AN INVESTIGATION OF SOME DIFFERENCES BETWEEN

ASPECTS IN HILL COUNTRY

A thesis presented in partial fulfilment of the requirements for the degree of Master of Agricultural Science in Plant Science at Massey University

Matthew Greg Lambert

1973

ABSTRACT

Climatic, edaphic and biotic variables were measured, over a twelve month period, at each of four aspects of a hill in the Southern Ruahine ranges. These variables were soil moisture status, soil temperature, air temperature, wind-speed, rainfall, soil nutrient status, sheep-dung deposition, and pasture botanical composition and productivity. Information on sunshine hours, maximum and minimum screen temperatures, relative humidity, and wind direction were obtained from the records of an adjacent meteorological station. Net radiation and potential evapotranspiration were calculated from meteorological data, and actual evapotranspiration from soil moisture data.

Large differences were recorded between aspects for most of the above mentioned variables. The wind during the observational period was a prevailing West/Northwesterly. Differences in net radiation between the north and south aspects were largest during the Winter and smallest during the summer months. In all cases the evapotranspiration values calculated were larger for the north than for the south aspect. Soil moisture tension differences were not detected during the winter months, but during the remainder of the year the north aspect was driest, followed by the east and west aspects, and the south aspect respectively. Differences between aspects, in terms of average monthly 4 cm. air temperature, were not apparent. However, large differences in the average monthly 4 cm. soil temperature of the various aspects were detected: during the January to August period the north aspect was warmest and the south coolest; during the October to December period the east aspect was warmest and the north and south aspects, which had similar average soil temperatures,were coolest.

The south and west aspect soils had greater nutritional limitations to plant growth than did the soils of the east and north aspects. This was probably due, at least in part, to nutrient transfer by grazing animals, and the differential action of soil-forming factors. Nitrogen mineralisation was closely associated with soil total nitrogen status, and was one of the main factors limiting pasture productivity. Soil moisture status was the other major limitation to pasture productivity. Pasture production during the observational period (346 days), for the east, south,west and north aspects respectively, was 9683, 3637, 2959 and 2771 kg./DM./ha. Some of the pasture species present were found

to be distributed in a definite pattern according to aspect, while for other species the pattern was indistinct. For a number of species no distribution pattern was detected. The patterns observed appeared to follow soil nutritional (especially mineral nitrogen) and soil moisture gradients.

Possible reasons for the above-mentioned differences, and some practical implications of these differences, are discussed.

ACKNOWLEDGEMENTS

Grateful acknowledgement is made to Mr E. Roberts for his supervision throughout this study, and to Mr D.A. Grant for suggesting this topic.

Thanks are also due to: Dr J.P. Kerr, Mr D.A. Grant, Mr J.S. Talbot, Dr R.H. Jackman, Mr P.R. Ball and Dr G.A. Wickham, for advice freely given, and the N.Z. Meteorological Service and the late Mr D.B. Edmond, for the loan of equipment.

This study was carried out while the author was holder of a State Services Commission Study Award.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

This section is intended as an introduction to the study which is to be described, and as a means of introducing certain general ideas concerning aspect differences.

"Ecology is the science concerned with living organisms, both plant and animal, in relation to their environment or habitat" (Levy, 1970). Such a definition might not find favour with the more pedantic members of the ecological discipline, but does manage to convey the basic meaning of the term 'ecology' ie. the study of organisms 'at home' (Odum, 1959). Odum (1959) states that many terrestial ecosystems "have a particularly complex structure involving numerous species, marked stratification and variable physical environment, ... In local situations there is much to be gained from singling out a restricted component (for study)....... At the same time it is important that whole systems be studied simultaneously, since certain fundamental interrelationships can not be readily determined by piecemeal study." Any study of variation in a single environmental factor is purely descriptive if only that factor is measured eg. a record of pasture botanical composition differences between aspects, or between any contrasting areas, does not provide any explanation for the differences observed. A complete analysis of edaphic, climatic and biotic differences between aspects would be an extremely large and complicated undertaking. It is, however, possible to elucidate some of the interrelationships existing between the various environmental factors, through the study of selected variables. The selection of the variables which were examined in this study was based on two criteria: firstly, feasibility of measurement, and secondly, the likelihood of differences occurring between aspects, as judged by discussion and by perusal of relevant literature.

The literature reviewed in this study is of two broad categories: firstly, literature dealing with general concepts of aspect differences, and secondly, specific literature, in most cases describing or reviewing experimental studies and the results obtained. The latter category is dealt with in Chapter I and the former is reviewed briefly below.

Microclimatic[1] differences are known to exist between land surfaces which are inclined in different directions, ie. between surfaces of different aspect (Warming, 1909; Braun-Blanquet, 1932; Geiger, 1965; Chang, 1968). Variation in the amount of direct solar radiation

(1) see discussion of the terms 'climate' and 'microclimate' in Introduction to Chapter I.

received by sloping surfaces is one of the main reasons for the existence of these microclimatic differences (Geiger, 1965). The associated differing energy input has a large influence on the energy balances which exist at the surfaces of the various aspects encountered in the hill country situation. A simple energy balance for a bare soil surface may be written as:

$$R_N + B + L + V = 0 \text{ (Geiger, 1965)}$$

where:

R_N = net radiation.

B = sensible heat loss to the ground.

L = latent heat loss due to evaporation.

V = sensible heat loss to the air.

The interrelationships of the elements of this balance are discussed in many texts, eg. Geiger, 1965; Slatyer and McIlroy, 1961; Munn, 1966. The magnitude of R_N is determined by the lack of balance between net incoming short-wave and net outgoing long-wave radiation. Near the ground, incoming short-wave radiation consists of a direct solar beam, and diffuse sky radiation, the latter coming from the whole hemisphere, although more intense in directions close to that of the sun itself (Slatyer and McIlroy, 1961). The proportion of incoming short-wave radiation which is diffuse varies from about 10% under clear-sky conditions, to 100% under overcast conditions. Thus, differences in short-wave radiation input between aspects will be greatest under clear-sky conditions. The proportion of the incoming short-wave radiation which is reflected from the surface it strikes is known as the albedo. The fraction not reflected is the net incoming short-wave radiation. The net outgoing long-wave radiation, mentioned above, represents the difference between terrestial and sky long-wave radiation.

The R_N component of the above balance is expended by sensible heat transfers which directly affect the temperature of the soil and air, and as latent heat during the evaporation of water. Slatyer and McIlroy (1961) point out that of all the variables involved in the energy balance only solar radiation can be regarded as at all independent of the others. Under steady conditions the factors of the balance adjust to come to an equilibrium. Geiger (1965) notes that the situation described above is often complicated by the horizontal transfer, or advection, of heat from surrounding areas, thus introducing an additional factor to the energy balance. Although the balance written above is for a bare soil surface, the addition of a vegetative cover to the surface would little alter the concepts developed in the above discussion.

It was previously noted that variation in the amount of direct solar radiation received by sloping surfaces is one of the main reasons for the existence of microclimatic differences in hill country. Wind also plays a role, in that air movement is involved in the determination of the magnitude of the components of the energy balance. Local winds may arise in mountainous hill country due to regions of different temperature (Geiger, 1965). However, in the New Zealand situation of prevailing winds and overall proximity to the coastline, and especially in the smaller-scale hill country of the North Island, it is probable that wind is only modified, rather than caused, by local topographic variation. Slatyer and McIlroy (1961) state that "wind is of considerable importance in microclimate, both as an element in its own right and because it is of such influence on the atmospheric structure of temperature and humidity". They conclude that the main effect of wind is to reduce extremes of variation in temperature and humidity, both in time and in space.

Local variation in rainfall may also occur in hill country. Geiger (1965) notes that the climate of slopes facing in different directions is affected to a large extent by moisture conditions, as well as radiation and wind, and that the smaller the topographic scale the more the local precipitation is determined by the wind field. In discussing small-scale precipitation differences, Geiger points out that more precipitation is found on the leeward than on the windward side of hills, especially where wind speeds are high. "By general agreement" (Geiger, 1965) precipitation is measured using horizontally disposed collecting surfaces, yet considerable controversy now exists as to the relative merits of using horizontal as opposed to tilted collecting surfaces (Geiger, 1965; Yates, 1970). Doubt also exists as to the proportions of recorded differences between aspects which are attributable to actual precipitation differences and those which are due to wind effects on raingauge catch (Rodda, 1966; Jackson and Aldridge, 1972).

Edaphic differences[1] between aspects might arise for any of a number of reasons. Ross (1971), in his review of aspect as a soil forming factor, notes that aspect, acting through microclimate and its effects on organisms, plays an important role in the ecology and thus soils of hillsides. Sears <u>et al</u> (1948) give figures for the annual nutrient turnover, via sheep excreta, for grazed pasture, and remark that fertilizer programmes should be constructed with reference to the transfer of dung and urine from one part of a paddock to another. Hilder (1966) discusses nutrient accumulation on stock camps under a sheep grazing regime, and also equates this accumulation with a loss from other parts

(1) Soil moisture status and temperature will be considered as climatic rather than edaphic factors; see Introduction to Chapter I.

of the paddock. The potential for nutrient transfer between aspects appears to exist, and coupled with the probable influence of microclimatic and pasture differences between aspects on animal grazing behaviour, such a transfer might be expected to lead to differences in soil and pasture characteristics between aspects. Grazing animals have a number of important effects on plant communities, these effects being due to physical damage, defoliation and the deposition of excreta (Spedding, 1971). Rumball and Grant (1972) go so far as to state that "the trampling, grazing, voiding animal is one of the major determinants of pasture composition."

From basic ecological concepts, variation in pasture structure, composition and productivity would be expected to be associated with the differing environments existing at different aspects.

The detection of variation in edaphic, biotic and climatic factors due to aspect, formed the basis of the study described herein. A hill in the Southern Ruahine ranges of the North Island was selected as an experimental site. Measurements of selected climatic, edaphic and biotic factors were made at each of the north, south, east and west aspects, over a twelve month period. A description of each of the selected factors was the prime aim of the study and the collection of data was cond ıcted with this in mind. However, a secondary aim did exist, namely to elucidate, where possible, the interrelationships existing between the environmental and pasture variables measured.

Throughout this thesis common names have been used, whenever possible, in referring to plant species. The corresponding botanical names have been noted the first time each common name is used in the text. A complete list of the common and botanical names of species encountered in this study is given in Appendix 10.

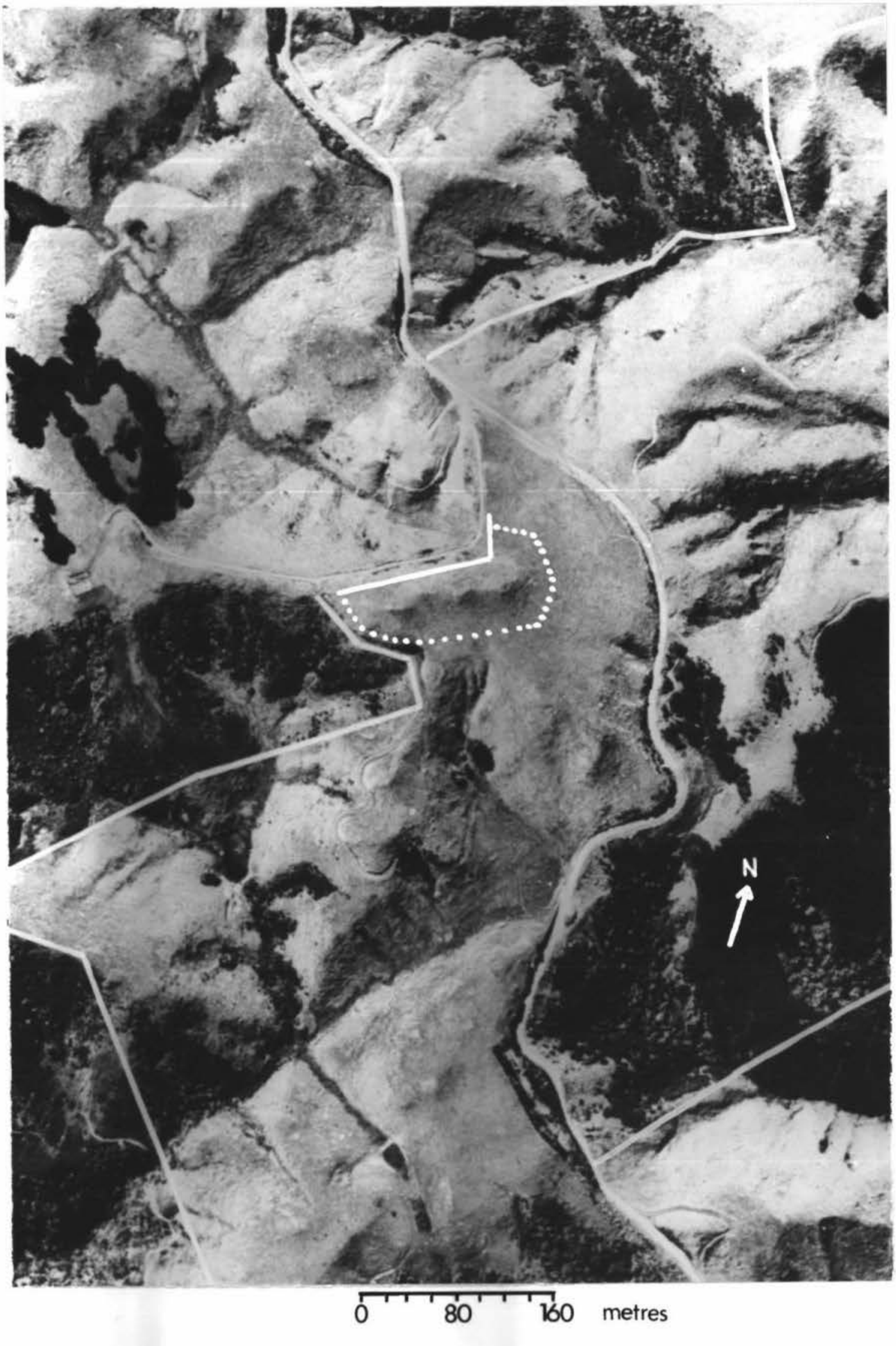

FIGURE I.1 Aerial View of Experimental area and Surrounds