VARIATIONS IN ALBEDO AMONG NATURAL AND DISTURBED SOUTH WESTERN CAPE VELD TYPES

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A B S T R A C T

Albedo is an important part of the radiation regime of any surface as it indicates the relative amount of solar radiation retained by the surface. Variations in albedo of the earth's land surface are broad. Bare, moist dark soils reflect as little as 9%, grasslands 26% and sandy deserts 37%. Man alters the natural environment in many ways, one of which is through altering the natural albedos. The primary aim of this project is to determine the actual variation in albedos amongst some South western Cape natural and disturbed veld types. Disturbances such as overgrazing, crop-development and fire are included.

Surface readings were taken during January and June in ten veld types and floristic and soil data as well as climatic variables were measured. Disturbed veld types were found to have significantly higher albedos ($\bar{\alpha}$ = 17.5%) than natural veld types ($\bar{\alpha}$ = 11.2). The net loss of radiation may have significant climatic implications, which are discussed.

A C K N O W L E D G E M E N T S

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Finally, above all, I would to thank the Creator who made this wonderful world in which we live. To Him this project is dedicated in the hope that Man will one day realize what he is doing to the earth.

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CHAPTER 1

INTRODUCTION

The future of Man on Earth is surely tied to the possible changes in the earth's albedo and especially to the question of whether or not the change is caused by the activities of Man

(Suomi & Vonder Haar, 1972)

1.1 The Problem

In order to study and understand the processes within a system, it is necessary to be fully aware of the flow of energy through that system. The energy flow in and out of an environment is, in many cases, a critical condition for the existence and propagation of life itself. (Gates 1962). Conditions on planet earth were created suitable for life, as we know it, to exist. Nevertheless, if changes to the earth's energy balance are made, it must be expected that the resultant impact on natural processes will affect the quality of life itself.

Much has been written concerning variations of the global energy balance caused by the sun, the tilt of the earth, the atmosphere and atmospheric processes and the nature of the earth's surface itself. (Eddy, 1976; Kondratyev, 1969; Linacre & Hobbs, 1977) Climatic changes during the earth's three billion years of existence have demonstrated how relatively minor perturbations in the energy budget have been magnified in their effects, and how a decrease or increase of 1 K in temperature can have cataclysmic effects. (Beckinsale, 1973) Changes in climate involve not only the atmosphere but also the world's oceans, ice masses and land surfaces. It is the changes to these surfaces which affect the global albedo -- the proportion of incident solar radiation reflected back into space. Man's activities are concentrated on the land surfaces and it is here that the most dramatic albedo changes take place.

The albedos of various land surfaces are given in Table 1.1:

Table 1.1. Values of albedo for various land surfaces

Surface	Albedo %
Black Soil	14
Black soil, moist	8
Brown soil, dry	20-30
Sand, white	37
Dense snow	86-95
Snow-covered forest	33-40
Tropical rain forest	12
Pine forest	12-14
Prairie	12-13
Sand dune shrubs	19
Mediterranean Batha	16
Desert shrubland	20-30
Winter wheat	16-23
Orange orchard	17
Maize	18
Sugar cane	15

After Kondratyev (1969), Oguntoyinbo (1970), Stanhill et al (1966) and others.

Changes in surface albedo -- hereafter referred to as albedo -- imply that the delicate balance of energy fluxes are being altered. Changes to climate are the direct consequence. The possible impact of human activity on climate has been realized since 1924 when Thomas Jefferson recognized the need for study of the significance of deforestation to the climate in the U S A. (Landsberg, 1970)

Various researchers have since debated the relative importance of albedo variations on climate, (Biswas & Biswas, 1979; Bryson, 1974; Charney, 1975, Kondratyev, 1969; Otterman, 1977) Some believe that the impact of changing albedos on climate 'do not appear to be comparable to other extrinsic (global) climate-changing factors' (Bryson, 1974 p 758) Nevertheless it is generally agreed that on a regional scale, and to a greater extent on a micro scale the impacts in many cases may be disastrous, (Charney et al, 1975) and almost always worse than originally thought. (Burroughs, 1981; Otterman, 1977, Sagan et al, 1979)

The unfortunate Sahel saga has shown that the increase in surface albedo due to overgrazing severely aggravates the process of desertification. (Charney et al, 1975; Wade, 1974) The famine that struck the Sahel region of the Western Sahara between 1967 and 1974 is thought to have killed some 100 000 people and left 7 000 000 others desperately short of food. (Wade, 1974) Previously, rainfall in the summer months was sufficient to replenish the grasses that provide food for the herd of cattle in the area. But when the rains failed, the entire region was denuded of vegetation. It is held that this led to an increased albedo -- the surface reflected more solar energy back into space. Charney (1975) argues that this then resulted in a net radiative loss, which produced general atmospheric subsidence and drying out over the area, thereby inhibiting or reducing the convection necessary for rain.

Otterman (1974) studied the effect of baring high-albedo soils in the Sinai-Negev region of Israel. He found a sharp contrast between the bright Sinai and the relatively dark Negev, visible from satellite photographs. Closer observation revealed a fence line separating the two regions. The Sinai side had been denuded of vegetation by over-grazing while on the protected Negev side, where there were few herds of cattle, the vegetation was relatively abundant. The area, as a whole, shared the same climate and rainfall.

Other researchers surveyed the albedo variation in various countries. (Barry & Chambers, 1966b; Jensen & Aslyng, 1965; Lin-Sien Chia, 1967; Oguntoyinbo, 1970) However, little has been written or researched on the South African situation. Much of the natural vegetation in this region has been severely grazed or converted for agricultural purposes. No attempts appear to have been made to physically monitor the amount of change taking place or to establish the possible climatic impact this change may be inducing.

This project has attempted to determine the albedo values of various land surfaces in the south-western Cape Province of South Africa and to investigate whether significant energy modifications are taking place as a result of the activities of man.

1.2 The Approach

Morris (1981) investigated the variation of albedo (or reflection coefficient, as he called it, following Monteith (1973), in the Cape Mountain Fynbos, a sclerophyllous heathland associated with a Mediterranean climate. He found that fynbos vegetation has an unusually low albedo, varying between 8% and 13%. He found no clear relationship between the specific vegetation and the various components of the radiation balance.

The present project further developed research in this field in South Africa. It investigated the nature of albedo variation in ten veld types within the South Western Cape. This area, especially the fynbos components, is of intense interest to ecologists at the present time. (Jarman, 1982) By comparing the albedos of natural vegetation with those of disturbed vegetation (i.e. a land surface which has vegetation altered by man-induced fire, over-grazing or agricultural development) it was possible to determine whether significant changes have in fact taken place.

A null hypothesis, H_o, was set up consisting of two parts:

H_o (A): There is no significant variation among different natural veld types

H_o (B): There is no significant variation between natural and disturbed veld types

To test the hypothesis, detailed and intensive measurements of the incoming and outgoing shortwave radiative fluxes were made at two adjacent sites within each veld type, one site carrying natural vegetation and the other disturbed vegetation. Calibrated albedometers and a digital recorder were used to obtain albedo values at twelve minute intervals between 09h00 and 17h00 each day. The results lent themselves to an experimental design suitable for analysis of variance.

All factors contributing to the reflection of shortwave solar energy at the surface were taken into account. Measurements and samples of soil and vegetation were taken and the air temperature, cloud cover and type, and windspeed were monitored.

1.3 The Objectives

The objectives of this study are:

Primary Objective

(a) To determine the variation of albedo among natural veld types and between natural and disturbed veld types;

Secondary Objectives

(b) To provide data on the albedo of the natural vegetation in the S W Cape Province;

(c) To assess the value of these techniques as an indicator,of the impact of man-induced changes on climate.

The concept of radiation balance and the importance and physical meaning of albedo are discussed in detail in Chapter Two. The methods of measurement and recording, as well as the instrumentation used, are also presented. The selection, location and description of the study sites are discussed in Chapter Three. In Chapter Four the results are summarised and the important variations are highlighted and discussed. Contributing factors and their possible effects are included. Analysis of results follows in Chapter Five. The implication of the statistical tests are explained and the relationships between the various sites and the nature of disturbances are discussed. In Chapter Six the general findings of this research are presented. Conclusions that can be drawn, the testing of hypotheses and suggestions for further research are also dealt with.

By systematic investigation of the albedo with regard to site variation, disturbance variation, time variation and seasonal variation, an assessment of the impact of anthropogenic changes on the radiation budget are made.

CHAPTER 2

RADIATION BALANCE AND ALBEDO

I believe that one of the most important tasks of physical sciences is keeping an account book of solar heat received by the globe with its air and water envelope

(A I Voeikov (1842-1916), quoted by Budyko, 1974)

2.1 Components of the Radiation Balance

Before studying the variation of albedo, it is important to define the term and the other components of the radiation balance. The latter can be loosely defined as the sum of the positive radiation 'gains' and the negative radiation 'losses' of the earth and its atmosphere. (Monteith, 1973)

Radiation 'gains' originate from the sun in the form of shortwave radiation. When the sun's rays are perpendicular to the earth's surface, the energy received is estimated to be between 1340 -- 1410 Wm^{-2} (1.92 -- 2.02 cal cm^{-2} min^{-1}). (Barry & Chorley, 1976) The amount of solar radiation received at any position on the earth's surface depends on the latitude of that position, the declination and longitude of the sun, the altitude of the sun and the slope of the surface. Daily totals can vary from 0 Whm^{-2} at the poles during mid-winter to 10400 Whm^{-2} at the equator to 12500 Whm^{-2} at the poles during mid-summer. (Smithsonian Tables, 1949)

In South Africa mean annual values at the top of the atmosphere vary between 8000 and 9000 Whm^{-2} daily, with minimum values found over the East coast and maxima over the Western interior. In summer daily maximum values occasionally exceed 11600 Whm^{-2} and in winter daily minima are around 5800 Whm^{-2}. Of the amount of energy received at the top of the atmosphere an average of 65% reaches the surface of which some 17% is diffuse, the remainder being direct. (All statistics are from Schulze, 1979)

Most of the radiation from the sun received at the surface is direct while some is diffuse, having been reflected or scattered onto the surface by clouds, other surfaces, or airborne particulate matter in the atmosphere. The direct radiation is shortwave (0.3-3.0μ) radiation while diffuse radiation can be shortwave or longwave (>3.0μ). The total incident shortwave radiation, S_T, is not all absorbed by the earth's surface. A certain proportion of it is reflected back through the atmosphere to space. The proportion of reflected radiation to incident radiation is the albedo, α, or the reflection coefficient as it also known. Values of α vary from 0 for a perfect black body to 1 for complete reflection. Therefore the amount of shortwave energy absorbed by the surface can be given as:

$$S_A = S_T - \alpha S_T \quad (1)$$

where S_A is the absorbed radiation
and αS_T is the reflected radiation

The total radiation 'gains' are the sum of the incoming shortwave radiation and any downward longwave radiation, i.e.

$$R_G = S_T + L_D$$

Radiation 'losses' consist of reflected shortwave radiation and any upward longwave radiation emitted from the surface. The latter is usually in the form of heat, i.e.

$$R_L = \alpha S_T + L_U$$

R_N, the net radiation is then:

$$R_N = R_G - R_L = (S_T + L_D) - (\alpha S_T + L_U)$$

or

$$R_N = S_T - \alpha S_T + L_D - L_U \quad (2)$$

R_N is thus the amount of 'available' energy at the surface of the earth. Having been absorbed, it is then rendered useful for life processes.

Kondratyev (1969, p 657) states:

> The study of the net radiation ..... is of extreme importance as (it) .... is the main determinant of the climate.

And, because climate is of major importance to biological processes it follows that net radiation is certainly an important determinant of the quality of life. It is thus important to consider any changes or variation that may influence or affect R_N. The albedo, α , is one component of the radiation balance that is undergoing such change. From equation (2) it can be seen that if α increases, the net radiation will decrease and vice-versa.

In reality the total energy balance cannot be expressed as simply as expounded above. Surface and atmospheric parameters such as water vapour content, transpiration rates, emissivities of substances and weather conditions influence the total fluxes of energy in and out of the system. (Monteith, 1973)

The Energy balance of the surface, or as Monteith (1973) calls it, the Heat balance, is given by him as:

$$R + M = C + \lambda E + J + G \qquad (3)$$

Where R = net gain of energy from radiation
M = net gain of energy from metabolism
C = loss of sensible heat by convection
λE = loss of latent head by evaporation
J = rate of change of stored energy
G = loss of heat by conduction to the environment

Although changes to the vegetated surfaces will affect many of the terms in this equation, this project limits the investigation to a component of the R term, specifically the negative shortwave component of this term, $\propto S_{T}$.

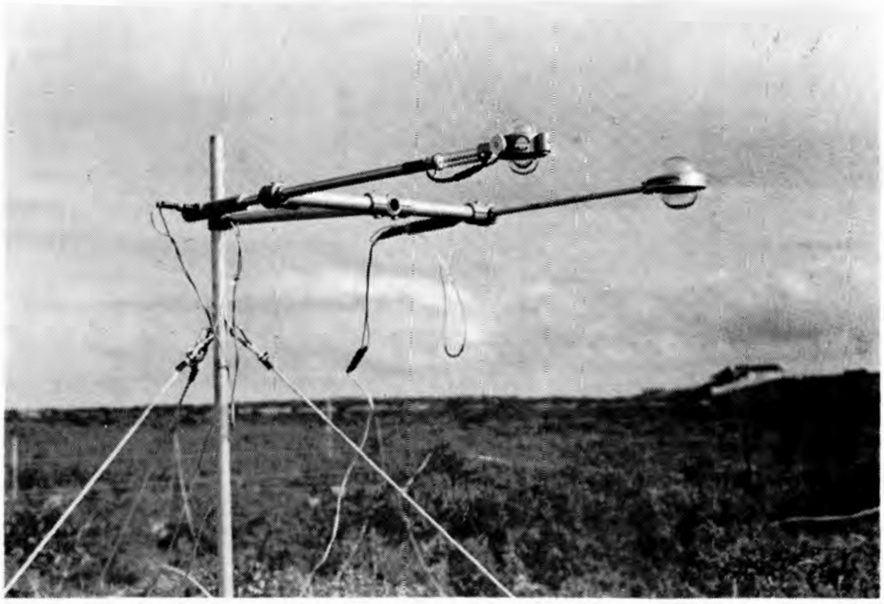
2.2 Instrumentation

Having determined the importance of detecting changes in the albedo, the question of how to accurately ascertain the albedo values of the different veld types arose.

The albedo, $\propto$, is given by $\propto S_{T}/S_{T}$. Therefore both these fluxes need to be measured as near to the surface as possible, in order to eliminate atmospheric interference. This made ground measurements preferable to aircraft or satellite observation. Also with ground measurements, more specific site selection and greater accuracy was possible.

As the shortwave radiation band consists of all radiation within the 0.3 to 3.0μ range of the spectrum, it is necessary for any instrument to be sensitive over as much of this range as possible.

The spectral characteristics of leaves determine the net energy absorbed and Gates (1962) has shown that the reflection and transmission spectra of single leaves are very similar. Visible light between 0.4 and 0.7μ is strongly absorbed by pigments such as chlorophyll, but between 0.5 and 0.55μ there is a small peak in both spectra, giving vegetation its characteristic green colour. Between 0.7 and 1.0μ little radiation is absorbed, but above 1.5μ and increasing to 3.0μ the leaf behaves like a black body. (Monteith, 1965) Therefore it was more important to include the lower end of the band than the upper where all energy is



<u>Fig 2.1</u> Radiation Instruments
Albedometer (left) and Net Radiometer (right)

<u>Fig 2.2</u> Data - logger with Print-out

absorbed anyway.

Two CSIRO Middleton Model CN9 Solari Albedometers were used to measure S_T and αS_T at neighbouring sites. Basically, they consisted of two Kipp and Zonen type solarimeters mounted back to back. On these instruments each sensing surface was covered by two glass domes, which were transparent to radiation in the spectral zone of 0.3-2.6μ (manufacturers' specifications). The double dome reduced the possible error caused by heating and radiation of long-wave radiation by the dome onto the sensing surface. (Morris 1981) Each sensing surface then transmitted an electrical current induced by the radiation energy, to the data recorder. The calibration coefficients of each sensing surface were used to convert the electrical units to radiation units. Calibration of the instrument was carried out by the author. A Kipp and Zonen solarimeter was used as standard and the albedometers were measured with each side facing upwards alternately. The new calibration coefficients were found to be around 6% lower than the original coefficients (1979). The given percentage calibration error of the instruments was quoted by the manufacturers as 2%.

Similar instruments have been used by Oguntoyinbo (1970) in Nigeria during a survey of albedos of land surfaces, and by Nkemdirim (1972) in Canada. Morris used these specific instruments at Cape Point in 1981. (See Fig. 2.1)

A Swissteco S-1 net radiometer with glass domes was used to determine S_A, the absorbed short wave radiation. This was done in order to act as a control. S_A is given as the difference between S_T and αS_T (see equation 1). The net radiometer, based on that described by Funk (1959) was used by Morris (1981) with polythene hemispheres in order to be transparent to both short and long wave radiation. These were replaced by glass domes to restrict the sensitivity to the shortwave region (0.3-2.6μ).

The net radiometer had two sensing surfaces, one upward and one downward facing, and responded to the difference of the two signals received by the surfaces (Gates, 1962). The resultant voltage current then indicates the net absorbed radiation, S_A, by means of another calibration coefficient. This could then be compared to S_A, calculated from the output of an albedometer located at the same site.

Within each veld type two sites were selected. The instruments were positioned on specially built stands, approximately one metre above the vegetation (Jensen & Aslyng, 1965). Federer (1968) claims that radiometers mounted 3 m above a flat surface gave 85% of the field of view within 15 m. Instruments positioned at 1 m would give 95% view within an area of 10 m diameter (Reifsnyder, 1967) Thus, instead of just measuring the cover immediately below it, the instrument measured over an area of approximately 78 m^2.

From each instrument, 50 m cables carried signals to the data-logger. The resistance of the wires was measured and taken into account. A six-channel Esterline-Angus digital data recorder with print-out facilities was used. At preset intervals of twelve minutes, from approximately 09h00 to 17h00, automatic readings were taken. (See Fig. 2.2)

In order to calculate the albedo, α, it was necessary to measure S_T and αS_T, by means of two solari-albedometers and an automatic data-logger. A net radiometer was used to measure S_A, to act as a check on the net shortwave radiation balance of the two types of instrument. The instruments were erected at ten veld types, each with two sites, and readings were taken throughout the day.

CHAPTER 3

THE STUDY SITES

> I am convinced that there can be no part of the Republic of South Africa which did not originally have a cover either of forest and closed scrub forest or scrub, or of perennial grass, even in the winter rainfall area and in regions receiving less than 150 mm of rain per annum
>
> (Acocks, 1975)

3.1 Introduction

As the smallest of the world's six floristic kingdoms the Fynbos Biome, or Capensis, is under a good deal of scientific focus at the present time. Reduced from its original extent of 67000 km^2 through the activities of man, to 42000 km^2 (Jarman, 1982), some 1200 endemic species of flora and fauna are severely threatened. It was thus apt that the veld types within this Biome were investigated for changing albedos as a method of assessing environmental impact.

The Fynbos Biome extends geographically from roughly 31° to 35° South and 18° to 17° East. It is characterised by five main veld types listed in Table 3.1 (Acocks, 1975). The original geographical extent of the same veld types is shown in Fig. 3.1. The area covered by these veld types falls mostly within the winter rainfall region of the Cape Province. This region enjoys a Mediterranean climate, corresponding to other areas of the world characterised by cool, humid winters, hot dry summers and accompanying distinctive flora (Kruger, 1979).

Further north and east of the Fynbos Biome lies the arid and semi-arid Karoo Biome which extends over more than 508 800 km^2 (Barnard et al, 1972). This area is characterised by low rainfall, usually non-seasonal, and extreme temperatures depending on the altitude and the distance from the sea. The flora is typically sparse and has an adaptable growing period to accommodate the unpredictable rainfall; typically around 50 mm pa in the dry NW increasing to around 250 mm pa in the east (Schulze, 1979).

Once consisting of vast grassy plains, supporting great herds of wildlife, the Karoo is mainly occupied by scattered farms with sheep rearing as the main livelihood. Overgrazing and drought together have led to the process of desertification advancing at a 'phenomenal speed' (Acocks, 1975) eastwards into the territory of sub-tropical and savannah vegetation.

> The (now apparent) idea of Karoo as being bare soil dotted with Karoo bushes - or, as H V Morton puts it, of Karoo bushes each in its own little desert - and occasionally covered with annual grasses and succulents, is a completely false one.
>
> (Acocks, 1975 p 5)

The importance of studying the impact of man on the vegetation is now more pronounced than ever.

3.2 Ten Veld Types

It was decided to include five veld types from each of the two biomes mentioned above in this investigation. The veld types (after Acocks, 1975) are listed in Table 3.1 and represented in Fig. 3.1.

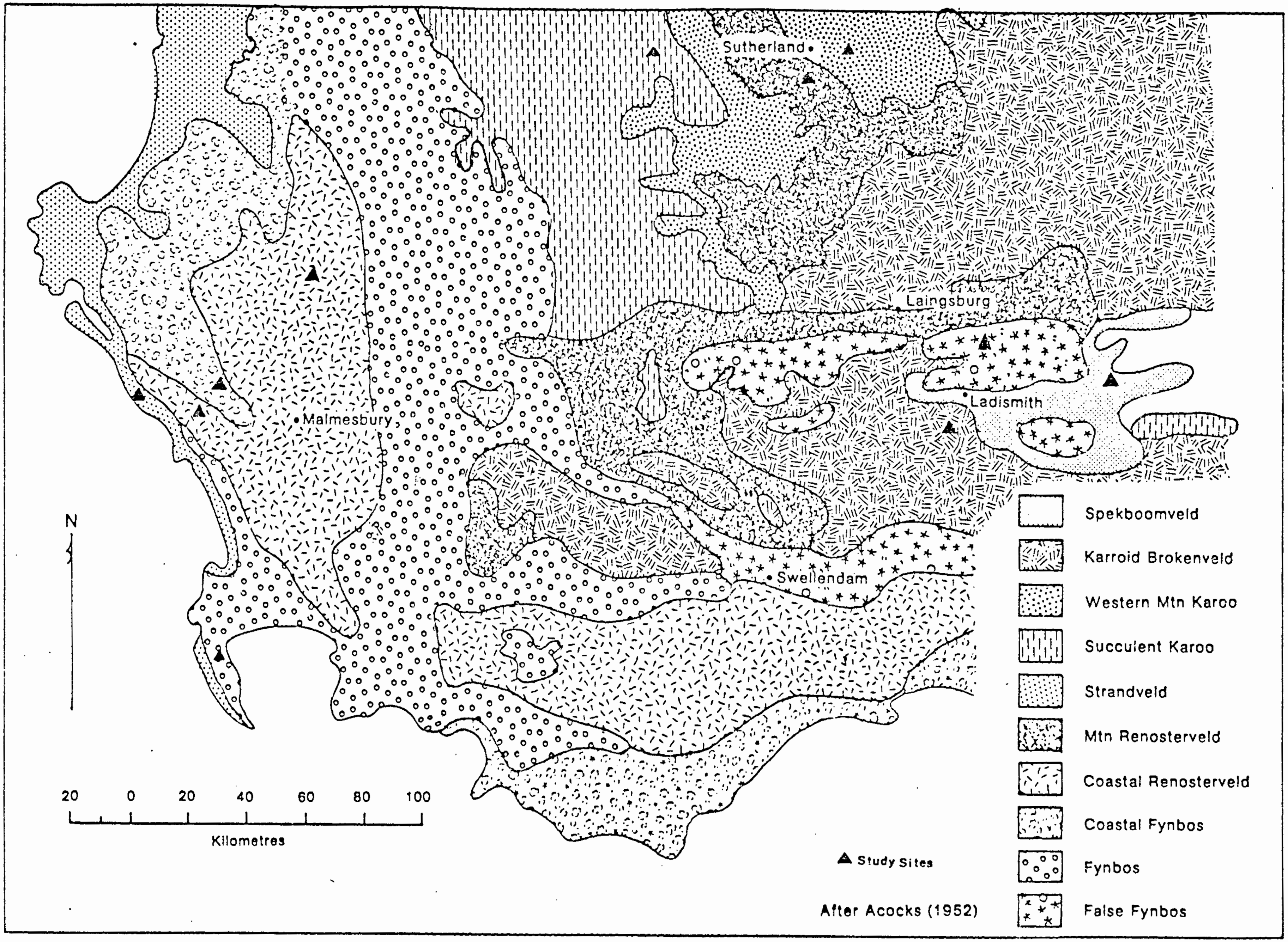


Figure 3.1 Veld Types of South western Cape

Table 3.1 Ten Veld Types in S W Cape (after Acocks, 1975)

	Veld Type	Acocks number	Biome
1	Mountain Fynbos	69	Fynbos
2	Coastal Fynbos	47	Fynbos
3	Coastal Renosterveld	46	Fynbos
4	Strandveld	34	Fynbos
5	Western Mountain Karoo	28	Karoo
6	Mountain Renosterveld	43	Karoo
7	Succulent Karoo	31	Karoo
8	False Fynbos	70	Fynbos
9	Spekboomveld	25	Karoo
10	Karroid Broken Veld	26	Karoo

It must be pointed out that no veld type exists as an isolated whole with discrete boundaries, but changes gradually from one type to another. Thus some veld types may display characteristics of another from a different biome. Mountain Renosterveld, for example, is often structurally and floristically like some fynbos communities, but is not included in that biome as it is 'more akin to Karoo in habitat and floristics ...' (Taylor, 1978).

Morris (1981) has found that Mountain Fynbos displays unusually low albedo values of between 8 and 13%. As yet no determination of surface albedos of other veld types have been made. The degree of change in especially the Karoo biome has been largely ignored (Acocks, 1975).

Table 3.2 shows the extent of natural vegetation remaining in the Fynbos biome in 1981, as interpreted from Landsat imagery by Bossi (1983). Most alarming is the reduction of Coastal Renosterveld (reduced by 85%). The area is now covered in vast plains of wheat in the NW (Swartland) and SE (Rûens) areas. The Strandveld type has also been reduced by 53% and Coastal Fynbos 47%. Figures for the Karoo are not available, although Mountain Renosterveld is included in Bossi's table.

Table 3.2

The extent of natural vegetation as mapped by Acocks (1953) and that remaining as interpreted from 1981 Landsat imagery (after Bossi, 1983)

Veld Type	1953 Area (km^2)	1981 Area (km^2)	Natural Vegetation lost
Strandveld (34)	4453	2072	53%
Mountain Renoster-veld (43	4754	3448	27%
Coastal Renoster-veld (46)	15285	2256	85%
Coastal Fynbos (47)	8770	4627	47%
Fynbos (69)	18345	16305	11%
False Fynbos (70)	18965	18347	3%

Acocks (1975) and others note with alarm the spread of the desert into the natural Karoo, from both the north and the west. Bad farming practice and continuous selective over-grazing have led him to expect desert encroachment to account for an unexpected doubling of desert and semi-desert at the expense of present Karoo veld types by 2050 A D. A National Park has been declared in an attempt to preserve some of the original Karoo vegetation and fauna, but as this Park encloses only 20 000 ha, other areas stressed from the harsh climate may never recover. (Acocks, 1975; Barnard et al, 1972)

The five Karoo veld types included in this project form only a small part of the biome which, according to Acocks (1975) consists of approximately twenty-one veld types.

3.3 Choice of Study Sites

When selecting specific natural and disturbed sites within each veld type, three specific conditions were kept in mind, viz.

(i) the natural site should be representative of the veld type;

(ii) the site should be relatively flat and accessible by foot, and to within 50 m by vehicle;

(iii) the disturbed and natural sites should not be more than 50 m apart.

As these considerations could only be fully implemented once in the field, cursory plans were made beforehand. To facilitate transport and accommodation, sites were selected in areas where three veld types came together. In order to avoid transitional zones, it became important to identify true veld types. This was done on the basis of Acocks' descriptions.

Thus three general areas were selected within which three types were represented. The first site was in the Cape Point Nature Reserve near Cape Town. The other nine were spread over the three general areas. Area one was in the vicinity of Darling, Area two near Sutherland and Area three around

Ladismith. A day's travel was required between each area and a few hours between the three veld types in each area. A distance of about 2500 km was covered on each round trip.

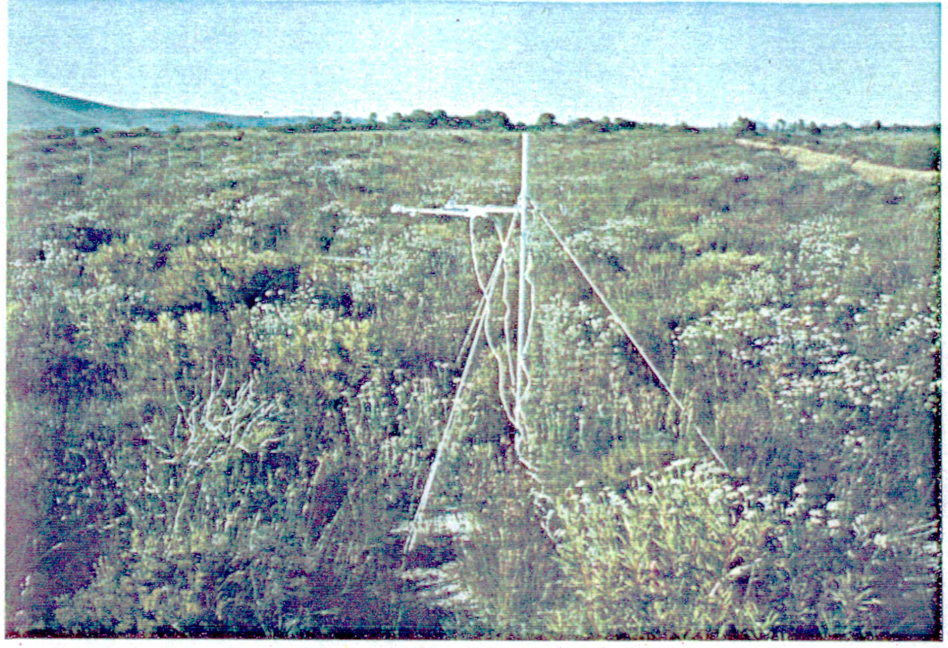
Once in the field, the selection of specific sites was found to be extremely difficult. Not only was it hard to comply with the three conditions above, but above all, natural vegetation was in most cases virtually absent. Very little vegetation has not been disturbed by human activity in some form or another. In many instances it was a case of selecting a natural site consisting of vegetation that was merely less disturbed than a disturbed site.

Although the selected sites could not sufficiently represent the entire veld type due to the wide diversity within each type, it is hoped that the measurements made will serve as an indication of the values to be expected from specific veld types.

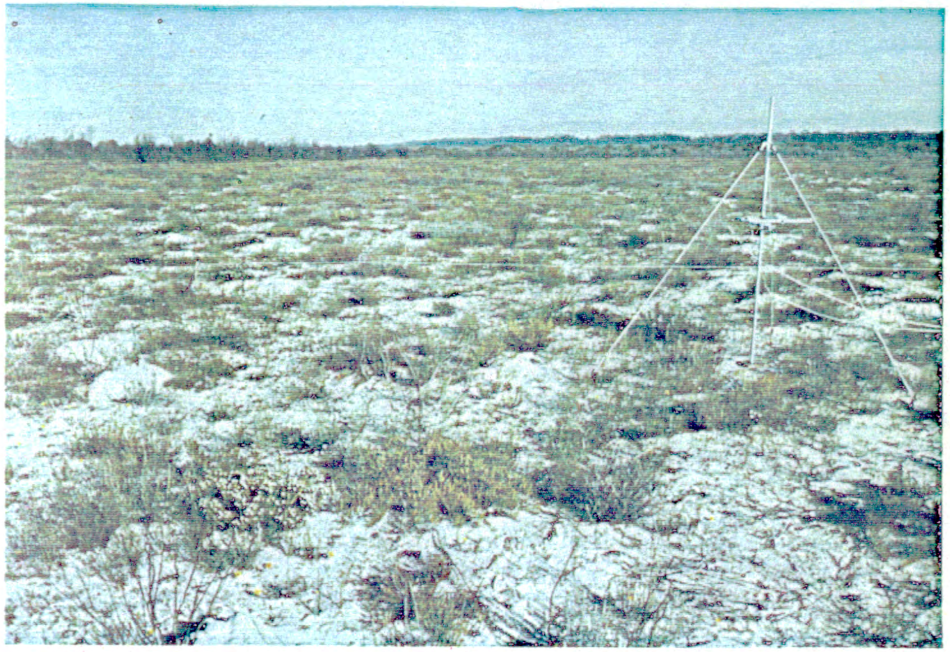
3.4 Site Description

Every attempt was made to ensure that the sites were representative of the veld types. Detailed descriptions of the site included vegetation cover, diversity and structure, as well as soil types, colour and moisture content. The results can be found in Appendix 3.

At each site a square of 10 x 10 m was demarcated around the intruments. Vegetation and soil measurements were taken within the quadrat. Photographs of some sites are included (see Figs. 3.2 to 3.4). Although it was desirable for each site to be covered entirely by vegetation, some veld types were exceedingly sparsely vegetated and this made the soil colour and conditions more important. The natural sites were usually found within

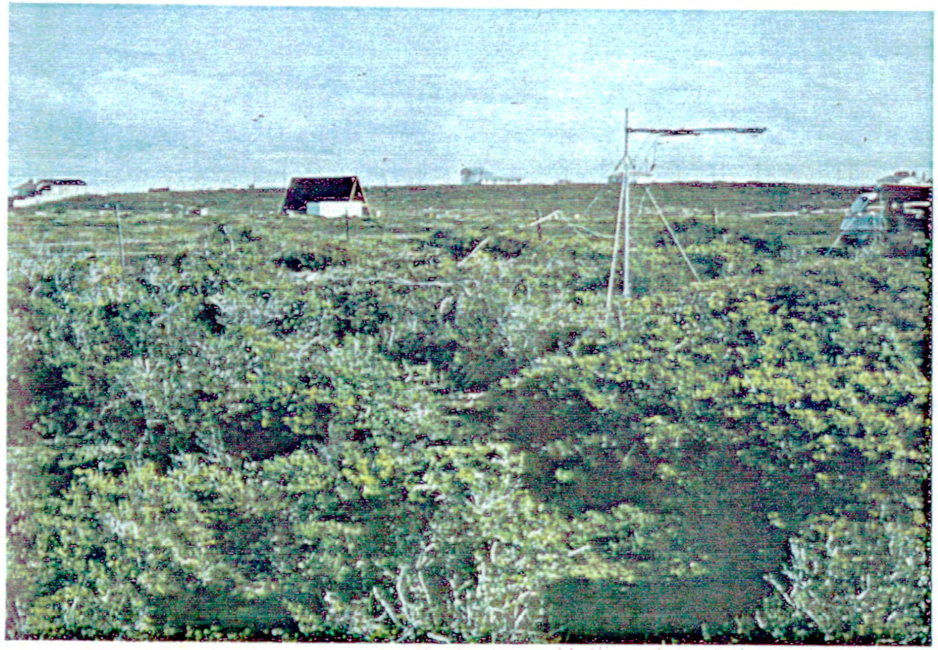


NATURAL

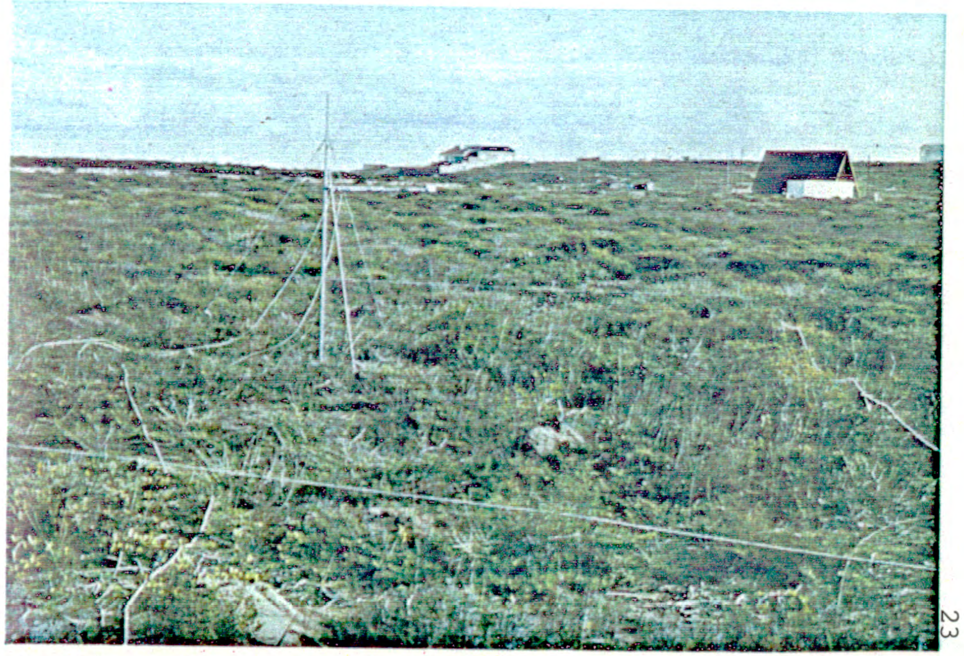


DISTURBED

Pella :Coastal Fynbos



NATURAL



DISTURBED

Yzerfontein : Strandveld

NATURAL

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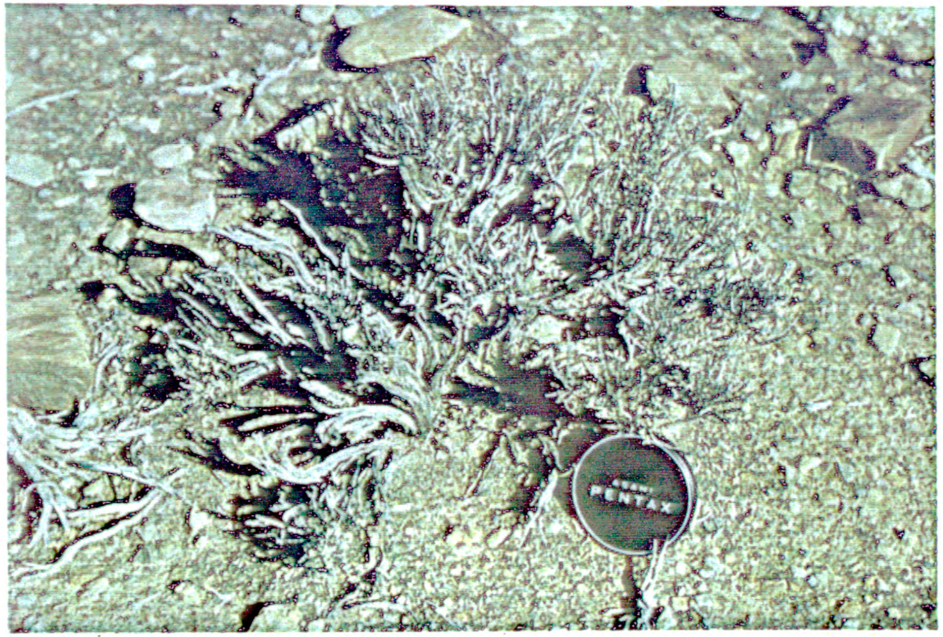
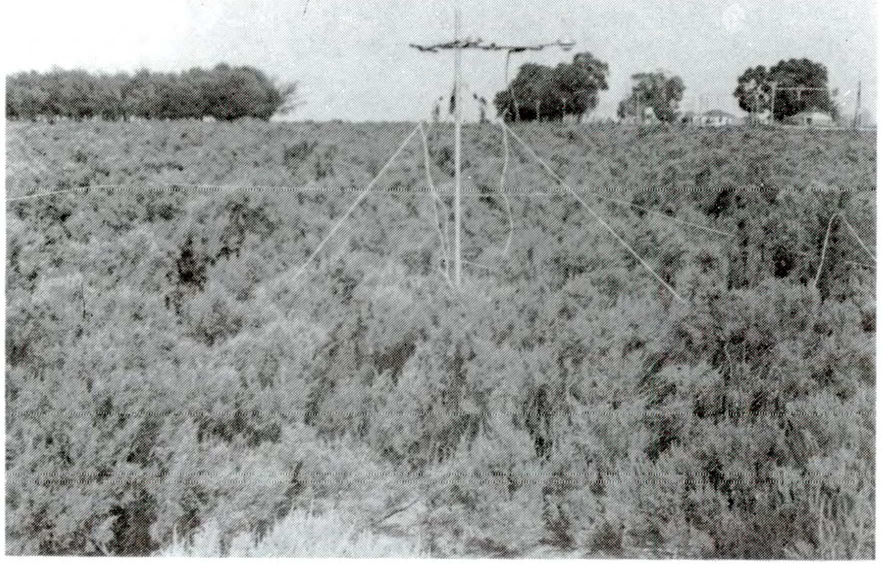
Sutherland : Mountain Renosterveld



An overgrazed Karoo Bush

Natural and Disturbed Karroid B Veld

Fig 3.3 Natural and Disturbed sites : Sutherland and Ladismith



NATURAL

DISTURBED

Vöelvlei : Coastal Renosterveld

NATURAL

DISTURBED

Bo-wadrif : Succulent Karoo

Fig. 3.4 Natural and Disturbed Sites Voelvlei and Bo-wadrif fences, or in areas not accessible to grazing animals. In some cases no sign of human activity was present at all, while in others vegetation showed evidence of former disturbance, such as old fire debris or animal tracks. Virtually all the sites displayed a high diversity of plants. The disturbed sites consisted mostly of over-grazed areas of natural vegetation or agricultural crop land. These two activities affect most natural vegetation in terms of area. At Site 1 no disturbed site was measured as this veld type (Mountain Fynbos) was used mainly as a control, from which the methods could be tested. At Site 2 (Pella) the effect of fire to induce good grazing on Coastal Fynbos was measured.

Strandveld at Yzerfontein (Site 4) had in some places been levelled and sub-divided into plots. Although the vegetation types were similar, apart from some grasses which had emerged on the disturbed site, it was clear, visually, that the area had been impacted by man (see Fig. 3.2). The other sites were either over-grazed (W Mountain Karoo, Mountain Renosterveld, Succulent Karoo and Spekboomveld) or cropland (Coastal Renosterveld, False Fynbos and Karroid Broken Veld).

Detailed site description was made in January and only detectable changes were recorded during the second set of measurements in June. In most cases very little change was recorded. The Darling (Coastal Renosterveld) site was destroyed by fire and had to be replaced completely. At Seweweekspoort -- False Fynbos -- the author was denied access to the only suitable site in the area in June. The dry stubble of a lucerne field in January had changed to a bright green flourishing crop in June at Ladismith in the Karroid Broken Veld (Site 10). The position of the natural site here had to be moved eastwards by 20 m to avoid shadow for large portions of the day. (See Fig. 3.3)

In all cases the plants were identified to at least the genus level, and many to the species level in the Bolus Herbarium at UCT. The identification served a twofold purpose, viz.

(i) to stipulate the exact nature of the vegetation which produced the specific readings; and

(ii) to show the relative representation of the different plants of the site within the veld type.

Investigation of the radiative properties and notably the albedo of the different veld types will not only make an important contribution to knowledge in the subject but also give an indication of the variation amongst veld types and the impact of Man's activities on the radiation balance.

CHAPTER 4

DISCUSSION OF RESULTS

4.1 Summary of Results

A short summary of results appears in Table 4.1. Detailed results can be found in Appendix 1. The data were processed by a Univac 1100 computer at the University of Cape Town, using a Fortran program written specifically for the purpose.

Table 4.1 Summary Table of Albedos

	Veld Type	JANUARY		JUNE		
		Natural	Disturbed	Natural	Disturbed	
1	Mountain Fynbos	10.6	-	-	-	(1)
2	Coastal Fynbos	10.9	29.1	11.1	22.6	
3	Coastal Renoster-veld	10.7	18.0	10.2	15.2	(2)
4	Strandveld	9.7	12.4	11.8	13.9	
5	Western Mtn Karoo	10.3	11.7	9.5	11.1	
6	Mountain Renos-terveld	7.8	10.9	9.5	11.6	
7	Succulent Karoo	16.4	21.5	15.1	23.0	
8	False Fynbos	14.7	26.6	-	-	(3)
9	Spekboomveld	12.8	13.4	12.3	14.4	
10	Karroid Broken Veld	11.5	22.7	7.8	20.8	(4)
	Mean	11.5	18.4	10.9	16.6	
	Std Dev.	2.4	6.8	2.2	4.8	

Notes: (1) Used for initial instrument checks only

(2) Sites changed between January & July due to burning of original site

(3) Access to site denied in June

(4) Site moved in June due to the shadow of a mountain

The albedo values of the Mountain Fynbos can be favourably compared to the results of Morris (1981). He does not give a single value for Fynbos but rather a range from 8 to 13% depending on the vegetation structure. The results here endorse his view that the Fynbos veld types generally display low albedo values. They can be compared to English heather -- 13.5 to 16% (Barry & Chambers, 1966b) -- and Mediterranean Batha -- 13 to 17% (Stanhill et al, 1966) -- which are similar in appearance. Structurally, they are different, not only because of different present climatic stresses but also through evolutionary development (Jarman, 1982).

The measurements taken at Cape Point were mainly used for instrument checking and no disturbed site was used for comparison. For all sites the weather conditions were monitored and soil and vegetation data collected. The results can be seen in Appendices 3 and 4. The data collection did not proceed without mishap. At Darling (Coastal Renosterveld), the site that was measured in January (Summer) had been destroyed by fire in June (see note (2) on Table 4.1). From Table 3.2 it was seen that very little of this veld type remains and another suitable site was found 60 km away near Voëlvlei.

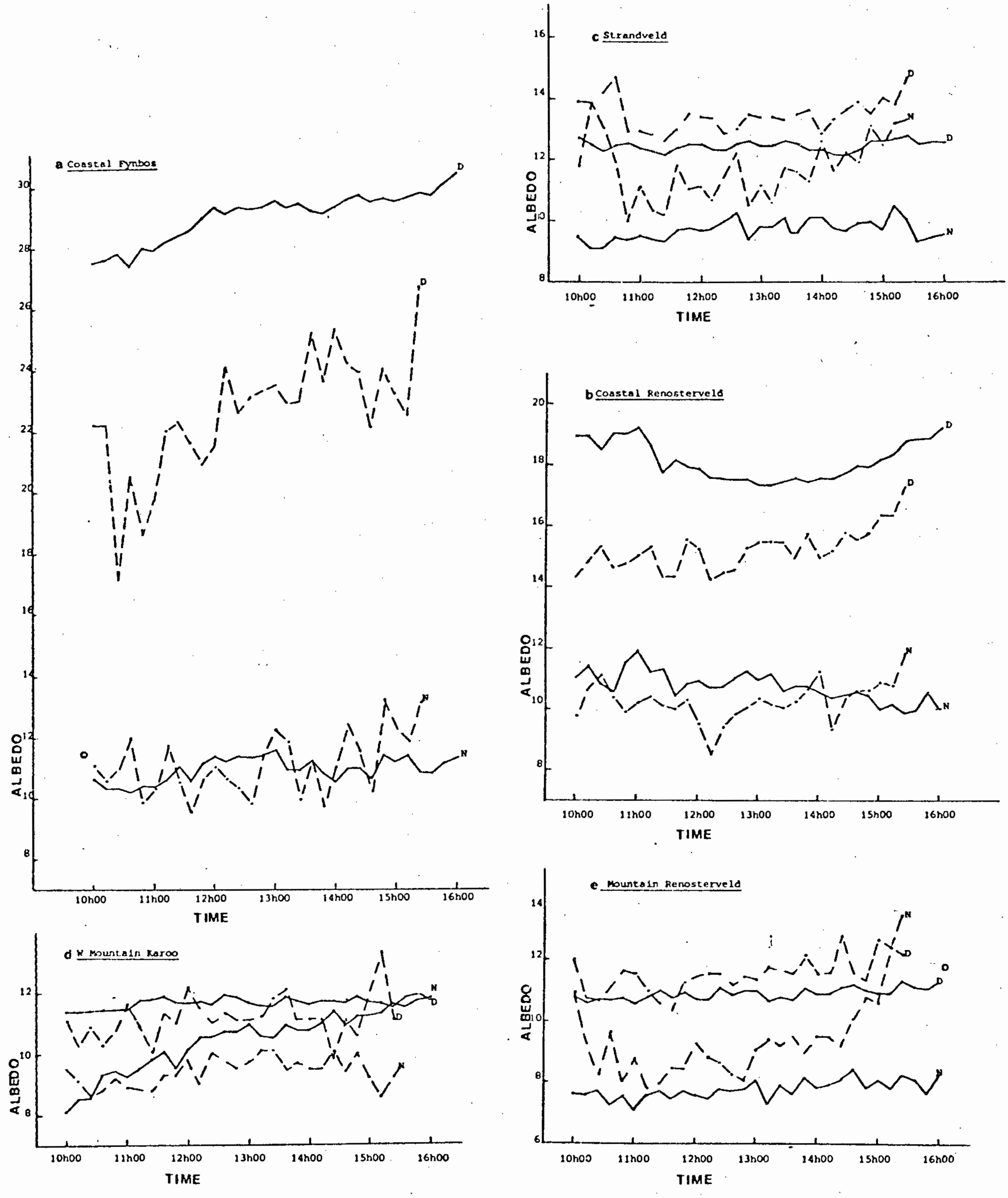
The False Fynbos site at Seweweekspoort, could not be measured during winter due to restricted access. This was unfortunate as another suitable site could not be found in the vicinity. (See note (3)). At Ladismith (Karroid Broken Veld), the only suitable site lay in the shadow of a mountain during June. This had not been a problem in January due to lower solar declination. The natural site was moved 20 m to allow a longer period of sunlight to shine onto the plot. The difference between the summer and winter readings can be explained by the upper sensor receiving a slightly longer period of direct sunlight than the surrounding plot. The second day of summer readings at this site was disregarded when the power supply failed, requiring manual measurements to be made; these later proved to be unacceptable.

It must be borne in mind that the intensity of incoming solar radiation at the surface in winter is about one third less than that in summer and this may be a reason for the more erratic behaviour of the albedos in June as seen in Fig. 4.1(a) - (i). For the natural sites there is, however, little seasonal difference.

From even a cursory glance at the results it is clear that the albedos of the disturbed veld types are considerably higher than those of natural veld types. Analysis of the degree of variation will follow in Chapter Five.

4.2 Between-Site Variation

The variation amongst the natural sites is comparatively small. (See Fig. 4.2) Other researchers give differences of between 15 and 26% in England (Barry & Chambers, 1966a), 13 and 24% (Kondratyev, 1969), 8 and 18% (Kriebel, 1979), 11 and 23% in Nigeria (Oguntoyinbo, 1970) and 15 to 33% in N Africa (Stanhill et al 1966) for variation of albedos over natural vegetation. Because the geographical area within which the sites were selected is not big, differences in conditions are not very great, but the climate does vary over short distances within the study area. For instance the average rainfall in the south-west is sometimes 1 000 pa, while in the north-east near Site five, it is less than 200 mm (Barnard et al 1972). Thus in a distance of 250 km one moves from evergreen Mediterranean shrubland to semi-desert Karoo vegetation.



KEY

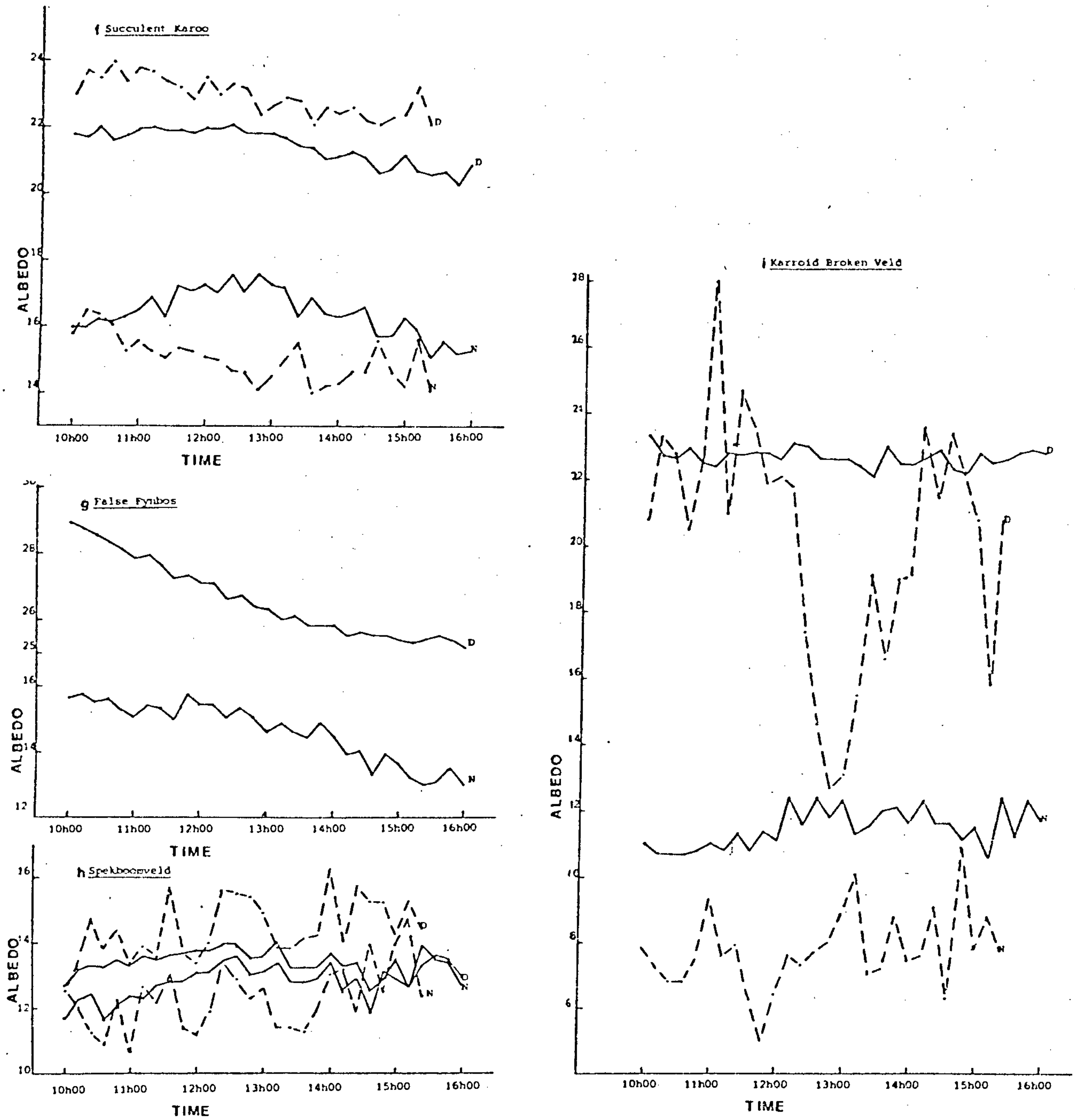
—— - Summer

— — - Winter

N - Natural site

D - Disturbed site

Fig 4.1(a)-(e) Diurnal variation of Albedo during January and June



KEY

—— - Summer

— — - Winter

N - Natural site

D - Disturbed site

Fig 4.1 (f)-(i) Diurnal variation of Albedo during January and June

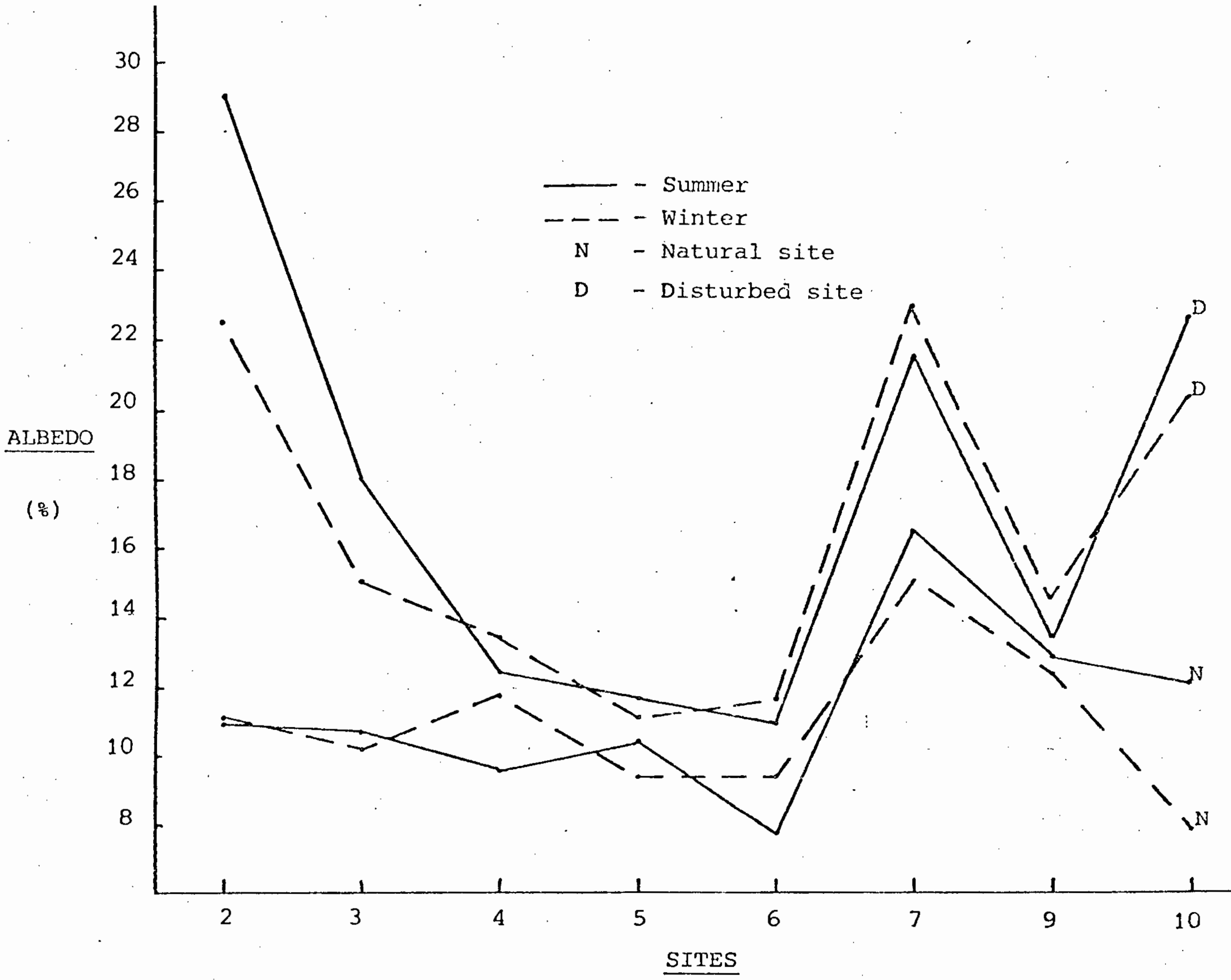


Fig. 4.3 Seasonal variation of albedo for 8 sites.

It is significant that the drier regions also do not display the usual high albedo values found by other researchers for similar vegetation types. Budyko (1974), for example, quotes savannah and semi-desert albedo values of 24% during the dry season and 18% during the wet season. The heat stressed vegetation with a fair amount of bare soil exposure would be expected to give higher reflection values than the 10 to 16% found here. It is important to remember these results when considering the role of vegetation on climate. (see Chapter Six)

The variation of albedo among the disturbed sites is linked to the nature of specific vegetation growing there as a result of Man's activities, rather than their geographical position. Factors such as irrigation and fire account for larger variation than natural climatic fluctuations, for example. It was found that of all types of disturbance fire had the greatest effect on albedo. Through almost complete destruction of the vegetation high albedo soils are exposed and until the vegetation recuperates, in some cases taking in the order of decades, the albedo remains high.

Agricultural crops differ in structure, homogeneity, colour and seasonality. Depending upon the season, farmers plant crops displaying different responses to solar energy. A light, ripe wheat crop will reflect more light (energy) than a growing, green lucerne crop in the visible spectrum. The response of fruit trees will differ from that of potato lands (Kalma & Stanhill, 1969).

The crops measured in summer were wheat, oats and lucerne. In January these crops had been harvested and what remained until the planting season, was short, dry stubble. The values of 18% for wheat, 26% for oats and 23% for lucerne compared well with other researchers. Fritschen (1967) found wheat to reflect between 18 and 23%, oats 16 and 25% and lucerne 20 and 27%. The lower values were recorded when the crop was wet and green and the upper values when dry and mature. Monteith (1959) found winter wheat values to vary between 20 and 27% and lucerne 22 to 24%.

The winter values of wheat and oats could not be measured but presumably would have corresponded with the lower values above. The winter value for a complete cover of green, irrigated lucerne was found to be 21% at Ladismith. Not unexpectedly this value was lower than the corresponding summer reading due, presumably, to the change in colour.

From inspection, the range of albedo within disturbed sites (January $\Delta\alpha$= 18.9%, June $\Delta\alpha$= 11.9%) was considerably higher than the range within natural sites (January $\Delta\alpha$= 8.6%, June $\Delta\alpha$= 7.3%). The significance and validity of these differences is tested in Chapter Five.

4.3 Within-Site Variation

4.3.1 Site 1 - Mountain Fynbos (Cape Point)

The variation within the natural veld type is discussed fully by Morris (1981). However, as no readings of disturbed vegetation were taken it is sufficient to suggest the types of impact that are found and perhaps estimate the resultant albedos.

α The most significant impacts other than urban use are fire, alien plants and agriculture. From the Coastal Fynbos site, the albedo of recently burned vegetation can be estimated at around 20 to 30%. Agriculture in the veld type is mainly restricted to grape-farming for which no albedos have been suggested.

The albedos of alien vegetation had not been specifically measured in the study area at the time of writing. The natural albedos as given by Morris of 8 to 13% are expected to be lower than for any agricultural activity. However, urbanisation which occupies -- especially in the vicinity of Cape Town -- a large area of former fynbos, has tended to decrease the surface albedo by as much as 2% (Sagan et al, 1979). Oguntoyinbo (1970) measured the albedo of dark tarmacs in Nigeria, revealing a value of 8%. This supports the conclusions of Morris that the Fynbos registers below-expected albedos.

4.3.2 Site 2 - Coastal Fynbos (Pella)

The natural site here consisted of healthy-looking fynbos of an average height of 1 m covering 80% of the surface. The albedo of 10.9% corresponds to that of Mountain Fynbos and compares well with the range put forward by Morris (1981). The disturbed site, reduced by fire to bare stumps and branches showed signs of one or two seasons' growth covering 40% of the site; 55% of the quadrat consisted of exposed dry, white sand, This undoubtedly explains the large albedo values of 22.6 to 29.1%. (See Fig. 3.2)

Fynbos vegetation often occurs on infertile sandy soil and despite the low nutrient level in the soil the vegetation thrives. Jarman (1982). Natural fire cycles, which maintain a regular and mature growth, have been estimated to have a frequency of forty years, whereas the human-origin fire frequency is expected to be far higher than this; up to 60% more frequent (Kruger, 1979).

The causes of fire in the Western Cape, according to Kruger (1979) were arson (17%), smokers (8%), lightning (11%), planned departmental burning (9%) and miscellaneous or unknown causes (55%). It is clear that Man's interference with nature has increased the incidence of fire. It is equally evident that the effect on the albedo is considerable.

4.3.3 Site 3 - Coastal Renosterveld (Darling - January, Voëlvlei - June)

In January, at Darling, Elytropappus rinocerotis - dominated vegetation covered 70% of the site on a gradual slope of 4 to 8°. The summer albedo of 10.7% measured at Darling differed sharply from the 18% of the adjacent wheatfield. The colour difference was certainly one explanation - the dry wheat stubble being a light beige colour, contrasting to the olive green of renosterbos. The wheat had recently been harvested and many researchers have found that at this stage of the crop, albedos are usually higher than at other stages. (Ahmed & Lockwood, 1979; Fritschen, 1967; Graham & King, 1961).

The replacement of large areas of natural Renosterveld by wheat in the S W Cape is cause for concern. Taylor (1978) claims that it 'has been so extensively ploughed for wheat growing that very little trace of natural vegetation remains' (p 215). The not too sandy soil, the 200-500 mm pa rainfall and the relative damped topography have made this area very suitable for growing of winter wheat (Barnard et al, 1972). The albedo for winter wheat averaged over a season, determined by Kondratyev (1969), was 19% and by Monteith (1959) 20%. From the research done by Bossi (1983), it can be seen that not only is this veld type in danger of extinction, (see Table 3.2) but if a significant albedo increase is incurred over a large area, the possibility of climate modification is more likely.

✶ · The June site differed in several respects. The sites at Voëlvlei were very flat and the natural Renosterveld consisted of a greater percentage cover of Elytropappus rinocerotis. The disturbed site had been burned recently and was covered in a ground layer of green grass, upon which cattle were grazing. But again the two land-uses produced largely differing albedos; 10.2% and 15% for natural and disturbed respectively.

The colour of Renosterveld may account for the very low readings. It is a dark olive green, but although structurally very different from the fynbos, it displays similar qualities ✶ i.e. evergreen ericoid and narrow sclerophyllous scrub (Kruger, 1979). The mere removal of natural vegetation, whether by fire or for cropland, unless replaced by similar or vegetation results in an increased albedo. The underlying soil, a dry, clay-loam displayed a light-brown colour which, when exposed, would reflect about 17%; according to Oguntoyinbo (1970). This figure has been presumably reduced by the vegetation cover that was present in the disturbed site. (See Fig. 3-4)

4.3.4 Site 4 - Strandveld (Yzerfontein)

The Strandveld vegetation comprises mainly the broad ✶ leafed sclerophyll woody scrub of dunes near the coast (Taylor, 1978). There is a great variety of species, with succulents especially prolific after good spring rains (Kruger, 1979). Acocks (1975) has described it as 'lilliputian forest'.

The natural site at Yzerfontein displayed low albedo values, 9.7% and 11.8% in January and June, with the disturbed sites 12.4% and 13.9% respectively. The disturbance was as a result of preliminary clearing of the site for building activity Although a large degree of vegetation cover remained, the vegetation height and structure had been changed. (See Fig. 3.2)

The total area of remaining Strandveld is given by Bossi 1983) as 2072 km^2, having been reduced by 53% from when Acocks originally surveyed the area (c1952). The major impact has been due to man's demand for coastal resorts. The thin strip of Strandveld along the Western Cape coast is slowly disappearing. The albedo values of structures that are erected are unknown - but large areas are prepared long before plots are sold. The effect is, however, probably not significant to regional or macro-scale climate.

4.3.5 Site 5 - Western Mountain Karoo (Sutherland)

This veld type occupies stony country made up in most cases of shale, fine sandstone and granite. (Acocks, 1975) Sheep farming has been practised here for many years. The rainfall is between 150 - 250 mm pa and in times of drought is barely enough to replenish the vegetation, severely depleted by overgrazing.

The natural site here, represented some vegetation which, due to its partially protected situation was closer to its natural state than the heavily grazed areas nearby. This was reinforced by the fact that fewer sheep tracks and droppings were evident in the 'natural' site. The albedo values within each site are not very different, being 10.3% and 9.5% for the 'natural' site and 12.4% and 13.9% for the disturbed site. The small difference does, nevertheless, indicate how over-grazing on a large scale may result in a significantly greater amount of energy being reflected back into space. In this way a thermal depression as described by Otterman (1974) may result in decreased rainfall or, alternatively, prolonged drought. This concept will be more fully developed later.

4.3.6 Site 6 - Mountain Renosterveld (Sutherland))

Mountain Renosterveld occurs interposed between fynbos and true Karoo formations in the zone of Mediterranean climate and some researchers have included it within the Fynbos Biome (Bossi, 1983). It is described as consisting of mid-dense low semi-deciduous shrubland, again displaying a predominance of Elytropappus rinocerotis (Kruger, 1979). The site selected was on a gradual slope of 2-3° from horizontal and the natural site covered by 65% natural vegetation, 15% soil and 15% litter. The disturbed site displayed only 45% vegetation cover, with 40% exposed soil. (See Fig. 3.3)

The soil, an orange-brown colour when dry, forms a hard crust and with a minimum of moisture the amount of energy absorbed by the surface is dependent mostly on the absorbtivity of the crust. Being lighter in colour than the dark vegetation it is logical to expect a higher albedo. The disturbed site's values of 10.9% in January and 11.6% in June are considerably higher than the natural sites, viz. 7.8% and 9.5%. It would appear that the albedo may be a direct indication, when compared to an area of maximum vegetation cover, of the degree of overgrazing. This possibility will be more fully explored in Chapter Six.

4.3.7. Site 7 - Succulent Karoo (Bowadrif)

This veld type occurs in what is called the Onder-Karoo, situated below the Sutherland plateau in the valley between the Roggeveld and the Koue Bokkeveld mountains. Rainfall varies from 50 to 150 mm pa, falling mostly in winter. It is dominated by succulents, mainly mesembryanthemums, with few trees or large shrubs (Acocks, 1975). Again it was found to be totally trampled and overgrazed; however few, if any, sheep were observed. It may have been that the veld was, at the time of measurement, too poor to support sheep, which would have been transported elsewhere. (See Fig. 3.4)

The difference between the natural and disturbed sites was once more a case of less overgrazed and overgrazed vegetation. The albedo values were: Natural site - 16.4% (January), 15.1% (June) and 21.5% (January), 23.0% (June) at the disturbed site. Because the rainfall is so low, the vegetation would take some years to recover completely and for the albedo to return to normal values. If the high albedo has caused an aggravation of the drought, the veld may never recover to its pristine condition.

4.3.8 Site 8 - False Fynbos (Seweweekspoort)

Most of this veld type is more or less indistinguishable from true fynbos and is regarded as the transitional form by Acocks (1975) and others (Kruger, 1979; Taylor, 1978). The study area is situated between two mountain ranges, the

Elandsberg in the north and the Klein-Swartberg in the south. The climatic conditions and the quartzitic sandstone soil suit the fynbos vegetation well. One finds too, similar crops to those of the drier Western Cape. Wheat, oats and fruit trees were encountered throughout the valley.

The oatfield at this site had been recently harvested in January. The bare dry stubble presented an albedo of 26.6% while the albedo of False Fynbos was, by comparison, only 14.7%. The high value for dry oats is supported by Fritschen (1967) who obtained an average seasonal value of 23%. The slightly high natural albedo value (14.7%) may be explained by the fact that the vegetation structure was markedly different from other fynbos communities previously encountered. The individual plants stood much higher and a predominance of tall plants resulted in a fair amount (50%) of bare grey-white soil exposure. Isolated plants from other veld types were found intermingled in this type; examples were aloes, karroid shrubs and grasses. The area of this veld type is fairly small and therefore human alteration may not result in a noticeable impact on it, but nevertheless contributes to the insidious change occurring across the face of the land.

4.3.9 Site 9 - Spekboomveld (Calitzdorp)

Also known as Succulent Mountain Scrub, this is an essentially dense mountain scrub, growing on steep sandstone, quartzites and shale slopes in the East and Southern Cape. (Acocks, 1975). The area receives 250-300 mm pa of rain and is dominated by the spekboom, Portulacaria afra, with other shrubs of the bushveld and karoo types.

The Spekboomveld itself is not altered by man on the steep slopes, but rather as slopes level out and spekboom becomes more accessible. According to Smith (1966) the spekboom is 'relished by all classes of stock' and as such has been almost 'eaten out of existence' (p 431) where it is accessible. The natural site included two or three entire trees of below-average height (one metre) and gave a value of 12.8% in January and 12.3% in June. The disrupted site, where evidence of grazing was present, displayed values of 13.4% and 14.4%.

The succulent natural spekboom veld was bright-green in colour, while the disrupted site contained mainly dry, grey plant cover and this colour difference might explain the variation in albedo. Smith (1966) states that the spekboom is drought-resistant and in many places covers the slopes completely.

4.3.10 Site 10 - Karroid Broken Veld (Ladismith)

This is the veld of the Great and Little Karoo, a veld dotted with dwarf trees and shrubs. In the Ladismith area, succulents dominated while grasses were scarce. The intense sheep farming of the area and the permanent scarcity of rain (150-300 mm pa) explain the barrenness of the area. The natural site is in this veld type was contrasted with a field of lucerne, recently harvested in January and in full growth during June. (See Fig. 3.3)

The natural site, covered by 70% of vegetation, displayed an albedo of 11.5% in January. During the June period of field work it was apparent that a nearby mountain would shade the site during parts of the day and the site was shifted some 20 metres eastwards. The resulting 7.8% albedo remains unexplained as it is extremely low for semi-arid vegetation. Other researchers give values of between 20-29% for desert shrubland (Ahmed & Lockwood, 1979). The only explanation offered for this anomaly is the perhaps unique behaviour of succulents (cf Succulent Karoo & Spekboom Veld) to absorb more solar energy that would otherwise be expected. More research needs to be done on this topic.

The lucerne field displayed more or less typical albedo values of 22.7% in January and 20.8% in June. Monteith (1959) quotes an average albedo of 22% and Fritschen (1967), a range of between 20 to 27% depending on season. The frequency of cropland encountered within the veld type correlated strongly with the available water supply and thus might not have a regional impact as rivers are scarce and the main activity was livestock farming. Nevertheless it was somewhat enlightening to discover that the bright green crop of lucerne displayed a far higher albedo (20.8%) than that of dry semi-arid natural vegetation (around 11%). This is a clear indication that colour is not the sole determinant of albedo, and is in agreement with the findings of Monteith (1959).

4.4 Seasonal and diurnal variation

It was not the author's explicit intention to investigate the seasonal variation but rather to obtain an average value of albedos for the different veld types. Many researchers have already established the seasonal and diurnal variation of natural vegetation and crops (Ahmed & Lockwood, 1979; Fritschen, 1967; Graham & King, 1961; Nkendirim, 1972).

With regard to seasonal variation, three sites of both natural and disturbed types, showed decreased albedos in June. For two of these the decreased albedo corresponded with the dry season. This agreed with the unexpected results encountered by Oguntoyinbo (1970) in Nigeria. Two veld types showed corresponding increased albedos for both natural and disturbed sites in June.

Three veld types displayed increased June albedos for one measurement and decreased albedos for the other. It would seem that factors such as unpredictable rainfall, soil moisture, drought, irrigation of crops, crop growth and the movement of livestock would make predictions of seasonal variability highly erroneous. Fig. 4.2 shows graphically how albedos differed seasonally for each veld type. The difficulty in determining a single trend will be noticed. Decreased solar altitude in winter is a factor that may need further investigation. Many researchers have shown that instrumental error and vegetation response are dependent on solar zenith angle.

As far as diurnal variation is concerned, authors such as Kalma & Badham (1972), Monteith & Szeicz (1961) and Oguntoyinbo (1970) have shown that general increases in albedo accompanied increased solar zenith angles. While some have suggested instrument error (Davies & Buttimor, 1969) others have found the effect to be due to the surfaces themselves. Lin-Sien Chia (1967) suggests that specular reflection of radiation by leaves causes an increase in albedo at increasing zenith angle.

In most cases the major albedo deviation from a linear response occurs before 10h00 and after 16h00 solar time. Thus, in order to avoid these deviations only measurements taken between these hours, were used in the analysis. The variation is nevertheless graphically presented in Fig. 4.1 and will be seen in most cases to be fairly invariant. However, some cases show definite trends, either increasing or decreasing during the day or otherwise displaying the valley-shaped trend supported by other researchers.

It is suggested that the diurnal and seasonal variations are certainly results of specific effects ascribed to the nature of the vegetation itself, the solar zenith angle and the climate. When considering average annual albedo climate and solar zenith angle may be regarded as 'constant' variables. Thus the seasonal variation becomes important only when Man's intervention makes it so, i.e. by disrupting the cycles of natural vegetation, by introducing non-constant variables such as semi-annual crops, irrigation and burning.

Seasonal and diurnal variation will be taken into account in an analysis of variance to determine their contribution to the total variance together with within-site-variation and between site variations.

CHAPTER 5

THE ANALYSIS OF VARIANCE

If you can speak of beauty in a statistical method, analysis of variance possesses it more than any other.

(Sokal & Rohlf, 1969)

5.1 Introduction

Analysis of variance (ANOVA) is a statistical technique used to test the statistical significance of the difference between the means of two or more groups. In a simple one-way analysis of variance each individual (or subject) is classified into a category. Several factors (or characteristics) may be involved in an analysis of variance model. In a three-way factorial analysis the individuals in each group are classified by three factors.

In this project three such characteristics were taken into account, namely, site, disturbance and time of day. In other words the model calculated the total variance of albedos and then the amount of variance attributable to veld type variation, disturbance variation and diurnal variation for each season. The 'Time' factor i.e. the twelve minute readings, was regarded as a within-group factor, while the other two factors were called grouping factors where the subjects are classified into specific groups, i.e. veld types and disturbance (natural or disturbed).

Thus the model used was a two grouping-factor and one within-factor analysis of variance. The second day of measurements of each site in January was regarded as a repeated measure and fell away in June, after 't' tests for each site showed that there was no significant difference between the two days.

A BMDP statistical package was used to conduct the ANOVA on the University of Cape Town's UNIVAC 1100 computer.

The results of the analyses are displayed in Tables 5.1 to 5.3. To test the hypothesis it was necessary to determine how much of the variation in albedo could be attributed to each factor and whether the variance was significant or not. Each case will be discussed in turn.

5.2. The Analysis of Variance

Variance is defined as the sum of the squares of all the cases divided by the degrees of freedom (number of cases -1). This value represents what is called the Mean Square (M.S.). Variance is statistically compared by means of an F-test. By definition the quotient, F, is equal to the variance of one sample divided by that of another.

The sources of variation in the Tables below and in the project as a whole were:

(a) Site, meaning the various veld types. Nine veld types were taken into consideration for this analysis. Only Site 1, the control site, was omitted;

(b) Disturbance, or whether the specific site was natural or disturbed;

(c) Time; the diurnal trend, measured between 10h00 and 16h00, during summer, and 10h36 and 16h00 in winter, at 12 minute intervals.

(d) Seasonality, or the difference between summer and winter measurements.

5.2.1 Summer Results (January) - Repeated measurements

The results of this analysis are found in Table 5.1 below:

Table 5.1 Summer ANOVA

Source	Source	Degrees of Freedom	Mean Square
Site	1773319.27	8	221664.91
Disturbance	1298541.78	1	1298541.78
SitexDisturbance	860801.53	8	107600.19
Error*	3257.42	18	180.97
Time	2032.76	30	67.76
Time x Site	27297.28	240	113.74
Time x Disturbance	2490.78	30	83.03
Time x Site x Disturbance	6835.92	240	28.48
Error*	6073.58	540	11.25

The variation due to the second day of measurement is represented in the error terms (*). From the above results it may be seen that the error M.S. is small, and subsequent 't' tests showed that there was no significant difference between the two days of measurement. Thus for the purposes of this test the error term is therefore inappropriate as the divisor for an F-test.

Site M.S. was considerably less than Disturbance M.S. variation; in the order of approximately six times. The Site X Disturbance interaction, which nowbecomes the new error term, is about half that of the Site M.S. term. Thus it is expected that the hypothesis $H_o(B)$ will be rejected, i.e. that the variance due to disturbance is greater than the between-site variance. An F-test to compare the evidence statistically will follow.

The within-factor, Time, displayed low variance, as did the interacting components. Once more the error M.S. term on the grounds of the 't' test was disregarded. The Time X Site interaction showed slightly higher variances than the Time X Disturbance interaction.

The F- values of the various components were calculated using the variations of Site X Disturbance and Time X Site X Disturbance variance as quotients. These results are presented below in Table 5.1 (a) together with the critical F values for the 95% significance level.

Table 5.1 (a) F-values and critical F-values-Summer

F Value			Critical Value		
F_S	=	2.06	($F_{8,8}$ (0.05)	= 3.44)	$F_S < F_C$
F_D	=	12.07	($F_{1,8}$ (0.05)	= 5.32)	$F_D > F_C$
F_T	=	2.38	($F_{30,240}$(0.05)	= 1.52)	$F_T > F_C$
F_{TxS}	=	3.99	($F_{240,240}$(0.05)	= 1.26)	$F_{TxS} > F_C$
F_{TxD}	=	2.92	($F_{30,240}$ (0.05)	= 1.52)	$F_{TxD} > F_C$

Thus F_D, F_T, F_{TxS} and F_{TxD} are all greater than the critical values. The variance of these components is significant. The variance according to disturbance is thus not only greater than that of site, but it is statistically significant whereas the site variance is not, $H_o(B)$ must therefore be rejected while $H_o(A)$ is accepted

Discussion of the interactive variation (i.e. V_{SXD}, V_{TxS}, V_{TxD} V_{TxDxS}) will follow in Section 5.2.4. The differences between the summer and winter results will also be presented.

5.2.2. Winter results (June) - Single measurement)

The winter measurements were taken for one day only and thus the error term for the ANOVA is the Site X Disturbance variance. The results are presented in Table 5.2.

Table 5.2 ANOVA — Winter Results

Source	Sum of Squares	Degree of Freedom	Mean Square
Site	347741.30	7	49677.33
Disturbance	349609.88	1	349609.87
Site x Disturbance	199091	7	28441.62
Time	6496.01	27	240.59
Time x Site	35257.26	189	186.54
Time x Disturbance	2627.56	27	97.32
Time x Site x Disturbance	29127.71	189	154.11

The 7 degrees of freedom indicate 8 sites, taking into account the missing winter data from the False Fynbos site. The 27 degrees of freedom instead of 30 are a result of narrowing down the number of measurements during the day. As the solar elevation was much lower in winter the early morning values are more susceptible to inaccuracy because of dewfall and shadows. In almost all cases the measurements for 10h00, 10h12 and 10h24 were rejected after a test for outliers was performed.

The variation according to Site is again smaller than that due to Disturbance, by approximately nine times. The Site X Disturbance interaction is again about half as large as the Site variation. Once again it is expected that the hypothesis $H_0(B)$ will be rejected, and $H_0(A)$ accepted.

In the within-factor variance, Time shows a fairly large variance, with Time X Site variance slightly lower, followed by Time X Site X Disturbance variance and then Time X Disturbance variance. This pattern varies slightly from the summer analysis.

The F values are presented in Table 5.2 (a)

Table 5.2 (a) F-Values, and critical F-values - Winter

F Values			Critical F-Values				
F_S	=	1.75	$(F_{7,7}$	(0.05)	=	3.79)	$F_S < F_C$
F_D	=	12.29	$(F_{1,7}$	(0.05)	=	5.59)	$F_D > F_C$
F_T	=	1.56	$(F_{27,189}$	(0.05)	=	1.55)	$F_T > F_C$
F_{TxS}	=	1.21	$(F_{189,189}$	(0.05)	=	1.30)	$F_{TxS} \leq F_C$
F_{TxD}	=	0.63	$(F_{27,189}$	(0.05)	=	1.55)	$F_{TxD} \leq FC$

In this case only F_D and F_T are greater than the critical F value for 95% probability. Thus the variance of disturbance and time are both significant. (The latter is not conclusive as the F_T and F_C are almost exact). This means that $H_0(B)$ is again rejected. Discussion and comparison with the summer results will follow.

5.2.3 Combined analysis

In this analysis, the albedos were averaged over the day and time of year was taken as a repeated measure for the analysis. The averaging of albedos over time is not strictly permissible, as in both cases diurnal variation was found to be statistically significant. Nevertheless it was done in an attempt to determine the degree of variance attributed to season, and in order to retain the same analysis.

The resulting ANOVA table is presented below (Table 5.3)

Table 5.3 Analysis of variance table - combined result

Source	Sum of Squares	Degrees of Freedom	Mean Square
Site	895756.37	6	14929.73
Disturbance	669416.17	1	669416.17
Site x Disturbance	498330.55	6	83055.09
Yeartime	6022.87	1	6022.87
Yeartime x Site	58041.75	6	9673.62
Yeartime x Disturbance	547.226	1	547.23
Yeartime x Site x Disturbance	39138.28	6	6523.05

Predictably, the Disturbance variance was again greater than the Site variance. The Yeartime variance appears to be rather small, or in any event not specifically high. The F-tests will reveal their significance.

The six degrees of freedom are due to one of the sites being changed in June. This site could not be brought into the comparison.

Table 5.3(a) F values and critical F values - Combined analysis

F-Values		Critical F-Values	
F_S	= 1.80	($F_{6,6}$ (0.05) = 4,28)	R_S < F_C
F_D	= 8.06	($F_{1,6}$ (0.05) = 5.99)	F_D > F_C
F_Y	= 0.92	($F_{1,6}$ (0.05) = 5.99)	F_Y < F_C
F_{YxS}	= 1.48	($F_{6,6}$ (0.05) = 4.28)	$F_{YxS} \leq F_C$
F_{YxD}	= 0.08	($F_{1,6}$ (0.05) = 4.28)	$F_{YxD} \leq F_C$

In this case only the variance attributed to Disturbance is significant. It would appear therefore that in this investigation seasonal variation was not significant. Seasonal variance, admittedly should have been measured throughout the year, but the scope and length of the project made it impractical. It cannot therefore be categorically stated that seasonal variance is insignificant but there is strong evidence that this is so.

5.3.4 Discussion

Understanding of the variance attributed to one of the three main grouping or within factors was straightforward. As sites, disturbance and time of day varied, it was expected that individual albedo values would vary as well. It is however more difficult to understand the variance attributed to interactive factors. When the response of the albedos over time for each of the factors is graphed, some understanding of the meaning of the significance of the interaction terms was gained.

In Figs 4.1 and 4.2 the variation of albedo for each site during the day as well as the seasonal variation is displayed. From Tables 5.1, 5.2 and 5.3 it is seen that the following variances were significant.

<u>Summer</u>	$V_{Disturbance}$, V_{Time}, V_{TxS}, V_{TxD}
<u>Winter</u>	$V_{Disturbance}$, V_{Time}
<u>Combined</u>	$V_{Disturbance}$

Other variances such as $V_{Yeartime}$, $V_{Yeartime \times Site}$, and V_{Site} were considerable but not significant. The variance of these terms can be gauged by the non-linearality of the graphs. For example the higher variance of Disturbance compared to that of Site is shown in Fig. 4.2 where the disturbed means are far more variable than the natural means. If the two summer or winter lines had been parallel to each other the variance would have been attributed to the Site factor only. The crossovers of the summer and winter graphs indicate that there is Yeartime variance and because the two sets of graphs do not run parallel, there is a Yeartime x Site variance.

The individual site graphs in Fig. 4.1 reflect the variance of Time for each site. The variation in winter was far more apparent than for summer and this may be attributed to the higher solar declination leading to more variable results. The increased angle of the sun from the vertical on both the instrument and the vegetation, it is suggested, leads to greater variability in albedo.

Time x Site and Time x Disturbance variation in summer indicate that the variation of albedo during the day is linked to the nature of the site and the nature of the disturbance respectively. During summer and winter the Time variation was significant - demonstrating that, independent of site or disturbance, the diurnal variation must be attributed to other factors, the most obvious being, as mentioned, the solar declination.

Similarly, the Disturbance variance indicates that albedo variations were most definitely linked to disturbance at a particular site and that the disturbed sites as such display greater variation than natural sites. The variation of albedo between different veld types was never statistically significant. Thus, independent of veld type, the level of disturbance influences the albedo significantly.

The variation which was attributed to Disturbance or, in other words, the within-site variation is one of the main interests of this project. It has been established there was a significant difference between natural and disturbed sites for veld types in the S W Cape. These results were verified by a 2-way analysis of variance utilizing daily values of albedo. Full tables of output from this analysis are presented in Appendix 2.

At a significance level of .05 (95% probability) $H_o(B)$ was rejected for both summer and winter cases. This confirmed the findings of the more specific three-way analysis. The F-values themselves are very similar, and this confirms that the mean albedos taken over the day did not lead to different results.

The Hypotheses, $H_{o(A)}$ and $H_{o(B)}$ having been accepted and rejected respectively in all three ANOVA tests, it must be concluded:

$H_{o(A)}$: There is no statistically significant variation in albedo among different natural veld types

$H_{1(B)}$: There is statistically significant variation between natural and disturbed veld types.

Full conclusions, more general discussion and full details on the possible impact of the research are presented in the next chapter.

CHAPTER 6

CONCLUSIONS AND DISCUSSION

> The human species has made a substantial and continuing impact on climate since the invention of fire, about a million years ago.
>
> (Sagan *et al*, 1979)

6.1 Fulfilment of the Objectives

The Primary objective of this study was to determine the variation of albedo among different veld types, and between natural and disturbed veld types. In order to do this ten veld type sites were selected for study, nine of which consisted of one natural and one disturbed site. One site was used as a control site, from which to compare the results of previous research. The sites were selected on the basis of Acocks' (1975) classification of South African veld types, and specific criteria relating to their accessibility and utilization by man. At each site radiation measurements were taken for two days in summer and one day in winter, at twelve minute intervals from 10h00 to 16h00 (local time).

The data were subjected to three-way ANOVA's to test the hypotheses $H_{o(A)}$ and $H_{o(B)}$. The former, $H_{o(A)}$, was accepted and the latter $H_{o(B)}$ rejected. An alternative hypothesis $H_{1(B)}$ was formulated and $H_{o(A)}$ and $H_{1(B)}$ form the main conclusion of this study, viz.

$H_{o(A)}$ There is no significant variation in albedo among veld types in the South Western Cape

$H_{1(B)}$ There is significant variation in albedo between natural and disturbed veld types in the South Western Cape, with the disturbed albedo consistently higher than the natural albedos

These hypotheses infer that the albedos of natural land surfaces have been significantly impacted by the activities of man.

Through burning, overgrazing and agriculture, man has increased the albedo by changing the nature of the natural veld types over large areas of the South western Cape. The effect of this increased albedo in the South African context will be discussed below.

The secondary objectives of the project were:

(a) To provide data on the local albedos, and
(b) To assess the value of the technique employed in monitoring albedo change.

Albedos of all the veld types were presented in Table 4.1. The values found there are daily means and the diurnal variation can be observed in Fig. 4.1. The results are not definitive as variation within the natural veld type may vary according to specific floristic composition. More detailed investigation is necessary to determine whether the values presented here are fully representative of the entire veld type. Nevertheless the values obtained are a valuable contribution to present knowledge in this field. They demonstrate that the albedos of natural vegetation throughout the South western Cape also display the unexpectedly low values found by Morris (1981) in the Mountain Fynbos. Even the maximum value of 16.4% measured in the semi-arid Succulent Karoo shrubland is considerably lower than the values for similar vegetation of between 20% to 30% quoted by other writers (Budyko, 1974; Hummel & Reck, 1979; Kondratyev, 1969; Otterman, 1977).

The diurnal variations of the surfaces were somewhat irregular, with some displaying the expected albedo increases with increased solar zenith angle, as found by some writers (Davies & Buttimor, 1969; Kalma & Badham, 1972). Reasons for greater afternoon increases have been put forward by Ahmad & Lockwood (1979) in terms of water stress leading to wilting and also, based on research by Nkemdirim (1972), because of spectral quality changes of the shortwave fluxes. However some sites in this project display an unexplained trend also found by Morris (1981), of lower afternoon values.

The techniques of low-level precise albedo-change investigation are undoubtedly of value. Accurate measurement of specific vegetation types is the most valuable asset of this methodology. By continual measurement of albedo on a micro-scale, such as was used, the changes of albedo can be monitored for specific areas at any time and with little difficulty. The alternative remote sensing techniques from satellite or aircraft are of value and many researchers have used them to determine albedos over larger areas. This approach may be useful for determining albedo values for regions, or whole veld types, but difficulty will be experienced in recognising and confirming the difference between natural and disturbed vegetation unless this occurs on a regional scale. Also, cloud contamination and atmospheric scatter make accurate data difficult to obtain (Henderson-Sellers & Hughes, 1982). Nevertheless, remote sensing methods may be useful to identify disturbed vegetation and, more specifically, to monitor their spread into other veld types. Further research on the South African situation is required.

The fulfilment of the objectives of this project would be of merely academic interest unless accompanied by a discussion of the implication of the research for mankind in general, and South Africans in particular.

6.2 Implications of this Study

Having determined that significant changes in surface albedo have been brought about by Man's activities, it remains to examine likely implications. Some researchers, as mentioned in Chapter

One, have related changing albedos to climate, (Bryson, 1974; Charney, 1975; Henderson-Sellers, 1980; Lockwood, 1983; Otterman, 1977), while others have determined other implications, such as variations in evapotranspiration (Seginer, 1967). Seginer evaluated the possibility of reducing the evapotranspiration of irrigated fields by increasing the albedo. He found that when the albedo of wet fields is increased from 25% to 40%, a 28% saving in water was expected due to resulting changes in the energy balance (His research was based on a numerical model and does not explain how one would go about increasing the albedo).

Most researchers, however, suggest that increased albedo is leading (or has led) to detrimental climatic effects. The reflection of additional incoming solar energy back into space is causing a decrease in sensible heat flux causing decreased atmospheric turbulence and subsequently less rainfall. (Charney, 1975; Otterman, 1974; Ratcliffe, 1978). A more detailed discussion of the climatic implications follows.

6.2.1 Climatic Impact

The albedo-climate feedback idea was introduced by Otterman (1974) who reasoned that the destruction of vegetation and exposure of soil would increase albedo and thus lower surface temperatures. This would in turn lower the sensible and latent heat fluxes to the atmosphere, and suppress convective air movement, resulting in less rainfall. Charney (1975) noted that in the Sahara some areas have negative radiation balances at the top of the atmosphere on hot summer days, in spite of the intense input of solar radiation through a cloudless atmosphere. He attributed the deficit to the high surface albedo (about 35%) and also to the high surface temperatures, due to lack of evaporation, which enhance outgoing terrestrial radiation. He postulates that overgrazing decreases the radiation balance, making it less positive or more negative. Lockwood (1983) maintains that this theory would also be valid for deserts with a positive radiation balance, as the main assumption is that adiabatic warming (descending motion), rather than advection, is the main manifestation of the decreased radiation balance.

That other areas of the earth's surface may react similarly is highly likely. Walker & Roundtree (1977) have shown from experiments that soil moisture aids rainfall, while soil dryness allows persistence of a dry season. Moist soil encourages a low surface albedo which is also maintained by a covering of natural vegetation. The removal of the vegetation similarly results in a lower surface moisture level and higher consequent albedo. Thus wherever natural vegetation removal or replacement is carried out on a large scale, leaving a covering or surface with a high albedo and lower moisture content, a rainfall decrease may be expected. The decreased rainfall may not necessarily occur in the same areas, as climatic processes and atmospheric turbulences are not merely locally caused phenomena, but the effects of the impact must ultimately be felt.

Sagan et al (1979) have considered the influence of most anthropogenic albedo changes on the earth's climate. They consider climatic modifications from desertification, the clearance of forest, urbanization, and salinization (See Table 6.1)

Table 6.1 Global Albedo Changes (after Sagan et al, 1979)

Process	Land type change	Surface albedo change %	Areal rate of change (km^2pa)	Global albedo change % over last 25 years
Desertification	Savannah → Desert	16-35	6×10^4	0.060
Salinization	Open field → salt flat	10-25 to 50	1.5×10^4	0.010-0.025
Temperate deforestation	Forest → field, grassland	12-15 summer	small	small
Tropical deforestation	Forest → Field, savannah	7-16	1×10^5	0.035
Urbanisation	Field, forest → city	17-15	2×10^4	-0.001

According to these authors changes in global albedo are 0.06% due to desertification and 0.035% due to tropical deforestation over the last ± 25 years. They further suggest that a total of 26×10^6 square kilometers of the earth's surface has undergone albedo change, resulting in a total albedo change over the last ± 25 years of 0.1% and over the past few millenia of 0.6%. Based on reckoning that a 1% change of the global albedo (currently 30%) will result in a surface temperature change of about 2° C, they estimate a global mean temperature depression of about 0.2° C over the last 25 years.

If large areas of altered surfaces, such as the areas now covered by agricultural crops had been taken into account, the impact measured by Sagan et al (1979) may, in fact, have been higher. In this project it was found that albedo changes in the order of 5 to 15% have been brought about in a country where around 80% of natural vegetation has been affected by farming activity (Barnard et al 1972).

The effect of global cooling may be offset by the increasing amounts of carbon dioxide in the atmosphere. Nevertheless, observations have shown that global mean temperature has declined by about 0.2° C since 1940 (Lockwood, 1983). Albedo variations have been implicated in singular climatic conditions over relatively small areas such as the United Kingdom. In 1976 the surface albedo of drought stricken England increased and it is claimed that the Northern European drought could have been exacerbated by internal albedo feedbacks (Ratcliffe, 1978). Henderson-Sellers (1980) admits however, that the short term effects of albedo changes on climate are not well established.

Droughts in South Africa are common. Rainfall in some areas is so low and irregular that human use of the land is severely restricted. The overgrazing that has taken, and still does take, place increases the albedo of the surface. Whether this aggravates the drought or not is, in South Africa, unproven, but further research may well reveal that the spread of desert is encouraged by man-induced changes to the albedo. These would include changes brought about in a non-drought environment where natural vegetation, with its naturally evolved albedo values, is being replaced by high albedo crops.

6.2.2 Remedial Measures

The 'What can be done about it?' question is a direct consequence of a discussion of implications of increased albedo. The two main causes of increased albedo in South Africa are thought to be overgrazing and agricultural crop development. To a lesser extent in South Africa, but not in some areas of the world, deforestation, urbanisation and fire are also activities which contribute to higher albedos. Overgrazing is aggravated by drought and increasing demand for meat, while crop development increases daily to cope with the high demand for food in this developing country.

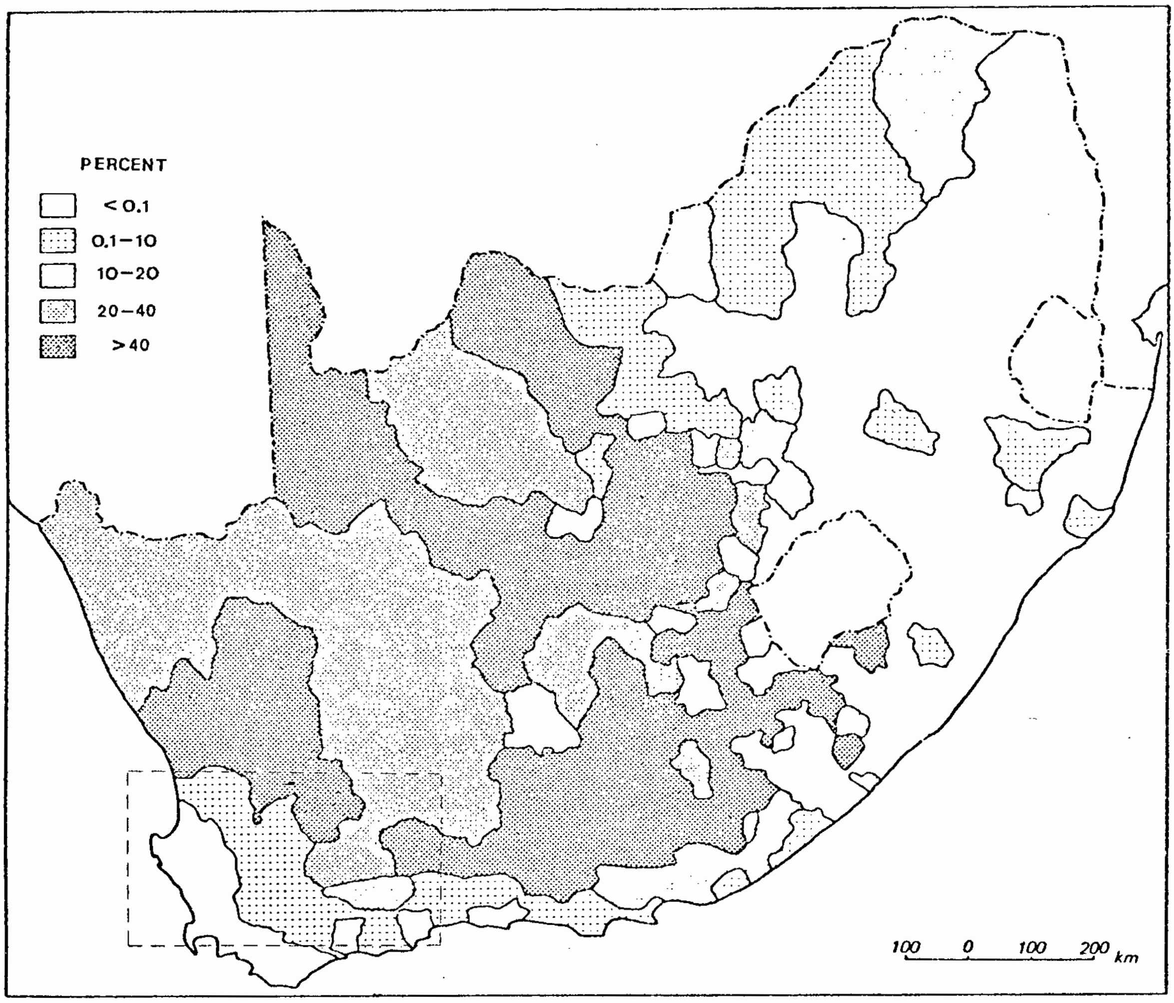


Fig 6.1 Frequency of Drought in South Africa: the percentage of months between 1948 and 1962 for districts officially declared drought-stricken, after Barnard et al (1972).

In many areas of South Africa, drought is regarded as the norm and rainfall is regarded as a scarcity. Over the study area, as seen from Fig. 6.1, the frequency of droughts can be seen as varying from 'almost never' in the south west to 'generally' in the northwest. Barnard et al (1972) maintains that when the natural vegetation is decimated by overgrazing during drought, to such an extent that there is little hope of recovery, the only effective measure is to withdraw all livestock from the stricken areas. However, withdrawal should commence before the veld has reached a point of no return. Once the vegetation (and albedo) is returned to its former state, the carefully monitored grazing of areas may continue.

The large scale conversion of natural vegetation to cropland cannot be stopped overnight. High albedo crops include many staple foods such as wheat, maize and indirectly lucerne, which are vital to the country's 20 million inhabitants. Improved farming practices where the indiscriminate reduction of natural veld is not condoned, may be the only method of improving the situation. (The average albedo of maize, given by Graham & King (1961) is 16%)

The most successful stimulus for implementing the above measures would come from proof of high-albedo/rainfall feedback and long-term research on this topic is needed. Only then might a large scale effort to restore natural vegetation and hopefully increase the rainfall, be seriously considered by farmers and agricultural planners.

6.3 Suggestions for further research

Aspects of possible future research have been mentioned above. Research effort could fall into two main categories:

(a) Determining on a wider scale the surface albedos of different land surfaces in South Africa, and

(b) More systematic investigation into climatic changes and the role of albedo feedback on the climate in this country.

'The possible impact of man's activities upon the climate can be best studied in terms of known and understood 'natural' change' (Schneider & Mesirow, 1976). The processes of albedo changes are known and understood and further research can develop the ability to determine the possible impact on the climate.

6.4 Conclusion

The aim of the project was to investigate variations in albedo among natural and disturbed veld types in the S W Cape. Field work entailed detailed and intensive measurements of surface albedo over ten veld types, taking both natural veld and man-induced alterations to the veld into account. Statistical evidence, through a three-way analysis of variance model, supported the hypothesis that no significant variation in albedo exists among veld types, but led to the rejection of the hypothesis that no significant variation in albedo exists within veld types - due to man induced disturbance. Consequently an alternative hypothesis was set up: that significant variation in albedo exists in veld types where disturbances have been introduced.

It was found that albedo increased on average, from 11.5% for natural vegetation, to 18.4% for disturbed vegetation in summer and similarly from 10.9% to 16.6% in winter. The increased albedos suggest possible climatic impacts but no proof or evidence exists to support this in this country and future research should address this.

That man is a primary agent in changing albedos is clear. Through farming activity, which in the case of South Africa occupies about 84% of the total land surface and contributes about 10% of the Gross Domestic Product (Barnard et al, 1972), human impact on the natural vegetation status has resulted. The spread of desert and karoo, caused by overgrazing is an already recognized problem (Acocks, 1975). The conversion of large areas of natural vegetation into cropland is more insidious and is found to have an equally large effect on the albedo.

The relatively low rainfall in South Africa is a severe limiting factor on the agricultural and economic growth of the country and any factors which may bring about reduced precipitation therefore need thorough investigation. The fact that southern Africa is presently facing one of its most crippling droughts reinforces this.

This research has revealed numerical evidence of changing albedos in the South western Cape. Albedo values for natural veld types were found and the effects of man-induced changes on the albedo were determined. The study area comprised only part of the Cape Province but reasonable extrapolation can be made to the rest of the country. However, quantified experiments on albedo-climate interactions are necessary and much more detailed models are required before final conclusions can be made regarding the influence of albedo on climate.

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APPENDICES

1	Solar Radiation Measurements	1/1
2	Two-Way ANOVAS	2/1
3	Field Data: Vegetation and Soils	3/1
4	Field Data: Cloudiness and Temperature	4/1

APPENDIX 1

RADIATION MEASUREMENTS

NOTE:

A test for outliers was performed on the results and rejected readings are given as .0 for all columns

SITE 1 DATE 5 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATIC (CALCULATI (W/SQ.M)(
1000	531.8	63.4	11.9	466.6	51.1	10.9	468.7	468.3
1012	944.7	105.5	11.2	751.2	85.2	11.3	827.6	839.2
1024	340.0	42.7	12.6	227.1	26.1	11.5	319.4	297.3
1036	937.6	93.5	10.0	947.1	102.7	10.8	816.1	844.1
1048	945.2	93.4	9.9	954.5	100.7	10.6	824.2	851.8
1100	1002.2	106.1	10.6	1026.3	112.0	10.9	868.9	896.1
1112	996.1	106.3	10.7	991.6	103.9	10.5	869.4	889.8
1124	990.9	101.7	10.3	1016.8	109.6	10.8	880.1	889.2
1136	985.2	102.7	10.4	1006.6	105.3	10.5	865.5	882.4
1148	1012.5	104.9	10.4	1042.0	107.9	10.4	896.6	907.5
1200	1001.5	99.0	9.9	1043.4	109.6	10.5	902.9	902.5
1212	1005.6	103.1	10.3	1049.6	109.0	10.4	909.7	902.5
1224	1020.3	106.1	10.4	1075.6	115.0	10.7	923.3	914.1
1236	1010.0	105.2	10.4	1072.2	116.8	10.9	914.9	904.8
1248	.0	.0	.0	.0	.0	.0	.0	.0
1300	1013.2	105.3	10.4	1074.0	112.0	10.4	684.1	907.9
1312	1003.2	105.7	10.5	1064.8	111.2	10.4	894.2	897.5
1324	997.9	106.8	10.7	1056.3	109.3	10.3	879.3	891.1
1336	1009.3	107.9	10.7	1069.4	112.6	10.5	883.3	901.4
1348	996.7	100.4	10.1	1054.2	109.9	10.4	872.0	896.4
1400	.0	.0	.0	.0	.0	.0	.0	.0
1412	980.5	99.2	10.1	1030.2	109.5	10.6	843.3	881.3
1424	972.1	105.8	10.9	1016.8	109.5	10.8	825.5	866.2
1436	974.1	100.6	10.3	1011.1	106.4	10.5	827.1	873.5
1448	933.5	110.6	11.8	1029.6	113.3	11.0	832.8	822.9
1500	927.4	102.3	11.0	958.2	104.0	10.9	776.1	825.1
1512	911.1	97.4	10.7	936.8	101.5	10.8	761.7	813.6
1524	920.0	100.0	10.9	942.5	105.7	11.2	766.7	820.0
1536	877.8	94.5	10.8	898.8	101.7	11.3	723.6	783.3
1548	828.6	94.2	11.4	838.3	95.1	11.3	671.3	734.5
1600	793.2	86.1	10.9	804.6	91.4	11.4	637.3	707.0

MEAN = 10.69 MEAN = 10.78
STD. DEVIATION = .62 STD. DEVIATION = .35
N = 29

SITE 1 DATE 6 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATION (CALCULATED) (W/SQ.M) (
1000	840.5	89.9	10.7	833.3	96.1	11.5	683.6	750.6
1012	865.3	90.0	10.4	862.1	99.4	11.5	720.4	775.2
1024	892.7	98.7	11.1	893.3	102.2	11.4	748.1	794.0
1036	908.6	93.5	10.3	911.8	99.5	10.9	771.9	815.1
1048	926.7	95.0	10.2	938.7	101.0	10.8	792.0	831.7
1100	943.1	94.6	10.0	958.1	100.6	10.5	810.9	848.5
1112	963.4	98.8	10.3	983.5	104.5	10.6	828.4	864.6
1124	978.1	105.1	10.7	1001.8	105.7	10.6	841.4	873.0
1136	986.9	105.1	10.6	1019.0	110.6	10.9	855.3	881.8
1148	990.9	107.7	10.9	1025.5	108.0	10.5	865.2	883.3
1200	997.9	106.6	10.7	1039.5	109.3	10.5	877.8	891.3
1212	995.8	102.1	10.3	1045.8	107.5	10.3	884.3	893.7
1224	993.8	102.1	10.3	1048.5	107.3	10.2	890.6	891.7
1236	998.9	106.6	10.7	1056.6	107.4	10.2	895.0	892.2
1248	999.6	110.4	11.0	1061.9	111.5	10.5	896.1	889.2
1300	1004.4	114.8	11.4	1064.9	109.2	10.3	896.3	889.5
1312	998.2	104.9	10.5	1063.6	105.0	9.9	895.8	893.2
1324	994.5	102.0	10.3	1064.1	106.2	10.0	890.3	892.6
1336	1000.1	108.7	10.9	1058.0	105.7	10.0	880.9	891.4
1348	991.2	100.6	10.2	1054.6	105.0	10.0	872.6	890.6
1400	989.6	105.0	10.6	1046.0	103.7	9.9	862.6	884.6
1412	978.9	103.0	10.5	1034.2	104.1	10.1	848.0	875.8
1424	965.7	97.6	10.1	1016.3	99.9	9.8	835.4	868.1
1436	965.6	106.8	11.1	1002.4	100.6	10.0	819.2	858.8
1448	943.8	100.6	10.7	979.0	100.5	10.3	800.9	843.1
1500	921.2	98.0	10.6	952.1	96.1	10.1	783.2	823.2
1512	905.5	101.3	11.2	930.7	96.7	10.4	762.0	804.2
1524	876.8	88.4	10.1	889.7	94.4	10.6	737.4	788.4
1536	844.6	88.3	10.5	863.9	90.1	10.4	712.6	756.2
1548	818.8	87.0	10.6	834.5	90.3	10.8	681.2	731.7
1600	783.7	77.1	9.8	807.4	86.2	10.7	645.9	706.6

MEAN = 10.55 MEAN = 10.46

STD. DEVIATION = .37 STD. DEVIATION = .46

N = 31

SITE 2 DATE 8 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATIO (CALCULATE (W/SQ.M)(
1000	838.5	87.1	10.4	826.5	233.7	28.3	687.5	751.4
1012	861.8	89.6	10.4	857.1	241.0	28.1	722.8	772.2
1024	893.6	95.7	10.7	893.0	252.0	28.2	749.7	797.9
1036	917.6	93.8	10.2	911.7	255.2	28.0	772.4	823.8
1048	935.8	100.0	10.7	934.4	265.6	28.4	790.7	835.8
1100	951.4	97.1	10.2	959.6	270.7	28.2	808.8	854.4
1112	968.8	100.5	10.4	984.8	279.2	28.4	825.5	868.3
1124	983.4	107.4	10.9	998.0	283.3	28.4	838.6	876.1
1136	982.2	100.1	10.2	1011.6	290.1	28.7	850.9	882.1
1148	1000.9	117.0	11.7	1029.1	301.3	29.3	862.6	883.9
1200	1003.1	116.1	11.6	1033.2	301.3	29.2	872.8	887.0
1212	999.1	112.4	11.3	1042.0	305.1	29.3	882.2	886.7
1224	1003.0	117.0	11.7	1050.5	308.8	29.4	887.2	886.0
1236	995.7	109.7	11.0	1057.1	309.8	29.3	892.2	886.0
1248	998.7	115.0	11.5	1060.2	310.6	29.3	893.7	883.7
1300	989.9	121.2	12.2	1055.6	316.0	29.9	894.5	868.7
1312	995.8	105.3	10.6	1067.2	313.6	29.4	890.9	890.5
1324	994.3	106.9	10.7	1066.1	315.9	29.6	884.8	887.4
1336	1002.9	114.3	11.4	1058.3	312.6	29.5	877.3	888.6
1348	1002.4	111.4	11.1	1053.1	307.8	29.2	873.3	891.0
1400	987.3	105.0	10.6	1046.5	309.8	29.6	859.0	882.3
1412	983.4	103.8	10.6	1034.1	305.9	29.6	847.5	879.6
1424	981.0	105.1	10.7	1025.1	300.2	29.3	835.2	876.0
1436	972.8	108.0	11.1	1010.0	300.4	29.7	820.5	864.9
1448	946.3	115.0	12.1	984.1	296.4	30.1	803.3	831.3
1500	930.0	98.7	10.6	959.9	285.6	29.7	782.1	831.3
1512	922.8	107.5	11.6	939.2	283.0	30.1	759.6	815.3
1524	896.5	100.4	11.2	912.4	273.7	30.0	737.9	796.1
1536	870.8	91.5	10.5	879.3	264.1	30.0	713.1	779.2
1548	847.5	95.1	11.2	845.1	257.2	30.4	680.2	752.4
1600	814.3	91.3	11.2	816.0	250.3	30.7	644.4	723.0

MEAN = 10.98 MEAN = 29.27

STD. DEVIATION = .56 STD. DEVIATION = .73

N = 31

SITE 2 DATE 9 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATIO (CALCULATE (W/SQ.M)(
1000	850.8	91.4	10.7	848.5	227.1	26.8	692.7	759.3
1012	872.0	89.0	10.2	872.8	236.9	27.1	729.0	783.0
1024	895.5	88.5	9.9	896.6	245.4	27.4	752.3	807.0
1036	923.3	94.3	10.2	928.4	248.3	26.8	780.0	829.0
1048	946.3	95.6	10.1	957.7	263.2	27.5	800.7	850.7
1100	967.7	101.5	10.5	980.1	270.9	27.6	818.2	866.2
1112	976.3	104.2	10.7	1001.0	281.7	28.1	827.3	872.1
1124	998.3	112.7	11.3	1019.8	288.7	28.3	845.1	885.6
1136	1003.3	107.2	10.7	1029.4	292.8	28.4	857.7	896.1
1148	1006.1	105.5	10.5	1050.8	300.9	28.6	871.5	900.7
1200	982.3	108.8	11.1	1034.3	304.0	29.4	848.5	873.6
1212	1017.6	112.0	11.0	1061.6	307.3	28.9	887.2	905.5
1224	1018.2	112.4	11.0	1075.0	313.8	29.2	899.0	905.8
1236	1020.4	118.3	11.6	1085.1	317.0	29.2	898.4	902.1
1248	1019.0	115.0	11.3	1087.5	318.3	29.3	901.3	904.0
1300	1018.9	111.4	10.9	1086.3	315.7	29.1	903.7	907.5
1312	1016.1	115.3	11.3	1077.7	315.0	29.2	895.8	900.8
1324	1006.7	111.6	11.1	1073.1	314.1	29.3	879.1	895.1
1336	1010.3	109.9	10.9	1073.1	309.1	28.8	878.3	900.4
1348	1013.8	105.5	10.4	1080.7	313.5	29.0	875.4	908.3
1400	1000.6	104.5	10.4	1061.1	307.9	29.0	857.9	896.1
1412	1009.0	114.3	11.3	1053.3	308.4	29.3	849.3	894.7
1424	991.1	110.6	11.2	1028.9	309.3	30.1	839.4	880.5
1436	978.7	98.4	10.1	1021.9	298.8	29.2	823.4	880.3
1448	964.9	103.4	10.7	993.3	289.0	29.1	800.7	861.5
1500	950.7	111.4	11.7	966.3	282.8	29.3	779.0	839.3
1512	931.3	104.3	11.2	952.2	278.0	29.2	766.2	827.0
1524	903.4	94.3	10.4	918.3	271.0	29.5	741.3	809.1
1536	882.7	97.3	11.0	889.1	260.6	29.3	716.2	785.4
1548	847.5	93.3	11.0	853.8	253.9	29.7	681.2	754.2
1600	824.1	92.9	11.3	820.6	247.0	30.1	644.6	731.2

MEAN = 10.83 MEAN = 28.77

STD. DEVIATION = .47 STD. DEVIATION = .90

N = 31

SITE 3 DATE 10 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATION (CALCULATED (W/SQ.M)(1
1000	956.4	106.5	11.1	945.2	182.6	19.3	780.8	849.9
1012	514.5	56.6	11.0	423.8	79.8	18.8	387.9	457.9
1024	1016.3	110.9	10.9	1021.3	194.4	19.0	863.7	905.4
1036	1050.0	108.1	10.3	1057.3	196.4	18.6	885.6	941.9
1048	1077.8	110.6	10.3	1061.4	194.2	18.3	908.1	967.2
1100	649.9	74.9	11.5	569.5	107.7	18.9	538.0	575.0
1112	630.0	74.6	11.8	819.8	155.7	19.0	536.1	555.4
1124	709.1	76.8	10.8	733.0	132.5	18.1	580.3	632.3
1136	1240.2	132.0	10.6	1276.4	234.4	18.4	1069.6	1108.2
1148	1086.9	119.1	11.0	1117.4	201.8	18.1	934.0	967.8
1200	1113.5	123.2	11.1	1156.8	207.8	18.0	964.6	990.2
1212	1022.8	113.5	11.1	1072.7	192.1	17.9	886.9	909.3
1224	876.4	91.9	10.5	741.1	129.4	17.5	711.5	784.6
1236	1026.2	110.6	10.8	1095.7	191.5	17.5	908.4	915.5
1248	1023.2	115.0	11.2	1096.1	193.3	17.6	898.2	908.2
1300	1044.2	113.9	10.9	1111.9	190.7	17.2	917.3	930.2
1312	1029.4	113.5	11.0	1102.4	191.4	17.4	901.0	915.9
1324	1014.7	104.0	10.3	1095.6	192.1	17.5	885.1	910.7
1336	1025.5	115.2	11.2	1086.5	192.9	17.8	881.2	910.3
1348	1024.1	111.2	10.9	1075.9	188.5	17.5	877.0	913.0
1400	1020.3	107.5	10.5	1069.2	187.2	17.5	867.8	912.8
1412	1012.1	106.1	10.5	1053.1	184.8	17.5	856.9	906.0
1424	982.6	104.2	10.6	1023.5	182.4	17.8	823.4	878.4
1436	995.3	107.3	10.8	1011.0	181.1	17.9	831.3	888.0
1448	976.5	102.0	10.4	985.9	177.2	18.0	813.0	874.5
1500	955.8	95.3	10.0	968.7	175.9	18.2	799.4	860.5
1512	940.4	97.2	10.3	927.7	167.3	18.0	776.9	843.2
1524	911.4	88.6	9.7	898.7	169.0	18.8	754.7	822.7
1536	885.3	85.8	9.7	868.3	166.1	19.1	728.3	799.4
1548	863.7	91.7	10.6	832.4	158.1	19.0	697.2	772.0
1600	820.7	79.6	9.7	796.7	153.0	19.2	661.6	741.0

MEAN = 10.69 MEAN = 18.17

STD. DEVIATION = .51 STD. DEVIATION = .64

N = 31

SITE 3 DATE 11 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	NATURAL SITE (1) REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	DISTURBED SITE (2) REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET BALANCE CHECK NET SW RADIATION (CALCULATED (W/SQ.M)(1
1000	807.5	88.2	10.9	756.5	140.5	18.6	680.4	719.3
1012	466.7	54.4	11.7	464.3	88.4	19.0	379.6	412.3
1024	799.1	85.3	10.7	853.9	153.2	17.9	696.6	713.8
1036	562.6	61.0	10.8	572.9	110.3	19.3	464.5	501.6
1048	412.5	52.3	12.7	404.5	79.1	19.6	321.0	360.2
1100	411.1	50.4	12.3	412.9	80.3	19.5	329.9	360.6
1112	1023.1	108.8	10.6	1030.9	187.3	18.2	871.5	914.2
1124	793.8	92.8	11.7	852.2	147.2	17.3	715.7	701.0
1136	984.3	100.4	10.2	1016.1	181.9	17.9	852.7	883.9
1148	997.4	105.4	10.6	1032.6	182.3	17.7	867.6	892.0
1200	1005.2	107.7	10.7	1047.8	184.2	17.6	878.6	897.5
1212	1002.4	103.8	10.4	1051.2	180.4	17.2	885.9	898.6
1224	1009.2	111.4	11.0	1067.5	186.6	17.5	892.7	897.9
1236	1009.8	113.3	11.2	1072.7	187.5	17.5	895.6	896.5
1248	1012.6	113.8	11.2	1076.7	186.8	17.4	897.1	898.8
1300	1013.4	110.0	10.9	1085.6	187.7	17.3	901.0	903.4
1312	1019.3	113.4	11.1	1084.6	186.1	17.2	898.4	905.9
1324	1021.7	109.9	10.8	1086.7	188.0	17.3	899.0	911.8
1336	1019.6	105.2	10.3	1070.7	184.1	17.2	888.0	914.4
1348	1021.6	108.2	10.6	1071.7	185.0	17.3	883.8	913.5
1400	1019.7	106.9	10.5	1064.4	186.2	17.5	877.0	912.8
1412	1011.0	102.6	10.2	1046.1	182.8	17.5	867.1	908.4
1424	1007.9	102.7	10.2	1033.9	181.1	17.5	858.2	905.1
1436	983.7	100.6	10.2	1001.1	178.9	17.9	832.8	883.2
1448	971.5	101.3	10.4	975.5	172.7	17.7	815.3	870.2
1500	958.8	93.7	9.8	956.8	171.4	17.9	806.7	865.1
1512	943.0	92.6	9.8	935.5	172.7	18.5	784.7	850.3
1524	1020.1	101.2	9.9	999.4	185.6	18.6	849.3	918.9
1536	943.4	95.7	10.1	918.1	169.2	18.4	778.7	847.7
1548	945.5	98.4	10.4	899.4	167.4	18.6	768.8	847.2
1600	821.9	84.1	10.2	795.1	152.0	19.1	656.4	737.8

MEAN = 10.71 MEAN = 17.97

STD. DEVIATION = .67 STD. DEVIATION = .73

N = 31

SITE 4 DATE 12 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATION (CALCULATE (W/SQ.M)(
1000	743.5	69.3	9.3	732.7	92.5	12.6	640.2	674.2
1012	917.3	85.0	9.3	910.0	109.0	12.0	783.7	832.3
1024	900.8	80.9	9.0	897.9	108.3	12.1	787.6	819.9
1036	900.5	82.1	9.1	908.2	110.5	12.2	781.6	818.5
1048	920.2	86.0	9.3	925.5	113.8	12.3	796.0	834.3
1100	950.5	89.4	9.4	964.3	119.6	12.4	823.7	861.0
1112	960.4	91.2	9.5	973.7	117.4	12.1	833.9	869.3
1124	968.5	91.7	9.5	987.1	116.8	11.8	845.1	876.7
1136	979.0	92.5	9.5	1004.0	120.8	12.0	860.8	886.4
1148	984.7	94.6	9.6	1018.7	126.4	12.4	869.9	890.1
1200	992.6	97.4	9.8	1027.1	126.0	12.3	881.2	895.1
1212	995.0	96.4	9.7	1037.9	126.3	12.2	890.9	898.7
1224	998.1	97.3	9.8	1046.2	127.1	12.1	896.9	900.8
1236	1002.9	103.0	10.3	1053.6	128.8	12.2	899.5	899.9
1248	996.3	94.1	9.4	1059.8	132.1	12.5	908.4	902.2
1300	1013.1	102.7	10.1	1070.2	127.4	11.9	913.3	910.4
1312	931.5	91.3	9.8	974.7	119.3	12.2	822.1	840.2
1324	983.6	96.2	9.8	1043.1	126.7	12.2	884.3	887.3
1336	1008.0	96.6	9.6	1073.7	133.2	12.4	906.0	911.4
1348	1002.2	99.7	9.9	1057.4	130.1	12.3	889.3	902.5
1400	986.5	95.7	9.7	1040.2	127.0	12.2	872.3	890.7
1412	983.5	92.8	9.4	1030.9	124.1	12.0	858.7	890.7
1424	968.3	92.2	9.5	1011.3	119.6	11.8	842.5	876.1
1436	956.3	90.3	9.4	999.6	122.6	12.3	829.4	865.9
1448	940.7	93.7	10.0	980.3	124.6	12.7	816.4	847.0
1500	926.6	91.2	9.8	954.1	117.7	12.3	797.8	835.4
1512	461.6	50.3	10.9	474.0	60.9	12.8	370.9	411.3
1524	977.2	97.4	10.0	996.4	128.9	12.9	856.1	879.9
1536	900.7	81.5	9.0	915.8	112.6	12.3	768.3	819.2
1548	890.1	81.3	9.1	902.4	112.5	12.5	759.9	808.9
1600	814.3	74.9	9.2	821.4	101.7	12.4	677.3	739.3

MEAN = 9.61 MEAN = 12.27
STD. DEVIATION = .40 STD. DEVIATION = .26
N = 31

SITE 4 DATE 13 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATIO (CALCULATE (W/SQ.M)(
1000	833.9	81.1	9.7	826.7	106.1	12.8	690.1	752.8
1012	857.7	77.4	9.0	855.6	110.3	12.9	723.8	780.3
1024	885.3	82.7	9.3	881.9	109.5	12.4	753.4	802.5
1036	911.5	90.2	9.9	909.2	115.1	12.7	775.6	821.3
1048	930.6	88.6	9.5	938.7	119.4	12.7	797.5	842.0
1100	950.8	91.0	9.6	957.4	118.1	12.3	815.8	859.8
1112	960.7	89.5	9.3	973.5	120.8	12.4	831.3	871.1
1124	971.2	89.7	9.2	998.8	124.7	12.5	848.5	881.5
1136	990.9	98.4	9.9	1018.8	130.7	12.8	860.5	892.5
1148	992.8	98.3	9.9	1022.0	129.2	12.6	873.1	894.5
1200	996.2	95.8	9.6	1039.0	132.1	12.7	887.7	900.4
1212	1003.7	97.9	9.8	1045.1	129.5	12.4	899.2	905.8
1224	1009.8	102.6	10.2	1056.1	133.4	12.6	903.9	907.3
1236	1012.6	103.4	10.2	1068.4	136.5	12.8	905.8	909.2
1248	1000.8	94.5	9.4	1068.5	135.2	12.7	909.9	906.3
1300	999.9	95.1	9.5	1066.3	134.5	12.6	907.1	904.8
1312	1009.2	99.3	9.8	1061.6	130.7	12.3	902.9	909.8
1324	1013.1	105.2	10.4	1075.2	140.3	13.0	899.0	908.0
1336	1008.4	97.0	9.6	1067.7	134.2	12.6	894.0	911.4
1348	1014.0	105.4	10.4	1051.1	128.9	12.3	884.1	908.6
1400	1009.9	106.1	10.5	1042.1	128.9	12.4	871.2	903.8
1412	995.1	100.2	10.1	1027.9	126.0	12.3	861.3	894.9
1424	979.8	95.6	9.8	1017.4	126.9	12.5	849.8	884.3
1436	969.7	100.1	10.3	989.0	121.0	12.2	833.6	869.6
1448	952.0	94.7	9.9	974.5	122.2	12.5	815.3	857.3
1500	928.1	88.7	9.6	953.4	122.6	12.9	798.1	839.4
1512	911.5	91.7	10.1	924.8	116.7	12.6	776.4	819.8
1524	890.8	89.6	10.1	897.0	114.2	12.7	751.5	801.2
1536	855.7	83.2	9.7	865.8	110.4	12.7	725.6	772.5
1548	.0	.0	.0	.0	.0	.0	.0	.0
1600	.0	.0	.0	.0	.0	.0	.0	.0

MEAN = 9.81 MEAN = 12.59

STD. DEVIATION = .37 STD. DEVIATION = .21

N = 29

SITE 5 DATE 15 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATIO (CALCULATE (W/SQ.M)(
1000	976.2	80.6	8.3	893.4	100.8	11.3	737.1	895.6
1012	989.8	85.2	8.6	924.2	103.3	11.2	765.6	904.6
1024	995.4	84.7	8.5	948.9	107.4	11.3	789.2	910.7
1036	1011.0	94.3	9.3	975.5	110.6	11.3	808.8	916.7
1048	1020.4	97.8	9.6	996.7	112.1	11.2	822.9	922.6
1100	1025.2	96.2	9.4	1020.3	114.2	11.2	840.4	929.0
1112	1030.2	102.2	9.9	1042.5	122.2	11.7	852.7	928.0
1124	1034.6	102.3	9.9	1063.7	124.5	11.7	869.2	932.3
1136	1042.1	109.5	10.5	1077.0	127.1	11.8	873.9	932.6
1148	1034.9	100.7	9.7	1082.5	124.8	11.5	885.6	934.2
1200	1037.5	105.7	10.2	1092.8	127.1	11.6	894.5	931.8
1212	1038.7	110.6	10.7	1095.8	125.9	11.5	900.0	928.1
1224	1039.9	108.8	10.5	1110.1	129.0	11.6	903.1	931.2
1236	1044.3	114.7	11.0	1114.3	130.9	11.7	902.1	929.6
1248	1036.4	110.2	10.6	1115.4	130.3	11.7	902.9	926.2
1300	1032.6	111.9	10.8	1111.7	128.1	11.5	903.1	920.8
1312	1022.1	107.2	10.5	1111.0	125.6	11.3	895.8	914.9
1324	1014.6	105.8	10.4	1113.5	125.9	11.3	897.1	908.7
1336	1003.7	114.1	11.4	1115.5	131.6	11.8	889.0	889.6
1348	983.3	107.9	11.0	1105.0	128.6	11.6	881.7	875.4
1400	965.7	106.6	11.0	1091.9	124.8	11.4	863.4	859.1
1412	984.1	113.8	11.6	1114.5	129.0	11.6	888.2	870.3
1424	938.4	113.4	12.1	1077.9	125.9	11.7	856.6	825.0
1436	935.6	106.3	11.4	1075.9	120.9	11.2	860.3	829.3
1448	880.7	106.0	12.0	1031.7	119.5	11.6	823.1	774.7
1500	863.9	104.3	12.1	1025.9	118.4	11.5	816.6	759.6
1512	.0	.0	.0	.0	.0	.0	.0	.0
1524	.0	.0	.0	.0	.0	.0	.0	.0
1536	810.2	99.3	12.3	983.9	112.1	11.4	806.2	710.8
1548	499.1	61.8	12.4	399.0	46.5	11.7	391.3	437.3
1600	736.2	95.3	12.9	928.3	106.6	11.5	728.0	640.9

MEAN = 10.64 MEAN = 11.50
STD. DEVIATION = 1.20 STD. DEVIATION = .19
N = 29

SITE 5 DATE 16 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATIO (CALCULATE (W/SQ.M)(
1000	861.0	68.1	7.9	853.6	98.2	11.5	713.9	792.8
1012	893.8	74.8	8.4	883.2	102.9	11.6	745.0	818.9
1024	916.7	78.8	8.6	913.1	106.0	11.6	769.6	837.9
1036	948.1	88.4	9.3	946.1	110.0	11.6	794.1	859.7
1048	956.4	88.4	9.2	965.1	112.8	11.7	810.1	867.9
1100	977.7	88.6	9.1	988.9	115.9	11.7	826.5	889.1
1112	985.7	90.3	9.2	1004.9	117.4	11.7	835.4	895.4
1124	967.2	93.9	9.7	1021.1	120.3	11.8	849.6	873.3
1136	1002.3	96.0	9.6	1038.5	123.1	11.9	863.1	906.3
1148	1009.0	93.9	9.3	1048.5	123.6	11.8	871.8	915.1
1200	1016.6	102.3	10.1	1064.8	124.1	11.7	882.7	914.3
1212	1013.5	105.4	10.4	1071.0	127.3	11.9	877.8	908.1
1224	1023.8	107.7	10.5	1080.9	125.4	11.6	894.8	916.1
1236	1028.7	108.5	10.5	1098.1	133.2	12.1	899.2	920.2
1248	1030.7	111.1	10.8	1101.3	132.3	12.0	900.0	919.6
1300	1036.1	114.5	11.1	1103.6	130.7	11.8	900.8	921.6
1312	1041.5	112.5	10.8	1107.1	131.1	11.8	893.5	929.0
1324	1043.0	110.5	10.6	1108.1	131.2	11.8	893.2	932.5
1336	1045.9	110.3	10.5	1103.8	131.8	11.9	889.3	935.7
1348	1038.7	108.7	10.5	1098.0	129.7	11.8	879.9	930.0
1400	1032.3	108.2	10.5	1087.6	127.9	11.8	865.5	924.1
1412	1032.1	109.1	10.6	1080.3	127.7	11.8	860.3	922.9
1424	1022.3	109.5	10.7	1054.8	123.0	11.7	844.3	912.8
1436	1008.5	105.6	10.5	1047.5	126.7	12.1	828.4	902.9
1448	987.7	102.4	10.4	1022.8	123.6	12.1	809.8	885.2
1500	966.1	100.9	10.4	987.4	116.9	11.8	786.6	865.3
1512	941.2	98.5	10.5	953.2	110.2	11.6	759.4	842.7
1524	906.8	101.1	11.1	918.0	106.2	11.6	734.8	805.7
1536	880.7	95.1	10.8	859.5	105.2	12.2	704.5	785.6
1548	847.4	94.0	11.1	854.1	103.4	12.1	665.3	753.4
1600	812.9	87.1	10.7	817.6	97.5	11.9	631.5	725.8

MEAN = 10.11 MEAN = 11.81
STD. DEVIATION = .85 STD. DEVIATION = .19
N = 31

SITE 6 DATE 17 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATIO (CALCULATE (W/SQ.M)(
1000	865.1	64.1	7.4	856.4	91.4	10.7	754.9	801.1
1012	901.6	67.9	7.5	896.2	95.3	10.6	792.3	833.7
1024	920.6	69.9	7.6	919.4	97.8	10.6	813.0	850.7
1036	939.2	64.5	6.9	947.3	99.6	10.5	835.7	874.6
1048	966.4	73.4	7.6	977.5	106.4	10.9	853.7	893.0
1100	969.1	65.3	6.7	985.9	102.4	10.4	866.3	903.8
1112	984.2	69.8	7.1	1005.5	105.0	10.4	874.4	914.4
1124	1009.3	75.2	7.4	1032.2	111.0	10.8	899.2	934.1
1136	1018.6	74.2	7.3	1049.3	111.0	10.6	910.7	944.4
1148	1025.5	79.6	7.8	1061.6	114.7	10.8	917.3	945.8
1200	1024.3	74.2	7.2	1073.1	113.0	10.5	925.4	950.1
1212	1052.6	77.6	7.4	1108.2	117.8	10.6	954.1	975.0
1224	1079.6	83.9	7.8	1141.4	127.4	11.2	976.9	995.7
1236	1116.7	86.9	7.8	1185.6	128.4	10.8	1013.4	1029.8
1248	.0	.0	.0	.0	.0	.0	.0	.0
1300	1105.2	83.8	7.6	1177.6	127.4	10.8	1016.6	1021.4
1312	1056.6	76.0	7.2	1131.8	124.8	11.0	961.2	980.6
1324	1068.5	81.1	7.6	1138.9	124.4	10.9	964.6	987.4
1336	836.7	63.7	7.6	622.3	67.3	10.8	635.2	773.0
1348	1060.4	82.3	7.8	1122.4	123.0	11.0	934.2	978.1
1400	.0	.0	.0	.0	.0	.0	.0	.0
1412	1056.9	77.1	7.3	1102.3	115.2	10.4	920.4	979.9
1424	1039.0	76.9	7.4	1080.4	116.0	10.7	900.0	962.1
1436	1020.8	81.8	8.0	1054.4	116.5	11.0	868.6	939.1
1448	993.4	78.9	7.9	1015.3	110.9	10.9	842.0	914.5
1500	965.4	77.4	8.0	980.3	106.3	10.8	809.0	888.0
1512	934.0	71.1	7.6	946.3	102.6	10.8	779.5	862.9
1524	917.6	76.7	8.4	921.1	106.4	11.6	756.5	840.8
1536	879.1	70.6	8.0	875.9	96.3	11.0	718.3	808.5
1548	845.6	64.8	7.7	846.6	95.2	11.2	682.5	780.7
1600	812.7	65.1	8.0	805.6	89.0	11.0	642.3	747.5

MEAN = 7.57 MEAN = 10.82

STD. DEVIATION = .36 STD. DEVIATION = .26

N = 29

SITE 6 DATE 18 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATIO (CALCULATE (W/SQ.M)(
1000	882.4	68.4	7.8	867.7	95.0	10.9	757.3	814.0
1012	914.6	70.8	7.7	905.8	95.9	10.6	792.6	843.8
1024	935.7	73.0	7.8	930.8	100.3	10.8	815.3	862.7
1036	954.1	72.9	7.6	953.8	103.6	10.9	832.6	881.2
1048	972.5	72.8	7.5	978.8	103.3	10.6	852.7	899.8
1100	993.9	74.1	7.5	1001.5	108.0	10.8	868.4	919.8
1112	1020.5	82.8	8.1	1037.2	116.3	11.2	890.6	937.7
1124	1024.0	82.6	8.1	1050.8	118.3	11.3	899.0	941.4
1136	1023.2	79.1	7.7	1053.8	115.6	11.0	906.5	944.1
1148	1036.1	79.7	7.7	1075.8	119.8	11.1	926.1	956.4
1200	1035.5	83.1	8.0	1078.2	118.9	11.0	925.6	952.4
1212	1039.4	78.7	7.6	1094.2	119.8	10.9	938.9	960.7
1224	1038.5	81.0	7.8	1101.8	121.7	11.0	941.0	957.5
1236	1054.7	81.6	7.7	1125.9	122.6	10.9	963.0	973.1
1248	1049.1	85.3	8.1	1124.1	127.6	11.3	947.6	963.8
1300	1050.9	88.8	8.5	1122.0	126.0	11.2	950.2	962.1
1312	1041.9	76.8	7.4	1114.2	116.8	10.5	937.6	965.1
1324	1057.6	85.3	8.1	1125.5	120.0	10.7	937.6	972.4
1336	1050.6	81.1	7.7	1111.7	117.9	10.6	924.3	969.5
1348	1042.4	88.8	8.5	1094.1	124.1	11.3	908.1	953.6
1400	1046.9	86.0	8.2	1097.0	121.9	11.1	905.5	960.8
1412	1038.7	87.8	8.5	1081.6	123.1	11.4	892.9	950.9
1424	1036.6	91.2	8.8	1073.4	123.1	11.5	879.9	945.4
1436	1028.6	91.6	8.9	1059.3	121.0	11.4	920.7	937.0
1448	992.8	77.3	7.8	1021.8	113.8	11.1	844.6	915.5
1500	980.3	79.3	8.1	993.4	109.9	11.1	821.8	901.1
1512	956.3	76.7	8.0	966.5	107.3	11.1	800.1	879.6
1524	928.7	75.2	8.1	931.5	102.3	11.0	773.0	853.5
1536	907.6	74.3	8.2	903.1	101.2	11.2	741.6	833.3
1548	870.8	66.5	7.6	865.3	94.3	10.9	699.2	804.3
1600	843.4	72.6	8.6	835.1	96.5	11.6	666.6	770.8

MEAN = 7.99 MEAN = 11.03

STD. DEVIATION = .39 STD. DEVIATION = .28

N = 31

SITE 7 DATE 19 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATIO (CALCULATE (W/SQ.M)(
1000	850.6	140.5	16.5	848.4	189.0	22.3	641.0	710.2
1012	880.6	144.2	16.4	881.3	193.9	22.0	672.6	736.4
1024	903.4	150.8	16.7	909.3	201.3	22.1	695.8	752.6
1036	927.5	154.3	16.6	934.6	202.2	21.6	719.6	773.2
1048	947.0	160.0	16.9	963.9	211.3	21.9	734.8	787.0
1100	964.4	158.1	16.4	987.6	216.3	21.9	751.3	806.3
1112	980.5	166.6	17.0	1008.0	222.8	22.1	761.5	813.9
1124	985.6	159.3	16.2	1025.5	225.2	22.0	779.8	826.4
1136	1003.9	174.2	17.3	1034.7	225.4	21.8	782.6	829.8
1148	1008.3	174.8	17.3	1055.3	232.6	22.0	788.6	833.5
1200	1004.9	167.0	16.6	1059.4	232.9	22.0	795.4	837.9
1212	1011.4	173.1	17.1	1065.4	235.3	22.1	804.6	838.3
1224	1024.2	182.7	17.8	1081.6	239.6	22.2	811.4	841.5
1236	1010.7	171.4	17.0	1075.6	234.6	21.8	811.9	839.3
1248	1016.8	179.8	17.7	1083.7	238.5	22.0	815.6	837.0
1300	1019.9	174.6	17.1	1088.6	236.3	21.7	818.4	845.3
1312	1017.2	172.6	17.0	1087.0	234.4	21.6	811.4	844.6
1324	1018.6	169.0	16.6	1087.1	233.9	21.5	809.0	849.6
1336	1025.6	175.3	17.1	1084.7	232.0	21.4	805.1	850.3
1348	1018.8	168.0	16.5	1075.9	228.5	21.2	799.9	850.8
1400	1013.4	162.4	16.0	1062.7	222.4	20.9	785.8	851.0
1412	1011.6	167.7	16.6	1060.2	228.2	21.5	777.7	843.9
1424	995.1	161.7	16.3	1033.6	217.2	21.0	762.5	833.4
1436	966.7	149.9	15.5	996.6	204.5	20.5	736.1	816.8
1448	954.3	147.7	15.5	982.8	204.7	20.8	728.3	806.6
1500	942.7	149.6	15.9	969.4	206.9	21.3	715.7	793.1
1512	924.2	143.6	15.5	937.8	194.1	20.7	695.3	780.6
1524	892.4	138.3	15.5	908.2	189.4	20.9	667.1	754.1
1536	868.3	134.2	15.5	878.0	182.0	20.7	643.3	734.1
1548	835.9	121.9	14.6	849.2	171.5	20.2	610.4	714.0
1600	806.7	123.4	15.3	813.9	172.4	21.2	571.4	683.3

MEAN = 16.45 MEAN = 21.52
STD. DEVIATION = .77 STD. DEVIATION = .56
N = 31

SITE 7 DATE 20 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATION (CALCULATED (W/SQ.M)(1
1000	844.5	131.3	15.5	835.5	178.4	21.4	633.6	713.2
1012	873.3	136.0	15.6	868.5	186.0	21.4	663.7	737.3
1024	901.0	142.5	15.8	909.7	200.2	22.0	689.1	758.5
1036	922.0	144.5	15.7	928.4	201.3	21.7	706.3	777.5
1048	941.4	147.6	15.7	951.5	205.1	21.6	723.3	793.8
1100	970.3	161.3	16.6	984.6	216.7	22.0	742.4	809.0
1112	984.2	165.3	16.8	1004.3	221.8	22.1	757.3	818.9
1124	986.4	161.4	16.4	1016.1	222.1	21.9	763.5	825.0
1136	1006.5	173.1	17.2	1039.4	229.1	22.0	774.8	833.5
1148	1006.3	169.7	16.9	1047.0	227.3	21.7	787.1	836.6
1200	1024.4	182.1	17.8	1064.6	234.7	22.0	799.9	842.3
1212	1008.3	171.4	17.0	1061.4	231.7	21.8	803.3	836.9
1224	1014.6	176.3	17.4	1077.5	237.0	22.0	807.5	838.2
1236	1015.9	175.9	17.3	1084.2	237.4	21.9	812.2	840.0
1248	1020.3	178.6	17.5	1082.0	233.7	21.6	809.6	841.7
1300	1027.5	180.2	17.5	1095.5	240.2	21.9	816.4	847.3
1312	1030.4	180.2	17.5	1096.0	239.4	21.8	812.2	850.2
1324	1012.5	163.0	16.1	1076.0	230.4	21.4	800.9	849.5
1336	1022.1	171.3	16.8	1080.4	230.9	21.4	796.0	850.8
1348	1015.2	165.4	16.3	1079.7	225.7	20.9	791.0	849.8
1400	1019.2	169.7	16.6	1070.6	229.6	21.4	780.3	849.5
1412	1002.9	162.5	16.2	1055.6	224.0	21.2	766.9	840.4
1424	1005.1	169.5	16.9	1045.1	222.0	21.2	761.5	835.6
1436	981.2	157.0	16.0	1015.6	210.6	20.7	743.7	824.2
1448	965.5	154.7	16.0	998.6	210.8	21.1	728.5	810.8
1500	958.2	160.3	16.7	977.0	205.9	21.1	712.8	797.9
1512	922.5	148.4	16.1	943.0	196.4	20.8	689.3	774.1
1524	884.8	130.4	14.7	903.4	183.6	20.3	662.4	754.4
1536	865.1	136.9	15.8	880.1	182.3	20.7	633.6	728.3
1548	835.5	132.2	15.8	841.0	171.9	20.4	601.0	703.3
1600	800.2	123.4	15.4	809.4	166.9	20.6	570.9	676.8

MEAN = 16.44 MEAN = 21.43
STD. DEVIATION = .75 STD. DEVIATION = .52
N = 31

SITE 8 DATE 22 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	NATURAL SITE (1) REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	DISTURBED SITE (2) REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET BALANCE CHECK NET SW RADIATIO (CALCULATE (W/SQ.M)(
1000	859.9	133.1	15.5	843.5	242.0	28.7	689.1	726.8
1012	892.7	145.5	16.3	878.5	252.7	28.8	715.2	747.2
1024	911.8	143.1	15.7	899.7	256.5	28.5	738.5	768.7
1036	937.4	150.0	16.0	929.2	262.4	28.2	756.2	787.4
1048	956.4	150.0	15.7	953.8	269.7	28.3	774.0	806.4
1100	976.9	154.6	15.8	980.5	277.7	28.3	792.0	822.3
1112	988.7	154.4	15.6	1003.8	282.2	28.1	806.9	834.3
1124	999.9	156.7	15.7	1016.7	282.0	27.7	821.1	843.2
1136	1010.2	156.2	15.5	1032.2	282.8	27.4	836.5	854.0
1148	1024.0	168.6	16.5	1054.1	290.9	27.6	843.0	855.4
1200	1017.5	158.9	15.6	1057.3	286.6	27.1	851.1	858.5
1212	1023.3	165.0	16.1	1070.7	289.8	27.1	855.0	858.4
1224	1017.2	154.8	15.2	1071.0	285.6	26.7	861.3	862.4
1236	1021.1	161.6	15.8	1081.1	289.2	26.8	856.6	859.5
1248	1020.1	155.7	15.3	1080.7	286.1	26.5	858.7	864.4
1300	1023.3	156.0	15.2	1077.6	288.3	26.8	854.3	867.3
1312	1026.9	160.8	15.7	1079.3	281.2	26.1	850.1	866.1
1324	1031.3	155.0	15.0	1075.6	280.2	26.1	848.5	876.3
1336	1023.1	152.7	14.9	1069.1	277.0	25.9	839.9	870.4
1348	1025.4	159.1	15.5	1063.7	275.7	25.9	830.7	866.3
1400	1014.5	150.4	14.8	1046.0	269.7	25.8	820.8	864.1
1412	1011.0	147.9	14.6	1028.0	264.5	25.7	811.6	863.0
1424	999.4	145.3	14.5	1011.2	258.4	25.6	797.5	854.1
1436	979.5	131.2	13.4	990.6	252.4	25.5	785.0	848.3
1448	965.9	140.9	14.6	964.0	247.2	25.6	760.9	824.9
1500	949.5	137.4	14.5	942.0	241.3	25.6	743.7	812.1
1512	921.1	125.2	13.6	909.8	231.3	25.4	724.3	795.9
1524	891.9	117.5	13.2	879.8	224.9	25.6	697.9	774.5
1536	864.0	115.0	13.3	849.9	218.5	25.7	665.5	749.0
1548	836.5	118.3	14.1	809.6	205.9	25.4	630.0	718.2
1600	802.6	111.6	13.9	778.4	198.7	25.5	597.8	691.1

MEAN = 15.07 MEAN = 26.70
STD. DEVIATION = .90 STD. DEVIATION = 1.15
N = 31

SITE 8 DATE 23 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATION (CALCULATED (W/SQ.M)(1
1000	867.8	136.0	15.7	850.3	247.0	29.0	653.0	731.8
1012	892.4	134.3	15.1	876.8	251.0	28.6	688.8	758.1
1024	922.7	141.2	15.3	904.8	257.8	28.5	714.7	781.4
1036	944.4	143.1	15.1	933.3	264.7	28.4	734.8	801.3
1048	961.4	142.6	14.8	953.4	265.8	27.9	753.6	818.8
1100	972.5	139.0	14.3	971.3	266.1	27.4	770.9	833.5
1112	1000.1	152.3	15.2	1003.7	279.3	27.8	783.7	847.7
1124	1005.9	151.2	15.0	1023.1	282.1	27.6	797.5	854.7
1136	1003.7	143.2	14.3	1028.2	278.1	27.1	812.4	860.5
1148	1020.6	152.6	15.0	1055.3	286.4	27.1	822.1	868.0
1200	1027.2	156.2	15.2	1068.8	289.7	27.1	832.6	871.0
1212	1029.4	151.8	14.7	1087.1	295.1	27.1	839.9	877.7
1224	1033.7	153.8	14.9	1081.5	287.1	26.5	845.9	879.9
1236	1042.6	154.9	14.9	1100.6	294.3	26.7	849.6	887.7
1248	1048.1	154.8	14.8	1102.4	290.1	26.3	849.0	893.2
1300	1049.8	148.2	14.1	1098.2	284.6	25.9	853.2	901.6
1312	1053.5	147.8	14.0	1105.7	287.8	26.0	850.6	905.8
1324	1059.1	151.6	14.3	1103.7	288.0	26.1	843.8	907.5
1336	1053.2	146.8	13.9	1092.7	280.8	25.7	836.7	906.4
1348	1053.7	149.7	14.2	1085.2	280.0	25.8	831.3	904.0
1400	1041.5	145.6	14.0	1070.6	276.0	25.8	824.2	895.9
1412	1027.9	136.1	13.2	1052.5	267.1	25.4	812.7	891.9
1424	1017.6	137.7	13.5	1036.4	265.8	25.6	801.5	880.0
1436	996.3	131.3	13.2	1010.1	257.4	25.5	782.4	865.0
1448	979.1	130.1	13.3	989.6	252.3	25.5	764.6	849.0
1500	954.5	122.1	12.8	959.4	242.4	25.3	745.8	832.3
1512	928.9	119.5	12.9	929.5	234.1	25.2	720.9	809.3
1524	901.9	115.9	12.8	899.5	227.3	25.3	695.1	786.0
1536	871.5	113.1	13.0	865.5	219.2	25.3	666.3	758.3
1548	837.9	108.3	12.9	831.9	211.8	25.5	628.7	729.6
1600	793.0	96.9	12.2	787.8	195.6	24.8	594.9	696.1

MEAN = 14.15 MEAN = 26.51
STD. DEVIATION = .94 STD. DEVIATION = 1.18
N = 31

SITE 9 DATE 24 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATI (CALCULAT (W/SQ.M)
1000	852.0	97.3	11.4	841.8	108.3	12.9	668.1	754.6
1012	892.6	115.2	12.9	879.3	117.7	13.4	696.9	777.4
1024	910.9	114.7	12.6	906.8	121.0	13.3	723.3	796.2
1036	923.1	105.4	11.4	929.2	121.0	13.0	744.5	817.6
1048	948.6	115.7	12.2	956.8	127.0	13.3	760.4	832.9
1100	972.4	122.9	12.6	978.5	129.2	13.2	775.3	849.5
1112	983.6	123.6	12.6	1004.5	137.2	13.7	788.6	860.0
1124	993.4	126.8	12.8	1019.4	140.2	13.8	800.1	866.6
1136	995.3	125.7	12.6	1027.1	140.0	13.6	810.6	869.6
1148	1002.2	125.4	12.5	1039.2	140.7	13.5	819.2	876.9
1200	1012.2	130.7	12.9	1053.5	144.2	13.7	831.8	881.5
1212	1009.9	129.6	12.8	1059.4	147.0	13.9	837.0	880.3
1224	1021.3	141.9	13.9	1068.2	148.6	13.9	839.1	879.4
1236	1015.3	135.7	13.4	1074.2	151.4	14.1	845.4	879.6
1248	1006.0	130.3	13.0	1065.0	145.4	13.6	841.4	875.7
1300	1019.1	138.6	13.6	1076.5	149.9	13.9	837.8	880.5
1312	1009.9	128.8	12.8	1069.4	146.6	13.7	834.4	881.1
1324	1020.5	136.8	13.4	1073.1	148.1	13.8	828.1	883.7
1336	1016.0	131.3	12.9	1063.1	140.5	13.2	821.6	884.7
1348	1015.9	136.2	13.4	1057.9	141.5	13.4	810.9	879.7
1400	1006.0	132.8	13.2	1049.7	143.8	13.7	802.0	873.2
1412	996.6	128.0	12.8	1032.9	141.2	13.7	791.5	868.6
1424	981.9	131.2	13.4	1005.4	134.9	13.4	773.2	850.7
1436	959.1	121.3	12.6	992.8	131.1	13.2	756.0	837.8
1448	943.5	121.1	12.8	959.2	126.0	13.1	739.5	822.5
1500	915.3	115.2	12.6	931.9	121.7	13.1	716.0	800.2
1512	887.0	113.8	12.8	897.2	109.4	12.2	693.5	773.2
1524	865.7	111.4	12.9	876.8	123.6	14.1	665.8	754.3
1536	836.4	114.6	13.7	837.3	114.1	13.6	631.0	721.8
1548	805.1	109.4	13.6	799.3	109.0	13.6	597.6	695.7
1600	758.6	97.9	12.9	753.4	100.4	13.3	560.2	660.7

MEAN = 12.87 MEAN = 13.48
STD. DEVIATION = .55 STD. DEVIATION = .39
N = 31

SITE 9 DATE 25 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATION (CALCULATED (W/SQ.M)(1
1000	838.4	100.3	12.0	826.2	104.2	12.6	656.4	738.1
1012	863.2	99.8	11.6	856.4	111.1	13.0	686.2	763.4
1024	890.7	108.9	12.2	889.0	118.0	13.3	710.2	781.7
1036	907.6	106.8	11.8	913.6	123.5	13.5	729.3	800.8
1048	927.3	111.6	12.0	934.7	128.7	13.8	745.0	815.7
1100	941.8	115.0	12.2	956.1	127.8	13.4	760.7	826.7
1112	953.6	114.4	12.0	972.2	132.0	13.6	773.2	839.2
1124	966.5	121.7	12.6	990.4	131.3	13.3	786.0	844.7
1136	980.1	128.0	13.1	1012.9	138.4	13.7	798.1	852.1
1148	992.3	131.0	13.2	1025.8	143.0	13.9	807.7	861.2
1200	991.9	132.6	13.4	1034.2	142.3	13.8	815.0	859.3
1212	999.9	133.9	13.4	1040.9	140.7	13.5	824.7	866.0
1224	1002.2	132.1	13.2	1057.0	147.8	14.0	827.9	870.1
1236	1023.5	141.1	13.8	1075.4	148.5	13.8	845.6	882.5
1248	1041.5	135.0	13.0	1099.9	147.9	13.4	863.4	906.4
1300	815.1	103.1	12.6	807.1	106.7	13.2	608.3	712.0
1312	643.6	90.3	14.0	672.6	96.8	14.4	473.7	553.3
1324	438.9	53.7	12.2	449.5	56.8	12.6	327.8	385.2
1336	1313.3	167.0	12.7	1377.8	183.7	13.3	1105.7	1146.3
1348	1129.1	141.1	12.5	1148.5	150.8	13.1	917.3	988.0
1400	1250.3	170.8	13.7	1296.0	176.2	13.6	995.1	1079.5
1412	908.0	111.2	12.2	939.1	121.0	12.9	631.0	796.8
1424	1281.0	158.6	12.4	1305.6	176.3	13.5	1041.9	1122.4
1436	670.1	74.0	11.0	702.9	83.9	11.9	509.5	596.1
1448	536.0	72.3	13.5	548.5	69.9	12.7	419.3	463.7
1500	385.4	51.2	13.3	386.9	53.5	13.8	295.4	334.2
1512	282.9	35.3	12.5	283.5	37.0	13.0	218.3	247.6
1524	211.2	29.2	13.8	213.9	29.4	13.7	156.8	182.0
1536	.0	.0	.0	.0	.0	.0	.0	.0
1548	118.3	15.9	13.4	119.7	15.8	13.2	89.4	102.5
1600	144.6	18.8	13.0	141.8	17.3	12.2	110.6	125.8

MEAN = 12.74 MEAN = 13.33
STD. DEVIATION = .74 STD. DEVIATION = .54
N = 30

SITE 10 DATE 26 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATIOI (CALCULATEI (W/SQ.M)(:
1000	841.6	92.9	11.0	827.9	192.9	23.3	653.2	748.7
1012	867.0	93.1	10.7	855.4	194.5	22.7	690.1	773.9
1024	897.5	96.2	10.7	885.8	200.0	22.6	720.9	801.3
1036	921.5	98.7	10.7	921.2	210.9	22.9	744.5	822.7
1048	939.6	101.5	10.8	941.8	211.5	22.5	764.1	838.1
1100	957.1	105.5	11.0	964.5	216.0	22.4	777.7	851.5
1112	969.4	104.3	10.8	987.2	225.2	22.8	793.9	865.1
1124	983.5	111.6	11.3	1002.5	227.6	22.7	804.6	871.9
1136	983.7	106.6	10.8	1018.1	231.8	22.8	817.4	877.2
1148	993.0	112.8	11.4	1028.5	234.9	22.8	828.1	880.1
1200	998.5	110.8	11.1	1037.4	234.7	22.6	837.8	887.7
1212	1016.6	125.7	12.4	1052.1	242.9	23.1	839.6	890.9
1224	1009.8	117.2	11.6	1059.0	243.4	23.0	851.6	892.7
1236	1009.2	125.4	12.4	1048.3	236.7	22.6	845.1	883.9
1248	1011.9	119.0	11.8	1061.6	239.8	22.6	858.4	893.0
1300	989.0	121.3	12.3	1035.4	233.9	22.6	831.3	867.7
1312	983.1	111.6	11.3	1039.4	233.2	22.4	829.9	871.5
1324	991.0	113.8	11.5	1044.3	231.1	22.1	824.2	877.3
1336	980.2	117.2	12.0	1040.3	239.2	23.0	803.8	863.0
1348	985.3	119.2	12.1	1031.1	231.8	22.5	807.2	866.1
1400	988.1	115.0	11.6	1036.5	233.4	22.5	810.3	873.1
1412	981.9	120.5	12.3	1017.8	230.2	22.6	797.8	861.4
1424	956.1	110.7	11.6	994.1	227.3	22.9	781.8	845.4
1436	934.8	108.9	11.6	972.0	216.5	22.3	760.9	825.9
1448	922.3	102.2	11.1	952.4	211.7	22.2	745.8	820.1
1500	896.2	102.9	11.5	931.4	212.3	22.8	731.9	793.2
1512	876.6	93.1	10.6	898.2	202.4	22.5	710.5	783.5
1524	847.8	104.7	12.4	865.7	195.4	22.6	680.4	743.0
1536	809.2	90.8	11.2	831.0	189.1	22.8	644.6	718.4
1548	777.5	96.0	12.3	784.7	179.5	22.9	606.4	681.5
1600	733.6	86.2	11.7	740.8	168.7	22.8	569.9	647.4

MEAN = 11.47 MEAN = 22.67

STD. DEVIATION = .58 STD. DEVIATION = .26

N = 31

SITE 10 DATE 27 1 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATION (CALCULATED (W/SQ.M)(1
1000	.0	.0	.0	.0	.0	.0	.0	.0
1012	561.9	60.8	10.8	436.7	101.6	23.3	363.3	501.1
1024	802.8	85.2	10.6	623.9	146.0	23.4	530.6	717.6
1036	716.8	73.0	10.2	935.8	260.3	27.8	789.4	643.8
1048	940.4	109.5	11.6	711.2	190.5	26.8	679.6	830.9
1100	917.4	109.5	11.9	1017.0	254.0	25.0	734.5	807.9
1112	888.8	91.2	10.3	736.2	190.5	25.9	522.8	797.5
1124	831.4	109.5	13.2	1029.4	254.0	24.7	862.6	721.9
1136	911.7	127.7	14.0	929.6	241.3	26.0	797.3	784.0
1148	602.1	91.2	15.2	748.7	190.5	25.4	627.4	510.8
1200	911.7	121.7	13.3	942.1	234.9	24.9	805.1	790.0
1212	837.2	115.6	13.8	873.5	222.3	25.4	588.2	721.6
1224	974.8	127.7	13.1	1004.5	260.3	25.9	849.6	847.0
1236	487.4	66.9	13.7	530.3	133.3	25.1	457.5	420.5
1248	906.0	121.7	13.4	948.3	247.6	26.1	823.4	784.3
1300	888.8	121.7	13.7	942.1	247.6	26.3	805.1	767.1
1312	900.2	127.7	14.2	948.3	241.3	25.4	823.4	772.5
1324	946.1	133.8	14.1	998.2	254.0	25.4	839.1	812.3
1336	888.8	127.7	14.4	942.1	241.3	25.6	786.8	761.0
1348	888.8	127.7	14.4	942.1	241.3	25.6	781.6	761.0
1400	894.5	133.8	15.0	967.0	247.6	25.6	786.8	760.7
1412	544.7	97.3	17.9	549.0	152.4	27.8	470.5	447.4
1424	969.0	139.9	14.4	998.2	260.3	26.1	828.6	829.1
1436	.0	.0	.0	.0	.0	.0	.0	.0
1448	888.8	133.8	15.1	935.8	247.6	26.5	784.2	754.9
1500	831.4	127.7	15.4	842.3	228.6	27.1	718.8	703.7
1512	716.8	127.7	17.8	811.1	228.6	28.2	692.7	589.0
1524	.0	.0	.0	.0	.0	.0	.0	.0
1536	739.7	115.6	15.6	748.7	203.2	27.1	627.4	624.1
1548	688.1	103.4	15.0	686.3	184.1	26.8	575.1	584.7
1600	682.3	103.4	15.2	661.3	177.8	26.9	575.1	578.9

MEAN = 13.83 MEAN = 25.94
STD. DEVIATION = 1.94 STD. DEVIATION = 1.17
N = 28

SITE 2 DATE 8 6 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATION (CALCULATED) (W/SQ.M)(1)
1000	.0	.0	.0	.0	.0	.0	.0	.0
1012	329.9	34.6	10.5	311.2	69.2	22.2	257.0	295.4
1024	389.5	42.3	10.9	389.6	66.7	17.1	316.3	347.2
1036	417.8	49.6	11.9	405.3	83.0	20.5	331.7	368.2
1048	473.6	46.4	9.8	453.8	84.5	18.6	364.1	427.3
1100	500.8	51.3	10.3	480.3	94.4	19.7	387.9	449.5
1112	519.0	60.6	11.7	504.4	110.8	22.0	406.0	458.3
1124	535.3	56.3	10.5	511.9	114.2	22.3	420.3	478.9
1136	550.4	52.4	9.5	522.5	112.6	21.6	430.5	498.0
1148	572.1	60.7	10.6	537.3	112.3	20.9	434.2	511.4
1200	574.6	63.4	11.0	552.7	118.9	21.5	438.6	511.2
1212	573.3	60.7	10.6	558.3	134.4	24.1	447.3	512.6
1224	588.9	60.4	10.3	553.6	125.3	22.6	450.4	528.5
1236	592.1	57.9	9.8	558.3	129.0	23.1	454.8	534.2
1248	581.3	66.1	11.4	568.0	132.3	23.3	449.3	515.1
1300	577.2	70.5	12.2	557.8	131.0	23.5	442.8	506.7
1312	579.7	68.6	11.8	557.6	127.6	22.9	441.2	511.1
1324	576.6	57.3	9.9	547.0	125.9	23.0	441.8	519.3
1336	560.2	62.7	11.2	546.6	138.0	25.2	432.9	497.6
1348	547.1	53.1	9.7	526.1	124.3	23.6	419.5	494.0
1400	527.9	58.0	11.0	521.0	131.8	25.3	406.2	469.9
1412	520.4	64.8	12.4	510.4	123.6	24.2	389.2	455.6
1424	497.7	57.1	11.5	490.0	117.3	23.9	369.9	440.6
1436	481.0	49.0	10.2	470.7	104.1	22.1	358.4	432.1
1448	457.8	60.6	13.2	450.8	108.1	24.0	346.9	397.2
1500	421.7	51.3	12.2	422.6	98.0	23.2	323.4	370.3
1512	398.9	47.0	11.8	403.1	90.9	22.5	297.5	351.9
1524	367.0	48.0	13.1	365.4	97.7	26.7	271.1	319.0
1536	.0	.0	.0	.0	.0	.0	.0	.0
1548	.0	.0	.0	.0	.0	.0	.0	.0
1600	.0	.0	.0	.0	.0	.0	.0	.0

MEAN = 11.07 MEAN = 22.58
STD. DEVIATION = 1.03 STD. DEVIATION = 2.04
N = 27

SITE 3 DATE 16 6 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATIO (CALCULATE (W/SQ.M)(
1000	248.7	24.5	9.8	246.6	35.2	14.3	210.7	224.2
1012	417.4	44.5	10.7	404.4	59.8	14.8	340.9	372.9
1024	376.0	41.9	11.1	362.0	55.2	15.3	307.1	334.1
1036	177.9	18.4	10.4	173.2	25.3	14.6	142.7	159.5
1048	352.6	35.0	9.9	335.5	49.4	14.7	292.5	317.6
1100	399.0	40.6	10.2	393.4	59.2	15.0	334.6	358.5
1112	478.3	49.9	10.4	462.8	70.6	15.3	396.8	428.4
1124	352.4	35.5	10.1	354.7	50.9	14.3	294.3	316.9
1136	266.5	26.6	10.0	261.5	37.5	14.3	219.6	239.9
1148	495.7	51.3	10.3	477.4	73.9	15.5	414.3	444.4
1200	607.5	57.5	9.5	583.7	88.5	15.2	501.4	550.0
1212	390.5	33.3	8.5	366.6	52.0	14.2	296.7	357.2
1224	476.9	44.7	9.4	454.6	65.4	14.4	387.7	432.2
1236	499.4	48.8	9.8	492.0	71.6	14.5	420.3	450.6
1248	571.8	57.2	10.0	544.7	82.6	15.2	457.7	514.6
1300	556.7	57.5	10.3	527.3	81.1	15.4	445.4	499.2
1312	550.4	55.6	10.1	520.6	80.3	15.4	436.5	494.8
1324	487.8	48.8	10.0	471.1	72.4	15.4	374.3	439.0
1336	540.2	55.1	10.2	505.5	75.6	14.9	424.8	485.1
1348	523.4	55.6	10.6	493.4	77.6	15.7	413.5	467.8
1400	226.8	25.4	11.2	220.9	33.0	14.9	188.7	201.4
1412	458.0	42.7	9.3	436.2	65.7	15.1	363.3	415.3
1424	446.6	46.0	10.3	423.3	66.4	15.7	353.4	400.6
1436	375.2	39.2	10.5	354.4	54.8	15.5	292.0	335.9
1448	432.9	45.3	10.5	407.6	63.9	15.7	341.1	387.5
1500	399.5	43.3	10.8	380.6	62.0	16.3	315.0	356.2
1512	376.0	40.3	10.7	358.6	58.4	16.3	296.2	335.7
1524	362.6	42.3	11.7	349.2	60.0	17.2	283.1	320.3
1536	297.0	32.1	10.8	283.3	47.3	16.7	232.6	264.9
1548	.0	.0	.0	.0	.0	.0	.0	.0
1600	.0	.0	.0	.0	.0	.0	.0	.0

MEAN = 10.24 MEAN = 15.23
STD. DEVIATION = .63 STD. DEVIATION = .73
N = 29

SITE 4 DATE 17 6 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATIC (CALCULATE (W/SQ.M)(
1000	.0	.0	.0	.0	.0	.0	.0	.0
1012	242.6	33.6	13.9	239.1	57.7	24.1	201.8	209.0
1024	368.9	48.1	13.0	326.3	46.4	14.2	309.0	320.8
1036	187.3	22.3	11.9	181.9	26.7	14.7	150.8	165.1
1048	483.3	48.3	10.0	470.0	60.6	12.9	395.2	435.0
1100	335.7	37.1	11.1	338.3	43.6	12.9	271.9	298.6
1112	371.3	38.3	10.3	409.0	52.3	12.8	314.7	333.0
1124	451.0	46.2	10.2	465.7	58.7	12.6	374.3	404.8
1136	270.2	31.8	11.8	264.5	34.5	13.0	213.8	238.4
1148	547.7	60.3	11.0	533.4	71.9	13.5	442.3	487.4
1200	484.8	53.7	11.1	368.2	48.7	13.2	364.7	431.1
1212	665.3	71.4	10.7	632.8	81.6	12.9	535.1	593.9
1224	344.1	39.5	11.5	310.0	40.3	13.0	264.3	304.6
1236	311.9	38.1	12.2	309.5	41.7	13.5	245.7	273.8
1248	484.2	50.7	10.5	484.5	65.0	13.4	382.2	433.5
1300	473.9	52.4	11.1	462.5	62.0	13.4	376.4	421.5
1312	657.8	69.8	10.6	588.8	78.5	13.3	535.3	588.0
1324	519.1	60.6	11.7	514.9	69.7	13.5	410.7	458.5
1336	633.5	73.7	11.6	624.1	84.7	13.6	501.1	559.9
1348	432.5	48.8	11.3	422.8	53.9	12.8	326.0	383.6
1400	309.9	39.0	12.6	298.8	39.9	13.3	237.1	270.9
1412	485.7	56.4	11.6	481.3	65.7	13.6	380.1	429.3
1424	469.2	57.1	12.2	467.7	64.9	13.9	365.2	412.0
1436	446.3	52.9	11.9	447.5	60.5	13.5	349.0	393.4
1448	427.4	56.1	13.1	430.2	60.3	14.0	331.2	371.3
1500	397.7	49.6	12.5	403.8	55.8	13.8	312.4	348.1
1512	369.7	48.8	13.2	380.6	55.9	14.7	287.8	320.9
1524	336.8	44.8	13.3	348.8	50.9	14.6	264.5	292.0
1536	308.4	46.0	14.9	317.3	49.0	15.5	240.0	262.4
1548	.0	.0	.0	.0	.0	.0	.0	.0
1600	.0	.0	.0	.0	.0	.0	.0	.0

MEAN = 11.81 MEAN = 13.94

STD. DEVIATION = 1.18 STD. DEVIATION = 2.10

N = 28

SITE 5 DATE 12 6 83

TIME	NATURAL SITE (1)			DISTURBED SITE (2)			NET BALANCE CHECK	
	INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATI (CALCULAT (W/SQ.M)
1000	.0	.0	.0	.0	.0	.0	.0	.0
1012	396.0	36.0	9.1	385.6	39.6	10.3	346.6	360.0
1024	425.6	36.6	8.6	410.7	45.0	10.9	368.8	389.0
1036	447.2	39.5	8.8	436.4	44.8	10.3	387.9	407.7
1048	474.4	43.5	9.2	454.6	49.2	10.8	404.6	430.9
1100	498.9	44.6	8.9	478.0	55.3	11.6	421.6	454.3
1112	560.0	53.2	9.5	517.9	56.5	10.9	481.5	506.8
1124	451.3	39.7	8.8	491.7	49.7	10.1	371.4	411.5
1136	550.8	51.0	9.3	519.7	58.8	11.3	454.3	499.8
1148	557.5	51.9	9.3	535.8	58.7	11.0	463.5	505.6
1200	576.5	56.5	9.8	547.3	67.0	12.2	471.6	520.0
1212	601.7	54.2	9.0	582.9	67.0	11.5	492.5	547.5
1224	506.3	50.6	10.0	414.9	45.6	11.0	444.1	455.7
1236	444.7	47.8	10.7	354.4	40.1	11.3	370.9	396.9
1248	.0	.0	.0	.0	.0	.0	.0	.0
1300	390.7	37.8	9.7	647.4	71.8	11.1	288.8	352.9
1312	369.4	37.3	10.1	364.2	40.8	11.2	324.9	332.2
1324	259.9	26.3	10.1	257.8	30.5	11.8	163.4	233.6
1336	328.3	31.2	9.5	334.3	40.4	12.1	292.2	297.1
1348	326.1	31.7	9.7	343.3	38.0	11.1	281.3	294.5
1400	.0	.0	.0	.0	.0	.0	.0	.0
1412	.0	.0	.0	.0	.0	.0	.0	.0
1424	199.6	20.1	10.1	198.0	18.0	9.1	174.9	179.5
1436	.0	.0	.0	.0	.0	.0	.0	.0
1448	195.4	19.6	10.0	196.8	20.9	10.6	173.0	175.8
1500	193.5	17.9	9.2	188.9	22.2	11.7	173.0	175.6
1512	162.8	14.2	8.7	161.8	21.5	13.3	142.2	148.6
1524	.0	.0	.0	.0	.0	.0	.0	.0
1536	189.3	16.6	8.8	190.5	22.6	11.9	163.6	172.7
1548	.0	.0	.0	.0	.0	.0	.0	.0
1600	110.2	11.4	10.3	110.4	10.9	9.9	99.9	98.8

MEAN = 9.47 MEAN = 11.12

STD. DEVIATION = .58 STD. DEVIATION = .87

N = 24

SITE 6 DATE 11 6 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATI (CALCULAT (W/SQ.M)
1000	415.5	45.6	11.0	401.5	48.6	12.1	347.7	370.0
1012	286.6	26.7	9.3	278.9	30.2	10.8	233.2	259.9
1024	398.7	33.2	8.3	387.8	41.5	10.7	330.1	365.6
1036	435.6	42.3	9.7	429.8	48.3	11.2	362.3	393.3
1048	474.3	38.4	8.1	459.9	53.8	11.7	393.7	435.8
1100	523.6	46.1	8.8	508.1	59.1	11.6	438.9	477.5
1112	525.2	41.1	7.8	507.4	55.9	11.0	442.0	484.2
1124	525.3	42.2	8.0	510.9	54.0	10.6	439.7	483.1
1136	526.7	44.9	8.5	508.0	53.1	10.4	438.9	481.8
1148	576.5	49.2	8.5	543.9	61.2	11.3	472.3	527.3
1200	582.6	54.4	9.3	554.0	63.5	11.5	480.7	528.2
1212	587.8	52.6	8.9	557.7	64.5	11.6	481.8	535.3
1224	584.6	50.7	8.7	561.8	65.0	11.6	486.5	533.8
1236	590.4	48.9	8.3	563.1	62.9	11.2	486.5	541.5
1248	585.6	47.3	8.1	559.0	64.1	11.5	486.7	538.3
1300	578.2	52.8	9.1	561.9	64.2	11.4	484.1	525.4
1312	576.8	54.0	9.4	553.1	65.2	11.8	479.7	522.9
1324	567.1	52.4	9.2	552.3	59.7	10.8	471.0	514.7
1336	.0	.0	.0	.0	.0	.0	.0	.0
1348	544.2	49.0	9.0	530.0	64.5	12.2	452.5	495.2
1400	.0	.0	.0	.0	.0	.0	.0	.0
1412	.0	.0	.0	.0	.0	.0	.0	.0
1424	495.9	45.7	9.2	490.6	63.0	12.8	414.6	450.1
1436	469.1	47.6	10.1	473.0	54.7	11.6	399.7	421.5
1448	446.6	48.4	10.8	451.9	51.4	11.4	383.5	398.1
1500	415.3	43.9	10.6	413.0	52.4	12.7	357.6	371.3
1512	384.3	47.9	12.5	400.6	49.7	12.4	331.5	336.4
1524	350.5	42.8	12.2	363.5	49.2	13.5	303.5	307.7
1536	312.5	42.6	13.6	326.2	43.5	13.3	273.4	269.9
1548	.0	.0	.0	.0	.0	.0	.0	.0
1600	.0	.0	.0	.0	.0	.0	.0	.0

MEAN = 9.51 MEAN = 11.64

STD. DEVIATION = 1.48 STD. DEVIATION = .80

N = 26

SITE 7 DATE 10 6 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATIO (CALCULATE (W/SQ.M)(
1000	.0	.0	.0	.0	.0	.0	.0	.0
1012	424.9	70.3	16.5	425.3	101.0	23.7	332.2	354.7
1024	360.3	59.1	16.4	354.7	83.5	23.5	278.1	301.1
1036	517.8	83.3	16.1	510.8	122.7	24.0	405.7	434.5
1048	423.9	64.8	15.3	416.5	97.5	23.4	337.5	359.1
1100	539.7	84.4	15.6	527.8	125.4	23.8	421.1	455.3
1112	519.3	79.4	15.3	507.9	120.3	23.7	406.2	439.8
1124	528.5	80.0	15.1	511.2	119.5	23.4	405.2	448.5
1136	433.0	66.7	15.4	417.0	96.8	23.2	322.6	366.3
1148	581.9	89.1	15.3	561.3	128.6	22.9	446.5	492.9
1200	612.8	92.5	15.1	591.6	139.3	23.5	464.8	520.3
1212	623.6	93.6	15.0	598.8	137.9	23.0	468.7	530.0
1224	617.4	90.8	14.7	593.3	138.0	23.3	463.5	526.6
1236	599.5	87.5	14.6	577.9	134.0	23.2	447.5	512.0
1248	577.0	81.1	14.1	555.1	124.6	22.4	433.1	495.9
1300	578.7	83.8	14.5	553.6	125.9	22.7	429.5	494.9
1312	580.5	87.4	15.0	554.1	126.7	22.9	430.8	493.2
1324	412.9	64.1	15.5	394.7	90.0	22.8	304.3	348.8
1336	505.8	70.9	14.0	487.7	107.6	22.1	378.2	434.9
1348	520.8	74.1	14.2	504.2	114.0	22.6	389.7	446.7
1400	539.4	77.3	14.3	518.4	116.2	22.4	402.3	462.1
1412	523.5	76.6	14.6	507.4	114.7	22.6	392.1	446.9
1424	377.6	55.1	14.6	365.9	81.3	22.2	282.8	322.5
1436	251.5	39.3	15.6	243.9	53.9	22.1	181.7	212.2
1448	317.4	46.4	14.6	310.7	69.3	22.3	238.9	271.0
1500	181.0	25.7	14.2	174.4	39.0	22.4	128.1	155.3
1512	154.3	24.0	15.6	149.7	34.8	23.2	109.3	130.3
1524	304.3	42.8	14.1	302.3	66.7	22.1	237.6	261.5
1536	154.1	24.1	15.7	148.6	34.4	23.1	109.8	130.0
1548	183.5	29.8	16.2	181.2	42.1	23.2	137.5	153.7
1600	.0	.0	.0	.0	.0	.0	.0	.0

MEAN = 15.08 MEAN = 22.96
STD. DEVIATION = .72 STD. DEVIATION = .56
N = 29

SITE 9 DATE 14 6 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATION (CALCULATED (W/SQ.M)(1
1000	402.2	51.1	12.7	333.4	42.0	12.6	324.4	351.1
1012	387.7	47.0	12.1	360.7	48.1	13.3	303.5	340.8
1024	419.8	47.3	11.3	389.7	57.1	14.7	321.8	372.5
1036	431.0	47.1	10.9	411.3	56.6	13.8	339.3	383.9
1048	461.2	56.9	12.3	431.4	62.0	14.4	358.1	404.2
1100	482.8	51.7	10.7	460.5	61.7	13.4	372.8	431.1
1112	495.8	63.7	12.8	472.6	65.5	13.9	389.2	432.1
1124	507.4	61.7	12.2	489.6	66.7	13.6	401.5	445.7
1136	514.5	66.8	13.0	486.6	76.3	15.7	406.2	447.7
1148	531.8	60.6	11.4	508.2	69.4	13.7	414.1	471.2
1200	536.7	59.6	11.1	510.5	68.5	13.4	416.9	477.1
1212	537.3	64.2	11.9	513.0	71.6	14.0	425.0	473.2
1224	546.3	75.0	13.7	517.5	80.9	15.6	425.3	471.3
1236	544.1	70.1	12.9	515.0	79.7	15.5	426.9	474.0
1248	536.4	66.0	12.3	511.1	78.9	15.4	425.6	470.4
1300	537.0	67.9	12.6	507.5	75.6	14.9	418.2	469.1
1312	532.7	60.6	11.4	508.4	69.9	13.8	413.0	472.1
1324	531.9	60.8	11.4	506.1	69.9	13.8	403.9	471.1
1336	511.2	58.0	11.3	493.5	69.7	14.1	397.1	453.2
1348	499.2	59.4	11.9	481.4	68.2	14.2	386.1	439.8
1400	487.7	63.4	13.0	465.0	75.5	16.2	371.2	424.3
1412	458.5	60.3	13.2	447.1	62.5	14.0	361.3	398.2
1424	419.8	50.0	11.9	429.9	67.5	15.7	338.5	369.8
1436	417.0	58.0	13.9	404.7	61.5	15.2	323.9	358.9
1448	390.6	48.8	12.5	390.4	59.4	15.2	300.6	341.8
1500	359.0	50.1	13.9	355.9	50.5	14.2	269.2	308.9
1512	324.5	47.8	14.7	332.7	50.6	15.2	253.0	276.7
1524	.0	.0	.0	.0	.0	.0	.0	.0
1536	.0	.0	.0	.0	.0	.0	.0	.0
1548	.0	.0	.0	.0	.0	.0	.0	.0
1600	.0	.0	.0	.0	.0	.0	.0	.0

MEAN = 12.34 MEAN = 14.42
STD. DEVIATION = 1.01 STD. DEVIATION = .93
N = 27

SITE 10 DATE 15 6 83

TIME	NATURAL SITE (1) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	DISTURBED SITE (2) INCOMING SHORTWAVE RADIATION (W/SQ.M)	REFLECTED SHORTWAVE RADIATION (W/SQ.M)	ALBEDO (%)	NET BALANCE CHECK NET SW RADIATION (MEASURED) (W/SQ.M)	NET SW RADIATIC (CALCULATE (W/SQ.M)(
1000	.0	.0	.0	.0	.0	.0	.0	.0
1012	197.8	14.2	7.2	261.9	61.1	23.3	169.1	183.6
1024	206.3	14.0	6.8	231.1	52.8	22.8	180.1	192.3
1036	215.3	14.7	6.8	216.4	44.4	20.5	184.5	200.5
1048	260.5	19.6	7.5	268.0	60.5	22.6	227.4	240.8
1100	236.2	21.9	9.3	243.9	68.4	28.0	203.4	214.3
1112	309.7	23.5	7.6	312.7	65.8	21.0	261.1	286.2
1124	282.3	22.3	7.9	284.3	70.2	24.7	241.8	260.0
1136	346.2	21.5	6.2	458.6	108.2	23.6	340.6	324.7
1148	357.1	17.7	5.0	324.9	71.1	21.9	296.2	339.4
1200	602.9	38.3	6.4	582.0	128.5	22.1	529.1	564.5
1212	586.3	44.7	7.6	593.8	129.6	21.8	504.8	541.6
1224	523.7	38.1	7.3	529.0	92.2	17.4	439.4	485.7
1236	357.5	27.5	7.7	358.1	52.4	14.6	293.0	330.0
1248	607.2	48.8	8.0	572.4	72.9	12.7	510.3	558.4
1300	512.8	45.9	8.9	509.3	66.5	13.1	430.8	467.0
1312	439.5	44.2	10.1	450.8	69.9	15.5	375.1	395.2
1324	271.4	18.9	7.0	272.7	52.0	19.1	219.8	252.5
1336	291.0	21.0	7.2	299.0	49.7	16.6	240.5	270.0
1348	412.3	36.3	8.8	425.1	81.0	19.0	347.9	376.0
1400	248.1	18.3	7.4	247.4	47.2	19.1	196.8	229.8
1412	327.6	24.8	7.6	313.4	74.1	23.6	265.1	302.8
1424	228.3	20.9	9.1	231.5	49.2	21.3	183.8	207.4
1436	541.5	34.2	6.3	540.3	126.3	23.4	447.3	507.3
1448	294.5	32.1	10.9	296.8	65.8	22.2	236.6	262.4
1500	.0	.0	.0	.0	.0	.0	.0	.0
1512	238.9	21.0	8.8	239.3	37.8	15.8	197.4	217.9
1524	.0	.0	.0	.0	.0	.0	.0	.0
1536	127.8	11.6	9.1	100.2	25.4	25.3	94.9	116.2
1548	196.3	20.3	10.3	113.5	29.7	26.2	165.2	176.1
1600	108.8	7.3	6.7	84.0	22.0	26.2	79.7	101.5

MEAN = 7.84 MEAN = 20.84
STD. DEVIATION = 1.36 STD. DEVIATION = 4.05
N = 28

APPENDIX 2

TWO-WAY ANALYSIS OF VARIANCE

Factor A : SITES
Factor B : DISTURBANCE

ANALYSIS OF VARIANCE - SUMMER ANOVA

B / A SITES	NATURAL	DISTURBED
2	10.9	28.8
3	10.7	18.3
4	9.7	12.5
5	10.3	11.7
6	7.8	11.0
7	16.1	21.4
8	14.7	26.9
9	12.7	13.4
10	12.6	24.4
Mean	11.7	18.7

S : 656.8   V : 37.4
S : 299.4   V : 219.8
S : 219.8   V : 17.2
S : 137.6
F_A : 2.175 F_B : 12.776

$H_{o(A)}$: There is no significant difference amongst sites

$H_{o(B)}$: There is no significant difference between Natural and Disturbed sites

From tables: $F_{8,8}(0.05) = 3.44 > F_A = 2.175$
$F_{1,8}(0.05) = 5.31 < F_B = 12.776$

$H_{o(A)}$ is accepted, $H_{o(B)}$ is rejected and $H_{1(B)}$ is accepted:

$H_{1(B)}$: There is a significant difference between Natural and Disturbed Veld Types.

ANALYSIS OF VARIANCE - WINTER ANOVA

A SITES \ B	NATURAL	DISTURBED
2	11.1	22.6
3	10.2	15.2
4	11.8	13.9
5	9.5	11.1
6	9.5	11.6
7	15.1	23.0
8	-	-
9	12.3	14.4
10	7.8	20.8
Mean	10.9	16.6

S : 326.6 V : 17.7
S : 124.4 V : 128.2
S : 128.2 V : 10.6
S : 73.9
F_A : 1.680 F_B : 12.140

$H_{o(A)}$: There is no significant difference amongst sites

$H_{o(B)}$: There is no significant difference between Natural and Disturbed sites

From tables: $F_{7,7}(0.05) = 3.79 > F_A = 1.680$
$F_{1,7}(0.05) = 5.59 < F_B = 12.140$

$H_{o(A)}$ is accepted, $H_{o(B)}$ is rejected and $H_{1(B)}$ is accepted:

$H_{1(B)}$: There is a significant difference between Natural and Disturbed Veld Types.

APPENDIX 3

VEGETATION AND SOILS

NOTES

1. 'Natural Vegetation' refers to the vegetation(natural or otherwise) actually growing in the site.
2. Data was collected in January and any changes noted in June.
3. Plants were, in most cases, named to the species level, but some only to genus level.

FIELD DATA : VEGETATION AND SOILS

SITE:...Pella A. LAT: $33^{\circ} 32'$ S LONG: $18^{\circ} 31'$ E

LOCATION:..3 km N of Pella ALTITUDE:.......250m

SLOPE: Level(0-3)[ ] Gentle(4-8)[X] Moderate(9-16)[ ]

VELD TYPE:....Coastal Fynbos

VELD COVER: Natural Vegetation.....80% Soil....15%

Litter ......5% Rock......%

Other(specify).......................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[ ]

Fine Sand(0.02-0.2mm)[X] Coarse Sand(>0.2mm)[ ]

SOIL COLOUR: White[X] Grey[X] Yellow ochre[ ]

Orange[ ] Red[ ] Brown[ ] Black[ ]

SOIL MOISTURE: Dry[X] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Serruria sp.................	.0.3-0.5.	10-15
Restio sieberi.............	0.6-1.0	5-10
Erica cerinthoides.........	0.3-0.4	5
Phylica parviflora.........	0.6-1.0	5
Luecospermum hypophyllo-...	0.1	5
...........carpodendron...	....	......
Protea repens..............	0.6-1.0	5
Elytropappus scaber........	0.6-0.8	5
Macrostylis villosa........	0.3-0.4	5
Metalasia spp..............	variable	<5
Willdenowia striata........	0.4	<5
Leucodendron salignum......	0.3-0.5	<5
Other Species		
Staberoha distachya........	0.8-1.0	2
Protea scolymocephala......	0.3-0.5	1
Erica mammosa..............	0.5-0.8	1
Macrostylis cassiopoides...	0.6-0.7	<1
Leptocarpus impolitus......	0.3-0.5	<1
Anthospermum aethiopicum...	0.3	<1
Centella virgata..........	0.3-0.5	<1
Zygophyllum sp............	0.1-0.3	<1
....	....	......

GENERAL:..NO NOTICEABLE CHANGE in winter

FIELD DATA : VEGETATION AND SOILS

SITE:...Pella... LAT: 33° 32' S LONG: 18° 31' E

LOCATION:..3km N of Pella ALTITUDE:.......250m

SLOPE: Level(0-3)[ ] Gentle(4-8)[X] Moderate(9-16)[ ]

VELD TYPE:Disturbed Coastal Fynbos

VELD COVER: Natural Vegetation.....40% Soil....55%

Litter ......5% Rock......%

Other(specify)........................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[ ]

Fine Sand(0.02-0.2mm)[X] Coarse Sand(>0.2mm)[ ]

SOIL COLOUR: White[X] Grey[ ] Yellow ochre[ ]

Orange[ ] Red[ ] Brown[ ] Black[ ]

SOIL MOISTURE: Dry[X] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Restio spp.................	0.1-0.2	5-10
Leucospermum hypophyllo-...	0.1	5-10
............carpodendron...	....	......
Phylica stipulari..........	0.1-0.2	<5
Phylica thunbergiana.......	0.1-0.2	<5
Gnidia oppositifolia.......	0.1	2
Petalacte coronata.........	0.1	2
Erica mammosa..............	0.2-0.3	2
Helichrysum rutilans.......	0.1-0.2	1
Elytropappus gnaphaloides..	0.1	1
....	....	......
....	....	......
Other Species		
Ehrharta ramosa............	0.3-0.4	<1
Lobelia linearis...........	0.5-0.6	<1
Crassula cymosa............	0.2-0.3	<1
Agalthepis dubia...........	0.2-0.3	<1
Aspalathus sp..............	0.05	<1
Metalasia sp...............	0.1-0.3	<1
....	....	......
....	....	......
....	....	......

GENERAL:No noticeable change in winter ,greener perhaps.

FIELD DATA : VEGETATION AND SOILS

SITE:.Darling... LAT: 33° 23' S LONG: 18° 22' E

LOCATION:.2 km SE of Darling ALTITUDE:.......150m

SLOPE: Level(0-3)[ ] Gentle(4-8)[X] Moderate(9-16)[ ]

VELD TYPE:Coastal Renosterveld.

VELD COVER: Natural Vegetation.....70% Soil....15%

Litter .....10% Rock.....5%

Other(specify).......................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[ ]

Fine Sand(0.02-0.2mm)[X] Coarse Sand(>0.2mm)[X]

SOIL COLOUR: White[ ] Grey[X] Yellow ochre[ ]

Orange[ ] Red[ ] Brown[X] Black[ ]

SOIL MOISTURE: Dry[X] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Elytropappus rinocerotis...	1.0-1.5	25-30
Helichrysum africanus......	0.6-0.8	20
Eriocephalus sp............	0.6-0.8	5-10
Aspalathus sp..............	0.8-1.0	5-10
Rhus glauca................	1.0-1.5	2
Willdenowia striata........	1.0-1.2	2
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
Other Species		
Rhus lucida................	0.6-1.0	1
Lobostemon fruticosus......	0.6-0.8	1
Salvia lanceolata..........	0.6-0.8	<1
Gnidia sp..................	0.6-0.8	<1
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......

GENERAL:.THIS SITE WAS NOT MEASURED IN WINTER

FIELD DATA : VEGETATION AND SOILS

SITE:.Darling... LAT: 33° 23' S LONG: 18° 22' E

LOCATION:.2 km SE of Darling ALTITUDE:.......150m

SLOPE: Level(0-3)[X] Gentle(4-8)[ ] Moderate(9-16)[ ]

VELD TYPE:Harvested wheatfield

VELD COVER: Natural Vegetation.....85% Soil.....5%

Litter .....10% Rock......%

Other(specify).........................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[ ]

Fine Sand(0.02-0.2mm)[X] Coarse Sand(>0.2mm)[X]

SOIL COLOUR: White[ ] Grey[X] Yellow ochre[ ]

Orange[ ] Red[ ] Brown[X] Black[ ]

SOIL MOISTURE: Dry[X] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Cynodon dactylon...........	<0.1	30-40
Triticum aestivum(wheat)...	0.1	20-30
unidentified grass.........	0.2-0.4	20
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
Other Species		
Helichrysum sp.............	0.1	<1
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......

GENERAL:.THIS SITE WAS NOT MEASURED IN WINTER

FIELD DATA : VEGETATION AND SOILS

SITE:.Voelvlei.. LAT: 33° 23' S LONG: 19° 00' E

LOCATION:.At Voelvlei station ALTITUDE:....200m

SLOPE: Level(0-3)[X] Gentle(4-8)[ ] Moderate(9-16)[ ]

VELD TYPE:Coastal Renosterveld.

VELD COVER: Natural Vegetation.....70% Soil.....20%

Litter .....10% Rock......%

Other(specify).........................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[X]

Fine Sand(0.02-0.2mm)[X] Coarse Sand(>0.2mm)[ ]

SOIL COLOUR: White[ ] Grey[ ] Yellow ochre[ ]

Orange[ ] Red[ ] Brown[X] Black[ ]

SOIL MOISTURE: Dry[X] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Elytropappus rinocerotis...	1.0	70

Other Species

GENERAL:This site measured in winter - no other species

FIELD DATA : VEGETATION AND SOILS

SITE:.Voelvlei.. LAT: 33° 23' S LONG: 19° 00' E

LOCATION:.At.Voelvlei station ALTITUDE:....200m

SLOPE: Level(0-3)[X] Gentle(4-8)[ ] Moderate(9-16)[ ]

VELD TYPE:.Disturbed C Renosterveld.

VELD COVER: Natural Vegetation.....90% Soil.....5%

Litter ......5% Rock......%

Other(specify)........................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[X]

Fine Sand(0.02-0.2mm)[X] Coarse Sand(>0.2mm)[ ]

SOIL COLOUR: White[ ] Grey[ ] Yellow ochre[X]

Orange[ ] Red[ ] Brown[ ] Black[ ]

SOIL MOISTURE: Dry[ ] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Unidentified green grass...	<0.1	90
Burnt remains of Elytro-... ....pappus....	0.1-0.3	5
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......

Other Species

....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......

GENERAL:This site measured in winter only

FIELD DATA : VEGETATION AND SOILS

SITE:.Yzerfontein LAT: 33° 21' S LONG: 18° 09' E

LOCATION:.1 km S of town ALTITUDE:.....50m

SLOPE: Level(0-3)[X] Gentle(4-8)[ ] Moderate(9-16)[ ]

VELD TYPE:Strandveld.

VELD COVER: Natural Vegetation.....75% Soil....10%

Litter .....15% Rock......%

Other(specify)......................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[ ]

Fine Sand(0.02-0.2mm)[X] Coarse Sand(>0.2mm)[ ]

SOIL COLOUR: White[ ] Grey[X] Yellow ochre[ ]

Orange[ ] Red[ ] Brown[X] Black[ ]

SOIL MOISTURE: Dry[ ] Damp[X] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Salvia aurea...............	0.8-1.2	15
Limonium perigrinum........	0.8-1.0	10-15
Ruschia sp.................	0.1-0.3	10-15
Lycium sp..................	0.6-0.8	5
Maytenus sp...............	0.3-0.5	5
Euphorbia sp...............	0.6-0.8	5
Salsola kali...............	0.5-0.6	5
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
Other Species		
Asparagus sp...............	variable	<5
Rhus sp....................	0.8-1.0	<5
Exomis microphylla.........	0.5-0.7	1
Crassula ammophila.........	0.5-0.7	<1
Cotelydon orbicularis.....	0.1	<1
....	....	......
....	....	......
....	....	......
....	....	......

GENERAL:.This site enclosed by a wire 1m fence

FIELD DATA : VEGETATION AND SOILS

SITE:.Yzerfontein LAT: 33° 21' S   LONG: 18° 09' E

LOCATION:.1km S of town...   ALTITUDE:.....50m

SLOPE: Level(0-3)[X] Gentle(4-8)[ ] Moderate(9-16)[ ]

VELD TYPE:Disturbed Strandveld

VELD COVER: Natural Vegetation.....55% Soil....25%

Litter ....% Rock......%

Other(specify).......................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[ ]

Fine Sand(0.02-0.2mm)[X] Coarse Sand(>0.2mm)[ ]

SOIL COLOUR: White[ ] Grey[X] Yellow ochre[ ]

Orange[ ] Red[ ] Brown[X] Black[ ]

SOIL MOISTURE: Dry[ ] Damp[X] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Limonium perigrinum........	0.6-0.8	10
Ruschia sp.................	0.3-0.5	5-10
Lycium sp..................	0.5-0.6	5-10
Euclea racemosa............	0.1-0.2	5-10
unidentified grass.........	0.6-0.8	5-10
Chrysanthemoides monilifera	0.5-0.8	<5
Asparagus sp...............	0.1-0.3	<5
Putterlickia pyracantha....	0.1-0.2	<5
Zygophyllum sp.............	0.1-0.3	<5
....	....	......
....	....	......
....	....	......
Other Species		
Salsola kali...............	<0.1	1
Exomis microphylla.........	0.1	<1
Cluytia daphnoides.........	0.1	<1
Euphorbia sp...............	0.1	<1
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......

GENERAL:NO CHANGE in winter, greener perhaps

FIELD DATA : VEGETATION AND SOILS

SITE:Sutherland A LAT: $32^{\circ} 23'$ S LONG: $20^{\circ} 46'$ E

LOCATION:.7 km E of town ALTITUDE:...1550m

SLOPE: Level(0-3)[ ] Gentle(4-8)[ ] Moderate(9-16)[X]

VELD TYPE:Western Mountain Karoo

VELD COVER: Natural Vegetation.....60% Soil....15%

Litter .....10% Rock....15%

Other(specify)......................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[ ]

Fine Sand(0.02-0.2mm)[X] Coarse Sand(>0.2mm)[X]

SOIL COLOUR: White[ ] Grey[X] Yellow ochre[ ]

Orange[ ] Red[ ] Brown[X]

SOIL MOISTURE: Dry[X] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Nestlera sp................	0.3-0.4	25
Chrysochoma tridendata.....	0.1-0.2	5-10
Nestlera sp................	0.2-0.3	5-10
Lycium sp..................	0.3-0.6	<5
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
Other Species		
Asparagus capensis.........	0.3-0.4	<1
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......

GENERAL:..NO CHANGE in Winter

FIELD DATA : VEGETATION AND SOILS

SITE:Sutherland A LAT: 32° 23' S LONG: 20° 46' E

LOCATION:7 km E of town.. ALTITUDE:...1550m

SLOPE: Level(0-3)[ ] Gentle(4-8)[X] Moderate(9-16)[ ]

VELD TYPE: Disturbed Western Mountain Karoo

VELD COVER: Natural Vegetation.....40% Soil....50%

Litter ......5% Rock.....5%

Other(specify).......................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[ ]

Fine Sand(0.02-0.2mm)[X] Coarse Sand(>0.2mm)[X]

SOIL COLOUR: White[ ] Grey[X] Yellow ochre[ ]

Orange[ ] Red[ ] Brown[X] Black[ ]

SOIL MOISTURE: Dry[X] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Chrysochoma tridentata.....	0.2	15
Lycium sp..................	0.1	15
Nestlera sp................	0.2-0.3	5
Lycium sp..................	0.3-0.4	<5
Lycium sp..................	1.0-1.5	<5
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
Other Species		
Asparagus capensis.........	0.3-0.4	<1
Felicia sp.................	0.1-0.2	<1
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......

GENERAL:NO CHANGE in Winter.

FIELD DATA : VEGETATION AND SOILS

SITE:Sutherland B LAT: 32° 26' S LONG: 20° 37' E

LOCATION:.5 km SW of town ALTITUDE:...1550m

SLOPE: Level(0-3)[X] Gentle(4-8)[ ] Moderate(9-16)[ ]

VELD TYPE:Mountain Renosterveld

VELD COVER: Natural Vegetation.....65% Soil....15%

Litter .....15% Rock.....5%

Other(specify).......................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[ ]

Fine Sand(0.02-0.2mm)[X] Coarse Sand(>0.2mm)[X]

SOIL COLOUR: White[ ] Grey[ ] Yellow ochre[ ]

Orange[X] Red[ ] Brown[X] Black[ ]

SOIL MOISTURE: Dry[X] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Elytropappus rinoceratis...	1.0-1.5	50-60
Euryops lateriflorus.......	0.8-1.2	10
Felicia filifolia..........	0.4-0.7	5
Other Species		
Dimorphotheca cuneata......	0.1-0.2	<1
Walafrida saxatilis........	0.3-0.4	<1
Pentzia sphaerocephala.....	0.2-0.3	<1

GENERAL:NO CHANGE in winter

FIELD DATA : VEGETATICN AND SOILS

SITE:Sutherland B LAT: 32° 26' S LONG: 20° 37' E

LOCATION:.5 km SW of town ALTITUDE:...1550m

SLOPE: Level(0-3)[ ] Gentle(4-8)[X] Moderate(9-16)[ ]

VELD TYPE: Disturbed Mountain Renosterveld

VELD COVER: Natural Vegetation.....45% Soil....40%

Litter ......5% Rock....10%

Other(specify).......................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[ ]

Fine Sand(0.02-0.2mm)[X] Coarse Sand(>0.2mm)[X]

SOIL COLOUR: White[ ] Grey[ ] Yellow ochre[ ]

Orange[X] Red[ ] Brown[X] Black[ ]

SOIL MOISTURE: Dry[X] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Dimorphotheca cuneata......	0.1-0.3	10-15
Elytropappus rinocerotis...	0.5-0.7	5-10
Felicia filifolia..........	0.3-0.5	5
Euryops lateriflorus.......	0.6-1.0	<5
Eriocephalus sp...........	0.1-0.2	<5
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
Other Species		
Helichrysum hamulosum......	0.2-0.4	<1
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......

GENERAL:.NO CHANGE in Winter

FIELD DATA : VEGETATION AND SOILS

SITE:..Bo-wadrif LAT: 32° 32' S LONG: 20° 14' E

LOCATION:60 km NW of Sutherland ALTITUDE:....650m

SLOPE: Level(0-3)[X] Gentle(4-8)[ ] Moderate(9-16)[ ]

VELD TYPE: Succulent Karoo

VELD COVER: Natural Vegetation.....50% Soil....45%

Litter ......1% Rock.....4%

Other(specify)........................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[X]

Fine Sand(0.02-0.2mm)[ ] Coarse Sand(>0.2mm)[ ]

SOIL COLOUR: White[ ] Grey[ ] Yellow ochre[ ]

Orange[X] Red[ ] Brown[X] Black[ ]

SOIL MOISTURE: Dry[ ] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Leipoldtia framesii........	0.2-0.4	20-25
Eberlanzia mucronifera.....	0.3-0.4	5-10
Pteronia lucilioides.......	0.5-0.6	5
Psilocaulon absimile.......	0.2-0.3	<5
Drosanthemum salicolum.....	0.1-0.2	<5
Spalmanthus sp.............	<0.1	<5
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
Other Species		
Galeria africana...........	0.5-0.6	<1
Atriplex halimoides........	0.1	<1
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......

GENERAL:NO CHANGE in winter

FIELD DATA : VEGETATION AND SOILS

SITE:..Bo-wadrif.. LAT: 32° 32' S LONG:20° 14' E

LOCATION:60 km NW of Sutherland ALTITUDE:....650m

SLOPE: Level(0-3)[X] Gentle(4-8)[ ] Moderate(9-16)[ ]

VELD TYPE:..Disturbed Succulent Karoo

VELD COVER: Natural Vegetation.....40% Soil....55%

Litter ......4% Rock.....1%

Other(specify)........................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[X]

Fine Sand(0.02-0.2mm)[ ] Coarse Sand(>0.2mm)[ ]

SOIL COLOUR: White[ ] Grey[ ] Yellow ochre[ ]

Orange[X] Red[ ] Brown[X] Black[ ]

SOIL MOISTURE: Dry[X] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Spalmanthus sp.............	<0.1	20-25
Drosanthemum sp............	0.2-0.3	5-10
Eberlanzia spinescens......	0.3-0.5	5
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
Other Species		
Eberlanzia sp..............	0.2-0.3	1
Psilocaulon.absimile.......	0.2-0.3	<1
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......

GENERAL: NO CHANGE in winter.

FIELD DATA : VEGETATION AND SOILS

SITE: Seweweekspoort LAT: 33° 22' S LONG: 21 20 E

LOCATION: 4 km W of the Poort ALTITUDE:..1175m

SLOPE: Level(0-3)[ ] Gentle(4-8)[X] Moderate(9-16)[ ]

VELD TYPE: False Fynbos (False Macchia)

VELD COVER: Natural Vegetation.....35% Soil....50%

Litter .....15% Rock......%

Other(specify)........................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[ ]

Fine Sand(0.02-0.2mm)[X] Coarse Sand(>0.2mm)[ ]

SOIL COLOUR: White[X] Grey[X] Yellow ochre[ ]

Orange[ ] Red[ ] Brown[ ] Black[ ]

SOIL MOISTURE: Dry[X] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Helichrysum rutilans......	0.4-0.7	5-10
Leucadendron salignum......	1.2-2.0	5
Leucadendron barkerae......	1.5-1.8	5
Metalasia muricata.........	0.5-0.8	<5
Restio laniger.............	0.1-0.2	<5
Elytropappus adpressus.....	0.8-1.0	<5
Unidentified grass.........	<0.1	<5
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
Other Species		
Helichrysum expansum.......	0.1-0.2	<1
Muraltia sp................	0.2-0.6	<1
Anthospermum aethiospicum..	0.8-1.5	<1
Ruschia amicorum...........	0.5-0.6	<1
Relhania squarosa..........	0.7-0.9	<1
....	....	......
....	....	......
....	....	......
....	....	......

GENERAL: Summer measurement only at this site.

FIELD DATA : VEGETATION AND SOILS

SITE: Seweweekspoort LAT: 33° 22' S LONG: 21° 20' E

LOCATION: 7 km W of the poort ALTITUDE: ..1175m

SLOPE: Level(0-3)[X] Gentle(4-8)[ ] Moderate(9-16)[ ]

VELD TYPE: Harvested Oatland

VELD COVER: Natural Vegetation.....50% Soil....45%

Litter ......5% Rock......%

Other(specify).......................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[ ]

Fine Sand(0.02-0.2mm)[X] Coarse Sand(>0.2mm)[ ]

SOIL COLOUR: White[X] Grey[X] Yellow ochre[ ]

Orange[ ] Red[ ] Brown[ ] Black[ ]

SOIL MOISTURE: Dry[X] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Ehrhata sp.	0.3-0.6	20
Cynodon dactylon	0.1	5-10
Avena sativa (oats)	0.2-0.3	5
Rumex autosella	0.1	<5
Silene sp.	0.1-0.3	<5
Senecio leptophyllus	0.1-0.2	<5
Other Species		
Chrysochoma tridentata	0.1-0.3	<1
Senecio augustifolius	0.6-0.8	<1
Manulea laxa	0.1-0.2	<1

GENERAL: Summer measurements only at this site.

FIELD DATA : VEGETATION AND SOILS

SITE: Calitzdorp LAT: 33° 17' S LONG: 21° 40' E

LOCATION: 6 km N of town ALTITUDE:...600m

SLOPE: Level(0-3)[ ] Gentle(4-8)[X] Moderate(9-16)[ ]

VELD TYPE: Spekboomveld

VELD COVER: Natural Vegetation.....60% Soil....20%

Litter .....10% Rock....10%

Other(specify)........................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[X]

Fine Sand(0.02-0.2mm)[ ] Coarse Sand(>0.2mm)[ ]

SOIL COLOUR: White[ ] Grey[X] Yellow ochre[X]

Orange[ ] Red[ ] Brown[ ] Black[ ]

SOIL MOISTURE: Dry[X] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Ruschia sp................	<0.1	10-15
Hereroa sp.................	0.1-0.2	5-10
Porticularia afra..........	0.5-1.0	5
Pteronia incana............	0.6-0.8	5
Thesium sp.................	0.5-0.8	5
Galenia africana...........	0.6-1.0	5
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
Other Species		
Lycium sp..................	0.3-0.5	<1
Chrysochoma tenuifolia.....	0.5-0.8	<1
Crassula subaphylla........	0.2-0.3	<1
Euphorbia mauritanica......	0.4-0.6	<1
Crassula muscosa...........	0.1-0.2	<1
Atromischus triflorus......	0.3-0.4	<1
....	....	......
....	....	......
....	....	......

GENERAL: NO CHANGE in winter

FIELD DATA : VEGETATION AND SOILS

SITE: Calitzdorp LAT: 33° 17' S LONG: 21° 40' E

LOCATION: 6 km N of town ALTITUDE:....600m

SLOPE: Level(0-3)[ ] Gentle(4-8)[X] Moderate(9-16)[ ]

VELD TYPE: Disturbed Spekboomveld

VELD COVER: Natural Vegetation.....55% Soil....30%

Litter .....10% Rock.....5%

Other(specify)........................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[X]

Fine Sand(0.02-0.2mm)[ ] Coarse Sand(>0.2mm)[ ]

SOIL COLOUR: White[ ] Grey[X] Yellow ochre[X]

Orange[ ] Red[ ] Brown[ ] Black[ ]

SOIL MOISTURE: Dry[X] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Pentzia incana.............	0.2-0.3	20-30
Ruschia sp.................	<0.1	<5
Pteronia paniculata........	0.6-0.8	<5
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
Other Species		
Indigofera obcordata.......	0.2	<1
Crassula subaphylla........	0.1-0.2	<1
Crassula muscosa...........	<0.1	<1
Aldromischus triflorus.....	0.1-0.2	<1
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......

GENERAL: NO CHANGE in winter

FIELD DATA : VEGETATION AND SOILS

SITE: Ladismith LAT:33° 32' S LONG:21° 08' E

LOCATION: 20 km ESE of town ALTITUDE:...500m

SLOPE: Level(0-3)[ ] Gentle(4-8)[X] Moderate(9-16)[ ]

VELD TYPE: Karroid Broken Veld

VELD COVER: Natural Vegetation.....70% Soil....10%

Litter .....20% Rock......%

Other(specify)........................%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[ ]

Fine Sand(0.02-0.2mm)[ ] Coarse Sand(>0.2mm)[ ]

SOIL COLOUR: White[ ] Grey[X] Yellow ochre[ ]

Orange[ ] Red[ ] Brown[X] Black[ ]

SOIL MOISTURE: Dry[X] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Pentzia incana............	0.3-0.4	10-15
Pentzia sp.................	0.2-0.4	5
Eriocephalus sp...........	0.3	5
Acanthacae sp..............	0.3-0.5	<5
Delospermum dejagerae......	0.2-0.3	<5
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
Other Species		
Galenia africana...........	0.6-0.8	1
Drosanthermum lique........	0.1	<1
Euphorbia mauritanica......	0.3-0.4	<1
Pteronia sp................	0.3-0.4	<1
Ruschia cymosa.............	0.2-0.4	<1
Putterlickia pyracantha....	2.0	<1
Cotyledon orbiculata.......	0.3-0.5	<1
Crassula sp................	0.1-0.2	<1
Blepharis capensis.........	0.5	<1

GENERAL:Winter site moved 20m E - no veg change.

FIELD DATA : VEGETATION AND SOILS

SITE: Ladismith LAT: 33° 32' S LONG: 21° 08' E

LOCATION: 20 km ESE of town ALTITUDE:....500m

SLOPE: Level(0-3)[ ] Gentle(4-8)[ ] Moderate(9-16)[ ]

VELD TYPE: Lucerne field

VELD COVER: Natural Vegetation.....40% Soil....20%

Litter .....40% Rock......%

Other(specify) Winter : Lucerne....100%

SOIL TEXTURE: Clay(<0.002mm)[ ] Silt(0.002-0.02mm)[X]

Fine Sand(0.02-0.2mm)[ ] Coarse Sand(>0.2mm)[ ]

SOIL COLOUR: White[ ] Grey[X] Yellow ochre[ ]

Orange[ ] Red[ ] Brown[X] Black[ ]

SOIL MOISTURE: Dry[X] Damp[ ] Wet[ ]

VEGETATION:

Predominant Species	Height(m)	%Cover
Medicago sativa (lucerne)..	0.2-0.6	40-100
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......

Other Species

....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......
....	....	......

GENERAL: In winter lucerne was in full growth - bright green

APPENDIX 4

CLOUDINESS AND TEMPERATURE

NOTES:

1. Sun partially obscured - Yes/No or (time).

2. Cloud symbols : Ci - Cirrus

   Cu - Cumulus

   Cc - Cirro-cumulus

   Cn - Cumulo-nimbus

   Cs - Cirro-stratus

   St - Stratus

   Sc - Strato-cumulus

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE:Cape Point VELD TYPE: Mountain Fynbos

DATE:05-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	-	-	-	20
10h00	1/8	Cu	No	25
11h00	1/8	Cu	No	25
12h00	1/8	Cu	No	25
13h00	1/8	Cu	No	25
14h00	1/10	Cu	No	25
15h00	1/10	Cu	No	24
16h00	1/12	Cu	No	23
17h00	1/12	Cu	No	22

COMMENTS:......................................

SUN OBSCURED: 10h24.................................

....

WIND (kph): 09h00: 5-10 W 12h00: 5-10 W 15h00: 5-10 W

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Cape Point VELD TYPE: Mountain Fynbos

DATE:06-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	-	-	-	24
10h00	-	-	-	25
11h00	-	-	-	25
12h00	-	-	-	26
13h00	-	-	-	26
14h00	-	-	-	27
15h00	-	-	-	26
16h00	-	-	-	24
17h00				

COMMENTS: Slight haze in afternoon...................

SUN OBSCURED:.....................................

....

WIND (kph): 09h00: SSE 20 12h00: SSE 15 15h00: SSE 15

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Pella   VELD TYPE: Coastal Fynbos

DATE:08-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	-	-	-	25
10h00	-	-	-	26
11h00	-	-	-	27
12h00	-	-	-	28
13h00	-	-	-	28
14h00	-	-	-	27
15h00	-	-	-	27
16h00	-	-	-	26
17h00	-	-	-	25

COMMENTS:..

SUN OBSCURED:....................................

....

WIND (kph): 09h00: SW 20   12h00: SW 20   15h00: SW 20

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Pella VELD TYPE: Coastal Fynbos

DATE:09-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	-	-	-	24
10h00	-	-	-	27
11h00	-	-	-	32
12h00	-	-	-	33
13h00	-	-	-	31
14h00	-	-	-	31
15h00	-	-	-	29
16h00	-	-	-	27
17h00	-	-	-	26

COMMENTS:..

SUN OBSCURED:....................................

....

WIND (kph): 09h00: SW 10 12h00: SW 15 15h00: SW 20

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Darling VELD TYPE: Coastal Renosterveld

DATE:10-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	1/3	Cu,Cs	Yes/No	22
10h00	1/3	Cu	No	25
11h00	2/3	Cu	Yes/No	28
12h00	2/3	Cu	No	26
13h00	1/4	Cu	No	28
14h00	-	-	-	30
15h00	-	-	-	28
16h00	-	-	-	28
17h00	-	-	-	26

COMMENTS:...

SUN OBSCURED: (09h12),09h36,(10h12),(11h12),11h24.....

....

WIND (kph): 09h00: WSW 5-10 12h00: WSW 10-15 15h00:WSW 10

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Darling VELD TYPE: Coastal Renosterveld

DATE:11-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	1/2	Sc,Cu	Yes	20
10h00	1/2	Sc	Yes/No	22
11h00	2/3	Sc,Cs	Yes	25
12h00	-	-	-	27
13h00	-	-	-	28
14h00	1/10	Cu	No	27
15h00	1/8	Cu	No	26
16h00	1/10	Cu	No	24
17h00				

COMMENTS: 2 - 3 hour's rain the previous night

SUN OBSCURED: 09h12->09h48,10h12,(10h24),10h36,10h48,
(11h24)..............................

WIND (kph): 09h00:WSW 10 12h00: WSW 10-15 15h00: -

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Yzerfontein VELD TYPE: Strandveld

DATE:12-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	1/8	Cs	No	24
10h00	3/8	Cs	Yes/No	25
11h00	1/8	Cs	No	26
12h00	1/10	Cs	No	28
13h00	1/8	Ci	No	28
14h00	1/10	Ci	No	27
15h00	1/8	Ci,Cs	No	26
16h00	1/10	Ci,Cs	Yes/No	23
17h00				

COMMENTS:...

SUN OBSCURED: (09h24)->(10h00),15h12..................

....

WIND (kph): 09h00: S 15 . 12h00: S 15 15h00: -

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Yzerfontein VELD TYPE: Strandveld

DATE:13-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	-	-	-	22
10h00	-	-	-	23
11h00	-	-	-	25
12h00	-	-	-	27
13h00	-	-	-	28
14h00	-	-	-	27
15h00	-	-	-	27
16h00	-	-	-	26
17h00	-	-	-	25

COMMENTS:...

SUN OBSCURED:...

....

WIND (kph): 09h00: S 10 12h00: S 10 15h00:S 10

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Sutherland A   VELD TYPE: Western Mount. Karoo

DATE:15-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	-	-	-	24
10h00	-	-	-	26
11h00	-	-	-	29
12h00	-	-	-	32
13h00	-	-	-	34
14h00	1/10	Sc	No	36
15h00	1/4	Sc	No	35
16h00	1/3	Sc	No	35
17h00	1/3	Sc	No	34

COMMENTS: Gusts of wind stir up dust

SUN OBSCURED: 15h12,15h24,(15h48),16h24,16h36.........

....

WIND (kph): 09h00: E 10   12h00: W 15   15h00: W 10

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Sutherland A VELD TYPE: Western Mount. Karoo

DATE:16-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	-	-	-	25
10h00	-	-	-	26
11h00	-	-	-	29
12h00	-	-	-	34
13h00	-	-	-	35
14h00	-	-	-	34
15h00	-	-	-	32
16h00	-	-	-	31
17h00	-	-	-	29

COMMENTS:...

SUN OBSCURED:....................................

....

WIND (kph): 09h00: W 10 12h00: W 10 15h00: W 10

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Sutherland B VELD TYPE: Mountain Renosterveld

DATE:17-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	-	-	-	25
10h00	-	-	-	27
11h00	-	-	-	29
12h00	-	-	-	31
13h00	1/8	Cu	No	32
14h00	1/8	Cu	Yes	34
15h00	1/8	Cu	No	34
16h00	1/10	Cu	No	33
17h00	1/10	Cu	No	31

COMMENTS: Gusty wind - thunderstorm afar off

SUN OBSCURED: 12h48,13h36..............................

....

WIND (kph): 09h00: S 5 12h00: W 5-10 15h00: -

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Sutherland B   VELD TYPE: Mountain Renosterveld

DATE:18-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	-	-	-	28
10h00	-	-	-	29
11h00	-	-	-	30
12h00	-	-	-	30
13h00	-	-	-	31
14h00	-	-	-	31
15h00	-	-	-	30
16h00	-	-	-	30
17h00				

COMMENTS:..

SUN OBSCURED:....................................

....

WIND (kph): 09h00: NE 10   12h00: SW 10   15h00: -

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Bo-wadrif VELD TYPE: Succulent Karroo

DATE:19-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	-	-	-	26
10h00	-	-	-	29
11h00	-	-	-	32
12h00	-	-	-	36
13h00	-	-	-	37
14h00	-	-	-	38
15h00	-	-	-	40
16h00	-	-	-	39
17h00	-	-	-	37

COMMENTS:...

SUN OBSCURED:...

....

WIND (kph): 09h00: NE 5-10 12h00: SW 10-15 15h00: SW 10-15

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Bo-wadrif VELD TYPE: Succulent Karoo

DATE: 20-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	-	-	-	30
10h00	-	-	-	32
11h00	-	-	-	35
12h00	-	-	-	35
13h00	-	-	-	39
14h00	-	-	-	38
15h00	-	-	-	37
16h00	-	-	-	37
17h00	-	-	-	36

COMMENTS:...

SUN OBSCURED:.....................................

....

WIND (kph): 09h00: NE 0-5 12h00: SW 10-15 15h00: SW 10

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Seweweekspoort VELD TYPE: False Fynbos

DATE:22-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	1/10	Cu,Sc	No	18
10h00	1/10	Cu,Cs	No	18
11h00	-	-	-	20
12h00	1/10	Cu,Cs	No	20
13h00	-	-	-	20
14h00	-	-	-	20
15h00	-	-	-	20
16h00	-	-	-	20
17h00	-	-	-	19

COMMENTS:..

SUN OBSCURED:....................................

....

WIND (kph): 09h00:SSE 20-25 12h00:S 25-30 15h00: S 25-30

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Seweweeksspoort VELD TYPE: False Fynbos

DATE:23-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	-	-	-	23
10h00	-	-	-	24
11h00	-	-	-	26
12h00	-	-	-	27
13h00	-	-	-	26
14h00	-	-	-	26
15h00	-	-	-	30
16h00	-	-	-	27
17h00	-	-	-	28

COMMENTS:..

SUN OBSCURED:....................................

....

WIND (kph): 09h00: SE 5 12h00: SE 5-10 15h00: SE 10-15

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Calitzdorp VELD TYPE:Spekboomveld

DATE:24-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	-	-	-	26
10h00	-	-	-	28
11h00	-	-	-	32
12h00	-	-	-	34
13h00	-	-	-	37
14h00	-	-	-	39
15h00	-	-	-	38
16h00	-	-	-	36
17h00	-	-	-	32

COMMENTS:..

SUN OBSCURED:..

....

WIND (kph): 09h00: SE 5 12h00: SE 10-15 15h00:SE 5-10

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE:Calitzdorp VELD TYPE: Spekboomveld

DATE:25-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	-	-	-	29
10h00	-	-	-	30
11h00	-	-	-	32
12h00	1/10	Sc	No	34
13h00	1/3	Sc	Yes/No	36
14h00	2/3	Cu,Sc	No	40
15h00	7/8	Cu,Sc	Yes	40
16h00	8/8	Cu,Sc	Yes	37
17h00	8/8	Sc,S	Yes	36

COMMENTS:......................................

SUN OBSCURED: (13h12),(14h12),(14h36),(14h48),15h12->
17h00.................................

WIND (kph): 09h00:SSE 5-10 12h00:SSE 5-10 15h00:SSE 10-15

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Ladismith VELD TYPE: Karroid Broken Veld

DATE:26-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	-	-	-	24
10h00	-	-	-	28
11h00	-	-	-	34
12h00	-	-	-	38
13h00	-	-	-	39
14h00	-	-	-	36
15h00	-	-	-	35
16h00	1/8	Cu	No	34
17h00	1/10	Cu	No	32

COMMENTS:.......................................

SUN OBSCURED:..................................

....

WIND (kph): 09h00: SE 0-5 12h00: SE 5-10 15h00: SE 10

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Ladismith VELD TYPE: Karroid Broken Veld

DATE:27-01-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	3/8	Cs	No	-
10h00	3/8	Cs	Yes/No	-
11h00	1/2	Cs	Yes/No	-
12h00	1/8	Cs	No	32
13h00	1/8	Cs	No	35
14h00	5/8	Cs	No	37
15h00	3/8	Cs	Yes/No	37
16h00	1/8	Ci,Cn	No	35
17h00				

COMMENTS:..

SUN OBSCURED:..

....

WIND (kph): 09h00: SE 0-5 12h00: SE 0-5 15h00: SE 0-5

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Pella VELD TYPE: Coastal Fynbos

DATE:08-06-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	-	-	-	15
10h00	1/3	Cs	Yes/No	17
11h00	1/8	Ci	No	19
12h00	-	-	-	19
13h00	-	-	-	19
14h00	-	-	-	18
15h00	-	-	-	16
16h00				
17h00				

COMMENTS:...

SUN OBSCURED:.....................................

....

WIND (kph): 09h00: Nil 12h00: S 5 15h00: Nil

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Voelvlei VELD TYPE: Coastal Renosterveld

DATE:16-06-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00				
10h00	2/3	Cc	No	17
11h00	3/4	Cc,St	No	17
12h00	3/4	Cc,St	No	18
13h00	1/2	Cc,St	No	19
14h00	1/2	Cc,St	Yes	22
15h00	1/4	Cc,St	No	19
16h00	1/4	Cc,St	No	20
17h00				

COMMENTS:...

SUN OBSCURED: (09h48),(10h24),10h36,(11h24),11h36,(11h48)
(12h12),(12h24),(13h24),(14h36).........

WIND (kph): 09h00: Nil 12h00: N 5 15h00: Nil

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Yzerfontein VELD TYPE: Strandveld

DATE:17-06-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	4/4	Cu	Yes	10
10h00	4/4	Cu	Yes	15
11h00	3/4	Cu	Yes	17
12h00	3/4	Cu	Yes/No	19
13h00	1/2	Cu	Yes/No	20
14h00	1/4	Cu	Yes	19
15h00	1/8	Cu	No	18
16h00	1/8	Cu	No	17
17h00				

COMMENTS: Ground moist , air misty.

SUN OBSCURED: 10h12,(10h24),10h36,(11h12),11h36,12h24,12h36
(12h48),(13h24),13h48....................

WIND (kph): 09h00: Nil 12h00: W 5 15h00: SW 5

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Sutherland A VELD TYPE: Western Mount Karoo

DATE:12-06-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	1/3	Cu	No	9
10h00	1/4	Cu	Yes	13
11h00	-	-	-	14
12h00	1/8	Cu	No	17
13h00	1/4	Cu	Yes	17
14h00	1/2	Cu	Yes/No	15
15h00	3/4	Cu	Yes	13
16h00	3/4	Cu	Yes	9
17h00				

COMMENTS: Early(<10h00) readings highly erroneous

SUN OBSCURED: (12h24),(12h36),12h48,(13h12),13h24,(13h36)
(13h48),14h12,14h36->16h12

WIND (kph): 09h00: SE 5 12h00: S 10 15h00: S 10

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Sutherland B VELD TYPE: Mountain Renosterveld

DATE:11-06-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	1/4	Cs	No	5
10h00	1/3	Cs	Yes/No	14
11h00	1/4	Cs	No	15
12h00	1/8	Cs	No	15
13h00	-	-	-	16
14h00	-	-	-	15
15h00	-	-	-	14
16h00	-	-	-	12
17h00				

COMMENTS:..

SUN OBSCURED: (10h12)..............................

....

WIND (kph): 09h00: Nil 12h00: Nil 15h00: Nil

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Bo-wadrif VELD TYPE: Succulent Karoo

DATE:10-06-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	1/2	Cs	No	15
10h00	1/2	Cs	Yes/No	16
11h00	1/3	Cs	No	18
12h00	1/4	Cs	No	20
13h00	1/4	Cs	No	23
14h00	1/4	Cs	No	25
15h00	1/2	Cu/Cs	Yes	21
16h00	2/3	Cs	Yes	19
17h00				

COMMENTS:...

SUN OBSCURED: (10h24->10h48),(11h36),(13h24),(14h24)
14h36,15h12,15h36,15h48,(16h12).........

WIND (kph): 09h00: SE 5-10 12h00: Nil 15h00: Nil

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Calitzdorp VELD TYPE: Spekboomveld

DATE:14-06-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	4/4	Cn	Yes	11
10h00	1/3	Cu	No	15
11h00	-	-	-	19
12h00	-	-	-	18
13h00	-	-	-	17
14h00	-	-	-	18
15h00	-	-	-	20
16h00	-	-	-	23
17h00				

COMMENTS: Misty,moisty before 10h00; cool wind followed

SUN OBSCURED: (09h36)..................................

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WIND (kph): 09h00: Nil 12h00: S 5 15h00: Nil

FIELD DATA : CLOUDINESS AND TEMPERATURE

SITE: Ladismith VELD TYPE:Karroid Broken Veld

DATE:15-06-1983

TIME	CLOUD COVER	CLOUD TYPE	SUN OBSCURED?	TEMP(deg C)
09h00	1/3	St	Yes	8
10h00	4/4	St/Sc	Yes	13
11h00	4/4	St/Sc	Yes	16
12h00	3/4	St/Sc	No	22
13h00	3/4	St/Sc	Yes/No	23
14h00	3/4	St/Sc	Yes	23
15h00	1/2	St/Sc	Yes	22
16h00	3/4	St/Sc	Yes/No	22
17h00				

COMMENTS:...

SUN OBSCURED: 09h24->11h24,(11h36),(11h48),(12h36),(13h12)
13h24,15h12,1524,16h12..................

WIND (kph): 09h00: Nil 12h00: Nil 15h00: Nil

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