 metres (usually in summer) and the most common snow line is at about 1600 m.a.s.l. (personal observation and report from local residents). It is not known what contribution to total precipitation mist and fog make but studies by Marloth, Nagel and others (Kerfoot 1968) indicate that it could be more than 100 percent of rainfall at altitudes above the cloud line where there are suitable surfaces on which condensation can take place.

2.7.3 Persistant rainfall over an extended period has on a number of occasions within living memory saturated the soil and caused severe soil slip and erosion, particularly where vegetal cover had been reduced by burning and grazing or by cultivation. Low lying areas have been flooded and roads rendered impassable. Storms of this nature occurred in 1925, 1941 and 1962 (personal communication from local residents).

2.7.4 Temperatures seldom drop to more than a few degrees below zero at the farms and although frost does occur it is not severe. Snow falls each winter on the mountain peaks and heavier falls, with snow lying as low as 900 metres a.m.s.l. and lower, occur once in four to seven years. Ravines at the source of the Sneeugat River are in permanent shadow in winter and frozen snow may lie here for several months.

2.7.5 Temperatures rarely exceed 32°C but in 1979 a prolonged dry spell when maximum temperatures were persistently over 30°C, placed irrigation systems under severe strain.

2.7.6 Over the past 20 years there have been only two severe hailstorms which caused extensive damage to fruit crops. These were in October 1978 and early summer 1980.

2.7.7 Strong easterly winds cause damage to fruit crops approximately every six years and over the past 10 years there have been two very severe storms which took the roofs off a number of buildings and caused extensive damage to Pinus radiata plantations on the Voorberg ridge.

2.7.8 Hot, dry north-easterly to northerly winds, known as berg winds, are occasionally experienced particularly in autumn and winter, but also at other times of the year. Temperatures may approach 40°C or more in the valleys creating extreme fire hazard conditions and placing heavy demands on irrigation systems.

2.8 Hydrology

2.8.1 The area includes portions of the Directorate of Water Affairs drainage regions 510, Olifants River, and 710, Berg River, and is the main catchment for a number of major tributaries of these two important rivers.

2.8.2 Examination and measurement of the 1:50 000 topographical maps reveals the following about the study area drainage. The Dwars, Ratel, Oudste, Tee and Agterste rivers as well as numerous smaller streams drain approximately 48,6 percent of the area northward into the Olifants River. The Vier-en-twintig, Leeu, Klein-Berg Rivers and a number of smaller streams drain runoff from the remainder of the area south and west into the Berg River, except for approximately 0,8% of the area in the vicinity of Michell´s Pass which feeds the Dwars River, which becomes the Breede downstream of the western approach to the pass.

2.8.3 The Clanwilliam and Bulshoek are important dams on the Olifants River with capacities of 121,4 million cubic metres and 6,47 million cubic metres respectively (Department of Water Affairs, pers. com.) while Smit (1970) reports that water pumped direct from the Olifants River provides 75 percent of the requirements for the irrigated lands in the Citrusdal valley.

2.8.4 An appreciable portion of the surplus winter flow of the Klein Berg, Leeu and Vier-en-twintig-Riviere Rivers is diverted by concrete-lined canals into the Voëlvlei dam which has a capacity of 164,1 million cubic metres (Weather Bureau, June 1980). The Vier-en-twintig-riviere - Leeu canal has a design capacity of 1 200 cubic feet per second (or 122 400 cubic metres per hour) and the Kleinberg channel slightly less. Annual volume diverted to Voëlvlei from the Klein Berg river is 63,2 million cubic metres (24 200 morgen feet) and from the Vier-en-twintig-Riviere and Leeu rivers 112,5 million cubic metres (43 100 morgen feet). The Vier-en-twintig-riviere catchment alone yields approximately 100,5 million cubic metres per annum. (Government white Paper W.P.K.-´68).

2.8.5 A further large dam is planned for the Berg River at the site of the Misverstand weir which is a short distance upstream of where the main north bound road crosses the river between Moorreesburg and Piketberg. (W.P.N.-´76).

2.8.6 The area of the combined catchments of the Vier-en-twintig-Riviere and Leeu rivers above the diversion weirs is 26 418 ha with an average annual rainfall of 1 087 mm giving an average run-off of some 190,6 million cubic metres, (W.P.-K. ´68), i.e. 66 per cent of rainfall.

2.8.7 The approximate area of Olifants River catchment within the study area is 39 600 ha with an estimated average annual rainfall of approximately 800 mm. At 60 per cent runoff, this portion of the catchment will contribute an estimated 190 million cubic metres to the annual flow of the Olifants River. An estimated annual rainfall of 1 000 mm over the remaining portion of the study area will yield approximately 88,6 million cubic metres to the Berg River system mainly via the Klein Berg River, and approximately 3,9 million cubic metres to the Breede River system via the Dwars River.

2.8.8 Data from Jonkershoek indicate that run-off as a percentage of rainfall increases progressively toward the source of the Eerste River, from about 29 percent at approximately 100 metres above mean sea level to over 67 percent at an altitude of 360 metres above mean sea level and higher (Van der Zel, 1971). Wicht (1947) states that runoff may be as much as 80 percent of rainfall in "precipitous high rainfall mountain peak areas". Rainfall also increases with altitude, from 737 mm at Stellenbosch, 107 metres above mean sea level, to 1 386 mm at Swartboschkloof, 320 metres above mean sea level, and 3 330 mm on the Dwarsberg, 1 219 metres above mean sea level.

2.8.9 Comparable rainfall figures for the study area are 429 mm at Porterville, 137 metres a.m.s.l., 947 mm (1970-1976) at the farm Rockhaven, 750 metres a.m.s.l. and 1107 mm (1972-1976) at Phoenix Rock, 730 metres a.m.s.l. The rainfall maps produced from data provided by the Department of Transport indicate a rainfall of 2400 mm at an altitude of approximately 1 200 metres a.m.s.l. (Rainfall Map Series; Government Printer, 1966).

2.8.10 Runoff is certain to follow the trend pattern indicated by measurements on the Eerste River so that a runoff figure of approximately 20 per cent may be expected at the foot of the Voorberg, 55 to 60 per cent on the plateau in the vicinity of the farms Rock Haven, Heidedal, Phoenix Rock and Berghoff, 50 to 55 per cent in the valley in the vicinity of the properties Drieboschfontein and Groot Winterhoek (De Tronk), 60 per cent on the flats of Groot Kliphuis farm and 55 per cent in the Perdevlei valley with figures in excess of 65 per cent at higher altitudes. Runoff of 80 per cent or more can be expected from the extensive naked steeply sloping rock surfaces of the mountain peaks. (Photo No. 11).

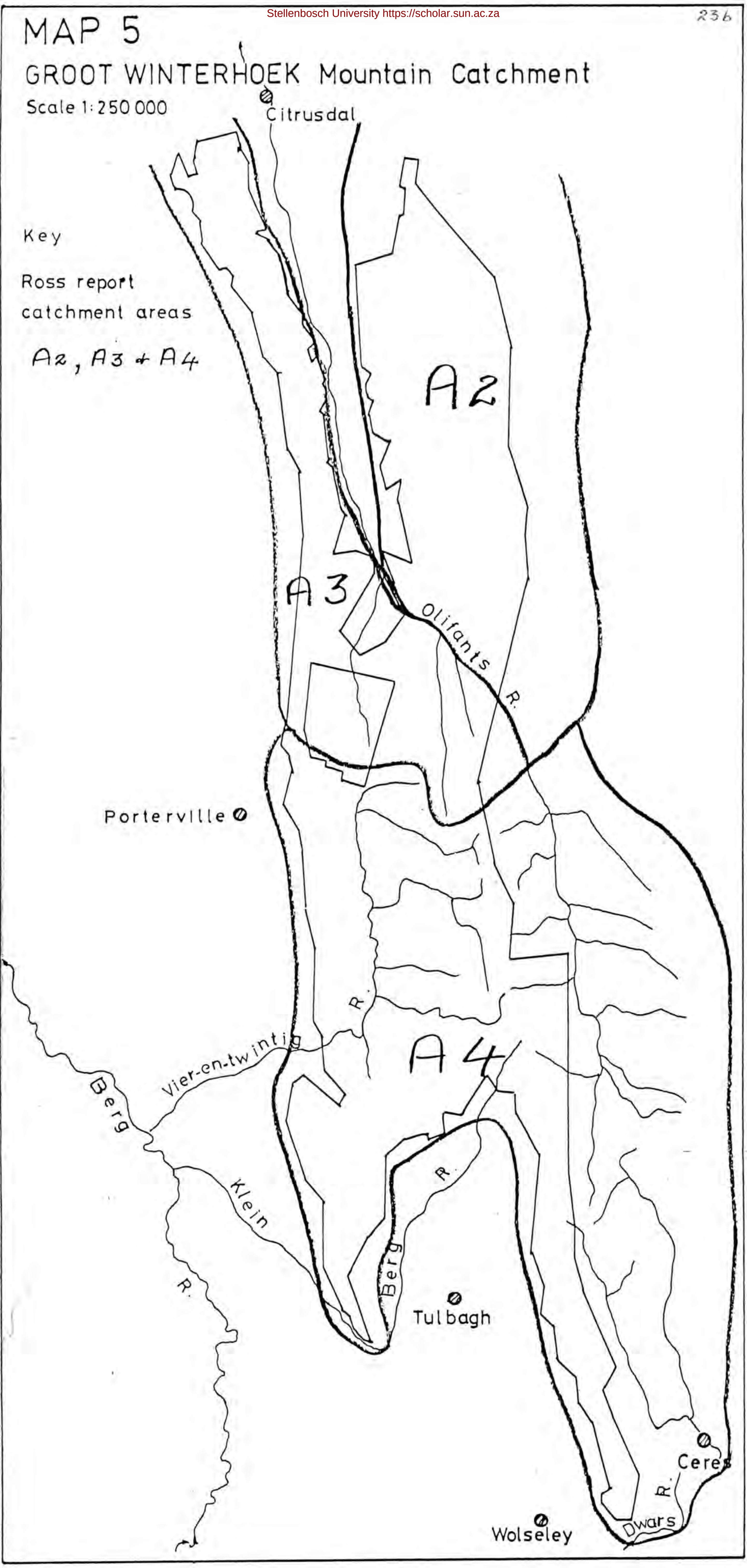
2.8.11 Flow rates rise and fall rapidly in response to commencement and cessation of rainstorms in the Western Cape mountains. The flow of the Eerste River normally returns to pre-storm level within, 24 hours of cessation of rainfall (Kark, 1949 in Van der Zel, 1971). That streams in the study area follow the same pattern was borne out by observation. Most of the smaller streams in the area are seasonal or only very a weakly perennial, although the main tributaries of the Vier-en-twintig-riviere and Olifants Rivers, such as the First and Second Sneeugat, Groot Kliphuis, Klein Kliphuis, Ratel, Dwars, Oudste, Tee, Agterste Rivers and others are all strongly perennial.

2.8.12 The study area includes part of Mountain catchment area A2 and practically all of catchment areas A3 and A4, as listed and described in the report of the interdepartmental committee on the conservation of mountain catchment areas in South Africa (Ross _et al_, 1961) (Map 5). This report gives the following annual unit run-off figures for these catchments:

A 2 315 morgen feet per square mile (317,5 mm)
A 3 68 morgen feet per square mile (68,5 mm)
A 4 682 morgen feet per square mile (687,4 mm)

PHOTO 11

Peaks and ridges of the Groot Winterhoek area, showing high percentage of exposed rock and steep slopes.


MAP 5
GROOT WINTERHOEK Mountain Catchment
Scale 1: 250 000
Key
Ross report catchment areas
A2, A3 + A4
Citrusdal
A2
A3
Olifants R.
Porterville
A4
Vier-en-twintig
R.
Berg
Klein
R.
R.
Berg
Tulbagh
Ceres
R.
Dwars
Wolseley

(Note: These run-off figures appear to be ultra conservative when compared with those used in the white paper W.P.-K.´68, and considering available rainfall data. They have, therefore, not been used in this study).

2.9 Biological features

2.9.1 Vegetation (Map 6)

2.9.1.1 Apart from some small evergreen forest relics, similar to Acock´s type 4, the whole area can be referred to Acock´s type 69, Mountain Fynbos (Acocks 1953).

2.9.1.2 Deacon (1977) has stated that Fynbos is a product of processes that have been operating repeatedly over the last two to two and a half million years. It is an ancient flora characterised by an exceptionally high degree of endemism (Kruger, 1977; Taylor, 1978). It is the flora of an environment in which fire is a natural factor and maintenance of its full range of species diversity is dependent upon periodic fire (Wicht, 1945; Kruger, loc.cit.). Concensus has not been reached on the question of optimum burning cycles or even on whether fire is an essential element of the Fynbos ecosystem, although this is almost certainly so. However, because of the virtual impossibility of excluding unnatural man-made fire from Fynbos for any period in excess of ten to twelve years, the question is probably of academic interest only.

Archaeologists and palynologists have detected climatic fluctuations from the early Pleistocene to the early Holocene, as well as less dramatic fluctuations in more recent times. These fluctuations were accompanied by changes in vegetation type boundaries including the advance and retreat of Fynbos out from and back into the coastal mountain ranges of the Cape Province (Van Zinderen Bakker, 1963, 1970; Butzer and Halgren, 1972 in Klein, 1974). Over the last approximately 8000 years however there is evidence of only minor fluctuations (Van Zinderen Bakker, 1963; Coetzee, 1964).

Within the broad Fynbos type as it exists today certain vegetation communities, associations or mixtures can be identified on black and white aerial photographs by their distinctive tones and textures or by a combination of these and topography or growing site. For land management it is useful to map the occurrence, extent and distribution of types of vegetation which differ in productivity, sensitivity to disturbance, aesthetic or other value, accessibility or negotiability, flammability and reaction or response to management. With the resources normally available it is impracticable to map vegetation types that cannot be consistently identified on aerial photographs.

The following vegetation-site types are normally identifiable on available photographs (black and white, 1:40000 to 1:50 000 contact print scale) and were used in his study:

(1) Evergreen riparian forest: (R.F.). Usually closed canopy forest rarely exceeding 15 metres top canopy height, typically two or three tiered. Commonest upper canopy species are Cunonia capensis, Podocarpus elongatus, Rapanea melanophloeos, Ilex mitis, Olinia cymosa, Platylophus trifoliatus. Lower canopy and forest fringe species include Maytenus acuminata, Heeria argentea, Pseudoscolopia sp., Hartogia schinoides, Metrosideros angustifolia, Halleria lucida and others. These small forests may be important for nature conservation and are certainly worth preserving. The type is fire resistant but may burn under extreme conditions when it would be severely damaged.

(2) Heeria - Maytenus bush. (HM). This type is comprised mainly of Heeria argentea and Maytenus oleoides, bushes or small trees up to approximately four to five metres top canopy height. The canopy may be closed but is usually somewhat open. Other species commonly present include Olea africana, Hartogia schinoides, Podocarpus elongatus, Maytenus acuminatus and Halleria lucida. Ficus cordata is associated with this type in the lowest portion of the Vier-en-twintig-riviere gorge. Associated understorey shrubs include Diospyros glabra, Myrica capensis, Rhus africana, Olea capensis var. capensis, and the climber Secamone

alpini. The type is further subdivided according to growing site although there does not appear to be any major difference in composition or physiognomic character on the different sites. The two identified and recognisable growing sites are:

(a) boulder scree (HMs) and (b) rocky outcrop (HMr). The same association is found along some stream banks where the stream flows through boulders and rubble usually retreating underground for part of the year. It is not easily distinguishable from evergreen forest on these sites however and has therefore not been mapped separately. The type is fire resistant and usually escapes burning. Under severe conditions however a fire may be carried into or through the bush-groups in which case severe scorching and death of portions of the crowns will result. The bushes are rarely completely killed and apparently dead limbs normally resprout within six weeks of being burnt.

(3) Tall riparian shrub (S.T.r.). Top canopy height may attain five metres. Species composition varies from pure stands of Leucadendron salicifolium on water logged sandy sites where the stream channel is often ill-defined, to Metrosideros angustifolia, Brachylaena neriifolia, Salix capensis associations. Ixianthes retzioides, Erica caffra and Freylinia lanceolata are also frequent components of the type in this area. This type usually escapes fire but will burn fiercely and may be completely destroyed under severe conditions.

(4) Tall closed shrub (S.t.c.). Most often dominated by Protea or Leucadendron species although Dodonaea and Cliffortia and, less frequently, Rafnia and Aspalathus species are equally well represented on some sites. Cliffortia ruscifolia may form virtually pure stands on disturbed sites, particularly sites previously heavily stocked with domestic animals. The type is further subdivided by site.

(4.1) Talus slope (S.t.c./t.). Most commonly dominated by Protea arborea.

(4.2) Shale band (S.t.c./s.). Commonly almost pure stands of Protea repens, Protea punctata (generally at higher altitudes), or Leucadendron rubrum. Leucadendron rubrum, known locally as "perdeoog", "tolbos" or "knopbos" and to some florists as "harlequin shrub", is one of the most sought after species in the dried flower trade and has been heavily exploited in this area. Dried capitula of Protea repens stripped to basal bracts are also sold for dry floral arrangements.

(4.3) Other sites (S.t.c./o.). Protea laurifolia is most commonly dominant, although other species may make up an apprecia-ble proportion of the canopy, for example Dodonea viscosa var angustifolia, Rafnia or Aspalathus species. Protea laurifolia is harvested on a large scale for both the local and export fresh flower markets and to a lesser extent for the dry flower market.

Fire burns fiercely through all three tall closed shrub types and they may be dangerous during burning or fire fighting operations. Danger is increased by loose rocky terrain and steep gradients on talus slopes.

(5) Tall open shrub (S.t.o.). This has the same basic composition as the tall closed shrub group but the tall shrub layer is open to sparse. It is again subdivided according to growing site, that is:

(a) tall open shrub on talus slope (Sto/t)
(b) tall open shrub on shale band (Sto/s)
(c) tall open shrub on other sites (Sto/o)

Fire danger may be even greater in this group than in the tall closed shrub group, particularly on talus slopes, because of the high proportion of very inflammable lower shrubs such as "slangbos" (Stoebe plumosa).

(6) Short closed shrub-restio veld (S-R.s.c.). This is a very broad group of plant associations none of which has any distinctive feature whereby it may be identified and delineated on available photographs. As with the previous groups it is subdivided according to site. Experience will show whether

this subdivision is meaningful and whether further subdivision by topographic units, for example rocky mountain top, scarp, north and south aspect, may be required. Canopy height varies from less than 0,5 metres to approximately 1,5 metres. This is by far the most common and wide spread group and includes the rocky sites at between 1300 and 1600 to 1700 metres above mean sea level where the commercially sought after Protea magnifica is found. Most of the commercially exploited minor species of the Proteaceae, Ericaceae and Restionaceae are also found in this group as is much of the mountain buchu, Agathosma betulina. Fire danger within this group may be expected to vary considerably in accordance with actual height and density of vegetation within the wide range of the group and with topography.

(7) Short open shrub-veld (S.s.o.). This veld type does not occur within the study area.

(8) Restio-shrub veld (R). This type is comprised of vegetation dominated by Restionaceae and Cyperaceae. It may be from about 10 centimetres to over 100 centimetres in height. It occurs on a range of sites, according to which it may be subdivided, but becomes more common with increasing altitude particularly on seasonally waterlogged sites. Fires in this type are usually relatively easy to control but can spread rapidly, the tufts appearing to explode, and tufts on peaty sites may smoulder for more than twenty four hours after the flame front

has passed. It is doubtful whether high altitude variants of this type should be deliberately burnt as a veld management practice.

2.9.2 Flora (Appendix 1)

2.9.2.1 Some interesting species occurrences have been recorded from the study area, for example Celtis africana from the lower reaches of the Vier-en-twintig-Riviere gorge and a Pseudoscolopia species which grows abundantly in the riparian zone of the Vier-en-twintig-Riviere and a number of its tributaries. Ixianthes retzioides is an attractive yellow flowered phreatic shrub found along the Vier-en-twintig-Riviere and its tributaries and on the tributaries of the Olifants River within the area. Protea rupicola occurs on the higher peaks, for example Groot Winterhoek peak.

2.9.2.2 Aloe haemanthifolia occurs in the koppies of Kliphuisvlakte and A. mitriformis is widespread. Disa uniflora is common and an attractive yellow mutant of this species has been found along stream banks in the Zuurvlakte-Kliphuisvlakte area. A large and attractive Lachnaea (L. buxifolia) occurs in the Kliphuisvlakte and Perdevlei areas.

2.9.2.3 The following naturally occurring Proteaceae are commercially exploited: Protea magnifica, P. cynaroides and P. laurifolia, Leucadendron rubrum and L. salignum, Leucospermum vestitum. A number of species of Ericaceae and Restionaceae are also harvested for the wild flower market. Both Bergbuchu, Agathosma betulina and oval leaf buchu, A. crenulata, have been harvested from these mountains for many years.

2.9.3 Fauna (Appendix 2)

2.9.3.1 Mammals (Appendix 2.1)

2.9.3.1 Of the larger, commonly seen mammals, Baboon (Papio ursinus), Grey Rhebuck (Pelea capreolus), Klipspringer (Oreotragus oreotragus), Dassie or Rock Hyrax (Procavia capensis), Grysbuck (Rhaphicerus melanotis), Red Mountain Hare (Pronolagus rupestris) and Scrub Hare (Lepus saxatilis), are common. Cape Grey Mongoose (Herpestes pulverulentus), Marsh mongoose (Atilax paludinosus), Porcupine (Hystrix africana-australis), and a number of small rodents are also common but are rarely seen. The little known Black and White Dormouse or 'Namtap' (Graphiurus ocularis), has been recorded on the farm De Tronk (or Groot Winterhoek). Leopard (Panthera pardus), Caracal Felis caracal), Genet (Genetta genetta) and Cape Wildcat (Felis libyca), all occur in the area as do the Bat-eared fox (Otocyon megalotis), and Aardwolf (Proteles cristatus). (Personal observation and Departmental records).

2.9.3.2 Birds (Appendix 2.2)

The avifauna of the area is typical of Western-Cape Mountain Fynbos except that there appear to be appreciably greater than normal numbers of Grey Wing Francolin (Francolinus africanus) in the vicinity of abandoned farmsteads. (Personal observation and Cape Bird Club).

2.9.3.3 Reptiles and Amphibians (Appendix 2.3)

2.9.3.3.1 These animals appear to be well represented in the area although no tortoises were observed. (Personal observation and Departmental records).

2.9.3.4 Fish (Appendix 2.4)

2.9.3.4.1 The Cape Kurper (Sandelia capensis) is abundant in that portion of the Vier-en-twintig-riviere system within the study area. It was in fact the only indigenous fish observed in that system during the course of field survey work. The Olifants River and tributaries, on the other hand, contain a number of species of red fin and other minnows, yellow fish, including the endangered Clanwilliam yellowfish (Barbus capensis), and others, many of which are endemic (Gaigher, 1973(a); Skelton, 1974, and personal observation).

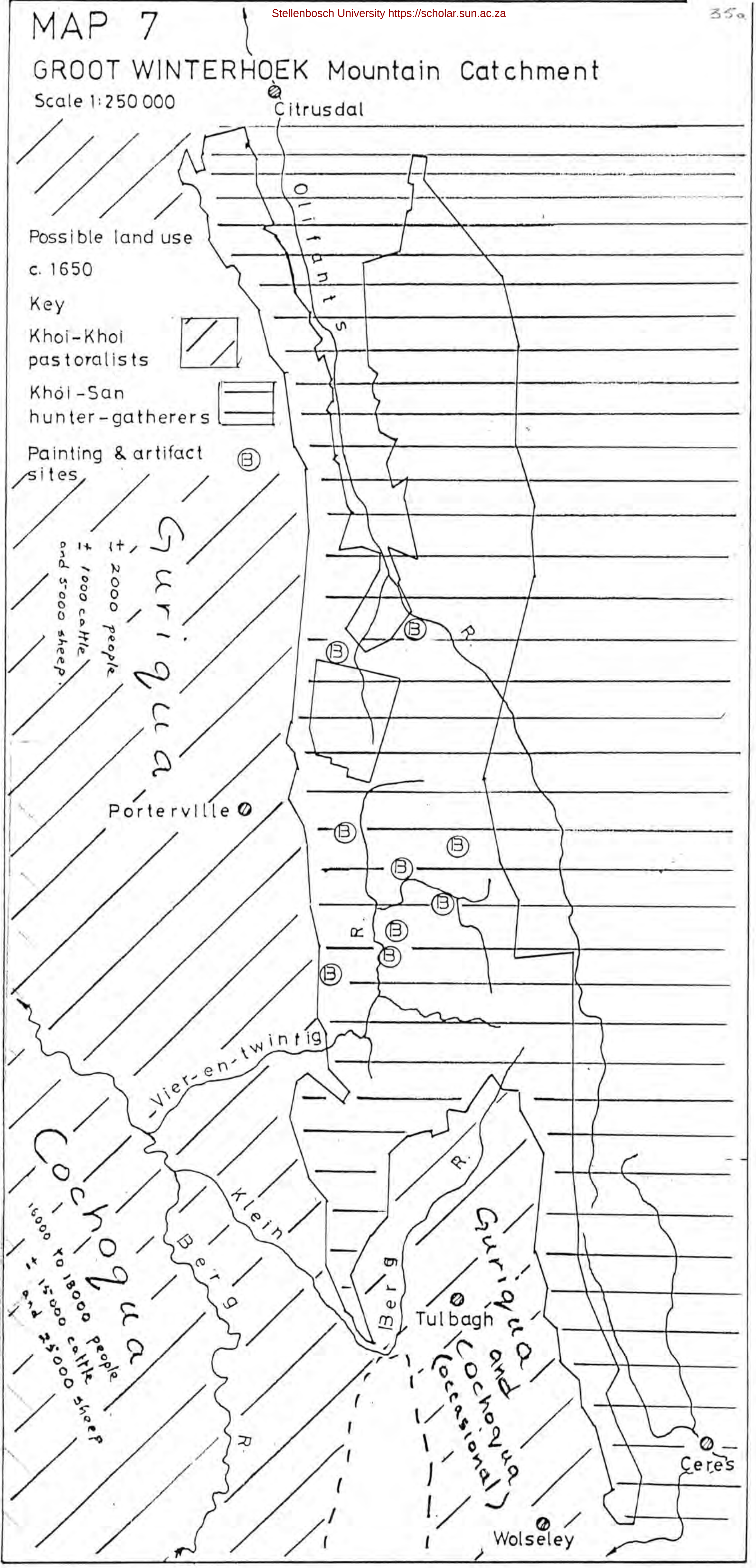
2.9.3.4.2 Exotic species such as trout (Salmo gairdneri), black bass (Micropterus sp.) and blue-gill (Lepomis macrochirus) have been introduced to various streams and dams. The lower reaches of the Vier-en-twintig-riviere still contain trout and the lower section of the Olifants River within the study area contains bass and blue-gill. (Gaigher, 1973(b); Cape Province Department of Nature and Environmental Conservation pers. com., and personal observation).

3. LAND USE

3.1 Land use before European Settlement

3.1.1 Quartzite handaxes found in both the Vier-en-twintig-riviere and Olifants Rivier valleys are evidence of Hominid presence in the study area at least as early as the Middle Pleistocene. Klein (1974) suggests that Acheulian handaxe makers may have been active in the Southern Cape from "as much as 700 000 B.P. to as recently as 100 000 B.P.". The Acheulian was followed by the Middle Stone Age "from perhaps 100 000 B.P. to 40 - 30 000 B.P." during which period "handaxes are completely absent". (Klein, loc.cit.). "All the known Middle Stone Age sites in the Southern Cape apparently date from the end of the last Interglacial or from the earlier part of the Last Glacial" (Klein loc.cit.). Between the Middle Stone Age and the appearance of later cultures there is a gap of many thousands of years (12 - 15 000 years, Klein, loc. cit). The most recent of the Later Stone Age microlithic industries is the so called Wilton dating from between 8 000 and 7 000 B.P. The aboriginal hunter-gatherers (known variously as Khoisan, Soaqua, Sonqua and Bushmen) were of this culture. Microlithic flakes and artifacts are to be found in several localities within the study area (Map 7).

3.1.2 Evidence from coastal and other cave excavations including


MAP 7
GROOT WINTERHOEK Mountain Catchment
Scale 1:250 000
Citrusdal
Olifants
Possible land use
c. 1650
Key
Khoi-Khoi pastoralists
Khoi-San hunter-gatherers
Painting & artifact sites
Guriqua
± 2000 people
± 1000 cattle and 5000 sheep
R.
Porterville
R.
Vier-en-twintig
Cochoqua
16000 to 18000 people
± 15000 cattle and 25000 sheep
Klein
Berg
R.
R.
Berg
Tulbagh
Guriqua and Cochoqua (occasional)
Ceres
Wolseley

analysis of faunal remains, fossil pollen and soil development patterns indicate numerous fluctuations in temperature and moisture regime from the early Pleistocene to the early Holocene. Changes in the vegetation induced by fluctuations in climate were reflected by changes in faunal species distribution. Increases in precipitation and/or decreases in temperature no doubt rendered the study areas less hospitable as a habitat for the majority of animals as well as for early man. Climatic fluctuations are discussed by Butzer and Halgren (1972) reported in Klein (1974), Deacon and Brooker (1976) and Van Zinderen Bakker (1963). Klein (1974) states that "with the appearance of the Wilton about 8000 B.P., environmental conditions essentially similar to historic ones seem to have become established in the Southern Cape". Van Zinderen Bakker (1963) and Coetzee (1964) find evidence in fossil pollen spectra from various Central and Southern African sites for a gradual warming up from the end of the Late Glacial (about 8540 B.P.) with minor fluctuations to the present.

3.1.3 Considering the evidence accumulated by the aforementioned researchers it is reasonable to assume that climatic conditions and vegetation in the study area have been relatively stable over the past 8000 years, and that people who were probably ancestral to the present day Bushmen (Klein, 1974) periodically hunted and lived in the study area over the whole of this period. There is evidence of seasonal migrations of these hunter-gatherers to the mountains in the summer when both coastal and inland lowlands become hot and dry and back to the lowlands in winter when the mountains are unpleasantly cold and wet, water is again available in the lowlands and edible bulbs and corms more easily detected due to the appearance of above-ground growth (Shackleton, 1973 in Klein, 1974; Parkington, 1977).

3.1.4 "Doughnut" digging stick weights, small chert scrapers and flakes and a number of rock shelters containing paintings are clear evidence of use of the area by Khoisan or Soaqua hunter-gatherers. An interesting and unusual painting of a sailing ship (Photo 12) probably records a group's first encounter with Europeans in or about 1488 whereas a painting of a solitary cow (Photo 13) probably indicates contact with Khoi-khoi (Hottentot) pastoralists at some much earlier date.

3.1.5 It is not known whether these early hunter-gatherer peoples practised any form of deliberate land management. There is speculation that they may have burnt the veld selectively both in order to encourage game to concentrate on succulent regrowth, making hunting easier, and to stimulate reproduction of the various edible iridaceous plant species which formed an appreciable portion of their diet. If this form of primitive land management did exist it is almost certain to have been practised for at least 8 000 years, that is for the whole period of the current climatic regime. The people and their land-use or management practices, whatever they might have been, were therefore as

PHOTO 12

Bushman painting of a sailing ship; from the Groot Winterhoek area.

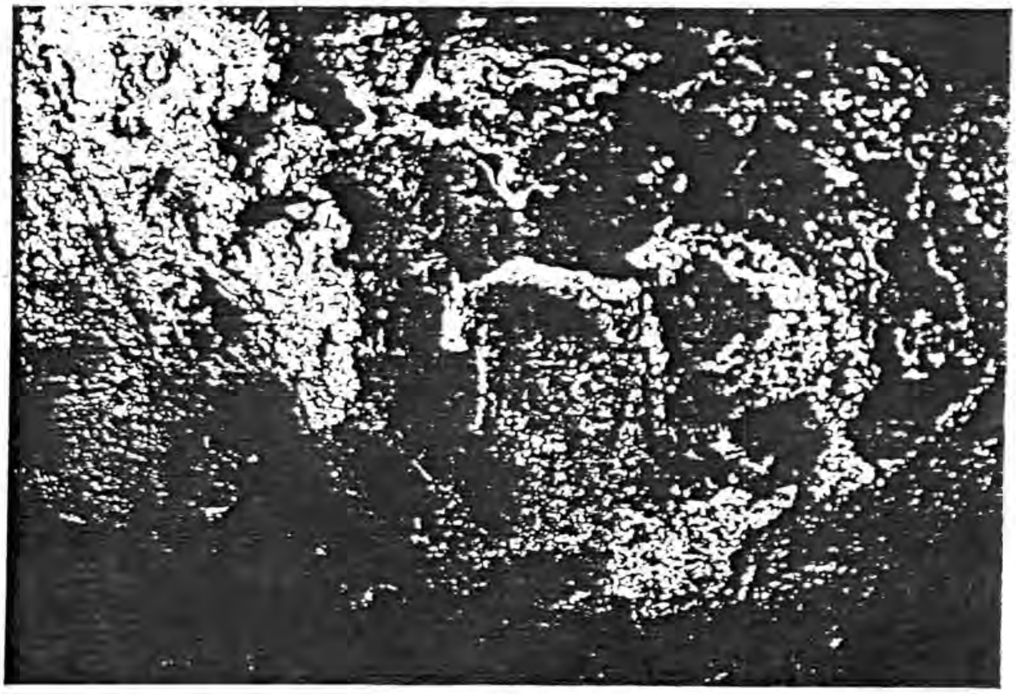


PHOTO 13

Bushman painting of a cow(?); from the Groot Winterhoek area.

much a part of the biome as the migratory herds of antelope and should be accepted as natural factors. People have been making hearth fires in this south-western corner of Africa for at least 100 000 years (Klein 1974 and Deacon 1975), so that man made veld fires would not have been unusual whether deliberately set or not.

3.1.6 The earliest records of European contact with Southern Africa (Bartholomeu Dias, 1488; Vasco da Gama, 1497, Antonie de Saldanha, 1503; and others) all mention contact with people with many sheep and cattle (Raven-Hart, 1967). For many years before Jan van Riebeeck established the Dutch settlement at the Cape in 1652, Portugese, English and Dutch ships called at various points along the coast and bartered with the local people for sheep and cattle for slaughter. After they had settled, the Dutch continued to obtain appreciable numbers of cattle and sheep from the indigenous people for some time.

3.1.7 As neither sheep nor cattle are indigenous to Southern Africa how long had these animals been in this area and how did they get here?

3.1.7.1 The changeover from hunting, fishing and gathering to cultivation of food plants and domestication of stock took place about 7 000 B.C. in the middle East (Mellaart, 1965; McEvedy, 1980). Some people kept animals but did not cultivate.

They led a nomadic life, were very mobile and spread rapidly in all directions in search of new pastures as their numbers grew and as the cultivators expanded onto land previously used for pasture. Their migrations took them into Africa. There is archaeological evidence of cattle being in Khartoum about 6000 B.C. and in East Africa about 2000 B.C. (Phillipson, 1977 in Deacon et al 1977). At about the former time, that is some 8 000 B.P., east- central and southern Africa were occupied by so-called "Bushmen" (Mc Evedy, 1980). These were aboriginal people physically and linguistically quite distinct from the Negroid people of north west Africa, the Nilotic people of north east Africa and the Pygmies of the west and central African forests. These hunter-gatherers with their "click-language" must have come into contact with the southward migrating nomadic pastoralists. Some of the hunters adopted the pastoralist economy and so became the first Khoi pastoralists or Khoi-Khoi later to become known as Hottentots by Cape settlers. Others either preferred the hunter-gatherer life or were unable to adapt for some reason and became known as Khoi-san or Bushmen (Elphick, 1977).

As with other stock owning people the Khoi-Khoi experienced a population explosion. Increasing population and stock numbers and pressure from stronger southward expanding people forced them southward ahead of the stronger tribes. They were later forced westward by Bantu speaking immigrants moving south down the east coast and ended up in the southern and western Cape (Stow, 1905; Elphick, 1977).

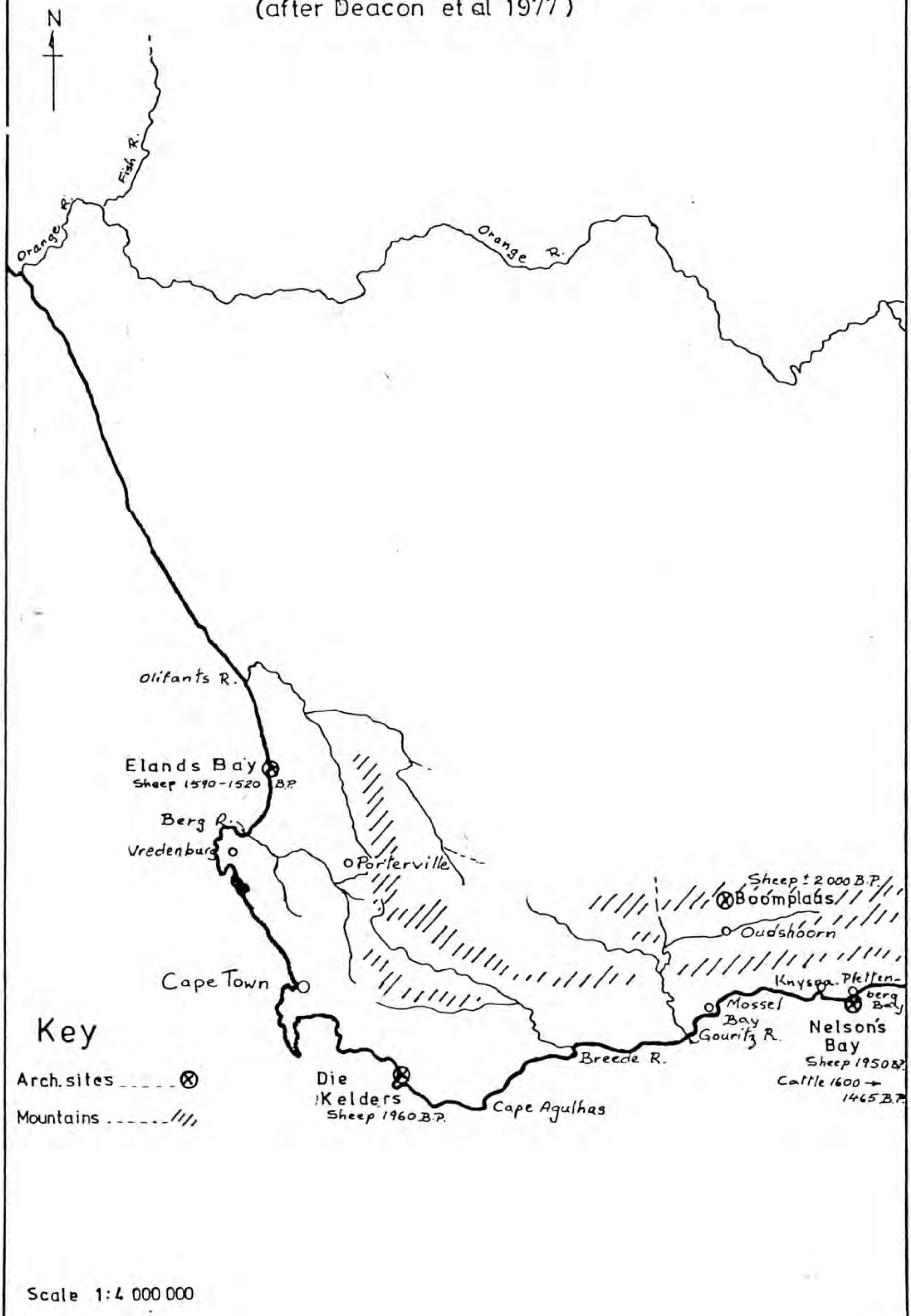
Archaeologists have found evidence of sheep in the southern Cape (Boomplaas) from as early as approximately 2 000 B.P. and of cattle possibly about 1 600 to 1 465 B.P. (Die Kelders) (Schweitzer, 1974, 1975 in Deacon et al, 1977). Map 8 shows the distribution of some archaeological evidence of domestic stock. These finds unfortunately provide no idea of numbers of stock involved and it is possible, or even probable, that the very early records reflected the presence of relatively small advance groups within the hunting range of local Khoi-san.

Stow (1905) was of the opinion that the Khoi-Khoi were still in the process of moving into the south-western Cape when sighted by Europeans for the first time in the mid fifteenth century and that they were confined to the coastal forelands. Stow quotes Barrow (1806) who reported that there were "no Hottentots in the interior beyond the mountains but only Bushmen". Elphick (1977) feels that there is evidence to indicate that the pastoralists had been established in the southern and western Cape for only a hundred years or so when first contact was made with Europeans.

3.1.8 Pastoralists throughout Africa burn the veld both to reduce predator cover and to improve inherently poor pasture

MAP 8 Archaeological sites with evidence of domestic stock

(after Deacon et al 1977)



by inducing more palatable new growth of vegetation. The Khoi-Khoi were no exception (Van Meerhof, 1661, in Mossop, 1927; Kolbe, 1745 in Elphick, 1977). However, the small numbers of people and stock involved in relation to available land probably meant that while the study area may have been subjected to more frequent fires than before, it was only infrequently subjected to short term use as pasture. This is thought to have been so because mountain pasture is so much poorer than that of the coastal plain that the latter would only have been abandoned in favour of the mountains in years when both pasture and water supplies became inadequate on the plain, that is in years of severe drought.

3.1.9 In summary then it can be postulated that from at least 8 000 B.P. to some time after 2 000 B.P. land use in the study areas was that of small roving bands of hunter-gatherer people who made use of the mountain area for a relatively short time each year and who may have deliberately set fire to the veld for a number of reasons, among them to encourage proliferation of geophytes which formed an appreciable portion of their diet, to aid them in hunting, or to clear dense vegetation. From between about 2 000 and 1 500 to about 600 B.P. (1 300 A.D.) occasional small groups of nomadic pastoralists moved into or through the area, their numbers gradually building up to the population density encountered by the first European visitors in the late fifteenth to early sixteenth century.

3.1.10 From about 1 300 A.D. to 1 652, when the Dutch supply post was established at the Cape, Khoi-Khoi population figures probably fluctuated about a fairly constant mean. While many early travellers report veld fires there are also reports of very dense vegetation and heavily wooded river valleys, for example those of the Berg, Vier-en-Twintig-Rivieren and Olifants rivers. Van Meerhof, who accompanied Jan Dankaert on an exploratory expedition to the Olifants River in 1660, writes of a variety of big game including hippoppotamus, rhinoceros, elephant, quagga and several species of antelope both large and small (Van Meerhof 1660 in Mossop, 1927). He also mentions an extensive fire which had been set by the Hottentots to provide grazing for their cattle. The party had to make a lengthy detour to avoid the fire (Van Meerhof, 1661 in Mossop, 1927). Such reports indicate that the veld had not been subjected to very frequent fires or been burnt on a short rotation up to that time. Repeated burning of Fynbos at short intervals soon results in elimination of the taller seed-regenerating woody shrubs and attempts at annual, or even two-to three-yearly burning of the same area very soon produces a fine-grained mosaic of uneven aged veld which will only burn in small patches. An "extensive fire" would be unlikely if not impossible in such veld. The reports also indicate that competition between people with their domestic stock and wild animals for "lebensraum" was still at a low level.

3.1.11 The best estimates of the numbers of people and stock of the various Khoi-Khoi groups are from records of the Dutch East India Company. The Company records are quoted by Stow (1905) and Elphick (1977) and Table 6 was compiled from the latter sources.

The seasonal migrations of the Peninsula groups took them through the territory from south of Saldanha Bay to Table Bay, Hout Bay and other parts of the Peninsula, eastward to the Hottentots Holland mountains, and reputedly as far as Swellendam on occasions, and northward again toward Saldanha Bay. They moved to Table Bay and the Peninsula pastures in the hot summer months from December to March.

The Cochoqua used the terrain from south of the Berg river mouth and moved in a seasonal cycle from Saldanha to Table Bay, to the upper Berg River and back down the River toward Saldanha. They moved parallel to the Peninsula groups but apparently did not mix with them.

The Guriquas occupied territory between the Berg and Olifants Rivers migrating seasonally from the coast near the mouth of the Berg River inland to the mountains then north to the Olifants, west to the coast at the mouth of the Olifants and south down the coast again.

Both the Guriqua and the Cochoqua made occasional use of the

TABLE 6

Estimates of Khoi-Khoi (Hottentot) population and stock numbers (Compiled from Stow, 1905 and Elphick, 1977)

Khoi-Khoi Group	Estimated numbers as at 1652, of People	Cattle	Sheep	Approx. area covered in seasonal migration (Km^2)	Approx. stocking density. Ha per small stock unit (S.S.U.) (1 cattle = 7 S.S.U.)
Peninsular groups	4 000 to 8 000	± 8 000	± 10 000	10 000	5
Cochoqua	16 000 to 18 000	± 15 000	± 25 000		
Guriqua	±2 000	± 1 000	± 5 000	8 800	73

Note: The estimated stocking density figures (last column) indicate that whilst the area between the Peninsula and the Hottentots Holland Mountains and south of the Berg river had approached capacity, the country north of the Berg rivier and west of the study area appears to have been under-utilized.

Tulbagh-Wolseley valley, known to the settlers as "het Land van Waveren".

3.1.12 From the above it may be seen that the Guriqua were the group most likely to have made use of portions of the study area, although the Cochoqua may occasionally have moved into certain easily accessible pastures in the southern portion of the area and the so called "Little Namaqua", who normally remained to the north of the Olifants, may have come south into the northern portions from time to time (Elphick 1977). It is probable therefore that, except for the most easily accessible portions, the study area remained unused by Khoi-Khoi pastoralists, and that even the accessible portions, such as the Voorberg, and Zuurvlakte were only used on those occasions when very dry conditions on the plains severely reduced both available pasture and water supplies. On such occasions it appears that stocking rates may have been as high as 35 small stock units per hectare (one small stock unit [S.S.U.] being one sheep, and one head of cattle taken as equivalent to seven small stock units). However, this is an impossibly high stocking density for mountain pastures to maintain for any length of time. At this rate the veld would have been totally denuded in a very short time.

3.1.13 All available evidence leads one to believe that up to 1652 at least, the study area had very seldom been used for pasturing stock and that the pasturing that did take place would have had no significant lasting effect on the ecology or hydrology of the area. Map 7 shows a postulated land use pattern for the mid seventeenth century immediately prior to European settlement at the Cape.

3.1.14 After the establishment of the trading post at the Cape in 1652 a number of complex factors combined to bring about a decline in the Khoi-Khoi population and in their stock numbers. They were reduced by diseases, imported by the colonists, by clashes with the colonists and by increased inter-clan fighting, partly caused by contact with European traders (Elphick 1977). By the end of the seventeenth century their numbers had been very severely reduced and white stock farmers had begun moving north toward the Vier-en-Twintig-Riviere in search of pasture for their increasing herds.

3.2 Early European Land Use in the study area and vicinity

3.2.1 It is a well documented fact that one of the main reasons for establishing a settlement at the Cape was to provide a revictualling point for the trading ships of the Dutch East India Company on the long journey from Europe to the Far East. The settlers obviously had to feed themselves as well as provide for passing ships and wild animals were a useful local source of meat.

In spite of early difficulties with ineffective firearms and an apparent abundance of game (Jnl. of J. van R., H.B. Thom, ed. 1952; Skead 1980) it apparently became necessary within a few years to exercise control over hunting in order to ensure a permanent supply of meat for the company garrison. In 1656 two permanent hunters were appointed to keep the garrison supplied with meat. These men were freed in 1657 but were given a monopoly to supply venison at fixed prices (Bigalke 1979). After 1661 all freemen were permitted to kill game for their own consumption, but in 1670 hunting was again restricted to permit holders (Bigalke, loc.cit). Later, apart from hunting permits, hunting rights to specified areas were leased to individuals by the Company.

Both permits and leases granted by the governors Simon and Willem Adriaan van der Stel were recorded in so caled "Wildschutten Boeken" which span the period 1687 to 1718 (Bigalke, 1979). The leases were for areas as far afield as the Olifants River and the Bokkeveld (State Archives, Cape Town; van der Merwe, 1972).

3.2.2 By the end of the seventeenth century wild animal numbers had been drastically reduced (Bigalke, 1979; Skead, 1980) and stock farmers, many of them former hunters, began leasing the hunting grounds for pasturing their domestic animals. The early grazing area leases were also recorded in the "Wilschutten Boeken". The earliest were for periods of up to six months, but later leases were for a full year at a time (Van der Merwe, loc.cit), for example those granted for six month periods to Messrs Jan Bothma in 1706 and Jan Wilderts in 1707 on the upper Vier-en-Twintig-Rivieren, Andries Burgers in 1730, Pieter Brijl in 1731 and Alwyn Smit in 1738, along the Voorberg in the region of present day Porterville and later yearly leases to Messrs Rudolph Liebenberg for "Septemberskraal aan de Vier-en-Twintig-Rivieren" in 1757 and Hugo Lambrechts for an area on the Klein Berg River in 1764 (Van der Merwe loc. cit; State Archives, Cape Town). These leased grazing areas were known as "vee lechtplaatsen" (Van der Merwe, loc. cit).

3.2.3 Before the end of the eighteenth century a number of the "vee lechtplaatsen" had been replaced by "leningsplaatsen". The conditions of lease for the latter included building a house and fortified kraal. The farmers also began cultivating land for wheat and planting vines and fruit trees (Van der Merwe, loc. cit). Farmers and their stock were now confined to particular beaconed off areas. It is logical to assume that as more of the valley land was brought under cultivation so use of mountain pastures increased. Furthermore enforced use of the same pastures every year and consequent attempts to burn the veld annually to provide more palatable feed no doubt led to the development of the so called patch burn system. This system in its traditional form entails going through the pasture area in mid to late summer and igniting any vegetation that will burn. Stock were pastured on the plains and lower mountain slopes for most of the year, including the winter months, and on higher mountain pastures for three to four months during the hottest and driest part of summer. Stock numbers were not large as may be seen from Table No. 7 adapted from Van der Merwe (1972) who abstracted the information from official records of the Batavian period.

3.2.4 It is strange that cattle are not listed in these records because at least some of the farmers of the area were reported as having acquired cattle. In 1738 some 2 000 head of cattle seized from Hottentots during a border skirmish were distributed among members of the Swartland Citizen Force who took part. These cattle are said to have been pastured in the Vier-en-Twintig-Rivieren area (Van der Merwe, 1972). However, stock numbers at this time appear to have been generally low.

3.2.5 Shortly after the second British annexure of the Cape, in 1810, the Governor, Sir John Cradock, introduced the perpetual quitrent system of land tenure whereby farmers gained permanent freehold title to their land. A list of some farms in and adjoining the study area with names of the farmers to whom they were first granted and the years in which the grants were registered is presented in Table 8 (See also map 9).

3.2.6 Most, but not all of these people had been leasing the farm for many years before the grants were registered, for example

TABLE 7

Selected statistics for some farms in the vicinity of Porterville during the Batavian period (after Van der Merwe 1972)

Farm	Owner	Number of sheep	Number of goats	Wheat sown (bags)	Vines
Pampoenkraal	Chris Ludolph Liebenberg	300	120	16	10 000
Matjiesrivier	Willem Burgers	460	400	27	-
Kleyne Elsebosch	Isak Schalk van der Merwe	100	150	30	8 000
Willems Valley	Andries Burgers	230	130	30	11 000
Tygerkloof	Widow Frederick Liebenberg	150	200	19	3 000
Houd-Constant	Widow Willem Burgers	200	235	30	14 000

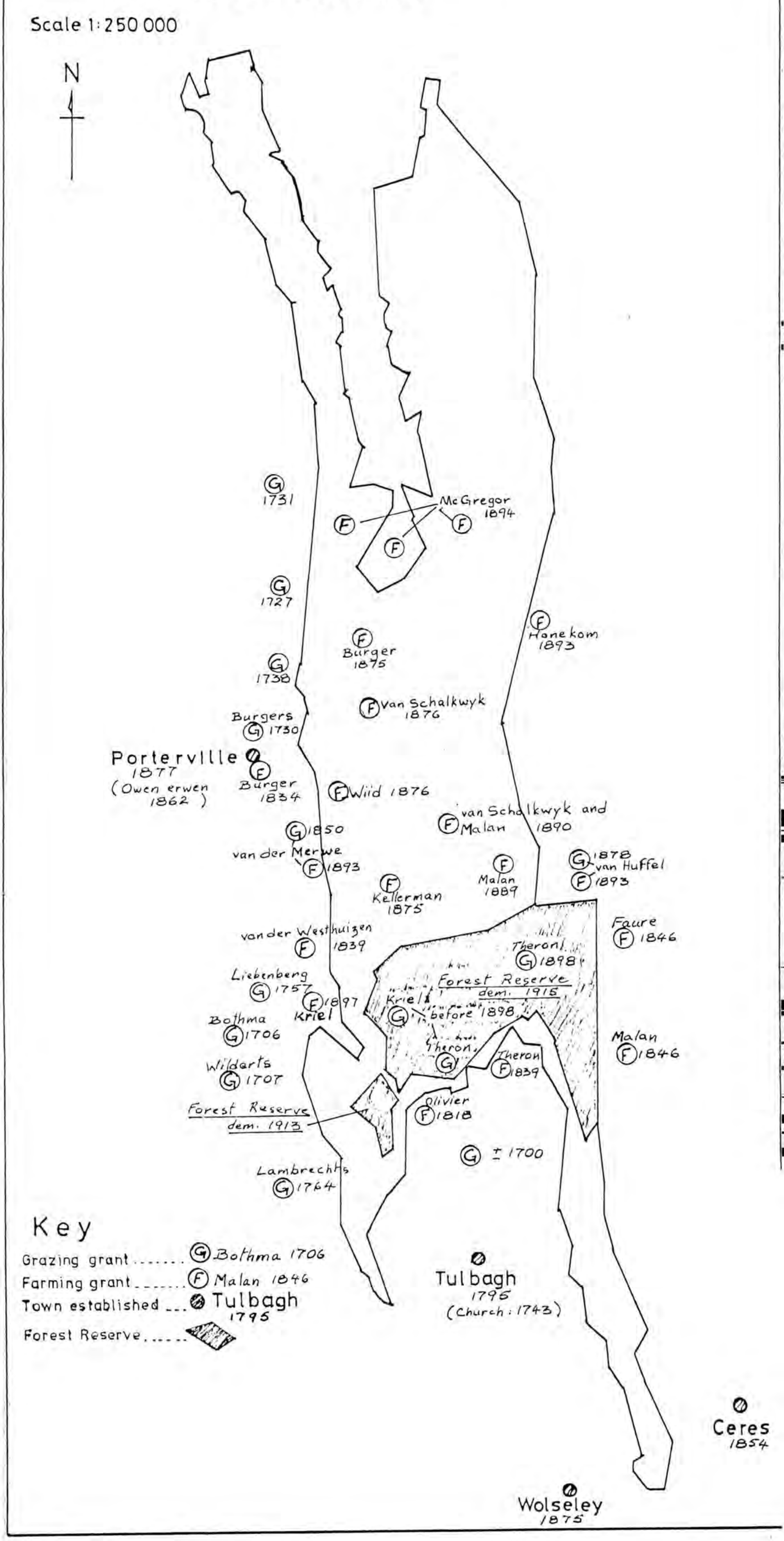
TABLE 8:

First registered owners and date of registration of some farms in the study area
(Information from the records of the Registrar of Deeds, Cape Town)

Farm	Name of Farmer	Year of grant registration
Roodezands kloof	Olivier	1818
Willems Vallij	Burger	1834
Winterhoek	Theron	1839
Dasbosch	Van der Westhuizen	1839
Kruip In	Malan	1846
Rosendaal	Faure	1846
Pampoenfontein	Burger	1875
De Tronk	Kellerman	1875
Zuurvlakte	Van Schalkwyk	1876
Louws legplek	Wiid	1876
Paarden Vallij	Malan	1889
Kliphuisvlakte	Van Schalkwyk and Malan	1890
Vischgat	Van Huffel	1893
Onder Bosch Kloof	Hanekom	1893

Driebosch	Van der Merwe	1893
Grasruggens		
Grootfontein and Grootfontein Extension	McGregor	1894

MAP 9 Early grazing and farming grants and Forest Reserves



the Burgers had been leasing Willems Vallij since 1730, Van der Merwe Driebosch since 1850, the Therons Winterhoek since about 1750 or earlier, and Van Huffel Vischgat since 1878 or earlier ("Oude Wild Schutte Boeken", Tulbagh magistrates records, and other registers, National Archives, Cape Town). The Kriels, whose properties were sited on the Vier-en-Twintig-Rivieren near where the river flows from the mountain range, used mountain pastures on the Solderberg until some time after the area had been set aside for forestry purposes. The Therons of Winterhoek similarly made use of the mountain pastures of Kleinvlei, Sneeugat and Sneeukoprivier (or Theronskloof) until some time after the greater part of this area had been reserved for forestry purposes along with the Solderberg and the Groot Winterhoek peak area. An application to purchase the portions which they had been using for pasture was turned down on the recommendation of the Conservator of Forests of the time (Hutchinson) because the land was "required for Forestry purposes", but the pastures were leased to the farmers for a number of years simply because it would have been virtually impossible to prevent them from running their stock there. The first application to purchase was submitted in 1898 and a second in 1900. (Correspondence on Surveyor General's files copy in Appendix 3). A descendant of the family who used the Kleinvlei pastures can remember driving cattle through a narrow gap on the edge of the rocky scarp onto Kleinvlei and then blocking the gap with a stone barrier, effectively confining the cattle to that portion of the mountain.

(Mr. H. Theron pers. com.).

Kloofsberg was proclaimed a Forest Reserve in 1913 and the Groot Winterhoek area, including the pasture areas mentioned above, was proclaimed a demarcated Forest Reserve in 1915. Map 9 shows the locality of the areas mentioned.

3.2.7 As suggested earlier (3.2.3), the commonly applied veld management system of patch burning would probably have developed naturally as a result of attempts to burn fynbos annually. Once the system has been established it is possible (and was also the practice) to patch burn safely, without fear of a runaway fire, on any convenient day through the summer, provided that extreme conditions of heat and wind are avoided (Mr. P.H. Smit, pers. com.). It was the practice to go through the veld annually in the summer and ignite all patches that would burn. After some experience patches that will burn are easily identified according to Mr. Smit.

3.2.8 In the central portion of the study area it was normal practice to burn out the vleis and sandy flats between the koppies of Kliphuisvlakte and Zuurvlakte annually and to patch burn the mountain veld proper. The vleis and flats which are dominated by restioid vegetation, were utilised principally by cattle whereas sheep and goats preferred the more shrubby vegetation of the slopes (Mr. W. Engelbrecht, pers. com.).

3.2.9 For successful stock farming, particularly with sheep and goats, it is essential to move to the Karoo (or other "sweet veld" area) in the winter. The longer the stock can remain on the "sweet veld" the better. Both the timing of the move and the length of stay in the Karoo depends upon when and how much rain falls there. In a year of normal rains the farmers moved to the Karoo with their stock in May or June and remained there until September. One farmer claims to have made a "profit" of R20 000 in 1976/77 because he was able to leave his sheep in the Karoo until November whereas in 1977/78 he had been unable to move to the Karoo as there had been no rain there at all. As a result he was forced to feed his sheep. His costs were therefore R6 500 higher than normal and his sheep remained in poor condition (Mr. P.H. Smit, pers. com.) (See also Impey, 1971).

3.2.10 Sheep and goats were herded in the mountains and kraaled every night to prevent predation especially by caracal and leopard. Cattle, however, were allowed to range free and a number of farmers left their cattle free ranging in the mountains throughout the year. Toward the end of the nineteenth century and in the early nineteen hundreds Frans Theron of Winterhoek kept cattle on the areas known as "Kleinvlei" and "Theron se kloof", mentioned earlier, and M.C. Kriel of Septemberskraal probably used the "Solderberg" in the same way. Cattle belonging to H.A. Lamprechts and others used at one time to roam freely from Zuurvlakte to the Visgat farm on the Olifants River (W. Engelbrecht pers. com.).

3.2.11 On the larger mountain properties three are a number of kraal sites between which the sheep and goat flocks were rotated in order to make full use of available pasture.

3.2.12 The mountain properties, Grasruggens, Pampoenfontein, Zuurvlakte, Louwslegplek, Kliphuisvlakte, Paarden Vallij (Perdevlei), Driebosch and De Tronk, and the mountain portions of other properties (portions within the study area) were used only as seasonal pasture until about 1850 when overseas interest in Buchu (Agathosma crenulata and A. betulina), stimulated by reports of its medicinial properties by Thunberg, Sparman and Wikar in the seventeen hundreds and later by Burchell, Latrobe, Hesse, Ecklon and Pappe, (the last in 1847), created an export market for the foliage of these plants (Smith, 1962).

3.2.13 Agathosma betulina is found in good quantities in the mountains from Tulbagh northward to the Cedarberg. Farmers with mountain property took advantage of the Buchu boom to augment their income and Buchu poaching, particularly from the "Crown Lands" and "Forest Reserves" was rife. In 1905 a special Forest Guard was stationed in the Winterhoek area in an attempt to control Buchu poaching (correspondence between the Conservator of Forests and Tulbagh Magistrate on Surveyor General's files). It was soon found that growth of the Buchu plant was stimulated by burning the veld after harvesting the Buchu. This suited stock farmers well as they already burnt the veld annually to improve pasture using the patch burn method described earlier. The system most commonly adopted for Buchu was as follows: Immediately after harvesting in December/January the Buchu producing area was burnt. Two years after the burn it was cut again and then again in the fourth year post burn. After the second cut (that is in the fourth year post burn) the area was burnt once more. As the Buchu generally grows in areas that are not particularly suitable for grazing it was relatively easy to integrate a Buchu burning cycle into the pasture patchburn system (Messrs P.H. Smit, J. Burger, W. Engelbrecht, pers. com.).

3.3 More recent land use

3.3.1 The mountain properties and portions of properties continued to be used almost exclusively as summer pasture, hunting grounds and for buchu harvesting until well into this century. Rudimentary herdsmen's huts were the only forms of residence in the mountains.

3.3.2 In 1909 a Mr. Retief bought De Tronk and sometime after this date he permitted a small group of Black people to settle on the property at a place now known as Ou Pos. The Blacks were known as the Makatese. There were five men, four of whom had wives, and about six children ultimately. They built houses, cultivated a small area of crops such as beans and tobacco (for making "roltabak") and kept a few sheep and goats. They also planted peach trees and, it is believed, the black wattle trees found on the site of their settlement today (Mr. R. Wigboldus, Mr. G. van der Merwe and others, pers. comm.). Apart from deserters and escaped convicts who were reputed to have occupied caves in the area from time to time, for example in Drosterskloof on the property Visgat, it is believed that the Makatese were the first people, other than Bushmen, to settle in these mountains and live there throughout the year. The stock farmers sent their flocks and herds into the mountains for three to four summer months only, in the care of herders who lived temporarily in small shacks or caves at various stock camps (veeposte). The advent of permanent residents heralded a new development in the land-use pattern.

3.3.3 In 1913 Sarel van Huffel of Vischgat (Visgat) bought a portion of Perdevlei and one of his sons moved to this property where he built a house soon afterwards. He too planted fruit and shade trees and cultivated a small area of crops such as beans and sweet potatoes.

3.3.4 In 1929/30 the Wigholdus brothers purchased the farm De Tronk and re-named it Groot Winterhoek. At about this time also a Mr. Malan acquired a portion of the Pampoenfontein property and planted deciduous fruit orchards. These did very well and others were encouraged to follow suit in spite of the fact that there was as yet no road into the area.

3.3.5 In 1936 Mr. W. Engelbrecht bought the property Louwslegplek on which he had been living for some years. He built a house, planted a small orchard (two or three hectares) about half a hectare of oaks (Quercus robur) and cultivated a small area at a site on the Groot Kliphuis River which he named Weltevrede. In 1941 Mr. Engelbrecht bought Kliphuisvlakte and a portion of Perdevlei where two of his sons then settled. They named the site of their homesteads Groot Kliphuis. A stock camp on this property located on the shale band in the Kleinkliphuis river valley was named Klein KLiphuis. The names are taken from two rock shelters, one near each site, both of which contain Bushman paintings. A third Engelbrecht son was set up on a portion of Louwslegplek known as Langvlei. One of the sons at Groot Kliphuis established about two hectares of orchard and cultivated five to ten hectares of annual crops, but the other two confined themselves to two or three hectares or less of annual crops and a few fruit and shade trees.

3.3.6 The Dasklip Pass road to the plateau and the Eselfontein and Pampoenfontein properties was completed in 1941 (Van der Merwe 1972). In the same year it was taken through to the Engelbrecht farm Weltevreden, and also to the Van der Merwes' stock camp at Agterdam on the farm Driebosch. One of the Van der Merwe brothers employed a herdsman who lived with his family permanently at Agterdam where he cultivated one or two hectares of annual crops and tended the sheep and goats. Another Van der Merwe brother built a house not far from the Engelbrechts at Weltevreden, on a portion of Driebosch which he named Drieboschfontein. Apart from a few hectares of annual crops Mr. van der Merwe also planted two to three hectares of bush tea and about one hectare of deciduous fruit.

3.3.7 The Wigholdus brothers had been developing Groot Winterhoek (De Tronk) in a small way over the years, but in 1950 Mr. Roelof Wigholdus bought his brother's half share in the property and began a concerted effort to build a road to the site they had selected. In 1951 the road was finally completed and Mr. Wigholdus then set about planting both deciduous and citrus fruit trees and several kinds of nut tree, including Hazels, Almonds, Pecans and Walnuts. He later planted Buchu, several hectares of Bush Tea and some pastures using clovers, <u>Seradella</u> and other fodder species.

3.3.8 Before the completion of the Dasklip Pass the only agricultural products, other than livestock, to come from the mountain properties were beans, twist tobacco (roltabak), dried fruit and later, Bush Tea. Buchu was harvested exclusively from the natural veld until very recently. Improved communications made it possible for mountain farmers to exploit the fresh fruit market. However only the farmers on those properties on the first portion of the plateau above the pass, that is the subdivisions of Eselfontein and Pampoenfontein, achieved any degree of success in this regard. Four families on these properties and one on the adjoining property, Zuurvlakte, are the only farmers left who are living on and actively farming mountain properties. These properties are discussed in detail below. Two more families have holiday properties in the same area.

3.3.9 On one other property within the study area, Farquharson's Request, currently owned by the Burger family and known to them as Boskloof, a house was built sometime early this century at a site called Goudini. Here also a small area was planted to fruit trees and nut trees and a hectare or two was cultivated annually. There is no road in to this homestead even today and it has been used only as a stock camp for many years now. A stock camp known as "Hans se werf" on the property Keerom Extension has been in periodic use from about the same time.

3.3.10 The Porterville plateau road was extended from Zuurvlakte to Groot-Kliphuis in 1951 and to Perdevlei in 1952.

3.3.11 The last grazing permits for the Forest Reserve were issued in 1934, and in 1949 Fire Protection Committees were appointed in terms of the Soil Conservation Act to control veld burning. The northern portion of the study area was included in the Citrusdal Fire Protection Committee area and the southern portion in the area of the Tulbagh-Wolseley Committee. For some reason the central portion including the Porterville plateau was not included in a Fire Protection Committee area and therefore veld burning remained uncontrolled.

3.3.12 Restrictions placed on veld burning combined with increasing general prosperity and standards of living, which indirectly gave rise to a severe shortage of herdsmen, caused many stock farmers to change their veld management methods. Others abandoned large scale stock farming in favour of irrigation farming on their valley properties and discontinued use of their mountain pastures altogether. Another factor which reduced the use of mountain pastures was the replacement of Dorper and similar relatively agile sheep with less mobile modern breeds of Merino that carry a heavy load of wool. These latter sheep cannot or will not negotiate even moderate slopes and are therefore very inefficient users of mountain pasture (P.H. Smit, pers.-com.). However, some farmers continued to burn with or without permit, and to make use of the pasture thus provided. Some stopped burning and put small numbers of goats and cattle onto their lower mountain slopes on a year round basis. All except two of the land owners who kept appreciable numbers of stock in the central area continued to apply the patch burn system of veld management until their properties were taken over by the

State between 1965 and 1975.

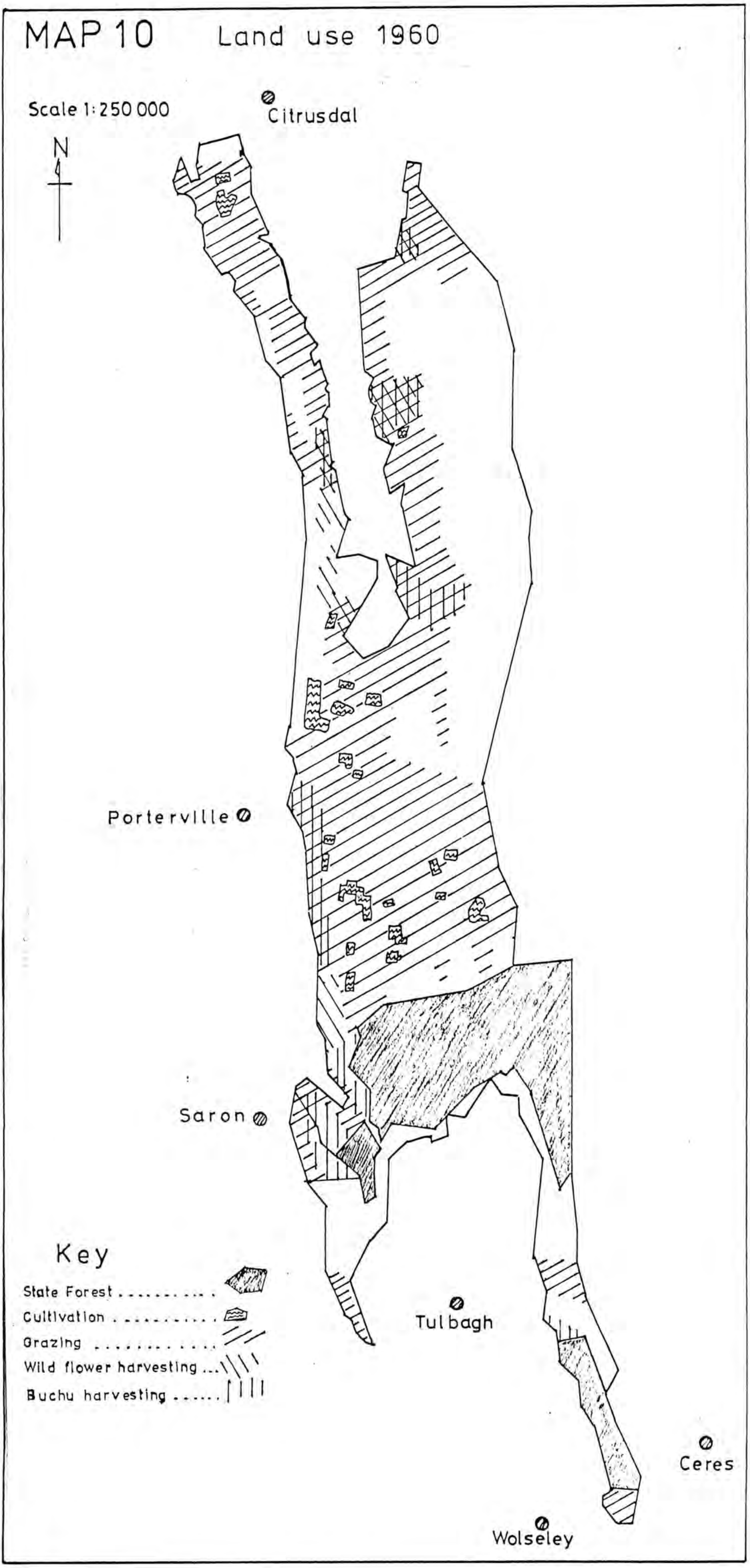
3.3.13 The exceptions were the Wigboldus brothers who kept only very few animals for their own use and did not deliberately burn their veld at all, and the Van Huffel family of Perdevlei. The latter family practiced annual patch burning to provide stock pasture as their father and grandfather had done before them, first on Visgat and later on both Visgat and Perdevlei. They continued this practice until 1973 when they began harvesting wild flowers and foliage for sale. After this all but a small number of livestock were removed from the farm and neither the adjoining slopes of Visgat nor Perdevlei were burnt again up to the time that the latter property was vacated by the Van Huffels in 1978. (Mr. E. van Huffel claimed to have had an income of over R23 000 in 1974 from the sale of wild flowers and foliage alone and maintained that this was more than the family had ever made from livestock in a single year).

3.3.14 No accurate records of past stock numbers are available but the figures presented in Table 9 are estimates obtained from Messrs G. van der Merwe and W. Engelbrecht. They will serve as an indication of the probable stocking densities of the mountain pastures during this land use phase. The estimates are approximate averages for the period 1960 to 1968 (Map 10 illustrates the land use pattern of 1960).

TABLE 9

Estimates of average stock numbers and of the number of people on some properties in the Groot Winterhoek area (about 1960 to 1968)

Property	Approximate numbers of People	Cattle	Sheep	Goats	Donkeys/ Horses	Estimated pasture area on these properties (Ha)	Stocking rates: Ha per small stock unit (1 head of large stock = 7 s.s.u.s)
1. Perdevlei	16	20	2 000	300	3	888	0,36
2. Kliphuisvlakte							
2.1 Groot Kliphuis	18	90	1 800	200	4	3 243	1,01
2.2 Klein Kliphuis	6	-	500	50	-		
3. Louwslegplek							
3.1 Weltevrede	8	20	1 000	100	-	1 182	0,65
3.2 Langvlei	5	5	500	20	2		
4. Driebosch							
4.1 Drieboschfontein	12	50	100	300	-	673	0,90
4.2 Agterdam	5	70	500	100	4	916	0,82
5. Groot Winterhoek (De Tronk)	15	10	50	-	-	1 537	12,81


MAP 10 Land use 1960
Scale 1:250 000
N
Citrusdal
Porterville
Saron
Tulbagh
Ceres
Wolseley
Key
State Forest ....
Cultivation ....
Grazing ....
Wild flower harvesting ...
Buchu harvesting ......

3.3.15 In 1961, a Government interdepartmental committee comprising officials of the departments of Agriculture, Forestry and Water Affairs of that time, acting on instructions arising from the commission of inquiry into South Africa's water resources (Ross et al, 1961) recommended that all of the properties within the upper catchment of the Vier-en-Twintig-riviere, not already under State control should be purchased by the State for the purposes of water conservation (Files of the Dept. of Agricultural Technical Services). The recommendations of this committee were implemented and the properties concerned were purchased or expropriated as indicated in appendix 4 and discussed in more detail below. The last property to be vacated was Perdevlei, in 1978, leaving only five active resident farmers in the mountains of the study area.

3.3.16 This, then, was the pattern of development of land use in the study area from the advent of Europeans into the country up to 1978. Up until about 1850 or 1860 the mountain properties were used only as stock pasture for three to five months each year and stocking rates appear to have been relatively low. The veld was patch burnt annually and the stock pastured on the new growth. After the latter date (1860) Buchu was regularly cut in the mountains, paths were opened into previously unused areas and the "buchu-veld" was burnt as described earlier. A small number of farmers moved permanently into the mountains and established irrigated orchards on a commercial scale. In the late 1940's to early 1950's most farmers discontinued use of mountain pasture for several reasons including stricter control of veld burning, which also affected buchu yields. In the late 1960's to early 1970's a growing market for Cape wild flowers, particularly Proteaceae, prompted some farmers to harvest these from their mountain veld as a partial substitute for the income previously derived from livestock and buchu.

3.3.17 These land use practices must have had some effect on the environment, particularly hunting and the annual veld burning followed almost immediately by pasturing of domestic stock. Hunting no doubt reduced the number and variety of antelope and other wild animals, and dense patches of Stoebe plumosa and Cliffortia ruscifolia in remote areas such as Theronskloof (or Sneeukop Rivier) may well be a result of earlier pasturing pressure. On available evidence it is not possible to say whether certain sparsely covered stony slopes are the result of frequent burning and over stocking, but the chances are that, while injudicious land use may have accelerated the process, the slopes in question are naturally stony and sparsely vegetated.

3.3.18 On the majority of those mountain properties where the farmers concerned were resident, stocking rates rose to very high levels and stock was kept on the mountain pastures for long periods each year, see for example Table 9. Here the signs of environmental degradation are readily visible, as will be discussed in more detail in a later section.

3.3.19 In some cases wild flower harvesting methods have also led to considerable environmental degradation.

3.4 Current land use

3.4.1 <u>A survey of current land use</u> within and adjoining the study area, carried out as time permitted between 1978 and 1980 produced information about the use of mountain lands most of which is presented in Tables 10 and 11 and illustrated on Map 10.

3.4.2 Aims of the Survey

3.4.2.1 The aims of the survey were to determine:

(i) land ownership status e.g. whether registered in the farmers own name, absentee landowner, syndicate or other ownership;

(ii) how and when the property was acquired, the price paid and the purpose of acquisition;

(iii) type and extent of land use, including veld management applied;

(iv) profitability, or economic viability of current land use of mountain land;

(v) how many people were dependant on mountain land for their livelihood;

(vi) the attitude of mountain land owners to that land;

(vii) their attitude to the mountain environment;

(viii) their opinion of the potential of their property;

(ix) their opinion of the mountain environment;

(x) their attitude to State control of land use in the interests of water conservation.

3.4.3 Method

3.4.3.1 There were two parts to the survey. Firstly the field investigation and recording of physical features and development. This was conducted according to standard procedures with the aid of topocadastral maps, air photographs and <u>in situ</u> investigation and recording (Directorate of Forestry files). Secondly the questionnaire survey.

3.4.3.2 Two forms of questionnaire were used during the survey. The first (Appendix 5) was designed simply to identify mountain properties, determine in whose name the properties were registered, who was living on the properties, who was working them and the form and intensity of land use and veld management. This was completed for each property during the course of the overall survey of the mountain catchment using all available sources of information including the records of the Surveyor General's office, the Divisional Council and the Department of Agricultural Technical Services, in situ inspection, air photographs, interviews with property owners and others living in or with knowledge of the area.

3.4.3.3 No great problems were experienced with this questionnaire, which was rather a combined check list cum questionnaire. That portion that could best be completed by the land owner or farmer in person was either sent by registered mail to the address recorded in the Divisional Council records, or handed to the head of the household concerned. Of the 102 landowners, 19 (18,6%) either could not be reached, did not reply or gave unsatisfactory answers. However, these owners represent a mere 3,3% of the total area. The information abstracted from the satisfactorily completed questionnaires is presented in Table 10.

3.4.3.4 The second questionnaire (Appendix 6) was designed to collect the same information as the first and also to determine

TABLE 10

Current Private Land-use (1978/80)

	Number of owners	% of owners	Approx. area (Ha)	% of total area
1. Data Base				
Property owners questioned	102	100	53 100	100
Unsatisfactory or no response	19	18,6	1 700	3,2
2. Homestead and sole or principal economic activity on mountain property	5	4,9	2 219	4,1
3. Pasture				
Cattle alone	-	-	4 400	8,3
Sheep alone	-	-	2 300	4,3
Goats alone	-	-	2 200	4,1
Sheep and cattle	-	-	1 900	3,6
Sheep and goats	-	-	4 600	8,7
Goats and cattle	-	-	1 300	2,4
Cattle, goats and sheep	-	-	800	1,5
Total veld pasture use	34	33,3	17 500	33,0
Unused portion of these properties	-	-	11 050	20,8
No stock at all in mountain veld	49 (1)	48,0	21 900	41,2
Stocking rates:				
Less than 4 ha. per S.S.U. (2)	23	22,5	11 500	21,7
4 to 8 ha. per S.S.U.	-	-	0	0,0
more than 8 ha. per S.S.U.	11	10,8	6 000	11,3
Time of pasturing:				
Autumn/Winter: 1 to 4 months	22	21,6	10 200	19,2
Autumn/Winter: longer than 4 months	1	1,0	300	0,6
Spring/Summer: 1 to 4 months	1	1,0	800	1,5
Spring/Summer: longer than 4 months	-	0,0	0	0,0
Year round	9	8,8	6 200	11,7

(Note: (1) More than half of these farmers stated that they or their fathers had pastured stock in the veld up until the time that burning was restricted in about 1946 to 1949.

(2) S.S.U. = small stock unit e.g. sheep or goat. One large stock unit e.g. horse or cow = 7 s.s.u.)

	Number of owners	% of owners	Approx. area (Ha)	% of total area
4. Wild plant harvesting				
Occasional buchu harvest	15	14,7	2 200	4,1
Some flowers etc. and buchu	2	2,0	2 100	4,0
Flowers and other ornamental material only	7	6,9	5 800	10,9
Total use of wild plant material	24	23,5	10 100	19,0

(Note: Only two land owners considered their income from wild flowers to be relatively important).

	Number of owners	% of owners	Approx. area (Ha)	% of total area
5. Cultivation				
Miscellaneous orchards plantations and annual crops	10	9,8	950	1,8
6. Recreation				
Private (i.e. family and friends only)	2	2,0	50	0,1
Facilities provided for profit	4	3,9	500	0,9
Total area used for recreation only			550	1,0
7. Veld management systems				
No burning	65	63,7	34 700	65,3
Occasional burn	11	10,8	8 150	15,3
Patch burning	8	7,8	6 400	12,1
Indiscriminate burning	4	3,9	1 800	3,4
Unknown	14	13,7	1 100	2,1

the economic viability of the various forms of land use and gather information about owner attitudes and opinions as listed in paragraph 3.4.2.1. This questionnaire was used only in that portion of the catchment selected for detailed study. It was drawn up after consulting examples of questionnaires used in agricultural economics surveys. These unpublished documents are held in the library of the Department of Agricultural Economics of the University of Stellenbosch, (e.g. Associated Elgin Farmers questionnaire; Sentrale Suiwelkooperasie Bpk. vraeboog; ʼn Bedryfs en Kostestudie van die Wynbedryf in die Wes-Kaap vraeboog). Information required by the Receiver Of Revenue, as reflected on the income tax form IT12, was also taken into consideration. The questionnaire was delivered to the land owners in person and discussed with them in order to eliminate misunderstanding and misinterpretation.

3.4.3.5 The planned approach was to work through the questionnaire discussing the questions with each individual and completing the questionnaire personally by recording replies given by the land owners during discussion. For a number of reasons, particularly unwillingness, or inability, on the part of the land owners to spend time discussing the questionnaire, this did not happen in practice. It was necessary to leave the questionnaires with the land owner in every case, to be completed when time allowed.

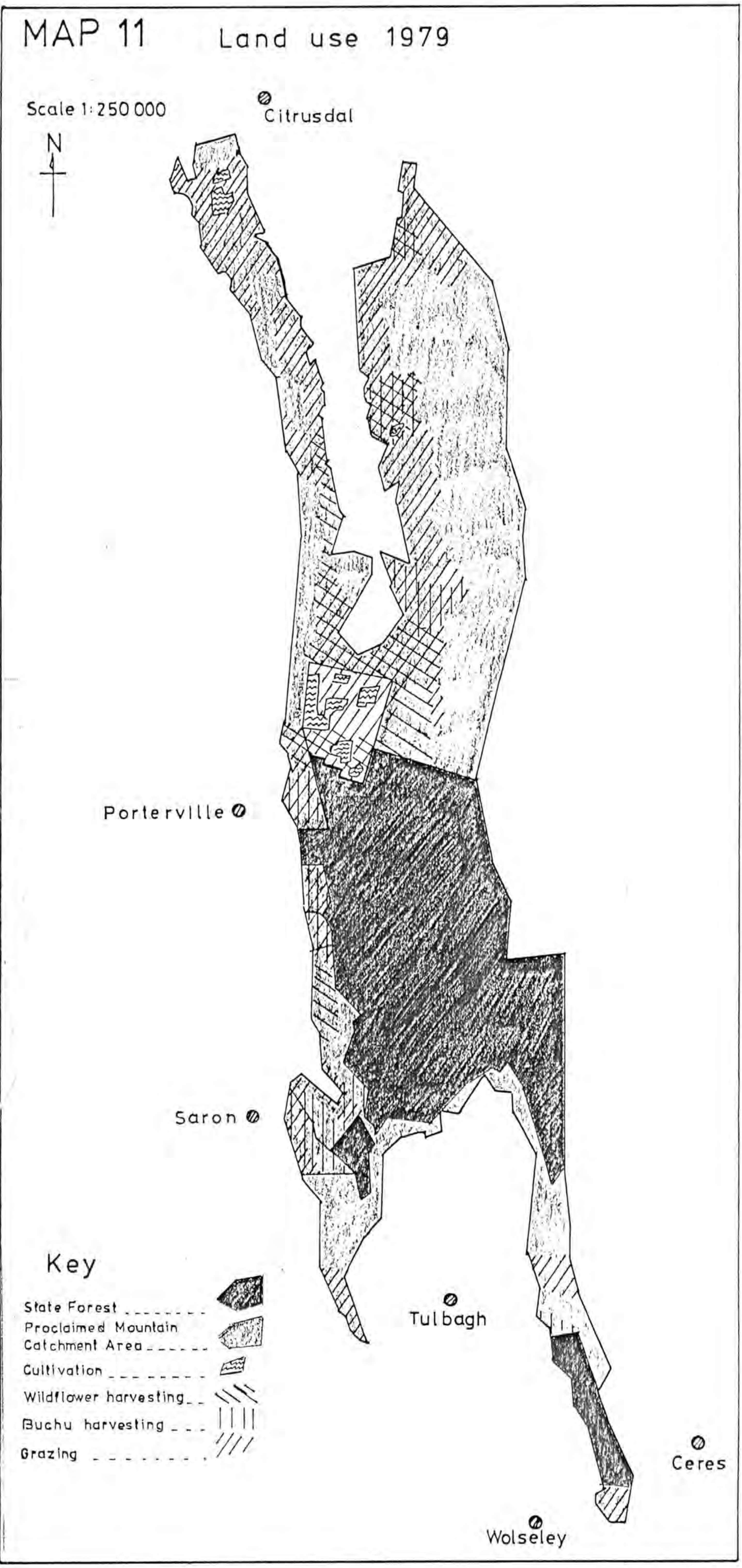
3.4.3.6 There are eight private landowners in the intensive study area. In spite of assurances that all information would be treated as strictly confidential and that no identification was required, one person refused to provide any information. Two of the eight were unavailable at the time of the survey. The remaining five owners completed the questionnaire conscientiously and were generally co-operative. However, interpretation of the questions and completeness of the answers varied and a number of return visits were made in an attempt to clarify certain points.

3.4.3.7 On studying the final data extracted from the questionnaires it became apparent that there was insufficient detail to assess the profitability of individual activities, or to check the owner's assessment of the relative economic importance of his activities. At the same time there was much unnecessary detail if the objective was simply to assess the economic viability of each owner's total farming operation or other land use.

3.4.4 Results

3.4.4.1 General (See also Table 10 and Map 11)

3.4.4.1.1 The majority (66 percent) of present day land owners in the study area inherited their properties. In the past these mountain lands were all used to a greater or lesser extent for pasturing stock, hunting, and the harvesting of wild plants


MAP 11
Land use 1979
Scale 1:250 000
N
Citrusdal
Porterville
Saron
Tulbagh
Ceres
Wolseley
Key
State Forest
Proclaimed Mountain Catchment Area
Cultivation
Wildflower harvesting
Buchu harvesting
Grazing

such as buchu (Agathosma spp) and bush tea (Aspalathus linearus); the latter only in the extreme northern portions of the study area.

3.4.4.1.2 Only 5% of mountain property owners live permanently on the properties and derive the major portion, if not all, of their income from them. These owners were the target of the detailed questionnaire survey, the results of which are discussed separately below.

3.4.4.1.3 The major traditional use of mountain land in this area is seasonal pasturing of domestic stock. However, over 60% of private land is no longer used at all for this purpose. On the other hand, judged on the basis of stocking rates recommended by the Department of Agricultural Technical Services, i.e. 8 to 12 hectares per small stock unit some 11500 hectares, or approximately 22% is still overstocked by 100% or more. About 4% of land owners still burn their veld indiscriminantly, but this represents less than 4% of the area of private land. A little over 65% of all private land is no longer deliberately burnt at any time, and on about 6 500 hectares, or 12%, the traditional patch burn system is practised both to provide improved pasture and as a precaution against run-away wildfires.

3.4.4.1.4 Most mountain properties have pockets of arable land which are reasonably accessible. Many of these pockets have been cultivated at some time in the past, and some are still cultivated regularly today. Most are clearly not viable economic units on their own but are, or were, cultivated to supplement the food supply of the farmer and his labour rather than to produce crops for sale. However, small quantities of dried fruit, particularly peaches, and some tobacco were occasionally sold (this study). Some of these arable pockets are individually or collectively large enough to constitute apparently viable units. However, only 2% of all private mountain land is currently being used for the cultivation of either perennial or annual crops. It is estimated that the total area of arable land does not exceed 5% of the catchment area and no more than two thirds of it is readily accessible.

3.4.4.1.5 Only 2% of owners regularly harvest wild flowers and derive a significant portion of their income from this use of the veld. A further 5% pick occasionally on a small scale but do not consider income from wild flowers to be indispensible. Buchu is also harvested only occasionally from the veld nowadays. In the same way that formal cultivation of buchu and bush tea has almost completely replaced harvesting from the natural veld, there is a growing tendency towards the cultivation of proteas and other marketable indigenous flora on irrigated fields. For this reason it is unlikely that wild flower picking will increase in the study area.

3.4.4.1.6 The reasons for the decline in the use of mountain veld for pasturing stock were discussed in an earlier paragraph (3.3.11), and it is probable that this form of land use will ultimately be phased out altogether.

3.4.4.1.7 With only 1% of private mountain land currently used specifically for recreation it would seem that the potential for this form of land use has hardly been explored. A considerable increase can be anticipated. Existing facilities such as hut camps, tent and caravan sites with ablution facilities, and even undeveloped camp sites with no facilities, in or near the mountains are fully booked a month or more in advance of the popular holiday periods (Messrs H.C. and E.H. Nieuwoudt of Sanddrif, A.P.C. Nieuwoudt of Kromrivier, P.L. du Toit of Driehoek and R. Heldsinger of Grootfontein, personal communication). While there are no visitor records for the Groot Winterhoek study area, data from the adjoining Cedarberg area indicate a 127% increase in visitor numbers from 1974 to 1983, equivalent to an annual rate of increase of 14% (Andrag, 1974; Citrusdal Chamber of Commerce, 1984). While part of this increase may be more apparent than real, because better control over access has probably reduced the number of visitors entering the area without permits, it is nevertheless quite clear that recreational use of mountain areas is increasing rapidly.

3.4.4.1.8 During the course of the departmental regional survey of mountain catchment areas, members of the survey team received many requests from businessmen and professional people for information about mountain properties that might come onto the market. These people were looking for mountain holiday retreats and were particularly interested in small subdivisions created before the introduction of legislation to control the subdivision of agricultural land (The Subdivision of Agricultural Land Act, No. 70 of 1970).

People appear to be willing to pay considerably more than the agricultural value when purchasing mountain land for recreation. Furthermore it is generally found that the smaller the property the higher the price per hectare. For example, a property of approximately 3 000 hectares, with an estimated maximum agricultural value (seasonal rough pasture only) of R8 per hectare (Divisional Council evaluation), was sold to the Mountain Club of South Africa in 1984 for the equivalent of about R30 per hectare (Mountain Club of South Africa, personal communication). In 1977 a property of less than 30 hectares with about four hectares of arable land was sold to a professional man for a mountain holiday home for the equivalent of about R530 per hectare (This study). If one deducts R1 200 per hectare for the arable land (as deduced from information provided by local farmers) the figure for the remainder is approximately R420 per hectare. Thirty rand discounted at 7%(1) per annum from 1984 to 1977 becomes R20 per hectare for the 3 000 hectare mountain property against over R400 per hectare for the 30 hectare property. This serves to illustrate the point made earlier concerning the relative value of mountain properties for recreation, and suggests that pressure on the authorities to permit some form of subdivision of mountain land of low agricultural value may be expected. The Share Block Control Act of 1980 does in fact make it possible for a number of people to build houses for their own use on a farm property without the need to formally subdivide that property.

3.4.4.2 Attitudes toward mountain land and state control of land-use

3.4.4.2.1 Four basic attitudes emerged from interviews with land owners. The two most common were generally manifested by the 97 owners whose homesteads and main farming activities were on the plain or in the Olifants River valley, but who owned tracts of mountain land of varying extent. They were:

(i) that without regular burning the mountain veld was quite useless and the Government was wrong to prevent farmers from

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(1) In 1978/79 the Land and Agricultural Bank of South Africa rate of interest on long term loans was 7%. For simplicity and uniformity 7% is used in calculation throughout this work, where appropriate.

burning as and when they felt it was necessary. These farmers were of the opinion that the veld should be burnt, not only to provide pasturage, but also to prevent devastating wild fires, to improve water supplies, and to improve buchu and bush tea yields;

(ii) that the greatest value of the mountains lay in the water yield and that protection of the veld was beneficial in this respect as it ensured perennial stream flow and prevented soil erosion. These farmers were of the opinion that if the veld were to be burnt it could be utilized for stock pasture, but they had seen erosion caused by stock kept in the mountains in their father's and grandfather's day. Furthermore herdsmen were now unobtainable and losses due to predation and theft too high if the stock were allowed to range free.

3.4.4.2.2 The remaining two basic attitudes were found principally among owners living either permanently or periodically on their mountain properties. These were:

(i) that the potential of the mountain farms, particularly for production of high quality deciduous fruit, was good and that they were undoubtedly viable. However, hard work and dedication was required and one had to accept that natural catastrophes such as wind and hail storms could periodically drastically reduce the year's crop or even destroy it completely. These farmers accepted that they were unlikely to become very wealthy, but placed considerable value on the aesthetic and spiritual assets of the mountain environment.

(ii) that apart from their value as water catchments, the principal values of the mountains were aesthetic and spiritual and that these intangible values greatly exceeded any agricultural value, whether actual or potential, that may exist.

3.4.4.2.3 On being questioned about the need and desiribility of State control of land-use in mountain catchment areas the majority (more than 80%) of those questioned were neutral or non-commital. A small number (between 8-9%) were positively in favour, with certain individuals adding the proviso that the State should work <u>with</u> the landowners in the conservation effort. A slightly larger number (about 10%) were very strongly against State interference of any kind in what a property owner does on or with his land. Two of the latter group went so far as to liken the envisaged control to that pertaining under a communist regime, although they were in fact doing very little with their own properties other than waiting for an opportunity to sell at a profit. Others in this category expressed fears that State control would discourage development of the mountain properties and reduce the number of individual farmers in the area to the detriment of the mountain farming community as a whole. They cited the purchase and expropriation of properties in the Vier-en-Twintig-Riviere catchment area as an example of what they considered to be unnecessary and undesirable State action. They were of the opinion that this action had severely reduced production potential (in terms of agricultural produce) and reduced community numbers. They felt that the probability of obtaining improved community services such as an all-weather access road, better school and health service facilities and a bus or road transport service had been virtually eliminated.

3.4.4.2.4 An influential group of local (Porterville area) residents, comprising both farmers and businessmen and including a man whose family once owned most of the Vier-en-Twintig-Riviere mountain catchment, see the area as a major tourist attraction. They have proposed the creation of a nature reserve, the "re-introduction" (sic) of big game animals, including hippopotami and elephants, and the development of scenic drives and other tourist facilities (Porterville Development Association minutes).

3.4.4.3 The detailed questionnaire

3.4.4.3.1 Information extracted from the detailed questionnaires is presented in Tables 11, 12 and 13. From Table 12 it appears that on farm 3, 11 hectares of deciduous fruit in full production is supporting a farmer and his wife and a small labour force. The surplus of income over expenditure before making allowance

TABLE 11

Information about properties in the intensive study area : taken from completed detailed questionnaires (Appendix 6)

(Note: To preserve the anonymity of respondents properties are identified by numbers only)

Subject (All areas in hectares)	Properties				
	1	2	3	4	5
Total area	647	603	120	208	28
Irrigated area; now	142	150	11	45	4
Irrigated potential	342	250	17	60	4
Dry land cultivation; now	0	0	6	15	0
Dry land potential	0	0	9	30	0
Timber plantation; now	80	50	1	30	2
Timber plantation potential	180	200	21	60	14
Rough veld pasture; now	350	300	29	110	16
Rough pasture potential	49	49	0	50	4
Wild flower area; now	(423)	(398)	(101)	(116)	(21)
Wild flower potential	(122)	(147)	(72)	(56)	(9)
No agriculture potential	73	98	72	6	5
Area occupied by roads, buildings, etc.; now	2	5	1	2	1
Probable area occupied when fully developed	3	6	1	2	1
Year of purchase	1959	1960-1974	1967	1977	1977
Total price paid (R)	51 760 =R80/ha	120 600 =R200/ha	9 960 =R83/ha	62 400 =R300/ha	14 800 =R529/ha
Estimated replacement values (R; 1979) of;					
Management buildings, including homestead	100 000	118 500	26 400	44 000	18 000
Production buildings	41 500	46 000	3 000	50 000	6 000
Production equipment and transport	76 000	76 000	40 000	40 000	10 000
Irrigation works and equipment	150 000	68 000	65 000	62 000	5 000
Roads	10 000	10 000	2 000	1 000	1 000
Fences	1 600	8 000	1 600	1 500	1 600
Powerlines	5 000	5 000	1 500	3 000	400
Crop areas					
1. Irrigated					
Deciduous fruit	131	105	11	25	3
Citrus	-	4	-	-	0,5
Vines (grape)	5	-	-	-	-
Tobacco	6	-	-	20	-
Artificial pasture	-	41	-	-	-
Indigenous flowers	2(e)	1(e)	-	1(e)	0,5

Note: e = estimate

TABLE 12

Income and expenditure data pertaining to the properties referred to in Table 11; taken from questionnaires (Appendix 6)

Subject	Properties 1	2	3	4	5
Expenditure (R)					
(Excluding interest on capital, and depreciation)					
1. Salaries and wages					
1.1 Management and supervision - including intrepreneurial rewards	12 000	20 000(e)	12 000(e)	12 000(e)	Nil (3)
1.2 Labour	40 000	19 000	5 500	8 000	Nil
2. Maintenance of capital works	4 385	7 750	1 350	1 450	500(e)
3. Maintenance and running costs of transport and equipment	13 600	24 000	6 400	8 500	Nil
4. Purchase of stores, fertilizer, etc.	31 800	18 000	3 350	14 700	Nil
5. Rail and other hired transport	2 000	3 000	80	1 000	Nil
6. Other costs; e.g. rates, taxes, electricity, etc.	15 700	12 640	1 678	2 543	500(e)
Totals	119 485	104 390	30 358	48 223	1 000(e)
Gross income (R) from:					
Deciduous fruit	166 900	147 000	31 000	12 000	Nil
Citrus	Nil	6 000	Nil	Nil	Nil
Timber	Nil	Nil	Nil	2 000 2.	Nil
Indigenous flowers	25 000 1.	1 200	Nil	6 000	Nil
Tobacco	3 000 (?)	Nil	Nil	2 000 (?)	Nil
Livestock	11 000	1 000	Nil	Nil	Nil
Miscellaneous minor produce, recreation etc.	3 100	Nil	Nil	Nil	Nil
Totals	209 000	155 260	31 000	22 000	Nil
Return (interest and depreciation excluded from costs)	89 515	50 870	642	-26 223	-1 000

Note: (e) = estimate

(?) = assumed source, not clear from questionnaire

1. This figure includes income from flowers bought in for re-sale and therefore does not reflect the yield of this property.
2. This seems high for an annual income from 30 ha of *Pinus radiata* in this area. It probably reflects a periodic rather than an annual income.
3. Holiday property, not managed for production.

TABLE 13

Gross income per annum per activity by properties (R per hectare)

Activity	Property 1	2	3	4	5	Weighted average
Deciduous fruit	1 274	1 400	2 818	480	-	1 312
Citrus	-	1 500 (1)	-	-	-	1 500
Timber	-	-	-	67 (2)	-	67
Wild flowers (3)	59 (4)	3 (5)	-	52 (6)	-	34 (7)
Tobacco	500	-	-	100	-	192
Livestock						
rough pasture	31 (8)	-	-	-	-	31
irrigated pasture	-	26 (9)	-	-	-	26

Notes:

1. Only one farmer is producing citrus for market.

2. Although all properties have some land under timber, only one farmer showed income from this source. The figure appears to be very high in relation to the area involved.

3. Proteas can be cultivated at densities of 3 000 or more plants per hectare. When in full production each plant should yield at least 10 saleable heads per annum; 30 000 per hectare at 50c each amounts to R15 000.

4, 5, 6 and 7. The figures returned are of little value because no indication is given of how much came from the natural veld on the property, how much from plantations and how much was either bought in, or harvested from another property (e.g. under licence or lease agreement).

8. This figure is clearly incorrect, as is the apparent stocking rate of two small stock units per hectare of natural veld. This is sixteen times the recommended maximum for the type of veld involved and could not be sustained.

9. This figure is low, if considered with the apparent stocking rate of 4,4 small stock units (equivalent) per hectare of irrigated pasture. However, a number of the units are riding horses, that produce no income.

for interest on invested or borrowed capital, but after tax (that is, return to land and capital, or return for short), was R642, according to the figures provided by the farmer. This is not a great margin and it is possible that the "entrepreneur´s reward" portion of the estimated R12000 for management and supervision may have to be considerably reduced in order to make provision for payment of interest on borrowed capital. If the purchase price of the land is appreciated from the year of purchase, i.e. 1967, to 1979 at seven per cent it becomes R22 432. Total capital replacement value in 1979 is therefore R161 932 including land. Expressed as a percentage of this amount, R642 is less than one half per cent, and R12 642 (made up of the farmers allowance for management and supervision plus return) is less than eight percent, which is little more than the land value appreciation rate used here. From Table 13 it may also be seen that this farmer´s return per hectare of deciduous fruit is more than double the weighted average for the area. These figures will be referred to again when the land use potential of the mountain catchment area is discussed.

3.4.4.3.2 While the data summarised in Table 12 are far from complete they do show that growing deciduous fruit is the most favoured and profitable farming activity, although the return from citrus appears to be of the same order. They also show appreciable total incomes from those properties that are being actively farmed.

3.4.4.3.3 Table 12 shows an appreciable income from wild flowers for property 1. The property has approximately two hectares planted to proteas, but the farmer also harvests from the natural veld on his own property and, under agreement, on a neighbouring property. He also buys in from a land owner who harvests from adjoining veld. It is therefore not possible to estimate an income per hectare for either his cultivated proteas or his veld from the data to hand. However, protea growers claim that yields of 12 000 flower heads per hectare per annum for <u>Protea cynaroides</u> and 30 000 for <u>P. magnifica</u> can reasonably be expected from irrigated plantations. Yields of this magnitude should produce gross income of about R6 000 to R9 000 per hectare (Prof. Strydom; Mr. Gibson of SAPPEX; personal communication). Yields of saleable material from the natural veld are as variable as the fynbos vegetation. Dense stands of <u>Protea laurifolia</u> can produce the equivalent of 40 000 capitula per hectare, or more; and natural stands of <u>P. magnifica</u> about 1300 per hectare (this study). The distribution of these and other Proteaceae is patchy and, at this stage in the knowledge of fynbos ecology, unpredictable. Furthermore, insect and other predator and pollinator damage, damage by wind and other factors and the assumed need to leave about 50 per cent of the crop on the bushes to produce seed in order to ensure regeneration, all go towards reducing the potential number of saleable flower heads. Any general figure quoted for potential wild flower income from natural veld in the study area can be no more than a guess. It was found that in some cases where flowers were being harvested from the veld, little thought was being given to ensuring a sustained yield or to prevention of environmental degradation. This may have been due to ignorance, lack of concern, or to the fact that the short-term profit margin was insufficient to allow correct conservation management. This facet is discussed in more detail below.

3.4.4.4 Properties acquired by the State in order to preserve the Vier-en-Twintig-Riviere mountain catchment.

3.4.4.4.1 Because of the adverse reaction of many people to the acquisition by the State of the properties in the mountain catchment area of the Vier-en-Twintig-Riviere (see for example paragraph 3.4.4.2.3 above), the former owners of the properties concerned were contacted and interviewed, where possible, in order to obtain their views on the matter. In those cases where former owners could not be contacted, members of the family who were directly involved were interviewed. The interviews were informal and were conducted in a relaxed atmosphere.

3.4.4.4.2 If one examines the properties and the circumstances of the owners one finds that the best developed of the properties was owned by a wealthy businessman who employed a farm manager to assist him in developing the farm. He planted almonds, pecans, walnuts and hazelnuts and several varieties of deciduous fruit under irrigation. He also cultivated bush tea and a small area of buchu on dry lands and developed a limited area of planted pasture. At the time the Government announced its intention of purchasing all of the properties in the Vier-en-Twintig-Riviere catchment area, the fruit and nut trees were not yet in full production, nor had the farm been developed to its full potential. The owner, whose health was failing and who had no family interested in the farm, was willing to sell but was not satisfied with the price offered by the State. The farm was ultimately expropriated.

3.4.4.4.3 Another of the properties was totally undeveloped and to this day is inaccessible other than on foot. It has little or no agricultural potential, although portions had been used for seasonal grazing in the past. However it has outstanding aesthetic and "wilderness" value. The owner was a professional man with international interests. It is virtually certain that he would have sold voluntarily had he not died whilst negotiations were under way. The property was expropriated.

3.4.4.4.4 A portion of a third property was expropriated after protracted negotiations failed to produce any agreement on the matter. The expropriated portion has little or no agricultural potential.

3.4.4.4.5 A fourth property was sold voluntarily by the owner who used it only for seasonal pasture for sheep and goats and some harvesting of wild buchu. This farmer lived on another property on the plain near Porterville. The land has limited agricultural potential and water is also a limiting factor.

3.4.4.4.6 A fifth property, also used principally for summer pasture for sheep and goats by the owner whose main farm was in the valley near Porterville, had a homestead which was permanently occupied by a farm supervisor. Development was limited to some two to three hectares of peaches and other fruit, and about the same area of bush tea. This farm was sold voluntarily.

3.4.4.4.7 The remaining three properties were owned by two sheep farming families who lived for the greater part of the year in the mountain but trekked with their stock to pasture lands in the Karoo for several months each year. These farmers had built homesteads on their mountain properties for each married member of the family, and housing of a sort for a few labourers. At each homestead a small area, nowhere greater than about 20 hectares, was cultivated. They planted fruit trees, particularly peaches, and cultivated cereals, beans, potatoes, sweet potatoes and tobacco, among other things. As was mentioned earlier these crops were principally for their own consumption although a portion of the crop was sometimes sold for cash.

3.4.4.4.8 Two of the three properties were sold voluntarily by the registered owner, although his adult sons were not happy with the arrangement and the daughters, who derived little benefit from the sale, even less so. Although they were far from wealthy, most were contented with their lot on the mountain farms. They enjoyed the freedom and independence of the life in spite of periodic hardship caused by drought, disease, and other natural hazards attendant upon this type of farming. All of the current adolescent and young adult generation and some of the parents received a good education. A son of the man who purchased one of the properties for the family attained professional status and is practicing as a medical doctor, and at least two of the current generation (nieces of the physician) are teachers. This would seem to indicate a progressive outlook and a higher than mere subsistence level income.

3.4.4.4.9 The last of the properties concerned was expropriated from a deceased estate against the wishes of the heirs. This family argued that they wished to continue farming and that it was impossible to purchase a property of equal actual and potential productivity for the amount offered by the State for their mountain farm. Two additional arguments were proferred. Firstly mountain and Karoo properties form a unit. Sheep farmers are dependent upon the nutritious Karoo pastures to fatten their stock and build up their condition so as to achieve good lambing rates, good quality wool and good slaughter condition. They are equally dependent upon the water and pastures of the mountains to maintain the stock over the Karoo drought period. The argument was that the expropriation of the mountain property rendered the Karoo property practically worthless and that both should therefore be purchased by the State. Alternatively the sum paid for the mountain property should enable the farmer to purchase an alternative suitably well watered property or to develop adequate water resources by sinking wells or boreholes and providing storage dams and watering points.

3.4.4.4.10 The second additional point made was that since the boom in the wild flower market, for both fresh and dried material, previously unproductive mountain veld was yielding a greater net income than the agriculturally productive area had ever realised. On the strength of this new source of income one member of the family concerned had purchased a four-wheel drive vehicle and was building a new and very much larger house. The wild flower harvesting activity is discussed below.

4. IMPACT OF LAND-USE ON THE ECOLOGY OF THE STUDY AREA

4.1 Introduction

4.1.1 In the previous section a picture has been presented of changing land use patterns in the study area from prehistoric times to the present. Six distinct major phases are discernible. These are:

In pre-historic times;

phase one, the Khoi-san hunter-gatherers

up to about 2 000 to 1 700 B.P.

phase two, the Khoi-Khoi pastoralists

from about 2 000 to 1 700 B.P. to 1 652 A.D.

then in historic times;

phase three, the European hunters and stock farmers

from about 1 652 to about 1 800 A.D.

phase four, the Settler farmers

from about 1 800 to about 1 880 A.D.

phase five, State control over water catchments

from about 1 880 A.D. to the present.

Phase five may be further subdivided as follows:

Firstly, the period from about 1880 to 1934 when control was somewhat loose and Crown lands and Forest Reserves were frequently leased out for grazing;

Secondly, the period from 1934 to 1949 during which control over State lands was improved, but there was little or no control over private land. No grazing permits were issued for Forest Reserves after 1934 (except on two occasions during drought emergencies). This step was taken in an effort to protect the mountain catchments from denudation by burning and grazing.

Thirdly, the period from 1949 to 1970. The Soil Conservation Act (No. 45 of 1946) provided for the proclamation of Fire Protection Areas with Fire Protection Committees to control veld burning within those areas. The first of these was proclaimed in 1949 in the Western Cape. This was another step taken in the effort to protect catchment areas. During this phase additional tracts of mountain land were purchased by the State and some properties situated in important catchments were expropriated in the interests of water conservation, for example those in the Vier-en-Twintig Riviere catchment;

Fourthly, the period from 1970 to the present.

The Mountain Catchment Areas Act (No. 63 of 1970) was promulgated in 1970 to enable the State to exercise control over all forms of land use in any area proclaimed to be a Mountain Catchment Area in terms of the Act. It is therefore no longer necessary for the State to purchase or expropriae private land in order to ensure the conservation of catchment areas.

4.1.2 In considering land use impact on the study area phases one and two may be ignored, firstly because the Khoi-san hunter gatherers were an integral part of the biological community and secondly the Khoi-Khoi pastoralist populations were probably relatively sparse and they are unlikely to have made any apprecia- ble use of the mountain pastures other than in extreme emergen- cies. The argument in support of the latter contention is that there was ample pasture of better quality on the coastal plain and the Khoisan, generally hostile to the Khoi-Khoi, had been driven into the mountains and were recorded as being a real danger to the Khoi-Khoi and their stock (Stow, 1905).

4.1.3 Phase three (1652 to about 1800) saw increasing pressure on and gradual elminiation of the larger antelope and other large wild animals from the south western coastal plains. The settlers first hunted and then moved in with their stock and began cultivating the land further and further afield from the settlement at the Cape of Good Hope.

4.1.4 In spite of the presence of Khoi-Khoi with their domestic stock, early records indicate the presence of considerable numbers of large antelope such as hartebeest and eland as well as occasional buffalo and elephant on the plains to the north and east of the settlement. Zebra were numerous and encounters with hippopotamus and rhinoceros are frequently mentioned (Mossop, 1927; Thom, 1952; Bigalke, 1979; Skead, 1980).

4.1.5 The role played by large herbivores in fynbos ecology is unknown so that the effect of their elimination is difficult if not impossible to assess. Early records indicate that antelope herds were more abundant in the area now known as the Swartland, where the soils are predominantly shale derived, than in the sandy soil area in the immediate vicinity of Cape Town e.g. the Cape flats (Bigalke loc. cit). Acocks (1975) suggests that the Rhenosterbosveld, which is the predominant natural vegetation type of the Swartland, was at one time more grassy than the few remaining patches are today. It is also probable that the vegetation of the shale derived soils was more palatable than that of the nutrient poor soils derived from sandstone and quartzite. Whatever the case may be, the ecological effect of the removal of all large wild herbivores from the system leaving only an insignificant number of small animals, has been effectively masked by other obvious effects of permanent settlement by European farmers. It appears unlikely that large wild animals played a significant role in the ecology of the study area, but their mere absence is "effect" enough for most people; the "effect" being either positive or negative depending upon view point. For the purpose of this study it is assumed that the disappearance of large nomadic antelope and other large wild animals from the fynbos scene had little or no adverse effect on the functioning of the ecological systems of the study area.

4.1.6 In the latter half of this phase (phase three) Khoi-Khoi stock dwindled to a very low number and settler farmers built up their flocks and herds. However, all of the farms recorded as having been leased out for grazing ("vee lechtplaatsen") were on the coastal plain or in broad low lying valleys so that it would appear that little, if any, use was made of the mountain pastures even in this period.

4.1.7 In phase four (about 1800 to about 1880) European farmers settled permanently on the fringe of the study area in increasing numbers, building homes and cultivating the land. I would suggest that it was during this time that stock owners began making regular use of the mountain pastures. As farming population and stock numbers built up farmers would have been forced to make use of the same areas year after year. Stock farmers also expanded into the dry inland plains such as, for example, the Ceres Karroo, and the typical transhumance pattern developed in which stock was taken into the "sour" Mountain Fynbos for three to five months in the height of summer, and back to the "sweet" veld of the Karroo or coastal forelands after the first good rains in the latter areas.

4.1.8 As explained in an earlier section, annual use of the mountain veld for pasture would have led almost automaticly to the development of the patch-burn system. This pattern of annual burning and grazing undoubtedly had a considerable effect on the ecology of the study area, and probably also on the hydrology. Harvesting of buchu on a commercial scale, which commenced about 1850, would also have had some impact on the areas affected. Although the effect of the patch burning system on vegetation or on the flora has never been studied, the effect of short rotation burning has been well documented for the fynbos by van Wilgen (1981).

4.1.9 Phase five was introduced in about 1880 when the Government of the Cape Colony made an effort to control mountain catchments by setting aside Forest Reserves and by limiting the use of the "Crown Lands" for grazing. In spite of this, grazing pressure on mountain lands belonging to the State appears to have been maintained until 1934 and on private land until 1949 at least. In 1934 all grazing permits were finally withdrawn and a complete ban was placed on veld burning in Forest Reserves. During the period 1949 to about 1951 Fire Protection Committees were appointed to exercise control over veld burning on private land. Thus from 1934 to the present the Forest Reserves (State Forests) have been free of domestic stock and many, but by no means all, privately owned mountain properties have been relieved of grazing pressure since about 1950.

4.1.10 As noted in an earlier paragraph, the central portion of the study area did not fall under the control of a Fire Protection Committee. Many of the farmers in this area continued burning and grazing until their properties were purchased or expropriated by the State to conserve the mountain catchment of the Vier-enTwintig-Riviere. However, one farmer substituted wildflower harvesting for his stock farming activity and stopped veld burning for this reason.

4.1.11 In the following section the impact of land use phases four and five are assessed.

4.2 Assessing impact

4.2.1 Types of impact

4.2.1.1 Some types and intensities of land use leave quite obvious impressions on the environment, for example:

1. elimination of large and spectacular wild animals;
2. access routes - roads, paths and stock trails;

3. development - agricultural fields, buildings, water works, fences;
4. alien vegetation - agricultural crops, timber plantations, weeds, woody invaders;
5. accelerated erosion and denudation - sheet erosion, drift sand, gully erosion, stream bank erosion.

Other manifestations of land use impact are less obvious and sometimes difficult to detect, for example:

6. changes in vegetation composition or density;
7. changes in the smaller animal populations;
8. changes in hydrology such as; streamflow, flood intensities and frequency, and water quality.

4.2.2 Obvious impacts

4.2.2.1 <u>Collection and presentation of the information</u>

During this study obvious signs of past and present land use were located, mapped and assessed with the aid of available air photographs and field survey augmented by in-situ photography where considered useful. The elimination of large wild animals which is one obvious impact of recent historical land use will not be discussed further, but see paragraph 4.1.3. Map 12 shows access routes, development sites, location of alien woody

MAP 12 General information

(Key on separate page)

MAP 12

KEY TO SYMBOLS

State Forest boundary	
Mountain Catchment Area boundary	
Farm road	
Jeep track	
Foot path	
Farm	▪ Langvlei
Eroded area	
Protea magnifica stand (harvested)	P. mag. (h)
Protea magnifica stand (not harvested)	P. mag.
Leucadendron rubrum stand	L. rub.
Water quality monitoring point	K.K. 1, R2, etc.
Alien woody vegetation .... (detail given below)	○ 16.

9. Pines and oaks
10. Pines, oaks, eucalypts and fruit trees
11. Opuntia (prickly pear)

12. Pines

13. and 14. Pines, oaks, poplars and fruit trees

15. Eucalypts

16. Eucalypts, pines, oaks, Sesbania, and fruit trees

17. Pines, oaks, eucalypts, wattles and fruit trees

18. Albizzia, pines, eucalypts, wattles, oaks, Opuntia, Agave, fruit trees

19. Pines, oaks, eucalypts, wattles, Sesbania, Opuntia and fruit trees

20. Wattles

21. Eucalypts, wattles, pines, Opuntia

vegetation, and sites of obvious denudation and accelerated soil erosion. By comparing this map with the historic land use maps and available data on stock numbers (Tables 9 and 10) it will be seen that serious degradation is almost invariably associated with continued use of the area for pasturing of stock, apparently at too high a stocking rate. Some wild flower harvesting methods are a more recent cause of environmental degradation. The focal points of denudation and erosion are, access routes, stock trails, stock camps, farmsteads and, in one case, a mine.
(Photos 14 to 19)

4.2.3 Impacts that are less obvious

4.2.3.1 <u>Pasturing of stock</u>

In order to determine the effect of grazing domestic stock on mountain fynbos, the vegetation on a number of sites known to have been subjected to this form of land use was surveyed using a modification of the standard descending point method, as used by the South African Forestry Research Institute. The areas to be surveyed were stratified into relatively homogenous subdivisions. The subdivisions were then traversed by a series of sample lines starting from randomly selected points on the fringe of, and proceeding across the area being sampled, in a direction perpendicular to the "grain" of the terrain. Point samples were taken at one metre intervals along the lines, using a 25 metre metallic-linen tape to measure distance and a "Specht

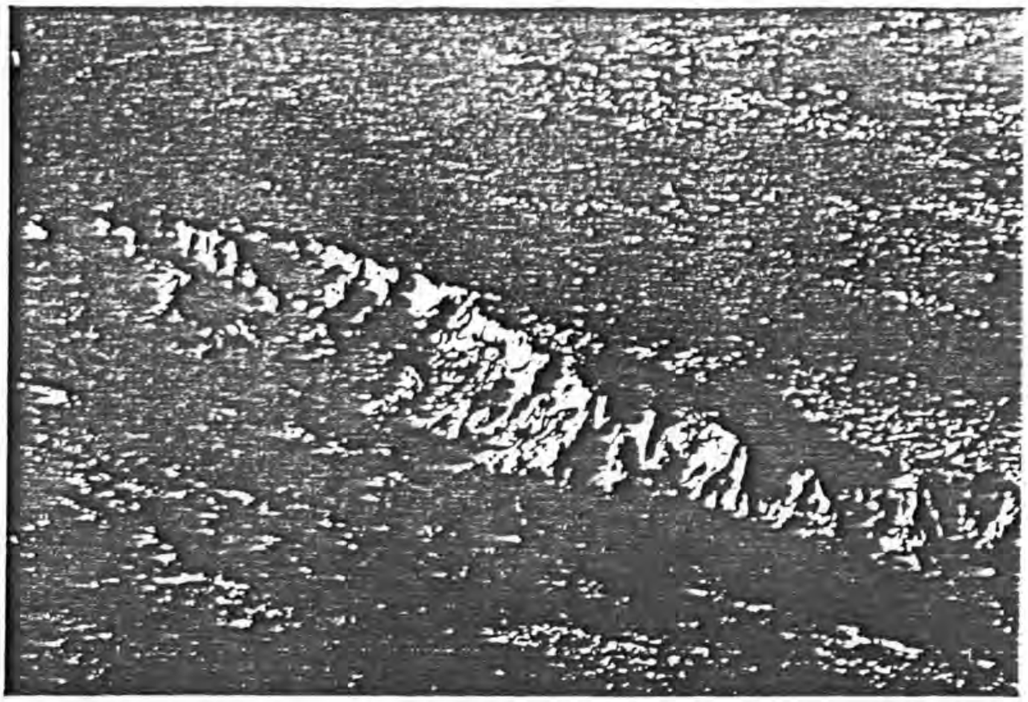


PHOTO 16

Gully erosion

PHOTO 17

Stream bank erosion

PHOTO 18

Wind erosion; drift sand at Perdevlei

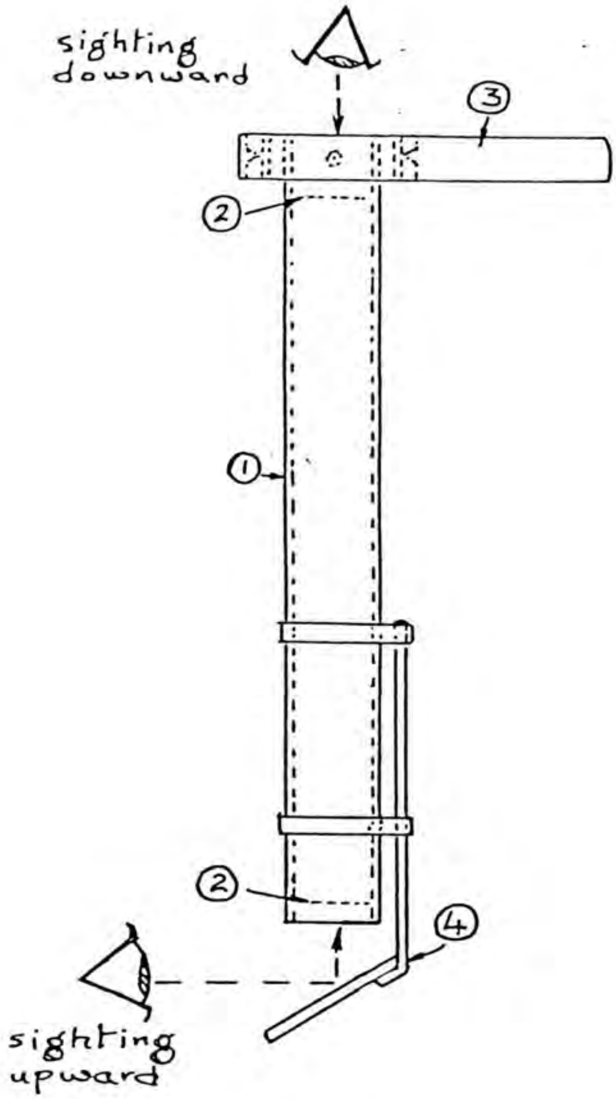
PHOTO 19

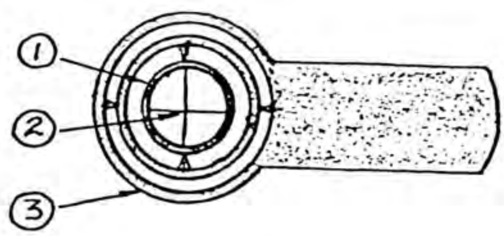
Wind erosion; drift sand at Groot Kliphuis. Rows of brushwood stacked as a reclamation measure.

sighting tube" (Fig. 3) to determine strikes (Specht 1972). A "Specht sighting tube" was made from a 15cm length of 125 mm copper tubing gimbal-mounted at the top and weighted at the bottom to improve stability and ensure that it hung vertically at all times while in use. Cross hairs fitted at both ends of the tube overcome the parallax problem. Precisely at each one metre point along the measuring tape a reading was taken by sighting down the tube and a note made of the species (plant growth form) or other object, such as stone, soil etc., in line of sight with the cross hairs. Canopy "strikes" and basal "strikes" (ground level) were recorded by growth form. Because of the time factor taxonomy was ignored in favour of recording plant growth forms and physiognomy only, the important factors for soil and water conservation being canopy cover, canopy height and plant density. It has also been shown that physiognomy is closely linked to taxonomy and that vegetation-type boundaries based upon a taxonomic classification agree very closely with those based upon a purely physiognomic classification in a given area (Taylor, 1981 and Campbell, 1985). The growth forms recognised were, shrubs (woody perennial plants, multi-stemmed or much branched at or - near ground level), graminoids (Gramineae only in this study), restioids (Restionaceae and Cyperaceae), and herbs (non-woody annual or perennial plants other than graminoids and restioids. Plants were also labelled as increasers, decreasers, or invaders (weeds), after a system of range-land assessment described in Stoddart and Smith (1955). In the absence of

FIGURE 3

The Specht sigting tube





1 Tube ± 20 cm long and 2,5 cm diametre.

2 Cross hairs: at both ends of tube.

3 Gimbal-mounted short handle.

4 Detachable swivelling mirror - for upward sigting when necessary.

positive information about palatability of species or stock preferences in Mountain Fynbos it was necessary to make certain assumptions in order to categorise plants as increasers, decreasers or invaders. By observation of heavily used sites it was possible to label such species as Cliffortia ruscifolia, Stoebe plumosa and certain others which have been collected and numbered but not yet identified, as increasers. Other species normally absent from the natural veld, such as Cynodon dactylon, Pentzia suffruticosa, and others, which were found to invade intensively-used sites were labeled invaders and those species known to be highly palatable and thus selectively grazed, such as Themeda triandra, were labeled decreasers. Due to lack of knowledge and information on the subject the majority of species could not be placed in any of the three categories and were listed as neutral or unknown. Much research is needed in this field. [Note: Species lists from both the Cedarberg and Groot Winterhoek catchment areas were subsequently submitted to pasture scientists of the Department of Agricultural Technical Services who were able to indicate broad degree of palatability for some plants. See Appendix 1].

The scope of the investigation was limited to vegetation-site types associated with shale band or other soils wholly or partly derived from shale or similar parent material. This was done in order to reduce the volume of work which would otherwise have been too great for the available resources. Furthermore these were the sites preferred by the pastoralists probably because the terrain is easier (less rocky) and they appear to have a greater percentage of palatable species, particularly grasses such as Themeda triandra.

Sites selected for enumeration were as follows (see also Map 12):

A. Stock camp or kraal sites. The immediate vicinity of disused kraal sites was sampled on the assumption that the effect of stock use would be emphasized and disturbance trends readily detectable.

The sites sampled were:

i. the Zuurvlakte camp, in use until about 1972;
ii. the Langvlei camp, in use until about 1967;
iii. the Klein Kliphuis camp, in use until about 1967;
iv. the Agterdam camp, in use until about 1965;
v. the Solderberg camp, not used since 1934 or earlier.

B. Pasture sites known to have been in use within the last five to nine years. These were:

i. Drosterberg area, in use until about 1975
ii. "Ghrie se vlakte", in use until about 1975
iii. Perdevlei area, in use until about 1975

C. Sites known to have been in use within the last 10 to 20 years. These were:

i. Zuurvlakte shale band area, in use until about 1970;
ii. Langvlei area, in use until about 1967;
iii. Kliphuis shale band area, in use until about 1967;
iv. Klein Kliphuis shale band area, ditto
v. Agterdam shale band area, in use until about 1965.

D. Sites known to have been used in the past, but not used since 1934 at the latest. These were:

i. Solderberg plateau area - a number of sites.

E. Sites said not to have been grazed within living memory. These were:

i. On the shale band above and to the east of the De Tronk (Groot Winterhoek) farmhouse.

Data from the enumerations were processed and analysed. The results are presented in Tables 14 to 26 and discussed below.

4.2.3.2 Small mammal communities were investigated in order to determine the effect of human residence and farming activity

TABLE 14

Vegetation sample data : Stock camp sites ('A' Sites)

Decending point canopy strikes by growth form and pasture class, and total basal strikes.

Plot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	13	15	16	17	18	19	20	$\bar{x}$	s	Σx
Vegetation Cover Category	Frequencies (possible total per plot = 25)																						
1. Canopy																							
1.1 Growth forms																							
1.1.1 Shrubs	7	10	3	0	6	0	1	3	0	11	15	4	2	1	0	12	17	7	7	4	5,500	5,196	110
1.1.2 Gramineae	8	9	14	17	12	12	8	14	14	7	3	8	12	14	21	8	1	7	19	13	10,550	4,673	211
1.1.3 Restionaceae and Cyperaceae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.1.4 Herbs (other)	4	0	3	0	3	2	1	0	2	0	2	3	3	3	0	0	0	2	0	0	1,400	1,429	28
1.2 Pasture Class																							
1.2.1 increasers	18	14	17	12	15	10	5	5	5	17	17	14	13	14	4	19	18	16	16	17	13,300	4,900	266
1.2.2 invaders	1	4	1	5	4	2	5	11	9	1	3	0	2	3	14	0	0	0	0	0	3,250	3,959	65
1.2.3 neutral (or unknown)	0	1	2	0	2	2	0	1	2	0	0	1	2	1	3	1	0	0	0	0	0,900	0,968	18
Total canopy strikes	19	19	20	17	21	14	10	17	16	18	20	15	17	18	21	20	18	16	16	17	17,450	2,625	349
2. Total basal strikes																							
2.1 All growth forms	10	7	8	8	10	10	6	9	9	8	10	7	6	9	13	11	6	9	2	12	8,500	2,460	170

TABLE 15:

Vegetation density : Stock-camp sites ('A' sites)

1. Canopy cover by growth form

Growth form	Canopy cover (c.c.) percent	Percentage of total c.c.(T)
Shrubs	22,0	31,5
Gramineae	42,2	60,5
Restionaceae and Cyperaceae	0	0
Herbs (other)	5,6	8,0
Total (T)	69,8	100,0

2. Canopy cover by pasture class

Pasture class	c.c. percent	percent of T
increasers	53,2	76,2
invaders	13,0	18,6
neutral (or unknown)	3,6	5,2

3. Basal cover

Total basal cover percent	34,0	-

TABLE 16

Vegetation sample data : Pasture sites subjected to heavy use to within the past 5 to 9 years ('B' Sites)

Decending point canopy strikes by growth form and pasture class, and total basal strikes.

Plot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	$\bar{x}$	s	Σx
Vegetation Cover Category	Frequencies (possible total per plot = 25)																	
1. Canopy																		
1.1 Growth forms																		
1.1.1 Shrubs	0	1	1	0	3	1	3	3	0	1	0	6	4	4	3	2,000	1,852	30
1.1.2 Gramineae	2	0	0	0	0	0	0	0	0	1	0	2	0	1	0	0,400	0,737	6
1.1.3 Restios and Cyperaceae	10	12	13	15	12	10	15	14	5	11	14	10	13	14	20	12,533	3,314	188
1.1.4 Herbs (other)	0	0	0	0	0	2	1	0	0	3	1	0	1	0	0	0,533	0,915	8
1.2 Pasture Class																		
1.2.1 increasers	2	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0,333	0,617	5
1.2.2 invaders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.2.3 neutral (or unknown)	10	12	14	15	15	13	19	17	5	15	15	18	18	19	22	15,133	4,155	277
Total canopy strikes	12	13	14	15	15	13	19	17	5	16	15	18	18	19	23	15,466	4,086	232
2. Total basal strikes																		
2.1 All growth forms	7	4	6	8	7	5	8	8	4	7	5	7	8	6	10	6,667	1,676	100

TABLE 17:

Vegetation density : Pasture sites subjected to heavy use within the past 5 to 9 years ("B" sites)

1. Cover percent by growth form

Growth form	Canopy cover (c.c.) percent	Percentage of total c.c.(T)
Shrubs	8,0	12,9
Gramineae	1,6	2,6
Restios and Cyperaceae	50,1	81,1
Herbs (other)	2,1	3,4
Total (T)	61,8	100,0

2. Cover percent by pasture class

Pasture Class	c.c. percent	percentage of T
increasers	1,3	2,2
invaders	0	0
neutral (or unknown)	60,5	97,8

3. Basal cover

Total basal cover percent	26,7

TABLE 18

Vegetation sample data : Pasture sites subjected to heavy use until approximately 10 to 20 years ago ('C' sites)

Decending point canopy strikes by growth form and pasture class, and total basal strikes.

Frequencies (possible total per plot = 25)

Plot No. / Vegetation Cover Category	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1. Canopy																												
1.1 Growth forms																												
1.1.1 Shrubs	0	2	3	10	3	7	0	0	4	3	4	9	9	9	3	2	5	2	4	2	5	3	6	2	5	8	8	14
1.1.2 Gramineae	2	0	1	1	1	0	2	0	0	0	1	6	4	2	0	0	0	0	0	0	3	1	1	1	1	3	4	1
1.1.3 Restios and Cyperaceae	14	10	3	3	7	6	13	10	9	10	8	5	4	5	8	6	8	4	7	9	6	9	7	10	14	4	4	3
1.1.4 Herbs (other)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1.2 Pasture Class																												
1.2.1 Increasers	2	2	2	4	2	6	0	0	2	2	0	9	11	7	0	0	4	0	4	0	2	1	1	0	1	7	10	10
1.2.2 Invaders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.2.3 neutral or unknown	4	10	5	10	9	7	15	10	12	11	13	11	6	9	12	8	9	6	7	11	12	12	13	13	19	8	6	8
Total canopy strikes	16	12	7	14	11	13	15	10	14	13	13	20	17	16	12	8	13	6	11	11	14	13	13	13	20	15	16	18
2. Total basal strikes																												
2.1 All growth forms	8	5	4	8	6	7	7	6	8	6	6	11	8	8	6	4	4	3	5	5	6	8	6	6	9	4	4	3

Plot No. / Vegetation Cover Category	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	x̄	s	Σx
1. Canopy																														
1.1 Growth forms																														
1.1.1 Shrubs	11	21	3	3	5	8	11	21	5	8	6	7	12	13	10	11	9	10	7	7	6	3	11	5	6	8	9	6,418	3,989	353
1.1.2 Gramineae	7	0	12	14	3	1	2	1	0	2	1	1	0	2	0	1	1	8	1	3	1	3	1	0	0	0	0	1,818	2,809	100
1.1.3 Restios and Cyperaceae	2	0	4	4	8	5	5	8	8	7	7	2	3	4	5	2	8	3	10	7	9	11	6	8	10	7	11	6,727	3,136	370
1.1.4 Herbs (other)	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	2	1	0	0	0,182	0,475	10
1.2 Pasture Class																														
1.2.1 Increasers	13	13	1	4	5	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,382	3,608	131
1.2.2 Invaders	0	0	0	0	0	0	0	0	1	6	4	2	7	5	5	8	6	5	1	1	1	1	2	2	1	1	7	1,200	2,214	66
1.2.3 neutral or unknown	7	8	18	17	11	12	15	16	12	11	10	9	8	14	10	6	12	16	17	18	15	16	16	13	16	14	13	11,545	3,563	635
Total canopy strikes	20	21	19	21	16	14	19	16	13	17	14	11	15	19	15	14	18	21	18	19	16	17	18	15	17	15	20	15,150	3,480	833
2. Total basal strikes																														
2.1 All growth forms	6	10	7	8	9	10	9	5	4	6	9	6	6	8	8	4	7	8	6	6	9	4	4	5	6	5	9	6,455	1,942	355

TABLE 19:

Vegetation density : Pasture sites subjected to heavy use until approximately 10 to 20 years ago ("C" sites)

1. Cover percent by growth form

Growth form	Canopy cover (c.c.) percent	Percentage of total c.c.(T)
Shrubs	25,6	42,4
Gramineae	7,3	12,0
Restionaceae and Cyperaceae	26,9	44,4
Herbs (other)	0,7	1,2
Total (T)	60,5	100,0

2. Cover percent by pasture class

Pasture Class	c.c. percent	percentage of T
increasers	9,5	15,8
invaders	4,8	7,9
neutral or unknown	46,2	76,3

3. Basal cover

Total basal cover percent 25,8

TABLE 20

Vegetation sample data : Pasture sites subjected to heavy use in the past but abandoned at least 46 years ago ('D' sites)

Decending point canopy strikes by growth form and pasture class, and total basal strikes

Plot No.	1	2	3	4	5	6	7	8	9	10	11	$\bar{X}$	S	ΣX
Vegetation Cover Category	Frequencies (possible total per plot = 25)													
1. Canopy														
1.1 Growth forms														
1.1.1 Shrubs	2	2	2	4	4	1	0	6	4	4	5	3,091	1,814	34
1.1.2 Gramineae	0	8	7	4	0	0	3	6	10	7	3	4,364	3,501	48
1.1.3 Restios and Cyperaceae	9	1	4	5	2	0	1	4	2	2	4	3,091	2,508	34
1.1.4 Herbs (other)	2	1	1	1	2	6	3	1	2	0	1	1,818	1,601	20
1.2 Pasture Class														
1.2.1 increasers	0	4	1	0	0	0	0	3	1	1	0	0,909	1,375	10
1.2.2 invaders	0	0	1	2	0	0	0	2	0	3	3	1,000	1,265	11
1.2.3 neutral or unknown	13	8	12	12	8	7	7	12	17	9	10	10,455	3,078	115
Total canopy strikes	13	12	14	14	8	7	7	17	18	13	13	12,364	3,695	136
2. Total basal strikes														
2.1 All growth forms	5	4	3	3	4	2	2	4	4	6	4	3,727	1,191	41

TABLE 21:

Vegetation density : Pasture sites subjected to heavy use in the past but unused for the last 46 years or longer ("D" sites)

1. Cover percent by growth form

Growth form	Canopy cover (c.c.) percent	Percentage of total c.c.(T)
Shrubs	12,4	25,0
Gramineae	17,4	35,3
Restios and Cyperaceae	12,4	25,0
Herbs (other)	7,3	14,7
Total (T)	49,5	100,0

2. Cover percent by pasture class

Pasture Class	c.c. percent	percentage of T
increasers	3,7	7,4
invaders	4,0	8,1
neutral or unknown	41,8	84,5

3. Basal area

Total basal cover percent	14,9

TABLE 22

Vegetation sample data : Sites reputedly not used for the pasturing of domestic stock within living memory ('E' Sites)

Plot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	$\bar{x}$	s	Σx
Vegetation Cover Category	Frequencies (possible total per plot = 25)																						
1. Canopy																							
1.1 Growth forms																							
1.1.1 Shrubs	1	3	1	2	2	3	1	2	2	2	2	2	3	1	2	1	1	1	2	3	1,850	0,745	37
1.1.2 Gramineae	2	1	3	10	5	2	1	2	4	1	7	2	5	3	0	0	2	0	1	2	2,650	2,519	53
1.1.3 Restios and Cyperaceae	13	17	12	13	14	10	14	13	14	13	13	13	12	12	13	16	12	17	15	14	13,500	1,732	270
1.1.4 Herbs (other)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0,150	0,366	3
1.2 Pasture Classes																							
1.2.1 increasers	Nil																						
1.2.2 invaders	Nil																						
1.2.3 neutral or unknown	As per Total c.c.																						
Total canopy strikes	17	21	16	25	21	15	16	17	20	16	22	17	20	16	16	17	15	18	18	20	18,150	2,680	363
2. Total basal strikes																							
2.1 All growth forms	6	12	2	11	5	5	4	5	4	6	9	6	9	8	4	5	6	7	4	12	6,450	2,724	129

TABLE 23:

Vegetation density : Sites reputedly never used for stock pasture ("E" sites)

1. Cover percent by growth form

Growth forms	Canopy cover (c.c.) percent	Percentage of total c.c.(T)
Shrubs	7,4	10,2
Gramineae	10,6	14,6
Restios and Cyperaceae	54,0	74,4
Herbs (other)	0,6	0,8
Total (T)	72,6	100,0

2. Cover percent by pasture class

Pasture Class	c.c. percent	percentage of T
increasers	0,0	0,0
invaders	0,0	0,0
neutral or unknown	72,6	100,0

3. Basal cover

Total basal cover percent	25,8

TABLE 24

Summary of data in Tables 14 to 23.

Sites.	Total cover (percentage)		Canopy cover provided by the following growthforms and pasture classes, expressed as a percentage of ground surface area						
Sites	Canopy	Basal	Shrubs	Gramineae	Restios and Cyperaceae	Herbs (other)	Increasers	Invaders	Neutral or unknown
A	69,8	34,0	22,0	42,2	0,0	5,6	53,2	13,0	3,6
B	61,8	26,7	8,0	1,6	50,1	2,1	1,3	0,0	60,5
C	60,5	25,8	25,6	7,3	26,9	0,7	9,5	4,8	46,2
D	49,5	14,9	12,4	17,4	12,4	7,3	3,7	4,0	41,8
E	72,6	25,8	7,4	10,6	54,0	0,6	0,0	0,0	72,6
			Percentage of total canopy cover provided by the above growthforms and pasture classes						
A			31,5	60,5	0,0	8,0	76,2	18,6	5,2
B			12,9	2,6	81,0	3,4	2,2	0,0	97,8
C			42,4	12,0	44,4	1,2	15,8	7,9	76,3
D			25,0	35,3	25,0	14,7	7,4	8,1	84,5
E			10,2	14,6	74,4	0,8	0,0	0,0	100,0

TABLE 25

Comparison of data from unused ('E') sites with that from each group of used sites ('A' to 'D').

Relative mean cover densities of vegetation growth forms and significance levels of difference of means

Site	Shrubs	Gramineae	Restios and Cyps	Herbs (other)	Total Canopy cover	Total Basal cover
A	>E @ 0,1%	>E @ 0,1%	<E @ 0,1%	>E @ 0,1%	X	X
B	X	<E @ 0,5%	X	X	X	X
C	>E @ 0,1%	X	<E @ 0,1%	X	<E @ 0,1%	X
D	>E @ 2,5%?	X	<E @ 0,1%	>E @ 0,1%	<E @ 0,1%	<E @ 0,5%

Note: >E @ 0,1% = mean density is greater (< = less than) than that of 'E' sites: p = 0,01

X = no significant difference

? = difference of doubtful significance

TABLE 26:

Comparison of data from the most intensively used sites (stock camps or "A" sites) with that from each other site group ("B" to "E")

Relative mean cover densities of vegetation growth forms; and significance levels of difference of means

<u>Site</u>	<u>Increasers</u>	<u>Invaders</u>	Total Canopy <u>Cover</u>	Total Basal <u>Cover</u>
B	<A @ 0,1%	<A @ 0,5%	X	<A @ 2,5%?
C	<A @ 0,1%	<A @ 1,0%	<A @ 2,5%?	<A @ 0,1%
D	<A @ 0,1%	X	<A @ 0,1%	<A @ 0,1%
E	<A @ 0,5%	<A @ 0,1%	X	<A @ 2,5%?

<u>Note</u>:

>A @ 0,1% = mean density is greater than (< = less than) that of "A" sites : p = 0,01

X = no significant difference;

? = difference is of doubtful significance on this facet of the ecology. Small mammals populations were sampled to compare sites that had been occupied permanently by people and their domestic animals (farmyard and permanent stock camp sites) with similar relatively undisturbed fynbos sites nearby. Two parallel trap lines of ten traps each, spaced 15 metres between lines and 15 metres between traps were set at each site, one pair of sites (farmyard and fynbos) with 20 traps each being sampled simultaneously. Two types of trap were used. The traps were placed alternately in the line with one type in first position in one line and the other type in first position on the adjacent parallel line. The traps used were P.V.C. traps developed by K. Willan (Willan, 1978) and Sherman collapsible metal traps. There was no marked difference in the trapping efficiency of the two types, both requiring careful adjustment of the springing mechanism in order to trap the very small rodents such as *Mus minutoides*. With the trigger set for these small mice other animals such as skinks, millipedes and even beetles (*Psammodes sp*) were also trapped. A record of small mammals trapped at the three pairs of sites is presented in tables 28 and 29. Results are discussed below.

4.2.3.3 To determine the effect of harvesting on wild flower populations representative populations of some of the commercially exploited Proteaceae were investigated. The selected populations were enumerated using the "wandering quarter" method of Cantana (1963) to estimate population density. Three stands of *Protea*

TABLE 28

Small mammals trapped on abandoned farmyard or stock camp sites and on relatively undisturbed but otherwise comparable fynbos sites between 1,5 km and 3 km distant from the farmer.

1. ZUURVLAKTE (Trapped December 1979)

1.1 Stock camp

No of trap nights	Trap success (%)	Total Number Animals caught	Species Caught	No of captures per species	No of animals per species
60	25,0	15	*Aethomys namaquensis*	13	8
			Rhabdomys pumilio	1	1
			Tatera afra	1	1

No of trap days	Trap success (%)	Total Number Animals caught	Species Caught	No of captures per species	No of animals per species
60	1,7	1	*Aethomys namaquensis*	1	1 (same animal caught previousl at night)

1.2 Fynbos (Approximately 2 km from farmyard)

No of trap nights	Trap success (%)	Total Number Animals caught	Species Caught	No of captures per species	No of animals per species
60	6,7	4	*Otomys irroratus*	1	1
			Tatera afra	1	1
			Mus minutoides	1	1
			Myosorex various	1	1

No of trap days	Trap success (%)	Total Number Animals caught			
60	0,0	0	0	0	0

2. GROOT KLIPHUIS (Trapped January 1980)

2.1 Farmyard

No of trap nights	Trap success (%)	Total Number Animals caught	Species Caught	No of captures per species	No of animals per species
60	1,7	1	*Rhabdomys pumilio*	1	1

No of trap days	Trap success (%)	Total Number Animals caught	Species Caught	No of captures per species	No of animals per species
60	3,3	2	*Rhabdomys pumilio*	2	2 (one animal caugh previously at night)

2.2 Fynbos (Approximately 2 km from farmyard)

No of trap nights	Trap success (%)	Total Number Animals caught			
60	0,0	0	0	0	0

No of trap days	Trap success (%)	Total Number Animals caught			
60	0,0	0	0	0	0

De Tronk/...

3. DE TRONK (First series - Trapped January 1980)

3.1 Farmyard

No of trap nights	Trap success (%)	Total Number Animals caught	Species Caught	No of captures per species	No of animals per species
60	25,0	15	*Aethomys namaquensis*	9	7
			Rhabdomys pumilio	5	4
			Otomys irroratus	1	1

No of trap days	Trap success (%)	Total Number Animals caught	Species Caught	No of captures per species	No of animals per species
60	6,7	4	*Rhabdomys pumilio*	3	2 (both animals
			Otomys irroratus	1	1 caught again at night)

3.2 Fynbos (approximately 200 to 350 metres from a field of *Seradella*)

No of trap nights	Trap success (%)	Total Number Animals caught	Species Caught	No of captures per species	No of animals per species
60	31,7	19	*Mus minutoides*	3	2
			Aethomys namaquensis	4	2
			Rhabdomys pumilio	12	7

No of trap days	Trap success (%)	Total Number Animals caught	Species Caught	No of captures per species	No of animals per species
60	15,0	9	*Rhabdomys pumilio*	9	8 (one of these animals was caught previously at night)

4. DE TRONK (Second series - Trapped April 1984)

4.1 Farmyard

No of trap nights	Trap success (%)	Total Number Animals caught	Species Caught	No of captures per species	No of animals per species
60	10,0	6	*Aethomys namaquensis*	1	1
			Acomys subspinosus	2	1
			Rhabdomys pumilio	1	1
			Otomys irroratus	2	1

No of trap days	Trap success (%)	Total Number Animals caught	Species Caught	No of captures per species	No of animals per species
60	6,7	4	*Aethomys namaquensis*	1	1
			Rhabdomys pumilio	1	1
			Otomys irroratus	1	1 (this animal previously caught at night)
			Crocidura cyanea	1	1

4.2 Fynbos (approximately 3 km from farmyard)

No of traps nights	Trap success (%)	Total Number Animals caught	Species Caught	No of captures per species	No of animals per species
60	11,7	7	*Aethomys namaquensis*	3	2
			Mus minutoides	3	3
			Elephantulus sp. (pobably edwardii)	1	1

No of trap days	Trap success (%)	Total Number Animals caught	Species Caught	No of captures per species	No of animals per species
60	1,7	1	*Aethomys namaquensis*	1	1 (this animal subsequently caught at night)

TABLE 29

Comparative small mammal species lists, excluding the data from sample pair No. 3 - De Tronk, January 1980

Stock camp/Farmyard Sites		Fynbos Sites	
Species	Frequency (Number of animals caught)	Species	Frequency (Number of animals caught)
Aethomys namaquensis	10	*Aethomys namaquensis*	2
Tatera afra	1	*Tatera afra*	1
Otomys irroratus	1	*Otomys irroratus*	1
Rhabdomys pumilio	5	-	-
Acomys subspinosus	1	-	-
Crocidura cyanea	1	-	-
-	-	*Mus minutoides*	4
-	-	*Elephantulus sp. (edwardii?)*	1
-	-	*Myosorex various*	1

Total number of species: 6 | 6

Total number of animals: 19 | 10

Number of species common to both site categories = 3 magnifica, two of P. laurifolia and two of Leucadendron rubrum were enumerated. In the P. magnifica stands the number of capitulae removed was estimated by counting the secateur cuts in three separate age classes viz. fresh cuts, assumed to have been made in the most recent flowering year, old cuts, assumed to have been the previous year's harvest, and older cuts, assumed to have been made two years (or seasons) ago or earlier. The position of the cut relative to the current seasons growth helped to determine in which season the head was taken off. Capitulae left on the bushes were also counted in the same categories viz. current year's heads, those of the previous season, and those older than two years. A note was also made of the state of maturity and vigour of each bush enumerated.

In the case of the P. laurifolia and L. rubrum stands a note was made merely of whether material had been cut from the bushes or not and a visual estimate made of the percentage of available capitulae removed. The L. rubrum was separated into male and female plants. Only the female capitulae are harvested in this area although branches from male shrubs are cut for "greens" in other areas.

Enumeration data are presented in Appendix 7. Summaries of the harvesting level and stand condition data are given in Table 30. Results are discussed below.

TABLE 30

1. *Protea magnifica* : Summarized stand condition data[1]

	Stand 1		Stand 2		Stand 3		Total	
Class	Freq.	% of total	Freq.	% of total	Freq.	% of total	Freq.	% of total
Mature	66	77	7	47	46	57	119	66
Immature	15	17	0	0	29	36	44	24
Unhealthy	2	2	1	6	1	1	4	2
Dead	3	4	7	47	5	6	15	8
Total	86	100	15	100	81	100	182	100

(1) Note: The oldest plants in all stands are estimated to be over fifteen years, but younger individuals are present in appreciable numbers.

2. *Protea magnifica* : Summarized harvesting data

Harvest year	Number of mature plants	Average capitula per plant	SD	Percentage of capitula removed in harvest
Stand 1:				
0	67	3,507	3,413	59
-1	62	5,274	5,154	75
-2+	52	4,769	5,020	65
Stand 2:				
0	8	5,100	3,603	34
-1	8	6,600	9,039	15
-2+	8	3,600	3,068	14
Stand 3:				
0	49	5,000	4,929	56
-1	43	5,349	4,099	75
-2+	34	4,088	3,511	45

(2) Note: 0 = current flowering season; -1 = previous season; -2+ = earlier seasons.

3. *Protea laurifolia* : Summarized stand condition data[3]

Class	Stand 1 Freq.	Stand 1 % of total	Stand 2 Freq.	Stand 2 % of total	Total Freq.	Total % of total
Mature	44	39	66	82	110	58
Immature	62	56	11	14	73	38
Dead	5	5	3	4	8	4
Total	111	100	80	100	191	100

(3) Note: The oldest bushes in both populations are estimated to be over 20 years old but average age of stand 1 is appreciably lower than that of stand 2.

4. *Leucadendron rubrum* Summarized stand condition data[4]

Class	Stand 1 Freq.	Stand 1 % of total	Stand 2 Freq.	Stand 2 % of total	Total Freq.	Total % of total
Mature						
Male	27	54	44	56	71	55
Female	21	42	31	40	52	41
Immature						
Male	0	0	0	0	0	0
Female	0	0	0	0	0	0
Dead						
Male	1	2	0	0	1	1
Female	1	2	3	4	4	3
Total						
Male	28	56	44	56	72	56
Female	22	44	34	44	56	44
Grand Total	50	100	78	100	128	100

(4) Note: These two stands are within 500 metres of each other and their age is estimated to be the same i.e. approximately eight to ten years.

4.2.3.4 <u>The effect of land use on water quality</u> was another factor considered. To gain some insight into this aspect stream water samples were taken from a number of points selected to test the effect, if any, of representative forms of land use and differing degrees of general degradation. The sampling points are indicated on Map 12 and are as follows:

i. Klein Kliphuis River, site one (KK1); at the point of exit from the Perdevlei valley, which shows severe signs of degradation including large gullies, surface erosion and an area of naked sand.

ii. Klein Kliphuis River, site two (KK2); at the high level bridge on De Tronk road upstream of the junction with the Groot Kliphuis river. Between KK1 and KK2 the river runs for about 9 kms through a narrow valley with relatively minor signs of degradation such as two small gullies and a small patch of bare sand at the Klein Kliphuis stock camp site. Erosion not active at present.

iii. Groot Kliphuis River, one site (GK); at the low level bridge on the De Tronk road upstream of the junction with the Klein Kliphuis River. Weltevrede Farm is immediately upstream of this point. There are a number of erosion gullies and extensive areas of surface erosion. However the farm was vacated in about 1967 and the erosion does not appear to be active at present.

iv. Ratel River, site one (R1); on the boundary between Kliphuisvlakte and Zuurvlakte. Upstream of the sampling point on Kliphuisvlakte there is no obvious accelerated erosion or other degradation and the area is now State Forest.

v. Ratel River, site two (R2); on the boundary between Zuurvlakte and Pampoenfontein (Berghof subdivision). Upstream of this sampling point and between this and the R1 sampling point the stream flows through an area currently used as pasture for sheep. It is used periodically throughout the year for a total of from six to eight months. Stocking rate varies up to approximately five or six small stock units per hectare, but is erratic.

vi. Ratel River, site three (R3); approximately on the boundary between Pampoenfontein (Heidedal sub-division) and Grootfontein. Upstream of this sampling point and below point R2 the river runs through an intensively developed farming area with a high proportion of the land under irrigated deciduous fruit orchards.

Samples were taken three times during the year, that is, at the end of summer, when streamflow was at its lowest; after a prolonged heavy early winter rainstorm; and after good rain in autumn.

Results are presented in Table 31 and discussed below.

TABLE 31

Water quality data from Groot Winterhoek mountain catchment stream samples.

	pH	Conductivity (Mic. Mohs)	Equivalent[(2)] total disolved solids (t.d.s.) (p.p.m.)	Suspended solids (Grammes/L)
April 1980				
KK1[(1)]	5,27	21,90	11,826	-
KK2	5,20	20,00	10,800	0,00083
GK	4,50	32,00	17,280	-
R1	4,20	31,00	16,740	0,00073
R2	4,25	31,20	16,848	0,00139
R3	4,89	34,00	18,360	0,00056
June 1980				
KK1	5,55	21,50	11,610	0,00045
KK2	5,53	15,90	8,586	0,00020
GK	4,90	26,20	14,148	0,00041
R1	4,50	22,10	11,934	0,00014
R2	4,59	23,60	12,744	0,00011
R3	4,59	33,00	17,820	0,00035
April 1981				
KK1	5,50	20,30	10,962	0,00025
KK2	5,37	20,80	11,232	0,00003
GK	4,70	36,30	19,602	0,00005
R1	4,38	39,00	21,060	0,00005
R2	4,47	35,70	19,278	0,00002
R3	4,76	58,00	31,320	0,00006

Note: 1. KK = Klein Kliphuis River, GK = Groot Kliphuis River, R = Ratel River; 1, 2 and 3 denote sample sites on these rivers : see paragraph 4.2.11 and Map 12.

2. Multiplication of the conductivity reading in micro mohs by the factor 0,54 gives an approximation of total disolved solids (T.D.S.) in parts per million. Water from undisturbed catchments in the Jonkershoek and Zachariashoek research areas gave readings of about 30 micro-mohs (Van Wyk, 1981).

4.3 Discussion

4.3.1 Obvious impacts

4.3.1.1 Soil erosion.

As indicated in an earlier paragraph, reference to Map 12 clearly indicates that gross degradation symptoms are in most cases directly associated with stock farming. Access routes for purposes other than stock farming are the next most common cause of degradation and crop farming combined with settlement the least common.

Table 32 sets out approximate areas affected by various forms of accelerated erosion.

Table 33 presents estimated proportions of the forms of erosion caused by each identified agency.

The relatively high percentage of undeveloped and uncultivated area displaying clearly visible signs of accelerated surface erosion is interpreted as an indication that land management of the areas concerned has been, and in some instances still is, unsatisfactory. It is not possible to say in precisely what way the management has been incorrect but most degradation is clearly associated with the pasturing of domestic animals.

TABLE 32:

Approximate areas in hectares of obvious accelerated erosion and percentage of total catchment area affected; by categories, (See also Map 12)

(1) surface or sheet erosion	(2) gully erosion	(3) stream bank erosion	(4) wind erosion
16 000	12	5	10
(19,650%)	(0,015%)	(0,006%)	(0,012%)

(1) Indicated by terracing, rills, incipient gullying, removal of surface soil, etc. (see photo's 14 and 15)

(2) Indicated by obvious gully development (see photo no. 16)

(3) Indicated by stream bank collapse and riparian vegetation engulfed by sand deposits (photo 17)

(4) Indicated by areas of unstable bare sand (photo's 18 and 19)

TABLE 33:

Erosion types by probable main cause

Type of erosion	Estimated percentage of erosion caused by: domestic stock	access routes(1)	cultivation	other
Sheet	99	-	1	-
Gully	80	19	1	-
Stream bank	95	4	1	-
Wind (drift sand)	-	-	100	-

Note (1) Excluding stock trails.

These estimates were made by estimating the total area of each type of erosion within the study area. The cause of erosion was obvious in most cases and could be presumed with reasonable certainty in the few cases where not obvious.

The probable cause of degradation is a combination of too frequent burning, too high a stocking density and introducing stock to the veld too soon after burning. This results in noticeably reduced vegetal canopy cover, reduced plant stand density and undesirable changes in the nature of the soil (brought about by trampling, by direct impact of raindrops on the unprotected soil surface, and possibly also by the effect of fire on physical and biological soil properties). Surface water flow during rainstorms is increased, resulting in the displacement of soil, manifested in such phenomena as debris dams, pedestalling of pebbles and grass tufts, and terracing. Terraces of up to 30 cms high were noted during the survey on slopes of less than 25 per cent (Photo 20).

Severe gully erosion was noted on a number of sites most of which had been used for the pasturing of large numbers of small stock with or without smaller numbers of cattle. Exceptions were gullies initiated by wash associated with access routes such as for example the vehicle track into a manganese mining site and a number of vehicle tracks used for wild flower harvesting. Virtually all of the the access routes into or within the mountains have resulted in gully formation to a greater or lesser extent (Map No. 12). An example of particularly severe gullying can be seen along the road to Kliphuisvlakte which was constructed across an extremely sensitive seasonally waterlogged sandy plain (Photo 21). There is a total of over 5 km of gully along this

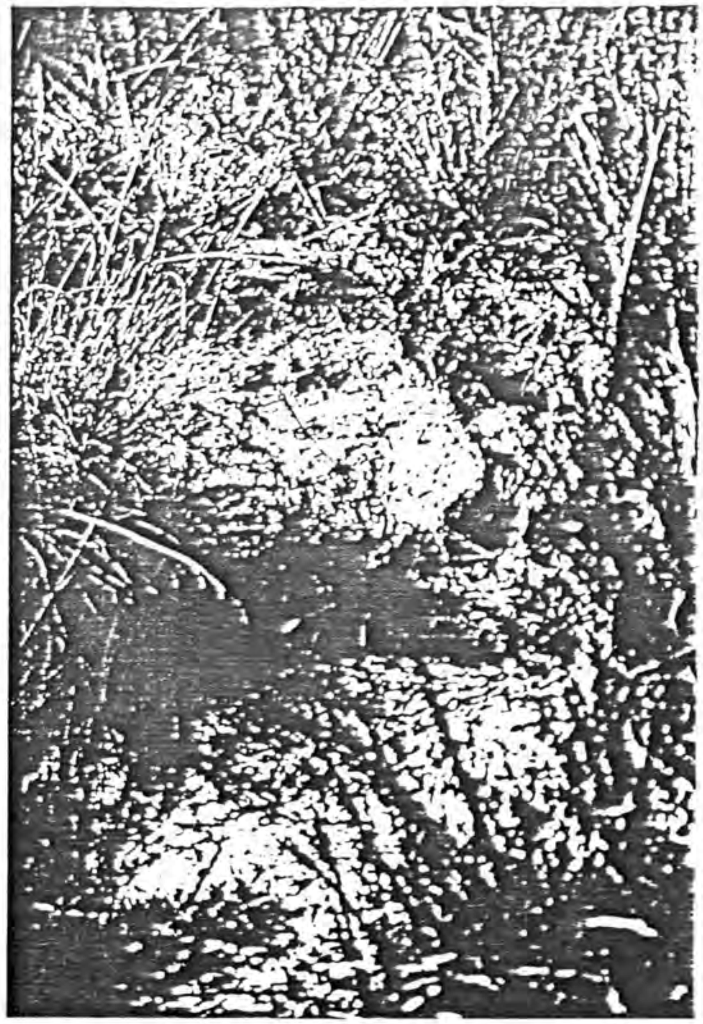


PHOTO 20

Surface sheet erosion, indicated by terracettes.

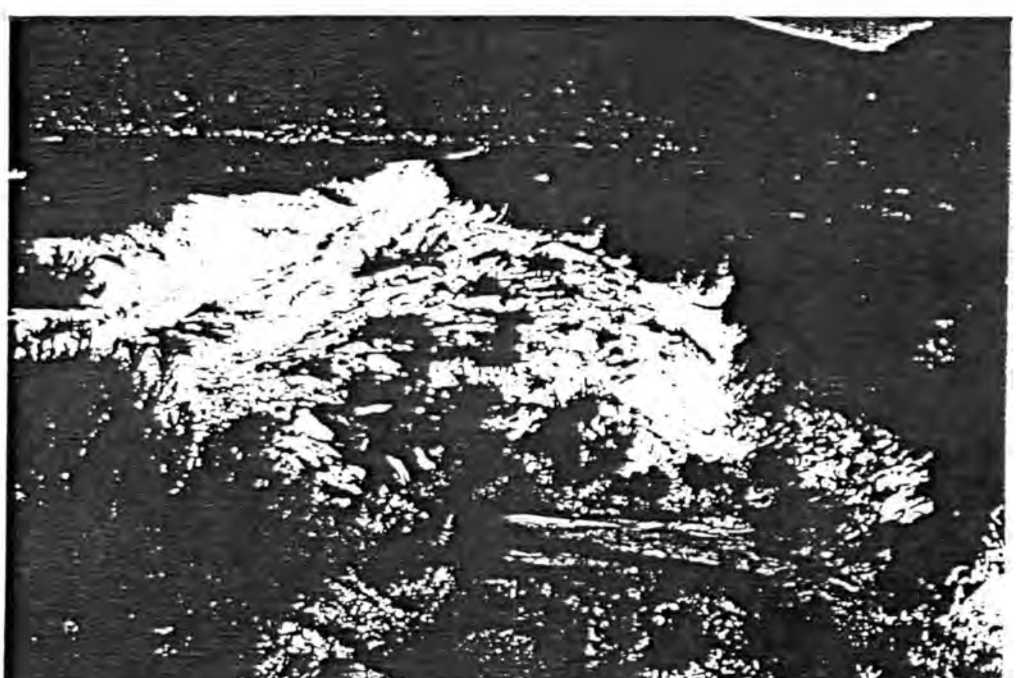


PHOTO 21

Roadside gully on a seasonally wet sandy plain.

road varying in cross section from 1,5 metres wide by 1,0 metre deep to 5,0 by 2,0 metres. Three of the larger gullies at Perdevlei (Photos 22 to 25) were roughly measured. The largest of these is 370 metres in length and has average cross sectional dimensions of approximately 40 metres wide by 10 metres deep. The second measures approximately 350 metres by 25 metres by five metres and the third approximately 200 by 15 by 10 metres. Typical cross sectional and plan shapes of these gullies are illustrated in Figure 4. The volume of soil removed from these gullies alone is approximately 111 000 m3, 32 800 m3 and 22 500 m3 respectively totaling 166 300 m3 or the equivalent of 33 260 five cubic metre lorry loads.

Other erosion gullies are illustrated in Photos 26 to 30.

According to local land owners all of the large erosion gullies, except those directly attributable to vehicle tracks, arose suddenly and dramatically during an exceptionally wet period in 1925. They were then enlarged by a similar wet period in 1941 although the enlargement was reputedly not as great as the initial removal of soil. A third period of heavy and prolonged rainfall in 1963 does not appear to have produced any additional gullies in these areas nor to have greatly enlarged the existing ones. Rainfall data for the years concerned were examined and are presented in Tables 34 and 35.

PHOTO 22

Gully erosion, Perdevlei

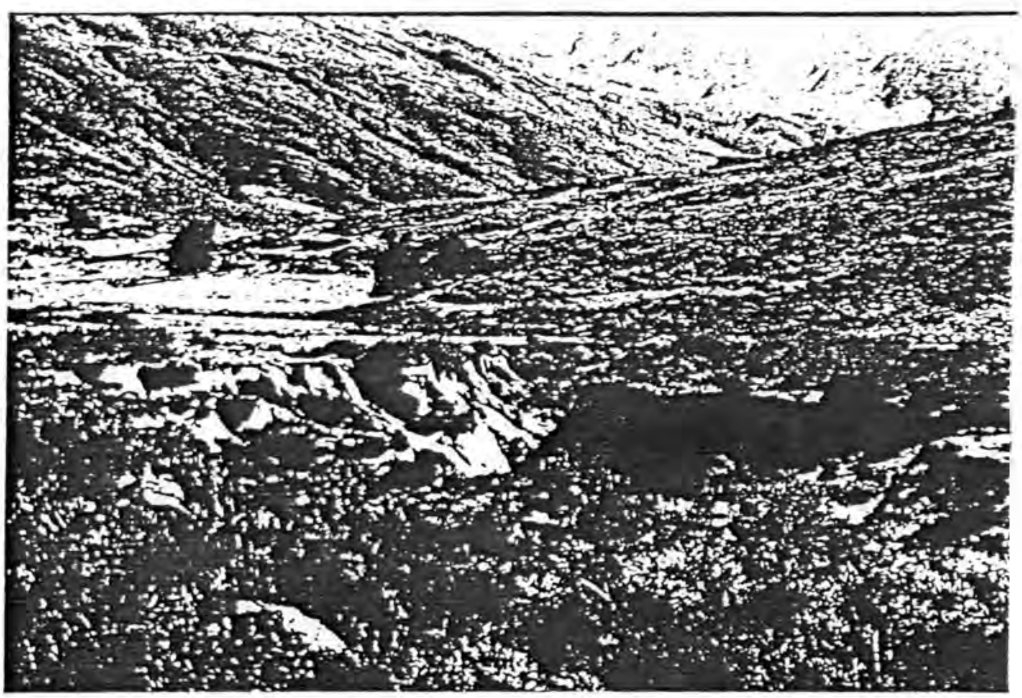


PHOTO 23

Gully erosion, Perdevlei

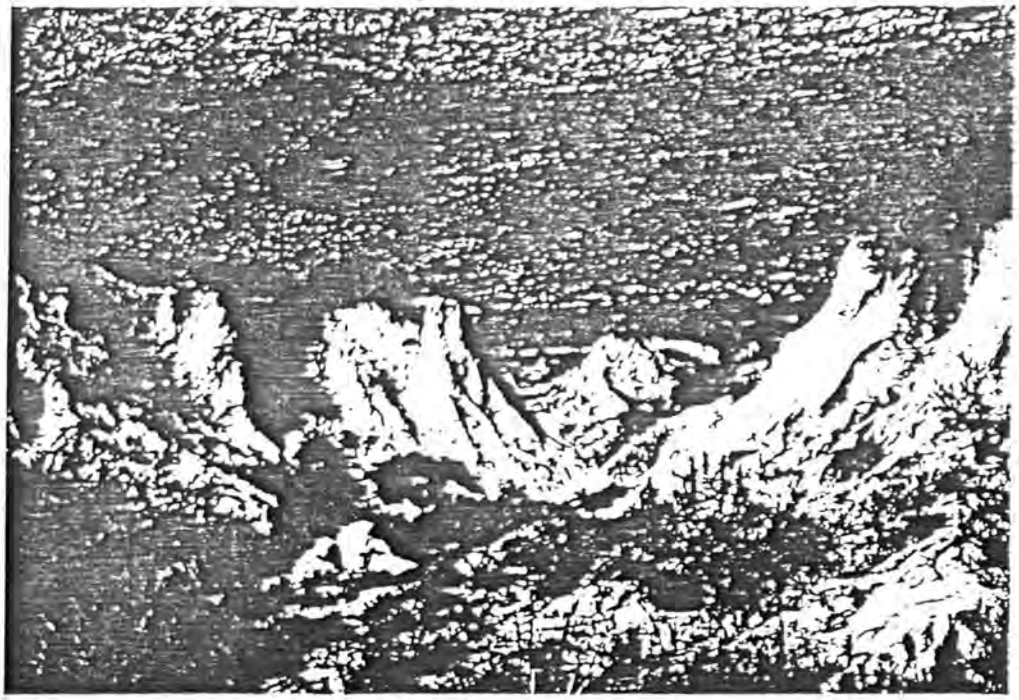


PHOTO 24

Gully erosion, Perdevlei. Depth approximately 10m.

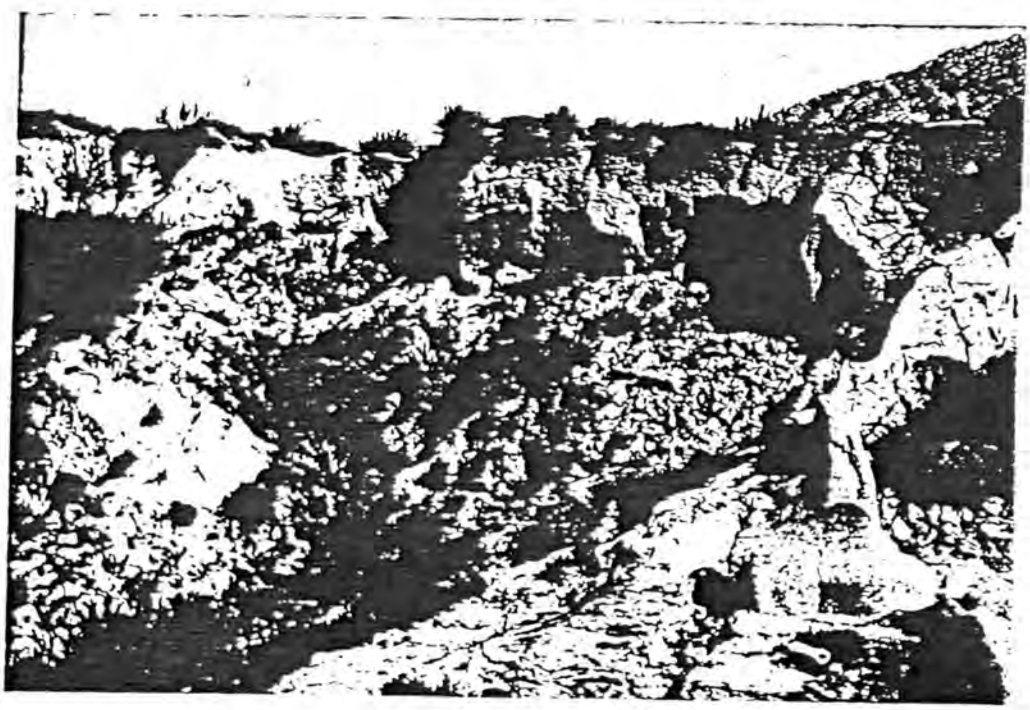


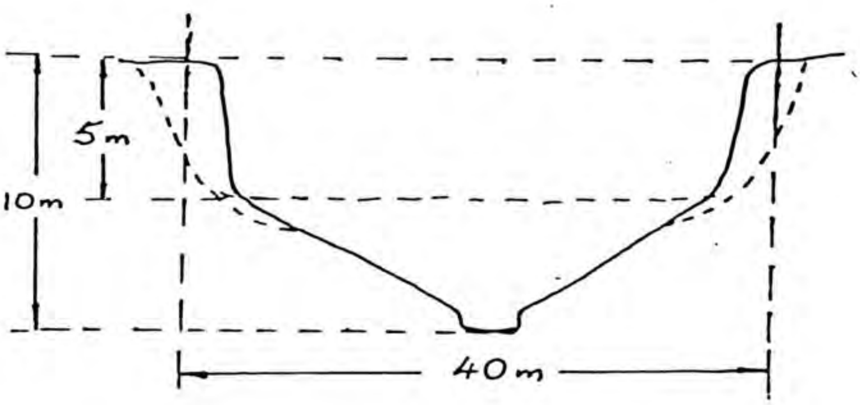
PHOTO 25

Gully erosion, Perdevlei (Note pied starling nesting holes in gully bank).

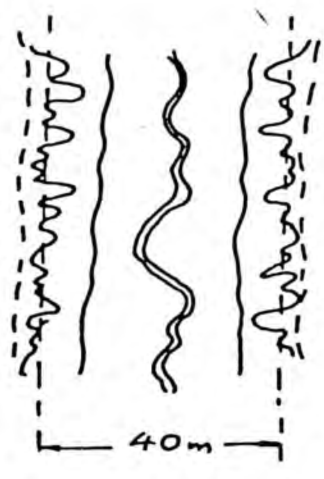
FIGURE 4

Typical cross section and plan of Perdevlei erosion gullys

- Dimensions of largest gully used for illustration
- Cross-sectional area is $300m^2$



Cross-section



Plan view

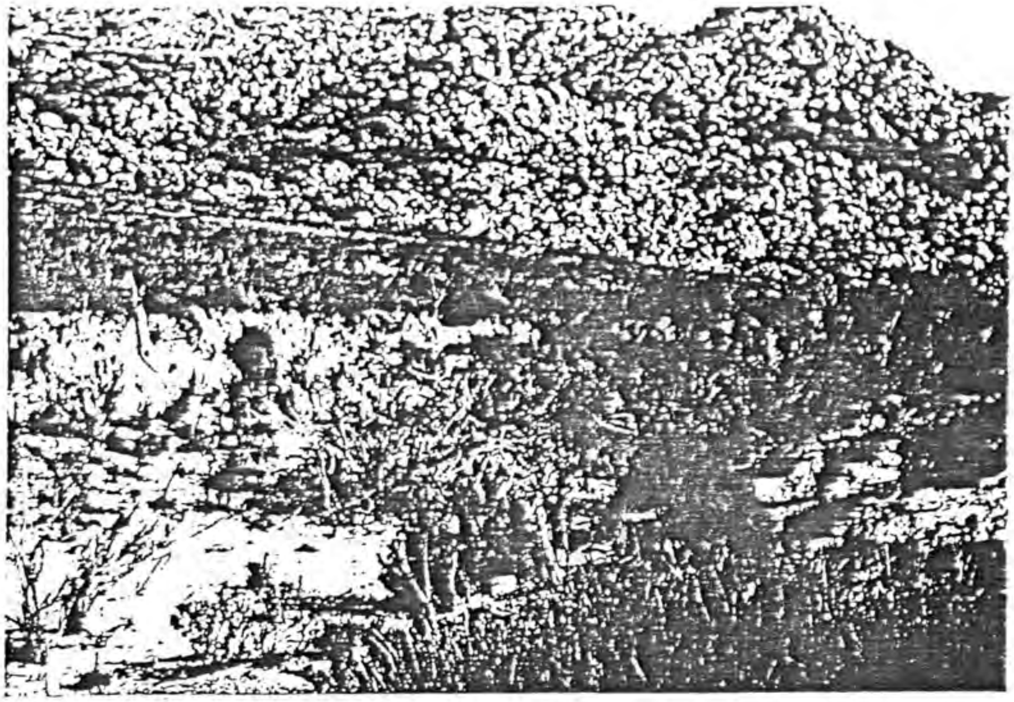


PHOTO 26

Gully erosion, Driebosch. Depth here approximately 1,5 m.

PHOTO 27

Gully erosion, Louws Legplek. Depth here approximately 2 m.

PHOTO 28

Gully erosion, Louws Legplek grazing area.

PHOTO 29

PHOTO 30

Typical gullys on heavily grazed lower shale slopes of the Witzenberg.

TABLE 34

Rainfall and other data for the years 1925, 1941 and 1963

	Rainfall (in mm) and other data for the meteorological stations and years shown											
	Porterville				Gouda				Tulbagh			
	1925	1941	1963	22 yrs Av.	1925	1941	1963	49 yrs Av.	1925	1941	1963	83 yrs Av.
Ann. tot. rainfall	572,5	643,9	489,1	429,3	533,7	761,8		522,9	520,7	732,0	442,8	477,5
Tot. rain days	47	71	63	47	34	41		42	45	65	47	53
% of Av. rainfall	133,4	150	113,9	100	102,1	145,7		100	109,0	153,3	92,7	100
Max. av. winter intensity (m.a.w.i.) (mm/day)	21,3	10,8	13,0	11,1	17,8	21,9		14,1	19,9	20,2	18,2	11,6
Month of m.a.w.i.	Jun	Jun	Aug.	Jun	Jun	May		May	Jun	May	Aug.	May
% of Av. max. intensity	191,9	97,3	117,1	100	126,2	155,3	not available	100	171,6	174,1	156,9	100
Total rain in month of m.a.w.i.	256,0	129,3	155,5	88,6	231,7	175,3		70,6	238,3	141,5	163,7	69,5
Rain days in month of m.a.w.i.	12	12	12	8	13	8		5	12	7	9	6
Max. Spring month rain	55,1	101,0	58,0	36,5	81,0	135,1		51,6	77,5	121,4	50,5	47,1
Rain days in that month	7	10	7	4	4	7		4	7	10	4	5
Month of max. spring rain	Oct.	Sept.	Nov.	Sept.	Oct.	Sept.		Sept.	Oct.	Sept.	Nov.	Sept.
Av. intensity in that month (mm/day)	7,9	11,1	8,3	9,1	20,3	19,3		12,9	11,1	12,1	12,6	9,4

TABLE 35

Extract of summarised rainfall data to 1950

Rainfall Station	Average annual rainfall to 1950 (mm)	Maximum (mm)	Year recorded	1921-1925 mean (mm)	1941-1945 mean (mm)
Porterville	426,2	585,7	1921	510,8	-
Saron	599,2	827,3	1878	-	-
Gouda	526,8	761,7	1941	520,2	624,8
Tulbagh	469,6	732,0	1941	497,8	594,9
Mont Pellier	534,4	810,8	1941	-	-

Although there are clearly insufficient data from which to draw firm conclusions there would appear to be a relationship between total rainfall for the year and the occurrence of severe erosion and also between heavy spring rains and the reported erosion. However as it is unlikely that such conditions had not occurred previously in the current climatic cycle, it would appear that land use had created conditions conducive to severe erosion. The progressively smaller effect of the 1941 and 1963 storm periods may indicate that the terrain was approaching and has now reached a state of equilibrium again which has accommodated the land use.

Total removal of top soil in the immediate vicinity of an old stock camp on the Solderberg has left areas naked of vegetation up to the present time although the site has not been used since 1934 or even earlier (Photos 31 and 32). A resident of Saron Village, who is now over 70 years of age, remembers going to the Solderberg with his parents as a young child (about 6 years of age) to cut buchu. He says that the stock camp was a disused ruin even then (Mr. H. Andrag pers. com., reporting conversation with Saron resident "Ou Jafta"). If this evidence is accepted, and there is no reason to doubt it, the stock camp was abandoned before 1916. Cattle may have been allowed to free range there subsequently however, as stock camps were only essential for the protection of small stock.

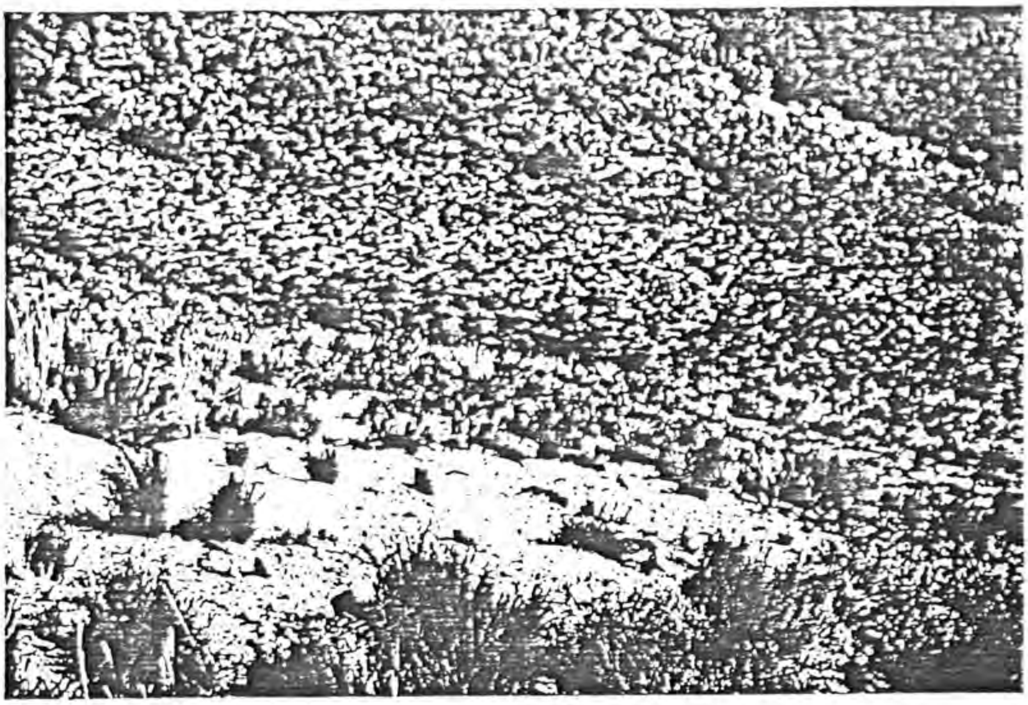


PHOTO 31

Naked soil patches and sparse vegetal cover caused by past grazing pressure and veld burning. Solderberg. Note binoculars on foreground patch, for scale.

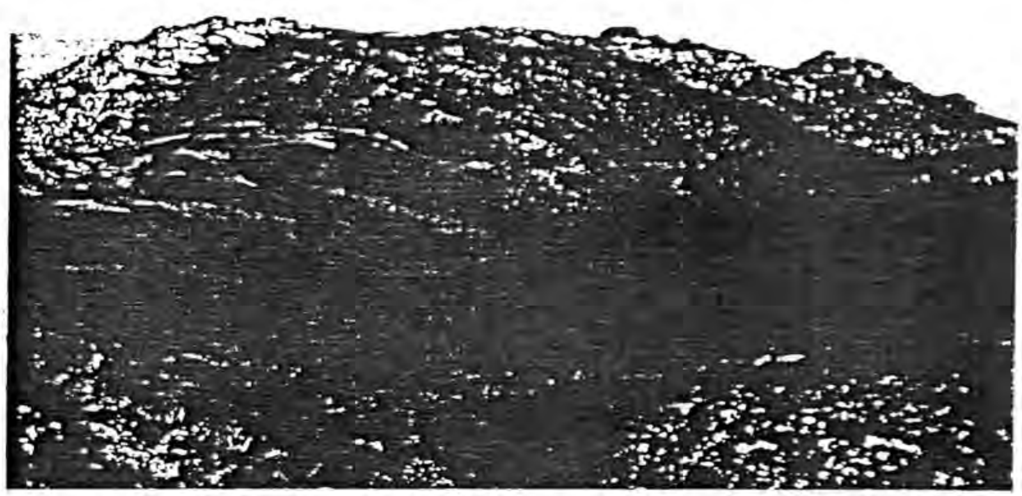


PHOTO 32

Solderberg pasture area showing typical "shale band" topography and sparse cover caused by past grazing pressure and veld burning.

Trampling by stock has caused total denudation and removal of top soil at other sites as well, for example on the properties Alandale, Farquharson's Request, Agterdam and Perdevlei (Map 12). All of these sites have finer textured soils associated with a shale substrate. Trampling in the vicinity of stock camps with coarser sandier soils such as Zuurvlakte, Langvlei and the upper camp on Agterdam, even though also closely associated with or sited near the shale band, has not resulted in such long lasting denudation. Although it is clear that they had been totally denuded at one time, these sites are once again fairly well covered albeit with unpalatable "increaser" and "invader" species such as <u>Cliffortia ruscifolia</u>, <u>Pentzia</u> sp. and others (see stock camp data in the following section).

Cultivation of annual crops, such as wheat, tobacco and beans, on light textured sandy soils has resulted in the development of unstable wind-blown drift-sand patches at Perdevlei and Groot Kliphuis. Fortunately the areas involved are small and stabilization measures have already been initiated by the Directorate of Forestry.

4.3.1.2 <u>Alien vegetation</u>.

Every farm homestead and stock camp is a focal point for alien vegetation and a potential source of weed infestation. These sites are indicated on Map 12 and approximate areas of woody alien species are given in Table 36.

The area is relatively free of aggressive woody aliens at present, but _Acacia mearnsii_ has been noted on sand levees along the upper Olifants River and _A. longifolia_ is present on at least one site remote from any dwelling on the Agterdam road. _Opuntia sp._ and _Pinus pinaster_ individuals have been seen on remote sites and _Sesbania_ and _Albizzia_ have commenced spreading downstream from Drieboschfontein and Perdevlei. If steps are not taken to eradicate these species while numbers are still small they pose a real threat to local ecological systems.

4.3.2 Impacts that are less obvious

4.3.2.1 _Changes in vegetation_

Vegetation data collected from the selected categories of mountain pasture site are presented in Tables 14 to 26.

Examination of Table 24, which presents a summary of the data from Tables 14 to 23, reveals a clear difference between the "A" and "E" sites (Stock camps and unused sites respectively) and the remaining "B", "C" and "D" sites, as well as between "A" and "E" sites themselves. This is to be expected as these sites represent the two extremes of the veld-use spectrum. However, there does not appear to be a clear and logical differential

TABLE 36:

Estimated areas of alien woody vegetation by species (in hectares) excluding areas which are still being farmed and the trees used and tended (See Map 11)

Species	Estimated infested area (ha)	Notes on distribution
Hakea	1 300	Scattered
Pines	800	Scattered
Eucalyptus	5	Individuals and small groups
Wattles	100	Along stream banks and scattered small groups
Albizzia	2	Stream banks and old homestead sites
Sesbania	2	Stream banks and old homestead sites
Opuntia	1	Some escaped individuals and small groups at old homestead sites
Oaks	3	Individuals and small plantations at old homestead sites
Poplars	1	Small groups near old homestead sites
Fruit trees	30	Small 1 to 3 ha orchards except at De Tronk where more than 20 ha is under fruit and nut trees.

gradation from the "B" sites (pastures subjected to heavy use until approximately 5 to 9 years ago) through the "C" sites (veld subjected to heavy use until some 11 to 20 years ago) to the "D" sites (veld subjected to heavy use in the past but abandoned more than 46 years ago). This may well be due to inherent site differences which were not apparent at the time of sampling but were nevertheless sufficient to mask the effects of grazing. There may also have been sustained differences in the actual level of use on the different sites, although this is unlikely as the sites were used by a succession of lessees and owners.

In order to determine the significance of the apparent differences the "t" test was applied to the sample component means. The unused sites ("E") have no increaser or invader component and therefore the vegetation growth form components of this site category were compared with those of each of the other site categories in turn. In contrast, 94,8 percent of the canopy cover on stock camp sites ("A") is made up of increasers and invaders. The increaser and invader components of this site category were therefore compared with those of each of the other site categories in turn. Total canopy cover and total basal cover, expressed as percentages were also compared in each case.

Results are presented in Tables 25 and 26.

Both "E" and "A" sites are significantly different to all other sites although the difference between the "E" and "B" sites rests on the grass component alone whereas in every other case the greater abundance of Restionaceae and Cyperaceae on the "E" sites appears to be the main distinguishing feature.

The predominance of increasers and, in all but one case, of invader species as well, distinguishes the "A" (stock camp) sites from all others.

"A" sites have the highest canopy and basal cover densities although the difference is not or is only weakly significant in the case of "B" and "E" sites. It may be seen from Table 43 that grasses make up 60,5 percent of the canopy cover and that 76,2 percent of the canopy cover comprises increaser species. These are mainly grasses (particularly <u>Pentaschistis cf thunbergii</u>) and "kweek" <u>Cynodon dactylon</u> which are typical of old stock-camp sites. Another plant which is virtually always present on these sites is <u>Carpobrotus sp.</u>

As mentioned earlier there is no clear and logical gradation evident in the data from "B", "C" and "D" sites. There is no pattern of progressive recovery from the most recently used sites through those abandoned earlier, toward the growth form distribution found on the unused sites. On the contrary, the most recently used pastures ("B" sites) show greatest similarity, and those abandoned more than 46 years ago ("D" sites), the least similarity to the unused sites ("E" sites) in total canopy and basal cover as well as in relative importance of component growth forms.

There is no apparent satisfactory explanation for the absence of a clear pattern, but it is likely that unobstrusive site differences have sufficient influence on vegetation physiognomy to obscure the effect of pasturage in this typically heterogeneous mountain veld.

4.3.2.2 Changes in the soil

Soil samples were taken from the stock camp sites and from adjoining fynbos to determine whether the concentration of animals had increased nutrient levels, particularly of nitrogen and/or phosphate, on the stock-camp sites thus inducing establishment and spread of species such as Cynodon dactylon to the exclusion of the typical fynbos restioid element, for example. Results are presented in Table 27.

While the data appear to indicate higher levels of phosphate, nitrate - N, and calcium in the soil samples from old stock camp sites, the "t" test indicates very low levels of significance for the differences between these means. No significant differnce at all is detectable in the levels of other components and

TABLE 27

Selected results of analysis of soils from abandoned stock camps and adjoining fynbos sites (See Appendix No. 8 for complete data).

Sample No.	Site	Dominant Vegetation	pH (H_2O)	R (ohms)	P (ppm)	NO_3-N (ppm)	Ca (NH_4OAc) (me %)	Total exch. cations (me %)
1	Langvlei	Cynodon	5,3	4600	25	2	0,94	1,21
2	Langvlei	Cynodon	5,9	3550	24	5	1,09	1,65
3	Langvlei	Carpobrotus	5,3	5500	7	2	0,81	1,63
4	Langvlei	Fynbos	5,6	5300	2	1	0,57	1,59
5	Agterdam	Carpobrotus	4,4	4000	4	6	1,44	2,16
6	Agterdam	Cynodon	5,5	4700	6	4	1,92	2,45
7	Agterdam	Fynbos	5,2	4400	3	2	0,67	1,07
8	Driebosch fontein	Cynodon	5,4	4000	5	1	1,54	2,16
9	Driebosch fontein	Cynodon	5,5	5500	3	2	1,64	2,27
10	Driebosch fontein	Fynbos	5,7	4800	2	1	1,32	1,96
	Fynbos means		5,5	4833	2,3	1,3	0,85	1,54
	Stock camp site means		5,3	4550	5,0*	3,1	1,34	1,93
	Level of significance**		NS	NS	5%	20%	20%	NS

Note: * Excluding the high values for P in samples 1 and 2.

**NS = not significant : 5% = significant at probability level 0,05 : 20% = significant at probability level 0,2 (t test).

properties measured. (Note: Further investigation of the association of Cynodon with high levels of phosphate, as indicated by two of the Langvlei samples - Table 27 - may prove interesting. It is known that sheep manure contains significant amounts of phosphate and pasture research has indicated that C. dactylon frequently contains relatively high levels of phosphate (T.D. Hall et al, 1965).

4.3.2.3 Changes in small mammal communities

As may be seen from Table 28, significantly more animals were trapped during the "trap nights" (in this case between the hours of approximately 18h00 and approximately 07h00) than during the "trap days" (approximately 07h00 to approximately 18h00) and Aethomys namaquensis was by far the most abundant species (12 animals), followed by Rhabdomys pumilio (5) and Mus minutoides (4). Other species represented by one or two animals only were, Tatera afra (2), Otomys irroratus (2), Acomys subspinosus (1), Crocidura cyanea (1), Myosorex varius (1) and Elephantulus sp (1).

It is interestng to note that of the 12 Aethomys caught 10 were from stock camp/farmyard sites. Rautenbach and Nel (1980) say of this species; "a particularly common nocturnal rodent, frequenting especially the more rocky areas of hillsides and summits. Although no direct evidence exists, this animal through sheer numbers and catholic diet, may prove to be of pest potential when brought into contact with human interests conducted within its habitat, ...". As has been mentioned Rhadomys pumilio was next in abundance to A. namaquensis but was found only on stock camps or farmyard sites. R. pumilio is reported to be a widespread and common rodent in southern Africa with a wide habitat tolerance (Rautenbach and Nel, loc. cit). It is generally stated to prefer dense vegetation (Roberts, 1951, and Shortridge, 1934, in Avery, 1979). Bond et al (in Avery, loc. cit) "found that its presence was correlated with continuous or extensive 'grass' patches, 'grass' including Poaceae, Cyperaceae and Restionaceae as well as Gramineae for the purpose of their classification". It seems at least possible that both A. namaquensis and R. pumilio may have been encouraged by agricultural or other activity at the stock camp/farmyard sites, either because of increased food supplies or changes in the habitat. R. pumilio, for example, would probably prefer the dense Seradella cover to the more open fynbos shrub.

Mus minutoides, which was only slightly less abundant than R. pumilio, appears to be absent from stock camp/farmyard sites, although it is known to occur on developed sites elsewhere. For example, these small mice have frequently been trapped in houses at Jonkershoek. According to Avery (loc. cit) "Mus minutoides is found in all manner of habitats ...". There is no ready explanation for its absence from the developed sites in this study.

Elephantulus edwardii is said to favour rocky outcrops (Avery, loc. cit) and Rautenbach and Nel (loc. cit) state that it was "recorded only from rocky outcrops, both amongst grass with scattered rock debris, as well as amongst boulders and rock debris devoid of any vegetation". The single Elephantulus specimen (thought to be E. edwardii) in this set of samples was trapped on a level fynbos site with occasional groups of large rocks and sparsely scattered rock debris, but with no significant grass component in the vegetation. The vegetation could be described as short to medium height shrub-restio veld of medium density, with scattered emergent tall shrubs.

A subspecies of Crocidura cyanea is reported by Avery (loc. cit) as inhabiting a wide range of vegetation in areas of above 500 mm rainfall. One of these insectivorous animals was caught on the De Tronk farmyard site in medium to tall shrub vegetation of medium density with patchy ground cover including dense kikuyu grass and Carpobrotus in some open areas. There is a small rocky koppie nearby and several groups of large rocks. Farmyard litter such as tins, metal drums and sections of iron roofing, is present on the site.

Myosorex varius is "very habit specific" according to Rautenbach and Nel (loc. cit) "existing only in a moist, very humid micro-habitat". However, Avery (loc. cit) reports that Bond et al found it in a wide variety of habitats. The single specimen of M. varius caught during this study was on the fynbos site of the Zuurvlakte pair. The vegetation is short shrub-restio with a noticeable grass component, of medium density and with scattered emergent shrubs of medium height. Groups of large rocks are present on the site and the soil is sandy.

Otomys irroratus is said to inhabit dense vegetation near water (Avery, 1979; Rautenbach and Nel, 1980) although Avery also reports that "Bond et al have found it in a range of habitats, none near water". The two animals trapped during this survey were both found in vegetation of only medium density. One was trapped (three times) on the De Tronk farmyard site which is within 100 metres of a small seasonal stream. The other individual was caught on the Zuurvlakte fynbos site which is a considerable distance from the nearest stream although there is at least one small watercourse that presumably carries water during rain storms.

The single Acomys subspinosus was caught on the De Tronk farmyard site (described above). This is not at variance with its range of habitat preference as reported in Avery (loc. cit) or Rautenbach and Nel (loc. cit).

Two individuals of the gerbil Tatera afra were caught, one on the stock camp site and one on the fynbos site of Zuurvlakte. These animals are said to prefer the sandy coastal plains but are also found in open ground with short grass, under bushes and in cultivated land (Avery, loc. cit) and Rautenbach and Nel (loc. cit) report occurrence of this species from Kliphuis in the Cedarberg. The Zuurvlakte sites both have sandy soil and the vegetation falls comfortably within the reported range of preference of the species.

No clear difference in small mammal populations that can be unequivocally ascribed to site modification by man has emerged from the survey data. The greater abundance of <u>Aethomys namaquensis</u> and the presence of <u>Rhabdomys pumilio</u> recorded from stock camp/farmyard sites may be indicative of human use but further investigation involving sampling many more sites would be necessary to prove significance one way or the other. It would appear rather that the species found are those to be expected from the habitats sampled and that the habitat modification that has taken place is insufficient or not on a great enough scale to cause significant changes in small mammal populations.
The low numbers recorded from the Groot Kliphuis farmyard and the apparent absence of rodents from the associated fynbos is presumably also a reflection of habitat. Vegetation is short (no more than 30 cm) and relatively sparse and large rocks and rock debris are absent. Shelter both from the elements and from predators is therefore poor.

4.3.2.4 The effect of harvesting wild plant material

Protea magnifica stands occur as small groups of plants scattered through very rocky terrain (Photo 33) at an altitude of from approximately 1300 metres to about 1600 metres above mean sea level. Probably because of their relative inaccessibility it appears as though all flower heads that are at a suitable stage for marketing are cut at each visit and that the stands may have been visited three times during each flowering period. An average of 56 percent of each season´s flower heads had been removed. Stands 1 and 3 were still vigorous and productive with appreciable numbers of seedlings and young plants. Stand 2 was not in good condition. More than half the plants tallied were either dead or dying. The vehicle track to Perdevlei runs through Stand 2 and this may account for the large number of dead plants, although the connection if any, is by no means clear. Other stands visited but not enumerated showed a similar pattern of harvesting and were in a similar condition to stands 1 and 3. Very remote stands had not been harvested at all (Map 11).

Protea laurifolia is considerably more widespread and numerous, occurring at altitutdes below 1300 metres in the same general locality as P. nitida and occasionally in mixed stands with the latter. There are a number of stands that are readily accessible, being close to existing roads. Harvesting pressure on

PHOTO 33

Protea magnifica habitat. Note bushes in flower to the left in the photograph. Bush at bottom right may have been killed by Phytophthora.

P. laurifolia populations is not great. It is estimated that not more than 30 percent of the flower heads are removed from any bush, and from the older bushes, many of which have reached heights of three metres and more, the proportion of heads removed is very much lower. Furthermore there are many populations that are not harvested at all. Baboons make a considerable impact by breaking off flower heads, and frequently also branches, in order to feed off the sweet basal portion of the florets. However, all populations visited were in a healthy and vigorous condition. Wherever bushes had been killed, by fire or other agency, there were invariably numerous replacement seedlings in the immediate vicinity of the dead plants. From node counts it appears that the Groot Winterhoek *P. laurifolia* does not flower before the ninth year with many individuals flowering for the first time in their 11th year.

The *Leucadendron rubrum* stands enumerated had been very intensively harvested for a number of years (approximately five to seven years) and, although the bushes appeared healthy, very few were bearing material that would have been suitable for harvesting. The current year's female flower heads were carried on short stems that would be unacceptable to the market. It is possible that earlier heavy selective cutting may have been responsible for this condition, or it may be that plant vigour had declined due to age. This species, although not as common in the area as *Protea laurifolia*, has as wide an altitudinal range and generally occurs in relatively dense almost pure stands. It is commonly associated with soils derived from shale or similar parent material.

Further research is required before the possible long term effect of repeated harvesting on natural populations of the species concerned can be assessed, but it is clear that seed stocks must be significantly reduced, particularly in the case of Protea magnifica. It was noted during enumeration that all three species were preyed upon by an unidentified rodent that climbs into the bush, cuts off the whole flower head by gnawing through the stalk at the base of the head, then extracts and eats the seed, or sweet basal portions of the florets in the case of P. laurifolia, on the ground. As mentioned above, baboons remove and destroy an appreciable number of P. laurifolia capitula. The extent of this predation by animals is unknown but it may prove to be significant if continued in stands of plants that are regularly harvested on a commercial scale.

Two observed practices connected with harvesting wild plant material in the mountain catchment that are clearly unacceptable are, firstly, the use of vehicles on unmade tracks or poorly constructed roads to gain access to the plants to be harvested and secondly, the use of insecticides and fungicides, especially in close proximity to mountain streams. It is doubtful whether the latter practice can have any real beneficial effect on the plants at all, in fact it is more likely to aggravate the situation in the long term by killing natural control organisms. The insecticides are carried into the mountain in concentrated form and mixed with water from some convenient stream. It is virtually impossible to prevent pollution of the stream even if one assumes that the labourer sent to do the spraying is concerned about the consequences of pollution and takes precautions against spillage or similar accidents.

Photographs 34 to 36 illustrate track development caused by the use of four-wheel-drive vehicles and tractor-trailer units, and also the rudimentary roads made for the purpose of harvesting wild plant material. The steep tracks devoid of planned drainage erode rapidly and severely. Appreciable quantities of material are washed into streams at road crossings. Gullies and washaways are repaired by digging material from the nearest roadside point (up slope) to provide fill which is very often washed out again by the next rainstorm. The points from which material is removed become additional foci for accelerated erosion. On easier terrain where no cutting is required multiple tracks develop particularly on seasonally wet sites. Tracking interferes with natural drainage patterns on such sites, and once the mat of organic material is broken gullies develop rapidly.

Apart from obvious adverse effects on local ecosystems, vehicle tracks through otherwise undeveloped mountain areas greatly

PHOTO 34

Roughly constructed vehicle track providing access to two Protea magnifica colonies.

PHOTO 35

Track shown in Photo 34 showing unstable nature of the terrain traversed. Track length is excessive in relation to the size of P. magnifica colonies.

PHOTO 36

Typical initial stage of vehicle track erosion. Note sensitive granular skeletal nature of the soil.

detract from the aesthetic value of those areas.

4.3.2.5 Changes in water quality

Water quality was investigated by sampling stream water at the points named in paragraph 4.2.11. Samples were taken in April 1980 at the time of lowest streamflow, in June 1980 when all streams were flowing strongly after a heavy storm, and again in April 1981 immediately after early autumn rains. Data obtained is presented in Table 31.

Whilst there are insufficient data to test the significance of the differences that exist the one fact that is clear is that all of the samples taken, regardless of time of year or stream flow rate were of clean, unpolluted water of high quality. The single conductivity reading of 58,00 micro mohs (which is equivalent to 31,32 p.p.m. of dissolved solids: van Wyk, 1981) obtained from the sample taken at point 3 on the Ratel River immediately below an intensively developed area of irrigated deciduous fruit orchards, may indicate some flushing out of nutrients derived from agricultural fertilizers by the first good rains of the season. However the evidence from one sample cannot be regarded as positive proof and in any case the TDS (total dissolved solids) level is still far below the 500 p.p.m. maximum acceptable for human consumption, (World Health Organisation, 1971).

The following chemical control agents are used by farmers in the area:

Insecticides : Gustathion, Ultracide, Thiodan;
Fungicides : Lime-sulphur, Dithane, Cyprex, Cupravit, Morestan;
Weed-killers : Gramoxone, Roundup, Paraquat, Reglone.

The following fertilizers are commonly used:

L.A.N. 3.1.5.(38); N.P.K. 2,3,4(30) chlorine free; dolomitic lime; super phosphate.

At present there is no simple method of testing for the presence of residual compounds from fungicides, insecticides or herbicides. Even very low concentrations of certain of these compounds may be harmful, at least to the microfauna and flora of the streams. By reducing or eliminating the food resource of higher animals the poisons could seriously disturb the ecology of the affected streams. A routine method of detecting traces of harmful compounds is urgently required for monitoring that aspect of water quality in mountain catchments.

5. SOME SOCIAL AND ECONOMIC IMPLICATIONS OF STATE CONTROL OF LAND USE IN MOUNTAIN CATCHMENT AREAS

5.1 State control of land use in mountain areas has developed from control of veld burning only to control of all forms of land use. In certain extreme cases land may be expropriated in order to ensure the conservation of a catchment.

5.2 From the point of view of many farmers, the introduction of strict control over veld burning reduced the utility of their mountain land sufficiently for them to abandon use of it altogether. As mentioned earlier, some 25 per cent of the land owners of the study area claimed to have discontinued using mountain veld after the introduction of veld burning control (Table 10). About 23 per cent of all land owners in the study area should reduce their mountain pasture stocking levels by at least 50 per cent to comply with Department of Agriculture recommendations. There are areas that have been degraded to the extent that stock must be totally excluded. It is probable that reduced permissable stocking rate with or without a reduction in total available area, because of existing serious degradation, will cause more farmers to discontinue use of their mountain veld.

5.3 Some land owners have concentrated on irrigation farming and do not require anything more from their mountain veld than a sustained yield of clean water. Others see wild flowers and/or public recreation as alternatives to stock pasture in their search for greater benefits from their mountain properties. However, as far as the latter group is concerned, the introduction of control over all forms of land use in proclaimed mountain catchment areas implies control over any development, including road construction, so as to prevent degradation. Strict control including the enforcing of certain standards, may render the proposed activity uneconomic.

5.4 Two land owners currently harvesting wild flowers from their mountain veld on a commercial scale should be required to upgrade their access roads and thereafter to maintain these roads to the recommended standard. If this is done, it is probable that their wild flower harvesting activities would no longer pay. An example of such a situation is discussed in detail in a following section.

5.5 It is possible that the reduced utility (as seen by the farmers) of mountain land as a result of stricter control over land use, has brought about a relaxation in the attitude of many farmers to recreationists, making it easier for the latter to obtain permission to walk, picnic, or even camp on private mountain land. The emphasis in the mountains appears to be shifting from private to public utility. However, as mentioned earlier, very few land owners are as yet capitalising on the demand for recreation opportunity.

5.6 The purchase or expropriation of all private land in the Vier-en-Twintig-Riviere mountain catchment area is an example of the ultimate land use control measure. Nine active farm community units (a unit being a farmer with his household and his permanent resident labour force) out of a total of 15 were removed from the Porterville plateau portion of the study area in this way. It can be argued, as indeed the remaining active farmers do, that the bargaining power of the mountain farming community for improved roads and other facilities, has been reduced to the point where it carries little or no weight in the Divisional Council. Looked at another way, the cost of public services per unit of agricultural production has been greatly increased. However, the State has established and staffed an administrative station on the plateau to manage the catchment area. Furthermore, recreational use of the area, especially of the State land, can be expected to increase. Individual farmer's attitudes toward the prospect of these developments vary considerably.

5.7 Discussion with land owners and other interested parties brought to light a wide spectrum of opinion about the value, potential and proper use of mountain land. The social and economic effect of State control over land use on mountain properties, whether it takes the form of outright purchase or of expropriation, or merely limits the land owner's freedom to use his land as he wishes, will obviously differ from case to case. While the majority of mountain property owners appear to have suffered no direct economic loss as a result of the implementation of catchment control measures, some feel that they are being prevented from realising the full economic potential of their property, and a few appear to have real cause for grievance. This does not imply that control is or was unnecessary nor that the measures adopted were inappropriate. However, it does appear that at least two of the families whose properties in the Vier-en-Twintig-Riviere catchment were expropriated, were worse off socially and financially after the control event than before.

5.8 To elaborate on this point, the families concerned were widely accepted as members of the mountain farming community when they lived and farmed in that area. Their farms, together with the associated sweet veld grazing areas in the Karoo, supported about 50 people (including farm hands). As mentioned earlier, they were reasonably content and enjoyed the freedom inherent in being land owners and farmers. Now, however, some individual members of these families have been classified and accepted as "white", and are living in white communities. Others have been classified "coloured" and have been obliged to move into coloured peoples' villages where they are being financially assisted by their children and other relatives. One couple, at least, wish to continue farming, but are unable to obtain a viable property with the money paid out for the mountain land. Another couple have been more fortunate, or more persistent, and, with the help of members of their family from a neighbouring district, have purchased and are developing a farm in the Ceres Karoo.

5.9 Individual cases of local community disruption of this nature may be unavoidable in the regional or national interest. If the evidence presented in an earlier section (paragraphs 4.2 and 4.3) is considered, there is little doubt that farming practices and land management of the sheep farmers in particular had caused, and were continuing to cause extensive environmental degradation of the catchment area. It is virtually certain that steadily declining productivity would ultimately have forced these people off the land without their being able to claim compensation. They would then have been a burden to the State or to their families, their land would have been rendered unproductive, and the catchment degraded to the extent of requiring costly rehabilitation work. On the other hand, by diversifying, practising conservation farming and reducing their dependence upon stock, some of them may have been able to continue living on and farming their land in perpetuity without detriment to the area or the water supply issuing from it.

5.10 The question of possible sustainable land uses and their compatibility with the principal management objectives of a water conservation area, is pursued in a following section.

5.11 State control of catchment areas implies management of some form or another. Such management could range from simple supervisory inspection of an owner's land management practices, to active management of all land use, as on State Forest for example. Whatever the level of State involvement there will be costs involved. State funds, manpower, equipment and infrastructure will need to be provided. Clearly, if management is left in the hands of the land owner, with no more than supervisory control by the State to ensure that water conservation objectives are not frustrated, direct monetary cost to the State will be minimal. However, land owners cannot be expected to expend resources on activities that are unlikely to provide an acceptable return. Abnormal conservation or rehabilitation work required by catchment management prescriptions and carried out by the owner, would probably have to be subsidised, and the Mountain Catchment Areas Act makes provision for this. Total State management would, in most cases, involve maximum direct State expenditure. Any expenditure, or costs, whether State or private, should be balanced by acceptable benefits. It can be assumed that land owners will ensure a favourable balance between their own private costs and benefits. The State must do the same; justifying all expenditure by ensuring concommitant regional or national benefits, that is, ensuring a favourable balance between public costs and benefits. This will be further discussed in the next section.

(Note: International benefits may also need to be taken into account, particularly where conservation is concerned).

THE INFLUENCE OF MOUNTAIN CATCHMENT AREA CONTROL MEASURES ON LAND MANAGEMENT IN THE GROOT-WINTERHOEK AREA OF THE WESTERN-CAPE : ECOLOGICAL, ECONOMIC AND SOCIAL IMPLICATIONS

by

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6 LAND USE POTENTIAL (OR CAPABILITY) OF THE MOUNTAIN CATCHMENT AREA

6.1 Introduction

6.1.1 Growing population, intensification of land-use and consequent depletion of natural resources make it vitally important that use of these resources be optimised. It is particularly important that use of renewable, or living, natural resources should not exceed levels that can be sustained in perpetuity. Over-use (overstocking) of natural veld for example, leads to denudation, accelerated soil loss and changes in species composition, reflected in reduced total productivity and reduced water quality. Over-use of a recreation area leads to the destruction of the properties from which the area derives its recreation potential.

6.1.2 To realise the ideal of optimal utilization of all natural resources, including perpetually sustainable use of living natural resources, total resource-use planning is essential. Ad hoc planning and decision making has very often been the rule in the past. Such an approach to the use of land, water, and other natural resources may be acceptable whilst these are in abundance, but clearly becomes rapidly less acceptable as demand increases relative to supply. As demand approaches supply limit it is no longer sufficient merely to decide whether a predetermined use of a portion of land, or other natural resource, is feasible or profitable in the short term. It becomes necessary to determine whether it is the best, or optimum, long term use. This, surely, is the basic reasoning behind national land use inventories and land classification systems developed to assist in land-use planning.

6.2 Determining land use capability of mountain catchments

6.2.1 In this section the aim is to find a method of determining optimum land use or mix of land uses for a proclaimed Mountain Catchment Area and the associated State Forest catchment. In any proclaimed Mountain Catchment Area the principal management objective is predetermined and non-negotiable. This objective is water conservation, defined as sustained production of optimum volume of clean water. However, other management objectives may be compatible with the primary objective and optimum national or regional welfare may be generated by multiple use management. The question to be addressed is, how can optimum land use be determined. The natural resources of a Mountain Catchment Area are: unpolluted water, soil, plant life, animal life, mountain landscapes, unpolluted air, unspoilt environment; while the commodities or goods that are or may be produced include: unpolluted water in the form of run-off and/or underground seepage to wells boreholes and springs; unpolluted air; opportunity for scientific study of fauna and flora, geology, gemorphology, and other natural science subjects; education opportunity; nature oriented outdoor recreation opportunity; agricultural produce in the form of fruit, nuts and similar perennial crops, or animal products from stock farming, or both; veld products in the form of wild flowers and other plant material; a diversity of natural genetic material of unknown but possibly great benefit to future generations. Many of these goods can be produced simultaneously but the production of certain commodities would either eliminate others or render their production impossible.

6.2.2 Study of historical and current land use in the catchment has indicated that there are seven mountain land use activities that may be both viable and compatible with water conservation objectives. These are:

(i) Nature conservation;
(ii) Dispersed, nature oriented outdoor recreation;
(iii) Forestry (commercial timber production);
(iv) Agriculture (perennial crops);
(v) Stock farming;
(vi) Wild flower harvesting from the natural veld;
(vii) Holiday homes (exclusive private recreation).

From the compatibility matrix in Figure 5, it can be seen that nature conservation and dispersed, nature oriented outdoor recrea-

FIGURE 5. Land use compatibility matrix

1 = fully compatible
? = conditionally compatible
0 = incompatible

	Water cons.	Nature cons.	Outdoor rec. - wilderness	Outdoor rec. - other	Timber prod.	Agric.	Stock	Wild flowers	Holiday homes
Water conservation	-	1	1	?	?	?	?	?	?
Nature conservation		-	1	1	0	0	0	?	?
Outdoor rec. - wilderness			-	0	0	0	0	0	0
Outdoor rec. - other				-	0	0	1	1	0
Timber prod.					-	0	0	0	0
Agriculture						-	0	0	0
Stock							-	0	1
Wild flowers								-	1
Holiday homes									-

tion are fully compatible, and that nature conservation may be compatible with wildflower harvesting and holiday homes provided that certain conditions are met. Compatibility of other uses may similarly be obtained from the matrix.

6.2.3 In order to arrive at optimum land use it is necessary first to determine land (or terrain) capability, or the ability of the various portions the area under consideration to sustain production of one or a range of useful or desirable commodities. In this particular case interest will be confined to the activities identified as being fully or conditionally compatible with water conservation, and listed above.

6.2.4 For every land use there are certain essential requirements and others that are considered desirable but not essential. There are also certain conditions that, if present, will inhibit specific uses.

6.2.5 Most land use depends to a greater or lesser degree on the inherent natural productivity of the land, or in other words, its inherent biological productivity. Biological productivity is, in turn, dependent upon the potential of the land, or site, to provide moisture, nutrients and energy for the development and sustenance of living organisms, or biota. Moisture availability is largely dependent upon precipitation and soil drainage. Availability of nutrients is primarily dependent upon composition of soil parent material such as underlying rock formations, and the degree to which chemical constituents are released, or transported, into a soil mantle by weathering and other processes. Energy originates from the sun and energy availability to on-site organisms will therefore depend principally upon degree, intensity and duration of site exposure to the sun.

6.2.6 Vegetation is known to reflect the total combination of site factors including soil properties and both macro and micro climate. For this reason, many land classification systems are based upon descriptions of the natural vegetal cover. However, it is argued that perturbances of the site severely hamper interpretation of the vegetation, making such systems difficult to apply and possibly unreliable.

6.2.7 Soil profiles also reflect a combination of site factors, including, to a great extent, the basic nature of the natural climax vegetation, for example, grassland, shrubland, forest or marsh. Although soil profile characteristics can be altered by land use, in most cases the changes are neither as abrupt nor as complete as, for example, those brought about in vegetation by fire. Basic soil type can usually still be identified. For this reason soils have been used as the principal component of a number of land classification systems. Agricultural capability classification is virtually exclusively based upon soil properties, for example the United States Soil Conservation

Service land capability classes (Wright, 1972), and the Canada Land Inventory "soil capability for agriculture" (Anon, 1970). However, soil surveys are costly in terms of time, and specialised staff and equipment requirements. Comprehensive soil surveys are therefore usually only carried out once an area has been identified as having potential for agricultural crop production, or where some other development requiring soil information is planned.

6.2.8 Land form is generally accepted as an important component of land classification systems. Land forms are major units of the land surface of distinctive configuration, such as mountains, valleys, plains, and so on. "Through varying height and degree of inclination of the ground surface, landforms interact with climate and directly influence hydrologic and soil forming processes; these, in turn, act as direct controls on ecosystems. Thus, landforms are an essential part of any classification of land on an ecosystem basis" (Bailey, 1981). There are a number of approaches to landform classification, ranging from those that distinguish landforms on the basis of existing inherent and observable properties (e.g. Kruger, 1972; MacVicar, 1974) to those that take developmental processes or genetic properties as the basis of distinction (e.g. Christian and Stewart, 1968). The first approach yields a classification that is of greater immediate practical relevance for land use assessment than the second, but inclusion of genetic properties is useful in certain cases. For example, it is useful to distinguish "flood plains" as a landform distinct from other plains. This is only possible if both inherent physical as well as genetic properties are taken into account in the classification.

6.2.9 Other site factors that have a bearing on land use include accessibility, negotiability, aesthetic quality, and so on. Many factors cannot easily be included in the initial assessment and must be considered in a second or subsequent phase.

6.3 Land classification systems

6.3.1 A number of land surface classification systems have been developed for the ultimate purpose of assessing land use potential. However, a single classification system that reflects the capability of an area in respect of every possible use would clearly be very complex and, as far as is known, no such system has been developed and successfully used anywhere.

6.3.2 The Canada Land Inventory employs a system in which the delineation of assessment units depends upon the particular use being considered. For example, the boundaries of the areal units assessed and classified according to agricultural capability are not the same as those classified according to recreation capability. Although the basic approach involves identifying regions of land surface that are biophysically (or ecologically) similar as broad units of assessment, the criteria according to which the ultimate units are selected depend upon the criteria whereby the required degree of similarity is defined for the particular land use being considered (Anon, 1970).

6.3.3 Once the major subdivision of the country into macro-climatic and geomorphological regions has been accounted for, agricultural capability, for example, is based primarily upon soil properties. In assessing recreation capability, on the other hand, soil properties become relatively unimportant and other site characteristics assume dominance (Anon, 1970).

6.3.4 The United States agricultural use capability classes are based upon physical characteristics of the land of immediate relevance to agriculture, such as soil, slope, erosion hazard, and so on (Wright, 1972).

6.3.5 Christian and Stewart (1968) developed a system based upon what they called "land systems", "land units" and "sites". A land system includes all areas of common genetic origin and is composed of land units which, in turn are composed of one or a group of geographically related sites distinguished by changes in genetic factors such as parent material and drainage, that is, factors reflected in changes of soil and vegetation. Land units comprise a number of sites, which are the basic units, and are parts of the land surface uniform in terms of landform, soils and vegetation (Moss, 1975 in Bainbridge, 1978).

6.3.6 Mac Vicar et al (1974) have developed a land classification system for South Africa, using climate, terrain form and soil, primarily for rain fed agriculture. They have three hierarchical levels of land unit which they name, from the simplest to the most complex, ecotope, land type, and land system. The three units are described as follows:

(i) "ECOTOPE. An ecotope is a class of land defined in terms of its macro climate (including, where necessary, aspect), soil and soil surface characteristic (mainly slope) such that, in terms of the farming enterprises that can be carried out on it, the potential yield class for each enterprise or the production techniques needed for each enterprise, there is a significant difference between one ecotope and any other.

"The word ecotope ... has been given the meaning of `a particular habitat within a region´ (Henderson et al, 1963). The word `habitat´, suggests a defined environment of living things, while the word, `particular´, suggests a narrow range of environmental variation. The question is how narrow must such a range be? We have interpreted it to mean the point beyond which further subdivision would not be significant to land users, particularly agricultural land users.

(ii) "LAND TYPE. A land type is a class of land over which the macro climate, the terrain form and the soil pattern each displays a marked degree of uniformity. This degree of uniformity is such that there would be little advantage in defining, on a country wide basis, smaller more uniform whole landscapes. One land type differs from another in terms of macro climate, terrain form and soil pattern, or one of these, or two of these ... "... a land type consists of a number of ecotopes, ..." the same ecotope may be found in several land types.

"A land type need not occur in nature as an uninterrupted block of land ...".

(iii) "LAND SYSTEM. A land system is a class of land over which the macro climate, the terrain form and the soil pattern, or one of these, or two of these display a lesser uniformity than in the case of the land type. However, the uniformity of these natural resources over one land system serves to distinguish it from other land systems. Land systems will inevitably reflect major differences in potential land use, and usually also in the climate and the natural vegetation.

"A land system consists of a number of land types related to one another in terms of climate, terrain form and soil, or one of these, or two of these ...

"For example, the Highland Sourveld of Natal might be a land system.

"A land type can never occur in more than one land system.

"A land system need not occur in nature as an uninterrupted block of land" (MacVicar et al, 1974).

6.3.7 Land types are identified by first mapping areas of markedly uniform terrain, in terms of drainage pattern, profile type, percentage level land and local relief, and termed "terrain morphological types" by Kruger (1973). These land types are then analysed in terms of their "terrain morphological units", (Kruger, loc. cit.) that is, crest, scarp, middleslope, footslope and bottomland. All five units are not always present.

6.3.8 Then, using the system of Verster (1973), "pedosystems", which are areas, comprising all or part of each terrain morphological type, with markedly uniform terrain and soil pattern, are identified and mapped. Finally the pedosystems are further classified, and subdivided where necessary, according to "macro climatic zone" (MacVicar, 1973). These final units are land types, classified according to terrain form (step one), soil pattern (step two), and macro climate (step three).

6.3.9 Ecotopes are then identified according to the definition above, and mapped.

6.4 Selection of a system for this study

6.4.1 The three units of MacVicar *et al* can be more or less equated to those of Christian and Stewart. However, the latter system makes use of genetic origin to distinguish the landform component, whereas the former emphasises inherent and observable properties of landform and is therefore preferred.

6.4.2 When dealing with a specific mountain catchment area, as in this case, the two major hierarchical units of classification are largley irrelevant. This is because one is usually working with a single land type within an identified land system. It is, therefore only the ultimate unit that is of interest. Either MacVicar's "ecotopes" or Christian and Stewart's "sites" would be appropriate. From the definition of "ecotope", however, it would appear to be acceptable practice to adapt the ecotope unit to suit the land use or range of land uses being considered along lines similar to the approach adopted for the Canada Land Inventory. On the assumption that this is the case, it was decided to use ecotopes, selected on the basis of those site factors considered to be significant for mountain catchment landuse, either singly or in combination, as the basic land surface unit in the capability assessment process.

6.5 Possible land uses

6.5.1 As explained earlier, because the study area is a mountain catchment to be managed primarily for water production, the range of possible land uses is limited to those that are compatible with the water conservation objective. As mentioned in paragraph 6.2.2, the following land uses may possibly be compatible. They are now considered further:-

(i) WATER CONSERVATION - Because the area has already been identified as and proclaimed a mountain catchment, this is the primary and non-optional land use with which all other land use within the area must be compatible.

(ii) NATURE CONSERVATION - Criteria which should be considered when assessing suitability for nature conservation are:-

(a) the degree to which the area has been disturbed, or changed from its natural state by development or exploitative land use. The less disturbed and more natural the area, the more suitable it will be for nature conservation. However, a rare or unique habitat which has been degraded but can be rehabilitated should be favourably weighted;

(b) the diversity of habitat types and ecosystems found and the extent to which the area is representative of a regional biome. The greater the diversity the more suitable the area for nature conservation;

(c) the presence of rare or endangered species and/or the suitability of the area for reintroduction and preservation of rare or endangered species. In this case degree of suitability should not be judged according to numbers of rare or endangered species alone. Degree of rarity, nature of threat to the species or habitat, uniqueness of site requirements of the species concerned, and so on, should also be taken into consideration;

(d) scientific importance or significance for research and education of natural processes or phenomena represented in the area. For example, geological strata, geomorphological processes, fossils, boulder streams and caves. The number and diversity of phenomena as well as uniqueness should be considered;

(e) the presence of archaeological sites or sites of historical significance, whilst not strictly "natural", should weight the assessment in favour of nature conservation.

(iii) NATURE ORIENTATED OUTDOOR RECREATION - The Department of Planning and the Environment (whose functions have since been divided between the Department of Constitutional Development and Planning and the Department of Environment Affairs) has adapted the terrain capability assessment techniques of the Canadian Land Inventory for use in compiling a National Outdoor

Recreation Plan for the Republic (Gouws et al, 1978). Dr. J.N.-Steyn and Mr. J.J. Booysen of the Department of Geography at the University of Pretoria were responsible for the system that was finally adopted.

It should be noted that the first aim of the Department of Planning was "To develop a system for identifying and evaluating the quantity as well as the relative quality of the natural physical recreational resources of South Africa" (Gouws et al, 1980). This is the reverse approach to that adopted here where the aim is to determine optimum land use, given a number of possible uses including outdoor recreation. However, much of the Department of Planning's system is applicable and it is worth discussing a little further.

According to this system the country is classified into "land systems" and "land facets", the latter being roughly equivalent to a unit in between the land types and the ecotopes of MacVicar et al. Two basic types of land system are distinguished, these are, coast-oriented and land-oriented. The Groot Winterhoek study area would be classified as a "broken mountainous landscape", which is one of a number of land-oriented mountain systems (Gouws et al, 1980).

Land units (systems and facets), that provide the basis for mapping, are further classified according to their recreational value judged in terms of both recreational activity elements and recreational viewing elements. Terrain capability for purposes of recreation is judged and graded according to five classes, class one being high and class five low. "For purposes of classification a terrain must basically be judged in terms of the total amount of recreation that it can generate and support per terrain unit per year under perfect market conditions" (op.cit.). The major portion of the study area could possibly be allotted to the terrain capability class 3 of this system, which is described as "A recreational terrain unit with medium potential capability for outdoor recreation and medium ability, taken as an average over the year, to generate and support outdoor recreation with a concentrated and/or extended pattern" (op.cit.). However, in this study, extensive dispersed recreational activities are seen as the only forms that would be compatible with water conservation objectives. The area would therefore be judged according to its ability to accommodate such activities as walking, mountaineering, primitive camping, picnicking, nature study and, in certain sections, scenic drives. However, it would almost certainly be downgraded to class 4 or even class 5, because of the need to limit the number of participants to comply with water conservation requirements.

Although the classification system of the Department of Planning and the Environment does take quality of recreation into account ("The classification (depends) ... on the ability of a terrain unit to generate and support a certain amount of recreation and on the quality of the recreation" (Gouws, et al, loc.cit.)), it is felt that insufficient provision has been made for "wilderness quality". The most suitable form of outdoor recreation for a mountain catchment would be of the wilderness type. The essence of a wilderness is its wild, undeveloped, natural character; its remoteness from any and all forms of development, and its freedom from large concentrations of people. Large numbers of recreationists would detract from "wilderness value". It appears, therefore, that an area that would be highly regarded as a wilderness would be ranked low on the terrain capability scale of this system.

The need to preserve wild undeveloped tracts of natural country and the value of such wilderness areas, has been discussed and debated by many (Thoreau and Leopold, 1962, in Sinden, 1969; Sinden, 1969; Frome, 1974). The Wildland Research Centre's report to the Outdoor Recreation Resources Review Commission of the United States of America (Anon, 1962) provides a comprehensive overview of the situation in that country, and a similar pattern of development, raising similar questions is discernable in South Africa (Andrag, 1977).

The United States Forest Service has set a standard of a minimum area limit of 100 000 acres (approximately 40 000 hectares) of roadless, undeveloped natural countryside for a wilderness area. The Wildland Research Centre, University of California, added the requirements that the area should exist as a single unit with boundaries reasonably free of indentations, because of external effects that detract from wilderness values on the boundary fringe; and that the succession of major ecological stages should not be interrupted by human influence (Anon, 1962). In South Africa, Ackerman (1972) suggested that wilderness areas "must be large enough, probably at least 1 000 hectares, to give visitors a feeling of isolation from the outside world". A thousand hectares is in fact probably too small an area to preserve many of the values associated with the wilderness concept. Even if the area were circular in shape, giving maximum area enclosed by minimum length of boundary and so minimising the external effects associated with the boundary fringe, the distance from the boundary to the centre of a 1 000 hectare tract would be less than two kilometres. Even in mountainous terrain this distance can in most cases be covered on foot in an hour or so; the sounds of traffic and the smells of industry are readily carried over greater distances under certain wind conditions and natural ecological processes can easily be disrupted for a considerable distance into the area by activities such as crop spraying, industrial atmospheric pollution, etc. on or near the boundary. While there may be an adequate rural buffer separating the natural area (wilderness) from sources of industrial pollution at the time of proclamation, the possibility of development right up to the boundary at some time in the future should be borne in mind.

The wilderness experience valued by recreationists includes a sense of remoteness and solitude in a vast natural area. This sense of remoteness and vastness is a personal thing that cannot be precisely defined. One person will be more easily satisfied than another but the American survey referred to above revealed that while many wilderness users were satisfied with the 40 000 hectare minimum set for wilderness areas, none would have been satisfied with a smaller area. A 40 000 hectare circular reserve could be crossed on foot via the centre point in two or three days, even in mountainous terrain. If allowance is made for the probability of external effects impinging upon valued wilderness properties for a distance equivalent to half a day's walk from the boundary, it is clear that the effective wilderness heart is considerably smaller than the nominal wilderness area. However, it is also clear that a much smaller peripheral buffer zone will be needed to preserve the wilderness heart in rugged mountainous terrain than on a plain with little topographic relief.

Apart from their recreational value, undeveloped areas where natural ecological processes continue to operate undisturbed, are invaluable both for research and for teaching. They are valuable sources of genetic material and serve as reference areas against which the effects of development can be measured

(Anon, 1980). But how can these values be quantified?

The report of the Wildland Research Centre (op cit) indicates a wilderness area use level of less than one percent of the population in 1960. The authors suggest that this may increase to about 5 percent by the year 2000. South African Forestry Department records for 1983 show that approximately 23 700 people visited proclaimed wilderness areas for an average of three nights per visit in that year. This represents approximately 0,08 percent of total population (or approximately 0,3 percent if black people are excluded) and an infinitesimal proportion of total recreational activity. These figures appear to support the frequently heard assertion that wilderness areas are very large areas preserved for the benefit of very few people. However, American experience (op cit) indicates that the mere existence of extensive wild natural places has a value for a considerable number of people, other than direct users, who are fully aware that they will never visit these areas. Because of the very large "third world" rural population in South Africa, a similar survey conducted here among the total population is likely to yield different results (e.g. see Hugo, 1974). The value placed upon wilderness, or nature oriented recreation, appears to bear a direct relationship to the level of education and degree of urbanisation (and industrialisation) of the people (Anon, 1962; Andrag, 1977; Taljaard, 1984).

Nevertheless, it is a fact that once destroyed (by development for example), wilderness can never be recreated and many of the options inherent in an undeveloped area are foreclosed for ever. This is not because man does not have the ingenuity to recreate wilderness, or at least a facsimile of the original that will be acceptable to future generations for the purposes of recreation, but because of the fact that, once a wild area has been developed, only a major catastrophe, some cataclysmic event, would be sufficient to wipe out the development and prevent immediate redevelopment. In many parts of Southern Africa population growth is outpacing education and social development so that the chances of strong popular demand for re-creation of wilderness is extremely remote. In South Africa the remaining undeveloped area that would qualify for wilderness status is limited to probably less than one per cent of the total land surface area. For these reasons, aesthetic and ethical values and also scarcity value should be considered together with more easily quantifiable economic factors. Furthermore, even though active users of wilderness areas currently represent only 0,08 per cent of the population, their needs are presumably legitimate and should therefore be taken into consideration.

Because of the special requirements that must be met for an area to qualify as wilderness, and because of the scarcity of potential wilderness areas, it is recommended that the recreation terrain capability assessment system be modified to accommodate this situation. A possible way of doing so with very little disruption of the system as it stands would be to recognise potential wilderness areas as a third basic type of "land system". There would then be coast-oriented land systems (C.), land-oriented land systems (L.) and land systems with wilderness area potential (W.), which could be either land or coast oriented. Alternatively "wilderness" could be added to the list of recreational components, and denoted by the lower case letter `z´ (the only letter as yet unused in the system´s annotation).

Whether it is regarded as a type of land system or as a recreational component, "wilderness" can be further classified by assigning it to one of five classes according to how close the area approaches the conception of ideal wilderness - class one being the highest in accordance with the approach of the current system.

In the final assessment of alternatives, identified wilderness potential should preclude all forms of land use necessitating development within that area for recreation or any other purpose except essential management.

For such a suggestion to have a chance of being accepted in South Africa the criteria for wilderness areas, apart from minimum size and wild undeveloped character, would have to include low agricultural potential and absence of strategic or otherwise important mineral resources in any significant quantity.

Even in those portions of a mountain catchment that do not qualify for wilderness status, recreational use should be confined to dispersed, low impact activities by small groups of people. The Department of Planning's system would be applicable as it stands in these areas. The folowing factors should be considered:

(a) Sensitivity e.g. presence of marshy areas, erodible soils, (particularly near stream banks), eroded sites, scree slopes, "alpine" vegetation, rare or endangered species. Sensitivity will reduce both suitability for recreation, and recreation use capability.

(b) Physical negotiability e.g. suitability of the terrain for walking, distribution of surface water, challenging rock climbs, presence of roads for vehicle access or scenic drives. Capability will increase in proportion to the number of easy and attractive walking routes with well distributed water. The existence of good scenic drives will also increase recreation capability.

(c) Attractiveness e.g. topographic diversity, view points, diversity of vegetation, mammals, birds, fish. Attractiveness <u>per se</u> should increase suitability, but will not increase recreation capability. However, a spread of attractions may do so. For example a full spread of attractions may accommodate botanists, bird watchers, anglers and others in the same area without conflict.

(d) Special features e.g. caves, waterfalls, swimming holes, rock formations, mountain peaks, gorges, forests, archaeological or historical sites. Again, the presence of special features will enhance the suitability of the area for recreation but recreation capability will be directly related to the number of special features, their distribution and accessibility.

(iv) FORESTRY

When considering the suitability of an area for forestry the following factors are important:-

(a) rainfall - a minimum annual precipitation of 800 mm is necessary;

(b) soils - well drained soil is essential, but moisture retention ability is also important;

(c) terrain - the terrain must be readily accessible and reasonably negotiable, or road making must be economically feasible so that harvesting costs may be kept to a minimum;

(d) area (extent and conformation) - the area must be large enough to make establishment of a plantation economically worth while. Conformation must be such that the total length of both internal and external fire breaks relative to the productive area, can be kept within reasonable bounds;

(e) other important factors include; exposure (frequency of severe wind, hail and snow storms could be decisive); and distance from markets.

(v) AGRICULTURE - should preferably be confined to permanent or at least perennial crops such as fruit and nut trees and vines. Annual crops or those which must be periodically rotated with annual crops are not considered suitable for catchment areas because of the greater risk of accelerated soil erosion that goes with annual cultivation.

The following factors are important:

(a) Water - adequate economic water supplies are needed to irrigate the available arable land;

(b) extent and distribution of arable land - sufficient arable land within the compass of a farm unit of reasonable size is essential - arable area should form one unbroken block if possible, so as to minimise transport costs. Alternatively, individual arable areas should be of reasonable size and within reasonable distance of each other and the administrative centre of the farm;

(c) soil type - soils must be actually or potentially suitable for the permanent or perennial crops that are to be established;

(d) access - the farm unit should be accessible by normal motor vehicle under all weather conditions. Transport of produce to market and emergency access are important considerations.

(e) location - the farm should be within reasonable distance of produce markets as well as sources of labour, fuel and materials.

(vi) STOCK FARMING - using natural veld pasture. The following factors must be taken into account:-

(a) extent of pasture area;

(b) palatability and nutritional value of plant species through the year;

(c) water availability and distribution;

(d) climatic conditions;

(e) sensitivity of the area to erosion - need to fence off stream banks, marshy areas or erosion prone slopes.

(f) predators;

(g) accessibility.

(vii) HARVESTING WILDFLOWERS - and other plant material from the veld. The following factors should be considered:-

(a) presence of suitable species - total quantity, distribution and seasonality are important;

(b) accessibility - particularly mode of access i.e. by vehicle over properly constructed and maintained roads, by off-road vehicle, or on foot only;

(c) distance to market;

(d) sensitivity of the area; the sensitivity of areas traversed by access routes is particularly important.

(viii) HOLIDAY HOMES - and similar exclusive recreational use. Important factors to consider are:-

(a) suitability of the area - attractiveness of the environment and existence of suitable building sites;

(b) water availability;

(c) accessibility by road suitable for normal family transport;

(d) sensitivity of the area - the more dispersed the occupation pattern in a catchment area the more acceptable, no occupation being the ideal. However, the desirability of widely dispersed holiday home units must be weighed against possible adverse effects of the extensive network of access roads necessitated by such a pattern of occupation.

6.6 Significant site factors (Map 13 and transparencies)

6.6.1 The following significant site factors, pertinent to the study area and possible land use, were mapped in classes as indicated below, at a scale of 1:50 000. Factors are represented on separate transparent overlays so that they may be considered individually or in any combination by superimposing the relevant overlay or overlays on a topo-cadastral base map. This is similar to the "sieve mapping technique of resource analysis" used by the Canadian Department of Agriculture and Food in the development of regional plans (Anon, 1970), and to the "hand drawn data file process" described by Steinitz <u>et al</u> (1976). Because of the volume of repetitive work involved, only a part of the study area is treated in detail in order to illustrate the process.

6.6.1.1 Topography: in three classes according to average gradient measured on the published 1:50 000 contoured topographical map over areas greater than approximately 200 by 500 metres, or about 10 ha. The classes are:-

(i) Moderate terrain, with slopes not exceeding 1:5 (11°).

(ii) Steep terrain, with average gradients of from 1:5 (11°) to 1:2 (26°).

(iii) Very steep terrain, with average gradients in excess of 1:1,2 (40°).

6.6.1.2 Altitude: subdivided into four apparently meaningful classes, with the aid of the contoured 1:50 000 maps, as follows:-

(i) up to 900 metres above mean sea level, 900 metres being about the general winter cloud or fog base level;

(ii) from 900 to 1300 metres above sea level, the latter being the most common summer low level cloud or fog base level and also the approximate lower altitudinal limit of Protea magnifica in this area;

(iii) from 1300 to 1600 metres above sea level, the latter being the most common snow line above which the vegetation is generally very short or dwarfed;

(iv) over 1600 metres above sea level.

6.6.1.3 Geology and soils: based upon geological maps and information obtained from the Department of Geological Surveys, field observations and aerial photographs. Information on the soils is extremely broad and merely indicates soils which are derived principally from sandstones and quartzites, those derived mainly from shales or mudstones and those which, although very sandy do have an admixture of fine material derived from shale or mudstone.

6.6.1.4 Degrees of rockiness; estimated on air photographs by means of a transparent grid overlay: in the following classes;

(i) less than 25 percent of area covered by outcropping rock and/or boulders;

(ii) rock outcrops and/or boulders covering 25 to 60 percent of the area;

(iii) extremely rocky terrain with more than 60 percent covered by outcropping rock and/or boulders.

6.6.1.5 <u>Vegetation</u>: in the classes listed in paragraph 2.9.1.

6.7 Synthesis of ecotopes (ultimate units of land for the purpose of land use classification) (Map 14)

6.7.1 Using the site factor overlays as explained above, and other relevant information where necessary, the following ecotopes were synthesised to be used in the study area for identifying areas of homogenous land use potential;

(i) Scree or rubble slope - at any altitude and with slope exceeding 1:5 (11°);

(ii) High altitude areas - above 1600 metres with any combination of other factors, except rockiness class (iii);

(iii) Areas in rockiness class (iii) - as described above:

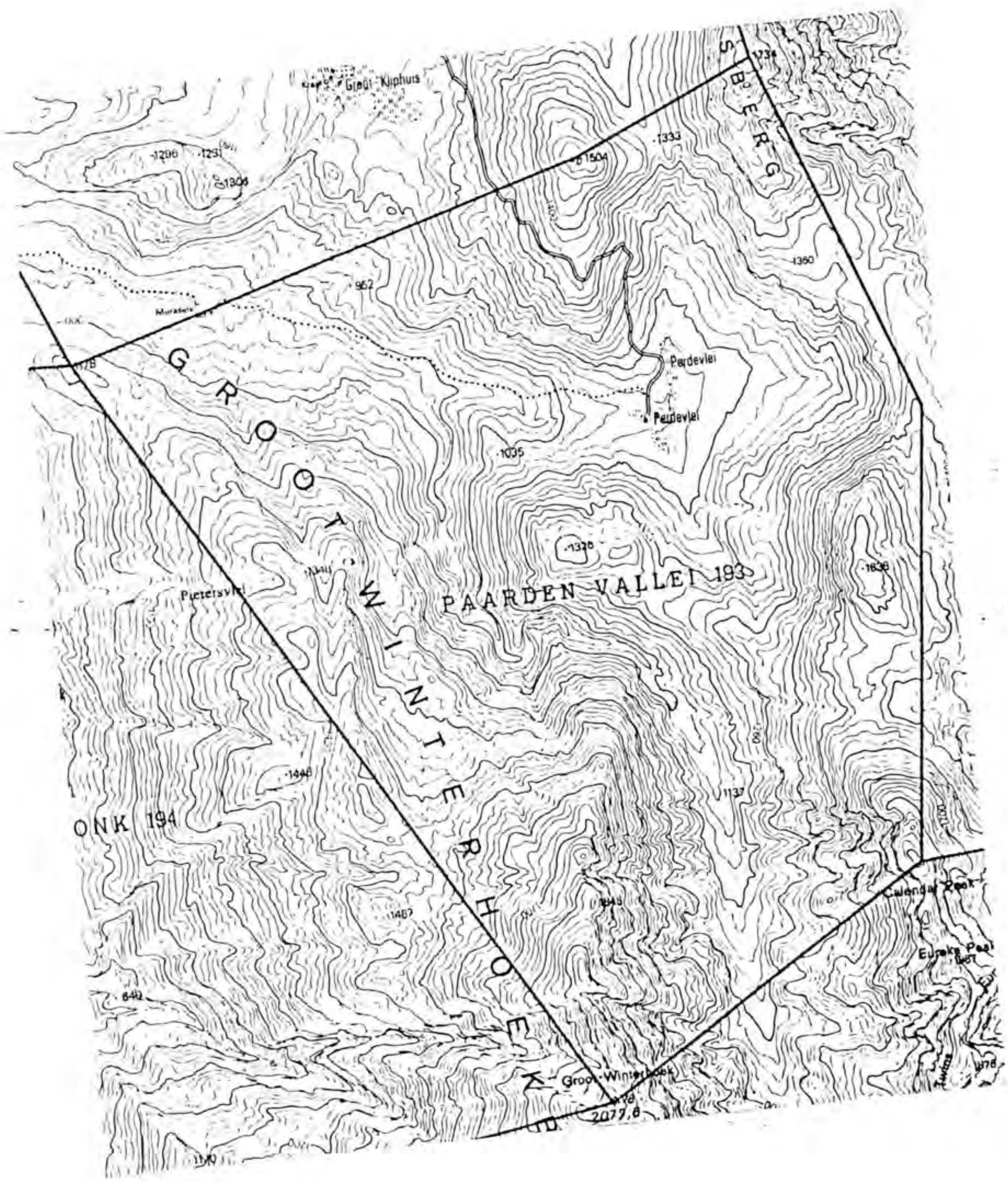
(a) above 1600 metres altitude and/or on slope class (iii);

(b) less than 1600 metres altitude and slope class (ii

(c) less than 1600 metres altitude and slope class (i

MAP 14

1:50 000



(iv) Seasonally waterlogged areas (hydromorphic soils) - all;

(v) Sites with soils in class `LS´ (loamy sand) other than those included in ecotope (i) to (iv) above:

(a) arable sites i.e. slope class (i) and rockiness class (i);

(b) non arable sites:

(b.a) slope class (i), rockiness class (ii);

(b.b) slope class (ii), rockiness class (i);

(b.c) slope class (ii), rockiness class (ii);

(b.d) slope class (iii) - all sites;

(vi) sites with soils in the class `S´ (sandy) other than those included in (i) to (iv) above;

(a) arable sites, i.e. slope class (i) and rockiness class (i);

(b) non arable sites;

(b.a) slope class (i), rockiness class (ii);

(b.b) slope class (ii), rockiness class (i);

(b.c) slope class (ii), rockiness class (ii);

(b.d) slope class (iii) - all sites

6.7.2 It should be noted that the ecotopes selected above provide only basic information about the terrain. A first assessment of land use potential can be made using ecotopes as a guide but more detail will be required for final evaluation of alternatives. The additional information required will vary according to the specific land use being assessed. For example actual or potential accessibility by motorised road transport and distance from market are important factors for agricultural development and a number of other uses; water availability is important for most land use; value for recreation or conservation will be influenced by special features such as interesting rock formations, large swimming holes, waterfalls, archaeological sites and so on, as mentioned earlier. All of this information can be represented on transparent overlays in much the same way as the basic site factors were recorded, and used in any required combination to classify the selected terrain units (ecotopes, facets or land systems depending upon the level of detail required), and to facilitate final decisions about land use.

6.8 ECONOMIC VALUE OF POSSIBLE LAND USES

6.8.1 Water production

6.8.1.1 The 1976/77 cost of water at Voelvlei dam was 1,48 cents per m3 and at Saldanha 37,5 cents per m3 (white paper, WP N-´76)(1). While this is probably not the best way of establishing a value for water in the catchment, it is assumed that people in the Saldanha area are willing to pay at least 37,5 cents per m3 and this is therefore taken as the minimum value at Saldanha. From cost data obtained from farmers in the study area it is estimated that the average cost of getting irrigation water onto the lands is approximately 2,4 cents per m3. This figure can therefore be taken as an indication of the minimum value of water to farmers in the study area. At the Saldanha figure the value of the estimated annual runoff from the study area (approximately 473 million cubic metres) is approximately R177 million (if evaporation in route to consumer and other losses are

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(1) Costs included in this figure are; redemption of all capital expenditure, interest therean, maintenance, operation, accumulated shortages and interest thereon of water storage, panification and delivery to the Saldanha area.

ignored) and at 2,4 cents per m3, approximately R11 million. Because water is such an indispensable commodity its value under extreme conditions of scarcity becomes practically incalculable. For the purpose of calculations that follow, however, the higher of the two values mentioned above will be used.

6.8.2 Nature Conservation

6.8.2.1 No satisfactory, universally accepted method of attaching a monetary value to nature or to the many attributes of natural, unmodified and unpolluted ecosystems has been devised as yet. There is no doubt in the minds of natural scientists and other informed individuals that conservation of natural ecosystems is essential for the well being - even the survival - of mankind (Caulfield, 1961 in Sinden, 1969; Heuting, 1980; Anon, 1980), and many higher minded people see nature conservation as a moral and ethical obligation (Smit, et al, 1984). However, the decision to preserve an undeveloped natural area intact is inevitably a political one based upon ethical judgements supported by persuasive scientific and moral argument. A decision model that appears to successfully accommodate intangibles, such as the value of nature conservation, is discussed and illustrated in a later section.

6.8.3 Facility Based Outdoor Recreation

6.8.3.1 The study area is generally unsuitable for day visitors because of distance from large urban populations (three to four hours drive one way), and access, which, in the final approach, is over a steep and winding gravel surfaced pass. It is, however, highly suitable for nature oriented recreation over weekends or longer periods. Using an approach similar to that suggested by Clawson (1959), Andrag's visitor data for the Cederberg conservation area (Andrag, 1977) and a conservative car running cost of 12 cents per kilometre (The Automobile Association figure for a two litre sedan was 16 c/km in 1979), and assuming an average of four persons per car, a mean travel cost figure of R14,64 per visitor is arrived at. Andrag (loc cit) found average length of stay to be 3,18 days. Using this figure, the travel cost per visitor day becomes R4,60. Per capita cost of food additional to normal cost at home is estimated at R2,00 per day and estimated daily cost of equipment purchased and used exclusively for nature oriented recreation is also estimated to amount to approximately R2,00. The last figure is derived as follows (price estimates for 1979/80):

Cost of hiking boots and other special items of clothing	R150
Estimated usefule life 5 years,	
Annual cost is therefore	R30
Cost of light tent, rucksack and other special	
equipment	R300
Estimated useful life 10 years	

Annual cost is therefore	R30
Total annual cost	R60
Estimated number of days use per year is 30;	
daily cost will therefore be	R2,00

The aggregate of these costs, which is R8,60, is assumed to be what visitors are willing to pay for a day in the Cederberg and will be used here to derive an estimate of the value of both facility based outdoor recreation and wilderness type recreation.

6.8.3.2 The non-wilderness facility based recreation value of each area will be derived by adding a camp site hire fee of 33,3 cents, which is the Directorate of Forestry's daily camp site tarrif divided by the maximum number of people permitted per site (R2 - 6), to the R8,60, giving R8,99 per visitor day (say (R9,00) and multiplying this by the estimated annual number of days use (i.e. 60) and a subjective assessment of the visitor carrying capacity per hectare of each ecotope (for example see Table 46).

6.8.3.3 For the purpose of estimating the recreation value of a farm environment as a source of income for the farmer in the study area, it is assumed that each farmer could handle 5 accommodation units from which he could derive a nett income of R5 per unit per day used, without undue disruption of his normal activities. Forestry Department records from the Cederberg indicate that the farmer could expect approximately 60 days of occupation per unit per year i.e. 300 unit-days at R5 per day which is R1500 per annum. If the farmer were to charge 20 cents per visitor per day access fee for the privilege of driving, walking or picnicking on other parts of his property, limiting visitor numbers to the subjectively determined carrying capacity of the ecotopes represented on his farm, this may yield significant additional income. There are a number of ways in which a farmer could supplement his income by providing facilities or services, or both, for visitors, but only the two mentioned above will be used in the evaluation exercise that follows in the next section.

6.8.4 Wilderness type Outdoor Recreation

6.8.4.1 The wilderness type recreation value of the area is derived by adding a pro-rata wilderness area entrance fee to the R8,60 arrived at above and multiplying this figure by a subjectively determined carrying capacity. The wilderness area entrance fee charged by the Directorate of Forestry, is R1,00 per person per week or part week, and average length of stay is 3,18 days (Andrag, loc cit), the average daily cost per visitor will, therefore, be 31,5 cents, bringing the total estimated willingness to pay figure to R8,91. This figure can be rounded up to R9,00, as was done in the case of non-wilderness type recreation. However, because of the dedication of wilderness recreationists, it is assumed that their "willingness to pay" will probably be least double this amount and a figure of R18 will, therefore, be used in the calculations that follow. Guided by personal experience, wilderness carrying capacity has been arbitrarily set at 0,01 visitors per hectare per day. The subject of wilderness area carrying capacity has been dealt with by many, including Andrag (loc cit) and Washburne (1982). The latter queries the value of setting an a priori carrying capacity figure, suggesting rather an efficient monitoring system that would be used to determine courses of action required at specific sites in order to maintain wilderness character. For the purpose of this exercise, however, a carrying capacity figure is necessary and the estimate of 0,01 visitor days per hectare will be used. It is assumed that recreational use of the area will be more or less limited to certain times of the year, as is the case in the Cederberg (Departmental records), amounting to approximately 60 days per year. Annual value per hectare will then be R10,80.

6.8.5 Commercial timber production

6.8.5.1 Judging by existing small plantations in the area it is estimated that there are two broad site classes into which the plantable ecotopes may be divided namely, poor sites with mean annual increment (MAI) of approximately 8 cubic metres and better sites where it is estimated that MAI would be approximately

12 cubic metres per hectare. The return per cubic metre on timber delivered to the small sawmill in Porterville, 28 kms distant, is assumed to be no more than R1,00. Transport costs are approximately 10 cents per cubic metre per kilometre if the vehicle returns empty between loads. Therefore, every additional kilometre over which the timber is transported reduces unit profit by at least 10 cents. If the additional distance is over the farmer's own roads (as opposed to public roads) his profit margin would be reduced by an additional amount per kilometre, equivalent to an appropriate proportion of the construction and maintenance costs of his road. The amount would, of course, vary with the total tonnage of all goods transported. The nett value per hectare of timber production is estimated to be R12 on the better sites and R8 on the poorer sites at the study area datum point which is a distance of 28 kilometres from the sawmill.

6.8.5.2 Afforestation is estimated to reduce streamflow by some 300 to 400 mm of rainfall equivalent (Bosch, 1981). Roading and harvesting will also cause a periodic increase in silt load of streams flowing through the area of operations (van Wyk, pers. comm.). Expressed in terms of cubic metres per hectare, streamflow reduction will be at least 3 000 cubic metres. This volume of water is worth at least R1 125 at the Saldanha - Vredenburg rate. Because of the difficulty of obtaining reliable information the cost of periodically reduced water quality will not be quantified in monetary terms for the purposes of this exercise.

6.8.6 Agriculture

6.8.6.1 There are no extensive contiguous areas of arable land in the study area, the largest being approximately 250 ha in extent spread over a number of subdivisions of the original Pampoenfontein property. Numerous more or less widely scattered arable pockets exist but many of these are so small and so isolated that they are practically valueless. Other sites, for example on the Solderberg, are for all practical purposes inaccessible.

6.8.6.2 While agriculture extension officers have estimated approximately 50 ha to be the minimum area of arable land required for an economic unit on the Porterville plateau (Mr. A. Viljoen, pers. com.), one farmer in this area is supporting himself on 11 ha of irrigated deciduous fruit (See Table 12).

6.8.6.3 Transport costs are clearly a major factor in determining profitability in any farming venture. The further from market and from a source of production requirements, the greater the weight of the transport cost element. Road haulage distance and road quality are critical to farmers of mountain land. Direct transport costs increase with increasing road distance and with decreasing road quality. Indirect transport costs, that is road maintenance costs, also increase with road length and terrain difficulty. While the landowner is not expected to contribute on a directly proportional basis to the maintenance costs of a public access road into the farming area, the cost of such roads to the community as a whole must be taken into account when considcering the costs and benefits of farming in remote mountain areas. The farmer is, however, responsible for his own farm roads, and providing and maintaining access to scattered small pockets of arable land could become excessively costly if minimum standards were to be enforced.

6.8.6.4 It is evident that what has happened in the past is that roads have been made and maintained to the minimum standard necessary to provide access, or to the standard which the farmer considered adequate or could afford. In a catchment area a relatively high standard of road construction and maintenance is essential if erosion and stream pollution are to be avoided. Estimated costs of construction and maintenance of roads of acceptable standard are presented in Table 37. It can be readily understood that the greater the length of road on the farm, and also the greater the distance from the farm to the market and/or source of essential supplies, the greater the productive capacity of the farm must be and, generally speaking therefore, the larger the minimum size of an "economic unit". The survey conducted during the course of this study showed that irrigated

TABLE 37

Rough guide estimates of road construction and maintenance costs; 1979.

Based upon discussions with civil engineers of the Piketberg and Clanwilliam Divisional Councils, and personal experience of road construction over sand and marsh in Northern Rhodesia (now Zambia)

Construction costs per kilometre, including drainage and gravel surfacing

Easy terrain	R 2 000
Class iii rocky terrain	R 4 000
Causeway over sand	R 4 000
Causeway over seasonal marsh	R10 000
Pass without rock	R10 000
Pass with rock	R15 000

Maintenance: Say R100 per kilometre per year.

Bridge Construction ("guestimates")

Major bridge (single lane, maximum of two spans)	R10 000
Minor bridge (single lane, low level)	R 2 000

fruit orchards yielded the greatest profit per unit area. The smallest apparently economic unit encountered comprised 11 ha of productive deciduous fruit (paragraph 7.6.2 above), which, because of the need for systematic replacement of over-mature (and therefore less productive) trees, requires a total irrigable area of 14,85 ha. (Assuming 7 years to bearing and 20 years productive life, then 1,35 ha are required per fully productive hectare; Prof. D. Strydom, pers. comm.). This unit is 28 km from the nearest railhead and 90 km from a deciduous fruit depot. It provides an acceptable income for the farmer and his family and supports four employees and their families as well.

6.8.6.5 Taking this unit as the datum line case and using a figure of R240 per km per year as an average road cost (made up of an annual maintenance cost plus 7 per cent per annum of the construction cost), based upon local experience (civil engineers of the Divisional councils of Clanwilliam and Piketberg; personal communication), every additional kilometre of road would require at least an additional 1,1 ha of irrigable area in order to maintain the same nett income level. Greater distance from market and source of supplies will of course also reduce the profit margin by increasing the transport element of production costs. Additional labourers are required during the fruit picking and packing season. These people must be transported from their places of residence in the more densely populated areas of the valley, involving at least two two-way trips per week and further adding to production costs. However, only the road construction and maintenance cost figure mentioned above is used to illustrate the combined significance of farm unit size and total road length.

6.8.6.6 In considering individual cases road costs will obviously vary according to terrain, bridge and culvert numbers and size, and other construction factors.

6.8.6.7 Clearly, those isolated pockets of arable land with a combined area of less than about 15 ha which are more than 28 kms from a market or railhead must be regarded as not worth developing in isolation. Some may of course be worth incorporating into a mixed farming venture.

[Note: Irrigated Proteas may be the most profitable crop of all in this area, but the market is fickle and there is insufficient evidence from this study, of successful cultivation on any appreciable scale for flowers to be considered as the foundation of an agricultural venture].

6.8.6.8 Irrigation implies the use of relatively large volumes of water and, therefore, a conflict arises between irrigation agriculture and the principal water conservation goal. However, if every hectare of potentially arable and accessible land in the proclaimed catchment of the Vier-en-Twintig-Riviere were irrigated at the recommended rate of 500 mm per annum, to augment winter rainfall of about 800 mm, (Piaget, 1971; Murdoch and du Pisani in van der Zel, 1971; Prof. D. Strydom, personal communication), and if none of this found its way back into the river system, which is unlikely, average annual flow at the diversion weir on the catchment area boundary would be reduced by about 1,4 percent, or approximately 2000 megalitres. At the Saldanha-Vredenburg rate of 37,5 cents per cubic metre 2000 megalitres (2 million cubic metres) is worth R750 000.

6.8.6.9 The very porous free draining sandy soils of the area require heavy applications of inorganic fertilizers to maintain productivity. Even though the practice is to apply frequent small doses it is probable that appreciable quantities of this fertilizer are leached out of the soil by rain and irrigation. Dissolved salts from fertilizers and traces of insecticides, fungicides, weedkillers and similar aids to farming, may reach the streams and be carried out of the catchment in the water. This would be in conflict with the second water conservation goal of the proclaimed catchment area, that is maintenance of water quality.

6.8.6.10 It may be argued, however, that even if every potentially arable hectare were cultivated and fertilized at recommended rates, the increase in level of dissolved salts in the water leaving the catchment would be insignificant (see results of water analyses in paragraph 4.3.2.15 to 17 and Table 31).

6.8.6.11 Using cost and yield figures extracted from Tables 12 and 13, an estimate of the gross income per hectare of deciduous fruit on a first quality site may be obtained; this is R2 818. Production costs for the 11 productive hectares of farm 3 (the smallest apparently viable unit) are R1 669 per hectare. Net income[1] per hectare of an 11 hectare unit is therefore approximately R1 149. Farms 1 and 2 have a range of site qualities and are approximately the same distance from markets and supply points as farm 3. From data obtained for farms 1 and 2 it is estimated that production costs per hectare for 110 productive hectares at this distance from markets and supply points ammount to approximately R800. For ease of calculation the gross income of quality one sites will be taken as R2 800 per hectare and the gross incomes of quality two and quality three sites are estimated to be R1 900 and R1 200 per hectare respectively.

6.8.6.12 Figure 6 is an estimated curve representing the relationship between productive area and production costs per hectare, based upon the two available sets of data. From this graph and the gross income figures given above, area/net income per hectare curves may be estimated for a range of productive areas for each site quality. Production costs are assumed to be the same

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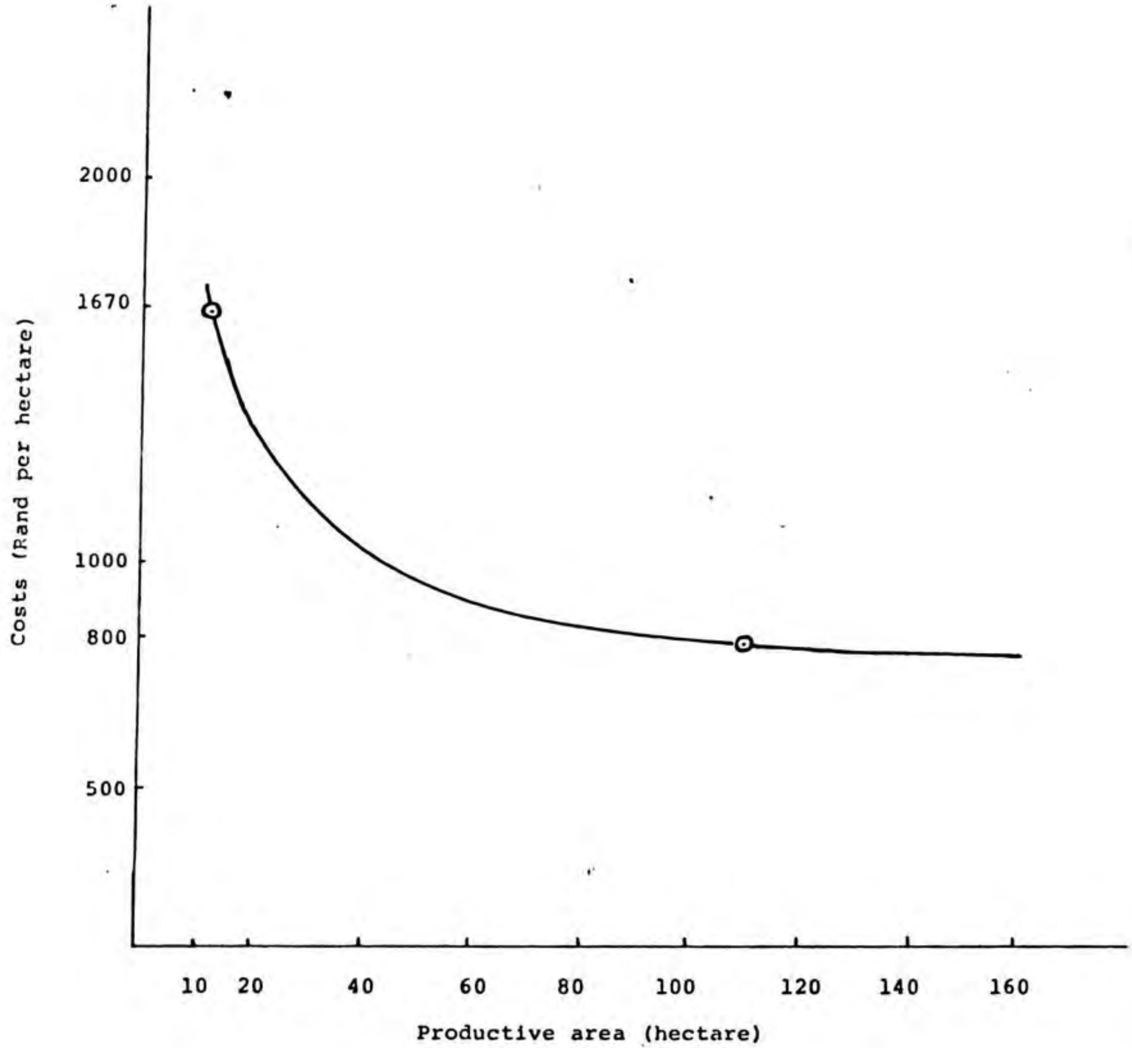
For this study net income is defined as gross income minus all costs (excluding interest and management reward).

FIGURE 6

Tentative relationship between production costs and productive area for irrigated orchards at the datum point in the study area



NOTE:

Estimated gross income yield per hectare from irrigated deciduous fruit orchards in the study area (Rands per hectare)

Best sites	(Class 1)	R2 800
Moderate sites	(Class 2)	R1 900
Poor sites	(Class 3)	R1 200

for all site qualities.

6.8.7 Stock farming

6.8.7.1 Little or nothing is known about the sustained yield value of natural mountain fynbos as pasture in spite of the fact that it has been used by white stockfarmers since about the middle of the eighteenth century, although always in combination with lowland pastures on a seasonal basis (see paras. 3.2.3 to 3.2.9). Traditionally, the veld was burnt to provide palatable pasture, and the usual practice was to bring the stock to the mountain pastures for from three to, at most, six months of the year. Farmers who for some reason have had to keep their stock in the mountains through the year have suffered stock losses, experienced reduced reproduction rates and reduced wool clip, both in quantity and quality (local information e.g. Mr.-P.H. Smit, personal communication).

6.8.7.2 State pasture scientists regard unmodified mountain fynbos as of little value for pasture and agricultural extention officers in fact recommend that stock should be kept out of the catchments altogether (Departmental records and Mr. A. Viljoen, personal communication). However, the Department recommends a stocking rate of from 8 to 12 hectares per small stock unit to those farmers who insist on using their mountain veld.

Obviously, unusable areas such as krantzes and mountain peaks, must be excluded from the total areal figure used to calculate permissable maximum stock numbers. Furthermore stock should not be introduced before the passage of at least one full growing season after the veld has been burnt. This requirement will reduce usable area by 25 per cent if the farmer burns on a four year cycle, which appears to be the minimum possible.

6.8.7.3 As mentioned in an earlier section, stock trails and denudation caused by overgrazing and trampling, have been a major cause of serious gully and sheet erosion in the study area. It would appear that in order to show a profit it has been necessary for farmers to stock the veld beyond the recommended safe carrying capacity (see Table 9). Even so, stock farmers encountered in the study area appeared to be struggling financially, whereas many of those who had abandoned stock farming in favour of producing citrus fruit or other irrigated crops in the valley, appeared to be more affluent.

6.8.7.4 It is perhaps not surprising that the mountain veld makes poor pasture. The soils are extremely poor in exchangable bases, and particularly in such vital elements as potassium and phosphorus without which domestic animals cannot thrive. Winter temperatures are also low. This is aggravated by high precipitation and much reduced radiation. There are few palatable legumes or grasses (see Appendix 6). All of this adds up to an environment which is by nature poor stock country.

6.8.7.5 There are some farmers however, who claim to have successfully kept cattle on mountain fynbos throughout the year, and others, in the northern section of the study area, who run goats on their mountain veld throughout the year. Therefore, the possibility of stock farming of some sort on certain selected areas cannot be entirely ruled out. However, from available evidence year round pasturing of stock on natural mountain veld does not appear to be a viable proposition at recommended stocking rates.

6.8.7.6 In order to meet the special requirements of soil and water conservation in the catchment area, stream banks, freshly burnt and other sensitive areas that could be damaged by stock should be protected by fencing. In many cases fencing costs alone would render stock farming uneconomic. An estimated net income of R20 per small stock unit is assumed <u>before</u> allowing for fencing costs. Assuming an initial cost of R400 per kilometre, a life of 10 years before total replacement and annual maintenance costs of R10 per kilometre, then the annual allowance that should be made for fencing will be approximately R50 per kilometre, equal to the nett return expected from 2,5 small stock units. The maximum permissable stocking rate in the catchment is 8 hectares per S.S.U. Is it possible to enclose 20 hectares within one kilometre of fence line? The minimum ratio of fence length to camp area will be obtained if the camp is circular in shape. A 20 hectare circular camp has a perimeter length of approximately 1 585 metres. Although the cost and return figures used here are no more than estimates, it would appear that where mountain veld pastures need to be totally fenced, stock farming becomes uneconomic when based on natural veld alone. It may be possible to improve the situation by fencing off the areas from which stock should be excluded and allowing the animals to range freely over the rest. Each case will have to be assessed individually.

6.8.7.7 It is a moot point whether the system involving seasonal migration, or transhumance, between mountain and valley pastures has any merit today. There would appear to be infinitely more efficient systems of stock farming. However, if a farmer can provide supplementary feed for his stock, by stall feeding or by making use of improved pastures, it may be possible to utilise certain portions of the catchment for grazing.

6.8.8 Harvesting of plant material from natural veld

6.8.8.1 In spite of claims to the contrary it is doubtful whether wild flowers and other plant material can be harvested from the natural veld of the study area in sufficient quantity to provide a permanent and regular income that would support a man and his family. Recent harvesting activities in the area have resulted in severe environmental degradation (see paragraphs 4.3.2.16 and 17) and there are indications that the productivity both of the sites and the species involved is being adversely affected by the scale of operations. However, there is insufficient data available to positively support this contention at present.

6.8.8.2 A survey of three widely separated populations of Protea magnifica, which is the local species commanding the highest price, indicated that average stand density is approximately 266 plants per hectare and average number of capitula (flower heads) per plant per season is approximately five. Sample counts in two stands that had been harvested indicated further that an average of over 60 percent of the total crop had been cut each year for three consecutive years (Table 30).

6.8.8.3 The total area of P. magnifica populations involved is estimated to be approximately 30 hectares on four separate sites varying in extent from five to 10 hectares and lying from 180 to 190 kilometres from the nearest market outlet (Cape Town). The final approach to all but one of these sites is over tracks negotiable only by tractors or four-wheel drive vehicles. Distances over such tracks vary from four to 12 kilometres. Furthermore, flowering period extends over two or three months and capitula cut too early or too late are not acceptable to the fresh flower market. Pollinating agents, including birds, rodents and large coleoptera begin visiting the flowers soon after the capitula have attained the ideal cutting stage. Unlike bees and other small insect polinators, the relatively large creatures damage the flower groups sufficiently to render the affected capitula unsaleable.

6.8.8.4 A landowner selling direct to the fresh flower market with the minimum of processing and handling can expect no more than 30 cents per head (SAPPEX, pers. com.). Running costs of a four-wheel drive pick-up amount to about 25 cents per kilometre (Dept. of Transport schedule of tarrifs, 1979/80). One round trip to all sites would amount to a little over 400 kilometres and the capacity of the vehicle would be approximately 3000 flower heads packed in cartons. The estimated total yield of the 30 hectares involved is approximately 40 000 capitula. However, it is unlikely that more than 70 percent of the total crop would be cut, which is 28 000 (the survey indicated about 60 per cent). This number would involve nine round trips at R100 per trip and assumed labour and material costs of approximately R1 000, if the farmer himself drives the vehicle at no charge to the operation. Total costs involved would therefore amount to approximately R2 000 for an income of R8 400, an apparent net income of R6 400.

6.8.8.5 This appears to present an attractive proposition although the calculation above is based upon the most profitable species in the area and on paying harvesting and packing labour at piece work rates equivalent to approximately R4 per day. No account is taken of the fact that seed regenerating wild plant populations are unlikely to be able to sustain production for very long in the face of a 60 to 70 percent removal of the annual seed crop, excluding natural predation. Furthermore, the erosion and general environmental degradation resulting from the use of unconstructed access routes is not compatible with the water conservation objectives of a mountain catchment area. It is estimated that to bring the access routes to an acceptable standard would cost a minimum of R4 000 per kilometre. There are approximately 38 kilometres of track to be upgraded, which would mean a capital outlay of some R152 000. At 7% per annum this would amount to R10 600 in simple interest alone. To this must be added maintenance costs of about R100 per kilometre or R3 800 per annum; a total expenditure of about R14 000 per annum on roads alone. This exceeds the estimated net income by more than 100 per cent.

6.8.8.6 More than half of the P. magnifica discussed above is on State Forest land, but even if it were all available to one landowner it is clear that it is not possible to harvest this product of the natural veld profitably without causing serious environmental problems, and possibly also causing the ultimate destruction of the plant colonies from which the harvest is derived.

6.8.8.7 Other saleable species, such as Protea laurifolia and Leucadendron rubrum are more plentiful and widely, although sporadically, spread on relatively more accessible sites. However they do not command as high a price as P. magnifica and greater care is needed in selecting undamaged and long stemmed material. Furthermore, old P. laurifolia bushes grow to three metres and more in height, often in dense stands, making a high percentage of the heads difficult to harvest. Repeated cutting of L. rubrum appears to have the effect of reducing flower cluster shoot length. Two heavily exploited stands estimated to be some 9 to 12 years old were investigated and, although the female bushes were covered with good crops of flower heads, most of the material was unsaleable due to the shortness of the flower head stems. A few apparently younger more vigorous individuals had longer shoots (Table 30).

6.8.8.8 P. laurifolia and L. rubrum, along with several other Proteaceae are found on well drained sites, from the low lying valleys and lowest mountain slopes up to about 1 300 metres above sea level. At the higher altitudinal limit they are occasionally found growing close to or even apparently mixed with P. magnifica although this is rare. Apart from P. magnifica, P. laurifolia and Leucadendron rubrum, the latter being sold only in the dried state, none of the Proteaceae contribute significantly to the saleable wild flower (as apposed to so called "greens") yield from the natural veld. Large quantities of Leucadendron salignum, various Ericaceae, Restionaceae, and other common genera are, however, harvested to provide "greens" or bulk material for the florists.

6.8.8.9 Protea magnifica populations are sparsely scattered on rocky sandstone sites at altitudes between approximately 1300 and 1600 metres above sea level. Other saleable shrubby material, including Proteaceae, is found principally on the well drained mesic sandstone sites up to approximately 1300 m.a.s.l. Marketable Restionaceae are found on similar sites and also on wetter sites which may be seasonally waterlogged. These communities all display the typical patchy distribution pattern of fynbos. Harvesting will therefore always be a labour-intensive operation and labour productivity will always be governed to a large extent by this distribution pattern.

6.8.8.10 It is likely that intensive cultivation in irrigated plantations will replace the harvesting of material from the natural veld. Increasing labour and transport costs should hasten this process. Another factor that will contribute to change is customer selectiveness, as increasing quantities of better quality material from selected and improved plantation stock reaches the market.

6.8.8.11 Whilst it is clear that wild plant material can contribute to a landowner's income under certain circumstances, it also appears to be extremely doubtful whether large scale harvesting from natural veld can be maintained at a profitable level for any length of time without seriously damaging the environment, causing accelerated soil erosion and probably also destroying the source of the harvest in the long term. For the purpose of the land use assessment exercise, however, an arbitrary figure of R3 per hectare will be used as an average net income value of the wildflower harvest from natural veld within reasonable walking distance (say five kilometres) of a road of acceptable catchment area standard.

6.8.9 Holiday homes (Exclusive private recreation)

6.8.9.1 To establish a nett value per hectare for this form of land use, it will be assumed that a form of "Share Block" scheme will be used and that unit size will be 50 hectares. The land owner will "sell" these units at a minimum price of R200 per hectare, while retaining the right to use the land for certain purposes such as wild flower harvesting. He will then reinvest the proceeds at 7 percent simple interest. Unit price on the above basis is R10 000 and annual income in the form of interest will be R14 per hectare.

6.9 The optimum land use objective

6.9.1 The objective in seeking to determine optimum land use is to maximise community benefit, or social welfare. In the case of a mountain catchment, the welfare of at least three communities is involved; the community of land owners whose properties have been included in the proclaimed area, the regional community who will benefit from the assured water supply and from the recreation opportunities and nature conservation associated with the water conservation action, and the national community who, among other things, will pay for the management of the conserved area through tax contributions but who will also benefit, if perhaps only indirectly, from the conservation action. It is suggested that it should be encumbent upon the Government to ensure that the catchment area is managed, or used, in such a way that maximum national benefit is generated with minimum, if any, reduction in the welfare of any community.

6.9.2 According to Graaf (1957) welfare is "a state of mind", it "is not an observable quantity like a market price or an item of personal consumption". Furthermore, he implies that the factual and ethical assumptions on which the conception of welfare are based are likely to be relevant and real only in a particular historical context (op. cit.). An individual´s, or a community´s, perception of welfare is clearly also influenced by developmental state and relative progress toward satisfying needs in the hierarchy of needs as expounded by Maslow (1954). For example, the Crossroads community is unlikely to attach the same value to nature conservation as would the Constantia community. Welfare, or benefit, is determined by a large number of variables, both economic, or quantifiable in monetary terms, and intangible qualitative variables that cannot be quantified in the same way. Graaf (loc. cit.) states that "a person's welfare map is defined to be identical with his preference map - which indicates how he would choose between different situations, if he were given the opportunity for choice".

6.9.3 Determining community or group welfare presents a number of problems not the least of which is caused by the fact that "groups do not frequently make unanimous choices" (op. cit.). Graaf (loc. cit.) sketches three concepts of group welfare. The first he calls "paternalist, as it is completely divorced from the preferences of the individual members of the group. The State, or paternalist authority, has its own ideas about welfare which may or may not take cognisance of economic factors...". The second concept of group welfare is that it is "no more than a heterogenous collection of individual welfares". This is the concept employed by Pareto (1929, in Graaf, loc. cit.) and leads to his "criterion for a maximum of group welfare: that it must not be possible to make any one man better off without making at least one other worse off". The third requires "ethical judgements" to be made "regarding the way in which one man's welfare is to be `added´ to another's" in order to arrive at group welfare. The question arises as to who should make these ethical judgements. It would seem to be clearly a matter for the politicians and ideally, in a democratic society, the members of the group or community concerned should contribute through their elected representatives. However, it is not as simple as that.

6.9.4 Adherents of the laissez faire economic theory of Adam Smith, the basic underlying concept of which "is that the unhindered persuit of self-interest by rational, utility-maximizing individuals leads to outcomes which are socially or collectively desirable" (Smit, 1981), maintain that the State should not interfere in private enterprise. This implies that it should be left to the individuals comprising the group to make the ethical judgements concerning group welfare. It should be clear, however, that when the "group" is the national community as a whole and what is being considered includes natural resources such as soil and water, attractive or inspiring landscapes, natural gene pools, and other "environmental goods" (Heuting, 1980), the unhindered pursuit of self-interest by individuals, or local communities, no matter how rational, is unlikely to lead to outcomes that are socially desirable in all cases.

6.9.5 There are a number of reasons for this. For example, the planning horizon of individuals is likely to be infinitely closer than that of the national community (represented by the government). Most individuals are unaware of the long term effects of their actions, and many appear not to care. In spite of government "interference" through conservation legislation, soil erosion, destruction of indigenous vegetation and degradation of the environment in many other ways continues unabated. According to Heuting (1980) "one difficulty is that some vital functions of the environment are not appreciated by people because they do not know how important these functions are to life on earth, including human life". He maintains that there is a cultural lag between the public and governmental bodies with regard to measures of environmental protection. It would, therefore, appear that a degree of "paternalism" would not be out of place. Clawson and Knetsch (1971) support this approach. They state that "the government must ... also allow its own preferences to count ... in a number of cases there is reason to regard the environmental functions as merit goods". They define merit goods as "goods the use of which the government wishes to encourage for certain reasons", such reasons being:

" (i) Individuals have insufficient knowledge of the merits of a good;

" (ii) The goods have a considerable positive external effect that benefits the community;

"(iii) Cultural heritage must be preserved"; (Natural heritage should be included here)

" (iv) Allowance must be made for future wants"

They state further that "the government can restrain the consumption of certain goods on account of inadequate knowledge of the harmful effect on the consumer or on account of negative external effects on the community. Such goods are called demerit goods".

6.9.6 The present generation, or the members of today's national community, cannot assume the right to pursue self interest to the detriment of members of future communities. If an individual uses land in such a way that its long term productive capacity is reduced this will undoubtedly have negative external effects on the community. Similar negative external effects will result if the action of individuals in a catchment area reduce that catchment's capacity to sustain production of high quality water, and possibly other "goods" as well. There is increasing awareness in informed leader circles that conservation, particularly of renewable natural resources, is not only the concern of national communities, but is vital to the welfare of the international community as well (Anon, 1980).

6.9.7 The key lies in the phrase "informed circles". It is considered essential that the government assume (and retain) responsibility for the maintenance of the country's renewable natural resources and their attendant supportive ecosystems. It is considered equally important for government to be guided by experts in the relevant fields when deciding upon measures to be adopted to achieve that goal (Smit, et al, 1984). However, public support, and in particular the support of the community most immediately concerned, is equally important. The public should, therefore, be involved in some more direct way than through the normal political process. This is probably best achieved through informed public interest groups such as Guide Plan Committees, established in terms of the Physical Planning Act (88 of 1967), and Regional Development Advisory Committees. In the specific case of mountain catchments, the public have been involved, to a certain extent, for many years through Fire Protection Area Committees and, since implementation of the Mountain Catchment Areas Act (63 of 1970), through Mountain Catchment Area Advisory Committees. The expertise on these advisory committees is provided by professionally qualified representatives of the Directorates of Forestry and Water Affairs and the Department of Agriculture.

6.9.8 As will become clear, the foregoing discussion is pertinent to the method that will be used to decide upon optimum land use in the study area.

6.10 Sorting of Land Use Possibilities and Capabilities

6.10.1 As in the case of the mapping of ecotopes, because of the volume of repetitive work involved, only a portion of the study area (the Perdevlei property) has been selected for detailed analysis to illustrate the decision process proposed in this work.

6.10.2 Table 38 lists ecotopes (see paragraph 6.7.1) in three capability classes against each potential land use. By referring to this table and using the ecotope map (Map 14) a capability map for each land use may be drawn on transparent material. If these land use capability transparencies are superimposed, areas with potential for one or more uses can be identified. That portion of the area suitable only for water conservation, nature conservation and wilderness-type outdoor recreation need not be considered in any further detail as these uses are fully compatible and completely fulfill the primary management objectives of the catchment area. A decision must be taken about the use of the remaining area and this decision, taken together with the initial decision to manage the area primarily for water conservation, is assumed to result in maximum national community benefit, without unnecessary reduction of local community welfare.

6.10.3 The mountain catchment area land use decision process is complicated by the fact that both quantitative and qualitative criteria are relevant. Both tangible and intangible "goods" are produced under the various land use regimes. Qualities must somehow be weighed up against quantities in order to arrive at a decision that will in fact maximise welfare.

6.10.4 The procedure followed below is based upon a method proposed by Gibson (1975). He describes the development and use of a mathematical model, designed "to provide the land manager with a fairly simple, yet comprehensive and rigorous methodology for evaluating and selecting multiple use alternatives that involve both quantitative and qualititative criteria" (Gibson, loc. cit.). The model is designed to be applied by an interdisciplinary planning team representative of the spectrum of resources of the area under consideration.

6.10.5 It is probably as well to state at the outset that Gibson's method of evaluating qualitative criteria suffers from the same short-coming as all other methods designed to quantify the non-quantifiable. There appears to be no way of avoiding an element of subjectivity. The interdiciplinary team approach is, in part, intended to ameliorate the problem and this appears to be all that can be hoped for at present.

6.10.6 Although an interdisciplinary planning team is no doubt desirable, it is considered sufficient in the case of mountain catchments for a professional forestry planner to work with the catchment area advisory committee and the development advisory committee in order to obtain the necessary balance of resource values, especially for those values that can only be subjectively determined. To initiate the process it is necessary to state objectives in priority order and, while the primary objective is predetermined, the advisory committees can assist in deciding priority order of compatible subordinate uses.

6.10.7 For the purpose of this exercise, objectives are stated in priority order for privately owned mountain catchment land as follows:

Priority	Land use objective
1	Water conservation: the maintenance of optimum permanent flow of potable water from the total proclaimed catchment area.
2	Maximum return: the generation of maximum return for the owner (or lessee) within the constraints imposed by the first objective; these constraints are:

(i) streamflow should not be significantly reduced (e.g. summer base flow not to be reduced by more than 5 per cent).

(ii) stream water quality should not be measurably reduced as regards turbidity (suspended solids), chemical composition (total dissolved solids, residues of herbicides, fungicides, insecticides or other poisons), B.O.D., bacterial count, or other criteria of purity.

3 Nature conservation: the maintenance of maximum natural species diversity, within the constraints imposed by objectives 1 and 2.

4 Outdoor recreation: the provision of maximum opportunity for nature oriented public outdoor recreation within the constraints imposed by the first three objectives and objective one in particular.

6.10.8 Gibson's method requires that management planning units be selected and for this exercise the synthesized ecotopes as described above will be used. While Gibson's planning units are more or less unique areas, ecotopes are terrain type units that recur over the whole planning area. What will emerge from the first assessment, therefore, is an indication of the preferred land use of each ecotope. A second assessment may be required before a final decision can be taken, depending upon the distribution pattern and relative extent of the ecotopes represented in the catchment, or portion of catchment, under consideration. This will become apparent during the course of working through the example, for which a portion of the total catchment management area is examined as explained in paragraph 6.10.1.

6.10.9 The model, as Gibson terms his procedure, has two phases. The first, or so called "evaluation phase", uses psychometric methods to quantify subjective considerations. These are then merged with quantifiable criteria in a "systematic and consistent manner" to derive a preference index for each management unit for each alternative use. The second phase makes use of a computer programme to integrate these indexes with specific objectives and constraints to select a planning alternative for each unit. However, the computer programme is not yet available in South Africa and therefore only the first phase will be worked through to obtain land use preference indexes for each ecotope. Thereafter the Perdevlei property will be assessed manually, using these indexes and the accepted objectives in the light of constraints specific to Perdevlei, such as actual area and distribution pattern of the ecotopes represented, accessibility, water availability, distance from market and profitability.

6.10.10 Evaluation of the planning units (ecotopes in this case) involves quantifying all criteria and deriving relative rankings of the units with respect to each alternative land use. This is achieved by, firstly, classifying the criteria into three major groups or "factor categories", secondly, defining a general scoring model in terms of these classifications, thirdly, quantifying the terms of the scoring model and finally, formulating the scoring model.

6.10.11 The three factor categories are: (i) critical factors, (ii) objective factors, and (iii) subjective factors.

6.10.11.1 A critical factor is one that, by its nature would preclude the selection of an alternative no matter how attractive that alternative might be relative to other criteria. The fact that the area is proclaimed mountain catchment would constitute a critical factor, for example.

6.10.11.2 Objective factors are those that can be quantified, usually in monetary terms.

6.10.11.3 Subjective factors are qualitative in nature. Social or ethical considerations would generally be classified as subjective factors because of the difficulty of quantifying these criteria in monetary or any other practical terms.

6.10.12 The development of the model to the stage of defining multi-use vectors for each management unit is described in Appendix 9. In this study example the matrix so generated is used as a basis for the final optimum land use decision.

6.11 Application of Gibson's Method to a portion of the Study Area

6.11.1 Sixteen ecotopes (see paragraph 6.7.1) and eight possible land uses have been identified for the study area. One of the uses, nature oriented outdoor recreation, has been subdivided into (i) wilderness-type recreation, (ii) recreation based upon the construction of pedestrian or equestrian trails, or both, simple picnic sites, primitive camping sites, and similar unsophisticated facilities and (iii) recreation based upon roads constructed for vehicular access, scenic drives and more sophisticated picnic and camp sites.

6.11.1.1 Table 38 presents an ecotope/use-capability matrix that shows that ecotopes (i), (ii), (iiia) and (iv), are only suitable for water conservation, nature conservation and wilderness-type recreation. These three ecotopes will, therefore, be combined and will, in fact, require no further assessment as the possible uses are mutually compatible and obviously fulfill the requirements of the principal management objective for the whole area.

6.11.1.2 Ecotopes (v.bd) and (vi.bd) have the same use potential as the three listed above except for being marginally useful for wildflower harvesting as well under certain circumstances.

Ecotopes (iiib) and (iiic) are shown as marginal for stock pasture. However, because of the very high percentage (60%) of

TABLE 38

Broad classification of ecotope use capabilities

0 = unusable; 1 = marginally usable; 2 = usable

	Ecotope															
	i	ii	iii			iv	v					vi				
			a	b	c		a	b				a	b			
Land use								a	b	c	d		a	b	c	d
1. Water conservation	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2. Nature conservation	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3. Outdoor recreation																
3.1 Wilderness type	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3.2 Foot trail access	0	0	0	1	1	0	2	2	2	2	0	2	2	2	2	0
3.3 Vehicle access	0	0	0	0	0	0	2	1	1	0	0	2	1	1	0	0
4. Timber plantation	0	0	0	0	0	0	2	1	2	0	0	1	0	0	0	0
5. Agriculture	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0
6. Stock pasture	0	0	0	1	1	0	2	2	2	1	0	2	2	2	1	0
7. Wild flower harvesting	0	0	0	1	1	0	2	2	2	2	1	2	2	2	2	1
8. Holiday homes	0	0	0	0	1	0	2	2	1	1	0	2	2	1	1	0

these ecotopes covered by rock, maximum carrying capacity is reduced to approximately 20 hectares per small stock unit, which is clearly uneconomic (refer to paragraph 6.8.7.6). For practical purposes these ecotopes can, therefore, be ignored as far as this use is concerned, except to note that it is unnecessary to deliberately exclude stock from them - other than for one growing season after a fire as is the case for all ecotopes. Ecotopes (v.bc) and (vi.bc) are also marginal for stock pasture because of both rockiness and steepness. Average maximum stocking rate in these areas is approximately 15 hectares per small stock unit, which is also uneconomic.

6.11.1.3 The majority of ecotopes are capable of supporting a number of alternative uses, either individually or in combinations. For the purpose of further assessment, water conservation, nature conservation and wilderness-type recreation will be taken together as one land-use alternative under the title "No development". This will reduce the number of use alternatives (Gibson's "planning alternatives j") to eight, and, because the use capability of ecotopes (i), (ii), (iii a) and (iv) is limited to the "no development" group, the number of ecotopes (equivalent to Gibson's "management units i" for the purpose of this exercise) that must be assessed can be reduced from 16 to 13.

6.11.2 For each of the use alternatives, factors that must be considered are listed in three categories, as described earlier;

these are, critical factors, objective factors and subjective factors.

6.11.2.1 The following factors will be considered:

Critical factors	Objective factors	Subjective factors
1. Effect on soil stability	1. Potential nett value per hectare (R) per annum	1. Effect on water quality
2. Site suitability	2. Effect on water yield - expressed as value of yield per hectare per annum (R)	2. Aesthetic impact and public attitude
3. Compatibility with principal management objective		3. Attitude of land owner
		4. Product scarcity value

5. Effect
on nature
conservation

The Mountain Catchment Area Advisory Committee, guided by experts from the Government departments represented on the Committee, and led by the forestry planner, can be of invaluable assistance in compiling the list of factors, and selecting those relevant to each case. The local development advisory committee as well as the catchment Committee should be involved in the paired comparisons exercise to determine the weights to be assigned to subjective factors in particular. If domineering personalities pose a problem the Delphi technique should be considered (Linstone and Turoff, 1975).

6.11.2.2 Evaluation of critical factor measures for the first use alternative, namely "no development", as defined earlier is unnecessary because there is no factor that would disqualify any ecotope in respect of this alternative. All critical factor indexes for all ecotopes will be "one" in respect of this group of uses. We can, therefore, proceed to evaluate the objective factor measures.

6.11.2.3 Objective factor measure evaluation is presented in Table 39

TABLE 39

Evaluation of objective factor measures (OFM) for use alternative; "No development"

(OFMij = {OFPij . (i OFPij)-1}

Ecotope	Objective Factor: Potential nett value per ha. per annum (R)	Objective Factor: Value of water yield per ha. per annum (R)	OFP	OFM
All(16)	10,8	3 000	3 010,8	0,0625

Because all ecotopes are considered equal in respect of this group of uses the objective factor measures for all ecotopes in respect of this alternative will be the same.

6.11.2.4 Subjective factor measures for the first use alternative are now determined. Table 40 ilustrates the determination of weights that will indicate the relative importance of each of the subjective factors, by the method of paired comparisons.

The next step is determination of the unit weights, which indicate the relative preference of the ecotopes with respect to the use alternative. Table 41 illustrates the determination of unit (or ecotope) weights for the subjective factor "attitude of land owner", by the method of paired comparisons.

Unit weights for the remaining subjective factors, "effect on water quality", "aesthetic impact" and "public attitude", "product scarcity value" and "effect on nature conservation" will be the same for all ecotopes in respect of the "no development" group of uses. Column totals and unit weights for these factors appear at the foot of Table 41.

The subjective factor measure for each management unit (ecotope) is now calculated using the equation:

TABLE 40

Determination of subjective factor weights (SFW)

	Subjective Factor				
	Effect on water quality	Aesthetic impact and public attitude	Attitude of land owner	Product scarcity conside-ration	Effect on nature conser-vation
1	1	0			
2	1		0		
3	1			0	
4	1				0
5		0	1		
6		1		1	
7		1			1
8			1	1	
9			1		1
10				1	1
Col tot	4	2	3	3	3
Grand total		15			
SFW	0,2667	0,1333	0,2	0,2	0,2

Determination of Unit Weights (U.W.) for Subjective Factor "attitude of land owner", land use alternative "no development" (Note: The table has been abridged to fit the page and is presented only to illustrate the procedure)

Comparison Decision	Ecotopes (Management units) i	ii	iii a	iii b	iii c	iv	v a	v b a	v b b	v b c	v b d	vi a	vi b a	vi b b	vi b c	vi b d	
1	1	1															
2	1		1														
3	1			0													
4	1				0												
5	1					1											
6	1						0										
7	1							0									
8	1								0								
9	1									0							
10	1										1						
11	1											0					
12	1												0				
13	1													0			
14	1														0		
15	1															1	
16		1	1														
17		1		0													
18		1			0												
19		1				1											
20		1															
110											1					1	
111												0	1				
112												0		1			
113												0			1		
114												0				1	
115													1	1			
116													0		1		
117													0			1	
118														0	1		
119														0		1	
120															0	1	
Column Tot.	15	15	15	10	11	15	1	5	5	7	15	1	5	5	7	15	147 = Grand tot
U.W.	0,1020	0,1020	0,1020	0,680	0,0748	0,1020	0,0068	0,0340	0,0340	0,0476	0,1020	0,0068	0,0340	0,0340	0,0476	0,1020	

TABLE 41a

Unit weights (U.W.) for all other Subjective Factors

Column Tot.	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	240 = Grand total
U.W.	0,625	0,625	0,625	0,625	0,625	0,625	0,625	0,625	0,625	0,625	0,625	0,625	0,625	0,625	0,625	0,625	

SFMij = k (SFWjk . UWijk) (See Appendix 9)
Table 42 presents these values.

6.11.2.5 To derive the preference index of each management unit (ecotope), Xj, the objective factor decision weight, must be determined. For the purpose of this example objective factors and subjective factors will be given the same weight and Xj will therefore be set at 1. Equation 1 (See Appendix 9) is employed to calculate the preference indexes. These are listed in Table 43 for the use group "No development". (Equation 1: PIij = CFMij [Xj . OFMij + (1-Xj).SFMij]).

6.11.2.6 Similar analyses are carried out for each use alternative and a table comprising multiple use vectors for each ecotope is compiled, using the preference indexes for each use alternative in a fixed sequence for each ecotope. The multiple use vectors are presented in Table 44.

[Note: To illustrate the evaluation of critical factor measures, which was unnecessary in the case of the "no development" use alternative, Table 45 presents the critical factor evaluation in respect of the "Hiking trail type recreation" use alternative. Similarly, Table 46 presents a more typical example of the evaluation of objective measures than Table 39 which lacks variability].

TABLE 42

Evaluation of Subjective Factor Measures for use alternative "no development"

Subjective Factor	Unit Weights																Subjective Factor Weight
	i	ii		iii		iv			v					vi			
			a	b	c		a			b			a		b		
								a	b	c	d		a	b	c	d	
Effect on water quality	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,2667
Aesthetic impact and public attitude	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,1333
Attitude of land owner	0,1020	0,1020	0,1020	0,0680	0,0748	0,1020	0,0068	0,0340	0,0340	0,0476	0,1020	0,0068	0,0340	0,0340	0,0476	0,1020	0,2000
Product scarcity consideration	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,2000
Effect on nature conservation	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,0625	0,2000
Subjective Factor Measure	0,0704	0,0704	0,0704	0,0636	0,0650	0,0704	0,0514	0,0568	0,0568	0,0595	0,0704	0,0514	0,0568	0,0568	0,0595	0,0704	

TABLE 43

Preference indexes for use alternative "No development"

(Xj = 1)

Ecotope	Objective Factor Measure	Subjective Factor Measure	Preference Index
i	0,0625	0,0704	0,0044
ii	0,0625	0,0704	0,0044
iii a	0,0625	0,0704	0,0044
b	0,0625	0,0636	0,0040
c	0,0625	0,0650	0,0041
iv	0,0625	0,0704	0,0044
v a	0,0625	0,0514	0,0032
b.a	0,0625	0,0568	0,0036
b	0,0625	0,0568	0,0036
c	0,0625	0,0595	0,0037
d	0,0625	0,0704	0,0044
vi a	0,0625	0,0514	0,0032
b.a	0,0625	0,0568	0,0036
b	0,0625	0,0568	0,0036
c	0,0625	0,0595	0,0037
d	0,0625	0,0704	0,0044

TABLE 44

Ecotope	Multiple Use Vector: No development	Hiking trail type recreation	Vehicle access recreation	Timber production	Agriculture	Stock pasture	Wild flowers	Holiday homes
i	(,0044	,0000	,0000	,0000	,0000	,0000	,0000	,0000)
ii	(,0044	,0000	,0000	,0000	,0000	,0000	,0000	,0000)
iii a	(,0044	,0000	,0000	,0000	,0000	,0000	,0000	,0000)
b	(,0040	,0065	,0000	,0000	,0000	,0068	,0029	,0000)
c	(,0041	,0100	,0000	,0000	,0000	,0082	,0044	,0144)
iv	(,0044	,0000	,0000	,0000	,0000	,0000	,0000	,0000)
v a	(,0032	,0084	,0178	,0767	,3101	,0135	,0109	,0055)
v ba	(,0036	,0121	,0152	,0498	,0000	,0079	,0103	,0122)
v bb	(,0036	,0047	,0140	,0529	,0000	,0100	,0068	,0055)
v bc	(,0037	,0074	,0000	,0000	,0000	,0084	,0046	,0152)
v bd	(,0044	,0000	,0000	,0000	,0000	,0000	,0005	,0000)
vi a	(,0032	,0087	,0254	,0706	,1900	,0131	,0128	,0177)
vi ba	(,0036	,0121	,0292	,0000	,0000	,0082	,0110	,0144)
vi bb	(,0036	,0076	,0198	,0000	,0000	,0107	,0125	,0122)
vi bc	(,0037	,0081	,0000	,0000	,0000	,0068	,0083	,0144)
vi bd	(,0044	,0000	,0000	,0000	,0000	,0000	,0023	,0000)

TABLE 45

Evaluation of Critical Factor Measures "Hiking trail type recreation"

Critical Factors

Effection soil stability

Site suitability

Compatibility with principle objective

Ecotope	Effect on soil stability	Site suitability	Compatibility with principle objectives	Critical Factor Measure	
i	0	0	1	0	(exclude)
ii	1	0	1	0	(exclude)
iiia	1	0	1	0	(exclude)
b	1	1	1	1	
c	1	1	1	1	
iv	0	0	0	0	(exclude)
va	1	1	1	1	
ba	1	1	1	1	
b	1	1	1	1	
c	1	1	1	1	
d	0	0	0	0	(exclude)
via	1	1	1	1	
viba	1	1	1	1	
b	1	1	1	1	
c	1	1	1	1	
d	0	0	0	0	(exclude)

Ecotopes i, ii, iiia, iv, vbd, and vibd are therefore disqualified from further consideration in respect of the use alternative "Hiking trail type recreation".

TABLE 46

Evaluation of Objective Factor Measures (OFM) : Use alternative "Hiking trail type recreation"

Estimate of carrying capacity (c.c.) visitordays per ha.	Ecotope	Potential nett visitor use value R. per ha. per yr. (1)	OFP	OFM (2)
0	i	0	0	0
0	ii	0	0	0
0	iii a	0	0	0
0,25	b	135	135	,0182
0,5	c	270	270	,0364
0	iv	0	0	0
2,0	v a	1 080	1 080	,1455
2,0	v ba	1 080	1 080	,1455
1,5	b	810	810	,1091
1,0	c	540	540	,0727
0	d	0	0	0
2,0	vi a	1 080	1 080	,1455
2,0	vi ba	1 080	1 080	,1455
1,5	b	810	810	,1091
1,0	c	540	540	,0727
0	d	0	0	0

(1) (Visitor use value = (R9 x 60 x cc) = OFP in this case)

(2) $(OFM_{ij} = OFP_{ij} \cdot ({}_{i}OFP_{ij})^{-1})$

6.11.3 The next step is to assess the Mountain Catchment Area on the basis of the use preferences indicated in Table 44, in conjunction with additional facts pertinent to specific areas and in the light of specific goals and constraints. As mentioned earlier, because of the amount of repetitive work involved, only that portion of the catchment area known as Perdevlei is assessed in detail in order to illustrate the procedure.

6.11.3.1 For the purpose of this exercise the area under consideration will be treated as private property, proclaimed Mountain Catchment Area in terms of Act 63 of 1970.

6.11.3.2 The ecotopes represented on the property Perdevlei were identified and mapped in the manner described earlier, and the area of each ecotope determined.

6.11.3.3 The use preferences for each ecotope indicated in Table 44 are used as a starting point. Indicated uses are then either confirmed or amended in the light of specific goals and constraints pertinent to the individual property, its owner and to its condition as proclaimed Mountain Catchment Area.

The owner´s goal is to derive maximum return on his investment with a minimum requirement of, say, R12 000 annual managerial reward.

The Government's goal are:

(1) to ensure that streamflow, and more specifically summer baseflow, is not reduced by more than, say, three percent (the figure should be set for each catchment depending upon importance of the water resource);

(2) to ensure that there is no measurable deterioration in stream water quality, in respect of turbidity (total suspended material), total dissolved solids, biological oxygen demand, bacterial count, traces of insecticides or other poisons, or other criteria of purity (using standard water quality monitoring techniques);

(3) to ensure that there is no significant accelerated soil erosion;

and, wherever compatible with the land owner's goals;

(4) to maintain the veld in as natural a condition as possible, and ensure that there is no unnatural loss of naturally occurring species in normally functioning ecosystems;

(5) to provide maximum opportunity for low intensity nature oriented, public outdoor recreation.

In order to be reasonably sure of achieving these Government (or community) goals, it is necessary to place certain restrictions on the land owner´s use of the area. These restrictions include:

(1) domestic stock levels must be limited to the recommended area per stock unit;

(2) stock management practices that give rise to stock trail and other soil erosion must be avoided;

(3) stock must be kept out of burnt veld for at least one full growing season after each burn;

(4) all roads and paths in the cathment area must be constructed to laid down standards, in which drainage is particularly emphasized;

(5) only permanent crops, such as fruit trees, may be cultivated, and no soil may be disturbed within 20 metres of a stream, whether the stream is permanent or not;

(6) no water may be permitted to drain directly into a stream or natural seepage area from a road or path or cultivated area or farmyard or stock pen or kraal, or other potential source of pollution. Storm water must be discharged onto a non-erodable surface at least 20 metres from a stream. Normal health regula-

tions are applicable to domestic sewage disposal.

6.11.3.4 Possible site-imposed constraints would include extent of useable area, accessibility, availability of water, distance form market, and so on. Accessibility, availability of water, and distance from market can be ascertained from transparency Map 15.

6.11.3.5 In the light of estimated potential value (Table 47) it is clear that the owner would base his activity upon maximum use of ecotope Va, which comprises a total area of 93 hectares on this property. However, there are 2,2 kilometres of stream and approximately 2,5 kilometres of seepage area perimeter within and adjoining the area of ecotope Va. The total area of ecotope Va must therefore be reduced by the area of a 20 metre strip 6,9 kilometres in length (2,2 + 2,2 + 2,5), which is 13,8 hectares (say 14 ha). Furthermore, two bridges will have to be built in order to gain access to a large part of the area. The estimated cost of the two bridges together is R12 000. At 7 per cent per annum this amounts to an annual cost of R840.

Reference to Map 15 and the table of road construction and maintenance costs (Table 37) will show that Perdevlei should be responsible for road costs of R5385 per annum; adding the annual cost of the two bridges mentioned above and a sum of R120 equivalent to 0,5 kilometre of internal road (as calculated earlier), brings the amount to R6 345. The R5 385 is made up as follows:

(1) the length of road constructed exclusively to provide access to the activity centre on Perdevlei is 6 kilometres, made up as follows:

4,5 km normal construction @ R2 000 per km	= R 9 000
plus 1,5 km of pass @ R10 000 per km	= R15 000
plus one major bridge @ R10 000	= R10 000
Sub total	= R34 000
converted to an annuity @ 7%	= R 2 380
plus annual maintenance cost at R100 per km	= R 600
Sub total	= R 2 980...(1)

(2) the length of road serving both Perdevlei and the adjoining property, Groot Kliphuis, but no other property, is 8 kilometres, made up as follows:

2,0 km normal construction @ R2 000 per km	= R 4 000
plus 2,5 km of causeway over both sand and bog @ R8 000 per km	= R20 000
plus 3,5 km of construction through class iii rocky terrain @ R4 000 per km	= R14 000
plus one major bridge @ R10 000	= R10 000
plus two minor bridges @ R2 000	= R 4 000

Sub total	= R52 000
converted to an annuity at 7%	= R 3 640
plus annual maintenance	= R 800
Sub total	= R 4 440
x 0,5(i)	= R 2 220...(2)

[(i)Note: Traffic load is assumed to be equal for the two properties. Road costs are therefore evenly divided].

(3) the remaining length of road to the study area datum point (28 kilometres from rail head at Porterville) serves a number of properties including Perdevlei and Groot Kliphuis. Perdevlei's share is estimated at 0,125 of the total for this 6 kilometre section, made up as follows:

5,7 km of normal construction @ R2 00 per km	= R11 400
plus 0,3 km of causeway over sand at R4 000 per km	= R 1 200
No bridges are involved	
Sub total	= R12 600
converted to an annuity at 7%	= R 882
plus annual maintenance	= R 600
Sub total	= R 1 482
x 0,125	= R 185...(3)

Sub totals (1) + (2) + (3) = R5 385

[Note: The calculation above is generalised in the following equation:

RCP1 = <[{(L1R1.cc1 + L2R1.cc2 + ...+Ln1R1.ccn1+R1Bc1+
R1Bc2+...+R1Bcn2).+(n1LR1.M)].TP1/TTR1>
+<[{(L1R2.cc1 + L2R2.cc2 + ... + Ln3R2.ccn3 + R2Bc1 +
R2Bc2 + ... + R2Bcn4).r}+(n3LR2.M)].TP1/TTR2> +
....+ <[{(L1Rn5cc1 + L2Rn5cc2 + ... + Ln6Rn5ccn6 +
Rn5Bc1 + Rn5Bc2 + ... + Rn5Bcn7).r}+(n6LRn5.M)].
TP1/TTRn5>

where:

RCP1 is the total annual access road cost to be borne by property P1;

L1R1cc1 is the cost of the total length (L1R1 kilometres) of that portion of road section one with construction cost cc1 rands per kilometre;

L2R1cc2 is the cost of the total length (L2R1 kms) of that portion of road section one with construction cost cc2 rands per kilometre;

Ln1R1ccn1 is the cost of the total length (Ln1R1 kms) of that portion of road section one with construction cost ccn1 rands per kilometre;

R1Bc1 is the cost of bridge one on road section one;

R1Bc2 is the cost of the second bridge on road section one;

R1B cn2 is the cost of the n2th bridge on road section one;

r is the annuity rate expressed as a decimal (e.g. 7% = .07);

M is the annual cost of road maintenance in rands per kilometre;

n1LR1.M is the annual cost of maintenance of the total length of road section one;

TP1/TTR1 is the ratio of the volume of traffic generated by the property (TP1) at the end of road section one to total traffic volume on road section one;

L1Rn5cc1 is the cost of the total length (L1Rn5 kms) of that portion of road section n5 with construction cost cc1 rands per kilometre;

Rn5Bcn7 is the cost of the n7 th bridge on road section n5;

n6LRn5.M is the annual cost of maintenance of the total length of road section n5

TPl/TTRn5 is the ratio of the volume of traffic generated by the property at the end of road section one to the total traffic volume on road section n5].

To determine the estimated net income from the useable area of ecotope Va, i.e. approximately 79 hectares, at the study area datum point, consult Figure 6. A productive unit of this size should yield an annual net income of approximately R1 540 per hectare, or a total of approximately R121 660. This total must be reduced by the additional cost of transporting both production needs and produce over the distance between point of production and the datum point, i.e. 20 kilometres, as well as by the property's share of annual road costs as calculated above. The net income figure for ecotope Va is based upon an average yield of approximately 40 tonnes of fruit per hectare, and transport costs are estimated to be approximately 10 cents per tonne per kilometre for this area (1979/80). Additional produce transport cost will, therefore, total R6 320. Assuming that transport of production needs other than those brought in on return trips (e.g. weekly transport of seasonal labour), ammounts to the same sum, then R12 640 plus road costs of R6345, that is R18 985, must be deducted from the calculated net income of R121 660, leaving a balance of <u>R102 675</u>.

Irrigation of 79 hectares will reduce dry season streamflow by 395 000m3. As the annual normal flow (basé flow) of the Vier-en-twintig-Riviere ammounts to about 43 million cubic metres (W.P.K.-68), summer flow is estimated to be about 21,5 million cubic metres. The reduction in summer flow caused by irrigating 79 hectares will therefore be less than two percent. This satisfies the first of the given Government goals.

6.11.3.6 Vehicle access based recreation combined with wild flower harvesting is the next most profitable land use as far as the owner is concerned. Ecotopes vi ba and vi bb have been identified as preference areas for this use combination. However, only about 56 ha of ecotope vi bb and 6 ha of vi ba are accessible by vehicle i.e. 62 ha can be allocated to this use combination to give a potential net income of R(6 x 26) + (56 x 21), i.e. <u>R1 332</u>.

Alternative uses for the remaining portions of these ecotopes include, holiday homes, stock pasture and hiking trail type recreation. Holiday homes are excluded because of inaccessibility to vehicles, and the ecotope map reveals that the length of fence that would be required to exclude domestic stock from sensitive areas, including stream banks, would make stock farming uneconomic.

Maximum accessible area, including all ecotopes, suitable for stock (apart from the areas already allocated) is 784 ha, from which a maximum net income of R1 307 may be expected. If no internal fences are erected, 33 kilometres of fencing will be required to exclude stock from sensitive areas and confine them to the property. At an estimated cost of R50 per kilometre per annum, the annual cost of fencing is R1 650, which exceeds the anticipated return from stock.

The only remaining alternatives are hiking trail type recreation with harvesting of wild flowers and wilerness type recreation. The balance of ecotope vi ba (74 ha) is all inaccessible to hiking trails, being cut off by sensitive terrain, and can therefore only be allocated to wilderness type recreation, worth approximately R9 per annum to the land owner (12c/ha, see Table 47). The remaining portion of ecotope vi bb is accessible and can be allocated to hiking trail type recreation with harvesting of wildflowers. Potential nett income from this area, which is 84 hectares, amounts to R1 764.

6.11.3.7 Ecotope iiib use preference is stock grazing with hiking trail type recreation. The accessible portion of the area was included in the calculations of total area available for stock against fencing requirements. The result is the same if the 10 accessible hectares of ecotope iii b are assessed alone. This area should therefore be allocated to the next best alternative use which is hiking trail type recreation with harvesting of wildflowers; giving a potential net income of R40 per annum (R4/ha, see Table 47). The remaining 51 hectares of ecotope iii b are inaccessible to hiking trails and should, therefore, not be used for regular wild flower harvesting either. Wilderness type recreation is the only remaining alternative and could yield a net income of approximately R6 per annum to the land owner.

6.11.3.8 Use preference for ecotope v bc is indicated as holiday homes with stock pasture. However, 174 hectares of this ecotope is inaccessible to vehicles and cost of essential fencing makes use as stock pasture uneconomic. The next best alternative use is holiday homes with wild flower harvesting and 72 hectares can be allocated to this combination to bring in a potential annual net income of R1152. Alternative uses for the balance of the area of ecotope v bc are, hiking trail type recreation with wildflower harvesting or wilderness type recreation. One hundred and nineteen hectares are inaccessible for hiking trails and must therefore be allocated to the latter use alternative for an annual net income of R14. The remaining 55 hectares can be used for hiking trail type recreation and wildflower harvesting to give a potential annual net income of R770.

6.11.3.9 Although the use preference of ecotope v bb is timber production, the combination of holidlay homes with wild flower harvesting will yield a higher net income for the owner even

TABLE 47

Potential annual ecotope values (rand per hectare) for the range of possible and mutually compatible land use alternatives, to the land owner and to the regional community under the given use regime

Ecotope	Possible use (Note: figures in brackets are owner values per hectare of that activity)	Potential value (R per ha) Owner	Community Water	Community Recreation
i	No development = wilderness type recreation (0,12)	0,12	3 000	10,8
ii	No development = wilderness type recreation (0,12)	0,12	3 000	10,8
iii a	No development = wilderness type recreation (0,12)	0,12	3 000	10,8
iii b	Hiking trail recreation (3,0) with wild flower harvesting (1,0) OR	4,0	3 000	135
	Stock pasture (1,0) with Hiking trail recreation (3,0) OR	4,0	3 000	135
	Wilderness type recreation (0,12)	0,12	3 000	10,8
iii c	Holiday homes (14,0) with harvesting of wild flowers (1,0) OR	15,0	3 000	0,0
	Holiday homes (14,0) with stock pasture (1,0) OR	15,0	3 000	0,0
	Hiking trails (6,0) with wild flower harvesting (1,0) OR	7,0	3 000	135
	Hiking trails (6,0) with stock pasture (1,0) OR	7,0	3 000	135
	Wilderness type recreation (0,12)	0,12	3 000	10,8
iv	Wilderness type recreation (0,12); but only if part of a large area, comprising other ecotopes as well, all of which is allocated to this use.	0,12	3 000	10,8
v a	Agriculture (maximum 2 320,0) OR	2 320,0	1 125	0,0
	Timber (12,0) OR	12,0	1 875	0,0
	Holiday homes (14,0) with stock pasture (2,5) OR	16,5	3 000	0,0
	Holiday homes (14,0) with wild flower harvesting (3,0) OR	17,0	3 000	0,0
	Hiking trails (24,0) with stock pasture (2,5) OR	26,5	3 000	1 080
	Hikingtrails (24,0) with wild flower harvesting (3,0) OR	27,0	3 000	1 080
	Vehicle access (24,0) with stock pasture (2,5) OR	26,5	3 000	1 080
	Vehicle access (24,0) with wild flower harvesting (3,0) OR	27,0	3 000	1 080
	Wilderness type recreation (0,12)	0,12	3 000	10,8
v ba	Timber (6,0) OR	6,0	1 875	0,0
	Holiday homes (14,0) with wild flower harvesting (2,0) OR	16,0	3 000	0,0
	Holiday homes (14,0) with stock pasture (1,0) OR	15,0	3 000	0,0
	Hiking trails (24,0) with wild flower harvesting (2,0) OR	26,0	3 000	1 080
	Hiking trails (24,0) with stock pasture (1,0) OR	25,0	3 000	1 080
	Vehicle access (24,0) with wild flower harvesting (2,0) OR	26,0	3 000	1 080
	Vehicle access (24,0) with stock pasture (1,0) OR	25,0	3 000	1 080
	Wilderness type recreation (0,12)	0,12	3 000	10,8

v bb	Timber (12,0) OR	12,0	1 875	0,0
	Holiday homes (14,0) with wild flower harvesting (3,0) OR	17,0	3 000	0,0
	Holiday homes (14,0) with stock pasture (2,5) OR	16,5	3 000	0,0
	Hiking trails (18,0) with wild flower harvesting (3,0) OR	21,0	3 000	810
	Hiking trails (18,0) with stock pasture (2,5) OR	20,5	3 000	810
	Vehicle access (18,0) with wild flower harvesting (3,0) OR	21,0	3 000	810
	Vehicle access (18,0) with stock pasture (2,5) OR	20,5	3 000	810
	Wilderness type recreation (0,12)	0,12	3 000	10,8
v bc	Timber (12,0) OR	12,0	1 875	0,0
	Holiday homes (14,0) with wild flower harvesting (3,0) OR	17,0	3 000	0,0
	Holiday homes (14,0) with stock pasture (2,5) OR	16,5	3 000	0,0
	Hiking trails (18,0) with wild flower harvesting (3,0) OR	21,0	3 000	810
	Hiking trails (18,0) with stock pasture (2,5) OR	20,5	3 000	810
	Vehicle access (18,0) with wild flower harvesting (3,0) OR	21,0	3 000	810
	Vehicle access (18,0) with stock pasture (2,5) OR	20,5	3 000	810
	Wilderness type recreation (0,12)	0,12	3 000	10,8
v bc	Holiday homes (14,0) with wild flower harvesting (2,0) OR	16,0	3 000	0,0
	Holiday homes (14,0) with stock pasture (1,66) OR	15,66	3 000	0,0
	Hiking trails (12,0) with wild flower harvesting (2,0) OR	14,0	3 000	540
	Hiking trails (12,0) with stock pasture (1,66) OR	13,66	3 000	540
	Wilderness type recreation (0,12)	0,12	3 000	10,8
v bd	Wild flower harvesting ( ) OR			
	Wilderness type recreation (0,12)	0,12	3 000	10,8
vi a	Agriculture (maximum 1 425,0) OR	1 425,0	1 125	0,0
	Timber (8,0) OR	8,0	1 875	0,0
	Holiday homes (14,0) with stock pasture (1,66) OR	15,66	3 000	0,0
	Holiday homes (14,0) with wild flower harvesting (3,0) OR	17,0	3 000	0,0
	Hiking trails (24,0) with stock pasture (1,66) OR	25,66	3 000	1 080
	Hiking trails (24,0) with wild flower harvesting (3,0) OR	27,0	3 000	1 080
	Vehicle access (24,0) with stock pasture (1,66) OR	25,66	3 000	1 080
	Vehicle access (24,0) with wild flower harvesting (3,0) OR	27,0	3 000	1 080
	Wilderness type recreation (0,12)	0,12	3 000	10,8
vi ba	Holiday homes (14,0) with wild flower harvesting (2,0) OR	16,0	3 000	0,0
	Holiday homes (14,0) with stock pasture (1,0) OR	15,0	3 000	0,0
	Vehicle access (24,0) with wild flower harvesting (2,0) OR	26,0	3 000	1 080
	Vehicle access (24,0) with stock pasture (1,0) OR	25,0	3 000	1 080
	Hiking trails (24,0) with wild flower harvesting (2,0) OR	26,0	3 000	1 080
	Hiking trails (24,0) with stock pasture (1,0) OR	25,0	3 000	1 080
	Wilderness type recreation (0,12)	0,12	3 000	10,8
vi bb	Holiday homes (14,0) with wild flower harvesting (3,0) OR	17,0	3 000	0,0
	Holiday homes (14,0) with stock pasture (1,66) OR	15,66	3 000	0,0
	Vehicle access (18,0) with wild flower harvesting (3,0) OR	21,0	3 000	810
	Vehicle access (18,0) with stock pasture (1,66) OR	19,66	3 000	810
	Hiking trails (18,0) with wild flowers (3,0) OR	21,0	3 000	810
	Hiking trails (18,0) with stock pasture (1,66) OR	19,66	3 000	810
	Wilderness type recreation (0,12)	0,12	3 000	10,8

vi bc	Holiday homes (14,0) with wild flower harvesting (2,0) OR	16,0	3 000	0,0
	Holiday homes (14,0) with stock pasture (1,0) OR	15,0	3 000	0,0
	Hiking trails (12,0) with wild flowers (2,0) OR	14,0	3 000	540
	Hiking trails (12,0) with stock pasture (1,0) OR	13,0	3 000	540
	Wilderness type recreation (0,12)	0,12	3 000	10,8
vi bd	Wild flower harvesting (1,0) OR	1,0	3 000	0,0
	Wilderness type recreation (0,12)	0,12	3 000	10,8

if the property were situated not further from market than the study area datum point. This property is, however, more than 20 kilometres further from market than the datum point, adding approximately two rand per cubic metre to the costs of transporting the produce (wet logs) to market (the sawmill). As the estimated profit is only one rand per cubic metre at the datum point, timber production would clearly be uneconomic on this property. Other arguments against timber production on this particular property are:

1. The ecotope is in the form of a long narrow strip straddling the upper reaches of a tributary of the Klein Kliphuis River (see Map 14). The available area will, therefore, be reduced by the amount of riparian zone required to be left unplanted. This is approximately 10 hectares.

2. The ratio of fire break area to total area is excessive, being approximately 20 hectares to 16 hectares, or 1,25 to 1, which is obviously unacceptable.

3. Streamflow will be reduced by approximately 64 000 cubic metres distributed more or less evenly over the year. Summer flow will, therefore, be reduced by approximately 32 000 cubic metres which is approximately 0,07 per cent of total summer flow. Reduction in streamflow is, therefore, not a significant factor in this case.

6.11.3.10 In view of these arguments timber production will be eliminated as a use alternative for ecotope v bb, and the area will be assessed for the use alternative holiday homes with wildflower harvesting. The use preference of ecotope vi bc is also holiday homes with wildflower harvesting and ecotopes v bb and vi bc will, therefore, be considered together. From Map 14 it may be seen that the total combined area of these ecotopes is inaccessible to vehicles. Holiday home use is therefore ruled out. The remaining 340 hectares may be allocated to this use alternative and can be expected to yield a net income of R5 440 per annum.

The next best alternative use for these ecotopes is a combination of hiking trail type recreation and wildflower harvesting. However, 185 hectares are inaccessible as far as hiking trails are concerned and should, therefore, also be excluded from regular use for flower harvesting. This area will be allocated to wilderness type recreation and will have a potential net income yield to the land owner of approximately R22 per annum. The remaining 172 hectares of ecotope vi bc and 36 hectares of v bb can be used for hiking trail type recreation combined with wild flower harvesting, and have a combined annual net income yield potential of R2 912.

6.11.3.11 The remaining ecotopes are too sensitive for any form of use other than wilderness type recreation, which has a potential net income value for the owner of approximately R0,12 per hectare per year. These are ecotopes i, ii, iii a, v bd and vi bd, and their combined area on Perdevlei amounts to 1 638 hectares. Net income potential to the land owner is approximately R192 per annum. Ecotope iv is regarded as too sensitive to permit of unnatural impact and therefore has no direct monetary value as far as the landowner is concerned.

6.11.3.12 By providing holiday accommodation, as suggested in paragraph 6.8.3.3, the land owner may gain an estimated additional net income of R1 500 per annum.

6.11.3.13 The owner's total potential annual net income from Perdevlei is, then, approximately R117 828 if he follows the use patterns as discussed. Under the same land use regime, this portion of the catchment area would have an estimated annual value of approximately R9 119 736 in terms of potential regional and national benefit (refer to Table 47) without any reduction in owner benefit. The final land use pattern and associated values are summarized in Table 48, and illustrated on Map 16.

6.11.4 The process of deciding optimum land use for a catchment area can be summarized as follows:

STEP: 1

TABLE 48

Final allocation of ecotopes to land use alternatives, with associated owner and community values, for Perdevlei.

Ecotope	Area (ha)	Allocated land use	Owner per ha.	Owner total	Community per ha. Water	Community per ha. Recreation	Community total
i	260	Wilderness type recreation	0,12	31	3 000	10,8	782 808
ii	175	Wilderness type recreation	0,12	21	3 000	10,8	526 890
iii a	360	Wilderness type recreation	0,12	43	3 000	10,8	1 083 888
iii b	61			46			184 901
	(10)	Hiking trail recreation with wild flowers	(4,00)	(40)	(3 000)	(135)	(31 350)
	(51)	Wilderness type recreation	(0,12)	(6)	(3 000)	(10,8)	(153 551)
iv	40	None	0,0	0	3 000	0,0	120 000
v a	93	Agriculture:		102 675			130 875
	(79)	effective area : class 1 soils	(1 299,68) (calculated)	(102 675)	(1 125)	(0)	(88 875)
	(14)	conservation area	(0,0)	(0)	(3 000)	(0)	(42 000)
v bb	36	Hiking trail recreation with wild flowers	14,0	504	3 000	810	137 160
v bc	246			1 936			768 985
	(72)	Holiday homes with wild flowers	(16,0)	(1 152)	(3 000)	(0)	(216 000)
	(55)	Hiking trail recreation with wild flowers	(14,0)	(770)	(3 000)	(540)	(194 700)
	(119)	Wilderness type recreation	(0,12)	(14)	(3 000)	(10,8)	(358 285)
v bd	99	Wilderness type recreation	0,12	12	3 000	10,8	298 069
vi ba	80			165			247 279
	(6)	Vehicle access recreation with wild flowers	(26,0)	(156)	(3 000)	(1 080)	(24 480)
	(74)	Wilderness type recreation	(0,12)	(9)	(3 000)	(10,8)	(222 799)
vi bb	140			2 940			533 400
	(56)	Vehicle access recreation with wild floers	(21,0)	(1 176)	(3 000)	(810)	(213 360)
	(84)	Hiking trail recreation with wild flowers	(21,0)	(1 764)	(3 000)	(810)	(320 040)
vi bc	697			7 870			2 185 878
	(340)	Holiday homes with wild flowers	(16,0)	(5 440)	(3 000)	(0)	(1 020 000)
	(172)	Hiking trail recreation with wild flowers	(14,0)	(2 408)	(3 000)	(540)	(608 880)
	(185)	Wilderness type recreation	(0,12)	(22)	(3 000)	(10,8)	(556 998)
vi bd	704	Wilderness type recreation	0,12	85	3 000	10,8	2 119 603
				R116 328			
		Provision of holiday accommodation:		R 1 500			
Totals: 2 991 ha				R117 828			R9 119 736

Potential annual value (R)

ACTION: Classify area according to significant basic physical characteristics i.e. characteristics that, singly or in combination, are likely to influence land use capability; and map these characteristics in the classes selected.

PRODUCT: A series of transparent overlays of the area; one for each characteristic mapped.

STEP: 2

ACTION: Synthesise meaningful terrain units or ECOTOPES by combining basic characteristics in a way that will accommodate the possible land uses that must be considered.

PRODUCT: A single transparent overlay showing ecotopes, identified by symbols.

STEP: 3

ACTION: With the aid of the method described, (i.e. the first part of Gibson's model) establish use preference indexes for each land use alternative in respect of each ecotope.
[Note: It is esssential that the Mountain Catchment Area Advisory Committee be involved in this step].

PRODUCT: Table of multiple use vectors for the ecotopes of the area. This table indicates use preference levels for each possible use i.r.o. each ecotope.

STEP: 4

ACTION: Examine each property in the proclaimed Mountain Catchment Area, and the associated State land, and, with the aid of the table of multiple use vectors, and in the light of specific private and public (Government) goals, and constraints pertaining to each property, decide upon an optimum land use, or land use mix, in each case.
[Note: Constraints not reflected in the synthesis of ecotopes include such factors as distribution, slope and area of each ecotope; accessibility; distance from market or supply point; availability of water in the required amount; special features, such as archaeological sites, unique geology, geomorphology, vegetation and flora, and/or special owner interest, e.g. private retreat].

PRODUCT: A map of the catchment area showing optimum land use pattern for each property, including the associated State land.

This process has been illustrated in the foregoing section for the Perdevlei property of the Groot Winterhoek Mountain Catchment Area as if it were still in private ownership.

6.11.5 As explained earlier, the second part of the assessment procedure, wherein account is taken of the specific goals and constraints pertinent to the property, or area, being assessed, was done manually. There are no great problems involved in using a manual procedure for this step but, if a large area with many individual properties were involved, it may be of advantage to make use of a computerised system such as that advocated by Gibson (1975), when available in South Africa.

However, nothing will relieve the planner of the task of quantifying a number of critical constraints by laborious field measurements and research.

6.11.6 Some of the steps in the first part of the procedure described, that is the synthesis of meaningful ecotopes by means of various combinations of basic terrain features, and a subsequent step involving assessment of accessability, distance from a datum point, water sources, special features, and soon, could also be computerised, for example by means of the C.A.D.D. (Computer Aided Design and Drafting) system described by Assad (1985). This and similar systems involving creation of a computer data base either by digitizing or scanning ready prepared maps or annotated and corrected air photographs, are in regular use in Canada, the U.S.A. and in Europe, but are relatively new and still extremely expensive in South Africa. The hand drawn data file system, as described by Steinitz et al (1976) and used in modified form here, is infinitely less expensive and is considered adequate for permanent conservation areas, the component sections of which are not subject to frequent changes in status, as is the case with commercial timber plantations. However, a computerised system has many advantages and would be a boon to land-use planners.

7. CONCLUSION

7.1 It is clear that mountain catchments are sensitive areas whose principle values lie in their capacity to intercept, take up and store rainfall and other precipitation and then to discharge it as a constant supply of clean, usable water via stream channels or subterranean seepage. There can be few who would disagree with the opinion that it is in the national interest to ensure that the capacity of mountain catchments to function in this way should be maintained at maximum efficiency in order to provide optimum sustained yields of high quality water. It is generally acknowledged that water could prove to be the limiting factor to development in South Africa. There is no natural resource of greater importance and every effort should be made to ensure conservation of supplies.

7.2 This study has confirmed that although there are small pockets that have proved to be highly productive in certain respects, the overall agricultural potential of the mountain catchment is insignificant. Pre-European land use was probably negligible and has had no apparent effect on the mountain ecosystems, but the common post-settlement use of portions of these areas as seasonal pasture for domestic stock has resulted in obvious degradation. This has happenned over no longer than the last 100 to 130 years and there is evidence to indicate that the process has been cumulative. Most serious degradation appears to have occurred over the last 50 to 70 years. Overstocking, especially of recently burned veld, and primitive access routes are the principal and most obvious causes of degradation. A more recent use of mountain veld, for harvesting wild flowers and other plant material on a commercial scale, involving the use of off-road vehicles to gain access to the harvesting grounds, is currently causing serious degradation principally in the form of eroding access routes. The use of fungicides and pesticides on the natural veld in an attempt to improve the acceptability of the harvested material gives further cause for alarm. The full effects of these practices on mountain ecosystems and on water quality are unknown but are potentially serious.

7.3 The stock carrying capacity of mountain fynbos is unknown but is clearly extremely low. Stocking rates recommended by the Department of Agriculture are so low that expenditure on conservation measures such as fencing, which is essential in a catchment area, makes stock farming on natural veld uneconomical. Similarly, catchment conservation requirements that should be met by commercial wildflower harvesters would in most cases render this activity uneconomical in mountainous terrain.

7.4 Fortunately, mountain fynbos soils are, generally speaking, not highly erodible, and when the cause is removed erosion gullys and denuded areas normally stabilise and vegetation returns relatively quickly. This can be seen in areas where stock has recently been completely removed from the veld. Where the land owners have also left the mountain property, eroded roads and tracks have begun growing over and driftsands, caused by repeated cultivation of annual crops on sensitive soils, are being stabilised by the Directorate of Forestry using simple and relatively inexpensive techniques. However, where stock are still being kept on natural mountain veld on a commercial scale the degradation process continues. Roads and tracks that are still in use remain focal points of gully erosion causing excessive sand and silt loads to be carried into streams. Any disturbance of the soil such as ploughing, road or dam building, particularly in or near water courses, can have disastrous consequences in these mountain catchments. Strict control of development of any kind is clearly essential.

7.5 Because the agricultural potential of mountain catchments of the fynbos biome is undoubtedly low, no important agricultural product is unique to mountain farms and conservation of water resources is of paramount importance, the obvious answer is for the State to acquire all significant mountain catchments outright, at least in this area. However, such action may cause dissatisfaction, or even hardship in some cases, among affected communities. Furthermore, initial purchase of the land involved would require large sums of money, and because the catchment areas should be scientifically managed for maximum national benefit rather than merely left untended, permanent commitment of both State funds and manpower would be necessary.

7.6 As much mountain land as possible should be acquired by the State and set aside primarily for water resource and nature conservation. However, the Mountain Catchment Areas Act, judiciously applied, can be a powerful but relatively inexpensive conservation tool. Careful planning of land use in proclaimed mountain catchment areas with the aid of a technique such as the one discussed in this report, should enable the Government to achieve optimum conservation without excessive expenditure of State funds. At the same time the land owners would enjoy continued use of their property. By assisting land owners to obtain maximum benefit from their mountain property, within the constraints imposed by the requirements of catchment conservation, the State could create a situation that would permit both private and community benefits to be maximised at minimum cost to the State in the long term.

7.7 It should be noted that mountain catchment conservation areas, whether they be private or State owned, have considerable recreation value. The State already accepts recreational use of mountain catchments as an element of the compatible multiple use spectrum for these areas. Private catchment land owners should be encouraged to permit compatible public recreation on their properties as well. They could derive direct benefit by charging access fees and providing facilities, but tangible and intangible community benefits would be much greater than the income accruing to land owners. The demand for both public and exlcusive private nature oriented recreation areas is growing rapidly. The latter demand has already encouraged speculative purchases of mountain properties at prices far in excess of their agricultural value. This development could make control of land use in proclaimed Mountain Catchment Areas more difficult than it otherwise would have been because the Government will be dealing with a different type of land owner on land that has acquired a much higher market value. It is therefore imperative in the interests of long term catchment conservation and assured sustained yields of high quality water, that uniform and stringent control over all development and land use be immediately implemented in all mountain catchments.

7.8 Finally, it is clear that much research is still needed into mountain catchment land-use potential, into the impact of various forms of land-use on mountain ecosystems and their components and on mountain catchment hydrology and the impact of one use on the other, and into public expectations and demands in relation to mountain catchment areas. This will demand a carefully co-ordinated multidiciplinary effort and require the expertise of ecologists, hydrologists, forestry and agricultural scientists, social scientists and economists. Terms of reference will have to be clearly and unambiguously stated and agreed to at highest level, so that the principal management objective of mountain catchments is not lost site of and is not permitted to become sub-ordinate to some relatively short term objective.

SUMMARY

1. Introduction

1.1 This study is about mountain catchment, or water source area, conservation and land use in the Groot Winterhoek Mountain Catchment Area of the Western Cape. This area comprises private land proclaimed in terms of the Mountain Catchment Areas Act, 63 of 1970, and the adjoining State Forest catchment area.

2. Description of the study area

2.1 The location of the area is shown on Map 1. Porterville, considered to be the gateway to the central portion, lies about 140 kilometres north of Cape Town and 120 kilometres east of Saldanha-Vredenburg, the two principal development nodes in the western Cape.

2.2 Geology is dominated by the Table Mountain group (Rust, 1967; Visser et al, 1973; Theron et al, 1975), comprising mainly quartzites, with the so called "shale band", formed by the Pakhuis and Cedarberg formations, a prominent feature of the topography. Rivers and streams are generally deeply incised and numerous geological faults determine much of the drainage pattern. Altitude ranges from about 137 metres above mean sea level on the plain near Porterville to over 2 000 metres on the quartzite peaks of the catchment area.

2.3 Shallow skeletal soils and structureless sands, that become waterlogged where drainage is impeded, predominate. In general, the mountain soils are nutrient deficient with low water retention properties but limited pockets of finer textured soils derived from shale and related parent material do occur.

2.4 The area falls within a Mediterranean-type climatic zone, with cold, wet winters and hot, dry summers. The prevailing winter rain-bearing winds are from the north-west, while south-easterly and easterly winds prevail through the summer months. Hot, dry north-easterly "berg winds" are an occasional feature, particularly in late autumn and winter and thunder storms, sometimes accompanied by heavy rain and hail, may occur, especially in spring or autumn. Extremes of heat and cold are rare, although snow falls annually on the high peaks.

2.5 The study area is the main catchment for a number of major tributories of the Olifants and Berg Rivers, while a small portion (about 0,8%) drains into the Breede River system. The two important irrigation dams on the Olifants River are the Clanwilliam and Bulshoek, both near the town of Clanwilliam, while Voëlvlei, an important dam for the Cape Town metropolitan area, and Misverstand, serving Saldanha-Vredenburg, are fed by the Berg River system.

2.6 Apart from small riparian strips and relict patches of evergreen forest similar to Acocks′ veld type 4, the whole area can be related to Acocks′ veld type 69, Mountain Fynbos. Within these two Acocks types eight physiognomic vegetation-site types were identified and mapped with the aid of aerial photographs and field data. A number of rare and interesting plant species occur, and buchu and several Proteaceae have been, and are, harvested in the area.

2.7 The faunal component of the ecosystems of the study area is not striking, but appears to be typical of south-western Cape mountains.

3. <u>Land use</u>

3.1 An introductory section compiled from published literature and unpublished archival records describes probable land use before the arrival of European settlers, the changing patterns of settler land use through to present times, and the history of Governmental water source area conservation efforts. It is suggested that the aboriginal huntergatherer people, known as Khoi-San or Bushmen, are unlikely to have had any disrupting effect on natural ecosystems. They can, in fact, be regarded as as much a part of pristine ecosystems as wild antelope. Archaeological evidence has indicated that a closely related people, the Khoi-Khoi or Hottentots, began moving into the south-western Cape with domestic animals from about 2 000 years B.P. These pastoralists brought with them the universal practice associated with cattle owning African peoples of burning the veld in advance of their movements to provide pasturage for their animals. This practice must have had some impact on the vegetation of the area. However, it appears likely that the numbers of people and animals involved up to the year 1652, when the Dutch trading and revictualling post was established at the Cape, would not have been large enough to have a significant lasting effect. It is also unlikely that the Khoi-Khoi pastured their stock in the mountains, except possibly in times of extreme drought.

3.2 Change came rapidly after establishment of the settlement at the Cape. By the end of the seventeenth century large wild animals had virtually been eliminated from the south western Cape. By this time too, the rapidly dwindling numbers of Khoi-Khoi had been driven far to the north of the study area. Grazing permits for the lowlands adjoining the study area were issued from about the first decade of the eighteenth century, and permanent settlement commenced before the end of the seventeen hundreds. During these early years of European settlement, the mountains were used only for hunting and for gathering medicinal and other wild plant produce, for example, buchu (<u>Agathosma</u> <u>spp.</u>) and bush tea (<u>Aspalathus</u> <u>spp</u>.). It was not until the mid eighteen hundreds that farmers began using mountain veld for seasonal pasture.

3.3 The first families moved their permanent homes into the mountains of the study area in about 1913. They were sheep farmers and took their stock to lowland pastures for three to four months over the severest part of the winter each year. Serious degradation of portions of the study area, indicated by gully, surface and streambank erosion, encroachment by unpallatable spiney plant species, the spread of invasive alien woody plants and the creation of driftsands, has taken place since then.

3.4 A pass was built in 1941 to give easier access to fruit farms on the plateau to the east of Porterville. Rough vehicle tracks to all occupied mountain properties were soon extended from this pass, contributing to the acceleration of the pace of degradation. Stock trails and vehicle tracks are clearly the most significant causes of erosion.

3.5 A survey was conducted to determine current mountain land use and the importance to each land owner of the mountainous portion of his property. Owners were also asked to express their views of Government catchment area control measures. A more intensive survey was made of those properties where the farmer is resident and conducts most, or all of his farming activities on a mountain property. A comprehensive questionnaire was used in the latter survey which was conducted by door to door visits and personal interviews. The main purpose of the intensive survey was to establish the relative profitability of the various land use activities and the overall profitability of each mountain farm unit. Only partial success was achieved. While gross yield per activity was generally given, the respondents were either reluctant to, or could not give a breakdown of production costs per activity. Profitability of separate activities were therefore estimated from gross yield figures per hectare and total costs per farm unit. Deciduous fruit produced under irrigation was generally found to be the most profitable activity, although the potential for irrigated plantations of indigenous flowers appears to be at least as good.

3.6 The broad land use survey revealed that only 42 percent of the private mountain catchment land is currently being used for any form of farming activity. Forty percent of the area is used for seasonal stock pasture, which is the commonest use. Only about two percent of the private mountain land is under cultivation and it is estimated that no more than five percent is arable.

4. Impact of land use

4.1 A field survey was carried out over the whole catchment area using standard forestry methods. Vegetation was mapped in site-physiognomic types and notes were made on fauna. The impact of past and present land use on the area was assessed and degraded sites noted on field maps. Detailed surveys were made of some specific aspects as an aid to assessing land use impact.

4.2 The vegetation on old stock camp sites and on a number of sites known to have been used for stock pasture at various times in the past, was surveyed using a modification of the decending point method. The object was to determine the impact of pasturing and the rate at which the veld recovered after being withdrawn from use. Application of the "t" test to sample data revealed a number of significant differences as regards presence or absence of increaser and invader species, and certain growth forms, but no clear recovery rate pattern.

4.3 Soil samples from old stock camp sites and adjoining fynbos were analysed and compared for possible indications of enrichment of the stock camp sites. Some indications of higher P, N and Ca concentrations in the stock camp samples were found, but "t" tests showed between mean differences to be insignificant.

4.4 Small mammal communities on abandonned homestead and stock camp sites and on similar sites with undisturbed fynbos a kilometre or more away were sampled. The two data sets were compared. There are apparently greater numbers of <u>Aethomys</u> <u>namaquensis</u> and <u>Rhabdomys</u> <u>pumilio</u> on stock camp and farm yard sites than in undisturbed fynbos. However, no clearly significant difference in small mammal populations that could be positively ascribed to site modification by man emerged from analysis of the data.

4.5 Surveys of a number of stands of *Protea magnifica*, *P. laurifolia* and *Leucadendron rubrum* were carried out to obtain an idea of stand density, level of harvesting activity, and to assess the impact of harvesting on the species concerned. It appears that between 50 and 60 percent of each season's flower heads had been removed from the accessible *P. magnifica* stands. *P. laurifolia* is relatively abundant and easily accessible. No more than 30 percent of the flower heads of these tall shrubs are taken. There are many stands within easy reach of existing roads and remote populations are not exploited at all. *L. rubrum* is heavily exploited for the dry flower market. Female flower heads can be cut in practically all stages of development and bushes can therefore be virtually stripped. The shrubs appear to deteriorate, producing progressively shorter stems until, after about five years, the material is no longer saleable.

4.6 Commercial wild flower harvesting is a relatively recent activity in the study area and no significant effect on populations of the target species was detected. The effect on the environment of vehicle access routes is, however, very obvious. Severe erosion of vehicle tracks is common. The use of pesticides on wild plant populations was observed. This practice should be prohibited in catchment areas.

4.7 Water samples taken over two years at representative points on streams in the catchment area revealed no significatn reduction in quality, as measured by conductivity (an indication of total dissolved solids content) and suspended solids content, due to agricultural activity or other disturbance.

5. <u>Some social and economic implications</u>

5.1 A survey of owners of land in the study area revealed a wide range of attitudes to State control of mountain catchments. The majority were positive or indifferent, but a small number were extremely critical and resentful of any form of interference in the use of their land.

5.2 The introduction of stricter control over veld burning in about 1949, caused many farmers to discontinue pasturing stock on their natural veld. However, an almost equal number are still overstocking their veld by 50 percent or more. Some areas are so badly degraded that only total removal of all stock for an indefinite period may reverse the trend. Control over all land use in proclaimed mountain catchment areas and the introduction of stricter measures to prevent erosion and pollution, is likely to reduce the profitability of activities such as pasturing of stock and wild flower harvesting. However, very few farmers are taking advantage of the growing demand for outdoor recreation.

This may provide significant income potential for owners of mountain land.

5.3 The expropriation of properties in the upper catchment of the Vier-en-Twintig-Riviere was generally unpopular. Both those whose land was expropriated and the remaining active mountain farmers were critical of this action. Two of the families whose land was expropriated would seem to have suffered both financially and socially as a result of their enforced change of status and life style. Members of the diminished mountain farm community are concerned that their chances of obtaining improved social services, such as schools, clinics, an improved access road and road transport service have virtually been eliminated. On the other hand, they are wary of the anticipated increase in recreationist traffic to the State Forest, to which the expropriated land has been added. They fear vandalism and a disturbance of their rural peace.

6. Land use potential

6.1 The aim of this chapter is to find a method of determining optimum land use for a mountain catchment. The principal management objective of mountain catchment areas is sustained production of optimum volumes of clean water. Water conservation is therefore the primary and overriding land use. The problem is thus reduced to deciding on the optimum mix of compatible subordinate uses.

As a first step, the inherent capability of the area to sustain the uses to be considered must be determined. Some systems of land capability classification are investigated and a system similar to that used by the Canadian Government in their Canada Land Inventory, but taking MacVicar´s ecotope as the ultimate unit of classification, is proposed and described.

6.2 Meaningful ecotopes are generated by considering the implications of significant site factors for the selected land use options. The site factors included are:

1. Topography; as reflected by slope, in three classes
2. Altitude; four classes
3. Geology and soils; only three broad soil classes
4. Rockiness; three classes
5. Vegetation; physiognomic-site types as mapped from survey data.

6.3 For this study 16 ecotopes were generated by using a mapping technique similar to "sieve mapping" (Canadian Department of Agriculture and Food) and the hand drawn data file process of Steinitz et al (1976). Each ecotope has an inherent capability level, or potential, in respect of each land use. An initial assessment of land use potential can therefore be made. However, other factors, such as size and situation of land units, accessibility, and availability of other essential resources must be taken into account in the final analysis.

6.4 The profitability or anticipated benefit of alternative uses is clearly of importance and the potential of each use is discussed on the basis of locally collected data or, where local data is not available, on the basis of reasonable estimates of costs and benefits. Land uses identified as absolutely or conditionally compatible with catchment conservation objectives are:

1. Nature conservation
2. Facility based outdoor recreation
3. Wilderness type outdoor recreation
4. Timber production
5. Agriculture (arable land)
6. Stock farming
7. Harvesting wild plant products
8. Holiday home development.

6.5 In order to illustrate the decision process a single farm property (Perdevlei) in the study area is subjected to the complete process. As is to be expected, certain ecotopes are suitable for a number of different and mutually exclusive uses. Furthermore, the anticipated benefits of the alternative uses may be either tangible or intangible or both. A means of deciding on the best alternative, in terms of community benefits, is required.

6.6 The decision process developed by Gibson (1975) is used to calculate land use priority indexes for each ecotope. These indexes are then used with other relevant site-specific information to arrive at a final decision about land use on the property. Important steps in Gibsons method are, firstly, determining land use objectives and assigning priorities to these objectives and, secondly, weighting intangible or subjective factors. It is suggested that the local Mountain Catchment Area advisory committee and development advisory committee should assist with these steps in order to ensure that the local community´s perception of increased welfare is as closely reflected as possible.

7. Conclusion

7.1 In conclusion it is suggested that because of the overriding importance of water conservation and the relatively insignificant agricultural potential of fynbos mountain catchments, as much land as possible should be acquired by the State and set aside for water resource and nature conservation. However, the Mountain Catchment Areas Act enables the Government to exercise sufficient control over land use on private land to achieve the necessary conservation objectives with minimum expenditure of State funds.

7.2 Much research is still needed to determine and quantify the impact of the various forms of possible land use on mountain ecosystems and hydrology. Public expectations and demands in respect of mountain catchments must also be researched, bearing in mind the increasing demand for outdoor recreation and the increasing scarcity of undeveloped natural refuges. Great care should be taken not to lose sight of the long term primary objective of mountain catchment area conservation, namely water conservation. It should not be allowed to become subordinate to any apparently more attractive short term objective.

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APPENDIX 1

First check list of plant species of the Groot Winterhoek Mountain Catchment Area

Family and Genus No.	Name	Palatability[1]
	Gymnospermae	
	Podocarpaceae	
13	*Podocarpus elongatus* L'Herit ex Pers.	
	Angiospermae - monocolyledones	
	Poaceae	
K 83	*Themeda triandra* Forsk.	XXX
K 160	*Ehrharta capensis* Thunb.	XXX
K 160	*E. calycina* Sm.	XXX
K 160	*E. ramosa* Thunb.	XX
K 160	*E. villosa* Schult. f.	XX
K 205	*Pentaschistis curvifolia* (Schrad.) Stapf.	X
K 208	*Pentameris macrocalycina* (Steud.) Schweick	X
	Cyperaceae	
465	*Ficinia indica* (Lam.) Pfeiffer	Xb
465	*F. radiata* Kunth.	Xb
494	*Tetraria burmanii* C.B. Cf.	Xb
494	*T. crinifolia* C.B. Cf.	Xb
494	*T. fasciata* (Rottb.) C.B. Cf.	Xb
500	*Chrysithrix capensis* L.	
	Restionaceae	
804	*Restio curviramis* Kunth.	Xb
804	*R. gaudichaudianus* Kunth.	Xb
804	*R. pedicellatus* Mast.	Xb
804	*R. sieberi* Kunth.	Xb
804	*R. strobilifer* Kunth.	Xb

(1) Rated by pasture scientists of the Department of Agriculture.
X - barely palatable; XX - palatable; XXX - palatable +;
XXXX - palatable ++
Xb - only young postburn shoots palatable.

807	*E. capensis* Schelpe.	Xb
807	*Elegia neesii* Mast.	Xb
807	*E. parviflora* Kunth.	Xb
808	*Leptocarpus vimineus* (Rottfs.) Pillans.	Xb
814	*Staberoha cernua* Dur & Schinz.	Xb
816	*Hypodiscus aristatus* Nees.	Xb
817	*Cannomois dregei* Pillans.	Xb
818	*Wildenowia humilis* Mast.	Xb
	Juncaceae	
936	*Juncus bufonius* L.	Xb
	Liliaceae	
984	*Bulbinella floribunda* (Aij.) Dur & Schinz.	
984	*B. triquetta* (L.f.) Kunth.	
1002	*Caesia contorta* (L.f.) Dur & Schinz.	
1026	*Aloe mitriformis* Mill.	
1026	*A. haemanthifolia* Berger et Marloth.	
1089	*Ornithogalum thyrsoides* Jacq.	
1113	*Asparagus rubicundus* Berg.	
	Haemodoraceae	
1160	*Dilatris ixioides* Lam.	
	Amaryllidaceae	
1191	*Cyrtanthus angustifolius* (L.f.) Ait.	
	Iridaceae	
1265	*Moraea caeca* Goldblatt	
1265	*M. cooperi* Bak.	
1265	*M. tripetala* (L.f.) Ker-Gawl	
1265	*M. sp. cf. M. barkerae* Goldbl.	
1284	*Bobartia orientalis* Gillett subsp. *occidentalis* Strid.	
1300A	*Engysiphon exscapus* (Thunb.) Lewis	
1300A	*E. longitubus* Lewis	
1310	*Babiana mucronata* Jacq. Ker-Gawl	
	Orchidaceae	
1432	*Schizodium bifidum* (Thunb.) Reichb. F. (= *S. inflexum* Lindl.)	

1434 *Disa uniflora* Berl.

1434 *D. venosa* Sw.

1434A *Orthopenthea bivalvata* (L.f.) Rolfe

1439 *Ceratandra atrata* (L.) Dur. & Schinz.

Angiospermae - Dicotyledones

Salicaceae

1873 *Salix capensis*

Myricaceae

1874 *Myrica cordata*?

Angiospermae - Dicotyledones

Ulmaceae

1898 *Celtis africana* Burnm. F.

Moraceae

1961 *Ficus cordata* Thunb.

Proteaceae

2024 *Brabejum stellatifolium* L.

2028 *Sorocephalus scabrides* Meisn.

2029 *Paranomus lagopus* (Thunb.) Salisb.

2030 *Serruria cygnaea* R. Br.

2030 *S. pedunculata* (Lam.) R.Br.

2030 *S. triternata* (Thunb.) R.Br.

2030 *S. sp. indet.* (Kruger 1616)

2031 *Mimetes cucullatus* (L.) R.Br.

2032 *Spatalla caudata* (Thunb.) R.Br.

2035 *Protea acaulos* (L.) Reichb.

2035 *P. cynaroides* L.

2035 *P. laevis* R.Br.

2035 *P. laurifolia* Thunb.

2035 *P. magnifica* Link

2035 *P. recondita* Buek ex Meisn.

2035 *P. repens* (L.) L.

2035 *P. rupicola* Mund ex. Meisn.

2035 *P. scolopendriifolia* (Salisb. ex Knight)
(= *P. scolopendrium* R.Br.)

2035 *P. witzenbergiana* Phillips

2036A *Leucospermum tottam* (L.) Br.

2037 *Leucadendron arcuatum* (Lam.) I
Williams

2037	*L. gydoense* I. Williams	
2037	*L. pubescens* R.Br.	
2037	*L. rubrum* Brm. F.	
2037	*L. salicifolium cancellata?*	
2037	*L. salignum* Berg.	
2037	*L. spissifolium* (Salisb.) ex Knight) I. Williams	
2038	*Aulax sp. (pinifolia?)*	
	Santalaceae	
2104A	*Colpoon compressum* Berg.	
2118	*Thesium sp.*	XX
	Polygonaceae	
2201	*Polygonum salicifolium* Brouss.	
	Aizoaceae	
2379	*Psammotropha anguina* Compton	XXX
	Mezembryanthemaceae	
2405	*Carpobrotus sp.*	
2405	*Lampranthus cappillaceas* (L. Bol.)	
	Ranunculaceae	
2541A	*Knowltonia capensis* (L.) Huth.	
	Lauraceae	
2813	*Cryptocarya angustifolia* E. Mey ex Meisn.	
	Roridulaceae	
3138	*Roridula dentata* L.	
	Crassulaceae	
3168	*Crassula dejecta* Jacq.	
3168	*C. fascicularis* Lam.	
3175	*Andromischus* (genus under revision)	
	Montiniaceae	
3238	*Montinia caryophylaceae*	XXX
	Cunoniaceae	
3269	*Platylophus trifoliatus* (Thunb.) D. Don.	
3275	*Cunonia capensis* L.	

	Bruniaceae	
3294	*Berzelia squarrosa* (Thunb.) Sond.	
	Rosaceae	
3388	*Cliffortia cristata* Weim.	
3388	*C. dregeana* Presf.	
3388	*C. ruscifolia* L.	
3388	*C. tuberculata* (Harv.) Weim.	
	Papilionoideae	
3646	*Coelidium cedarbergensis* Hutchings M.S.	XX
3646	*C. sp. nov.* (Kruger 1388)	XX
3654	*Rafnia amplexicaulis* Thunb.	
3654	*R. perfoliata* E. Mey	
3654	*R. sp.*	
3662	*Aspalathus flexuosa* Thunb.	
3662	*A. linearis* (Burm. F.) R.Dahl.	XX
3662	subsp. *linearis*	
3662	*Aspalathus spinosissima* Dahlg.	
3662	*A. quinquefolia* L.	
3754	*Sutherlandia frutescens* (L.) R.Br.	XX
	Geraniaceae	
3928	*Pelargonium alpinum* Eckl. & Zeyh.	X
3928	*P. coronopifolium* Jacq.	X
3928	*P. longifolium* (Burm. F.) Jacq.	X
3928	*P. myrrhifolium* (L.) Aij.	XX
3928	*P. sp.* (Durand 320)	
	Rutaceae	
4037	*Agathosma capensis* Duemmer	
4037	*A. craspedata* E. Mey.	
4037	*A. imbricata* (L.) Willd.	
4037	*A. odoratissima* (Montin) Pillans	
4037	*A. virgata* (Lam.) Bartl. et. Wendl.	
4044	*Macrostylis decipiens* E. Mey ex Sond.	
	Anacardeaceae	
4589	*Heeria argentea* (E. Mey.) O. Kuntze	
4594	*Rhus africana* Mill.	X
4594	*Rhus angustifolia* L.	X
4594	*Rhus cuneifolia* Thunb.	X
4594	*Rhus tomentosa* L.	X

Aquifoliaceae

4614 *Ilex mitis* (L.) Radlk.

Celastraceae

4626 *Maytenus acuminatus* (L.f.) Loes.

4626 *M. oleoides* (Lam.) Loes.

4641 *Cassine parvifolia* Sond.

4654 *Hartogia schinoides* C.A. Sm.

Sapindaceae

4831 *Dodonaea viscosa* Jacq. var. *angustifolia* Banth.

Rhamnaceae

4886 *Phylica nervosa* Pillans

4886 *P. odorata* Schltr.

4886 *P. plumosa* L.

4886 *P. cf. bolusii* Pillans (Kruger 1393)

Malvaceae

4986A *Anisodontea triloba* (Thunb.) Bates

Flacourtiaceae

5296 *Kiggelaria africana* L.

5304A *Pseudoscolopia polyantha* Gilg.

Thymelaeaceae

5435 *Gnidia sp.* (Durand 284)

5460 *Lachnaea ambigua* Meisn.

5460 *L. buxifolia* Harv.

5460 *L. globulifera* Meisn.

5460 *L. penicillata* Meisn.

5460 *L. striata* Meisn.

Myrtaceae

5588 *Metrosideros angustifolius* Smith.

Umbelliferae

5894 *Centella affinis* (Eckl. & Zeyh.) Adamson

5926 *Arctopus echinatus* L.

Ericaceae

6237 *Erica bergiana* L.

6237 *E. breviflora* Dulfer (= *E. scariosa* Thunb.) Durand 316

6237 *E. caffra* L.

6237	*Erica corifolia* L.	
6237	*E. daphiniflora* Salisb.	
6237	*E. haematosiphon* Guth. et. Bol.	
6237	*E. inflata* Thunb.	
6237	*E. involucrata* Klotzsch ex Benth.	
6237	*E. junonia* Bolus	
6237	*E. leucanthera* L.f.	
6237	*E. lucida* Salisb.	
6237	*E. mammosa* L.	
6237	*E. oxysepala* Guthrie & Bof.	
6237	*E. subulata* Wendl.	
6243	*Eremia curvistyla* (N.E. Br.)	
6243	*E. totta* (Thunb.) D.Don.	
6246B	*Scyphogyne muscosa* (Ait.) Steud.	
	Myrsinaceae	
6313	*Myrsine africana* L.	
6314	*Rapanea melanophloeos* (L.) Mez.	
	Ebenaceae	
6404	*Euclea crenulata*	
6406	*Diospyros glabra* (L.) De Wint.	
	Oleaceae	
6434	*Olea africana* Mill.	
6434	*O. capensis var. capensis*	
6440	*Jasminum glaucum* (L.f.) Ait.	
	Asclepiadaceae	
6860	*Secamone alpinii* Schultes	
	Boraginaceae	
7117	*Lobostemon glaucophyllus* Buek.	X
	Stilbaceae	
7134	*Stilbe albiflora* E. Mey.	
	Labiata	
7264	*Leonotis leonurus* R.Br.	X
7290	*Salvia africana - coerulea* L.	XX

Scrophulariaceae

7493 *Halleria lucida* L.

7493 *H. eliptica* Thunb.

7494A *Oftia africana* (L.) Bocq.

7498 *Ixianthes retzioides* Benth.

Selaginaceae

7568 *Selago sp.*

•7569 *Microdon lucidus* Choisy

Companulaceae

8668 *Wahlenbergia sp.*

Lobeliaceae

8694 *Lobelia sp.* XX

Asteraceae

8936 *Brachylaena neriifolia* (L.) R.Br.

9000 *Helipterum variegatum* (Berg.) DC.

9008 *Leontonyx spathulatus* (Thunb.) Less. XX

9037 *Stoebe aethiopica* L.

9037 *S. plumosa* Thunb.

9041 *Elytropappus rhinocerotis* Less.

9043 *Metalasia muricata* (L.) R.Br.

9320 *Eriocephalus africanus* L. XX

9357 *Hippia pilosa* (Beru.) Druce.

9417 *Euryops sp.*

9420 *Othonna cf o. quinquedentata* Thunb.
(Taylor 468/2)

APPENDIX 2

Fauna of the Groot Winterhoek Mountain Catchment Area. (list incomplete)

2.1 Mammals (List compiled from Departmental survey records and personal observations)

Elephantulus edwardi	Cape elephant shrew
Myosorex varias	Forest shrew
Crocidura cyanea	Reddish-grey musk shrew
Papio ursinus	Chacma baboon
Pronolagus crassicaudatus	Natal red rock-hare
Lepus saxatilis	Scrub hare
Georychus capensis	Cape mole-rat
Hystrix africae-australis	Cape porcupine
Graphiurus ocularis	Black and white dormouse
Acomys subspinosus	Cape spiny mouse
Aethomys namaquensis	Namaqualand rock rat
Mus minutoides	Dwarf mouse
Rhabdomys pumilio	Striped mouse
Otomys irroratus	Vlei rat
Genetta genetta	Common genet
Herpestes pulverulentus	Cape grey mongoose
Atilax paludinosus	Marsh mongoose
Panthera pardus	Leopard
Felis caracal	Caracal
Felis lybica	Cape wildcat
Procavia capensis	Cape hyrax
Sylvicapra grimmia	Grey duiker
Oreotragus oreotragus	Klipspringer
Raphicerus melanotis	Cape Grysbuck
Pelea capreolus	Grey Rhebuck

2.2 Birds (numbers refer to Austin Roberts's "The Birds of South Africa"; list compiled from records of the Cape Bird Club and personal observations)

61	*Bubulcus ibis*	Cattle Egret
72	*Scopus umbretta umbretta*	Hamerkop
81	*Threskiornis aetheopicus*	Sacred Ibis
95	*Anas sparsa sparsa*	Black Duck
105	*Sagittarius serpentarius*	Secretary Bird
123	*Falco tinninculus rupicolus*	Rock Kestrel
130	*Elanus caeruleus*	Black-shouldered Kite
133	*Aquila verreauxi*	Black Eagle
152	*Buteo rufofuscus rufofuscus*	Jackal Buzzard
154	*Buteo buteo vulpinus*	Steppe Buzzard
156	*Accipiter rufiventris rufiventris*	Red-breasted Sparrowhawk
169	*Circus maurus*	Black Harrier
178	*Francolinus africanus*	Grey-wing Francolin
181	*Francolinus capensis*	Cape Francolin
189	*Coturnix coturnix*	African Quail
192	*Numida meleagris*	Crowned Guinea-fowl
212	*Fulica cristata*	Red-knobbed Coot
242	*Stephanibyx coronatus coronatus*	Crowned Plover
311	*Columba guinea phaeonota*	Rock Pigeon
312	*Columba arquatrix arquatrix*	Rameron Pigeon
314	*Streptopelia semitorquata*	Red-eyed Turtle Dove
316	*Streptopelia capicola capicola*	Cape Turtle Dove
317	*Stigmatopelia senegalensis senegalensis*	Laughing Dove
343	*Cuculus solitarius*	Red-chested Cuckoo
368	*Bubo africanus*	Spotted Eagle Owl
373	*Caprimulgus pectoralis*	Fiery-necked Nightjar
374	*Caprimulgus tristigma*	Freckled Nightjar
386	*Apus melba*	Alpine Swift
390	*Colius striatus*	Speckled Mousebird
395	*Megaceryle maxima*	Grant Kingfisher
404	*Merops apiaster*	European Bee-eater
412	*Coracias garrulus*	European Roller
418	*Upupa africana*	African Hoopoe
445	*Geocolaptes olivaceus*	Ground Woodpecker
466	*Mirafra apiata*	Clapper Lark
502	*Cecropis cucullata*	Greater Striped Swallow
506	*Ptynoprogne fuligula*	Rock Martin

523	*Corvus capensis*	Black Crow
524	*Corvultur albicollis*	White-necked Raven
540	*Chaetops frenatus*	Rock-Jumper
543	*Pycnonotus capensis*	Cape Bulbul
559	*Monticola rupestris*	Cape Rock-Thrush
564	*Oenanthe monticola monticola*	Mountain Chat
570	*Cercomela familiaris familiaris*	Familiar Chat
576	*Saxicola torquata torquata*	Stone Chat
581	*Cossypha caffra*	Cape Robin
612	*Bradypterus victorini*	Victorin's Scrub Warbler
637	*Cisticola fulvicapilla fulvicapil-la*	Neddicky
651	*Prinia maculosa maculosa*	Karoo Prinia
672	*Batis capensis*	Cape Batis
686	*Montacilla capensis capensis*	Cape Wagtail
703	*Macronyx capensis colletti*	Orange-throated Longclaw
707	*Lanius collaris*	Fiscal Shrike
709	*Laniarius ferrugineus*	Boubou Shrike
722	*Telophorus zeylonus*	Bokmakierie
733	*Sturnus vulgaris*	European Starling
745	*Onychognathus morio*	Red-winged Starling
746	*Spreo bicolor*	Pied Starling
749	*Promerops cafer*	Cape Sugarbird
751	*Nectarinia famosa*	Malachite Sunbird
753	*Anthobaphes violacea*	Orange-breasted Sunbird
760	*Cinnyris chalybeus*	Lesser Double-collared Sunbird
775	*Zosterops pallidus*	Cape White-eye
786	*Passer melanurus*	Cape Sparrow
799	*Ploceus capensis*	Cape Weaver
810	*Euplectes capensis*	Cape Widow
857	*Serinus canicollis*	Cape Canary
863	*Crithagra sulphurata*	Bully Seed-eater
873	*Fringillaria capensis*	Cape Bunting

2.3 Reptiles and Amphibians (List compiled from Departmental survey records and personal observations)

Crotaphopeltis hotamboeia	Herald snake
Psammophylax rhombeatus	Rhombic skaapsteker
Naja nivea	Cape cobra
Bitis atropos	Berg adder
Phyllodactylus sp.	Gecko
Agama atra	Rock agama
Microsaura pumila pumila	Cape dwarf chameleon
Mabuya capensis	Cape three striped skink
Acontias lineatus lineatus	Legless skink
Cordylus cataphractus	Armadillo lizard
Pseudocordylus microlepidotus microlepidotus	Crag lizard
Bufo rangeri	Raucous toad
Heleophryne sp.	Ghost frog
Rana fasciata	Long-toed rana
R. fuscigula	Cape rana
R. greyi	Spotted rana

2.4 Fish (List compiled from Gaigher 1973(b); Cape Province Department of Nature and Environmental Conservation personal communication, and personal observation)

Barbus capensis	Clanwilliam yellow fish (Olifants River)
B. calidus	Clanwilliam redfin (Olifants River)
B. serra	Sawfin (Olifants River)
Galaxias zebratus	Galaxia (Olifants River)
Salmo gairdneri	Rainbow trout (exotic) (Twenty-Four-Rivers)
Sandelia capensis	Cape Kurper (Twenty-Four-Rivers)

A page from the archive records of the Surveyor General.

Crown Land – Winterhoek

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(1) Description of the piece of land applied for by Messrs J.K. and A.J. Viljoen.

Lot A, in extent 141 morgen 1,04 square roods: bounded northwards by Lot B and Crown Land, south-eastwards by part of "Berg Plaats," and north-westwards & south-westwards by Crown Land, situated in the field-cornetcy of Winterhoek Division of Tulbagh.

(2) Description of piece of land applied for by Mr F.P. Theron

Lot B, in extent 444 morgen 257 square roods: bounded northwards by Middle of a Stream, south-eastwards and south-westwards by part of "Berg Plaats", southwards by Lot A, south-eastwards by middle of Boschenbosch Stream, – north-eastwards, eastwards, north-westwards & westwards by Crown Land: situated as the foregoing.

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Description of the piece of ground applied for by Mr M.C. Kriel

Lot C, in extent 1110 morgen 530 square roods: bounded north-westwards, north-eastwards & south-eastwards by Crown Land, south-westwards & westwards by Lot No 21 called Vier-en-twintig Rivers Poort: situated in the [illegible]

APPENDIX 4

Properties purchased or expropriated between 1961 and 1978 for protection of the Vier-en-Twintig-Riviere catchment area

Property	Area (Ha)	Previous Owner	Date of purchase/ expropriation
Portion 3 of Driebosch known as Drieboschfontein	768	Mr. J. van der Merwe	1967
Lot 1058 known as Klip-huisvlakte	5140	Mr. W. Engelbrecht	1968
Rem. of Lot 1057 portion of Paarden Vallei	1462	Mr. W. Engelbrecht	1968
Rem. of Lot 1056 Louws Legplek	2514	Mr. W. Engelbrecht	1968
Remainder of the Farm Driebosch known as Agterdam	965	Mr. G. du P. van der Merwe	1962
De Tronk re-named Groot Winterhoek	2918	Mr. R. Wigboldus	1975
Portion 2 of Paarden Vallei known as Perdevlei	1058	Mr. S. von Huffel	1975
Portion of Paarden Vallei known as Sneeukop River	471	Mr. H. Grimbeeck	1975
Portion of Rem Lot 1059 known as Zuurvlakte	850 (approx.)	Mr. H. Lambrecht	(?) 1977

Land use questionnaire 1.

QUESTIONAIRE CONCERNING LAND-USE BY OWNERS OF PRIVATE PROPERTY WITHIN MOUNTAIN CATCHMENT AREAS

MOUNTAIN CATCHMENT AREAS: ....

Registered owner: ....
Farm Name: ....
Farm No.: ....
Division: ....

(Mark with cross in appropriate block)

1. Is the indicated area being utilised for grazing — Yes ☐ No ☐

(a) If "yes" indicate to within the nearest 10 units what utilisation is taking place
(i) Small stock: ....
(ii) Large stock: ....

(b) Please indicate during what period the land is being utilised for grazing each year: ....

2. Is the area in question being utilised for the harvesting of indigenous Flora (Flowers and/or greenery) — Yes ☐ No ☐

If "yes", indicate the estimated percentage of your gross annual income which this constitutes ☐ %

3. Are there any permanent improvements situated on the area in question? — Yes ☐ No ☐

If "yes", kindly complete the following:

	Yes	No
(a) Fences	☐	☐
(b) Roads	☐	☐
(c) Buildings	☐	☐
(d) Water pipes (Above ground)	☐	☐
(e) Canals	☐	☐
(f) Weirs	☐	☐
(g) Dams	☐	☐
(h) Flower plantations	☐	☐
(i) Buchu or tea plantations	☐	☐
(j) Plantations (Timber)	☐	☐
(k) Lands	☐	☐
(l) Power lines	☐	☐
(m) Telephone lines	☐	☐
(n) Any other improvement of importance (Please specify)	☐	☐

4. Are there any servitudes registered against the property in question ? ☐ ☐

   If "yes" give brief description and indicate the servitudes on the enclosed map which must be returned to this office.

5. Do you apply rotational burning on the property in question ☐ ☐

6. Do you have any objection to the burning of the property on a tentative 12 year rotation. ☐ ☐

   If "yes", indicate your reasons.

....

Signature Date

Owner/Manager

(Indicate capacity of signatory)

In the case of a company, indicate the Spokesman ....

....

Land use questionnaire 2.

QUESTIONNAIRE TO ASSESS LAND-USE PRACTICES AND CONDITIONS IN THE MOUNTAIN AREAS OF THE WESTERN-CAPE

TO: Land-owners in the study area. Your co-operation in this project is respectfully requested. You are not obliged to answer the questions, but the information asked for is needed to fully assess the land use situation in the area concerned.

All information given is regarded as strictly confidential. It is not necessary to sign the document or give your name, if you do not wish to do so. It is hoped, therefor, that you will help, and answer the questions fully and as accurately as possible.

Thank you.

....

D.P. Bands

CONSERVATION PLANNING OFFICER
Department of Forestry
Western-Cape Forestry Region

NOTE: Unless otherwise requested, please make a X against appropriate statements. Please mark all statements that are applicable.

1. PROPERTY INFORMATION

1.1 NAME: ....

1.2 Registered number and Magisterial district (e.g. Ceres no. 52/4) ....

2. INFORMATION ABOUT THE PROPERTY OWNER

2.1 Name	Date of birth	Place of birth	Current and previous occupation/ or profession
....	....	....	....

Qualifications ....

2.2 Was the property inherited, or received as a gift? | YES | NO |

2.3 If answer to 2.2 is 'NO', what were your reasons for purchasing?

1. As an investment.
   - 1.1 to engage in productive farming, personally .. [ ]
     or with the help of a manager, ... [ ]
   - 1.2 with a view to: sub-division,
     into holiday allotments .... [ ]
     township development .... [ ]
     recreational development .... [ ]
2. As a hedge against inflation .... [ ]
3. To provide relief from taxation .... [ ]
4. For retirement .... [ ]

5. For relaxation/ ...

5. For relaxation .... ☐
6. For nature conservation .... ☐
7. Because it was a bargain......................... ☐

2.4 If answer to 2.2 is 'Yes', how do you see the value of the property?

1. An investment

1.1 to engage in productive farming, personally ... ☐
or with the aid of a manager .... ☐

1.2 with a view to:
sub-division into holiday allotments .... ☐
township development .... ☐
recreational development .... ☐

2. As a hedge against inflation .... ☐
3. As providing relief from taxation .... ☐
4. As a retirement place .... ☐
5. For relaxation .... ☐
6. For nature conservation .... ☐
7. A liability to be sold as soon as possible ..... ☐

3. INFORMATION ABOUT THE RESIDENT FARMER, IF NOT ALSO THE OWNER

3.1 Name	Date of birth	Place of birth	Previous or other occupation(s) or profession
....	....	....	....

Qualifications ....

3.2 Is the property owner related to you .... YES / NO

3.2.1 If so,/ ...

3.2.1 If so, how?

1. husband/wife .... [ ]
2. father/mother .... [ ]
3. parent-in-law .... [ ]
4. son/daughter/in-law .... [ ]
5. other .... [ ]

3.2.2 Are you leasing the farm? .... YES | NO

3.3 Why did you select this area in which to farm?

1. Productive, profitable area .... [ ]
2. Attractive area with sufficient potential to support your family in reasonable comfort . [ ]
3. An attractive area to retire to provided that you have a good pension or other regular income .... [ ]
4. You like it here even though conditions are difficult .... [ ]
5. The property was inherited and you have no choice .... [ ]

3.4 Do profits from the farm enable you to:

1. Maintain the standard of living you would wish YES | NO
2. Provide university or equivalent level education for your children, should they desire it .... YES | NO
3. Take an annual holiday with your family ...... YES | NO
4. Take an occasional holiday with your family in good harvest years .... YES | NO

INFORMATION/ ...

4. INFORMATION ABOUT THE PROPERTY

4.1 Area freehold .... Ha
leasehold .... Ha Total ...... Ha

4.2.1 Purchase price of freehold? R ....Ha

4.2.2 Year purchased? ....

4.2.3 What do you estimate the current market value to be for the farm sold lock stock and barrel
1. R .... per Ha
2. R .... for farm as a whole

4.2.4 If you could obtain a loan for half of the purchase price, what would you be willing to pay for the farm today lock, stock and barrel.
1. R .... per Ha
2. R .... for the farm as a whole

4.3 Meteorological information

4.3.1 Average annual rainfall (please state period of recording e.g. 1950 to 1977) ....

4.3.2.1 Mean minimum temperature of coldest three months. (Please state which months) ....
....

4.3.2.2 Mean maximum temperature of hottest three months. (Please state which months) ....
....

4.3.3.1 You experience severe ☐ / mild ☐ / no ☐ hailstorms;

4.3.3.2 Hail/ ...

4.3.3.2 Hail is frequent ☐ / occassional ☐ and occurs in the month(s) of

J	F	M	A	M	J	J	A	S	O	N	D

4.3.4.1 Severe ☐ / mild ☐ / no ☐, frost is experienced.

4.3.4.2 Frost is frequent ☐ / occasional ☐ in the month(s) of

J	F	M	A	M	J	J	A	S	O	N	D

4.3.5.1 Severe ☐ / mild ☐ / no ☐, snowstorms are experienced.

4.3.5.2 Snow is frequent ☐ / occasional ☐ in the month(s) of

J	F	M	A	M	J	J	A	S	O	N	D

4.3.6.1 Severe ☐ / mild ☐ / no ☐, damaging wind storms are experienced.

4.3.6.2 Damaging winds are frequent ☐ / occasional ☐, in the month(s) of

J	F	M	A	M	J	J	A	S	O	N	D

4.4 Altitude: from .... to .... m.a.s.l.

4.5 Areas:

4.5.1 Total area arable land in production or lying fallow after being in production, including improved (planted) pastures, dry and irrigated lands .... Ha.

4.5.1.1 Area under/ ...

4.5.1.1 Area under irrigation, including irrigated planted pasture .... Ha.

4.5.1.2 Total area under:

1. Deciduous fruit .... Ha; number of trees ....
2. Citrus .... Ha; number of trees ....
3. Vines .... Ha; number of trees ....
4. vegetables .... Ha;

4.5.2 Total area of utilisable natural pasture .... Ha

4.5.3 Total area under timber/pole/firewood plantation .... Ha

4.5.4 Area under roads, buildings, yards, dams, etc. .... Ha

4.5.5 Balance i.e. mountainous, rocky, or inaccessible terrain .... Ha

4.6 <u>Information about farming activities</u>

4.6.1 Please list your farming activities in order of importance according to gross income.

<u>Activities</u> (or farming divisions)

1.1 Deciduous fruit
1.2 Citrus fruit
2.1 Sheep
2.2 Goats
3.1 Beef cattle
3.2 Dairy cattle
4. Cereals
5. Fresh vegetables (including green mielies)
6. Feed crops

7. Potatoes/ ...

7. Potatoes
8. Onions
9. Poultry
10. Pigs
11. Forestry
12. Indigenous flowers and foliage
    1. from the natural veld
    2. from plantations or improved veld
13. Other cut flower cultivation
14. Buchu
15. Bush Tea
16. Honey
17. Outdoor recreation facilities or opportunity
    1. pony hire
    2. picnic sites
    3. camp sites
    4. bungalow hire
    5. wild land access fee
18. Other (please state briefly)

4.6.3 Do you use your natural veld for grazing? | Yes | No |

4.6.3.1 What stock do you run?

1. sheep ☐
2. goats ☐
3. cattle ☐
4. other (please state) ☐

4.6.3.2 Do you consider it necessary to burn the veld to provide grazing? | Yes | No |

4.6.3.2.1 If you do not burn, what system do you apply?

1. Fenced camps ☐ / free ranging ☐ /, hearded and kraaled at night ☐.

2. Graze mountain / ...

2. Graze mountain veld only during the months of

J	F	M	A	M	J	J	A	S	O	N	D

or all year round. ☐

3. graze for:
   1. one to four weeks per time with .... weeks rest between; ☐
   2. four to eight weeks per time with .... weeks rest between ☐
   3. eight weeks to three months per time with .... weeks rest between; ☐
   4. three to six months per year every year commencing in the month of

J	F	M	A	M	J	J	A	S	O	N	D

   5. all year round every year. ☐

4. stocking rate:
   .... large, and/or .... small stock per Ha.

4.6.3.2.2 If you do burn, what system do you use?

1. Patch burn ☐ / general burn ☐, in the months of

J	F	M	A	M	J	J	A	S	O	N	D

2. Do you aim for a clean burn ☐, or a light patchy burn ☐ ?

3. When do you put your stock into the burnt veld?
   1. one to four weeks after the burn ☐
   2. four to eight weeks " " " ☐

3. eight weeks to three months after the burn

4. three to six months " " "

5. at least one full growing season after the burn

4. For how long do you keep your stock on the veld?

1. one to four weeks, (a) once only until next burn / or (b) per time, with .... weeks rest between, repeated until next burn ;

2. four to eight weeks, as in 1(a) or 1(b)

3. eight weeks to three months, as in 1(a) or 1(b)

4. three to six months, as in 1(a) or 1(b)

5. year round every year until the veld requires burning again in approximately .... years.

5. Maximum stocking rate:
.... large and/or .... small stock per Ha.

6. what burning cycle do you aim for?

1. patch burn

1.1 every year

1.2 every two years

1.3 " three "

1.4 " three to six years

1.5 longer cycle, please state .... yrs

2. general burn/ ...

2. general burn

2.1 general burn every 4 to 6 years

2.2 " " " 6 to 8 "

2.3 " " " 8 to 12 "

2.4 " " at longer intervals
(state) .... yrs

4.6.3.5 If you use your natural veld for seasonal grazing only, where do you keep your stock for the rest of the year?

1. On a farm in the Karoo

1.1.1 own property

1.1.2 leased property

1.2.1 natural veld

1.2.2 improved pasture

1.2.2.1 dry land

1.2.2.2 irrigated

2. On a farm in the Swartland

2.1.1 own property

2.1.2 leased property

2.2.1 natural veld

2.2.2 cereal stubble

2.2.3 improved pasture

2.2.3.1 dry land

2.2.3.2 irrigated

3. On this farm

1. on improved pasture

2. on stubble lands

3. in feed pens

4.6.3.6/ ...

4.6.3.6 If you move your stock seasonally:

1. how do you move them?

1.1 trek [ ]

1.2 lorry transport [ ]

1.3 rail transport [ ]

1.4 combination (state) [ ]

2. How far do you move them? .... km

3. When do you move them out?

J	F	M	A	M	J	J	A	S	O	N	D

4. When do you move them back?

J	F	M	A	M	J	J	A	S	O	N	D

4.6.3.7.1 Do you make use of a herdsman who lives with the stock in the veld? YES | NO

2. If so, does he kraal the stock each night YES | NO

3. Do you suffer stock losses YES | NO

1. through predation - leopards [ ]

2. - caracal [ ]

- other animals (state) [ ]

2. through theft [ ]

3. through straying in mountains [ ]

4. are these losses significant YES | NO

please estimate numbers per year

.... small stock

.... large stock

4.6.3.8 If you do/ ...

4.6.3.8 If you do not utilise your veld for grazing, what is the reason?

1. Not interested ☐
2. not profitable ☐
3. undesirable because of impact on the environment ☐
4. stock losses through predation/theft too high ☐
5. unburnt veld not palatable and (1) do not wish to burn because of undesirable effect on veld and/or water supplies ☐

   or (2) burning is not permitted ☐

4.6.3.9 Stock numbers. Please give the number of animals you normally have on the farm, as follows:

1. sheep:
   1. ewes ....
   2. rams ....
   3. hamels ....
2. goats:
   1. ewes ....
   2. rams ....
   3. kapaters ....
3. cattle:
   1. cows ....
   2. bulls ....
   3. oxen ....
4. horses ....
5. donkeys ....
6. other grazers or browsers (state) ....
   ....

4.6.4 Do you use/ ...

4.6.4 Do you use your natural veld for harvesting wild flowers? YES ☐ NO ☐

4.6.4.1 If yes, what system of veld management do you apply?

1.1 Complete protection from fire with system of fire breaks and fire fighting force to extinguish all fires that occur ☐

1.2 Periodic controlled burn - every 4 to 6 years ☐

6 to 8 years ☐ , 8 to 12 years ☐ ,

longer (state) .... years ☐

to rejuvenate veld and reduce fire hazard on a systematic basis - ☐

1.3 Intensive harvesting of every saleable bloom or branch to reap maximum profit before the inevitable fire destroys everything, reducing the harvest to nothing for several years ☐

1.4 What measures do you adopt to ensure that the productivity of the veld is maintained or improved e.g. harvest a maximum of 50% of the flower heads per bush or plant. Use only very sharp sterilised pruning shears for harvesting, etc. Please describe briefly.

4.6.4.2 What are the species harvested? Please list in order of importance, and give month(s) of harvesting for each species.

4.6.5.1 Do you derive/ ...

4.6.5.1 Do you derive any income from providing recreational facilities/opportunities for

(a) the general public | YES | NO |

(b) certain individuals | YES | NO |

4.6.5.2 If so what do you provide?

1. picnic facilities, to approved standards
2. camping facilities, to approved standards -
   1. for tents,
   2. for caravans
3. wildland walking
4. camping/or picknicking at undeveloped sites
5. ponies for hire
6. fishing
   1. in stocked dams, for
      1. trout
      2. bass
      3. other species (state)
         ....
   2. in stocked streams, for
      1. trout
      2. bass
      3. other species (state)
         ....
   3. in natural waters for indigenous species such as
      ....
      ....
      ....
7. guided walks
8. bungalows or hutted camps with approved facilities (ablution etc.)

4.6.6.1 How far/ ...

4.6.6.1 How far are you from your nearest neighbour? .... kms

2. How many neighbours have you within (10) km radius? .....

3. How far is it to the nearest tarred road? .... kms

4. How far is it to the nearest:

1. general dealer ....kms
2. butcher .... kms
3. primary school .... kms
4. secondary school .... Kms
5. church .... kms
6. hospital with maternity facilities .... kms
7. district clinic .... kms
8. dentist .... kms
9. doctor .... kms
10. cinema .... kms
11. city .... kms
12. railway station .... kms
13. bus stop .... kms
14. road transport service depot .... kms

4.6.7 What chemicals do you use in your farming operations - brand names will be sufficient.

1. insecticides ....
2. fungicides ....
3. weed killers ....
4. other poisons (please state purpose ....

   ....

5. fumigants

   soil ....

   fruit and seed ....

   buildings ....

6. Fertilisers ....

5. Information/ ...

5. INFORMATION ABOUT THE PEOPLE LIVING ON, AND DEPENDENT UPON THE FARM.

5.1 <u>Farmer</u>

Number of adults (18 yrs+) in farmer's household, (including full time domestics) ....

Number of children (under 18 yrs) ....

5.2 <u>Farm manager 1</u>

Number of adults in household (as above) ....

" " children in " " " ....

<u>Farm manager 2</u>

Number of adults in household (as above) ....

" " children in " " " ....

5.3 <u>Foreman 1</u>

Number of adults (as above) ....

" " children as " ....

<u>Foreman 2</u>

Number of adults (as above) ....

" " children " " ....

5.4 <u>Artisans, Drivers and other skilled workers and their families</u>

Number of adults ....

Number of children ....

5.5 <u>Semi-skilled and unskilled labourers and families</u>

Number of adults ....

Number of children ....

5.6 Squatters or/ ...

5.6 Squatters or tennants wholly or partially supported by the farm

Number of adults ....
" " " ....

6. INVENTORY AND VALUATION OF PERMANENT IMPROVEMENTS

6.1.1 Farm homestead, outbuildings etc.

Item	Replacement cost (R)	Age (yrs)	Estimated annual maintenance cost R
Building 1	....	....	....
B " 2	....	....	....
" 3	....	....	....
" 4	....	....	....
" 5	....	....	....

6.1.2 Management & Supervision(Managers & Foremen) houses and outbuildings

Item	Replacement cost (R)	Age (yrs)	Estimated annual maintenance cost R
Building 1	....	....	....
" 2	....	....	....
" 3	....	....	....
" 4	....	....	....
" 5	....	....	....
" 6	....	....	....
" 7	....	....	....
" 8	....	....	....
" 9	....	....	....
" 10	....	....	....

6.1.3 Artisans/ ...

6.1.3 Artisans etc., houses and outbuildings

Item	Replacement cost (R)	Age (yrs)	Estimated annual maintenance cost R
Building 1	....	....	....
" 2	....	....	....
" 3	....	....	....
" 4	....	....	....
" 5	....	....	....
" 6	....	....	....
" 7	....	....	....
" 8	....	....	....
" 9	....	....	....
" 10	....	....	....

6.1.4 Labour houses and outbuildings

Building 1	....	....	....
" 2	....	....	....
" 3	....	....	....
" 4	....	....	....
" 5	....	....	....
" 6	....	....	....
" 7	....	....	....
" 8	....	....	....
" 9	....	....	....
" 10	....	....	....
" 11	....	....	....
" 12	....	....	....
" 13	....	....	....
" 14	....	....	....
" 15	....	....	....

6.1.5 Buildings/ ...

6.1.5 Buildings leased out

Item	Replacement cost (R)	Age (yrs)	Estimated annual maintenance cost R
Building 1	....	....	....
" 2	....	....	....
" 3	....	....	....
" 4	....	....	....
" 5	....	....	....
	....		

6.1.6 Other buildings connected with supervision & labour e.g. school buildings, community hall, clinic etc.

Item	Replacement cost (R)	Age (yrs)	Estimated annual maintenance cost R
Building 1	....	....	....
" 2	....	....	....
" 3	....	....	....
" 4	....	....	....
" 5	....	....	....
" 6	....	....	....
" 7	....	....	....
" 8	....	....	....
" 9	....	....	....
" 10	....	....	....

6.2 Production buildings: e.g. workshops, sheds, pack stores, pig styes, milk sheds etc.

Building 1	....	....	....
" 2	....	....	....
" 3	....	....	....
" 4	....	....	....
" 5	....	....	....
" 6	....	....	....
" 7	....	....	....
" 8	....	....	....
" 9	....	....	....
" 10	....	....	....

6.3 Water/ ...

6.3 Water supply: e.g. reservoirs, dams, pumphouses, permanent pipe lines, furrows and irrigation systems, boreholes etc.

Item	Replacement cost (R)	Age (yrs)	Estimated annual maintenance cost R
Item No. 1	....	....	....
" 2	....	....	....
" 3	....	....	....
" 4	....	....	....
" 5	....	....	....
" 6	....	....	....
" 7	....	....	....
" 8	....	....	....
" 9	....	....	....
" 10	....	....	....

6.4 Roads & fences, power lines

	Total distance km	Replacement cost R	Age yrs	Estimated annual maintenance cost R
roads	....	....	....	....
fences	....	....	....	....
power lines	....	....	....	....

7. RUNNING COSTS

7.1 Management and Supervision

Salaries and value of benefits received, such as farm produce, insurance cover, medical attention, purchased food, entertainment, transport, protective & other clothing, etc.

R ....

7.2 Labour, artisans, skilled & unskilled workers.

Wages and value of benefits as for 7.2 above.
Recruitment & registration etc. R ....

7.3 Vehicles,/ ...

7.3 Vehicles, machinery and equipment

7.3.1 Transport and administrative vehicles:
Depreciation or hire charge, maintenance, servicing, fuel, lubricants, tyres, batteries, etc. R ....

7.3.2 Other vehicles, tractors, combines, pumps, welding and lighting plants, etc. Total costs as for 7.3.1 above R ....

7.4 Interest on bonds, loans, overdraft, etc. R ....

7.5 Purchases

1. Expendable tools and materials R ....
2. Spray materials R ....
3. Fertilisers R ....
4. Weed killers & other chemicals R ....
5. Stock, poultry & other feeds R ....
6. Other R ....

7.6 Hired transport, cartage, road or rail transport of goods farm produce, stock or personnel R ....

7.7 Divisional council rates R ....

7.8 Miscellaneous other costs

Bank charges	R ....
Telephone charges	R ....
Electricity charges	R ....
Bookkeeping & audit	R ....
Membership Agric. Assoc. or Union	R ....
Membership of Co-op.	R ....
Agric. technical publications	R ....
Water, rates & charges	R ....
Stationery	R ....
Technical advice	R ....
Entertainment	R ....
Travelling & Accommodation	R ....
Other	R ....

8. Information/ ...

8. <u>Information about gross income from each farming subdivision</u>

8.1 Deciduous fruit

	1. fresh	R ....
	2. canning	R ....
	3. drying	R ....
2. Citrus fruit		R ....
3. Grape vines		
	1. table grapes	R ....
	2. wine grapes	R ....
4. Sheep		
	1. wool & skins	R ....
	2. slaughter	R ....
	3. breeding,stud fees	R ....
5. Goats		
	1. hair & skins	R ....
	2. slaughter	R ....
	3. breeding,stud fees	R ....
6. Cattle		
	1. slaughter, incl. hides	R ....
	2. dairy produce	R ....
	3. Breeding stock, stud fees etc.	R ....
7. Cereal crops		R ....
8. Vegetables, incl. green mealies		R ....
9. Feed crops,(lucern, hay etc.)		R ....
10. Potatoes		R ....
11. Onions		R ....
12. Poultry, incl. eggs		R ....
13. Pigs		R ....
14. Forestry		R ....
15. Wild flowers harvested from		
1. natural veld		R ....
2. Harvested from plantations or artificially enriched veld		R ....
16. Other cut flowers		R ....

17. Buchu/ ...

17. Buchu
    1. wild R ....
    2. cultivated R ....
18. Bush tea
    1. wild R ....
    2. cultivated R ....
19. Honey and/or wax R ....
20. Provision of recreation facilities or opportunity
    1. Wildland hiking, picnicking and camping at undeveloped sites R ....
    2. picnicking or camping (tents or caravans) at prepared sites with approved facilities (toilets etc.) R ....
    3. Bungalow or cottage hire R ....
    4. Hire of ponies R ....
    5. Hire of guides or labour R ....
21. Land hired out R ....
22. Vehicles, machinery or equipment hired out R ....
23. Contract work carried out R ....
24. Dividends/Interest R ....
25. Other private income R ....
26. Subsidies on fixed improvements or other R ....
27. Insurance received R ....
28. Other (specify) R ....
29. Other animals e.g. horses, donkeys, dogs, rabbits, chinchilla etc. etc. R ....

9. GENERAL INFORMATION ABOUT POTENTIAL

9.1 Is the farm developed to its full potential as far as arable land is concerned? | YES | NO |

9.2 Will you be able to develop it to its full potential | YES | NO |

9.2.1 If not/ ...

9.2.1 If not, what are the reasons?

1. you feel you are too old ☐

2. you have insufficient capital ☐

3. there is insufficient labour ☐

9.3 Is water a limiting factor? | YES | NO |

9.4 What is the total assured volume of water available to you?

1. with dams ....
2. without dams ....

9.4 How much more arable land is there?

1. irrigable .... Ha
2. non-irrigable .... Ha

9.5 How much (more) afforestable land is there? .... Ha

9.6 In your opinion, is there any potential for improving the natural veld for grazing? | YES | NO |

9.6.1 If so, please say briefly how you would suggest this could be done

....
....
....
....
....

10. <u>General comments about State control of mountain catchment areas.</u>

10.1 How has State intervention in land use in mountain catchment areas affected you so far? Please comment freely on separate sheets of paper if necessary.

10.2 How do you feel State control of land use in mountain catchment areas may affect you in future?

10.3 Do you feel/ ...

10.3 Do you feel that State control of land use in mountain catchment areas is desirable or undesirable, necessary or unnecessary. Comment more fully if you wish.

....

....

....

....

....

10.4 Do you agree that it is desirable for conservation areas, including water conservation and nature conservation areas, to be controlled and/or owned by the State and managed for the long term benefit and enjoyment of all?

....

....

....

....

....

10.5 How do you feel about the speculative development of wild lands of low agricultural potential?

....

....

....

....

....

10.6 Other than state ownership or rigid State control of development, how else can it be ensured that the relatively small undeveloped wild area in the Western Cape remains unspoilt for the benefit of all South Africans.

....

....

....

....

....

SB

ADDENDUM

1. How do you market your produce?

1.1 Through a co-op or other organisation ☐

1.2 Arrange your own transactions ☐

2. How far are you from your nearest market depot or railhead ? Please state distance for each product where applicable:

Product	Kms
....	....
....	....
....	....
....	....
....	....
....	....
....	....
....	....
....	....
....	....

3. Do you have marketing problems?
Please discuss briefly.

APPENDIX 7

WILDFLOWER HARVEST : WANDERING QUARTER SURVEY DATA

1. *Protea magnifica*

1.1 Stand condition and density

Condition	Number of plants							%
	Population 1		Population 2		Population 3		Totals	
	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2		
Mature	36	30	6	1	25	21	119	66
Immature	10	5	0	0	23	6	44	24
Unhealthy	1	1	1	0	1	0	4	2
Dead	3	0	5	2	2	3	15	8
Plants/ha	359		185		206			

1.2 Harvesting level

Harvest Year	Population 1		Population 2		Population 3		Mean harvest percent
Current:							
Heads cut	140	(= 59%)	14	(= 34%)	138	(= 56%)	55,9
Heads left	96		27		107		
Total flower heads	236		41		245		
Total mature plants	67		8		49		
Mean heads per mature plant	3,5		5,1		5,0		

Previous:

Heads cut	246	(= 75%)	8	(= 15%)	173	(= 75%)	69,9
Heads left	82		45		57		-
Total flower heads	328		53		230		
Total mature plants	62		8		43		
Mean heads per mature plant	5,3		6,6		5,4		

Earlier:

Heads cut	161	(= 65%)	4	(= 14%)	63	(= 45%)	54,8
Heads left	87		25		76		
Total flower heads	248		29		139		
Total mature plants	52		8		34		
Mean heads per mature plant	4,8		3,6		4,1		

Note:

1. Mean number of heads per plant (n = 331) = 4,9 (say 5)

2. Mean percentage of total crop harvested (n = 331) = 61

3. Mean plant density (n = 399) = 266,25 plants per hectare of populated area.

2. *Protea laurifolia*

2.1 Stand condition and density

Population 1: (n = 79)

Mature plants	:	82,1% (oldest plants over 20 years)
Immature plants	:	13,8% (including 7,5% under 3 years)
Dead plants	:	4,1%
Total plant density	:	755 per ha of populated area.

Population 2: (n = 109)

Mature plants	:	39,6% (oldest plants over 20 years)
Immature plants	:	55,9% (including 12,6% under 3 years)
Dead plants	:	4,5%
Total plant density	:	430 per ha of populated area.

3. *Leucadendron rubrum*

3.1 Stand condition and density

	Population		Means
	1 (n = 50)	2 (n = 79)	
Mature plants : male	54%	55,7%	55%
female	42%	40,5%	41%
Immature plants : male	0	0	0
female	0	0	0
Dead plants : male	2%	0	1%
female	2%	3,8%	3%
Density; plants per ha of populated area	700	629	656

4. General note

Three sites on the western slopes of Groot Winterhoek peak were examined in November 1977 approximately six years after the area had burnt.

Site one had a southerly aspect and carried *Protea repens, P. magnifica* and *P. punctata* in mixture.

Site two had an easterly aspect and carried *P. repens* and *P. magnifica* in mixture.

Site three had a south-easterly aspect and carried *P. magnifica* only.

Each site was within 500 metres of each of the others. Altitude between 1400 and 1500 m, a.m.s.l.

The following counts were made:

P. repens (all post fire regeneration)

	flowered	not yet flowered
Site 1	27	12
Site 2	4	16
Site 3	No *P. repens*	

P. magnifica

	survived fire	killed	dying	seedlings
Site 1	6	1	12	31
Site 2	1	0	0	22
Site 3	3	0	8	23

P. punctata

	survived fire	killed	flowered	not yet flowered	seedling
Site 1	0	7	4	29	0
Sites 2 & 3	No *P. punctata*				

APPENDIX 8

NALYSIS OF SOIL SAMPLES FROM OLD STOCK CAMP SITES AND ADJOINING FYNBOS

ample area	Lab No.	Sample No.	pH (in KCl)	pH (in H_2O)	Resistance (ohms)	P. p.p.m.	Total N %	NH_4-N p.p.m.	NO_3-N p.p.m.	Ox.C. %	K (NH_4OAc) me %	Ca (NH_4OAc) me %	Mg (NH_4OAc) me %	Na (NH_4OAc) me %	Total cation exch.	Dominan Vegetati
angvlei	6073	1	4,1	5,3	4 600	25	0,069	9	2	2,61	0,08	0,94	0,16	0,03	1,21	Cynodon
	6074	2	4,5	5,9	3 550	24	0,069	11	5	2,31	0,26	1,09	0,25	0,05	1,65	Cynodon
	6075	3	4,0	5,3	5 500	7	0,068	9	2	2,68	0,35	0,81	0,30	0,17	1,63	Carpobro
	6076	4	4,3	5,6	5 300	2	0,050	10	1	1,95	0,67	0,57	0,17	0,18	1,59	Fynbos
gterdam	6077	5	3,1	4,4	4 000	4	0,126	14	6	5,80	0,31	1,44	0,25	0,16	2,16	Carpobro
	6078	6	4,4	5,5	4 700	6	0,080	9	4	2,94	0,10	1,92	0,27	0,16	2,45	Cynodon
	6079	7	4,2	5,2	4 400	3	0,083	7	2	3,34	0,08	0,67	0,16	0,16	1,07	Fynbos
Driebosch	6080	8	4,2	5,4	4 000	5	0,092	10	1	3,42	0,09	1,54	0,35	0,18	2,16	Cynodon
	6081	9	4,5	5,5	5 500	3	0,094	9	2	3,82	0,10	1,64	0,30	0,23	2,27	Cynodon
	6082	10	4,5	5,7	4 800	2	0,099	11	1	3,23	0,12	1,32	0,31	0,21	1,96	Fynbos
Means	$\bar{x}$ = fynbos		4,3	5,5	4 833	2	0,077	9	1	2,84	0,29	0,85	0,21	0,18	1,54	
	$\bar{y}$ = stock camps		4,1	5,3	4 550	5	0,085	10	3	3,37	0,18	1,34	0,27	0,14	1,93	
Rank order of means			$\bar{x} > \bar{y}$	$\bar{x} > \bar{y}$	$\bar{x} > \bar{y}$	$\bar{x} < \bar{y}$	$\bar{x} < \bar{y}$	$\bar{x} < \bar{y}$	$\bar{x} < \bar{y}$	$\bar{x} < \bar{y}$	$\bar{x} > \bar{y}$	$\bar{x} < \bar{y}$	$\bar{x} < \bar{y}$	$\bar{x} > \bar{y}$	$\bar{x} < \bar{y}$	
Significance level of difference of means			ns	ns	ns	P<5% P>2,5%	ns	ns	P<20% P>10%	ns	ns	P<20% P>10%	ns	ns	ns	

Note: ns = not significant
P <5%
P >2,5% = significant at 5% level but not at 2,5% level

APPENDIX 9

A DESCRIPTION OF THE DEVELOPMENT OF GIBSON'S MODEL, TAKEN FROM GIBSON (1975).

1. "Scoring Model Definition

The general scoring model is based upon a combination of the three factors just discussed (critical, objective and subjective factors). For each unit i and each planning alternative (land use alternative) j, a preference index, PIij, is defined as follows:

$$PIij = CFMij \;.\{Xj \;.OFMij + (1-Xj).SFMij\} \quad \text{... (Equation 1)}$$

"where CFMij = the critical factor measure for management unit i, planning alternative j
(CFMij = 0 or 1)

OFMij = the objective factor measure for management alternative i, planning alternative j
($0 \leq OFMij \leq 1, \sum_j OFMij = 1$)

SFMij = the subjective factor measure for management unit i, planning alternative j

$(0 \leqslant SFMij \leqslant 1, \sum_j SFMij = 1)$

Xj = the objective factor decision weight for planning alternative j
$(0 \leqslant Xj \leqslant 1)$

"Each of these terms is discussed below. By definition, given a planning alternative, those units with a high preference index are preferred over those units with lower indexes. It is also implicit ... that high values imply preference ...

"<u>Derivation of Factor Measures</u>

"<u>Critical factor measure</u>. To determine the preference index of a unit for a planning alternative, the four terms of Equation 1 must be evaluated. The first of these is the critical factor measure, which is defined as:

$CFMij = \prod_k CFIijk$ ... (Equation 2)

where CFIijk is defined as the critical factor index for management unit i, alternative j, with respect to critical factor k . A critical factor index is either one or zero depending upon whether the alternative j is excluded from consideration for management unit i on the basis of that critical factor or not. Note that if any critical factor index for a given unit and alternative is zero, then CFMij and PIij in turn are zero, thus indicating that the alternative should be excluded from further consideration for that unit. Therefore, if unit i is to receive a non-zero preference index for alternative j, the critical factor indexes for that alternative must all be one.

"Objective factor measure. By definition, all `Objective Factors´ can be measured in or converted to a common quantitative unit such as dollars. However, in order to insure compatability between objective and subjective factor measures, objective factor costs are converted to dimensionless indexes. The objective factor measure for management unit i, alternative j, in terms of objective factor costs, is defined as:

$$OFMij = \{OFCij \cdot \sum_i (1/OFCij)\}^{-1} \quad \ldots \text{(Equation 3)}$$

where OFCij is the total objective factor cost for management unit i, alternative j. For a given planning alternative, development of Equation 3 is based on three restrictions: (1) the unit with the minimum cost must have the maximum measure, (2) the relationship of the total objective factor cost for each unit as compared to all other units must be preserved, and (3) the sum of the objective factor measures must equal one. Restrictions (1) and (3) are imposed to ensure that the objective factor measure will be compatible with the subjective factor measure. The consequence of restriction (2) is that a unit with one-half the objective factor cost of another is assigned twice the objective factor measure of the other unit.

"If the objective factor measure is based on a quantifiable unit where magnitude is desired (e.g. profit in dollars), Equation 3 would be replaced as follows:

$$OFMij = \{OFPij \;.(\textstyle\sum_{i} OFPij)^{-1}\} \text{ ... (Equation 4)}$$

where OFPij is the total objective factor profit for management unit i, alternative j.

"<u>Subjective factor measure</u>. The subjective factor measure for management unit i, alternative j, is determined by two quantities: (1) the relative weight (or importance to the evaluation) of each subjective factor, and (2) the weight (or attractiveness) of management unit i relative to other management units for each of the subjective factors given alternative j. Mathematically, the subjective factor measure for management unit i, alternative j, is defined as:

$$SFMij = \textstyle\sum_{k}(SFWjk \;.UWijk) \text{ ... (Equation 5)}$$

where:

SFWjk = the weight of subjective factor k relative to all subjective factors, given planning alternative j

UWijk = the weight of management unit i relative to all units for subjective factor k, given planning alternative j.

"Values of the subjective factor weight, SFWjk, and the unit weight, UWijk, are determined with the aid of a subjective quantification technique referred to as preference theory. Preference theory relies on psychometric methodologies (Guilford, 1954) which derive quasi-quantitative ranks or scores for subjective-type variables. Fascal (1965) presents the method of paired comparisons. Paired comparisons methodologies evaluate factors by comparing them two at a time. When comparing two factors (or units), three ordinal results are possible: (1) the first factor (unit) is considered more important (is preferred over [sic]) in the evaluation than the second, (2) the second factor is considered more important than the first, or (3) both factors are considered equally important .... The corresponding numerical values assigned to each of the aforementioned results are, respectively: (1) 1 for the first factor and 0 for the second, (2) 1 for the second factor and 0 for the first, and (3) 1 for both factors. Factors are compared on a pair-wise basis, recording the appropriate values beside the factors, until all possible two-way comparisons have been made.

"When applying the method outlined above, one should insure that results of the comparison decision are transitive; that is, consistent. For example, if the first factor is deemed more important than the second, and the second is deemed more important than the third, then the first must be more important than the third.

"A preference matrix can be constructed to ease the task of comparing factors ....

"Once preference values have been assigned, the factor (unit) weights are calculated. A factor weight is calculated as the ratio of the number of times a factor was preferred (or) held indifferent to the total number of comparisons made (for n factors, $n!/2!(n-2)!$ comparisons are made".

2. Gibson goes on to describe an alternative to the paired comparisons method. This alternative makes use of the principle of rank order, comparing all factors simultaneously. The method will not be discussed here as the paired comparisons method appears to be simpler to apply and equally effective. Ross (1934) discusses a very effective paired comparisons method and presents a table of optimum orders for the listing of pairs to be compared. However, this method will not be followed up here either, as Gibson's method, while not as sensitive, is adequate and fits in with the rest of his "model".

3. Gibson continues:

"The procedures described above are used to determine: (1) the relative importance of each subjective factor k, given planning alternativej, SFWjk, and (2) the relative preference of each management unit i to subjective factor k, given planning alternative j, UWijk.

"<u>Objective facotr decision weight</u>. The last term of Equation 1 to be ascertained is the objective factor decision weight for planning alternative j, Xj. This term represents a measure of the relative importance assigned, or weight given, to the objective factors in selecting the most preferred management unit for planning alternative j (recall $0 \leqslant Xj \leqslant 1$). Since a high degree of subjectivity is involved in the determination of the value of Xj, the sensitivity of the preference indexes to changes in the objective factor decision weight should be tested.

"<u>Redefinition of Model</u>.

"The value of each management unit´s (i) preference index for a given alternative j, PIij, is now redefined in terms of the factors just discussed:

$$PIij = \{\prod_k CFIijk\} . \{Xj . \{OFCij . \sum_i (1/OFCij)\}^{-1} + (1 - Xj) . \sum_k (SFWjk . UWijk)\} \ldots \text{(Equation 7)}$$

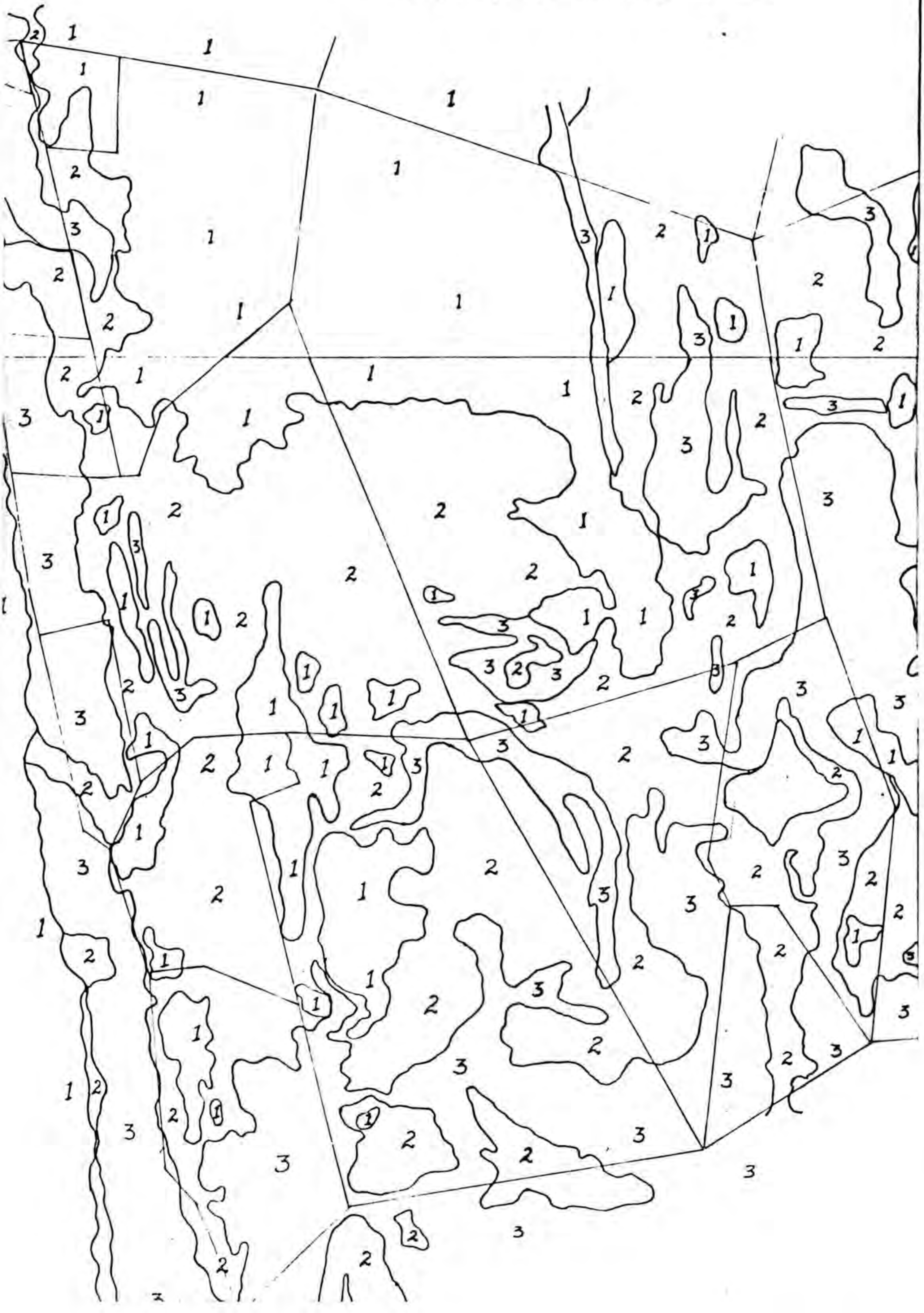
"Determination of the preference indexes yields a ranking of the management units under consideration for various planning alternatives. Those units with larger preference indexes are preferred to those with small prefernce indexes".

4. A multi-use vector can now be defined for each management unit. The components are the PIij values.

$$MUVi = (PIi1, PIi2, \ldots PIij \ldots PIiJi) \ldots \text{(Equation 8)}$$

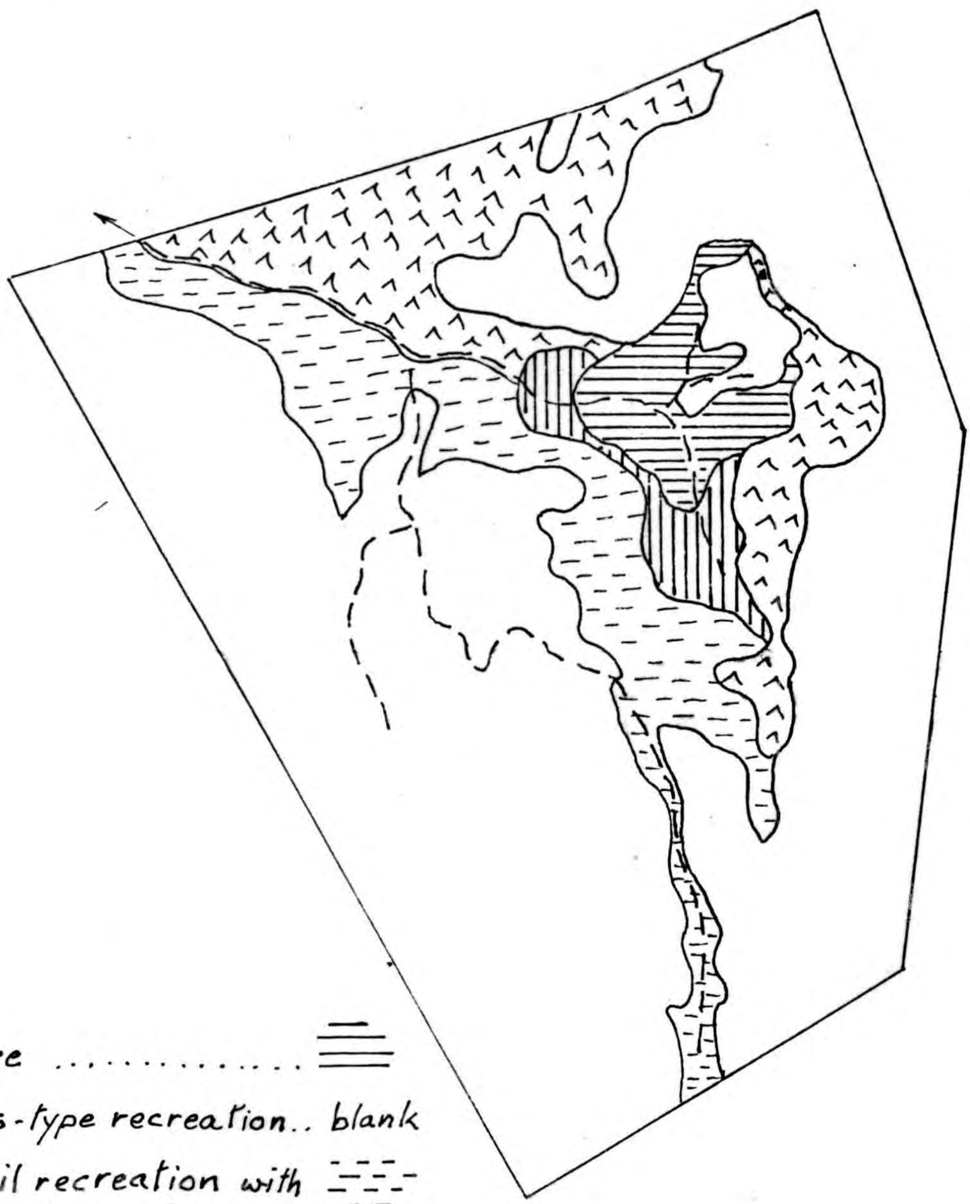
P 13 Slope

Moderate slopes ≤ 1:5 (11°) 1
Steep slopes ≈ 1:5 to 1:2 (11° to 27°) 2
Very steep slopes ≈ > 1:1,2 (40°) 3



MAP 16 Perdevlei optimum land use

1:50 000



Key

Agriculture ....

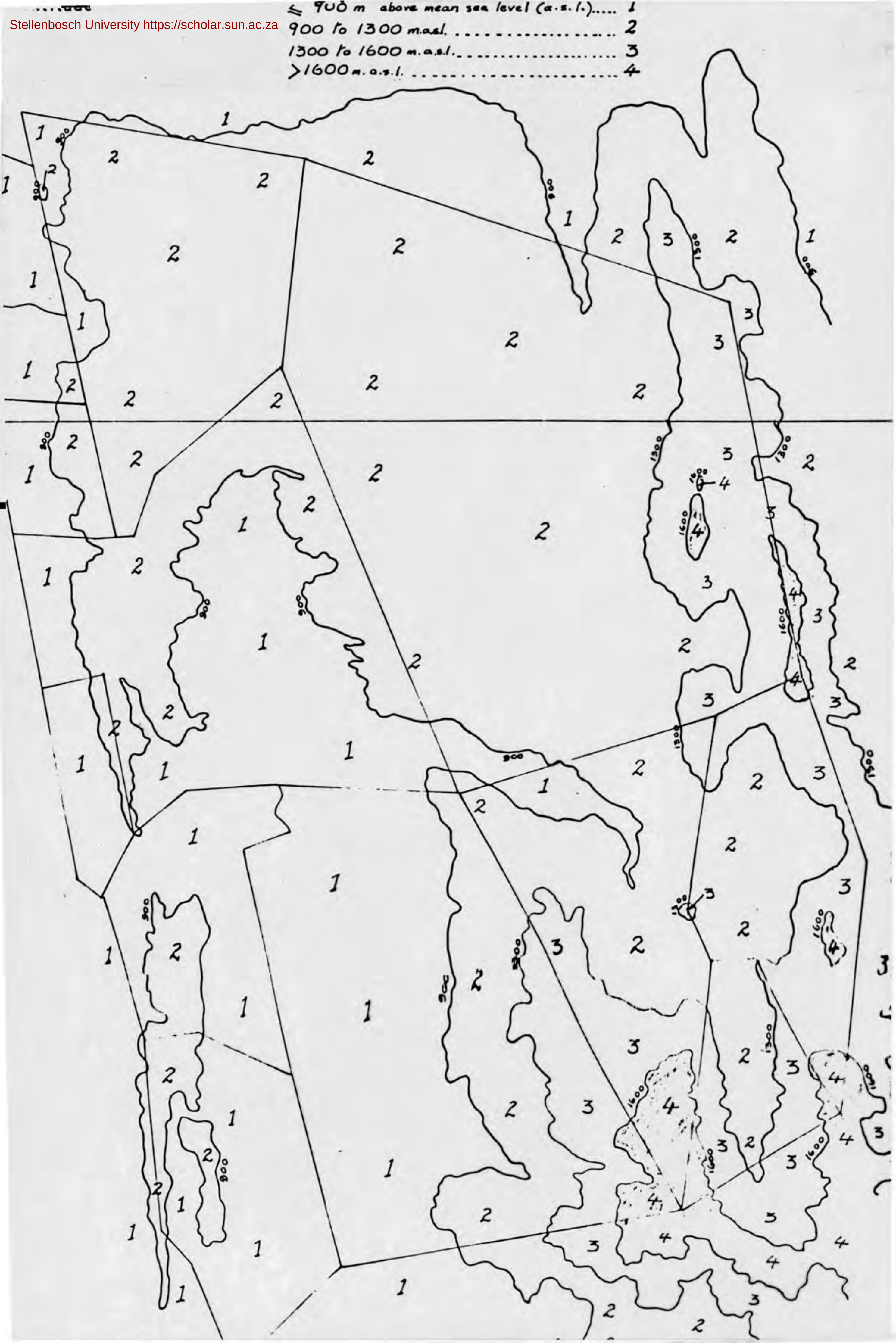
Wilderness-type recreation.. blank

Hiking trail recreation with wild flower harvesting ....

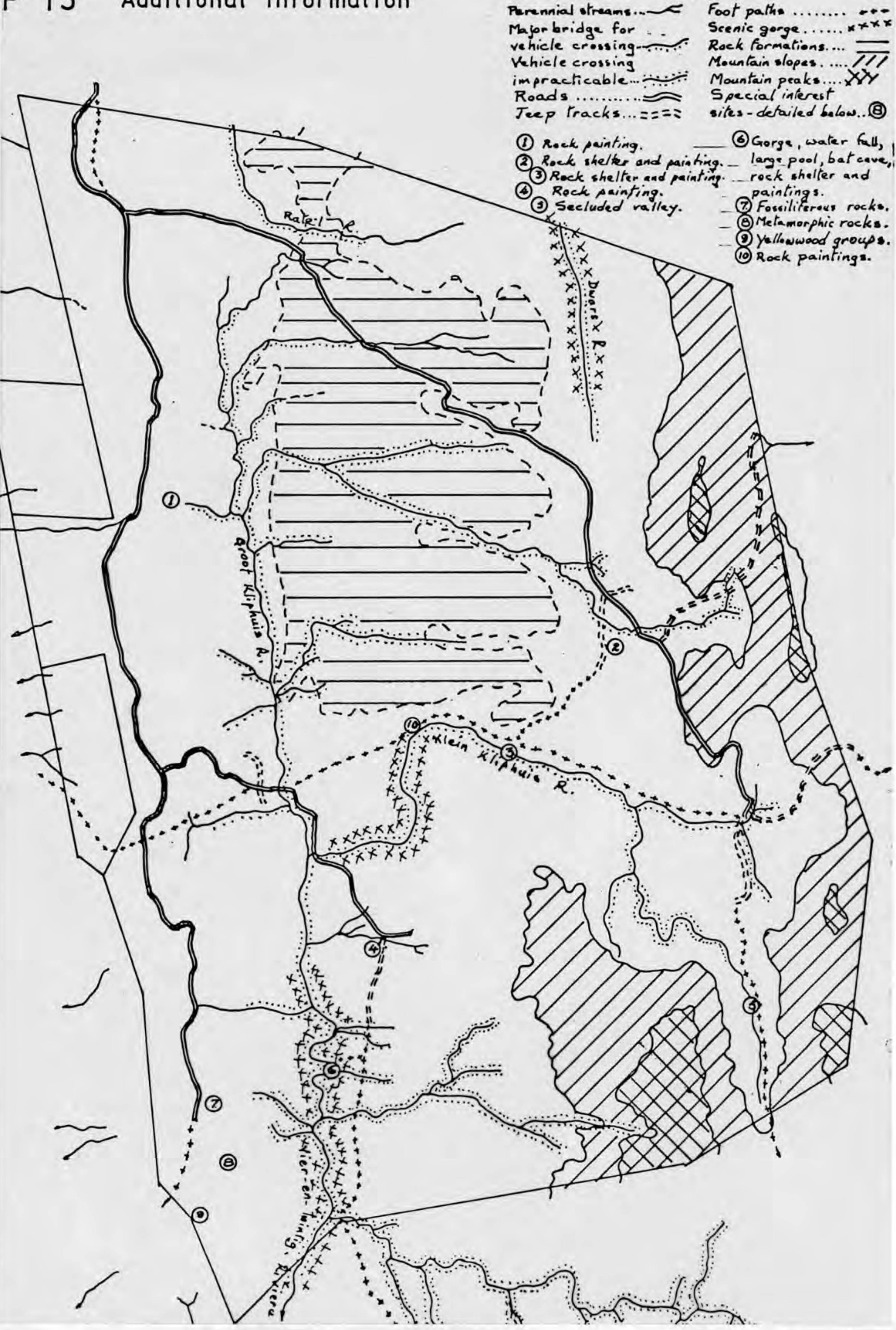
Vehicle access recreation with wild flower harvesting..

Holiday homes with wild flower harvesting.....

Stream ....

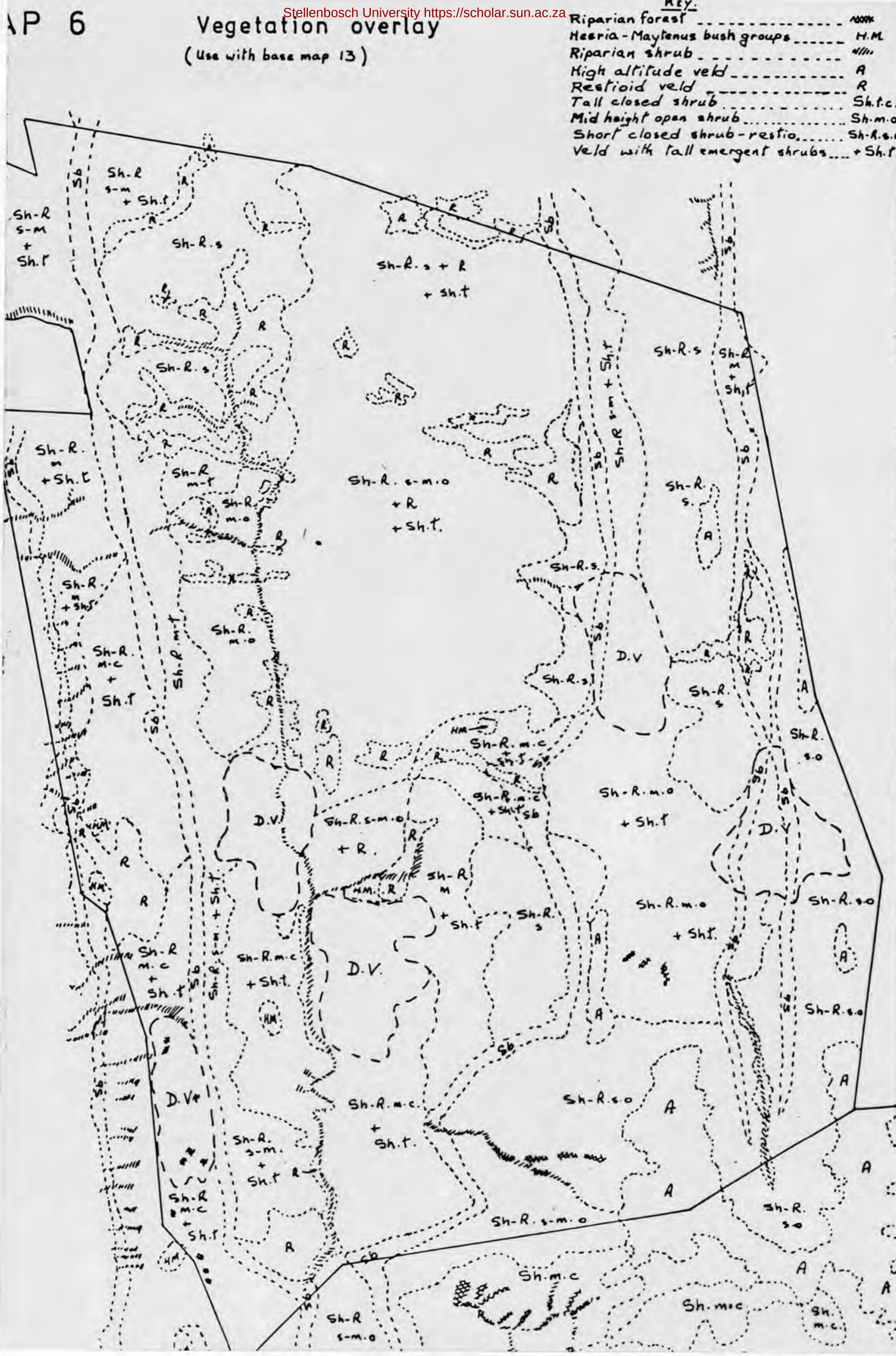

≤ 900 m above mean sea level (a.s.l.)..... 1
900 to 1300 m.a.s.l. 2
1300 to 1600 m.a.s.l. 3
>1600 m.a.s.l. 4

P 15 Additional information



AP 6 Vegetation overlay

(Use with base map 13)



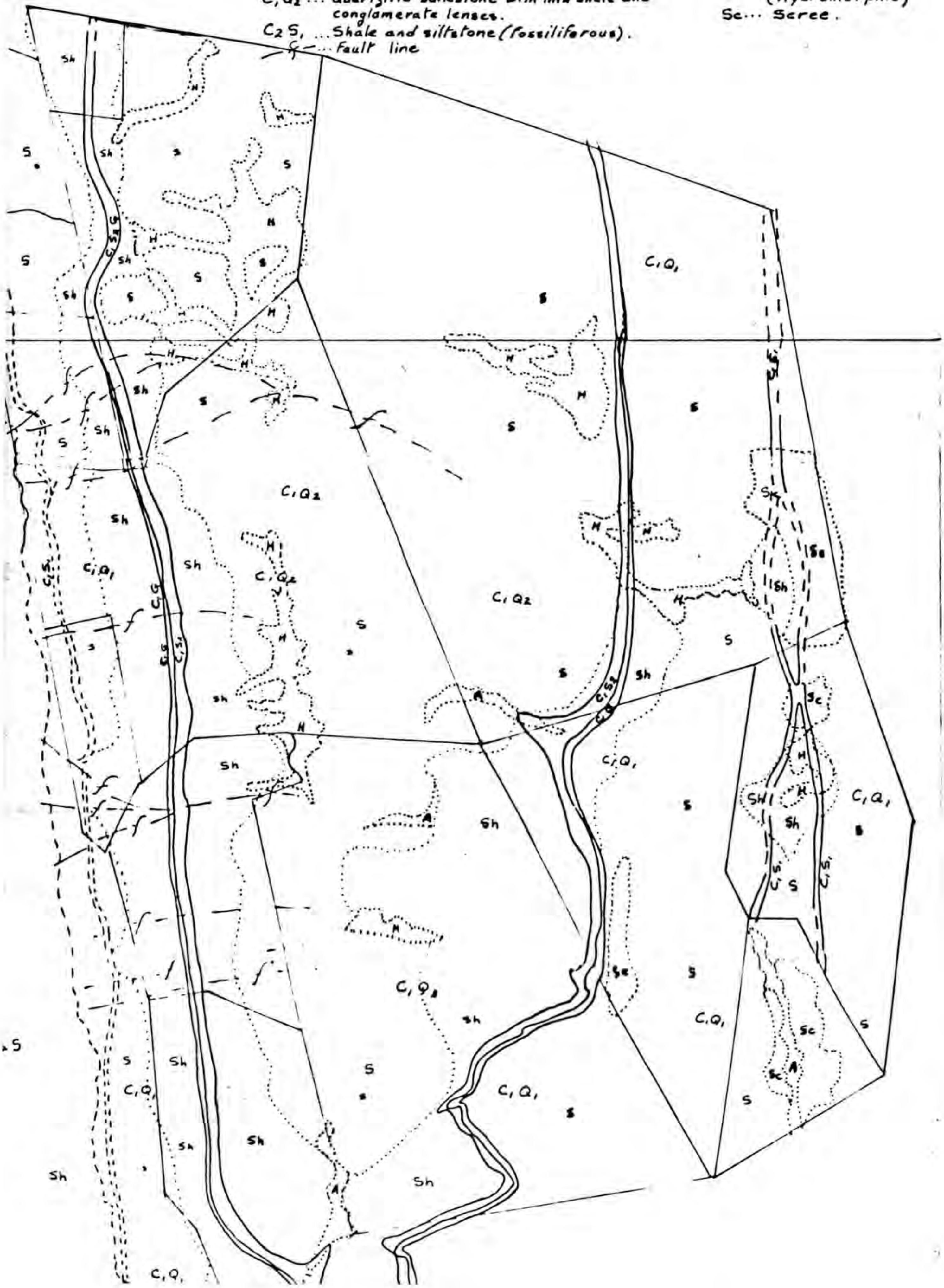
1 **Geology and Soils**

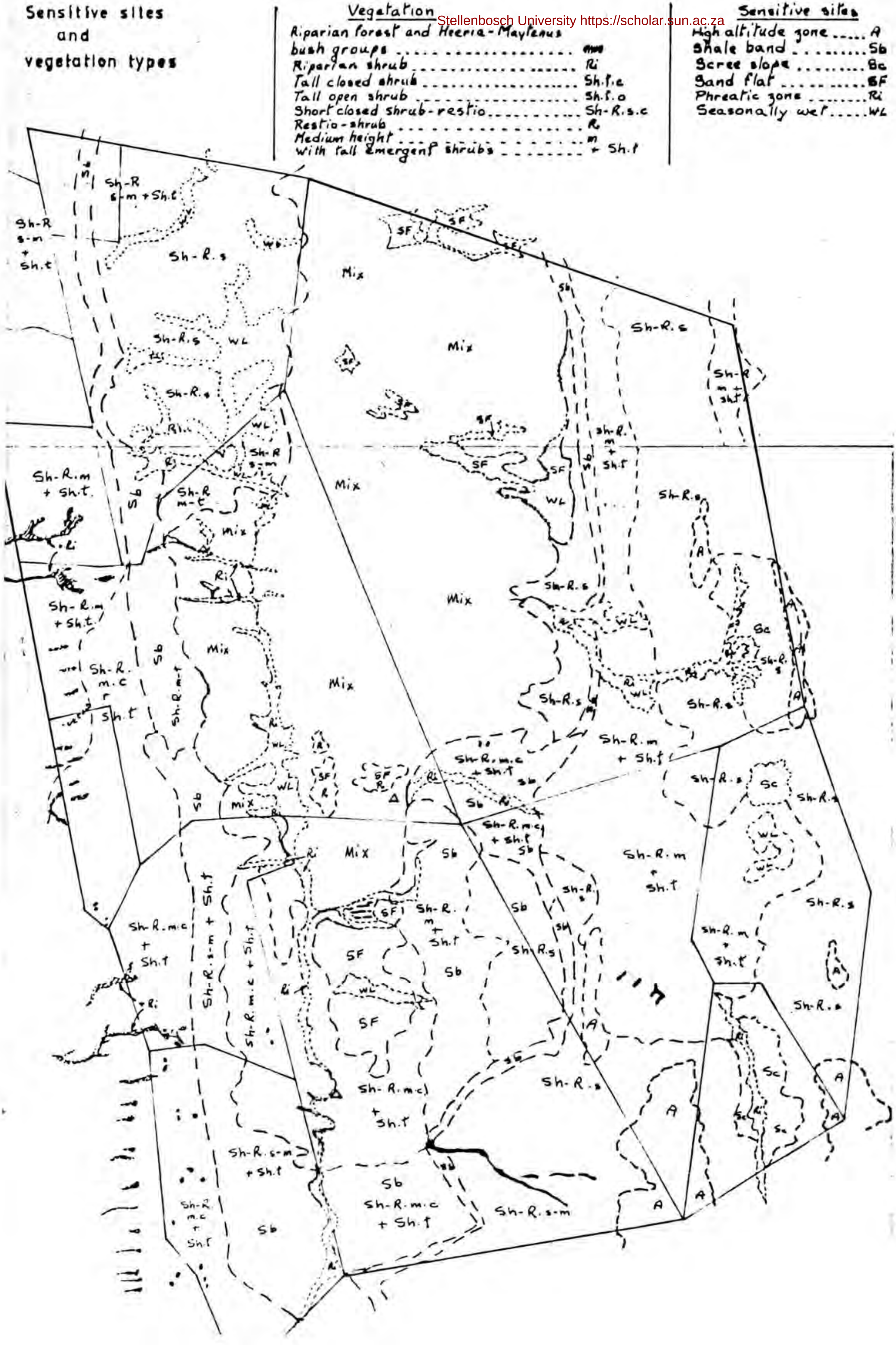
Geology

MaS ... Malmesbury shale.
C_1Q_1 ... Sandstone, minor grit, conglomerate and shale.
C_1S_1 ... Thinly bedded sandstone, siltstone and mudstone.
C_1G ... Tillite, grit and conglomerate.
C_1S_2 ... Shale and arenaceous shale.
C_1Q_2 ... Quartzitic sandstone with thin shale and conglomerate lenses.
C_2S_1 ... Shale and siltstone (fossiliferous).
f ... Fault line

Soils

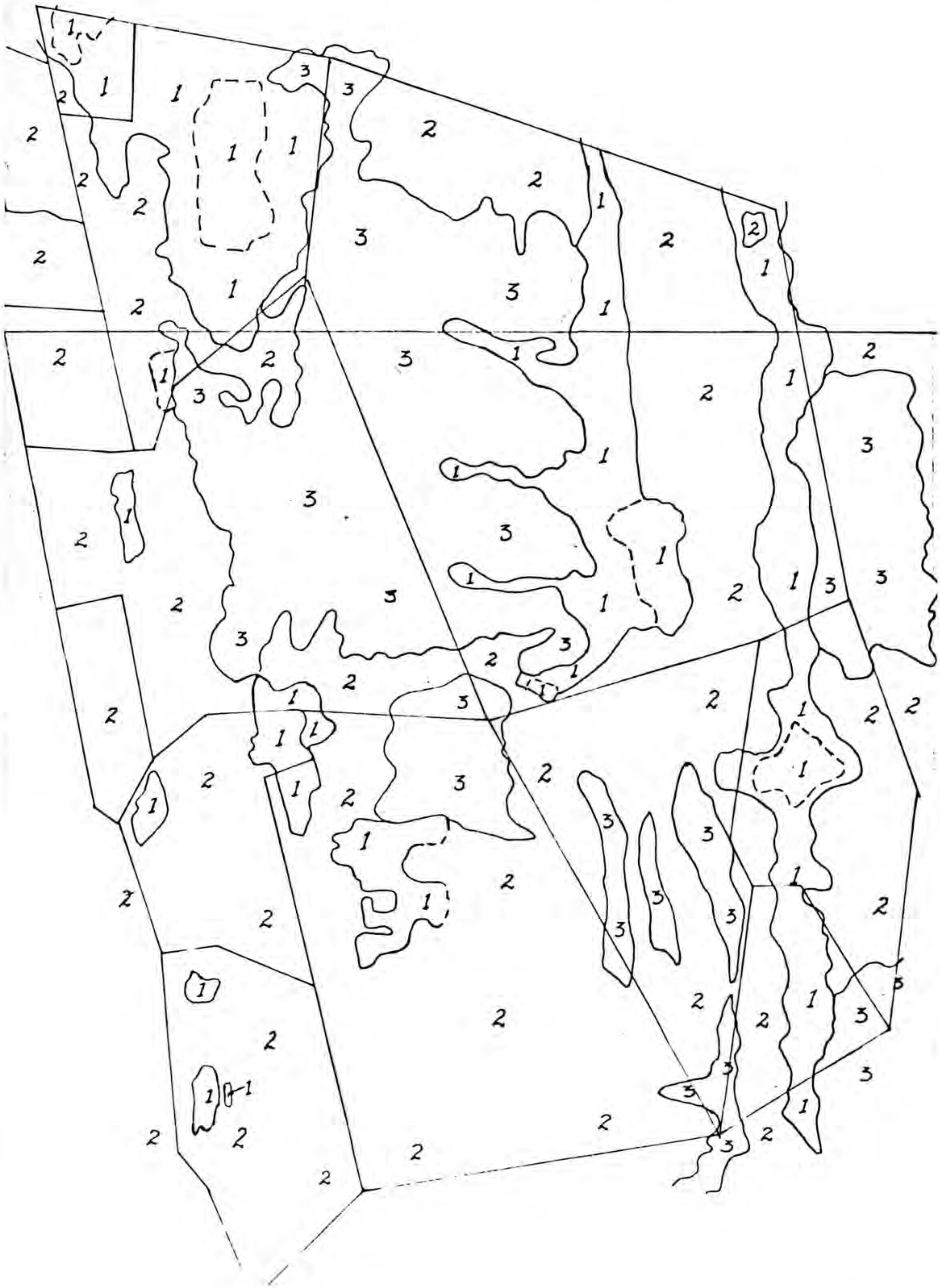
Sh ... Shale derived
S ... Sandstone or quartzite derived.
A ... Alluvial
H ... Seasonally wet (Hydromorphic)
Sc ... Scree.




Sensitive sites and vegetation types
Vegetation
Riparian forest and Heeria-Maytenus bush groups
Riparian shrub ... Ri
Tall closed shrub ... Sh.t.c
Tall open shrub ... Sh.t.o
Short closed shrub-restio ... Sh-R.s.c
Restio-shrub ... R
Medium height ... m
with tall emergent shrubs ... + Sh.t
Sensitive sites
High altitude zone ... A
Shale band ... Sb
Scree slope ... Sc
Sand flat ... SF
Phreatic zone ... Ri
Seasonally wet ... WL

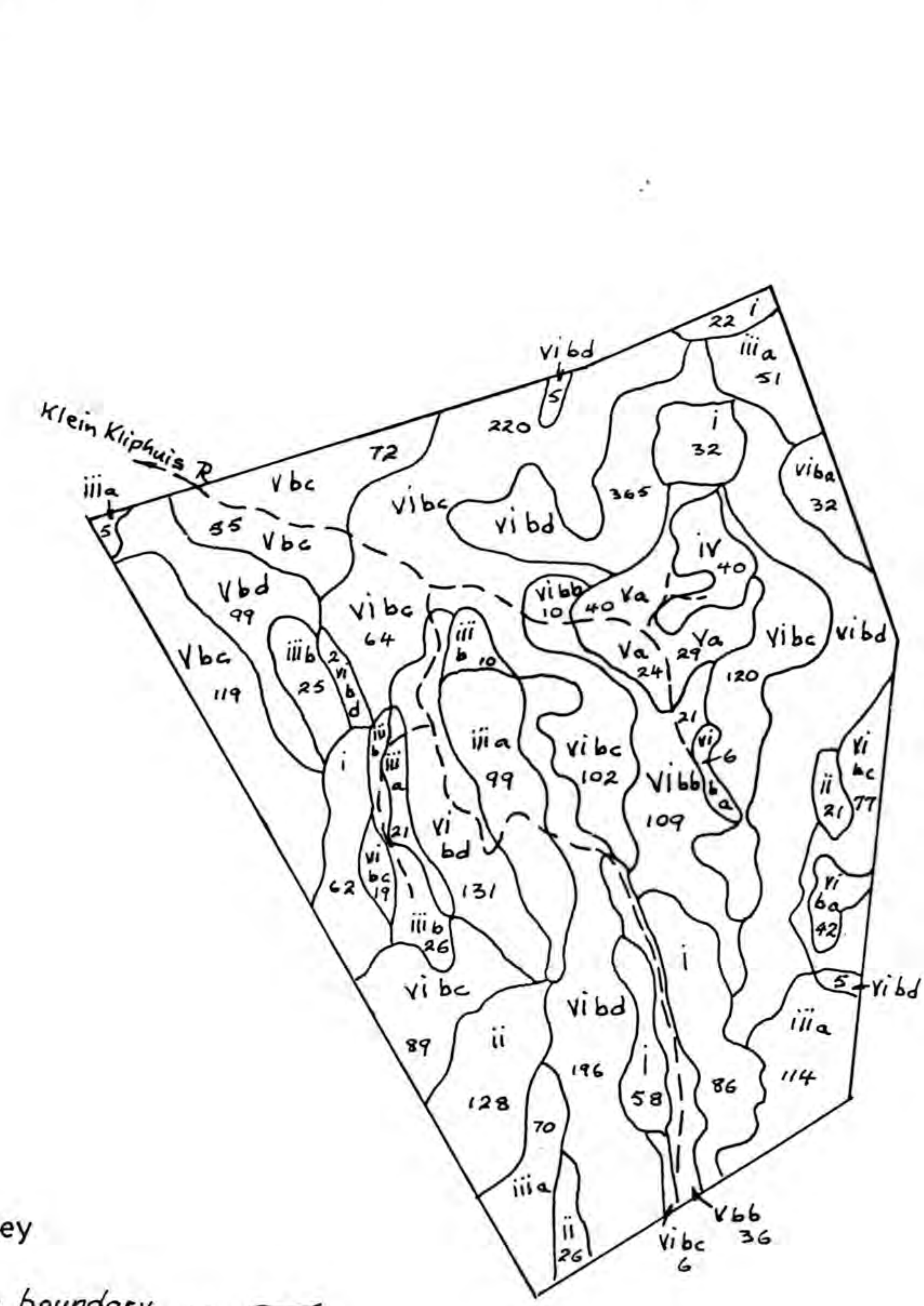
Rockiness

Little or no rock ; < 25% surface rock 1
Moderately rocky ; 25% to 60% surface rock ... 2
Very rocky ; > 60% surface rock 3



MAP 14 Perdevlei ecotopes

1:50 000



Key

Ecotope boundary .... ~~

Stream .... - - -

Ecotope symbol ..... vi bc

Ecotope area (ha.) ... 72