THE EFFECTS OF RECENT LANDUSE ON A FYNBOS SITE

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CONTENTS

ABSTRACT

Landuse from 1920 to 1981 on the Fynbos Biome Research site at Pella, approximately 40 kilometres north of Cape Town, South Africa, and its immediate environs was studied to investigate possible causal relationships between land-use and management practices and the resultant ecosystem.

Fire has constituted the major perturbation in recent history. Prior to 1960 the Fynbos Site was intentionally fired on a 3 to 4 year rotation, possibly effecting net nutrient losses to the system. After 1960, unintentional burning occurred on average every 7 years.

The Fynbos Site has been lightly browsed by livestock from 1920 to 1976 and bushcut between 1965 and 1970, with minimal long-term effects.

Gravel quarry pits were dug in 1971 and subsequently abandoned, constituting disturbed soils prone to colonisation by invasive acacias.

The increase in cultivated land surrounding the site after 1962 served to isolate the fynbos stand from nearby fynbos communities and exacerbate erosion of soils and their subsequent deposition on the Fynbos Site.

Extraneous transformation of land has served to facilitate the progressive encroachment of pest plants, principally *Acacia Saligna* and

A. cyclops, on the Fynbos Site. The uncontrolled spread of these plants poses a severe threat to the persistence of this fynbos stand.

The need to incorporate possible extraneous influences on potential conservation areas into management considerations is discussed, as is the importance of size and shape of a conservation-worthy area and the need to plan viable networks of reserves in the coastal lowlands of the Western Cape.

CHAPTER 1

INTRODUCTION

"Studies of ecosystems on this planet, except for those of very small areal extent, can be neither complete nor valid unless they take account of the pervasive and sometimes overwhelming role played by man's activities."

– Aschmann 1973

1.1 RATIONALE AND OBJECTIVES

Conservation of the Fynbos Biome of the South and South Western Cape is widely identified as having a high priority in South Africa (Edwards 1974; Hall 1978; Louw 1979). Results of a preliminary assessment of the survival status of flora in the coastal lowlands of the Western Cape Province indicate that conservation standards have been much less adequate in this area than elsewhere (Hall in prep.). Of the initial extent of Coastal Fynbos mapped by Acocks (1953) in this area, only 52% remains (Bossi & Moll in prep.); and of the original area of Coastal Fynbos between the Berg River and False Bay a mere 14% remains (Boucher in press). The encroachment of urban areas cultivated land and invasive weeds – in particular *Acacia saligna*, the Port Jackson willow, and *Acacia cyclops*, the rooikrans – is rapidly bringing about a decline in the extent and condition of the remaining communities which are primarily utilised as natural grazing for livestock. Of the existing three reserves in this particular veld type, only about 12 ha (hectare) are considered to be pristine fynbos; the remaining 26 or so ha are invaded by alien vegetation (Ashton *et al.* in prep.). The future of Coastal Fynbos in the South Western Cape lowlands is clearly in the balance and begs attention.

In the preliminary synthesis on fynbos ecology (Day *et al.* 1979) one of the more important issues deserving attention was that of present and past patterns of landuse in the biome. In addition, the practice of grazing with attendant burning practices on indigenous vegetation was noted as being poorly understood. Although management policies for fynbos systems have been formulated, these have tended to focus on burning regimes in forestry reserve areas and the history of landuse and management practices in fynbos on farmland is a virtually unexplored field.

The Pella Research site of the Fynbos Biome Project is a component of Acocks (1953) veld Type No. 47; Coastal Fynbos on sand of the West Coastal forelands, and has been proposed as a conservation worthy area (Ashton *et al.* in prep.). It lies on Portion 2 of Burgher's Post, farm No. 754 in Groenkloof East or district No. 4 of the Malmesbury Division (see Figs. 1 & 2). The site is located in 3318 DA, near to the Moravian Mission Village of Pella, and is marked by survey beacon CF 7.3.

As the site has been hired for research purposes by the CSIR since July, 1979, it is currently an area of intensive multi-disciplinary study. Little is known of the history of landuse on the Pella site, of management practices employed in its utilisation as farmland or of external influences which may have affected the condition of the site. As a representative portion of remaining Coastal Fynbos in the South Western Cape lowlands it offers a unique opportunity for a retrospective landuse study.

An historical perspective of landuse, management practices and external influences on the Pella site should aid the current interpretation of existing variables on this site. Furthermore, it was hoped that the study might serve as an historical analogy for extrapolation to present and future management of this and comparable fynbos sites, thereby promoting optimal management and conservation of this particular veld type with its associated fauna.

1.2 A BRIEF HISTORY OF LANDUSE IN THE AREA

The decision to use agricultural land for cropping or pasturage will depend on the nature of the soil and the availability of water. Contemporary events, economic incentives and changing awareness as to the consequences of past landuse with the concomitant introduction of restrictive legislation will undoubtedly affect decisions on landuse.

The Pella site lies in the sandy west coastal region from Cape Town to Namaqualand, commonly known as 'Sandveld' (Wellington 1955). In order to furnish an introductory setting to the study a brief description of landuse potential in this area, with an account of constraints and major influences on such landuse, is given below.

The light sandy soils of this region are extremely prone to wind erosion when deprived of protective vegetation cover through cultivation or repeated firing and, being of low water-retaining capacity, are ill suited to grain farming on a large scale (Talbot 1947). The soils are generally deficient in phosphorous and nitrogen, and there are deficiencies in trace elements, especially copper, cobalt and manganese (Louw 1969; Schutte 1960). The natural veld is not very productive of food for mammals (Bigalke 1978) and is regarded by farmers as poor grazing for livestock. The nutritional problems associated with using the veld as grazing are aggravated by the scarcity of water sources in many areas. In summary, the agricultural potential of the area is limited.

Prior to 1880, sheep-raising formed the main source of the farmer's income in the Sandveld (Talbot 1947). However, the problems with wheat importation after the Great War (1914-1918) (Dept. of Agriculture 1918), coupled with the Wheat Importations Restrictions Act of 1930 which stabilized domestic prices for wheat at levels well above free world prices, served as a powerful incentive to farmers to plough up unsuitable soils and cultivate grain (Talbot 1971).

On the outbreak of World War II in 1939, it became imperative to produce sufficient wheat to support the Union's needs, hereby improving the earlier trend to clear all potentially waste land for grain cropping. Although the disadvantages of cropping poor sandy soils were periodically brought to attention (Leppan 1923; Grosskopf 1940) new fields on light soils susceptible to wind erosion continued to be ploughed. A side effect of this intensified cultivation of land and the reduced crop rotation on farms was the tendency to encourage overstocking on the remaining veld.

Although the Sandveld was less affected by this period of over-exploitation of soils than the Swartland areas, it too exhibited increasing evidence of erosion, especially wind erosion (Talbot & Talbot 1968).

Reaction to the over-exploitation of soils in, among others, the coastal lowland areas took the form of a White Paper on Agricultural Policy which introduced the concept of 'Conservation Farming'. The subsequent promulgation of the Soil Conservation Act of 1946, appropriately hailed as a declaration of war on soil erosion, ushered in a new era of farming in South Africa (Rabie 1976). This reflected a growing awareness in, and need for, control over both soil and veld degradation, and a need for revaluation of past management practices. Recently, there has been a shift back to more mixed farming in the Sandveld, with small-scale grain cultivation complementing the farming of livestock - mainly sheep and cattle. Nonetheless, an estimated 45% of natural grazing land had been ploughed by 1979 (Viljoen 1979) and this figure is felt bound to increase.

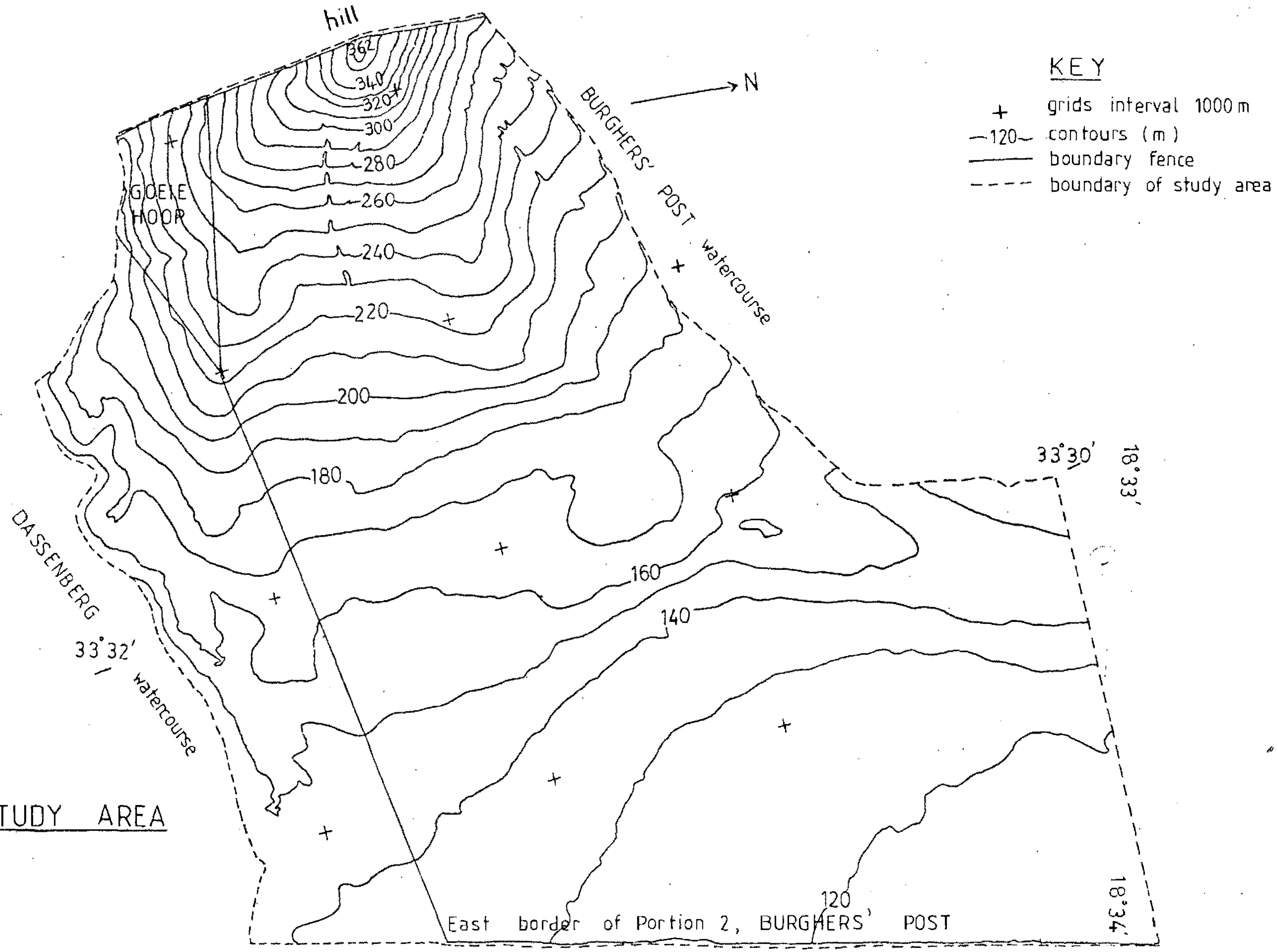

FIGURE 1: STUDY AREA

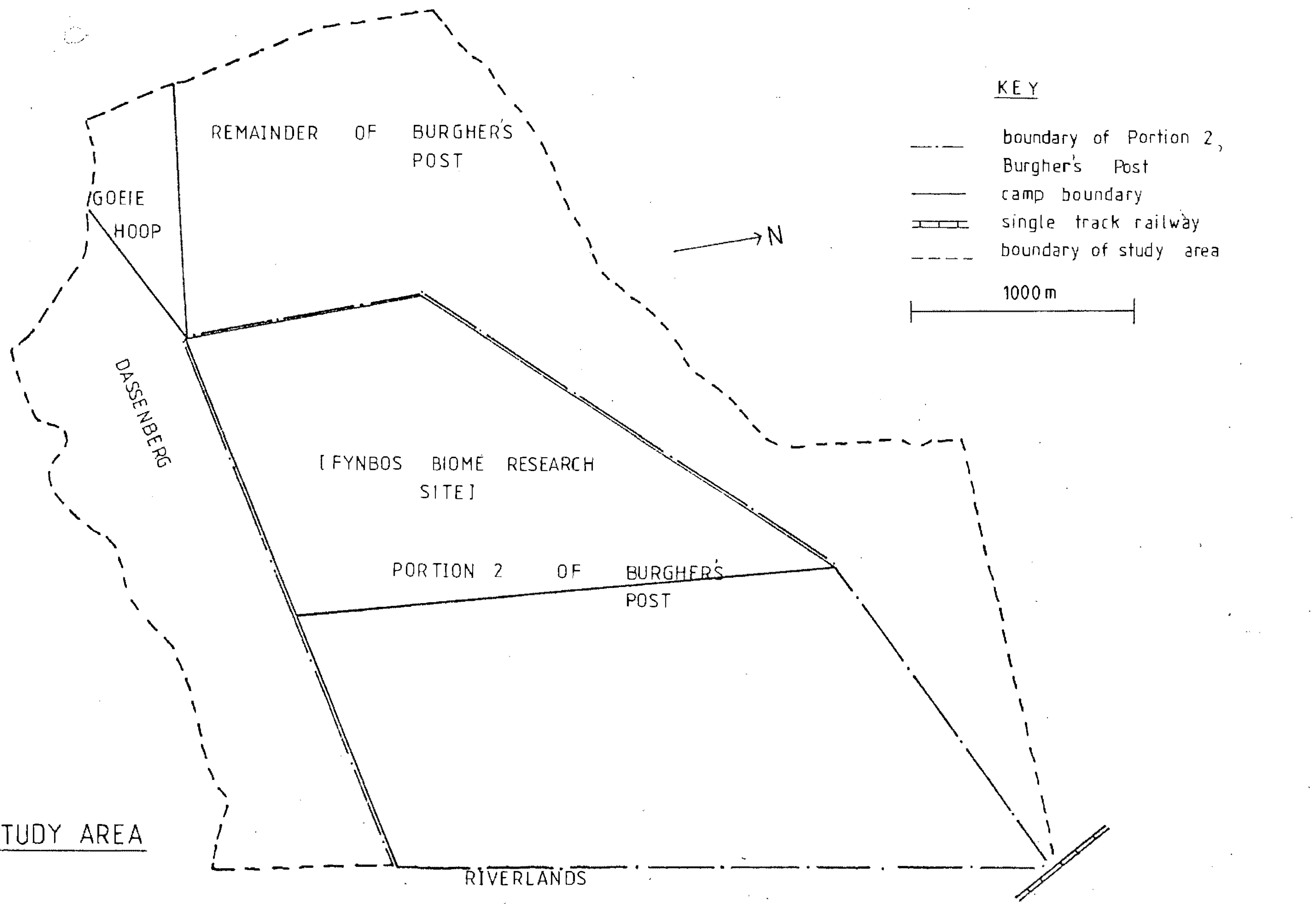

FIGURE 2 : STUDY AREA

CHAPTER 2

METHODS

To facilitate the compilation of a comprehensive account of the history of the Pella site it was decided to restrict the time span of study to that of available aerial photograph records and of literature pertaining specifically to the fynbos. As the earliest air photographs of the area were taken in 1938 and the bulk of literature on fynbos ecology dates from 1920 (Jarman *et al.* 1981), the study period was fixed at from 1920 to 1981 inclusive.

It is felt to be imperative at the outset to define the terms 'land' and 'landuse' as employed in this study. 'Land' was taken to include the soils, flora and fauna peculiar to the area; 'landuse' to encompass both naturally-occurring and anthropogenic events or activities which may have served to modify the status of such 'land'.

Data for the study were collected from two broad sources: (1) historical information, and (2) scientific data. The sequence of collection of relevant information is as presented below; in most instances consecutive steps are reliant on data from earlier steps in the collection procedure for direction or explanation. The objectives of data collection were to identify those elements of 'landuse' (as defined above) both on and adjacent to the Fynbos Biome Research site and monitor the temporal effects of such 'land-use' on the soils and vegetation principally through the medium of aerial photograph interpretation, and on fauna through historical documentation and information gleaned from interviews.

2.1 HISTORICAL INFORMATION

2.1.1 The Deeds Office

The history of land ownership was traced through the respective deeds of transfer, and any conditions of ownership and servitudes pertinent to the site were recorded.

2.1.2 The Cape Archives Depot

Material from the Deeds Office furnished a number of subject leads for investigation: names of landowners, names of farms in the immediate vicinity of the Fynbos Biome Research site, the subject matter of conditions and servitudes as well as agricultural activities in the region constituted some of these. Government records, especially Divisional Council minutes from both the Malmesbury and Cape areas proved helpful. Where newspaper articles judged to be relevant to the study were cited these were consulted, as were proclamations and provincial ordinances.

2.1.3 Moravian Mission Archives

Mission records and annual reports from both the Mamre and Pella stations were searched for pertinent information.

2.1.4 Libraries

Literature from the South African Library and the African Studies Division of the University of Cape Town Library contributed to general information on landuse and major happenings in the Sandveld/Mamre area.

2.1.5 Interviews

All past and present landowners of the site (and their wives), or their living relatives, were questioned in depth on the subject of landuse using the written guide-sheet shown below. Aerial photographs were taken to these informal interviews to indicate the exact area of study and to facilitate the identification of disturbances evident on these photographs.

Written guideline used in interviews:

1. Rainfall: What is the expected annual rainfall?
   Have there been any years of particularly high or low rainfall?
   What, if any, were the effects of these?

2. Nature of landuse: What was the land used for?
Why was it used in this way?

3. Management practices: (depending on (2)) What animals were kept?
What were the stocking rates?
Was a rotation of cropping/grazing employed?
Was the veld burned? If so, how often? When?
Were livestock grazed on the veld immediately following a burn?
What, if any, other activities were carried out to ameliorate grazing? When? How often?
Were pesticides sprayed on croplands? When? How often? Which pesticides?
Were fertilizers employed on cropland? Which fertilizers?

4. Accidental fires: Can you recall any years of fire on or in the vicinity of the site?
How frequent were such fires?
Did they occur in any particular season?
What were likely causes of fires?
Were attempts made to curb the spread of such conflagrations?

5. Soil erosion: Were there problems with gully and/or wind erosion in the area?
Were there any specific areas which were

particularly susceptible to erosion?

Can you remember any years of aggravated erosion?

6. Alien vegetation: When were alien plants first noted?

Which alien plants occurred in the area?

Where?

Was the spread of these plants counteracted in any way?

7. Fauna: What wild animals occur in the area?

Were any animals hunted or destroyed as vermin?

8. External influences: Did local inhabitants or extraneous livestock trespass on the land or damage it in any way?

Were there any incidents of poaching or flower picking in the area?

Can you suggest any other possible influences?

Farm managers were similarly questioned, as were persons considered to be knowledgeable about the area. Any farm or personal records specific to the site were noted.

In addition to the above, the agricultural extension officers for the Malmesbury and Cape areas, Moravian church ministers (past and present) and a number of residents at the Pella village were interviewed in connection with the study.

2.1.6 Scientific articles

The content of and comments on articles written on a particular landuse or management topic over a period of time can be invaluable as a measure of changing attitudes and awareness. In this way, 'scientific' data can constitute historical information. Any such attitude changes encountered whilst referencing scientific articles (see section 2.2), were recorded.

Problems in the search for historical information on the Pella Research site focused on the paucity of data specific to the actual site. Although general accounts of landuse and agricultural practices in the area were found to be adequate, farm records tended to be biased to a financial, 'balance-book' approach and seldom comprised accounts of the more commonplace activities such as livestock rotation to and from camps, exact stocking rates or incidence of veld fires. Interviews frequently yielded apparently contradictory reports and conflicting information and, in the absence of written evidence, it was difficult to extract a clear picture of contemporary activities.

The site is situated in the Divisional Area of Malmesbury and, lying in the Sandveld, is atypical of the vast majority of Swartland farms. For this reason past statistical records and census data reflecting trends in landuse in the Malmesbury division cannot be considered applicable to the research area.

2.2 SCIENTIFIC DATA SOURCES

2.2.1 Winter Rainfall Region of the Department of Agriculture and Fisheries

As the Burgher's Post weather station ceased to function after 1976, it was decided to include other stations in the locality to obtain some degree of continuity of data and an idea of general rainfall trends.

Rainfall figures for the study area were obtained from the following stations for the years given in parenthesis:

Weather Station	Latitude	Longitude	Altitude
Burgher's Post (1928-1976)	33°30'	18°32'	183 m
Malmesbury (1928-1978)	33°27'	18°44'	152 m
Grasrug (1980, 1981)	33°28'	18°50'	213 m
Philadelphia (1941-1981)	33°40'	18°35'	76 m

The mean annual rainfall for Coastal Macchia is 448,2 mm with a standard deviation of 80,68 mm (Fuggle 1981). Where the total annual rainfall values from at least 2 of the above weather stations exceeded one standard deviation from this mean in any particular year, this year was isolated as having had either exceptionally high or low rainfall. The given maxima (either daily or monthly) were studied for a measure of the intensity of precipitation. A higher intensity would, undoubtedly, have affected the severity of runoff from slopes and thus may be correlated with any observation or aggravation of rill or gulley erosion. A prolonged dry spell may, in contrast, have exacerbated wind erosion. The prime object of studying rainfall figures was, therefore, to isolate extremes.

2.2.2 Aerial photographs

The following black and white stereo pairs of the site were obtained from the Surveyor General's Office:

Job No.	Strip No.	Photo No.	Date
12638	54	49896/7	Feb/March 1938
	56	49984-49980	
454	11	8198-8200	December 1960
619	10	355-357	April 1968
498/22	4	375-378	? 1972
786	9	0538-0540	March 1977

and from the Survey Department at the University of Cape Town:

2	-	93-103	May 1979

(A set of colour prints was also obtained for the May 1979 photographs.)

Additional black and white photographs of the site were taken in December 1980, but these were not stereopairs and were used to map only the burn pattern and possible signs of soil erosion or deposition (see below).

Photographs ranged in scale from approximately 1:10 000 in 1979, 1:20 000 in 1938, 1:30 000 in 1960, 1968 and 1972 to 1:50 000 in 1977.

It was decided, when undertaking the interpretation of aerial photographs, to restrict the area of study to the Fynbos Biome Research site and the immediate environs. The watercourses to the north and south of the site, the Burgher's Post hill to the west of the site and the eastern boundary of Portion 2 of Burgher's Post were adopted as boundaries to the study area (Figs 1, 2).

A Topcon mirror stereoscope, with a magnification of three, was used to map a number of variables of the study area on to a set of three sheets of clear tracing paper for each year of photographic interpretation, as follows:

Sheet 1:
Firebreaks, camp boundaries, buildings, kraals, roads and tracks were marked on this sheet. (Tracks were visually discriminated from roads on the basis of width.)

Light-toned, poorly defined streaks and blotches of sand were taken to be indicative of soil deposition as consequence of wind erosion, as were conspicuous blowouts from cultivated fields. Evidence of soil deposition is more easily detected than are erosional forms resulting from wind action (Avery 1977). As the light Sandveld soils are extremely susceptible to wind erosion when deprived of vegetation cover, bare areas of soil, including roads, tracks and firebreaks, were taken to exemplify probable sources of wind erosion. Dendritic patterns on hillslopes and stereoscopically visible rills or gullys were noted as evidence of water erosion, together with fans of deposited soil wash continuous with the bases of larger gullys.

Windmills and watering points were also marked on Sheet 1.

The identification of many of the above variables from air photographs was complicated and at times thwarted by changes in the vegetation cover. For example, erosion patterns and paths were virtually invisible on newly burned tracts, and on densely vegetated ground they appeared much reduced in dimension.

Sheet 2:
Vegetation cover was classified into the following three categories principally on the basis of shades of grey but confirmed, where possible, by the stereoscopic impression of vegetation density: Bare ground, medium cover and dense cover.

To standardise these categories a grey scale was compiled taking actual shades from the aerial photographs, ranging from grey-cream (bare ground) through grey ('medium cover') to dark grey/black ('dense cover'). This method relies on a uniformly coloured substrate for efficacy, especially where the vegetation cover cannot be ascertained solely on the basis of stereoscopy. Darker soils will prejudice classification and analyses of burn patterns must take such influence into account.

There was only one area on the Fynbos Biome site which was significantly darker and affected the classification of vegetation cover (grid squares J7; K5, 6, 7; L5, 6, 7; M6, 7 in Fig. 36) and burn analyses here had to be modified accordingly.

Using the date of a known fire in February 1976 and air photographs taken subsequent to this fire it was possible to draw up the following tentative relationship between vegetation cover category and vegetation age post-fire:

'bare ground'	:	0-2 years post-fire
'medium cover'	:	2-5 years post-fire
'dense cover'	:	> 5 years post-fire.

(This is largely borne out by observations of the vegetation cover change from 1968 to 1972 aerial photographs.)

Although the above relationship will undoubtedly be modified by burn intensity, it is the best available tool to trace the fire history of an area.

Cultivated land areas were noted on Sheet 2, as were indications of bush-cutting, quarrying, clearing or similar disturbance to the vegetation cover.

Sheet 3:

Alien vegetation was marked on this sheet. Mature pine trees were relatively easy to detect on the larger scale black and white aerial photographs, being distinctly darker than the indigenous vegetation. Acacias and young pines, however, proved to be extremely difficult to isolate on the basis of shape and grey shade.

(Recent work by Marrao (1982) concludes that differentiation between alien acacia species and low indigenous bushes in black and white air photographs is extremely inefficient. It is felt that for any work involving the detection of alien vegetation with certainty, colour prints or colour infra-red prints are essential.)

According to Milton (1980) acacias overtop the indigenous vegetation within the first two years of growth. On this basis, bushes noted stereoscopically to be conspicuously taller than the surrounding vegetation were taken to represent acacias or other young alien trees. A shortcoming of this method was that, where tall alien bushes were interspersed with large indigenous bushes or younger alien plants, the relative height differences were much reduced and their detection was obviated.

Ground checks of what appeared to be alien plant stumps facilitated confirmation of the occurrence of older acacias, but where young acacias were concerned or where fires had repeatedly razed an area, such confirmation was not possible.

As the estimated annual input to an acacia seed-bank of juvenile acacias (less than five years old) is negligible (Milton & Hall 1981), and as these plants attain a height of up to 2 m within the first two years of growth (Milton 1980) it appears unlikely that acacias not detected on aerial photographs would be of long-term significance. However, for the purpose of determining density or abundance of aliens this method is clearly inadequate and serves merely to indicate distribution of these plants.

Areas afforested with exotic pines and eucalypts were also mapped on Sheet 3; species and dates of planting were obtained from R. Andrag.

Individual vegetation units, stereoscopically taller than the surrounding indigenous vegetation, were marked as bush units on this sheet. These units were found in the field to comprise large individual plants of the re-seeding species *Protea repens* as well as coppicing or resprouting shrubs; discrimination between the re-seeding *Protea* and resprouting plants being impossible on aerial photographs. It is possible that young acacia saplings of insufficient height to be detected as alien vegetation (see above) were detected as bush units on this sheet.

(It was initially hoped to infer migration of the re-seeding *Protea* species after fire from the distribution of bush units, but as it was not possible to distinguish between those species noted as bush units, the value of this variable was found to be limited.)

Problematic in a retrospective study of this nature is the inability to field check observations from air photographs, especially where temporary features are concerned.

Planimeter readings of camp sizes and areas of cultivated land in the entire study area for each year of photographic interpretation were taken in triplicate using a Coradi Cora-Senior planimeter. These were related back to a known ground area, namely that of Portion 2 of Burgher's Post, to quantify such changes over time. Although not strictly accurate, these planimeter values serve adequately for comparative purposes.

Sets of map sheets for all the years of study were photographically scaled to 1:10 000 using the 1:10 000 orthophoto map of 1972 (3318DA) as a reference size. A series of maps of the Fynbos Biome Research site were then transcribed from the photographic negatives on to transparent sheets to allow for retrospective comparisons.

To obtain an estimate of error inherent in this method of standardization, the situation of immobile landmarks such as camp boundaries and roads on Sheets 1 of the resultant maps was compared. A maximum linear displacement of these landmarks was found to be 39 m on the ground.

(It should be noted here that the error inherent in this method of scale standardization of aerial photographs could probably have been reduced by using more sophisticated equipment such as the Bausch and Lomb Zoom Stereo transfer scope. This instrument can be used to correct distortion due to flight angle between stereopairs and has an enlargement capability of seven.)

However, the edge effect distortion remains and only the centre of the field can be accurately used.)

Two summary grids of the site were compiled for the period of study; the first showing the years and frequency of burn (1960-1981) and the second showing indications of disturbance: erosion, soil deposition or soil wash, alien vegetation, bushcutting and quarrying. (A grid square was marked as burned if more than 50% of it fell into the 'bare ground' category.) A grid size of 150 m by 150 m was chosen to represent these findings as this was felt to be a compromise between the need for detailed description - that is, the smallest practicable grid size - and the need to minimise potential error within each grid square.

In order to ascertain whether the existing vegetation communities on the Pella site reflect its recent history of landuse, transparent map sheets of burn patterns from 1960 to 1980, of soil erosion and deposition and of bushcutting from 1938 to 1980 were overlaid on to the vegetation mapping (carried out by Boucher & Shepherd (in prep.) during 1979/80). By comparing the vegetation communities of regions of different landuse history on the same soil forms (mapped by Fry in 1979/80) it was possible to examine any correlation between past landuse and the resultant vegetation.

Simulated overlays of burn patterns from 1960 to 1981 (where the fire history could be determined with certainty from aerial photographs), of bare soil areas from 1938 to 1981 (reflecting quarrying, soil erosion or deposition), and of bushcutting on the site prior to 1981 were mapped to summarise the disturbance on the Fynbos Site in recent history.

It must be borne in mind when utilising such composite maps that the use of aerial photographs in interpreting the history of an area furnishes only a punctuated account of the historical continuum and hence correlations between variables may be difficult to determine.

Maps of the entire study area were photographically scaled to A4 size. Camp boundaries, signs of soil erosion or deposition and of alien plant encroachment external to the site were transcribed on to one transparent sheet for each year of study, and the extent of cultivation on to a second sheet. The remaining external variables such as roads, paths, vegetation cover and bush units were thought to be unimportant to the site *per se;* any disturbances that were effected by changes in these variables are likely to have been manifest in terms of signs of soil erosion or deposition, or alien plant encroachment as mapped above.

2.2.3 Existing variables on the Fynbos Research site

The site was visited intermittently from December 1981 to June 1982 in order to obtain ground truth for variables noted on aerial photographs and to record any distinctive or irregular features. Plant samples from the larger bush units on the site, likely candidates for detection as such in aerial photographs, were collected and identified.

Unfortunately many of the more ephemeral features or those evident from the earlier air photographs proved impossible to confirm in the field; a drawback in work of this nature.

2.2.4 Scientific articles

The direction of literature search was determined by findings in previous sections of this study, and served primarily to explore the likely transient and long-term consequences of past landuse and management on the Pella ecosystem.

2.2.5 Ongoing research work at Pella

Researchers were questioned as to the general findings of their particular topic of study on the Fynbos Research site, and implications pertinent to this study were noted.

CHAPTER 3

RESULTS

"Because of the often unconsolidated substrate and its location, the Coastal Fynbos ecosystem is subject to more frequent disturbances than other types" (Kruger 1978) in the form of overgrazing, burning and exploitation for firewood (Walsh 1968).

As the dictates of the landowner principally determine the use and condition of his land, and in order to maintain temporal continuity in this section, the results have been divided into six periods of land ownership (A - F). Within each period, results have been grouped thematically; the respective themes drawing on results from both 'historical' and 'scientific' data sources. The order of presentation of results is constant throughout this section, providing a common thread linking the different periods of ownership. 'External' influences are taken to be those activities or incidents initiated extraneous to the site which may have had repercussions on the site ecosystem. Results which do not constitute 'external' influences pertain specifically to the Fynbos Biome Research site. Rainfall data are considered separately.

(Archival references are indicated by numerals in parentheses, and listed separately from the 'scientific' references at the end of this study.)

3A 1920 - 1 May 1923

3A 1 Rainfall:

There were no records for this period.

3A 2 The Fynbos Site:

(This refers to the land which now constitutes the Fynbos Biome Research site.)

3A 2.1 *Land ownership conditions and servitudes*

The remainder of Burgher's Post Farm, 2227 morgen 38 square roods in area, was owned by Philippus Albertus Cloete. (Portion 1 of the farm was purchased by the Colonial Government in 1902 in connection with construction of the Kalabaskraal-Hopefield Railway.)

Transfer of the Burgher's Post farm (and subsequently of Portion 2 of this farm) was subject to the endorsement of servitude reading: "In terms of Section 261 of Ordinance No. 13 of 1917; certain trek-paths over the land hereby conveyed have been reduced in width as will more fully appear on reference to Government Notice No. 296 dated 31 August 1918 and resolution of the executive committee of Provincial Council dated 13 January 1919 filed with transfer No. 7453 dated June 1920." (Transfer No. 12374 of 20.11.1902.) (This condition will henceforth be referred to as the 'Trekpath Condition' (see Appendix D1).)

3A 2.2 - 3A 2.7:

No information could be obtained on the landuse, management practices, soil erosion and deposition, vegetation cover, alien vegetation, bush units or fauna on the Fynbos Site in this period. It is probable that the Fynbos Site was used as natural grazing for livestock.

3A 3 External influences on the site:

3A 3.1 *Trekpath*

The trekpath from Klipheuwel farm on the Paarl/Malmesbury Divisional Boundary through the Malmesbury Division from south-east to west to the farm 'Oudepost' on the sea coast, known as the Saldanha Bay trekpath, passed from Michiel Heyns Kraal (now Riverlands) across Burgher's Post farm to Nieuwe Post. Its function was to afford access from agricultural lands of Paarl to the pastoral lands on the coast.

From the Divisional Council records, it appears as if the practice of trekking was on the decline at this time: "...trekking for the purpose of finding grazing for the animals is, to a large extent, a thing of the past..." (1). However, the fact that the Saldanha Bay trekpath, in terms of Government Notice No. 296 of 31 August 1918, had not been cancelled must be taken as an indication that at least stretches of the trek were still in use. In the absence of aerial photographs or other records prior to 1938 it was not possible to determine either the situation of the trekpath or of camp boundaries on Burgher's Post. If there was no fence separating the current Fynbos Research site and the trekpath, it is possible that trekking livestock may have strayed on to the site, contributing to grazing or trampling pressures. In addition, trekkers may have fired vegetation to ensure grazing for the next trek.

3B <u>1 May 1923 - 6 May 1926</u>

3B 1 Rainfall:

No rainfall data exist for this period, although Compton (1923) reported a very dry summer in the South Western Cape with a somewhat severe water crisis in 1922/3.

3B 2 The Fynbos Site:

3B 2.1 *Land ownership, conditions and servitudes*

On 1 May 1923 the remainder of Burgher's Post farm was sold to Pieter Adriaan Bergh, a then member of parliament for Malmesbury.

The transfer deed No. 3162 contained the Trekpath condition (3A 2.1).

3B 2.2 *Landuse*

Cattle and Merino sheep were kept on the farm, and possibly a few crops were grown (Bergh, pers. comm. 1982). More detailed accounts of landuse could not be traced, but it seems certain that the study area was used as grazing for livestock.

3B 2.3 - 3B 2.7

No information on management practices, vegetation cover, soil erosion and deposition, alien vegetation or fauna could be obtained for this period.

3B 3 External influences on the site:

3B 3.1 *Trekpath* (see 3A 3.1)

3C 6 May 1926 - 26 June 1958

3C 1 Rainfall:

(See Appendix A for total annual rainfall figures from the four weather stations used in this study.)

Between 1930 and 1940 there were "fairly light but sufficient" rains in the South Western Cape (Sim 1965). In 1936 an extremely low annual rainfall was recorded: the total at Burgher's Post was a mere 328,1 mm and at Malmesbury 356,1 mm. Exceptionally heavy rains fell in the Western Cape in 1941 (Wicht 1945) and again in 1944 and 1945. In 1941 the annual totals at Burgher's Post and Malmesbury were 884,8 and 661 mm respectively; monthly maxima were recorded in May. Burgher's Post received 198,0 mm with a daily maximum of 59,7 mm in this month!

1947 was a relatively dry year although the annual precipitation at Burgher's Post weather station fell within the $\overline{x} \pm 1$ S.D. (mean ± one standard deviation) range for Coastal Fynbos (see Fuggle 1981).

Annual rainfall figures for 1950, 1952 and 1953 were comparatively high, and 1954 was, without doubt, the most severe year on record in terms of rainfall intensity and concomitant damage. In May of 1954, 264 mm of rain were recorded at Burgher's Post, of which 155 mm fell in three consecutive days (17 May: 43 mm, 18 May: 42 mm, 19 May: 70 mm). The total annual rainfall at this station was 872,2 mm, and at Malmesbury 679,5 mm. Rains were reported to have swept away local bridges and caused much damage to lands; some of which had to be re-ploughed (Van Breda, pers. comm. 1982). Local inhabitants regarded this deluge as perhaps the worst experienced in the area for the past 50 years (2). In addition to the above-mentioned years of exceptional rainfall, 1951 and 1956 were recalled by farmers in the area to have been years of relatively heavy rains (H.R. Andrag, Van Breda, pers. comm. 1982). Precipitation in the latter years appears to have been extremely localised as only the Burgher's Post station recorded high annual rainfall figures.

In 1958 extremely low rainfall was noted at both the Philadelphia and Malmesbury weather stations; the Burgher's Post station received extremely high precipitation!

3C 2 The Fynbos Site:

3C 2.1 *Land ownership, conditions and servitudes*

On 6 May 1926 the remainder of Burgher's Post farm was sold to Alexander Jacobus van Breda.

The deed of transfer No. 4263 included the Trekpath Condition (3A 2.1).

3C 2.2 *Landuse*

A.J. van Breda managed a thoroughbred horse stud on the farm which constituted the major source of income. The Fynbos Site and immediate surroundings were used solely as grazing for cattle and a number of Merino sheep (Van Breda, pers. comm. 1982).

3C 2.3 *Management practices*

The present Fynbos Research site was situated within 'veld' camps 1 and 2 of 250 and 360 ha respectively (Fig. 22) on what now constitutes Portion 2 of Burgher's Post.

3C 2.3.1 *Grazing*

No data for stocking rates or densities, or rotation of grazing could be obtained for this period. A.J. van Breda erected a windmill on the current Fynbos Research site shortly after purchase in 1926 (grid square IS on Fig. 35), and another on the now strip-cropped section of Portion 2 of Burgher's Post (Van Breda, pers. comm. 1982). There was a naturally occurring seasonal waterhole on the Fynbos Site at this time.

3C 2.3.2 *Burning*

The fynbos on the farm was burned on rotation when the vegetation grew too thick for livestock to penetrate and graze, probably every 3 to 5 years (Van Breda pers. comm. 1982). According to F.W. Duckitt (pers. comm. 1982), patch-burning in this area was widely employed to ameliorate grazing. It was carried out in late winter/spring after rains had fallen; wet soils were believed to protect the roots and seeds, and regrowth of vegetation was extremely rapid. Fynbos was fired in the late afternoon when there was little or no wind, thus ensuring that only the older patches of vegetation burned.

3C 2.4 *Soil erosion and deposition* (Fig. 3)

On a regional scale, numerous articles focusing on the growing sense of responsibility of farmers as regards overcoming soil erosion were beginning to appear in the local Malmesbury newspaper, *De Zwartlander*, prior to the promulgation of the Soil Conservation Act of 1946. "The foolhardiness of overstocking" was "generally acknowledged" (p.6, 11 October 1930).

Although livestock tracks were visible on the site in 1938, converging at the windmill, these were not extensive and are not thought to have exemplified overstocking.

Despite the numerous burn patterns which rendered it difficult to isolate areas of possible erosion, patches of bare ground were evident at the waterhole, at an area to the south east of the water-hole, and in the north west corner of the site. Bare areas in the former two instances were probably representative of localized trampling and concomitant wind erosion. In the latter area, bare patches of soil are thought to be effected principally by local deposition of soils blown by south westerly winds - predominant in summer - from ploughed land to the west of the site. There is a slight elevation of ground in this north west corner (Fig. 1) and soils blown over this rise can be expected to lose velocity and settle here. Particle sizes of soil in this area are similar to those of wind-borne soils (pers. obs.) and this seems to be a plausible explanation for this phenomenon. Localized activity of both the Cape dune mole (*Bathyergus suillus*) and common black mound termite (*Amitermes hastatus*) may contribute to the patchy appearance of soils here.

In 1938, soil wash from sheet and rill erosion present on the hill to the west of the site had not yet impinged on the Fynbos Site.

For the location of livestock tracks, see Fig. 3. There was what appears to be a motor vehicle road to the windmill on the Fynbos Site, and another road along the boundary between camps 1 and 2 (Fig. 7).

3C 2.5 *Vegetation cover* (Fig. 4)

It is apparent from the aerial photograph of the research area in 1938 that intentional patch-burning had been executed to improve the grazing for livestock. The Fynbos Site comprised small disjunct patches of bare ground and 'medium' vegetation cover; only a minute area of the ground cover (roughly 3%) could be classed as 'dense', indicative of vegetation of a minimum age of more than 5 years. Planimeter readings of the bare ground further reveal that approximately 58% of the present Fynbos Research site had been burned within the two years prior to this photograph, giving the 'medium' vegetation cover – approximately 39% of the total vegetation – an estimated age of between 3 and 5 years at the time of the burn. (This confirms the tentative burn rotation given in 3C 2.3.2.)

The two dark lines conspicuous on the site in the 1938 air photograph, along the boundary fence separating camps 1 and 2, appear to have been thin strips of mature fynbos; wide tracts of bare soil on either side of these strips probably acting as temporary firebreaks.

3C 2.6 *Alien vegetation and bush units* (Fig. 5)

3C 2.6.1 *Alien vegetation*

The problem of encroaching alien vegetation in this area was first realized in the early 1930's (Duckitt pers. comm. 1982). There were no alien plants growing on what now constitutes the Fynbos Research site in 1938.

3C 2.6.2 *Bush units*

The bushclump species *Rhus laevigata* and *Diospyros glabra*, and the re-seeding *Protea repens* were found from field observation to constitute the majority of large bush units on the site and hence the most likely candidates for detection as such from aerial photographs. The distribution of bush units appears to be concentrated at the darker coloured soil mounds on the site, and in areas of Clovelly soil form where saprolite lies within 2 metres of the surface ('sCv; 'mCv' soils, Appendix B). The mound vegetation, Strandveld, comprises a large proportion of *Diospyros glabra* as does the 'D' vegetation community of *Phylica cephalantha* fynbos on sCv and mCv soils (Appendix C).

The remaining areas of scattered bush units were largely coincident with vegetation community 'B' of the *Diospyros glabra-Salvia lanceolata* shrubland as mapped by Boucher and Shepherd (in prep.). This community represents a mosaic of Strandveld and Coastal Fynbos elements, with renosterveld affinities (Boucher, pers. comm. 1982) and thus includes a large proportion of *Diospyros glabra* and *Rhus laevigata*.

3C 2.7 *Fauna*

The steenbok *Raphicerus campestris* and grey duiker *Sylvicapra grimmia* were abundant in this area at this time, as were the carnivores *Thos mesomelas*, the 'rooijakkals' or black-backed jackal, and *Vulpes chama* the 'draai-jakkals' or silver jackal (Rand 1955).

According to Rose (1950) several farmers owning livestock in sourveld considered the tortoise a menace to cattle, and destroyed any such reptiles on farmland. Prior to the introduction of supplementary mineral licks in about 1940 (Du Toit et al. 1940) cattle displayed a craving for anything which would supply the deficient phosphorus in their diet; this included small tortoises dead or alive! The consumption of dead tortoises was believed to cause 'lamsiekte' and hence the destruction of these creatures.

(Unfortunately no particulars regarding the occurrence or hunting of fauna on the site could be obtained; the above serves merely to indicate the likely occurrence of animals in the area and possible factors influencing their abundance. See also 3C 3.7 below.)

3C 3 External influences on the site:

3C 3.1 *Trekpath*

No sign of a trekpath across Burgher's Post could be found on either the 1938 or later aerial photographs. From complaints and meetings as to the condition of the Saldanha trekpath (3, 4) it seems likely that only sections of it were still in use. No reference to either the Burgher's Post, Michiel Heyn's Kraal or Nieuwe Post farms was found for this period, and the Trekpaths Commission of 1936 omitted the Saldanha Trekpath from its report. An article in *De Zwartlander* of 11 October 1930 stated that "The cruel and uneconomic practice of trekking with stock is definitely on the wane". Despite extensive investigation, no positive confirmation of recent use of this particular trekpath could be obtained; the majority of landowners from the Klapmuts and Franschhoek area questioned thought it likely that this trekpath fell into disuse prior to 1900. It therefore seems unlikely that the trekpath referred to in the Deed of Transfer was still in use, or that its presence had any bearing on the Fynbos Site.

3C 3.2 *Fires*

Although there were complaints of uncontrolled fire in the Mamre area (5, 6) these are thought to be too remote from the site to have had any influence on it.

3C 3.3 *Cultivation of land* (Fig. 6)

Cultivation in the study area was largely restricted to the hill slope to the west of the Fynbos Site and, to a lesser extent, the land alongside the Burgher's Post watercourse. Eleven percent of the total study area had been ploughed.

3C 3.4 *Soil erosion and deposition* (Fig. 7)

From the 1938 aerial photograph it can be seen that the hill had been ploughed across the slope with no precautions - such as strip cultivation or contouring - having been taken against soil erosion. Rill erosion was conspicuous on the hillslope, as were areas of soil wash. The spate of heavy rains in the 1940's and 1950's (3C 1) undoubtedly served to exacerbate soil erosion on this vulnerable slope, as can be seen on subsequent aerial photographs.

Wind patterns in the vicinity of the Fynbos Site are unfortunately not known, but these will be influenced by local topography and in turn affect patterns of wind erosion and soil deposition. Patches of bare ground were evident in the north corner of camp 1 and are similar in appearance to those found in the north west corner of the site, exemplifying a probable continuance of soil deposition on the declivity.

Although the area of settlement parallel to the Dassenberg watercourse is sparsely vegetated and shows distinct signs of trampling and probable wind erosion, the Fynbos Site is situated on relatively elevated terrain and influence from this region in terms of wind erosion is felt to be minimal.

3C 3.5 *Alien vegetation* (Fig. 7)

Two blocks of *Pinus pinaster*, the cluster pine, and *P. pinaster* and *P. radiata* were planted in 1954 and 1956 respectively between the Dassenberg watercourse and the Burgher's Post boundary fence. Both plantations were bordered by a narrow margin of *Eucalyptus* trees, and amounted to a total of 6,44 ha in area (R. Andrag, pers. comm. 1982). *Pinus pinaster* is now notorious as an alien plant invader (Stirton 1978) and these afforestations constitute potential sources of dispersal of cluster pine seeds to Burgher's Post land in a summer south easterly wind; wind dispersal is extremely effective in spreading seeds of this tree (Kruger 1977).

Pines were present in and alongside the settlement at the Dassenberg water course in 1948, and a small stand of *Pinus pinaster* was evident on Goeie Hoop land. Pines and a few acacias were dotted on the Burgher's Post hillslope.

3C 3.6 *Fauna*

The Groenkloof area was prized as a strong drawcard for city folk who were interested in hunting. As Hopkins (19) stated "Vandag nog is die wild van Groenkloof 'n steek trekpleister vir die stedelinge en geen wonder is dit selfs dat die goewerneurs af en toe 'n uitvluggie na die duinewêreld met sy klein wild net oorkant Tafelbaai gemaak het nie".

Perhaps as consequence of this, game north of the Blaauwberg-Tygerberg Valley was being rapidly depleted by hunters (7). A resolution was passed on 26 July 1955 to close the hunting season in the Mamre area for an indefinite period in response to numerous complaints that the wild animals in this region were being injudiciously eradicated (8, 9). Possibly aggravating the rapid reduction in numbers of wild antelope were "native dogs" which were deemed responsible for heavy losses among these animals (Rand 1955).

Rewards for the destruction of, amongst others, 'rooijakkals', 'draaijakkals' and *Felis caracal*, the 'rooikat' were offered by the Divisional Councils of Malmesbury and the Cape, according to Provincial Ordinance No. 10 of 1927 (10, 11, 12, 13), providing further incentive to eradicate these stock-destroying carnivores.

It was resolved to declare the 'nagmuis', *Tatera afra*, vermin in 1954 (14).

3C 3.7 *Fertilizers and pesticides*

No data could be obtained.

3C 3.8 *Other*

According to Rev. Barley, whose father was stationed at Pella from 1929 to 1937, livestock owned by inhabitants of the mission village was grazed to the south and west of the village only, and never near Dassenberg or Burgher's Post.

3D <u>26 June 1958 to 29 March 1962</u>

3D 1 Rainfall: (Appendix A)

Although 1960 was a year of district-wide drought (15), rainfall at Burgher's Post station was within the mean ± 1 standard deviation range for Coastal Fynbos (2.2.1). Heavy rains fell in 1959 and again in 1962.

(The 1950 to 1962 period was considered by farmers and local inhabitants at Pella mission village to have been one of consistently high rainfall (H.R. Andrag, Rev. Barley, Duckitt, Van Breda, pers. comm. 1982).)

3D 2 The Fynbos Site:

3D 2.1 *Land ownership, conditions and servitudes*

On 26 June 1958, the remainder of the Burgher's Post farm was sold to A.J. van Breda's son, Christopher Alexander van Breda, who managed the farm until it was sold in 1974 to the Agricol Seed Company.

The transfer deed No. 8883 contained the Trekpath Condition (3A 2.1).

3D 2.2 *Landuse*

The thoroughbred horse stud was not found to be a viable concern, and was sold shortly after 1958. Possibly having had to find a surrogate for the major source of income, extensive ploughing and clearing of ground was carried out effecting a fourfold increase in arable land area on the farm (Van Breda, pers. comm. 1982).

The site and immediate surrounds continued to be used exclusively as natural grazing for livestock in this period, as the soils were considered to be too 'dry' and nutrient poor - or "dead" - for cultivation (Van Breda, pers. comm. 1982).

3D 2.3 *Management practices*

Camp 1 was reduced from 250 to 191 ha and camp 2 from 360 to approximately 355 ha after 1958 (Fig. 12).

3D 2.3.1 *Grazing*

From 1000 to 1200 Merino sheep and about 20 cattle were kept on Burgher's Post farm. This yields a sheep:cattle ratio of 50:1.

Livestock was seldom grazed in fynbos camps during the summer months but rather on 'oulande' (old lands) or stubble lands after the harvest of mixed oats and serradella (*Ornithopus sativus*) or wheat crops. A rotation of grazing, using six veld camps, was employed in the winter/spring months so that animals were grazed in the same camp every six to eight weeks (Van Breda, pers. comm. 1982). From the above information, it was possible to estimate both the stocking density - at between 3 and 6 SSU (small stock units) per ha - and the stocking rate - at between 4 and 7 ha per SSU per annum (six small stock units equal one large stock unit).

Cattle were always grazed first in the fynbos camps to exploit the long palatable shoots and to 'open up' the vegetation for sheep which nibble at shoots and greenery exposed by the larger animals: "Cattle eat long; sheep eat short" (Van Breda, pers. comm. 1982). Domestic animals were never allowed to graze fynbos immediately after a fire; burned areas were rested for one growth season (that is one year) before being subjected to grazing pressures.

Livestock was never enclosed in a kraal or tethered at any point within the fynbos camps, obviating excessive trampling in concentrated areas (Van Breda, pers. comm. 1982).

3D 2.3.2 *Burning*

C.A. van Breda could not recall having burned the low-lying fynbos areas intentionally. Intentional firing of vegetation was predominantly carried out on the mountain slopes in very dense vegetation.

3D 2.3.3 *Control of alien vegetation*

No measures were taken to check the spread of either acacias or cluster pine in those areas not cultivated (see 3D 3.5).

3D 2.4 *Soil erosion and deposition* (Fig. 8)

A small spill of soil wash on to the Fynbos Site is evident for the first time in the 1960 aerial photograph, fanning out from the conspicuous gully eroded into the Burgher's Post hill.

As in 1938, there were patches of bare ground in the north west corner of the site, presumably due to localized deposition of soil (3C 2.4). Faint blotches of soil were evident to the north of the soil wash, these are thought to reflect drift of soil particles from the wash area - possibly supplemented by soil deposition from ploughed fields to the west of the site - in the face of south westerly winds in the dry summer months.

There were no indications of livestock trampling on the site. Many of the livestock tracks noted in the 1938 aerial photographs were absent from the 1960 photographs (Figs 3, 6).

Apart from a newly constructed vehicle road, traversing the north east corner of the site and affording access to the windmill on the now strip-cropped portion of Burgher's Post 2 from the Burgher's Post homestead, the situation of suspected vehicle tracks was the same in 1960 as in 1938.

3D 2.5 *Vegetation cover* (Fig. 9)

The ground cover appears to have been less patchy in 1960 than in 1938, reflecting the cessation of intentional veld-burning. The majority of vegetation fell into the 'medium' cover category, implicit of an age of from 2 to 5 years. Furthermore, the proportion of vegetation older than 5 years (roughly 34%) had increased as compared to that in 1938. Only a small tract of land amounting to 3% of the site area near the north west corner of the site appears to have been burned since 1958; possibly with intention, as the burn pattern is consonant with that of controlled patch burning.

3D 2.6 *Alien vegetation and bush units* (Fig. 10)

3D 2.6.1 *Alien vegetation*

Two relatively large alien plants, thought to be pines, were evident in the soil wash area in 1960.

A few acacias were growing on and adjacent to the wash overburden, their seeds probably having been carried down the erosion gully on the Burgher's Post hill on to the Fynbos Site. A single alien acacia bush was visible at the waterhole in the 1960 aerial photograph; the seed is likely to have originated in bird faeces.

The initial distribution of acacias on the site seems to be coincident with comparatively moist soils of relatively high productivity.

3D 2.6.2 *Bush units*

The distribution of bush units was similar to that noted in 1938 aerial photographs (3C 2.6.2). Discrepancies in distribution are attributable to the certain incidence of patchy fire between 1938 and 1960, razing tracts of vegetation; consistency in distribution to the fact that 2 of the 3 species detected as bushclumps are resprouters after fire. (The third, *Protea repens*, is a re-seeder.)

3D 2.7 *Fauna*

The steenbok, grey duiker and grysbok (*Raphicerus melanotis*) roamed the low-lying fynbos areas (Van Breda, pers. comm. 1982). None of these antelope was hunted by the owners on the farms Burgher's Post or Dassenberg.

Other animals noted on the farm were the grey mongoose, *Herpestes pulverulentus*, the Cape dune mole, *Bathyergus suillus*, and the 'rooikat'; the latter proving the exception to the policy of no hunting on the Burgher's Post farm.

Snakes and tortoises were commonplace on farms in this area.

Although baboons and dassies - both declared vermin - resided in the hilly regions of the area, they never ventured onto the low-lying areas (Van Breda pers. comm. 1982).

3D 3 External influences on the site:

3D 3.1 *Trekpath*

The trekpath was never used in this period and its location on the farm was not known (Van Breda, H.R. Andrag, pers. comm. 1982).

3D 2.3 *Fires*

Accidental fires were frequent in the area and constituted a major external influence on the Fynbos Site.

Causes of accidental conflagrations were numerous and seemed to be exclusively anthropogenic. Sparks from the steam engine travelling along the single track railway at the north east corner of Burgher's Post farm (Fig. 2) initiated many fires (Van Breda, pers. comm. 1982), attempts at smoking out bees from hives on Dassenberg farm, setting fire to bushes to kill snakes supposedly lurking within, discarded cigarette butts, constitute but a few of the possible causes of fire.

Small fires started in the Pella village or at isolated houses along the Dassenberg watercourse spread uncontrollably towards the Burgher's Post farm, principally in the summer months when fanned by southerly winds. Although the inhabitants of Pella never officially fired vegetation near the mission village, small areas were burned 'on the sly' either to improve grazing for livestock or to secure firewood, and on occasions fire spread (Rev. Barley, pers. comm. 1982).

3D 3.3 *Cultivation of land* (Fig. 11)

From air photographs it can be seen that the area of cultivated land had increased from 11 to 13% of the total study area from 1938 to 1960. This increase was principally due to afforestation and clearing of Dassenberg land in 1954 and 1956 (3C 3.5).

3D 3.4 *Soil erosion and deposition* (Fig. 12)

Of interest to note is the marked reduction in cultivated land on the hillslope to the west of the site since 1938 (Fig. 6) and a concurrent use of bush strips and contours to combat soil erosion. Despite these measures, rill and gully erosion from the hillslope had advanced since 1938 as an aftermath of poor agricultural practice, and soil wash from the deep gully on the declivity extended across the boundary on the Fynbos Site. It is plausible that the exceptionally high annual rainfall recorded in 1941, 1944, 1945 and periodically throughout the 1950 decade (3C 1, 3D 1) was responsible for rapid escalation of erosion on this hill and that the exacerbated soil wash had reached the Fynbos Site by the mid 1950's. Successive layers of overburden deposited on the Fynbos Site (Appendix B) may be expected to tally with those years of severe precipitation.

In common with the 1938 aerial photographs are the signs of trampling and probable wind erosion in the settlement area of the Dassenberg watercourse, and the patches of bare ground in the north west corner of camp 1 in the 1960 photographs (3C 3.4).

The reduction in size of camp 1, potentially increasing the stocking density and thus grazing pressures on the site, did not appear to effect increased trampling or wind erosion in this camp.

Extensive cultivation of Burgher's Post land in this period (3D 2.2) possibly served to alleviate all year round grazing pressures on the fynbos areas, as livestock was grazed on cropped lands during the summer and autumn months. This would simultaneously have aggravated problems of wind erosion and subsequent soil deposition on the site promoted by the trampling of liv estock on stubble and old lands to the west and north of the Fynbos Site in the dry summer months.

3D 3.5 *Alien vegetation* (Fig. 12)
From the 1960 aerial photographs, it is evident that the community of cluster pines (pers. obs.) on the Goeie Hoop land had increased markedly in extent between the years 1938 and 1960.

The number of alien plants on the hillslope to the west of the site had grown since 1938, largely tracing the course of rills or gullys. Seed appears to have been moved downslope giving higher densities of bushes in drainage lines on the declivity.

Acacias appear to have spread unchecked along the Burgher's Post watercourse, their establishment possibly facilitated by the prior clearing and cultivation of land in this area (3C 3.3).

There were a few acacias at the windmill site in camp 2 of the study area in 1960.

C.A. van Breda recalls there having been a number of Port Jackson willows on Burgher's Post at least since 1940. The Port Jackson willow (*Acacia saligna*) and rooikrans (*Acacia cyclops*) were treated with a 'laissez-faire' attitude and were not removed from farmland unless they obstructed the ploughing of cultivated fields. In this case, the offending bush was often merely set alight and subsequently removed (Van Breda, pers. comm. 1982).

3D 3.6 *Fauna*

The inhabitants of Mamre were said to hunt wild antelope in the vicinity with dogs (Van Breda, pers. comm. 1982).

Coloured folk in the area are said to prize the tortoise as food (Rev. Barley, Duckitt, pers. comm. 1982).

Rewards continued to be offered for 'rooijakkals', 'rooikat' and 'draaijakkals' in the area (16).

3D 3.7 *Fertilizers and pesticides*

Nitrates, granular phosphates and potash (NPK) in the ratio of 2:3:2 were applied to cultivated lands on both the Dassenberg and Burgher's Post farms, as was lime on occasion to reduce soil acidity.

Cereal crops were sprayed annually in August from the air with 2-4-D (2, 4 Dichlorophenoxyacetic acid), a selective translocated preemergence herbicide which acts on broad-leaved weeds such as wild vetches (*Vicia* species) and 'wilde ramnas' (*Raphanus* species) (Van Breda, pers. comm. 1982). Spray would undoubtedly have drifted and settled on to the Fynbos Site.

3D 3.8 *Other*

C.A. van Breda could recollect neither incidents of straying animals nor woodcutters nor flower-pickers nor vagrants trespassing on Burgher's Post farm.

Residents of Pella mission village collected firewood primarily from the sides of the road to Katzenberg from the old Cape Town-Darling road to the west, and from the nearby cemetery to the north; rarely (if ever) venturing on to either the Burgher's Post or Dassenberg farms (Rev. Barley, pers. comm. 1982).

3E <u>29 March 1962 - 28 December 1967</u>

3E 1 Rainfall: (Appendix A)

Fairly heavy rains fell in 1962. For the remainder of this period there were no years of exceptional rainfall.

3E 2 The Fynbos Site:

3E 2.1 *Land ownership, conditions and servitudes*

On 26 March 1962 Portion 2 of the farm Burgher's Post was sold to Hellmut Rudolf Andrag. This portion measured 699,9990 morgen

(599,5716 ha) in area.

The deed of transfer No. 3811 contained the Trekpath Condition (3A 2.1).

3E 2.2 *Landuse*

Portion 2 was divided into two camps shortly after purchase. One camp was then subdivided into four smaller camps and strip-cropped and afforested in blocks (Fig. 17, 18). The other remained as a fynbos camp and was used solely for grazing livestock. (The latter constitutes the existing Fynbos Biome Research site.)

The fynbos camp was not ploughed as it was felt to be too dry and infertile an area for cultivation (H.R. Andrag, pers. comm. 1982). For cultivation to have had any measure of success, the site would foreseeably have needed the continual application of fertilizer and probably a system of irrigation. The capital input to the site would, in all probability have exceeded resultant yields, and thus cultivation of this land was not seen as a viable proposition.

3E 2.3. *Management practices* *

The two camps on Portion 2 of Burgher's Post were fenced shortly after purchase. The fynbos camp measures 251 ha of the total area of Portion 2.

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* C.A. van Breda opened a file with the Agricultural Technical Sciences (ATS) for the remainder of the Burgher's Post farm in 1963, after the transfer of Portion 2 of the farms. As the latter is situated in the Malmesbury Division and was purchased by the owners of Dassenberg farm, which lies in the Cape Division, no records of Portion 2 of Burgher's Post are kept by the ATS.(now the Dept. of Agriculture and Fisheries).

3E 2.3.1 *Grazing*

Andrag Brothers, owners of the Dassenberg farm since 1942, kept a flock of from 600 to 900 Dohne Merino sheep in the winter season (less in summer), and a herd of from 110 to 120 Jersey milk cows. The sheep:cattle ratio thus ranged from 5:1 to 8:1.

Livestock was grazed on oats/serradella stubble and old lands in the dry summer months and on the fynbos 'veld' from mid-winter to spring when young grasses were sprouting. A four camp rotation of grazing was used during this 3 to 4 month period at an estimated stocking density of 2 to 6 SSu per ha. This yields a stocking rate of 4 to 7 ha/SSu per year in the fynbos camps.

As in 3D 2.3.1, cattle were always grazed before sheep in the natural veld, and livestock was never grazed on fynbos immediately after fire. Burned areas were rested for at least one year following a conflagration.

Livestock was brought into kraals at night to protect them from marauding dogs in the area, but was never enclosed or tethered at any point on the Fynbos Site. (There was a kraal on the adjoining strip-cropped section of Portion 2 of Burgher's Post (Fig. 18).)

Vegetation on the site was regarded as having poor nutritional value and the soils as being too dry to promote prolific growth of palatable grasses in the rainy season. For this reason, the full extent of Portion 2 was used for grazing - that is, livestock had simultaneous access to both the Fynbos Site and the strip-cropped area. As the strip-cropped camp was wetter and offered more extensive pasture, animals tended to aggregate in this section (H.R. Andrag, pers. comm. 1982). Above estimates of stocking density and stocking rate for veld camps in this period thus probably exceed actual stocking density and stocking rate on the Fynbos Site.

3E 2.3.2 *Burning*

The site was never burned intentionally as the potential fire damage to adjacent afforested and cropped areas, and to the wooden fence poles and boundary wire, was extensive (H.R. Andrag, pers. comm. 1982). Accidental conflagrations on the site were contained as soon as possible by ploughing fire-breaks, digging sand trenches or clearing bands of vegetation (H.R. Andrag, pers. comm. 1982).

From interpretation of the 1968 aerial photographs it is apparent that an accidental fire swept the Fynbos Site in about 1966 (see 3F 2.5), and a firebreak from the south east to the north west corner of the site was cleared in an attempt to curb it.

3E 2.3.3 *Control of alien vegetation*

Large acacias on the site were periodically chopped down by the owner, but not according to any fixed schedule. No dates of such clearing could be ascertained.

3E 2.3.4 *Bushcutting*

In an attempt to ameliorate the grazing on the Fynbos Site, sections of vegetation were initially cut in 1965/6 using a tractor-driven rotary mower (or Gyramor) set to cut the veld at approximately 75 cm above the ground surface (H.R. Andrag, pers. comm. 1982) (see also 3F 2.3.3, 3F 2.5).

An area of ground of roughly 40 metres by 40 metres near the eastern boundary of the site was cleared in 1965/6 for the establishment of an apiary stand (Fig. 15), and later fenced to deter 'locals' who frequently stole the honeycombs from the hives. Due to persistent robbing of the hives and the incidence of accidental veld fires, the stand was later abandoned (H.R. Andrag, pers. comm. 1982).

3E 2.4 *Soil erosion and deposition*

In the absence of aerial photographs, no observations could be made for this period.

3E 2.5 *Vegetation cover*

As no aerial photographs were taken of the site between 1960 and 1968, inferences regarding fires and vegetation ages for this period had to be made from 1968 aerial photographs (see 3F 2.5 below). It appears that an accidental fire in about 1966 razed approximately 60% of the vegetation on the Fynbos Site.

3E 2.6 *Alien vegetation and bush units*

3E 2.6.1 *Alien vegetation*

One or two cluster pines (*Pinus pinaster*) were growing near the western boundary fence at the base of the Burgher's Post hill when the site was purchased. The seeds are thought to have blown there from the stand of cluster pines on the Goeie Hoop land in a summer south westerly wind.

Port Jackson willows (*Acacia saligna*) were growing along the southern boundary fence of the Fynbos Site on the date of purchase. Acacias were also present at the derelict windmill and at the silted up waterhole on the site in 1962 (H.R. Andrag, pers. comm. 1982).

3E 2.6.2 *Bush units*

Distribution of bush units was impossible to determine in the absence of aerial photographs.

3E 2.7 *Fauna* (see also 3D 2.7)

The steenbok, grey duiker and grysbok inhabited the low-lying areas; the steenbok being the most abundant of the antelope species.

The bat-eared fox, *Otocyon megalotis*, porcupine, *Hystrix africaeaustralis*, and grey mongoose were also encountered in the area, and an aardvark, *Orycteropus afer*, was thought to reside in the vicinity of the Fynbos Site (H.R. Andrag, pers. comm. 1982).

Any surviving 'rooikat' in the area remained in the hilly refuges, as did baboons and dassies, and were not hunted by the owners of Dassenberg.

Reptiles on Dassenberg and Burgher's Post included a wide variety of snakes, and at least two - maybe three - species of tortoise (H.R. Andrag, pers. comm. 1982): the 'rooipens', *Chersine angulata;* the 'padlopertjie', *Homopus areolatus;* and possibly the geometric tortoise, *Psammobates geometricus.* (The latter has not been previously recorded in this area, although it has been found in the past on Waylands farm, Darling; also in the Sandveld. Greig, pers. comm. 1982.)

Hawks, owls, guinea fowl, and francolin were frequently spotted in the area; no avifauna were hunted.

3E 3 External influences on the site:

3E 3.1 *Trekpath* see 3D 3.1

3E 3.2 *Fires*

Accidental fires periodically ravaged the area, usually in the dry summer months. The frequency of fires on Dassenberg and Burgher's Post was on average once per annum, affecting different parts of the land each year. No dates of fire on the site could be obtained for this period. Causes of fire were the same as in 3D 3.2 above.

Although the Moravian church condemns the destruction of living plants (Rev. Joorst, pers. comm. 1982), the pressing demand for fuel often drove the inhabitants of Pella village - and undoubtedly other settlements or squatter houses - to set fire to green trees for later collection as firewood. Such generations of fire may have increased the frequency of accidental fires.

3E 3.3 *Cultivation of land*

In the absence of aerial photographs, the exact proportion of cultivated land in the study area could not be determined for this period, but the clearing and strip-cropping of parts of Portion 2 of Burgher's Post increased this value. (The percentage of cultivated land was probably comparable to that in 1968 (3F 3.3).)

3E 3.4 *Soil erosion and deposition*

The elevated annual precipitation in 1962 probably effected an additional layer of wash overburden from the Burgher's Post hill on to the Fynbos Site.

3E 3.5 *Alien vegetation*

The clearing and strip ploughing of land adjoining the Fynbos Site in 1964/5 may be envisaged as having facilitated the encroachment of alien plant species on to the Fynbos Site, providing corridors of bare soil for their seeding and successful growth.

A block of land of 12,58 ha on the strip-cropped section of Portion 2 of Burgher's Post was afforested with *Pinus radiata* in 1962. Although this is an exotic species of pine, it is not considered to be a 'pest plant' (Taylor 1969) and the likelihood of it spreading rapidly is small.

3E 3.6 *Fauna* (see also 3D 3.6)

Local inhabitants from Pella and isolated houses in the immediate area of the Fynbos Site frequently hung wire nooses on the boundary fences of the farm camps to trap wild antelope for food (H.R. Andrag, pers. comm. 1982).

Both Mr H.R. Andrag and Mr C.A. van Breda commented on the overwhelming menace of undernourished domestic dogs in the area which hunted in packs and killed or maimed livestock and other small mammals. According to Mr F.J. Roelofse, the agricultural extension officer for the Malmesbury Division, the problem of marauding domestic dogs has been, and remains, a major problem on farms situated near Coloured townships or settlements.

Divisional Council rewards for 'rooikat', 'rooijakkals' and 'draaijakkals' continued to be offered in this period (17).

3E 3.7 *Fertilizers and pesticides*

As in 3D 3.7, the continued application of fertilizers and aerial spraying of pesticides on to cultivated lands adjacent to the site may have inadvertently affected the ecosystem of the Fynbos Site.

3E 3.8 *Other*

Mr H.R. Andrag could not recall any incidents of flowerpickers, vagrants, woodcutters, or extraneous livestock having trespassed on to the Fynbos Site.

3F <u>28 December 1967 to December 1981</u>

3F 1 Rainfall (Appendix A)

No years of exceptional rainfall were experienced from 1967 to 1973. 1973 was a relatively dry year: Burgher's Post weather station recorded its lowest annual precipitation figure of 392 mm since 1936 (328,1 mm), although this falls within the mean ± one standard deviation range for Coastal Fynbos.

In 1974 and 1976 the annual rainfall figures at all stations superseded the mean ± 1 standard deviation range for Coastal Fynbos.

1977 is believed to have been the wettest year on record in the Cape. The Malmesbury weather station noted an annual total of 744,8 mm, exceeding previous annual maxima at this station. 636,9 mm of rain were recorded at Philadelphia. This was surpassed by only the 1957 rains when 649,2 mm of rain fell. Despite these records, the level of precipitation did not match that of the 1954 deluge: maximum monthly rainfall at Philadelphia and Malmesbury was 125,0 and 143,8 mm respectively in 1977 as compared to 167,1 and 196,2 mm in 1954.

1978 was a relatively dry year.

3F 2 The Fynbos Site:

3F 2.1 *Land ownership, conditions and servitudes* (Appendix D1, D2)
On 28 December 1967, Portion 2 of Burgher's Post was purchased by Heuwelvlak (Eiendoms) Beperk, and has remained the property of this company to date.

The deed of transfer No. 30086 contained the Trekpath condition (3A 2.1) and a servitude of perpetual pipieline and temporary occupation ceded to the Republic of South Africa.

In terms of external servitude Ex 119/77 of 1977 relating to the water scheme from the Berg River to Saldanha, right of temporary occupation on the Fynbos Site, for the purpose of constructing a perpetual water-course from the Withoogte Purification Works to Dassenberg Reservoirs near Atlantis, holds valid until 31 December 1983. The demarcated area of the permanent servitude is a stretch of land of approximately 3160 metres long and 15 metres wide. A tract of land of the same length and width is to be reserved for right of temporary occupation during construction. The expropriation of land took effect from 1 March 1977 in terms of section 60 of the Water Law No. 54 of 1956.

According to the deed of cession K559/77S of 1977 (Appendix D2) section 3, the servitude area would not be fenced, no improvements to the servitude area may be made and the area may only be used as grazing or for the cropping of shallow-rooted plants. A permanent road would be laid down in the area to afford access to construction works. On completion of the pipeline, the landowner is to be given concession of a 12 mm pipeline connection per 1 km of piping over his land (H.R. Andrag, pers. comm. 1982).

Appendix D2 depicts the situation of the intended pipeline and area of temporary occupation on the Fynbos Research site, although recent observations of marker flags on the site suggest that the ultimate siting of the pipeline may be different from that mapped in servitude 559 of 1977.

In the deed of transfer No. 30086, Mr H.R. Andrag declared under oath that he was in possession of the soil conservation scheme which had been declared applicable to land in this area, and knew the contents thereof (Appendix D3).

The Fynbos Site lies in the Darling Soil Conservation District which is bounded by the Atlantic Ocean on the west, the Magisterial District of Bellville in the south and the soil conservation districts of Malmesbury and middle Swartland in the east, and Hopefield in the north. The Soil Conservation Scheme for the Darling district dated 1.9.54 was substituted by an amended scheme of 19 November 1962 for this district (Appendix D3), which took effect from 15 March 1963. All landowners and occupants of land in the Darling Soil Conservation District were bound by this scheme in terms of Act 45 of 1946 - pertinent features of the Scheme, constituting controls on landuse and management practices, will be cited in the relevant sections below.

According to Mr F.W. Duckitt, a member of the soil conservation committee established in 1970 for the Darling/Malmesbury/Hermon area, although the 1969 Soil Conservation Act repealed the 1946 Act and dissolved the concept of soil conservation districts with respective committees (Rabie 1976) the conditions of the earlier district schemes are still applicable although not binding upon white landowners in these districts. Power now lies with the Minister of

Agriculture and Malmesbury Soil Conservation Committee to declare a direction applicable to particular land.

3F 2.2 *Landuse*

The Fynbos Site was employed solely as grazing for livestock from 1967 to 1976. According to Mr A. Biesensagh, Manager of the remainder of Burgher's Post farm, the Fynbos Site has not been grazed by domestic livestock since his arrival in February 1976.

In October 1970, the Divisional Council of the Cape notified the owners of Heuwelvlak (Eiendoms) Beperk of their intention to site a gravel quarry on the fynbos camp of this land. The gravel was required for the maintenance of the road to the Pella Mission Station which had been noted by the Malmesbury Divisional Council to be in an extremely poor condition (18). In early 1971, 59 gravel pits were excavated, but the extent of gravel on the site transpired to be considerably less than had initially been estimated, and the proposed quarry site was abandoned.

The CSIR signed a lease on the fynbos camp of Portion 2 of Burgher's Post in July 1979. It has been used as a site for research on the Coastal Fynbos on sand on the west coastal forelands subsequent to this date.

3F 2.3 *Management practices*

3F 2.3.1 *Grazing*

Stocking rates and grazing rotation on the site prior to 1976 were the same as in 3E 2.3.1 above, and complied with stipulations of the Darling Soil Conservation Scheme whereby "... at least one quarter of the total grazing area of each farm is withdrawn, in rotation, from grazing for the full growing season, in order to rest and produce seed. The area grazed must be used in such a manner that the veld is not damaged" (section E3(1)).

"In order to carry out grazing control effectively each camp must have a stock drinking place" (section E3(3) of the Amended Darling Soil Conservation Scheme 1962).

As there were only the wrecked remains of a windmill and reservoir on the Fynbos Site at the time of purchase of this land in 1962 (H.R. Andrag, pers. comm. 1982) it was obligatory in terms of the soil conservation scheme to employ a camp with a watering point in conjunction with the Fynbos Site for grazing (see 3E 2.3.1). (There was an operating borehole with windmill and four shallow dams on the strip-cropped section of Burgher's Post, Portion 2.) Subsequent to 1969 the above conditions were not binding, but stocking rates on burned veld were not to exceed 3 ha per small stock unit per year, and government subsidies for fencing of natural veld camp were not applicable unless there was a watering point in each camp (Roelofse, pers. comm. 1982).

3F 2.3.2 *Burning*

In terms of section E4(1) of the Amended Darling Soil Conservation Scheme (1962), "No veld within this Soil Conservation District shall be burnt without the prior written authority of the District Committee". Subsequent to the repeal of the 1946 Act in 1969, veld-burning was prohibited without prior written notification to the Agricultural Extension Officer and supervision by the Soil Conservation Committee for the Malmesbury area (Roelofse, Joubert, pers. comm. 1982). None of the legislative controls on veld burning applies to Coloured-owned land - Goeie Hoop or Katzenberg - in the area.

Mr H.R. Andrag never burned the fynbos purposefully, but the incidence of accidental fires in the area was frequent. Conflagrations on the Fynbos Site were curbed and extinguished as rapidly as possible to obviate damage to property (3E 2.3.2).

There were two incidents of fire on the Fynbos Site in the period 1967 to 1981; the first in February 1976 (Biesenbagh, pers. comm. 1982) and the second on 5 November 1980 (Jarman, pers. comm. 1982). The existing firebreak on the site, cleared in about 1966, was extended as far as the northern boundary, and two additional firebreaks were ploughed near the south west end of the Fynbos Site to contain the 1976 conflagration (Fig. 24).

"Every owner or occupier or person in charge of land in this Soil Conservation District shall make or cause to be maintained a fire belt of at least ten (10) feet wide but not exceeding one hundred (100) feet in the veld vegetation, forest or plantation along every boundary of his property." (Section E6(1) of the Amendment of the Soil Conservation Scheme for the Darling Soil Conservation District 1962.)

As the northern and western boundaries of the Fynbos Site are situated on the boundary of Mr H.R. Andrag's land (and of the remainder of Burgher's Post farm), firebreaks had to be maintained along these boundaries until 1969. In 1968 (and 1972), firebreaks were evident only along the northern boundary (and eastern boundary between the fynbos and strip-cropped/afforested sections) of the site (Figs. 13,19), suggesting that the clearing of firebreaks was partly independent of legal requirements. Firebreaks on all four boundaries of the Fynbos Site were evident in 1977 (Fig. 24) and 1979 (Fig. 29), although the southern firebreak appeared to be overgrown with acacias in 1979. In February 1980, existing firebreaks on and at the perimeter of the site were re-cleared by bushcutting (Jarman, pers. comm. 1982).

3F 2.3.3 *Control of alien vegetation* (see 3E 2.3.3)

Acacias at the waterhole appear to have been cleared between 1968 and 1972, and near the south west corner of the site in the region of soil wash and close to the south east corner between 1977 and 1979 (3F 2.6.1). No confirmation of this could be obtained, as no records of alien vegetation chopping were kept by the owner. It is thus possible that *ad hoc* wood-cutters in the area were responsible for the removal of acacias (see 3F 3.8).

3F 2.3.4 *Bushcutting*

Bushcutting was carried out in a number of areas near the south west corner of the site from 1965/6 (3E 2.3.4) to 1969/70 (Figs 15, 20) (R. Andrag, pers. comm. 1982).

From aerial photographs taken in 1968, it can be seen that tracts of veld delimiting the intended extent of bushcutting had initially been cut, and only portions of the vegetation within these demarcated areas had ultimately been bushcut; probably because the fynbos proved too thick to penetrate.

A small stand of vegetation to the south of the soil wash area seems to have suffered repeated bushcutting prior to 1968, and the ground appeared to be bare in the 1968 aerial photographs (Fig. 15). Only one other tract of land (grid squares C5, D5, E4, E5 on Fig. 35) appears to have been bushcut on more than one occasion; having been cut prior to 1968 and again before 1972 (Fig. 38).

3F 2.3.5 *Quarrying*

The Cape Divisional Council was, in terms of Ordinance No. 15 of 1952, supposed to have observed, among others, the following two conditions when undertaking this operation: Topsoil would be re-levelled after the removal of gravel, and precautions would be taken to avoid the creation of a dust nuisance.

At the beginning of 1971, a tract of land traversing the site from the south west corner to the existing quarry area was bulldozed to afford access for heavy trucks to the proposed gravel quarry (Fig. 19). An area near the northern boundary of the site (grid square K6 on Fig. 35) was found to contain a rich deposit of gravel. Having excavated the gravel from this pit, the bulldozer moved on to dig 58 smaller test pits (Fig. 20), apparently using soil colour as an indicator of possible underlying gravel. (The situation of test pits largely coincides with the relatively dark Clovelly soil form where saprolite lies within 2 metres of the surface, and the darker coloured soil mounds on the site (Appendix B).) As deposits of gravel on the Fynbos Site were not found to be extensive, quarrying ceased.

3F 2.3.6 *Other*

Fencing erected by Mr H.R. Andrag shortly after the purchase of the site in 1962 was replaced along the southern boundary in February 1980 by the CSIR as it was damaged in places (Jarman, pers. comm. 1982).

A borehole was sunk in January 1980 and a windmill was erected in March 1980 to supply water to research workers. Two small wooden huts were built in 1980 and 1981 near the south west corner of the site (Fig. 34) to house both research workers and the necessary equipment.

3F 2.4 *Soil erosion and deposition* (Figs 13, 19, 24, 29, 34)

1968: The overburden of soil wash on the site, as seen from 1968 aerial photographs, had increased markedly in extent since the 1960 photographs. The comparatively elevated clay content of the soil wash overburden would cause these soils to become saturated relatively quickly during rainy weather, encouraging runoff and soil particles to travel incrementally down the drainage gradient on the site.

Extending from the obvious wash area were a number of reaches of bare ground, one coincident with a depressed path to the south east of the soil wash, thought to be indicative of additional soil wash (Fig. 13). Exceptionally high rainfall in 1962 must have exacerbated soil erosion and concomitant soil wash from the hillslope to the west of the Fynbos Site on to the site.

The suspected patterns of soil deposition on the site, noted in the 1938 and 1960 aerial photographs, were repeated in 1968 although their extent and distribution were not identical. Discrepancies in the latter are probably due to changes in contemporary vegetation cover and hence in conspicuousness of such patterns.

Trampled ground, devoid of vegetation, was first evident in 1968 near one of two gates in the eastern boundary fence of the site, opposite the kraal and reservoir in the strip-cropped section of Burgher's Post 2 (Fig. 13). This is thought to reflect crowding of livestock passing to and from the fynbos to the strip-cropped section. There were no other indications of trampling on the site, and as livestock tracks were largely restricted to this area, overstocking is thought to have been unlikely.

Concurrent with the changes in camp boundaries subsequent to subdivision of Burgher's Post in 1962 was a change in the situation of roads and tracks on the Fynbos Site. A number of minor roads along the northern boundary, and a major road across the site from the eastern to the northern boundary related to the fencing of Portion 2 of Burgher's Post shortly after purchase, were first apparent in the 1968 aerial photographs.

The boundary fence between camps 1 and 2 prior to 1962 left an indelible impression on the Fynbos Site (Figs 8, 13), presumably as a consequence of compaction of soils along this line. (This imprint is evident in all the aerial photographs to date.)

1972: The area of soil wash appears to have contracted in 1972 (Fig. 19) probably due to both the increase in vegetation cover in this area since 1968 and the absence of years of exceptionally heavy rainfall.

In addition to the patc hes of bare ground noted in 1968, a number of bare areas relatively prone to wind erosion were conspicuous on ground that had been bushcut between 1956/6 and 1969/70, some two to seven years earlier (Figs 15, 19, 20). It is possible too, that minute quantities of soil wash could have been washed into the upper reaches of these areas from the western boundary, as the reduced vegetation cover would facilitate the passage of water down the drainage line to the south east corner of the site where soils are wetter.

A temporary road to the waterhole on the site was made between 1968 and 1972, and was associated with bushcutting or clearing of alien vegetation from this area.

<u>1977</u>: Subsequent to 1972, further deposits of soil seem to have been washed on to the Fynbos Site from the erosion gulley on the Burgher's Post hill, following the depression of a small path to the south east of the granite wash overburden (Fig. 24). This incremental wash of soil is likely to reflect the heavy precipitation recorded in 1974.

<u>1977</u>: Areas of soil deposition and trampling noted in the 1972 aerial photographs could not be detected on bare soils in the 1977 photographs (this area was burned in 1976). Patches of bare ground were evident in the two tracts of repeated bush cutting (3F 2.3.4).

<u>1979</u>: As in 1972, the extent of soil wash appears to have diminished in 1979 (Fig. 29). 1978 was a relatively dry year, allowing re-growth of vegetation in this area and thereby causing this phenomenon.

The irregular vegetation cover and concomitant bare patches of ground near the north west corner of the site noted in earlier air photographs and thought to be indicative of localized soil deposition, were evident in 1979.

Although reduced in extent since 1977, patches of bare soil on the tract of land bushcut in 1965/6 and again in 1969/70, vulnerable to wind erosion, were still visible in 1979, nine years after the incident.

A number of the minor roads and tracks on the Fynbos Site disappeared between 1972 and 1979, probably reflecting disuse - regrowth of Coastal Fynbos on previously compressed soils thus appears to have been fairly rapid. At the scale of vegetation survey used by Boucher and Shepherd in 1979/80, there was no correlation between plant communities and the position of old roads or fence lines (Boucher, pers. comm. 1982).

1980: Patches of bare soil after the 1980 fire were restricted to the north western end of the Fynbos Site; the probable area of soil deposition by wind (Fig. 34). Signs of soil wash and further indications of wind erosion - or deposition - were not possible to detect on the newly burned ground.

3F 2.5 *Vegetation cover* (Figs 14, 15, 20, 25, 30, 34)

1968: From analysis of the vegetation cover in aerial photographs taken in 1968, it is apparent that there had been an accidental fire on the site approximately 2 years earlier. This fire seems to have started near cropped land to the north of the site and spread southwards, probably encouraged by a northerly wind, sweeping across any firebreaks on the northern boundary. If a firebreak had not been cleared across the site in an attempt to control the extent of burn (3E 2.3.2), it is probable that the fire would have razed the entire stand of fynbos which had attained a minimum age of 6 years. (Most fynbos is inflammable from an age of 4 years (see 4.2.1.2).) The estimated range of burn is shown in Fig. 14, and amounts to approximately 60% of the site, similar to the discontinuous area patch-burned in 1938 (3C 2.5).

The possibility of there having been a fire on the Fynbos Site between

1960 and 1966 is negligible. Patterns of vegetation cover evident on the 1960 aerial photographs are consistent with those in the unburned vegetation in the 1968 photographs. (Noting the indications of intentional patch burning on a small scale in 3D 2.5, between 1958 and 1960, it can be assumed that intentional veld-burning on the site ceased from 1960.)

Tracts of bushcutting were easily identified from 1968 aerial photographs (Fig. 15).

<u>1972</u>: Four years later, as can be seen from the 1972 aerial photographs, vegetation cover in the area burned in 1966 had increased from 'bare'/'medium' in 1968 to a uniform 'medium', and traces of pre-1968 bushcutting had largely disappeared. Only the repeatedly bushcut area to the south of the soil wash and patches of vegetation (grid squares B5, C5, D5, on Fig. 35) to the west of a subsequently bushcut tract marked in Fig. 20, were still noticeable. A number of patches of dense vegetation had been bushcut subsequent to 1968 (Fig. 20); study of the vegetation cover in these areas dates bushcutting at between 1969 and 1970.

The Fynbos Site does not appear to have burned between the years 1968 and 1972.

Localities of gravel quarry pits are distinct in the 1972 aerial photographs (Fig. 20).

1977: The accidental conflagration in February 1976 appears to have spread on to the Fynbos Site from the vicinity of the Burgher's Post watercourse; the firebreak along the northern boundary thus being ineffectual. This fire burned about 78% of the site; the most extensive burn to date (Fig. 25). The majority of fynbos burned in the 1966 fire was consumed in the 1976 fire having attained an estimated age of 10 years. Patches of vegetation not burned in 1966, for example in the south west region of the site, had reached a minimum age of from 19 to 23 years by 1976, having last been burned between 1954 and 1958.

There were no traces of past bushcutting or the gravel quarry pits in the 1977 aerial photographs; detection of the latter being impossible on the recently burned land.

1979: Three years and three months after the accidental conflagration in 1976, the fynbos in the burne d area (excepting the darker soil areas) was uniformly of 'medium cover', whilst the remainder of the Fynbos Site was covered by 'dense' plant growth (Fig. 30). There were minimal indications of the smaller gravel pits dug in 1971; only the large quarry (grid square K6 on Fig. 35) was conspicuous.

1980: The unintentional fire in November 1980, which appears to have originated to the south of the Fynbos Site and crossed the ineffectual firebreak on the southern boundary burned approximately 32% of the site and razed almost the entire stand of mature fynbos near the south west corner (Fig. 34). The minimum age of this vegetation is estimated to have been between 23 and 25 years old. Three small patches of mature fynbos (grid squares A1 and B1, B7 and F4 on Fig. 36) escaped the 1980 fire and are thought to constitute the oldest stands of fynbos on the site.

3F 2.6 *Alien vegetation and bush units* (Figs 16, 21, 26, 31)

3F 2.6.1 *Alien vegetation*

1968: In addition to the two pine trees detected in the soil wash area of the Fynbos Site in 1960, there was a third pine near the northern boundary fence in 1968 (Fig. 16). All three are *Pinus pinaster*, the cluster pine, and as such are labelled 'plant invaders' (Stirton 1978). A likely source of spread of these trees was the pine stand on the Goeie Hoop/Burgher's Post land (3E 2.6.1).

The pines are evident in all aerial photographs subsequent to 1968, and are still standing on the site (June 1982), having an estimated maximum age of 44 years. These pines constitute incremental sources of spread of this pest tree.

As in 1960, acacias were growing in and to the north of the soil wash area in 1968, and at the waterhole (Fig. 16). In both the latter places, acacias appeared to be on the increase. New areas of infestation were near the northern boundary fence of the site to the east of the solitary pine, and on the small hillock situated there (grid square M7 on Fig. 35). Acacias seem to have spread progressively to this land from sources external to the northern boundary (Fig. 18). One or two acacias were present at the derelict windmill site and a dramatic flush of these plants was evident along the southern (Dassenberg) boundary fence of the site.

The ploughing of land adjacent to the southern boundary prior to 1960 (Fig. 11), in particular the disjunct strip of ground running southwards from the Fynbos Site parallel to the cultivated field, had inadvertently provided a corridor for the spread of acacias from the settlement alongside the Dassenberg watercourse to the site. Acacia seeds in the faecal deposits of birds utilizing both the southern boundary fence and the old windmill as roosts constitute a feasible explanation for the initial seeding of these aliens, especially *Acacia cyclops*, in these areas (Glyphis *et al.* 1981, Stirton 1978).

1972: By 1972, after the fire in 1966, acacias at the windmill site and along the Dassenberg boundary fence had increased in number (Fig. 21). Acacia plants appeared to be spreading on to the site from the south east corner and along the northern boundary, where, as in 1968, there was at least one acacia bush growing on the small hillock to the east of the solitary pine (grid square M7 on Fig. 35).

Alien acacias, evident at the waterhole in 1968, appear to have been cleared prior to 1972; probably to facilitate bushcutting in this area, or to afford access to water.

1977: Acacias had increased in number at and to the north of the soil wash area, along the western boundary fence and at the old windmill site in 1977; none of these localities had been burned in the 1976 fire. Acacias continued to grow along the Dassenberg boundary fence of the site and in the south east corner of the site, had reappeared at the waterhole and proliferated near the large quarry pit since 1972 (Fig. 26).

1979: A fourth pine was detected in the 1979 aerial photograph (Fig. 21) to the south west of the waterhole (grid square D7 on Fig. 35); seed from afforested blocks of *Pinus pinaster* on Dassenberg land probably having blown on to the site in a south easterly wind.

Acacia bushes seem to have been chopped down in the region of soil wash, at the south west corner of the site and close to the south east corner between 1977 and 1979 (Figs 26, 31). Abundance of acacias at the windmill site had increased markedly by 1979, and alien bushes were evident in the vicinity of ground disturbed by gravel quarrying in 1971, and on the hillock to the east of the lone pine in this area.

Acacias growing in the immediate soil wash area in 1979 were principally *Acacia cyclops*, the rooikrans. Elsewhere on the site, *Acacia saligna*, the Port Jackson willow, was the principal invader (Boucher, pers. comm. 1982).

1980: After the fire in November 1980 acacias sprouted prolifically in areas extending from the western boundary fence eastwards, and from the southern boundary northwards on to the Fynbos Site (pers. obs.) reflecting the accumulation and dispersal of acacia seed in these regions in the absence of fire. Distribution of acacias in the latter area seems to coincide with the Clovelly soil form where saprolite lies within 2 m of the surface (Appendix B), possibly reflecting preferential invasion of soils with a relatively elevated nutrient status and modified water retention. (Soils developed from granitic saprolite, although leached, have a comparatively high nutrient content (Lambrechts 1979) and, although overlain by recent drift sands, where saprolite is close to the soil surface this affects nutrient status.)

3F 2.6.2 *Bush units*

1968: In the interval between 1960 and 1968, scattered bush units had appeared to the south of the soil wash area (Figs 10, 16).

1972: The principal increase in bush units was in the north west region of the site (Figs 16, 21) reflecting either an increase in the dimensions of existing resprouting species or the cumulative appearance and growth of *Protea repens*, a reseeder, in the absence of fire since prior to 1960.

1977: In 1977, a marked reduction in bush units was evident in areas burned in 1976. Remnants were visible on the Clovelly soil form where saprolite occurs within 2 m of the surface, on the darker soil mounds, and scattered in regions where bush units were detected in 1972 (Fig. 26). A number of *Protea repens* bushes growing at the edge of the large quarry pit (grid square K6 on Fig. 35) were not burned in the 1976 fire, seemingly protected by the surrounding débris

(Boucher, pers. comm. 1982). (These plants thus constituted a source of *Protea* seed for local re-establishment post-fire.)

<u>1979</u>: The principal point of interest regarding the distribution of bush units was the increase in this variable to the south east of the soil wash area and along the Dassenberg boundary of the site, possibly relating to the growth of vegetation after the 1965/6 to 1969/70 bushcutting (Fig. 31).

Further increase in the number of bush units was concurrent with the increase in age of vegetation post-fire, probably exemplifying growth of both resprouting and re-seeding species.

3F 2.7 *Fauna*

In addition to the fauna noted in previous sections (3D 2.7, 3E 2.7), the following mammals are known to occur on the site: large spotted genet, *Genetta tigrina;* striped fieldmouse, *Rhabdomys pumilio;* Cape gerbil, *Tatera afra* (Pepler, pers. comm. 1982); common mole rat *Cryptomys hottentotus* (Davies, pers. comm. 1982); and the Cape hare *Lepus capensis* (pers. obs.).

Avifauna spotted on the site in recent years can be grouped into pre-fire (April to September 1980) and post-fire (February to December 1981) observations. As these lists are somewhat lengthy and include birds noted flying over the site - that is, not strictly inhabitants of the fynbos - they appear in Appendix E. Three of the six birds endemic to the Cape fynbos are found on the site: the Cape sugarbird, *Promerops cafer;* the orange-breasted sunbird, *Nectarinia violacea* and the Cape francolin, *Francolinus capensis.* Of the four nectarivorous species observed on the Fynbos Site, only one - the itinerant lesser double-collared sunbird, *Cinnyris chalybeus* - has been recorded subsequent to the 1980 fire.

Reptiles observed on the Fynbos Site include *Chersine angulata* (the 'rooipens' tortoise) and a number of lizards of the Family Scincidae: *Mabuya* species (pers. obs.).

No insect collections have been undertaken on the Fynbos Research site, but termitaria and small ant mounds are numerous. There are at least two species of termite on the site (pers. obs.): the ubiquitous black-mound termite, *Amitermes hastatus*, a wood eater; and the snouted harvester termite, *Trinervitemmes* sp. (*trinervoides?*), which builds relatively large greyish-brown mounds on the more clayey soils of the site. Mounds of the latter termite have been noted in the soil wash area, and on the Clovelly soil form near the large quarry pit and adjacent to the Dassenberg boundary fence where saprolite lies within 1 metre of the surface (Appendix B).

A minimum of three species of ant appear to exist sympatrically on the Fynbos Site (pers. obs.): *Ocomyrmex barbiger* - possibly a new subspecies (Prins, pers. comm. 1982) - *Camponotus mystaceus* and *Camponotus simulans* (?) - possibly a new species (Prins, pers. comm. 1982).

3F 3 External influences on the site:

3F 3.1 *Trekpath* - see 3D 3.1

3F 3.2 *Fires* - see 3E 3.2

3F 3.3 *Cultivation of land* (Figs 17, 22, 27, 32)

The proportion of cultivated land increased from 13% in 1960 to 52% of the total study area in 1968 and 1972. This increase was primarily due to the strip cropping and afforestation of Portion 2 of Burgher's Post (3E 3.3); incremental ploughing on the hillslope and to the north of the Fynbos Site contributed to the increase.

By 1977, the area of cultivated land had risen to 54% of the study area, due to the enlargement of ploughed fields to the north east of the site.

3F 3.4 *Soil erosion and deposition* (Figs 18, 23, 28, 33)

"All land under cultivation, shall be effectively protected against wind and water erosion." (Section E1(1) of the Amendment of the Soil Conservation Scheme for the Darling Soil Conservation District, 1962.)

Although attempts have been made to incorporate bush strips on cropped lands from 1968 to date, in many cases these appear to have been discontinuous, extremely narrow and probably ineffectual, especially on the hillslope where rill and gully erosion were rife. In 1977 bush strips on cropped ground near the hilltop, evident in previous photographs, had disappeared (Fig. 27), and soils had thereby been rendered increasingly vulnerable to both wind and water erosion.

As in 1938 and 1960, there were indications of probable soil deposition to the north and north west of the Fynbos Site in all subsequent aerial photographs.

The extent of bare patches of soil to the north east of the north west corner of the site increased progressively from 1968 to 1979, concurrent with the increase in cultivated land in this area. The grazing and trampling of livestock on strip-cropped ground to the north of the site in the dry summer months must have aggravated the transport and subsequent deposition of light soils here, contributing to the phenomenon of patchiness.

The Goeie Hoop land seems to have suffered some measure of wind erosion between the years 1977 and 1979, probably as a result of ploughing at this time. Transport of soils from this land in a south westerly wind were likely to encounter bush strips or fynbos before or on reaching the Fynbos Site; effecting localized soil deposition near the western site boundary.

The erection of electrical pylons parallel to the Dassenberg boundary of the Fynbos Site in 1974 was recorded in aerial photographs taken in 1977 and 1979 in the form of patches of bare ground at the bases of pylons. A maze of vehicle tracks to and from each pylon can be identified on these photographs, constituting further tracts of disturbed ground prone to invasion by pest plants.

Signs of trampling and likely wind erosion persisted in the area of settlement alongside the Dassenberg watercourse, but repercussions of these on the site biota are thought to be negligible (3C 3.4).

3F 3.5 *Alien vegetation* (Figs 18, 23, 28, 33)

A row of pines (*Pinus radiata*) was planted along the boundary fence between Portion 2 and the remainder of Burgher's Post farm in about 1970 (Van Breda, pers. comm. 1982) and a line of gums (*Eucalyptus cladocalyx*) was planted along the fence line between the strip-cropped area and the Fynbos Site on Portion 2 of Burgher's Post shortly after 1972 (R. Andrag, pers. comm. 1982). (The *Eucalyptus* trees exhibit allelopathy; inhibiting the development of undergrowth at their bases and thereby forming a natural firebreak. They are thus though to act as a deterrent to ground fires in fynbos, preventing low fires outside plantations and cropped lands from spreading into these.)

Four additional blocks of land on the strip-cropped section of Burgher's Post 2, a total of 47,64 ha, were afforested with *Pinus radiata* in 1968 and 1969 (Figs 18, 23). As noted in 3E 5 above, this species is not a pest tree and its presence does not constitute a threat to the fynbos vegetation *per se*.

The group of cluster pines on the Goeie Hoop land spread markedly between 1960 and 1968 (Figs 12, 18) and continued to expand in subsequent years, probably facilitated by the provision of bare soils through cultivation. Spread of acacias - both *Acacia saligna* and

Acacia cyclops - amongst these pines (pers. obs.) was probably concurrent with the growth of the pine stand although acacias were shadowed by the taller trees and hence not detected in aerial photographs.

The encroachment of acacias on the hillslope to the west of the Fynbos Site since 1960 has largely been restricted to the pattern of rills and gullys (3D 3.5) and to bush strips on the cultivated slope.

Apart from the hill area, both *Acacia saligna* and *A. cyclops* had increased in abundance on the strip-cropped section of Portion 2 of Burgher's Post following the cultivation of land pre-1968. It seems probable that acacias spread on to this land from the Riverlands farm to the east, on which these pest plants are spreading uncontrolled (H.R. Andrag, pers. comm. 1982). Prior to the ploughing of this camp, acacias were restricted to the windmill site in 1960 (Fig. 12).

As postulated above (3F 2.6.1) the ploughing of Dassenberg land adjacent to the Fynbos Site encouraged the spread of acacias in this region. Acacia plants first ap pear dotted along the border of the cultivated land in the 1968 aerial photograph, spreading progressively to date. The additional disturbance of soils accompanying the erection of electrical pylons in 1974 probably facilitated the proliferation of alien plants in this area.

Acacias have increased in abundance, seemingly unchecked, on land between the Burgher's Post watercourse and the northern boundary of the site since 1960. In 1960, acacia bushes were scattered along the watercourse in this area (3D 3.5). Eight years later acacias, predominantly *Acacia saligna* (pers. obs.) had spread towards the Fynbos Site (Fig. 18); their distribution apparently coinciding with those areas of land that had been cultivated from 1938 to 1960 and then abandoned (Figs 6, 11, 17). The continued expansion of this stand of acacias is disclosed in aerial photographs taken after 1968 (Figs 23, 28, 33), and has been restricted to those areas not actively cultivated.

Mr C.A. van Breda, manager of the remainder of Burgher's Post until 1974 only removed those acacias which physically obstructed the plough on cultivated lands on his farm. Andrag Bros., owners of Dassenberg, chopped acacias sporadically throughout this period. Mr Peters (who sublets the Goeie Hoop land from the owner, F.M. van Niekerk) does not control the spread of acacias (or pines) on Goeie Hoop. Only Mr A. Biesenbagh, the current manager of the remainder of Burgher's Post farm, purports to be systematically clearing the land of acacias.

3F 3.6 *Fauna* (see also 3D 3.6; 3E 3.6)

Mr H.R. Andrag, a keen apiarist, periodically transported a number of hives to the strip-cropped area of Burgher's Post 2 when the eucalypts, planted shortly after 1972, were in flower. In addition to these hives, there are a number of other apirary stands on Dassenberg in close proximity to afforested areas such as to the south of Portion 2 of Burgher's Post. (All pine plantations here are surrounded by a narrow margin of *Eucalyptus* trees whose flowers have a high yield of nectar and are attractive to bees.) The presence of hives adjacent to the site may facilitate the pollination of fynbos species by bees.

In May and October 1975, July 1976 and May and August 1977, the Department of Nature and Environmental Conservation undertook to relocate game from the Atlantis area to other regions of the Cape Province. A number of antelope were simultaneously trapped and removed from veld surrounding the Pella Mission village in 1975 (Rev. Cornelius, pers. comm. 1982). As figures relating specifically to game trapped at Pella could not be isolated, the total number of animals caught in the 1975 excursions are presented below:

May 1975: 3 grysbok, 26 duiker, 21 steenbok
October 1975: 1 grysbok, 6 duiker, 1 steenbok.

Actions serving to deplete wild fauna are the same as those noted in 3E 3.6 above. Both wire nooses on the boundary fences and numerous large dog tracks were noted on the Fynbos Site (pers. obs.)

3F 3.7 *Fertilizers and pesticides*

As documented in 3E 3.7, Mr C.A. van Breda aerially sprayed cereal crops on the remainder of Burgher's Post farm on an annual basis with 2-4-D.

The Agricol Seed Company, which purchased this farm in 1974, has aerially sprayed crops of lupins grown on land to the west of the site in October and November of each year with a copper sulphate solution - probably Bordeaux mixture - against powdery mildew fungus. In addition to this, crops were sprayed with MCPA (2-methyl-4-chlorophenoxyacetic acid), a selective translocated spray for broad leaved weeds such as vetches (*Vicia* species) and 'wilde ramnas' (*Raphanus* species) in winter (Biesenbagh, pers. comm. 1982).

Melons were very occasionally grown on the strip-cropped section of Portion 2 of Burgher's Post and hand sprayed against insect pests (R. Andrag, pers. comm. 1982). This spray is unlikely to have drifted on to the Fynbos Site.

3F 3.8 *Other*

The Pella villagers habitually collected firewood from the cemetery as in Rev. Barley's time and from areas in the immediate vicinity of the mission (Rev. Cornelius, pers. comm. 1982). They are not thought to venture on to either Dassenberg or Burgher's Post land in search of firewood, although Boucher and Shepherd observed people collecting wood of the Port Jackson willow near the boundaries of the Fynbos Site in 1979/80 (Boucher, pers. comm. 1982). There are a number of squatters on Goeie Hoop who are known to collect firewood, principally acacias, from the surrounding areas (Peters, pers. comm. 1982), possibly accounting for this observation.

FOR KEY TO FIGURES 3 TO 34 SEE FOLDOUT AFTER FIG. 34

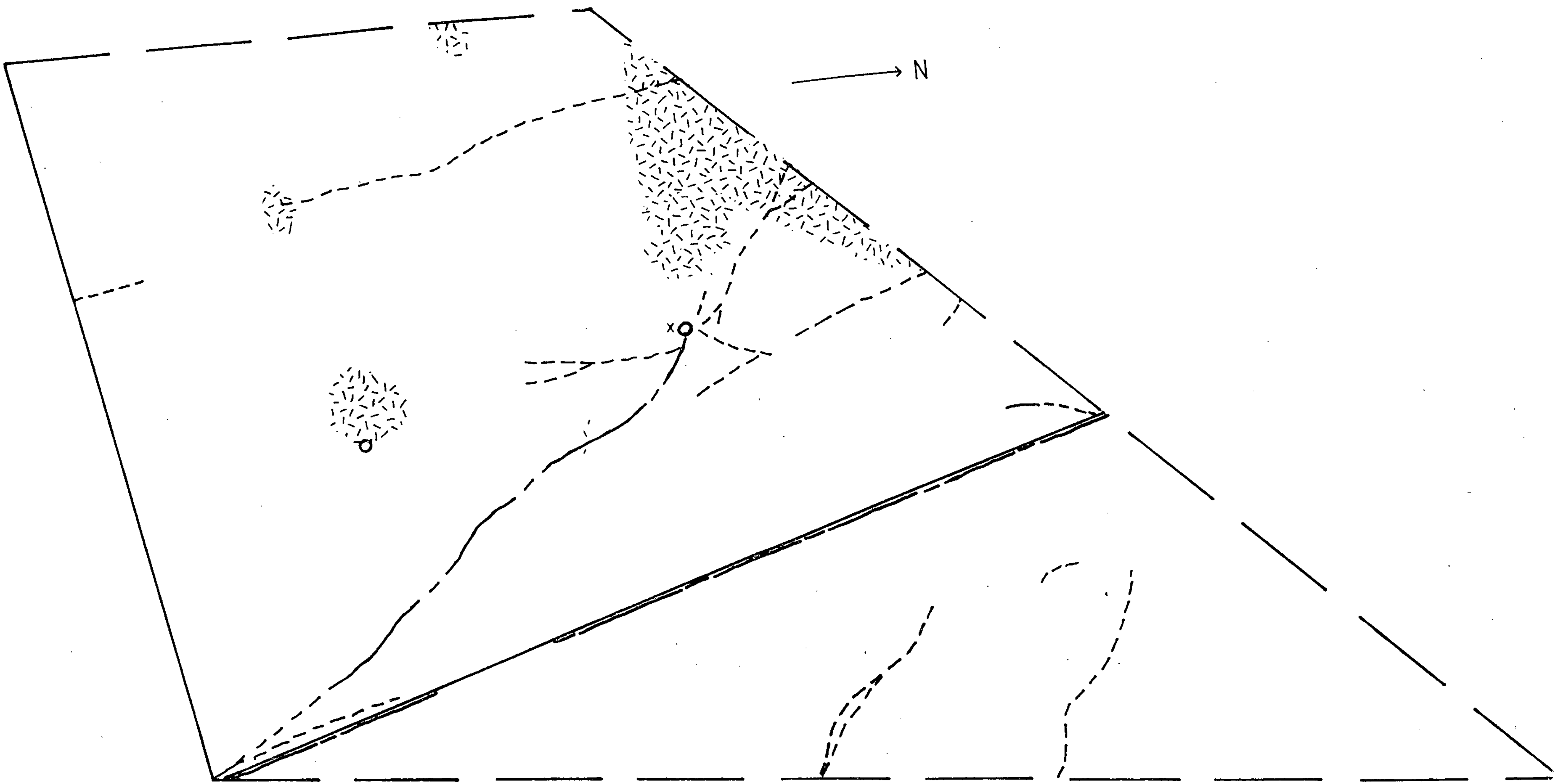

FIGURE 3: BARE SOIL AREAS, ROADS, TRACKS, FIREBREAKS AND WATERING POINTS (1938)

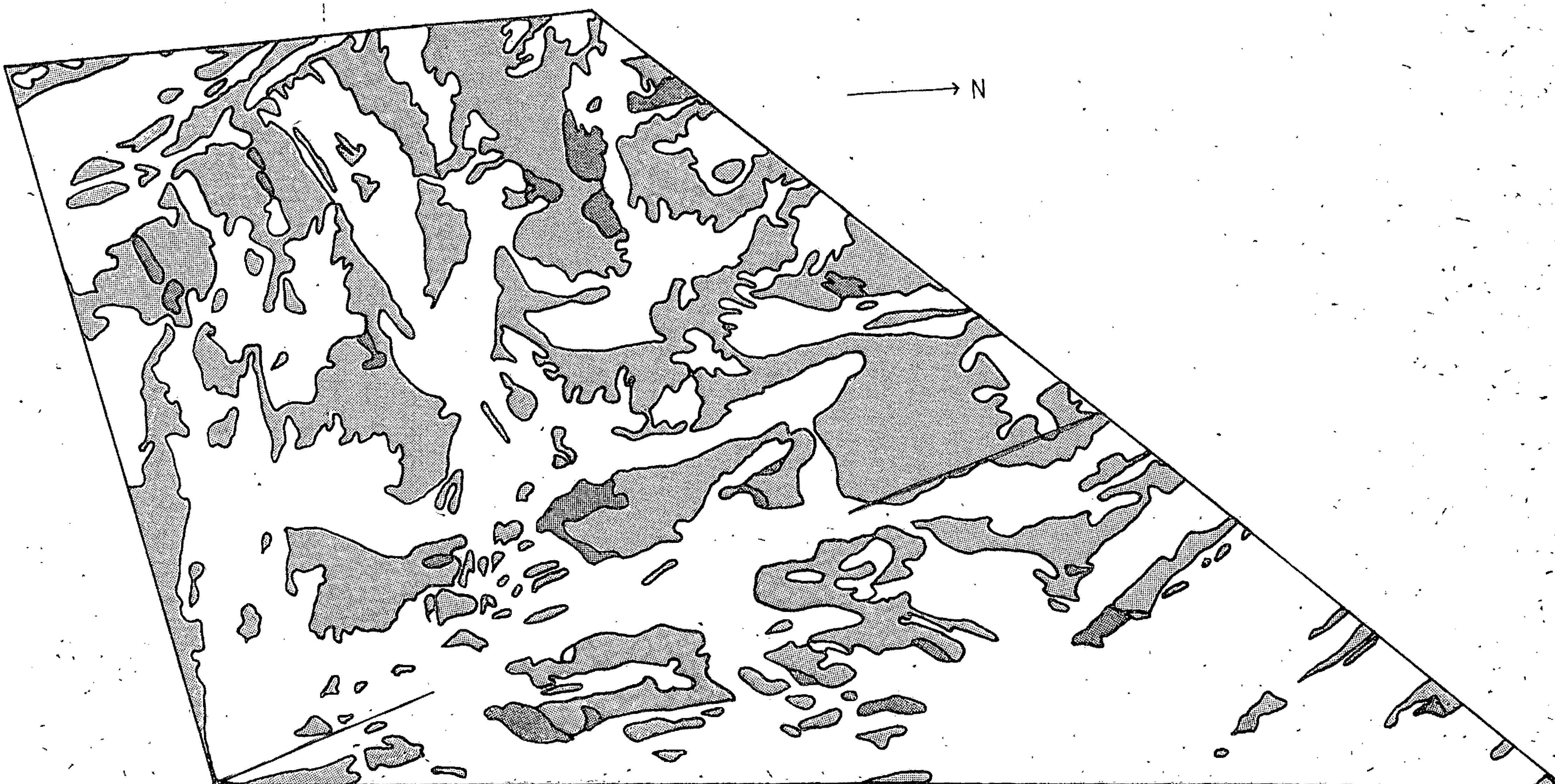

FIGURE 4: VÈGETATION COVER (1938)

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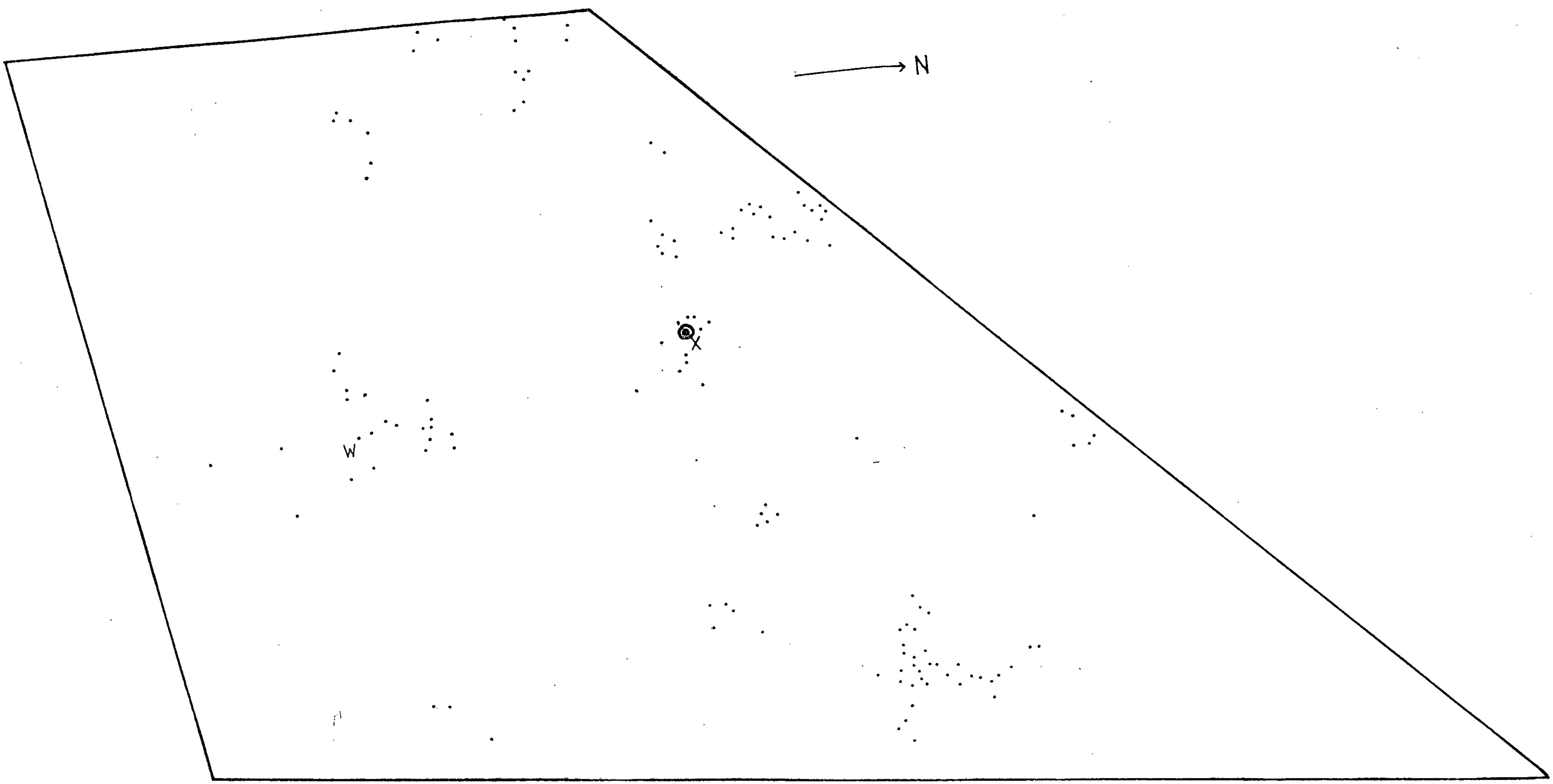


FIGURE 5 : ALIEN VEGETATION AND BUSH UNITS (1938)

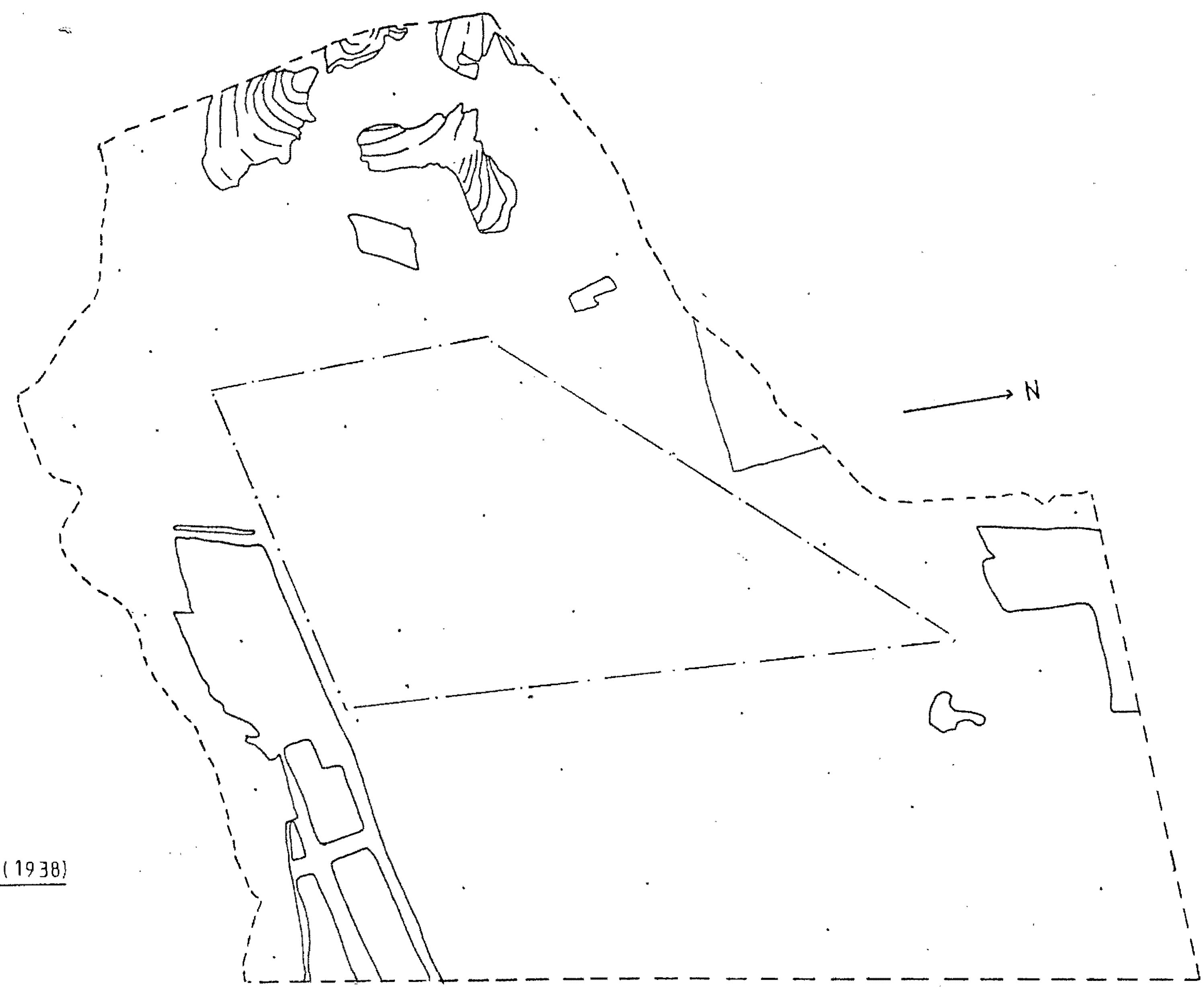


FIGURE 6 :

CULTIVATED LAND (1938)

FIGURE 7:

BARE SOIL AREAS AND ALIEN VEGETATION (1938)

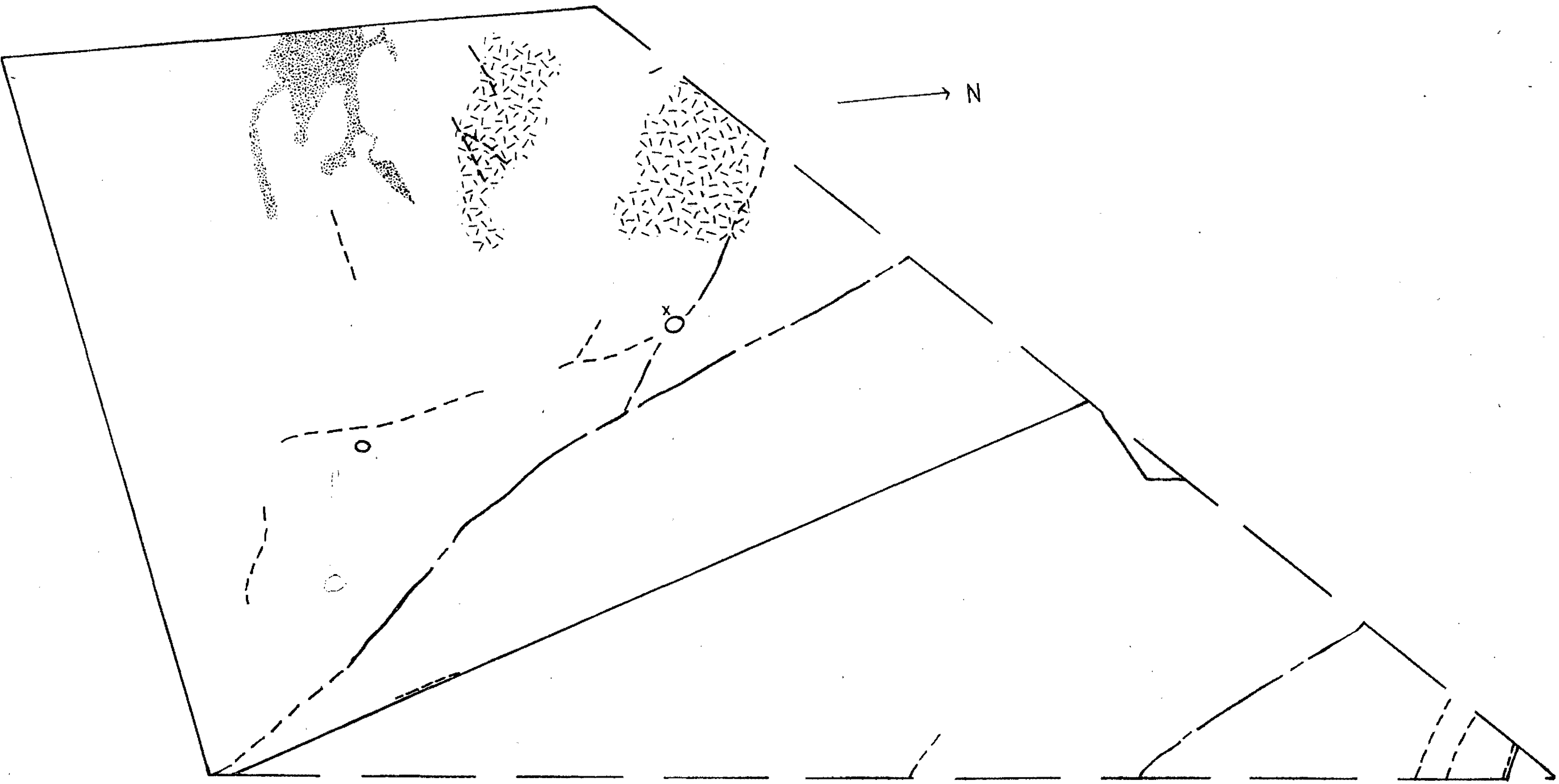


FIGURE 8: BARE SOIL AREAS, ROADS, TRACKS, FIREBREAKS AND WATERING POINTS (1960)

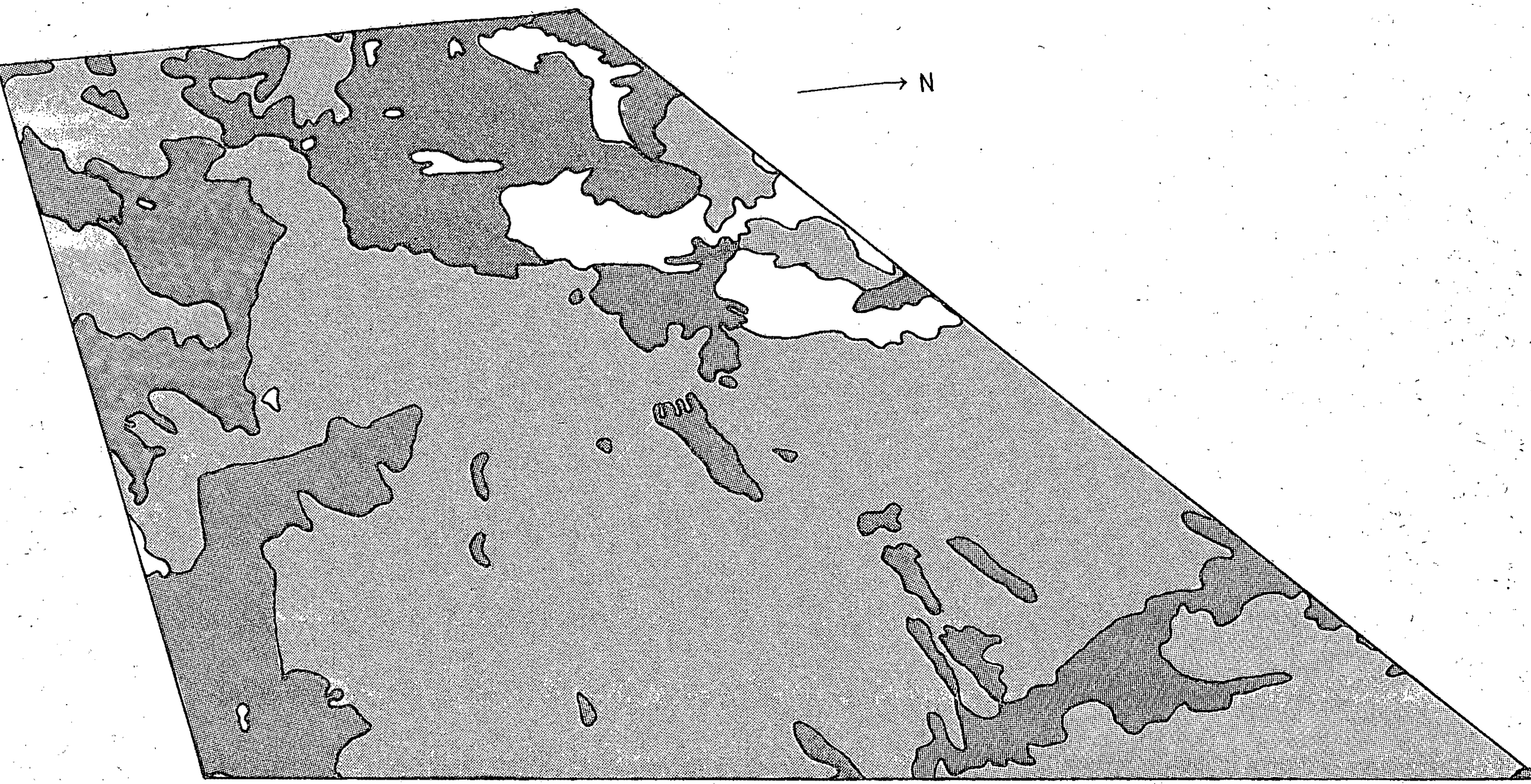


FIGURE 9: VEGETATION COVER (1960)

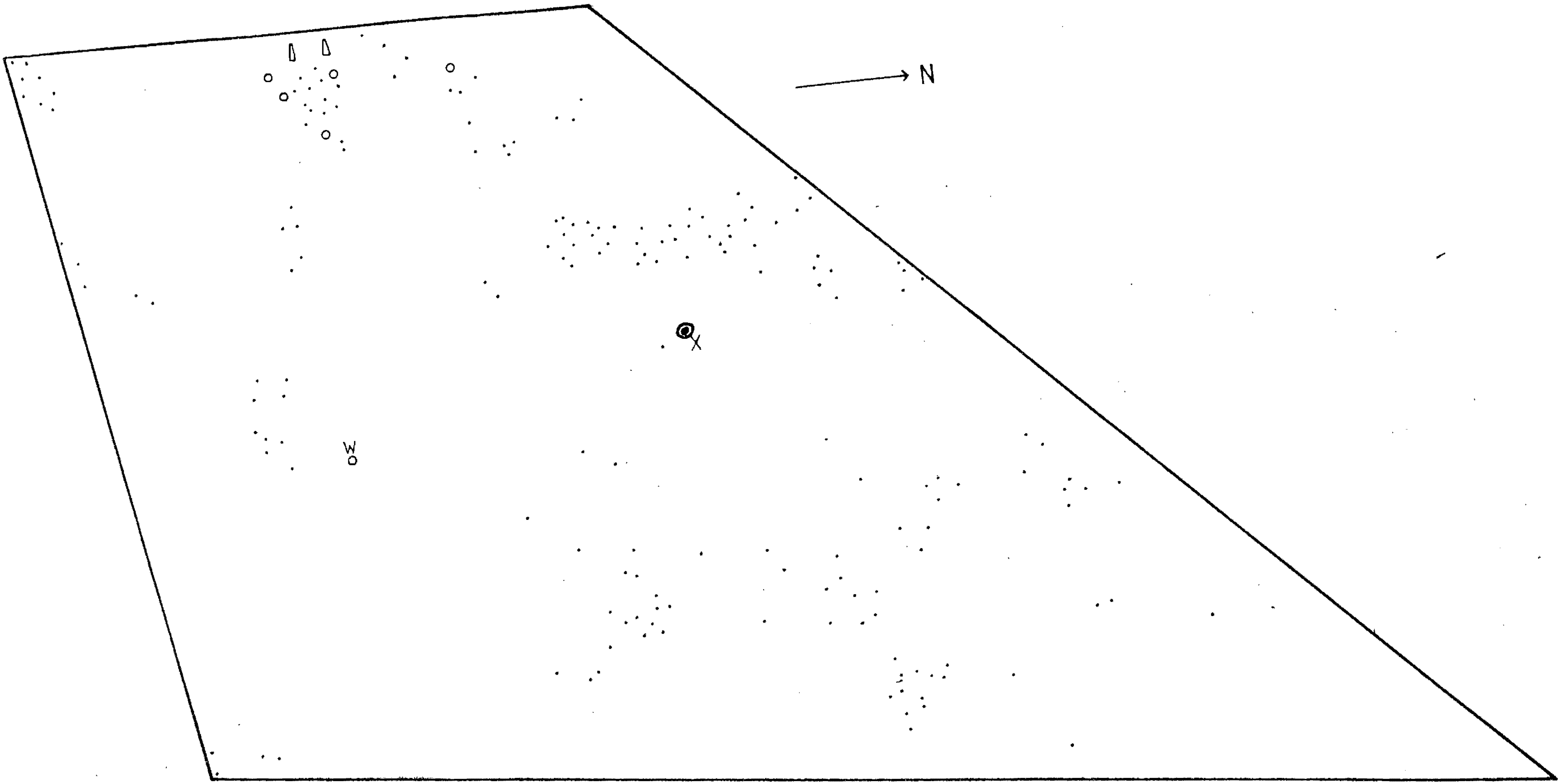


FIGURE 10: ALIEN VEGETATION AND BUSH UNITS (1960)

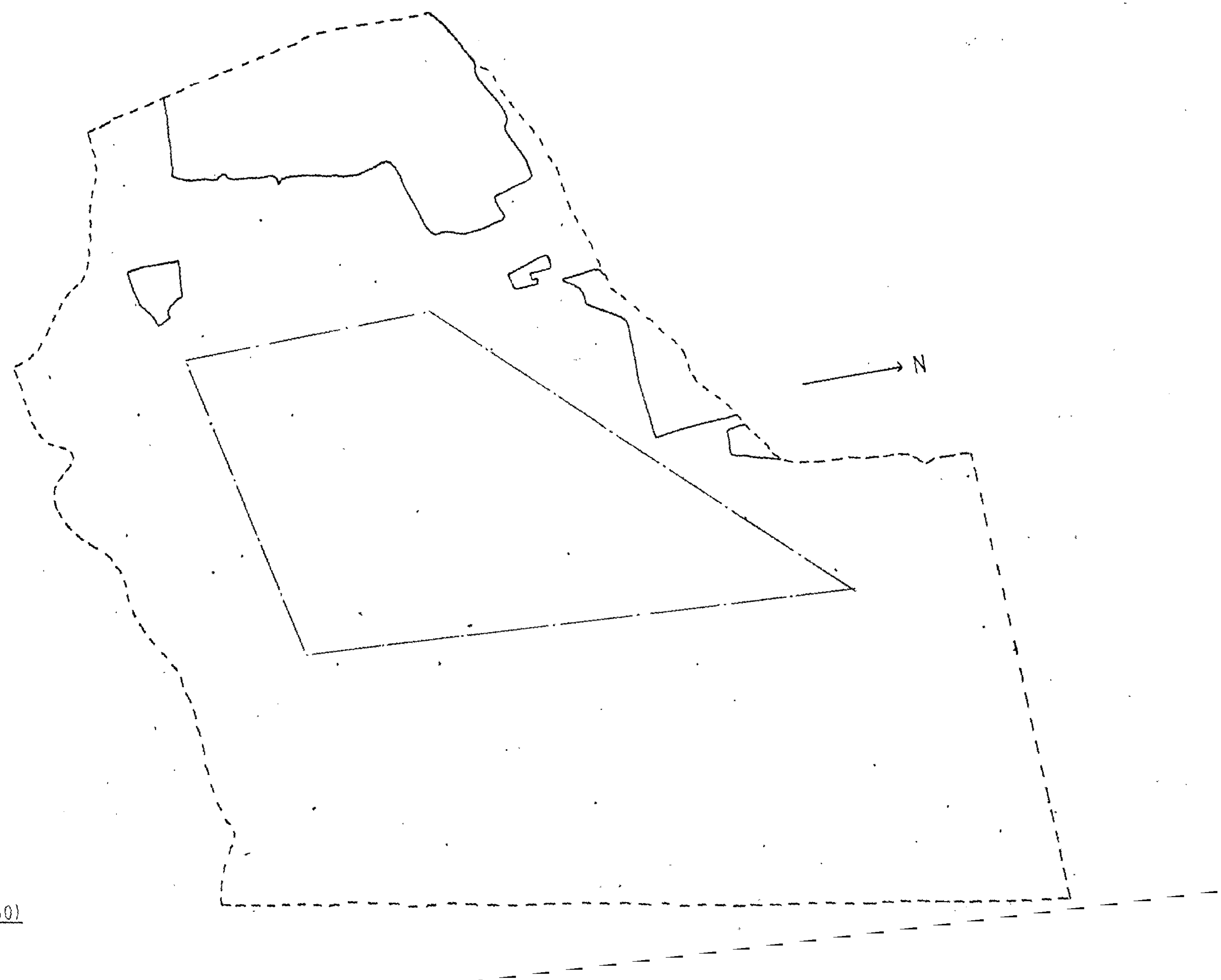


FIGURE 11:

CULTIVATED LAND (1960)

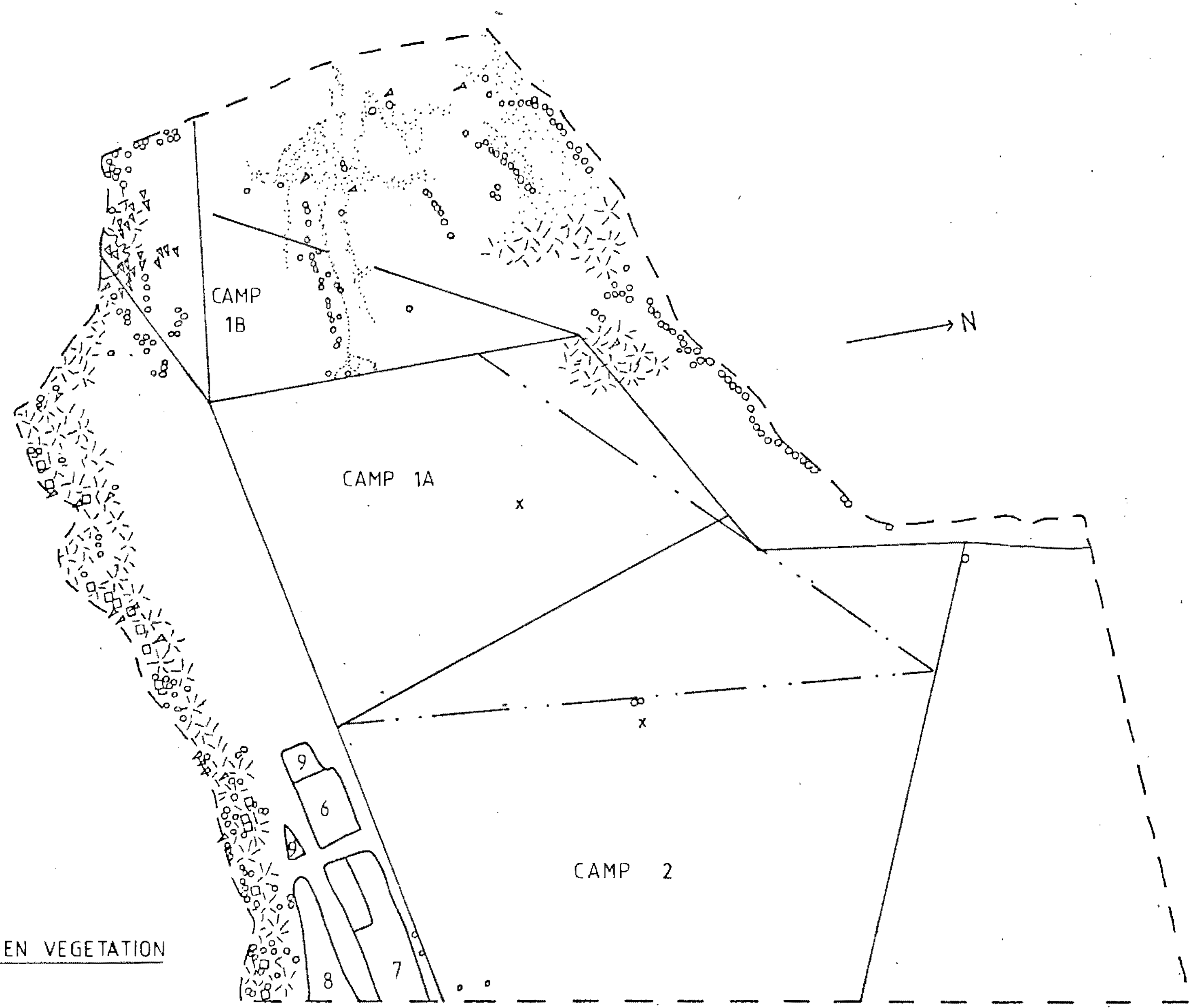


FIGURE 12:

BARE SOIL AREAS AND ALIEN VEGETATION

(1960)

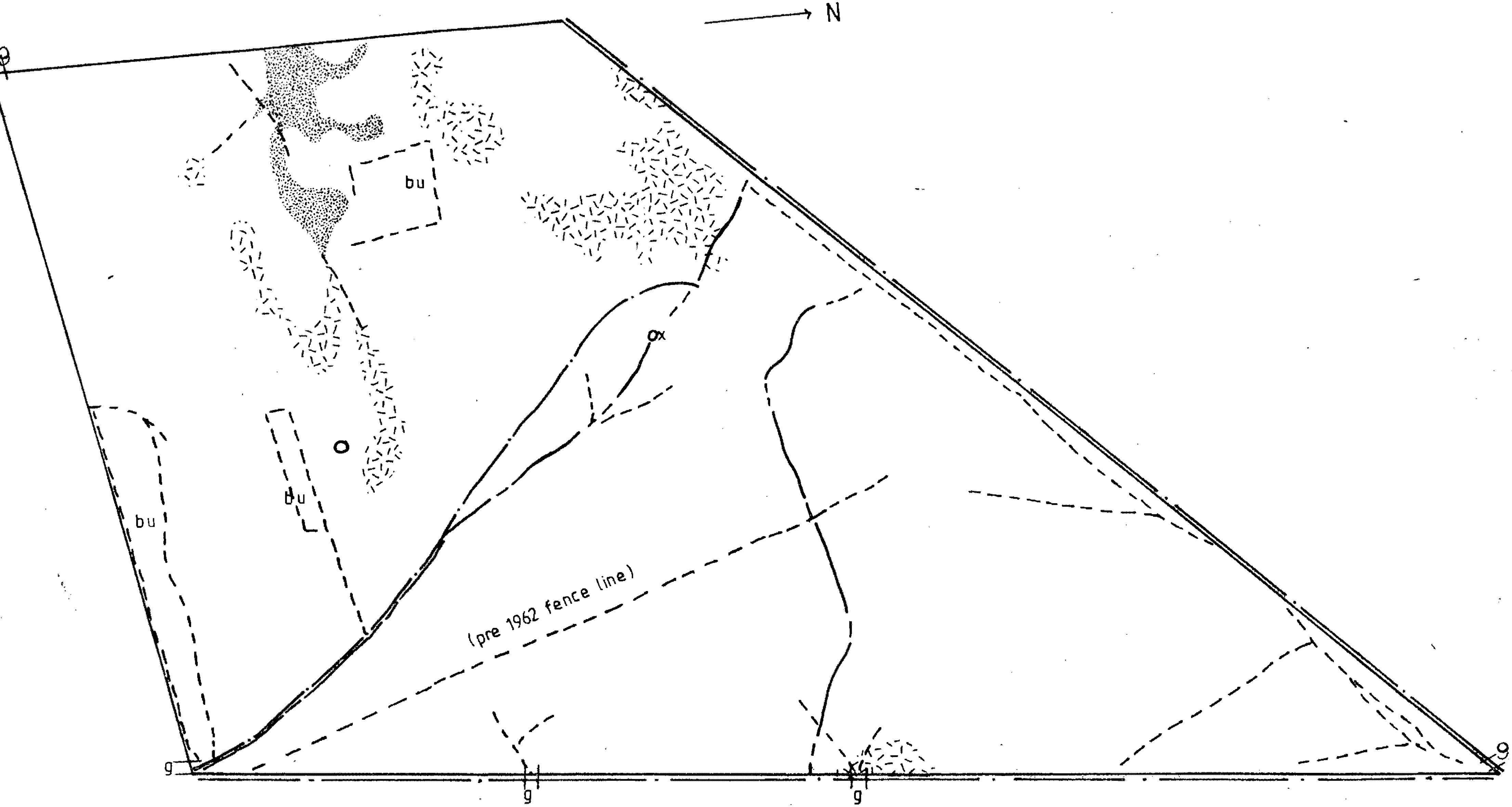


FIGURE 13: BARE SOIL AREAS, ROADS, TRACKS FIREBREAKS AND WATERING POINTS (1968)

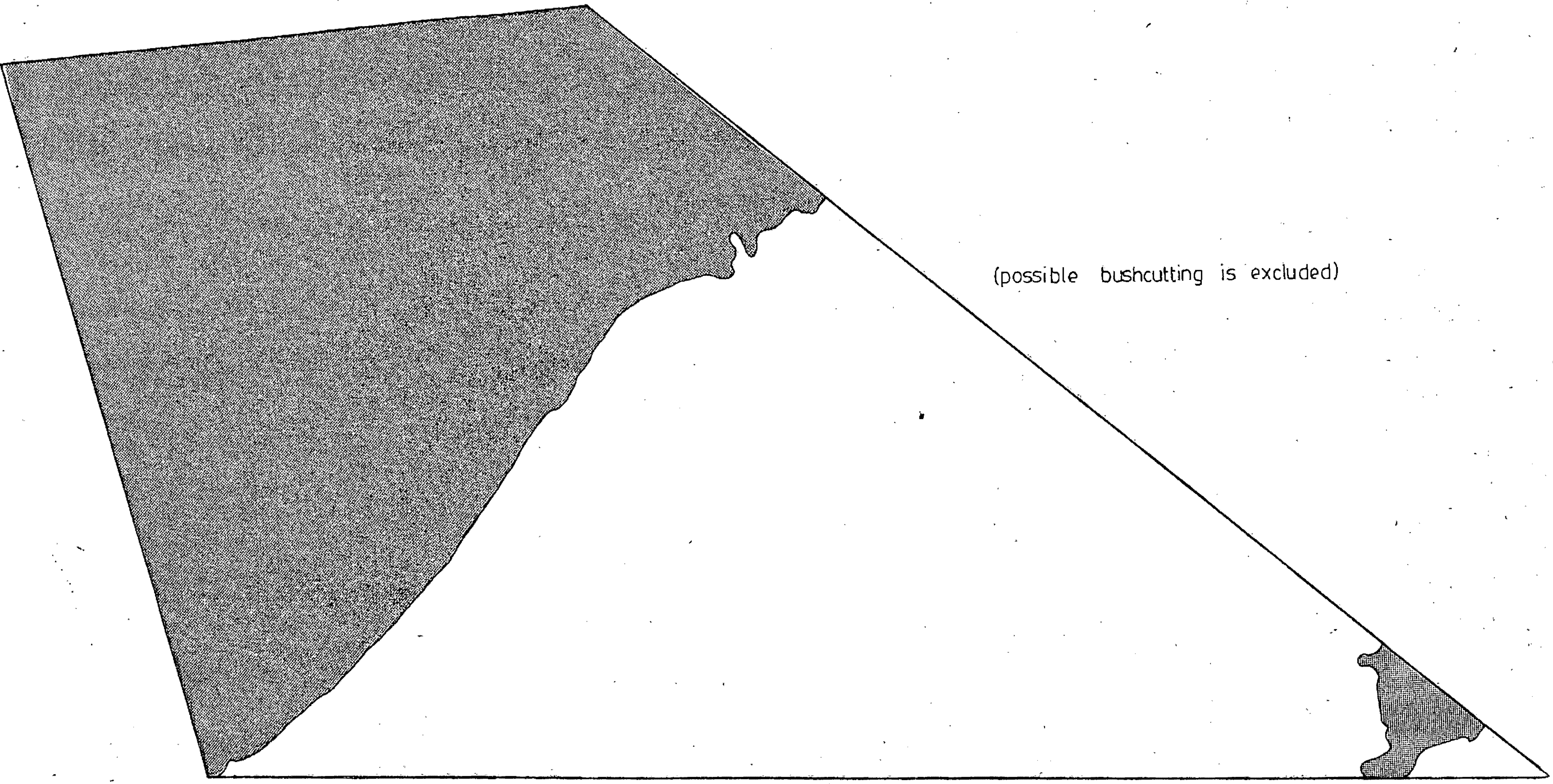


FIGURE 14: VEGETATION COVER (1966?)

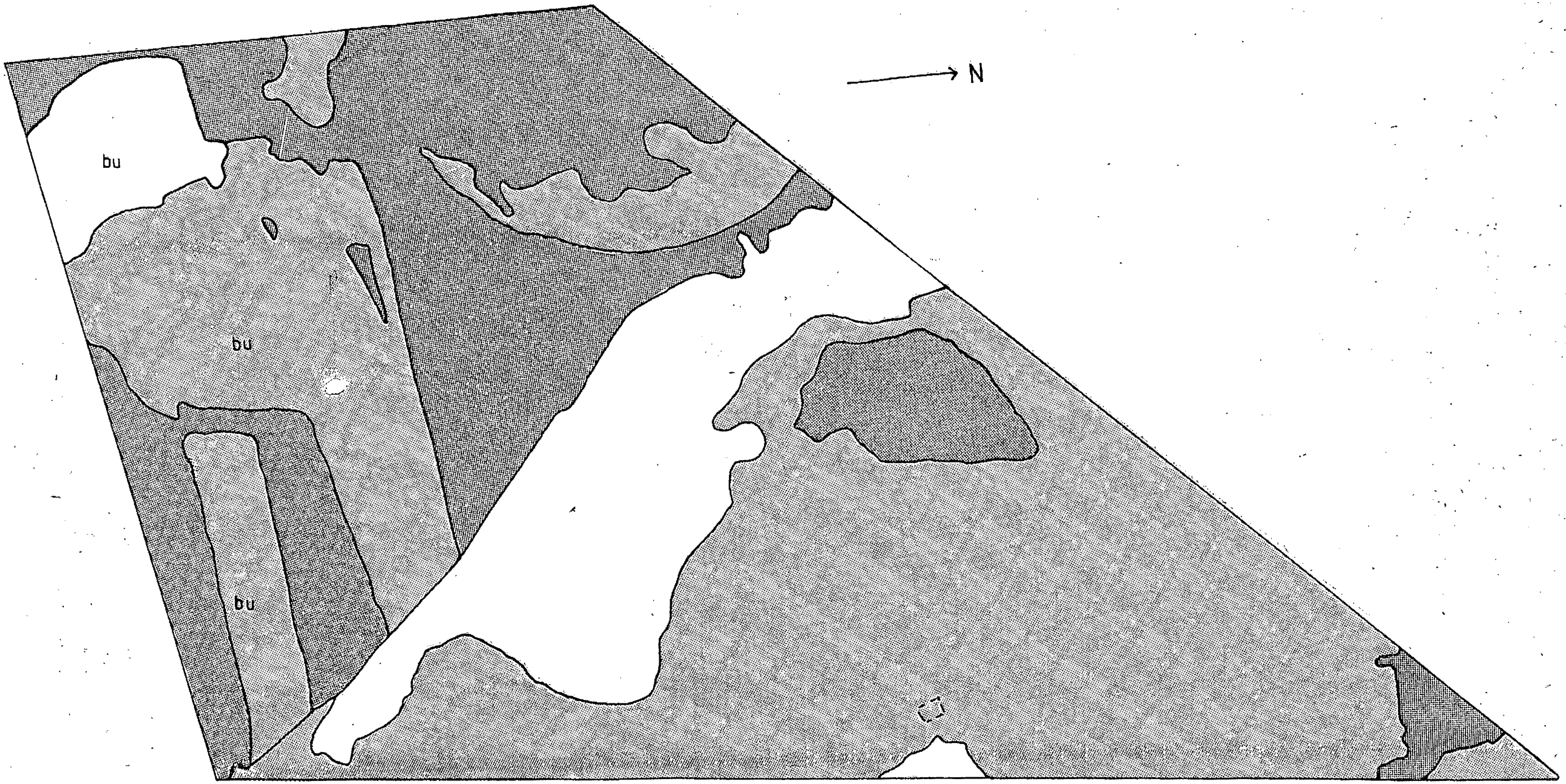


FIGURE 15: VEGETATION COVER (1968)

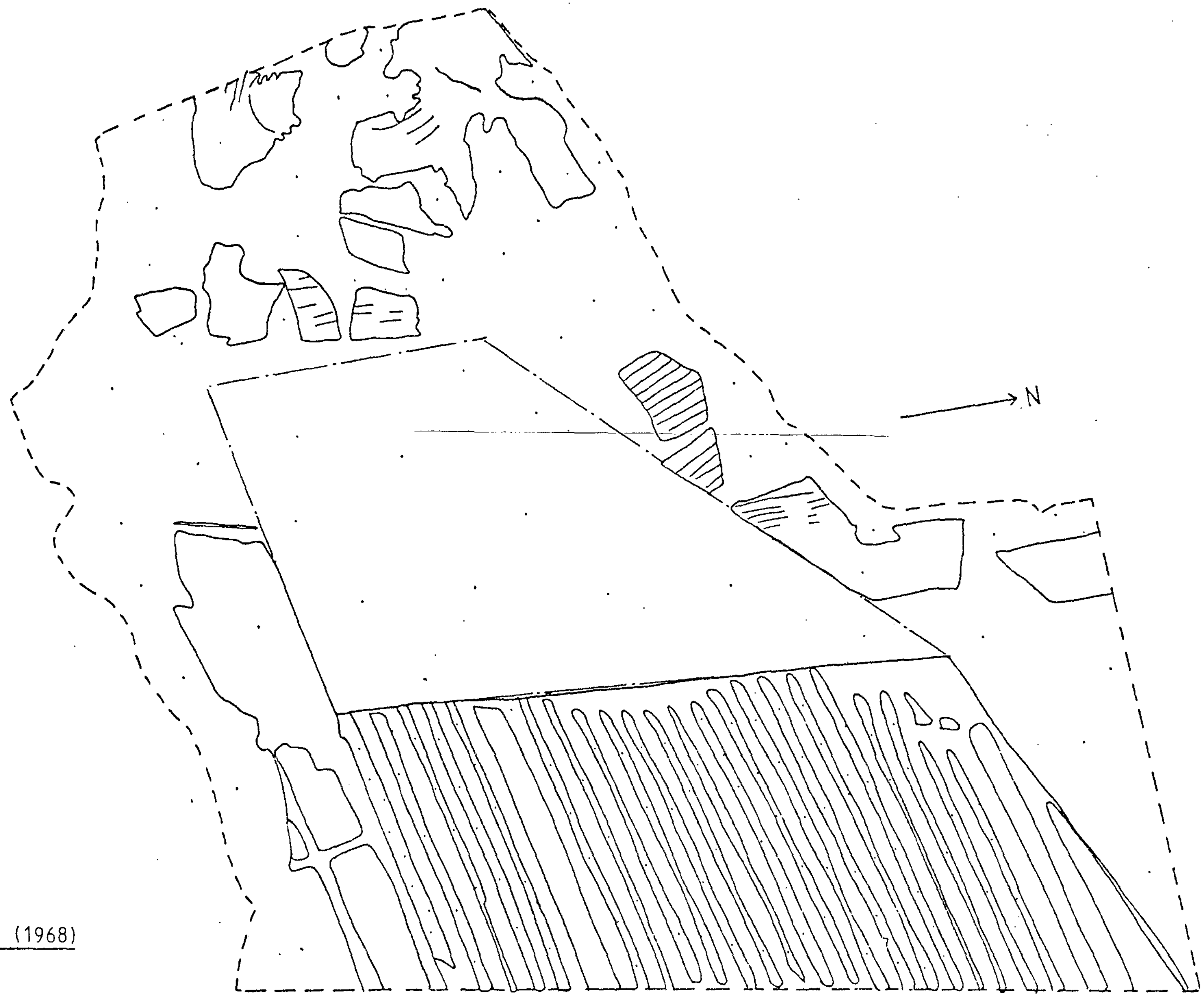


FIGURE 17 :

CULTIVATED LAND (1968)

FIGURE 18:

BARE SOIL AREAS AND ALIEN VEGETATION

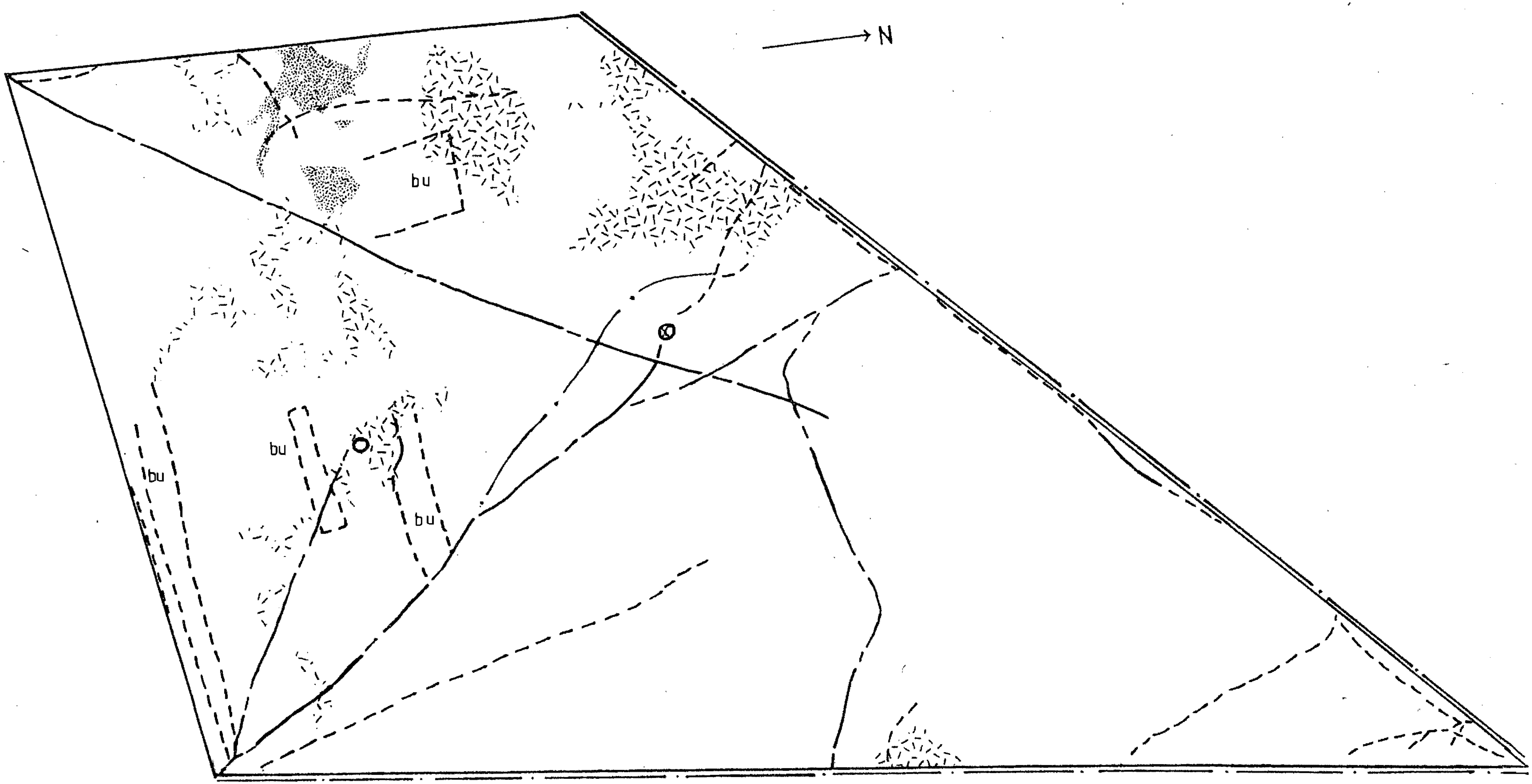


FIGURE 19 : BARE SOIL AREAS, ROADS, TRACKS, FIREBREAKS AND WATERING POINTS (1972)

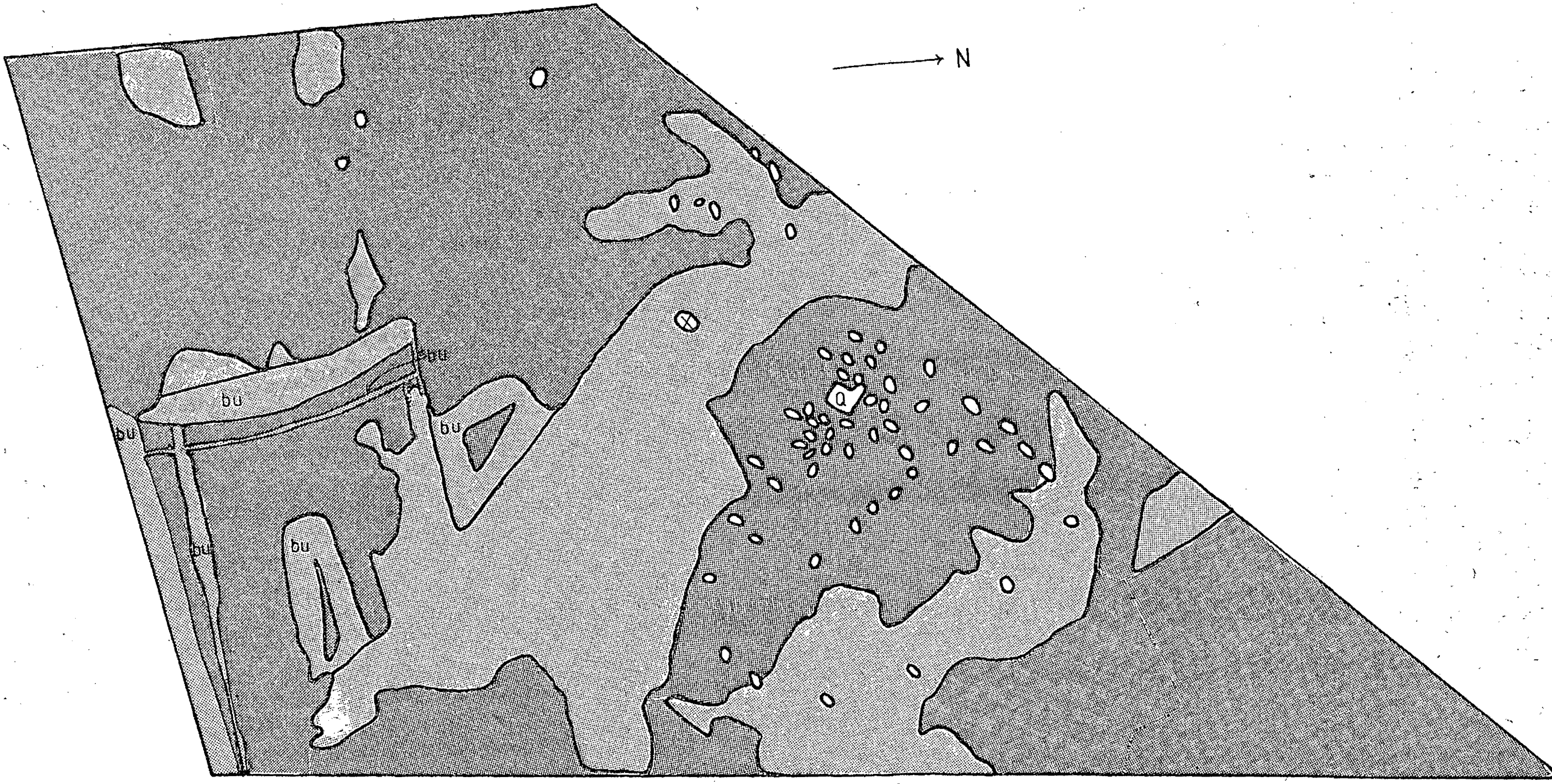


FIGURE 20: VEGETATION COVER (1972)

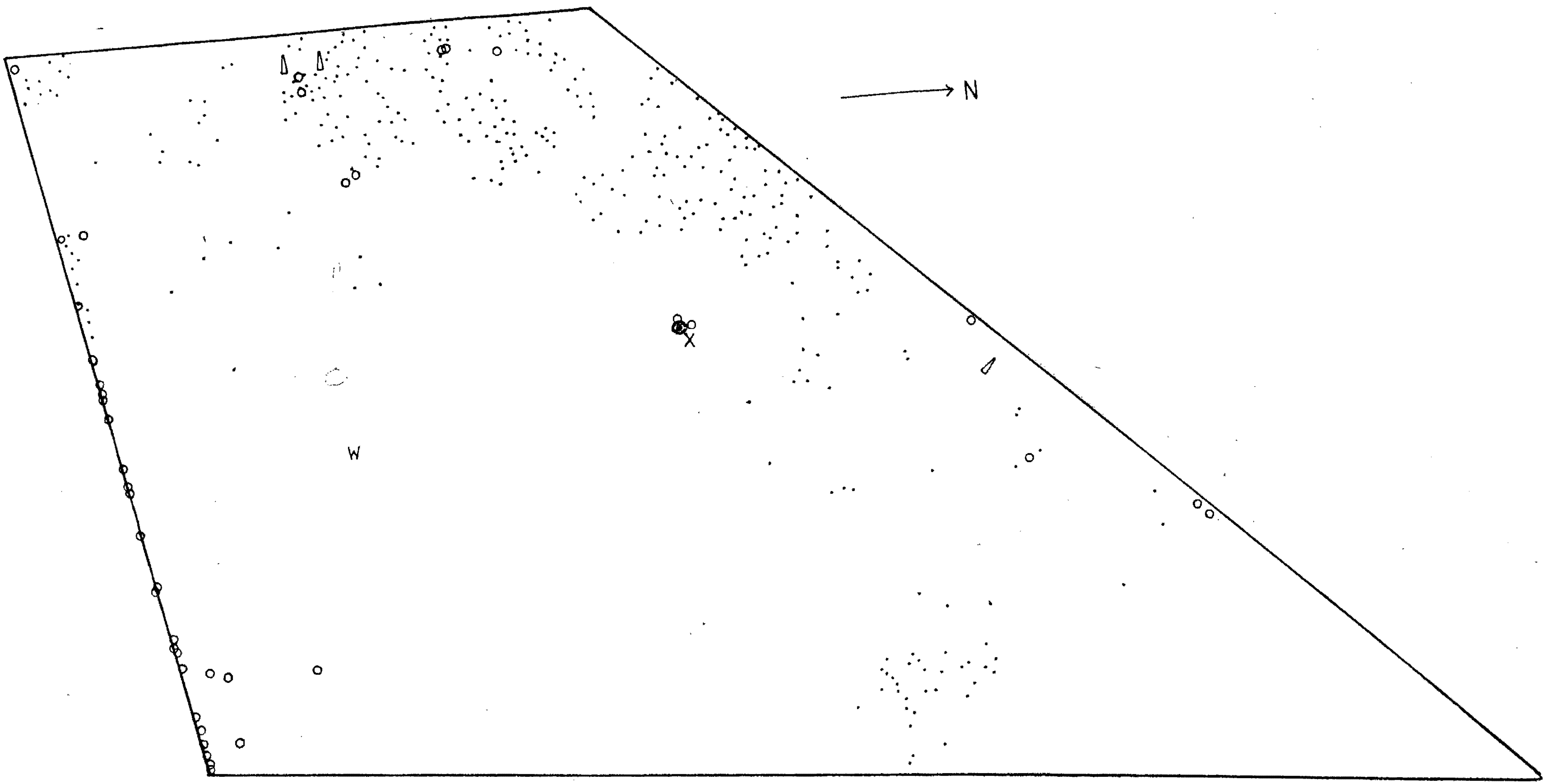


FIGURE 21: ALIEN VEGETATION AND BUSH UNITS (1972)

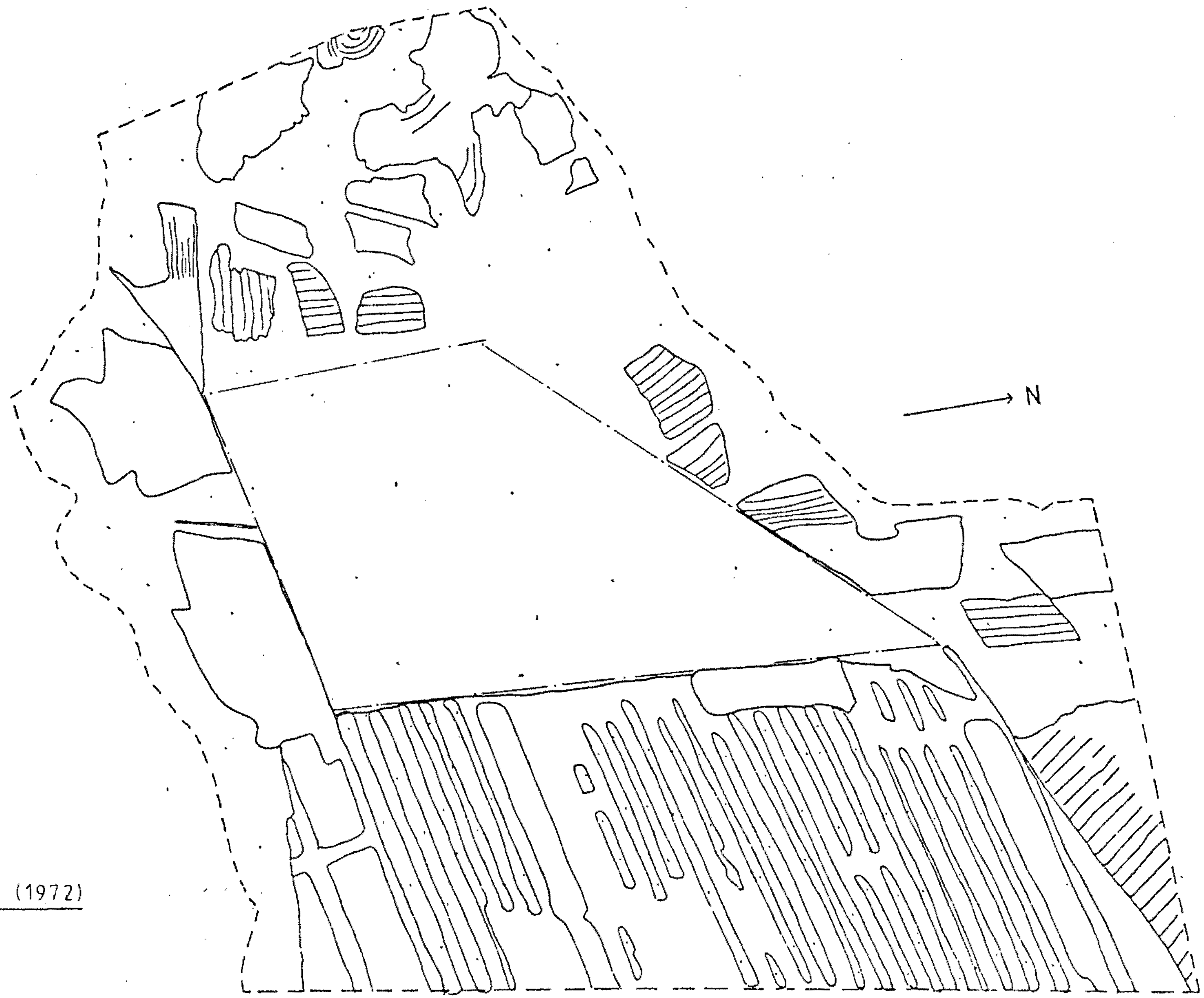


FIGURE 22:

CULTIVATED LAND (1972)

FIGURE 23:

BARE SOIL AREAS AND ALIEN VEGETATION (1972)

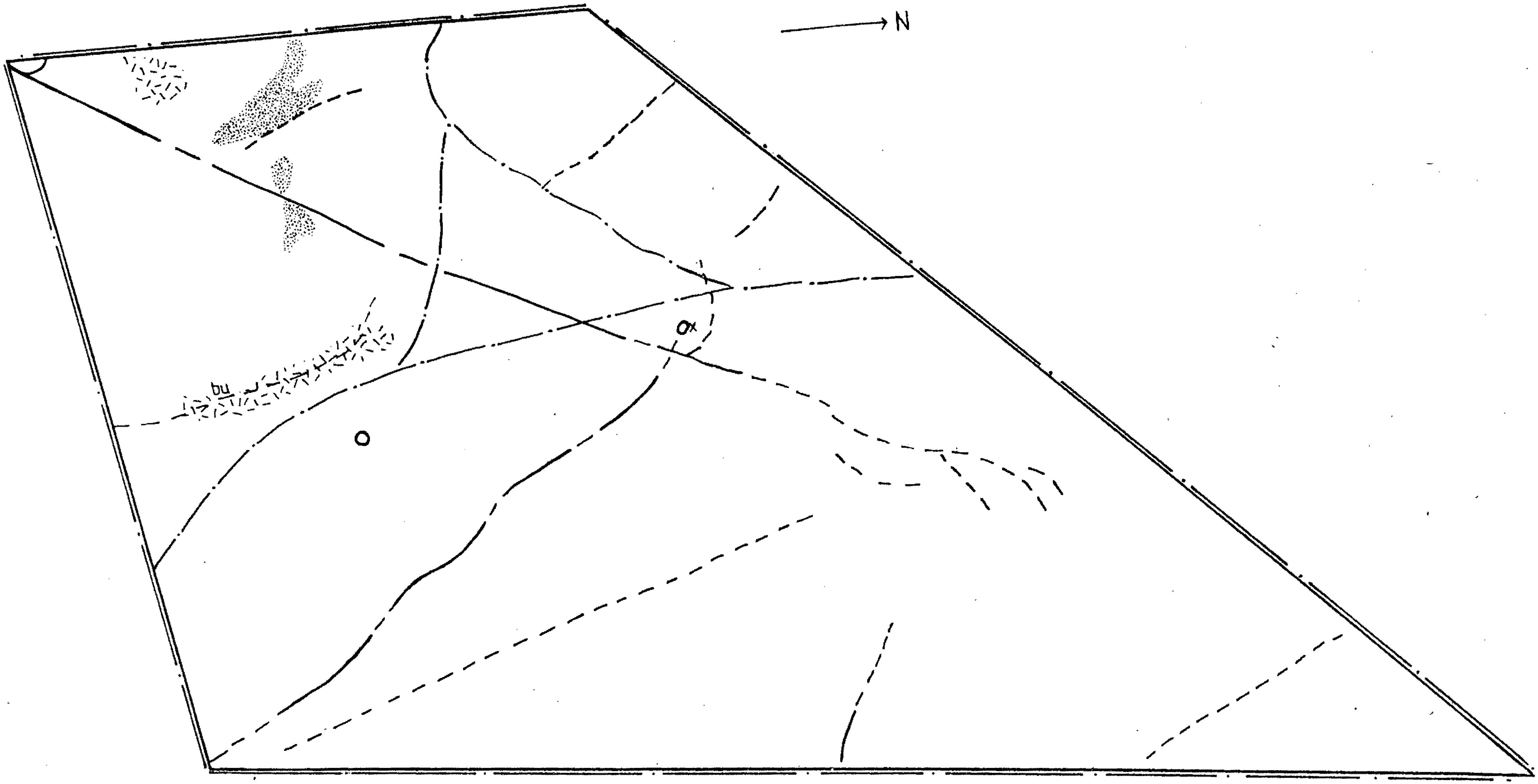


FIGURE 24: BARE SOIL AREAS, ROADS, TRACKS, FIREBREAKS AND WATERING POINTS (1977)

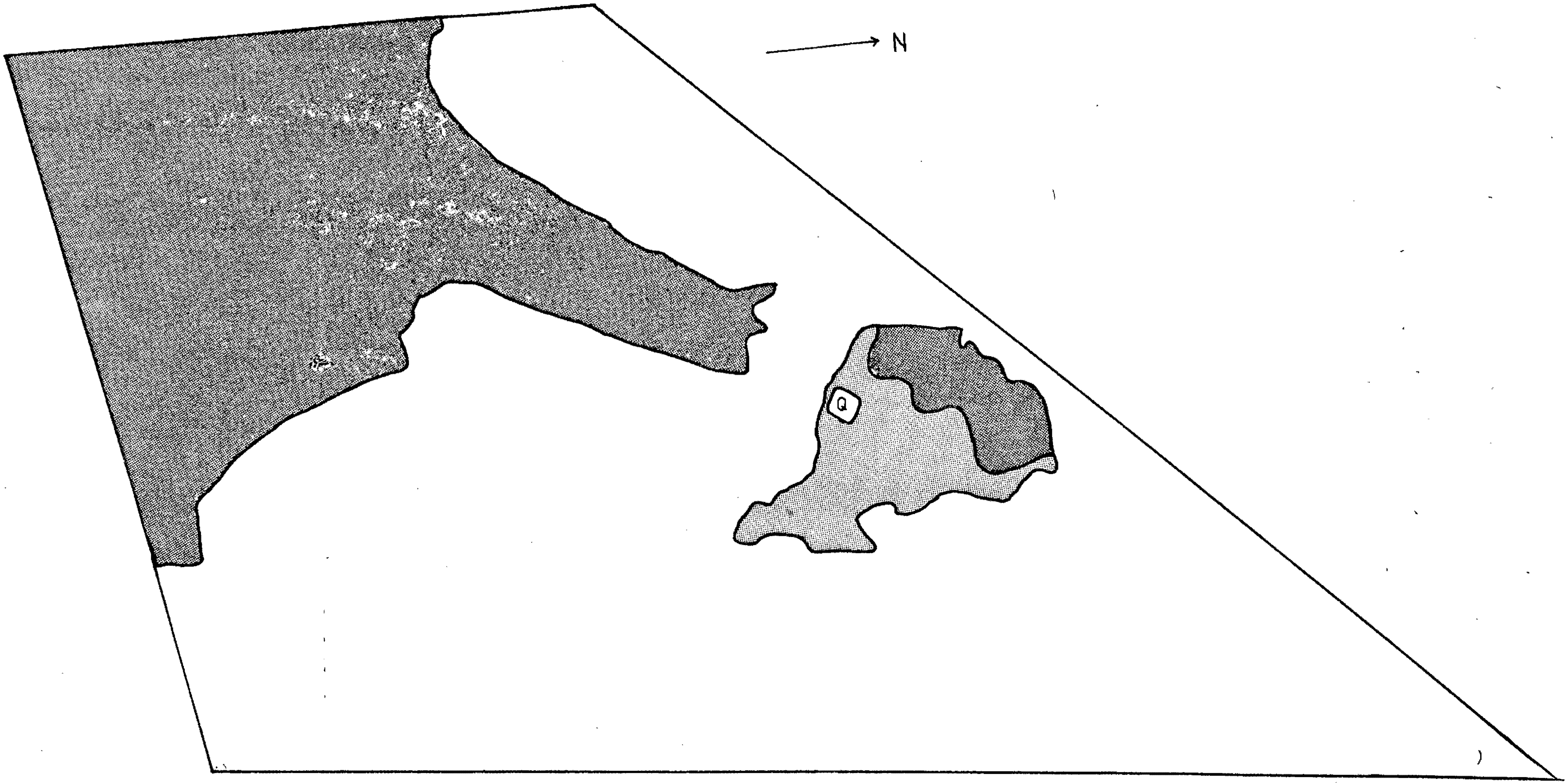


FIGURE 25: VEGETATION COVER (1977)

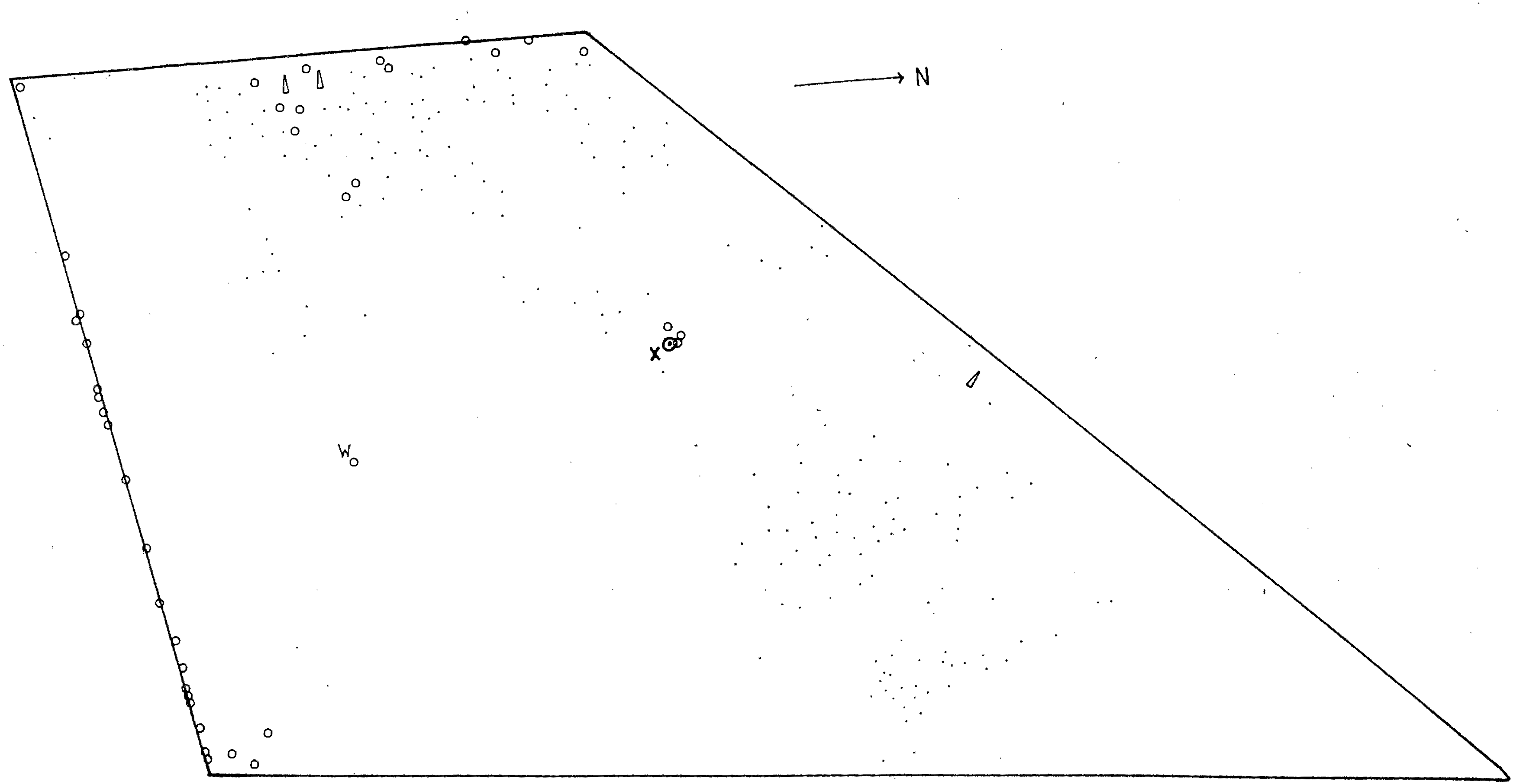


FIGURE 26: ALIEN VEGETATION AND BUSH UNITS (1977)

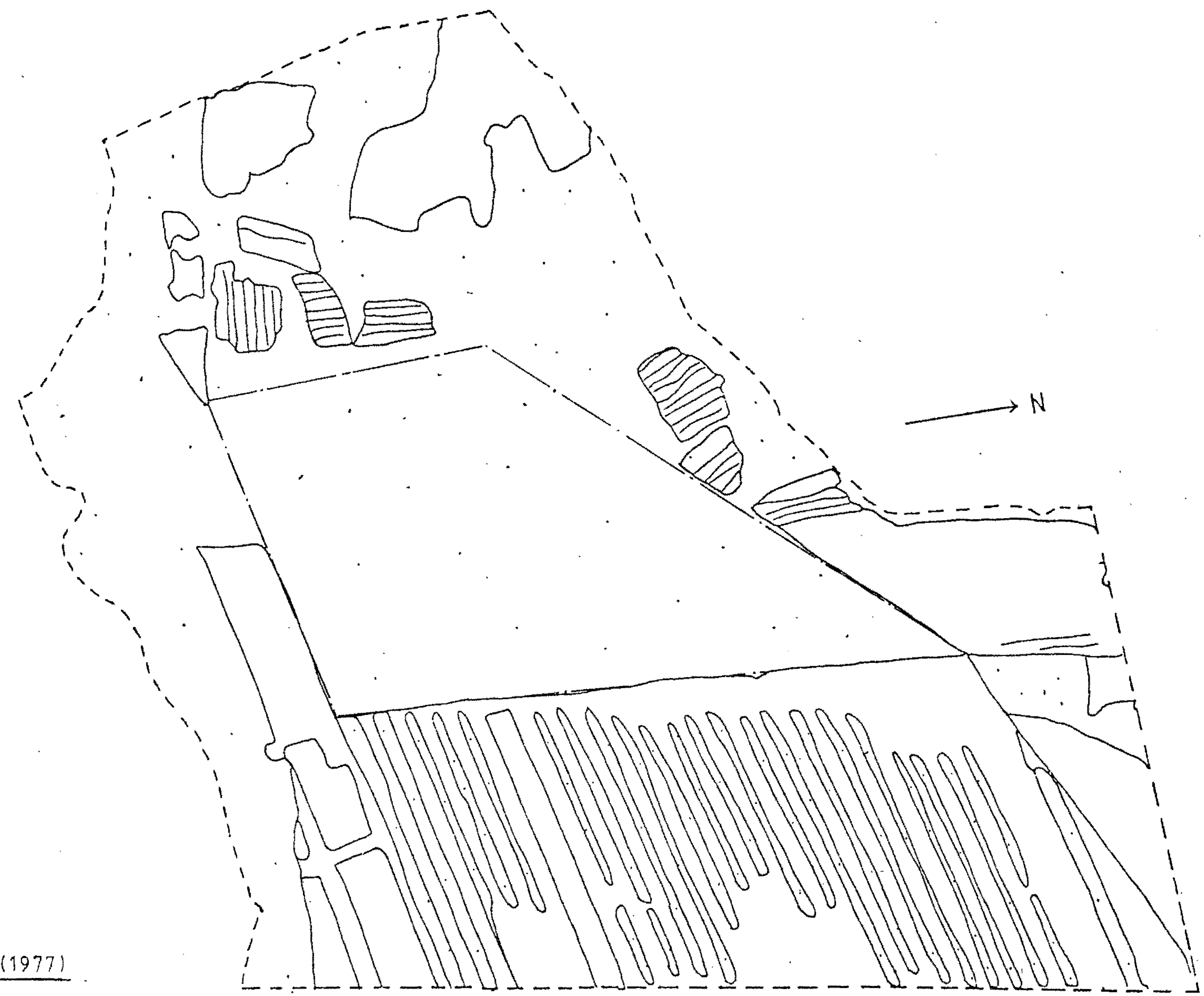


FIGURE 27:

CULTIVATED LAND (1977)

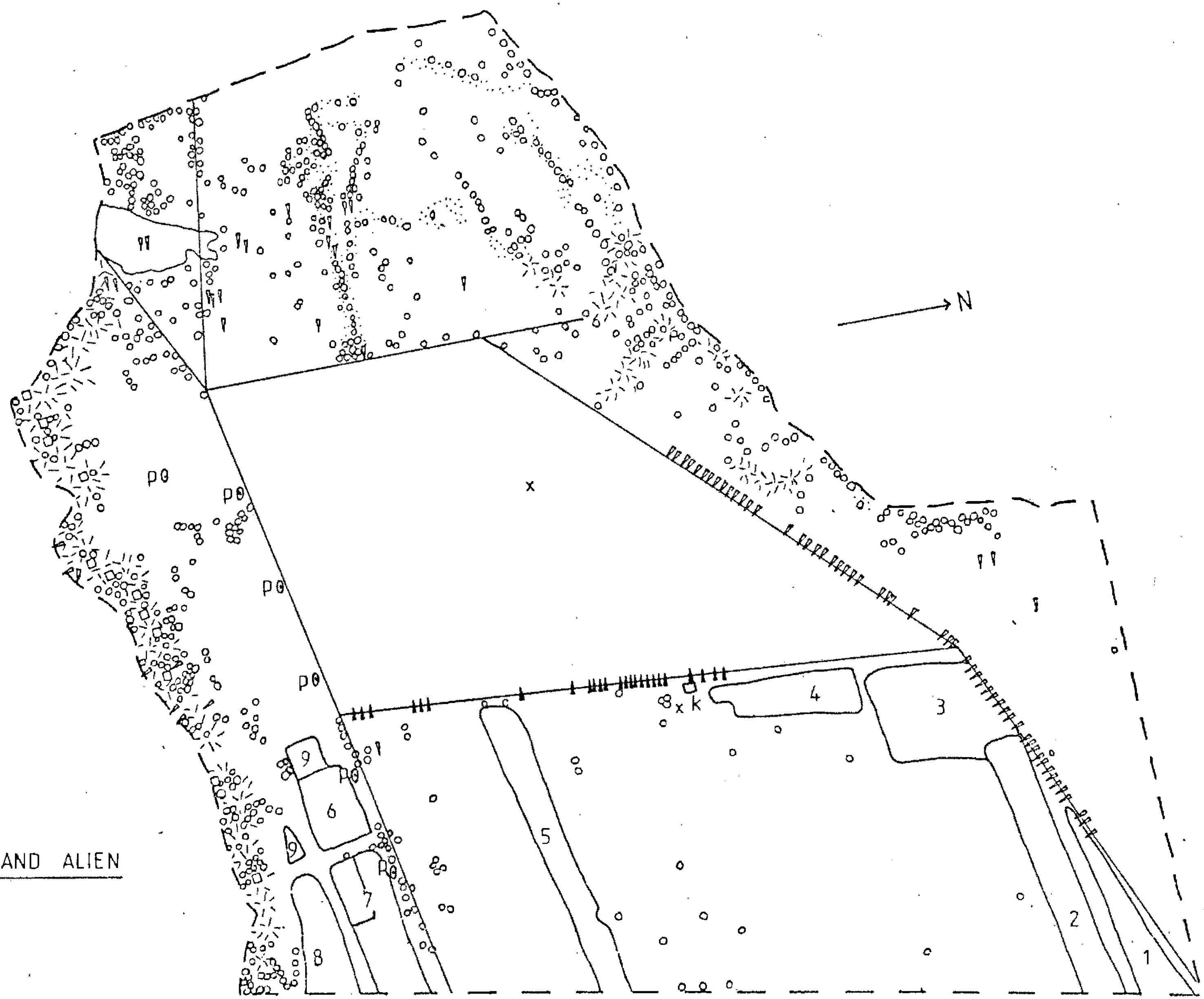


FIGURE 28:

BARE SOIL AREAS AND ALIEN VEGETATION (1977)

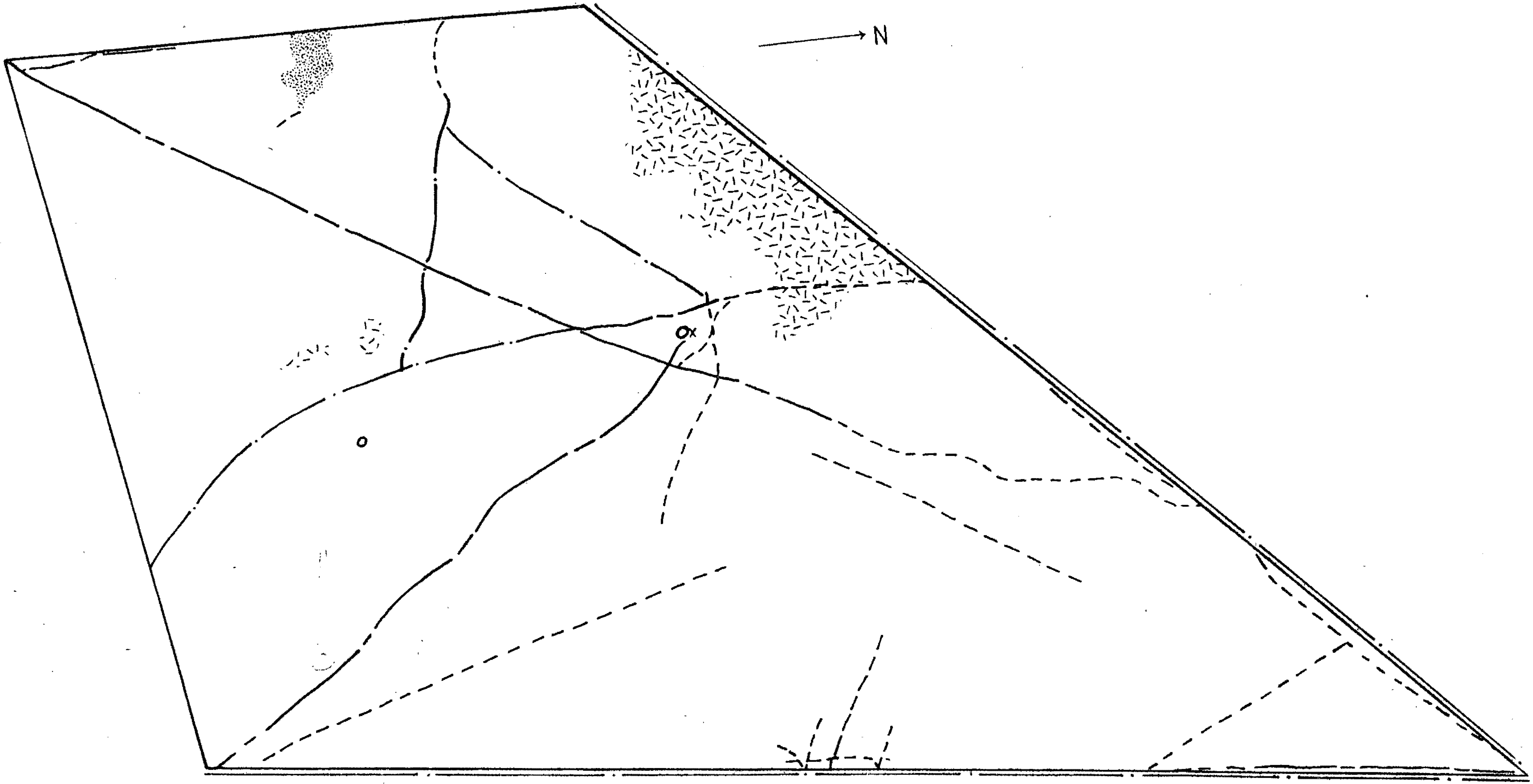


FIGURE 29 : BARE SOIL AREAS , ROADS , TRACKS , FIREBREAKS AND WATERING POINTS (1979)

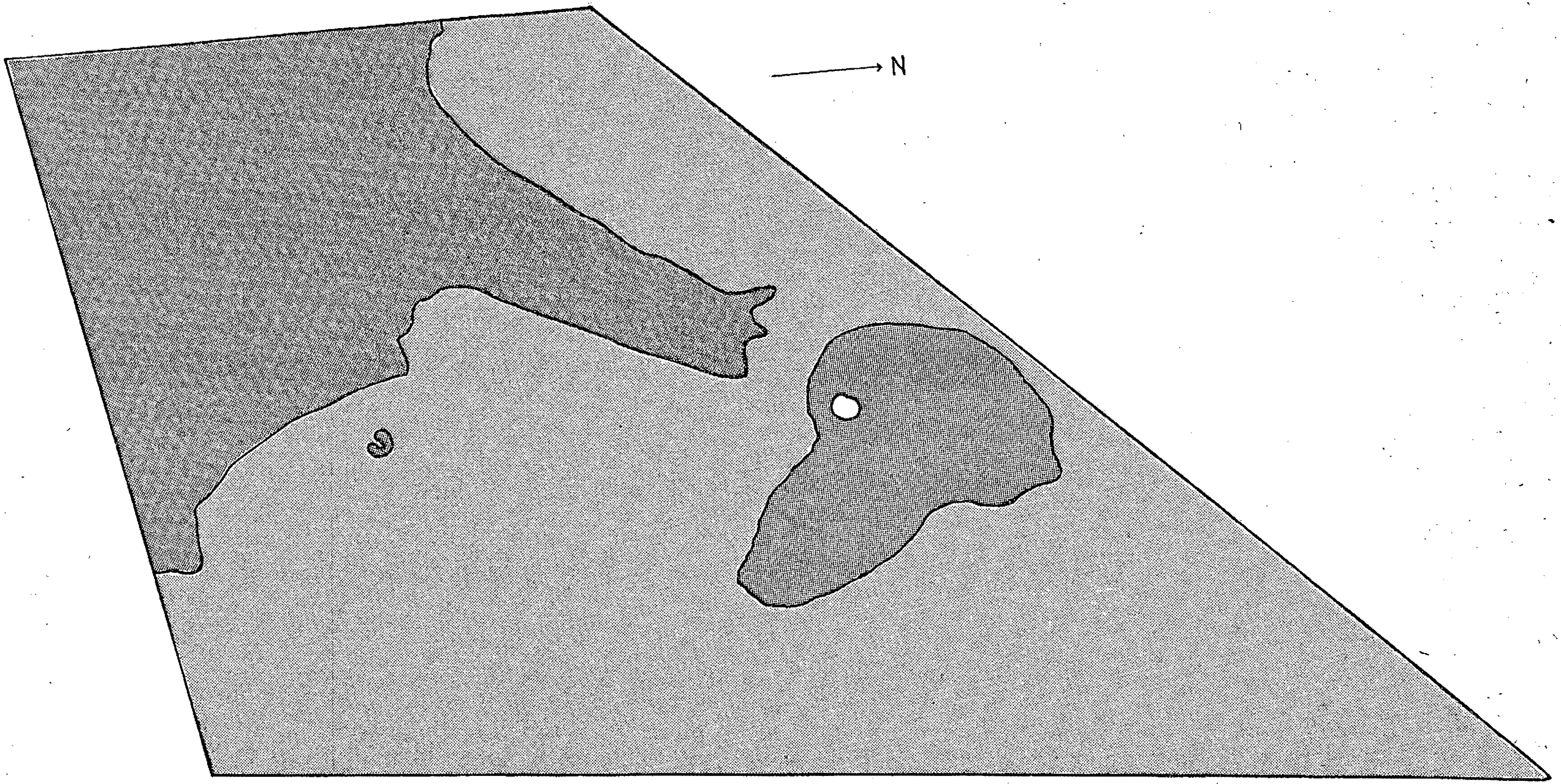


FIGURE 30: VEGETATION COVER (1979)

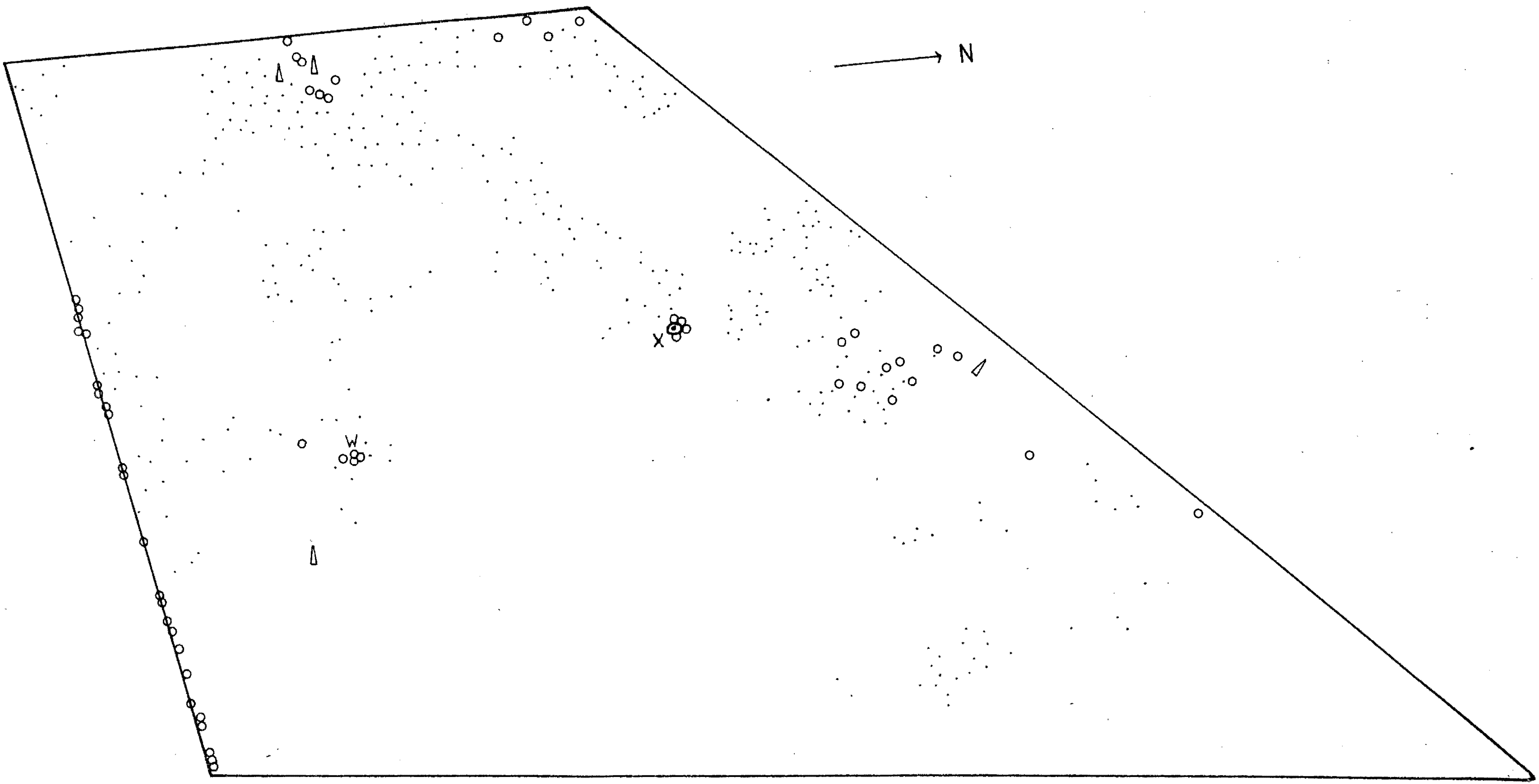


FIGURE 31: ALIEN VEGETATION AND BUSH UNITS (1979)

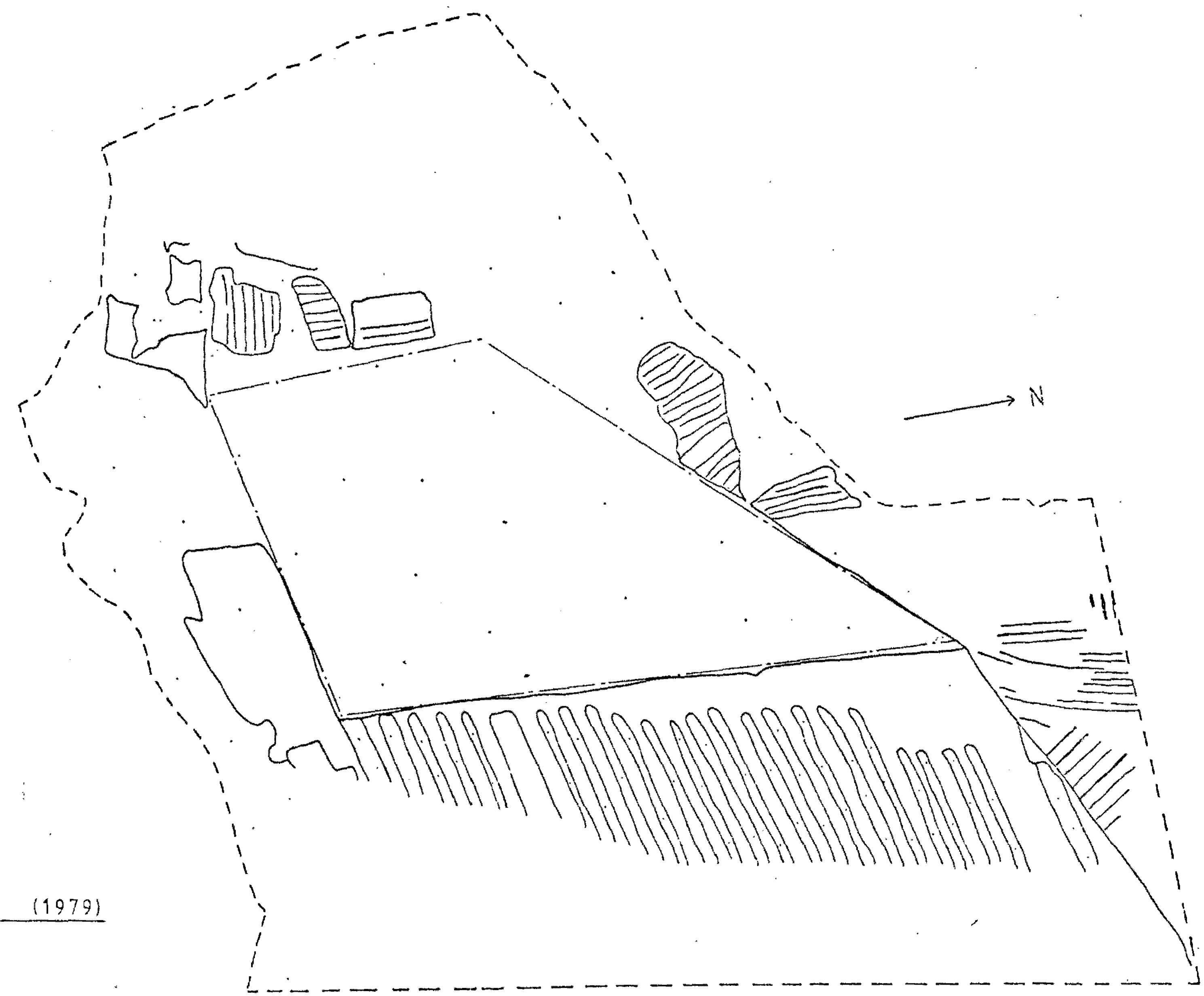


FIGURE 32:

CULTIVATED LAND (1979)

[incomplete]

FIGURE 33:

BARE SOIL AREAS AND ALIEN VEGETATION (1979)

(incomplete)

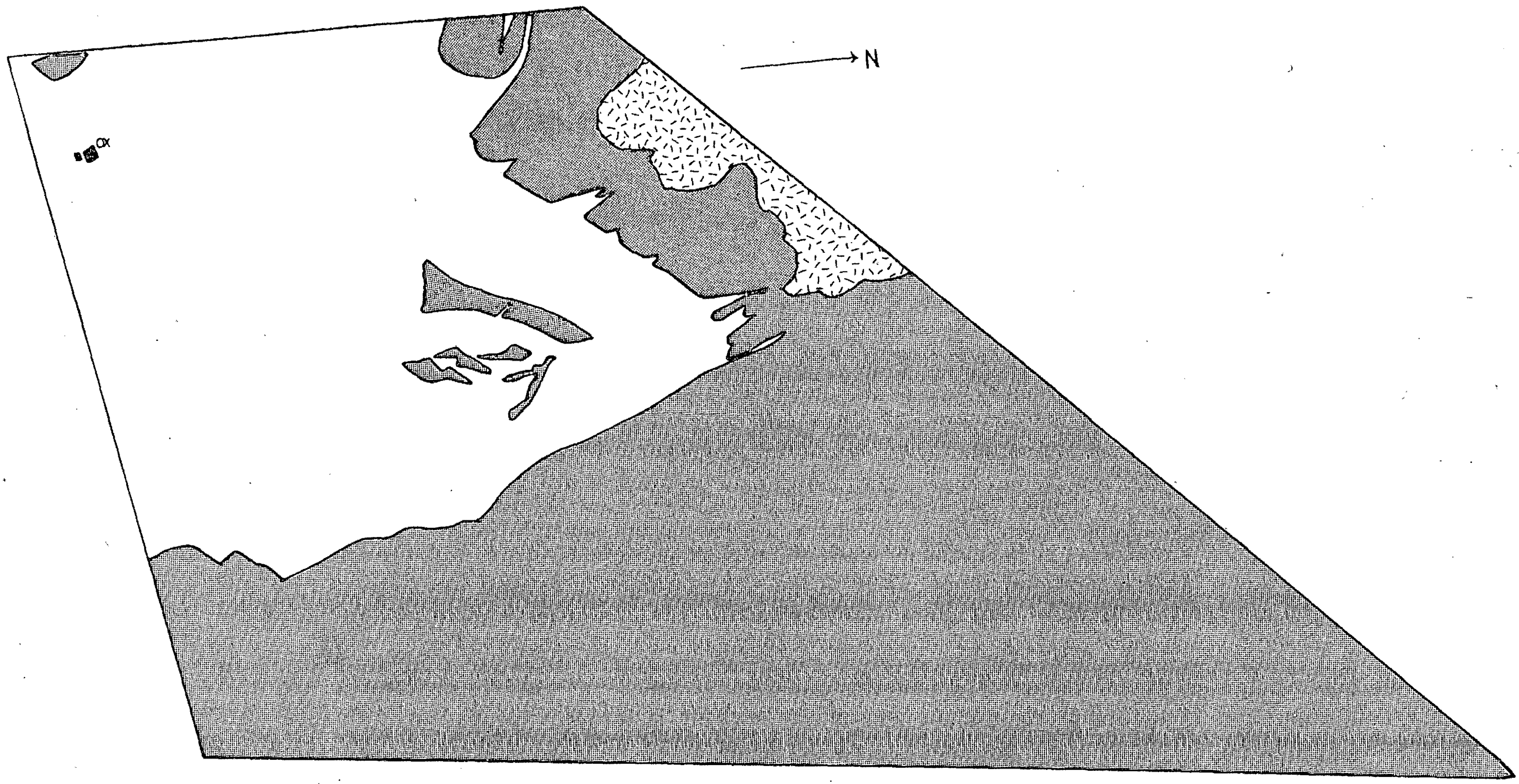
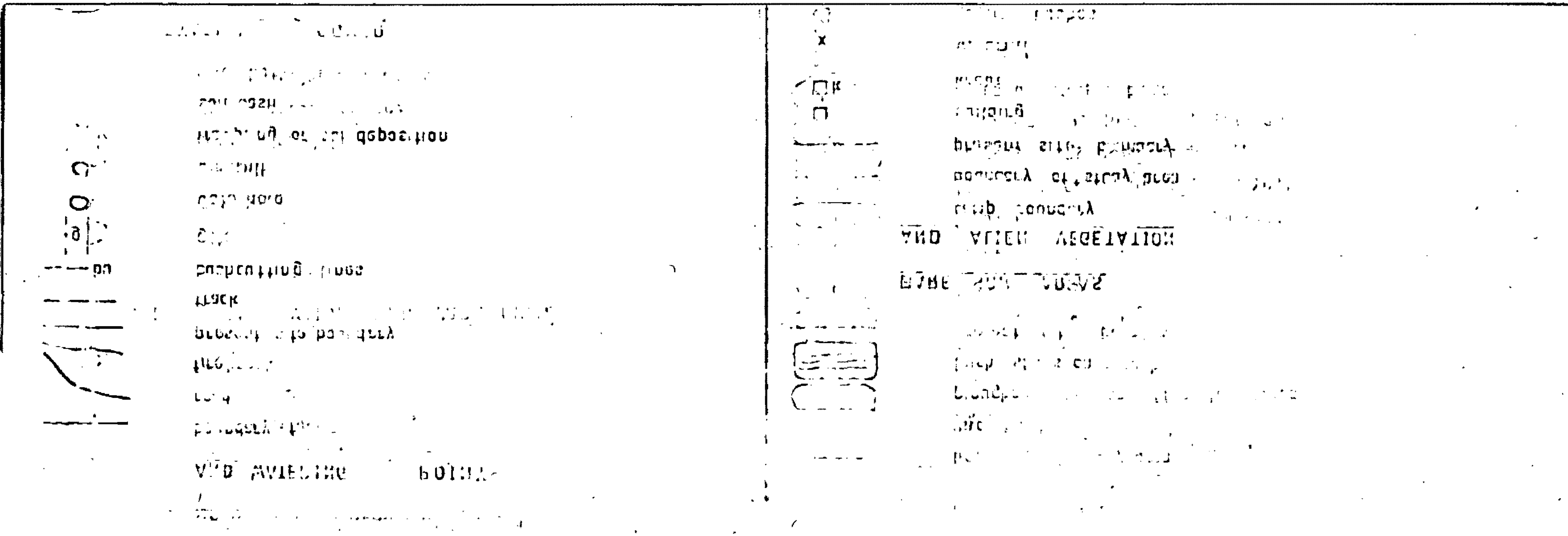


FIGURE 34: VEGETATION COVER AND BARE SOIL AREAS (1980)


building
present site boundary
boundary of study area
AND ALIEN VEGETATION
BARE ROCK/SAND
track
present site boundary

CHAPTER 4

DISCUSSION

Throughout this section, the paucity of research on long-term effects of different activities on the fynbos ecosystem is evident, and thwarts any specific deductions. Inferences are thus restricted to comparisons of likely effects from one landuse and management regime to the next.

4.1 RAINFALL

Levels of precipitation recorded in the same time interval at weather stations used in this study differed markedly between stations; with particular emphasis on annual rainfall recorded in years of low rainfall (e.g. 3C 1).

The mean annual rainfall figures ± 1 standard deviation at the Burgher's Post station (altitude 183 m), Malmesbury station (altitude 152 m) and Philadelphia station (altitude 76 m) for the period 1941 to 1976 were 598,4 ± 142,7 mm, 456,8 ± 108,2 mm and 417,6 ± 92,7 mm respectively. It appears that altitude significantly influences both the quantity of and variability in annual rainfall totals within this area.

The average rainfall in the vicinity of the Fynbos Site is estimated by farmers to be from 450 to 625 mm per annum, above the mean annual rainfall figure of 448,2 mm for Coastal Fynbos given by Fuggle (1981). This tallies closely with annual precipitation records from the Burgher's Post station and thus rainfall figures from this station are thought to best approximate precipitation on the Fynbos Site.

None of the people interviewed in the study could recollect any drought years. The study area appears to receive high rainfall relative to the surrounding areas. Total annual rainfall at the Burgher's Post station fell below the mean $\pm$ 1 standard deviation range for Coastal Fynbos in only one year, 1936, as compared to the six 'dry' years noted for other stations. It is thus unlikely that rainfall is a limiting factor to landuse in the study area; more probably the nature of soils determines landuse.

Insofar as detecting years of exceptional rainfall was concerned, the method employed appears to have been effective. Although aggravation of erosion on and soil wash from the Burgher's Post hillslope could be linked to years of heavy rainfall, smaller scale effects of exceptional precipitation could not be discerned from aerial photographs.

4.2 THE FYNBOS SITE

4.2.1 Landuse and management practices, and their possible effects

Decisions to leave the Fynbos Site uncultivated and use it solely as grazing for livestock seem to have been directly related to the infertility of the sandy soils of the site and their inability to retain water (3D 2.2, 3E 2.2). (Talbot (1947) similarly noted that the relatively 'sour' soils in the Sandveld were not cultivated and were often used for grazing.) Cultivation of the site was perceived to be not economically viable (3E 2.2).

Constraints on the clearing and ploughing of virgin soil contained in the Soil Conservation Scheme for the Darling District (1962) and the Soil Conservation Act No. 76 of 1969 may have constituted further deterrents to the ploughing of land not previously cultivated.

It is tempting to suggest that much of the remnant lowland fynbos today is situated on relatively dry, least fertile soils of the low-lying areas of the coastal forelands as consequence of selective cultivation of those areas gauged to be potentially fertile; but further studies would be necessary to test this postulate.

4.2.1.1 Grazing

In the early 1920's, the detrimental effects of pasturing on fynbos were expounded in terms of the degradation of soils, replacement of palatable by inedible plant species and the removal of nitrogen from grazed lands (Compton 1926).

Until after the 1940's, pasturing on the natural vegetation was seldom dissociated from veld-burning (Wicht 1945) and it is thus difficult to determine any detrimental effects of grazing of fynbos in isolation from firing. Nonetheless, contemporary opinion was as follows: "While there is some doubt about the benefits to be derived from complete fire protection of the scrub, and about the possible harm that might be done by controlled burning, there is no doubt as to the bad effect of pasturing and the good effects of excluding domestic animals" (Wicht 1945). Wicht continues to say that the natural vegetation of the South Western Cape was not suitable for sustained grazing and it was hoped that this practice would disappear in times to come.

In 1959 the realm of grazing and veld management in the winter-rainfall area was still virtually unexplored, and there was an urgent appeal for research in this field to ascertain the carrying capacities and nutritive values of the different veld types (Jordaan 1959).

Thus one can deduce that the management of livestock grazing on the fynbos vegetation had, until recently, been a practice determined largely by trial and error, and such quantitative variables as stocking rates and optimal stocking densities were probably apprehended subconsciously.

Livestock farming on the fynbos was, no doubt, harassed by nutritional factors; deficiencies in crude protein, phosphorous, copper, cobalt and manganese being common (Louw 1969). In addition, the predominantly unpalatable nature of the vegetation necessitated the use of large grazing camps on the lowland areas; from 100 ha to approximately 300 ha (Duckitt, pers. comm. 1982). Camps of less than 100 ha were likely to be trampled and wind erosion of light soils concomitantly exacerbated. (At no stage from 1938 to date were grazing camps in the study area less than 191 ha in area - 3C 2.3, 3D 2.3, 3E 2.3.)

The carrying capacities estimated in recent years for fynbos differ widely. That for Coastal Fynbos and Strandveld is given at from 1 to 2 ha per small stock unit (SSU) (Duckitt, pers. comm. 1982), for Macchia veld in the Coastal Region from 2 to 3 m (1,7 to 2,6 ha) per SSU (Amendment of the Soil Conservation Scheme for the Darling Soil Conservation District 1962), for true and false Macchia from 6 to 20 or 4 to 20 ha per SSU per year respectively (Tainton 1981).

There is a paucity of information on optimal grazing systems in the fynbos. Work to date has focused on the Strandveld vegetation of the Western Cape coast where a 4-camp system at a stocking density of 1 SSU per ha and a 3-month grazing period is advocated in preference to a system employing a greater number of camps at a higher stocking density of 6 SSU per ha and a grazing period of 14 days (Joubert 1971).

On the Fynbos Site, stocking densities have ranged from 2 to 6 SSU per ha (3D 2.3.1, 3E 2.3.1) from 1958 to 1976, and the natural veld was only grazed from winter to spring for 3 to 5 months. This yields stocking rates of approximately 4 to 7 ha per SSU per year, consonant with the figures for carrying capacity given above. (As fynbos was only grazed in the wetter seasons of the year when young grasses were shooting, carrying capacity will be elevated compared to estimates of annual carrying capacity.)

In none of the aerial photographs was there evidence of extensive trampling on the Fynbos Site (3C 2.4, 3D 2.4, 3F 2.4) and it is thus unlikely that overstocking was characteristic of the recent history of landuse.

The grazing of domestic livestock on the Fynbos Site may, potentially, have affected both the vegetation and soils. To firstly consider the possible impact on vegetation: It is known that plant species vary in palatability and this results in selective grazing if stocking rates are low (Acocks 1953). Under continual grazing it has long been recognized that eradication of the more palatable species and gradual replacement by inedible species may occur (Compton 1926). That is, intensive grazing may effect a long-term change in the plant species composition. Both sheep and cattle have been grazed on the site, sheep:cattle ratios ranging from 50:1 to 5:1 (3D 2.3.1, 3E 2.3.1). Cattle are less selective in their grazing habits and do less damage to the veld than sheep (Du Preez 1969) and thus possibly the post-1962 grazing regime with a sheep:cattle ratio of from 5:1 to 8:1 was less detrimental to the fynbos vegetation than the earlier regime with a sheep:cattle ratio of approximately 50.

There is a dearth of information on species of fynbos grazed or browsed selectively by livestock. From studies by Joubert and Stindt (1979), Stindt and Joubert (1979) and Whitaker (1980) it can be inferred that plants of the genera *Aspalathus*, *Eriocephalus*, *Pentaschistis*, *Metalasia*, *Ehrharta* and *Rhus* are palatable to livestock. *Willdenowia striata*, *Phylica stipularis*, *Passerina vulgaris* and 'kweekgras', *Cynodon dactylon*, were likely to have constituted a number of those plants browsed by sheep.

The period of intentional patch-burning with concomitant grazing is likely to have encouraged intense browsing by livestock on any palatable species in the remnant patches of vegetation and may, in the long term, have favoured the survival of unpalatable species. Wicht (1945) notes, "...where grazing and browsing are combined with veld-burning, the sclerophyll scrub may be deteriorated in the following ways: species may disappear, undesirable species may become dominant, and plant growth may become generally weakened or exterminated on certain sites...".

In later years, when accidential fires razed large tracts of vegetation, initial regeneration of plants would have been less affected by grazing as livestock was excluded for at least one year after a burn (3D 2.3.1, 3E 2.3.1).

Trampling of animals on fynbos vegetation may well have destroyed young seedlings or young shoots initiating growth at any time from late winter through to summer (Kruger 1978), or covered short plants with sand, suppressing plant growth or the recovery of vegetation post-fire. On a beneficial note, soil moved by walking animals may have buried seed and promoted germination, and the trampling of litter undoubtedly promoted its decomposition and recycling of nutrients which, in this system, may be a limiting factor to plant growth. Livestock may too have aided the dispersal of seed, and excreta from domestic animals recycled nutrients to the soil. Kraaling of livestock at night from 1962 to 1976 may have diminished the quantity of nutrients returned via faecal matter to the fynbos camp relative to the pre-1962 period, but this effect is thought to be minimal. (The loss of nutrients from a system contained in animal products is minute compared to that of cultivated crops (Tainton 1981) and is considered to be negligible here.)

In the absence of vegetation analyses prior to 1979, any exclusion of species, change in species composition or long-term detrimental effects of grazing were impossible to determine. As noted earlier, it seems unlikely that the Fynbos Site was overstocked and, taking the above considerations into account, the long-term repercussions of livestock browsing the vegetation in the study period would appear to be small.

Potential physical effects of grazing livestock on the soils of the Fynbos Site may be examined by way of soil erosion and soil compaction.

Prior to the cessation of intentional veld-burning, livestock was, in all probability, allowed to browse the patchwork of burned vegetation at all times of the year. Although animals were likely to have aggregated at those areas of vegetation burned in previous years, any trampling of soils denuded of vegetation in the dry summer months must have exacerbated wind erosion on the Fynbos Site. Signs of trampled ground and concomitant wind erosion were limited to the water-hole and one other area on the site in 1938 (3C 2.4), although areas of newly burned ground may have masked further indications of erosion.

Post-1960, when veld-burning was solely accidental and the fynbos was utilised as grazing only in the winter and spring when soils were relatively moist, the aggravation of wind erosion compared to earlier years must have been much reduced. The fact that livestock was never grazed on vegetation immediately after a fire (3D 2.3.1, 3E 2.3.1) must too have reduced potential wind erosion on the Fynbos Site. Areas of trampled ground in aerial photographs taken after 1938 were restricted to the eastern boundary of the Fynbos Site and are thought to reflect crowding of livestock moving from one veld camp to another rather than grazing pressures *per se* (3F 2.4). In conclusion, any exacerbation of soil erosion subsequent to (and including) 1960 as a result of grazing seems to have been minimal.

It is known that the static load of cattle and sheep is 1,7 and 0,65 kg/cm² respectively, and that the potential deformation of dry sand has a value of 2 kg/cm² (Tainton 1981). None of the livestock tracks detected from aerial photographs was consistent in situation, and the long-term effects of soil compaction or deformation as consequence of grazing livestock were thus probably negligible.

Specht (1973) notes in respect of Mediterranean-type ecosystems of Australia that the grazing pressure of native animals on the flora has been minimal.

After 1976, when domestic livestock was not grazed on the Fynbos Site, the grazing impact of native animals on both soils and vegetation has probably been minimal.

Wild game are less selective in their grazing habits than domestic livestock (Du Preez 1969) and are flexible in their choice of food to accommodate seasonal and local fluctuations in their food supply (Leuthold 1977). In a study in the west coast Strandveld (Adams 1980) 95% of all available plant species were browsed by at least one of the Cape grysbok, steenbok or duiker. Species on the site noted to have been grazed in 1979 by fynbos fauna (Boucher & Shepherd, in prep.) are presented in Appendix F1, as are plants likely to be browsed by grysbok, steenbok and duiker (Adams 1980; Manson 1974).

The number of large fynbos mammals on the site after 1976 was minimal as compared to numbers of domestic livestock prior to this date, and effects of fynbos fauna on soils of the Fynbos Site are thought to be minimal.'

4.2.1.2 Burning (see Figs 36, 37)

Fire on the Fynbos Site has undoubtedly constituted the major perturbation in recent history. As a brief introduction to this section, it is interesting to trace the change in attitude towards veld-burning since 1920:

In the 1900's, veld-burning to provide green pasturage was a ubiquitous management tool, probably adopted by European settlers from indigenous peoples (Botha 1924; Schelpe 1976). According to Moll *et al.* (1980) it can be assumed that "...the fynbos has been subjected to frequent fires (probably once every 10 to 20 years) for at least the last 300 years". This period of repeated short interval firing was probably as long as 2000 years (Boucher in press; Moll *et al.* 1980); an overwhelming proportion of species in the western coastal forelands withstanding recurrent fire at five yearly intervals (Boucher in press).

In the early 1920's results of indiscriminate veld-burning were manifest in the deterioration of vegetation, reduction in soil fertility and enhanced vulnerability to erosion (Compton 1926; Marloth 1924; Pillans 1924), and informed opinion advocated total protection of the indigenous vegetation from fire. The Final Report of the Drought Commission in 1923 condemned veld-burning but, as was noted by Levyns (1929): "Unfortunately the findings of such a commission have small effect on the farmers who indulge in the practice".

In the 1930's fire was suggested as a useful management tool, consonant with 'healthy' vegetation if exercised with caution. Phillips (1936) in his paper entitled "Fire in vegetation: A bad master, a good servant and a national problem", noted in respect of the 'fijnbos': "Firing does, of course, temporarily improve the browse and grazing, poor in the best of conditions - hence its being practised by owners of sheep and other stock".

Acocks in 1935, noted that the fynbos vegetation appeared to be pre-adapted to recovery after fire, and Wicht (1945) was one of the first to postulate that fire in the fynbos was a natural phenomenon. This revelation was later supported by other botanists - Kruger (1976), Le Roux (19 66), Martin (1966), Taylor (1972), to name but a few.

Legislation to tighten controls on firing of the natural vegetation on private lands owned by Whites was introduced in 1946 with the promulgation of the Soil Conservation Act, but implementation of such control was largely unsuccessful (Rabie 1976) on White-owned land. (The Forest and Veld Conservation Act No. 13 of 1941 did not prohibit burning of veld on private land on condition that it was not left unattended and did not spread or cause damage to another.) The prohibition of firing of vegetation in the Darling Soil Conservation District without prior written authority (3F 2.3.2) since 1962 did not eliminate the incidence of accidental fires in the area, although it may have encouraged relatively rapid extinguishing of such fires on White-owned land (Roelofse, pers. comm. 1982).

The fire history of the Fynbos Site may now be examined bearing the above framework in mind. Investigation of the recent burn patterns on the Fynbos Site (3C 2.5, 3D 2.5, 3F 2.5) enables one to separate the burn history into a pre-1960 and post-1960 period on the basis of management; intentional patch-burning being carried out in the former period and accidental fires dominating the latter.

As no aerial photographs of the Fynbos Site were taken between 1938 and 1960 it was not possible to monitor the probable relaxation in burn period (suggested by patterns of vegetation cover in the 1960 photographs) during this 22 year period. Hence estimates of burn frequency, gauged from the 1938 aerial photograph, are likely to reflect firing prior to this date but probably overestimate the mean frequency of fire in the 1950's.

4.2.1.2.1 *Pre-1960 period*

Before 1960, the study area seems to have been subject to a burning frequency of from 3 to 4 years in accordance with estimates by Pillans (1924) and Wicht (1945) of burn period. According to Wicht (1945), the maximum length between controlled burns was limited because, the older the vegetation, the greater would be the risk of extensive accidental fires. Martin (1966) reports that, under exceptional circumstances, fire can occur in 2 year old vegetation, although four years of regrowth are usually necessary to sustain spreading fire (Bands 1977; Kruger 1977a; Kruger 1977b).

Regular patch-burning of fynbos prior to 1960 is likely to have affected (1) the condition and composition of indigenous vegetation; (2) the fertility of soil; and (3) the fauna dependent on the vegetation for habitat.

Following Gill (1975) the components of a fire regime are given as the variables, frequency of fire, fire intensity and season of fire occurrence. The fynbos follows a characteristic succession after fire (Kruger 1977a). Burning of the fynbos sets back the succession (Martin 1966) and repeated firing will "...probably cause many species characteristic of seral communities to disappear" (Wicht 1945).

Jordaan (1949) first drew attention to the importance of the primary juvenile period in determining whether or not a species would survive a given fire regime. The repeated occurrence of fire before a species has reached the mature phase will tend to eliminate that species (Gill & Groves 1978; Moll & Gubb 1981). Patch-burning on the Fynbos Site, carried out at a seeming frequency of 3 to 4 years prior to 1960, could well have eliminated any reseeding species, particularly Proteaceae, requiring more than 4 years to mature. The minimal change in species diversity (in 50 square metre plots) between 4 year regenerating fynbos - 61 species - and mature fynbos - 57 species (Boucher & Shepherd, in prep.) reflects the adaptation of vegetation on the Fynbos Site to the short return period of burning prior to 1960.

From results of vegetation sampling carried out in 1979 by Boucher and Shepherd, it is apparent that *Protea repens* has the longest primary juvenile period of species on the Fynbos Site. This protea is known to flower at an age of 3 years (Van der Merwe 1966; Taylor 1977, pers. obs.) and, although the 'safe' period between successive burns is given at about 8 years for *Protea repens* (Jordaan 1949) its ability to flower and produce viable seed in the third year of growth undoubtedly safeguarded its long-term survival in this community. Any minutes patches of vegetation that escaped repeated burning on a 3 to 4 year return period must have constituted potential sources for re-seeding from adjacent areas (3C 2.5).

It seems plausible that any extinction of re-seeding species from the study site is likely to have occurred at the outset of intentional patch-burning on this 3 to 4 year rotation; that is, many years before the time period considered in this study. In the absence of vegetation sampling prior to 1979, however, this contention is impossible to confirm.

With an increasing interval between fires, the fuel load increases and burns are likely to be more intense (Bands 1977; Gill & Groves 1978; Van Wilgen 1980). Whereas the burn frequency will largely determine the survival of plant species, the post-fire performance will be determined by the intensity and season of fire (Kruger & Bigalke in prep.). One can infer from the short succession burns before 1960 that the intensity of fires was likely to have been low and that these fires spread slowly. According to Kruger and Bigalke (in prep.) abnormally low intensity fires would favour growth of graminoid and restioid herbs. Wicht, in 1948, first drew attention to the possible role of the season of burn in post-fire regeneration of vegetation, suggesting that burning in autumn was more unfavourable than burning in mid-summer. Subsequently, work by Bond (1981), Jordaan (1965) and Kruger (1977a) has indicated that the season of burn could differentially affect survival and growth of both resprouting and seed regenerating species. It appears that repeated late summer/autumn burns will favour the seeding shrubs, and repeated spring burns will favour the restionaceous and resprouting plants. Fires in the summer months are considered best for fynbos in the Western Cape as most species have flowered and produced seed by that time (Kruger 1977a). To maintain a characteristic diversity of species, however, burning season should be varied (Bands 1977). Patch-burning in the Western Cape Sandveld seems to have been carried out principally in the spring months when the risk of fire spreading was minimal (Bands 1977; Duckitt, pers. comm. 1982). Repeated patch-burning in the spring season, prior to 1960 should, theoretically, have favoured the growth of restionaceous and resprouting species in the long term, although this is impossible to substantiate. However, as both the season and intensity of burn pre-1960 would appear to have favoured graminoid and restioid species it is feasible that repeated burns of the same nature over a prolonged time period may have had irreversible effects on composition of the lowland fynbos vegetation.

Studies on the effects of fire on soil nutrients and micro-organisms in fynbos have focused on short-term changes (Brown in prep.; Coley in prep.; Stock in prep.) and there is a dearth of information on the long-term implications of different fire regimes on the soil status. For this reason, any inferences as to the long-term effects of the fire history on the Fynbos Site are tentative.

According to Raison (1979) fire has three basic effects on soils:

direct action of heat (ephemeral); removal of litter and standing crop, creating new microclimates (transient); and the redistribution and changed availability of nutrient elements. The following discussion concentrates on the long-term aspects of the third effect.

Wicht (1945), having observed large clouds of wind-borne ash being transported away from a fire, wrote: "This loss cannot be made good if fires reoccur too often, and must be an important factor in causing the vegetation to retrogress". Groves (1977) and Van Wilgen and le Maitre (1980) draw attention to the possible significance of loss of nutrients, principally nitrogen in smoke and wind-blown ash; Mooney (1982) notes that mediterranean type ecosystems suffer large losses in nutrients as a result of frequent fires, and according to Raison (1979) the quantifies of phosphorus, magnesium, calcium and potassium released by burning scrub vegetation are high in relation to both the total and available quantities of these elements in soils.

Nitrogen seems to be the most important nutrient factor in fires. Apart from the direct effects of fire on nutrient cycling there are potential longer term effects as regards this element (Raison 1979). Chapman (1967), and Robertson and Davies (1965) found that there were net losses of nitrogen from lowland heathlands in Britain burned on a 12 year cycle; nitrogen losses seeming to be directly related to the fire intensity. De Bano and Conrad (1978) similarly found that up to 40% of nitrogen in plants and litter in a chaparral ecosystem was lost after fire, this fraction increasing with increasing fire intensity. As there are few nitrogen fixing micro-organisms even in the early stages of succession in fynbos (Mooney 1982), and as the natural fire frequency is estima ted at from 6 to 30 years (Kruger 1978) or longer (Moll *et al.* 1980), it seems likely that the 3 to 4 year burn period on the Fynbos Site prior to 1960 may have effected net long-term losses of nitrogen from this system. Although volatilised nitrogen was not quantified in the 1980 fire, a net loss of this element to the fynbos ecosystem was probable (Stock, pers. comm. 1982).

Phosphorus too, may be lost to the system in smoke and wind-borne ash. Fairly heavy losses of this element in ash and smoke seemed likely in the 1980 fire (Brown pers. comm. 1982), although these were not quantified. Although the loss of phosphorus in fire is small relative to other nutrient losses (Groves 1977) it may be considerable relative to the input of this element, and net losses of phosphorus on a protracted 3 to 4 year burn rotation - as on the Fynbos Site before 1960 - seem possible.

The likely low intensity fires on the site pre-1958 may have minimised potential nutrient losses, and burning in the virtual absence of wind may have reduced the possible export of nutrients as ash in wind.

(Data for losses of other nutrients could not be obtained, but as both phosphorus and nitrogen are essential for plant growth, and as fynbos systems are characterized by low nutrient status, long-term depletion of these elements may have had significant repercussions on the site ecosystem.)

Long-term effects of repeated fire on micro-organisms would seem to be negligible, as recovery rates post-fire are fairly rapid (Coley in prep.).

The indirect effects of increased exposure of soil to wind erosion through recurrent firing of vegetation may too have effected long-term changes in the soil nutrient status. When devoid of a protective mantle of vegetation, soils in the Sandveld are extremely prone to wind erosion. The wind attacks the most productive horizon of the soil profile, and carries away the lighter mineral particles and organic matter of the topsoil, thereby removing most of the readily available plant nutrients (Talbot 1947). Pre-1960, patch burning played a major role in destroying the protective vegetation cover of the sandy soils of the site and, in combination with the trampling of livestock, is likely to have exacerbated the transport and loss of the relatively fertile uppermost soil layers.

Although not directly related to the effects of a fire regime on the indigenous vegetation, the encroachment of alien vegetation cannot be considered in isolation from such a regime. Compton (1926) first cautioned that burned areas were prime targets for invasion by exotic plants such as hakea, wattle and cluster pine where parent plants were near enough to supply seed. Although there were no alien plants on the site in 1938 (3C 2.6.1), in later years and in areas in close proximity to the site, frequent patch-burning probably facilitated the spread of acacias pre-1960. (Although frequent fire may have prevented the accumulation of large numbers of acacia seed, in a soil seedbank two year old saplings can set seed (Milton & Hall 1981) and thus fire on a 3 to 4 year rotation is unlikely to have arrested spread of these plants.)

The patchiness of surviving vegetation after the controlled firing of small disjunct areas prior to 1960 provided a heterogeneity of habitat important for the survival of a diverse assemblage of animals (Main 1977). Persistence of a faunal population depends only on the survival of an adequate nucleus from which reinvasion post-fire can occur, and the nature of patch-burning would seem to fulfil this requirement.

Large mammals are likely to flee from fire; small mammals, fossorial arthropods and reptiles probably retreat into underground refuges to escape burning. Depleted small mammal communities as consequence of fire may recover within 2 to 3 years, and insect communities, thought to suffer most losses of the fynbos fauna in fire, revert to pre-burn densities and compositions within a year (Bigalke & Willan, in prep.). Of the reptiles, the tortoise is believed to be extremely vulnerable to fire, and in the case of the endemic geometric tortoise an inter-fire period of not less than 10 years is recommended to obviate depletion of populations (Greig in prep.). Avifauna would undoubtedly flee from fire, returning almost immediately post-fire except in the case of the Cape sugarbird which relies on influorescences of *Protea* species for both nectar and satellite insects for food. *Protea repens* on the Fynbos Site flowers at 3 years and hence this bird may be expected to return approximately 3 or 4 years after a burn, assuming that the number of influorescences on the site renders a visit energetically viable - other specialist nectarivores, such as the lesser double collared sunbird, which are potentially important in the pollination of fynbos plants (Siegfried in prep.), are known to visit the Fynbos Site some 16 months after a burn (pers. obs.); well within the fire return period before 1960.

The mortality of fauna in any fire will be influenced by the season of burn in relation to the stage in the life cycle of a species. Naturally occurring conflagrations occur primarily in summer in the Western Cape (Bands 1977) and the repeated veld burning in early spring prior to 1960 may have adversely affected populations of those mammals - for example the South Western Cape endemic grysbok - who give birth at this time (Manson 1974). According to Winterbottom (1963) nesting of birds in the fynbos reaches a peak in spring, and disruption of nesting or destruction of nests by repeated spring burns was possible.

The majority of the effects of fire on fynbos fauna, incorporating both fluctuations in population size and migrations to and from the post-fire environment, appear to be transient; recovery of populations occurring within 3 or 4 years. As patch burning destroys only small tracts of vegetation and leaves interspersed refugia of habitat for fauna, the probable long-term impact of burning on a 3 to 4 year rotation on fynbos animals - with the possible exception of the geometric tortoise - would seem to be minimal. In combination with external pressures on fauna prior to 1960, however (4,3,5), repeated spring burning may have had significant repercussions - if only transient - on the size of populations.

4.2.1.2.2 *Post 1960 period*

After 1960 intentional burning of the Fynbos Site was not carried out and all conflagrations were initiated external to the site by human action (3F 2.5).

The decision not to burn intentionally does not appear to have stemmed from restrictive legislation on this activity, introduced nation-wide in 1946 and in the Darling Soil Conservation District in 1962 (see above), but rather from the increased risk of fire damage to property concomitant with the increase in cultivated and afforested areas bordering the Fynbos Site.

Analyses of the burn patterns from 1960 to 1981 (Fig. 37) reveal that the mean frequency of fire on the site was 7 years, giving a probability of 0,143 fires per year. In this period, 0,50% of the site remained unburned, 27,64% was burned once, 67,67% was burned twice, and 4,19% was burned thrice. As the area of the site is estimated at 251 ha (3E 2.3), the mean fire interval per hectare could be calculated at 11,96 years for the 1960 to 1981 period. The minimum burn period of vegetation between 1960 and 1981 appears to have been the 4 years and 9 months between the February 1976 and November 1980 burn - greater than the probable return period of fire prior to 1960 - the maximum between 23 and 25 years (3F 2.5).

With the increase in cultivated land and afforested areas surrounding the Fynbos Site after 1962, the stand of inflammable indigenous vegetation may be seen to have constituted an increasing fire hazard (see above). The ploughing of firebreaks on and at the perimeter of the site, independent of those required by the Darling Soil Conservation Scheme prior to 1969 (see 3F2.3.2) in this period, to curb the extent of burns, supports this. Firebreaks ploughed on the northern and southern boundaries of the site to insulate it from extraneous fires seem to have been ineffectual, possibly because they were not of sufficient width or adequately maintained.

Coastal Fynbos is probably readily inflammable at an age of 3 to 4 years post-fire. In the absence of patch burning, the vegetation on the Fynbos Site soon becomes uniformly vulnerable to accidental conflagrations and, without quenching, would be entirely razed in each incident of fire. The ploughing of firebreaks on the site has inadvertently facilitated the temporal accommodation of a heterogeneous ecosystem, in addition to reducing the potential exposure of soil to wind erosion in the event of a more extensive burn.

The effect of the relaxed fire regime in the years after 1960 is thought to have been beneficial to the vegetation on the Fynbos Site, possibly favouring the re-seeding species as the reduced fire frequency would enable a greater proportion of plants with comparatively long primary juvenile periods to attain maturity and replenish seed stocks. The occurrence of species in the study area post-1960 is likely to have been dictated by their ability to survive the fire regime in the pre-1960 period, and has probably been relatively unaffected by the later fire regime. Overlays of burn patterns from 1960 to 1979 on the vegetation communities mapped by Boucher and

Shepherd (in prep.) in 1979 (Appendix C) show no correlation between recent burn history and the nature of the vegetation at the community level. The latter seems to be largely determined by the soil form and series (see Boucher & Shepherd, in prep.; Fry in prep.).

As the burn age of fynbos on the site after 1960 had increased compared to that of the patch-burned vegetation, the intensity of burn may be expected to have increased accordingly (see 4.2.1.2.1). The elevated burn intensity would favour an increase in the loss of nutrients in each fire (see below).

Of the three burns between 1960 and 1981, two are known to have occurred in summer (3F 2.3.2); one in early summer (November 1980) and one in late summer (February 1976). The late summer fire originated to the north of the Fynbos Site and spread southwards, perhaps fanned by a northerly wind, as did the 1966 fire which may, ratiocinately also have occurred in late summer/autumn. With the change in fire regime after 1960, there appears to have been a concurrent shift in the season of burn from predominantly late winter or spring to summer. This may have favoured the reseeding shrubs in the post-burn environment, reinforced by a longer return period between burns.

As regards the encroachment of alien vegetation, fire has been labelled the chief cause of displacement of indigenous vegetation by exotic plants (D'Ewes 1960; Roux & Middlemiss 1963). With the escalating abundance of acacias in the study area after 1960, concomitant with increased cultivation, the reduced fire frequency on the Fynbos Site decreased the incidence of exposure of bare soils to invasion by these plants relative to the pre-1960 fire regime. In addition, as elevated fire temperatures trigger acacia seed germination, and as the post-fire environment with its boosted levels of pH (Milton & Hall 1981), potassium and phosphorus in the surface soil (Bean 1962) may favour the establishment of acacias, the reduced fire frequency may have minimised potential germination and colonisation of the site.

The increased intensity of post-1960 fires relative to earlier patch-burns may have effected a greater loss of nutrients, principally nitrogen, in each fire; but the longer period of recovery between consecutive burns (almost double that in the pre-1960 period), allowing returns of this element largely through precipitation (estimated at 1 to 2 kg/ha per year: Stock, pers. comm. 1982), is thought likely to have more than compensated for any aggravated losses attributable to this factor. As no work has been done to date on the long-term effects of different fire regimes on the nutrient status of the fynbos ecosystem, suffice to say that the post-1960 period would probably have been more conducive to sustained nutrient levels than the pre-1960 period of patch-burning.

Effects of soil exposure post-fire in the period after 1960 would have been the same as those prior to 1960, although trampling of livestock on newly burned soils pre-1960 may have exacerbated wind erosion relative to the latter period. The mean proportion of the Fynbos Site burned in accidental fires is similar to that burned intentionally in 1938, but as the mean frequency of fire in the later period was almost half that in the pre-1960 period potential transport of topsoil and nutrients would be much reduced, favouring the retention of nutrients in the Fynbos Site ecosystem.

As for the pre-1960 period (4.2.1.2.1), the long-term effects of fire on fauna post-1960 were probably minimal. The relaxed fire frequency undoubtedly facilitated the recovery of animal populations and, although the extent of any one burn exceeded that in the earlier regime there was vegetation cover providing habitat for fauna on at least one fifth of the site at all times, and newly burned areas providing young, palatable fodder. (In the absence of firebreaks, possibly allowing total combustion of vegetation on the Fynbos Site, repercussions of habitat destruction on fauna may have been dire; especially in the light of the increase in land transformation immediately external to the site after 1962.)

The change in burn season from late winter/spring to summer/autumn from the pre- to the post-1960 period may have alleviated possible pressures on breeding antelope and nesting birds.

4.2.1.3 Control of alien vegetation

Prior to 1962 there was no counteraction to spread of alien plants on the Fynbos Site or on other areas used solely for grazing (3D 3.5). Between 1938 and 1960, two pines and a number of acacias established themselves on the site; their growth and reproduction being thus unimpeded.

After 1962, acacias were hacked periodically by the landowner. No measures were taken to control the spread or growth of the cluster pine on the site. From aerial photographs taken after 1960, it is apparent that any control of acacias is likely to have had minimal impact on the long-term status of these plants on the Fynbos Site. Probable clearing of acacias was only evident prior to 1972 at the waterhole, and between 1977 and 1979 (3F 3.5). As predominantly large trees were chopped (3E 2.3.3), these would have contributed an enormous number of seeds to a soil seedbank prior to destruction. For mature *Acacia saligna* seed production is in the order of 10 x 10^3 seeds per m^2 of projected canopy per year and for mature *A. cyclops* about one third this amount. This yields an estimated annual input of 4245 viable seeds per m^2 for *A. saligna* and 360 for *A. cyclops* (Milton & Hall 1981).

Although a two year old sapling can set seed, large crops of seed are not produced until the *Acacia* (*cyclops* or *saligna*) is over 5 years old (Milton & Hall 1981). As the fire frequency post-1960 was reduced relative to the pre-1960 period, in the absence of a systematic clearing or weeding programme the maturation of acacias and contribution to a soil seed bank on the Fynbos Site was facilitated; the potential ages of acacias on the site being equivalent to the interval between successive burns.

It is apparent, therefore, that past chopping of acacias on the site is likely to have had minimal impact on the accumulation of inordinate numbers of acacia seed in soils of the site. Seed predation appears to be a minor factor in depleting seed stores of acacias in the South Western Cape: rodents, especially *Rhabdomys pumilio* (found on the site), apparently the main predators, destroy only an estimated 1% of seed from acacia thickets on the Cape Flats (Shelton 1975). Longevity of acacia seed is not known, but *Acacia saligna* may reappear after absence of some 160 years from dormant seed in Australian post-fire succession (Hall 1979). "The large seedbank is a major obstacle to the removal of Australian acacias from the indigenous vegetation of the Cape." (Milton & Hall 1981.) This may too apply to the Fynbos Site!

4.2.1.4 Bushcutting (see Figs 35, 38)

"There are few, if any, areas that have been burnt but not grazed and browsed, and where no burning is practised, the development of tall, woody shrubs reduces the pasturage to practically nothing after five or six years" (Wicht 1945).

As fire was not used as a management tool after 1960 to ameliorate grazing for livestock, and as some areas on the Fynbos Site remained unburned for up to 23/25 years (3F 2.5), bushcutting was carried out in an attempt to promote the growth of palatable species from 1965/6 to 1969/70 (3E 2.3.4, 3F 2.3.4).

Acocks (1935) noted that cutting the indigenous vegetation favoured growth of Restionaceae, and results of experiments conducted in the west coast Strandveld showed that bush-slashing promoted the most rapid increase in growth of palatable grass cover, more so than veld-burning

(Joubert 1969). Bushcutting on the Fynbos Site, however, was not found to be effectual in improving the grazing (H.R. Andrag, pers. comm. 1982).

The estimated minimum age of vegetation at the time of bushcutting was five years, and only two small tracts of fynbos appeared to have been repeatedly bushcut (3F 2.3.4). Any *Protea* plants or other reseeders in the bushcut areas would probably have flowered and set seed prior to being cut, and any dominance of Restionaceae or other sprouting plants after bushcutting is likely to have endured only until the next fire (1980).

A comparison of bushcut areas with undisturbed vegetation on the same soil form yielded no correlation between bushcutting and resultant vegetation community, indicating that this activity had not seemingly effected any changes in the plant composition. Despite there being few *Protea repens* in the bushcut area prior to 1980 (Boucher, pers. comm. 1982), apparently concentrated within the area of Clovelly soil form near the southern boundary where saprolite lies within 2 m of the surface (pers. obs.), a number of juveniles of this species have been recorded in this area post-fire (Kyriacou, pers. comm. 1982) and would suggest that long-term impacts of bushcutting on the site are negligible.

The practice of cutting fynbos to improve grazing exposed the sandy soils of the site - and probably nutrients - to transport by wind; this effect enduring for up to 9 years after bushcutting (3F 2.4).

As postulated in 3F 2.4, bare patches of soil effected by bushcutting may have channelled runoff and soil particles from the wash overburden into the bushcut areas in subsequent years of heavy rainfall (1974, 1976, 1977), as many of these areas were situated on the probable drainage line of the Fynbos Site.

4.2.1.5 Quarrying (Figs 35, 39)

The quarrying for gravel in early 1971 on the site did not disturb extensive areas of ground. Topsoil was relevelled after excavation and precautions were to have been taken to avoid the creation of a dust nuisance (3F 2.3.5). That is, the inevitable erosion of soil by wind concomitant with the destruction of vegetation cover and agitation of soils must be assumed to have been minimised. Indications of the smaller gravel pits had, to a great extent, disappeared by 1979, eight years later. The destruction of vegetation cover in these areas (and habitat for fauna) thus appears to have been a temporary phenomenon. The large gravel quarry (grid square K6 on Fig. 35) remains an eyesore on the Fynbos Site and recolonization by indigenous vegetation has been minimal (pers. obs.).

Probable long-term consequences of quarrying centre on the provision of disturbed soils for infestation by acacias, principally *Acacia saligna*, the Port Jackson willow (pers. obs.). The excavation of gravel test pits in close proximity to mature acacias (Figs 16, 21) may have contributed to the dispersal of seeds of these plants (in a soil seedbank) to areas in the immediate environs. A dramatic increase in numbers of acacias in the more intensive quarrying area (on Clovelly soil form near the northern boundary where saprolite lies within 2 m of the surface: Appendix B) was evident in 1979 (Fig. 31), their establishment possibly facilitated by both the above considerations.

4.2.2 Soil erosion and deposition (Figs 35, 39)

Although the majority of bare areas of soil on the Fynbos Site were seemingly initiated by soil erosion external to the site, the possible effects of soil deposition by wind and wash will be discussed here.

Overlays of bare soil areas from 1938 to 1979 on the vegetation communities of the site (Appendix C) reveal a positive correlation between the soil wash overburden and vegetation community 'C' of *Diospyros glabra* - *Elytropappus rhinocerotis* mid-high sparse shrub and a tentative correlation between areas of soil deposition and vegetation community 'B' which is a mosaic of Strandveld and fynbos species (Boucher, pers. comm. 1982), having elements of both. Soils in the soil wash area consist of relatively clayey material with different, generally elevated nutrient properties from the characteristic Pella soils (Fry, pers. comm. 1982). The altered water retention and nutrient properties of this area are reflected in the growth of rhenosterbos in the 'C' community, usually associated with clay or clay-loam soils (Kruger 1979). The 'B' community of *Diospyros glabra* -*Salvia lanceolata* is thought to be coincident with areas of ground where the granitic parent rock is relatively close to the surface (Boucher, pers. comm. 1982). In addition, it is possible that soils deposited from cultivated lands adjacent to the site or those which have been carried from the soil wash area and re-deposited have a slightly altered nutrient status as compared to other soils in the area. Talbot (1947) points out that dust deposits contain elevated quantities of nutrients, namely organic matter, phosphorus, nitrogen and colloidal material relative to drifted soils left behind. Characteristics of fynbos suggest that it is a nutrient stressed vegetation (Boucher 1977). Thus even minute changes in soil nutrient status may have repercussions on the nature of the vegetation.

4.2.3 <u>Alien vegetation</u> (Fig. 35)

The distribution of acacias on the site from 1960 is of interest here in that disturbance of some kind, causing the exposure of bare soil patches, seems to be a prerequisite for initial invasion. The initial areas of infestation, namely the soil wash area, patches of bare ground to the north of the wash due to localised soil deposition, and the waterhole site, noted to be trampled in 1938, either constitute disturbed areas or reflect perturbations effected by extraneous agricultural practices. The majority of subsequent areas of infestation, including the windmill clearing, quarry pits, boundary fences and adjacent exposed soils in the form of firebreaks, roads and tracks too exemplify disturbed areas, but one acacia appears to have established itself in fynbos that has not been subject to obvious disturbance -

(e.g. grid square M7 on Fig. 35).

With the rapid impingement of acacias from surrounding areas on to the Fynbos Site since 1960 (compare Figs 12, 28) the probability of seed reaching the site increased dramatically, as did the chances of bare areas of soil - whether caused by man-made or natural perturbations, or being implicit in the broken canopy of the fynbos vegetation - being colonised by these pest plants. Spread of acacia seed, both to the site and on the site, from mature plants may be aided by birds (sparrows, doves and starlings, in particular: Acocks 1935, Stirton 1978), by the burrowing of the Cape dune mole, by small rodents such as the Cape gerbil and the striped fieldmouse, and possibly by ants on the site (see 3F 2.7). Although wind is thought to be a minor agent in seed dispersal (Milton 1980) drift of acacia seeds (and light soils) on exposed soil surfaces may facilitate their spread.

Fire stimulates germination of acacia seed, and no fire recurs soon enough to kill acacias before maturity (Kruger & Bigalke, in prep.) As the post-fire environment is conducive to the germination of acacias (4.2.1.2) and as both *Acacia saligna* and *A. cyclops* exhibit shoot growth peaks slightly before a sample of indigenous species (Sommerville 1981) and are highly precocious, they are likely to gain a competitive advantage over the fynbos vegetation after fire. With each successive fire, the relative abundance of acacias in the community is likely to increase, as was evident on the 1972 and 1979 aerial photographs following the 1966 and 1976 fires respectively, and after the 1980 fire (pers. obs.); especially in the absence of an effective weeding programme as has been the case on the site in recent history (4.2.1.3).

Excepting the two cluster pines in the soil wash area of the Fynbos Site, the situation of *Pinus pinaster*, as noted by Kruger (1977) is not limited to recently burned or otherwise disturbed vegetation. Elimination and control of the cluster pines on the site is seen to be a minor problem relative to that of acacia eradication. Although extremely precocious, these trees have a minimum juvenile period of from 5 to 10 years (Kruger 1977) (compared to the 2 year period for Port Jackson willow and rooikrans) and are highly conspicuous in the fynbos, unlike the younger acacia plants.

4.2.4 Fauna

Information (gleaned from interviews) on the occurrence of fauna on the Fynbos Site in recent years does not furnish a chronological account of such. Rather, as much of the information from individual sources is likely to comprise incomplete, subjective description, collective accounts are taken to give an indication of fauna on the site. As regards contemporary pressures on native animals, possibly affecting species abundance and composition, it is necessary to investigate those activities external to the site which were pertinent to fauna (see 4.3.5). (The long-term effects of past landuse and management practices on fauna of the site, with emphasis on burning, are thought to have been minimal: 4.2.1.2.)

From a collective account of fauna (3D 2.7, 3E 2.7, 3F 2.7 and listed in Appendix G) it is evident that the Fynbos Site harbours two of the seven living mammal species strictly endemic to the South Western Cape: the Cricetid Cape gerbil, *Tatera afra*, and the Cape dune mole, *Bathyergus suillus*. Both are technically rare but not uncommon where present (Meester 1976). The Cape grysbok, *Raphicerus melanotis*, found on the site, is characteristic of the South Western Cape, but is not strictly endemic (Bigalke 1978). It requires dense vegetation as a habitat, and Coastal Fynbos is ranked fifth to Coastal Rhenosterveld as the most important veld type to this animal (Manson 1974). Possibly its small territorial range of from 129 to 937 square metres (Manson 1974) enables it to adapt well to agricultural activities, and the Fynbos Site probably constitutes a suitable refuge to a number of individuals in the locality.

The supposed occurrence of an aardvark on the site, the only surviving member of the order Tubulidentata and a listed rare and endangered species (Meester 1976) increases the value of the site in terms of its conservation potential, although the distribution of this mammal is determined more by the presence of ants and termites than by vegetation type.

As noted earlier, three of the six bird species endemic to fynbos are known to occur on the site: the Cape sugar-bird (*Promerops cafer*), the orange-breasted sunbird (*Nectarinia violacea*) and the Cape francolin (*Francolinus capensis*).

Of the reptiles reputed to occur on the Fynbos Site, the geometric tortoise is endemic to the South Western Cape and its survival is endangered by the disappearance of the lowland habitat and possibly by too frequent firing of vegetation (Greig & Burdett 1976). The protection of remnant areas of fynbos, exemplified by the Fynbos Site, is thus imperative to obviate extinction of this animal.

No systematic sampling of invertebrate life on the Fynbos Site has been carried out but, of the observed insects, one species of ant appears to represent a new species of the genus *Camponotus*, and one a possible new sub-species of *Ocomyrmex barbiger* (Prins, pers. comm. 1982). As the greatest number of endemic animals is to be found amongst the invertebrates (Bowden 1978; Enrödy-Younga 1978; Pinhey 1978; Van Bruggen 1978) the site may provide habitat for a number of endemic species.

The effect of fauna on the soils of the site may be significant: organic content of mounds of the Cape dune mole are known to be 50% to 60% that of surrounding soils, and soil turnover by these mole rats is dramatic (Davies, in prep.); the activities of termites and fossorial ant species are sure to influence vegetation cover and possibly nutrient status and percolation of soils. As stated by Ruelle (1978), "However, dull, secretive and slow-moving as they are, termites may be more important in the ecological set up than many other insects". Rodents (Wiens & Rourke 1978) and a number of birds (Mostert *et al.* 1980; Siegfried, in prep.) are thought to play an important role in the pollination of certain fynbos plants. All fauna play an essential role in nutrient recycling, ensuring that available nutrients do not become inextricably incorporated into long-lived plants and thereby facilitating post-fire succession.

Fauna are thus an integral part of the Fynbos Site ecosystem and are essential to its long-term diversity and viability, and in turn depend on conservation of the natural veld for their survival.

4.3 EXTERNAL INFLUENCES ON THE SITE

4.3.1 Fires

Pillans (1924), apropos the Cape Peninsula, wrote: "Most of the fires are intentional and are lighted either by persons who have rights over the ground or by unauthorised persons who hope to secure firewood from the killed shrubs and trees"; and Compton (1926) echoed this observation: "Near Cape Town the firewood gatherer is often responsible for conflagrations which he starts in order to kill the proteas and other shrubs which he will later collect and sell as fuel; and the same is the case near other towns and villages".

During the years when patch burning was practised on the Fynbos Site and surrounding pastureland, the influence of fires started external to the site must have been minimal as fuel loads and subsequently the risk of fire spreading would have been low. In later years, after 1960, when intentional firing of fynbos was not carried out, any extraneous fires constituted a potential hazard to the site where continuous corridors of inflammable material were present from the origin of fire to the site.

Study of aerial photographs from 1960 to date discloses that accidental conflagrations on the site were initiated external to the site on uncultivated land immediately beyond either the north or south boundary fence.

From data collected on the potential sources of fire (3D 3.2) it is apparent that causes of accidental fires were exclusively anthropogenic. Of the suggested causes of fire, discarded cigarette butts and intentional burning for firewood seem to have been the most probable in recent years, although little positive confirmation of the latter could be obtained.

The exclusion of Coloured-owned lands (Goeie Hoop and Pella) from soil conservation and thus restrictive veld-burning legislation, seems unlikely to have exacerbated problems of accidental fires in the area; none of the fires after 1960 having been initiated on these lands.

No conflagrations appear to have been started on the Fynbos Site post-1960. With effectual firebreaks both on and at the perimeter of the site, control of the future occurrence of fire should be practicable.

4.3.2 Cultivation of land

The effects of increase in area of cultivated land surrounding the site, from 11% of the study area in 1938 to 54% in 1977 were multiple. In addition to the factors considered below, cultivation inadvertently exacerbated soil erosion (4.3.3), encouraged the encroachment of alien vegetation (4.3.4) and was inseparable from the use of fertilizers and pesticides in the Sandveld (4.3.5).

Loss of plant species may have been concomitant with the clearing of indigenous vegetation for cropping and afforestation which effectively diminished the extent of natural habitat for fynbos fauna.

The effect of land transformation in the study area has been to render the remnant portion of fynbos - the Fynbos Site - increasingly insular and isolated from neighbouring stands of fynbos, and simultaneously to elevate its importance as a natural refugium for both indigenous flora and fauna.

"The number of species that a proposed reserve can hold at equilibrium is a function of its area and its isolation" (Diamond 1975). Applying the theory of island biogeography (MacArthur & Wilson 1967) extinction of species was inevitable as a result of the decrease in extent of the initial fynbos stand. As the equilibrium position of the site as regards species composition cannot be determined, and assuming that both its shape and size are fixed, efforts to minimise further isolation and insularization would seem imperative to the long-term viability of the site; considerations obtaining to conservation thus extending beyond the confines of the site.

4.3.3 Soil erosion and deposition

Before 1939, the menace of soil erosion was seriously considered by only a minority of farmers (Ross 1963). In 1938, absence of contouring or the use of bush strips on the uniformly ploughed hillslope reflected this (3C 3.4). Sheet erosion was evident and wind erosion from the large expanse of exposed soils was highly probable.

Contouring and strip cropping on cultivated lands was advocated in 1945 prior to the promulgation of the Soil Conservation Act of 1946 (Bennett 1945). Talbot (1947) attributed most of the eroded areas in the Sandveld to the plough and only a relatively small portion to burning and overgrazing, noting that contour ploughing was almost unknown in the region prior to 1944.

The Soil Conservation Act of 1946 was largely ineffectual (Rabie 1976), but binding stipulations on anti-erosion measures in the Soil Conservation Scheme for the Darling District, compiled in 1954, seem to have had some effect by 1960: "According to dependable surveys approximately 60% of all regularly cultivated lands were protected against surface erosion by 1960. Serious gully erosion still occurs alongside cultivated lands." (Amendment of the Soil Conservaiion Scheme for the Darling Soil Conservation District 1962) In 1960, erosion on the Burgher's Post hillslope had increased markedly; rills and gullys were conspicuous and soil wash had spilled on to the Fynbos Site. Efforts to control erosion in the form of contour ploughing and use of bush strips were first observed in 1960 (3D 3.4).

Subsequent to 1960, gully erosion on the hillslope has advanced, the area of cultivated land in the study area increased and despite the somewhat erratic use of bush strips on cropped fields, wind erosion was undoubtedly exacerbated. According to Talbot (1947) the Sandveld soils are highly susceptible to wind erosion where deprived of vegetation cover, and almost all cultivated and cleared lands have suffered an appreciable degree of such erosion.

Soils blown from cultivated lands to the west of the Fynbos Site in southerly winds in the dry summer months appear to be deposited on the site where vegetation or the local topography arrests wind-borne soil (3C 2.4, 3D 2.4, 3E 2.4). Although the effects of moving soil particles on vegetation are not known, growth of plants continually exposed to wind blown sand may be hampered.

As regards gully erosion, a quote from Talbot (1947) is pertinent here: "Even today the soil erosion which has been extending or accelerating for thirty years or longer is still proceeding practically unhindered on the majority of farms." The Burgher's Post hillslope, cropped continually from at least 1938, has never been adequately protected against erosion with the result that gully erosion has proceeded unchecked over the years. This type of erosion "skims the cream off the soil and pours it down the sluit" (Talbot 1947) to be deposited in this case as an overburden on the Fynbos Site. Soils in the wash area have different nutrient properties from the remainder of soils on the site (Fry, pers. comm. 1982), and effect a change in the vegetation associated with this area (4.2.2).

4.3.4 Alien vegetation

Compton (1926), Acocks (1935), Adamson (1938) and Wicht (1945) commented on the rapid spread of hakea, acacias and the cluster pine in the indigenous vegetation of the Cape; Wicht (1945) warning that one of (if not) the greatest threats to the Cape vegetation was suppression through the spread of vigorous exotic plant species. Since then, this warning has been repeated by numerous authors, for example D'Ewes (1960), Milton (1980), Hall *et al.* (1980), Stirton (1978), Taylor (1975) and Shaughnessy (1980).

Intentional planting of acacias as wind breaks has been extensively carried out in the past century: *Acacia cyclops* and *Acacia saligna* were sown in the Blaauwberg reserve in 1924 and 1925 (Shaughnessy 1980); were recommended for use as wind breaks in 1945 (Bennett 1945); and are, according to F.W. Duckitt of the Darling/Malmesbury/Hermon Soil Conservation committee, still planted today for this purpose.

Neither the rooikrans, Port Jackson willow nor cluster pine found in the study area has been declared a noxious weed. As acacia leaves are useful as fodder when finely chopped and wood is used as fuel, and as pines are not widely perceived as pest trees, measures to keep the spread of these plants in check have been minimal in recent history.

The encroachment of pest plants on to the site appears to have been concomitant with the increase in cultivation of land in the study area after 1962, facilitated in the absence of measures to check their spread. Principal routes of encroachment of acacias have been via the Burgher's Post and Dassenberg watercourses, via previously cultivated and then abandoned lands, via cleared tracts of land and by way of gully and rill erosion (3D 3.5, 3F 3.5).

The high seed output of *Acacia saligna* relative to that of *A. cyclops* (Milton & Hall 1981) combined with the possible selective removal of *A. cyclops* for firewood in the past (the wood of this species is harder than that of *A. saligna* and thus preferred) and the coppicing habit of *A. saligna* may be factors favouring the dominance of the latter acacia in this area.

Both the afforested areas of the cluster pine, *Pinus pinaster* - an important timber producer in nutrient poor soils (Kruger 1977) - on Dassenberg land to the south east of the site (3C 3.5) and the stand of this pine spreading from Goeie Hoop to Burgher's Post land are thought to constitute sources of spread of this pest tree on to the site (3F 2.6.1).

The progressive encroachment of invasive alien plants on to the Fynbos Site from surrounding land poses a serious problem with regard to future management of this stand of indigenous vegetation. In addition to constituting a threat to the survival of the flora on the Fynbos Site *per se*, pest plants threaten to suppress those remnants of fynbos beyond the site boundaries which form potential links between the Fynbos Site and other fynbos communities in the area; facilitating isolation of the site.

Where the eradication and control of pest plants, especially acacias, is not obligatory on privately owned land, it is unlikely that landowners will spread large sums of money on the repeated clearing of these plants from land not cultivated. Without state backing, therefore, the problem of pest plant encroachment can only increase.

4.3.5 Fauna

An evaluation of long-term effects of landuse both on and in the immediate surroundings of the Fynbos Site on its fauna is extremely difficult in the absence of past sampling on the site. In effect, the study is largely restricted to consideration of transient effects on those species which have survived the pressures of the past and neglects the possible extinction of species.

Actions serving to deplete the animal populations in the environs of the site, excluding those of habitat destruction which affect all fauna, have been directed principally at three groups of fauna: the antelope (grysbok, steenbok, duiker); the large carnivores declared vermin (black-backed jackal, silver jackal, lynx); and tortoises.

Antelope have been hunted by people in the vicinity of the site for many years both as sport (3C 3.6, 3D 3.6) and as a source of food (3E 3.6). Native dogs, noted to 'find a fiendish pleasure in killing sheep' (Hanekom 1957) probably took their toll of small mammals on the site (3E 3.6) and translocation of game from the area in 1975 further depleted populations of grysbok, steenbok and duiker (3F 3.6). Although not strictly applicable to the study area, the increased conservation measures for these (and other) antelope - from the Ordinary Game Schedule in the Wildlife Protection Amendment Ordinance No. 7 of 1951 to the Protected Wild Game Schedule of the Nature and Environmental Conservation Ordinance No. 19 of 1974 - may well reflect a perceived increase in scarcity of game in many areas in the Cape.

Rewards for stock-destroying carnivores (listed above) were offered in terms of Ordinance No. 10 of 1927, No. 21 of 1946 and No. 26 of 1957 (and amendments thereof) and undoubtedly served as added incentive to eradicate these animals in the study area prior to 1962 (3C 3.6, 3D 3.6, 3E 3.6). The large spotted genet, known to occur on the site (3F 2.7) was declared vermin in 1957, but its notoriety appeared negligible compared to the larger carnivores and no mention of it was found in historical records. Both the silver jackal and black-backed jackal known to have occurred in this area (Rand 1955) are no longer in evidence, perhaps reflecting the efficacy of vermin extermination.

The declaration of the 'nagmuis' or Cape gerbil vermin in 1954, is unlikely to have had severe effects on populations of these animals on the site; the menace of the 'nagmuis' being associated with cultivated lands. (No mention of this animal was made by landowners interviewed.)

Tortoises were prized as food by Coloured people in the area (3D 3.6) and were considered a menace to stock farming in the early 1900's and hence destroyed (3C 2.7). Combined pressures on tortoise populations from frequent fire (to which they are extremely vulnerable), destruction of habitat and the above two factors may have been severe in threatening the survival of species in the pre-1960 period, especially the endemic geometric tortoise. (All tortoises have been protected since the Nature Conservation Ordinance No. 26 of 1965.)

No data on actions serving to deplete avifauna in the area were encountered, although increased habitat fragmentation and insularization must influence immigration and visitation of itinerant species to the site. (The majority of avifauna, including endemic fynbos birds, have fallen under the Protected Wild Animal or Protected Game Schedule since Ordinance No. 20 of 1950.)

4.3.6 Fertilizers and pesticides

Application of phosphatic fertilizer to soils in the winter rainfall region has been advocated from 1929, as well as the use of nitrates, potash and lime where soils were acid (Dept of Agriculture 1929).

Granular phosphates, potash, nitrates and lime have been employed on all cultivated lands in the study area from 1958 (3D 3.7), and probably earlier. Although these are generally administered concurrently with the planting of seeds, one must not eliminate the possibility of minute quantities of fertilizer in topsoil being transported by wind or soil wash on to the Fynbos Site. This applies in particular to ploughed fields on the hill to the west of the site; soil being washed down the erosion gully or being carried by southerly winds in the dry summer months on to the site. This could, theoretically, elevate the nutrient status of soils affected by localized soil deposition and modify the nature of vegetation. (Specht (1973) found that addition of phosphates and nitrates to mediterranean sclerophyllous shrubs in Australia promoted a marked increase in growth of many species, effected in increase in leaf area index and an unusually early growth of shoots in summer.)

Aerial spraying of pesticides on to lands adjacent to the Fynbos Site was restricted to the use of 2-4-D, MCPA - both translocated herbicides which act selectively on dicotyledonous plants - and a copper sulphate solution, probably Bordeaux mixture, used as a fungicide (3D 3.7, 3F 3.7).

Although similar to MCPA, 2-4-D is a stronger herbicide (Franken, pers. comm. 1982). Both these phenoxyacetic acids affect protein and ribose nucleic acid synthesis, in very high concentrations inhibiting photosynthesis and in low concentrations acting as auxins and stimulating plant growth (De Villiers, pers. comm. 1982). As the drift of herbicide on to the Fynbos Site is likely to have been in very low concentrations, stimulation of growth of maturing and juvenile plants is likely to have been minimal; possible detrimental effects focusing on young seedlings (Brent, pers. comm. 1982).

Drift of copper sulphate spray on to the Fynbos Site is unlikely to have affected the indigenous vegetation.

The possible effects of the above pesticides on insect life and soil micro-organisms are not known.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
27	T7 BU 8-	P68279 T27 BU 8-	W 68279	P68279 W6829	A 68 27 W 68 T 382	A8279 T68 2 Q 2	A 79 T2	T3 8290										
BU 8-	BU 8 -	W7 T8 BU 8-	A7 W68 27 BU 8-	A 627 W682 Q 2 BU 8-	W8 T682	T 682	T 20	T368290	T6 290									
8 279 BU 8-	BU 8-	BU 8-	W 687 BU 8-	W 682 BU 8-	W 6	T 82	T 68 2	T368290 Q2	T368290 Q 2	T290								
82 79	T2 BU 8-	T 2 BU 8-	W 27 T82 BU 8-	T8279 BU 8-2-			T8 2	T 3829	T8 29 Q 2	T390	T3 90							
8279	A8279 BU 8-2-	T7 BU 8-2-	T38279 BU 8-2-	A8 T3 8279 BU 8-2-	T 2 BU 2-	BU 2-		A 279 (windmill) Q 2	T9	A9 T9 Q 2	A9 Q 2	A 2						
	A8279 2- BU 8-	BU 8-	A9 T 2 BU 8-	A 6879 (waterhole) T3 2 8 BU 8-2-	BU 2-	BU 2-			Q 2	A 9 Q 2	A 9 Q2	P8 27 9 Q2	A 8					
	A 8279 2- BU 8-	T 2 BU 8-2-	P9 T 2 BU 2-	BU 8-	BU 8-2-			Q 2	Q2	Q 2	Q 2	A8 29 Q2		A2				
	A8 279 BU 2-	T2 BU 8-2-	T 2 BU 8-2-	BU 8-				Q 2	Q2			Q2		A29				
	A 827 9 BU 2-	A 8 2 7 BU 8-2-	T 2 BU 8-2-					Q 2		BC 8- Q 2								
0	BU 2-	BU 2-							Q 2	T8 2 BC 8-	T 8 2							

KEY TO 150m x 150m GRID

- A — Acacia saligna or A.cyclops
- P — Pinus pinaster
- W — soil wash
- T — bare soil areas, other than soil wash
- Q — quarrying
- BU — bushcutting
- BC — bush clearing

- 3 — 1938
- 6 — 1960
- 8 — 1968
- 8- — before 1968
- 2 — 1972
- 2- — before 1972
- 7 — 1977
- 9 — 1979
- 0 — 1980

FIGURE 35 : GRID SUMMARY OF ALIEN VEGETATION, DISTURBED SOILS & ACTIVITIES (EXCEPT BURNING) FROM 1938 – 1981

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
	F2 B30	F2 B30	F2 B30	F2 B30	F1 B0	F2 B70	F1 B7	F2 B37	F1 B7										
	F2 B30	F2 B30	F1 B0	F1 B0	F2 B30	F1 B0	F1 B7	F2 B37	F1 B7	F2 B3 7									
	F2 B30	F1 B0	F1 B0	F1 B0	F2 B30	F2 B70	F1 B0	F2 B67	F1 B7	F1 B7	F3 B3 67								
	F2 B30	F2 B30	F2 B30	F2 B30	F1 B0	F2 B37	F1 B7	F2 B30	F0	F3 B68-7	F3 B68-7	F3 B68-7							
	F2 B30	F2 B30	F2 B0	F1 B70	F2 B37	F3 B370	F3 B8-70	F3 B8-70	F3 B38-7	F3 B68-7	F3 B68-7	F3 B68-7	F3 B3 8-7						
6		F1 B0	F3 B370	F3 B370	F2 B70	F3 B370	F4 B38-70	F4 B38-70	F2 B8-7	F3 B38-7	F2 B8-7	F2 B8-7	F3 B38-7	F2 B8-7					
7		F1 B0	F3 B370	F2 B70	F1 B7	F3 B38-7	F2 B8-7	F2 B8-7	F3 B38-7	F3 B38-7	F2 B8-7	F2 B8-7	F3 B38-7	F3 B38-7	F3 B38-7				
8		F1 B7	F2 B37	F2 B37	F2 B37	F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7	F2 B8-7	F2 B8-7	F3 B38-7	F2 B3 8-7	F3 B38-7	F3 B38-7	F3 B38-7			
9		F1 B7	F2 B37	F3 B38-7	F3 B38-7	F2 B8-7	F2 B8-7	F3 B38-7	F2 B8-7	F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7		
10		F2 B37	F2 B8-7	F2 B8-7	F3 B38-7	F3 B38-7	F3 B38-7	F3 B387	F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7	F2 B37	
11											F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7	F3 B38-7

KEY TO 150m x 150m GRID

F fire frequency
B year of burn:
3 1938
6 1960
8- 1966?
7 1976
0 1980

[A grid square was considered burned when more than 50% of it fell into the vegetation cover category of 'bare ground']

FIGURE 36: GRID SUMMARY OF BURNED AREAS FROM 1938 TO 1981

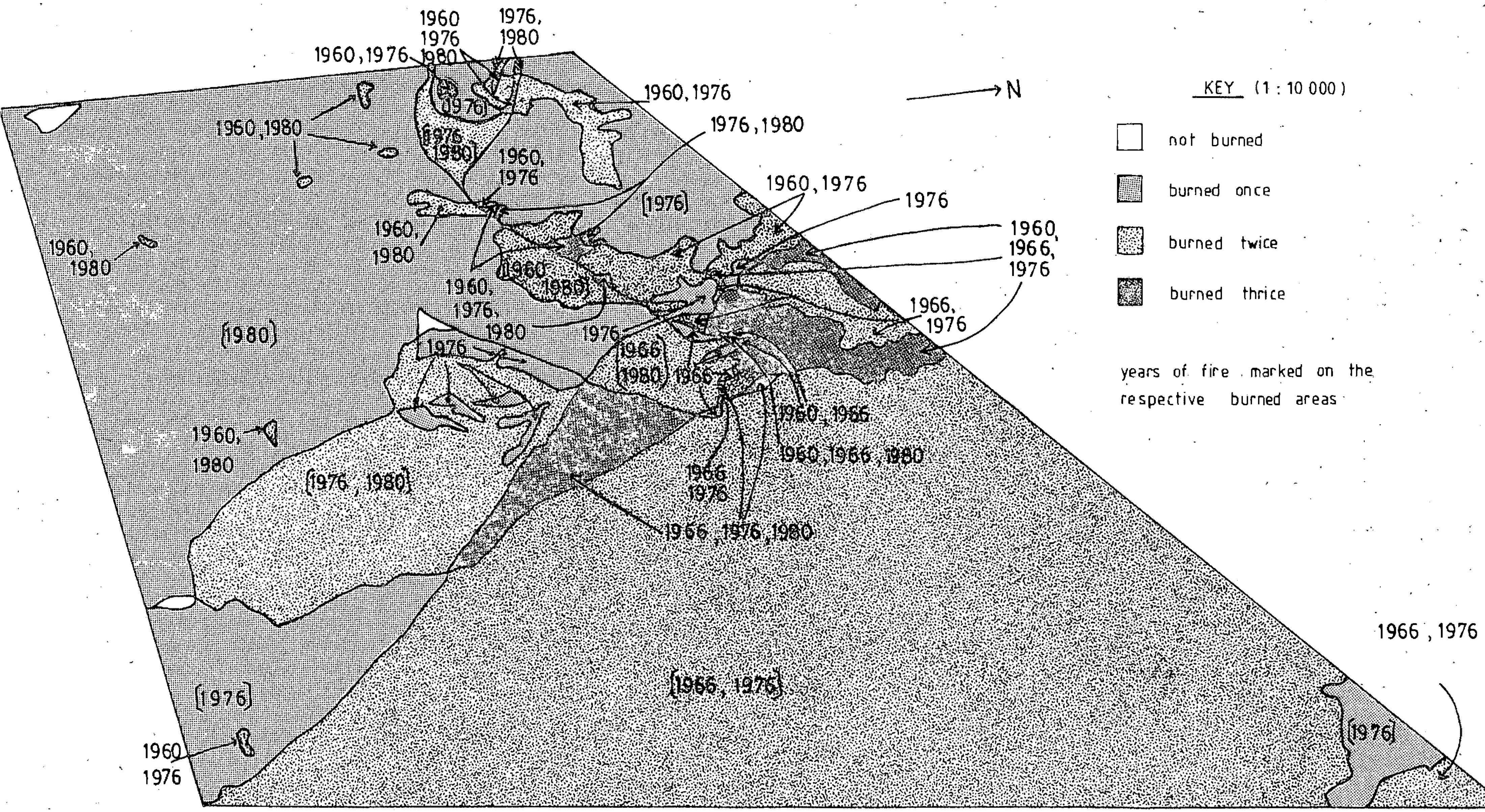


FIGURE 37: SIMULATED OVERLAY OF BURN PATTERNS FROM 1960 TO 1981

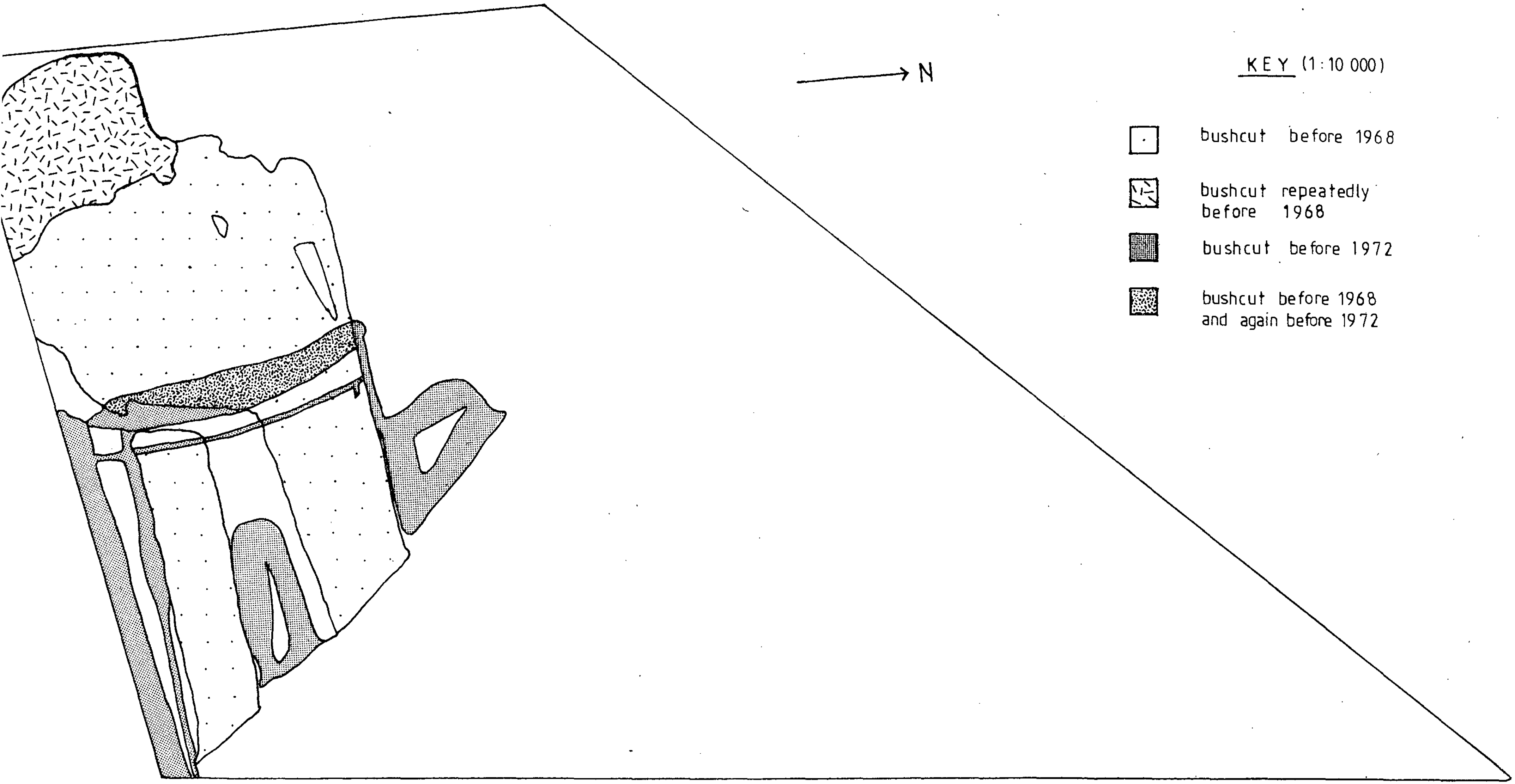


FIGURE 38: SIMULATED OVERLAY OF AREAS BUSHCUT FROM 1965/6 TO 1969/70

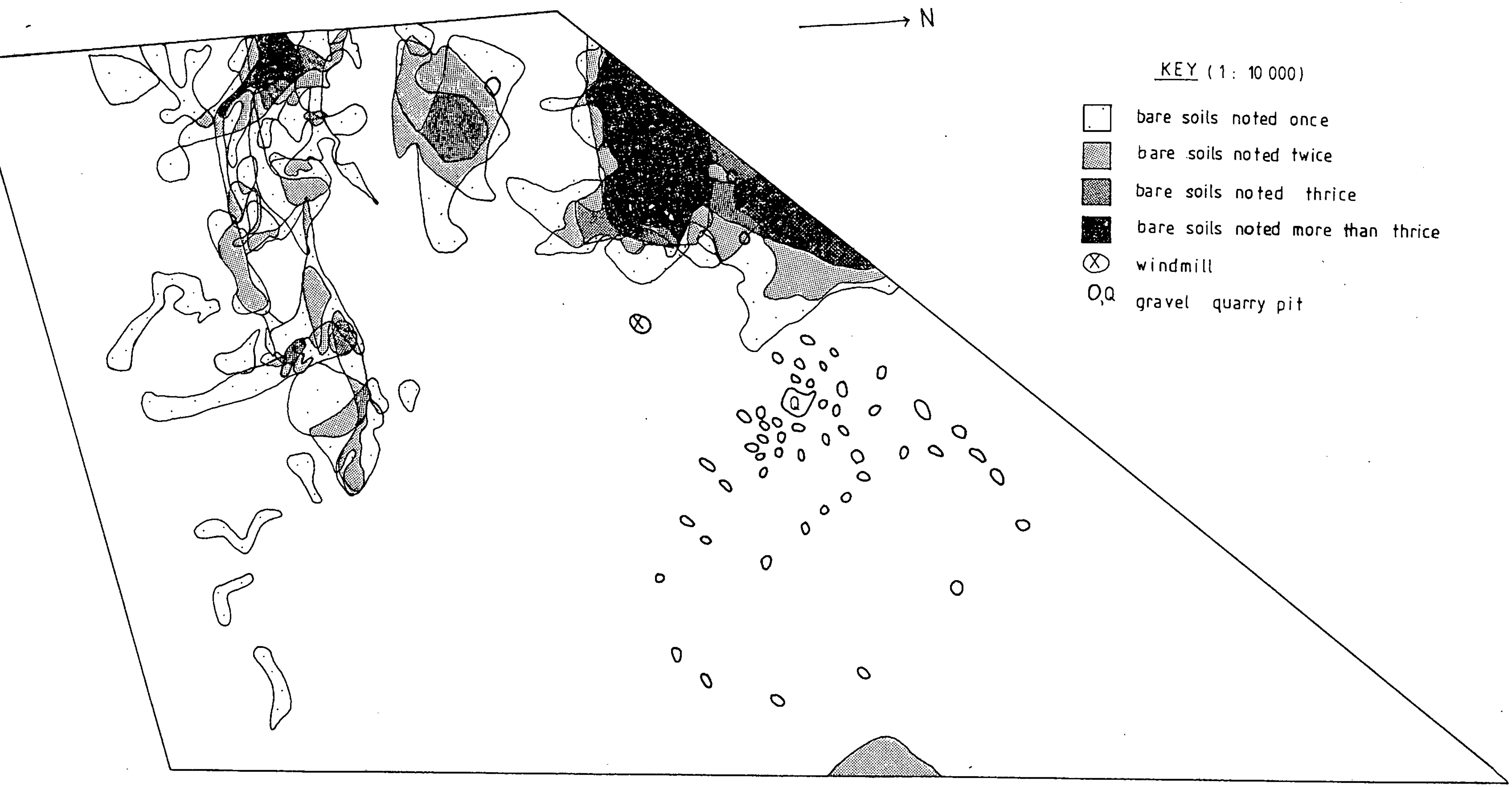


FIGURE 39: SIMULATED OVERLAY OF BARE SOIL AREAS FROM 1938 TO 1981

CHAPTER 5

GENERAL CONCLUSIONS AND IMPLICATIONS FOR CONSERVATION

5.1 GENERAL CONCLUSIONS OF THE STUDY

5.1.1 Fire has been the major perturbation on the Fynbos Site subsequent to 1920. Patch burning on a 3 to 4 year rotation prior to 1960 possibly caused net long-term losses of nutrients to the system and eliminated those re-seeding species having a primary juvenile period of more than 3 to 4 years. Accidental conflagrations after 1960, initiated external to the Fynbos Site on an average return period of 7 years, may have minimally affected the nutrient status of the system.

5.1.2 Other forms of landuse, namely grazing, browsing and bush-cutting appear to have had minimal long-term impact on the site. With the exception of one large gravel quarry pit, constituting a localised sterile area prone to invasion by alien acacias, the long-term impact of quarrying operations seems to have been negligible.

5.1.3 The progressive cultivation of land surrounding the Fynbos Site in recent history exacerbated erosion of soils by both wind and water, effecting deposition of wind-borne soil and soil wash on to the site; the latter affecting the nature of the plant community in this area.

5.1.4 The encroachment of the Port Jackson willow (*Acacia saligna*), the rooikrans (*A. cyclops*) and, to a lesser extent the cluster pine, on to the Fynbos Site appears to have been concomitant with the transformation of land; undoubtedly facilitated by the 'laissez-faire' attitude of landowners to these plants. The severe threat to the survival of this indigenous stand of vegetation (and others), posed by the unchecked spread of alien vegetation on land surrounding the Fynbos Site, is likely to be aggravated in future years without compulsory control of these pest plants on privately-owned land.

5.1.5 The destruction of vegetation cover in the immediate surround of the site has served to isolate it from other fynbos areas, a factor which may be detrimental to its long-term viability.

This study may be used to draw retrospective parallels of probable landuse with other areas of Coastal Fynbos in the South Western Cape lowlands. Although unique in its situation and minor features of past landuse, the changing fire regime, grazing patterns and alien plant encroachment on the Fynbos Site in recent history are likely to be comparable with other areas of Coastal Fynbos currently in a similar condition.

5.2 IMPLICATIONS OF RESULTS OF THIS STUDY FOR CONSERVATION

In view of the role enacted by conditions extraneous to the Fynbos *Site* in its recent history, two implications for conservation can be formulated:

5.2.1 <u>The size and shape of a conservation-worthy area assume elevated importance</u>

Complete transformation of lowland fynbos either by man's activities or by alien vegetation, seems inevitable if not adequately conserved. According to Kruger (1977c), the absolute minimum size of an effective reserve is of the order of 100 km². In many areas of the fragmented Western Cape coastal lowlands this would appear to be impossible, and managed clusters of smaller reserves would seem to be the next best available option towards meeting the requirements of insular biogeography (Hall, in prep.).

In respect of long-term viability, noting that "many reserves are too small and too prone to pressure from outside to give long-term protection to habitats" (Hall 1978), the parameters of size and shape of a proposed conservation worthy area assume elevated importance as regards minimising vulnerability to external influences - notably alien vegetation encroachment -, internal pressures such as fire, disease, inbreeding; thereby promoting effectual integral functioning of the ecosystem.

An almost circular reserve would maximise the surface area to perimeter ratio and thereby minimise potential pressure from outside, and the influence of extraneous factors on a conserved area should be inversely proportion to its size.

The significance of both size and shape of natural reserves has been stressed by Diamond (1975); shape in the context of minimising dispersal distances within a reserve, and size with reference to the number of species a reserve can hold at equilibrium.

Thus, in the ranking of potential reserves, from both an external and an internal perspective, shape and size of conservation-worthy areas afford high priority, especially in the Western Cape lowlands where maximum reserve sizes are likely to be suboptimal.

5.2.2 The need to plan a functional network of reserves is essential

Basing priority rating of conservation-worthy areas on existing variables is felt to be misleading in that features such as species diversity and the endangered species complement may reflect a transient condition especially in the coastal lowlands where fragmentation of remnant areas of fynbos is rife and equilibrium positions in many of these refugia have, in all probability, not been attained.

More important is the need to ensure that barriers to migration, pollination and genetic exchange, both within and between veld types are not erected; and in this way optimise the long-term viability of a particular ecosystem. A study of spatial and temporal scales of fynbos habitat in relation to avian (Siegfried, in prep.) and insect pollinators is thought to be necessary in planning such a network especially in the fragmented Coastal Fynbos and Rhenosterveld where visitation by pollinators must persist if potential extinction of plants is to be obviated.

It is evident from this study that conservation of the coastal lowland fynbos cannot focus on the intrinsic features of conservation-worthy areas in isolation from potential external influences; hidden costs of likely extraneous variables, in particular the escalating problem of alien vegetation encroachment, should be taken into account.

CHAPTER 6

RECOMMENDATIONS

6.1 SPECIFIC RECOMMENDATIONS FOR MANAGEMENT OF THE FYNBOS SITE

6.1.1 Fire and firebreaks

In view of the susceptibility of fynbos on the site to accidental fire and the need to maintain a heterogeneous ecosystem, a network of firebreaks both on and at the perimeter of the site would seem essential to avoid distruction of the entire fynbos stand in any one fire. The vegetation must be adapted to a fire frequency of approximately 4 years (4.2.1.2.1); this constituting the minimum return period of fire if elimination of plant species is to be avoided. According to Kruger (1978) fire would have occurred naturally at intervals of 6 to 30 years in fynbos, or longer (Moll *et al.* 1980). To accommodate heterogeneity of succession and maintenance of plant species on the Fynbos Site, the season of burn should be varied as should fire frequency between 4 and 30 or 40 years. The optimal burn frequency should depend on rates of nutrient and replenishment post-fire to obviate a net depletion in nutrient status of the system over time.

6.1.2 Alien vegetation

In a sample of 200 threatened fynbos plants, more than 50% were affected by alien plant encroachment (Hall *et al.* 1980). As nine species on the Fynbos Site are of rare/endangered/vulnerable/uncertain status (Boucher, pers. comm. 1982), and as acacias are likely to replace fynbos in all but the most stressed habitats (Milton 1980), the need for an effective eradication programme on the Fynbos Site is imperative.

The current distribution and estimated ages of acacias should be mapped - possibly using large-scale colour aerial photographs -, soil seed stores quantified and records kept of measures taken to control the spread of these plants. In this way, their potential rate of spread can be monitored in the knowledge of contemporary events, and the efficacy and costs of eradication techniques can be gauged.

Effective control of fire on the Fynbos Site should facilitate removal of *Acacia* thickets and seeds. For example, according to Milton (1980), acacias should be felled and stacked some months before a burn - where accidental fires dominate the scenario, as on the Fynbos Site since 1960, such management is impracticable.

6.1.3 Bush strips

The Fynbos Site constitutes an island refuge for endemic and other fauna. Implicit in the long-term viability of the site ecosystem is the need to minimise its isolation (4.3.2) and to allow for migration and dynamic exchange of genetic material between it and other fynbos stands in the area. The importance of maintaining existing strips of fynbos and sheltered corridors of indigenous vegetation - for example, bush strips of fynbos on the strip-cropped section of Portion 2 of Burgher's Post - linking islands of fynbos at Pella, Mamre and Riverlands is emphasised.

6.2 RECOMMENDATIONS FOR FUTURE RESEARCH ARISING FROM THIS STUDY

6.2.1 Fire and nutrients

Knowledge of the long-term effects of different fire regimes on the nutrient status of the ecosystem, incorporating rates of replenishment of nutrients to the system, is essential to optimal fire management of fynbos. To date, determination of the optimal burn frequency of fynbos (Bands 1977; Martin 1966; Taylor 1978; Van Wilgen 1980) has focused on the maintenance of vegetation components and species diversity, and the question of nutrient status of the ecosystem has been largely ignored. The slow growth rate of small, long-lived leaves and the virtual absence of ruderals suggests that fynbos is nutrient stressed (Boucher 1977; Martin 1966; Milton 1980). Changes in the nutrient status of fynbos systems may have repercussions in terms of susceptibility to alien plant invasion, replacement by a more eutrophic vegetation type and growth rates of fynbos plants; and the interactions between such variables should be investigated.

6.2.2 Wind erosion

The nutrient dynamics concomitant with the transport, drift and deposition of Sandveld soils, and effects of moving soil particles on young seedlings afford attention. (Any disturbance of vegetation cover both in and extraneous to conservation-worthy areas in this area is likely to be manifest in terms of wind erosion.)

6.2.3 Pesticides

The effects of commonly used aerially sprayed pesticides on the fynbos flora, associated fauna and soil micro-organisms should be investigated, especially where a proposed reserve is situated on rural farmland.

6.2.4 Invertebrate fauna and micro-organisms

The role of invertebrate organisms, soil fauna and soil micro-organisms in the pollination of fynbos plants, in nutrient cycling and in modification of soil structure and nutrient status is a field begging attention.

The need to conceptualise the fynbos ecosystem as a complex of inter-relating, inter-dependent parts is stressed: only when these interactions are better understood can the full implications and repercussions of different landuse patterns on component of the fynbos biome be traced.

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APPENDICES

APPENDIX A

Total annual rainfall figures (mm) from Burgher's Post, Malmesbury and Philadelphia weather stations

Year	Burgher's Post	Malmesbury	Philadelphia
1928	446,1	262,7	-
1929	429,9	380,9	-
1930	387,1	365,3	-
1931	466,2	410,2	-
1932	587,9	430,8	-
1933	533,8	478,5	-
1934	445,9	429,6	-
1935	453,8	361,8	-
1936	328,1	356,1	-
1937	577,7	382,1	-
1938	509,9	326,8	-
1939	387,0	316,4	-
1940	531,2	435,2	-
1941	884,8	661,0	451,1
1942	591,1	492,9	372,2
1943	434,4	444,6	391,8
1944	800,2	612,2	399,7
1945	613,5	531,4	458,4
1946	459,2	406,0	357,5
1947	421,7	337,7	303,9
1948	483,3	463,2	400,4
1949	492,0	455,3	406,5
1950	571,4	550,9	429,1
1951	833,4	451,4	445,1
1952	618,4	588,0	483,0
1953	601,4	511,6	559,3

- continued

Appendix A (contd)

Year	Burgher's Post	Malmesbury	Philadelphia
1954	872,2	679,5	511,5
1955	771,5	435,3	520,3
1956	721,0	423,3	440,4
1957	779,3	610,3	649,2
1958	648,7	343,0	339,0
1959	648,7	529,0	350,0
1960	457,3	271,8	244,4
1961	542,7	383,5	263,6
1962	786,3	558,4	482,2
1963	460,4	390,3	310,5
1964	498,3	412,0	362,6
1965	654,1	396,8	354,6
1966	505,1	396,8	322,2
1967	494,1	390,9	402,5
1968	618,1	488,0	496,7
1969	464,8	308,3	402,4
1970	595,1	373,0	442,4
1971	413,6	256,8	376,4
1972	424,1	324,8	368,5
1973	392,0	363,4	320,1
1974	783,0	611,6	618,3
1975	558,6	438,6	434,7
1976	647,6	554,9	563,3
1977	-	744,8	636,9
1978	-	307,0	354,1
1979	-	Moved to Gras-rug (Lat.33°28' Long. 18°50' Alt. 213 m)	339,9
1980	-	429,4	398,1
1981	-	405,9	494,1

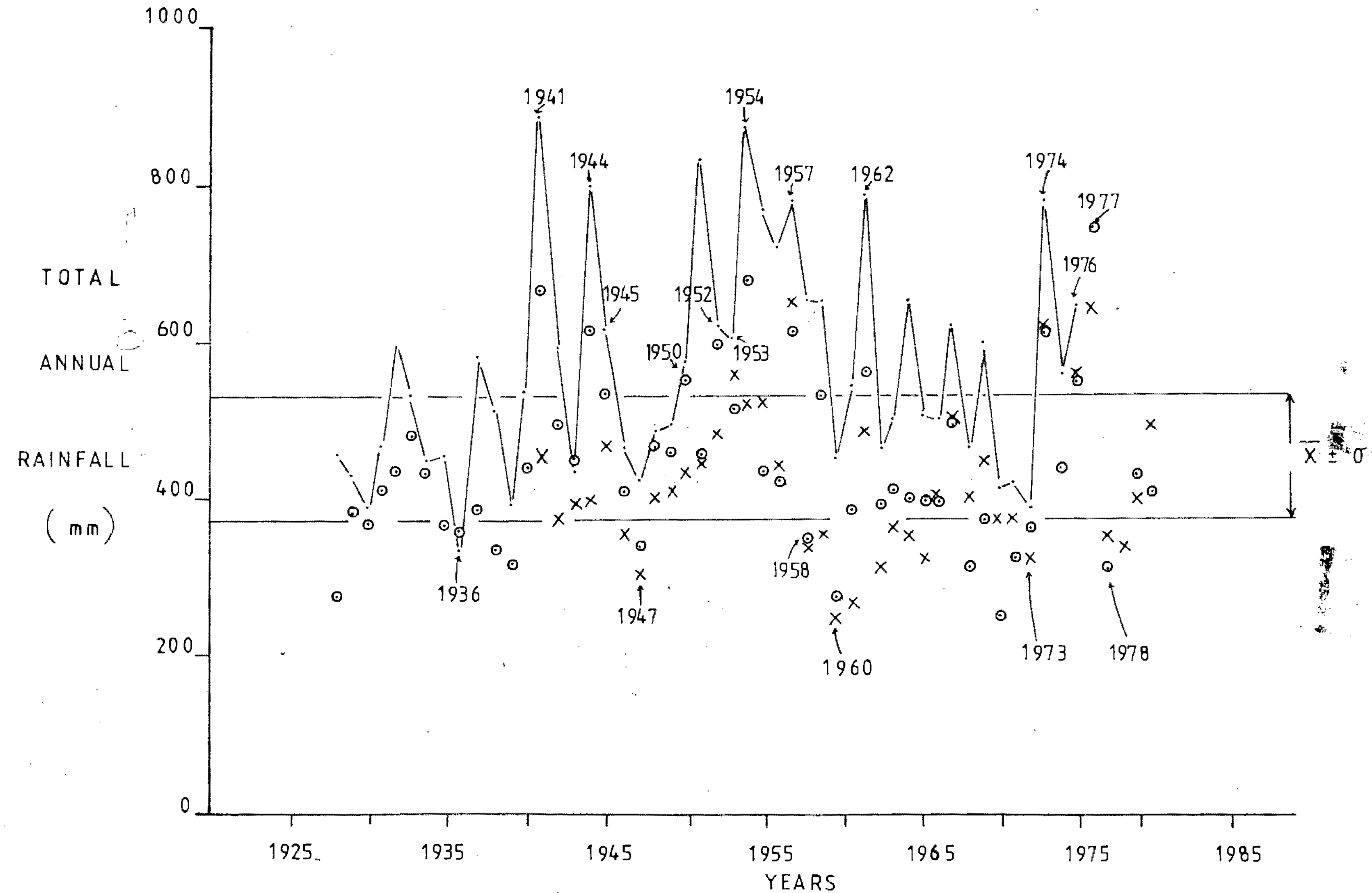
APPENDIX D

CONDITIONS AND SERVITUDES

APPENDIX D1 : TREKPATH CONDITION

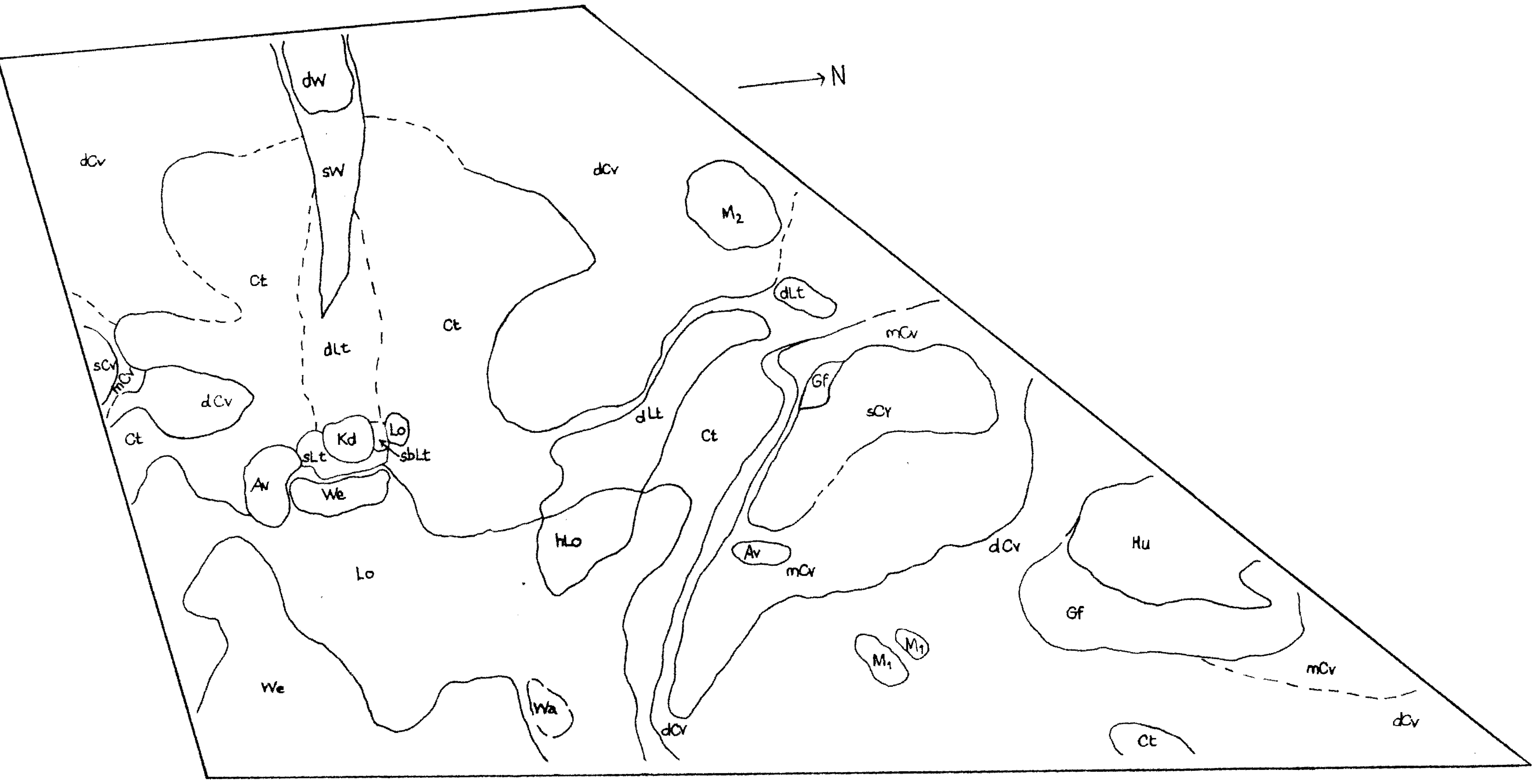
APPENDIX D2 : SERVITUDE OF PERPETUAL PIPELINE AND TEMPORARY OCCUPATION

APPENDIX D3 : DECLARATION REGARDING SOIL CONSERVATION SCHEME; AND BINDING CONTENTS OF THE AMENDMENT OF THE SOIL CONSERVATION SCHEME FOR THE DARLING SOIL CONSERVATION DISTRICT



APPENDIX A : RAINFALL (1928–1981) AT BURGHERS POST (·), MALMESBURY (⊙) AND PHILADELPHIA (×)

$\overline{X} \pm \sigma$ = mean annual rainfall for coastal fynbos ± 1 standard deviation: 448.20 ± 80.68 mm (Fuggle 1981)
[years of exceptional rainfall are indicated on the graph]

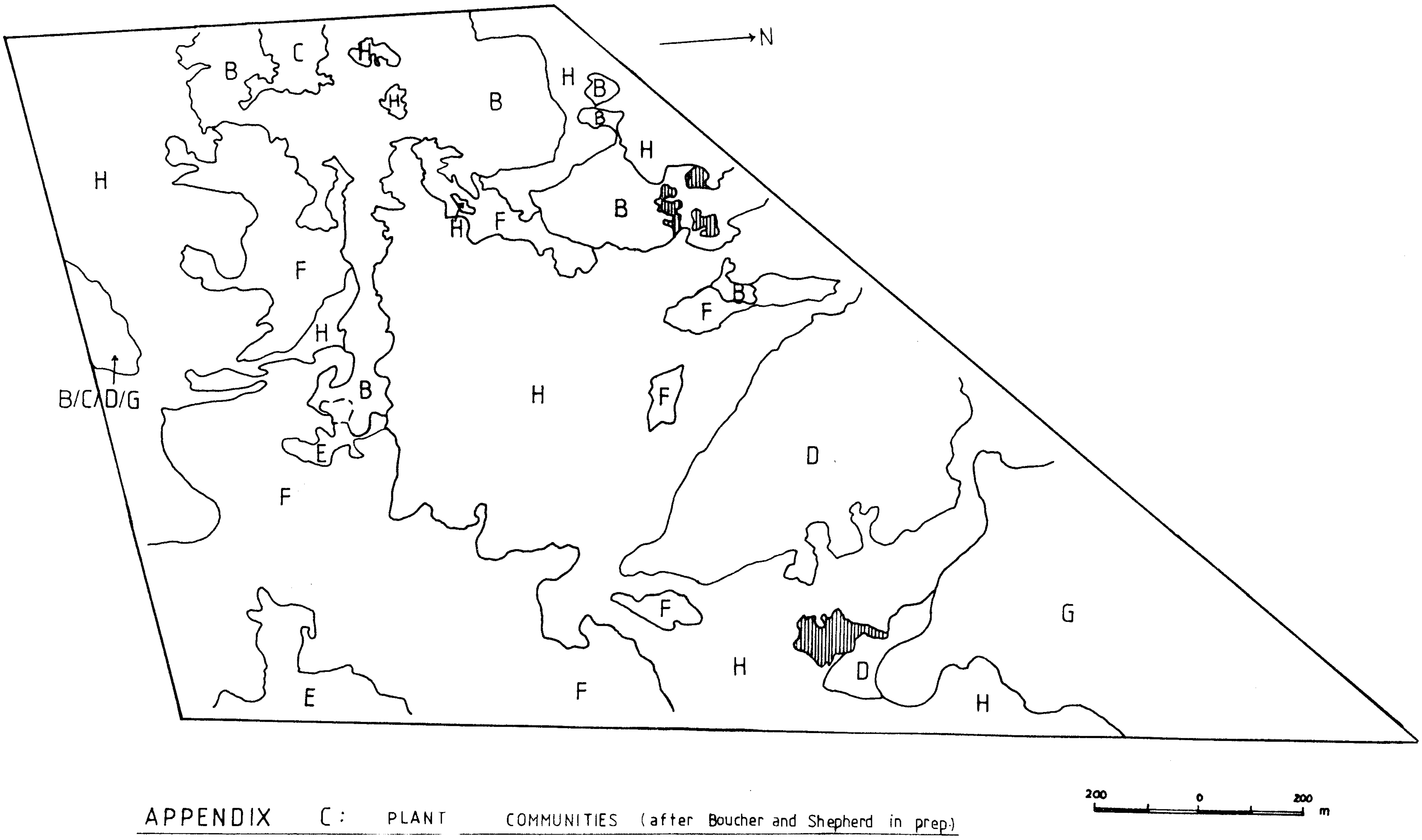


APPENDIX B: SOIL CLASSIFICATION (after Fry, in prep)

LAND TYPES		
Dominant feature	Subdivision Criteria	Map symbol
Yellow sandy loam wash overlaying grey medium sands		
Gritty material, badly sorted, with a number of thick (± 2,5cm) clay lamellae	Wash overburden less than 50cm in depth, and less than 3 clay lamellae	sW
	Wash overburden greater than 50cm in depth, and greater than 3 clay lamellae	dW
Mounds of darkish yellow brown medium sands		
Mounds with darker colours and greater particulate organic matter than surrounding soils	Large isolated mounds	M_1
	Group of smaller mounds occurring together in dCv soil	M_2

SOIL CONSOCIATIONS				
Dominant feature	Soil Classification Form	Series	Phase	Map symbol
Well drained red and yellow medium sands				
Saprolite within 2m				
Uniform red	Hu	11(21)	Saprolite within 0,5–2m	Hu
Uniform yellow over uniform red	Gf	10•	Saprolite within 2m for most of classified area	Gf
Uniform yellow	Cv	11	Saprolite within 1m	sCv
			Saprolite between 1-2m	mCv.
No saprolite within 2m				
Uniform yellow	Cv	11		dCv
Moderately drained yellow medium sands				
Uniform yellow over soft plinthic	Av	12	Saprolite generally within 2m	Av
Moderate to poorly drained grey medium sands on gleyed clay				
Bleached E over gleyed clay	Kd	11	White saprolite at between 1 and 2m	Kd
Moderate to poorly drained grey medium sands				
Soft plinthic mottling below bleached E	Lo	20	Hard plinthic nodules, darkened horizon or leached material within/below plinthic B	Lo
			Dark brown ferrihumic horizon within soft plinthic B	hLo
Hard plinthic layer below bleached E	Wa	20	Depth of hard plinthic layer approximately 1m	Wa
Soft plinthic mottling within 30 cm of surface	We	20	Hard plinthic nodules can occur below 1m	We
Podzolised grey medium sands with bleached E horizon				
Saprolite within 2m				
Dark brown ferrihumic B below E	Lt	11	Friable ferrihumic; soft dark nodules can occur	sLt
			Hard ferrihumic	sbLt
No saprolite within 2m				
Dark brown ferrihumic B below E	Lt	11	Friable ferrihumic. Soft dark nodules can occur	dLt
Yellow brown sands below E	Ct	11	Usually with ferrihumic nodules in yellowish brown horizon	Ct

•Clay < 6 %



APPENDIX C: PLANT COMMUNITIES (after Boucher and Shepherd in prep.)

KEY TO PLANT COMMUNITIES:

1. EUCLEA RACEMOSA STRANDVELD

▥ 1·1 Salvia lanceolata — Wiborgia obcordata Low to Mid-high Closed Shrubland

2. EUCLEA RACEMOSA STRANDVELD / PHYLICA CEPHALANTHA FYNBOS MOSAIC

[B] 2·1 Diospyros glabra — Salvia lanceolata Mid-high Open Shrubland

3. PHYLICA CEPHALANTHA FYNBOS

[C] 3·1 Diospyros glabra — Elytropappus rhinocerotis Mid-high Sparse Shrubland

[D] 3·2 Diospyros glabra — Hermannia alnifolia Mid-high Open Shrubland

[E] 3·3 Diastella proteoides — Berzelia abrotanoides Mid-high Open Shrubland

[F] 3·4 Diastella proteoides — Eroeda imbricata Mid-high Sparse Shrubland

[G] 3·5 Leucospermum parile — Stoebe leucocephala Low Mid-dense Shrubland

[H] 3·6 Leucospermum parile — Thamnochortus punctatus Mid-high Open Shrubland