J. Wheeler

The three volcanic mountains of Egmont National Park (left to right); Kaitake, Pouakai and Egmont viewed from the Maui platform.

VEGETATION STUDIES IN THE TARANAKI LAND DISTRICT, NEW ZEALAND

by

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ABSTRACT

Sampling of the indigenous vegetation of the Taranaki Land District was carried out to describe and explain significant features of vegetational change along environmental gradients. Five major locations were sampled; the three volcanic mountains of Egmont National Park (Egmont, Pouakai and Kaitake), the associated volcanic ring plain and the Taranaki Upland. The sampling which was mainly along altitudinal and moisture gradients involved the collection of both quantitative and semi-quantitative plot data.

Direct and indirect gradient analyses were then carried out on the data; the techniques employed included graphing, ordination and classification. Analysis enabled the definition of the main vegetation types at each of the sampling locations and of the important environmental factors associated with the vegetation pattern.

Comparison of the results obtained at each of the sampling locations revealed differences in the structure and composition of the vegetation and in the pattern of vegetational change along the gradients. The three volcanic mountains within Egmont National Park show differences in the vegetation consistent with the sequence of volcanic activity (the Taranaki Volcanic Succession). Sectors of Mt Egmont exhibit differences which relate closely to the pattern of recent eruptions particularly the Burrell eruption of 1655 A.D. The vegetation at equivalent altitudes on Pouakai, an older more eroded volcanic remnant, is at a more advanced stage of development. A complex pattern of species (woody species and tree ferns) distribution on the three mountains (Egmont, Pouakai and Kaitake) is outlined and attributed in some instances to the changing availability of habitats on each mountain. This is associated with the sequence of mountain building, erosion and dissection. The vegetation pattern of the Taranaki Upland by contrast more closely reflects the pattern of topography and substrate and the forests are richer in vascular species. Analysis of the distribution of species (woody species and tree ferns) shows that inland Taranaki was the probable source for almost all of the species found in the forests of Egmont National Park.

Comparisons of the pattern of vegetational change along altitudinal gradients of the mountains of Egmont National Park and some other southern hemisphere mountains reveal certain similarities. With respect to other North Island (New Zealand) volcanic mountains examined the similarities are marked. Like Mt Egmont, Pouakai and Kaitake these mountains all support podocarp-broadleaved forests from which the beech species (*Nothofagus* spp.) are absent. The forests of Egmont National Park are interpreted as illustrating stages of a landscape and vegetation succession apparent on volcanic mountains throughout the North Island. Features which characterise the present stage of development of the forests of Mt Egmont include the overwhelming dominance of kamahi (*Weinmannia racemosa* var. *racemosa*), the absence of forest tree species such as quintinia (*Quintinia serrata*) and the relatively low altitude tree-line.

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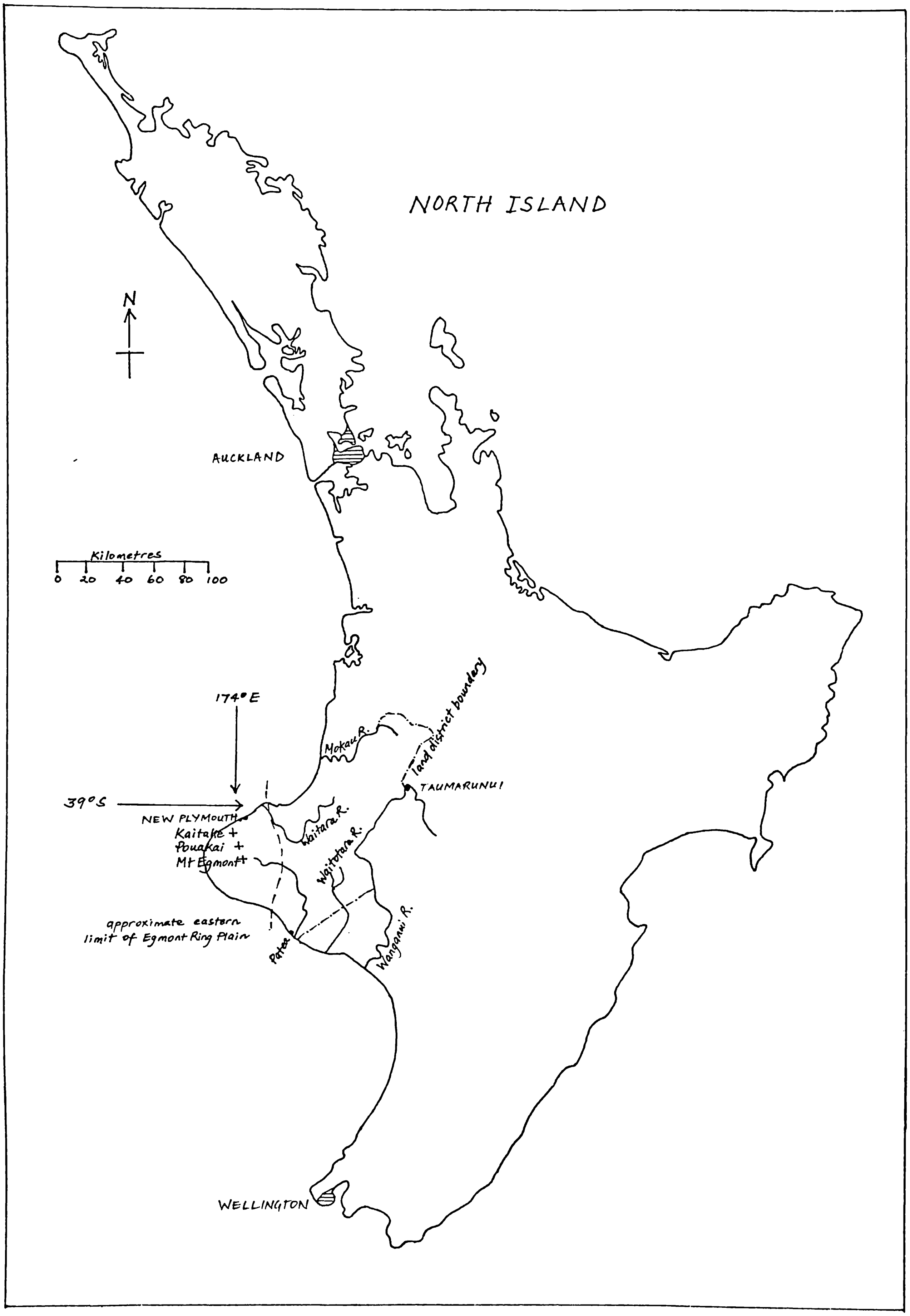
CHAPTER 1

INTRODUCTION

Study location

The Taranaki Land District (973,000ha) stretching from the Mokau River in the north to Patea in the south and bounded by the coastline to the west and the Wanganui River in the east (see Figure 1.1) is the setting for the vegetation studies presented in this thesis. The largest single unit of indigenous vegetation reserved within the land district is the Egmont National Park (33,537ha) and this area is the focus of a major part of the study. The national park and much of western Taranaki landscape is dominated by the dormant volcano Mt Egmont (2518m) and its associated ring plain. Two older eroded volcanic remnants, Pouakai (1399m) and Kaitake (684m), also part of the national park, adjoin the north-western slopes of Mt Egmont. The remainder of the Taranaki Land District in contrast is of sedimentary origin and consists mainly of low hill-country (150m-600m) known as the Taranaki Upland.

Figure 1.1 LOCATION OF STUDY AREA



Study aim

The aim of this study was to describe and explain significant features of vegetational change along environmental gradients and to use this information to provide a comparative analysis of the major features of the indigenous vegetation within the Taranaki Land District.

Study approach

The approach of this study derived first from the observations made and the experience gained in the study area over a number of years and second from a reading of the literature on vegetation description and analysis particularly gradient analyses (Curtis and McIntosh (1951), Whittaker (1956) etc.). A deliberate effort was made to seek out gradients and their 'zoned' assemblages of species and to provide an adequate coverage of the study area by examining these gradients at a large number of locations. Pielou (1977) has since described succinctly the justification for seeking out zoned communities. 'There are many ecological questions that can be investigated far more directly, and that can be answered with far greater clarity by studies in naturally occurring zoned communities than anywhere else... Because natural zonation (which can be thought of as the outcome of a natural experiment) is so ecologically informative, it is worthwhile to seek it out even in places where it would not automatically be expected... Such places are far more deserving of study than the elusive 'homogeneous community' traditionally beloved of ecologists' (Pielou, 1977, p248).

Vegetation data collected along various gradients was thus interpreted as the outcome of a natural experiment (as noted by Pielou, 1977). The distribution and performance of plant species along the gradients examined were considered in relation to other plant species and to environmental and historical factors. Most of the environmental site data noted was of the type which approximated specific physiological effects on the vegetation for example altitude, aspect, soil depth, drainage conditions etc. as described by Kellman (1975). Explanation of the vegetation pattern was then attempted.

During the course of the study a number of the original intentions regarding sampling procedure and vegetation assessment were discarded as unworkable for reasons of practicality. The sampling was originally intended to be entirely quantitative. It was however eventually limited to initial quantitative gradient analyses in each of the major sampling locations (Kaitake, Pouakai, Mt Egmont and the Taranaki Upland) and completed using more comprehensive semi-quantitative analyses. This was because of the uneconomic returns for the amount of time invested in quantitative sampling. In this respect the study methods of vegetation assessment tended to swing back to the semi-quantitative methods widely used before the advent of gradient analysis (e.g. Braun-Blanquet, 1932). The approach to numerical analyses employed by this study (notably classification and ordination of vegetation data) was to use the statistical techniques as a tool for simplifying and summarising complex vegetation data which was then related to the major environmental gradients already determined from field observations. Numerical analysis was not used for testing hypotheses. Although as a result of field observations it became obvious that no two patches of vegetation are ever exactly alike (as pointed out by Gleason, 1926), and that vegetation boundaries may be either abrupt or gradual (see Clarkson, 1977), attempts have still been made to describe vegetation types. The types are described on the basis of dominance (by cover and basal area) of species in the top stratum and as such can be recognised easily and quickly in the field.

Nomenclature

Vascular species nomenclature for the most part follows that of Druce (1973, 1977) because familiarity with the plants found in the Taranaki Land District made it apparent that some of the plants present are undescribed in the standard references (Allan, 1961 and Moore and Edgar, 1970). In other cases the species described by the standard references is in fact an aggregate of species. Instances where Druce (1973, 1977) was not followed or where it was felt some explanation of the name used is warranted are described in Appendix 9. Many of the dominant or frequently occurring vascular species are referred to by their common name and Appendix 10 lists the common names used and their scientific equivalents. The nomenclature of mosses referred to follows that of Allison and Child

(1971).

Outline of the thesis

The study area is examined in detail in Chapter 2 with sections describing the geology, soils and volcanic history, climate, human activity and its effect on the vegetation, other animals and previous botanical research. Chapter 3 describes and justifies the methods used for data collection and analysis. Chapter 4 comprises the results and analyses for all the places examined with major sections describing Kaitake, Pouakai, Mt Egmont and the Taranaki Upland. Chapter 5 summarises and discusses these results and analyses. The first section outlines the nature of species distribution as determined by the field observations throughout the Taranaki Land District. The remaining sections compare the flora and vegetation of, firstly, the three volcanoes of the national park (Kaitake, Pouakai and Egmont); secondly, Egmont National Park with that of the Taranaki Upland, and finally the mountains of Egmont National Park with some other southern hemisphere mountains.

CHAPTER 2

THE STUDY AREA

1. GEOLOGY, SOILS AND VOLCANIC HISTORY

Two major and contrasting landforms make up the Taranaki Land District. These are: the Taranaki Volcanic Succession (Egmont, Pouakai and Kaitake and the associated ring plains) and the Taranaki Upland block (gently inclined beds of sedimentary rocks). The features and locations noted in the following description of these two major landforms are displayed on Figures 2.1 and 2.2.

The Taranaki Volcanic Succession

Aspects of the volcanic history, geology, and soils of the Taranaki Volcanic Succession are described by Grant-Taylor (1964), Druce (1964, 1966), N.Z. Soil Bureau (1968), Tonkin (1970), Neall (1974, 1976) and Aitken et. al. (1978). The information of particular relevance to a study of the vegetation is summarised from these sources and presented below. According to Neall (1974, 1976), the linear sequence (NNW to SSE) of volcanic activity began at Paritutu and the Sugar Loaf Islands near New Plymouth 1,750,000 years ago. This was followed by Kaitake, Pouakai and Egmont respectively active 575,000 years ago, 250,000 years ago and 70,000

Figure 2.1 TARANAKI VOLCANIC REGION LOCATION MAP

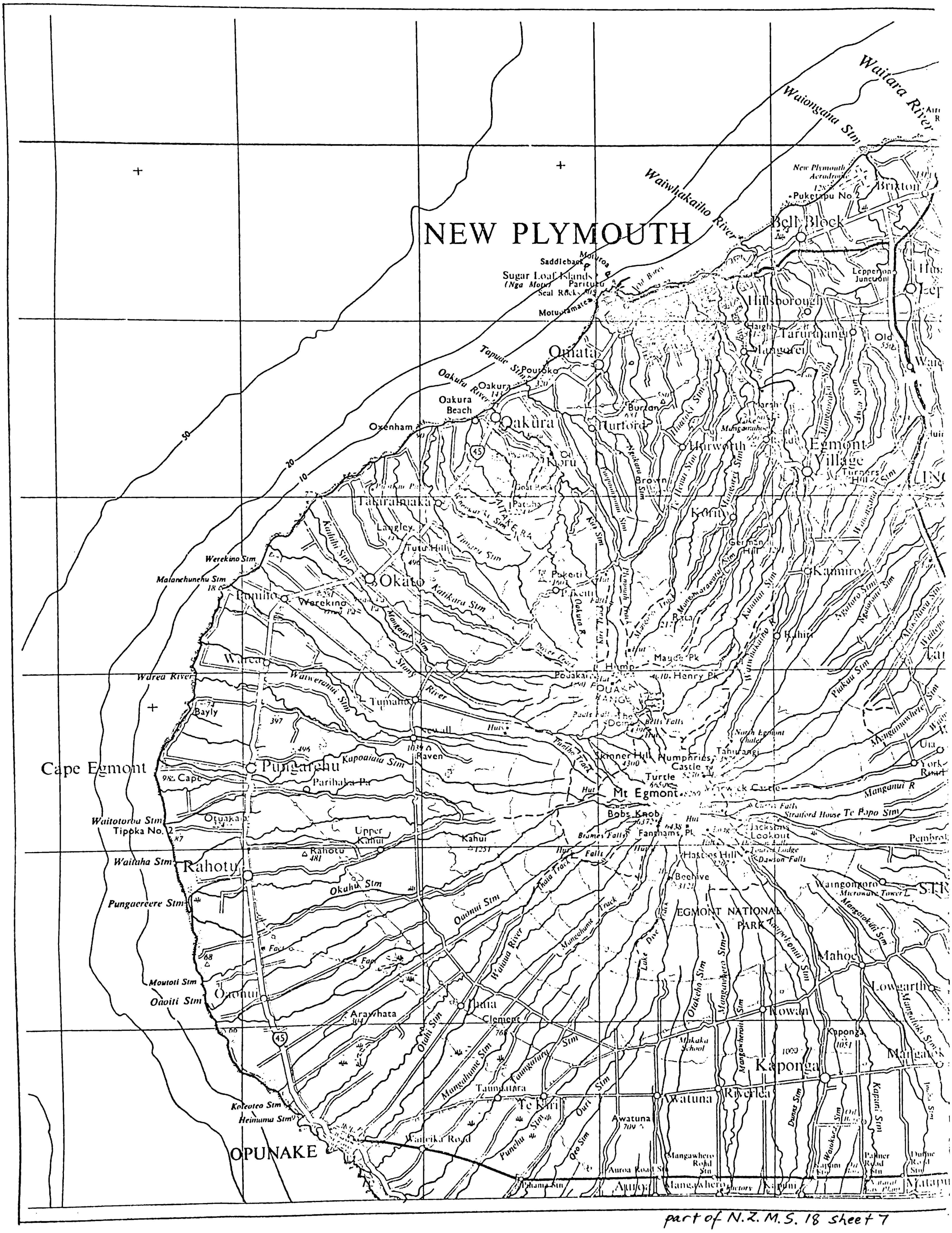


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Figure 2·2

TARANAKI UPLAND LOCATION MAP

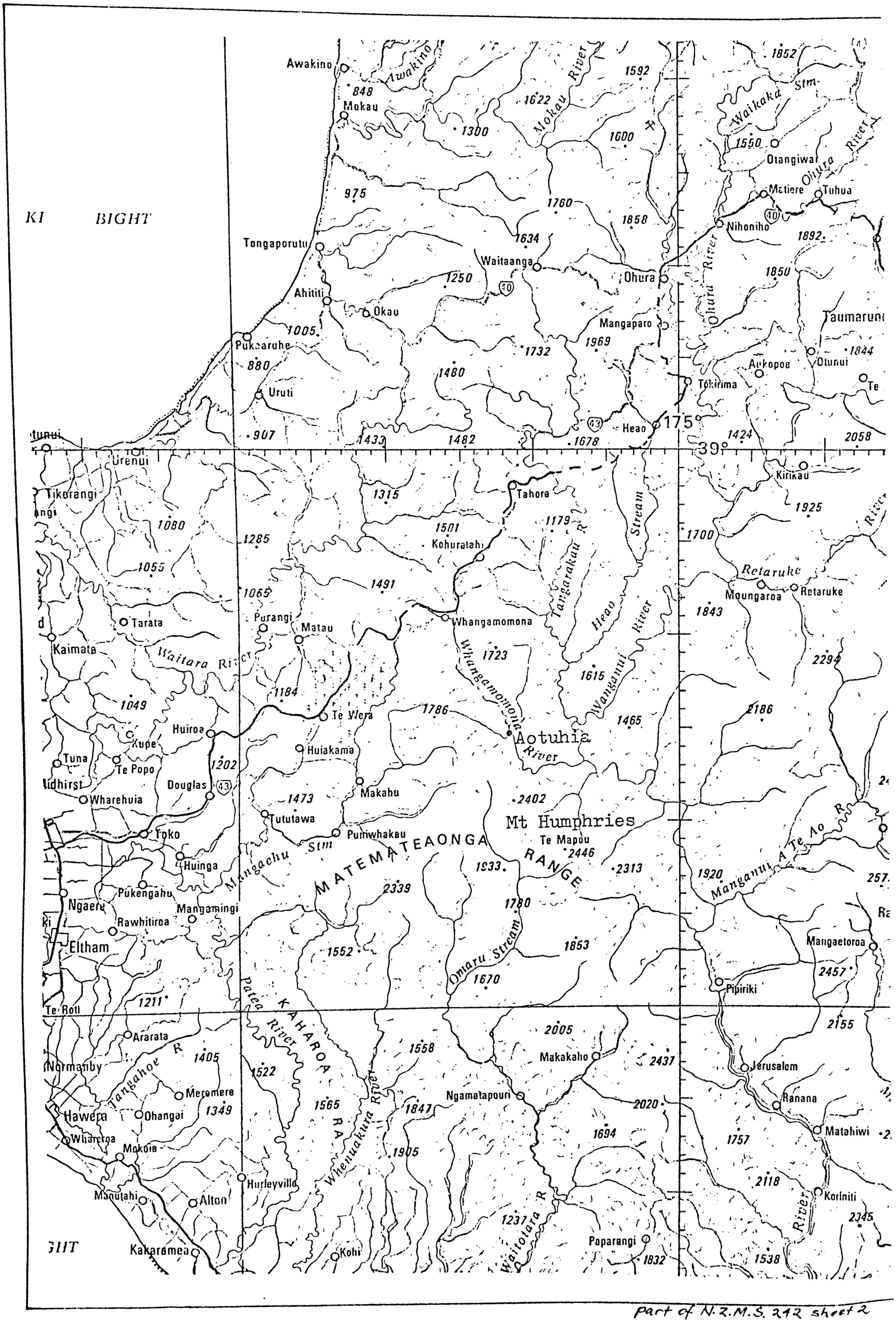

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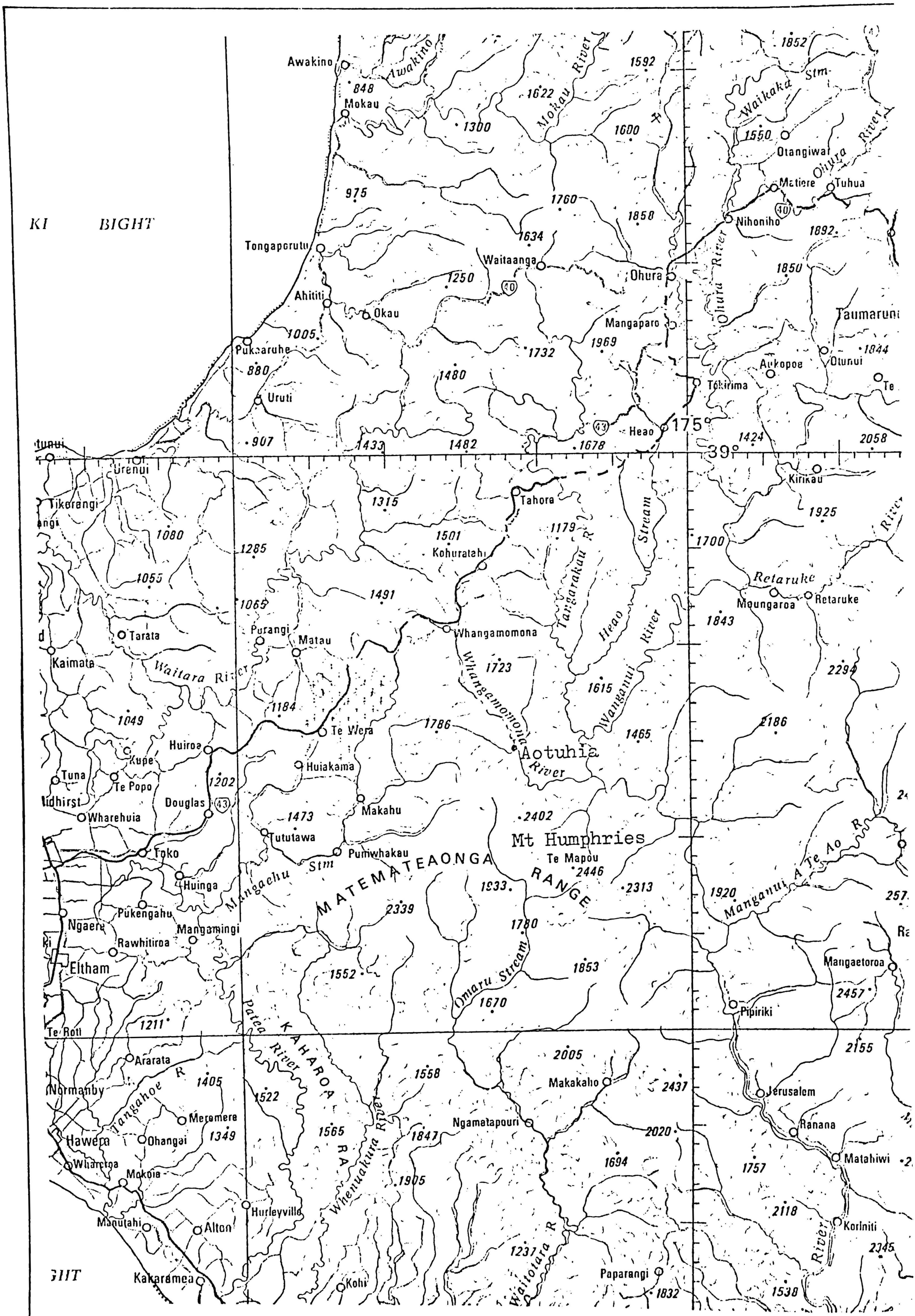
Figure 2·2 TARANAKI UPLAND LOCATION MAP



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years ago. The sequence Kaitake, Pouakai and Mt Egmont thus forms a series of progressively younger volcanic landforms. A number of other much smaller and more recent domes, for example the Beehives, Pukeiti, the Dome, and Skinner Hill, detract from the overall pattern.

Kaitake exhibits an advanced stage of erosion which has reduced the volcano (estimated to be originally as large as Egmont is now) to a circular area of radiating ridges which rise to a central point, Patuha 684m a.s.l.

Pouakai is less dissected than Kaitake and retains much of the smooth lower and middle slopes characteristic of andesite volcanoes. Parts of the Pouakai Ring Plain are still preserved between Inglewood and Okato and along the eastern boundary of the Egmont Ring Plain. Pouakai is also estimated to have originally been of a similar height as present day Egmont. The highest peaks, Pouakai (1377m), Maude Peak (1221m) and Henry Peak (1222m) are remnants outlining the form of the original volcano. Between these peaks an extensive 'plateau' of diverse topography presents a relatively large zone for subalpine vegetation in comparison to what is available on the larger and still conical Mt Egmont.

Mt Egmont is a substantially intact volcano reaching 2518m a.s.l. Lahars, debris flows, lava flows, ash and lapilli showers all originating from Mt Egmont in a complex sequence of events over the last 70,000 years have shaped the present day characteristics of the Taranaki landscape. The complete cone and its associated gently sloping ring plain spread from Cape Egmont in the west to beyond Stratford in the east. Superimposed on the cone and the ring plain is an almost perfect pattern of radial drainage. Particularly relevant to the development of the present day cover of vegetation is the most recent volcanic activity and erosion of the mountain. Some trees living at present exhibit the effects of recent eruptions in their growth form and the vegetation at many locations on Mt Egmont is still readjusting to the damage caused by the recent volcanic activity. Between 1500 and 1550 A.D. four small hot flow deposits (the Newall and Waiweranui eruptions) descended the Stony River catchment on the north-western slopes reducing much of the native bush to carbonised logs. Fires also swept 3 km northwards across the western slopes of the Pouakai Range (Druce 1964). Even more recently, around 1655 A.D., the Burrell eruptions deposited pumice gravel over a large area on the ESE side, andesitic gravel on the WNW side and ash on all the upper slopes of Egmont (Druce 1964). The Burrell eruptions are therefore a major factor which affected the composition and structure of the vegetation at many of the upper altitude sites examined at East Egmont for this study. The most recent eruption on Egmont, the Tahurangi eruption of 1755 A.D., was very small and deposited five to twelve centimetres of ash on the upper slopes of the mountain and in most places the upper part of the present soil has formed from this material (Druce 1964).

As well as the recent volcanic disturbances, the vegetation cover has been greatly affected in places by debris flows. The heavy rainstorms experienced on Egmont and the fact that much of the mountain is unstable anyway, has resulted in a series of at least eleven debris flows over the last 400 years (Neall 1974). The western crater rim was the source of a number of these flows and the most recent debris flows include ones below the Pyramid Stream.

On a smaller scale is damage caused by flooding in many of the rivers and streams, for example in the Mangahume, Punehu, Waiwhakaiho, Manganui, Maketawa, and Kapuni Streams. As a result, stream courses may, to a greater or lesser extent, show margins clothed in trees of different size and kind from those making up the bulk of the forest on the mountain. Smaller land slides initiated by heavy rainstorms, sometimes in conjunction with the damage to the vegetation caused by goats and/or opossums, are also common, e.g. the very recent 1976 examples near North Egmont. As Druce (1964, 1976b) has noted, the spectacular natural erosion will continue as long as the upper slopes of Egmont remain unstable.

The soils of the south-eastern sector of Egmont National Park have been described in detail by Tonkin (1970) and all are recent soils. Two major soil groups were described: Tahurangi and Burrell soils, both derived from andesitic tephra. The Tahurangi soils are mainly subalpine (above 990m and below 1371m) although extending in places down to 670m. The Burrell soils are upland temperate soils below 990m. Minor soil groups described included recent soils from alluvium, for example the Hangatahua soils which line the Manganui and Kapuni Rivers and soils from peat with interbedded tephras as found at Potaema Bog. As Tonkin (1970) notes, both Tahurangi and Burrell soils are relatively unweathered mineral soils and the percentage base saturations of the mineral horizons are very low, thus these soils are impoverished. The important source of readily available nutrients for the vegetation is the litter layer. The overriding factor reflected by all of these soils is the high rainfall. This causes high leaching losses, a humus shift in the porous A horizon and, because of the stratified nature of the soil body, a significant lateral movement of water containing dissolved materials such as iron hydroxides. The soil chemistry is very similar throughout the range of slope and altitude of all of these soils, pH, for example, averaging 5.0. Gross features such as soil depth (of the A horizon), stability, and drainage characteristics however, relate very closely to the increasing slope angles recorded at higher elevations on the mountain.

The soils of the remainder of the national park, Pouakai and Kaitake have been described and mapped, although in much less detail, by the N.Z. Soil Bureau (1968). The principal soils are the Inglewood-Patua soils which are yellow-brown loams and the steepland soils related to the Te Kie-Awapuku soils which are brown granular loams. The yellow-brown loams relate more closely to the soils of the Egmont Ring Plain while the steepland soils on the top of Kaitake and Pouakai provide an interesting comparison with the soils present on other old volcanoes in the North Island, notably Pirongia and Maungatautari. The main differences between the soils of upper Kaitake and Pouakai and those on Egmont is that on steeper slopes many of the layers of ash have been stripped away and weathering of the underlying andesitic rock is also contributing to soil formation. The soils are therefore more mature and the mineral layers are more weathered. Many of the flatter sites on the extensive 'plateau' on the top of Pouakai exhibit well developed layers of peat while the Ahukawakawa Swamp is composed of peat with interbedded tephras.

Outside the national park andesitic volcanic ash is still the parent material for the soils of the Egmont Ring Plain where it forms thick deposits on little-dissected flat to undulating land (Aitken et. al. 1978). East of Stratford the ash mantle becomes progressively thinner and discontinuous, partly because of increasing distances from the source and partly because much of it has been removed in the process of dissection. The major soil groups described by Aitken et. al. (1978) are New Plymouth soils, Stratford soils, Inglewood soils, Lowgarth soils, and Rowan soils. Collectively all of these soils are yellow-brown loams which are moderately to strongly acid and moderately to strongly leached. They are classed as semi-mature, a stage of soil development indicated by the presence of weakly developed prismatic or nutty structures in their subsoils. As Ward and Hocking (1956) note, these are among the richest soils in Taranaki and are in effect self-fertilising because they have a reserve of unweathered minerals which, as they weather, become available to plants.

Other soils occurring on the ring plain include:

soils developed from young lahars, for example the Uia soils near Midhirst, and those developed from alluvium, for example the Rahotu soils and the already described Hangatahua soils. On the edge of the ring plain are a number of areas of soil forming peat deposits which appear to have formed as the result of ponding which was caused by the interruption of drainage patterns during formation of the ring plain. These areas located to the east of Eltham (Ngaere Swamp) and Midhirst and near Ratapiko are termed Eltham soils. There are layers of volcanic ash and lapilli interbedded within the peat. Two areas examined for this study, Meier's Bush and Charteris' Bush are on Eltham soils.

The Taranaki Upland

Aspects of the geology and soils of the Taranaki Upland are described by Nicholls (1956), Ward and Hocking (1956), N.Z. Soil Bureau (1968), Aitken et. al. (1978) and in the Aotuhia Regional Land Use Study (1978). As outlined later, the composition and structure of the vegetation of the Taranaki Upland relates closely to its geology, soils and topography.

The Taranaki Upland is a great block of gently inclined beds (3-7^{o}) of massive sandstones and unconsolidated mudstones. In the Pliocene the area was part of an extensive peneplain that has since undergone tectonic uplift and been dissected by major rivers. There is a general tilt to the south-west giving a gradual fall in height of ridges from 2500' (762m) in the east to 500' (152m) near the coast or adjacent to the

Egmont Ring Plain. A pause in uplift formed a number of wide inland valleys now 500-700' (152m-213m) above sea level, for example the Ohura Valley, however a final rejuvenation of the landscape resulted in the rugged terrain characteristic of most of the country still covered in forest. Typically there is an intricate series of long, sharp-crested accordant ridges with narrow deep valleys (Nicholls, 1956). Although most of the rocks are silty sandstones (Matemateaonga sandstone) and sandy siltstones (Urenui siltstone), within the sandstones and siltstones are conglomeratic bands, limestones, and concretionary layers (known locally as 'shellrock') and harder sandstone caps some of the ridges.

Airfall volcanic ash from the Egmont volcanoes is present on plateaux and flatter ridge tops, but has been washed off most slopes and accumulated as volcanic alluvium in valley bottoms and in the colluvium at the base of slopes. Of particular relevance to the vegetation composition and structure, especially areas which have been cleared previously and now support secondary growth, is the tendency for the siltstones and mudstones to superficial slumping when surface layers become saturated with water after intense and heavy rain.

As Aitken et. al. (1978) and the Aotuhia Regional Land Use Study (1978) note, the soils of the Taranaki Upland are of two main types: those in which volcanic ash is still an important component, and those of the steeper slopes where the volcanic ash is thin or absent and the soils are derived from sedimentary rocks. The

New Plymouth hill soils belong to the former and are found in the Toko and Douglas districts. They are yellow-brown loams and are thus closely related to the soils of the Egmont Ring Plain. Soils derived from the sedimentary rocks include the Tahora steepland soils, Kohuratahi hill soils, Tirangi steepland soils, Whangamomona steepland soils, and the Moumahaki steepland soils. All of these soils are yellow-brown earths or related steepland soils and are of low to medium fertility. Apart from slope, the soil limitations of many of the yellow-brown earths include nutrient deficiencies, shallow profiles over hard sandstone, and high susceptibility to slip erosion.

2. CLIMATE

A wide range of climatic conditions occur in the Taranaki Land District. The climate ranges from what has been locally loosely termed 'subtropical' in frost free sheltered coastal sites near Oakura and the Kaitake volcanic remnant through to nival on the upper slopes of Mt Egmont where there is a perpetual cover of snow and ice. Accurate long term climatic data is available from five weather stations in the region which are administered by the New Zealand Meteorological Service (see New Zealand Meteorological Service, 1973). These are New Plymouth Aerodrome, New Plymouth, Stratford Demonstration Farm, Manaia Demonstration Farm, and Te Wera Forest. Other important climatic data which has been collected over a shorter period is that from within Egmont National Park at Stratford Mountain House, Dawson Falls, and North Egmont as reported by Coulter (1976).

This data is also supplemented by data from a range of 'unofficial' recording stations such as the Pukeiti Rhododendron Trust. Unfortunately no long term data is available for a great number of locations including Pouakai, Kaitake, and much of inland Taranaki. The main features of the climate of each of the major sampling locations have already been described in Coulter (1976) and the Aotuhia Regional Land Use Study (1978) and the relationship of the Taranaki climate with the remainder of New Zealand is described in the N.Z. Atlas (Wards, 1976). A summary of the basic information is provided here as a background to this study, particularly those aspects of climate which are reflected by the vegetation composition and structure.

Two overriding environmental gradients, temperature and rainfall, interact to provide the range of climatic conditions reflected by the vegetation. The warmest parts of the Taranaki Land District are in the immediate vicinity of the west coast. The normal temperature (as defined by the N.Z. Meteorological Service, 1973) at New Plymouth (49m a.s.l.) is 13.4°C and at Manaia (98m a.s.l.) 12.3°C. Further inland and at higher elevations the normal temperature is lower, so that at Stratford (311m a.s.l.) and Te Wera (180m a.s.l.) it is 11.2°C while at the Stratford Mountain House (846m a.s.l.) it is 9.0°C. Using the lapse rate (described by Coulter, 1976, as a decrease in air temperature near the ground on average of approximately six degrees C. per 1000m), the normal temperature along the altitudinal gradient of Mt Egmont can be roughly estimated, as listed in

Table 2.1.

Table 2.1 Normal temperature estimates along the altitudinal gradient on Mt Egmont

	Altitude	Normal Temperature °C
New Plymouth	49m (160')	13.4
Stratford	311m (1016')	11.2
Stratford Mountain House	846m (2766')	9.0
Estimate	1346m (4401')	6.0
Estimate	1846m (6036')	3.0
Estimate	2346m (7671')	0.0
Estimate for Summit	2518m (8260')	-1.97

The average number of days per year with ground frost and snow at each of the stations also gives a good indication of temperature differences. At New Plymouth for example, the average number of days of ground frost is 6.9, at Stratford, 73.1, and at Stratford Mountain House, 95.6. Further inland at Te Wera the value is 71.8. The average numbers of snow days per year for the same locations are 0.1, 0.6, 14.0, and 0.0 respectively. The highest points in inland Taranaki, for example Mt Humphries, are estimated to receive snow on average less than 2.0 days per year. Higher elevation sites above the Stratford Mountain House on Mt Egmont of course, record even higher average snow and frost days. Coulter (1976) estimates that freezing level occurs 'at approximately 3500m on average (it lies between 2800m and 4200m for about two-thirds of the time) in mid summer while in mid winter the corresponding levels are

1750m (1150m and 2350m)' (Coulter, 1976, p52). As well as the general decline in temperature from the coast to inland localities and with increasing elevation, the temperature range also becomes much greater. Thus at New Plymouth the mean daily range is 6.9°C, at Stratford it is 8.4°C, Te Wera, 10.6°C, and at the Stratford Mountain House, 8.0°C. This feature of the climate is even further exaggerated at higher altitudes on Mt Egmont, where as Coulter (1976) notes, 'when there is no wind and skies are clear, bare ground surfaces - such as scoria or rocks - and the air in contact with them will be heated strongly under the influence of mid-day summer sunshine, and temperatures will then be five to ten degrees higher than the free air average for the season and altitude in question. In these conditions, when the sun sets, intense radiational cooling takes place and this will give a very rapid drop in surface temperatures' (Coulter, 1976, p53).

The distribution of rainfall in the Taranaki Land District relates directly to the orographic effect of the mountains, particularly Egmont, on the moisture laden prevailing winds blowing from the Tasman Sea. Thus more rain falls on the seaward slopes of the mountain than on the coast. Coulter (1976) states 'the overall result is seen in the pattern of mean annual rainfall. This amounts to about 1500mm near the North Taranaki coast, around 1100mm to 1300mm near the South Taranaki coast, and increases more or less parallel with the contours of the land to about 6500mm at the 1000m level and probably about 8000mm near the 2000m line, but with somewhat more rain on the northern and western slopes than elsewhere' (Coulter, 1976, p52). Further inland at Te Wera Forest the mean annual rainfall is approximately 1800mm and probably exceeds 2000mm in most of the Aotuhia region. Some of the extreme values recorded on the mountain are particularly notable. At the Stratford Mountain House for example, 1574mm were recorded in the single month of July in 1974, this being one of the highest monthly totals ever recorded in New Zealand, while during a 48 hour period in February 1971, 795mm of rain fell. The erosional effects of such intense falls have already been described in the previous section.

A number of other features of the climate are particularly relevant with regard to plant growth and the vegetation. These are wind, relative humidity including cloud cover, and sunshine hours. Exposure to wind of course varies greatly in relation to aspect and topography, however there is a general trend towards stronger winds nearer the coast and at higher elevations. At the coast near New Plymouth average wind speed is 16km per hour while further inland at Stratford it is 11km per hour. Coulter (1976) estimates the average wind speed at the summit to be about 40km per hour. Damage caused to the translator towers at the Hen and Chickens site on Egmont and the windshaping and wind throw of trees on the higher slopes all attest to the strength of the winds in exposed locations. As well, Druce (1964) notes that the coastal winds carry salt appreciable distances inland and damage to tree crowns, particularly of kaikawaka, has often been attributed to this. The mountains also cause much distortion in the overall wind flow pattern of Western Taranaki. Thus at New Plymouth the westerly winds from the coast are the most frequent while at Stratford, northerly and southerlies are more common. The channelling of wind between Egmont and Pouakai is another case of distortion of the normal pattern. In contrast to the coastal side of Taranaki, many of the sheltered valleys in inland Taranaki are almost wind free.

Relative humidity also increases with elevation above sea level and away from the coast. At New Plymouth the average at 9 a.m. is 78%, while at Stratford and Te Wera Forest respectively it is 83% and 84%. Higher up Mt Egmont at the Stratford Mountain House the average at 9 a.m. is 87%. Related to relative humidity is the incidence of cloud cover, fog, and mist. At higher altitude sites, for example Dawson Falls, North Egmont, and the Stratford Mountain House, the sky is quite commonly clear in the morning and clouded over in the afternoon. An annual average of 38 fog days occurs at the Stratford Mountain House and the formation of a cloud cap covering much of the upper slopes of Mt Egmont is well known. Further inland in the Aotuhia region the wind-free valleys cause temperature inversions resulting in early morning fogs throughout the year.

Average sunshine hours are consequently greatest on the coast. At New Plymouth the average is 2110 hours, about 50% of the total possible. For most of the inland area it is probably less than 1800 hours while for high altitude locations such as Dawson Falls and the Stratford

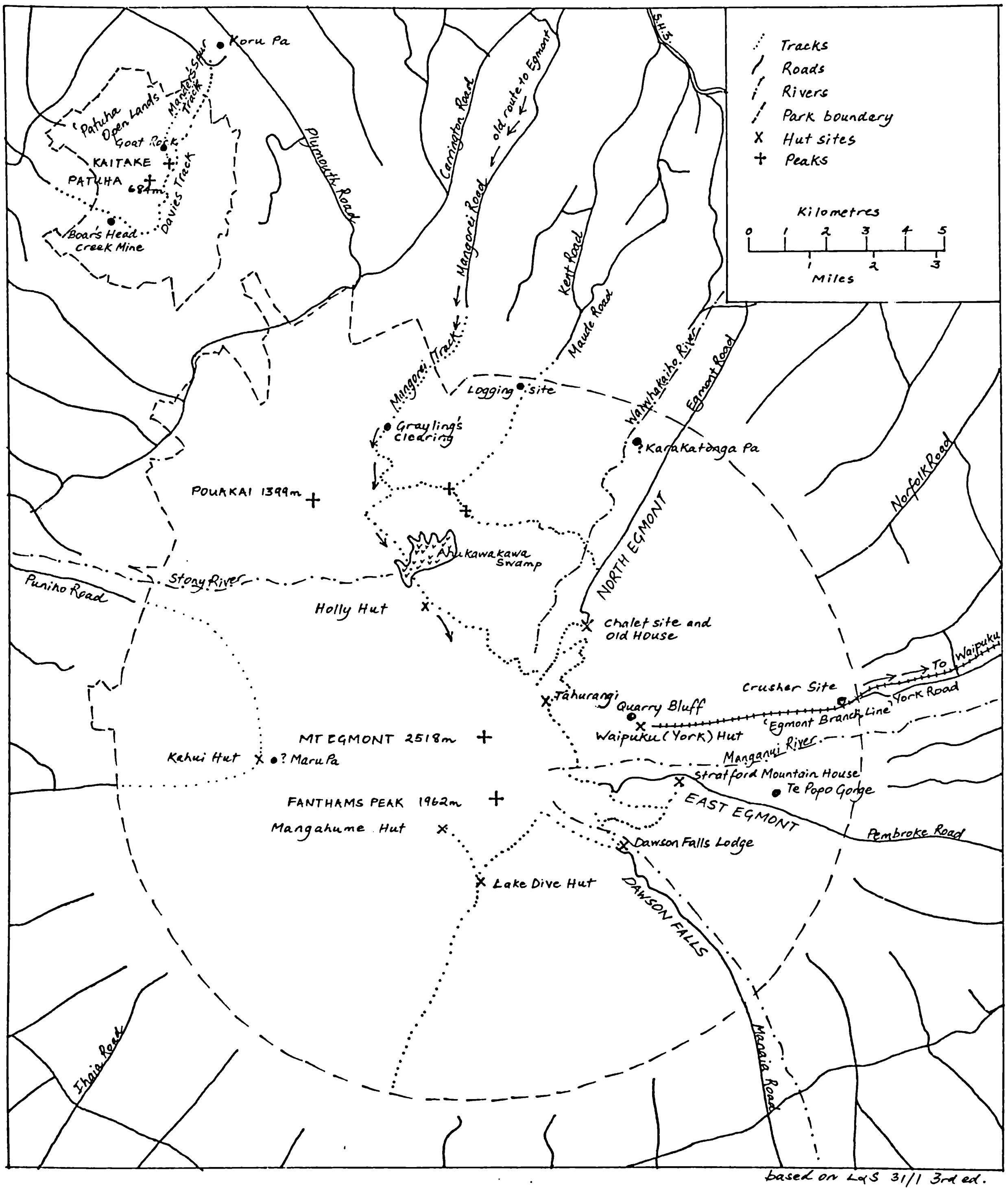
Mountain House it is probably less than 1000 hours.

In short, the climatic conditions in most of the Taranaki Land District (with the exception of the higher altitude areas on the mountains) are very favourable for plant growth. There is an ample to excessive supply of rain and temperatures are warm enough to permit almost continuous growth throughout the year. In relation to other regions of New Zealand the climate of Taranaki has been described by Garnier (1958) as belonging to 'Middle New Zealand' and as such conforms closely to the average conditions associated with New Zealand as a whole.

3. HUMAN ACTIVITY AND ITS EFFECT ON THE VEGETATION

While the Egmont National Park vegetation has enjoyed comparative protection from the effects of human activity (as a result of legislation in particular the Egmont National Park Act 1900), the vegetation of the Egmont Ring Plain and much of the Taranaki Upland has not. At the time of the arrival of the European much of the coastal land and ring plain had already been greatly modified by the relatively dense settlement of the Maori (see Smith, 1910) and the early colonists described the large areas dominated by bracken fern resulting from the clearing and burning off of forest for the cultivation of crops (see Rutherford et. al., 1940). The effects of human activity became far more dramatic however following the arrival of the European. The whole Taranaki landscape was within the short space of one hundred years transformed from a predominantly indigenous forest land to an agricultural pasture land dominated by exotic

Figure 2·3 SITES OF MAJOR HUMAN ACTIVITY IN EGMONT NATIONAL PARK



based on L&S 31/1 3rd ed.

species.

The present day landscape consists of vegetation in which a complete range of combination and integration of exotic and indigenous species are to be found. Some of the most interesting combinations for example result from the colonisation of exotic species by indigenous epiphytes. *Phymatosorus diversifolius* and *Pyrrosia serpens* quite commonly grow on the barberry (*Berberis glaucocarpa*) which as a hedgerow is a feature of the present day landscape. As well, the epiphytic orchids *Dendrobium cunninghamii* and *Earina mucronata* and the epiphytic shrub *Griselinia lucida* are commonly found growing on *Pinus radiata* and *Cupressus macrocarpa* which have been widely planted as shelter belts and woodlots.

At the present time approximately 14 percent (138,000 ha) of the Taranaki Land District is classified as national park, scenic reserve, or state forest. Except for some areas of state forest the majority of this land will continue to support indigenous forest. Large areas of privately owned land also support indigenous vegetation. By far the greater part of all of this land is above 1500' a.s.l. (457m) so that the upland and montane forests are well represented but the lowland (ring plain) and coastal forests are reduced to small scattered remnants (see New Zealand Atlas (Wards, 1978) Contemporary Forest Cover).

The process of change is by no means at an end. Primary forest and secondary forest which developed from previous unsuccessful attempts to farm the Taranaki Upland continue to be cleared for agriculture. Studies of the successions resulting when large numbers of farms were abandoned in the 1930's are included in this study in the section describing the Taranaki Upland. The very small and unviable remnants of indigenous vegetation on some farms continue to degrade and become invaded by a range of exotic plant species as do some of the smaller scenic reserves. This invasion by exotic plant species initiated by man, both planned and unplanned, is so advanced now that only the most remote and inaccessible areas covered in indigenous forest do not support at least a few adventive species. This feature of the vegetation is well illustrated by distributions of some exotic species noted during the course of this study. Catsear (*Hypochoeris radicata*) is now found in the tussock-herbfield of both Egmont and Pouakai. A rhododendron species grows in places in the Egmont shrubland, and ragwort (*Senecio jacobaea*) flourishes on the banks of the remote Heao Stream.

Much of the vegetation in Egmont National Park is substantially unaltered in composition (at least in the top strata - emergents, canopy, and subcanopy) by comparison with its composition just prior to the European discovery of New Zealand. The effects of human activity throughout the recent history of vegetation development are however underestimated by all of the authors cited later in the section describing previous botanical research. Obviously the Maori provided the first instances of human activity on the slopes of the mountain and in fact the discovery of Maori ovens beneath the layers of volcanic ash was one of the clues which lead to the realisation that Egmont has an extremely recent volcanic history. Both as a source of food, particularly birds, and also as a source of red ochre (kokowai) the resources of the mountain attracted the Maori. As well the Maoris buried their dead in many hiding places on the upper slopes of Egmont and on the Pouakai and Kaitake Range (e.g. Goat Rock). The focus of major effects on the vegetation would have been settlements and although not widespread because of the climatic inhospitality of the mountain, several important settlement or pa sites did occur within the boundaries of the national park. Although it is only possible to describe a few examples for the purposes of this study, the current research by Mr D.H. Rawson of New Plymouth demonstrates just how extensively the area now in national park was used by the Maori.

Two of the most important sites within the national park were Maru and Karakatonga while Koru Pa, another important site, is located just outside the national park boundary in the vicinity of Davies Track at the foot of the Kaitake Range (see Figure 2.3). Karakatonga dates back to 1400 A.D. according to the tribal history while Maru was a refuge for the Taranaki Tribe when the Waikato Maoris attacked in 1826. Both sites would have had major impacts on the surrounding vegetation, Karakatonga in particular, because as Scanlan (1961) notes it was no mere place of refuge but a village of importance with a council house and marae. Located at an altitude of 600m it is questionable how much clearing of the forest for crops would have occurred if present day gardening success at the park boundary is any guide. However even the Maru site is purported to have had secret cultivation sites further down the mountain near the present day Kahui Hut (880m). The supposed Karakatonga site is now overgrown with a dense cover of forest principally multi-stemmed kamahi no different to the vegetation found in similar sites on river terraces of the Waiwhakaiho. Likewise the site indicated as Maru Pa on NZMS 169 (5th ed.) is covered with scrub vegetation dominated by leatherwood similar to surrounding sites although recent investigation by Mr D.H. Rawson of New Plymouth casts doubt on this being the true location of Maru Pa.

Major changes in vegetation composition and structure have resulted from the more recent occupation of Europeans. The initial exploration of Egmont was from New Plymouth via the Pouakai Range (see Figure 2.3). James Henry, a scottish nurseryman, and one of the first guides of the Pouakai route cleared vegetation to plant scottish heather and blue currant in 1870. He also built up a trade with America and elsewhere in mountain plants and seed of the toi (*Cordyline indivisa*). As early as 1872 the Provincial Government voted £100 ($200) for a bridle track (Mangorei Track) over the ranges. Eventually constructed in 1873 log bridges built to cross the small streams around the 'Extinguisher' were of kaikawaka. To this day the Mangorei Track still shows evidence of the extensive disturbance to the vegetation at places like Grayling's Clearing. Even the eminent botanist Thomas Cheeseman who visited Egmont via the Pouakai route used kaikawaka on his camp fire (Scanlan, 1961). The combined effect on the vegetation by the fuel gathering activities of all of the early parties which visited the mountains must have been considerable particularly in instances where large groups camped in the bush for several days at a time.

The establishment of the Old House (North Egmont) 1892, the Dawson Falls Hostel 1896, the Stratford Mountain House (see Figure 2.3) together with associated roading and subsequent extensions and modifications all had an effect on the surrounding vegetation. Perhaps the most important one was the tendency for species such as Hall's totara and kaikawaka to be used for everything from firewood to fence battens and building materials. The fireplace at the Old House (North Egmont) for example could accommodate logs up to 2m in length. Although these practices have long since ceased and the impact was restricted to the immediate vicinity, evidence for these activities is still obvious inside the forest. Near the North Egmont Chalet site for example numbers of Hall's totara stumps point to the exploitation of this species. Much of the vegetation nearby is not true 'climax' notably the vegetation near the Nature Walk in which leatherwood is prominent. Unconfirmed reports of commercial supply of Hall's totara battens from this area prior to 1920 have also been made.

Of all the places within the Egmont National Park the area most disturbed by human activity is the Kaitake Range. Logging, land clearance and mining activities are all identifiable. The Boar's Head Creek location (see Figure 2.3) has been the scene of intermittent activity since 1870 when a specimen crusher operated, although by 1877 this particular venture had ended. Konini Creek north of Boar's Head Creek was also the site of a 'drive' in 1898. The most recent mining activity was that of prospectors like R.W. Davies who worked in the vicinity of Boar's Head Creek. Large numbers of tree ferns and lancewood in the disturbed kohekohe, pukatea, tawa and hinau forest attest to the damage to the vegetation which has occurred. Logging and land clearance occurred in the area known as the Patua Open Lands Reserve and is referred to in detail in the section on Mander's Spur Track Ridge. The vegetation affected was forest in which the large trees were principally tawa, kohekohe, pukatea, hinau and rimu.

In 1908 a metal crushing plant operated by water power from a dam in the Manganui River operated inside the national park at the end of York Road (see Figure 2.3). Rock was transported from a quarry (Quarry Bluff) near the site of the present day Waipuku (York) Hut (945m) by rail. The line being known as the Mt Egmont Branchline began at the settlement of Waipuku and was some 6 miles 2 chain (10km) in length. The size of the old shunting area, the refuse dumps, and the old bottles and debris which may be found scattered amongst the trees confirm that while in operation the human impact on the vegetation would have been marked. The old crusher site, railway lines and shunting area are still in the process of revegetation. Important species in the succession at present are bracken fern, gorse, *Coriaria arborea*, *Coprosma 'taylorae'*, *Astelia fragrans*, and *Rubus* *cissoides* all of which form a new stratum above the ground cover composed principally of pasture grasses and adventive weeds. Elsewhere on the fringes of old tracks more advanced successional stages are apparent in which kamahi forms dense multi-stemmed stands. These sites are not easily overlooked but other significant changes in the forest composition particularly near the Waipuku Hut are. Again Hall's totara and kaikawaka were the major casualties. Hall's totara stumps are still present short distances from the edge of the old railway line and large logs which had been split and stacked ready for later use have also been found rotting under the trees. Kaikawaka is absent from the top stratum of vegetation (emergents, canopy and large subcanopy) on the York Road Track Ridge (Clarkson, 1977) although seedlings and small saplings are present. The large kaikawaka were probably milled out during the period of quarrying operations from 1908-1923 as they are present on the major ridges either side of the York Road Track Ridge. A thorough search for remnants has yet to be made to confirm or refute this suggestion. The fringes of the old railway line above the Waipuku Hut are notable for the large specimens (up to 6.5m in height) of *Olearia ilicifolia* which have established since the disturbance while other areas nearby are notable for the dominance (80% RBA) of Hall's totara (5-32cm d.b.h.) which appears to have established after partial clearing of the forest. The track margins and large areas which were cleared near Quarry Bluff support shrubs (50cm - 2m in height) the principal species including *Cassinia vauvilliersii*, *Hebe odora*, *Coprosma 'taylorae'*, and leatherwood. Although high goat populations in recent years have further exacerbated this situation much of this shrub vegetation probably resulted from the initial disturbance by the quarrying activities.

Eleven years after the York Road quarrying operations had ceased in 1934, forest near the end of Kent Road and the Te Popo Gorge was the scene of a short lived logging operation organised by the East Committee of the Egmont National Park Board (see Figure 2.3). The chairman had financed park board activities out of his own pocket and was endeavouring to recover these debts. Scanlan (1961) reports that a bush tramway and cableway had been installed at the Te Popo Gorge location and that orders for posts and firewood were being taken by the committee. In the Kent Road location a tally of timber stacked showed 1,280 broadleaf, hinau and totara posts, 1,920 battens, seventy-five cords of firewood and many strainers. Rotted stacks of firewood covered with vegetation were still present in the Te Popo location in 1960 but there are no signs of this past logging remaining today.

Scanlan (1961) also reports that in 1927 the Egmont National Park Board decided to help the rimu trees by instructing staff where practicable to cut through the attached rata if they thought the rimu could be saved. The belief at the time was that rata were 'killing off' the rimu trees. This measure was shortlived however after strong public reaction.

Today human impacts on the vegetation are minimal compared to those of the past although as increasing numbers of people use the park this is changing. Large numbers of people now climb to the summit of Egmont during summer and the moss-herbfield, herbfield, and rock and scoria slope vegetation along the main summit routes via Dawson Falls, Stratford, and North Egmont is damaged annually. This damage is greatest when climbers stray from using a single track or when on their return from the summit indulge in a little scoria slope sliding. There can be no doubt that over recent years this damage has increased and along the main summit routes the vegetation is not reclaiming disturbed sites at the rate at which new damage occurs.

4. OTHER ANIMALS

Introduced animals are the agents of the greatest changes in vegetation composition and structure presently occurring in Egmont National Park and the remaining forests of Taranaki. In the national park goats, opossums, hares, and straying cattle and sheep all contribute to this change while in the forests of the Taranaki Upland in some places pigs and deer also have an impact on the vegetation.

The history of the introductions of opossums, goats and hares and the first reports of straying cattle within the national park are outlined in Atkinson, G.G., (1964), Mawhinney (1976), and by the New Zealand Forest Service (1965). From the information contained in these reports it is obvious that all of these animals have been a major factor in shaping the structure and composition of the vegetation at many locations throughout the national park for a period in excess of 70 years. The same authors also outline the vegetation changes which have been attributed to these animals and this information is summarised below in order that the descriptions of the present day vegetation which appear in Chapter 4 may be viewed within the perspective of this long history of animal modification. In addition Atkinson, I.A.E., (1964) details the effects of goats on the vegetation of a part of Mt Egmont. Reference back to some of the earlier descriptions of the vegetation for example Scherer et. al. (1881) reported in Scanlan (1961) is also made in order to estimate just how great this vegetation modification has been.

The reported vegetation modification by goats is of three main types. The vegetation composition is altered as the species palatable to goats are eaten, prevented from regenerating successfully, and are replaced by less palatable species. The vegetation structure is altered as the understorey layers of vegetation accessible to goats are more or less removed. Finally there develop what are locally referred to as 'dead areas', sites at which intensive modification of the vegetation by goats has lead to spectacular damage. In the lower altitude forest species which in the past have been depleted by goat browsing of both foliage and bark include *Coprosma* spp., *Aristotelia serrata*, *Alseuosmia macrophylla*, *Pseudopanax* spp., *Fuchsia excorticata*, *Geniostoma ligustrifolium*, *Schefflera digitata*, and *Pittosporum eugenioides*. In severely damaged sites, particularly on stream bank slips for example, grasslands of *Microlaena avenacea* and *Uncinia* spp. developed, while in some places in the forest *Pseudowintera* spp., *Myrsine salicina* and the tree ferns *Dicksonia squarrosa* and *Cyathea smithii* became prominent in the understorey. The pattern reported however varies considerably from place to place on the mountain depending on the original composition of the vegetation and the tendency for goats to concentrate their activities in selected favourable sites. As Atkinson, I.A.E., (1964) has noted there are reciprocal effects of vegetation on goats as exemplified by the absence of significant browsing in bogs and on some alluvial terraces and the possible attraction to goats of vegetation containing large proportions of grass or vegetation exposed to wind-carried salt. In higher altitude forests *Coprosma* spp., *Pseudopanax* spp., *Griselinia littoralis*, and *Fuchsia excorticata* have been depleted in places and *Pseudowintera colorata* being generally unpalatable has become the almost exclusive shrub and understorey species in places. The extent of the modification of the upper altitude forest is less than at lower altitudes and has probably been overestimated at times. The descriptions of Scherer et. al., (1881) reported in Scanlan (1961) for example show clearly that even before the goats and opossums arrived on Mt Egmont the higher altitude forest 'lacked undergrowth' and had a 'park-like appearance'. As well it seems likely that *Pseudowintera colorata* was already the leading dominant in many of the upper altitude forests before the influence of browsing animals eventuated. The areas of extreme goat damage ('dead areas') have all been reported from sites near the lower boundary of the shrub communities. At these sites goats have camped for long periods and have eventually almost completely destroyed large patches of vegetation with severe erosion of the steep slopes resulting. A site of approximately 2ha near the Quarry Bluff at the headwaters of the Mangamawhete Stream for example, has been observed by the author over a period of 15 years and is at present in an advanced stage of recovery. The canopy of leatherwood, *Pseudopanax* spp., and *Olearia arborescens* was almost completely removed leaving bare ground which developed into a herbfield-grassland. After the reduction of goat numbers by hunting a range of shrub species re-established in the area, many normally associated with higher altitude sites for example *Cassinia vauvilliersii* and *Hebe odora*.

Opossums are second only to goats in the impact they have made on the vegetation structure and composition. In fact as Pracy (1965) has observed opossum habitats are improved by the activities of goats in depleting the ground and shrub tier vegetation so that most of the major damage to vegetation within the national park occurs as the result of the combined activities of goats and opossums. Pracy (1965) goes as far as claiming that opossums alone have little effect on the regeneration of canopy species. The modification of vegetation by opossums reported results from canopy defoliation and bark scratching or biting. In the lower altitude forest highly palatable species such as *Senecio kirkii* and *Alseuosmia macrophylla* have been depleted and scattered heavy defoliation of kamahi and other species has resulted over extensive areas where highly palatable scrub hardwoods such as *Pseudopanax* spp., *Fuchsia excorticata* and *Aristotelia serrata* occur in abundance and provide balance and variety in feeding. Most of the descriptions of the lower altitude forest written before 1930 for example emphasize the abundance of *Senecio kirkii* as an epiphyte and on the forest floor. At the present the combined attack by opossums and goats has reduced *Senecio kirkii* numbers to the extent that it is only occasionally seen and almost always as an epiphyte. Kamahi defoliation is greatest in the Kaitake Range below 450m where kamahi constitutes only a minor component of the podocarp-broadleaved forest and this is also the situation in forests of inland Taranaki. Kohekohe and titoki, both components of the semi-coastal forest in the Kaitakes, also continue to suffer severe defoliation and mortality. Emergent rata has also been killed occasionally by opossum browsing but, as both Druce (1964) and Pracy (1965) note, widespread mortality of rata on Egmont was reported long before the advent of serious opossum damage. In the upper altitude forest the most severely affected species are *Pseudopanax* spp. particularly *Pseudopanax colensoi* which is often killed as a result of defoliation. Occasional deaths of Hall's totara, a semi-palatable for opossums, have also been reported. Opossums eventually cause their habitat to become less favourable as the palatable species are depleted and thus a 'natural regulation' of numbers results. Pracy (1965) for example describes a natural decline in opossum numbers on Egmont between 1949 and 1951. Thus adequate and often abundant regeneration of canopy species is evident and as Pracy (1965) notes canopy gaps resulting from the death of defoliated species are usually quickly occupied by marked regeneration of ground cover species such as *Astelia* spp. and *Microlaena avenacea* and the shrubs *Pseudowintera colorata, Myrsine salicina,* and *Coprosma* spp. Opossums tend to have little impact on the vegetation of the shrub communities unless goats have already opened it up. In this way opossums contributed to the mortality of leatherwood and *Pseudopanax simplex* at the already cited 'dead area' near Quarry Bluff by defoliation.

Hares are now common above bush-line in Egmont National Park. Their impact in the tussock-grasslands is marked in some places as the result of browsing on the young tillers at the base of red and silver tussocks and on some of the palatable herbs such as *Ourisia macrophylla* var. *macrophylla.* The crowns of damaged tussocks are often colonised by spreading herbs such as everlasting daisy which in turn may be browsed giving a distinctive hummocky form to the vegetation. The greatest impact of hares however is on the vegetation colonising slip faces for example at North Egmont where the *Epilobium* spp., *Gunnera monoica, Raoulia tenuicaulis* and everlasting daisy all of which form vegetative mats are extensively browsed. This browsing, along with the fact that goats tend to congregate on slip faces, tends to slow down their colonisation and succession. Atkinson, G.G. (1964) reports that hares may sometimes chew bark on *Pseudopanax colensoi* and that the numbers of dead animals found after winter snows have disappeared indicates that there is some measure of control exercised by the rigours of winter.

Straying farm animals, cattle and to a much lesser extent, sheep have always been a problem in the national park particularly as boundary fences were often incomplete or non-existent. In the early 1900's it was a deliberate farm practice to turn animals into the park when feed was short during winter. The humorous stories of the 'Me and Gus' series authored by Frank S. Anthony (Anthony, 1938) and set in the Midhirst area adjacent to the park boundary include a chapter entitled 'Winter feeding the Herd'. This vividly describes the problems associated with relocating cattle after they had been illegally set loose in the park. Even now some sections of the park boundary are poorly fenced and during the course of this study modification of the vegetation composition and structure by stray cattle was observed at a number of locations particularly in the forest margins of Kaitake and Pouakai Ranges. Intermittent cattle damage to parts of the Egmont forest margin near York Road have been observed by the author over a period of 15 years. Sheep on the other hand have only been observed by the author in the forest margins and river valleys on the lower reaches of the Lake Dive Track. Although the damage by cattle is only intermittent major changes in vegetation composition and structure result. The sheer bulk and weight of cattle beasts means that the forest floor, ground and shrub tiers are trampled underfoot leaving an open understorey as the cattle search for palatable shrub species such as *Coprosma* spp., *Melicytus ramiflorus*, and *Geniostoma ligustrifolium*. The effects of cattle on the forest margins of parts of the Kaitake Range are described in detail in the Kaitake section of Chapter 4.

Little specific information is available on the effects of introduced animals on the vegetation of the Taranaki Upland. The effects are however comparable with those in the national park except that the lack of a continuous and planned attempt to control noxious animals as carried out in the national park means that the impacts on the vegetation are even greater in places. Goats are still run by many farmers to keep down noxious weeds and are thus free to browse within and along forest margins. Wild cattle and sheep are also present in many areas of the Taranaki Upland even as far afield as the remote Heao Gorge. The effect of opossums on kamahi has already been cited. In addition to these animals pigs and deer also contribute to the modification of the vegetation although their numbers at present appear to be much lower than in early settlement days. The major impacts on the vegetation of the Taranaki Upland like those of Egmont National Park result from heavy infestation of goats and both the primary and secondary forests are affected. Of the 13 forest remnants examined during the course of this study on or near the Egmont

Ring Plain eight showed evidence of modification by animals, mainly cattle from adjacent farmland, and in three of these remnants, one of which is a domain (Rotokare), grazing was a deliberate farm practice.

In short, introduced animals have had, and continue to have, an influence on the composition and structure of the vegetation examined in the Taranaki Land District. This is an everchanging influence as population levels of goats and opossums fluctuate depending on the effectiveness of control measures through time and from place to place. As well there is the 'natural regulation' as animals react to the changes they have initiated in the vegetation and the vegetation recovers. Although at present the condition of the vegetation at many locations in the national park is better than it has been in previous years there are still places where damage is severe. As Druce (1964) has pessimistically stated 'it is true some areas have been saved but over much of the park the trend towards degradation has been no more than retarded' (Druce, 1964, p54). In many places in the Taranaki Upland and in the forest remnants of the ring plain the degradation continues.

PREVIOUS BOTANICAL RESEARCH

The flora and vegetation of Egmont National Park and the remainder of the Taranaki Land District has been studied and described by only a limited number of researchers since Dieffenbach (1843) first wrote the account of his ascent of Mt Egmont. Most of the botanical literature relating to Egmont National Park has been reviewed in detail by Clarkson (1977) and does not require repeating. Instead a summary of the significant points made in the major papers is provided here in order to give the relevant background to this study and to show how it has explored areas barely mentioned in most of the previous work. Only a few of the published contributions to the botany of the study area can be considered important in the sense that they provide more than just cursory descriptions of the vegetation. The work of Cockayne (1921, 1925, 1928), Levy (1923), Oliver (1931), Schweinfurth (1962), Nicholls (1956) and Druce (1961, 1964, 1966, 1974, 1976) is the most valuable. A comprehensive list of botanical references published and unpublished additional to those cited is provided in the Select Bibliography.

Cockayne (1921, 1925 and 1928) described the major zones of vegetation of the eastern side of Mt Egmont: Subtropical Rainforest (with two groups of associations, a kamahi group and a kaikawaka-Hall's totara group), Shrub-composite scrub, Herbfield (tall tussock and dry herbfield), Fellfield, Scoria slopes and Rock communities. For each of these zones Cockayne (1928) provided in some detail the dominant and/or common species in each vegetation stratum and in describing what he considered were the major causal factors for zonation emphasized the importance of the average winter snow-line. This was by far the most detailed account of vegetation up until the appearance of Druce's 1964 chapter on the vegetation in the Egmont National Park Handbook. Cockayne (1921, 1925, 1928) gave due emphasis to the floristic variability at upper altitudes by describing separately the goblin forest (kamahi forest) and kaikawaka-Hall's totara forest. He also estimated the total number of species (trees, herbs, shrubs, grasses and ferns) to be only 220 with the caution that this value was certainly too low; and hinted at the succession taking place in the lower altitude forest by noting the replacement of rimu by rata.

Oliver (1931) reported on the discovery of a Maori oven beneath layers of volcanic material on Egmont. This was the first publication to draw proper attention to the fact that Egmont had erupted within very recent times; in fact as Druce (1976b) notes no mention of the possibility of any recent eruption had been made in the Geological Survey Bulletin of 1927 (Gibson and Morgan, 1927) dealing with Taranaki. Oliver (1931) estimated the last eruption on Egmont to have occurred 500 years before 1931 and described the effects on the vegetation in the vicinity of the Stratford Mountain House in particular drawing attention to the presence of large numbers of stumps of kaikawaka and Hall's totara trees which he presumed were killed by the eruption. Oliver (1931) also noted that not only were the beeches (*Nothofagus* spp.) absent from Egmont but listed 10 other species characteristic of North Island mountain areas above 2000' (609m) which were also absent.

Schweinfurth's (1962) major contribution was in pointing out the floristic and physiognomic similarities apparent when comparing the vegetation of Mt Egmont particularly the montane forest (goblin forest) with that of Tasmania and the humid tropics.

Druce (1961, 1964, 1966, 1974, 1976b) provides the most comprehensive work on the flora and vegetation of Egmont National Park to date. These five publications, one of which (Druce, 1964) has been revised twice in more recent editions of the national park handbook, include a great variety of information. The first quantitative data on changes in species structure and composition with increasing altitude on Mt Egmont appears in Druce (1964). Descriptions of the effects of recent volcanic activity and erosion on species composition, structure, and regeneration and on the effects of browsing animals are included in Druce (1964, 1966, 1976b). Estimates of the date of occurrence of the most recent ash and lapilli showers (Burrell 1655 A.D. and Tahurangi 1755 A.D.) obtained by tree-ring analysis are described in Druce (1966). Comparisons of aspects of the national park vegetation and flora with the remainder of the North Island are included in Druce (1961, 1964, 1974, 1976b). The most significant points outlined in these publications are that the vegetation composition and structure on Mt Egmont still closely reflects the effects of the recent disturbances from volcanic activity, erosion and animal damage and that the flora is decidedly poor by comparison with other places at similar latitudes in the North Island. In fact Druce (1974) notes that there are some 300 odd 'missing plants' mostly tussock and herbfield species. By growing many of the Egmont species and varieties (once considered as endemics) alongside species from other locations, and by continually checking and updating species distributions within New Zealand, Druce has shown during the course of these publications that endemism in the Egmont flora has in the past been overemphasized. Finally Druce (1974) has recorded just over half (~667) the higher plants known to occur in the North Island on Mt Egmont (including Pouakai and Kaitake), a much higher number than previous estimates probably because as Druce comments most visitors had their sights fixed on the summit cone soaring above the surrounding ring plain and as a result took little notice of the forest, let alone the bogs and swamps, on their way to the alpine tussock and herbfield. Another possible reason for the previous underestimates cited by Druce is that many of the species are very localised in their distribution.

Levy (1923) in a rarely cited paper on the 'Taranaki Back-Country' describes the primary forest types and the various successions resulting in the growth of secondary forest. Levy (1923) notes for the first time many of the ideas expanded later by Nicholls (1956) notably the suggestion that the true climax forest is one dominated by tawa with few if any podocarps and that the presence of black beech confined to dry ridge tops indicates it is a remnant of a once more widespread forest type. As well, Levy (1923) provides what is still the most detailed published account of the forest successions following land clearance in the 'Taranaki Back-Country'.

Nicholls (1956) describes in detail eleven major forest types from the Taranaki Upland in what is the only comprehensive published account of the vegetation of the Taranaki Upland. The ten primary forest types described include: the Waitaanga Type (a podocarp/hardwood type), the Waitaanga Silver Beech Type, the Mokau Type (a podocarp/hardwood type), the Hutiwai Type (a riparian podocarp/hardwood type), the Panirau Type (a dry ridge podocarp/hardwood type), the Coastal Type (a predominantly broadleaved type), the General Podocarp/ Hardwood Type, the Matemateaonga Type (a higher altitude hardwood type) and the Hard and Black Beech Types. A single secondary forest type the Whitianga Type (a podocarp/hardwood type) was also described. Significant points made by Nicholls were that the Taranaki Upland forests are primarily an association of hardwoods, their grouping is dependent on topographically controlled factors, and that the evidence suggests that the basic hardwood species have been in equilibrium with the general environment since about 15,000 years ago.

In Chapter 1 it was noted that this study attempted to examine the vegetation of Egmont National Park and the Taranaki Land District at a large number of locations. It can be seen from the foregoing summary of the important contributions to botanical research in the Taranaki Land District that many areas have received little attention or rather very little has been published about them. These include the vegetation of the Pouakai and Kaitake volcanoes, the forest remnants of the Egmont Ring Plain, the recently (since Levy, 1923) induced successions of the Taranaki Upland, and much of the

Matemateaonga Range. Of course the isolation of the Taranaki Upland has been the major factor for the lack of botanical research in that area while in the case of the ring plain nearly all the forests had been cleared for farming long before any detailed documentation of their botany was considered. In addition no attempt has yet been made to provide a comparative study of the major features of the vegetation in the whole of the Taranaki Land District. By examining in some detail the vegetation of Egmont, Pouakai, Kaitake, the Egmont Ring Plain forest remnants and some of the forests of the Taranaki Upland one of the intentions of this study is to attempt such an overview.

CHAPTER 3

METHODS

1. DATA COLLECTION

The vegetation at five major locations within the Taranaki Land District was sampled. The five major locations included: Kaitake, Pouakai, East Egmont, the Egmont Ring Plain, and the Taranaki Upland (Aotuhia - Mt Humphries). All are shown on the location maps; Figures 2.1 and 2.2 in Chapter 2. The data collected at each of these locations ranged from quantitative data collected from quadrats or line transects through to semi-quantitative data collected from quadrats and lists of vascular species present. A summary of the bulk of the data collected from each of the major sampling locations is presented on Table 3.1 below. A more complete account of the data collected and sampling sites is provided at the beginning of each section describing the results obtained at each major sampling location (Chapter 4).

The majority of the vegetation data was collected along altitudinal gradients using a predetermined sampling procedure. The sampling procedure employed resulted from previous experience at attempting to sample vegetation adequately at one of the major sampling locations (East Egmont) as outlined in Clarkson (1977).

Table 3.1 Type of data collected at each major sampling location

		Quantitative No. of Sites	Semi-quantitative No. of Sites
Kaitake		7	34
Pouakai		11	76
East Egmont		70	
Aotuhia - Mt Humphries		33	
Ring Plain remnants			23
TOTAL	254	121	133

The primary considerations in developing this sampling procedure included: 1) the need to make the data collected comparable with that already described in Clarkson (1977), 2) the need to obtain a representative combination of species in the sample, 3) the need to obtain an adequate coverage of the location being sampled, and 4) the limitation imposed by the time available to do the job. The need to make the data comparable with Clarkson (1977) was satisfied in that, with the exception of some of the more specialised sampling programmes used, the same vegetation categories were used and these are detailed on Table 3.2. The requirement for a minimal area to be sampled in order to obtain a representative combination of species has been discussed by Mueller-Dombois and Ellenberg (1974), Kershaw (1973), Kellman (1975) and Clarkson (1977). In Clarkson (1977) an attempt using nested quadrats and multiple transects was made to determine the minimum quadrat size or line transect length in a variety of vegetation types at East Egmont: forest, shrub-tussockland, and herbfield. Minimum quadrat size or line transect lengths decided on were of the order of 200m^2 in forest, and 25m^2 or 3 x 10m transect lengths in tussock grassland and herbfield. It was also noted by Clarkson (1977) that a much larger quadrat would be necessary to adequately sample the forest below 853m (2800') because of the size and spacing of the large canopy and emergent trees. In fact a number of researchers including Hopkins (1955) claim that it is impossible to objectively determine a minimum quadrat size. They disclaim the existence of a minimal area in which the species composition can be adequately represented because the concept of a minimal area can only be valid if true homogeneity occurs within the vegetation community being sampled. As Kershaw (1973) notes it is clear from the existence of pattern at numerous scales in apparently homogenous vegetation that minimal area can never be more than a gross approximation and accordingly some subjective judgement is necessary in assessing whether the area sampled is large enough to reflect the characteristics of that particular community. The size of the quadrats and line transects used was, therefore, decided in light of experience gained in the previous study (Clarkson, 1977) and after much reconnaissance of the vegetation in the major sampling locations. In the lower altitude forest of East Egmont for example, quadrats of up to 600m^2 were used to sample the vegetation and further estimates of the composition of the canopy and emergents were obtained using the point-centred-quarter method of Cottam and Curtis (1956). In the shrub-tussock vegetation on the Pouakai Range however, a quadrat size of $25m^2$ was used. Further details of the quadrat size or line transect length employed to sample the vegetation are included at the beginning of each section describing the results obtained at each major sampling location (Chapter 4). The need to obtain an adequate coverage of the location being sampled was the main consideration which resulted in the use of a stratified sampling procedure. Thus although the actual site to be sampled was selected randomly the sites were as far as possible spaced so that the altitudinal interval between sites was never greater than 76m (250'). This ensured that along each of the altitudinal gradients sampled the fluctuating importance of species along the gradient could be adequately determined. Clarkson (1977) discusses problems associated with too large an altitudinal interval. In most cases the average altitudinal interval between sites was even less than 76m (250') and enabled the later averaging of quadrat data into 61m (200') elevation intervals as outlined in the Kaitake section of Chapter 4. The vegetation sampling of other environmental gradients, for example the moisture gradients, was less objective. Suitable sites, that is sites which exemplified the overall pattern at a location, were simply selected and quadrats were systematically located along a transect parallel to the moisture gradient. The time available for the study was the major constraint on the amount and type of data collected in each location. For each of the quadrats/line transects sampled an attempt was made to list all of the vascular species present and to note any other species present in the immediate vicinity. As well non-vascular species which assumed prominence in the vegetation were also noted, for example, the *Racomitrium* spp. in the moss-herbfield and *Weymouthia mollis* in the upper altitude forest. Further to this data estimates of the cover contribution by species to the vegetation strata were made either quantitatively or semi-quantitatively. For just over half of the sites (133/254) listed in Table 3.1 the estimates were semi-quantitative and for the remainder (121/254) they were quantitative.

During the course of the study it was realised that the time invested in sampling the vegetation quantitatively was in some locations limiting the possibility of obtaining an adequate coverage. Thus an investigation was made into the relative merits of quantitative and semi-quantitative (ranking) methods of assessing vegetation. Sites which had already been sampled quantitatively were resampled using semi-quantitative methods. The resampling took place over one year after the initial sampling and, using the same vegetation categories as before, the species in each layer were simply ranked (down to tenth place) according to their relative cover contribution to the vegetation. As well a group of undergraduate botany students unfamiliar with the location were taught to recognise the main species and then attempted to rank the leading five species in each vegetation stratum according to their relative cover contribution at each of the sites. The results were collated and compared with the results obtained from the quantitative (relative basal area or relative cover data) sampling which form the basis for the graphs shown in the North Egmont section of Chapter 4. Both of the ranked vegetation assessments closely paralleled the results obtained quantitatively both in terms of the order of importance of each species at each site and in the pattern of change in species dominance through altitude. There were minor exceptions, for example at sites 1, 2 and 3 the semi-quantitative assessments consistently showed that mahoe was of greater relative importance in the top and second stratum than did the quantitative assessment. As well at site 8 near the camphouse the semi-quantitative assessments both recorded Hall's totara as more important than kamahi in the top stratum while the quantitative data showed the reverse to be the case. In the shrub layer failure to distinguish between different *Coprosma* species resulted in bimodal distributions being determined by some of the students. Apart from these differences however the results of the semi-quantitative assessment showed quite clearly that the pattern of change in floristic composition and the composition of the major vegetation types can be very adequately determined using semi-quantitative data. The main advantage of this is the time saved in sampling. For example, comparable results were obtained in four days of semi-quantitative sampling in comparison to nearly four weeks of quantitative sampling at North Egmont. Of course although this type of data is suitable for direct gradient analysis and describing the main vegetation types it is no substitute for the standard quantitative data necessary to determine successional trends, i.e. number of stems per size class. Mueller-Dombois and Ellenberg (1974) have similarly noted the advantages of this type of semi-quantitative data in comparison to quantitative data and Bannister (1966) has demonstrated the use of subjective estimates of cover abundance as the basis for ordination. As Mueller-Dombois and Ellenberg (1974) have noted in comparing a range of vegetation studies, 'a quantitative analysis per se is not always better, although it is often favoured because it is quantitative' (Mueller-Dombois and Ellenberg, 1974, p126). As a result of this investigation it was decided in two of the main sampling locations, Pouakai and Kaitake, to collect small initial data sets quantitatively and additional more comprehensive data sets semi-quantitatively. Further comments regarding the time saved in using this approach and the representativeness of the initial data set in relation to the more comprehensive data set are made in the sections describing Kaitake and Pouakai in Chapter 4.

All of the data collected for the forest remnants on the Egmont Ring Plain employed the semi-quantitative method.

Although throughout this study emphasis was placed on the collection of data describing the composition and physiognomy of the top stratum of vegetation (canopy and emergents), as these species are exposed directly to the macro-climate of the location and contribute most to the biomass of the vegetation, the species in other strata were also sampled in detail. A list of the data collected at quantitatively and semi-quantitatively sampled sites is given in Table 3.2. Emphasis was given to the contribution by cover of species in most of the vegetation categories because, as Daubenmire (1968) notes, cover gives a better indication of biomass than does the number of individuals and is therefore of greater ecological significance. Data relating to the vegetation which was recorded in addition to that listed on Table 3.2 included notes describing any apparent disturbances to the vegetation (human, animal, volcanic, erosion etc), the structure of the vegetation, height estimates, and regeneration performance of the major top stratum species. Actual site data collected included altitude, slope, aspect and descriptions of substrate and drainage conditions. Altitude was determined using an altimeter (13-2000-IN Aircraft Inst. Develop. Inc. Wichita, Kansas) and known spot heights in the locations particularly those of huts, trig stations, track junctions, and national park markers used as reference points. The altimeter proved to be accurate to within ± 10' (3m) on days in which the weather was stable, however because of the erratic climate in the national park, altitudes required checking up to four times on some sites. Aspect was recorded as a compass bearing and slope angle was estimated.

Table 3.2 Summary of vegetation data collected at each site

	Quantitative			Semi-quantitative		
	Relative Basal Area or Relative Cover	Relative Density	Presence	Complete Rankings	Dominants Ranked	Presence
Top Stratum (Emergents and canopy)	+	+	+	+		+
Second Stratum (Subcanopy)	+	+	+	+		+
Shrub Stratum		+	+		+	+
Ground Cover Inc. seedlings			+		+	+
Lianes and epiphytes			+		+	+

2. METHODS OF ANALYSIS

The methods of analysis used in this study range from simple tabulation and graphing of vegetation data through to ordination and classification. The graphing of data is of two main types, both of which are examples of direct gradient analyses as described by Whittaker (1967, 1973), 'Vegetation samples are arranged . . . according to known magnitudes of (indexes of position along) an environmental gradient which is accepted as the basis of study', (Whittaker, 1967, p209). The two types of graph used are single transects along an environmental gradient and composite transects resulting from the amalgamation of data from several transects. Clarkson

(1977) has discussed in more detail the implications of data amalgamation on the resulting interpretation of pattern notably that this method illustrates continuity in vegetation composition which cannot be demonstrated on the ground. The method is however useful in providing a generalisation (or abstraction) of species distributions in major sampling locations and is only one of several methods of analysis used in this study. The procedure is described in detail where it is first used in the section describing the Kaitake Range in Chapter 4.

For the ordination and classification of vegetation data two computer packages were used extensively. These were SPSS v7 Statistical Package for the Social Sciences, version 7 which is described in Nie (1975) and BMDP-77 Biomedical Package which is described in Brown (1977). A detailed account of the differing viewpoints on the use of ordination and classification techniques has already been provided in Clarkson (1977) and does not warrant repeating. The approach of this study is that advocated by Orloci (1978) in that analysis has been approached without prior commitment to one or other of the tenable vegetation hypotheses, and, as Mueller-Dombois and Ellenberg (1974) have advocated, analysis has generally proceeded from ordination to classification.

In using ordination techniques the approach is that of indirect gradient analysis as described by Whittaker (1967, 1973) in which 'vegetation samples are compared with one another in terms of degrees of difference in species composition and on the basis of these degrees of difference are arranged along axes of variation. The axes may or may not correspond to environmental gradients; but if they do correspond, the approach to environmental gradients is indirect or inferential'. 'No end points for the axes are specified, but the computations extract axes as principal directions of variation in the samples submitted', (Whittaker, 1973, p301). The actual programme used for ordination was type PA1 (Principal Components Analysis) from SPSS v7 and is described in detail by Nie (1975). The correlation matrix was calculated using Pearson's product moment correlation coefficient. As Kellman (1975) notes, 'Principal components analysis aims at a simplified display of sites along a number of axes fewer than those specified by the number of species in the original data matrix', (Kellman, 1975, p69). The number of axes extracted relate sequentially to the variation extracted, with the first principal component viewed as the single best summary of linear relationships. Once the simplified display of sites has been produced species abundance or environmental measures can then be overlayed on the plot ordination to indicate specific trends in the ordination, as described by Kershaw (1973). The use of mathematical models involves a number of assumptions which are often difficult to meet in the analysis of vegetation data. This has already been discussed in Clarkson (1977) although the most important assumptions with regard to principal components analysis include that of linearity in species correlations with influencing factors and that of orthogonal arrangement of the axes extracted (no correlation existing between the axes). Throughout this study however the technique was used as a fast and accurate method of summarising and ordering data. As Kershaw (1973) points out in reference to the assumptions described, 'it is fortunate that these limitations do not detract to any great extent from its considerable power in this area of ecology', (Kershaw, 1973, p228).

Once ordinations of the vegetation data had been produced classification of the data followed. The main technique used was average linkage cluster analysis which is described in Brown (1977). It is polythetic (based on many attributes), agglomerative (groups are formed on the basis of fusions) and hierarchical (small groups are further combined according to their similarities into broader groups). The advantages and disadvantages of the various classification techniques are described by Sokal and Sneath (1963), Whittaker (1973), Everitt (1974), Mueller-Dombois and Ellenberg (1974) and Orloci (1978), however a comparison of the results obtained from a number of clustering techniques and similarity indices showed little variation in the groups defined. It was therefore decided that the average linkage cluster analysis, a widely used general purpose classification, would be used throughout. Site cluster analysis was carried out using BMD:P2M and the distance measure selected was Euclidean distance as described in Brown (1977). This is a particularly useful cluster analysis because average species compositions are produced at each stage of amalgamation.

Species cluster analysis was carried out using BMD:P1M which clusters the species on the basis of a measure of similarity derived from Pearson's product moment correlation coefficient. Dendrograms constructed from the average linkage cluster analysis of both sites and species are presented in the results in Chapter 3 and graphically show sites or species as clusters linked together at certain levels of similarity.

The variable used for most of the quantitative analysis including the ordinations and classifications was relative cover which was variously determined from basal areas of the tree species (πr^2 measured at 1.5m above the ground), the relative area occupied by the crown of shrub and tussock species or from the percentage point cover of tussock and herbfield species. Relative instead of absolute values have been used throughout because of the extreme range of vegetation types sampled and the impracticality of attempting to compare these types on any absolute basis. There are limitations in this use of relative values as already described in Clarkson (1977) notably the false impressions which can be gained in comparing sites of extremely low total cover with those comprising a complete cover of vegetation. This is compensated for however by the separate presentation of data describing the changes in vegetation physiognomy and structure in some of the sampling locations. For the semi-quantitative analysis the species rankings according to cover contribution were weighted using a 9 to 0 scale where 9 = leading dominant and 0 = absent and thus ordination techniques could be applied. A similar procedure is outlined by Bannister (1968). The procedure for amalgamating and graphing species rankings is outlined in the section on the Kaitake Range (Chapter 4) where it is first used.

CHAPTER 4

RESULTS AND ANALYSIS

A. THE VEGETATION OF THE KAITAKE RANGE

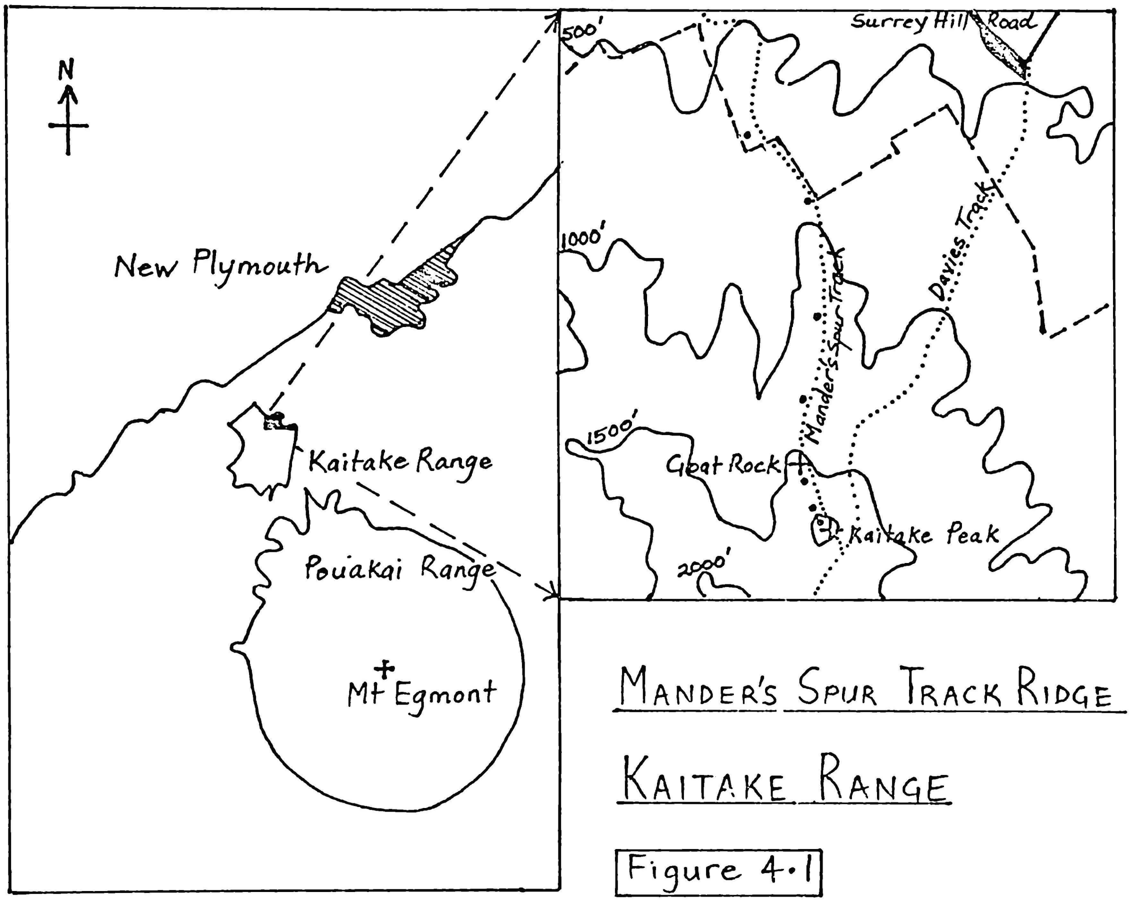
Introduction

In order to describe and explain the significant features of vegetational change along the major environmental gradients on the Kaitake Range two sampling programmes were completed. The first, a quantitatively based sample, consisted of seven quadrats located along the altitudinal gradient on the Mander's Spur Track Ridge. The second, a more comprehensive sample, involved the collection of data from a further 34 sites located in four other sectors of the Kaitake Range. The results of these two sampling programmes are presented below.

1. MANDER'S SPUR TRACK RIDGE

Introduction

The Mander's Spur Track Ridge is located between the end of Wairau Road (90m a.s.l.) and Kaitake Peak (650m a.s.l.) on the Kaitake Range in the north-western sector of Egmont National Park (see location may Figure 4.1).



MANDER'S SPUR TRACK RIDGE

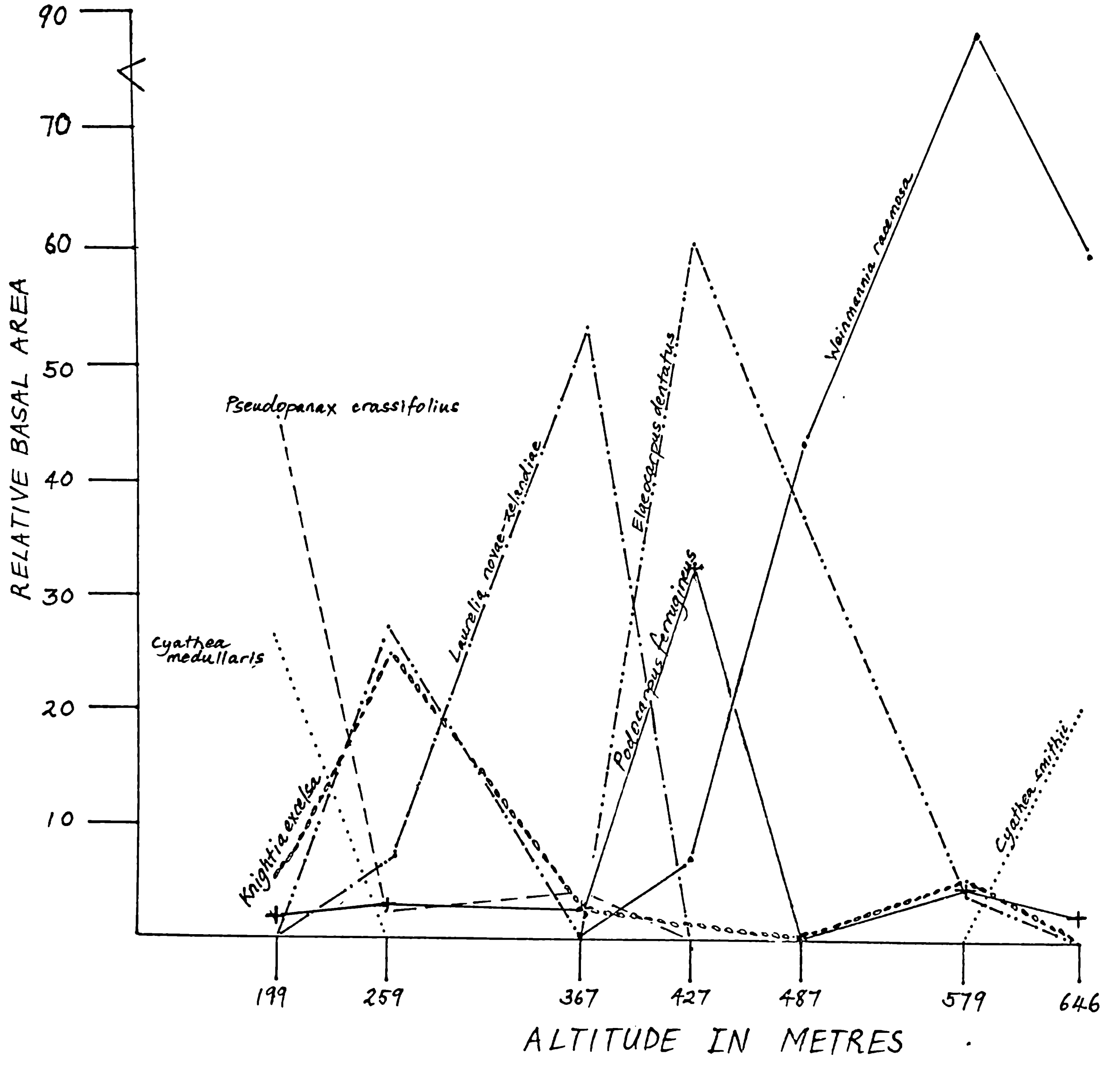
KAITAKE RANGE

Figure 4·1

Table 4.1 Sampling sites on the Mander's Spur Track Ridge

Site No.	Feet	Metres	Quadrat Size	Slope Angle	Aspect
7	2120	646	$200m^2$	22-27	W
6	1900	579	$400m^2$	27-32	W
5	1600	487	$500m^2$	25-28	W
4	1400	427	$400m^2$	20-35	W
3	1200	367	$200m^2$	7-12	W
2	850	259	$600m^2$	5-15	WNW
1	650	199	$400m^2$	30-35	WNW

Figure 4.2 TOP STRATUM SPECIES RELATIVE BASAL AREA >20%



Seven sites between 190m and 650m were examined (see Table 4.1). The distance between site 1 (199m) and site 7 (646m) is approximately 2.4km thus the average gradient for the ridge is 1:5.37. Slope angles of 20-35° recorded in sites 4-7 emphasize the fact that the steepest part of the altitudinal gradient occurs above 400m. Ridge alignment is mainly north to north-west and all the sites examined had aspects ranging from west to west-north-west.

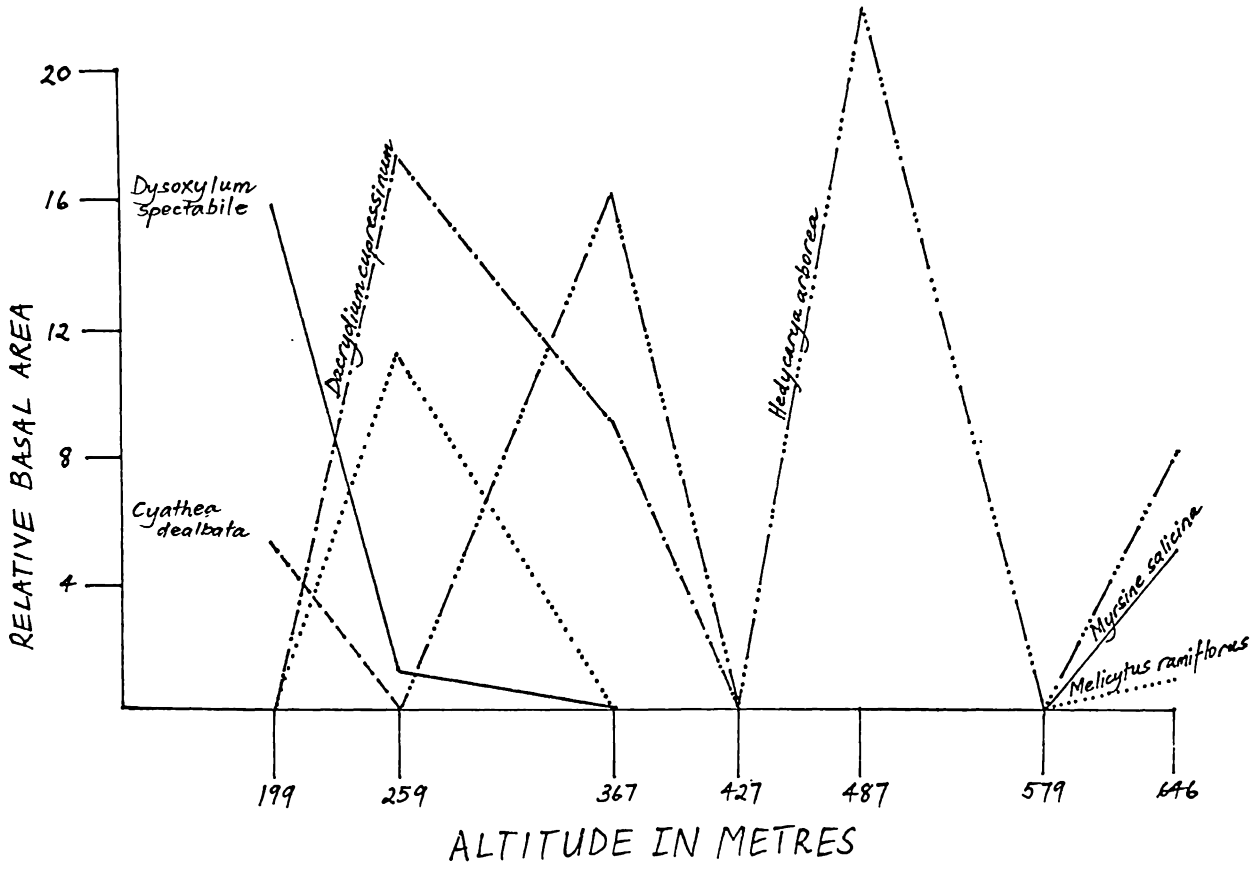
Top stratum (canopy and emergents) species Relative Basal Area (R.B.A.) >20% (8 species)

Eight species achieve values greater than 20 percent: lancewood, mamaku, rewarewa, pukatea, hinau, miro, kamahi and soft tree fern (see Figure 4.2). Lancewood is dominant and mamaku second dominant below 300m; lancewood however continues to be represented as an associate up to 400m. Rewarewa is most important below 350m although it is represented up to 600m. Pukatea dominant at site 3 (365m) is not represented above 450m. Hinau dominant at sites 2 and 4 (259m, 427m) is scattered throughout the area below 600m. Miro present in all but one of the sites is second dominant at site 4 (427m). Kamahi is distributed above 400m and is dominant from site 5 (487m) to site 7 (646m). Soft tree fern is represented once only in the canopy at site 7 (646m).

Top stratum species R.B.A. >5% <20% (6 species)

Six species achieve values between 5 and 20 percent: silver fern, kohekohe, pigeonwood, rimu, toro and mahoe (see Figure 4.3). Silver fern is recorded below 250m only while kohekohe distributes a little higher to 300m. Both

Figure 4·3 TOP STRATUM SPECIES RELATIVE BASAL AREA >5<20%

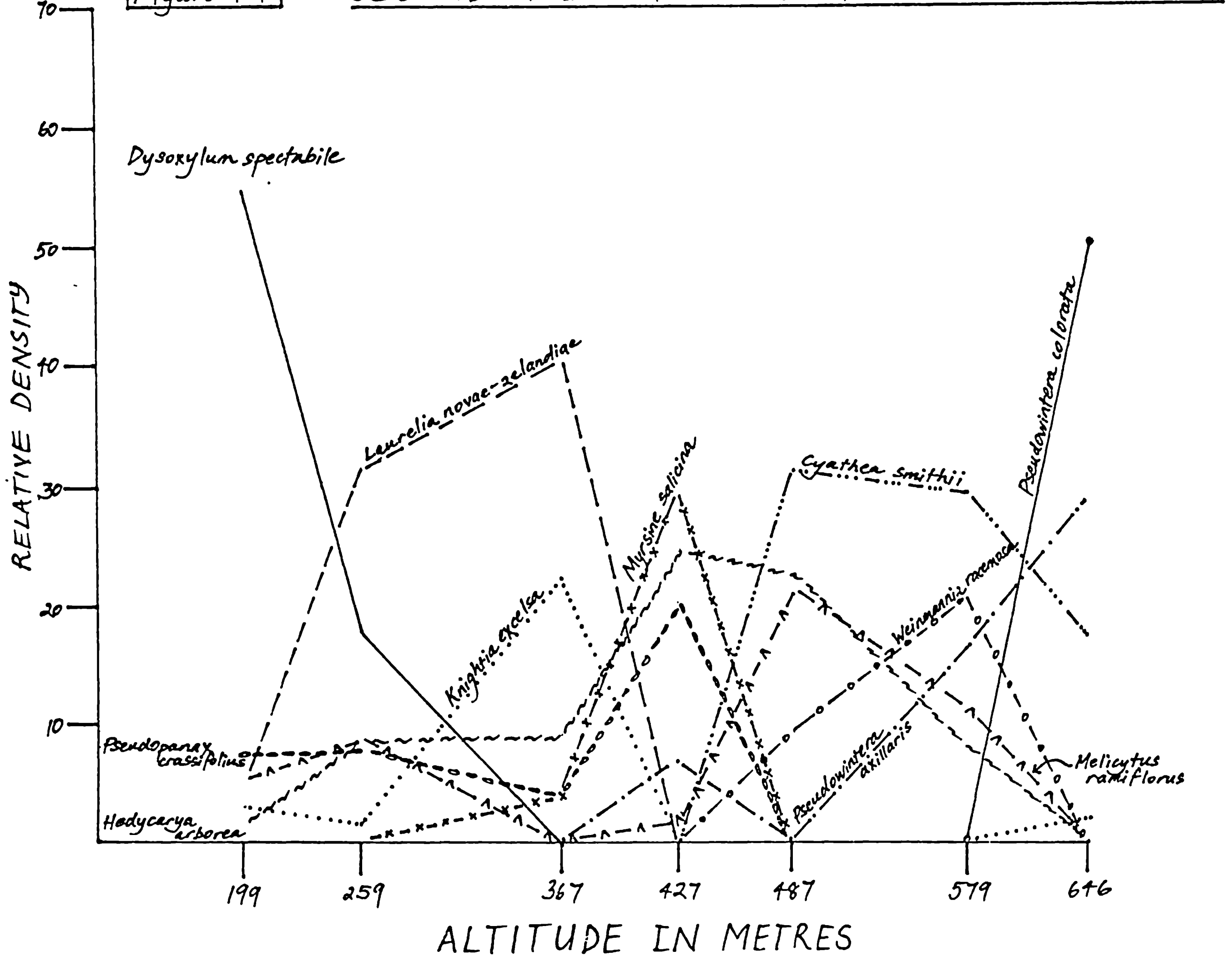


species are therefore important associates of dominant lancewood and second dominant mamaku. Rimu associates with both hinau and pukatea in sites 2 and 3 (259m, 366m). Pigeonwood distributed above 300m, fluctuates in importance, recording its highest values as an associate of pukatea in site 3 (366m) and of kamahi in site 5 (487m). Mahoe is even more patchy in its distribution occurring in site 2 (259m) as an associate of hinau and site 7 (646m) as a component of the kamahi dominated canopy. Toro is recorded once only in site 7 (646m).

Second stratum (subcanopy) species Relative Density (R.D.) >20% (11 species)

Species achieving values greater than 20 percent were: kohekohe, pukatea, rewarewa, pigeonwood, lancewood, toro, soft tree fern, kamahi, pepperwood, mahoe and mountain pepperwood (see Figure 4.4). Four of these species kohekohe, pukatea, rewarewa and lancewood are distributed below 450m. Kohekohe is dominant in the subcanopy beneath hinau and pukatea canopies. Rewarewa and lancewood are distributed throughout the sites below 450m. Three species, pigeonwood, mahoe and toro, distribute throughout most of the Mander's Spur Track Ridge. Pigeonwood gradually increases in importance up to site 4 (427m) and then declines being unrecorded in the uppermost site. Toro parallels the pigeonwood distribution but it is not as widespread being unrecorded in sites 1 and 6 (198m, 585m). Mahoe reaches its maximum importance at site 3 (487m) beneath the kamahi canopy. The final four species, lowland pepperwood, mountain pepperwood, soft tree fern and kamahi

Figure 4.4 SECOND STRATUM SPECIES RELATIVE DENSITY >20%



are all important components of the subcanopy beneath the kamahi dominated canopy above 450m. Soft tree fern dominates the subcanopy at sites 5 and 6 (487m, 585m). Kamahi has a similar distribution to that in the canopy but it was not represented in the uppermost site. Lowland pepperwood, first represented at site 4 (427m) beneath a hinau dominated canopy becomes increasingly important right up to site 7 (646m). Mountain pepperwood was recorded only at site 7 (646m) where it dominates the subcanopy.

Third stratum (shrub layer) species >20% R.D. (5 species)

Five shrub species achieve values greater than 20 percent (see Figure 4.5). Two of the species, pigeonwood and kiekie, are distributed below 450m. Pigeonwood is dominant at sites 1 and 2 (198m, 259m), beneath the lancewood and hinau canopies respectively, while kiekie is dominant at sites 3 and 4 (366m, 427m), beneath pukatea and hinau canopies respectively. Two species, soft tree fern and lowland pepperwood, are distributed above 350m. Soft tree fern is dominant in sites 5 and 6 (487m, 585m) beneath the kamahi canopy and pepperwood is second dominant in the same sites. Mountain pepperwood is distributed above 500m being dominant in site 7 (646m) beneath the kamahi canopy.

Ground cover (fourth stratum) species first and second dominants (6 species)

Forest oat grass, nikau, hooked sedges (*Uncinia* spp.), crown fern, and *Blechnum filiforme* all rank as either first or second dominant in the ground cover stratum. The most

Figure 4·5

THIRD STRATUM SPECIES RELATIVE DENSITY >20%

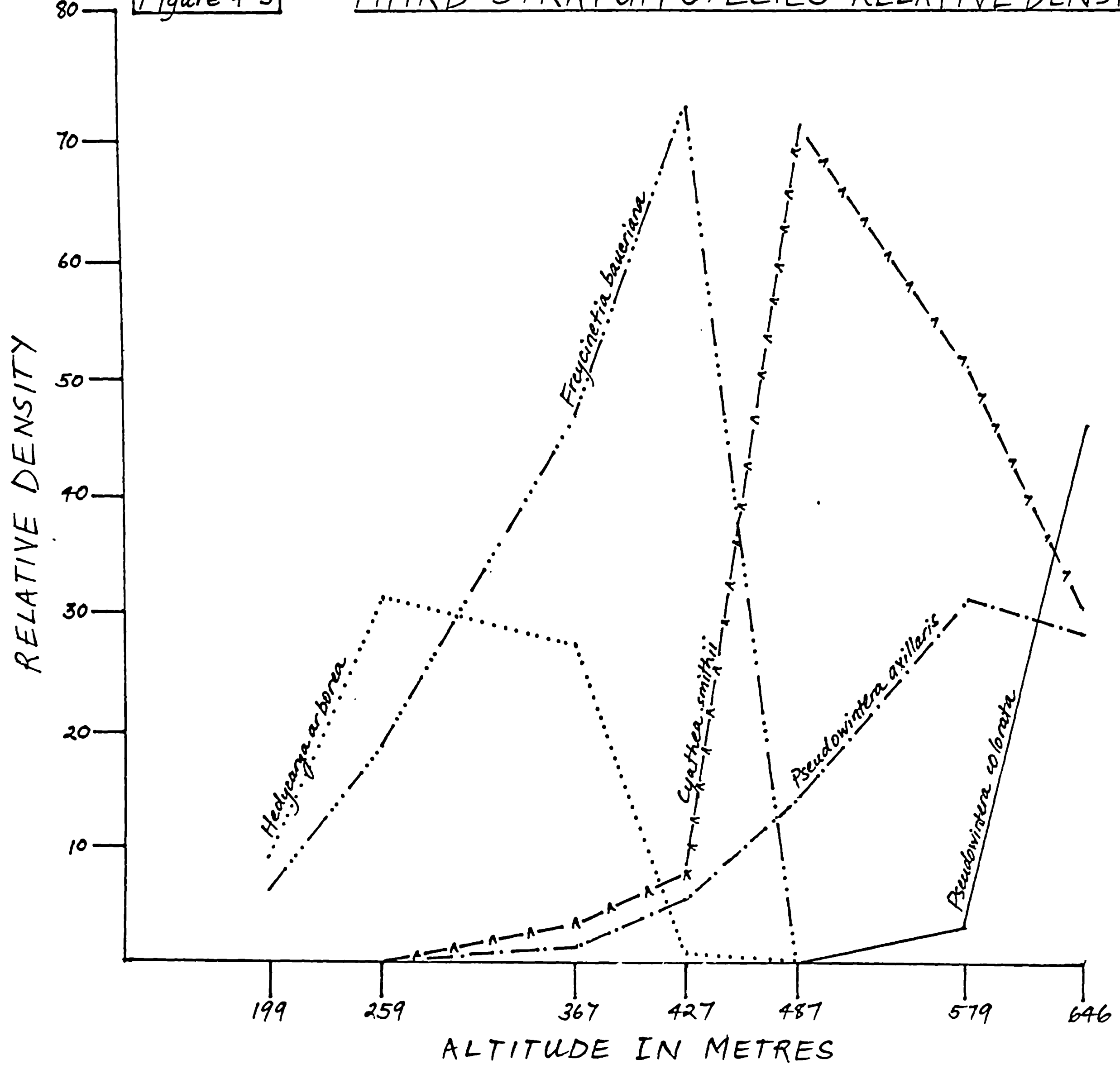
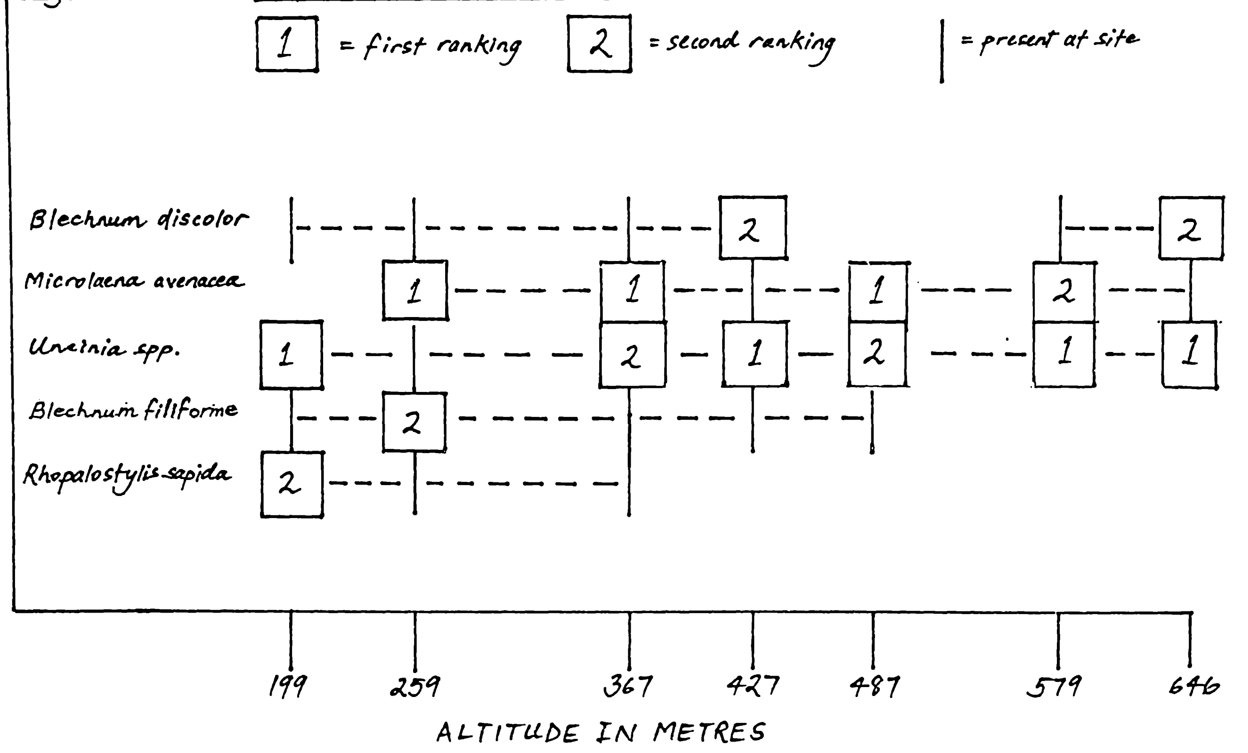


Figure 4.6 GROUND COVER SPECIES FIRST AND SECOND DOMINANTS



important ground cover species are forest oat grass, distributed above 200m, and the hooked sedges (*Uncinia uncinata, Uncinia gracilenta*) distributed throughout (see Figure 4.6). Crown fern is scattered throughout becoming more important above 400m. Nikau is only present below 400m and *Blechnum filiforme* below 500m.

Lianes and epiphytes dominant species (5 species)

Supplejack, kiekie, hound's tongue fern, hanging spleenwort and a filmy fern were all ranked as dominant in one or more of the sites. Supplejack dominant in sites 1 and 2 (198m, 259m) gives way to kiekie in sites 3, 4 and 5 (366m, 427m and 487m). In sites 6 and 7 (585m, 646m) dominance is shared between hound's tongue fern, hanging spleenwort, and a filmy fern (*Hymenophyllum sanguinolentum*).

Vegetation types

On the basis of the species distributions outlined above and placing special emphasis on the importance of the top stratum in determining vegetation types it is convenient to recognise four main floristic forest types along the altitudinal gradient. The first is a lower altitude type (below 250m) in which lancewood dominates the top stratum and kohekohe the subcanopy. The second is a lower-middle altitude type (250m-375m) in which pukatea, hinau and rewarewa are all important in the top stratum and pukatea dominates the subcanopy. Both the first and second types are very disturbed, a feature which is amplified in later sections. The third type is an upper-middle altitude type (375-500m). Hinau dominates the top stratum and miro is an important associate. Pigeonwood and toro are most important in the subcanopy. Kamahi becomes increasingly important towards the upper limit of this type. The fourth type is an upper altitude forest type (above 500m) in which kamahi dominates the top stratum. Hinau, miro and rewarewa are important associates. The leading subcanopy dominants are soft tree fern, kamahi and pepperwood. The three forest types below 500m are floristically more diverse in the top stratum and shrub layer particularly and therefore the recognition of types is more arbitrary. The forest above 500m is more easily characterised by the marked dominance of kamahi in the top stratum and soft tree fern in the subcanopy.

Succession on the Mander's Spur Track Ridge

The old Patuha Open Lands Reserve, an area located between Wairau Road in the north and Weld Road in the south of the Kaitake Range, is one of the few locations in Egmont National Park which has been logged. Approximately 300 acres were logged prior to 1926 (Mawhinney, 1976) and between 1926 and 1953 various exotic species were planted in this area. Much of this exotic forest has since been clearfelled to allow regeneration of indigenous species although stands of macrocarpa (*Cupressus macrocarpa*), *Eucalyptus* spp., *Pinus* spp., redwood (*Sequoia sempervirens*) and Douglas fir (*Pseudotsuga menziesii*) still remain. The Mander's Spur Track Ridge, being an extension of the Wairau Road, borders the disturbed area and below 450m at least shows major signs of the previous disturbance, notably the absence of large podocarps and canopy tawa and many areas in the early stages of succession. With this in mind the sixteen 100m^2 components of the larger quadrats in sites 1 to 4 were recorded separately and in detail to examine the composition and regeneration of the vegetation resulting from this disturbance and from animal browsing (mainly wandering cattle and goats). As a result of this data collection frequencies, densities and relative densities of all the species recorded in the top stratum, subcanopy, and shrub stratum were calculated. As well, frequency of seedlings of the major canopy (top stratum) species was calculated and seedling presence was characterised as either rare, frequent, or abundant in each quadrat thus the performance or regenerative ability of each of the major top stratum and subcanopy species could be assessed. Table 4.2 and Figure 4.7 show the data obtained for selected species. Figure 4.7 in fact depicts the size class (d.b.h.) structure of the populations of some of the top stratum and subcanopy species. Numbers of stems in eight diameter classes, of mostly 10cm, ranging from 0-70cm (the range of stem diameters encountered in the sixteen quadrats) are plotted. The d.b.h. of all stems > 50cm in height was measured to accomplish this.

Size class (d.b.h.) structure

The size class structure of the populations of rewarewa, kohekohe, miro, rumu, pigeonwood, pukatea,

Table 4.2 Frequency (F) and density data (D) for major species

	TOP STRATUM			SUBCANOPY		
	F	D	RD	F	D	RD
Kohekohe	25.0	8	6.3	31.3	46	26.7
Rewarewa	56.3	15	11.9	31.3	8	4.7
Pukatea	31.3	17	13.5	43.8	30	17.4
Rimu	25.0	6	4.8	-	-	-
Miro	50.0	14	11.1	18.8	3	1.7
Lancewood	37.5	22	17.5	50.0	17	9.9
Hinau	31.3	17	13.5	6.3	1	0.6
Pigeonwood	6.3	2	1.6	56.3	15	8.7

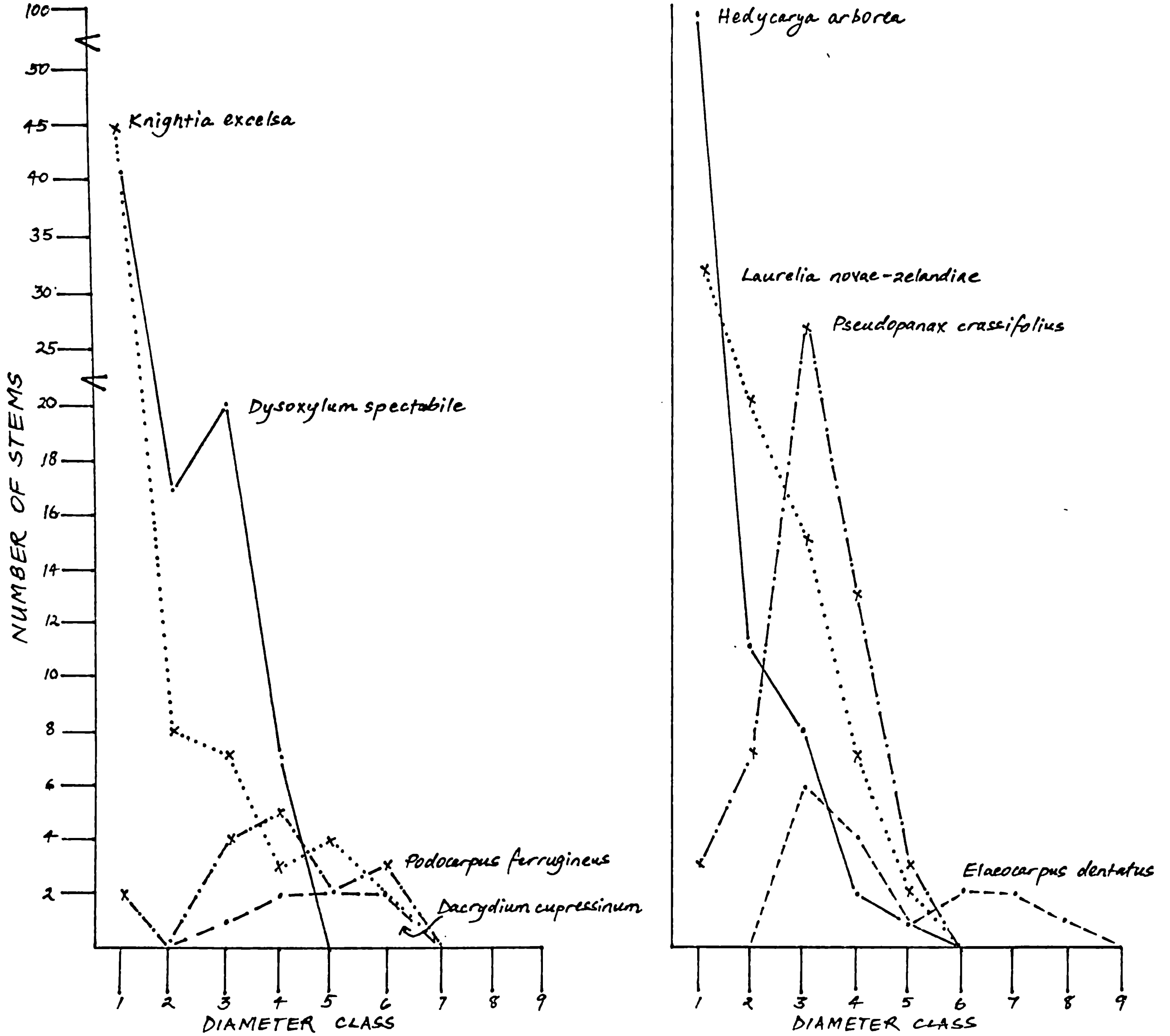
SHRUBS			SEEDLINGS
F	D	RD	F
31.3	49	7.7	6.3
56.3	43	6.8	68.8
56.3	40	6.3	25.0
-	-	-	-
12.5	2	0.3	25.0
18.8	3	0.5	43.8
-	-	-	31.3
68.8	94	14.8	81.3

Frequency = percentage of quadrats in which species is recorded.

Density = absolute number of stems.

Relative Density = number of stems as a percentage of total number of stems in the stratum.

Figure 4.7 SIZE CLASS (D.B.H.) STRUCTURE OF SELECTED SPECIES



1 = 0-3.9, 2 = 4.0-9.9, 3 = 10.0-19.9, 4 = 20.0-29.9, 5 = 30.0-39.9, 6 = 40.0-49.9, 7 = 50.0-59.9, 8 = 60.0-69.9 cm

lancewood and hinau are depicted on Figure 4.7. Of these species pigeonwood, pukatea, rewarewa and kohekohe all appear to be regenerating well with large numbers of saplings (<10cm d.b.h.) present. Presence of large numbers of saplings or seedlings is however insufficient evidence for effective regeneration if vigour and survival rate are not considered as well. In spite of the large numbers of kohekohe and pukatea present and alive in the <10cm diameter class their mortality rate appears to be extremely high mainly as the result of animal browsing. Five dead stems of kohekohe were recorded all less than 10cm d.b.h. and all with obvious browsing damage. The majority of live stems >10cm d.b.h. also showed signs of browsing damage and as well many of the subcanopy individuals exhibited marked foliage damage consistent with insect attack. Pukatea stems >10cm d.b.h. also appeared to be preferred by browsing animals but to a much lesser extent than kohekohe.

Lancewood, rimu, miro and hinau in contrast to the species already described are regenerating poorly. Large numbers (26) of lancewood individuals were recorded in the 10-19.9cm d.b.h. class but comparatively few (10) individuals <10cm d.b.h. This fact, along with the presence of several large dead lancewood stems (21.4, 7.9, 8.6, 10.2, 9.0cm d.b.h.) in the canopy and subcanopy, supports the premise that lancewood has already reached the peak of its representation in the succession and is declining in importance as it is overtopped by rewarewa and pukatea.

Rimu is failing to regenerate effectively, no individuals less than 10cm d.b.h. being recorded. The individuals present in the top stratum are however young and relatively small (17.4 - 45.6cm d.b.h.) and presumably date back to the period just after the logging disturbance. Rimu probably established very rapidly in the higher light intensities resulting from the opening up of the original canopy.

Miro, in contrast to rimu, is regenerating, although not as effectively as rewarewa or pigeonwood. Miro seedlings were recorded in 4 of the 16 quadrats (25%) and in one case the seedlings were abundant. Numbers of stems >10cm d.b.h. however are low, with few seedlings surviving beyond the 10-49.9cm diameter classes so that, like rimu, many of these individuals are small, young adults.

Hinau is another species with poor regeneration. No stems >50cm height and less than 10cm d.b.h. were recorded. Seedlings however were present in 5 of the 16 quadrats (31%) and in one quadrat they were abundant. It appears that few seedlings are surviving to recruit the <10cm diameter classes. Two relatively distinct diameter classes are apparent in the 10-69.9cm range. The first, a presumably younger group, ranges from 10-39.9cm d.b.h. (12) and the second group of larger, presumably older individuals (5) ranges from 40-69.9cm d.b.h. Assuming diameter correlates reasonably well with age these two diameter class groups represent two major periods of establishment by hinau.

Future trends

Rewarewa, kohekohe, pigeonwood and pukatea are all regenerating well although in the case of kohekohe and pukatea cattle and goat browsing are having a marked detrimental effect on the survival of saplings and seedlings. Elimination of this browsing pressure would ensure greater success for these species. Lancewood is likely to become less important in the top stratum as it is overtopped by rewarewa and pukatea however it should remain as a minor subcanopy component. Rimu, although failing to regenerate at present, will remain important in the top stratum eventually becoming more emergent and thus physiognomically dominant in at least two of the quadrats measured. The relatively long life span of rimu should ensure future opportunities for regeneration particularly in areas nearby still in early successional stages. Failing this, rimu will eventually decline in importance. Miro, being marginally more successful at regeneration, should remain as an important component of the top stratum for some time. Unless the rate of recruitment of the >10cm d.b.h. class improves however miro also will decline in importance although gradually. The high density and frequency of pigeonwood (64, 68.8%) in the shrub layer suggests that this species should make up a much greater component of the subcanopy in the future. Nikau, a species not included in the data presented in Table 4.2 because it is not important in the top stratum, also records high densities and frequencies in the shrub layer (47, 62.5%) and should also become more important in the subcanopy in future. Nikau would also benefit from a removal of browsing pressure as the majority of individuals<50cm in height exhibit damage. Elimination of the present pattern of browsing by cattle and goats would in fact have a rapid impact on both the composition and the density of the shrubs and the ground cover species. At present, numbers of shrubs range from 10 per $100m^2$ in highly modified sites to 61 per $100m^2$ in less modified sites. Overall the composition of the vegetation is notable for the extremely poor representation of the more palatable species such as mahoe, hangehange, and *Coprosma* spp. as well as the effects on pukatea and kohekohe already cited.

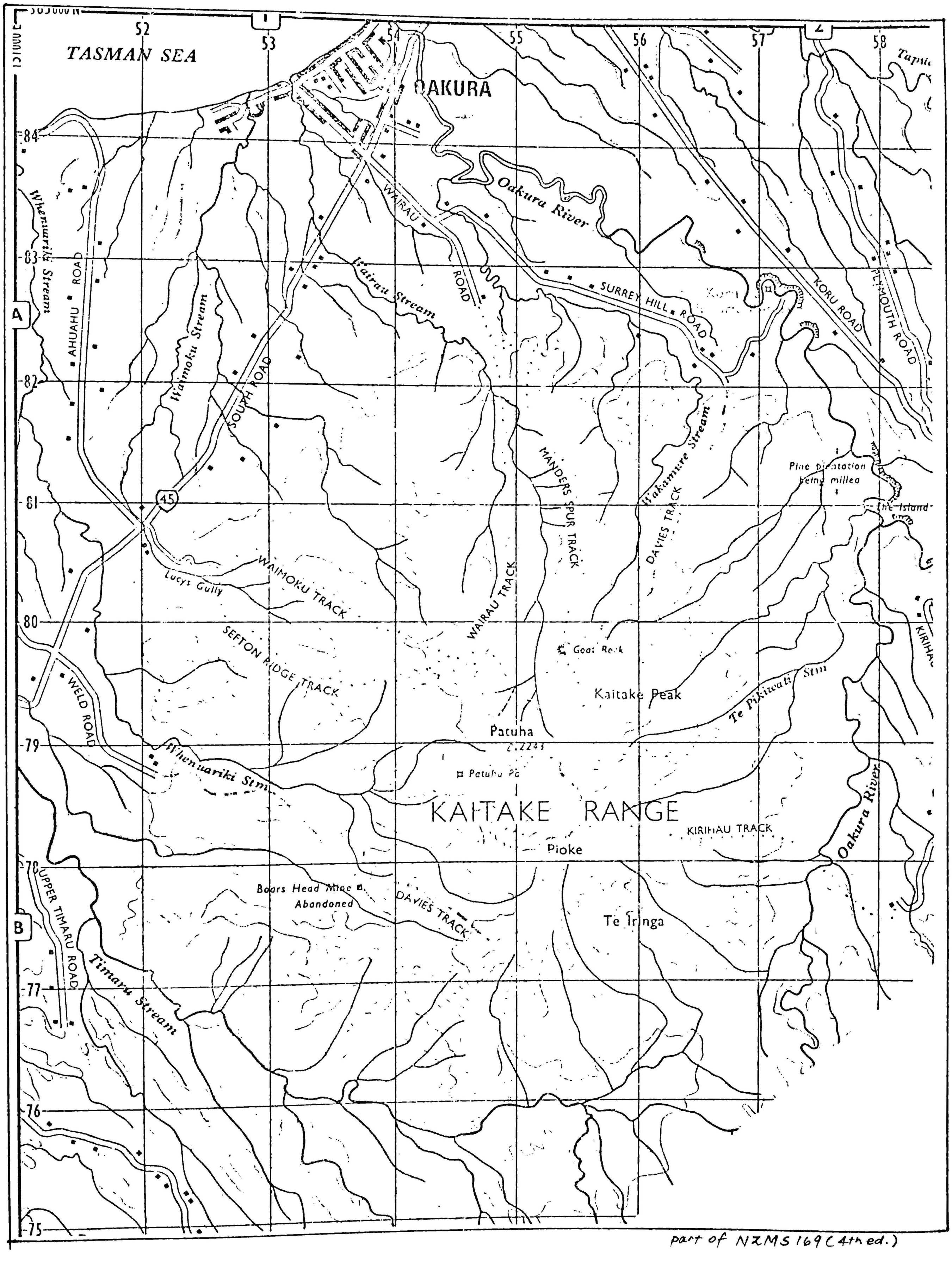
2. THE REMAINDER OF THE KAITAKE RANGE

Introduction

In order to examine more comprehensively the vegetation (floristic) types present in the Kaitake Range and to determine how representative the results obtained in sampling the altitudinal gradient on the Mander's Spur Track were, semi-quantitative data from a further 34 sites was collected. The justification for the use of semi-quantitative data has already been outlined in Chapter 3 however it is important to note that while it took in excess of 50 hours fieldwork to quantitatively sample seven sites on the Mander's Spur Track Ridge the semi-quantitative sampling of an equivalent number of sites took 12 hours in the field. The data collected on the Mander's Spur Track Ridge was recoded into the semi-quantitative form and included in the total data set. Thus a total of 41 sites most $400m^2$

Figure 4.8

KAITAKE RANGE LOCATION MAP



part of NZMS 169 (4th ed.)

were examined and employed to describe and explain the major floristic changes along the altitudinal gradient (183m (600')-670m (220')) and provide the basis for defining the major forest vegetation types in the Kaitake Range. Locations cited in this description are shown on Figure 4.8 and site details are listed in Appendix 1. The data thus collected was analysed in two main ways. First, the data was grouped mainly by sets of five quadrats into 61m (200') elevation intervals similar to the method of direct gradient analysis employed by Whittaker (1956). Any floristic types so determined are abstractions of the floristic tables and as such become abstract community types. The second analysis employed individual plot data allowing sites with similar vegetation to be grouped into community types that can be observed in the field.

Direct gradient analysis (after Whittaker, 1956)

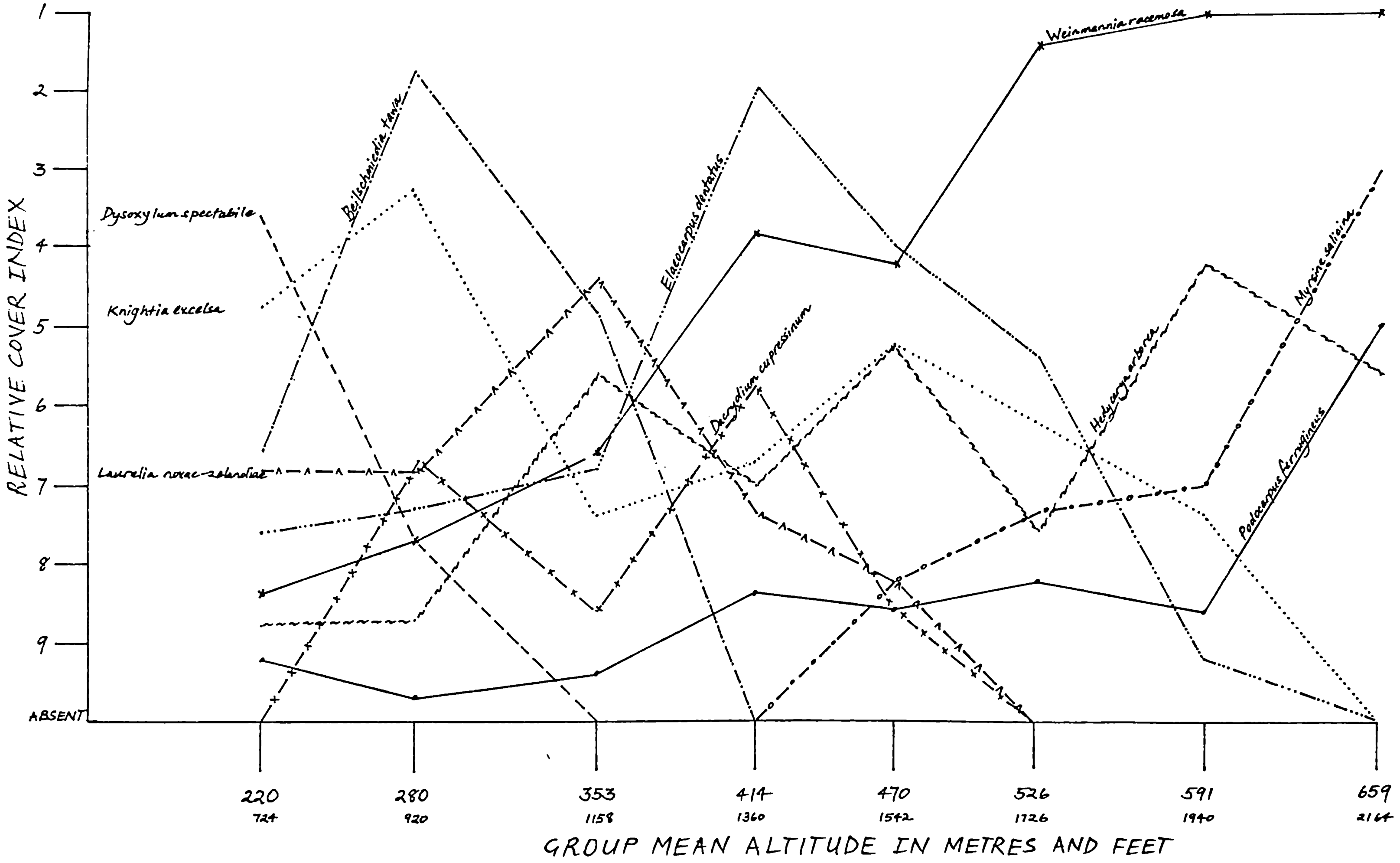
The results of this analysis are summarised on Figure 4.9 Relative Cover Indices of the major top stratum species, Figure 4.10 Relative Cover Indices of the major subcanopy species, and Table 4.3 Leading dominants from all strata.

Relative Cover Indices of the major top stratum species

Figure 4.9 was constructed by first calculating the relative cover index for each species in each 61m (200') elevation interval. This was accomplished by averaging the ranking of the species in each plot (which ranged from 1 (first leading cover dominant) to 10 (absent)) to

Figure 4·9

RELATIVE COVER INDICES OF THE MAJOR TOP STRATUM SPECIES



obtain its relative cover index. Thus a species which was leading dominant in all five quadrats of the 61m (200') elevation interval would score a relative cover index of 1 while a species absent in all five quadrats would score a relative cover index of 10. Figure 4.9 therefore depicts the changes in relative cover of major species (species 1st, 2nd or 3rd leading dominant in any elevation group) in eight 61m (200') elevation groups along the altitudinal gradient from 183m (600') to 670m (2200'). Examination of Figure 4.9 shows clearly the changing pattern of top stratum species dominance through altitude. In general each species reaches a peak value below or above which it declines in importance although some species show a much wider altitudinal range than others. Kamahi and pigeonwood for example are represented in all of the eight elevation groups while kohekohe occurs in two only. In part this relates to the altitudinal range sampled which obviously cuts off the 'tail' of the kohekohe distribution however few species can match the altitudinal range of kamahi. There is some degree of similarity in the distributions of a few species for example pigeonwood, miro and kamahi all show a general increase in importance with increasing altitude and toro is mainly present where kamahi is the leading dominant. For the most part however there is little coincidence in species distribution. The fact that Whittaker's (1956) method of analysis may in part account for this has been described in Clarkson (1977) and should be kept in mind.

Vegetation types

It is still possible albeit arbitrarily to delimit several major floristic vegetation types on the basis of this data. Below 240m the forest is dominated by three main species: tawa, rewarewa, and kohekohe. It is the importance of kohekohe in the top stratum which sets this forest apart from the other forest types. Above 240m and up to 370m the forest is dominated by the three main top stratum species: tawa, rewarewa and pukatea. Important associates are pigeonwood, rimu and hinau. Below 300m this forest is principally a tawa-rewarewa type while above 300m pukatea becomes more prominent. Above 370m and up to 490m hinau becomes the leading dominant with kamahi second dominant, and important associates being rimu, rewarewa and pigeonwood. Beyond 490m kamahi is the clear dominant and important associate species are pigeonwood, toro and miro. It is therefore convenient to recognise four major vegetation types on the basis of the distributions of the top stratum species.

1) forest below 240m, in which kohekohe is a leading dominant;
2) forest above 240m, and up to 370m in which tawa is the leading dominant;
3) forest above 370m, and up to 490m in which hinau is the leading dominant; and
4) forest above 490m in which kamahi is the leading dominant.

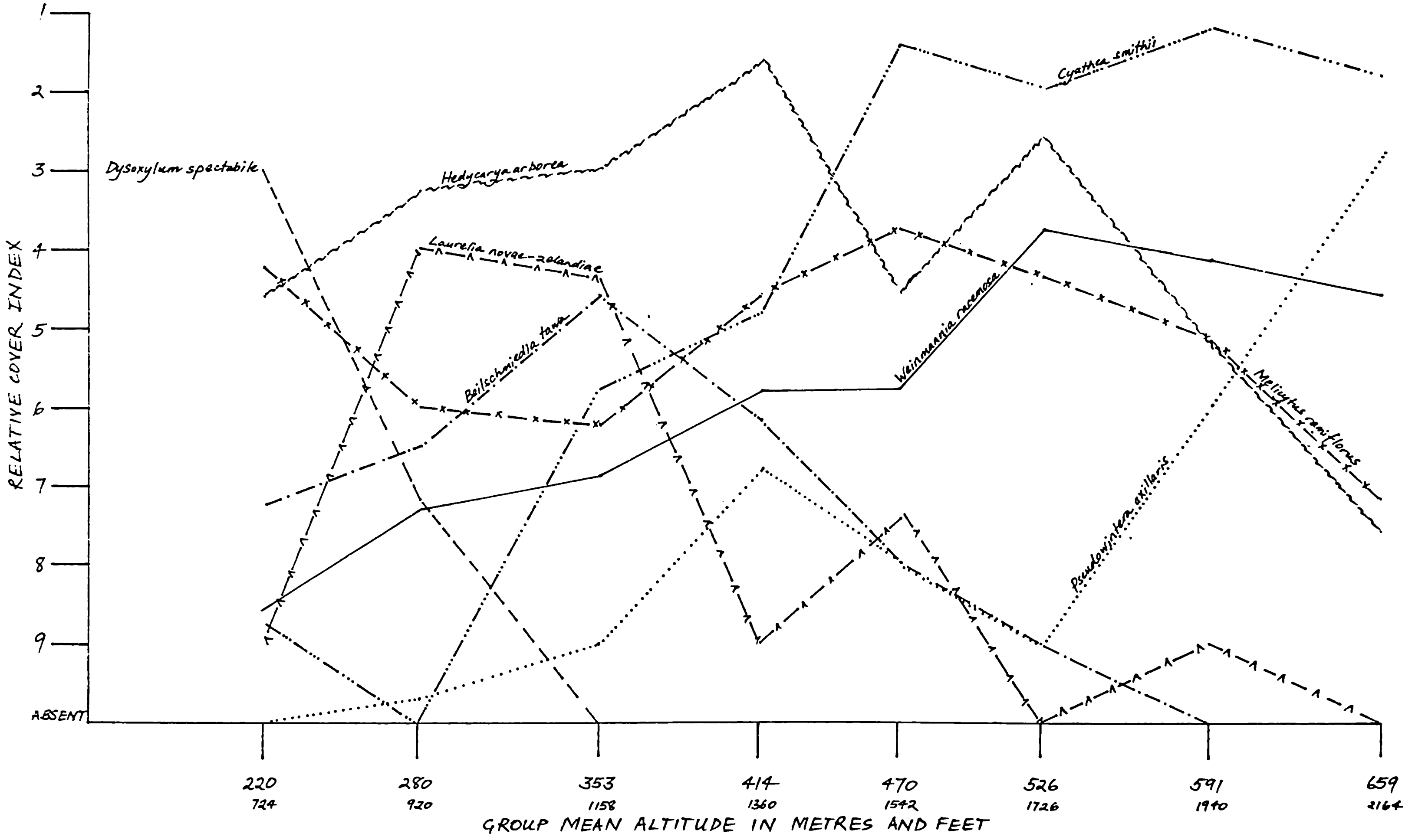
Comparison of these types shows that the kamahi type above 490m is the most homogeneous with the characteristic extreme dominance of kamahi. The forest types below 490m are more heterogeneous with many more species achieving medium relative cover indices.

Relative Cover Indices of the major subcanopy species

Figure 4.10 was constructed in the same manner as Figure 4.9 and depicts the changes in relative cover of the major subcanopy species with increasing elevation. Like the distributions of the top stratum species each subcanopy species tends to reach a peak value above or below which it declines in importance. A few species distributions are similar, for example kamahi, soft tree fern and mountain pepperwood all show a general increase with increasing altitude. Pigeonwood and mahoe are distributed throughout the eight elevation groups and tawa and pukatea both decline in importance above 370m. Comparison of Figures 4.9 and 4.10 reveals that species recorded as major in both the top and subcanopy strata exhibit very similar altitudinal distributions in both strata. Kohekohe and kamahi for example have an almost identical pattern of distribution in both the top and subcanopy strata. Tawa and pukatea in contrast have a wider altitudinal range in the subcanopy stratum than in the top stratum. There is also a deal of coincidence between different species belonging to different strata for example soft tree fern in the subcanopy with kamahi in the top stratum. In general the distribution of subcanopy species along the altitudinal gradient reinforces the pattern already apparent for the top stratum albeit providing greater continuity to the vegetational change.

Figure 4·10

RELATIVE COVER INDICES OF THE MAJOR SUBCANOPY SPECIES



Leading dominants from all strata

The fact that the data collected on the Kaitakes encompassed all strata of the vegetation enabled the leading dominants for the shrub stratum, ground cover stratum, and liane/epiphyte stratum to be determined for each of the eight elevation groups. This data is presented on Table 4.3 and provides a summary of the major floristic changes in all strata along the altitudinal gradient. The four vegetation types defined on the basis of the top stratum species are further reinforced since there is a deal of coincidence in the distributions of dominant species from different strata. Soft tree fern for example is invariably a leading dominant in the subcanopy and shrub strata where the top stratum is dominated by kamahi. Pigeonwood, forest oat grass, and the hooked sedges in contrast provide continuity to the floristic change being represented as leading dominants throughout the altitudinal gradient. In spite of the degree of continuity provided by some species close examination of the raw data and Figures 4.9, 4.10 and Table 4.3 shows that for the Kaitake data a general species transition zone occurs in elevation groups four ($\bar{x}$ = 414m) and five ($\bar{x}$ = 470m), that is, in both groups four and five a major changeover in species dominance and presence occurs and is completed by elevation group six ($\bar{x}$ = 526m). This results in the replacement of a 'lower altitude' forest type with an 'upper altitude' forest type. In this transition zone the major changeover in top stratum dominance is centred on the replacement of tawa as the leading dominant by

Table 4.3 Leading dominants from all strata

Group mean Altitude	220m	280m	353m	414m
Top stratum	kohekohe rewarewa tawa	tawa rewarewa rimu	pukatea tawa pigeonwood	hinau kamahi rimu
Second stratum	kohekohe mahoe pigeonwood	pigeonwood pukatea silver fern	pigeonwood pukatea tawa	pigeonwood mahoe soft tree fern
Shrub layer	kohekohe pigeonwood kawakawa	kiekie pigeonwood tawa-nikau	kiekie soft tree fern wheki-crown fern	soft tree fern kiekie silver fern
Ground cover	*Uncinia uncinata* forest oat grass *Blechnum chambersii*	forest oat grass *Uncinia uncinata* crown fern	forest oat grass *Uncinia uncinata* crown fern	forest oat grass *Uncinia uncinata* kiekie-crown fern
Lianes and epiphytes (in all sites in group)	*Asplenium lucidum* *Blechnum filiforme* Supplejack *Metrosideros perforata*	*Collospermum hastatum* Supplejack kiekie	*Phymatosorus diversifolius* *Phymatosorus scandens* *Collospermum hastatum* *Asplenium flaccidum* *Metrosideros perforata*	*Phymatosorus diversifolius* *Asplenium flaccidum* *Hymenophyllum* spp.

470m	526m	591m	659m
hinau kamahi rewarewa-pigeonwood	kamahi hinau rewarewa	kamahi pigeonwood soft tree fern	kamahi toro miro
soft tree fern mahoe pigeonwood	soft tree fern mahoe kamahi	soft tree fern kamahi mahoe-pigeonwood	soft tree fern lowland pepperwood toro
soft tree fern kiekie lowland pepperwood-wheki	soft tree fern lowland pepperwood kiekie	soft tree fern lowland pepperwood mountain pepperwood	soft tree fern lowland pepperwood mountain pepperwood
forest oat grass *Blechnum fluviatile* *Uncinia uncinata*	forest oat grass *Uncinia uncinata* *Blechnum fluviatile-Uncinia gracilenta*	forest oat grass *Uncinia uncinata*	forest oat grass *Blechnum fluviatile*
kiekie *Asplenium flaccidum* *Phymatosorus diversifolius*	*Metrosideros perforata* *Asplenium flaccidum* *Phymatosorus diversifolius*	*Rumohra adiantiformis* *Asplenium flaccidum*	*Astelia solandri* *Asplenium flaccidum* *Rumohra adiantiformis* *Hymenophyllum* spp.

kamahi as the leading dominant. In the subcanopy it is the replacement of pigeonwood by soft tree fern which is significant and in the shrub layer the changeover from kiekie as a leading dominant to soft tree fern. The pattern is not as clear cut for the ground cover stratum because of the continuity provided by forest oat grass and the hooked sedges however the fact that from elevation group five onwards *Blechnum fluviatile* becomes a leading dominant could be considered significant. In the liane-epiphyte category it is the overlap of the kiekie and hanging spleenwort distributions, the increasing range of epiphytes found on soft tree fern (notably raurekau), and the increasing importance of filmy ferns which further accentuates the species transition zone obvious in the top stratum.

Individual plot data analysis

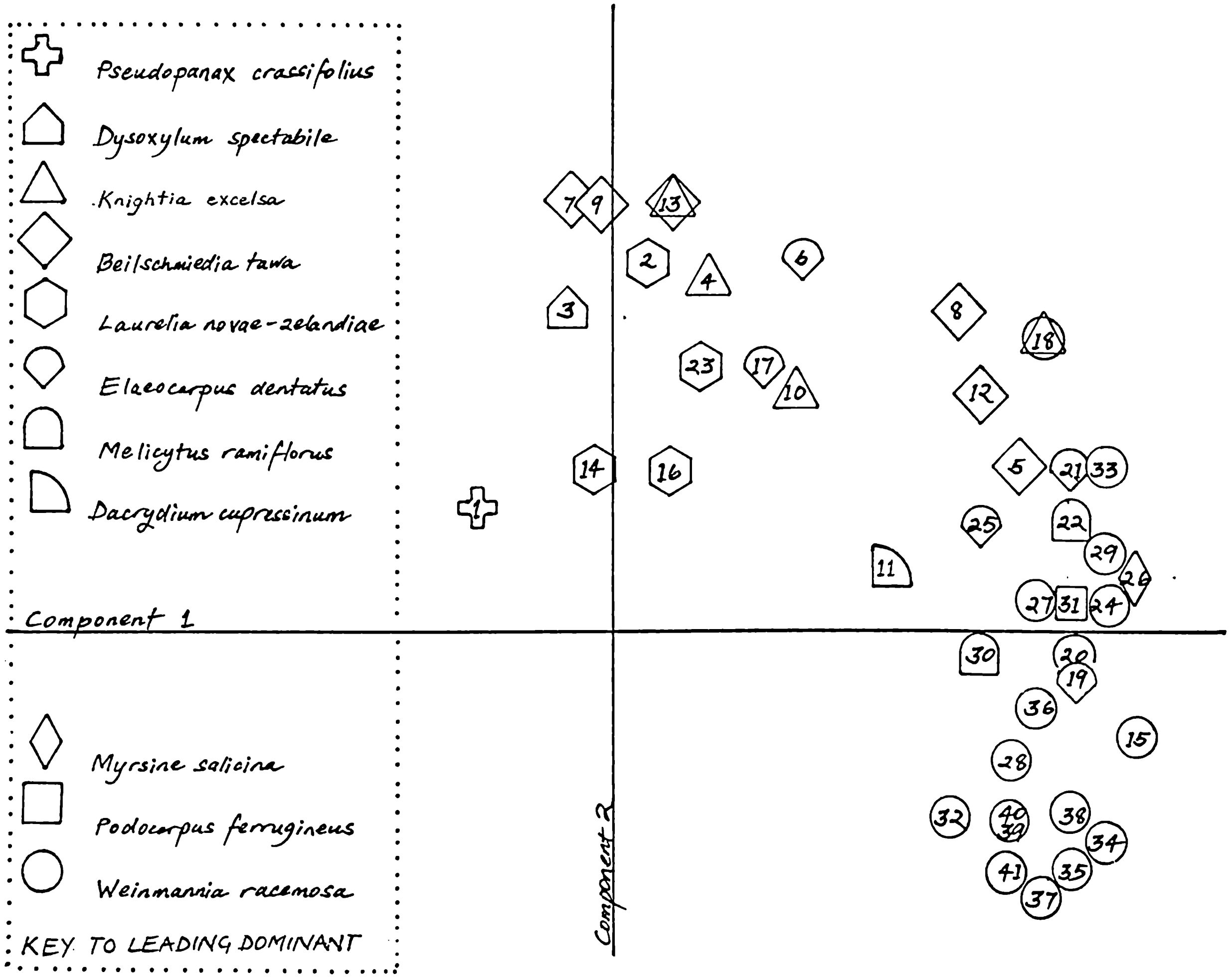
Individual plot data is the basis of the analysis presented below. The analysis is both inverse and normal, that is, by species and by plots and is concerned only with the top and subcanopy strata because the data recorded for these strata is the most detailed. These strata make up the major part of the vegetation biomass and are the most important with regard to any attempted forest typing. Not all the results obtained have been presented because all of the methods of analysis employed for example, for plot ordination, gave similar results which do not require repeating. The results of the various analyses that are presented are depicted on Figures 4.11-4.14. All of these figures except Figure

4.14 are ordination diagrams resulting from Principal Component Analyses (PA1 Factor Analysis SPSS v7). Figure 4.14 is a cluster analysis (BMD:P1M).

Plot ordination using top stratum species relative cover

Figure 4.11 is an ordination diagram based on the first two components of a principal component analysis (P.C.A.) of the 41 sites using top stratum species relative cover. The first two components account for 48.5% of the variance. A symbol representing the leading dominant at each site has been overlayed on the plot ordination to indicate specific trends in the ordination and reference back to the environmental data associated with each plot (aspect, slope, altitude, location etc.) enables indirect determination of the major environmental gradients reflected by the species. Figure 4.11 shows clearly that altitude is the major environmental gradient as each of the sites (1-41) is numbered in sequence from the lowest to the highest altitude and for the most part this sequence is reflected in the ordination. Sites which noticeably do not conform to this altitudinal sequence include sites 5, 11, 14, 15, 16, 17, 19, 20, 23 and 33. Of these sites 5, 11, 15 and 20 are located on the Kirihau Track Ridge probably one of the steepest and narrowest ridges in the Kaitakes. In contrast to most other locations kamahi is second dominant to tawa at an altitude of only 240m, and is the dominant top stratum species above 370m. Sites 14, 16, 17 and 23 have in common a large component of pukatea (1st or 2nd dominant) in the top stratum and the fact that their average slope

Figure 4·11 PLOT ORDINATION USING TOP STRATUM SPECIES RELATIVE COVER



angles are all less than 10° which is considerably less than the average slope angle for their respective elevation group. Pukatea is well known as an important component of forest on poorly drained sites and while these sites could not be classed as very poorly drained they are certainly less well drained than the majority of sites in their respective elevation group. In the case of site 16 from Mander's Spur Track the effects of various disturbances have already been noted in the detailed examination of that location and the large component of pukatea in this instance is mainly young individuals less than 20cm d.b.h. In summary the ordination shows that the major environmental gradient is altitudinal but various other environmental factors for example slope may modify the floristic sequence associated with this gradient. The floristic sequence is essentially from lower altitude forest (below 490m) in which a range of species including kohekohe, tawa, pukatea, hinau, rimu and rewarewa are dominant depending on altitude and other factors such as slope or aspect to upper altitude forest where for the most part regardless of slope, aspect etc., kamahi is the top stratum dominant.

Plot ordination using top stratum species presence/absence

Figure 4.12 is an ordination diagram based on the first two components of a P.C.A. of the 41 sites using top stratum species presence/absence data. The first two components account for 43.7% of the variance, only five percent less than the semi-quantitative data. Comparison of Figures 4.11 and 4.12 shows that the sites exhibit a

Figure 4-12

PLOT ORDINATION USING TOP STRATUM SPECIES PRESENCE/ABSENCE

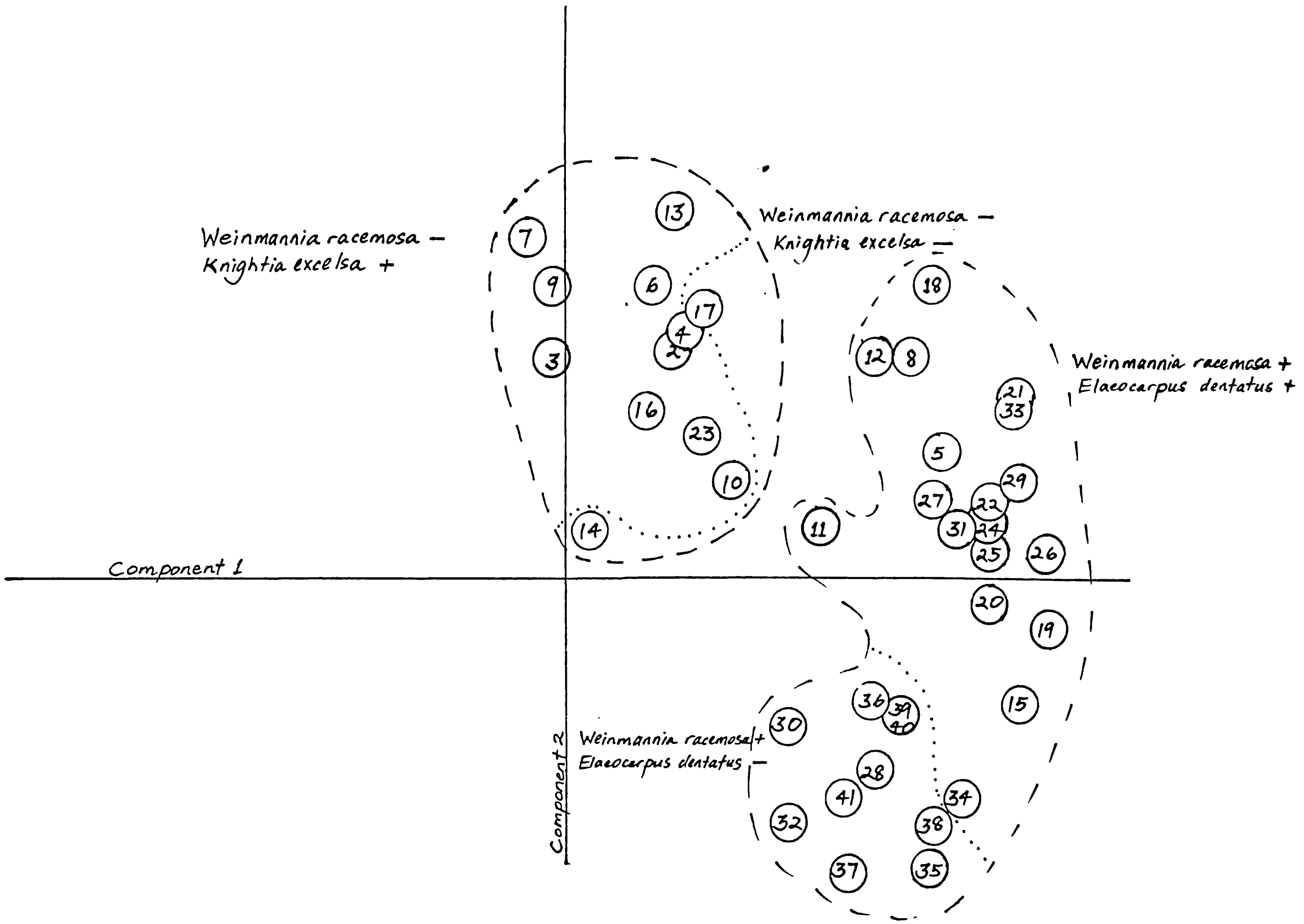
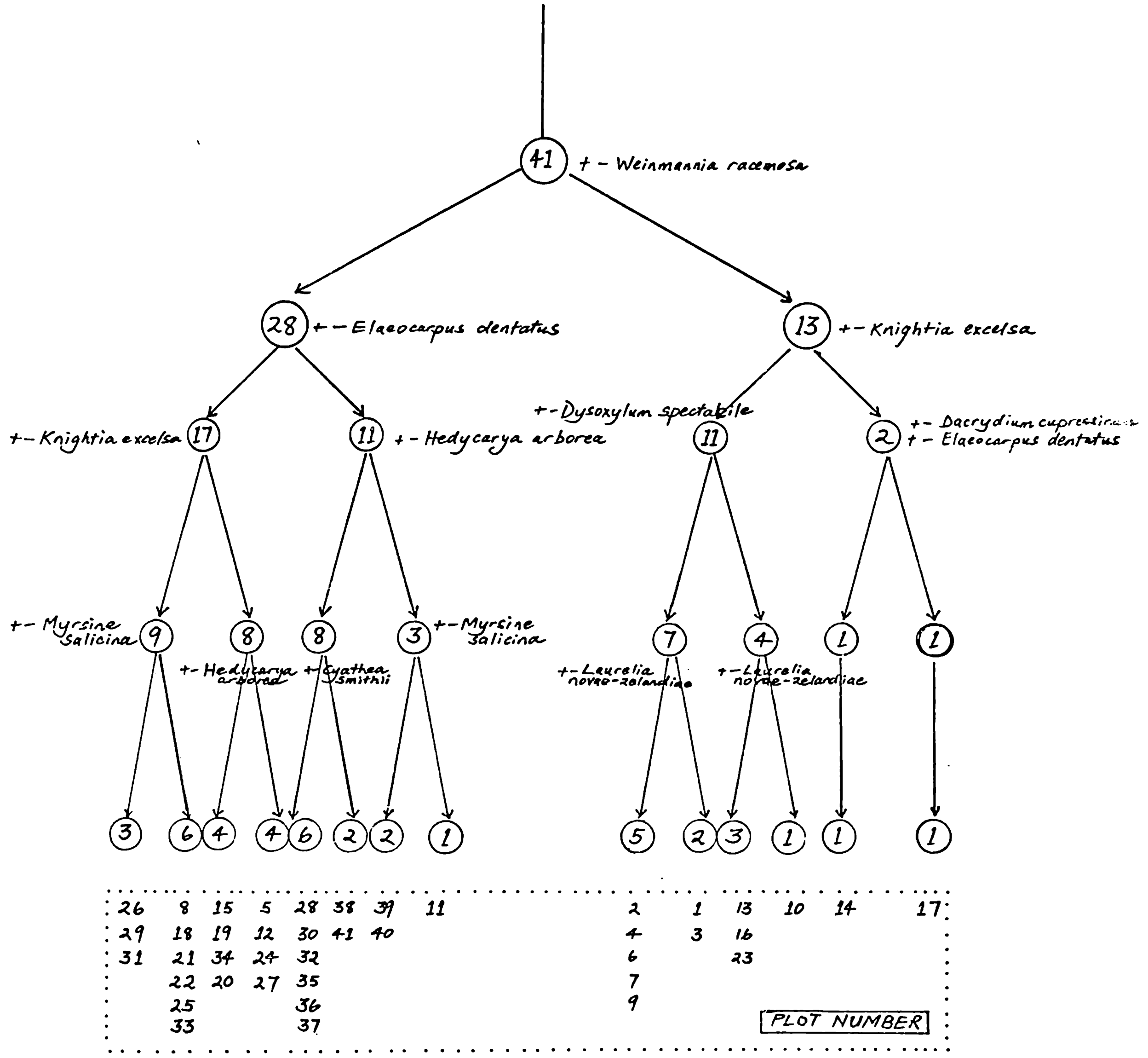


Figure 4·12A

PLOT CLASSIFICATION

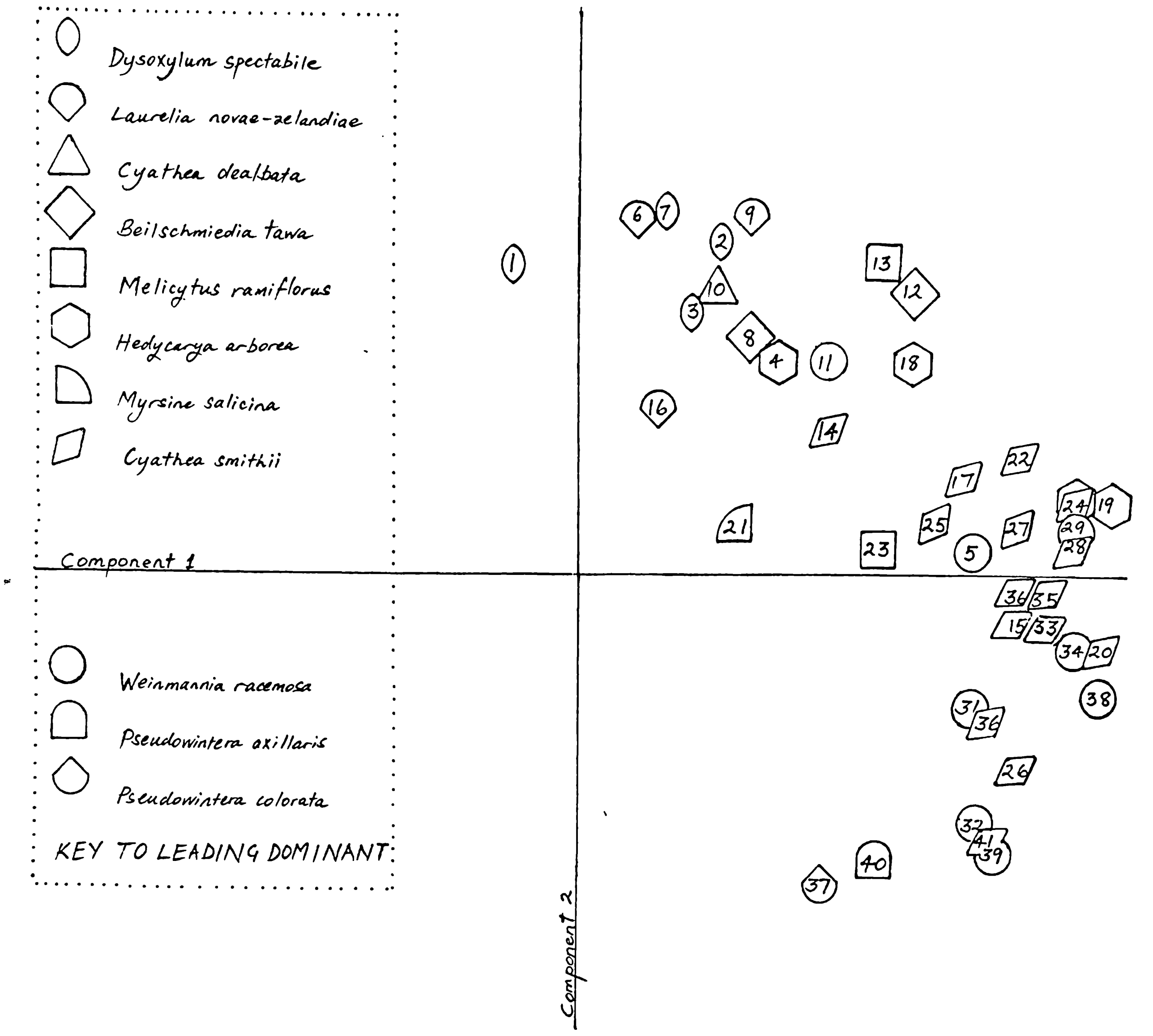


similar location on the ordination diagram relative to each other, and that altitudinal gradient is again the overriding one. The ordination has been overlayed with a simple divisive classification based on the successive division of plot groups by presence/absence of the most frequent species. The simple divisive classification is depicted separately on Figure 4.12A. The primary division of the 41 plots is into 28 plots containing kamahi and 13 plots in which kamahi is absent. The second division of the 28 plots containing kamahi is made on the basis of presence/absence of hinau and there are 17 in which hinau is present and 11 in which hinau is absent. The second division of the 13 plots in which kamahi is absent yields 11 plots in which rewarewa is present and 2 plots in which it is absent. Like the previously described ordination several plots do not conform to the underlying altitudinal sequence. Again these are mainly plots in which pukatea is present or are plots located on the Kirihau Track Ridge.

Plot ordination using subcanopy species relative cover

Figure 4.13 is an ordination diagram based on the first two components of a P.C.A. of the 41 sites using subcanopy species relative cover. The first two components account for 57.1% of the variance nearly nine percent more than the top stratum species ordination. The ordination has been overlayed with a symbol representing the leading subcanopy dominant at each site to indicate specific trends in the ordination. Again reference back to the environmental data associated with

Figure 4·13 PLOT ORDINATION USING SUBCANOPY SPECIES RELATIVE COVER



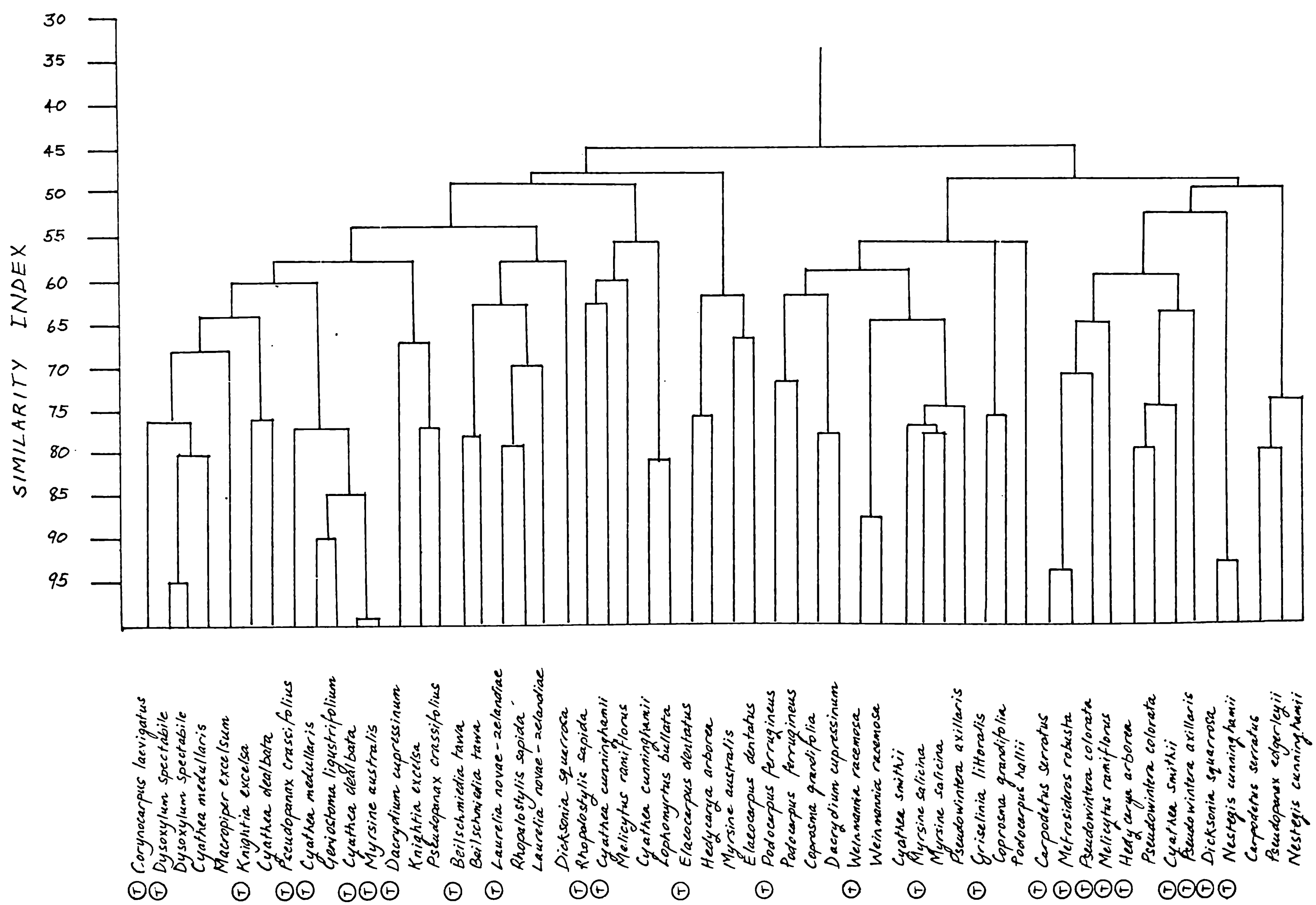
each plot (aspect, slope, altitude, location etc) enables indirect determination of the major environmental gradients reflected by the subcanopy vegetation. As for the top stratum, the major environmental gradient reflected by the subcanopy is the altitudinal one and once again a number of sites obviously do not conform to this overall trend. The most obvious are sites 5, 15, 16, 19 and 21. Probable reasons for this have been advanced for the top stratum ordinations already and these also apply to the subcanopy vegetation. In fact comparison of the top stratum and subcanopy ordinations reveals a high degree of similarity in the ordering and relative position of the 41 sites and this was a consistent feature of all the ordinations performed.

Species cluster analysis (top stratum and subcanopy combined) relative cover

Figure 4.14 is a dendrogram obtained from an average linkage cluster analysis (BMD:P1M) performed on 56 of the top stratum and subcanopy species recorded in the 41 sites. As is to be expected after examining the site ordinations, the species clusters obtained relate very closely to their altitudinal distributions. At the usually accepted 50% level of similarity five groupings are apparent. The first, includes the species from top stratum karaka through to subcanopy wheki and is a 'lower altitude' cluster. The second, includes the species from top stratum nikau to subcanopy ramarama again a 'lower altitude' cluster. The third, includes the species from top stratum hinau through to subcanopy

Figure 4·14

SPECIES CLUSTER ANALYSIS (Top stratum and subcanopy combined)



hinau, species of 'middle altitudes'. The fourth, includes the species from top stratum miro through to subcanopy Hall's totara an 'upper altitude' cluster, and the fifth cluster, also an 'upper altitude' one includes the species from top stratum marbleleaf through to subcanopy black maire. The cluster analysis effectively summarises the top stratum and subcanopy species relationships as species most likely to be associates are grouped together. For example, in the cluster containing top stratum kamahi the other members of the cluster are subcanopy kamahi, top stratum and subcanopy toro, subcanopy soft tree fern, and subcanopy pepperwood. At a lower level of similarity 40%, the altitudinal trend is further emphasized by the fact that only two clusters of species are recognised. The first, from top stratum karaka through to subcanopy hinau and the second, from top stratum miro through to subcanopy black maire. This primary division is based upon two major species groups: species which are distributed only below 490m or are more prominent below that altitude and species which are distributed only above 490m or are more prominent above that altitude. Species which occupy both strata in the vegetation exhibit some interesting relationships in this cluster analysis. Some species, for example, tawa, kohekohe, kamahi, miro and toro show close similarity in their top stratum and subcanopy distributions while others for example rewarewa, soft tree fern, marbleleaf, rimu and pigeonwood do not. In the case of pigeonwood although it is important in middle altitudes as a subcanopy component it becomes an increasingly important component of the top stratum at higher altitudes (above 370m). Soft tree fern, dominant as a subcanopy component above 460m only ever becomes a leading dominant in the top stratum above 600m. The separation of the altitudinal distributions of species represented in the two vegetation strata particularly in the instances described above results mainly from the physiognomic potential of the species in relation to its competitors. Thus pigeonwood is able to reach the top stratum at higher altitudes because the top stratum is much lower (a function both of the environment and the species growing there). The same could be said for soft tree fern, but for species such as rewarewa and rimu the phenomenon relates more to the fact that the upper altitudinal limit exhibited by many tree species is invariably exhibited by individuals growing in strata other than the top stratum. Thus small subcanopy (pole-size) rimu are found growing at much higher altitudes than large mature individuals and probably represent the progeny of lower altitude adults possibly emphemeral but constantly restocked. The same feature of distribution is apparent for rewarewa at the upper limits of its distribution (600m).

Vegetation types

The data analysis presented above using individual plot data also makes it possible albeit arbitrarily (in view of the continuous nature of the floristic change in the vegetation shown on the various plot ordinations) to delimit several major floristic types by grouping together plots with similar species composition. As a result of the various analyses performed it was considered that two major groups of plots could be recognised: the first a relatively homogeneous group of those plots occurring above 490m in which kamahi is the leading top stratum dominant and kamahi and/or soft tree fern are prominent in the subcanopy; and the second, a relatively heterogeneous group of those plots located below 490m in which a range of tree species are recorded as top stratum and subcanopy leading dominants.

In the case of plots below 490m, if criteria were to be selected to further subdivide the forest types the simplest and most effective method would be on the basis of the leading top stratum dominants. The floristic subtypes which can thus be defined are: lancewood forest, kohekohe forest, rewarewa forest, tawa forest, pukatea forest, rimu forest, hinau forest, mahoe forest, and kamahi forest.

One plot only of lancewood forest was recorded, plot 1 (Mander's Spur) at 198m. Kohekohe forest also was recorded in one plot only, plot 3 (Davies Track) at 219m. Both are disturbed forests close to the margins of the national park boundary. Plots 2, 7 and 10 with kohekohe as the leading subcanopy dominant are closely allied to plot 3.

Forest in which rewarewa is top stratum dominant or codominant was recorded in plots 4, 10, 13 and 18 between 238m and 402m, on a range of slopes and aspects, but in two locations only, Patuha and Davies Track.

Tawa forest was recorded in 6 plots: 5, 7, 8, 9, 12 and 13 representing all the sampling locations except Mander's Spur where tawa is noticeably poorly represented in all strata (a feature already cited in the detailed section on Mander's Spur and resulting from disturbance). The altitudinal range of this subtype is 244m to 338m and it was most frequently recorded on medium slopes (10-15°) and through the complete range of aspects.

Pukatea forest was recorded in four plots (2, 14, 16 and 23). Locations represented were Mander's Spur, Patuha and Waiomuku. Most plots had slope angles less than 12° except in one instance where the plot was located next to a stream bed. Pukatea forest is thus characteristically related directly or indirectly to soil drainage factors although pukatea is more frequent as subcanopy leading dominant in a greater range of sites.

Only one plot in which rimu was leading dominant was recorded, plot 11, a rather anomalous plot in that it was the only site recorded at the Kirihau Track location with a low slope angle (5-10°).

Hinau forest was recorded in five plots (6, 17, 19, 21 and 25), representing the range of locations sampled. Hinau forest represents the upper altitudinal limits of the 'lower altitude forest' being recorded between 259m and 487m. It is particularly noticeable that this forest subtype has its lower altitudinal limit on the Kirihau Track Ridge already cited because of the steepness and narrowness of the main ridge. Hinau forest is closely allied to kamahi forest in that kamahi is invariably one of the other leading dominants in both the top and subcanopy strata. It could therefore be viewed as a transitional forest between lower and upper altitude forest.

Kamahi forest occurs in four plots below the 487m contour. These are plots 15, 18, 20 and 24. This subtype is found between 366m and 463m on the Kirihau and Davies Track locations where ridges begin to narrow and become steeper (greater than 20°). It is also particularly noticeable that kamahi is first recorded as a leading dominant on the Kirihau Track Ridge as low as 244m and this trend concurs with the trend already outlined for hinau forest. It appears to be a general rule that the changeover from the lower altitude forest type to one more similar to the upper altitude kamahi type occurs at much lower altitudes when slope angles are very steep or ridges become very narrow. Kamahi dominated forest is also found at lower altitudes than 'normal' lining stream banks or in shaded gullies. Kamahi is obviously better adapted to these conditions than its competitors.

In summary the individual plot data points to the fact that a convenient way of classifying the forest found on the Kaitakes is first by the delineation of two major types, lower altitude (mosaic) forest and higher altitude kamahi forest on the basis of the floristic changes relating to the overriding environmental gradient - altitude. Further division of the lower altitude forest is extremely arbitrary because as it has already been noted forest composition varies according to other environmental factors as well to form a mosaic in which a number of major forest species share dominance.

At the lower altitudinal limit of sampling a forest subtype in which kohekohe is prominent in the top and subcanopy strata was only just detected. This forest subtype is represented nearer the margins of the Kaitake forests and has been subject to a great deal of disturbance. This subtype is also referred to in the section describing ring plain forest remnants. In essence the two methods of data analysis, direct gradient analysis and individual plot data analysis serve to highlight the same features of the Kaitake forests but via abstract community types in the first instance and via on the ground distributions in the second instance.

Obviously comparisons between the Kaitake Range forests and other Taranaki and New Zealand forests can and should be made in light of the descriptions provided in this section. As well the presence of the species transition zone and other features of the vegetation require more detailed explanation. These comparisons and explanations are best made after the forests in each of the other study areas has been described and therefore such discussion is reserved until then.

The representativeness of the results obtained from Mander's Spur Track Ridge

At the outset of this discussion it was stated that one of the express purposes of collecting data from a further 34 sites was to determine how representative the results from the single location were. It can now be said that for the altitudinal gradient at least the Mander's Spur results outline adequately the major changes in species composition through altitude apparent on the whole of the Kaitake Range. A comparison of the figures depicting major species distributions for Mander's Spur and the direct gradient analysis for the whole of the Kaitakes shows this clearly. There are differences in detail of course, the most obvious being the already cited poor representation of tawa at the Mander's Spur location. Additionally this single transect data cannot provide insights into the other major environmental gradients obtained by the greater sample size. Finally since the direct gradient analysis data being averaged is more continuous, species distributions appear more individualistic, and vegetation changes appear less abrupt. In spite of these differences the single ridge data gives a good outline of the major vegetational changes along the altitudinal gradient and also enables the definition of the two major forest types. The additional data is however essential to gauge the relative importance of species from location to location and to determine the importance of other environmental factors. In fact further data could now be collected to examine more closely some of the features of vegetation pattern on the Kaitake Range.

Non-forest vegetation on the Kaitake Range

Forest does not cover the whole of the Kaitake Range. Important sites in which forest is lacking are Patuha Peak, Kaitake Peak, Goat Rock and Kirihau Peak. All of these sites are steep rocky outcrops suffering obvious and continuing impacts from human activity, and browsing by goats and opossums. They all support a grassy turf composed of a range of adventive weeds and grasses as well as small indigenous herbs and grasses including *Lagenifera pumila* and *Rytidosperma* spp. Shrubs and tree ferns normally important in the shrub layers of the kamahi forest are also prominent around the margins of these clearings in particular mountain pepperwood, lowland pepperwood and soft tree fern. Goat Rock, Kirihau Peak and some of the other rocky outcrops of the Kaitake Range are unique in that they support the only mountain flax growing within the national park. Not only does mountain flax grow as a rupestral but it is also present as an epiphyte in the kamahi forest near Goat Rock. In fact all of the open areas or the margins thereof support a number of species not normally present in the kamahi forest including *Gaultheria antipoda, Hebe corriganii, Helichrysum 'alpinum', Ophioglossum* sp. (c.f.*coriaceum*), *Libertia grandiflora* and *Stichetus cunninghamii.* The high frequency of rimu and Hall's totara seedlings and saplings (usually damaged by browsing) is also a feature of some of the margins of these open sites and of track sides. The presence or high frequency of some indigenous species could therefore be considered unnatural in the sense that it has resulted from unnatural forest disturbance. The presence of *Helichrysum 'alpinum'* and the high frequency of rimu and Hall's totara seedlings in particular come into this category.

The flora of the Kaitake Range

While the objective of this study was primarily to describe and explain the vegetational patterns evident in a number of locations within and adjacent to the Egmont National Park the very nature of the data collected to do this enables some comments to be made on the flora particularly with reference to Druce's 1973 Checklist of the Higher Plants... A number of species not listed by Druce as present on the Kaitake Range were encountered both as the result of the formal data collection and from general observation. The species present on Kaitake Range but not listed by Druce include: *Leptopteris superba, Ophioglossum* sp. (c.f.*coriaceum*), *Helichrysum 'alpinum', Pseudopanax anomalus, Asplenium hookerianum* s.s., *Astelia fragrans, Lemna minor* and *Typha orientalis.* These species records boost the vascular species total for the Kaitakes from 226 up to 234.

B. THE VEGETATION OF THE POUAKAI RANGE

Introduction

In order to describe and explain the significant features of vegetational change along the major environmental gradients on the Pouakai Range four sampling programmes were completed. The first, quantitatively based, consisted of eleven quadrats located along the altitudinal gradient on the Henry Peak Track Ridge. The second, a more comprehensive sample, involved the collection of semi-quantitative data from a further 40 sites below 1220m a.s.l. located in four other sectors of the Pouakai Range. The third sampling programme involved the collection of semi-quantitative data from another 31 sites above 1220m a.s.l. through a range of aspects and slope angles. The fourth sampling programme consisted of the collection of data from five sites on the margin of the Ahukawakawa Swamp 914m a.s.l. in order to outline the vegetational change associated with a moisture gradient. A total of 87 sites were thus examined and the results of these sampling programmes are presented below.

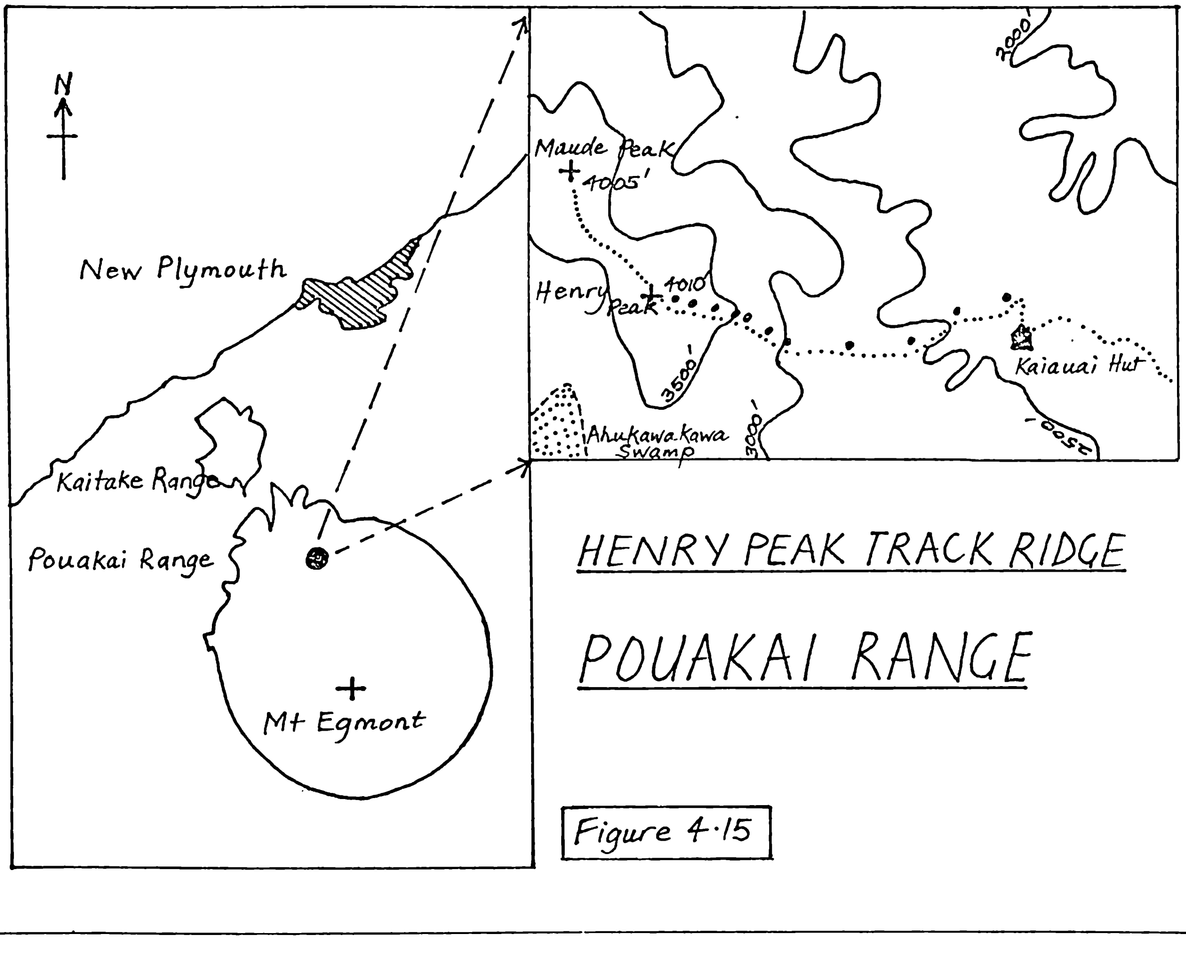
1. HENRY PEAK TRACK RIDGE

Introduction

The Henry Peak Track Ridge (Kaiauai Track) is located between the Kaiauai Hut (715m) and Henry Peak (1222m) on the Pouakai Range in the north-eastern sector of Egmont National Park (see location map Figure 4.15). Eleven sites between 650m and 1210m were examined (see

Table 4.4 Sampling sites on the Henry Peak Track Ridge

Site No.	ALTITUDE Feet	 Metres	Quadrat Size	Transect Length	Slope Angle	Aspect
11	3960	1206	-	60m	15-20	NE
10	3770	1148	-	60m	15-20	NE
9	3570	1087	-	60m	15-20	NE
8	3450	1051	-	60m	15-20	NE
7	3400	1036	-	60m	15-20	NE
6	3200	975	$100m^2$	-	25-40	NE
5	3000	914	$200m^2$	-	22-27	NE
4	2780	847	$400m^2$	-	15-20	N
3	2600	792	$400m^2$	-	15-20	N
2	2350	716	$400m^2$	-	20-25	N
1	2150	655	$600m^2$	-	0-05	N.



HENRY PEAK TRACK RIDGE

POUAKAI RANGE

Figure 4·15

Table 4.4). The distance between site 1 (655m) and site 11 (1206m) is 2km approximately thus the average gradient for the ridge is 1:3.63. Slope angles of 22-27° and 25-40° in sites 5 and 6 respectively emphasize the fact that the steepest part of the altitudinal gradient is between 800 and 1000m. Below 700m the average gradient (1:8.0) is far more gentle. Ridge alignment is mainly east to south-east, and all of the sites examined had aspects ranging from north to north-east.

Top stratum (canopy and emergents) species Relative Basal Area (R.B.A.)/Relative Cover (R.C.) >20% (3 species)

Three species achieve values greater than 20 percent: kamahi, leatherwood and rata (see Figure 4.16). Kamahi and leatherwood are the only top stratum dominants with kamahi dominant up to 1025m where it is overtaken by leatherwood. Rata is second dominant to kamahi below 800m.

Top stratum species R.B.A./R.C. >5% <20% (11 species)

Eleven species achieve values between 5 and 20 percent: miro, rimu, *Pseudopanax simplex*, koromiko, Hall's totara, broadleaf, toro, red tussock, *Gahnia procera*, *Myrsine divaricata* and *Coprosma pseudocuneata* (see Figure 4.17). Of these species miro and rimu associate only with kamahi, distributing below 850m. *Pseudopanax simplex*, koromiko, Hall's totara, broadleaf and toro associate with kamahi and leatherwood. Hall's totara, toro and broadleaf are more important near the upper limits of kamahi dominance while koromiko and

Figure 4·16

TOP STRATUM SPECIES RELATIVE BASAL AREA/COVER >20%

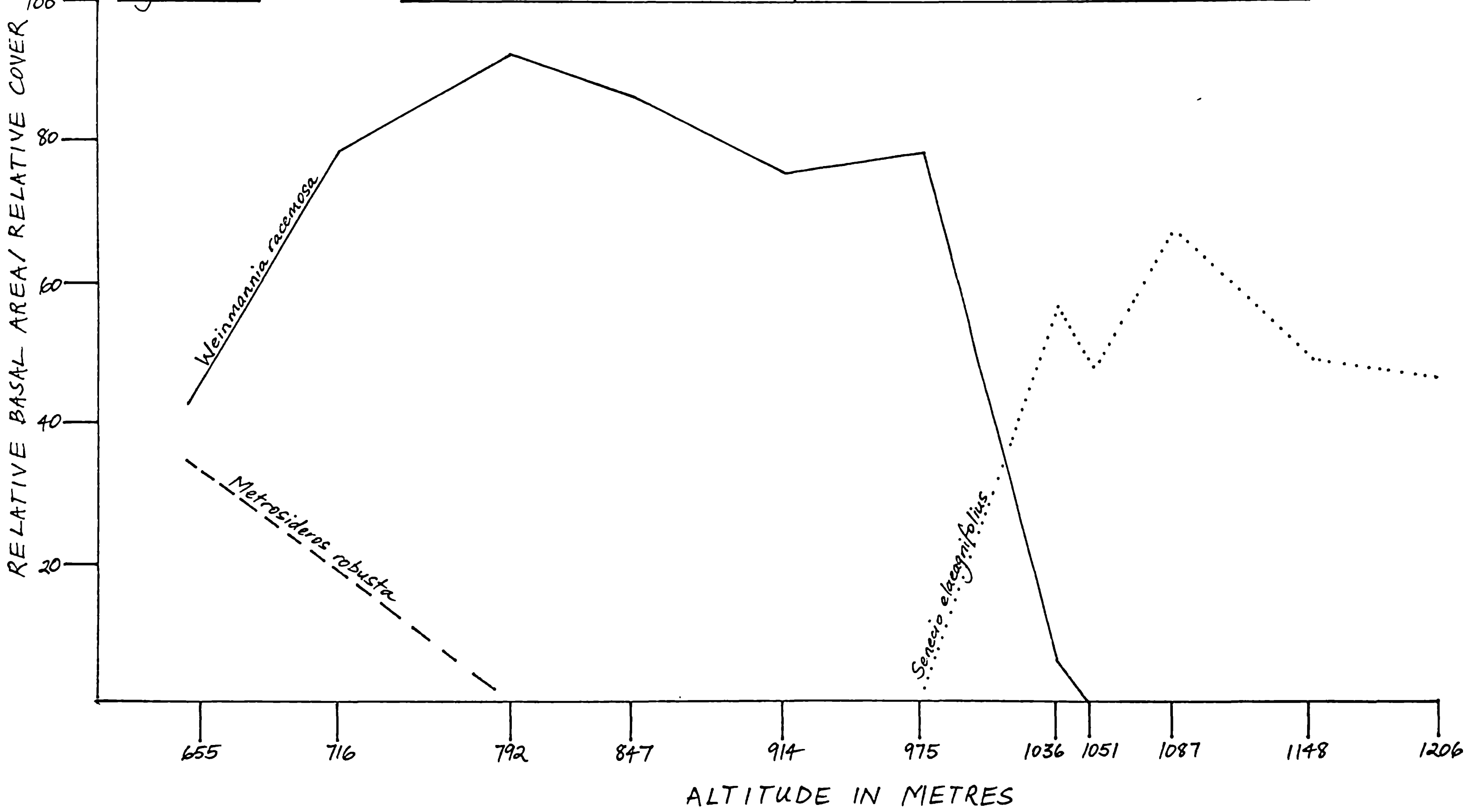
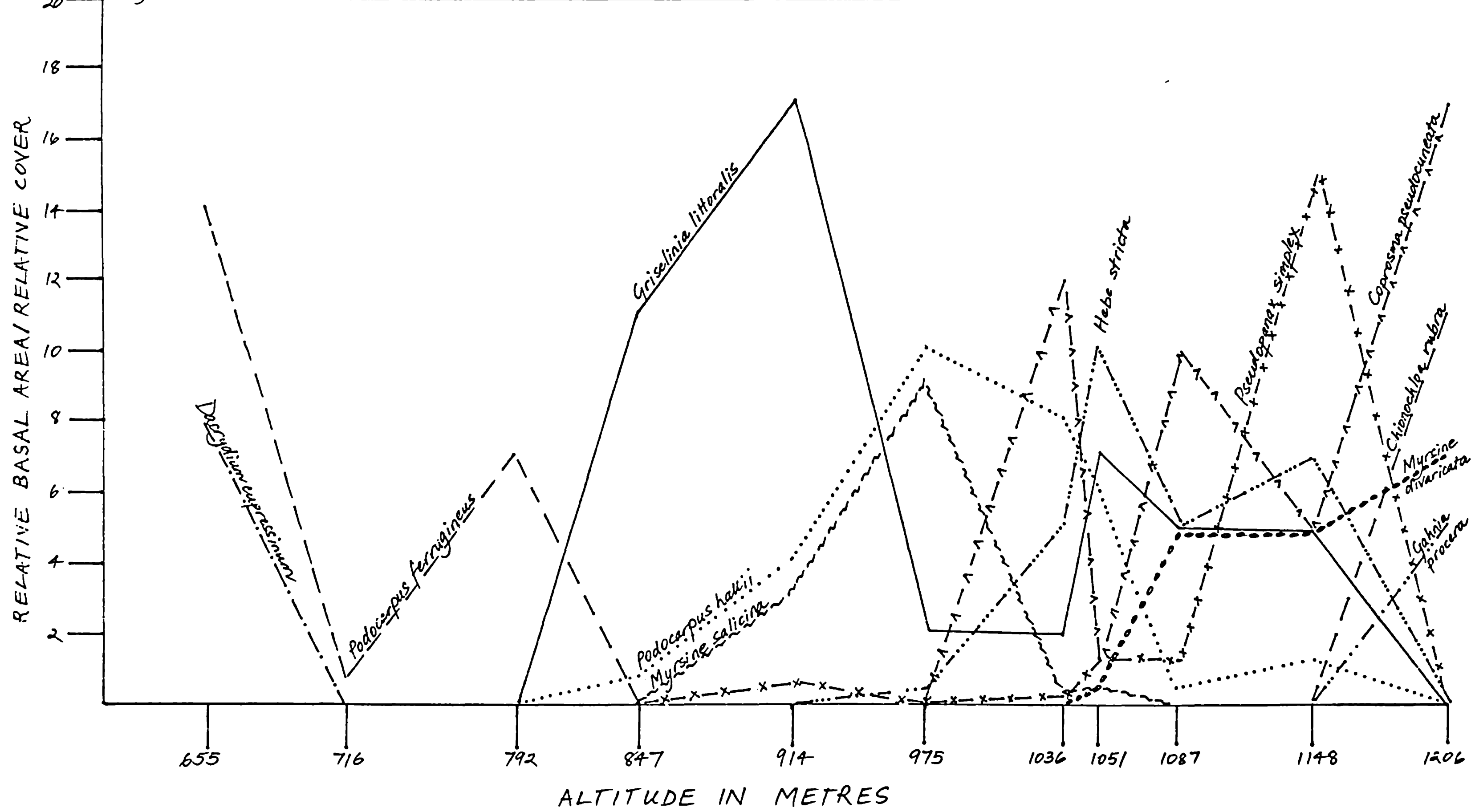


Figure 4·17 TOP STRATUM SPECIES RELATIVE BASAL AREA/COVER >5 <20%



Pseudopanax simplex are more important near the lower limits of leatherwood dominance. Red tussock, *Gahnia procera*, *Myrsine divaricata* and *Coprosma pseudocuneata* are all associates of leatherwood and were not recorded below 1000m.

Second stratum (subcanopy) species Relative Density (R.D.) >20% (8 species)

Eight species achieve values greater than 20% in the kamahi dominated forest: mahoe, miro, soft tree fern, Hall's totara, mountain pepperwood, black maire and kamahi (see Figure 4.18). Mahoe, miro and soft tree fern are all distributed below 850m while Hall's totara and mountain pepperwood are distributed above 750m. Kamahi is important throughout while toro and black maire exhibit scattered distributions.

Third stratum (shrub layer) species R.D. >20% (3 species)

Three shrub species achieve values greater than 20% in the kamahi dominated forest: pepperwood, soft tree fern and mountain pepperwood (see Figure 4.19). Pepperwood is dominant below 700m, soft tree fern above 700m and below 790m and mountain pepperwood above 790m. Mountain pepperwood is the only major shrub species recorded in all of the kamahi dominated sites.

Ground cover (fourth stratum) species first and second dominants (10 species)

Nine species were recorded as either first or second ranked ground cover dominants (see Figure 4.20). Of

Figure 4.18

SECOND STRATUM SPECIES RELATIVE DENSITY >20%

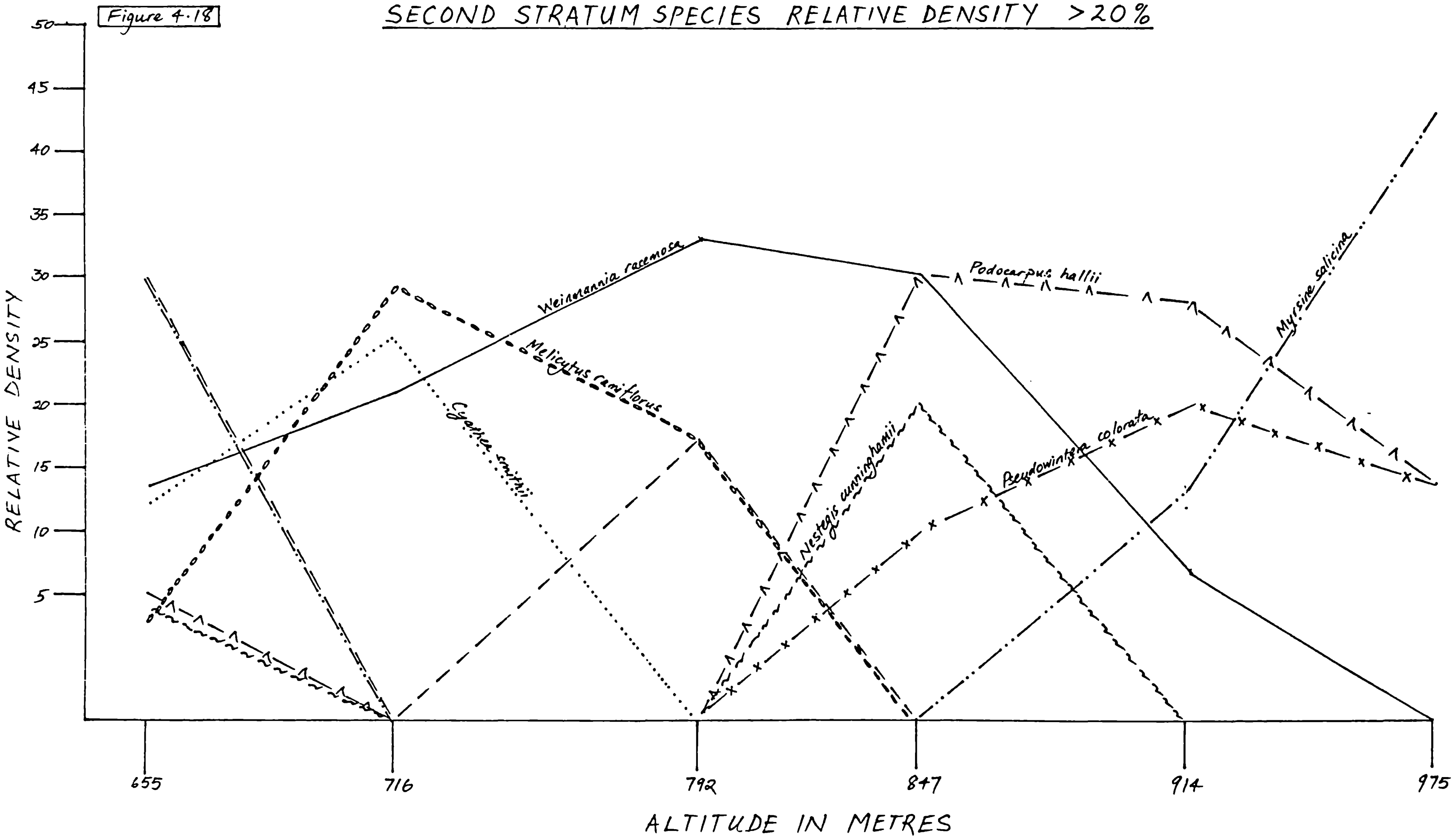


Figure 4-19

THIRD STRATUM SPECIES RELATIVE DENSITY >20%

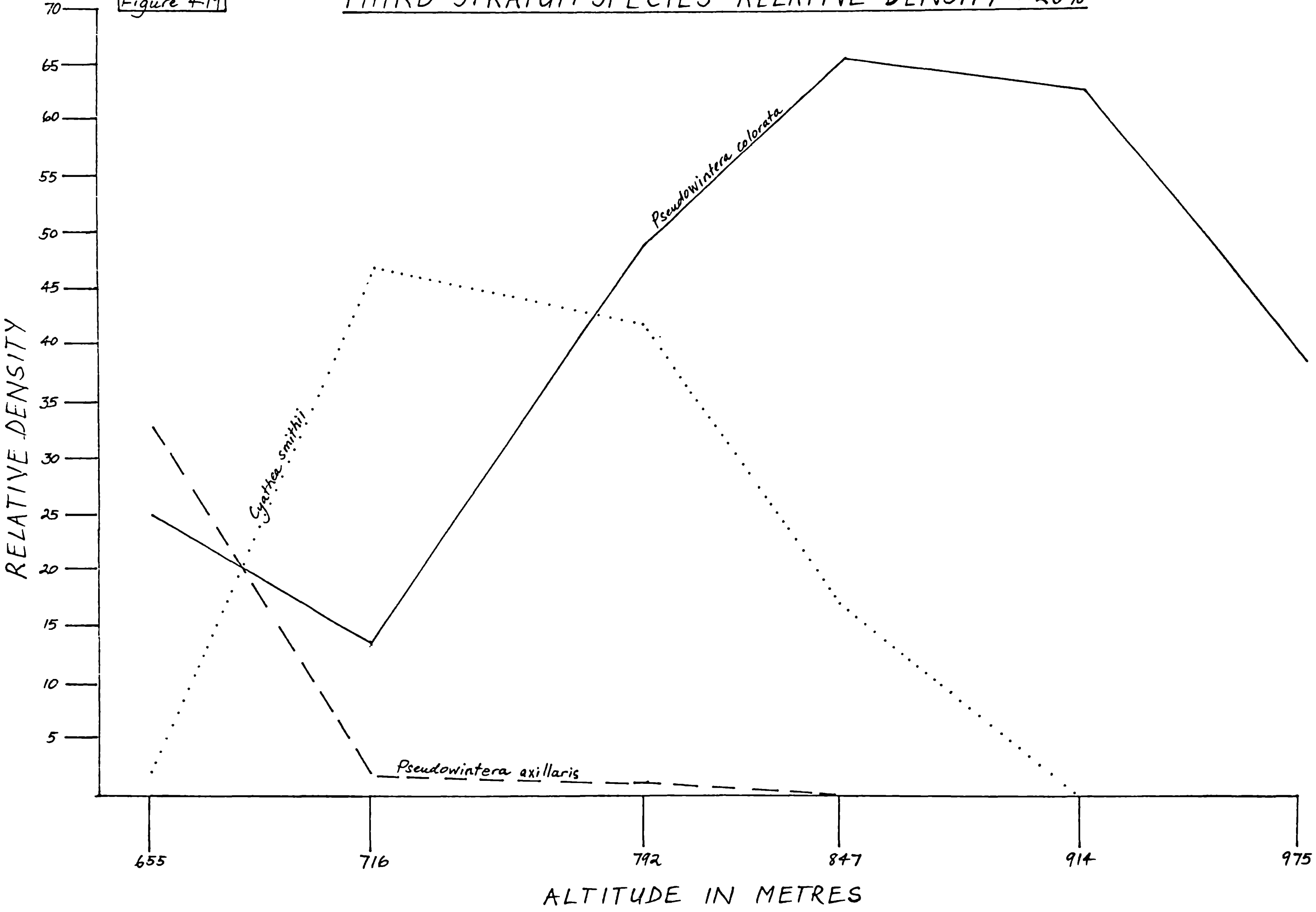
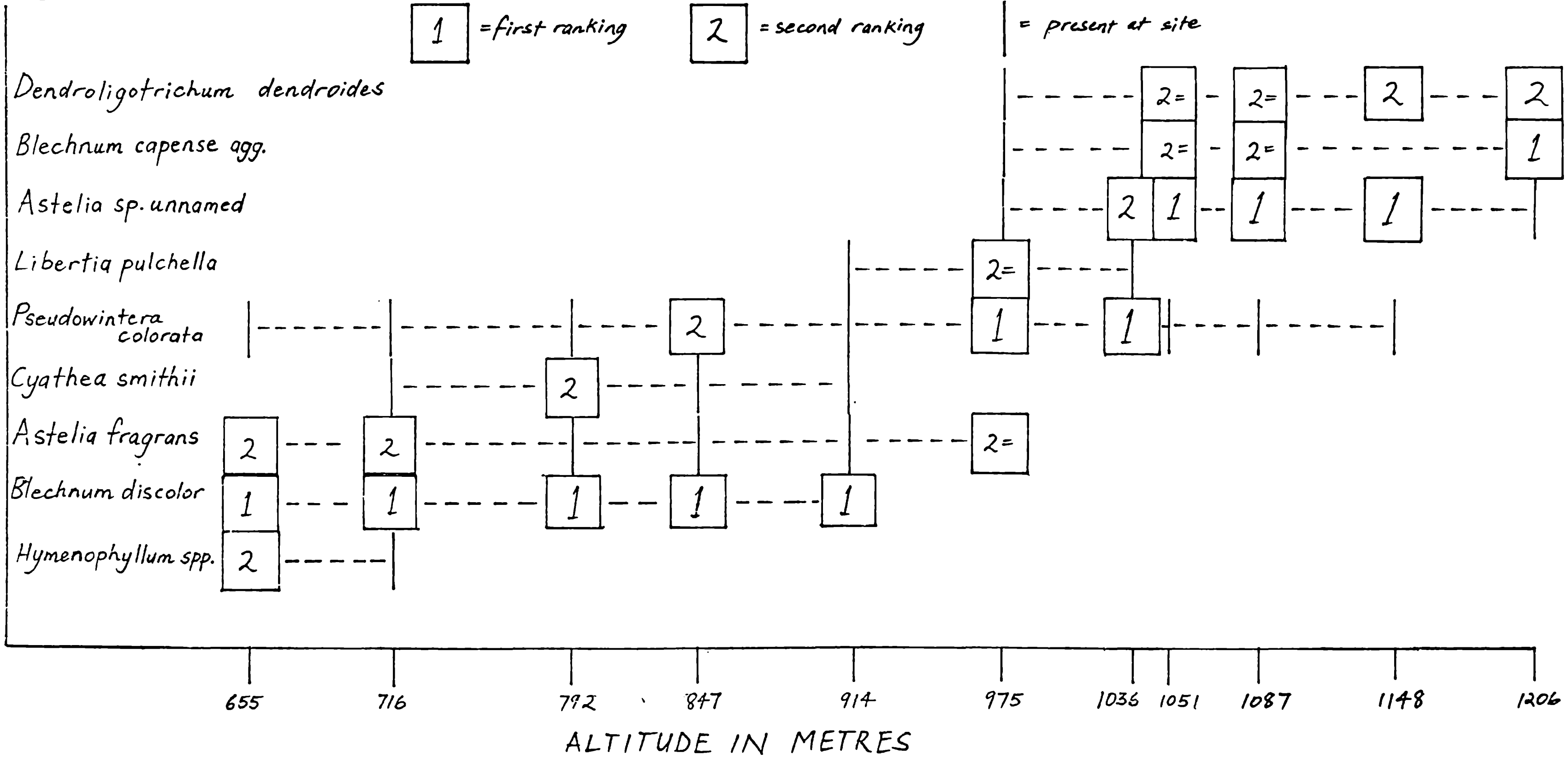


Figure 4.20

GROUND COVER SPECIES FIRST AND SECOND DOMINANTS



these, crown fern, *Astelia fragrans*, filmy ferns, principally *Hymenophyllum dilatatum* and *H.sanguinolentum*, and soft tree fern are most important beneath the kamahi canopy. Mountain pepperwood and *Libertia pulchella* are most important at the interface between kamahi dominated sites and leatherwood dominated sites. *Astelia* sp. unnamed, *Blechnum capense* agg. and *Dendroligotrichum dendroides* are most important beneath the leatherwood canopy.

Lianes and epiphytes dominant species (7 species)

Astelia solandri, hanging spleenwort, filmy ferns, kidney fern and *Grammitis billardieri*, were all ranked as dominant in one or more of the sites. *Astelia solandri*, kidney fern and hanging spleenwort are dominant below 1000m. Hanging spleenwort and filmy ferns (principally *Hymenophyllum multifidum* and *H.flabellatum*) become dominant above 1000m and *Grammitis billardieri* and *H.multifidum* are important in the leatherwood shrub sites.

Vegetation types

On the basis of the species distributions outlined above, and placing special emphasis on the importance of the top stratum in determining vegetation types, it is convenient to recognise four main floristic types along the altitudinal gradient. The first is a lower altitude forest type below 800m in which kamahi is top stratum dominant, rata subdominant, and miro is an important associate. Mahoe, kamahi and soft tree fern are prominent in the subcanopy. The second type is an upper altitude forest type (800m-1000m) in which the top stratum is dominated by kamahi with broadleaf and Hall's totara as important associates. Kamahi, Hall's totara and black maire are prominent in the subcanopy. The third type is a shrub type dominated by leatherwood and in which *Coprosma pseudocuneata* and broadleaf are important associates (1000m-1150m). The fourth type is a shrub-tussock type in which leatherwood dominates and *Coprosma pseudocuneata* and red tussock are important associates. This type occurs above 1150m.

Successional change on Henry Peak

Although the main aim of the sampling programme was to describe and explain the changes in vegetation composition along the altitudinal gradient, a number of features of successional change in the vegetation sampled were detected. Three main features are apparent. The first is the recent and dramatic 'die-back' of Hall's totara in and nearby sites 1 - 4. The second and less recent feature is the death of large numbers of emergents in and nearby sites 8 - 10. Finally, the third feature is the presence of dead logs and stumps of rata in and nearby sites 3 and 4.

Large numbers of Hall's totara (10.0-70.0cm d.b.h.) have died recently on the Henry Peak Track Ridge, many within the last few years (1976-1977). Mortality rates are highest between 700 and 850m a.s.l., where in some places (for example sites 3 and 4), most if not all of the top and second stratum individuals recorded were dead. The reverse situation is true above 850m a.s.l. where in both sites 5 and 6 almost all individuals recorded were alive and healthy. The cause of the 'die-back' of Hall's totara between 700-850m is not clear cut. Obviously a large proportion of individuals greater than 50.0cm d.b.h. would be old anyway. Possible causes, however include opossum and insect damage. Damage consistent with opossum browsing was noted on both small and large individuals. Crown apical shoots in particular had been eaten with regrowth leading to the production of two new shoots lower down the stem. Insect damage (tortricid caterpillar) was also noted on a number of individuals resulting in the death of some of the new seasons terminal shoots. The individuals concerned appeared to be coping with this minor damage in comparison to that attributable to opossum browsing.

Dead emergents above the canopy dominated by leatherwood are a widespread feature nearby sites 8-10 (up to 5 dead emergents per $500m^2$). Close examination of all the dead emergents in any nearby sites 8-10 revealed they comprised both kaikawaka and Hall's totara. At lower altitudes (1000-1050m a.s.l.) at least, Hall's totara comprises up to 50 percent of the remains. It is apparent that at some previous date (probably less than 50 years ago) much of the leatherwood canopy present between 1000-1050m was in fact a second stratum beneath scattered kaikawaka and Hall's totara. Kaikawaka and Hall's totara shrub-sized individuals are present in the understorey throughout much of the leatherwood dominated area below 1100m and a few small individuals of kaikawaka just reach to the canopy stratum. Further more detailed investigation would be necessary to determine the cause and timing of these deaths although disturbance such as partial clearance or burning seems a likely explanation.

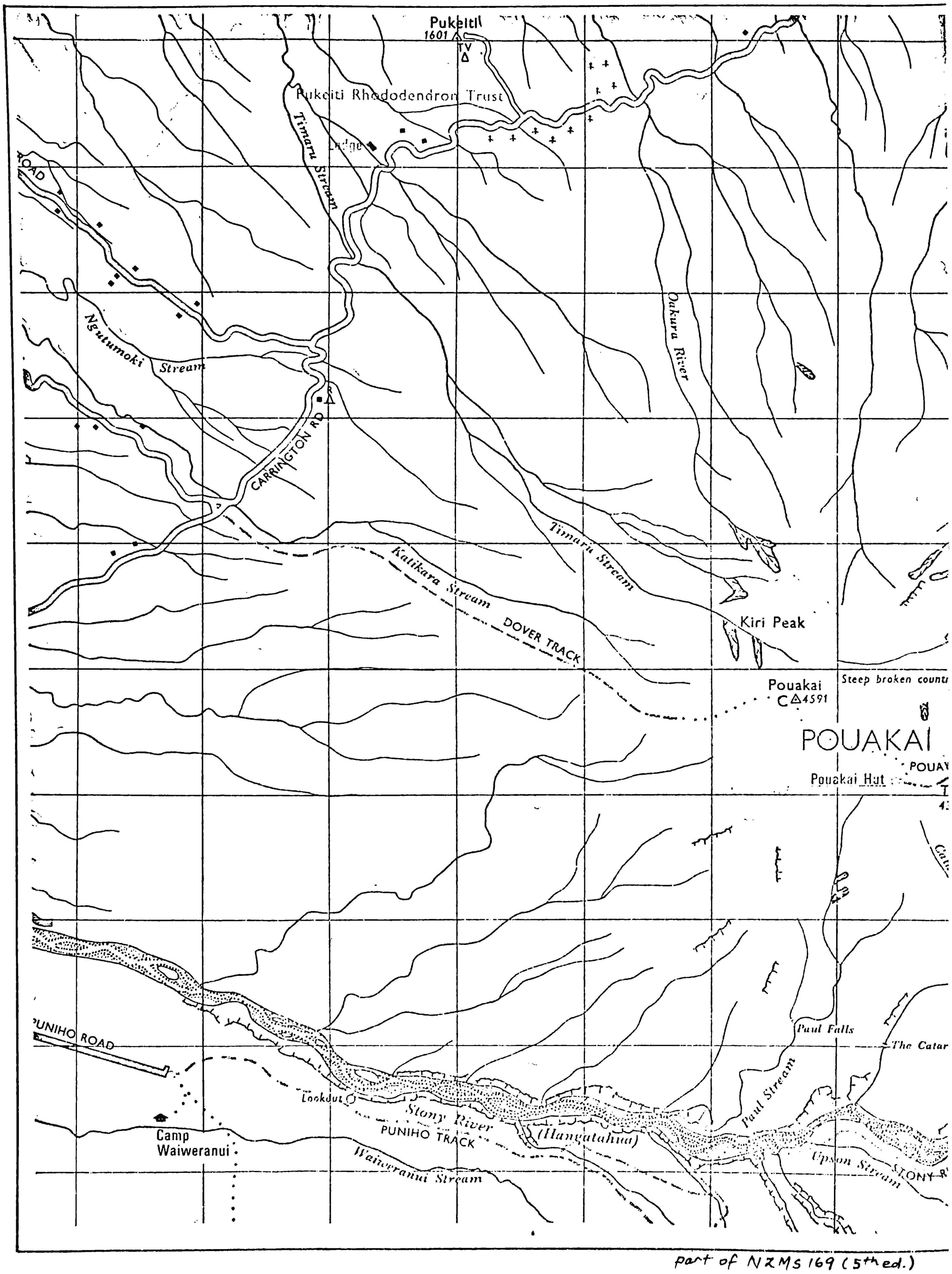
Live rata individuals were only observed below 800m a.s.l. on the Henry Peak Track Ridge, however there is much evidence that in the past rata was distributed up to 850m a.s.l. albeit sparsely. Remains of large rata were found in and nearby sites 3 and 4 and in the case of site 4 contributed much to the structure of the present day vegetation. Canopy kamahi and broadleaf, multi-leadered and sprawling, have grown up from the remains of a dead rata which must have been at least 1.5m d.b.h. when living. The same succession appears to have occurred in and nearby site 3 but is further advanced with few remains of the rata logs left. As well, dead epiphytic rata was recorded on a dead top stratum Hall's totara individual. The live rata individuals present below 800m all appeared healthy although some minor opossum browsing was evident.

2. FOREST AND SHRUB VEGETATION BELOW 1220m a.s.l.

Introduction

In order to examine more comprehensively the vegetation (floristic) types present in the Pouakai Range and to determine how representative the results obtained in sampling the altitudinal gradient on the Henry Peak Track were, semi-quantitative data from a further 40 sites was collected. The data collected on the Henry Peak Track Ridge was recoded into the semi-quantitative form and included in the total data set. Thus a total of 51 sites, mostly 400m^2 in the forest below 914m, and 200m^2

Figure 4.21 POUAKAI RANGE LOCATION MAP



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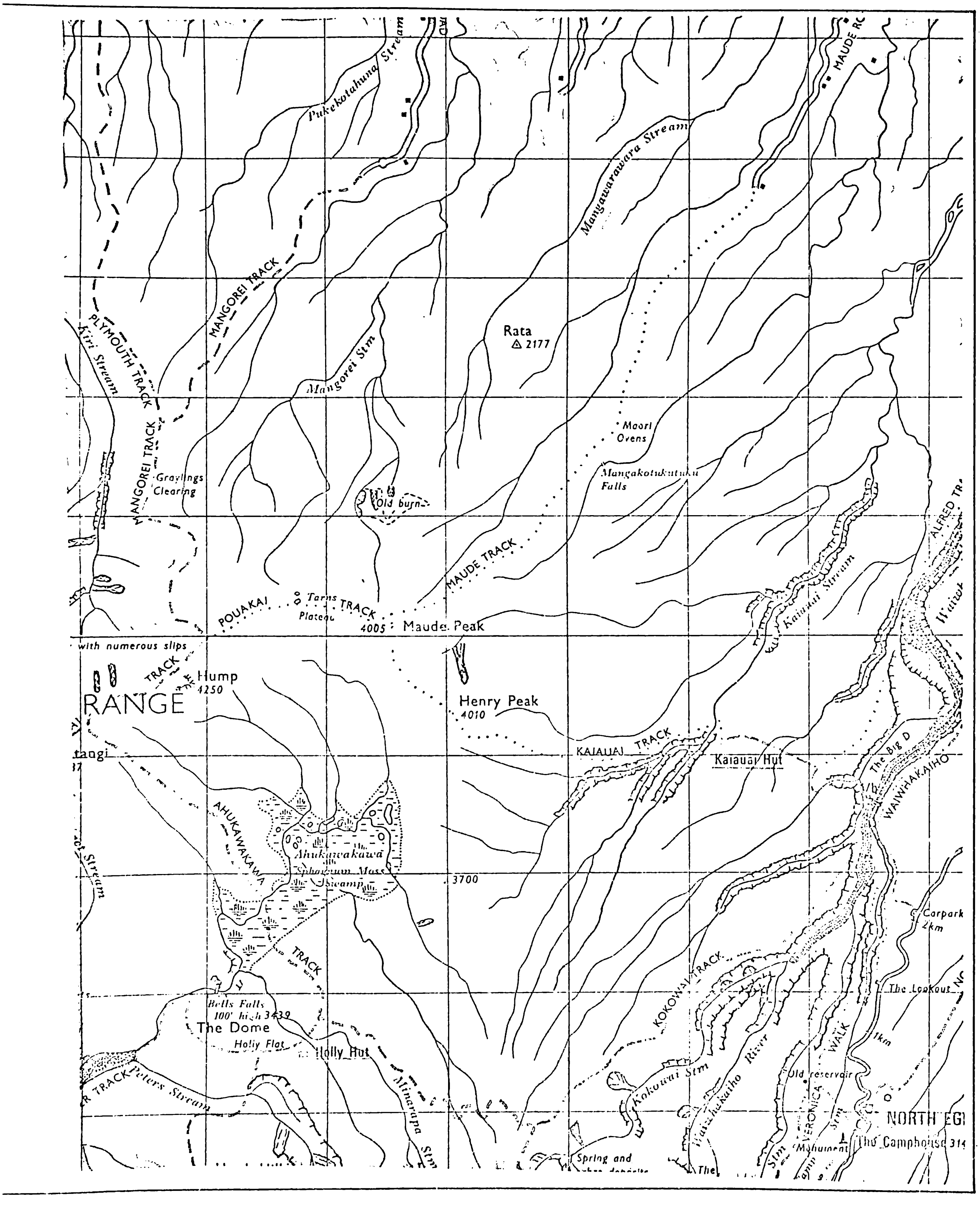

Pukekotahuna Stream
MAUDE RD
Mangawarawara Stream
MANGOREI TRACK
PLYMOUTH TRACK
Kiri Stream
Mangorei Stm
Rata
2177
Moori Ovens
Mangakotukutuku Falls
MANGOREI TRACK
Graylings Clearing
Old burn
MAUDE TRACK
ALFRED TR
Kaiauai Stream
POUAKAI
Tarns
TRACK
Plateau
4005
Maude Peak
with numerous slips
TRACK
The Hump
4250
RANGE
Henry Peak
4010
KAIAUAI TRACK
Kaiauai Hut
The Big D
WAIWHAKAIHO
tangi
AHUKAWAKAWA
Ahukawakawa Sphagnum Moss Swamp
3700
Stream
TRACK
Carpark
2km
KOKOWAI TRACK
The Lookout
Bells Falls
100' high 3439
The Dome
Holly Flat
Holly Hut
Peters Stream
Minarapa Stm
Kokowai Stm
Waiwhakaiho River
WALK
VERONICA
1km
Old reservoir
NORTH EG
Monument
The Camphouse 314
Spring and
The
Stm

above this altitude, were examined and employed to describe and explain the major floristic changes along the altitudinal gradient 540m-1220m and to provide the basis for defining the major forest and shrub types in the Pouakai Range. The locations cited in this description are shown on Figure 4.21 and site details are listed in Appendix 2. The data thus collected was analysed in two ways; direct gradient analysis and individual plot analysis as already described for the Kaitake Range.

Direct gradient analysis

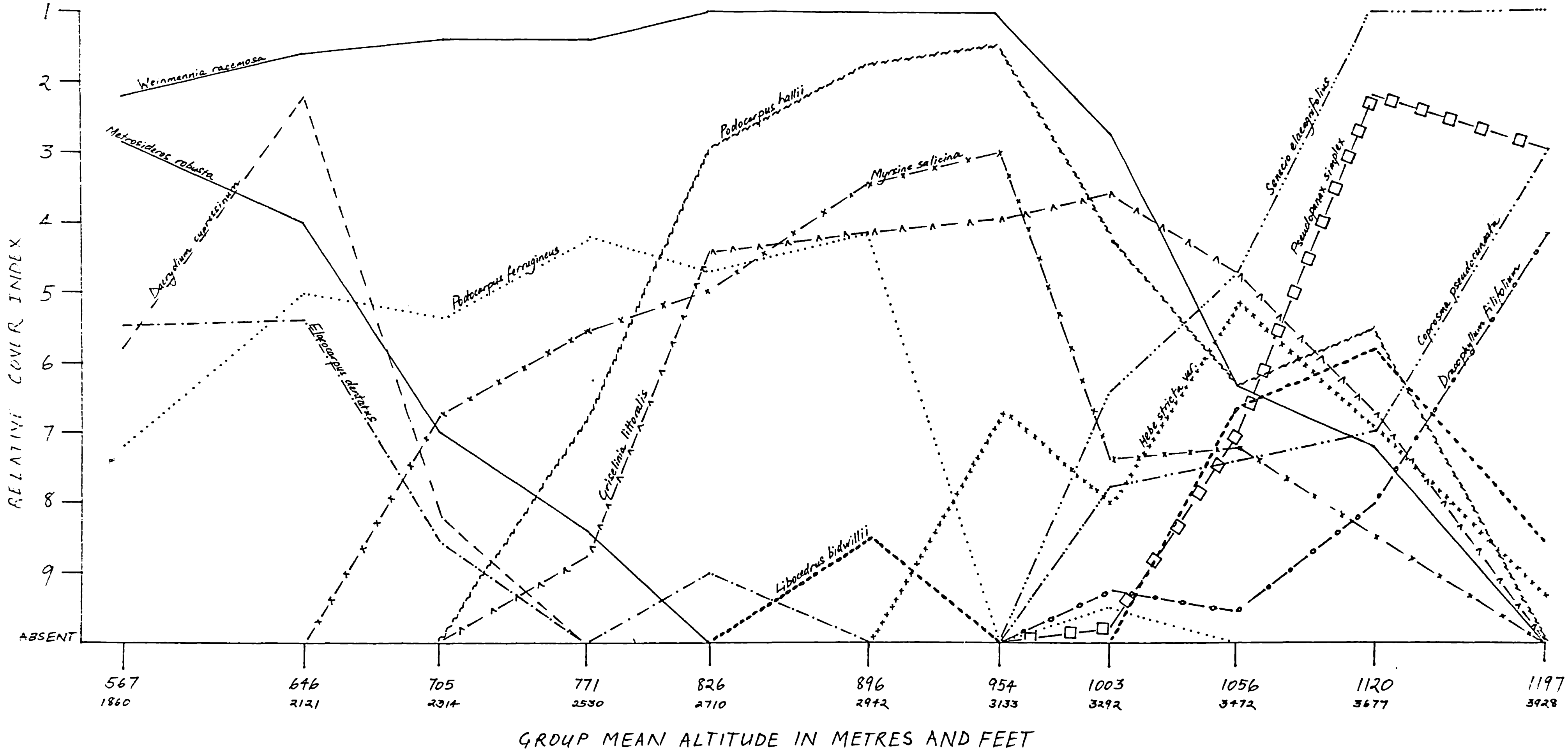
The results of this analysis are summarised on Figure 4.22, Relative Cover Indices of the major top stratum species, Figure 4.23, Relative Cover Indices of the major subcanopy species, and Table 4.5, Leading dominants from all strata.

Relative Cover Indices of the major top stratum species

Figure 4.22 depicts the changes in relative cover along the altitudinal gradient of the leading dominants on the Pouakai Range. In general each species reaches a peak value above or below which it declines in importance. Kamahi displays the widest altitudinal distribution being represented in 10 of the 11 elevation groups and is leading dominant in 8 elevation groups. There is some coincidence in the distributions of a number of species. Hinau, rata and rimu, for example, all increase in importance below 760m, while toro, broadleaf, and Hall's totara all increase in importance

Figure 4·22

RELATIVE COVER INDICES OF THE MAJOR TOP STRATUM SPECIES



above 760m. Leatherwood, inaka, *Pseudopanax simplex* and *Coprosma pseudocuneata* are all recorded for the first time in elevation group 8 ($\bar{x}$ = 1003m) and increase in importance above this altitude. Other species show little or no coincidence in their distributions. Miro for example is most important in between the distributions of rata, rimu and hinau and Hall's totara, toro and broadleaf. Koromiko, likewise, is most important where the kamahi and leatherwood distributions overlap. Kaikawaka distributes both as part of the upper altitude forest in which kamahi dominates and in the leatherwood dominated shrub communities.

Vegetation types

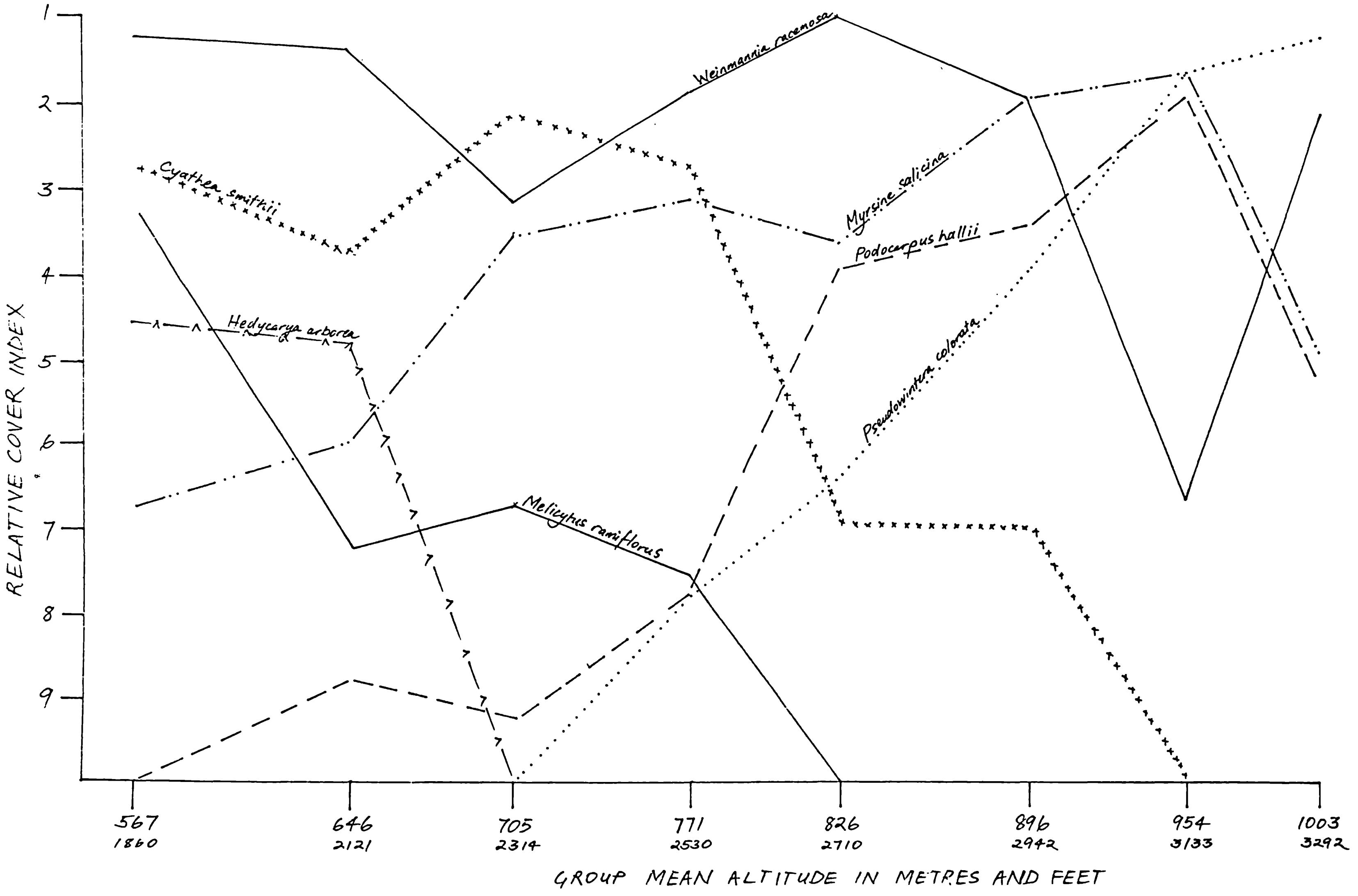
On the basis of the data presented on Figure 4.22 several major floristic vegetation types may be recognised. The major division is into forest dominated by kamahi and shrub communities dominated by leatherwood and this occurs at 1036m approximately. Important species associated with leatherwood are inaka, *Pseudopanax simplex* and *Coprosma pseudocuneata*. The forest in which kamahi is dominant may be further subdivided into forest below 760m, in which rata, rimu and hinau are important associates and forest above 760m, in which Hall's totara, toro and broadleaf are associates.

Relative Cover Indices of the major subcanopy species

Figure 4.23 depicts the changes in relative cover of the major subcanopy species with increasing elevation.

Figure 4·23

RELATIVE COVER INDICES OF THE MAJOR SUBCANOPY SPECIES



Subcanopy data is presented only for elevation groups up to and including elevation group 8 ($\bar{x}$ = 1003m) because beyond this elevation it was not possible to clearly define a second stratum. Instead a shrub or 'understorey' layer was recorded. In general each species reaches a peak value above or below which it declines in importance however kamahi and toro provide floristic continuity to the second stratum of vegetation being recorded in all of the elevation groups. Pigeonwood, mahoe and soft tree fern successively drop out with increasing elevation while from elevation group 2 ($\bar{x}$ = 646m) onwards, mountain pepperwood and Hall's totara become increasingly important components of the subcanopy strata. Comparison of Figures 4.22 and 4.23 reveals that the distributions of species recorded as major in both the top and second stratum are very similar. The increasing importance of toro in the top stratum above elevation group 2 ($\bar{x}$ = 646m) is paralleled in the subcanopy stratum. Similarly the distribution of Hall's totara in the top stratum is paralleled in the subcanopy stratum. In both instances however the species is recorded first as a subcanopy component at least one elevation group (61m) below the first record in the top stratum. The distribution of the major subcanopy species along the elevation gradient reinforces the pattern described for the top stratum providing further justification for subdividing the kamahi forest at 760m in that mahoe, pigeonwood and soft tree fern give way to Hall's totara and mountain pepperwood as subcanopy associates beyond this altitude. As well, the distributions of the major subcanopy species provide greater continuity to the vegetational change, particularly those of toro and kamahi.

Leading dominants from all strata

The leading dominants for all strata are presented on Table 4.5. This data provides a summary of the major floristic changes which occur in all strata along the altitudinal gradient. The vegetation types defined on the basis of the top stratum data are further reinforced by the tendency for coincidence between the distributions of dominant species from different strata. Thus in the kamahi forest below 760m soft tree fern is an important subcanopy component, pepperwood is the dominant shrub species and supplejack is an important liane. In the kamahi dominated forest above 760m, toro and Hall's totara are important associates in the top stratum, mountain pepperwood and filmy ferns are prominent in the ground cover and filmy ferns are a feature of the epiphytic component. Kamahi and crown fern in particular provide floristic continuity to these changes being represented as leading dominants in the top stratum/second stratum and ground cover respectively in all the kamahi forest. The major division between kamahi forest below 1036m and leatherwood shrubland above 1036m in the top stratum is also reinforced by the distribution of leading dominants in other strata particularly by the importance of *Astelia* sp. unnamed and *Dendroligotrichum dendroides* in the ground cover and *Grammitis billardieri* as an epiphyte. The coincidence of

Table 4.5 Leading dominants all strata

Group mean altitude	567m	646m	705m
Top stratum	kamahi rata hinau	kamahi rimu rata	kamahi miro rata
second stratum	kamahi soft tree fern mahoe	kamahi soft tree fern pigeonwood	soft tree fern kamahi toro
Shrub layer	lowland pepperwood soft tree fern pigeonwood	lowland pepperwood soft tree fern mountain pepperwood	lowland pepperwood soft tree fern mountain pepperwood
Ground cover	crown fern *Uncinia uncinata* *Hymenophyllum* spp.	crown fern *Hymenophyllum* spp. *Asplenium bulbiferum*	crown fern forest oat grass lowland pepperwood
Lianes and epiphytes (in all sites in group)	supplejack *Astelia solandri* *Griselinia lucida* - *Rumohra adiantiformis*	supplejack *Astelia solandri* *Dendrobium cunninghamii*- *Hymenophyllum* spp.	*Astelia solandri* supplejack *Collospermum* spp.

Table 4.5 contd.

771m	826m	896m	954m
kamahi miro toro	kamahi Hall's totara broadleaf	kamahi Hall's totara toro	kamahi Hall's totara toro
kamahi soft tree fern toro	kamahi toro Hall's totara	kamahi toro Hall's totara	toro-mountain pepperwood Hall's totara
soft tree fern mountain pepperwood lowland pepperwood	mountain pepperwood Hall's totara soft tree fern	mountain pepperwood Hall's totara toro	mountain pepperwood Hall's totara koromiko
crown fern mountain pepperwood *Hymenophyllum* spp.	crown fern *Hymenophyllum* spp. mountain pepperwood	mountain pepperwood crown fern *Hymenophyllum* spp.	mountain pepperwood crown fern *Hymenophyllum* spp.
Astelia solandri *Hymenophyllum* spp. kidney fern	*Hymenophyllum* spp. kidney fern *Asplenium flaccidum*	*Hymenophyllum* spp. *Asplenium flaccidum*-*Weymouthia mollis*	*Hymenophyllum* spp. *Asplenium flaccidum* *Weymouthia mollis*

Table 4.5 contd.

1003m	1056m	1120m
kamahi broadleaf Hall's totara	broadleaf leatherwood koromiko	leatherwood *Pseudopanax simplex* Hall's totara
mountain pepperwood kamahi toro		
mountain pepperwood Hall's totara *Astelia fragrans*	mountain pepperwood *Coprosma tenuifolia* Hall's totara	*Coprosma pseudocuneata* *Coprosma 'taylorae'* *Myrsine divaricata*
mountain pepperwood *Astelia* sp. unnamed *Hymenophyllum* spp.	*Astelia* sp. unnamed *Blechnum capense* agg. *Dendroligotrichum dendroides*	*Astelia* sp. unnamed *Dendroligotrichum dendroides* *Blechnum capense* agg.
Hymenophyllum spp. *Asplenium flaccidum* *Weymouthia mollis*	*Hymenophyllum* spp. *Libertia pulchella* *Grammitis billardieri-Asplenium flaccidum*	*Grammitis billardieri* *Luzuriaga parviflora* *Hymenophyllum* spp.

Table 4.5 contd.

1197m

leatherwood

Coprosma pseudocuneata

inaka - *Pseudopanax simplex*

Blechnum capense agg.

Astelia sp. unnamed

Dendroligotrichum dendroides

Grammitis billardieri

Hymenophyllum spp.

Luzuriaga parviflora

distributions of species in different strata is not exact however, with *Astelia* sp. unnamed, also an important component of the upper kamahi forest (elevation group 8) and filmy ferns remaining as an important epiphytic component in the leatherwood shrubland. In spite of the degree of continuity provided by some species close examination of the raw data and Figures 4.22, 4.23 and Table 4.5 show that for the Pouakai data two species transition zones are apparent. The first of lesser importance occurs in elevation group 4 ($\bar{x}$ = 771m); that is moving from elevation group 3 ($\bar{x}$ = 705m) up to elevation group 5 ($\bar{x}$ = 826m) a major changeover in species dominance occurs in some strata. This results in the replacement of a 'lower altitude' kamahi forest type by an 'upper altitude' kamahi forest type. In this transition zone the major changeover in second stratum dominance is centred on the replacement of soft tree fern as the leading dominant by toro. In the shrub layer it is the replacement of pepperwood by mountain pepperwood which is significant. The pattern is not as clear cut for the ground cover however crown fern is eventually displaced by mountain pepperwood as the leading dominant. In the liane-epiphyte category it is the increasing importance of filmy ferns and hanging spleenwort which is significant. The second transition zone is one of greater importance because it involves the replacement of the 'upper altitude' kamahi forest by a leatherwood shrubland. This zone occurs in elevation group 9 ($\bar{x}$ = 1056m). Moving from elevation group 8 ($\bar{x}$ = 1003m) up to elevation group 10 ($\bar{x}$ = 1120m) a major changeover in species dominance occurs in most strata and in addition there are major structural changes in the vegetation which are referred to elsewhere (see section on physiognomy and structure). In the top stratum leatherwood replaces kamahi. In the shrub layer mountain pepperwood is replaced by *Coprosma pseudocuneata* and in the ground cover *Astelia* sp. unnamed, *Blechnum capense* agg. and *Dendroligotrichum dendroides* supersede mountain pepperwood and its associates. In the liane-epiphyte category it is the increasing importance of *Grammitis billardieri* and the declining importance of filmy ferns which is significant.

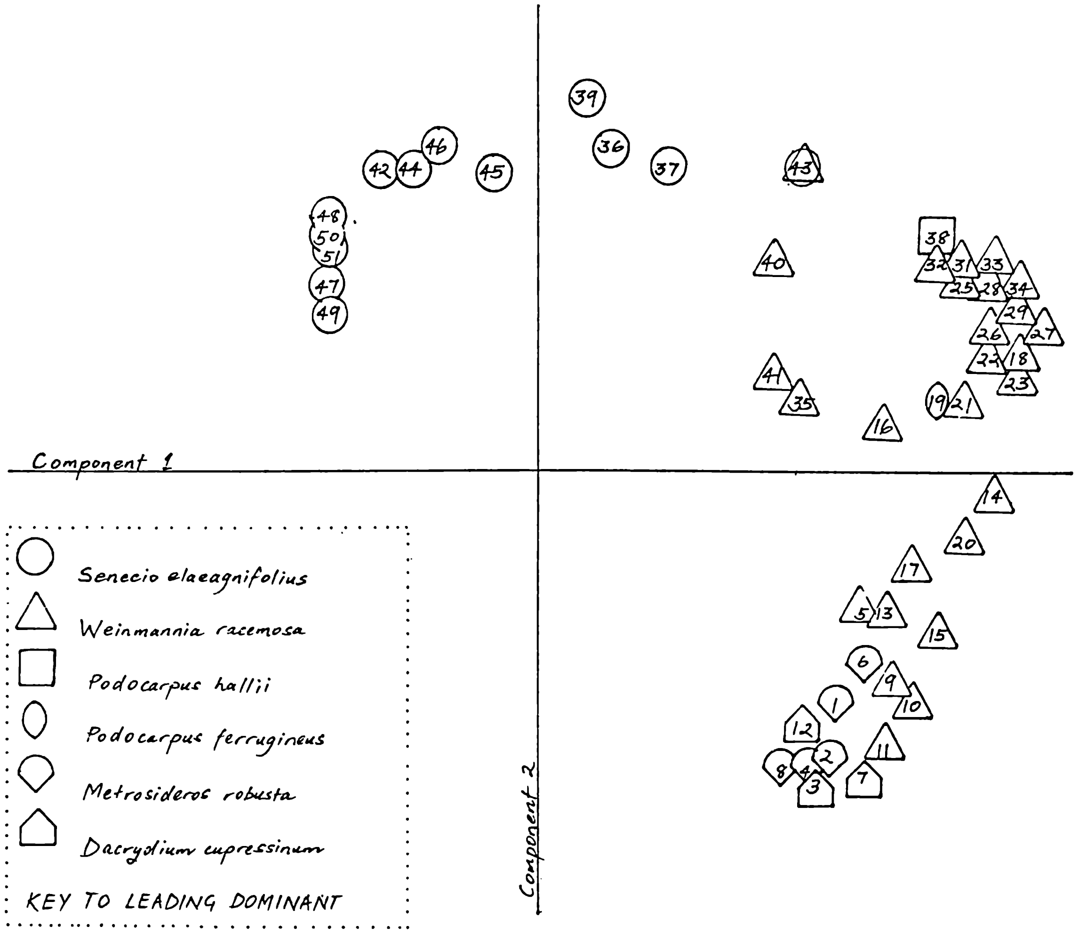
Individual plot data analysis

The Pouakai data was analysed in the same way described already for the Kaitake data. Results of these analyses are depicted on Figures 4.24-4.27. All of the figures except Figure 4.27 are ordination diagrams resulting from Principal Component Analysis (PA1 Factor Analysis SPSS v7). Figure 4.27 is a cluster analysis (BMD:P1M).

Plot ordination using top stratum species relative cover

Figure 4.24 is an ordination diagram based on the first two components of a P.C.A. of the 51 sites using top stratum species relative cover. The first two components account for 58.9% of the variance. A symbol representing the leading dominant at each site has been overlayed on the plot ordination to indicate specific

Figure 4.24 PLOT ORDINATION USING TOP STRATUM SPECIES RELATIVE COVER



trends in the ordination. Reference back to the environmental data associated with each plot enables indirect determination of the major environmental gradients reflected by the species.

Altitude is obviously the major environmental gradient reflected by the species as each of the plots (1-51) is numbered in sequence from the lowest to the highest altitude and for the most part this sequence is repeated by the ordination.

Sites which most noticeably do not conform to this altitudinal sequence include sites 35, 40, 41 and 43. Sites 35 and 41 (1005m, 1097m) are from the Ahukawakawa Track location, site 40 (1054m) is from the Mangorei Track location, and site 43 (1106m) is from the Dover Track location. All of these sites are near the major changeover point from kamahi forest to leatherwood shrubland and all have aspects ranging from 230° through to 20°. The anomaly is basically an aspect difference in that sites with more northerly aspects at these altitudes tend to support a low forest in which kamahi is prominent or even shares dominance with leatherwood while on sites with southerly aspects leatherwood shrubland is dominant.

This point is best illustrated by focusing on the differences in composition apparent between sites 35 and 36 both from the Ahukawakawa Track location and both at an altitude of 1005m. Site 35 has an aspect of 20° and site 36 an aspect of 200°, that is, they are from opposite sides of the same ridge. Site 35 is dominated by kamahi (75% cover) and site 36 by leatherwood (>50% cover). The major associates of kamahi at site 35 are Hall's totara and broadleaf while the major associates of leatherwood at site 36 are broadleaf and *Coprosma 'taylorae'*. These major floristic differences are further accentuated by the fact that the vegetation at site 35 is low forest (~7.5m) with a closed canopy while that at site 36 is tall shrubland (~4.5m) with a discontinuous canopy.

An important feature of site 35 not revealed by the analysis of this data (because only live plants are included) is the presence of dead 'spars' of kaikawaka in the kamahi canopy. These dead kaikawaka trees probably date back to the destruction of vegetation in this area by the Newall eruptions (1550 A.D.). Some of the now dominant kamahi and broadleaf individuals in this site established epiphytically on the stumps of trees killed by the Newall eruptions.

Differences in floristic composition which relate closely to aspect are particularly well developed on the Ahukawakawa Track Ridge and relate to the alignment of ridges in relation to the prevailing winds from the west coast. Sites with northerly aspects are sheltered from winds while those with southerly aspects are exposed. The winds, which are often of gale force and salt-laden, are probably the major factor although, in addition, northerly aspects receive more sunshine than southerly ones and would thus enjoy warmer temperatures overall.

Although the remainder of the sites in the ordination follow generally an altitudinally related sequence this pattern is by no means perfect particularly for sites 1-20. Much of the variation here relates to the presence or absence of rata and rimu as emergents in the top stratum. The Mangorei Track location in particular exhibits a great deal of disturbance associated with early European activity in the area (see section entitled Human activity in Egmont National Park) and sites 5, 13 and 14 in which thickets of kamahi often established on old rata logs, dominate the top stratum and large rimu and rata are absent presumably result from this disturbance.

In summary however the ordination shows that the major environmental gradient is altitudinal although other factors, principally aspect and disturbance, do affect the pattern. The floristic sequence is from lower altitude forest in which kamahi is usually the second or third dominant through to upper altitude forest in which kamahi is almost invariably the leading dominant and finally to shrubland in which leatherwood is leading dominant. Site 17 on the Maude Track (740m) marks the highest altitude site in which either rata or rimu was recorded in the top stratum and could thus be used arbitrarily to denote the boundary of upper and lower altitude kamahi forest on the ordination diagram. The forest then grades into upper altitude kamahi forest in which miro is prominent, e.g. sites 17, 20, 14, 19, 21, 23, 24 and 27 and on to upper altitude kamahi forest in which Hall's totara is prominent, e.g. sites 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 38, 40 and 41. Kamahi forest then grades into leatherwood shrubland, e.g. sites 40 and 43 in which kamahi and leatherwood are the leading dominants. In the sites dominated by leatherwood the higher altitude sites, e.g. 47, 48, 49, 50 and 51 are characterised by the importance of *Coprosma pseudocuneata* and/or inaka as associates while the lower altitude sites dominated by leatherwood, e.g. 36, 37, 39, 45 and 46 are characterised more by the importance of koromiko, *Pseudopanax simplex* or the continued presence of broadleaf and/or Hall's totara and/or kamahi. Approximate altitudinal ranges for these vegetation types are for lower altitude forest up to 760m, for upper altitude kamahi forest from 700m, up to 1100m, and for leatherwood shrubland above 1000m.

Plot ordination using top stratum species presence/absence

Figure 4.25 is an ordination diagram based on the first two components of a P.C.A. of the 51 sites using top stratum species presence/absence. The first two components account for 55.9% of the variance only 3 percent less than for the semi-quantitative data. Comparison of Figures 4.24 and 4.25 shows that each of the sites exhibits a similar location on the ordination relative to each other. Again the overriding environmental gradient reflected is the altitudinal one. The ordination has been overlayed with a simple divisive classification based on the successive division of plot groups by presence/absence of the most frequent species. The simple divisive classification is depicted separately on Figure 4.25A. The primary division of the 51 plots is into 42 plots containing kamahi and 9 plots in which it is absent. The second division of the 42

Figure 4·25 PLOT ORDINATION USING TOP STRATUM SPECIES PRESENCE/ABSENCE

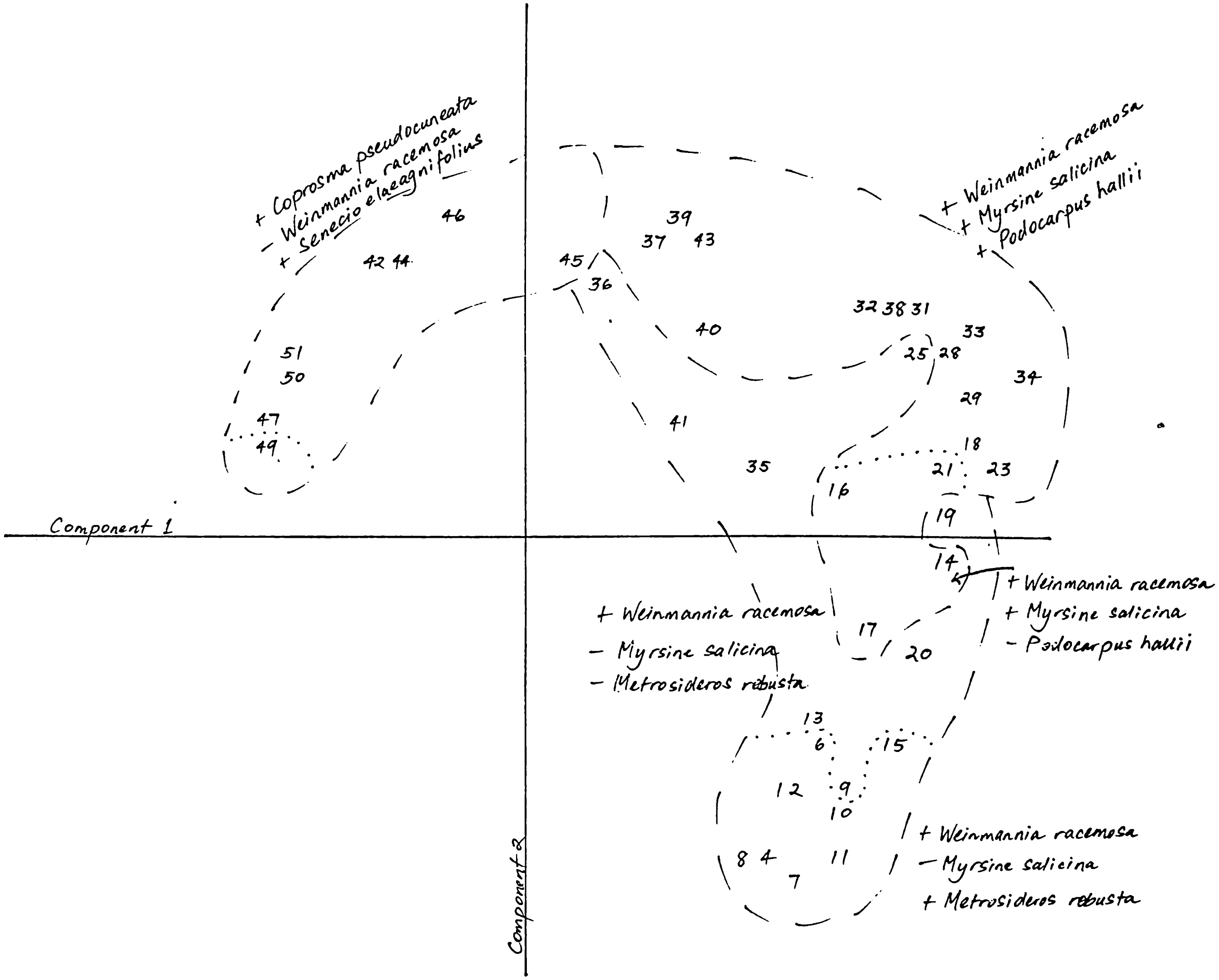
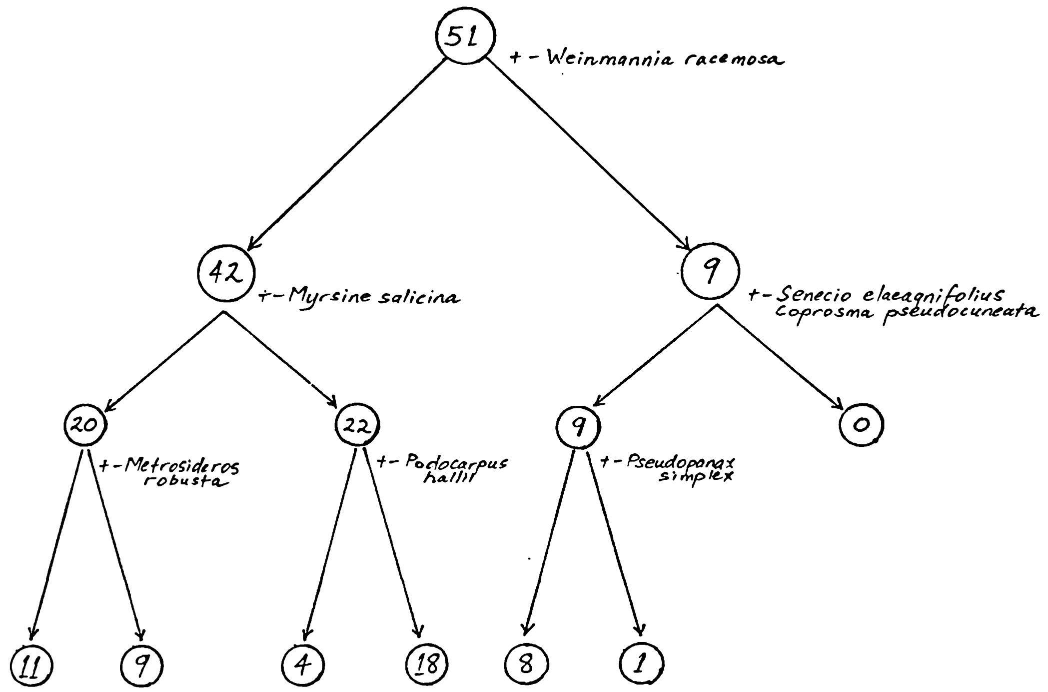


Figure 4·25A PLOT CLASSIFICATION



11	9	4	18		8	1
1	5	14	18	33	42	49
2	9	16	22	34	44	
3	13	17	23	37	45	
4	19	21	24	38	46	
6	20		26	39	47	
7	25		27	40	48	
8	35		28	43	50	
10	36		29		51	
11	41		30			
12			31			
15			32			

PLOT NUMBER

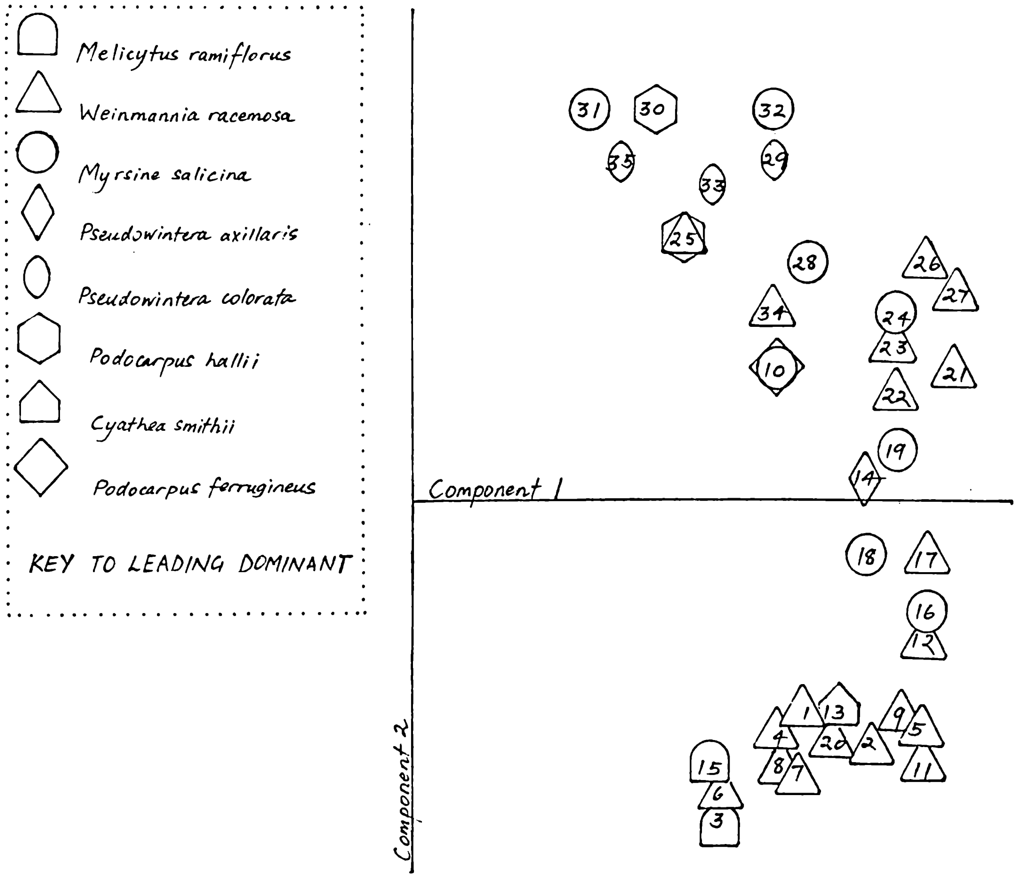
plots containing kamahi is made on the basis of the presence/absence of toro and there are 20 plots in which toro is present and 22 in which it is absent. The 9 plots without kamahi have not been further subdivided because both leatherwood and *Coprosma pseudocuneata* are found in all of them. This ordination highlights a major difference in composition apparent in the plots from the Ahukawakawa location (35, 41, 36) that is the absence of toro in the top stratum.

Plot ordination using subcanopy species relative cover

Figure 4.26 is an ordination diagram based on the first two components of a P.C.A. of the 35 sites in which it was practicable to distinguish a subcanopy stratum. The first two components account for 63.1% of the variance. The ordination has been overlayed with a symbol representing the leading subcanopy dominant at each site to indicate specific trends in the ordination and again reference back to the environmental data associated with each plot enables indirect determination of the major environmental gradients reflected by the subcanopy vegetation.

Once again the major environmental gradient reflected is the altitudinal one although not as strongly as is the case for the top stratum data. Kamahi is a major subcanopy component throughout and toro and mountain pepperwood are more important in sites above 730m. A number of plots noticeably do not conform to the overall altitudinally based trend, in particular plots 10, 15 and 20 all of which are from the Henry Peak

Figure 4·26 PLOT ORDINATION USING SUBCANOPY SPECIES RELATIVE COVER



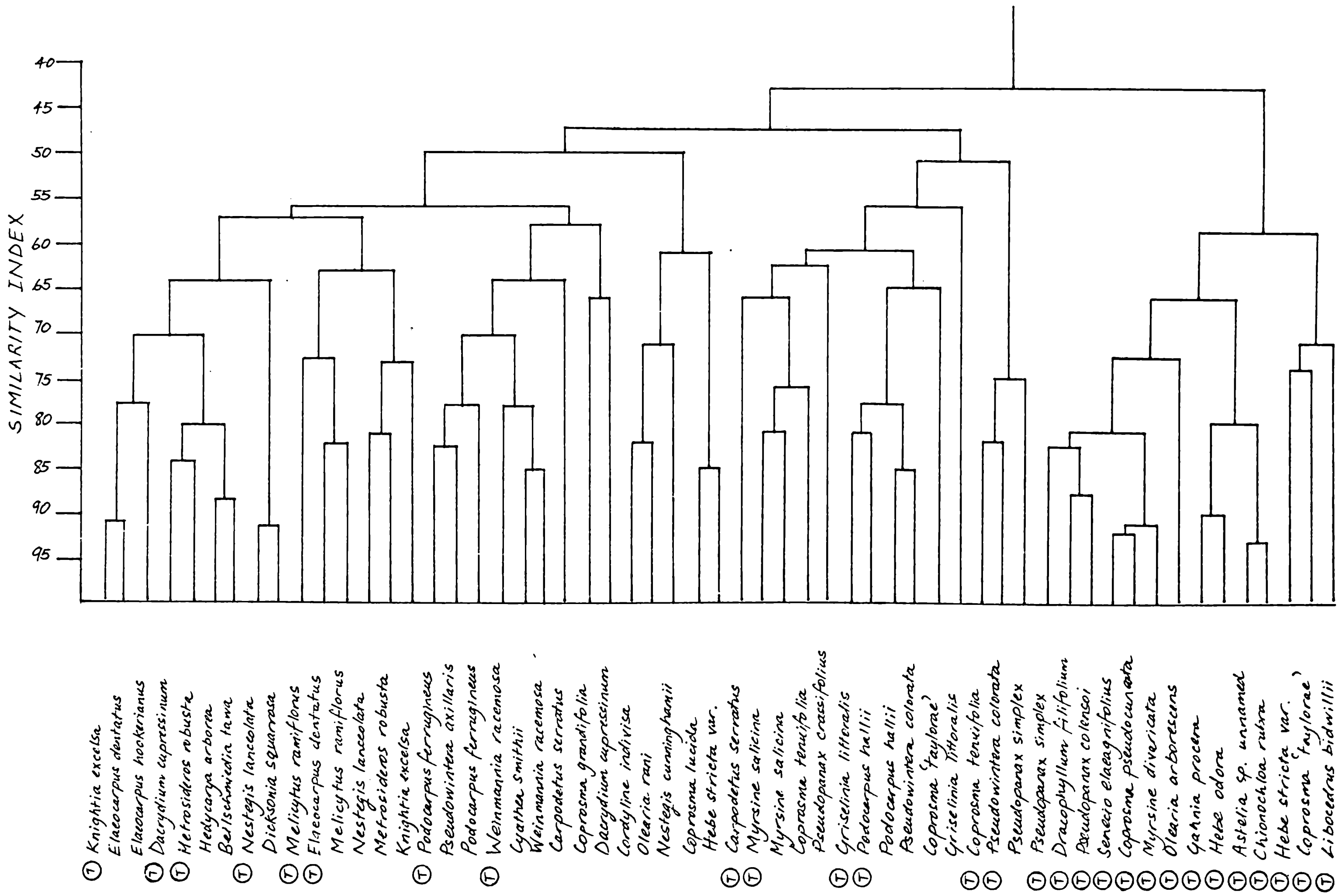
location. Plots 15 and 20 appear on the ordination to be more closely allied to lower altitude sites principally because they contain large components of mahoe which is more important at lower altitudes in other locations. Plot 10 is more closely allied to higher altitude plots principally because of its large component of toro which appears to have grown up and dominated the subcanopy stratum after the fall of a large top stratum rata-kamahi complex.

Species cluster analysis (top stratum and subcanopy combined) relative cover

Figure 4.27 is a dendrogram obtained from an average linkage cluster analysis (BMD:P1M) performed on 57 top stratum and subcanopy species recorded in the 51 sites. This cluster analysis further emphasizes the importance of the altitudinal gradient reflected in the site ordinations in that the species clusters obtained relate very closely to the altitudinal distributions of the species involved. At the 50% level of similarity 3 species clusters are apparent.

The first, includes the species from top stratum rewarewa through to subcanopy koromiko and includes all the forest species which distribute below approximately 910m. At similarity levels greater than 50% this cluster separates into 3 sub-groups of species, the first containing lower altitude species (<760m) including top stratum rewarewa, rimu and rata and the second containing middle altitude species (>760m) including top stratum kamahi and miro. The third sub-group includes species of

Figure 4.27 SPECIES CLUSTER ANALYSIS (Top stratum and subcanopy combined)



very limited importance in terms of cover contribution.

The second species cluster includes the species from top stratum marble leaf through to top stratum mountain pepperwood and is thus composed of species which are most prominent above 910m including top stratum Hall's totara and broadleaf.

The third species cluster includes all the species from top stratum *Pseudopanax simplex* through to top stratum kaikawaka. This cluster is composed of mostly shrub species prominent above 1060m and includes top stratum leatherwood, kaikawaka and *Coprosma pseudocuneata.*

The cluster analysis effectively summarises top stratum and second stratum species relationships grouping together associated species. For example in cluster one subcanopy pigeonwood and tawa are grouped with top stratum rimu and rata and subcanopy soft tree fern and kamahi are grouped alongside top stratum kamahi. Species which occupy both strata in the vegetation exhibit some interesting relationships in this cluster analysis. Some species, for example kamahi, Hall's totara, and toro show close similarity in their top stratum and second stratum distributions while others for example rimu, rewarewa, marble leaf, koromiko, *Coprosma tenuifolia, Coprosma 'taylorae'*, and *Pseudopanax simplex* do not. The same reasons already advanced for the Kaitake data are again tenable. Thus koromiko, *Coprosma tenuifolia, Coprosma 'taylorae'*, marble leaf, and *Pseudopanax simplex* all appear first along the altitudinal gradient as second stratum species eventually becoming components of the top stratum as other species can no longer compete and the top stratum becomes much lower. Rimu and rewarewa on the other hand are last represented along the altitudinal gradient by small second tier shrub and ground cover stratum individuals.

Vegetation types

The data analysis presented above using individual plot data also makes it possible, albeit arbitrarily (in view of the continuous nature of floristic change in the vegetation along the altitudinal gradient shown by various plot ordinations), to delimit several major floristic types by grouping together plots with similar species composition. As a result of the various analyses performed it was considered that two major groups of plots could be recognised, the first in which kamahi is a leading dominant in the top stratum (generally below 1060m) and the second in which leatherwood is a leading dominant (generally above 1060m). In the case of the plots below 1060m, if criteria were to be selected for further subdividing the type, the simplest and most effective method would be on the basis of the leading top stratum dominants. The floristic subtypes which can thus be defined are rimu forest, rata forest, miro forest, Hall's totara forest and kamahi forest.

Three plots of rimu forest were recorded, 3, 7 and 12, all from the Maude Track over a range of aspects but all with slope angles 100. The plot altitudes ranged from 567m up to 682m.

Four plots of rata forest were recorded, plots 1, 2, 4 and 8 (548-635m) from Maude Track and from a range of aspects and on slopes less than 15°.

Kamahi forest was recorded in 29 plots (579-1106m) in all of the sampling locations over the complete range of aspects and on slopes ranging from 5° up to 40°. Kamahi forest was recorded at its lowest altitudes where there had been vegetation disturbance for example plot 5 (592m) on the Mangorei Track and at its highest altitudes on northerly aspects for example plot 43 (1106m) on the Dover Track and plots 41 (1054m) and 40 (1054m) on the Ahukawakawa and Mangorei locations respectively. In the majority of cases slope angles were greater than 15°.

Miro forest was recorded once only in plot 19 (774m) on the Dover Track and is closely allied to kamahi forest.

Hall's totara forest also was recorded in one location only plot 38 on the Dover Track (1042m) and again is closely allied to kamahi forest.

Thirteen plots in which leatherwood was leading or co-dominant were recorded (1005m-1219m). The lowest altitudes at which leatherwood shrubland was recorded was plot 36 (1005m) Ahukawakawa with a southerly aspect. All plots were on slopes exceeding 15°.

In summary the individual plot data points to the fact that a convenient way of classifying the vegetation 1220m on the Pouakais is first by the delineation of two major types; forest below 1040m in which kamahi is a leading dominant and leatherwood dominated shrubland above 1040m. The forest below 1040m can be further subdivided on the basis of the leading dominants other than kamahi into forest below 760m and forest above 760m. Rimu and/ or rata are prominent below 760m. Above 760m miro and toro are prominent at first but at higher levels Hall's totara and broadleaf become the leading dominants.

3. SHRUB AND TUSSOCK VEGETATION ABOVE 1220m a.s.l.

Introduction

While the major sampling programme on the Pouakai Range concentrated on the vegetation below 1220m a.s.l. that is the forest and shrub vegetation, an additional sample of 31 25m^2 plots was collected above 1220m a.s.l. in order to determine the major components of the shrub and tussock vegetation and to provide guidelines as to the important environmental factors reflected by the vegetation. The fact that the data was collected in early winter meant that many species such as *Bulbinella hookerii* and mountain buttercup had begun to die back and consequently were less important than during the spring and summer months. The data thus collected was analysed in a number of ways including species and site ordinations. The analysis revealed that the sample of 31 plots was too small to show conclusively how the vegetation reflected major environmental factors such as aspect, slope and drainage because of the complexity of interactions. Some basic information on the composition of the vegetation was provided however, as were useful guidelines for a further more extensive survey proposed for 1981-82.

Vegetation composition

The vegetation was recorded in two categories:

1) top stratum species (>15cm in height) forming the

top layer of vegetation and 2) ground cover species (<15cm in height) making up the ground cover beneath the top stratum. Table 4.6 shows the relative frequencies of each of the species recorded in the top stratum on the basis of their presence in the 31 sites. Of the 31 sites examined red tussock was the top stratum leading dominant in 24 of the sites, leatherwood in 5 sites while *Schoenus pauciflorus* and *Podocarpus nivalis* were leading dominants in one site each. A list of species encountered in the ground cover in the 31 sites included in Appendix 3. The vegetation thus grades from sites in which tussock comprises 95% of the top stratum cover through to sites in which shrubs comprise 95% cover. This feature of the vegetation is further amplified with reference to Figure 4.28 a species cluster analysis (BMD:P1M) of 26 of the species recorded in the top stratum. Two distinct clusters are apparent at the 45% level of similarity. Cluster one includes red tussock, mountain koromiko, *Schoenus pauciflorus*, mountain buttercup, *Coprosma depressa*, *Hierochloe novae-zelandiae*, *Bullinella hookerii*, *Microlaena colensoi*, *Gaultheria* sp. unnamed, *Gaultheria* sp. unnamed x *Pernettya macrostigma*, *Hebe tetragona* var., *Cassinia vauvilliersii*, *Coprosma 'paludosa'*, silver tussock and *Uncinia egmontiana*. Cluster two includes leatherwood, inaka, *Pseudopanax colensoi*, *Coprosma pseudocuneata*, *Astelia* sp. unnamed, *Myrsine divaricata*, *Gahnia procera*, *Pseudopanax simplex*, *Blechnum capense* agg., *Podocarpus nivalis* and kaikawaka. The two species clusters recognised at the 45% level of similarity thus emphasize the fact that the sites sampled may be

Figure 4.28 SPECIES CLUSTER ANALYSIS USING TOP STRATUM SPECIES RELATIVE COVER

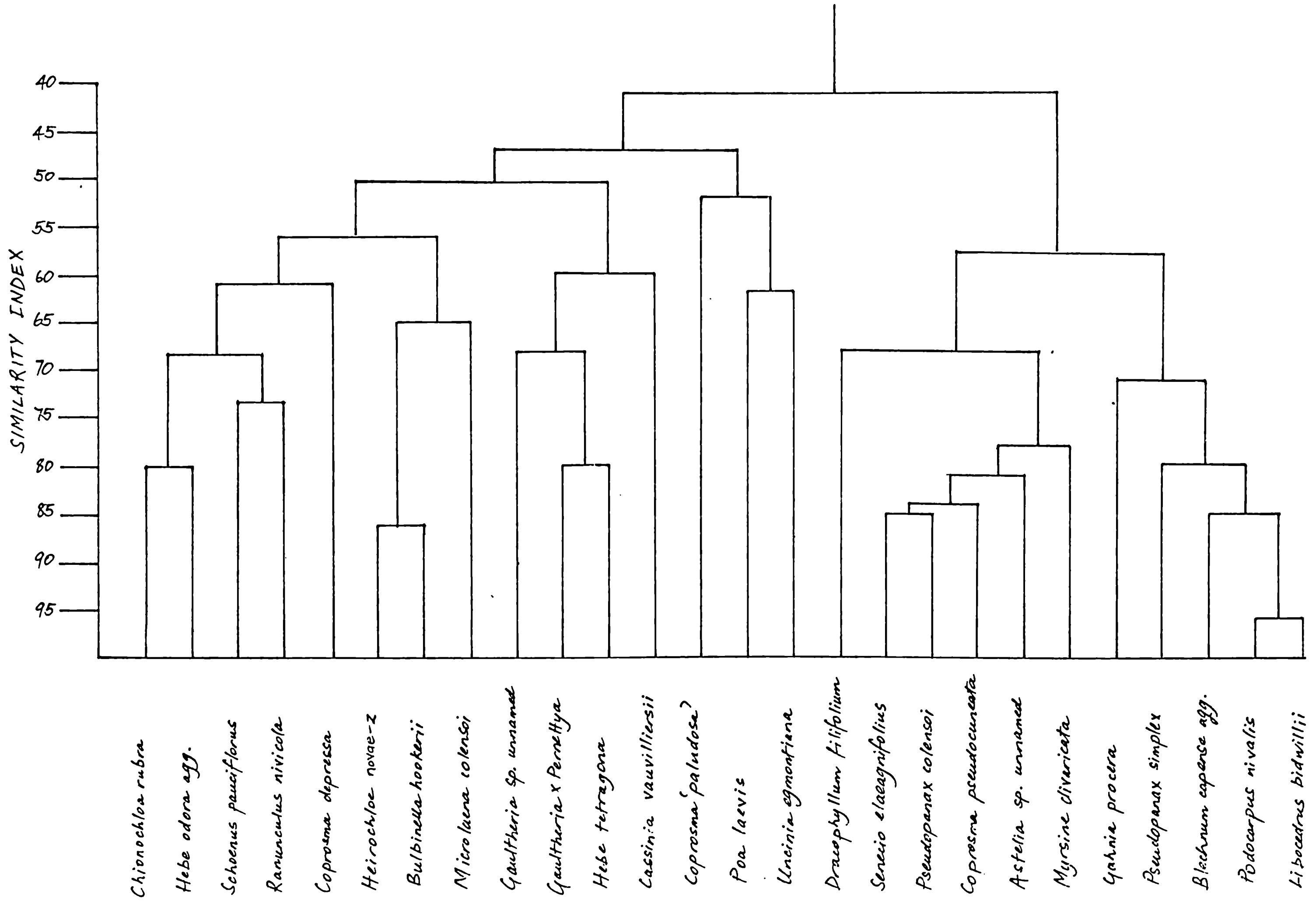


Table 4.6 Relative frequencies of top stratum species

Chionochloa rubra	96.8
Hebe odora agg.	90.3
Schoenus pauciflorus	77.4
Dracophyllum filifolium	64.5
Ranunculus nivicola	48.4
Cassinia vauvilliersii	48.4
Senecio elaeagnifolius	41.9
Coprosma 'paludosa'	35.5
Poa laevis	32.2
Hierochloe novae-zelandiae	29.0
Astelia sp. unnamed	29.0
Myrsine divaricata	25.8
Coprosma pseudocuneata	25.8
Bulbinella hookerii	25.8
Pseudopanax colensoi	25.8
Coprosma depressa	25.8
Gaultheria sp. unnamed	16.1
Uncinia egmontiana	9.7
Gahnia procera	9.7
Pseudopanax simplex	9.7
Gaultheria sp. unnamed× *Pernettya macrostigma*	6.4
Hebe tetragona var.	6.4
Microlaena colensoi	6.4
Blechnum capense agg.	6.4
Podocarpus nivalis	6.4
Libocedrus bidwillii	6.4
Ourisia macrophylla var. *macrophylla*	3.2
Blechnum penna-marina	3.2
Olearia arborescens	3.2
Hebe stricta var. *egmontiana*	3.2
Pseudowintera colorata	3.2

categorised into two relatively distinct groups depending on the relative importance of the red tussock component in relation to the shrub component particularly leatherwood and inaka. This pattern is paralleled in the ground cover layer because herbfield is well developed in the spaces between tussocks when they are well spaced but decline in cover as the tussocks become more clumped or alternatively as the top stratum shrub cover increases. Plants such as *Blechnum capense* agg., *Gahnia procera* and *Astelia* sp. unnamed are prominent at the expense of herbfield species where there are gaps in the top stratum shrub cover. These major differences in vegetation composition above 1220m a.s.l. relate to a complex interaction of environmental factors which is inconclusively determined because of the small sample size. As a general rule however the vegetation composition in each of the sites relates to one or other of a number of closely inter-related factors including slope and drainage, aspect (including exposure to wind and relative insolation) and substrate. Sites dominated by red tussock tend to be the flatter sites in which drainage is poor. The poorer the drainage the greater the component of *Schoenus pauciflorus* as an associate and its eventual dominance over red tussock. On the wettest sites large hummocks of *Oreobolus pectinatus* interspersed with *Celmisia glandulosa* var. *latifolia* are a feature. Sphagnum moss is also present in some of these sites. The shrub component increases as drainage becomes better on steeper slopes, particularly those of northerly aspects or less exposed to the wind. The steepest and most exposed sites are dominated by representatives of the herbfield including *Celmisia gracilenta* var., *Forstera bidwillii* var. *densifolia*, *Racomitrium* spp., *Poa colensoi* and *Anisotome aromatica*. *Podocarpus nivalis* was recorded once only as leading dominant on a steep rocky outcrop.

4. THE AHUKAWAKAWA SWAMP MARGIN - a moisture gradient

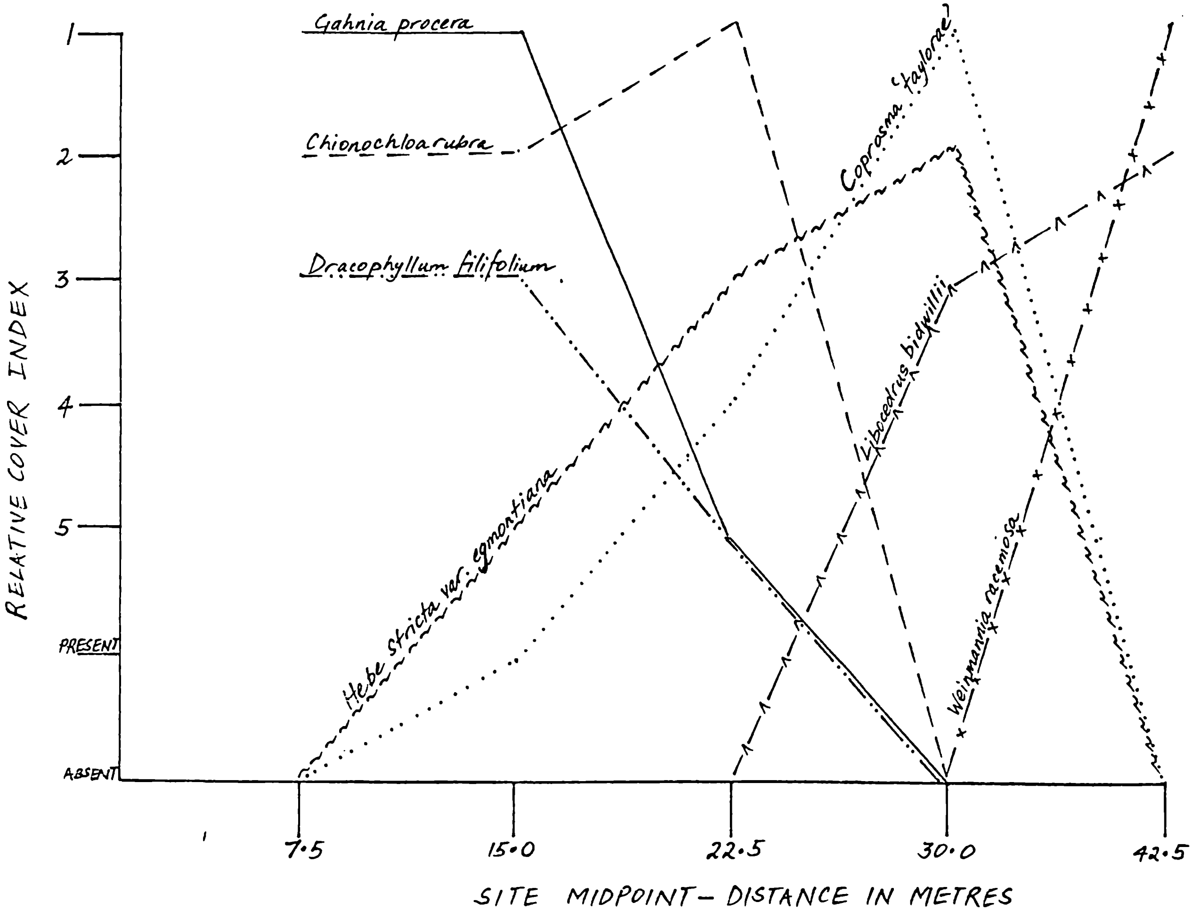
Introduction

The Ahukawakawa Swamp (916m) abuts on to the south-east edge of the Pouakai remnant volcano. (See location map Figure 4.21). Up to 1.5km at its longest and widest axes the swamp alone has been shown by Druce (1976b) to contain nearly 260 vascular plant species. Across the margin of the swamp within a short distance (as little as 30m in places) the vegetation changes from low growing grasses, herbs, rushes and sedges through to kamahi forest in response to the increasing slope and its associated improvement in the conditions of drainage and soil aeration. In order to examine more closely this change in species composition and the associated structural vegetation changes data was collected from a single transect consisting of five quadrats each 25m^2 in area located systematically at 7.5m intervals across the margin of the swamp. The changes in species composition of the leading top stratum dominants are shown on Figure 4.29.

Top stratum species leading dominants

Figure 4.29 shows how the top stratum species composition

Figure 4.29 SPECIES COMPOSITION (TOP STRATUM) ACROSS A MARGIN OF THE AHUKAWAKAWA SWAMP



changes completely within a distance of only 50m. *Gahnia procera*, red tussock and inaka respectively are the leading dominants in the first two sites. At site 3 red tussock becomes the leading dominant and koromiko and *Coprosma 'taylorae'* second and third dominants. *Gahnia procera*, red tussock and inaka are all displaced by site 4. Site 4 is dominated by *Coprosma 'taylorae'*, koromiko and kaikawaka but by site 5 kamahi is the leading dominant and kaikawaka second dominant.

The floristic change in the top stratum is paralleled in the ground cover with sphagnum the leading dominant (>80% cover) in sites 1 and 2, *Blechnum penna-marina* the leading dominant at site 3 and forest oat grass the leading dominant in sites 4 and 5. A particularly unusual twiggy shrub recorded in site 4 as a component of the top stratum and the understorey was *Hymenanthera* sp. unnamed. This is the only location within the national park where this species was observed by the author during the entire period of study. (A complete list of species recorded in each of the five sites is included in Appendix 4).

As well as the floristic changes associated with this moisture gradient, major structural changes were recorded. At site 1 the maximum height recorded for the top stratum was 1.2m for red tussock. Inaka reached 1.4m at site 2 and at site 3 flax was 2.2m in height. Kaikawaka was emergent at a height of 4.26m at site 4 and up to 8.0m at site 5. At sites 1, 2 and 3 it was practicable to distinguish only two vegetation strata; the top stratum and ground cover stratum. For site 4 and 5 however the structure was more complex, kaikawaka being emergent above a lower canopy of shrubs at site 4 and both kamahi and kaikawaka forming a top stratum above the shrub layer at site 5. A well developed understorey dominated by *Coprosma* spp. (*C. 'taylorae'* and *C. 'paludosa'*).was present at site 4 and at site 5 an understorey and a shrub layer both dominated by mountain pepperwood.

The total number of vascular species recorded increases from 25 per 25m^2 in site 1 (poorly drained) up to 44 per 25m^2 in site 5 (well drained). Epiphytic species were first recorded at site 4 with two epiphytic species and in site 5 eight epiphytic species were recorded.

The floristic and structural changes in swamp margin vegetation in response to the moisture gradient parallel those changes described elsewhere in response to the altitudinal gradient. The most poorly drained sites exhibit a low growing vegetation in which shrubs, tussock, other grasses, rushes, sedges and herbs are all present. With the improving conditions of drainage associated with increasing slope, shrubs become dominant. Finally in the best drained sites, forest dominated by kaikawaka and kamahi is present.

The reason for the high number of species noted by Druce (1976b) in the Ahukawakawa Swamp is obviously the great range of plant habitats provided particularly by the swamp margins. As it is shown by this data, conditions range from those suitable for tree growth through to conditions suited to semi-aquatic plants within the short distance of 50m. The number of different species present in a very small area, therefore is extremely high.

C. THE VEGETATION OF THE EASTERN SIDE OF MT EGMONT

Introduction

In order to describe and explain the significant features of vegetational change along some of the major environmental gradients on the eastern side of Mt Egmont, seven sampling programmes were completed. All of the sampling programmes were quantitative. The first consisted of 33 sites located along the altitudinal gradient at North Egmont from the park boundary to over 1850m a.s.l. The second involved collection of data from a further 25 sites between 730m and 1400m at the York Road, Dawson Falls and Lake Dive locations. The remaining five sampling programmes were small by comparison and were employed to investigate the main features of vegetation change in relation to environmental gradients other than the altitudinal gradient. Two moisture gradients were examined. The first involved the collection of data from nine quadrats located at intervals across the margin of the Potaema Bog (670m) and the second measuring the vegetation composition across a small stream channel in the herbfield at Mangahume (1322m). The remaining three sampling programmes involved recording the herbfield composition in sites ranging from those with a stable substrate to those on unstable debris flows near Humphries Castle (1554m), examining a transect across a shrub ring on the Razorback (1432m) and measuring the size class (d.b.h.) structure of kaikawaka and Hall's totara stands near Lake Dive.

1. NORTH EGMONT

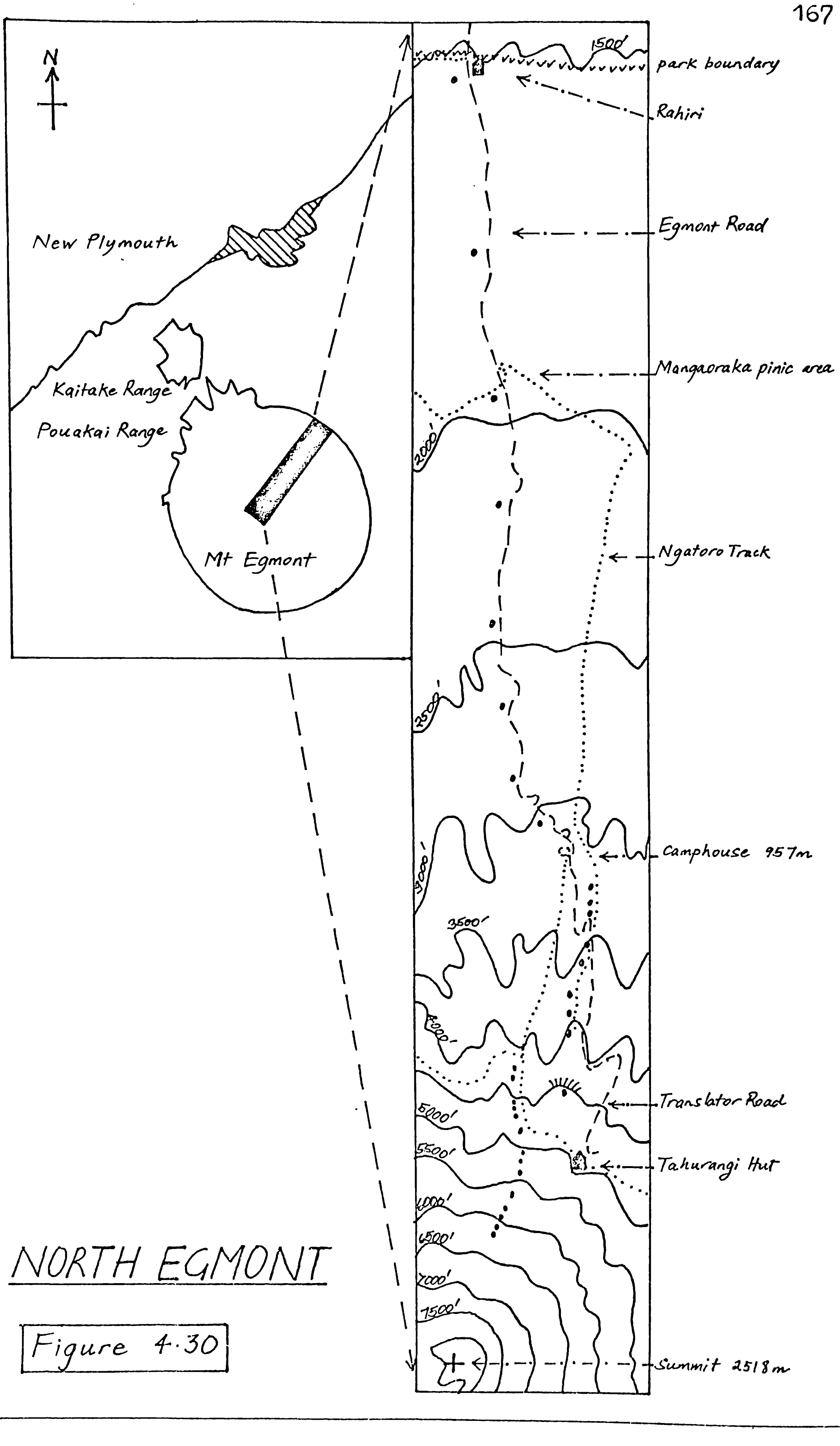
Introduction

North Egmont is the name given to the general area in the north-eastern sector of Egmont National Park for which the main access route is the Egmont Road (see Figure 4.30). A number of the most commonly used walking tracks in the national park link with the Egmont Road: the Waiwhakaiho Track near the national park boundary, the Mangaoraka Track originating at the Mangaoraka Picnic Area, the Ngatoro Track extending up to the old North Egmont Chalet site, the Razorback originating near the Camphouse and a commonly used route to the summit, the Translator Road an extension of Egmont Road up to the Translator site near Tahurangi Hut and Blundell's Track a now disused track an extension of the Ngatoro Track. All of these tracks were used to examine thirty-three sites between 450m and 1900m (see Table 4.7). The distance between site 1 (480m) and site 31 (1868m) is 4.8km approximately, thus the average gradient for the area sampled is 1:3.46. Slope angles greater than 20^{o} recorded above 950m emphasize the fact that the steepest part of an altitudinal gradient occurs above this height. In fact the average gradient for the area sampled above 950m is 1:2.91. Ridge alignment is mainly north-east, therefore all the sites examined had aspects ranging from east-north-east to east-south-east. Two extra sites (32 and 33) near Tahurangi Bluff were examined to measure shrub composition in slip prone areas and supplementary data (employing the point centred quarter method of Cottam and Curtis (1956)) was collected at

Table 4.7 Sampling sites at North Egmont

No.	Altitude Feet	Altitude Metres	Slope Angle	Transect	Quadrat	Aspect
33	4080	1243	25-30		100m^2	NNE
32	4550	1386	13-17		25m^2	NE
31	6130	1868	25-30		25m^2	NE
30	6020	1834	25-30		25m^2	NE
29	5890	1794	25-30		25m^2	NE
28	5780	1761	30-33		25m^2	NE
27	5680	1731	23-27		25m^2	NE
26	5385	1641	23-27		25m^2	NE
25	5210	1587	19-21		25m^2	NE
24	5120	1560	20-25		25m^2	NE
23	5000	1523	25-30		25m^2	NE
22	4900	1493	30-35		25m^2	ENE
21	4680	1426	15-20		25m^2	NE
20	4665	1421	22-27	60m		NE
19	4565	1391	22-27	60m		NE
18	4465	1360	25-30	60m		NE
17	4310	1313	25-30	60m		NE
16	3960	1206	30-35	60m		NE
15	3825	1165	28-32	60m		NE
14	3660	1115	24-26	60m		NE
13	3600	1097	7-11		100m^2	NE
12	3500	1066	28-32		150m^2	NNE
11	3410	1039	28-32		225m^2	NNE
10	3305	1007	30-35		225m^2	N
9	3200	975	18-22		225m^2	NNE
8	3005	921	5- 7		400m^2	NNE
7	2865	873	5- 7		400m^2	NNE
6	2680	817	10-15		600m^2	NNE
5	2461	750	5- 7		600m^2	NNE
4	2232	680	0- 3		600m^2	NNE
3	1936	590	0- 5		600m^2	NNE
2	1805	550	0- 5		*600m^2	NNE
1	1575	480	5-10		*600m^2	NNE

* Supplemented with P.C.Q. data (16 sites, 64 trees)



NORTH EGMONT

Figure 4·30

sites 1 and 2 to obtain a more representative estimate of the widely spaced canopy and emergent species.

Top stratum (canopy and emergents) species Relative Basal Area (R.B.A.)/Relative Cover (R.C.) >20% (15 species)

Inspection of all the site data including that collected using the point centred quarter method of Cottam and Curtis (1956) reveals fifteen species which achieve values greater than 20 percent in the top stratum at North Egmont. Of these species nine are dominant at one or more of the sites examined, while the remaining six are of subdominant status only (see Figure 4.31). Kamahi is dominant below 1050m in all but one of the sites examined where rata was recorded as the dominant. Rimu and hinau are associated with the kamahi and rata below 750m. Broadleaf first recorded at site 6 (817m) becomes dominant above 1050m. Hall's totara associates with broadleaf throughout its altitudinal range while kaikawaka is important as the subdominant in broadleaf dominated sites. Leatherwood becomes dominant above 1100m but Hall's totara and broadleaf are still represented. Inaka is an important associate of leatherwood but also extends above 1400m into the sites dominated by red tussock. Silver tussock and *Hebe odora* are both important associates of red tussock. Silver tussock exhibits a more restricted altitudinal range and was dominant in one site (site 22, 1493m) while *Hebe odora* was recorded throughout the red tussock dominated sites. Above 1500m red tussock gives way to everlasting daisy which fluctuates in importance becoming dominant

Figure 4.31

TOP STRATUM SPECIES RELATIVE BASAL AREA / COVER > 20%

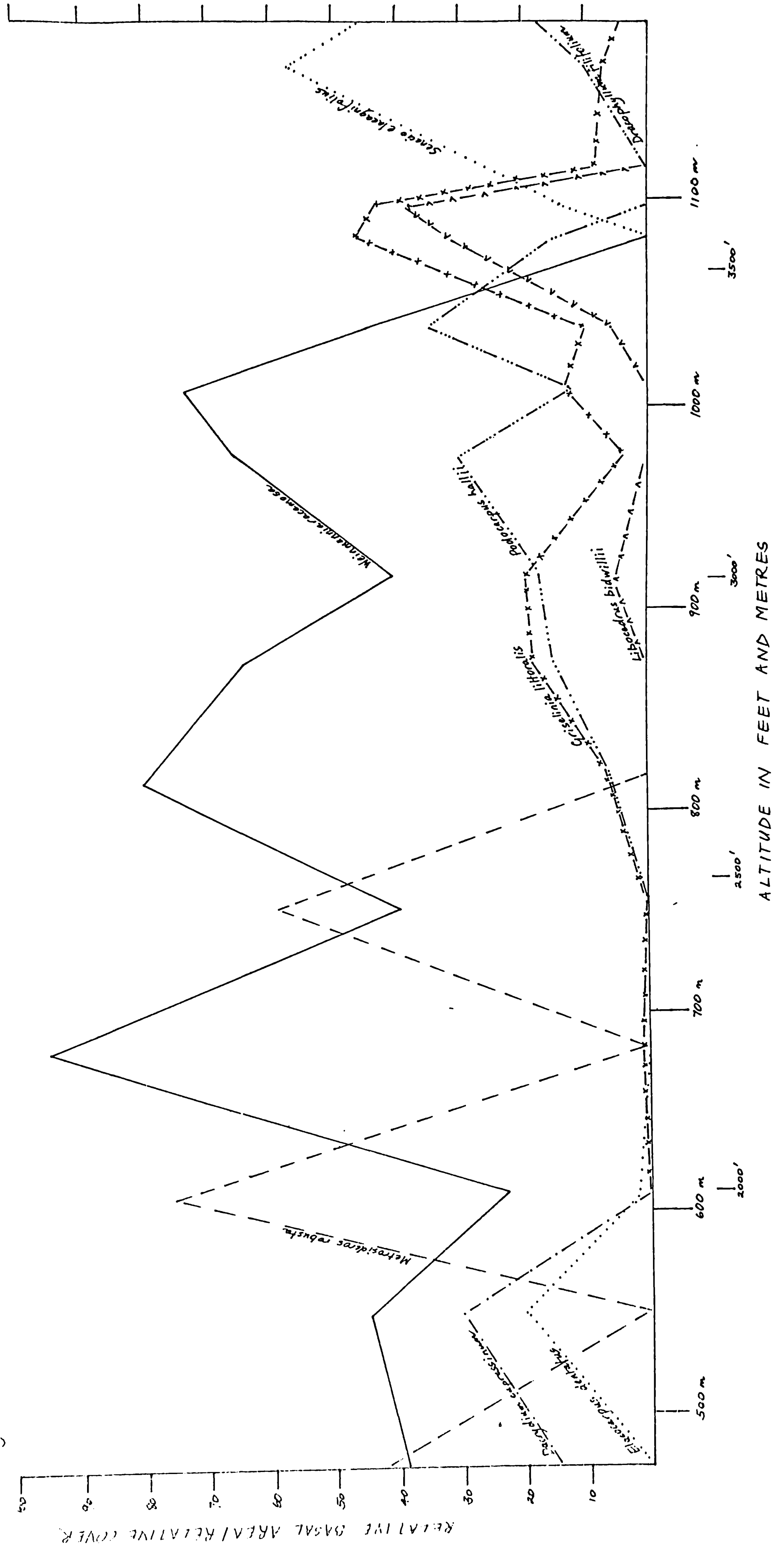
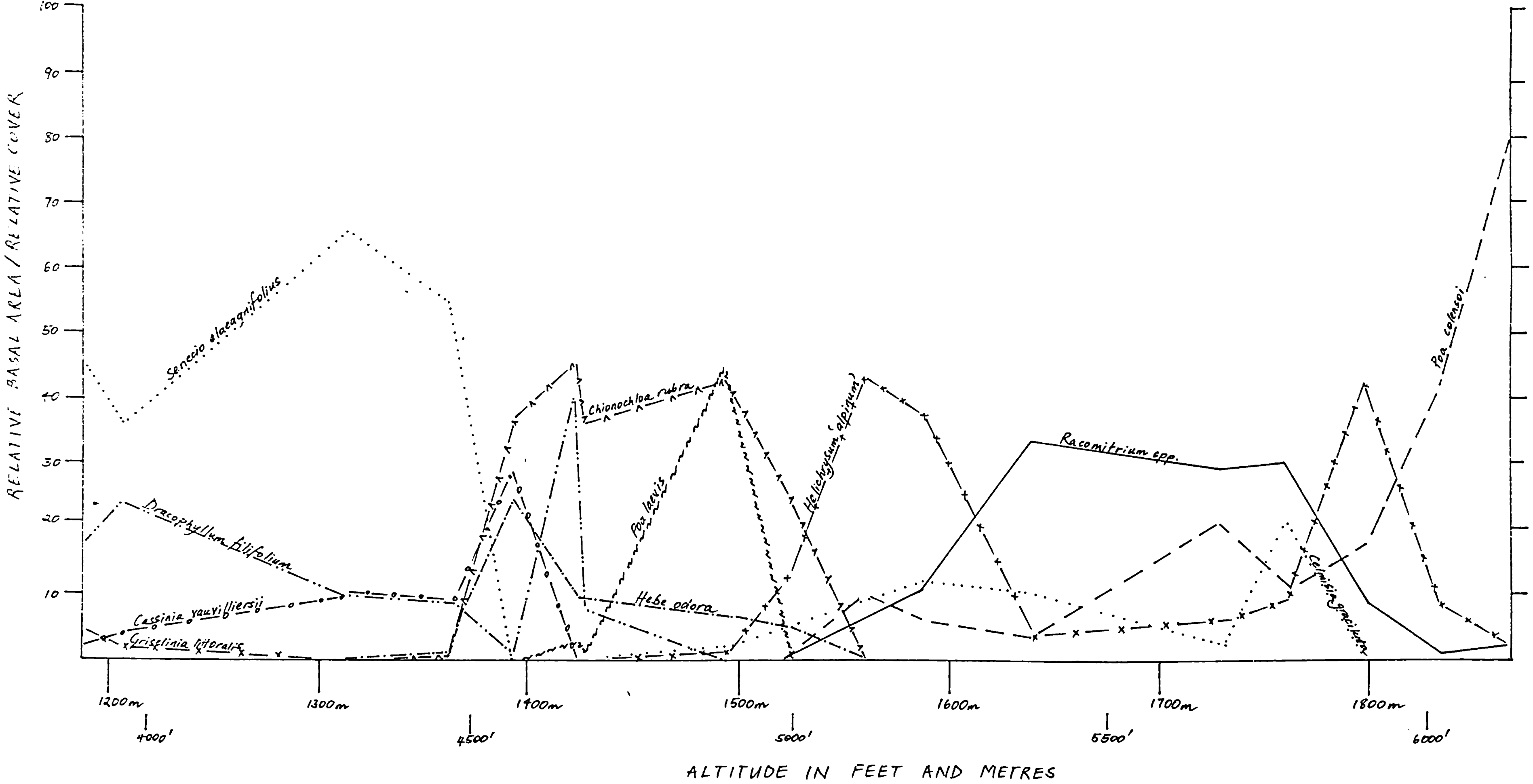


Figure 4·31 contd.

TOP STRATUM SPECIES RELATIVE BASAL AREA / COVER > 20%



in sites 24 and 29 (1560m, 1794m). Moss (*Racomitrium* spp.) dominates between 1600 and 1780m and above 1800m blue tussock takes over. *Celmisia gracilenta* var. is an important associate in the sites dominated by everlasting daisy and moss.

Top stratum species R.B.A./R.C. >5% <20% (16 species)

Sixteen species achieve values greater than 5 percent but less than 20 percent in the top stratum at North Egmont (see Figure 4.32). Four tree species mahoe, tawa, toro and *Pseudopanax arboreus* are associates of kamahi. Mahoe and tawa are both distributed below 860m but are most important below 600m. Toro and *Pseudopanax arboreus* distribute below 1000m, toro parallelling the lower altitude distribution of broadleaf. Mountain pepperwood is recorded once only as an associate of broadleaf. Four shrub species distributions are centred on sites dominated by leatherwood. *Pseudopanax simplex* recorded first in the upper kamahi dominated sites is most important as an associate of leatherwood at the lower limit of leatherwood's altitudinal range. Koromiko and *Pseudopanax colensoi* are most important in sites where leatherwood is clearly dominant while *Coprosma pseudocuneata* is most important towards the upper limits of leatherwood dominance. Herb species important in sites dominated by everlasting daisy, moss and blue tussock include *Anisotome aromatica*, *Pentachondra pumila*, *Coprosma pumila*, *Forstera bidwillii* var. *densifolia*, *Celmisia glandulosa* var. *latifolia*, *Gaultheria* sp. unnamed and *Drapetes dieffenbachii*. All of these species

Figure 4·32

TOP STRATUM SPECIES RELATIVE BASAL AREA / COVER >5% <20%

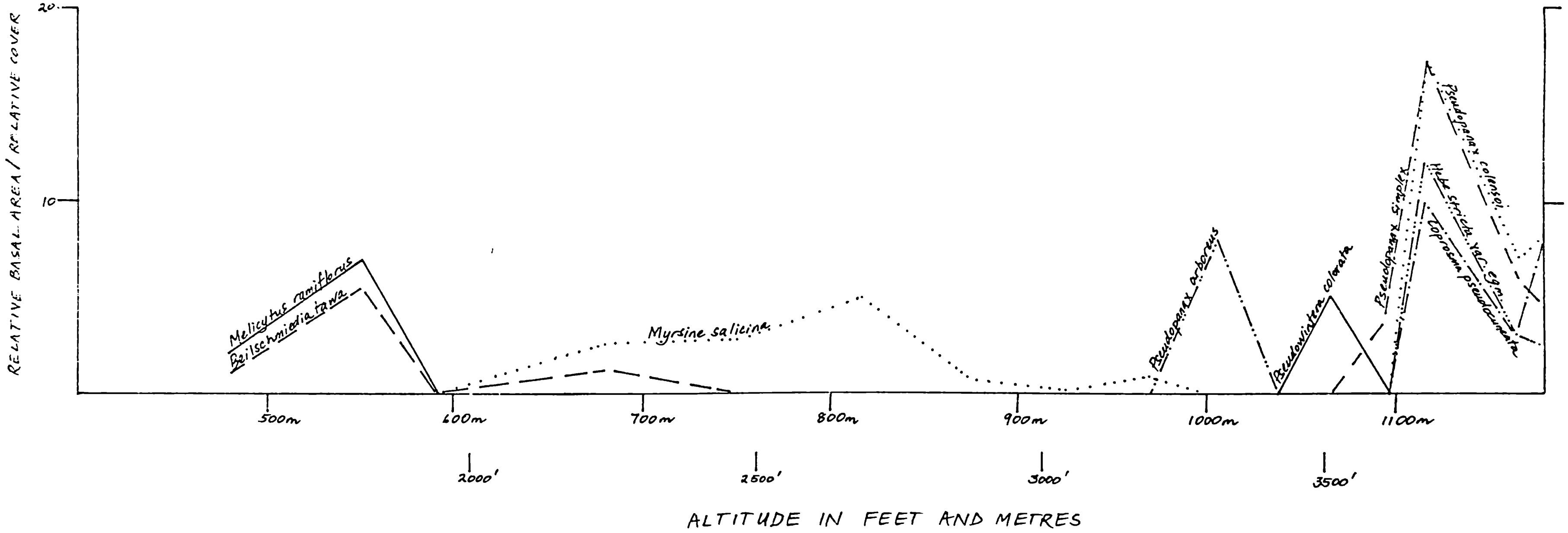
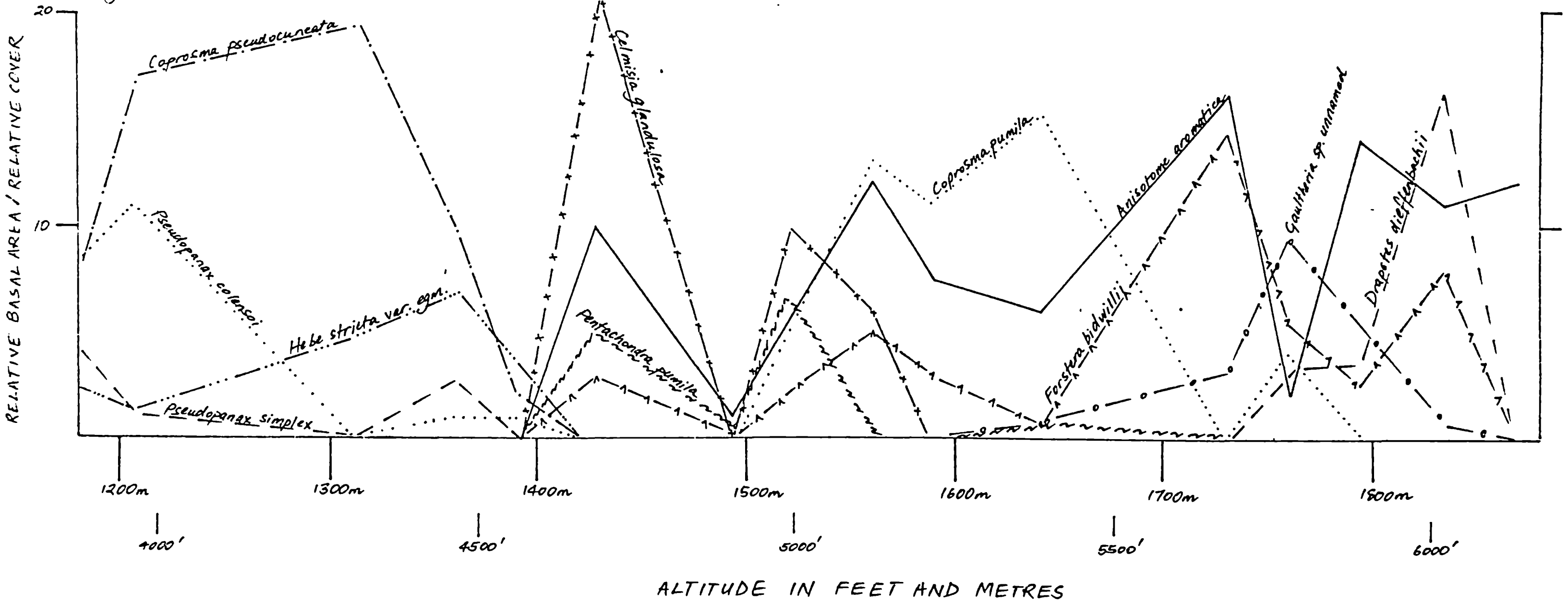


Figure 4.32 contd.

TOP STRATUM SPECIES RELATIVE BASAL AREA / COVER >5% <20%



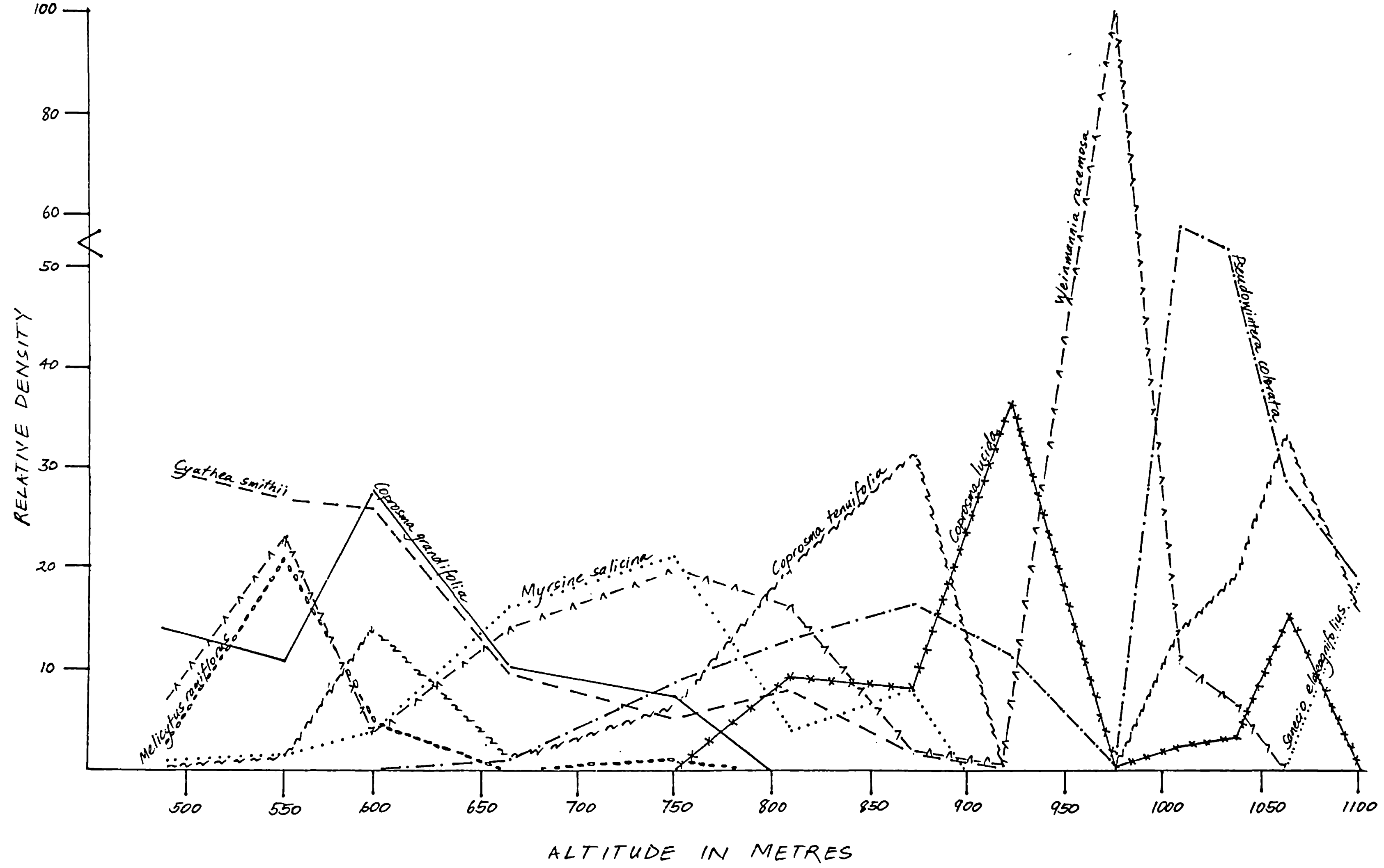
are first recorded as in the top stratum above 1400m. *Pentachondra pumila* distributes up to 1550m, *Celmisia glandulosa* var. *latifolia* to 1580m, *Coprosma pumila* to 1780m, *Forstera bidwillii* var. *densifolia*, *Gaultheria* sp. unnamed and *Drapetes dieffenbachii* to 1850m and *Anisotome aromatica* even higher to 1870m.

Second stratum (subcanopy) species Relative Density (R.D.) >20% (9 species)

A subcanopy or second stratum of vegetation was recorded up to site 13 (1097m) at North Egmont (see Figure 4.33). Nine subcanopy species achieve values greater than 20 percent: mahoe, soft tree fern, toro, kamahi, *Coprosma grandifolia*, *Coprosma lucida*, *Coprosma tenuifolia*, mountain pepperwood and leatherwood are confined to the kamahi dominated forest. Mahoe, soft tree fern and *Coprosma grandifolia* are all distributed below 900m while toro, *Coprosma tenuifolia* and kamahi itself are widespread in the subcanopy. Toro in fact dominates the subcanopy at sites 4 and 5 (680m, 750m) while *Coprosma tenuifolia* is subcanopy dominant in sites 6, 7 and 12 (817m, 873m and 1066m). The extreme dominance of kamahi (100%) in the subcanopy at site 9 (975m) reflects the almost complete removal of understorey species by goat browsing rather than any competitive superiority of kamahi at this altitude. *Coprosma lucida* is distributed between 750m and 950m dominating the subcanopy in site 8 (921m). Mountain pepperwood recorded above 600m is most important in sites 10 and 11 (1006m, 1039m) at the upper limits of kamahi canopy dominance and

Figure 4·33

SECOND STRATUM SPECIES RELATIVE DENSITY > 20%



beneath a broadleaf dominated canopy respectively. Leatherwood is an important component of the subcanopy beneath the broadleaf dominated canopy of site 13 (1097m).

Third stratum (shrub layer) species >20% R.D. (4 species)

A shrub layer or third stratum of vegetation was recorded up to site 13 (1097m) at North Egmont. Only four species achieve values greater than 20 percent: pigeonwood, soft tree fern, *Coprosma tenuifolia*, and mountain pepperwood (see Figure 4.34). Pigeonwood distributed below 750m is dominant at site 2 (550m) and soft tree fern distributed below 920m is dominant at site 3 (590m). Mountain pepperwood and *Coprosma tenuifolia* are widespread. Mountain pepperwood, present in all but two of the 13 sites, is dominant in nine of them (700m-1097m). *Coprosma tenuifolia*, recorded at all but one of the sites, is the dominant shrub at site 10 (1007m). Pigeonwood and soft tree fern are therefore more important in the shrub stratum in the sites where emergent rata and rimu associate with the canopy dominant kamahi while mountain pepperwood and *Coprosma tenuifolia* are more important in the sites where kamahi or broadleaf are canopy dominants.

Ground cover (fourth stratum) species first and second ranked dominants (11 species)

A ground cover or fourth stratum of vegetation was recorded up to site 20 (1421m) and the distributions of ground cover first and second dominants are summarised on Figure 4.35. Eleven species were thus recorded. Six

Figure 4.34 THIRD STRATUM SPECIES RELATIVE DENSITY >20%

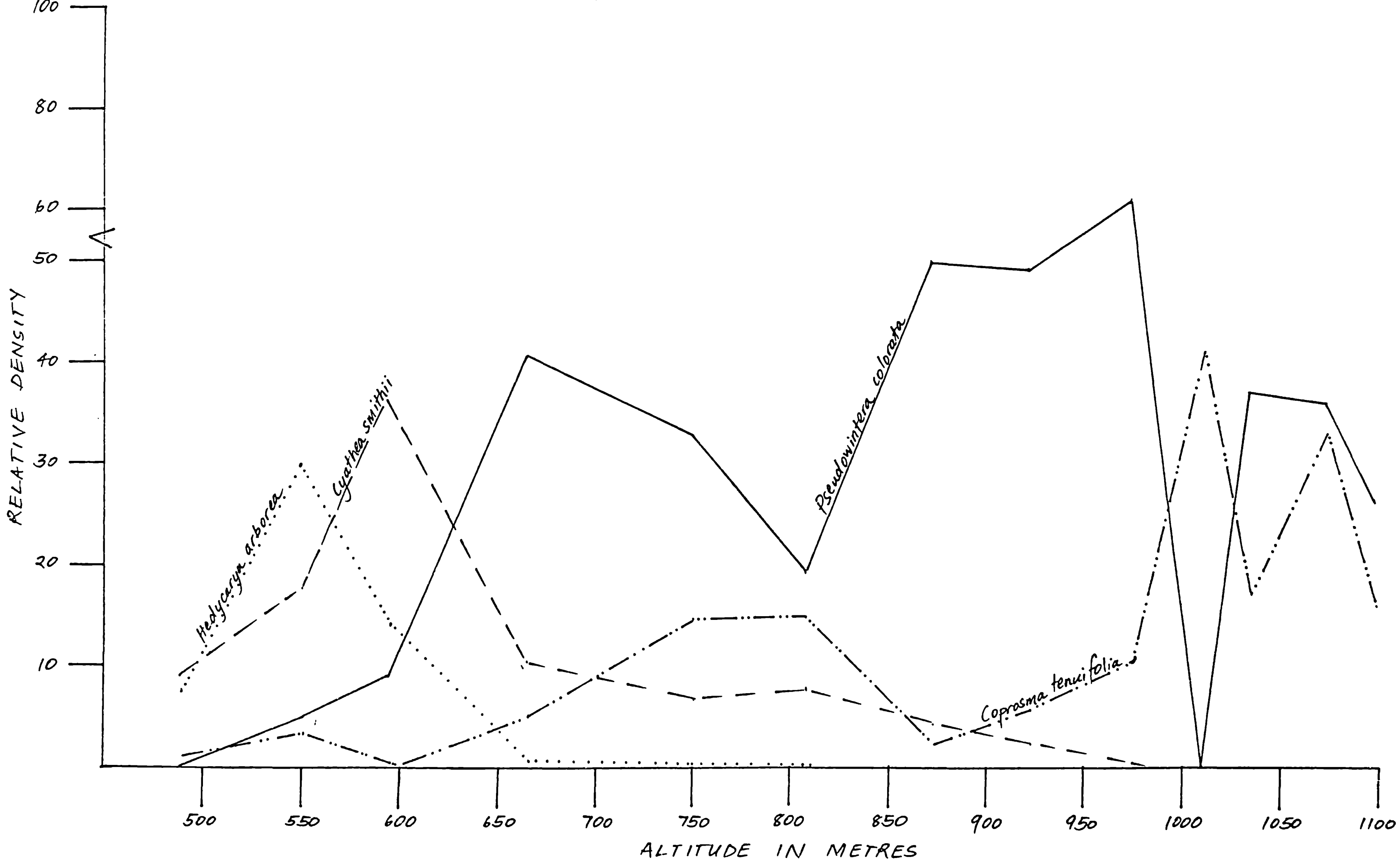
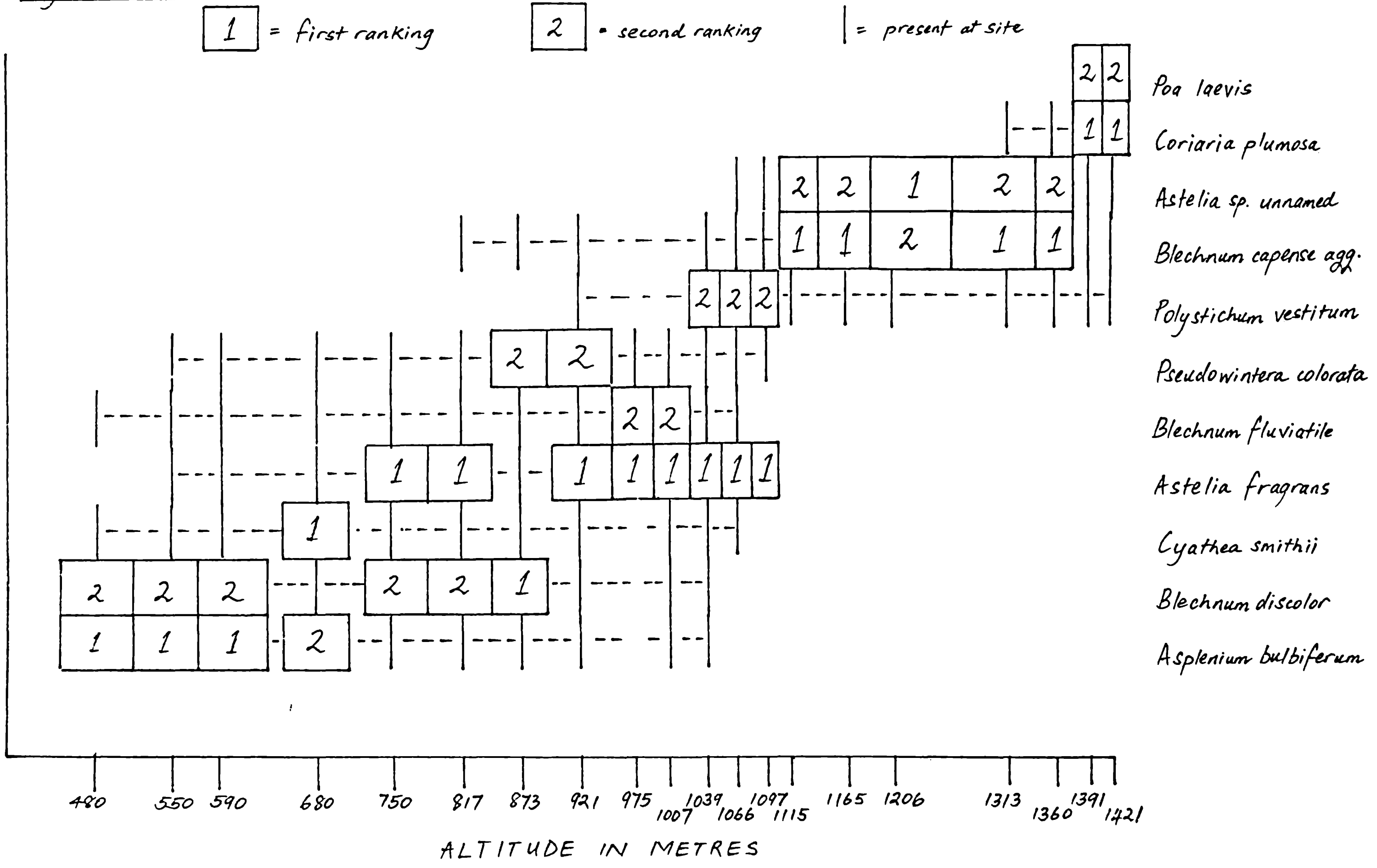


Figure 4.35 GROUND COVER SPECIES FIRST AND SECOND DOMINANTS



species, *Asplenium bulbiferum*, crown fern, soft tree fern, *Astelia fragrans*, *Blechnum fluviatile* and mountain pepperwood in the higher altitude forest sites. Three species *Polystichum vestitum*, *Blechnum capense* and *Astelia* sp. unnamed were recorded in both forest and shrub dominated sites. *Polystichum vestitum* is however most important above 1030m in the upper altitude forest sites while *Blechnum capense* and *Astelia* sp. unnamed are ground cover dominants above 1075m beneath the leatherwood canopy. Two species, silver tussock and *Coriaria plumosa*, were recorded as ground cover dominants at the leatherwood-red tussock canopy interface.

The declining importance of rata between 500 and 600m a.s.l.

In the vicinity of sites 2 and 3 (500-600m) many remains including logs and stumps of rata are scattered throughout the present day vegetation. Logs up to 3m in diameter and 20m in length are present and the structure of the vegetation in these locations is characteristically a mass of sprawling multi-leadered kamahi individuals (as many as 9 top stratum stems >60cm d.b.h.). As well, species such as broadleaf, young rata and *Pseudopanax* spp. may be perched on the rata remnants or growing on the already present kamahi complex. Quantitative measurement such as recording species basal area is hardly practical in such localities. It is clear from the number of rata remnants in some sites that in the recent past (last one hundred years?) rata was more numerous. The very low numbers of young developing rata recorded appear insufficient to even maintain the present densities of live top stratum individuals (1-3 per 1000m^2). Combined with this the fact that a number of live top stratum ratas present are showing the adverse affects of opossum damage makes it clear that between 500 and 600m at North Egmont at least, rata will decline in importance. The regeneration pattern of rimu, the most common host of the developing rata described in the next section also has an important bearing on any assumed decline.

Rimu regeneration

Rimu is distributed from the national park boundary ($\sim$450m) up to the vicinity of site 6 (817m) at North Egmont. True emergent rimu however rarely occur above 750m. Seedlings have been noted, albeit scattered, throughout the whole area below 750m while saplings or poles (<20cm d.b.h.) recorded in plots 1-6 totalled only 5. In fact the total number of individuals other than top stratum ones observed while examining the sites between 480-900m and the area close by was less than forty. Of these at least one third observed were epiphytic. One individual for example occurring on rata remnants near site 2 (250m) and others occurring in the mass of epiphytes present on many kamahi complexes. Examples of small epiphytic rimu which had grown up to 5cm d.b.h. only to 'fall off' their host because their inability to adopt other than their rigid pole-like growth form, were observed at North Egmont and at several other locations. It is clear that although the mature rimu present at North Egmont seed successfully few if any seedlings or saplings locate in situations suitable for growth to maturity. The relatively low densities of top stratum rimu apparent (1.15 per 1000m^2 PCQ, 0.5 per 1000m^2 quadrat data) would also severely limit the possibilities of suitable host trees for rata. It seems very significant that the best examples of rimu regeneration observed by the author occur in forest margins near the national park boundary and in 'second-growth' forest nearby.

Miro on the increase?

Miro is distributed from the national park boundary ($\sim$450m) up to the vicinity of site 10 (1007m) where in fact one emergent individual (61cm d.b.h.) bore viable seed in 1976. The majority of top stratum miro however occur below 900m as do the subcanopy and shrub stratum individuals. A total of 88 individuals 20cm d.b.h. were recorded in the 13 sites between 450 and 1100m (total area sampled = 4850m^2) and 85 of these occurred in the sites below 820m (total area sampled = 3600m^2). Seedlings were recorded as present in 11 of the 13 sites and rated abundant in four sites all below 820m. General observations in the wider area below 820m confirmed these results. A number of epiphytic miro were also observed. Thus in contrast to rimu, miro regeneration is certainly successful up to the 20cm d.b.h. stage. Whether or not these individuals survive in the future is questionable. The small numbers of top stratum miro recorded in the quadrat data (0.5 per 1000m^2) suggest that if the recruitment of >20cm d.b.h. stages was as successful in the past, then mortality must have been extremely high in the larger size classes. It is possible however that the numbers of individuals present today in the < 20cm d.b.h. classes are the result of conditions more favourable to regeneration than those prevailing in the past. If this is the case miro may well become a more important top stratum component in the North Egmont forest. The 10-20cm individuals present in the sites between 450m and 800m certainly appeared vigorous and healthy and gave every indication of successfully reaching the top stratum. Miro unlike rimu appears to be tolerant of the closed canopy of kamahi and thus capable of growing up to reach the top stratum of vegetation. This is presumably the key to its success.

The kamahi success story

No other species is as successful in the North Egmont forest as kamahi. Distributed from the national park boundary up to the vicinity of site 11 (1039m) kamahi was recorded in all the vegetation strata. In fact the overwhelming majority of kamahi seedlings are epiphytic and few seedlings or shrubs were recorded terrestrially. Those observed on the ground had inevitably been browsed by goats and this browsing pressure has probably caused the disproportionate numbers of epiphytic seedlings and saplings in comparison with those occurring terrestrially. The range of kamahi complexes is also striking. Relatively large kamahi which have begun life epiphytic on soft tree fern, rata, totara and kamahi itself have all been observed. In fact few tree species have not been recorded as hosts and in the case of kamahi-broadleaf complexes it is often unclear which species was the original host. Multi-leadered and sprawling kamahi individuals in the lower altitude sites have already been referred to in previous sections. There are many instances where kamahi, after attaching to and developing on a suitable host, has toppled over from sheer weight. New leaders grow up at right angles to the prostrate trunk and thus kamahi continues to dominate the top stratum. Kamahi seems to be extraordinarily resilient to this sort of catastrophe and the effects of this on the vegetation structure at many sites is confusing. The sprawling trunks and huge mounds of kamahi complexes which result are impossible to assess quantitatively as it is impossible to distinguish one from another. It is clear that the dominance of kamahi must in part result from this ability to grow beneath a shaded canopy and make use of sites generally unsuitable to species which do not have this flexibility of form. Other species which begin life epiphytically, for example rimu, totara and miro, are doomed to failure while epiphytic *Pseudopanax* spp. are not as effective competitors in the lower altitude forest as the higher altitude forest because they do not grow large enough to retain dominance in the top stratum. This is not to say that all kamahi individuals are successful. The lower altitude forest is littered with many dead kamahi trunks, but they deteriorate quickly in contrast to species such as rata or Hall's totara. It is more by virtue of rapid turnover that there is always another kamahi 'on the spot' despite the high mortality rate. One obvious consequence of this kamahi success could be the decline of other competing species. It is possible that the declining importance of rimu in the lower altitude forest may well be as much a function of the success of kamahi and rimu's inability to adopt other growth forms as any postulated regeneration gap (see Wardle, 1963).

Slip face successions near treeline

Slips are a comparatively common occurrence at North Egmont in the vicinity of Ngatoro Ridge and the Razorback. On the Razorback the location of the Summit Track and the Translator Road have obviously exacerbated the situation. Many slips however are a 'natural' occurrence, that is they seem to have occurred not as the direct result of any form of animal disturbance but rather as a result of intense rain storms. The most recent (1977) large slip occurring after such a storm is located in the Ngatoro stream valley and denuded an area of approximately 210,000m^2. The whole valley below tree-line in fact supports a number of distinct age group populations of kaikawaka and Hall's totara all of which are the result of the sequence of succession of slip faces. Observation and comparison of these sites has enabled the sequence of succession to be determined. It can generally be summarised as:

1) Colonisation of the slip face by herbs and grasses. Of particular importance are: *Raoulia tenuicaulis*, everlasting daisy, *Coriaria plumosa*, *Coriaria pteridioides*, and *Gunnera monoica*.
2) Establishment of an increasing diversity of herbs and

grasses and the shrubs: koromiko, *Hebe odora*, inaka, broadleaf, leatherwood, *Cassinia vauvilliersii*, *Pittosporum tenuifolium*, *Coprosma pseudocuneata* and *Coprosma 'taylorae'*.

3) Development of a shrub community which passes through several stages of succession with *Hebe odora* and *Cassinia vauvilliersii* dominant at earlier stages followed by inaka and koromiko and later by leatherwood. By this stage small kaikawaka and/or Hall's totara are present in the understorey or share the top stratum with the shrub species.
4) Kaikawaka and/or Hall's totara eventually become fully emergent and the shrub species principally leatherwood, broadleaf and koromiko remain as a lower canopy stratum.

Preliminary dating of some kaikawaka and Hall's totara indicate that this succession may be of the order of 200-250 years. The effects of animals, goats, opossums and hares, have modified what was probably once a fairly standardised succession. Hares in particular eat the earlier colonisers, *Raoulia tenuicaulis* and everlasting daisy, while goats congregate on the slip faces and slow down the whole sequence of succession by continually grazing the herbs and grasses. This has in some instances led to the establishment of 'stable' plagioclimax communities which support a good cover of species characteristic of stages 1 and 2 along with a range of introduced weeds and grasses and various unpalatable species such as mountain pepperwood, forest oat grass, and hooked sedges. Another characteristic of this slip face succession is the prevalence of many 'higher altitude' species (e.g. red tussock, moss, *Celmisia* spp.) which in the normal course of events are out competed by the final stages of succession.

Slips have occurred above tree-line as well and a number of large slip faces are apparent between 1100m and 1200m on both sides of the Ngatoro stream. The climax vegetation on these sites appears to be shrub communities in which kaikawaka and Hall's totara are only present in the understorey. The sequence of succession is very similar to that already described apart from the increased range of 'higher altitude' species and an end point at stage 3. The most important feature seems to be the increased dominance of inaka on old slip faces with steep slopes and with skeletal soils. The inaka gives an obvious brown-gold colouring to the vegetation cover and detracts from the expected altitudinal sequence in which leatherwood is the dominant at these altitudes. Koromiko, red tussock, *Hebe odora* and broadleaf also appear as more important components than expected on old slip faces or the debris accumulations in the valley bottom. The occurrence of these vegetation patterns is of obvious importance with regard to sampling along the altitudinal gradient. Unless care is taken in determining successional stages for each vegetation type sudden changes in species dominance along the altitudinal gradient are more likely to result from crossing a discontinuity in soil type and successional stage evident after such a natural catastrophe rather than a natural species transition zone. The shrub-tussock interface sites in particular reflect these problems.

Hall's totara and kaikawaka and tree-line stability

Hall's totara and kaikawaka are both important species since they generally form the tree-line. Broadleaf of course is also distributed at high altitudes but its ability to adopt a shrub-like growth habit makes it a less useful indicator of the upper limits of tree growth. The site data collected between 850 and 1250m gives indications of change in the population structure of both Hall's totara and kaikawaka. In particular between 900m and 1100m many dead top stratum Hall's totara and kaikawaka (20cm-60cm d.b.h.) were observed. The predominance of dead large individuals is consistent with the dying out of an older population group. The greater success of kamahi and broadleaf in reaching and dominating the top stratum is resulting in a decline in the importance of Hall's totara in particular in the sites between 900 and 1050m. Seedlings of Hall's totara were recorded in all the sites examined (11) between 850m and 1250m and they were particularly abundant at site 6 (817m) where 39 saplings ($<$20cm d.b.h.) occurred in an area 600m^2. Surprisingly large numbers of seedlings and saplings occur above site 20 (1066m), the site at which the last adult Hall's totara were formally recorded. In fact even at site 15 (1165m) five saplings ($<$20cm d.b.h.) were present in an area 100m^2, one reaching the top stratum of vegetation. Individuals have in fact been observed up to 1200m on ridge sites with their terminal shoots just penetrating the canopy.

Kaikawaka seedlings and saplings are infrequent by comparison. Although several saplings ($<$ 20cm d.b.h.) were observed in the general area none were recorded in the site data. Seedlings were present in only 3 of the 11 sites. It seems very significant that the locations harbouring the largest numbers of both Hall's totara and kaikawaka seedlings are track margins. Recent trimming (1978) of the Translator Road sides for example caused a 'flush' of kaikawaka and Hall's totara seedling growth. This seems consistent with the seral behaviour of kaikawaka on slip faces already described. Kaikawaka, like Hall's totara, is a frequent understorey inhabitant of the leatherwood dominated sites up to 1200m. The size class (d.b.h.) of many of the Hall's totara and kaikawaka above 1100m give a deceptive indication of age for a Hall's totara individual 15cm d.b.h. gave a ring count of 150 years and a 30cm d.b.h. disk of kaikawaka had at least 250 annual growth rings. It seems certain that given an amelioration of climatic conditions the source of an emergent tree-line some 100m higher up the mountain side is ever present beneath the leatherwood canopy. Leatherwood exhibits a complementary relationship, seedlings being recorded as far down as site 5 (750m) beneath a kamahi canopy. In disturbed sites and track or road margins it occurs almost down to the national park boundary. Leatherwood shrubs and subcanopy individuals also occur up to 50m below the point at which leatherwood appears in the top stratum. Any changes favouring leatherwood over Hall's totara and kaikawaka would allow this ever present source of a shrub top stratum to dominate.

2. FOREST, FOREST-SHRUBLAND, SHRUBLAND AND SHRUB-TUSSOCKLAND ON THE EASTERN SIDE OF MT EGMONT

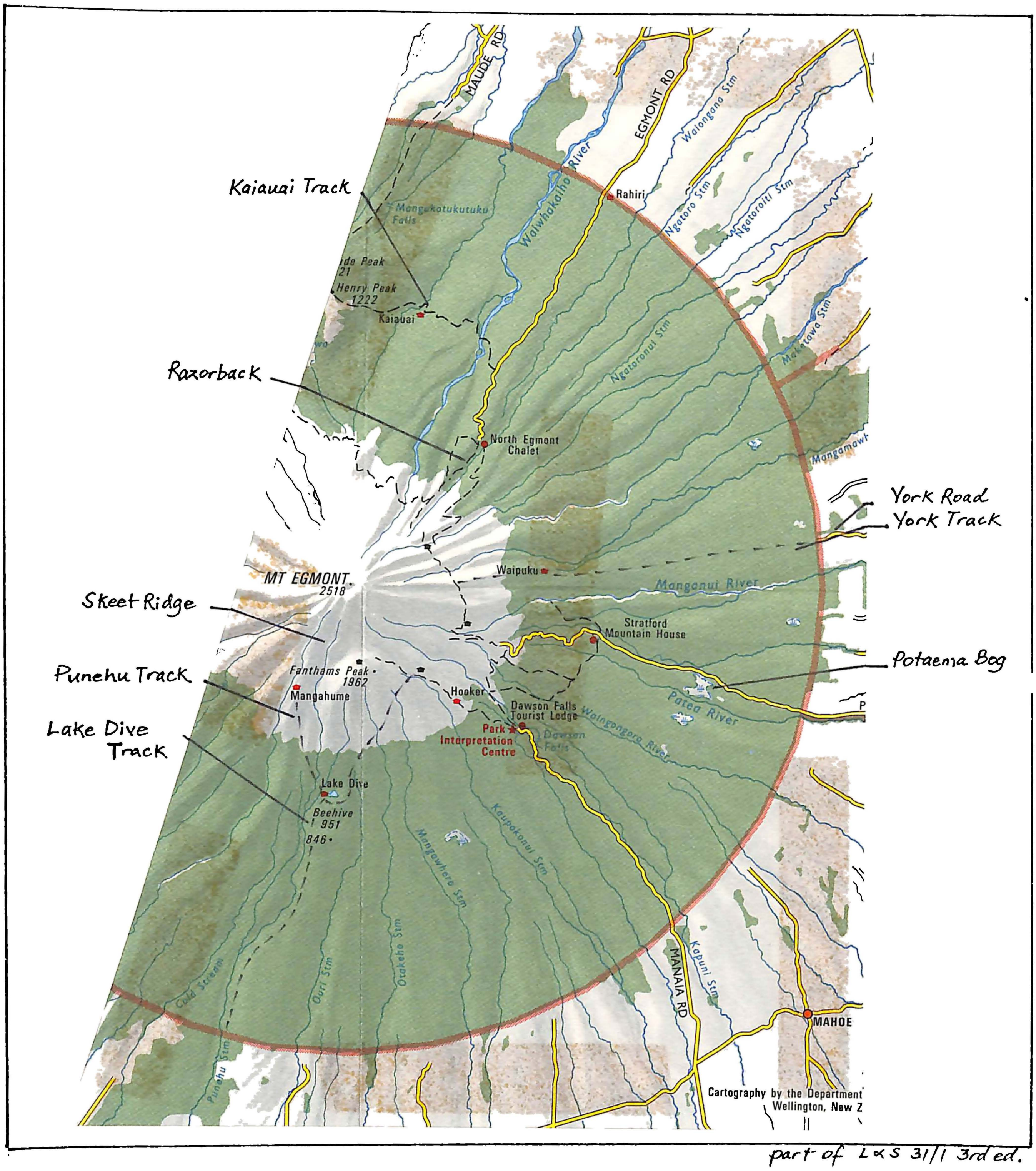
Introduction

In order to obtain more comprehensive data on the vegetation between 730m and 1400m on the eastern side of Mt Egmont 37 further sites were sampled. This data combined with the 15 sites from North Egmont within the same altitudinal limits made a total of 52 sites altogether. The additional sites sampled were from several locations on the eastern side of Mt Egmont including York Road Track Ridge, Punehu-Skeet Ridge, Dawson Falls, Lake Dive and the Kaiauai Track. These locations are shown on Figure 4.36 and site details are listed in Appendix 5. The data thus collected was analysed in a similar way to the Pouakai and Kaitake data. Direct gradient analysis was used to provide average data for the vegetation between 730m and 1400m and average linkage cluster analyses (BMD:P1M and BMD:P2M) were performed on both sites and species. In contrast to the Pouakai and Kaitake data however the data used was all quantitative.

Direct gradient analysis

The results of this analysis are depicted on Figures 4.37 and 4.38. Each figure was constructed in the same way described already for the Kaitake and Pouakai data in that species relative cover values were averaged for each of the eleven 61m (200') elevation intervals.

Figure 4.36 MT EGMONT (Eastern side) LOCATION MAP



part of L&S 31/1 3rd ed.

Relative Basal Area (R.B.A.)/Relative Cover (R.C.) of the major top stratum species

Figure 4.37 provides a summary of the major top stratum species distributions for the eastern side of Mt Egmont. Each species has a peak value above or below which it declines in importance and the pattern depicted is basically the same as that already described for North Egmont although the averaging of data from different locations has 'smoothed' the species curves. The key features are the decline of rata above 760m, the decline of kamahi above 880m, the importance of Hall's totara, broadleaf and kaikawaka between 910m and 1100m, the dominance of the leatherwood above 1100m and of red tussock above 1280m.

Relative Density (R.D.) of the major subcanopy species

Figure 4.38 provides a summary of the distributions of the major subcanopy species on the eastern side of Mt Egmont in six elevation groups from 730m up to 1100m. Again the pattern is basically the same as described already for North Egmont although the averaging of data from a range of locations has 'smoothed' the species curves. The key features are the fluctuating but continuous importance of Hall's totara and *Coprosma tenuifolia*, the dominance of mountain pepperwood above 850m, and the declining importance of the dominant kamahi and its associates toro and soft tree fern above 790m. Comparison of Figures 4.37 and 4.38 reveals a degree of coincidence between the decline of kamahi in the top stratum and kamahi, toro and soft tree fern in the

Figure 4.37

RELATIVE BASAL AREA / COVER OF THE MAJOR TOP STRATUM SPECIES

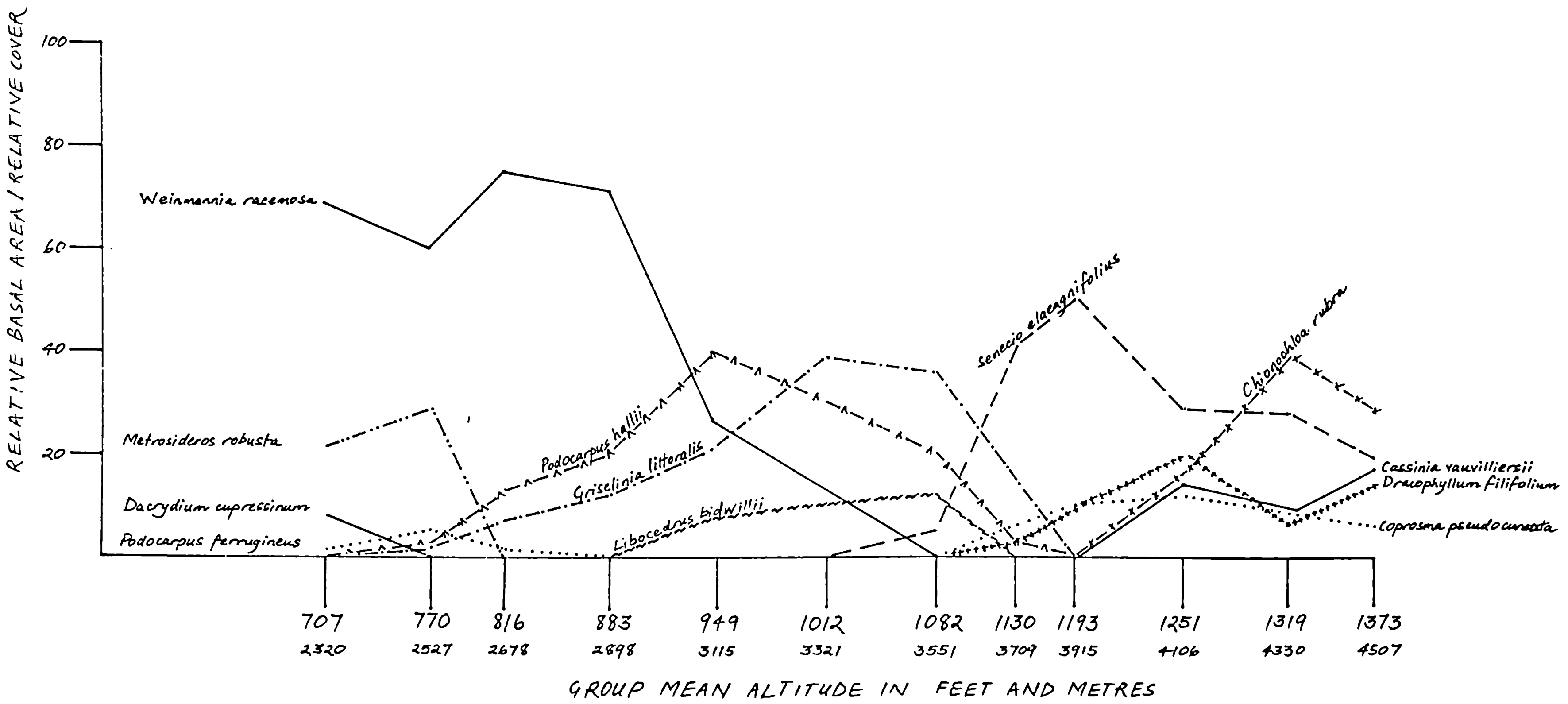
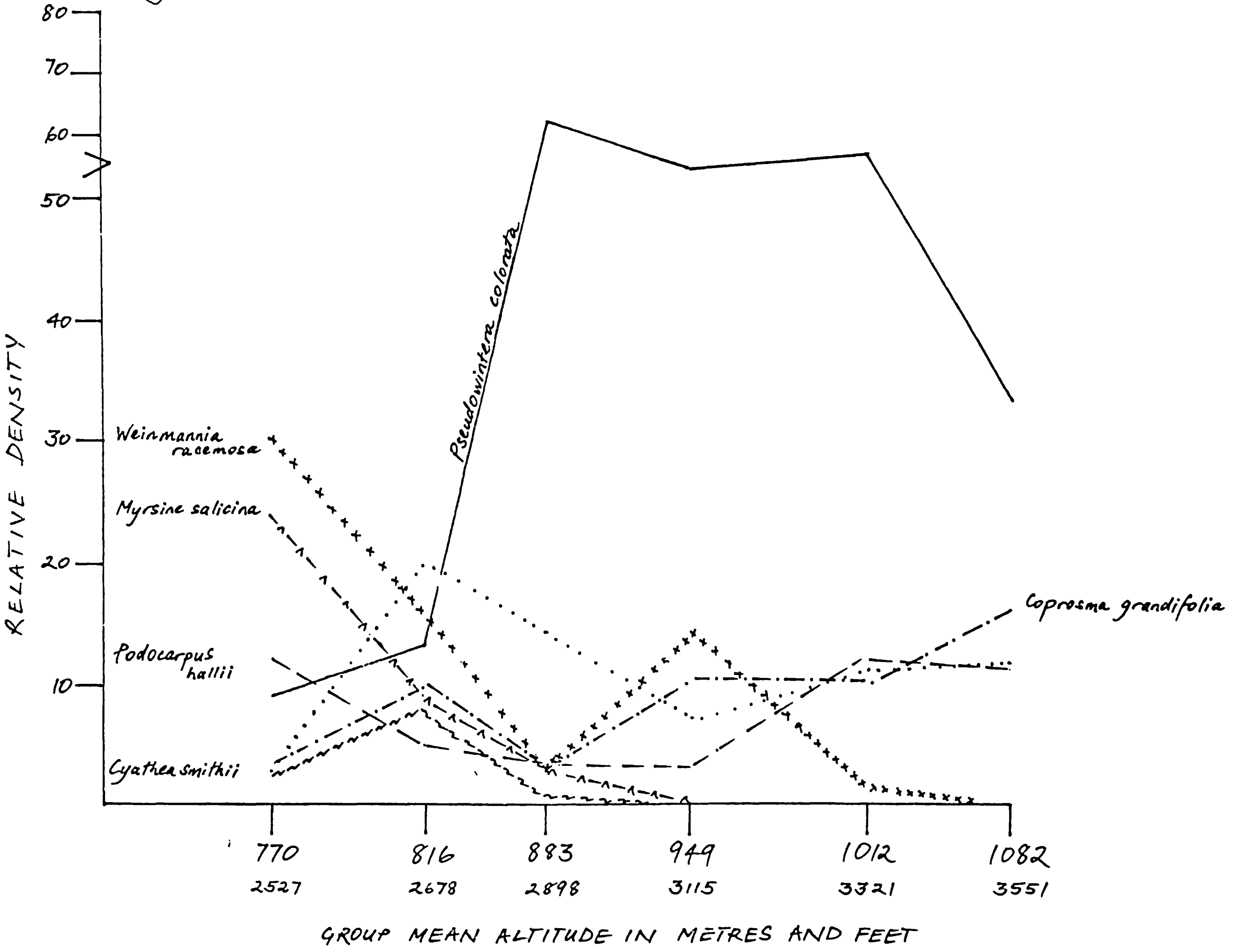


Figure 4·38 RELATIVE DENSITY OF THE MAJOR SUBCANOPY SPECIES



subcanopy. As well, the increasing importance of Hall's totara and broadleaf in the top stratum is paralleled by the increasing importance of mountain pepperwood in the subcanopy.

Leading dominants from all strata

The leading dominants from all strata for each of eleven elevation groups are presented on Table 4.8. Like the changes described already for the top and second strata there is some coincidence between species dominance in the other vegetation strata. In the ground cover for example crown fern is leading dominant where kamahi is first or second dominant in the top stratum and *Astelia* sp. unnamed is a leading dominant where broadleaf or leatherwood are first dominants in the top stratum. In the liane-epiphyte category filmy ferns become more prominent where Hall's totara and broadleaf are important associates of kamahi in the top stratum, while *Grammitis billardieri* and *Usnea* sp. are prominent where leatherwood dominates the canopy. These trends are however only general trends and for the most part there is little coincidence between the distribution of individual species in different strata.

Individual plot data analysis

Analysis carried out on the individual plot data (58 sites) collected between 450m and 1400m is presented below. This includes the 52 sites described already in the direct gradient analysis section (730m-1400m) and the 6 North Egmont sites located below 730m. Because of the

Table 4.8 Leading dominants all strata

Group mean altitude	770m	816m	883m
Top stratum	kamahi rata miro	kamahi Hall's totara broadleaf	kamahi Hall's totara broadleaf
Second stratum	kamahi toro Hall's totara	kamahi mountain pepperwood toro	mountain pepperwood *Coprosma tenuifolia* kamahi
Shrub layer	mountain pepperwood *Coprosma tenuifolia* *Pseudopanax crassifolius*	mountain pepperwood *Coprosma grandifolia* Hall's totara	mountain pepperwood *Coprosma tenuifolia* Hall's totara
Ground cover	crown fern *Astelia fragrans* forest oat grass	crown fern *Astelia fragrans* forest oat grass	crown fern mountain pepperwood *Astelia fragrans*
Lianes and epiphytes	supplejack *Astelia solandri* *Phymatosorus diversifolius*	*Astelia solandri* *Phymatosorus diversifolius* *Asplenium flaccidum*	*Phymatosorus diversifolius* *Hymenophyllum* spp. *Asplenium flaccidum*

Table 4.8 contd.

949m	1012m	1082m
Hall's totara kamahi broadleaf	broadleaf Hall's totara kamahi	broadleaf Hall's totara kaikawaka
mountain pepperwood kamahi *Coprosma grandifolia*	mountain pepperwood Hall's totara *Coprosma tenuifolia*	mountain pepperwood *Coprosma grandifolia* Hall's totara
mountain pepperwood *Coprosma tenuifolia* *Coprosma grandifolia*	mountain pepperwood Hall's totara *Coprosma tenuifolia*	mountain pepperwood Hall's totara *Coprosma tenuifolia*
mountain pepperwood *Blechnum fluviatile* forest oat grass	mountain pepperwood *Astelia* sp. unnamed *Blechnum fluviatile*	*Astelia* sp. unnamed mountain pepperwood *Polystichum vestitum*
Hymenophyllum spp. *Asplenium flaccidum* *Weymouthia mollis*	*Hymenophyllum* spp. *Asplenium flaccidum* *Phymatosorus diversifolius*	*Hymenophyllum* spp. *Asplenium flaccidum* *Rubus australis*

Table 4.8 contd.

1130m	1193m	1251m
leatherwood broadleaf *Coprosma pseudocuneata*	leatherwood inaka - *Coprosma pseudocuneata*	leatherwood inaka red tussock
Astelia sp. unnamed *Blechnum capense* agg. *Dendroligotrichum dendroides*	*Blechnum capense* agg. *Astelia* sp. unnamed *Dendroligotrichum dendroides*	*Ourisia macrophylla* var. *macrophylla* *Blechnum capense* agg. *Astelia* sp. unnamed
Hymenophyllum spp. *Grammitis billardieri* *Asplenium flaccidum*	*Grammitis billardieri* *Usnea* sp. *Hymenophyllum* spp.	*Grammitis billardieri* *Usnea* sp. *Hymenophyllum* spp.

Table 4.8 contd.

1319m	1373m
red tussock	red tussock
leatherwood	leatherwood
mountain cottonwood	mountain cottonwood
Celmisia glandulosa var. *latifolia*	*Celmisia gracilenta* var.
Ourisia macrophylla var. *macrophylla*	*Ourisia macrophylla* var. *macrophylla*
Blechnum capense agg.	*Racomitrium lanuginosum* var. *pruinosum*

range of vegetation types present the analysis which yielded the most useful summary was of the classification type. Thus the results presented below are all average linkage cluster analyses of sites and species (BMD:P1M and BMD:P2M). Figures 4.39 and 4.40 are site cluster analyses for the top and subcanopy strata and Figures 4.41 and 4.42 are species cluster analyses of the top stratum and subcanopy species respectively.

Site cluster analysis using top stratum species R.B.A./R.C.

Four major and one minor site clusters were defined by the average linkage cluster analysis (BMD:P2M) (see Figure 4.39 and Table 4.9). Cluster 1 consisting of 9 sites with a mean elevation of 1337m is a tussock-shrubland cluster in which the leading dominants on average are red tussock, *Cassinia vauvilliersii* and inaka. Cluster 2 consisting of 15 sites with a mean elevation of 1226m is a shrubland cluster in which the leading dominants on average are leatherwood, *Coprosma pseudocuneata* and inaka. Cluster 3 consists of a single site from Dawson Falls (1097m) in which the leading dominants are *Pseudopanax colensoi*, leatherwood and Hall's totara. Cluster 4 is a shrub-forest cluster consisting of 17 sites with a mean elevation of 1017m. The leading dominants on average are broadleaf, Hall's totara and kaikawaka. The fifth and final cluster is a forest cluster consisting of 16 sites with a mean elevation of 806m. The leading dominants on average are kamahi, rata and Hall's totara. Closer examination of each of the clusters reveals a

Figure 4·39 SITE CLUSTER ANALYSIS USING TOP STRATUM SPECIES RELATIVE BASAL AREA/COVER

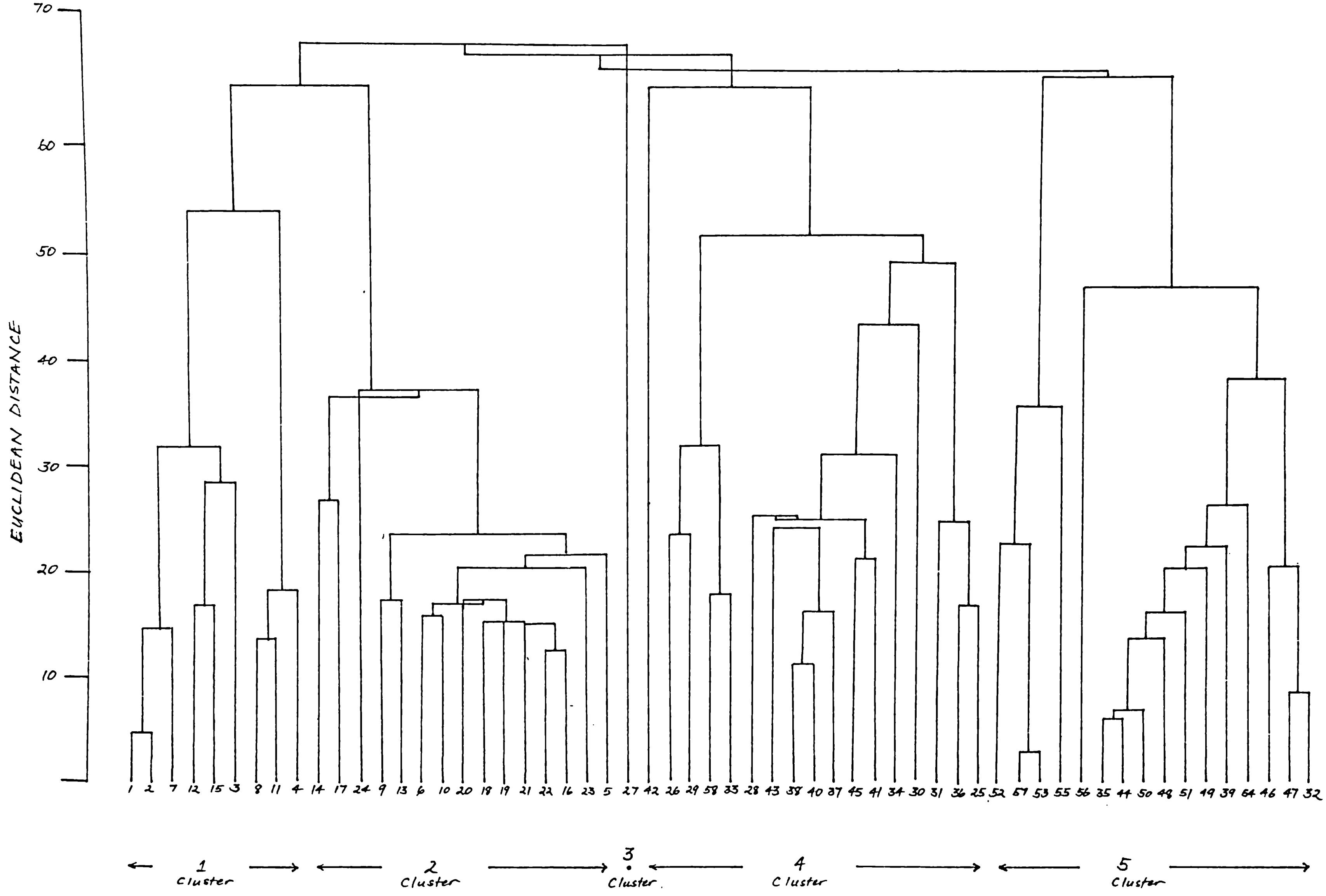


Table 4.9 Mean Relative Basal Area/Relative Cover values for top stratum dominants in the site clusters defined

	Number of sites	Lower limit in m	Mean altitude in m	Upper limit in m
Cluster 1 Tussock-shrubland				
1. *Chionochloa rubra* (44.0)				
2. *Cassinia vauvilliersii* (19.8)	9	1234	1336	1386
3. *Dracophyllum filifolium* (14.7)				
Cluster 2 Shrubland				
1. *Senecio elaeagnifolius* (50.3)				
2. *Coprosma pseudocuneata* (11.7)	15	1115	1226	1371
3. *Dracophyllum filifolium* (10.6)				
Cluster 3 Shrubland				
1. *Pseudopanax colensoi* (60.0)				
2. *Senecio elaeagnifolius* (13.0)	1	1097	1097	1097
3. *Podocarpus hallii* (11.0)				
Cluster 4 Forest-shrubland				
1. *Griselinia littoralis* (39.0)				
2. *Podocarpus hallii* (35.1)	17	917	1017	1104
3. *Libocedrus bidwillii* (11.3)				
Cluster 5 Forest				
1. *Weinmannia racemosa* (58.8)				
2. *Metrosideros robusta* (13.9)	16	480	806	1039
3. *Podocarpus hallii* (11.4)				

number of reasonably distinct subgroups in some instances.

In cluster 1 for example the subgroups relate to the relative importance of tussock, inaka and leatherwood in each of the plots with higher altitude sites tending to have a greater component of tussock or inaka.

In cluster 4 the shrub-forest cluster, the subgroups relate to major differences in the presence or amount of kaikawaka, Hall's totara and broadleaf in the top stratum. Kaikawaka for example, is absent from the sites sampled at York Road and Dawson Falls but is very important at North Egmont and Lake Dive. Kamahi was recorded at the highest elevations in the North Egmont sites and this upper altitudinal limit of kamahi in the top stratum is progressively lower in the York Road, Dawson Falls and Lake Dive locations. These major differences make the definition of vegetation types a complex problem highlighting the dangers involved in averaging the data collected from spatially separated sites into 'average' vegetation types. The major differences in species composition and in particular the possibility that the upper altitudinal limit of kamahi on the eastern side of Egmont relates directly to the past history of volcanic disturbance is examined in more detail in Chapter 5.

In cluster 5 the forest cluster, there are also relatively distinct subgroups which relate to the contribution made to the top stratum by associates of the usual leading dominant kamahi. Rata is prominent in the sites below 760m but above this altitude Hall's totara and broadleaf are the most important associates of kamahi. The site clusters obtained confirm that the major change in the vegetation is the one associated with altitude although altitude in part infers part volcanic disturbance in that sites at higher altitudes are closer to the source of the recent eruptives notably the Burrell ash and lapilli.

Site cluster analysis using subcanopy species R.D.

Two major site clusters were defined by the average linkage cluster analysis (BMD:P2M) (see Figure 4.40 and Table 4.10). Cluster 1 consisting of 17 sites with a mean elevation of 851m has on average *Coprosma grandifolia*, *Coprosma tenuifolia* and kamahi as the leading dominants. Cluster 2 consisting of 15 sites with a mean elevation of 982m has on average mountain pepperwood, Hall's totara and *Coprosma tenuifolia* as the leading dominants. A single anomalous site from North Egmont (975m) noted already in the North Egmont section and characterised by the extreme dominance of kamahi remains as a separate entity. The altitudinal gradient is not reflected as strongly as is the case for the top stratum data emphasizing once again the fact that the subcanopy is sheltered from the macroclimate of the site. Closer examination of the two major clusters reveals a number of subgroups. Cluster 1 is made up of four subgroups more closely related to the altitudinal gradient, one of the subgroups for example consisting of all the North Egmont plots below 830m. Cluster 2 can be further subdivided into 3 subgroups however all have mountain pepperwood as the leading dominant and the variation from subgroup to subgroup is related to the varying amounts of the other important species Hall's totara, *Coprosma tenuifolia* and

Figure 4.40 SITE CLUSTER ANALYSIS USING SUBCANOPY SPECIES RELATIVE DENSITY

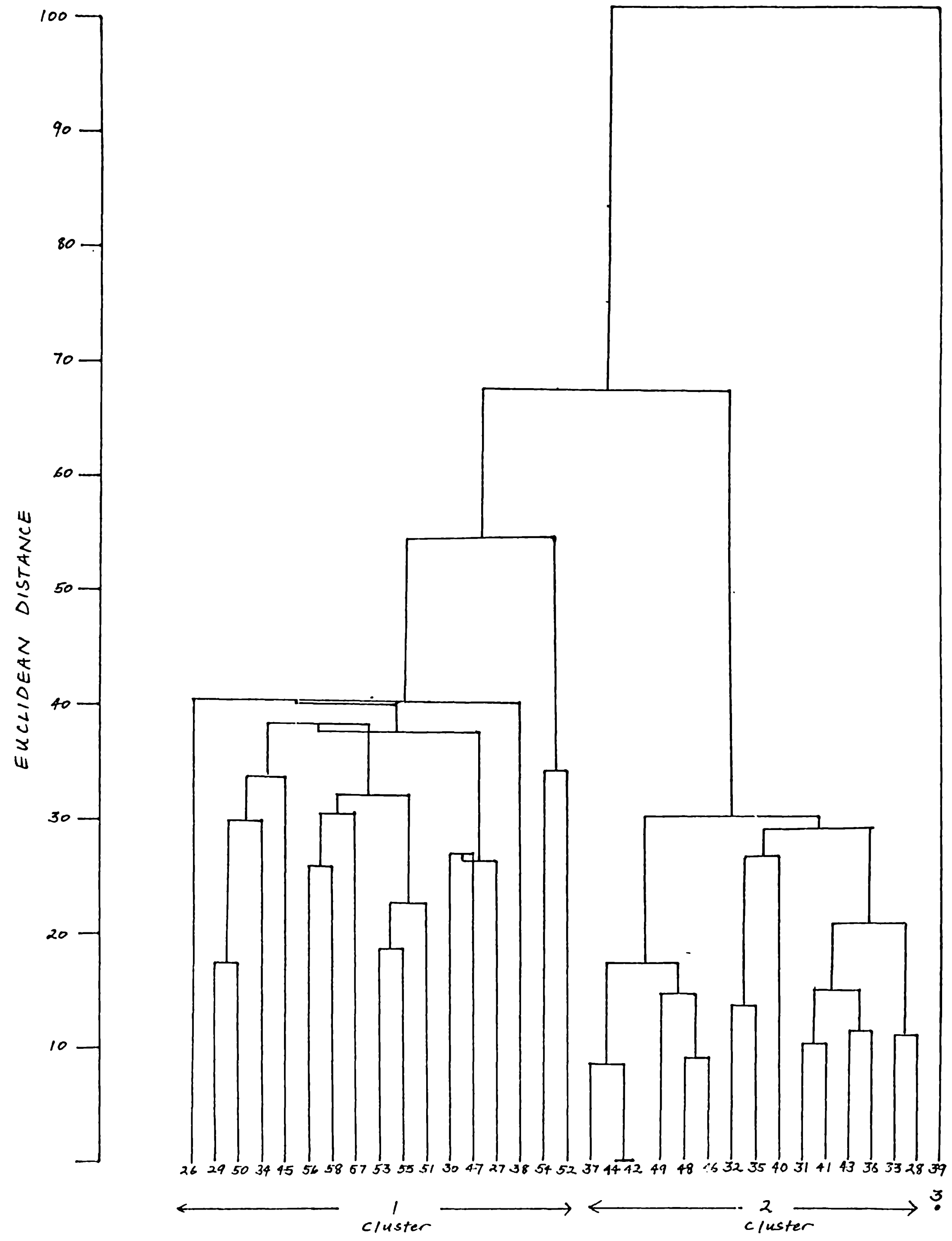


Table 4.10 Mean Relative Density values for subcanopy dominants in the site clusters defined

	Number of sites	Lower limit in m	Mean altitude in m	Upper limit in m
Cluster 1				
1. *Coprosma grandifolia* (19.6) 2. *Coprosma tenuifolia* (13.1) 3. *Weinmannia racemosa* (12.2)	17	480	851	1097
Cluster 2				
1. *Pseudowintera colorata* (73.4) 2. *Podocarpus hallii* (8.6) 3. *Coprosma tenuifolia* (4.9)	15	877	982	1088
Cluster 3				
1. *Weinmannia racemosa* (100.0)	1	975	975	975

Coprosma grandifolia. Comparison of Figures 4.39 and 4.40 shows that the two major clusters defined for the subcanopy relate to some extent to the forest-shrub and forest clusters defined for the top stratum. The forest-shrub sites above 910m in which broadleaf, Hall's totara and kaikawaka are dominant tend to be characterised by the large component of mountain pepperwood in the subcanopy. The forest sites below 1066m in which kamahi is important in the top stratum on the other hand have a greater component of other species such as *Coprosma grandifolia* and *Coprosma tenuifolia* in addition to mountain pepperwood.

Top stratum species cluster analysis

Figure 4.41 depicts the results of an average linkage cluster analysis (BMD:P1M) performed on the 25 most important top stratum species. At the 50% level of similarity 4 species clusters are apparent: Cluster 1 includes all species from leatherwood to *Pseudopanax colensoi,* cluster 2 includes all species from inaka to silver tussock, cluster 3 includes all species from Hall's totara to lancewood and cluster 4, all the species from kamahi to rata. The species cluster analysis thus supports the results obtained by the site cluster analysis as the four species clusters relate directly to the four major site clusters. Thus species cluster 1 consists of all the species important in the shrubland site cluster 2. Similarly species cluster 2 consists of all the species important in the tussock-shrubland site cluster 1 and species cluster 3 consists of all the species important in

Figure 4.41

TOP STRATUM SPECIES CLUSTER ANALYSIS

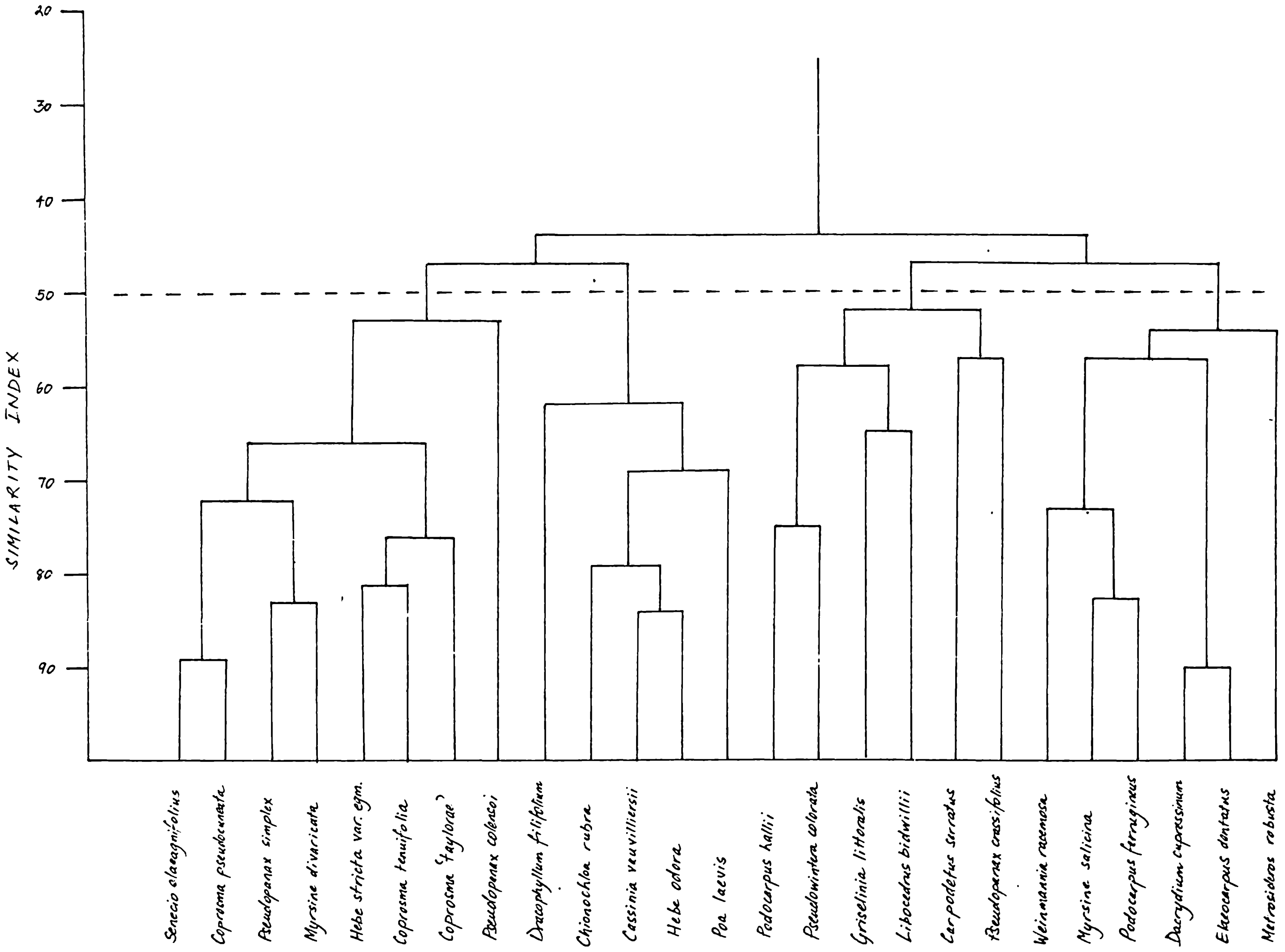
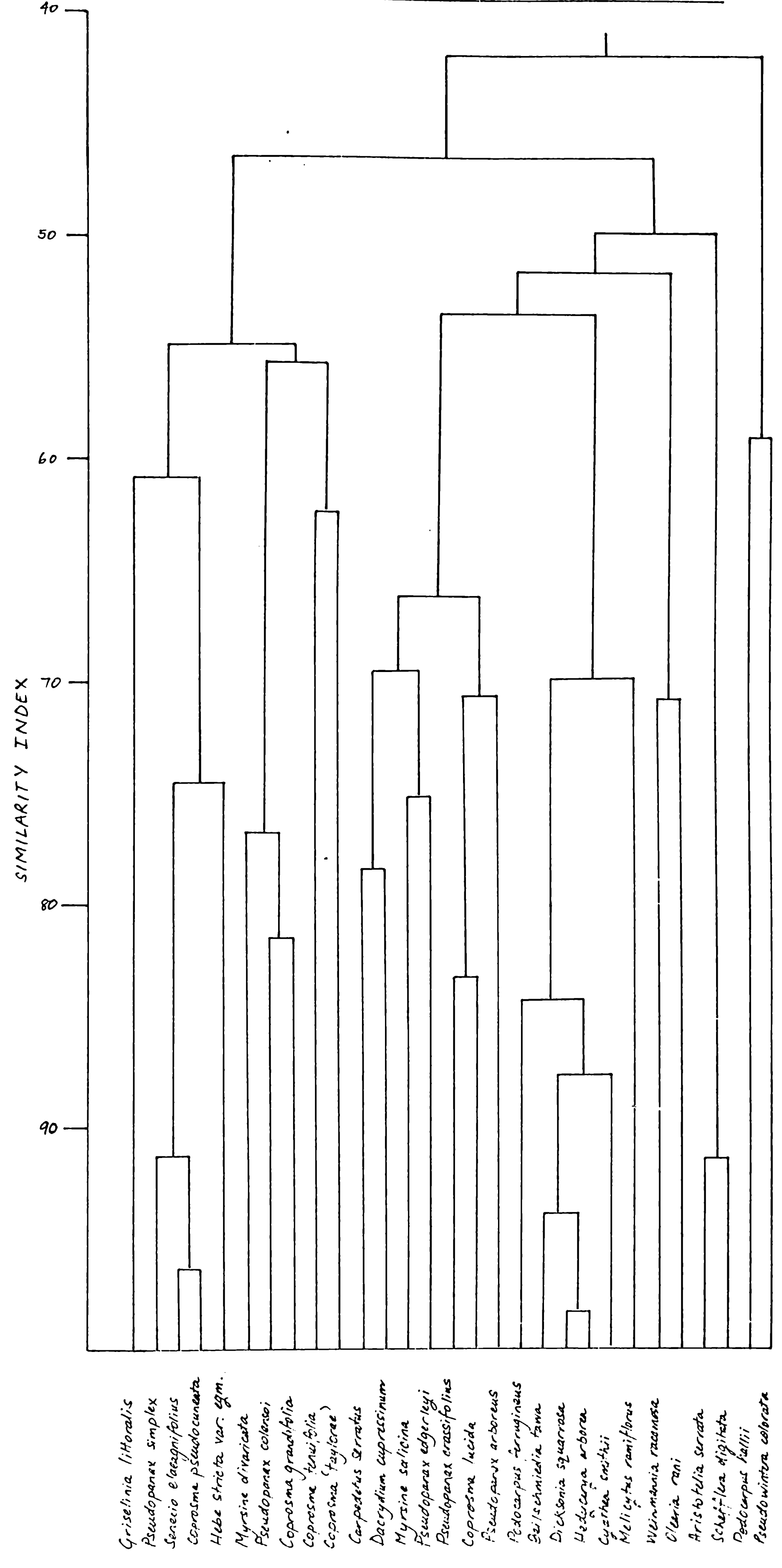


Figure 4.42 SUBCANOPY SPECIES CLUSTER ANALYSIS



the forest-shrub site cluster 4. The final species cluster 4 consists of all the species important in the forest site cluster 5.

Subcanopy species cluster analysis

Figure 4.42 depicts the results of an average linkage cluster analysis (BMD:P1M) performed on the 29 most important subcanopy species. At the 50% level of similarity three species clusters are apparent: cluster 1 includes all species from broadleaf to *Coprosma 'taylorae'*, cluster 2 includes all species from marbleleaf to pate, and cluster 3 consists of two species only, Hall's totara and mountain pepperwood. The subcanopy species clusters are difficult to relate to the subcanopy site clusters however in general subcanopy species with similar altitudinal distributions are grouped together. Thus the first cluster contains species distributed or dominant above 910m and the second cluster contains species distributed or dominant below 910m. The third cluster contains only Hall's totara and mountain pepperwood both of which become subcanopy dominants above 760m.

3. SHRUB AND TUSSOCK VEGETATION ABOVE 1220m a.s.l.

Introduction

In order to compare the shrub and tussock vegetation above 1220m on the eastern side of Mt Egmont with that already described in the Pouakai section of this chapter data collected from 26, 25m^2 plots is presented below. Most of this data results from the recoding or reorganisation of data already presented. Like the

Pouakai sample this sample of 26 plots is too small to show conclusively how the vegetation reflects major environmental factors such as slope, aspect and drainage conditions. It does however provide some basic information on the composition of the vegetation above 1220m and provides useful guidelines for a further more extensive survey proposed for 1981-1982.

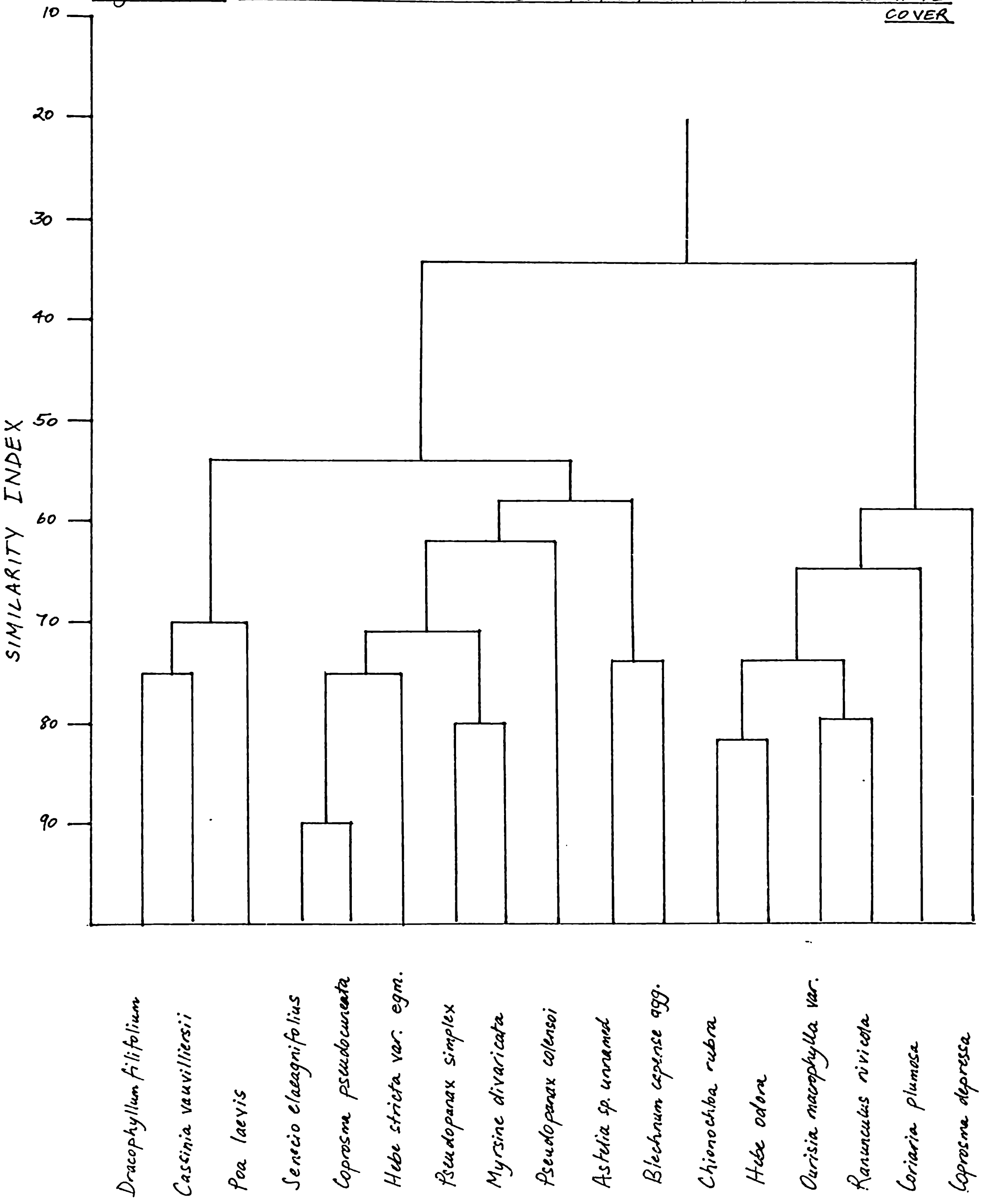
Vegetation composition

The vegetation was recorded in two categories in the same way as the Pouakai data:

1) Top stratum species (>15cm in height) forming the top layer of vegetation, and,
2) Ground cover species (<15cm in height) making up the ground cover beneath the top stratum.

Table 4.11 shows the relative frequencies of each of the species recorded in the top stratum on the basis of their presence in the 26 sites. A list of species encountered in the ground cover in the 26 sites is included in the appendices. Of the 26 sites examined red tussock was the top stratum leading dominant in 14 of the sites, leatherwood in 7 sites, inaka in 4 sites and *Cassinia vauvilliersii* in one site. The vegetation thus grades from sites in which tussocks comprise 95% of the top stratum cover through to sites in which shrubs comprise 95% of the cover. This feature of the vegetation is further amplified with reference to Figure 4.43 a dendrogram constructed from the results of an average linkage cluster analysis (BMD:P1M) of 17 of the species recorded in the top stratum. Two distinct clusters are

Figure 4.43 SPECIES CLUSTER ANALYSIS USING TOP STRATUM SPECIES RELATIVE COVER



apparent at the 50% level of similarity. Cluster one includes inaka, *Cassinia vauvilliersii*, silver tussock, leatherwood, *Coprosma pseudocuneata*, *Hebe stricta* var. *egmontiana*, *Pseudopanax simplex*, *Myrsine divaricata*, *Pseudopanax colensoi*, *Astelia* sp. unnamed and *Blechnum capense* agg. Cluster two includes red tussock, *Hebe odora*, *Ourisia macrophylla* var. *macrophylla*, *Ranunculus nivicola*, *Coriaria plumosa* and *Coprosma depressa*. The two species clusters recognised at the 50% level of similarity like those described already for the Pouakai data emphasize the fact that the sites sampled may also be categorised into two relatively distinct groups depending on the relative importance of the red tussock component in relation to the shrub component particularly leatherwood and inaka. As a general rule red tussock becomes more important than leatherwood or inaka at higher altitudes but like the situation described already for Pouakai other factors such as drainage and aspect are important. Where drainage is poor red tussock replaces the shrubs at lower altitudes and shrubs are more prominent at higher altitudes on sites with a northerly aspect. Major differences in top stratum composition between the Pouakai and Egmont locations are evident for example, the importance of *Schoenus pauciflorus* in the Pouakai location and its absence from Egmont. Conversely *Coriaria plumosa* is present in the Egmont sites and absent from the Pouakai sites. These differences and possible reasons for them are discussed in Chapter 5.

Table 4.11 ____ frequencies of top stratum species in shrub and tussock vegetation on the eastern side of Mt Egmont

Chionochloa rubra	96.1
Hebe odora	84.6
Dracophyllum filifolium	69.2
Senecio elaeagnifolius	69.2
Cassinia vauvilliersii	69.2
Coprosma pseudocuneata	57.7
Ranunculus nivicola	46.1
Pseudopanax colensoi	38.5
Ourisia macrophylla var. *macrophylla*	38.5
Poa laevis	38.5
Hebe stricta var. *egmontiana*	23.1
Pseudopanax simplex	19.2
Coriaria plumosa	19.2
Myrsine divaricata	15.4
Astelia sp. unnamed	15.4
Blechnum capense agg.	15.4
Coprosma depressa	11.5
Hierochloe redolens	7.7
Coprosma 'taylorae'	3.8
Olearia arborescens	3.8
Gahnia procera	3.8
Aciphylla squarrosa	3.8
Pentachondra pumila	3.8

4. MANGAHUME HERBFIELD - a moisture gradient

Introduction

One of the obvious environmental gradients in the herbfield is the moisture gradient present across small stream channels or on the margins of small pools of permanent water. Many of the stream channels are completely covered with herbfield vegetation the composition of which reflects the range of moisture status from sites which are permanently waterlogged to sites which are well drained. In order to determine the changes in composition along such a gradient a stream channel near the Mangahume Hut was sampled using the point cover method. Fourteen two metre transects were located parallel to the stream bed (see Figure 4.44A) and the vegetation at each 5cm interval along each of the transects was recorded. The stream channel profile rises gradually (see Figure 4.44B) from the stream bed some 90cms. Pools of water were still present in the stream bed during January 1978, one of the driest summers on record. The moisture status of each of the sites is directly related to the depth of water table which becomes closer to the surface nearer to the stream bed. It was expected therefore that species most adapted to waterlogged conditions would be dominant towards the centre of the stream channel while those more adapted to freely drained sites would be dominant at the edge of the stream channel.

Vegetation composition

Some of the vegetation data obtained is presented

Figure 4·44A SAMPLING METHOD

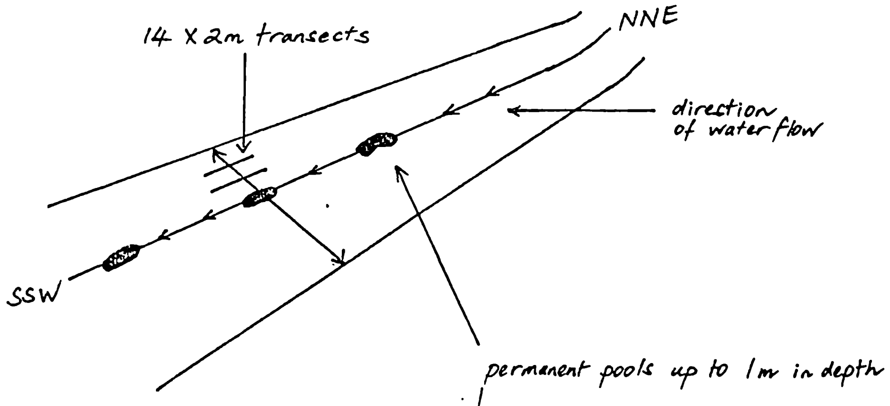
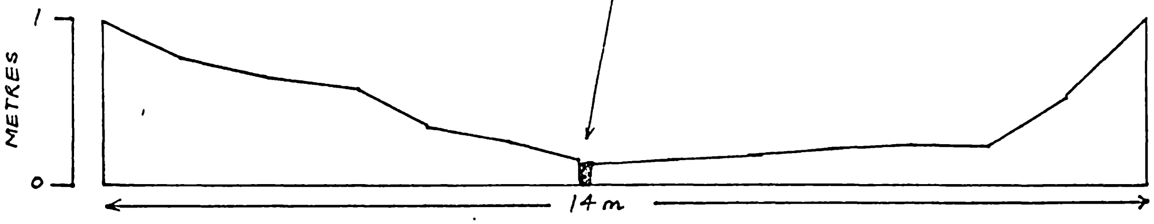
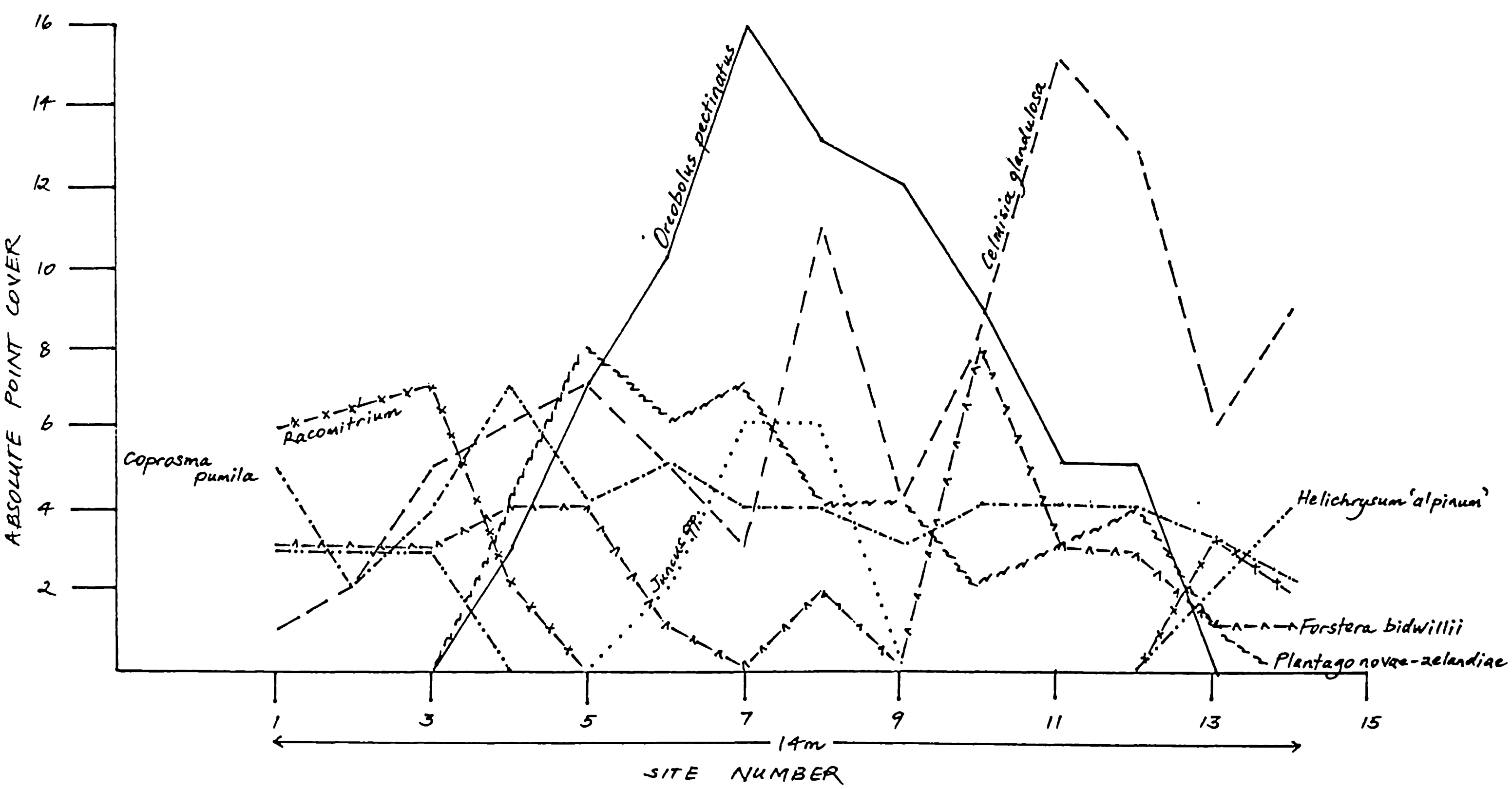


Figure 4·44B STREAM CHANNEL PROFILE



on Figure 4.45 which shows the changes in composition across the stream channel. *Juncus* spp. (*novae-zelandiae*, *pusillus*) are confined to sites 5, 6 and 7 in or near the permanent pools of water. *Oreobolus pectinatus* and *Plantago novae-zelandiae* reach their peak representation near the permanent pools of water but extend out on to the stream channel as well. *Forstera bidwillii* var. *densifolia* is most important at the sites midway between the stream bed and the edge of the stream channel. *Celmisia glandulosa* var. *latifolia* and *Coprosma pumila* fluctuate in importance throughout the sites but both reach their maximum representation midway between the stream bed and the edge of the stream channel. *Poa colensoi* and *Anisotome aromatica* fluctuate in importance on the stream channel sites but are absent from the stream bed. Moss (*Racomitrium lanuginosum* var. *pruinosum*) and everlasting daisy distribute mainly on the low hummocks at the edge of the stream channel. Some species of lesser importance, although not depicted on Figure 4.45, exhibit similar distributions to the major species. *Pentachondra pumila*, *Gaultheria* sp. unnamed and *Uncinia* sp. occupy sites similar to *Racomitrium lanuginosum* var. *pruinosum* and everlasting daisy. Species recorded in too few sites to characterise their distributions included: *Oxalis lactea*, *Celmisia gracilenta* var., *Lycopodium fastigiatum*, *Ourisia macrophylla* var. *macrophylla*, *Drapetes dieffenbachii*, *Hebe odora*, *Aporostylis bifolia*, *Euphrasia cuneata* and a *Luzula* sp.

Figure 4.45 SPECIES COMPOSITION ACROSS A STREAM CHANNEL AT MANGAHUME



5. POTAEMA BOG - a moisture gradient

Introduction

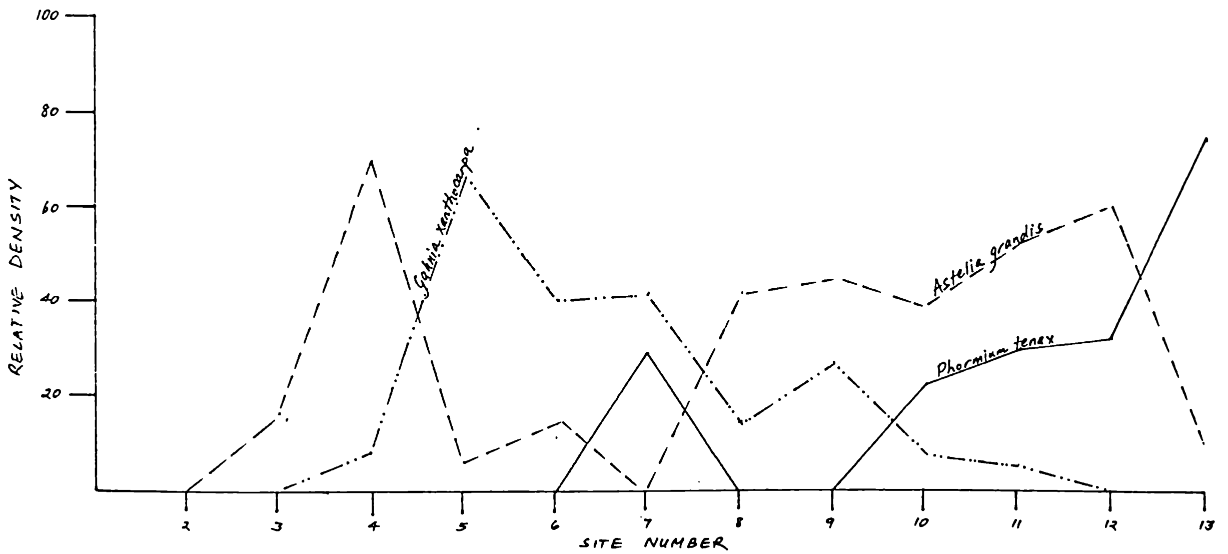
The Potaema Bog is located on the Stratford side of Egmont some 3km inside the national park boundary at an altitude of 670m. Only a small bog approximately .5km at its widest point, Potaema Bog is dominated for the most part by a mixture of rushes, sedges, herbs and moss. Across the margin of the bog the vegetation changes from tall podocarp hardwood forest to a low forest dominated by kamahi to a shrubland dominated by manuka and flax and finally to rush-sedge-herb/mossland within as short a distance as 100 metres in places. In order to examine the changes in vegetation composition and structure associated with this moisture gradient, 13 12.6m^2 plots were located systematically at 10 metre intervals across a part of the bog margin and the vegetation was recorded in three strata: top stratum, second stratum and ground cover stratum.

Vegetation composition

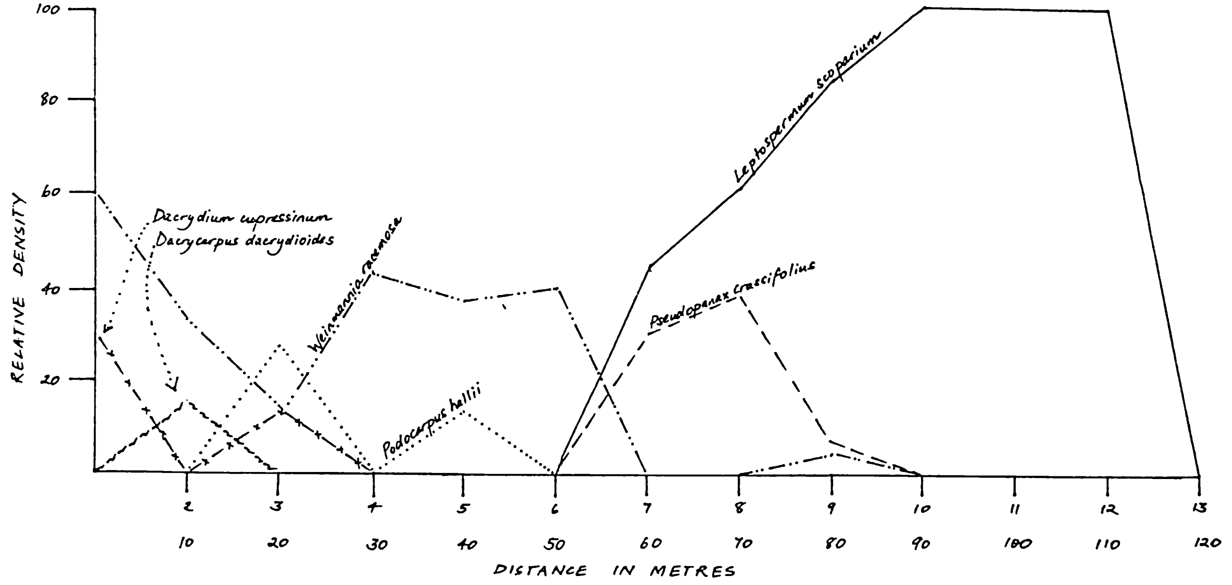
Figure 4.46 shows the changes in composition of the major species for the top and second stratum. In the top stratum kamahi forest at first with a component of rimu and then with Hall's totara gives way to manuka shrubland and finally to vegetation dominated by flax. In the second stratum *Gahnia xanthocarpa* one of the leading dominants beneath the kamahi gradually declines in importance closer to the bog centre. *Astelia grandis* fluctuates in importance at first but eventually replaces *Gahnia xanthocarpa* as the leading dominant. Flax first

Figure 4.46 SPECIES COMPOSITION ACROSS A MARGIN OF THE POTAEMA BOG

SECOND STRATUM MAJOR SPECIES



TOP STRATUM MAJOR SPECIES



recorded beneath the kamahi canopy also fluctuates in importance at first but eventually becomes the leading dominant in site 13, the site closest to the bog centre sampled. *Blechnum capense* agg. was recorded as dominant ground cover throughout most of the transect although mosses, liverworts and the small creeping herbs *Pratia angulata* and *Gonocarpus aggregatum* become increasingly important on the wetter sites closer to the centre of the bog. In fact pools of water near some of those sites supported the aquatic species *Potamogeton suboblongus*. As well, *Juncus* spp. principally *Juncus gregiflorus* and *Scirpus* sp. were recorded in the ground cover of sites 10-13. Major structural changes also take place in the vegetation sampled along the transect. The maximum height of the vegetation for example decreases markedly from being 20m at site 1, 9.14m at site 4, 5.48m at site 6, 3.96m at site 9, and less than 2m in the flax dominated site 13. The total number of vascular species recorded at each site ($12.5m^2$) also declines marginally from a maximum of 34 at site 1 to 2 at site 13. The numbers of vascular lianes and epiphyte species in particular declines from a maximum of 8 species at site 3 to 0 from site 7 onwards. The changes in vegetation composition and structure along this moisture gradient at the Potaema Bog in part resemble the changes already described for the various altitudinal gradients sampled within the national park. Floristically, for example, the kamahi dominated forest from sites 2-5 fringing the Potaema Bog has similarities to the montane forest dominated by kamahi above 760m for top stratum associates of the kamahi include toro, broadleaf, Hall's totara and *Pseudopanax simplex*. As well, *Libertia pulchella*, *Coprosma tenuifolia* and *Pseudopanax anomalus* species also more prominent above 760m are present in the ground cover. Structurally the change from a tall forest to shrubland and finally to a vegetation dominated by flax also parallels the changes encountered along altitudinal gradients. The main factor responsible for the changes in vegetation composition and structure across the bog is obviously the deterioration in soil drainage and the subsequent problems of oxygenation of plant root systems. This deterioration in drainage conditions thus parallels the general deterioration of climate associated with increasing altitude in that large plants are gradually replaced by smaller ones along the environmental gradient. Potaema Bog is also of interest because of the distinctive combinations of species found there and because it is floristically much richer than most equivalent sized areas. This is the result of the diversity of plant habitats offered in particular by the bog margins. A range of species normally found much higher up the mountainside (see previous descriptions of altitudinal gradients) for example kaikawaka, *Olearia arborescens*, inaka and *Cassinia vauvilliersii* may be found growing in close proximity to kahikatea and all the species common in the kamahi dominated lower altitude forest. The poorly drained conditions provide a 'competitive release' for the normally higher altitude species. Nearer the centre of the bog a diverse range of rushes, sedges, herbs and ground orchids, and even true aquatic species such as *Potamogeton suboblongus* add to the floristic richness of the area even further. Another feature of note at the Potaema Bog is the large numbers of rimu seedlings, saplings and poles around the bog margins particularly where kamahi no longer forms such a closed canopy. Another species prominent on these bog margins is *Cyathodes fasciculata*. In both instances it appears that the ability to tolerate the poor drainage conditions enables rimu and *Cyathodes fasciculata* to enjoy light conditions more suited to their success. A complete list of the species recorded in the Potaema Bog and the adjacent bogs is found in Appendix 6. A number of the species recorded here were not found anywhere else within the national park. Examples of species noted as present only in the Potaema Bog and the adjacent bogs are: *Gleichenia dicarpa*, *Olearia virgata*, *Neomyrtus peduculata* and *Lepidosperma australe*.

6. SLOPE, STABILITY AND HERBFIELD COMPOSITION

Introduction

Much of the herbfield vegetation at North Egmont reflects the effects of continual movement erosion and undermining of the substrate on which the plants grow. Steep slopes, high rainfall and the freezing and thawing of snow and ice are all factors. In order to determine the vegetation composition over the range of conditions from stable moss-herbfield through to the extremes of unstable substrate a range of sites in the vicinity of Humphries Castle were examined and data was collected from six representative sites each $1.5m^2$. Percentage point cover (144 points) was measured to compare differences in vegetation composition and cover at each of these six sites. The data obtained is summarised on Table 4.12.

Vegetation composition

Herbfield cover ranged from 6% on sites of extreme instability (lapilli-gravel slides) through to 93% in stable moss-herbfield (large andesite boulders). The stable sites are characterised by a predominance of moss, mainly *Racomitrium lanuginosum* var. *pruinosum* and *Racomitrium crispulum*. Associated with the mosses are a range of herbs and grasses particularly *Celmisia gracilenta* var., *Celmisia glandulosa* var. *latifolia*, *Poa colensoi* and *Forstera bidwillii* var. *densifolia*. Intermediate sites have less moss and herbs particularly everlasting daisy and *Forstera bidwillii* var. *densifolia* are more prominent. On the most unstable sites where there is a slow but continuous creep of lapilli and gravel three species in particular contribute to the extremely small component of vegetation cover. These are everlasting daisy, *Epilobium glabellum* and *Montia* sp. In some instances *Montia* sp. is the only vascular plant species present. Seventeen species per $1.5m^2$ were recorded in the most stable site sampled while two species were recorded in the most unstable site sampled.

Table 4.12 Herbfield composition and cover of six sites near Humphries Castle

Site	1	2	3	4	5	6
Scoria, lapilli, gravel	51	3	36	51	4	96
Ash	9	+		6		
Boulders	6	4	6	16	8	
Racomitrium crispulum	4	27	3	1	26	
Helichrysum sp. unnamed	13	+	15	7	3	
Poa colensoi	8	5	5	1	3	
Celmisia gracilenta var.	2	7	11	1	2	
Racomitrium lanuginosum var. *pruinosum*	+	20	+	+	38	
Forstera bidwillii var. *densifolia*	3	7	3		1	
Anisotome aromatica	+	4	+	1	2	
Celmisia glandulosa var. *latifolia*	+	15	7	2	6	
Drapetes dieffenbachii		1	+			
Litter		3	1	3	1	
Luzula sp.	2	+	+	3	1	
Lycopodium fastigiatum		+		+		
Gaultheria sp. unnamed		+		3	2	
Oreomyrrhis colensoi		+	+	2	+	
Coprosma pumila			9		1	
Poa laevis			+			
Wahlenbergia albomarginata	+	+	+	+	+	
Euphrasia cuneata		+				
Polytrichum sp.	+	+	+	+	+	
Raoulia tenuicaulis		+	+			
Montia sp.				+		2
Epilobium glabellum						2
Number of species	11	17	16	15	14	2
Total vegetation cover %	34	93	40	27	88	4

7. SHRUB RINGS ON THE RAZORBACK

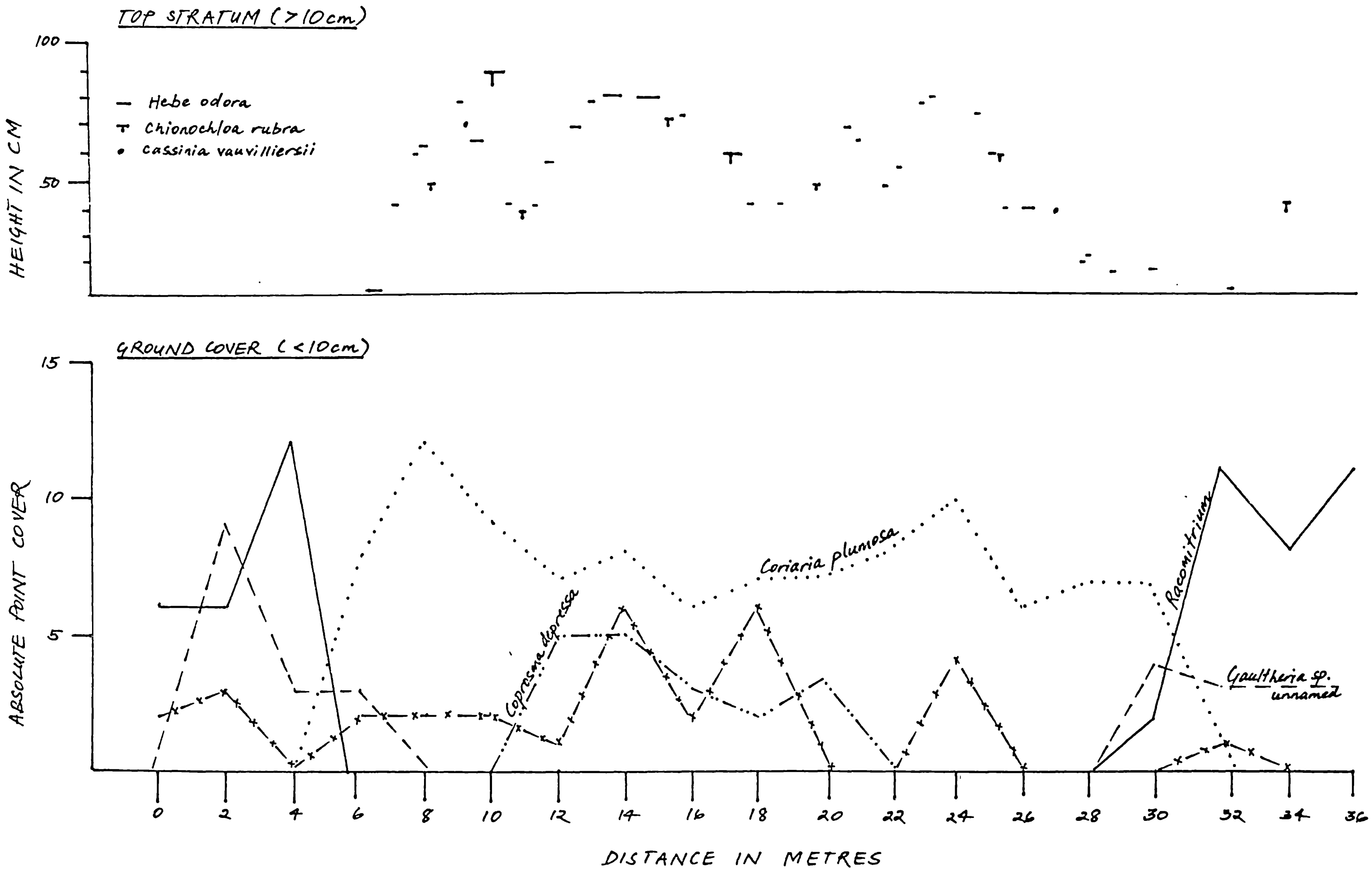
Introduction

Circular rings of plant growth are a feature of a number of places on Mt Egmont. The most simple rings are those composed entirely or predominantly of single species for example patches of *Raoulia tenuicaulis*, everlasting daisy or *Coriaria* spp. and these are widespread particularly on disturbed sites such as slip faces. More complex rings however are also found in many places on Egmont. On the Carrington Ridge and Puniho Hill where a covering of *Racomitrium* moss at lower than normal altitudes attests to past volcanic and debris flow disturbance there are rings of *Coriaria plumosa* surrounding patches of *Chionochloa rubra*, while on old slip faces on the Razorback are shrub rings of *Hebe odora* also associated with *Coriaria plumosa*.

Vegetation composition

In order to examine in more detail the composition of one of these shrub rings a transect 36m in length across a shrub ring was employed to measure the vegetation composition in two strata ground cover (<10cm) and top stratum (>10cm). The ground cover composition was sampled (point cover) every two metres along the transect and the top stratum species cover (span) and height along the same transect was determined. The results of this sampling are summarised on Figure 4.47 which shows the distributions of all top stratum species along the transect, as well as, the major ground cover species. Two zones of *Hebe odora* dominance are

Figure 4·47 TRANSECT ACROSS A SHRUB RING ON THE RAZORBACK



apparent on Figure 4.47 where the transect crosses the two sides of the shrub ring. These two zones of *Hebe odora* dominance are both within the area in which *Coriaria plumosa* is the dominant ground cover. Beyond the margins of the ring growth there is no top stratum only a ground cover layer dominated by *Racomitrium lanuginosum* var. *pruinosum* and *Gaultheria* sp. unnamed. The transect data and observations of a number of ring growths at different stages of development on Egmont enables some explanation of these vegetation patterns. Inevitably the simple ring growths are found on relatively bare surfaces such as slip faces and the circular growth is the result of vegetation spread by species such as *Coriaria pteridioides*, *Coriaria plumosa*, everlasting daisy and *Raoulia* spp. *Coriaria* spp. are well documented as nitrogen-fixers (see Silvester, 1978) and thus an increasing range of species become associated with the coriaria rings as the soil conditions improve. This is not purely the result of the nitrogen availability but also because of other effects such as moisture retention, shading and additions of litter. The vegetative spread and annual die-back of the *Coriaria* spp. combined with the eventual loss of vigour at the point of original growth, permits a range of species to become established behind the advancing front of growth. Great variation can be observed in the composition of species which eventually occupy this space depending on a range of factors including the stage of development of the growth ring, the altitude at which it is located. Thus on Puniho

Hill and Carrington Ridge, red tussock dominates the centre of the ring growths although a range of herbs and grasses occupy spaces between the tussocks. In the ring growth sampled on the Razorback however, *Celmisia gracilenta* var. and *Coprosma depressa* were important associates of the *Coriaria plumosa* still growing in the centre of the ring. The widespread presence of growth rings in which red tussock and *Coriaria* spp. are associates particularly at the upper limit of the tussock dominated vegetation on the eastern side of Egmont is evidence of a continuing process of vegetation development. In the absence of disturbance (volcanic, erosional, etc.) these sites are capable of supporting a much greater and more advanced vegetation cover.

8. KAIKAWAKA AND HALL'S TOTARA STANDS NEAR LAKE DIVE

Kaikawaka

Kaikawaka is widespread near Lake Dive between 950m and 1100m and a few isolated individuals occur down to 450m on the banks of the Punehu Stream. Transport of seed down the stream and the presence of stream bank sites free from the competition of the lower altitude forest trees explain this latter feature of kaikawaka distribution. In sites examined at 960m and 1036m on the Lake Dive Track Ridge, kaikawaka is the dominant top stratum species and at 960m in particular is a striking feature of the vegetation. Similar sized kaikawaka trunks are distributed throughout the forest giving the appearance of a tended woodlot. Actual densities of kaikawaka at 960m range from 3-5 per 100m^2

and basal areas from 5051cm^2 - 7062cm^2 per 100m^2. The height of the top stratum individuals ranges from 10m to 14m and the d.b.h. of live individuals from 21-52cm.

Associates of the kaikawaka in the top stratum are Hall's totara and broadleaf which may be independent of, or epiphytic on, kaikawaka or Hall's totara. In the subcanopy Hall's totara is dominant, actual densities ranging from 3-6 per 100m^2. Mountain pepperwood and marbleleaf are also important components of the subcanopy. The shrub layer is dominated by mountain pepperwood and *Coprosma tenuifolia* is prominent. Forest oat grass is clearly dominant in the ground cover layer and mountain pepperwood and *Blechnum fluviatile* are second and third ranked in order of cover contribution.

The fact that kaikawaka belong to an even-aged population is supported by the d.b.h. data collected in a total area of 900m^2 and summarised on Table 4.13 below. Twenty of the total 23 live kaikawaka individuals recorded had d.b.h.'s between 30 and 60cm and of these 12 had d.b.h.'s between 40 and 50cm. An extensive search of the area failed to reveal any seedlings of kaikawaka, in fact the smallest individual observed in the vicinity was a 15cm d.b.h. dead understorey specimen. A few very large kaikawaka (>1m d.b.h.) were observed however probably less than 5% of the total population in the vicinity of the 960m site. A core taken from a 41cm d.b.h. individual showed that it was at least 315 years old (M.R. Boase pers. comm.) so that the much larger individuals (>1m d.b.h.) presumably belong to a much older age group (>350 years, i.e. predating the Burrell eruption) and are possibly the parents of the kaikawaka now present. Although failing to regenerate, the kaikawaka on the Lake Dive Track Ridge is at least healthy in appearance and seed production was observed on several individuals in June 1976.

In sharp contrast to the kaikawaka stands on the Lake Dive Track Ridge are the relict stands present on the Fanthams Peak side of Lake Dive. Here a very large area extending from the lake margins (920m) up to about 1120m is dominated by broadleaf which is epiphytic on the dead and decaying trunks of kaikawaka. Hall's totara is an important associate although many individuals of this species are also dead. The kaikawaka trees appear to have died out more or less simultaneously. Invariably broadleaf, which had probably already established on kaikawaka in some instances, developed its own supporting stems to remain as the top stratum dominant.

Hall's totara

Hall's totara is distributed between 750m and 1175m on the Lake Dive Track Ridge. It is most important in and around the site examined at 944m where it dominates the top stratum. Densities of live top stratum Hall's totara reach up to 5 per 100m^2 and basal areas up to 11,700cm^2 per 100m^2 in this location. Some of the tallest individuals exceed 14m in height. Beyond the site at 944m Hall's totara is overshadowed in importance in the top stratum by kaikawaka and broadleaf and the bulk of the population consists of subcanopy individuals.

Table 4.13 summarises the size class structure of Hall's totara in eight sites between 800m and 1100m a total sample area of 1525m^2. Over half of the Hall's totara (42/72 = 58%) range from 10-40cm d.b.h. emphasising the numerical importance of the smaller subcanopy individuals in this location. Scattered throughout are a number of much larger individuals >50cm d.b.h. some of which are dead. These individuals probably represent a much older population of Hall's totara which has almost completely died out. Whether or not the Hall's totara presently in the subcanopy will eventually reach the top stratum and replace the obviously older kaikawaka remains to be seen. Opossum damage to the Hall's totara is not as marked at this location as in other places at east Egmont but many of the larger Hall's totara already support epiphytic broadleaf which could hinder their success in the top stratum. Whatever the outcome, Hall's totara, in contrast to kaikawaka, is regenerating effectively in that seedlings are widespread and abundant in many areas between 750m and 1100m. This includes the site at 960m where kaikawaka and broadleaf are the leading top stratum species. The present day numbers of individuals <10cm d.b.h. (19/72 = 26%) indicate that most of the seedlings do not survive however even if the present subcanopy Hall's totara fail to reach the top stratum sufficient individuals will be present in the future to maintain and eventually increase the importance of Hall's totara on the Lake Dive Track Ridge.

Table 4.13 Kaikawaka and Hall's totara size class (d.b.h.) structure

Kaikawaka 960m-1036m (total area sampled 900m^2)

D.B.H.		Live	Dead
1	2- 9.9		
2	10-19.9		1
3	20-29.9	2	1
4	30-39.9	4	1
5	40-49.9	12	
6	50-59.9	4	1
7	60-69.9	1	
8	70-79.9		
		23	4

Hall's totara 800m-1100m (total area sampled 1525m^2)

D.B.H.		Live	Dead
1	2- 9.9	19	
2	10-19.9	15	4
3	20-29.9	14	3
4	30-39.9	13	1
5	40-49.9	5	3
6	50-59.9	3	
7	60-69.9	2	
8	70-79.9	1	1
9	80-89.9		1
		72	13

D. VEGETATION PHYSIOGNOMY AND STRUCTURE IN EGMONT NATIONAL PARK

Introduction

Just as the vegetation changes floristically with increasing altitude so too does its physiognomy and structure (height, stature, stratification and growth form). Physiognomic and structural change is harder to quantify than floristic change because such a range of features change altitudinally all altering the total character of the vegetation. As well, the fact that 'physiognomy depends in the last instance... on floristic composition' (Van Steenis, 1972) makes it impossible to consider these changes apparent with increasing altitude in isolation from the changes in composition already described.

In order to detail some of these physiognomic and structural changes forest data collected from twenty six sites (North Egmont 13 sites, Henry Peak Track Ridge 6 sites, and Mander's Spur Track Ridge 7 sites), is presented below. As well, the physiognomic and structural changes which occur in the shrub, tussock and herbfield vegetation are described using data collected from 13 sites in the Punehu-Skeet Ridge location. All of these sites have already been used for the floristic analyses in earlier sections of this chapter and so actual sampling location, altitude etc., can be found there.

1. FOREST VEGETATION

Eleven variables were used to quantify the physiognomic and structural changes in the forest vegetation along the altitudinal gradient. These were:

1) Top stratum mean basal area in cm^2.
2) Total top stratum basal area per $100m^2$ (sum of top stratum species basal areas) in m^2.
3) Number of top stratum stems per $100m^2$.
4) Maximum top stratum height in metres.
5) Top stratum volume (total basal area (2) x maximum top stratum height (4)) in m^3.
6) Subcanopy mean basal area in cm^2.
7) Number of subcanopy stems per $100m^2$.
8) Number of shrub layer stems per $100m^2$.
9) Total number of stems per $100m^2$ (top stratum + subcanopy + shrub layer).
10) Total basal area per $100m^2$ (top stratum + subcanopy) in m^2.
11) Mean basal area (top stratum + subcanopy) in cm^2.

North Egmont

Data for the North Egmont location is presented separately on Table 4.14 and depicted in conjunction with data from the other two locations on Figures 4.48-4.58.

Top stratum mean basal area (Figure 4.48) decreases from the maximum $7292cm^2$ recorded at site 2 to $338cm^2$ at site 13. Equivalent mean d.b.h. values for these basal areas are 96.3cm and 20.7cm respectively. The line representing the decline in mean basal area is 'stepped' in appearance, a feature which relates in part to the dominance of particular species along the altitudinal gradient. Thus at site 4 for example the absence of rimu and rata results in a major decline in mean basal area

Table 4.14 Forest physiognomy and structure; North Egmont

Site No.	Altitude in metres	Top stratum mean basal area in cm^2 1	Top stratum total basal area per $100m^2$ in m^2 2	Top stratum number of stems per $100m^2$ 3	Top stratum maximum height in m 4	Top stratum volume per $100m^2$ in m^3 5
1	480	6060	1.21	2.0	22.0	26.62
2	550	7292	0.97	1.3	24.0	23.28
3	590	6773	1.81	2.7	18.0	32.58
4	680	1680	0.98	5.8	20.0	19.60
5	750	2083	1.42	6.8	17.0	24.14
6	817	823	0.86	10.5	15.0	12.90
7	873	973	0.88	9.0	13.5	11.88
8	921	901	1.10	12.2	13.5	11.00
9	975	1097	1.36	12.4	10.0	13.60
10	1007	568	1.02	8.0	8.5	8.67
11	1039	404	1.09	12.0	8.0	8.72
12	1066	376	0.85	22.7	6.5	5.52
13	1097	338	0.88	26.0	5.0	4.40

Subcanopy mean basal area in cm^2 6	Subcanopy number of stems per 100m^2 7	Shrub layer number of stems per 100m^2 8	Total number of stems per 100m^2 9	Total basal area per 100m^2 in m^2 10	Mean basal area in cm^2 11
557	13.7	20.2	35.9	1.97	1260
956	11.8	15.8	28.9	2.10	1597
617	13.2	12.5	28.4	2.62	1654
297	15.8	30.7	52.3	1.45	669
319	14.8	49.0	70.6	1.90	875
232	14.5	52.7	76.9	1.20	497
49	19.7	20.2	48.9	0.97	338
83	26.7	30.2	69.1	1.33	340
91	0.4	24.9	37.7	0.61	1063
123	23.5	20.4	51.9	1.31	721
105	14.7	23.1	49.8	1.25	561
36	24.0	23.3	70.0	0.94	201
136	31.0	45.0	102.0	1.23	216

from 6773cm^2 (92.8cm d.b.h.) in site 3 to 1680cm^2 (46.2cm d.b.h.) in site 4.

The number of top stratum stems per 100m^2 (Figure 4.50) increases from 2 in site 1 up to 26 in site 13 and the inverse relationship of this variable with mean basal area results in little if any trend for total top stratum basal area per 100m^2 (Figure 4.49) along the altitudinal gradient. Values range from 1.81m^2 at site 3 to 0.85m^2 at site 12.

Maximum top stratum height (Figure 4.51) declines from 18.0m in sites 1-4 to 5.0m in site 13. An approximate estimate of top stratum volume obtained by multiplying maximum top stratum height by mean basal area (Figure 4.52) shows a decline from the maximum value of 32.58m^3 in site 3 to 4.40m^3 in site 13.

Subcanopy mean basal area (Figure 4.53) parallels the trend for top stratum mean basal area. Although there is a deal of fluctuation in the values recorded for sites 7-13 a general decrease from values 557cm^2 in sites 1-3 to values 200cm^2 in sites 7-13 is apparent. The maximum mean subcanopy basal area 956cm^2 recorded at site 2 is equivalent to a mean d.b.h. of 34.8cm while the minimum 36cm^2 recorded at site 12 is equivalent to a mean d.b.h. of 6.7cm.

The number of subcanopy stems per 100m^2 (Figure 4.54) ranges from 0.4 at site 9 (probably the result of destruction of the understorey by goat browsing) to 31 at site 13. There is however a general trend towards increasing subcanopy stem numbers along the altitudinal gradient.

The number of shrub layer stems per 100m^2 (Figure 4.55) shows no general trend, the lowest value of 20 occurring in site 2 and 3, and the maximum of 52.7 in site 6.

Total numbers of stems per 100m^2 that is top stratum, subcanopy and shrub layer combined (Figure 4.56) show a general increase from 28-36 in site 1-3 up to 122 in site 13.

Total basal area per 100m^2 (top stratum and subcanopy combined) (Figure 4.57) shows a general decline with increase in altitude. The maximum value 2.62m^2 was recorded at site 3 and the minimum value 0.61m^2 at site 9 already cited as having a disturbed understorey.

Mean basal area that is the mean of all top stratum and subcanopy stems (Figure 4.58) decreases from 1260cm^2 in sites 1-3 to 201cm^2 in sites 12 and 13. Equivalent mean d.b.h.'s are 40cm and 16cm respectively.

Henry Peak Track Ridge (Pouakai Range)

Physiognomic data for the Henry Peak location is presented separately on Table 4.15 and depicted in conjunction with data from the other two locations on Figures 4.48-4.58.

Top stratum mean basal area declines gradually and evenly from 2601cm^2 in site 1 to 298cm^2 in site 6. Equivalent mean d.b.h.'s are 57cm and 19cm respectively. These values are very similar to those recorded at equivalent altitudes at the North Egmont location.

The number of top stratum stems per 100m^2 increases rapidly from 5.8 at site 1 to 36.0 at site 6. The

Table 4.15 Forest physiognomy and structure; Henry Peak Track Ridge

Site No.	Altitude in metres	Top stratum mean basal area in cm^2 1	Top stratum total basal area per $100m^2$ in m^2 2	Top stratum number of stems per $100m^2$ 3	Top stratum maximum height in m 4	Top stratum volume per $100m^2$ in m^3 5
1	655	2601	1.52	5.8	20.0	30.40
2	716	1786	1.07	6.0	18.0	19.26
3	792	937	0.70	7.5	10.0	7.00
4	847	645	0.82	12.7	9.5	7.79
5	914	501	1.03	20.5	5.5	5.66
6	975	298	1.07	36.0	2.5	2.67

Subcanopy mean basal area in cm^2	Subcanopy number of stems per $100m^2$	Shrub layer number of stems per $100m^2$	Total number of stems per $100m^2$	Total basal area per $100m^2$ in m^2	Mean basal area in cm^2
6	7	8	9	10	11
124	6.8	33.2	45.8	1.60	1265
153	8.0	14.7	28.7	1.19	853
126	5.2	27.7	40.4	0.77	604
65	4.5	28.2	58.7	0.85	494
28	10.0	99.5	130.0	1.06	346
40	9.0	82.0	127.0	1.11	247

densities for sites below 850m coincide closely with the North Egmont values but above 850m densities are much greater. Like the North Egmont location total top stratum basal area shows little if any trend, the maximum value of 1.52m^2 being recorded at site 1 and the minimum 0.70m^2 at site 3.

Maximum top stratum height declines rapidly from 20.0m at site 1 to only 2.5m at site 6. These values are generally lower than those for equivalent altitudes at the North Egmont location.

Top stratum volume also declines rapidly with increasing elevation from 30.4m^3 in site 1 to 2.67m^3 in site 6. Again these values are generally lower than for equivalent altitudes at the North Egmont location.

Subcanopy mean basal area parallels the trend for top stratum mean basal area declining from 124cm^2 at site 1 to 40cm^2 at site 6. Equivalent mean d.b.h.'s are 12.6cm and 7.1cm respectively. These values are much lower than in equivalent sites at North Egmont.

The number of subcanopy stems per 100m^2 ranges from 4.5 in site 4 to 10.0 in site 5 with no consistent trend apparent. Five sites exhibit lower subcanopy stem densities than those recorded at equivalent altitudes at North Egmont.

The number of shrub layer stems per 100m^2 fluctuates along the altitudinal gradient. The maximum of 99.5 was recorded at site 5 and the minimum 14.7 at site 2. Values are generally dissimilar to those recorded at North Egmont.

The total number of stems per 100m^2 ranges from 28.7 recorded in site 2 up to 130.0 in site 5. There is a general increase along the altitudinal gradient and most of the site densities are not comparable to those recorded at North Egmont.

Total basal area per 100m^2 declines at first from the maximum 1.60m^2 recorded in site 1 to a minimum of 0.77m^2 in site 3. There is a general increase then up to the 1.11m^2 recorded in the uppermost site 6. Values are generally lower than those recorded at North Egmont although site 6 has a much higher total basal area compared to the equivalent North Egmont site 9 already cited for its damaged understorey.

Mean basal area declines gradually and evenly from 1265cm^2 at site 1 to 247cm^2 at site 6. The equivalent mean d.b.h.'s are 40.1cm and 17.7cm respectively values which coincide very closely to those recorded at North Egmont.

Mander's Spur Track Ridge (Kaitake Range)

Physiognomic data for the Mander's Spur Track location is presented separately on Table 4.16 and depicted in conjunction with data from the other two locations on Figures 4.48-4.58.

Top stratum mean basal area fluctuates but shows a general increase from 387cm^2 in site 1 up to 1877cm^2 in site 5. There is a sharp decline to 432cm^2 in site 7. Equivalent mean d.b.h.'s are 22.2cm, 48.9cm and 23.4cm respectively. The low values recorded below 400m reflect the disturbance of vegetation which has occurred in the past and not the altitudinal gradient as such. Site 6 is the only site at which canopy mean basal area approaches

Table 4.16 Forest physiognomy and structure; Mander's Spur Track Ridge

Site No.	Altitude in metres	Top stratum mean basal area in cm^2 1	Top stratum total basal area per $100m^2$ in m^2 2	Top stratum number of stems per $100m^2$ 3	Top stratum maximum height in m 4	Top stratum volume per $100m^2$ in m^3 5
1	199	387	0.45	11.7	9.1	4.09
2	260	646	0.51	7.8	12.2	6.22
3	366	396	0.50	12.5	12.2	6.10
4	426	960	0.60	6.2	15.2	9.12
5	487	702	0.43	6.2	13.7	5.89
6	585	1877	0.89	4.7	12.2	10.86
7	646	432	0.86	20.0	4.6	3.95

Subcanopy mean basal area in cm^2 6	Subcanopy number of stems per $100m^2$ 7	Shrub layer number of stems per $100m^2$ 8	Total number of stems per $100m^2$ 9	Total basal area per $100m^2$ in m^2 10	Mean basal area in cm^2 11
398	17.0	11.7	40.4	1.13	394
411	10.7	7.8	26.3	0.95	511
69	12.0	48.0	72.5	0.58	236
415	8.5	49.7	64.4	0.95	646
417	7.0	4.5	17.7	0.72	551
702	7.5	15.2	27.4	1.42	1158
226	16.0	40.0	76.0	1.22	340

the values recorded in sites at North Egmont and Henry Peak.

Total top stratum basal area/100m^2 shows a general increase from 0.45m^2 at site 1 to 0.80m^2 in sites 6 and 7. Site 5 is the exception recording only 0.43m^2. Again the sites below 400m are successional and would be expected to have lower values than equivalent sites at North Egmont and Henry Peak. Above 400m however values are still much lower than those recorded at the other two locations.

The number of top stratum stems per 100m^2 fluctuates markedly between site 1 and site 7. The minimum value 4.7 was recorded at site 6 and the maximum 20.0 at site 7. Both values are predictable site 6 being a 'climax' stand, has fewer but larger stems, while site 7 on steep slopes near the Kaitake summit supports many small multi-stemmed kamahi. Site 6 thus records most similar top stratum stem densities to sites at equivalent altitudes at North Egmont and Henry Peak.

Maximum top stratum height 9.1m in site 1 increases to the maximum value recorded, 15.2 in site 4 then decreases to the minimum value recorded, 4.6m in site 7. Again the reason is obvious with the successional sites below 400m exhibiting lower maximum canopy heights and site 4 a 'climax' stand, dominated with a large component of miro recording the greatest maximum canopy height. Site 7 on the steep slopes near the Kaitake summit supports a 'dwarfed' kamahi forest.

Top stratum volume ranges from 3.95m^3 in site 7 to 10.86m^3 in site 6 and the successional sites below 400m all recorded values less than 6.30m^3. Canopy volumes are therefore much lower than for equivalent altitudes at North Egmont and Henry Peak.

Subcanopy mean basal area fluctuates markedly between sites 1 and 7. The minimum value 69cm^2 occurs in site 3 and the maximum 702cm^2 in site 6. Equivalent mean d.b.h.'s are 9.4cm and 29.9cm respectively. The subcanopy at site 3 is dominated by young pole size pukatea and rewarewa while 'climax' kamahi and soft tree fern dominate the subcanopy vegetation at site 6. Subcanopy mean basal areas are slightly lower than those recorded in equivalent sites at North Egmont and Henry Peak.

The number of subcanopy stems per 100m^2 tends to decline at first from the maximum 17.0 at site 1 to 7.0 at site 5 and then increases again to 16.0 at site 7.

The number of shrub layer stems per 100m^2 ranges from the minimum 7.8 in site 2 to the maximum 49.7 in site 5.

Both the numbers of subcanopy and shrub layer stems are roughly comparable with those recorded at similar altitudes at North Egmont and Henry Peak.

Total stem numbers per 100m^2 fluctuate markedly from site 1 through to site 7, the minimum value of 17.7 in site 5 and the maximum value 76.0 in site 7. The total stem number in site 6 27.4 is very similar to values recorded at similar altitudes at North Egmont.

The values for total basal area per 100m^2 and mean basal area are generally lower at the Mander's Spur location than those recorded at North Egmont and Henry Peak.

In summary then the vegetation changes markedly in its

Figure 4.48

TOP STRATUM MEAN BASAL AREA

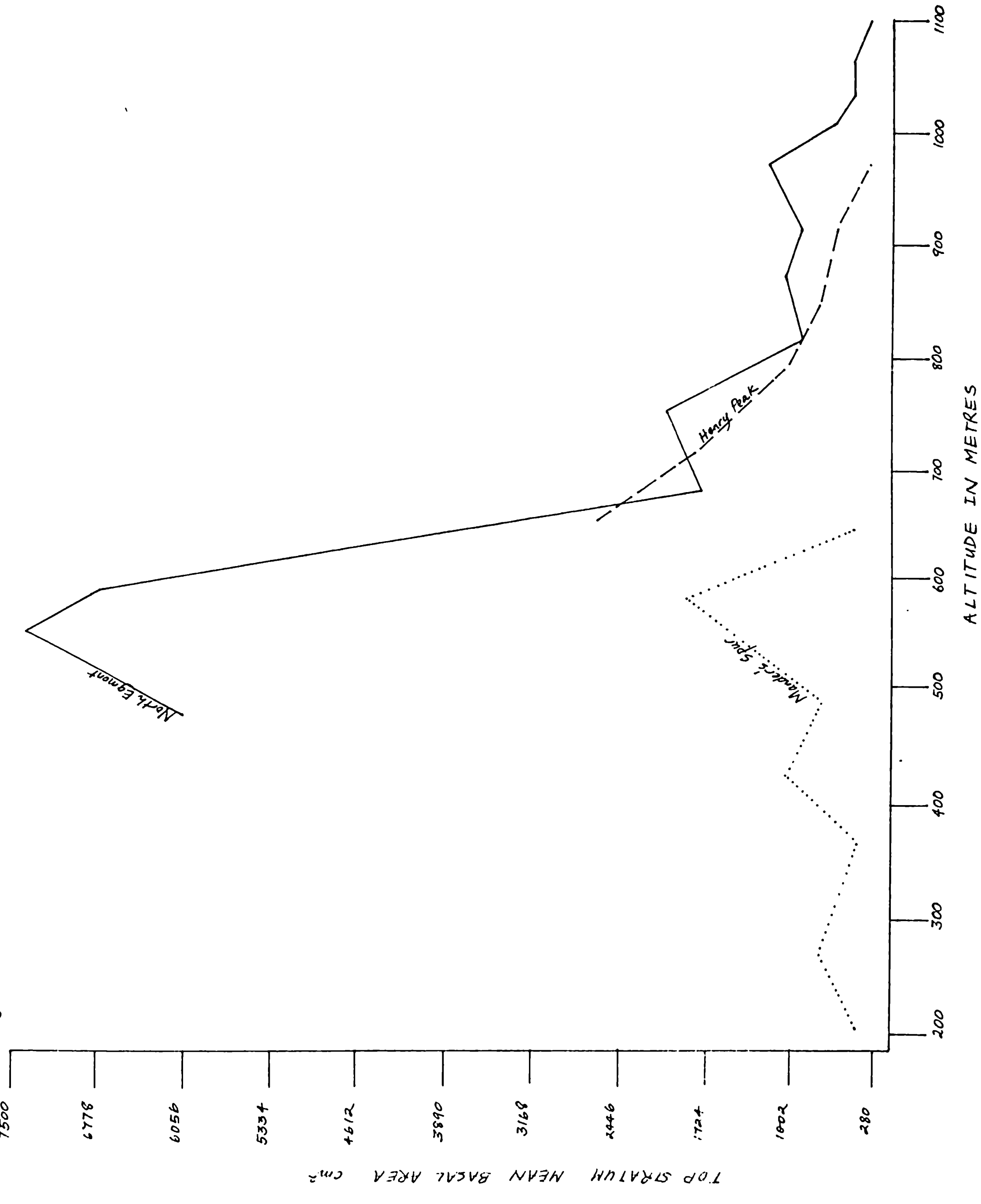


Figure 4.49

TOP STRATUM TOTAL BASAL AREA

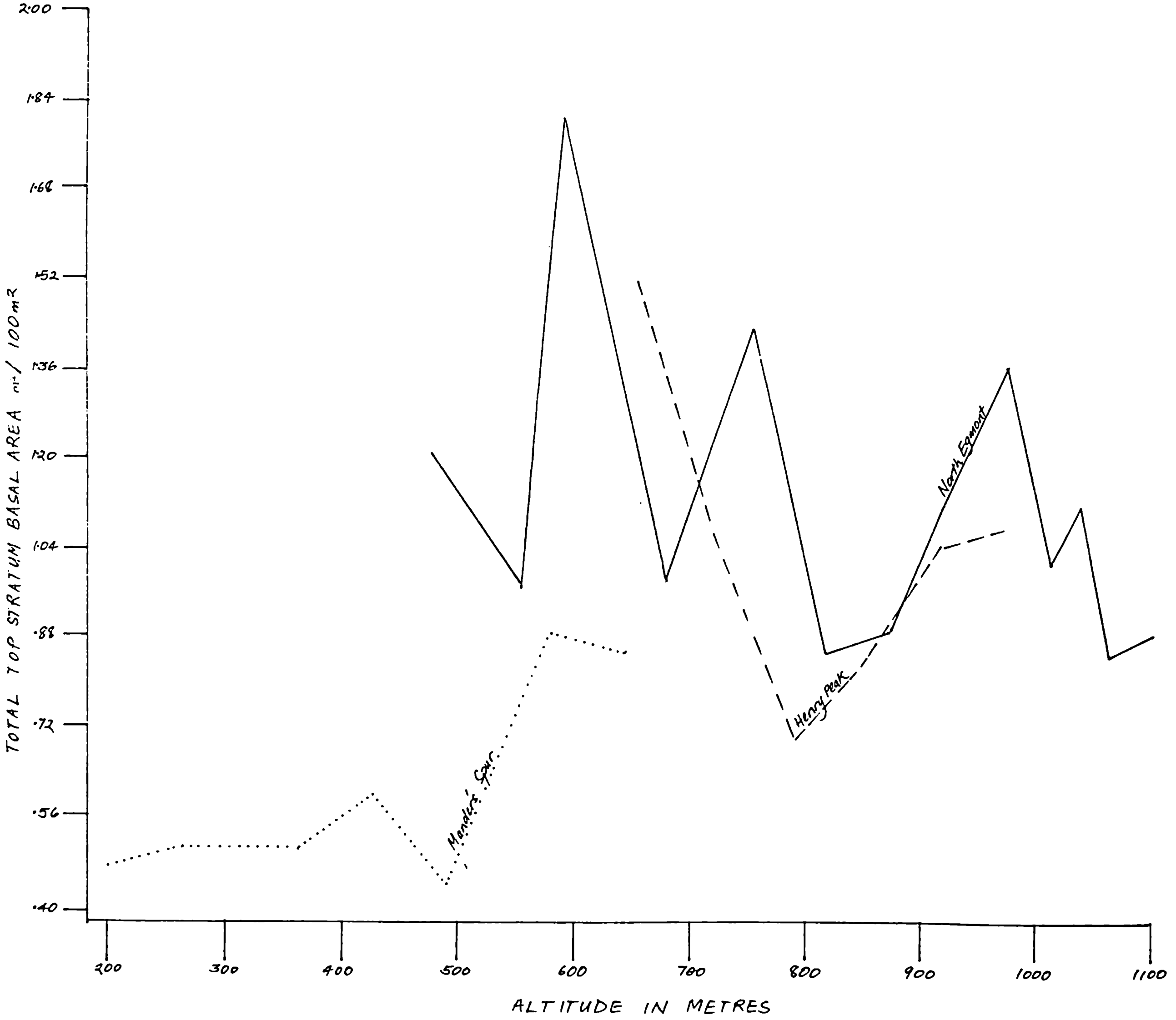


Figure 4·50

NUMBER OF TOP STRATUM STEMS PER 100 m^2

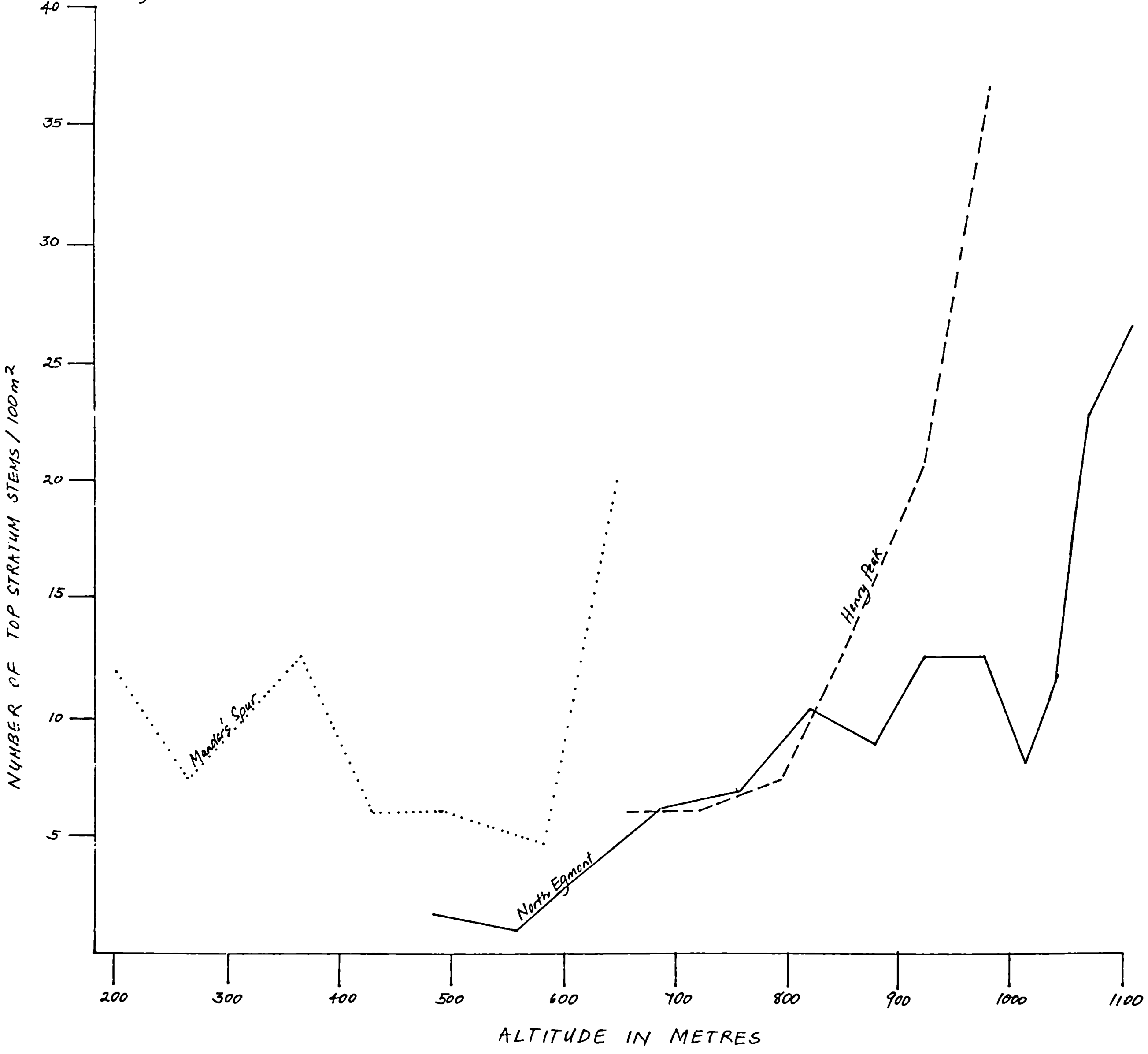


Figure 4.51

MAXIMUM TOP STRATUM HEIGHT

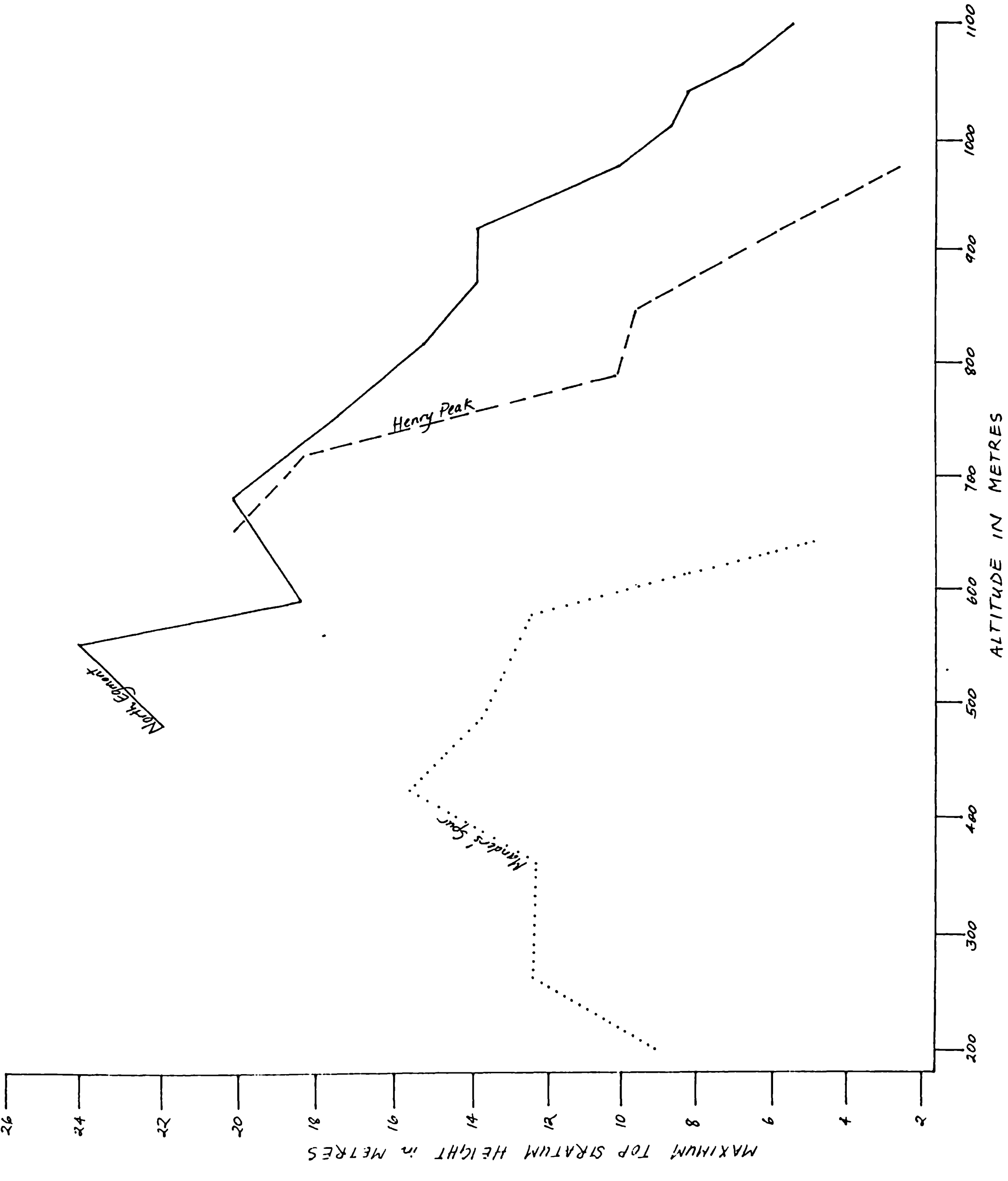


Figure 4.52

TOP STRATUM VOLUME

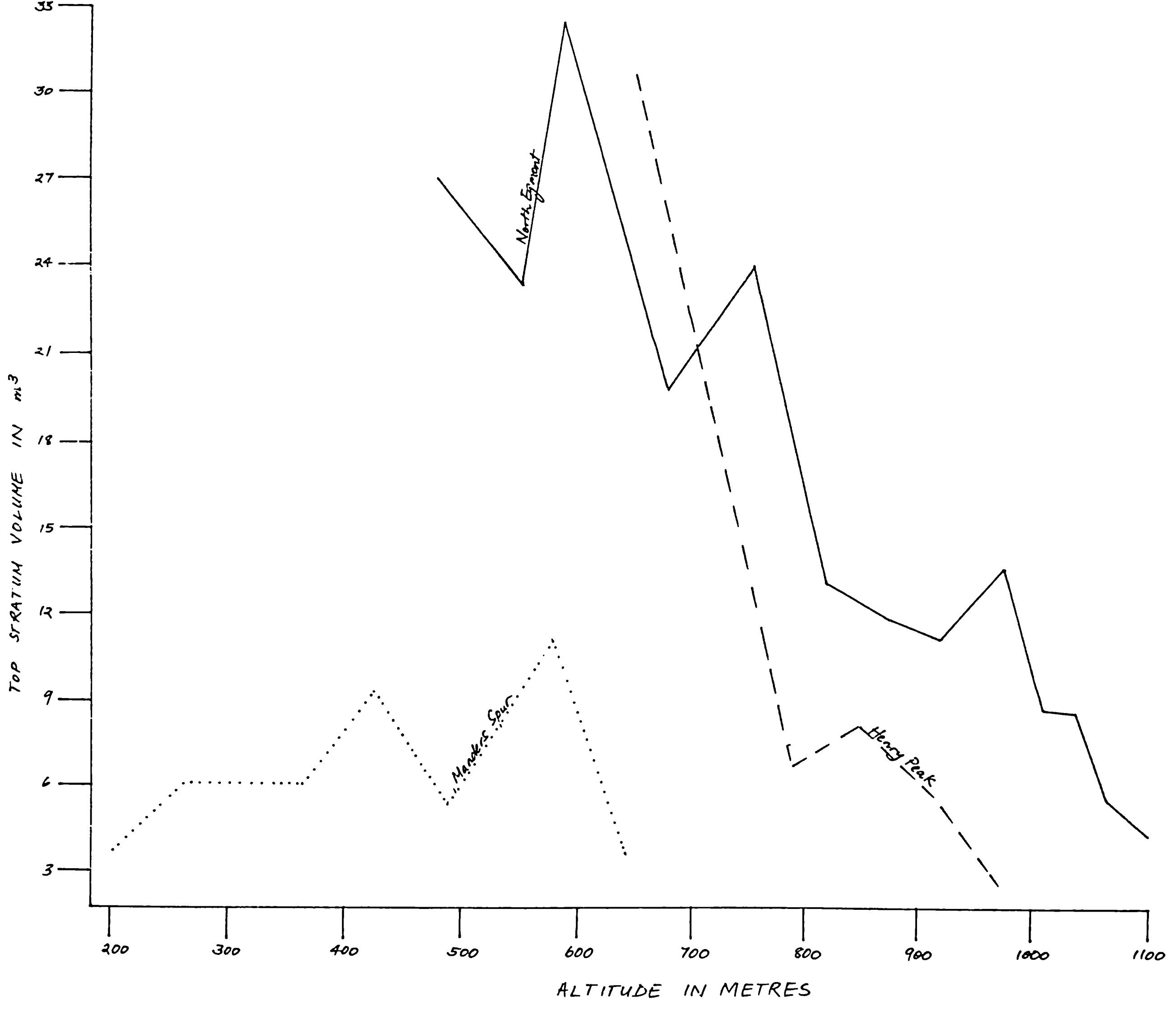


Figure 4.53

SUBCANOPY MEAN BASAL AREA

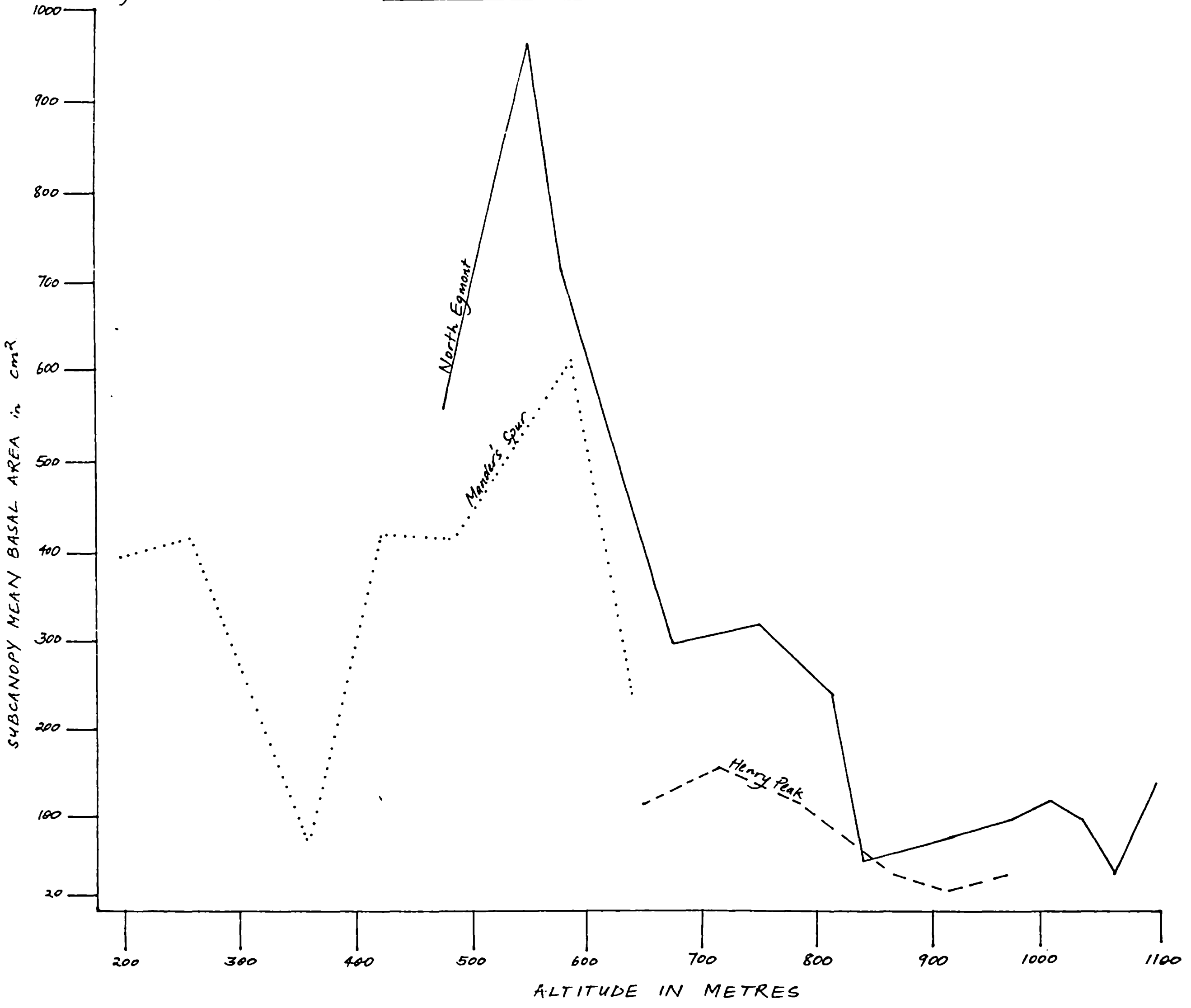


Figure 4·54

NUMBER OF SUBCANOPY STEMS PER 100m²

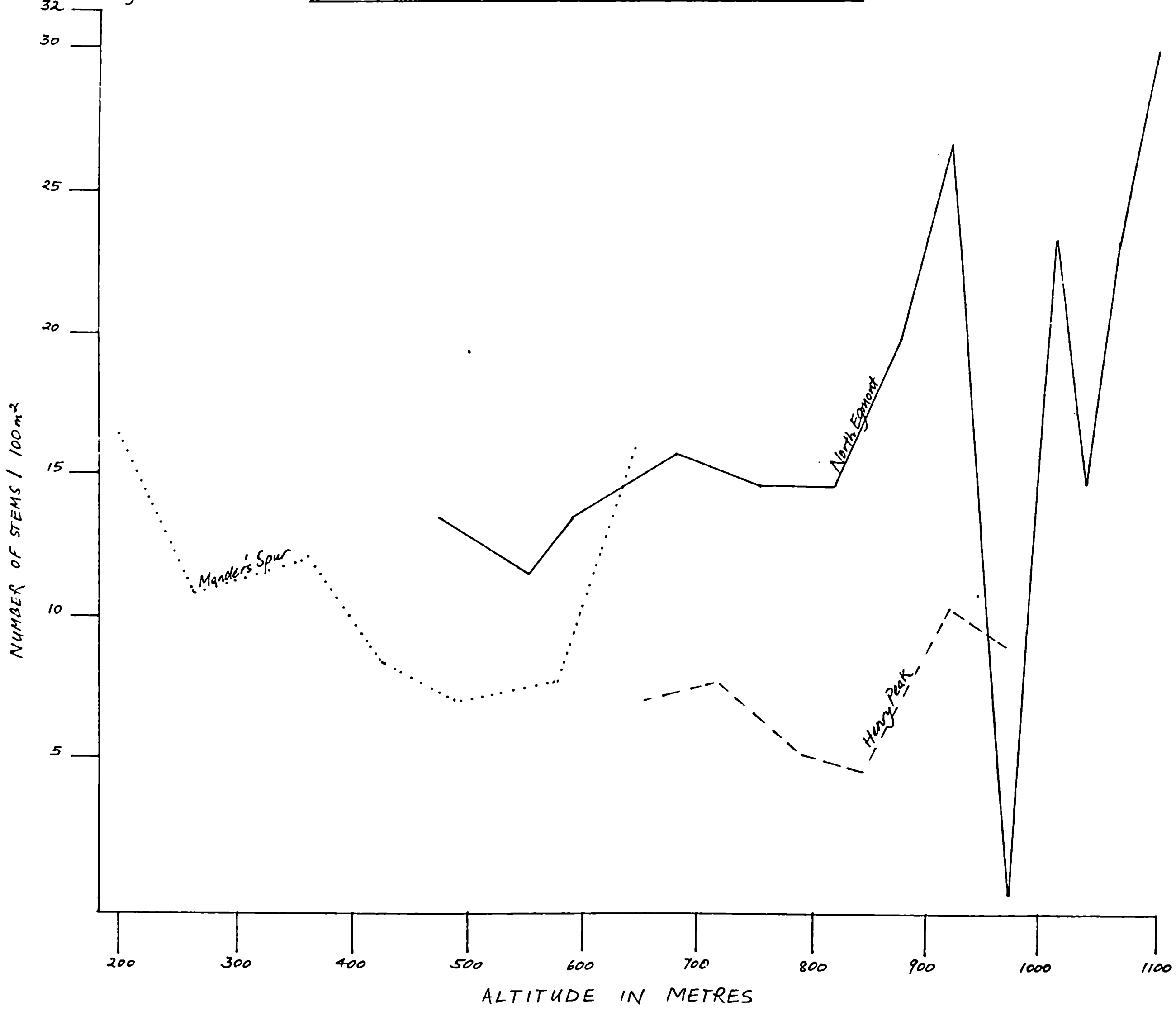


Figure 4.55

NUMBER OF SHRUB LAYER STEMS PER 100m²

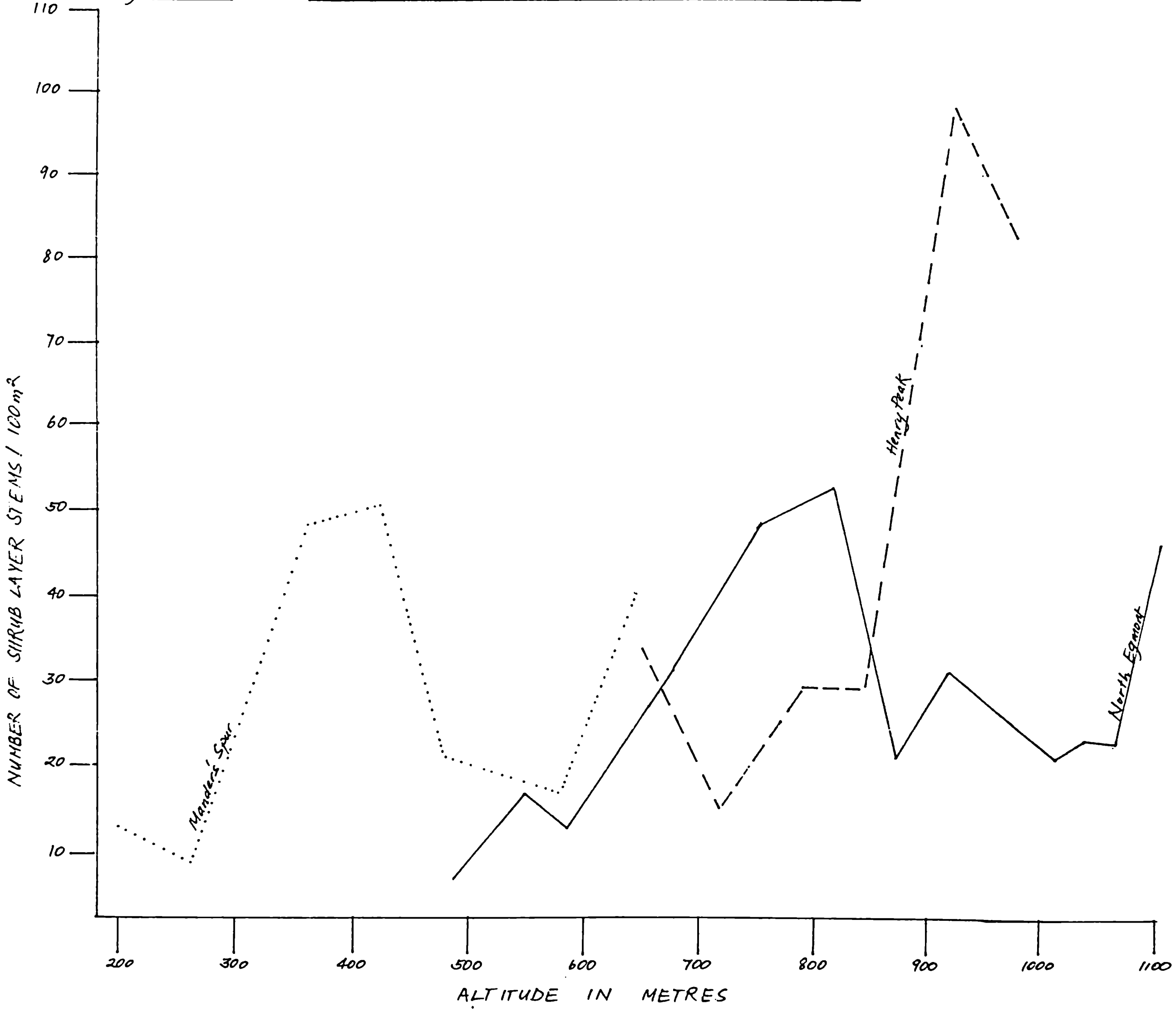


Figure 4.56

TOTAL NUMBER OF STEMS (Top stratum + subcanopy + shrub layer) PER 100 m^2

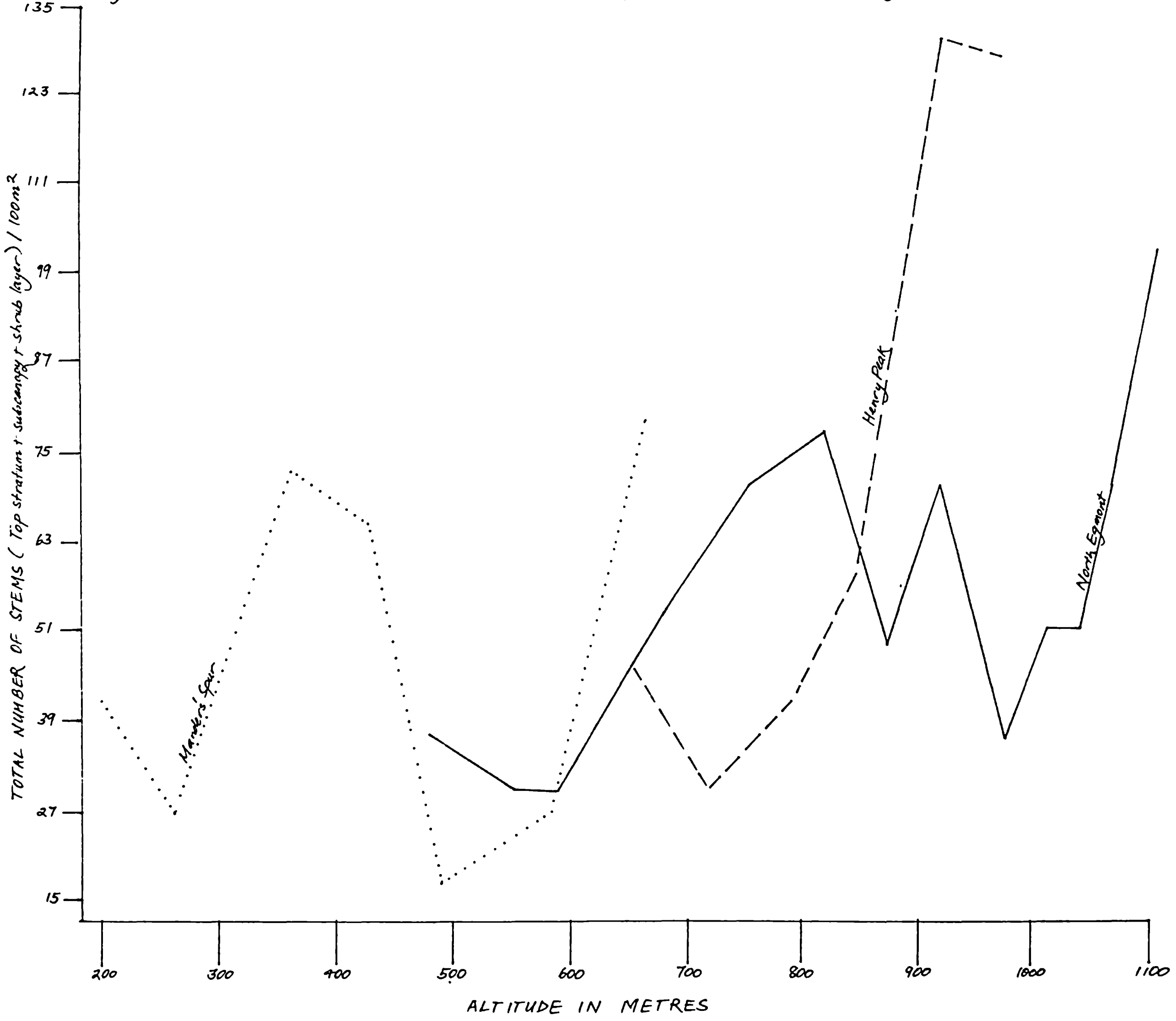


Figure 4.57

TOTAL BASAL AREA (Top stratum + subcanopy) PER 100 m^2

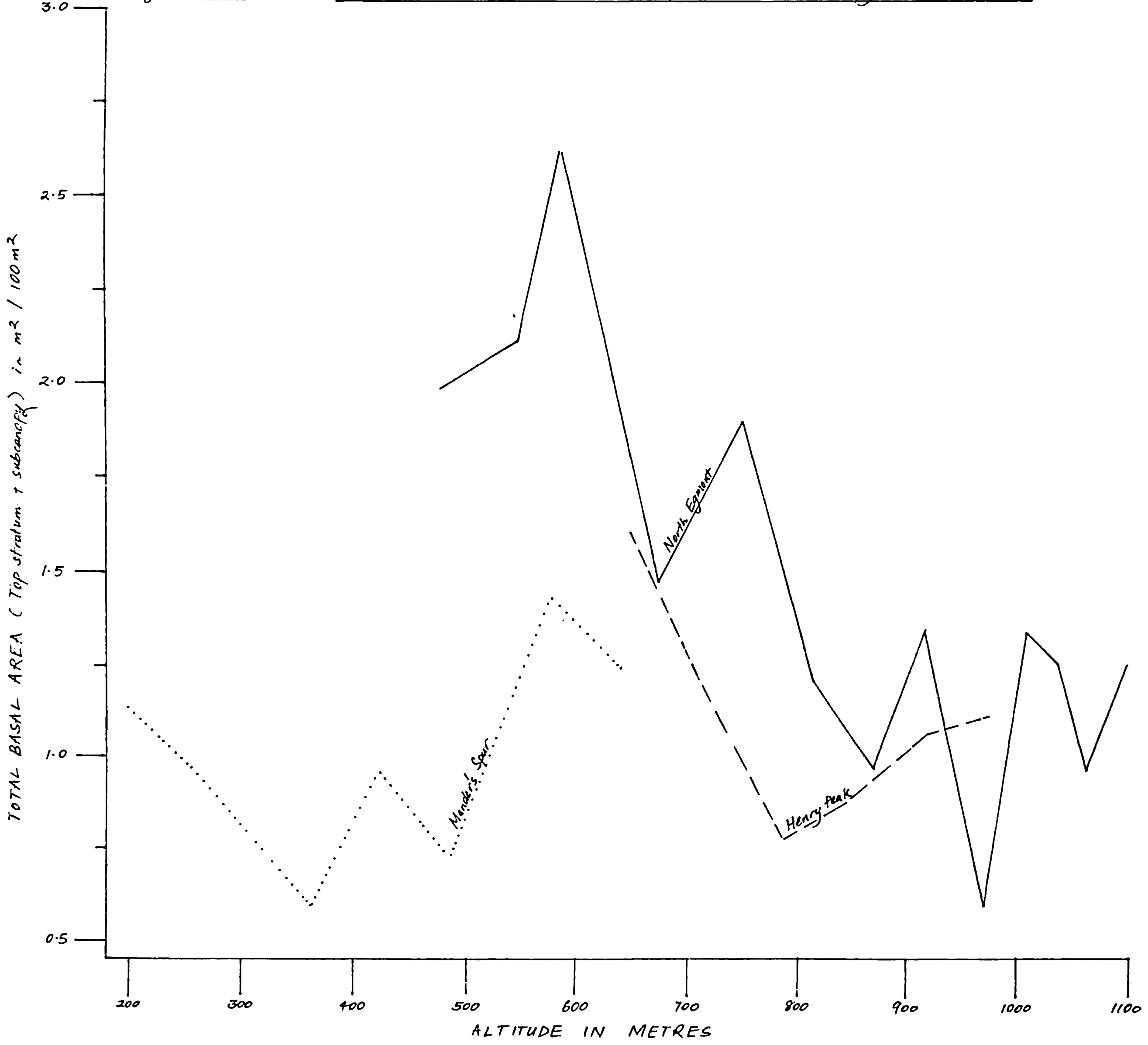
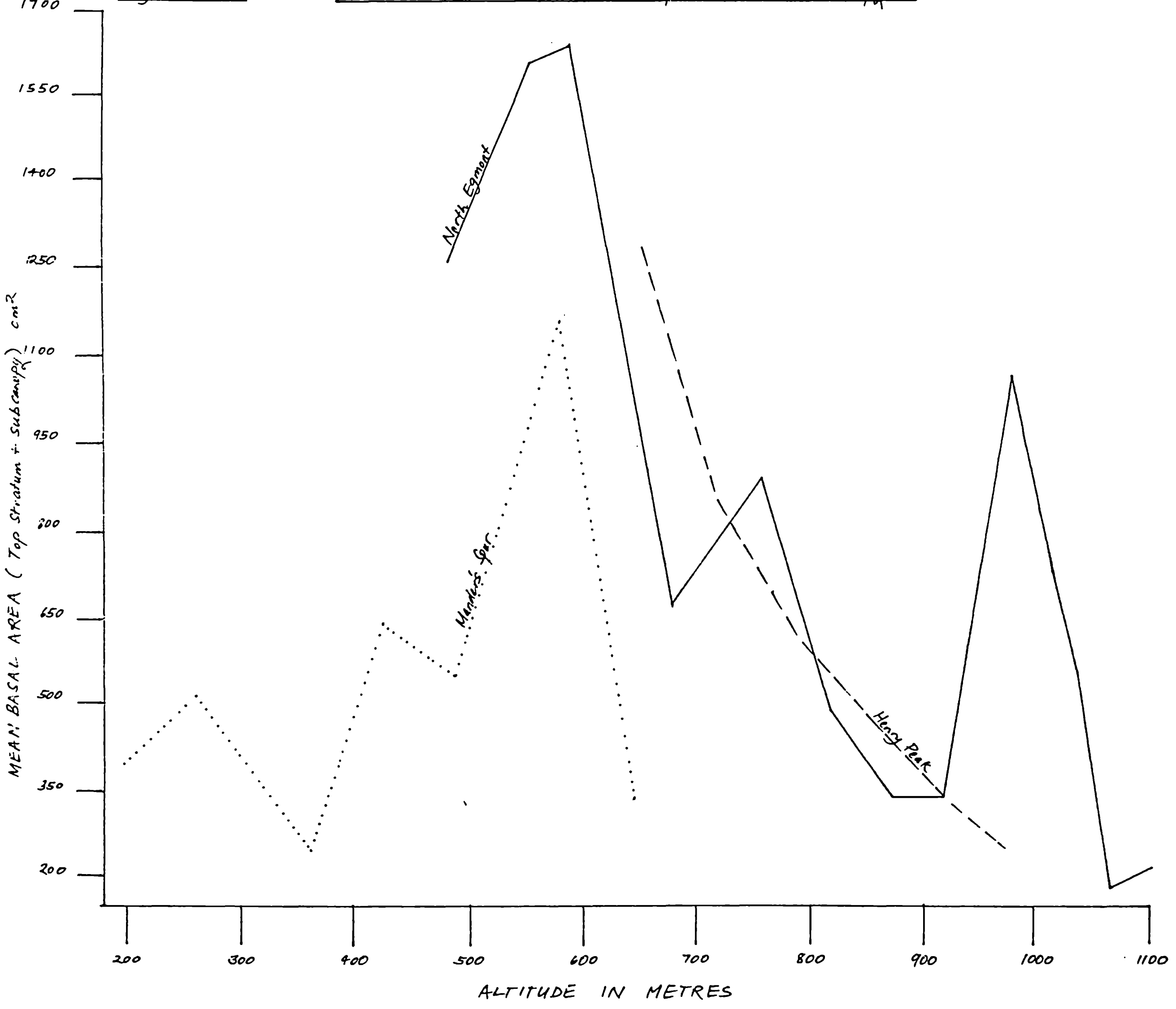


Figure 4.58

MEAN BASAL AREA (Top stratum + subcanopy)



physiognomy and structure between 450m a.s.l. and 1100m a.s.l. The vegetation decreases in stature and greater numbers of small stems gradually replace small numbers of large stems. The inverse relationship between top stratum and subcanopy stem numbers per $100m^2$ and mean top stratum and subcanopy basal area tends to even out the total basal area of vegetation recorded along the altitudinal gradient. Calculation of a measure of top stratum volume by multiplying the maximum height of vegetation by its total basal area shows clearly that the most important physiognomic change is decreasing stature. Whereas the two strategies (fewer-larger stems) and (more-smaller stems) tend to even out total basal areas and thus the way vegetation is packed into a given space, the major differences in canopy height result in major differences in top stratum volume along the altitudinal gradient. Fluctuations in the values of variables such as subcanopy numbers, subcanopy mean basal area and shrub numbers result in part from the arbitrary nature of delimiting vegetation strata. Small diameter stems may often be taller than large diameter stems. Thus total stem numbers and mean basal area (emergents, canopy and subcanopy combined) best describe the general trends apparent along the altitudinal gradient. The data collected at North Egmont, Henry Peak, and Mander's Spur Track provides quantitative evidence for the major physiognomic and structural changes in forest vegetation which occur along the altitudinal gradient between 400m and 1100m a.s.l. As well, the data shows the differences in forest physiognomy and structure which result from major disturbances.

The sites above 400m on the Mander's Spur Track and all the sites at North Egmont and Henry Peak contain primary stands of vegetation; that is for the most part the top stratum of vegetation (emergents, canopy and subcanopy) is substantially the same as it was prior to the European settlement. The major underlying gradient is the altitudinal one. Forest decreases in stature with increasing elevation and low densities of large sized stems are gradually replaced by higher densities of smaller stems. Animal damage to the understorey is also responsible for some of the fluctuation in values for example the already cited site 9, North Egmont.

The data collected at each of the three locations is useful as a comparison of what may be termed altitudinal equivalence. A given altitude at a given location being the expression of a range of environmental factors is not equivalent environmentally to the same altitude at a different location although they may be generally similar. Comparison of the physiognomic data for the three locations amplifies this point. Maximum top stratum height for example, although at first similar at altitudes below 800m at North Egmont and Henry Peak, declines more rapidly at the latter location. What could be considered as the parallel decline in maximum top stratum height on the Mander's Spur Track Ridge occurs between 450m and 650m. Comparison of the uppermost forest sites measured at each location shows that although physiognomically similar there are major differences floristically. At North Egmont the uppermost forest site is dominated by broadleaf and kaikawaka, at Henry Peak by kamahi, broadleaf and Hall's totara and near the Kaitake Peak by kamahi. Thus the vegetation type present in site 13 at North Egmont is vegetation type characteristic of the 'full stretch' provided by Egmont and is not present on the lower peaks Henry and Kaitake. The kamahi-broadleaf-Hall's totara forest of site 6 Henry Peak is equivalent floristically to the forest in sites 8, 9, 10 and 11 at North Egmont and therefore occurs some 50m a.s.l. lower than is the case at North Egmont. The kamahi forest at site 7 is equivalent to forest of site 6 at North Egmont and site 3 Henry Peak thus in altitudinal order is found higher at North Egmont than on Henry Peak which in turn is found higher than at Mander's Spur Track. The altitudinal difference between site 6 North Egmont and site 7 Kaitake is approximately 200m. The physiognomic features which the forests have in common centre on low stature and in addition on high top stratum, subcanopy and shrub stem densities and low mean basal areas for the top stratum and subcanopy.

Even though these sites are physiognomically similar they are floristically dissimilar and the major factors responsible for the physiognomic similarity appear to be slope, substrate and exposure. Slope and exposure are highly correlated with altitude in that closer to the summit of each mountain there is a tendency for rapid steepening of slope and increased exposure to winds. Substrate and drainage are also affected. The substrate for example exhibits shallower soil depths and base rock is closer to the surface or even protruding in places.

On porous scoriaceous soils the increase in slope makes for freer drainage although where the base rock is near the surface drainage may be severely impeded in places. As well cloud and mist is more frequent near the summits of Kaitake and Henry Peak and on the upper slopes of Mt Egmont. All of these factors contribute to the dwarfing of the forest particularly on Kaitake where the true upper altitudinal limit of the forest is not reached. On Henry Peak and at North Egmont the temperature decrease associated with increasing altitude is probably more important as the forests are at considerably higher altitude.

The forest below 400m on the Mander's Spur Track has been variously disturbed by logging and animal disturbance (see section on Kaitake) and the forest physiognomy provides further evidence of these disturbances. Maximum top stratum height, mean basal area for the top stratum and subcanopy, top stratum and subcanopy stem densities, and top stratum volume are all much lower than would be expected by comparison with North Egmont and Henry Peak. Subcanopy mean basal areas on the other hand compare favourably with those recorded at the other two locations and emphasize the importance of this understorey which in many cases is in the process of, or eventually will, overtop the present canopy. In sites 1 and 2, for example, the principal subcanopy species are kohekohe and pukatea respectively and these species would be expected to replace the high component of lancewood and mamaku in the canopy of site 1 in particular.

One important feature of the changing physiognomy and structure of the forests which was not measured quantitatively was the increasing importance of epiphytic establishment of shrubs and trees. In comparing floristic and physiognomic discontinuity Clarkson (1977) noted the importance of species like broadleaf which, because of its ability to adopt a number of growth forms (independent tree, independent shrub, tree of epiphytic origin, epiphytic shrub, etc.), provides a deal of floristic continuity across the physiognomic boundary which occurs between forest and shrub communities. This flexibility of form is also a feature of kamahi and examples of this have already been noted in the North Egmont section. The epiphytic strategy in tree establishment and control of the canopy becomes more important in the forest with increasing elevation so that in the kamahi dominated vegetation found above 750m at North Egmont and Henry Peak for example almost all species to a greater or lesser extent may be found growing epiphytically and the range of tree complexes present is also great. Kamahi, broadleaf, *Pseudopanax colensoi* represent the extreme of species most versatile at reaching the canopy by this strategy while Hall's totara is closer to the other extreme achieving success only rarely.

2. SHRUB, TUSSOCK AND HERBFIELD VEGETATION

Introduction

Changes in the physiognomy and structure of the vegetation along the altitudinal gradient are not confined to the forest. In fact the most critical changes occur at the interfaces between the forest and shrub communities, the shrub and tussock dominated communities, and at the point where herbfield (a compact turf composed mainly of herbs and grasses) replaces tussock dominated vegetation. These changes have in part been described by Clarkson (1977) particularly for the tree-shrub interface and shrub-tussock interface. At the tree-shrub interface tree species such as Hall's totara become less and less emergent so that eventually their apical shoots are level with the leatherwood dominated canopy and finally at the upper limits of their altitudinal range they are understorey components. Detailed descriptions of the changing physiognomy of kaikawaka and leatherwood may be found in Clarkson and Edmonds (1978) while Schweinfurth (1962) described the physiognomic changes occurring in kamahi. Stem numbers per 100m^2 continue to rise exponentially because of the even more multi-stemmed habit of the shrubs, notably leatherwood. The vegetation canopy becomes more tight-knit and compact and leaves are more crowded towards the terminal ends of branches. It becomes impracticable to separate canopy and subcanopy strata with the top stratum of vegetation a dense interwoven mat occupying the 1.50m-2.25m height class. A feature noted by Cockayne (1928) relating to this was the presence of certain shrubs of extremely dense habit living below the general level of the 'roof' so adding to the impenetrability of the association. The compact nature of the canopy is probably partly responsible for the poor development of ground cover vegetation which may occupy as little as 15% of the ground cover layer, the remaining 85% being covered with litter particularly of leatherwood leaves and inaka 'needles' and bare substrate. At the shrub-tussock interface the compact nature of the shrub canopy changes markedly. At first occasional tussocks appear growing up through gaps in the shrub canopy (leatherwood dominant) and eventually as these gaps become larger, smaller stature shrubs including *Cassinia vauvilliersii* and the herb *Astelia* sp. unnamed occupy the spaces. *Blechnum capense* agg. along with a range of smaller plants normally prominent in the herbfields are often important as ground cover components in these gaps. This pattern is more pronounced where goat and opossum damage is severe. The canopy layer thus becomes a complex mix of both tussocks and shrubs ranging from 20cm up to 1.25m in height and forming a patchwork overtop of an ever increasing ground cover component made up principally of herbfield species. Clarkson (1977) did not detail quantitatively the physiognomic and structural changes from shrub to tussock and then herb dominated vegetation so data describing these changes is presented below.

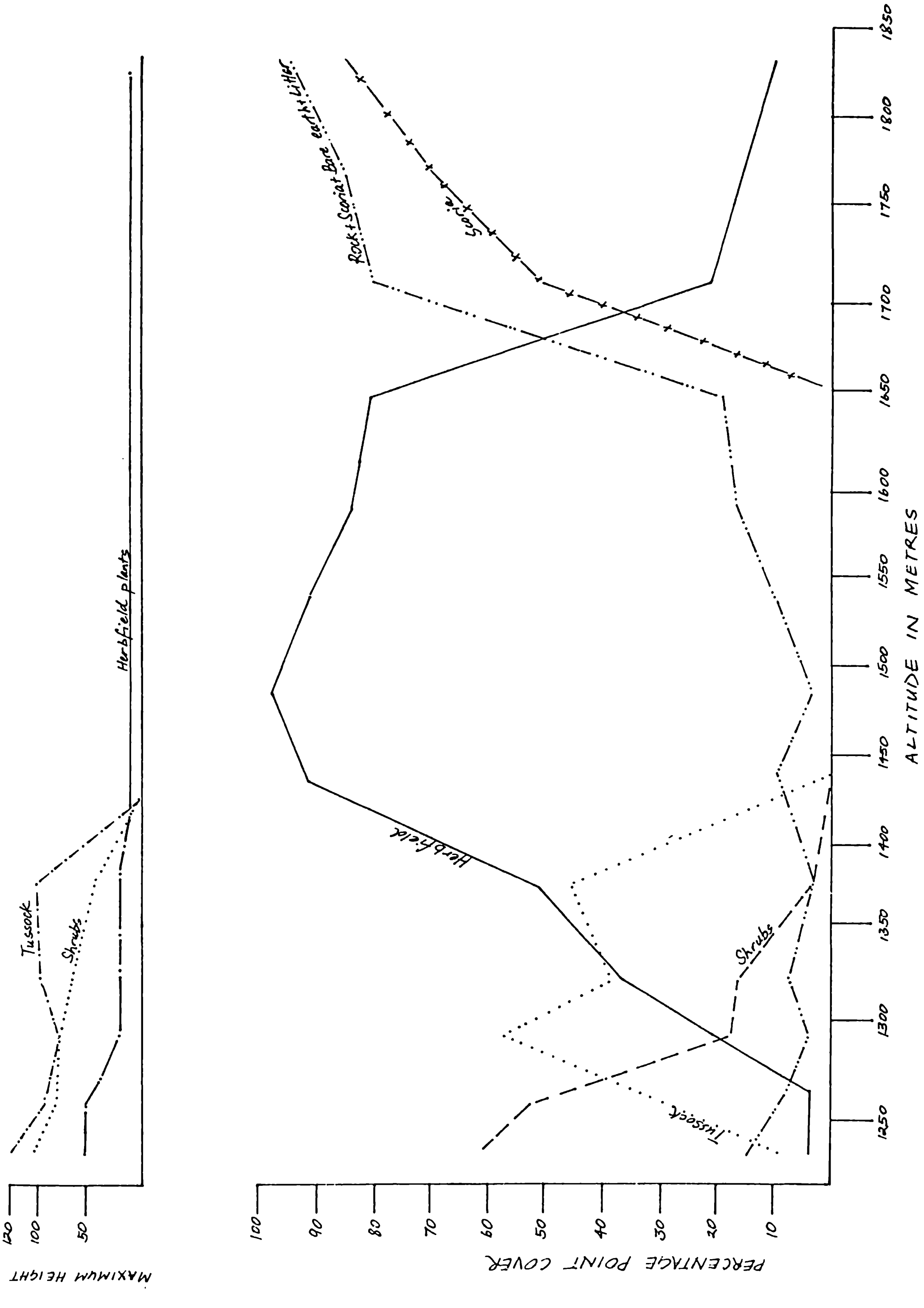
Punehu-Skeet Ridge (Mt Egmont)

Vegetation height and cover data collected at the Punehu-Skeet Ridge location between 1200m and 1850m summarised on Table 4.17 and Figure 4.59 is used to describe the changes mentioned above. Percentage point cover was determined by stretching a tape out above the top stratum of vegetation. Projecting an imaginary line at right angles to the tape towards the ground at set intervals enabled the uppermost vegetation species encountered to be recorded. If no plants occupied the

Table 4.17 Shrub, tussock and herbfield vegetation; Punehu-Skeet Ridge

Site No.	Altitude		Percentage tussock	Percentage shrubs	Percentage herbfield	Earth and litter	Rock	Scoria	Maximum shrub height cm	Maximum tussock height cm	Maximum herbfield height cm
	Metres	Feet									
13	1828	6000	-	-	5	-	10	85	-	-	10
12	1767	5800	-	-	15	-	14	71	-	-	10
11	1706	5600	-	-	21	23	6	50	-	-	10
10	1645	5400	-	-	81	10	9	-	-	-	10
9	1584	5200	-	-	84	13	3	-	-	-	10
8	1535	5040	-	-	91	3	6	-	-	-	10
7	1484	4870	-	-	97	1	2	-	-	-	10
6	1441	4730	-	-	91	1	8	-	-	-	10
5	1380	4530	46	3	48	3	-	-	42	90	20
4	1328	4360	38	17	37	8	-	-	60	85	20
3	1299	4260	57	18	21	4	-	-	70	72	20
2	1267	4160	28	53	4	8	-	-	76	85	50
1	1234	4050	10	61	4	15	-	-	90	123	50

Figure 4.59 SHRUB, TUSSOCK AND HERBFIELD VEGETATION ; PUNEHU - SKEET RIDGE



area above the ground cover stratum this stratum was recorded as belonging to one or other of the following categories:

1) herbs and grasses
2) bare earth - litter
3) lapilli
4) bare rock

As well the maximum height achieved by shrub, tussock and herb species was noted at each location.

Examination of Table 4.17 and Figure 4.59 enables the major trends to be outlined. Shrub cover declines from 61% at 1234m, to 3% at 1380m. Not only does the total shrub cover decline but the crown diameter of individuals declines markedly as well. Leatherwood for example records a crown diameter of 1.41m at 1234m but at 4260m this is reduced to only 0.52m. At 1234m tussock already makes up 10% of the cover usually protruding up through the gaps in the shrub cover. This competition with, and shelter from, the surrounding shrubs tends to make the tussocks grow taller than in the sites where they are actually dominant. Thus the maximum height recorded for red tussock at 1234m is 1.23m while at its uppermost site, 1380m, the maximum is 0.90m. From about 1280m onwards the total cover of tussock in the top layer of vegetation exceeds the cover by shrubs. Tussocks make up 57% of the cover at 1299m and shrubs only 18%. Tussocks decline quickly from 46% of the cover at 1380m to 0% at 1441m. Herbfield makes up only 4% of the cover at 1234m (this 4% is only the portion not overtopped by shrubs and tussocks) and steadily increases to the maximum value recorded, 97% at 1484m. Herbfield forms an extensive turf at this altitude with only 3% of the substrate uncovered. The maximum height recorded for herbs at 1234m is 0.50m by *Ranunculus nivicola* but at 1535m all herbfield species are less than 1.0cm in height, the majority even less than 5cm. This is of course subject to much variation depending on the season of sampling. The total exposed substrate (bare rock + lapilli + bare earth + litter) is 15% at 1234m and declines to 3% at 1484m where herbfield development is greatest. From this point onwards the herbfield forms a less and less continuous cover until by 1706m patches of herbs and grasses contribute only 21% of the total cover while the total exposed substrate is 79%. At the uppermost site this reaches 95% with the herbs and grasses covering only 5% of the ground. Closer examination of the various components of the substrate shows that from 1645m onwards lapilli and scoria form the bulk of the exposed substrate making up 50% of the cover at 1706m and 85% at 1828m. Rock cover is also more important in the highest altitude sites making up 14% of the cover at 1767m. At lower altitudes the lapilli and scoria is more stable and therefore is more easily colonised by plants. From about 1670m onwards the scoria is more or less constantly on the move forming large scoria slips and being cut by freshly formed drainage channels each time the snow thaws. In association with the deterioration of climatic factors this instability of the substrate makes it increasingly difficult for plants to successfully establish on the upper slopes of the mountain.

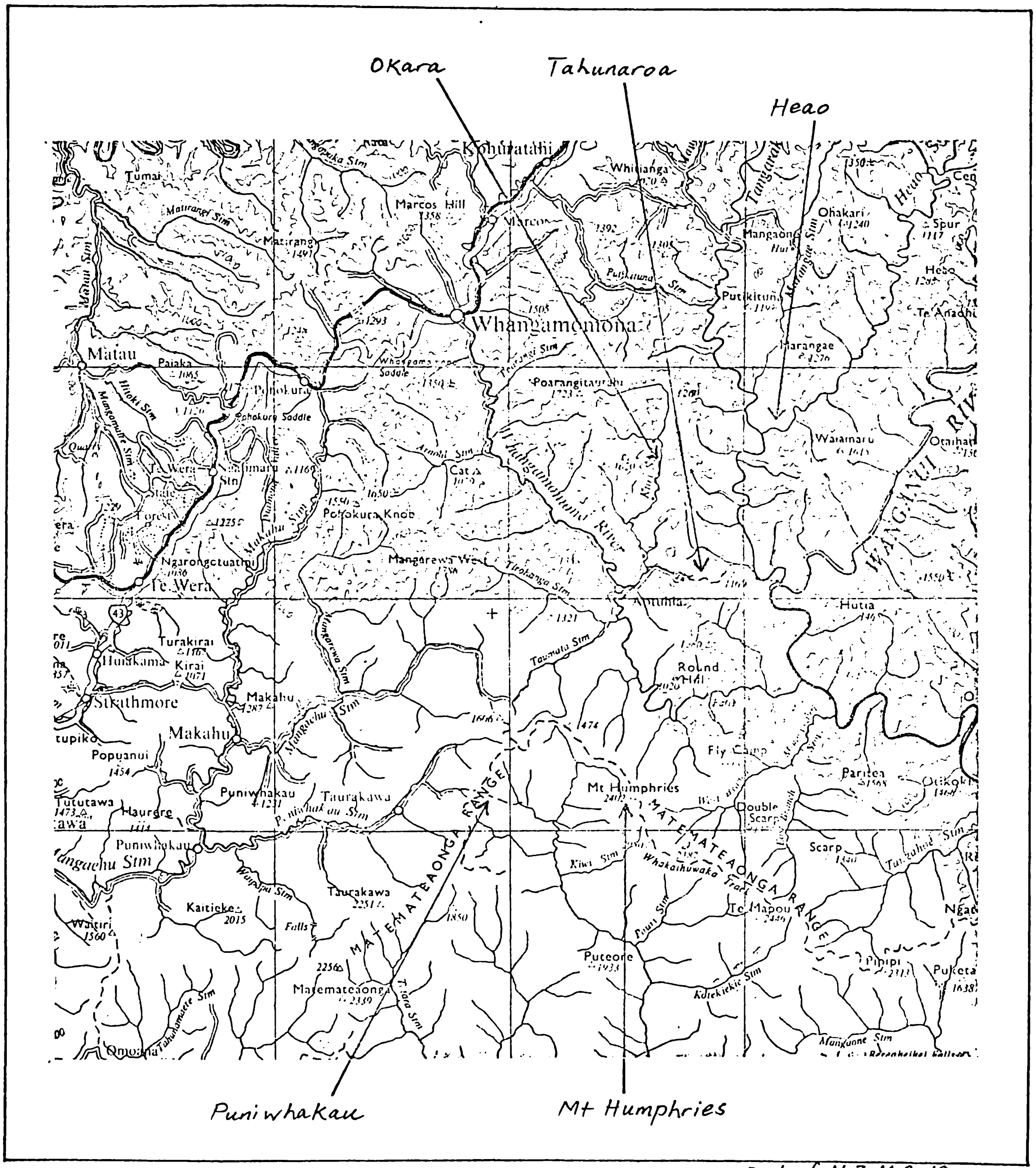
E. THE VEGETATION OF THE TARANAKI UPLAND

Introduction

Two locations in Upland Taranaki, Aotuhia and Mt Humphries, were visited to collect data to describe and explain the significant features of vegetational change along major environmental gradients. As well, data was collected to elucidate some of the recent vegetation successions apparent on abandoned farmlands. All of the data collected provided an opportunity to examine the floristic and physiognomic relationships of the Upland Taranaki and Egmont National Park forests. The place names Aotuhia and Mt Humphries refer to extensive tracts of land within Upland Taranaki and at these locations, a total of thirty three sites, were sampled quantitatively (see Figure 4.60 and Table 4.18). This data, although insufficient to encompass the complete range of vegetation present in these areas, is never-the-less sufficient to provide a useful comparison with the forests of Egmont National Park. Time available and access were the major constraints against more extensive collection of quantitative site data. Quadrats of $100m^2$, $200m^2$ and $400m^2$ were used variously to measure quantitatively the vegetation for all strata (total area of $5100m^2$).

Subsequent analysis showed that the combination of the canopy (top stratum) including emergents and the subcanopy relative density data provided the most useful summary of the vegetation composition in the two locations. This data was used to produce the ordination diagram (Figure 4.61) based on a Principal Components Analysis (PA1 Factor Analysis SPSS v7) of the 33 sites. All of the

Figure 4·60 SAMPLING LOCALITIES IN UPLAND TARANAKI



part of N.Z.M.S. 18 sheet 7

Table 4.18 Sampling sites at Aotuhia and Mt Humphries

Site No.	Location	Feet	Metres
1	Mt Humphries	2260	688
2	Aotuhia (Okara)	500	152
3	Mt Humphries	1660	506
4	Mt Humphries	1460	445
5	Mt Humphries	1180	359
6	Mt Humphries (Puniwhakau)	950	289
7	Mt Humphries	2400	731
8	Mt Humphries	1120	341
9	Mt Humphries	2060	628
10	Mt Humphries	1360	414
11	Mt Humphries	1960	597
12	Aotuhia (Heao)	480	146
13	Mt Humphries (Puniwhakau)	920	280
14	Mt Humphries	1000	305
15	Mt Humphries (Puniwhakau)	920	280
16	Aotuhia (Heao)	490	149
17	Mt Humphries	1260	384
18	Mt Humphries	2160	658
19	Mt Humphries (Puniwhakau)	920	280
20	Mt Humphries	1560	475
21	Mt Humphries	1860	567
22	Mt Humphries	2360	719
23	Mt Humphries	2320	707
24	Aotuhia (Tahunaroa)	700	213
25	Mt Humphries	2210	673
26	Mt Humphries (Puniwhakau)	950	289
27	Aotuhia (Okara)	900	274
28	Aotuhia (Tahunaroa)	770	235
29	Aotuhia (Okara)	500	152
30	Aotuhia (Okara)	480	146
31	Aotuhia (Tahunaroa)	750	228
32	Mt Humphries (Puniwhakau)	960	292
33	Mt Humphries (Puniwhakau)	960	292

Quadrat Area m^2	Slope Angle	Aspect	Other
100	3- 6	SW	
-	5-10	SE	1st 100 stems
100	24-27	SW	
100	15-17	SW	
100	18-21	SW	
100	12-15	SW	
100	2- 5	N	
100	1- 4	SW	
100	20-23	SW	
100	12-15	SW	
100	13-16	SW	
400	47	SW	
100	17-20	SW	
-	30-80	SW	Belt transect 20 x 5m
100	27-30	E	
400	38-45	SW	
100	13-15	SW	
100	26-30	SW	
100	30-33	NE	
100	5-40	SW	
100	14-17	SW	
100	7-10	SE	
100	17-20	NW	
400	20	N	
100	2- 5	SW	
100	20-23	E	
200	35	NW	
400	37	NW	
200	32	W	
200	2	SE	
400	27	SE	
100	15-18	E	
100	27-30	E	

vegetation in the two locations is disturbed to some degree and ranges from primary forest with relatively minor understorey damage (e.g. site 12 Heao) to secondary forest and shrubland which continues to be disturbed by animal browsing (e.g. Tahunaroa site 31). For the purposes of this description the term primary refers to all sites which retain at least their top stratum unmodified while the term secondary applies to all stands which have been cleared partially or completely. These are either developing relatively undisturbed or are continually modified by animal browsing.

Individual plot data analysis

The ordination diagram (Figure 4.61) summarises the major floristic gradients apparent in the 33 sites with each site plotted according to its loadings on the first two components (1 = 30.6% of the variance and 2 = 18.5% of the variance of the Principal Components Analysis.

A number of reasonably clear cut clusters of sites are apparent:

a) comprising quadrats 14, 15, 16, 17, 19, 20 and 27; basically a kamahi dominated cluster,

b) comprising quadrats 28, 29, 31, 32 and 33; a manuka dominated cluster, and

c) comprising quadrats 1, 2, 3, 4, 5, 6, 9, 10, 11, 12 and 21; basically a tawa dominated cluster.

A number of sites depicted on the ordination diagram appear as intermediates to those listed above. Site 18 for example is an intermediate between the tawa dominated sites and the kamahi dominated sites have a mixed

Figure 4.61

PLOT ORDINATION USING TOP STRATUM AND SUBCANOPY SPECIES RELATIVE DENSITY

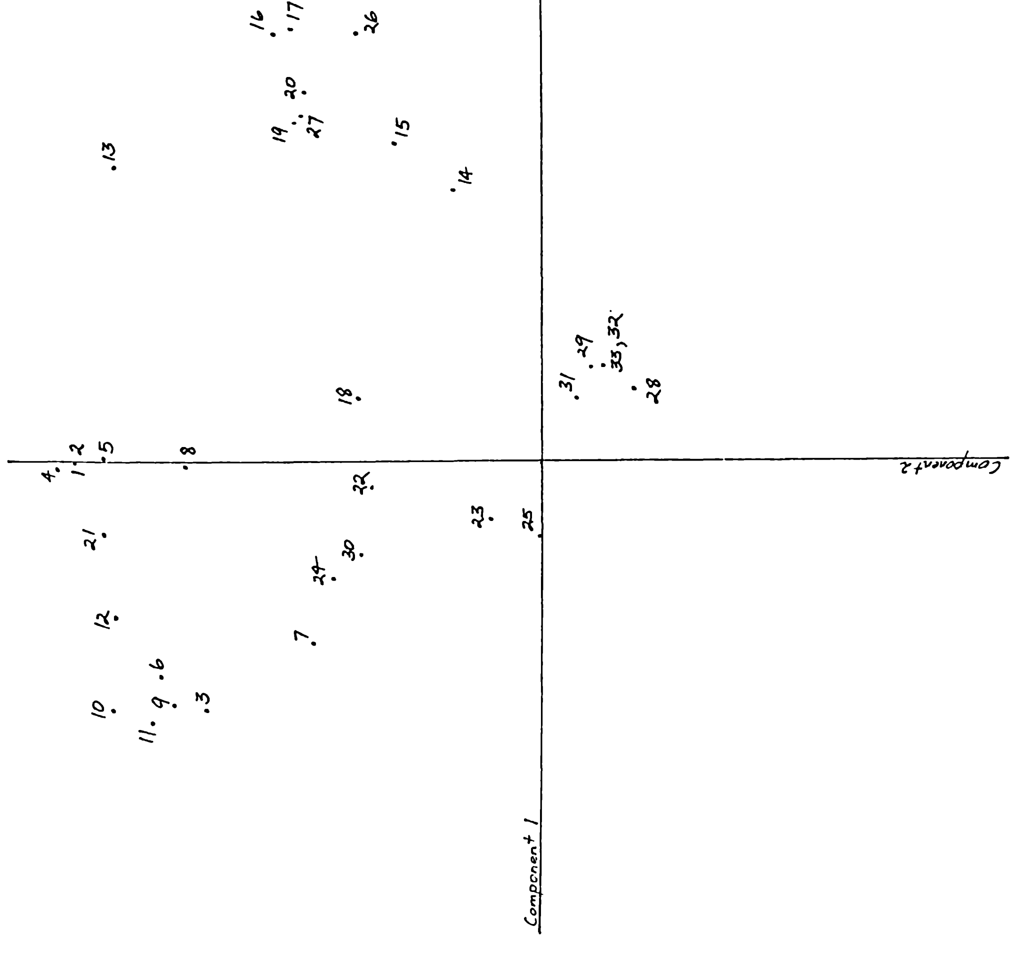
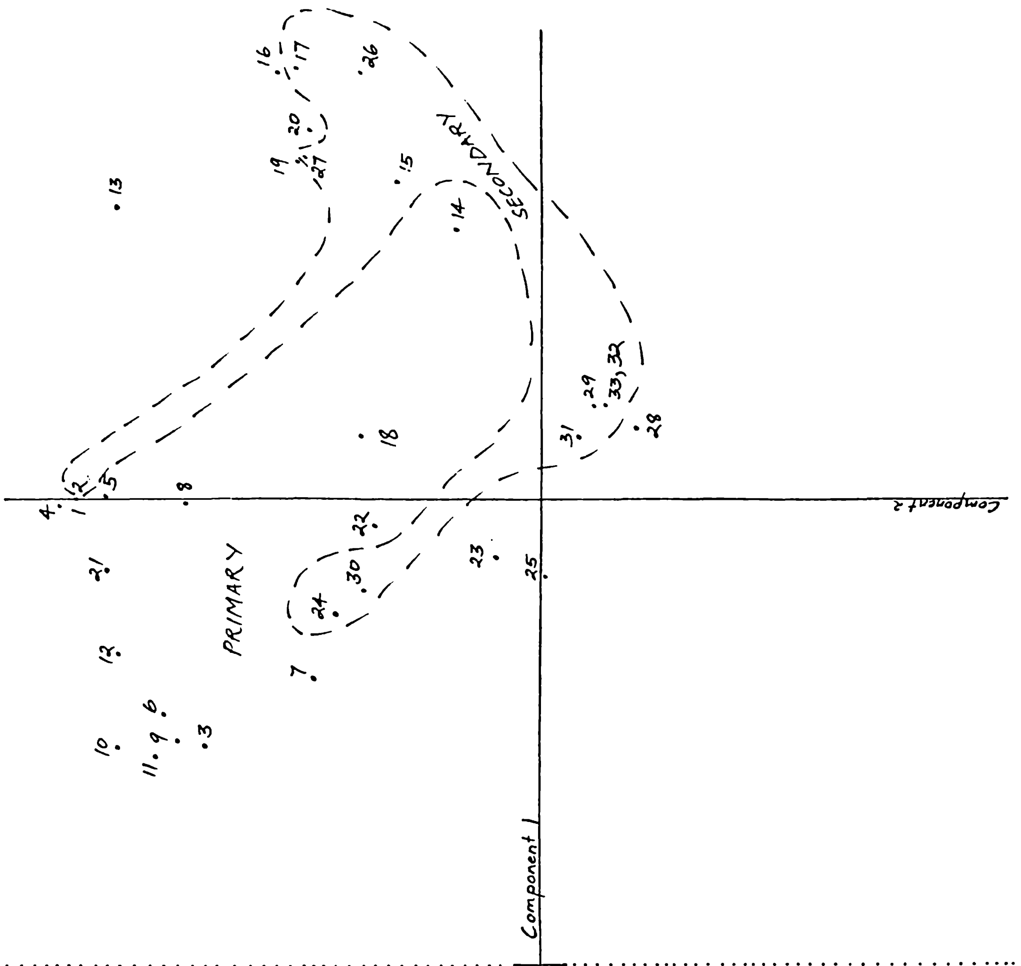


Figure 4.61A

PRIMARY FOREST / SECONDARY FOREST AND SHRUBLAND



composition. Examining the environmental data, successional stage of the site, and superimposing major species relative densities on the ordination (see Figures 4.61A-4.61E) enables the floristic gradients to be related to the underlying environmental gradients.

Two major floristic gradients are apparent. The first involves dominance by either tawa or kamahi in the primary forest (see Figures 4.61A, 4.61B and 4.61C). Sites located nearest site 6 and site 10 on the ordination diagram have high relative densities of tawa while sites located nearest sites 13 and 16 have high relative densities of kamahi.

In the primary forest stands the major underlying environmental factors are those of substrate: soil type, drainage characteristics, slope and soil depth. Tawa tends to dominate on flat to medium slopes where the soils are colluvium derived mainly from siltstone while kamahi is more important at higher altitudes (above 600m), on steeper ridge sites, or near riverbanks. Both tawa and kamahi are found together in sites 1, 2, 3, 4, 5, 8, 12, 13, 16, 18, 21 and 22 so that there tends to be a gradual change in dominance from tawa on the lower hill slopes to kamahi at higher altitudes. Site 13 marks the switch in dominance from tawa to kamahi on the ordination diagram. The remaining primary forest stands which are dominated by species other than kamahi or tawa have obvious differences in environmental site factors which explain their differences in vegetation composition. Site 7 is a high altitude site (731m) with a large component of Hall's totara and some broadleaf. Site 22, another high altitude

Figure 4·61B RELATIVE DENSITIES OF *Beilschmiedia tawa*

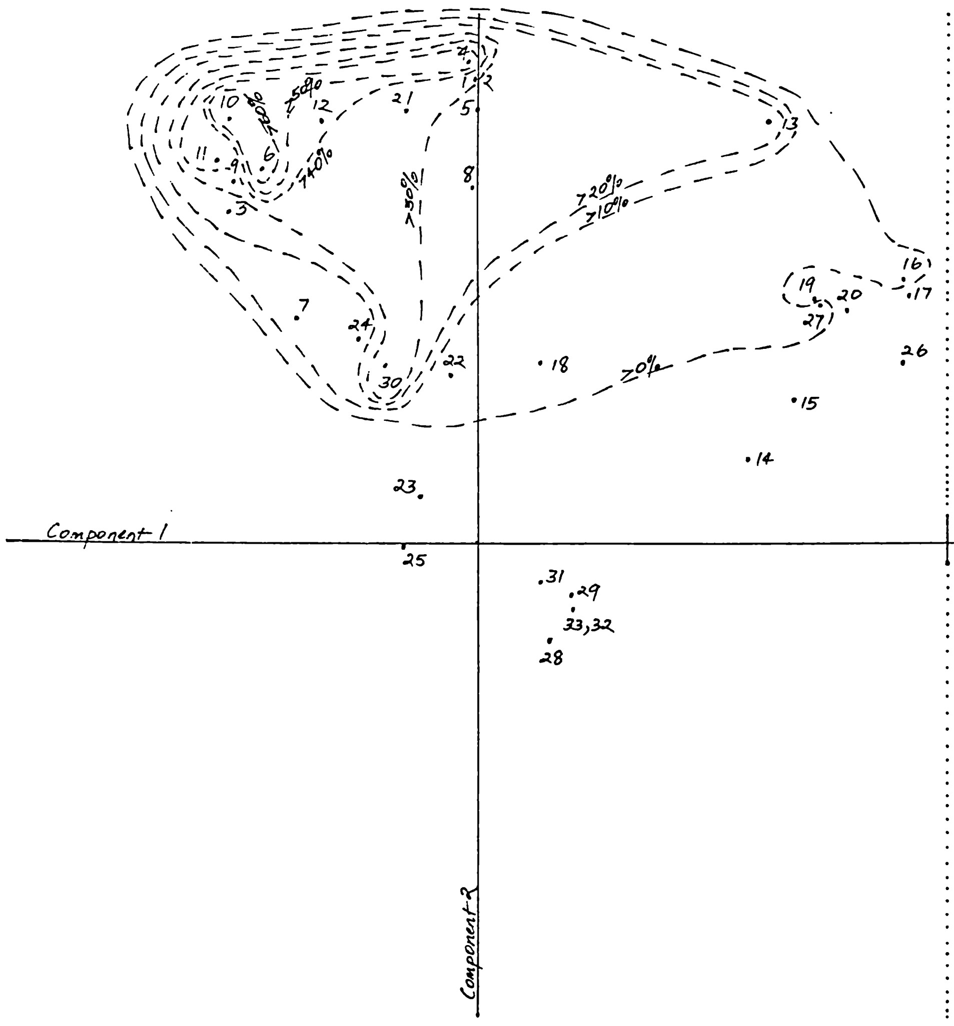


Figure 4·61C RELATIVE DENSITIES OF *Weinmannia racemosa*

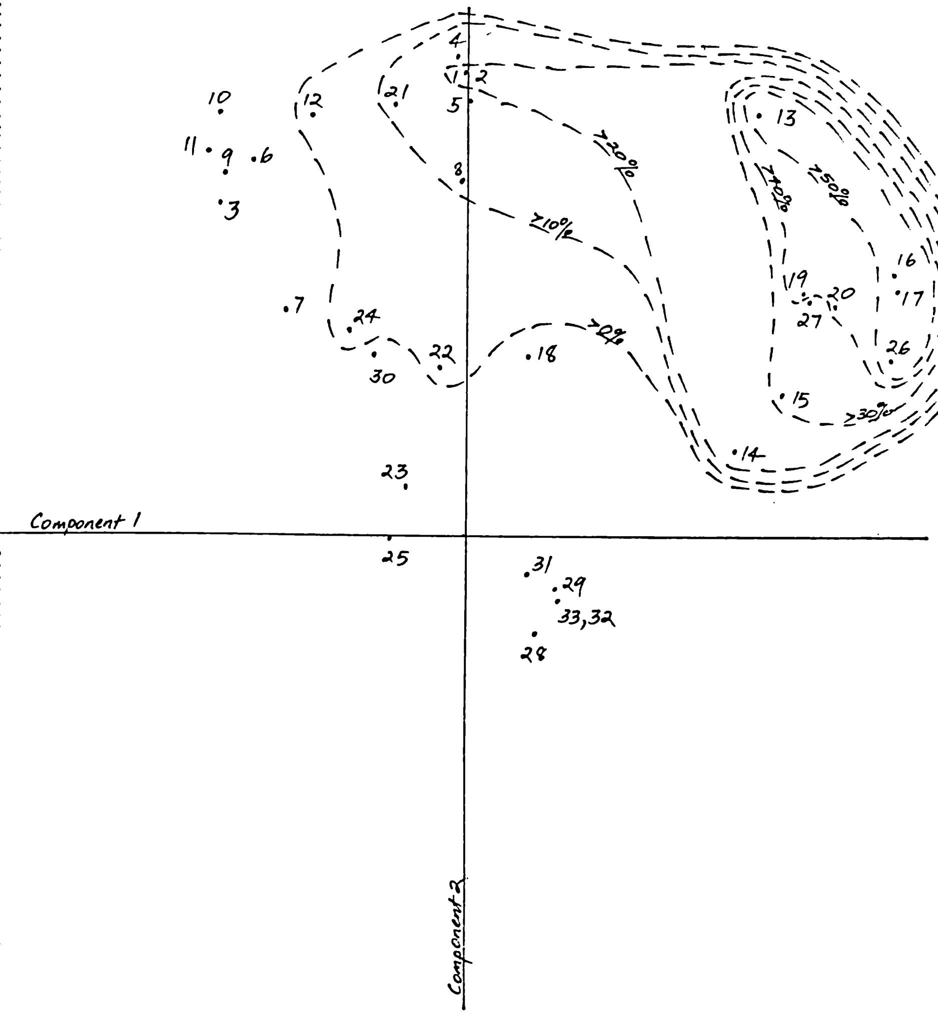


Figure 4.61D RELATIVE DENSITIES OF *Leptospermum scoparium*

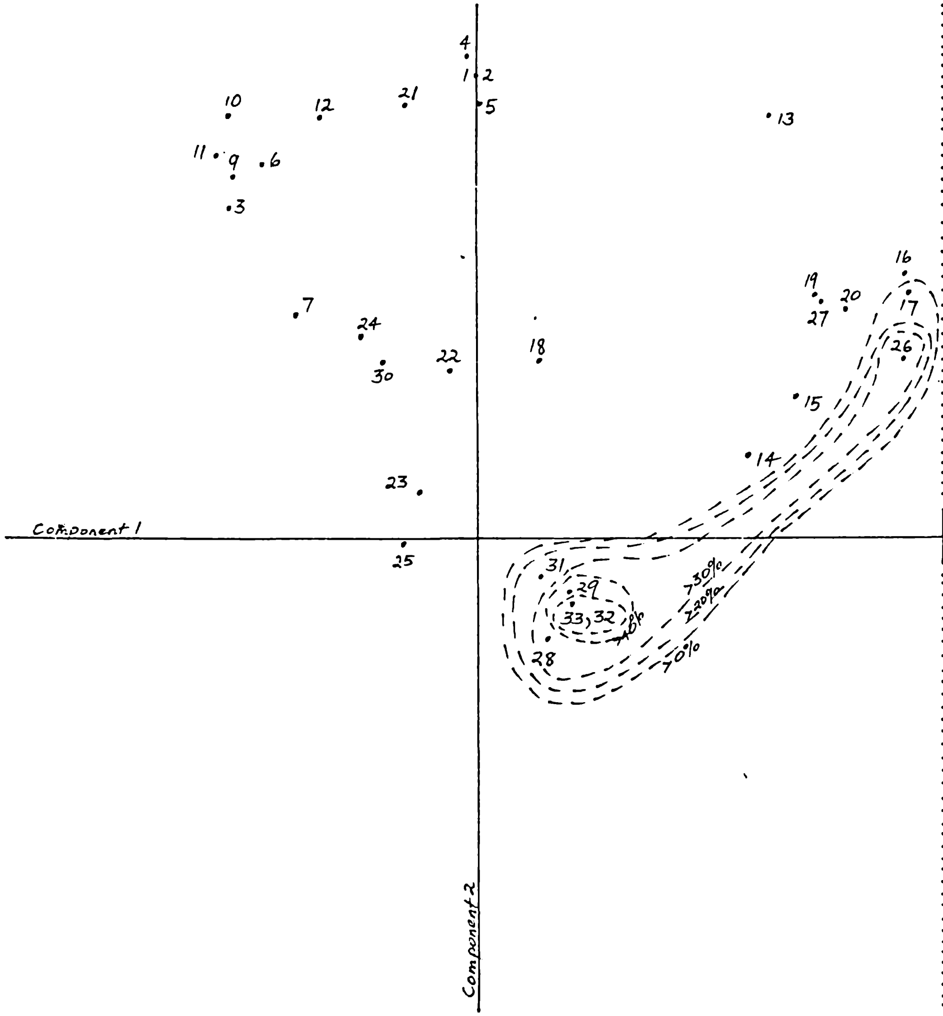
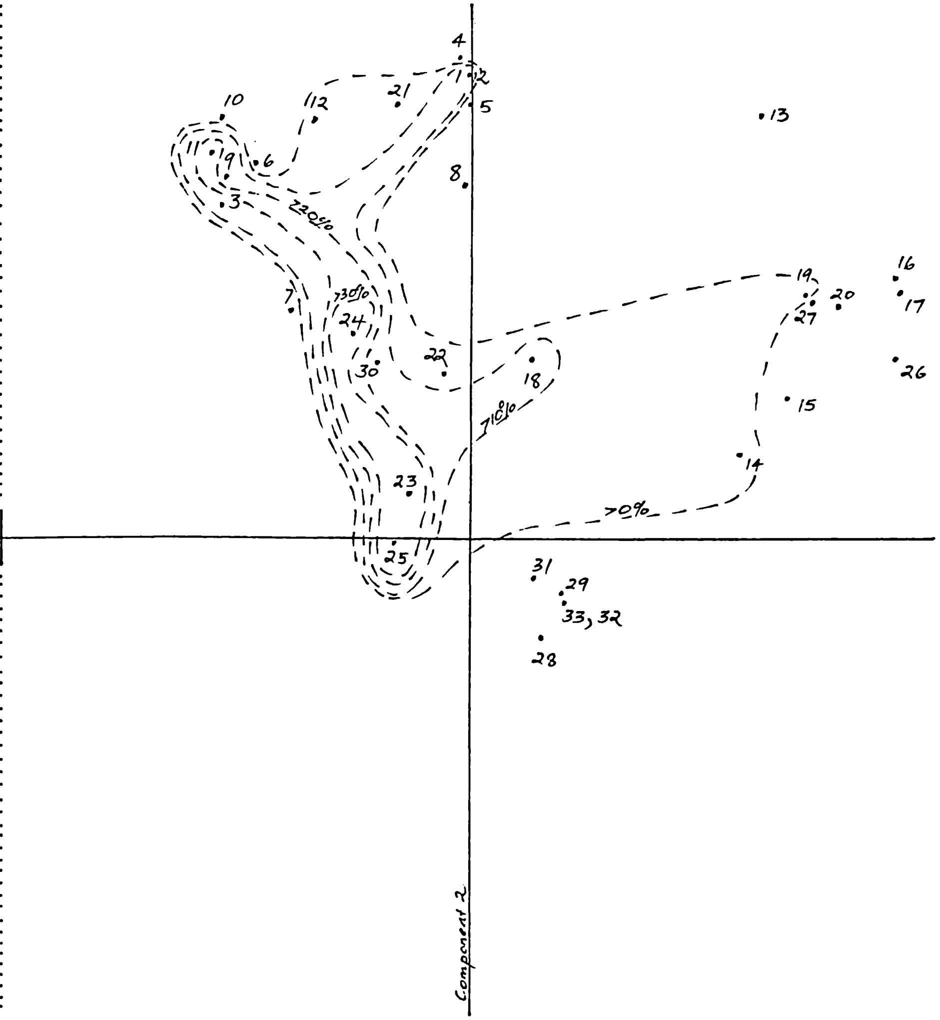


Figure 4.61E RELATIVE DENSITIES OF *Melicytus ramiflorus*



site (719m) on an exposed ridge, is dominated by hinau. Sites 23 and 25 are dominated by soft tree fern and fuchsia respectively, mahoe being second dominant in both sites. Located in shallow basin-like gully heads these sites represent poor drainage variants. Site 18 is located on a shell-rock outcrop at 658m and comprises a complex mixture of species. Mahoe, pigeonwood and kamahi are the most important. The number of relatively uncommon ground cover species recorded at this site including *Elatostema rugosum*, *Rhabdothamnus solandri* and *Libertia grandiflora* probably results from the relative inaccessability of parts of the outcrop from browsing goats although the damper soil conditions are also a factor. Site 14, a steep riverbank site with papa banks >45° slope, is dominated equally by *Coriaria arborea* and kamahi. *Aristotelia serrata* and *Coprosma grandifolia* are also important while in the ground cover *Elatostema rugosum* and *Blechnum capense* drape the continually damp papa banks. Site 28 is located on a sandstone ridge and the canopy is completely comprised of black beech in the top stratum. Large numbers of manuka and *Cyathodes fasciculata* stems 0-15cm d.b.h. are present in the disturbed understorey. *Cyathodes fasciculata* however is also very common in the understorey of undisturbed black beech forest. The fact that this site abuts on to abandoned farmland accounts for this disturbance. In spite of this disturbance (probably a combination of goat, sheep and cattle browsing) the black beech is regenerating successfully at present with seedlings present and an average of four saplings >10cm d.b.h. per

$100m^2$.

The second major floristic gradient is a successional one involving sites supporting secondary vegetation, forest or shrubland, a series grading into either tawa or kamahi dominated forest (see Figure 4.61A). The earliest successional stages quantitatively sampled are those in which manuka is dominant or very important. This includes sites 29, 31, 32 and 33. On the ordination diagram (see Figure 4.61D) manuka declines in importance towards sites 15, 17, 26 and 27. There is a corresponding increase in kamahi representing much later successional stages. Thus sites 17 and 27 have equivalent amounts of kamahi in the top strata as the climax kamahi sites but manuka and/or *Cyathodes fasciculata* remain as minor understorey components. Site 2 represents an even later successional stage in which manuka and *Cyathodes fasciculata* are absent and kamahi is declining in importance and being replaced by tawa. *Dicksonia squarrosa* is an important component in sites 30 and 31. In the former it has resulted from heavy cattle damage further disturbing the second growth tawa forest while in the latter it appears in its usual role as an associate of manuka in an early successional stand. Site 24 is another containing tawa which has been further disturbed being located right on the bush edge. Mahoe and silver fern are the most important components of the vegetation.

The two major floristic gradients already described above are amplified on Figures 4.62 to 4.65B.

Figure 4.62 GENERALISED LANDSCAPE AND VEGETATION TYPES IN THE TARANAKI UPLAND

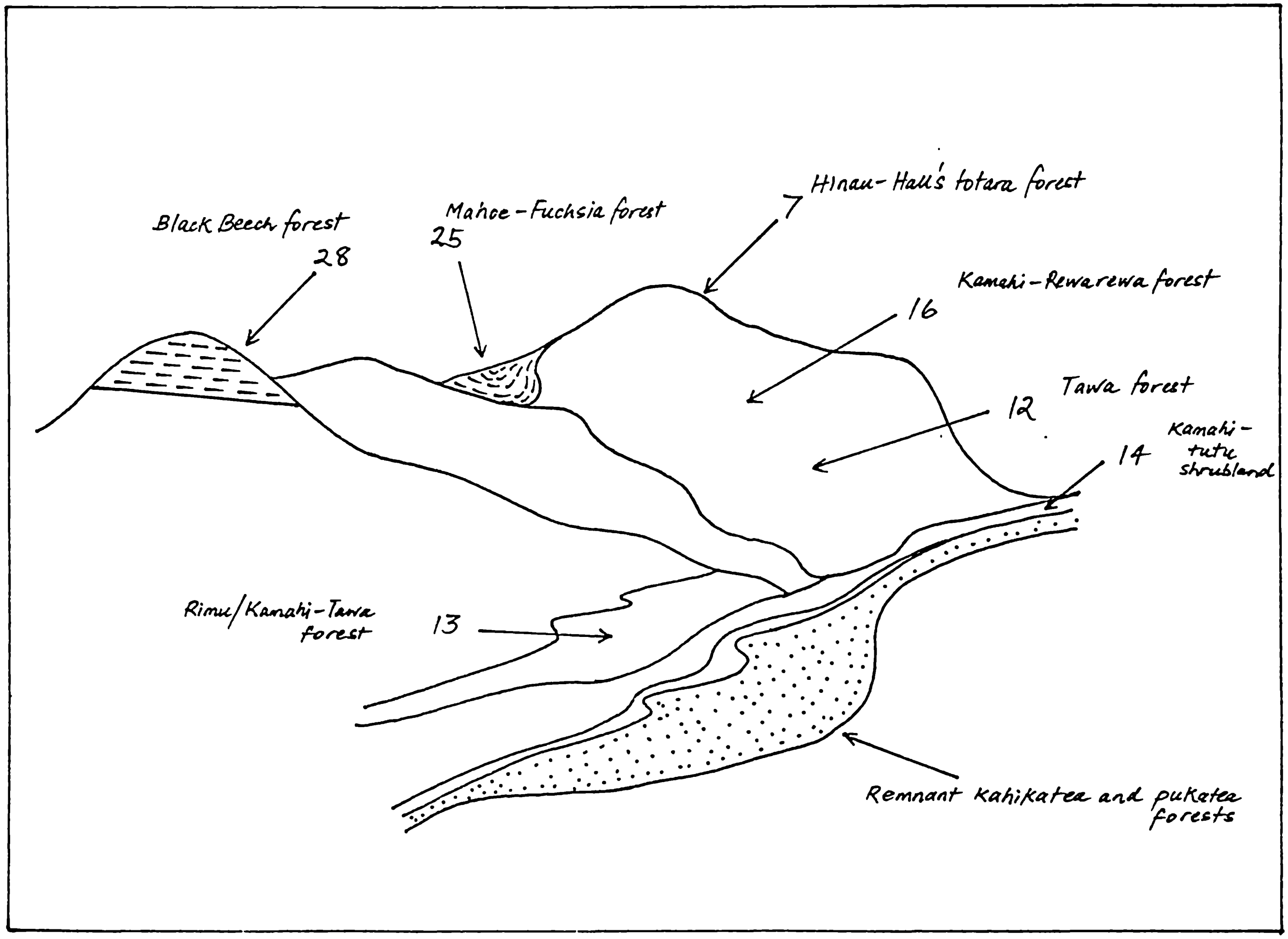
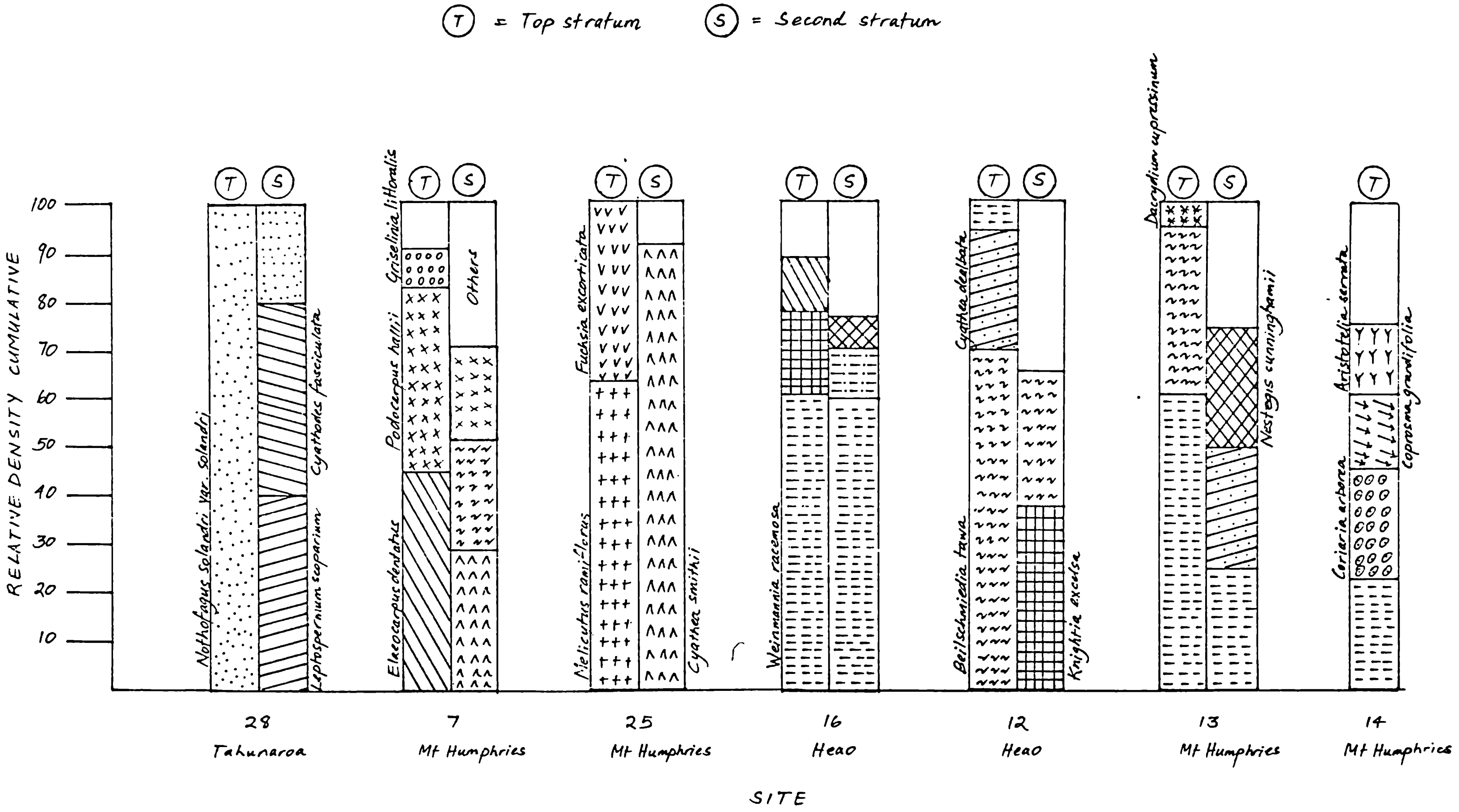


Figure 4·63 REPRESENTATIVE VEGETATION TYPES IN THE TARANAKI UPLAND



Vegetation composition, topography and substrate

The vegetation composition of the range of major topography and substrate types is presented in greater detail on Figure 4.63. Vegetation composition at each of these representative sites (Figure 4.63) can be related directly to the major landscape features shown on the generalised landscape diagram (Figure 4.62).

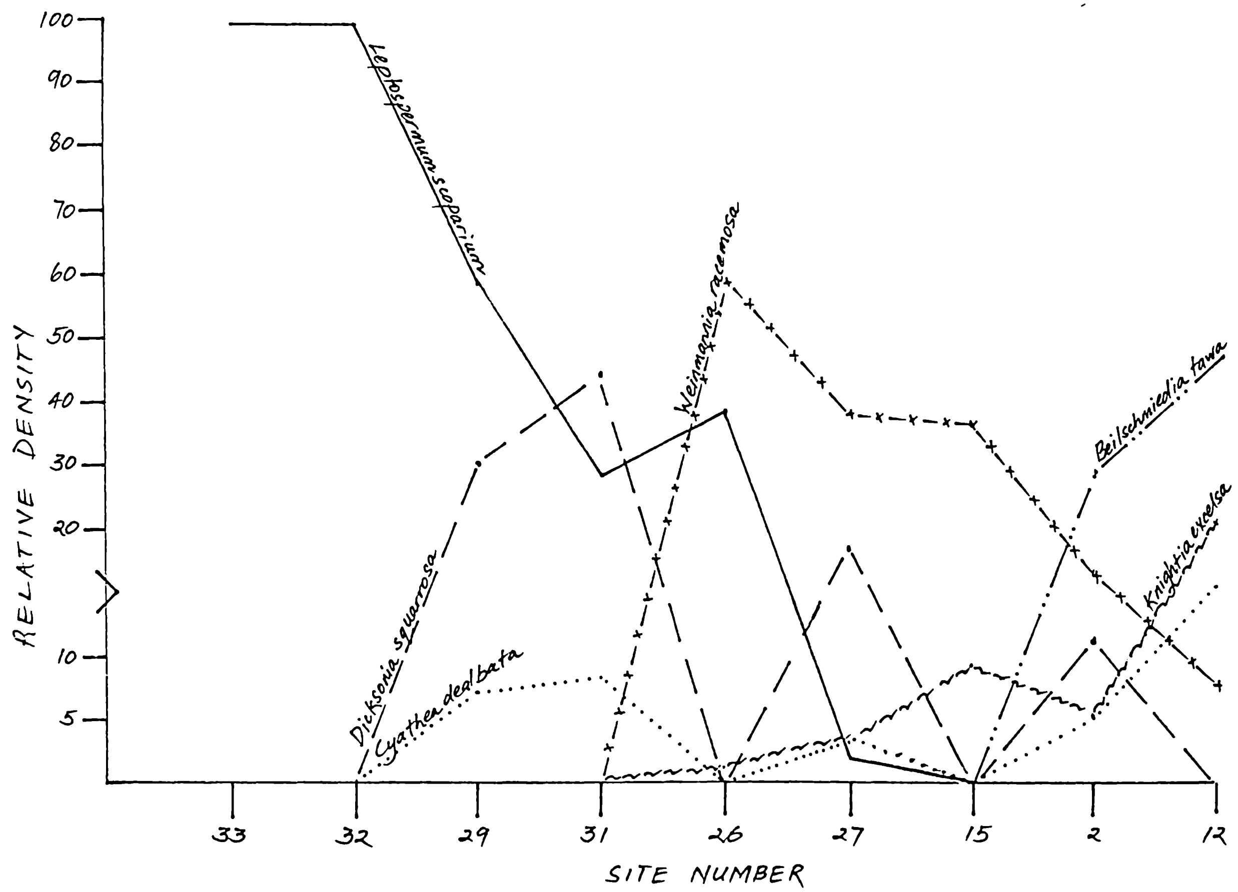
A major primary forest type was not sampled quantitatively because it remains only as a few scattered remnants. This is the kahikatea forest which once occurred on river flats in the Aotuhia and Mt Humphries locations. All that remains is isolated clumps of small kahikatea, pukatea and titoki on some of the abandoned river flats. A few very large kahikatea and pukatea were noted in the more inaccessible areas, for example in gully heads near the Heao sites. As well kahikatea seedlings were recorded in site 12 (Heao).

Successional changes in the vegetation

The successional changes in floristic composition and vegetation structure are depicted on Figures 4.64, 4.65A and 4.65B. Sites which come from similar slope (substrate etc.) and which had been left relatively undisturbed to develop were selected. These sites were ordered according to the method of leading dominants (Brown and Curtis 1952), although climax adaptation numbers were not calculated. Instead, the sites were simply plotted equidistant on the abscissa (see Figure 4.64). After this floristic ordering of sites other variables including mean canopy height, mean d.b.h., number of stems per 100m^2, total basal area

Figure 4.64

INFERRED SUCCESSIONAL CHANGES IN COMPOSITION OF HILL SLOPE VEGETATION



per 100m^2, volume per 100m^2, and number of vascular epiphytic species were plotted on Figures 4.65A and 4.65B. The floristic and structural changes which occur in lower hill slope vegetation in the Aotuhia and Mt Humphries locations are thus summarised from the point at which manuka is the dominant at least. The succession described is by no means the only succession apparent. Depending on how efficient forest clearance was and depending on other factors such as grazing and browsing pressure and 'burning off' practices, many differences with respect to detail and rate of succession are apparent. The general tendency however is for the establishment of a tawa dominated forest on the lower hill slopes whether via a kamahi dominated type or more directly.

The reversion of formerly cleared land begins with the invasion of species like bracken fern, *Paesia scalerula* and blackberry. Large patches of these species are established and manuka seedlings begin to appear as well. The manuka eventually forms a low bushy canopy (2m) which reduces the light to, and thus the vigour of, the initial invaders. In the Mt Humphries and Aotuhia locations pasture reversion to forest appears to depend to a great extent on the reduction of grazing and browsing pressure. At present continued grazing and browsing by wandering cattle, sheep and goats is slowing the advent of successional stages beyond dominance by bracken fern, *Paesia scalerula* and manuka in many places. In some sites, for example, site 31 (Tahunaroa) there is evidence of turnover of manuka in the top stratum, with dead and fallen individuals being replaced by manuka again. Manuka is thus maintaining itself as top stratum dominant. In most places however manuka is eventually overtopped by larger species principally kamahi but also mahoe, rewarewa, *Coriaria arborea* and *Dicksonia squarrosa* in some cases. *Dicksonia squarrosa* may also be indicative of slip sites with thin soils. Cores taken from kamahi in site 27 (Okara) indicated that some of the canopy individuals were at least 45 years old and possibly older considering the problems of dating multi-stemmed individuals. There is probably a great deal of variation however in the time taken for kamahi to become dominant depending on the proximity of seed sources and particularly how heavy grazing and browsing pressure is at the site. In many places it was noted that kamahi and mahoe were present in the ground cover beneath manuka but were continually browsed thus preventing them growing up into the canopy. Kamahi in turn declines in importance although remaining as an important component in most of the tawa dominated sites. Rewarewa and silver fern also remain as important associates of the tawa. Cores taken from kamahi in site 12 (Heao) indicated that some of the canopy individuals were at least 70 years old thus kamahi probably dominates successional stands for at least 50 years before tawa becomes dominant. The seedling species (see Table 4.19) present at each site give a preview of the possible future canopy dominants and add further evidence for the sequence of succession already described. Manuka for example was recorded at the seedling stage in sites 32 and 31 only. Kamahi seedlings were recorded beneath the manuka and *Dicksonia squarrosa* dominated canopies in sites 32, 29 and 31. Mahoe seedlings were present in all the sites examined but formed only a relatively minor component of the top stratum in the later stages of succession. The species characteristic of the climax stands, rewarewa, rimu and tawa, appear first in the successional sequence beneath the kamahi canopy in site 27.

Associated with the floristic changes outlined above are changes in the physiognomy and structure of the vegetation. Table 4.19 and 4.20 and Figures 4.65A and 4.65B quantify a few of these changes following the site order employed floristically on Figure 4.64. Moving from manuka dominated sites (sites 32 and 33) through to vegetation dominated by tawa (site 12) the following trends are apparent:

1) Canopy mean height increases from 5.0m to 22.3m.
2) Mean d.b.h. (of stems >2m in height) increases from ~4cm to ~17cm.
3) Stem numbers (of stems >2m in height) decrease from >240 to ~20 per 100m^2.
4) The combination of trends shown for 2) mean d.b.h. and 3) stem numbers results in a fluctuating total basal area per 100m^2. The highest total basal area however occurs in manuka dominated vegetation (sites 29 and 32) with total basal area exceeding 0.5m^2.
5) Volume (as roughly estimated by multiplying canopy mean height by mean basal area) increases from 1.1m^3 at site 33 up to 3.69m^3 in site 29. Volume then

Table 4.19 Presence of seedlings of selected species

Species	Site Number								
	33	32	29	31	26	27	15	2	12
Leptospermum scoparium		+		+					
Aristotelia serrata	+	+	+	+	+				
Carpodetus serratus	+	+	+		+				
Brachyglottis repanda	+	+	+		+	+			+
Melicytus ramiflorus	+	+	+	+	+	+	+	+	+
Weinmannia racemosa		+	+	+	+	+			+
Podocarpus totara				+		+		+	
Dacrydium cupressinum						+		+	
Beilschmiedia tawa						+		+	+
Knightia excelsa						+	+	+	+
Podocarpus ferrugineus							+		+

Table 4.20 Physiognomy and structure of hill slope vegetation

Site number	Mean d.b.h. cm	Mean basal area cm2	No. stems 100m^2	Mean canopy height	Total basal area m2	Volume m3	No. of vascular epiphytic spp.
33	4.0	13	248	5.0	0.3224	1.61	0
32	5.4	23	250	5.0	0.5750	2.87	3
29	11.2	98	71	5.3	0.6958	3.69	4
31	11.0	95	26	5.3	0.2470	1.31	8
26	7.5	44	67	6.8	0.2948	2.01	4
27	11.3	100	39	7.6	0.3900	2.96	15
15	13.6	145	22	7.6	0.3190	2.42	7
2	16.7	219	20	18.3	0.4380	8.01	15
12	17.1	230	21	22.3	0.4830	10.77	11

Figure 4.65A INFERRED SUCCESSIONAL CHANGES IN STRUCTURE AND PHYSIOGNOMY OF HILLSLOPE VEGETATION

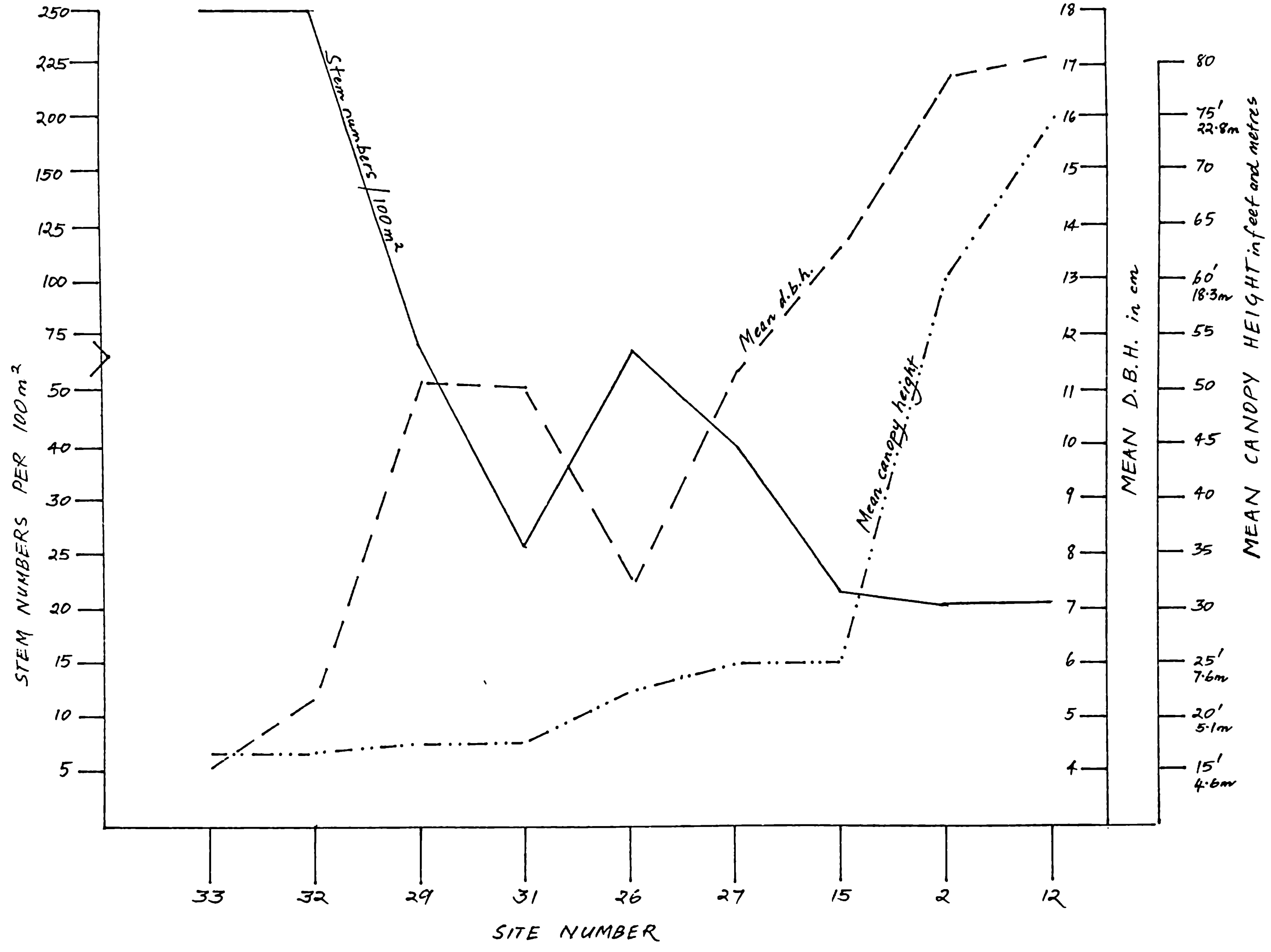
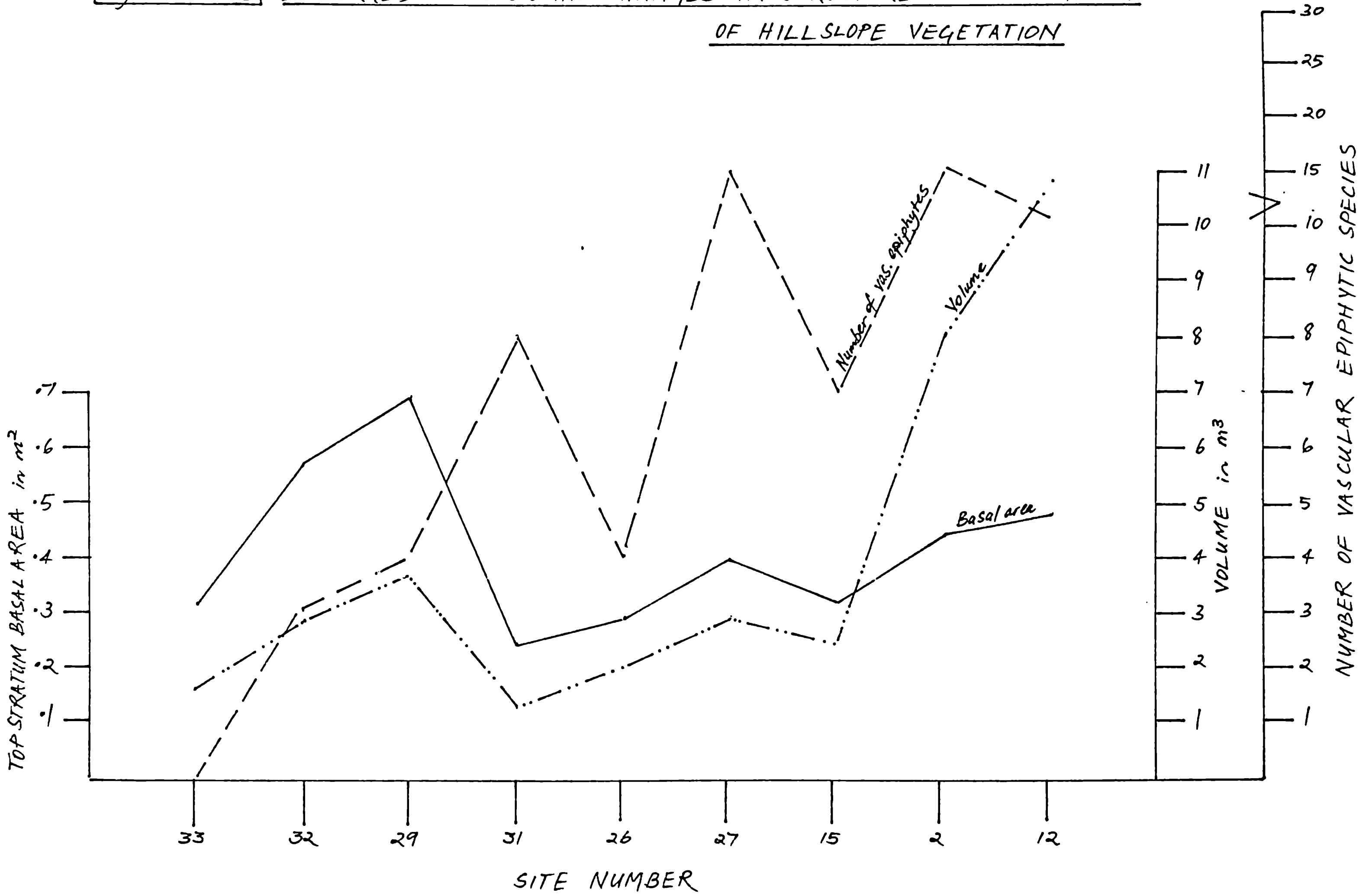


Figure 4·65 B INFERRED SUCCESSIONAL CHANGES IN STRUCTURE AND PHYSIOGNOMY OF HILLSLOPE VEGETATION



declines to 1.31m^3 in site 31 but increases gradually at first to 2.0m^3 in sites 26, 27 and 15 and then rapidly increases to 8.0m^3 in sites 2 and 12.

6) Numbers of species of vascular epiphytes increases from 0 to 2 in the manuka dominated sites 33 and 32 respectively to more than 10 in sites 27, 2 and 12.

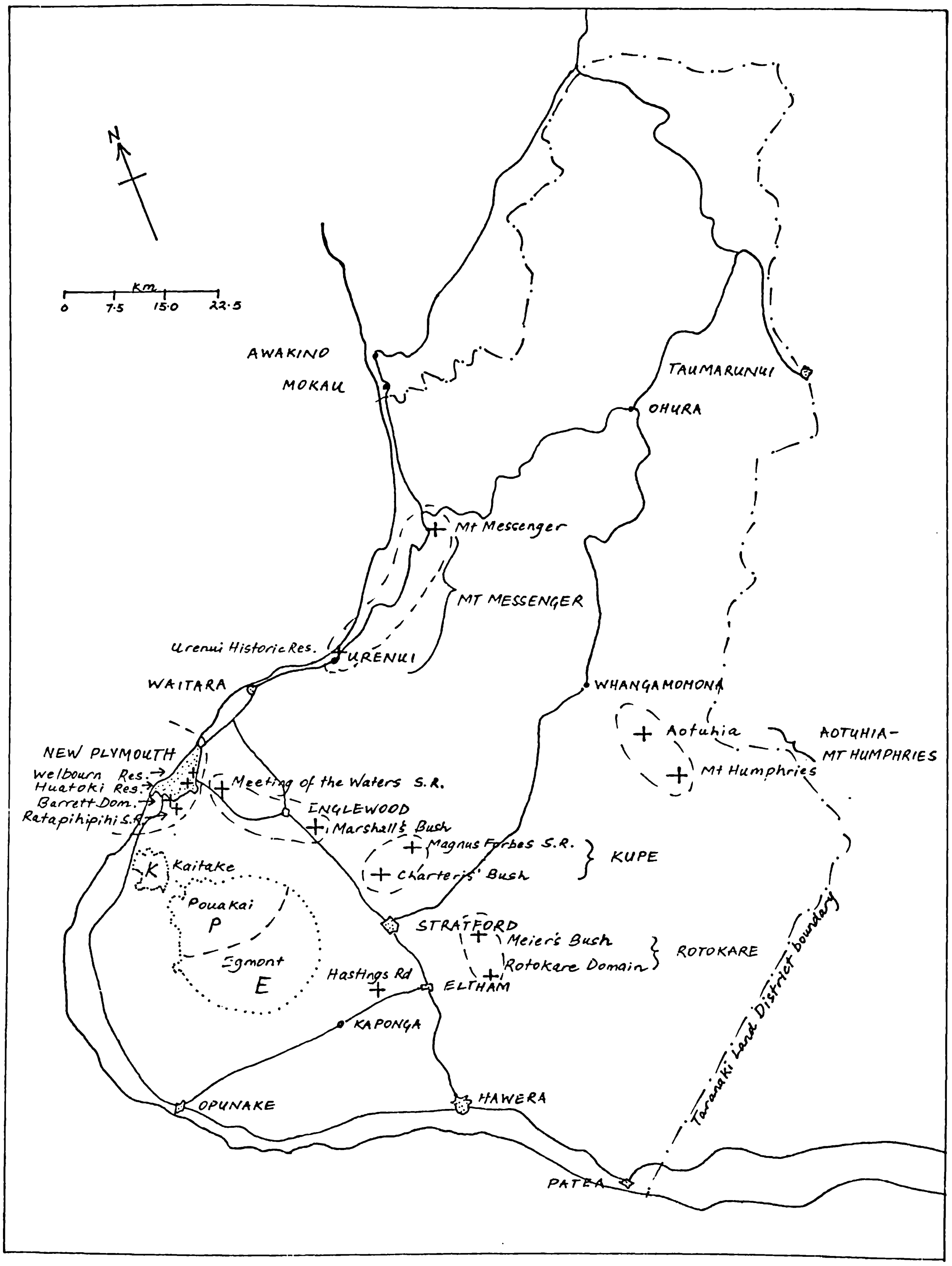
Miles (1979) has questioned the validity of successional inferences obtained by ordering temporally, spatially separated sites. This analysis however gives some general indication of the likely pattern of vegetation succession on the lower hill slopes following forest clearance. Essentially succession involves the replacement of a manuka shrubland first by a kamahi forest and later by a tawa dominated forest. Of all the stages the tawa forest is the richest floristically, mainly because of the greater numbers of vascular epiphytes and ground cover fern species present in stands of equivalent area. As well, the tawa forest is structurally more complex being multi-layered by comparison with the simple canopy and understorey layering of the manuka shrubland. There are of course exceptions to these general observations. Stands which have been partially disturbed only, or are prevented from developing at a 'normal' rate because of animal pressure often have even greater numbers of species than equivalent stands of tawa dominated forest. In these sites there is a complex mixture of species prominent in both the early and later stages of development described already. The sequence of change is by no means clear cut because of the already described variation in degree of forest clearance and the subsequent control exerted by browsing and grazing animals. In some instances however it is possible for the change from manuka shrubland to kamahi forest to occur within 50 years and that tawa may eventually dominate this forest within another 50 years.

F. FOREST REMNANTS AND SCENIC RESERVES

Introduction

As has already been noted in the section on the Taranaki Upland, forest once covered most of the Taranaki Land District. Any examination of the vegetation of Egmont National Park restricted to the artificial boundary of the park fails to give the forests on Egmont the perspective attained by examining the related forests nearby. In fact on topographic grounds any study of the vegetation of the whole of Mt Egmont includes all of the ring plain as well. Nearly all of the forest which once covered this area is now gone. By referring to the descriptions available written by early European settlers, surveyors and explorers, particularly Rutherford et. al. (1940) and Skinner (1946), and by examining forest remnants and scenic reserves which still contain vestiges of the earlier vegetation cover, it is however possible to build up a picture of the pre-European vegetation. Thirteen locations (see location map Figure 4.66) on or near the edge of the ring plain were examined in order to do this. The major vegetation types present were determined and species lists compiled. The species lists focussed on the presence of woody species and tree ferns and an attempt was made to list all species in these categories at each of the locations. Other species were also listed (epiphytes, lianes, ground cover etc.) but not as comprehensively because of time limitations. The species data thus collected is used in the following section along with the comparable data from Egmont National Park and the Taranaki Upland to provide a summary of the

Figure 4.66 FOREST REMNANTS AND SCENIC RESERVES LOCATION MAP



major floristic differences from place to place within the Taranaki Land District.

Forest types

From the data collected at each location and a comparison of the leading dominants in the top stratum with those represented within the national park at least five major forest types either absent from or poorly represented within the national park may be distinguished. These types may be defined purely on the basis of the prominence in the top stratum of a limited number of species: kohekohe, pukatea, tawa, swamp maire and quintinia. The forest types thus defined include coastal-semi-coastal forest in which kohekohe is prominent, semi-swamp forest dominated by pukatea, lowland tawa forest, swamp forest dominated by kahikatea or swamp maire, and upland kamahi forest in which quintinia and Hall's totara are important associates.

Forest in which kohekohe is prominent was recorded at Barrett Domain, Ratapihipihi Scenic Reserve, Welbourn Reserve, Urenui Historic Reserve and Huatoki Reserve. All of these locations are below 155m a.s.l. and all are within 20km of the coast. Forest dominated by pukatea was recorded in all of the above locations except Urenui and in addition was recorded at Rotokare Domain. Again all of the locations in which pukatea is dominant are below 155m a.s.l. but extend up to 35km from the coast. This forest was always recorded in poorly drained sites or stream sides. Both pukatea dominated forest and kohekohe dominated forest thus provide a direct link with the forests examined on the margins of the Kaitake Range.

Tawa forest was obviously the most widespread type on the ring plain before the forest clearances as evidenced by the early descriptions and by the prominence of tawa in most of the forest remnants. This forest type was recorded at Meeting of the Waters Scenic Reserve, Marshall's Bush, Magnus Forbes Scenic Reserve, Meier's Bush, Rotokare Domain, near Mt Messenger and at Hastings Road. Important associate species include rewarewa, rimu, rata and hinau although most of the remnants are highly modified and tawa is more important than would have been the case formerly. Many of the large podocarps (rimu and totara) for example have been logged out of these remnants. Most of the medium to well drained sites above 150m on the ring plain would have once supported forest dominated by tawa. This forest type still extends up to about 600m a.s.l. in much of the Taranaki Upland. As well, tawa is present as a component of the kamahi dominated forest just inside the park boundary today and tawa dominated forest is present in places in the Kaitake Range (see Kaitake section). The tawa forest at Mt Messenger is floristically distinct from the other locations because of the presence of mangeo and quintinia as associates of tawa.

Most of the poorly drained sites below 550m a.s.l. were covered by forest in which kahikatea and/or swamp maire were leading dominants although matai was also prominent in some places. Kahikatea occurs in the Potaema Bog within the national park at an altitude of 670m although it is not the overall dominant. Swamp maire occurs just inside the park boundary on the eastern and western slopes of Mt Egmont although it is not a leading dominant. At the Meeting of the Waters Scenic Reserve matai is prominent on alluvial terraces beside the Waiwhakaiho River although previous forest clearance and subsequent regeneration in part appear responsible for its present day high densities. Thus with decreasing elevation and the greater availability of poorly drained sites on the lower more gentle slopes of Egmont large areas most now drained for farmland were dominated by kahikatea and swamp maire. Locations where this forest is still present include Charteris' Bush, Rotokare Domain and Meier's Bush. The latter location is near the old Ngaere Swamp which once supported the most extensive stands of this forest type.

In marked contrast to the forests of Egmont National Park forest in which kamahi is dominant is not common on the ring plain. Exceptions include forest remnants lining some of the larger rivers, for example the Manganui River, and areas of previously cut over forest now supporting dense thickets of kamahi forest. At higher altitudes however, generally above 550m off the edge of the ring plain near Mt Messenger and in the Taranaki Upland, kamahi forest again becomes prominent. Near Mt Messenger however it is distinct because of the presence of quintinia as an associate of kamahi in the top stratum of vegetation while in the understorey other species recorded such as *Gaultheria paniculata* and *Phyllocladus trichomanoides* add to this difference.

One important forest type noted by the early settlers was coastal forest dominated by karaka. Very little of this forest type remains today. Karaka was however recorded in 9 of the locations sampled and was generally most important in locations close to the coast, for example Barrett Domain, Ratapihipihi Scenic Reserve, Welbourn Reserve and Huatoki Reserve. Again these forests provide a direct link with the forests on the coastal margins of the Kaitake Range which also contain karaka. A small area (<1ha) at Rotokare Domain some 21km from the coast supports karaka dominated forest. It is possible that this grove of trees is the result of old Maori plantings.

Table 4.21 Species frequency as top stratum leading or co-dominant in forest and shrub sites

	Taranaki Upland	Ring Plain	Kaitake	Pouakai	Egmont
manuka	4(11.4)				3 (4.9)
kahikatea		1 (4.3)			1 (1.6)
swamp maire		2 (8.7)			
matai		1 (4.3)			
karaka		1 (4.3)			
fuchsia	1 (2.8)				
tutu	1 (2.8)				
wheki	1 (2.8)				
black beech	1 (2.8)				
lancewood			1 (2.3)		
kohekohe		4(17.4)	1 (2.3)		
pukatea		3(13.0)	4 (9.3)		
rewarewa	1 (2.8)		4 (9.3)		
tawa	8(22.8)	11(47.8)	6(13.9)		
rimu	1 (2.8)		1 (2.3)	3 (5.1)	1 (1.6)
rata	3 (8.6)			5 (8.5)	4 (6.5)
mahoe	2 (5.7)		2 (4.6)		
hinau	3 (8.6)		5(11.6)		
toro			1 (2.3)		
miro			1 (2.3)	1 (1.7)	
kamahi	9(25.7)		17(39.5)	30(50.3)	15(24.6)
Hall's totara				1 (1.7)	7(11.5)
broadleaf					8(13.1)
kaikawaka					2 (3.3)
Coprosma 'taylorae'				1 (1.7)	
Podocarpus nivalis				1 (1.7)	
Pseudopanax colensoi					1 (1.6)
Cassinia vauvilliersii					1 (1.6)
leatherwood				17(28.8)	14(22.9)
inaka					4 (6.5)
	35	23	43	59	61

G. DATA COMPARING THE VEGETATION COMPOSITION AT EACH MAJOR SAMPLING LOCATION

Species frequency as top stratum leading or co-dominant in forest and shrub sites

Table 4.21 summarises the species relative frequency as top stratum leading or co-dominant in the 209 sites sampled supporting forest or shrub vegetation in the Taranaki Land District. Each species was scored for each record as a leading or co-dominant species in the top stratum vegetation sampled and the resulting total expressed as a percentage of the total recorded. This summary is presented as a supplement to the detailed vegetation type descriptions already presented in this chapter in order to enable a simple and rapid comparison to be made of each of the main forest and shrub types as defined by leading or co-dominants in the top stratum at each of the major sampling locations. The importance of a relatively few top stratum hardwood species, particularly kamahi, tawa, pukatea, kohekohe and leatherwood, in characterising the vegetation at each major sampling location in the Taranaki Land District is readily apparent from this Table. A fuller comparison of the vegetation types and floristics at each of the major sampling locations follows in Chapter 5. The final presentation of data below is a summary of the distributions of woody species and tree ferns in nine subdistricts within the Taranaki Land District.

Species (woody species and tree ferns) distribution in nine sub-districts within the Taranaki Land District.

The data collected during the course of this study enabled the compilation of Table 4.22 which summarises the distributions of woody species and tree ferns in nine sub-districts examined within the Taranaki Land District. Although all vascular species were recorded during this study a summary is presented only for the woody species and the tree ferns because only for these species can any certainty be placed on whether they are present in or absent from a location. This is mainly because of the ease with which large woody species can be found in comparison to the other much smaller vascular species. As well, as has already been noted in Chapter 2, the large woody species can be considered to be the most important component of the vegetation. The other vascular species found at each location are however described in the detailed descriptions of the vegetation provided for each major sampling location earlier in this chapter and as well lists of these species have been provided in the appendices for some of the locations examined. Completion of further surveys of the vegetation in the Taranaki Land District during the period 1981-1982 should enable the summary presented to be extended to the remaining groups of vascular species.

The sub-districts shown on Table 4.22 are Egmont, Pouakai, Kaitake, New Plymouth, Inglewood, Mt Messenger, Kupe, Rotokare and Aotuhia-Mt Humphries. These sub-districts resulted from the amalgamation of data obtained from sampling locations in close proximity. This procedure is depicted on the location map Figure 4.66 which shows each of the sampling locations and the approximate limits of each of the nine sub-districts. This method of presentation was considered more useful as it ensured a range of topography and habitat types in each sub-district had been examined, for example presenting the data from a single swamp forest location such as Charteris' Bush would have been of little use. Table 4.22 thus summarises the main differences in floristic composition apparent from place to place within the Taranaki Land District. A total of 171 different vascular plants (including hybrids) are listed. Of these, 31 species were recorded in all of the nine sub-districts and of the total 171 different vascular plants 160 were recorded in actual plot data or species lists compiled at a site. The additional 11 plants were noted between sites during the study or were drawn to the attention of the author by other people in particular Mr J. Hedditch of Stratford. A number of other plants presumed to be hybrids were noted during the study, particularly *Coprosma* spp. hybrids, but because of uncertainty as to their parentage they have not been included in Table 4.22. Several distributions are recorded as tentative only and marked thus (?). In these instances either the species presence has been reported to the author but has not actually been seen, the identification is tentative and requires further collections, or the species is definitely present but its status (natural or adventive) is uncertain.

When the total number of different vascular plants is considered Egmont has the greatest number (103) with Pouakai second (96) and Mt Messenger has the third greatest number (91). A closer examination of each of the categories of woody species shows that Egmont and Pouakai both have the greatest total principally because of their greater numbers of dicot shrubs, 46 and 43 respectively. By contrast Mt Messenger and Aotuhia-Mt Humphries have the greatest numbers of dicot trees, 38 and 34 respectively, and dicot lianes, 12 and 14 respectively. Kupe and Rotokare also have 12 dicot liane species. The large numbers of dicot shrubs recorded on Egmont and Pouakai relate to the presence of higher altitude habitats not found in any of the other sub-districts. The greater numbers of dicot trees and dicot lianes in the Mt Messenger and Aotuhia-Mt Humphries sub-districts could relate to the fact that unlike Egmont and Pouakai these areas have barely been disturbed by volcanic activity while in addition the Mt Messenger sub-district has semi-coastal habitats not found on Egmont or Pouakai. The low number of different plants recorded for the Inglewood sub-district is attributable both to the small area actually examined (forest remnants) and the effects of cattle browsing at one of the locations (Marshall's Bush). The differences between sub-districts as shown on Table 4.22 relate to altitude, distance from the coast, latitude, and differences pertaining to volcanic history and landform.

Table 4.22 Species (woody species and tree ferns) distribution in nine sub-districts within the Taranaki Land District

GYMNOSPERM TREES AND SHRUBS (9)	E	P	K	N	I	M	K	R	A
Dacrydium cupressinum	+	+	+	+	+	+	+	+	+
Libocedrus bidwillii	+	+							
Phyllocladus trichomanoides				?		+			
Podocarpus dacrydioides	+		+	+	+	+	+	+	+
Podocarpus ferrugineus	+	+	+	+	+	+	+	+	+
Podocarpus hallii	+	+	+			+			+
Podocarpus nivalis		+							
Podocarpus spicatus	+		+	+	+		+		+
Podocarpus totara				+	+	+	+	+	+
	6	5	5	6	5	6	5	4	6

MONOCOT TREES AND SHRUBS (5)	E	P	K	N	I	M	K	R	A
Cordyline australis	+	+	+	+	+	+	+	+	+
Cordyline banksii	+	+	+			+	+		+
C.australis x *C.indivisa*	+								
Cordyline indivisa	+	+							+
Rhopalostylis sapida			+	+	+	+		+	
	4	3	3	2	2	3	2	2	3

DICOT TREES (58)	E	P	K	N	I	M	K	R	A
Alectryon excelsus var.*excelsus*			+	+	+	+	+	+	+
Aristotelia serrata	+	+	+	+	+	+	+	+	+
Ascarina lucida var. *lucida*		+							
Beilschmiedia tawa	+	+	+	+	+	+	+	+	+
Carpodetus serratus	+	+	+	+	+	+	+	+	+
Corynocarpus laevigatus			+	+	+	+		+	
Dodonaea viscosa				?		+			
Dysoxylum spectabile			+	+	+	+			
Elaeocarpus dentatus	+	+	+	+	+	+	+	+	+
Elaeocarpus hookerianus	+	+					+		+
Entelea arborescens						+			
Eugenia maire	+			+			+	+	+
Fuchsia excorticata	+	+	+	+	+	+	+	+	+

DICOT TREES continued	E	P	K	N	I	M	K	R	A
Griselinia littoralis	+	+	+						+
Hedycarya arborea	+	+	+	+	+	+	+	+	+
Hoheria angustifolia	?								
Hoheria glabrata	?								
Hoheria populnea	+	+	+	+	+	+	+	+	+
Knightia excelsa	+	+	+	+	+	+	+	+	+
Laurelia novae-zelandiae	+	+	+	+	+	+	+	+	+
Litsea calicaris						+			
Lophomyrtus bullata			+	+	+		+	+	
Lophomyrtus obcordata			+	+	+				
Macropiper excelsum var. *excelsum*			+	+	+	+		+	
Melicope ternata				+		+			
Melicytus lanceolatus	+						+		+
Melicytus ramiflorus var. *ramiflorus*	+	+	+	+	+	+	+	+	+
Metrosideros excelsa						+			
Metrosideros robusta	+	+	+	+	+	+	+	+	+
Mida salicifolia			+						
Myoporum laetum var. *laetum*			+	+		+			
Myrsine australis	+	+	+	+		+	+	+	+
Myrsine salicina	+	+	+		+	+	+	+	+
Nestegis cunninghamii	+	+	+	+	+		+		+
Nestegis lanceolata	+	?		?	+	+	+	+	+
Nestegis montana							+		+
Nothofagus fusca									?
Nothofagus menziesii									?
Nothofagus solandri var. *solandri*									+
Nothofagus truncata						+			
Olearia rani	+	+	+			+	+	+	+
Paratrophis microphylla				+	+		+	+	
Pennantia corymbosa	+	+					+	+	+
Pittosporum crassifolium						+			
Pittosporum eugenioides	+	+	+	+	+	+			
Pittosporum tenuifolium	+	+				+			+
Pseudopanax arboreus	+	+	+	+		+	+	+	+
Pseudopanax colensoi	+	+							+
Pseudopanax crassifolius	+	+	+	+	+	+	+	+	+

DICOT TREES continued	E	P	K	N	I	M	K	R	A
Pseudopanax edgerleyii	+	+	+						+
Pseudopanax laetus						+			
Pseudopanax lessonii						+			
Pseudopanax simplex	+	+							
Quintinia serrata						+			+
Schefflera digitata	+	+	+	+	+	+	+	+	+
Sophora microphylla						+			
Vitex lucens			+	+	+	+			
Weinmannia racemosa var. *racemosa*	+	+	+	+	+	+	+	+	+
	32	29	31	31	26	38	28	26	34

TREE FERNS (7)	E	P	K	N	I	M	K	R	A
Cyathea colensoi		+							
Cyathea cunninghamii			+	+		+			+
Cyathea dealbata	+	+	+	+	+	+		+	+
Cyathea medullaris	+	+	+	+	+	+		+	+
Cyathea smithii	+	+	+	+	+	+		+	+
Dicksonia fibrosa									+
Dicksonia squarrosa	+	+	+	+	+	+	+	+	+
	4	5	5	5	4	5	1	4	6

DICOT SHRUBS (72)	E	P	K	N	I	M	K	R	A
Alseuosmia macrophylla	+	+	+	+	+	+	+		+
Alseuosmia pusilla	+	?							
Aristotelia fruticosa var. *microphylla*	+								
Brachyglottis repanda var. *repanda*	+	+	+	+	+	+	+	+	+
Carmichaelia arborea	+	+				+		+	+
Cassinia leptophylla						+			
Cassinia vauvilliersii	+	+							
Coprosma acerosa						+			
Coprosma areolata	+		+	+			+	+	
Coprosma australis (grandifolia)	+	+	+	+	+	+	+	+	+
Coprosma colensoi			+						
Coprosma depressa	+	+							
Coprosma lucida	+	+	+					+	+
Coprosma 'paludosa'		+							

DICOT SHRUBS continued	E	P	K	N	I	M	K	R	A
Coprosma pseudocuneata	+	+							
Coprosma pumila	+	+							
Coprosma repens						+			
Coprosma rhamnoides				+	+				
Coprosma robusta	+	+	+	+	+	+	+	+	+
Coprosma rotundifolia					+			+	
Coprosma 'taylorae'	+	+							
Coprosma tenuicaulis				+				?	
Coprosma tenuifolia	+	+							
Coriaria arborea var. *arborea*	+	+	+	+	+	+	+	+	+
Coriaria plumosa	+								
Coriaria pteridioides	+	+							
Cyathodes fasciculata	+					+	+		+
Cyathodes fraseri	+	+							
Dracophyllum filifolium	+	+							
Dracophyllum latifolium						+			
Dracophyllum strictum						+	+		+
Gaultheria antipoda	+	+	+			+	+	+	+
Gaultheria oppositifolia						+			+
Gaultheria paniculata						+			+
Gaultheria sp. unnamed	+	+							
G. antipoda x G. sp. unnamed	+								
G. depressa-x Pernettya macrostigma		+							
Geniostoma ligustrifolium	+	+	+	+	+	+	+	+	+
Griselinia lucida	+	+	+	+	+	+	+	+	+
Hebe corriganii	+	+	+						
Hebe odora "erect"	+	+							
Hebe odora "prostrate"		+							
Hebe stricta var. *egmontiana*	+	+	+						
Hebe stricta var. *macroura*						+			
Hebe stricta var. *stricta*	+	+	+	+		+	+	+	+
Hebe townsonii						?			
Hebe venustula		+							
Hebe venustula x H. stricta var.		+							
Hymenanthera sp. unnamed		+							
Ileostylis micrantha							+		
Leptospermum scoparium	+	+	+	+		+	+	+	+
Leptospermum ericoides	+								+

DICOT SHRUBS continued	E	P	K	N	I	M	K	R	A
Muehlenbeckia axillaris	+	+							
Neomyrtus pedunculata	+								
Olearia arborescens	+	+	+						+
Olearia capillaris		+							
Olearia ilicifolia	+								
Olearia townsonii						+			+
Olearia virgata var. *virgata*	+								
Pentachondra pumila	+	+							
Pimelea prostrata	+								
Pittosporum cornifolium							+	+	
Pittosporum kirkii		+							
Pseudopanax anomalus	+	+	+						
P. anomalus x P. simplex	+	+							
Pseudowintera axillaris	+	+	+			+			+
Pseudowintera colorata	+	+	+						+
Rhabdothamnus solandri			+	+		+	+	+	+
Senecio elaeagnifolius	+	+							
Senecio kirkii	+	+	+	+		+			+
Solanum aviculare			+	+	+			+	+
Urtica ferox	+						+		+
	46	43	22	15	10	25	17	17	25

MONOCOT LIANES (2)	E	P	K	N	I	M	K	R	A
Freycinetia baueriana subsp. *banksii*	+	+	+	+	+	+	+	+	+
Ripogonum scandens	+	+	+	+	+	+	+	+	+
	2	2	2	2	2	2	2	2	2

DICOT LIANES (18)	E	P	K	N	I	M	K	R	A
Calystegia tuguriorum			+	+		+			
Clematis foetida								+	+
Clematis paniculata	+	+	+	+	+	+	+	+	+
Clematis quadribracteolata							?		
Fuchsia perscandens									+
Metrosideros colensoi							+	+	+
Metrosideros diffusa	+	+	+	+	+	+	+	+	+
Metrosideros fulgens	+	+	+	+	+	+	+	+	+
Metrosideros perforata	+	+	+	+	+	+	+	+	+

DICOT LIANES continued	E	P	K	N	I	M	K	R	A
Muehlenbeckia australis	+	+	+	+	+	+	+	+	+
Muehlenbeckia complexa						+			
Parsonsia capsularis	+	+	+		+	+	+	+	+
Parsonsia heterophylla		+	+	+		+	+		+
Passiflora tetrandra			+	+	+	+	+	+	+
Rubus australis	+	+	+				+	+	+
Rubus cissoides var. *cissoides*	+	+	+	+	+	+	+	+	+
Rubus schmidelioides var. *schmidelioides*	+							+	+
Tetragonia sp. (*trigyna*?)						+			
	9	9	11	9	8	12	12	12	14

DISTRICTS ARE:	TOTAL
E = Egmont (within the national park)	103
P = Pouakai (within the national park)	96
K = Kaitake (within the national park)	79
N = New Plymouth (Ratapihipihi S.R., Huatoki R., Welbourn R., Barrett Domain)	70
I = Inglewood (Meeting of the Waters S.R., Marshall's Bush)	57
M = Mt Messenger (Mt Messenger, Urenui)	91
K = Kupe (Magnus Forbes S.R., Charteris' Bush)	67
R = Rotokare (Rotokare Domain, Meier's Bush)	67
A = Aotuhia (Aotuhia, Mt Humphries)	90

Montane and subalpine plants

Egmont and Pouakai share some 17 different plants adapted to montane and subalpine habitats not recorded in the other sub-districts. These are: *Libocedrus bidwillii*, *Senecio elaeagnifolius*, *Coprosma pseudocuneata*, *Coprosma pumila*, *Coprosma depressa*, *Coprosma 'taylorae'*, *Coprosma 'paludosa'*, *Hebe odora* agg. 'erect', *Cassinia vauvilliersii*, *Coriaria pteridioides*, *Cyathodes fraseri*, *Dracophyllum filifolium*, *Gaultheria* sp. unnamed, *Coprosma tenuifolia*, *Muehlenbeckia axillaris*, *Pseudopanax simplex* and *Pentachondra pumila*. *Cyathodes fraseri* is also present on the coast near New Plymouth outside the sub-districts examined.

Proximity to the coast

A number of plants (19) may be termed coastal or semi-coastal because they are only present or prominent in the sub-districts close to the coast. These are: *Rhopalostylis sapida*, *Corynocarpus laevigatus*, *Dysoxylum spectabile*, *Entelea arborescens*, *Lophomyrtus bullata*, *Myoporum laetum*, *Cassinia leptophylla*, *Coprosma repens*, *Coprosma acerosa*, *Metrosideros excelsa*, *Melicope ternata*, *Sophora microphylla*, *Pittosporum crassifolium*, *Pseudopanax lessonii*, *Vitex lucens*, *Hebe stricta* var. *macroura*, *Calystegia tuguriorum*, *Muehlenbeckia complexa*, and *Tetragonia* sp. *(trigyna?)*.

Latitude

A number of plants (14) are distributed naturally mainly in the northern districts (north of latitude 39°S) of Taranaki. Many have already been listed as coastal or semi-coastal including: *Vitex lucens, Melicope ternata, Pseudopanax lessonii, Sophora microphylla, Pittosporum crassifolium* and *Metrosideros excelsa.* In addition to these are: *Phyllocladus trichomanoides, Litsea calicaris, Nothofagus truncata, Dracophyllum latifolium, Hebe townsonii, Quintinia serrata, Olearia townsonii* and *Pseudopanax laetus.*

In addition to these major trends Table 4.22 shows there is a great deal of floristic difference between the three major landforms of Taranaki: the volcanic remnants, ring plain and Taranaki Upland. This is examined in detail in Chapter 5.

The flora of the Egmont and Pouakai floristic areas

The vegetation data collected from the Kaitake, Pouakai and Egmont locations enables some comments on the flora particularly with reference to Druce's (1973) Checklist of the Higher Plants... This has already been done for the Kaitake floristic area (see Kaitake section). In the case of the Pouakai and Egmont floristic areas as defined by Druce (1973) a number of extensions to species distributions were noted. Extensions to species distributions were noted for *Cyathodes fasciculata, Melicytus lanceolatus, Melicope ternata* (all in the Pouakai floristic area although not in the area of the Pouakai Range within the park) and *Nestegis lanceolata* (in the Pouakai floristic area including the park). Species not listed by Druce (1973) and recorded during this study were: *Urtica ferox* (on the western slopes of

Egmont and within the park) and *Gaultheria oppositifolia* (in the Pouakai floristic area although not in the park). These species records boost the vascular species total for the Pouakai floristic area from 431 to 435 and for the Egmont floristic area from 492 to 493.

CHAPTER 5

DISCUSSION

1. THE NATURE OF SPECIES DISTRIBUTION

The observations and measurements of species performance and distribution throughout Taranaki which form the basis of the vegetation descriptions in Chapter 4 also enable the formulation of an overall summary of the nature of species distribution.

Along the altitudinal and moisture gradients studied most species show a bell shaped response curve (measured as relative cover) with an optimum or peak value above or below which species cover declines. This feature of species distribution has been discussed fully by Whittaker (1967, 1973) and by Kellmann (1975) and relates to species tolerance limits to the range of environmental factors including competition from other species. Some species, for example kamahi, exhibit great amplitude in their range of distribution (see figures of top stratum distributions for Egmont, Pouakai and Kaitake) while others, for example kaikawaka, have a narrow amplitude. Other species exhibit skewed or bimodal response curves, for example inaka. Although in some cases this is a reflection of a failure to hold constant some factors of change along the altitudinal gradient, for example stage of vegetation development or drainage conditions, in other cases this may result from a competitive release caused by the decline of competing species. Some of the interactions shown between leatherwood and inaka, and Hall's totara, broadleaf and kaikawaka come into this category and as well Clarkson (1977) described the same feature with reference to leatherwood, mountain cottonwood, inaka and red tussock distributions. These features of species distribution have also been discussed by Whittaker (1967, 1973), Kellmann (1975) and Ogden et. al. (1979).

When particular vegetation strata are examined it is usually found that species have different optima in different strata or at least their amplitude is greater in some strata than in others. This has been discussed for a number of species in Chapter 3 including rimu and rewarewa on the Kaitakes. Sampling along altitudinal gradients originally drew attention to this feature of species distribution because invariably seedlings or shrubs of a species were encountered moving down the altitudinal gradient well before top stratum individuals. The presence of small Hall's totara and kaikawaka beneath the leatherwood canopy and the possible consequences of this on future tree-lines has also been discussed in the North Egmont section of Chapter 4. If it could be assumed that individuals of smaller size or in lower height strata were younger than larger taller individuals this feature of species distribution would be another expression of the often reported niche separation of seedlings, young individuals and adults of a single species discussed by Grubb (1977). A more likely possibility is that the individuals occurring in lower vegetation strata occur there only as a result of the shelter afforded by the top stratum, will never reach the top stratum, but are continually restocked from successful individuals at lower altitudes. Species not normally components of the top strata, for example pigeonwood, may in conditions causing a lowering of the top stratum of vegetation, for example steepening of slope and exposure to wind, reach the top stratum. This feature of species distribution is described in the Kaitake section of Chapter 4. While the changes in dominance of species in the top stratum generally correlated strongly with the gradient being sampled this was not always the case for other strata as described for the second stratum in the Pouakai section of Chapter 4. Barton (1972) in his description of the Hunua Range vegetation reports the same situation. Both Daubenmire (1968) and Webb et. al. (1967) discuss the fact that the large tree layer of the vegetation strongly reflects the macroclimate of a site whereas other vegetation may not because of the buffeting it receives from the macroclimate and the importance of other macroclimate and edaphic factors in determining the distribution of understorey species.

With increasing altitude there is a greater degree of epiphytic establishment of some of the large trees, for example kamahi and broadleaf. Likewise at higher altitudes shrub species such as *Coprosma grandifolia* and the *Pseudopanax* spp. may establish epiphytically further complicating the overall pattern of species distribution. As well, species not normally considered as epiphytes, for example kaikawaka, leatherwood and Hall's totara, may very rarely establish epiphytically and survive to reach the top stratum of the vegetation. Vegetative layering of trees and shrubs is also more common at higher altitudes. As altitude increases so does the relative humidity and rainfall and together this brings about the increasing incidence of epiphytic establishment and layering.

The degree of overlap in host-epiphyte relations relates to the overlap in species amplitudes. Thus rata was recorded as epiphytic mainly on rimu in the lower montane forests on Egmont but more often on tawa and pukatea in the ring plain and Taranaki Upland forests. Broadleaf was recorded predominantly on Hall's totara and kaikawaka. There appears therefore to be little exclusivity in the host-epiphyte relationship, rather the commonly available canopy tree becomes the predominant host. The interaction between genetically endowed flexibility of form of a species and the influence of the environment is often complex and difficult to separate. Broadleaf is more often of epiphytic origin in the upper montane forest than in the lower montane forest and is invariably a terrestrially established shrub in the leatherwood shrubland. A still further complication is the stage of development of the vegetation. Rata for example is of predominantly terrestrial origin on river margins or debris flows and predominantly epiphytic in tall forests although on occasions it is also of terrestrial origin even in these forests. The availability and quality of light as it relates to vegetation cover thus appears to determine the mode of rata establishment.

When the distribution of a species is examined on a regional (whole of Taranaki) as opposed to a single gradient basis further features of a species distribution become apparent. Some species are more prominent at their upper altitudinal limit in valley bottoms or on valley and ridge sides, for example kamahi, broadleaf and pukatea, while others, particularly Hall's totara and kaikawaka, are more prominent on ridge tops or ridge sides. This pattern relates to different species abilities to withstand the periodic and sometimes intense drought characteristic of freely drained ridge tops. Coupled with this many species exhibit their lower altitudinal limit along river banks and river margins where the moisture status of the sites is more closely allied to the general condition at higher altitude. Thus kamahi lines river banks at its lower altitudinal limit near the coast, kaikawaka occurs at 670m in the Potaema Bog and pukatea, prominent in the lower altitude forest on Kaitake, is a dominant in swamp forest on the lowland. In the latter instance as Cockayne (1921) notes pukatea is a 'semi-obligate' in that it hardly occurs in any other community. In general, species become increasingly restricted to special sites beyond the upper or lower limits of their optimum on the gradient.

The periodic disturbance of vegetation along river banks and margins is also a reason for species exhibiting their lower altitudinal limit in these sites. Thus kaikawaka occurs below 490m on the banks of the Punehu and Manganui Streams, and leatherwood grows on some river margins near the national park boundary.

Allied to the fact that some species record their lower altitudinal limit on disturbed sites such as river margins is the fact already described in the North Egmont section of Chapter 4 that species characteristic of higher altitudes are often prominent in successional vegetation on sites immediately below their recorded optimum on the gradient. This general fact has been noted by Daubenmire (1968) and with specific reference to Egmont by Druce (1961). As well, there is the general trend for some early successional species for example *Coriaria* spp., *Muehlenbeckia axillaris* and *Pimelea prostrata* to become severely restricted in distribution as vegetation development proceeds. This feature of species distribution is amplified later in the discussion in which the flora and vegetation of each of the mountains in Egmont National Park is compared.

The successional sequence - altitudinal sequence parallel is also apparent to some degree in the moisture gradients described already in Chapter 4 (Potaema Bog margin and Ahukawakawa Swamp margin) in that species characteristic of higher altitudes become prominent in the progressively wetter parts of the swamp margins. The most important consequence of this compressed sequence of species distributions is that the margins of swamps although relatively small in area contain a remarkably high number of species in comparison to other sites. This has already been discussed in relation to the Potaema Bog and Ahukawakawa Swamp in Chapter 4.

Some species are regionally disjunct in their distribution, for example *Pimelea prostrata* and *Cyathodes fraseri* present in the herbfield on Egmont reappear on the coast near New Plymouth as components of consolidated dune vegetation and on roadside cuttings in the Taranaki Upland. *Cyathodes fasciculata* is less restricted in distribution but is prominent near the coast, in the Potaema Bog and as a component of black beech forest and second growth manuka shrubland on sandstone ridgecaps in the Taranaki Upland. Cockayne (1921) and Burrows (1964) have both described examples of New Zealand mountain species found also on the coast and Seddon (1971) describes a similar pattern for some of the British mountain flora.

The presence of widely scattered pockets of black beech confined to sandstone ridgecaps in the Taranaki Upland (this is well illustrated on the Forest and Scrub Types Map of the Aotuhia Regional Land Use Study 1978) is typical of a relict species whose area becomes progressively restricted, for example, by general climatic change or by competition from an invading species as outlined by Seddon (1971). Both Levy (1923) and Nicholls (1956) have discussed the present day distribution of black beech and claim it is evidence for a more extensive and continuous distribution in the past.

The fact that adaptive radiation has produced large numbers of species in some genera, notably *Coprosma* and

Pseudopanax, which distribute as altitudinal series with each species having an optimum at progressively higher altitudes has important consequences (e.g. *Pseudopanax lessonii*, *P. arboreus*, *P. crassifolius*, *P. anomalus*, *P. simplex*, *P. colensoi*). Many of the species hybrids listed in this study (see Table 4.22) occur where species distributions overlap along the altitudinal gradient. Thus *P. simplex* x *P. anomalus* is most common on Pouakai between 1050m and 1150m where the parent species overlap. The same is true for *Gaultheria antipoda* x *Gaultheria* sp. unnamed which occurs on Egmont between 1127m and 1219m where the parent species also overlap. Sites periodically disturbed in some way, for example river margins and heavily browsed partially cleared forest near the national park boundary, are also prime sites for discovering hybrids. *Cordyline australis* x *Cordyline indivisa* was recorded on Egmont in such a site while *Coprosma* hybrids are most common in the many river valleys and river margins inside the national park.

All of these observations of species performance and distribution are linked together by the inseparable inter-relationship between a species tolerance to environmental factors and competition from other species. Each species exhibits its own tolerance limits to the range of environmental factors so that species with similar tolerance limits have the potential to exhibit similar distributions. Actual distributions are however determined by additional factors such as how effectively species disperse, colonise, regenerate and compete with other species. As well, the complex range of plant species inter-relationships, from host-epiphyte relationships in which no obvious harm or benefit to either species can be demonstrated, through to host-epiphyte relationships in which harm or benefit can be demonstrated complicates the distinction between species association on the same site and species competition. Miles (1979) has noted, because of the many ways in which plants use and modify their environment, competition is a complex phenomenon and is thus a much used but poorly understood term. Harper (1977) has simply defined competition as the hardships which result to organisms from the proximity of their neighbours. In many instances a fundamental relationship can be demonstrated between the height attained by plant species in order to obtain a sufficient amount of light and the subsequent overtopping and shading out of other species, although this is only one expression of competition. Thus Daubenmire (1968) describes the difference between canopies of a herb layer, shrub layer or tree layer in terms of the difference in the amount of supporting tissue required to lift these canopies. The ratio of non productive to productive (i.e. photosynthetic) cells is at least doubled with increase in stature from herb to low tree. This means that the taller the plant the greater the proportion of unproductive cells. As the supply of moisture, nutrients, or heat declines, the proportion of unproductive cells must be reduced, and accordingly plant stature declines. The moisture and altitudinal gradients described in Chapter 4 may thus be explained and the importance of competition in determining species composition and distribution can also be appreciated because many of the species of shorter stature are capable of growing outside the poorer sites to which they are relegated following a disturbance. The experimental work of Byer (1969) and Miles (1972) illustrates how competition is of critical importance in determining species composition at any location. In both cases they describe how species from distinctive vegetation types and soils grew at least as well on soils where they did not occur naturally as on soils where they did, the inference being that interspecific competition was the main factor determining their natural distribution. The ease with which many of the Mt Egmont high altitude grass species were grown to maturity at low altitude and in Hamilton soils (by the author during the course of this study to determine their taxonomy accurately) also demonstrates this feature of species distribution. In some cases however species are so specialised in their adaptation to particular sites that they are unable to grow normally in very different conditions, for example *Ourisia macrophylla* var. *macrophylla* and *Ranunculus nivicola*. Finally, although the interaction between a species tolerance to the environment and competition from other species provides a way of explaining the many and varied features observed regarding species distribution the role of chance in determining which species colonise any newly available sites must not be overlooked. Levin (1977) describes this as a 'founder effect' and notes the consequent importance of subsequent resistance to invasion by competitors.

Daubenmire (1968) stresses the importance of competitive exclusion and how within a sector of a gradual ecological gradient one or a few plant species assume dominance excluding or nearly excluding other species which could grow there if the dominants were removed. The plant community or vegetation type can thus be defined by the ecotone at which the shift in dominance in conspicuous species occurs. A number of types of ecotone are described by Daubenmire (1968) ranging from ecotones with fixed positions determined by a relatively immutable environmental discontinuity to those which may be properly called tension zones. In tension zones the transition may be abrupt as a result of plant interactions, especially competition, even though the extrinsic factors exhibit a continuous gradient, or the transition may be a gradual blending of two vegetation types that reflect a gradual blending of two distinct factor complexes. Daubenmire (1968) also distinguishes between this type of ecotone and one in which two vegetation units interdigitate rather than merge by degrees terming the latter a mosaic ecotone. Quite different and distinct are the boundaries which result from the destruction of part of an established vegetation and the successional development of a new vegetation alongside or within the already established vegetation. Perhaps the greatest complexity in determining vegetation boundaries arises during intermediate stages of succession when species may be growing amongst others with which they rarely associate once the principle of competitive exclusion operates to restore equilibrium.

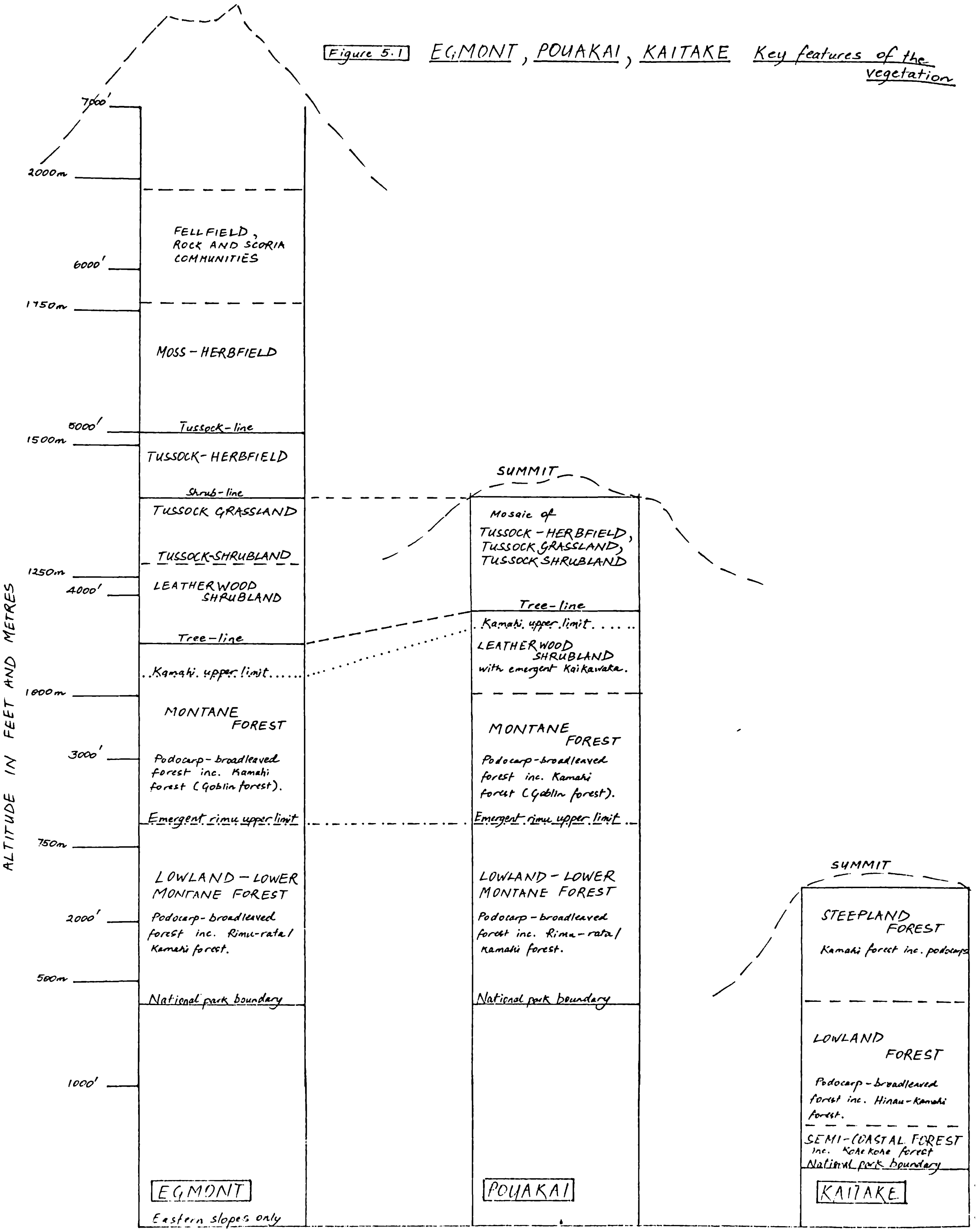
Much of Daubenmire's (1968) interpretation is contradictory to the interpretation of advocates of gradient analysis such as Whittaker (1967, 1973), Bray and Curtis (1957), and Curtis and McIntosh (1951). In fact Daubenmire uses the evidence of competitive exclusion, the resulting ecotones, and the way in which this enables the definition of vegetation types or communities to deliberately argue that the individualistic concept of species distribution and the continuum are untenable. The continuum-discrete community controversy is discussed in detail in Clarkson (1977) as are the problems associated with the use of ordination and classification techniques advocated by the supporters of each viewpoint. Some recent studies have shown that both with regard to the methods of analysis and the interpretations of distributions that the viewpoints may not be antithetical and that species distributions may be interpreted as either discrete or continuous depending on different circumstances. Thus for example Beals (1969) showed that on steep gradients the vegetation itself imposed disjunctions on an extrinsically continuous environmental gradient whereas along gentle gradients this did not occur and Clarkson (1977) showed that either continua or discrete vegetation types could be emphasized at different locations on Egmont. Above all much of the plant association controversy relates to the degree of emphasis placed on overlap of distributions, how alike two stands of vegetation need to be before they are considered to belong to the same type, what are acceptable methods of sampling and analysis of vegetation, and the purpose of studying the vegetation. In fact the work of supporters of both points of view can be demonstrated to contain some common ground and some of the argument is largely semantic, a criticism which could also be levelled at earlier work of the present author (Clarkson, 1977). It has already been noted in Chapter 1 that no two patches of vegetation are exactly the same and in several places in Chapter 4 that the definition of vegetation types is arbitrary. However, as Daubenmire (1968), Beals (1969) and Clarkson (1977) have shown, vegetation boundaries may be either abrupt or gradual and this is also apparent in considering the ecotones described in this study. Thus the definition of vegetation types is more arbitrary in some instances than in others depending on the ecotone described. The boundary of black beech forest on sandstone ridgecaps is an ecotone of the first type described by Daubenmire (1968) and other boundaries relate to disturbance such as slips or debris flows. Many of the boundaries however are more like the tension zones described by Daubenmire (1968) including the change from lower montane forest to montane forest at 790m, on Pouakai and Egmont, and the more marked forest shrub interface on Pouakai and Egmont. Thus the complete range of types of ecotones or transition zones has been described in Chapter 4. The presence of these ecotones also relates to competitive exclusion of species in relation to a number of different combinations of environmental change. The black beech forest boundary relates directly to the different substrate and thus moisture and soil conditions encountered on the sandstone ridgecaps as opposed to the mixed mudstone and sandstone colluvium of the lower hill slopes of the Taranaki Upland. The belts or girdles of vegetation around the margins of the Potaema Bog and Ahukawakawa Swamp relate to the gradual lessening in depth of water and the consequent improvement in factors such as oxygen availability for plant roots. Finally the altitudinal transition zones relate to the gradual deterioration of environmental conditions as described already in the climate section of Chapter 2. Unfortunately this pattern of change is complicated by the recent volcanic and other disturbances also outlined in Chapter 2. Further details of how the environment changes along altitudinal gradients and which environmental factors are considered most important in determining vegetation ecotones and thus the boundaries for vegetation types are given in the remaining sections of the discussion in which the vegetation of the Kaitake, Pouakai and Egmont volcanoes is compared as is the vegetation of the major landforms: mountains, ring plain and upland.

2. KAITAKE, POUAKAI AND EGMONT: A COMPARISON

It was noted in Chapter 2 that the Taranaki Volcanic Succession resulted in a series of progressively younger volcanic landforms. A parallel sequence in overall vegetation composition and structure could therefore be expected. All of the results presented in Chapter 4 provide the basis for such a comparison of the vegetation of the three volcanoes of Egmont National Park and for an examination of this expectation. Figure 5.1 summarises some key features of the vegetation on each of the three mountains revealing a number of significant differences between each of them.

Egmont, the most recent volcano, still relatively intact and reaching 2518m a.s.l., exhibits vegetation ranging from lower montane podocarp-broadleaved forest through to moss-herbfield, fellfield, and rock and scoria communities. The older more dissected Pouakai by comparison is of insufficient altitude to exhibit true moss-herbfield or fellfield although it does have extensive herbfields relating to poor drainage conditions. Both Pouakai and Egmont have tussock grassland, tussock-herbfield, tussock-shrubland and shrub-tussockland. Shrub species grow to the top of Pouakai and the average shrub line is at an equivalent altitude on Egmont although both inaka and *Hebe odora* reach altitudes in excess of 1675m on Egmont. The treeline as represented by the upper limit of emergent kaikawaka is higher on Pouakai (1190m) than on Egmont (1130m). The upper limit of top stratum kamahi on Pouakai (1160m) is also higher than on Egmont (1130m). This incidentally is higher than the upper limit of kamahi (3600'-1099m on Mt Tarawera) described by Wardle (1966). The upper limit of emergent rimu is approximately 790m on both Egmont and Pouakai. Kaitake, the oldest and most dissected volcanic remnant reaching

Figure 5.1 EGMONT, POUAKAI, KAITAKE Key features of the vegetation



only 684m a.s.l., supports forest vegetation to the top, although some areas on the rocky peaks have only a covering of shrubs or herbs and grasses.

Alpine vegetation

The moss-herbfield, fellfield, rock and scoria communities of parts of Egmont have been described already in Clarkson (1977) and further descriptions of these vegetation types at North Egmont and Mangahume are included in Chapter 4. Appendix 8 lists all of the species recorded in these vegetation types on Egmont and the list includes a number of species not recorded on Pouakai or Kaitake. These species include *Polystichum cystostegia*, *Rytidosperma viride*, *Poa novae-zelandiae*, *Colobanthus* sp. unnamed, *Montia* sp., *Epilobium glabellum* and *Carex pyrenaica* var. *cephalotes*. All of these species with the exception of *Rytidosperma viride* commonly distribute above 1500m and could therefore be considered as high altitude species not likely to be found on the much lower Pouakai and Kaitake mountains. However, the prominence of *Rytidosperma viride* in low altitude sites, for example on Mt Tarawera in the central North Island, could mean that its absence from Pouakai is a reflection of the different successional stage of the vegetation or alternatively that it is intolerant of poor drainage.

Tussock-shrubland and shrub-tussockland

The composition and structure of the tussock-shrubland and shrub-tussockland on Egmont and Pouakai has already been described in Chapter 4 however Table 5.1 provides a summary of the relative frequency and relative cover indices of top stratum species recorded in the two locations and highlights the major differences between the two locations. As well, lists of all the species recorded in the ground cover of this vegetation are found in Appendices 3 and 7. Although on both Egmont and Pouakai the two leading species both in terms of relative frequency and contribution to cover are red tussock and *Hebe odora* agg., there are differences in the composition and in the relative importance of other species. The most significant differences centre on the importance of *Schoenus pauciflorus* and *Coprosma 'paludosa'* at the Pouakai location and *Coriaria plumosa* on Mt Egmont. *Schoenus pauciflorus* is the third most important species both in terms of frequency and cover contribution recorded in the Pouakai sample yet it is absent from Mt Egmont. *Coprosma 'paludosa'* occurred in 35.5% of the sites on Pouakai and was also unrecorded from Mt Egmont. *Coriaria plumosa* occurred in 19.2% of the sites on Egmont but was never seen on Pouakai. These differences in floristic composition of the top stratum highlight the major differences between habitats at comparable altitudes on Pouakai and Egmont. *Schoenus pauciflorus* is well documented as a species prominent in very poorly drained sites (see Campbell, 1964) and much of the tussock-shrubland and shrub-tussockland on Pouakai is very poorly drained by comparison with that on Egmont. Many sites on the extensive rolling tops of Pouakai are very flat, there is a considerable development of peat

Table 5.1 Egmont and Pouakai tussock-shrubland: a comparison

	Egmont R.F.	Pouakai R.F.	Egmont R.C.I.	Pouakai R.C.I.
Chionochloa rubra	96.1	96.8	2.8	1.9
Hebe odora	84.6	90.3	5.9	5.3
Schoenus pauciflorus	-	77.4	-	5.5
Dracophyllum filifolium	69.2	64.5	6.9	7.2
Cassinia vauvilliersii	69.2	48.4	6.8	10.4
Senecio elaeagnifolius	69.2	41.9	7.0	9.9
Coprosma 'paludosa'	-	35.5	-	11.7
Ranunculus nivicola	46.1	48.4	10.4	10.5
Coprosma pseudocuneata	57.7	25.8	8.5	12.1
Pseudopanax colensoi	38.5	25.8	11.8	12.7
Ourisia macrophylla var. *macrophylla*	38.5	3.2	11.1	14.9
Poa laevis	38.5	32.2	11.3	11.2
Coprosma depressa	11.5	25.8	14.0	13.0
Hebe stricta var. *egmontiana*	23.1	3.2	13.0	14.7
Pseudopanax simplex	19.2	9.7	13.8	14.2
Coriaria plumosa	19.2	-	12.7	-
Astelia sp. unnamed	15.4	29.0	14.0	13.2
Myrsine divaricata	15.4	25.8	13.6	12.7
Gaultheria sp. unnamed	-	16.1	-	13.5
Hierochloe redolens	7.7	-	14.3	-
Hierochloe novae-zelandiae	-	29.0	-	12.5

R.F. = Relative Frequency

R.C.I. = Relative Cover Index

and flushes and seepages are common. In contrast on Egmont the underlying bedded ash and lapilli coupled with steep slopes allow freer drainage of most sites.

Structural differences were also apparent between the vegetation sampled at comparable altitudes on Egmont and Pouakai. On Pouakai the vegetation is generally of lower stature, shrubs are more widely spaced and there is a more extensive ground cover of herbs. These differences are also a function of the poorer conditions of drainage on Pouakai. The differences evident in comparing the composition of the top stratum of the vegetation are further emphasized by the composition of the ground layer. Sphagnum (*Sphagnum* sp. *cristatum*?) is present as a ground cover component in a number of places on Pouakai and *Oreobolus pectinatus* is often a leading dominant. Species recorded on Pouakai (see Appendices 3 and 7) but not on Egmont which further attest to the greater extent of poorly drained habitats include *Bulbinella hookerii* and *Celmisia setacea*. The importance in the sites at Egmont of *Coriaria plumosa*, an early successional species, and like other *Coriaria* spp. supporting bacteria capable of fixing atmospheric nitrogen (see Silvester, 1978 and Allen, et. al. 1966), emphasizes the fact that much of this vegetation is at earlier stages of development than the vegetation at comparable altitudes on Pouakai. The widespread occurrence on parts of Egmont of shrub rings and *Coriaria* rings characteristic of developing vegetation (described in the North Egmont section of Chapter 4) is also evidence of this difference. Species recorded on

Egmont but absent from or of little importance on Pouakai which further emphasize these differences in the vegetation are *Muehlenbeckia axillaris*, *Pimelea prostrata* and *Cyathodes fraseri*. The presence of a number of other species on Pouakai which are absent from Egmont is more difficult to explain in terms of limited availability of suitable habitats and probably relates to the fact that they have simply failed to colonise Egmont as yet. Plants belonging to this category include *Podocarpus nivalis*, *Microlaena colensoi*, *Hebe odora* "prostrate", *Gaultheria* sp. unnamed x *Pernettya macrostigma* and *Hebe tetragona* var. *Podocarpus nivalis* was recorded on weathered rocky outcrops on Pouakai, a habitat also available on Egmont. The performance and distribution of *Podocarpus nivalis* in Tongariro National Park also seems to confirm that there is no real reason why this species could not grow successfully on Egmont. The presence of *Hebe odora* "prostrate" only on Pouakai can not be explained without first clarifying its taxonomic status and the presence of *Gaultheria* sp. unnamed x *Pernettya macrostigma* is particularly puzzling considering one of the parents, *Pernettya macrostigma*, was not recorded at all. Perhaps the greatest differences between the vegetation on Egmont and on Pouakai are represented by sites of easterly aspect (1158m) near the lower limit of shrub-tussockland on Maude Peak. Here red tussock, kamahi, kaikawaka, broadleaf, inaka, mountain cottonwood and *Hebe odora* are all found growing together. This overlap in the distribution of major species never occurs on Mt Egmont.

Shrubland

Leatherwood dominated shrubland is the most widespread vegetation type between 1095m and 1280m on Egmont and between 1066m and 1280m on Pouakai. On both Pouakai and Egmont the overall dominance by leatherwood and the fact that most of the subdominant species are common to both locations, for example inaka, *Coprosma pseudocuneata*, *Pseudopanax simplex*, *Pseudopanax colensoi* and *Coprosma 'taylorae'*, clearly shows the similarity of the vegetation type on both mountains. There are, however, subtle and important differences in composition and structure. Some of these features have already been noted with reference to Figure 5.1. The higher tree-line of kaikawaka on Pouakai means that in many locations kaikawaka is emergent above a lower stratum of leatherwood, particularly alongside drainage channels or small stream tributaries as at the Maude and Mangorei Track locations or on poorly drained sites as at the Dover Track location. As well, the higher upper limit of kamahi in the top stratum means that in many places on Pouakai there is a direct interface between kamahi and leatherwood. The kamahi forest thus grades almost imperceptibly into leatherwood shrubland. As well, on Pouakai kamahi may be found as a top stratum associate of kaikawaka, a much less common occurrence on Egmont. On Egmont kaikawaka is more prominent at lower elevations and often associated with disturbances such as slipping as described for North Egmont.

Top stratum and second stratum differences in composition between the leatherwood shrubland on Pouakai and Egmont centre on the presence of *Cyathea colensoi*, *Hebe venustula* and *Olearia capillaris* on Pouakai and *Aristotelia fruticosa* and *Olearia ilicifolia* on Egmont. The fact that a species like *Cyathea colensoi* with such readily dispersed spores has not established on Egmont is hard to understand. All of the species cited are however localised in distribution and were only rarely of importance with regard to cover contribution of the vegetation. Far more significant is the generally greater contribution to cover of inaka on Egmont than on Pouakai, a feature relating to the widespread instability of slopes on Egmont and the predominance of inaka at a stage of development in the vegetation prior to leatherwood assuming dominance. In contrast, on Pouakai, inaka is prominent on the many poorly drained sites on the extensive rolling tops particularly nearer the Maude and Henry Peaks.

Ground cover species prominent in the shrubland of both Pouakai and Egmont are *Blechnum capense* agg. and *Astelia* sp. unnamed. Some of the ground cover species recorded on Pouakai again emphasize the poorly drained 'peaty' soils while on Egmont they point to the early stages of vegetation development. Thus on Pouakai sphagnum, *Abrotanella caespitosa*, *Gahnia* spp., and a range of *Carex* spp. were all recorded in the ground cover while on Egmont *Coriaria pteridioides* and *Coriaria plumosa* were prominent mainly in openings in the shrub canopy or slip faces as described at North Egmont.

The presence of a leatherwood dominated shrubland in many places below 1150m at east Egmont relates to the past history of volcanic disturbance in particular the Burrell eruption. This is discussed in more detail in the following section on montane forests. Above 1150m however, most of the leatherwood shrubland could be considered as a 'climax' vegetation type in that at these altitudes the climatic conditions, steep slopes and skeletal soils are unsuitable for the development of any sort of forest vegetation.

Wardle (1965), taking *Olearia colensoi* as an example, speculates on the significance of the xeromorphic characters of plants growing in subalpine environments. All of the features described by Wardle (1965) for *Olearia colensoi* (including rigid leaves densely tomentose below and thin flaking bark) as adaptations to a cool wet cloudy subalpine environment are shared by leatherwood (*Senecio elaeagnifolius*) and the same argument could be advanced taking it as the example. Leatherwood could thus be considered as an 'ecological equivalent' to *Olearia colensoi* on the Tararua Range in the North Island. At both places the climatic conditions are extremely similar particularly with regard to the high rainfall and common occurrence of fog and mist, a fact noted by Zotov (1938) and offered as an explanation for the relatively low timber-line on Egmont and the Tararua Range. Unfortunately there is probably no location on Egmont where the timber-line or tree-shrub interface is presently a good indicator of the true climatic limits of tree growth because of the very recent history of volcanic disturbance there.

Montane forest

Although forest vegetation is found on all of the volcanoes only Pouakai and Egmont are high enough to support true montane forest. Floristically and structurally the montane forests of Pouakai and Egmont are very closely related particularly the high altitude kamahi forest (goblin forest). The differences between the two relate to the higher altitudinal limit of kamahi on Pouakai. The direct interface between kamahi and leatherwood in places on Pouakai means that many of the species found in the leatherwood shrubland are relatively more prominent in the understorey of the kamahi forest on Pouakai than on Egmont. Of all the locations sampled on Egmont none showed a direct leatherwood-kamahi interface. Instead a forest type in which Hall's totara and/or kaikawaka are emergent above a broadleaf-mixed shrub stratum occupies the space between kamahi (goblin forest) and leatherwood shrubland. Figures 5.2, 5.3, 5.4, 5.5, 5.6 and 5.7 show the results obtained by sampling across the forest-shrubland interface at five separate locations on Egmont and one on Pouakai. Some of this data was presented originally in Clarkson (1977). Although only estimates of the top stratum species distributions, field observations at each of these locations confirm that these estimates adequately summarise the change in the vegetation which occurs at the forest-shrubland interface. The figures are arranged in a sequence from north to south and, as well, an estimate of the relative impact of the Burrell eruption (1655 A.D.) at each location is indicated by the

Figure 5.2 HENRY PEAK FOREST–SHRUBLAND INTERFACE

(trace)

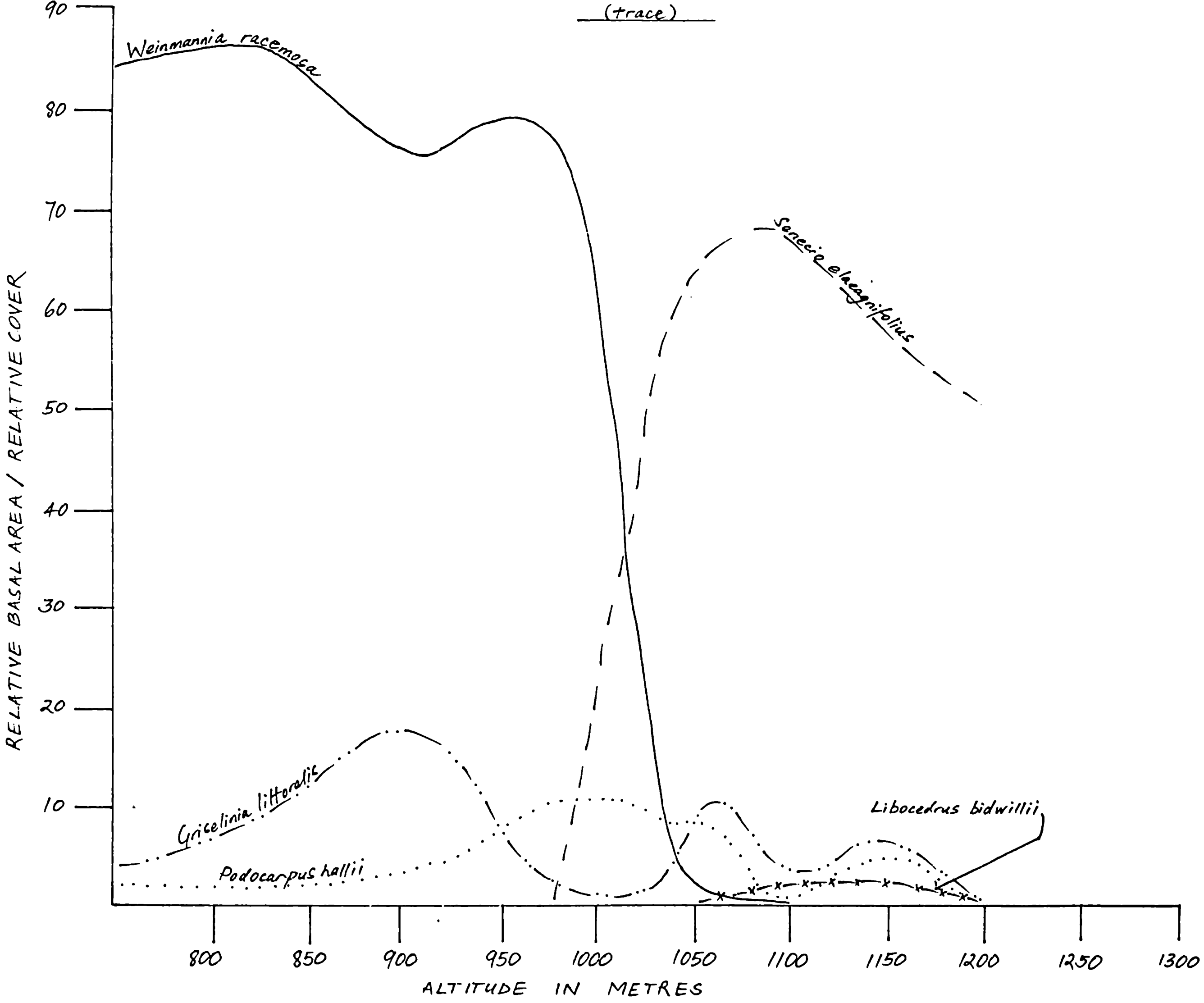


Figure 5·3 NORTH EGMONT FOREST—SHRUBLAND INTERFACE

(2·5–5·0cm)

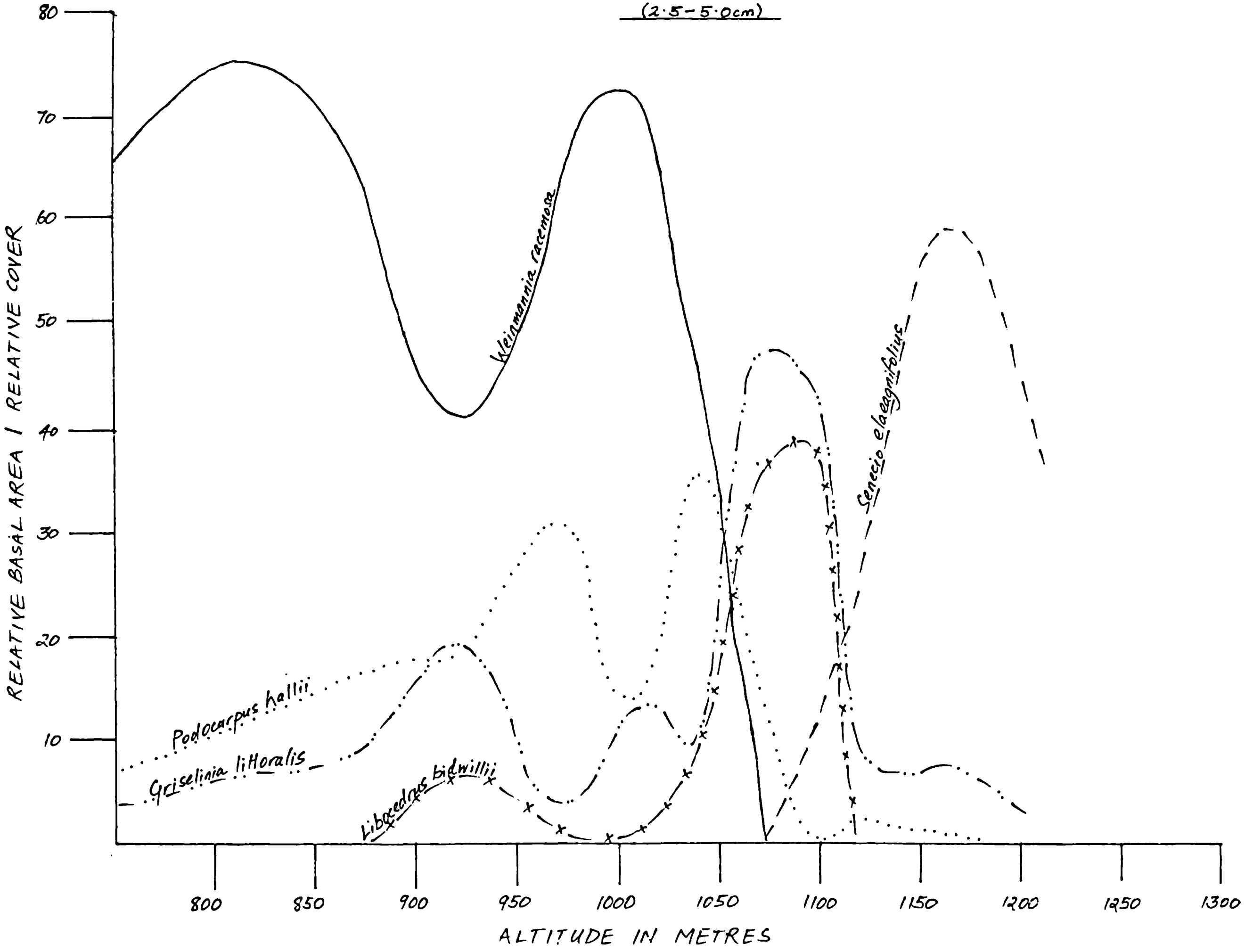


Figure 5.4 YORK TRACK FOREST-SHRUBLAND INTERFACE

(15·0–22·0cm)

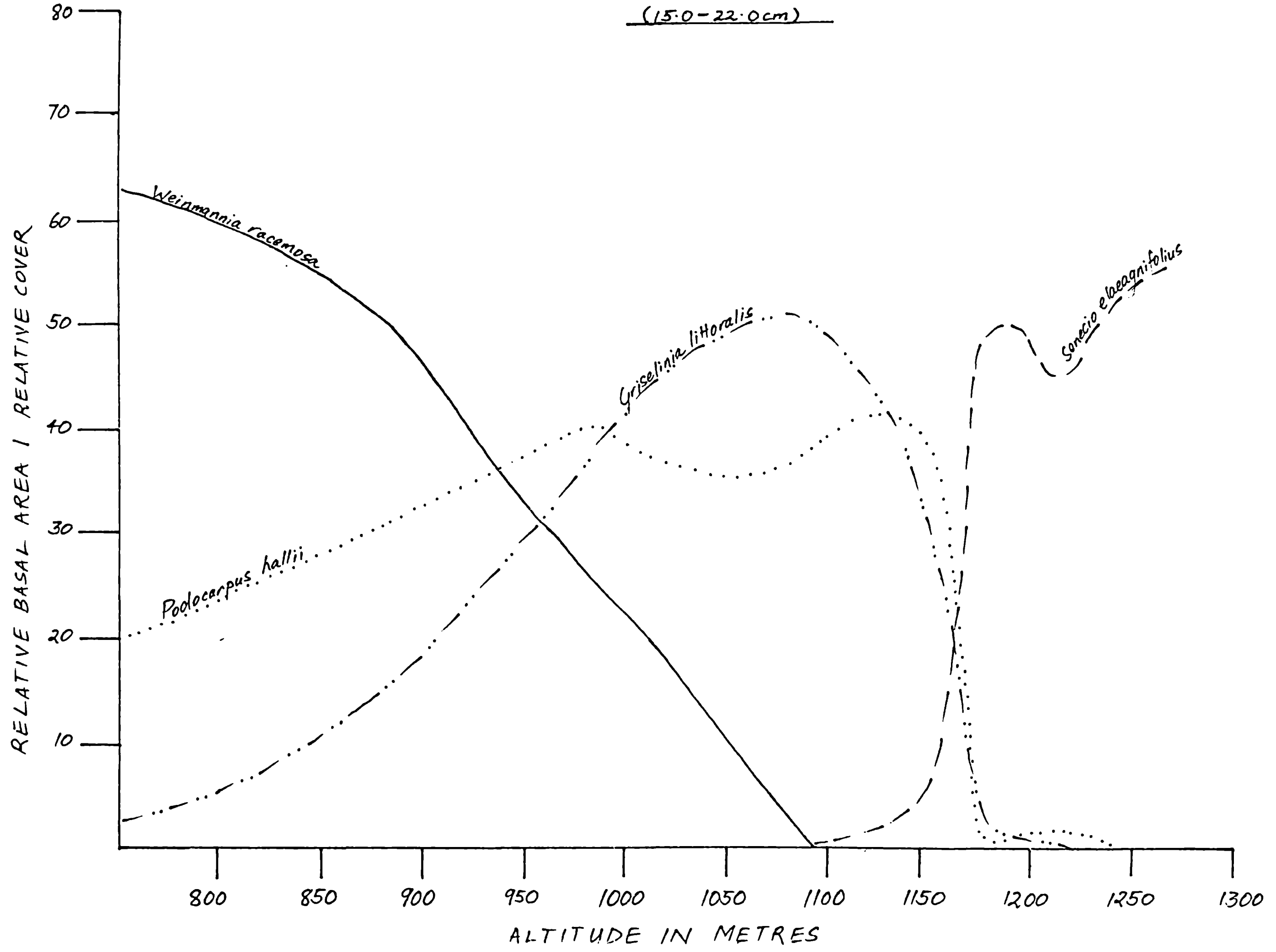


Figure 5.5

STRATFORD FOREST-SHRUBLAND INTERFACE

(22.0– 30.0cm)

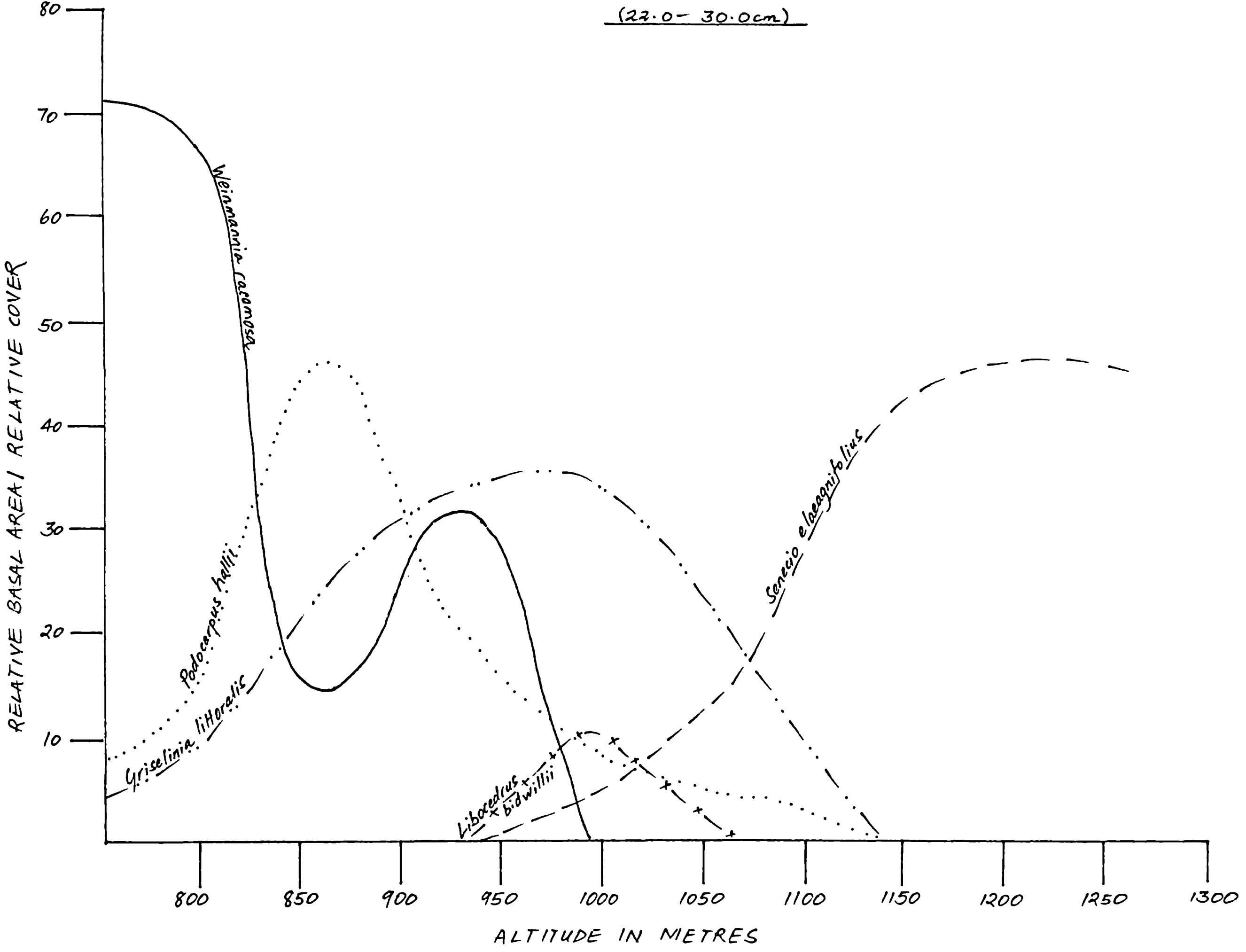


Figure 5·6

DAWSON FALLS FOREST-SHRUBLAND INTERFACE

(30·0 – 38·0cm)

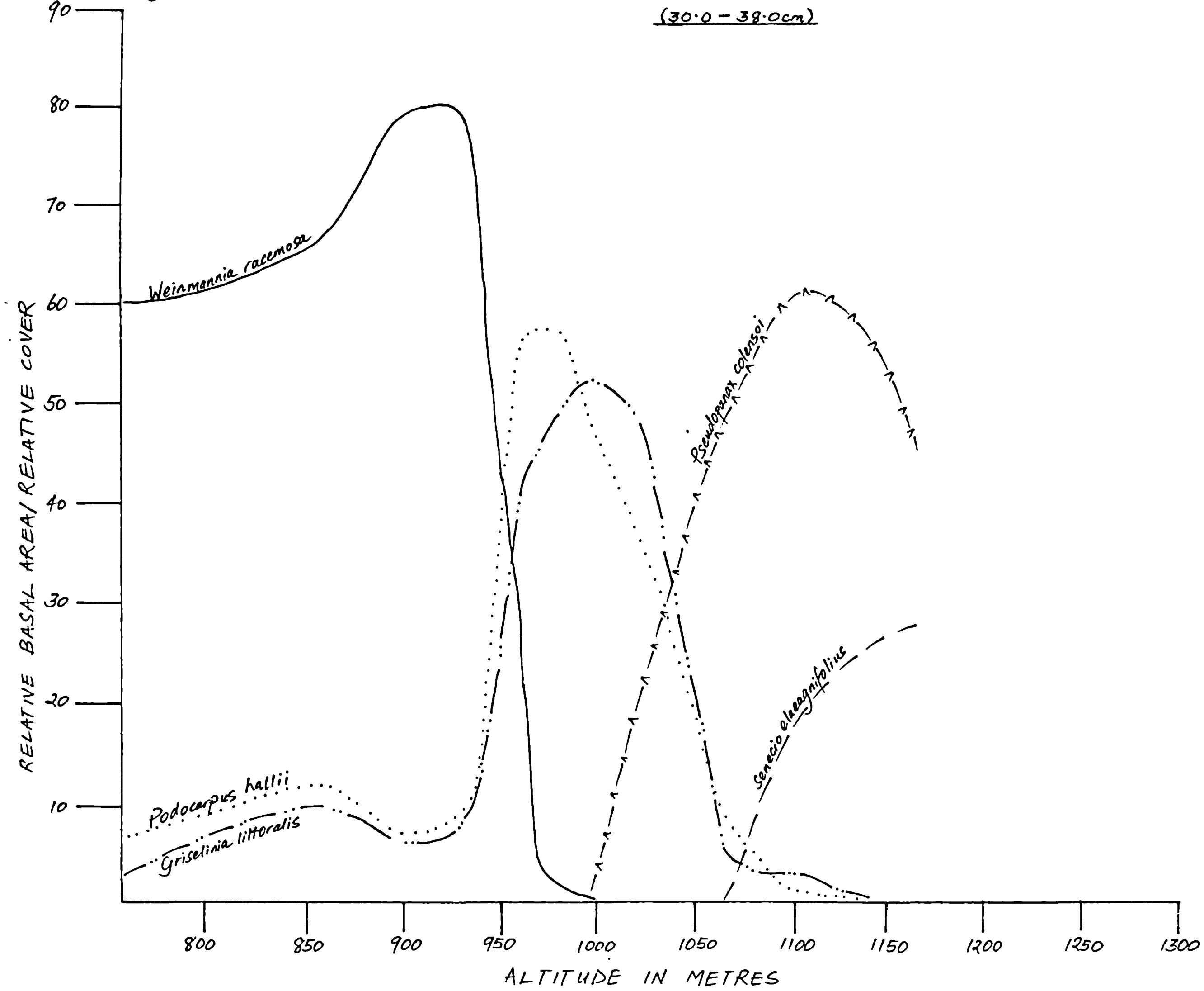
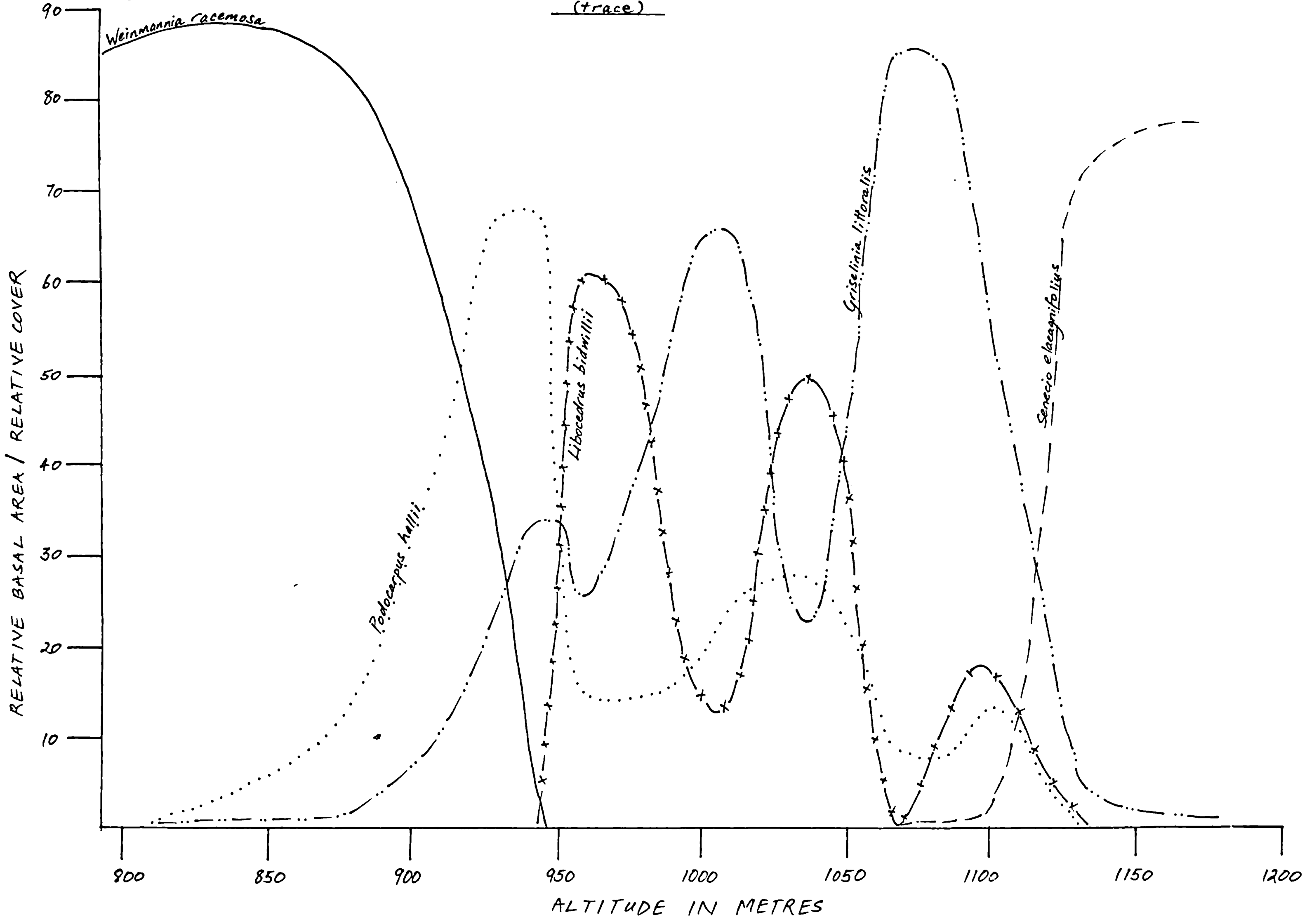


Figure 5.7 LAKE DIVE FOREST-SHRUBLAND INTERFACE
(trace)



approximate depth of lapilli as reported by Druce (1966) and Tonkin (1970).

The highest altitudinal limits of kamahi are generally shown at the locations which received the least impact from the Burrell eruption with the only exception being the Lake Dive location. Thus moving from Dawson Falls to Henry Peak there is a gradual increase in the upper limit of kamahi. This feature of the vegetation probably relates directly to the effects of the Burrell eruption in that the greatest depth of Burrell lapilli (30-38cm) is recorded at the Dawson Falls location while the smallest (a trace) is recorded at the Henry Peak location.

At Dawson Falls any kamahi located at higher altitudes than at present prior to the Burrell eruption would have been damaged physically and chemically by the ash and lapilli showers and additionally may even have been scorched. At altitudes above 950m this promoted a vigorous growth of Hall's totara probably already present as saplings or small trees beneath the fatally damaged kamahi and shrub canopy. Below 950m some of the canopy gaps created were colonised by kanuka, a species well known as light demanding and early successional. The ability of some of the damaged kamahi to resprout from epicormic shoots probably enabled a rapid return to dominance below 950m. The presence of a number of dead trunks of Hall's totara projecting through the lapilli beds indicate that many individuals of this species were killed. The rapid decay rate of kamahi as compared to Hall's totara would have removed any evidence of the mortality rate of kamahi. Many of the kamahi present now however have begun life epiphytically on the Hall's totara remnants. Although both pre-Burrell Hall's totara and kaikawaka occur at Dawson Falls only a very limited number of kaikawaka are to be found above 970m. Between 970m and 1070m near the summit track there is a small group of kaikawaka many with short boles and adventitious roots which attest to the fact that they are pre-Burrell. Twelve of these trees were dated by Mr P. Dunwiddie (Tree Ring Laboratory, Tuscon, Arizona). The oldest (with a d.b.h. of 55cm) is 412 years old and at least eight of the trees predate the Burrell eruption (1655 A.D.). The remaining trees probably established within 50 years of the end of the Burrell eruption in canopy gaps created by the damage.

At Stratford and York Road the kamahi upper limit is slightly higher than at Dawson Falls. Kaikawaka is a more important component of the top stratum of vegetation at Stratford than at Dawson Falls and is absent from York Road. The absence of kaikawaka from the top stratum at York Road has already been noted in Chapter 2 (in the section describing Human Activity in the national park) and appears to result from the logging of kaikawaka in the early 1900's. The presence of top stratum kaikawaka at comparable altitudes on the ridges adjacent to the York Track supports this contention as does the presence of a number of smaller shrub size kaikawaka in the disturbed area near Quarry Bluff on the York Track. At Stratford between 1050m and 1100m there are some large short boled multi-leadered kaikawaka emergent above the leatherwood shrubland canopy. These trees obviously predate the Burrell eruption and along with sites like those near the Plateau (1143m) which support a post-Burrell Hall's totara forest-shrubland these features point to the fact that the upper limits of forest here are determined mainly by the recent volcanic disturbances.

At North Egmont the kamahi upper limit is considerably higher than at Dawson Falls and the lesser impact of the Burrell eruption as indicated by 2.5-5.0cm depths of Burrell lapilli at this location probably accounts for this. Kaikawaka is a particularly important component of the vegetation between 1000m and 1120m at North Egmont. Judging by bole lengths and the presence or absence of adventitious roots, less than 10% of the trees at North Egmont appear to predate the Burrell eruption. The population age structure relates more closely to other disturbances notably the slip faces already described in the North Egmont section of Chapter 4 and flooding on the margins of the Ngatoro Stream. The presence of large kanuka along stream margins below the old chalet site also points to the importance of this type of disturbance to the vegetation composition and structure.

The Lake Dive location exhibits the lowest upper limit of kamahi of all the locations depicted (below 944m a.s.l.). According to Druce (1966) and Tonkin (1970) only a trace of the Burrell lapilli can be found in the vicinity of Lake Dive. It might have been expected therefore that the upper limit of kamahi at this location would be as high as that at North Egmont. Instead as already described in Chapter 4 extensive stands of kaikawaka and Hall's totara occur there. This location requires more detailed investigation (age-diameter study) in order to determine how the development of these kaikawaka stands relates to the recent volcanic history of Egmont. It is possible (as noted by Clarkson 1977) that the much lower upper limit of kamahi at this location relates to the climatic conditions. By comparison to similar altitudes on the eastern slopes of Egmont this location has longer snow-lie during the winter months, lower precipitation rates, lower insolation in late afternoon and is more directly exposed to salt-laden sea winds. These features of the climate would all favour development of a kaikawaka and Hall's totara forest instead of a kamahi dominated forest.

On Henry Peak in the Pouakai Range there is a direct interface between leatherwood and kamahi. The forest-shrubland boundary is therefore very hard to define particularly in valleys and on ridge sides where kamahi extends to its upper altitudinal limit as an almost prostrate shrub. The altitude at which this interface occurs, however, shows that kamahi has only a slightly higher upper limit in the top stratum than at North Egmont. Kaikawaka in contrast is present at much higher altitudes than at North Egmont or any of the other Egmont locations depicted. Kaikawaka trees on Henry Peak are present more as emergents above a leatherwood shrub canopy than is the case at the Egmont locations where broadleaf and other tall shrubs such as

Pseudopanax simplex and *Pseudopanax colensoi* are prominent. The pattern of vegetation change (see Figure 5.2) implies that a compression of the floristic changes occurs on Pouakai because of the steepening of the altitudinal gradient and a corresponding reduction in the available horizontal space for species to distribute. For this reason, as well as the fact that species are closer to their 'natural' upper limits on Pouakai, the overlap between the major species in the top stratum is greater along the altitudinal gradient on Pouakai than on Egmont. At present at locations like North Egmont forest species as components of the top stratum are below their potential upper altitudinal limit. The past history of volcanic disturbance and continuing instability of the upper slopes prevents anything but temporary extensions to forest species upper limits. Thus the species ecotones determined at the forest-shrub interface on Egmont at least mainly reflect those disturbances rather than the deterioration of climatic factors along the altitudinal gradient. On Pouakai however, the forest-shrubland ecotone relates more closely to the deterioration of climatic factors and thus the replacement of the tree growth form by the better adapted shrub growth form.

Kamahi forest (Goblin Forest)

Where kamahi is particularly prominent (between 850m and 975m) on Pouakai and Egmont a very distinctive forest is found. Cockayne (1928) noted that 'on Mt Egmont kamahi forest is so striking that it has received the popular and expressive name of "Goblin Forest". It occurs as a distinct belt from the neighbourhood of Dawson Falls to the North Egmont house and it probably extends right round the mountain... *Weinmannia* decrease in stature and becomes much-branched, the branches at first more or less erect, but with increase in altitude they extend far horizontally and are gnarled and irregular in shape. Both trunks and branches are covered densely with mosses, liverworts and filmy ferns (*Hymenophyllum multifidum*, *H. villosum*, *H. flabellatum*) which could not be in such profusion but for the frequent rain' (Cockayne, 1928, p.269, 270).

Epiphytism reaches its zenith in these forests with many of the top stratum individuals of kamahi having themselves begun life epiphytically on logs or stumps of other individuals. As well, many of the top stratum kamahi support large epiphytic shrubs and trees both of kamahi and other species such as *Pseudopanax simplex*, *P. colensoi* and broadleaf. Hall's totara, often festooned with *Weymouthia mollis* and broadleaf, are the most common top stratum associates of kamahi although extensive patches of pure kamahi forest are common. The closed, tight knit canopy, distinctly two layered appearance of the forest and understorey, and lack of lianes add to its character. Forest of this type is well developed at Dawson Falls (Summit Track, Ridge Track), Stratford (Kamahi Walk, Moss Walk, Curtis Falls Track) and North Egmont (Connett Walk). One woody species recorded in this forest type on Egmont and nowhere else was *Alseuosmia pusilla*.

This forest type does not occur right around the mountain as postulated by Cockayne (1928) but instead cuts out in the vicinity of the Minarapa Stream on the north-eastern side of Egmont and above the Oaonui Hut on the south-western side. On these western slopes of the mountain seral shrub communities in which kanuka is prominent grow on the series of fans formed from debris flows washed down from the unstable slopes (according to Druce, 1964, after the Newall eruptions). In some places notably near Holly Hut on the north-eastern side of Egmont 'islands' of kamahi forest can be found establishing amongst predominantly shrub communities particularly near stream sides and in sheltered valleys.

The most important environmental factors governing the composition and structure of goblin forest include the exceptionally high rainfall (6340mm at Dawson Falls), the high incidence of fog and mist, high humidities, steepness of slopes, exposure to wind, and the considerably lower temperatures recorded at these altitudes (see Climate section Chapter 2). The direct and indirect effects of all of these factors on the vegetation of tropical mountains have been described by various researchers including Leigh (1975), Grubb (1974), Whitmore (1975), Van Steenis (1962, 1972) and Grace (1977). Cloud and mist and subsequent high humidities affect transpiration rates and photosynthesis is limited by the lowered light intensity and quality. As well, temperatures are further lowered during periods of cloud and mist cover. The high rainfall causes leaching of nutrients from soils so that the rate of nutrient cycling from litter layers is a regulator of plant growth and may lead to dwarfing and gnarling of trees. It has already been noted in Chapter 2 (Geology and Soils) that Tonkin (1970) described the Tahurangi and Burrell soils as impoverished. The high wind velocities and exposure to wind has additional dwarfing and shaping effects on the vegetation and in contradiction to the comments of Grubb (1974) regarding the importance of wind in determining forest structure on tropical mountains, the canopy is often directionally wind clipped. The lower temperatures characteristic of these altitudes (see Climate section Chapter 2) slow down growth rates, shorten the growing season and even cause die-back of tender new growth. Thus in contrast to the situation on tropical mountains there is good reason to believe that wind and temperature are of considerable importance on Egmont. The goblin forest on Egmont has snow blanketing the canopy layer of the forest on occasions during the winter season, a feature not at all characteristic of tropical mountains.

The leaves of kamahi parallel the characteristic leaf structures reported for high altitude forest species (Grubb 1974) in that they are smaller, thicker and tougher than leaves of other species from lower altitude forest. Accordingly they are probably adapted to trade off the various problems associated with cloud and mist, short lived sunny periods, and the loss of minerals such as potassium and phosphorus from live leaves through leaching by the extremely high rainfall.

Lower montane, lowland and semi-coastal forests

Lower montane and lowland forests, that is forests below the upper limit of emergent rimu (790m), occur on Egmont, Pouakai and Kaitake. The lower montane forest (forest above 450m usually characterised by the prominence of kamahi) on Pouakai and Egmont is extremely similar floristically, physiognomically and structurally. On both Egmont and Pouakai the lower montane forest is a podocarp-broadleaved forest mainly rata-rimu/kamahi forest. At east Egmont however rimu densities are extremely low (less than one tree per 1000m^2) in places and in many cases the forest is more of a mixed broadleaved forest in which kamahi, mahoe, hinau and rata are prominent. The rata are emergent above the remainder of the forest and result from epiphytic establishment on rimu most now long dead. The poor regeneration performance of rimu is in marked contrast to that of kamahi and miro and has been described already in the North Egmont section of Chapter 4. Moving from north to south on the eastern side of Egmont mahoe becomes more prominent than kamahi and this has been attributed by Druce (1964) to a combination of partial destruction of the previous forest and the increased fertility of the soil following the 'topdressing' of ash. A smaller scale pattern is also apparent within this type of forest, mahoe being more prominent on the flatter sites and kamahi on raised ground or at stream margins. This pattern could also be related to ash being stripped off raised ground and collecting in hollows.

Most of the lower montane forest on Pouakai is rata-rimu/kamahi forest although rimu densities are higher in places (for example the Maude Track) than at North Egmont. In other places rimu is absent from the top stratum as for example in the rata-kamahi forest on the south-western slopes of Pouakai where as Druce (1964) notes the forest developed on burnt logs of the previous forest destroyed by fires strated by the Newall eruptions. Terrestrial rata-kamahi forest also established directly on the fans formed by debris flows on the west side of Egmont. In the vicinity of the Stony River at Blue Rata Scenic Reserve is a small remnant of the forest which according to Maxwell (1947) originally covered 'scores of acres' of stony ground on either bank of the Stony River where it emerged from the national park boundary. Clarkson, B.R. (1980) describes the forest at Blue Rata Scenic Reserve as comprising a canopy dominated by kamahi with components of tawa, hinau and rewarewa. Scattered terrestrial rata emerge above the canopy making this a rata/kamahi forest.

Forest in which kamahi is extremely dominant and in which there are almost no emergents occurs as a fringe alongside most of the large rivers such as the Waiwhakaiho and Manganui. Terrestrially established rata, other broad-leaved trees and podocarps are scattered only occasionally amongst the kamahi.

At comparable altitudes to the lower montane forest of Pouakai and Egmont there is on Kaitake a steepland variant of podocarp-broadleaved forest. Near the summits of Kaitake, Pioke and Patuha this forest resembles physiognomically the goblin forest of higher altitudes. This forest has been described in detail in the Kaitake and Physiognomy and Structure section of Chapter 4. Kamahi dominates the forest and it is dwarfed, windshaped and often multi-leadered. Away from the more exposed peaks miro is occasionally emergent above the kamahi canopy. The forest is distinctly two layered and although filmy ferns and a *Weymouthia* sp. (*Weymouthia* sp. *cochleariifolia?*) are present the kamahi is not as thickly clothed with epiphytes as in the true goblin forest. Floristically however the forest here is more closely related to the lower montane forest of Pouakai and Egmont. This critical difference to the true goblin forest is evidenced by the presence of species of lowland distribution in the canopy, for example rewarewa, and the scarcity of montane species such as broadleaf and Hall's totara. As well, because of the stunting of the forest, species such as pigeonwood, toro and soft tree fern which do not reach the top stratum at comparable altitudes on Egmont or Pouakai, are also associated with kamahi in the top stratum. This forest type is not found anywhere else within the national park. Although all the woody species found in this forest with the exception of *Coprosma colensoi* occur on Egmont and Pouakai a number of non-woody species were recorded here and nowhere else within the park. These include *Phormium cookianum*, *Libertia grandiflora* and *Phymatosorus novae-zelandiae*.

The ecotone between lower montane (steepland forest) forest and the lowland forest on Kaitake is described in detail in the Kaitake section of Chapter 4. The important environmental factors responsible for this major changeover in species dominance and the associated changes in physiognomy and structure include the rapid steepening of slopes, increased exposure to wind, and the tendency for cloud and mist to cover the Kaitake peaks particularly in the afternoon. The ecotone between lower montane forest and lowland forest which occurs at approximately the same altitude on Egmont and Pouakai is less marked probably because slopes are more gentle, less exposed, and the cloud base is generally higher on these larger mountains. In particular the changes in physiognomy and structure of the vegetation are not as marked as is the case on Kaitake.

Lowland and semi-coastal forest

Below 450m on Kaitake is a lowland podocarp-broadleaved forest. Tawa, which is only important for a short distance inside the national park boundary on the eastern slopes of Egmont and on Pouakai, is prominent in many places on Kaitake. Important associates of the tawa are kamahi, rewarewa, hinau and rimu. With decreasing altitude on the west and north-west slopes of Kaitake kohekohe, pukatea, nikau and rewarewa become prominent so that below 300m the forest is a semi-coastal type. Floristically this forest is unique within the national park as the park boundaries on average occur at 450m at east Egmont and on Pouakai thus effectively excluding the possibility of this type occurring at any other location. Woody species and tree ferns recorded only in these Kaitake forests within the national park include titoki, ramarama, taurepo, kawakawa, *Hoheria salicifolia*, ngaio, puriri, *Cyathea cunninghamii*, *Solanum aviculare* and *Passiflora tetrandra*. Some examples of non-woody species recorded within the national park only in this forest type include *Arthropodium candidum*, *Botrychium biforme*, and *Dichondra repens*.

Swamps and bogs

The Ahukawakawa Swamp and Potaema Bog are the major 'wetland' vegetation features within the national park. Ahukawakawa Swamp (914m a.s.l.) as well as being some 244m higher above sea level than Potaema Bog (760m a.s.l.) has as the term swamp suggests much more extensive areas of open water. As a result there are considerable differences in the vegetation composition and structure of both places. The most widespread vegetation type at the Ahukawakawa Swamp is tussock-sedge/mossland while at the Potaema Bog it is a sedge-rush/mossland. Both Ahukawakawa Swamp and Potaema Bog are distinctive because of the combination and numbers of different species found there. As has already been noted this feature of the vegetation relates to the range of plant habitats which can be found within a comparatively small area at these locations. Both Ahukawakawa Swamp and Potaema Bog support a number of species not recorded anywhere else within the national park. These species were; at Ahukawakawa Swamp, *Hymenanthera* sp. unnamed, *Nertera balfouriana*, and *Plantago triandra* and at Potaema Bog, *Gleichenia dicarpa*, *Olearia virgata*, *Neomyrtus pedunculata* and *Lepidosperma* *australe*.

It can be seen from the above comparison that the vegetation of each of the mountains within Egmont National Park (Egmont, Pouakai, Kaitake) is different both in its composition and structure. To some extent this is simply a function of where the original park boundaries were set, for example, the small amount of tawa forest on Egmont and Pouakai in comparison to Kaitake. Where the vegetation is comparable, however, the differences relate directly to the sequence of landform development associated with the Taranaki Volcanic Succession. For this reason each of the volcanoes within the national park has something botanically different to offer.

A complex pattern of species distribution has been outlined. Many species are confined to a single mountain or part thereof. This feature of distribution results from the continuous process of invasion and extinction of species as the availability of suitable habitats changes. The process is initiated by various disturbances to the landscape principally volcanic activity and erosion and continues as plants modify and compete for the available habitats. Many plant habitats are lost through time as a mountain decreases in size and height through erosion. There is an associated loss of species which grow only in these habitats.

On Egmont the rate of successional change is still very rapid because of its recent history of volcanic activity and erosion. By comparison, on the older mountains, Pouakai and Kaitake, the vegetation is at a more advanced stage. As well, because Pouakai and Kaitake are more eroded and therefore much lower in height, many species, particularly those that grow at higher altitudes, are no longer found. Conversely, some species now growing on Pouakai have, as yet, failed to colonise seemingly suitable habitats present on Egmont.

FORESTS OF EGMONT NATIONAL PARK AND THE TARANAKI LAND DISTRICT: A COMPARISON

At the outset of this study it was noted that only within the perspective of the remainder of the Taranaki Land District do the key features of the national park vegetation become clear. All of the results presented in Chapter 4 provide the basis for a comparison of the forest vegetation of the park and that in the remainder of the Taranaki Land District. In particular the sections Distributions of woody species and tree ferns (Table 4.22) and Forest remnants and scenic reserves enable this comparison.

This data shows that the forests of the park are characterised by the dominance of kamahi while those of the ring plain and much of the upland are dominated by tawa. As it has already been noted the tawa forests on Kaitake provide the common link between these forests. Closer examination and comparison of the distribution of tawa and kamahi in these forests reveals critical differences in the distribution of those species in the park, on the ring plain and in the uplands. Tawa grows to the top of the Matemateaonga Range (745m a.s.l.) in the uplands although as a component of the top stratum of the vegetation it is usually only found up to 610m. In the national park tawa is rarely a component of the top stratum above 450m although the species distributes above 760m at North Egmont. Kamahi, on the other hand, is prominent in all of the park forests examined with the exception of those below 450m on Kaitake. There are two main reasons for these important differences. First, the prominence of kamahi in the forests of the park, particularly on Egmont below 760m probably results from the recent volcanic disturbances. Second, there are definite climatic (particularly rainfall) and soil differences between the two locations as outlined earlier in Chapter 2. The prominence of kamahi throughout the forests of the park below 760m could thus be interpreted as a successional stage in forest development which will eventually lead to a greater component of tawa. Alternatively kamahi may always remain more important in the forests of the park because of the generally higher rainfall, higher relative humidity, greater cloud cover and different soil conditions.

A comparison of the forests of the park (below 760m), ring plain and upland with emphasis on the plants most thoroughly recorded (woody species and tree ferns) shows that the forests of the ring plain and upland are richer in species than those within the park. Obviously a number of these species, for example the coastal and semi-coastal species recorded on the coastal ring plain would not be expected to occur in the forests of the park. Leaving these species aside woody species and tree ferns which were not recorded inside the national park were *Phyllocladus trichomanoides*, *Litsea calicaris*, *Lophomyrtus obcordata*, *Nestegis montana*, *Nothofagus fusca*, *Nothofagus menziesii*, *Nothofagus solandri* var. *solandri*, *Nothofagus truncata*, *Paratrophis microphylla*, *Pseudopanax laetus*, *Quintinia serrata*, *Dicksonia fibrosa*, *Coprosma rotundifolia*, *Coprosma tenuicaulis*, *Dracophyllum latifolium*, *Dracophyllum strictum*, *Gaultheria oppositifolia*, *Gaultheria paniculata*, *Clematis foetida*, *Fuchsia perscandens* and *Metrosideros colensoi*. All of the remaining woody species and tree ferns in the forests of the park below 760m occur elsewhere in the Taranaki Land District with the exception of *Libocedrus bidwillii* and *Ascarina lucida* although four other species *Pittosporum kirkii*, *Neomyrtus pedunculata*, *Coprosma colensoi* and *Mida salicifolia* all appear on Table 4.22 as recorded in the park only. The author has observed all of these four species elsewhere in the Taranaki Land District in sites not formally sampled for this study.

These data and observations show quite clearly that the most probable source for all of the species in the forests of the national park below 760m is the nearby forests of the remainder of the land district. It is also possible to speculate that some of the species now absent from the park but obviously capable of growing successfully there might someday colonise. The major limitation to this possibility is the fact that now the forests of the mountains, ring plain and uplands are no longer contiguous. The farmland between thus acts as a barrier to the successful spread of species via short distance dispersal towards the west. The only possibility of this colonisation now by natural means is relatively long distance dispersal effected by wind or birds. Of all the forest species absent from the national park perhaps the species most suited to the conditions there would be *Quintinia serrata* which, interestingly, is prominent on the Waikato volcanic remnants to the north, particularly Pirongia, Maungatautari and Karioi.

4. THE MOUNTAINS OF EGMONT NATIONAL PARK AND SOME SOUTHERN HEMISPHERE MOUNTAINS: A COMPARISON

While the species complement on each of the mountains in Egmont National Park is in the strictest sense unique (see Miles, 1979, p8), the pattern of vegetational change along altitudinal and other environmental gradients is not. The features of change, both floristic and physiognomic, parallel those described already for other volcanic mountains of the North Island and the Southern Hemisphere by many authors. In order to illustrate these similarities some features of the vegetation of the mountains of Egmont National Park are compared with other volcanic mountains of the North Island, particularly those of the Waikato district which have been studied in some detail by the author (see Clarkson, 1981). As well, selected examples of Southern Hemisphere volcanoes reported in the literature are included. The work of Van Steenis (1962, 1972) in his comprehensive study of the volcanoes and mountain flora of Java in particular, provides many insights for those familiar with the vegetation of New Zealand volcanoes.

The descriptions of vegetational change along altitudinal gradients at each of the volcanoes of Egmont National Park presented in Chapter 3 are very similar to those provided by Richards (1952), Van Steenis (1962, 1972), Wade and McVean (1969), Grubb (1974), Whitmore (1975) and Paijmans (1976). All of these authors describe the parallel changes of physiognomy, structure and floristics which occur with increasing altitude on mainly tropical mountainsides in the Southern Hemisphere and the general zones of vegetation which can be defined in terms of these physiognomic, structural and floristic characteristics. As was noted earlier in Chapter 2 (previous botanical research), Schweinfurth (1962) was the first to point out the similarity of the Egmont forests, particularly the montane forest (goblin forest), to those in Tasmania and the humid tropics.

For the most part, the similarities are physiognomic and structural and there is little floristic relationship between the locations described. The profile diagrams of Robbins (1962) and Clarkson and Edmonds (1978) pictorially summarize the changes in physiognomy and structure of the vegetation on Egmont and can be compared with those of tropical mountains for example in Whitmore (1975). In some instances, however, there are remarkably close floristic relationships between Egmont National Park and the overseas vegetation described.

Just how similar the pattern of change including floristics can be is best illustrated by comparing Armstrong and Macey's (1979) account of the vegetation of Sangay volcano (5160m) in Ecuador with the situation in Egmont National Park. Located only 2° latitude south of the equator prominent species on Sangay include *Cedrela* sp. (Meliaceae) in the subtropical rainforest; *Podocarpus oleofolius* and *Weinmannia syradifolia* in the lower montane rainforest; and *Weinmannia* spp. and *Oreopanax* spp. (Araliaceae) in the montane rainforest. The equivalent sequence for Egmont National Park is of course *Dysoxylum spectabile* (Meliaceae); *Podocarpus hallii* and/or *Podocarpus ferrugineus* and *Weinmannia* *racemosa; Weinmannia racemosa* and *Pseudopanax* spp. (*P. simplex* and *P. colensoi;* Araliaceae). Thus, although separated by some 37° of latitude, Egmont and Sangay exhibit strikingly similar patterns of vegetational change along their respective altitudinal gradients.

Other general features of similarity between the pattern of altitudinal zonation on tropical mountains and that in Egmont National Park have been noted by Walter (1971, 1973). With reference to the upper limit of forest, Walter (1973) has described how the situation on Egmont is similar to the wet tropics. The evergreen broadleaved species of subtropical origin become shorter and shorter with increasing altitude finally forming a compact closed canopy only 1-2m above the ground. They are succeeded by a dense scrub of shrub-like Compositae and *Hebe*, dove-tailed in a mosaic-like fashion with the high-alpine tussock grassland. The upper forest limit is therefore very difficult to distinguish, a condition common on tropical mountains. This is certainly the case on Pouakai where, as it has already been noted, the top stratum dominants, kamahi and leatherwood, have a direct interface.

The possibility that the lowland forests of New Zealand possess features which ally them to tropical forests has been examined in some detail recently by Dawson (1962), Dawson and Sneddon (1969) and Webb (1978) although, as Webb (1978) describes, this possibility has been debated since the earliest descriptions of New Zealand vegetation were made. Webb (1978) has shown that physiognomically, structurally and floristically, even the North Auckland rainforests are only marginally cool subtropical (relict subtropical). The general similarity between the patterns of altitudinal zonation outlined in this study and the fact that the most important species, kamahi, belongs to the genus *Weinmannia*, the members of which are often prominent in montane forests of the Southern Hemisphere tropics and subtropics (see Godley, 1979 and Bernardi, 1963), point to the fact that the resemblance between the vegetation is more than just superficial. Certainly, as Webb (1978) describes, the abundance, cover and diversity of certain tropical life forms in the North Island lowland forest is considerably less than in tropical and subtropical regions. The wet oceanic climate, however gives the forest the general appearance or character of the subtropics. Penfound (1962) is one of many overseas researchers to ascribe these similarities to the oceanic climate of New Zealand. For the reasons outlined above there is obviously good justification for continually using the tropical and subtropical perspective to consider aspects of the indigenous vegetation of the North Island, particularly the northern most half.

Much closer to Egmont National Park the volcanic remnants of the North Island, in particular, Pirongia, Maungatautari, Karioi, Edgecumbe and Tarawera, provide perspective in understanding both the pattern of vegetation succession in relation to the history of volcanic activity and the subsequent dissection and erosion of mountains. Mt Tarawera, although of a different form and geology to Egmont, provides the greatest insights into the pattern of vegetation development after destruction by volcanic eruption. Because the eruption (1886) was so recent, the newly-established kamahi dominated forest of Tarawera illustrates some of the features which would have been of importance in the recovery of forest on Egmont after the Newall and Burrell eruptions. At its frontier the top stratum of kamahi forest on Tarawera still contains many of the shrubs, *Olearia* spp., *Gaultheria* spp. and *Coprosma* spp., which dominated before kamahi became prominent. Further down the mountain the decaying trunks and branches of once dominant *Olearia* spp. and *Coriaria arborea* can be found amongst the now dominant kamahi. On the lower slopes of Tarawera kamahi damaged by the eruption sprouted new leaders enabling a quick return to dominance. The low numbers of epiphytic species attest to the youthfulness of the forest and the large numbers of Hall's totara and *Nestegis lanceolata* seedlings and saplings indicates these species will eventually be associates of kamahi in the top stratum. In some places above the general forest limits 'islands' of kamahi forest have developed, particularly on shaded stream banks. In other areas *Phyllocladus glaucus* established and grew very rapidly in the suitable light conditions and is at present emergent above the now closed kamahi canopy. Shrub rings and grass/herb-lichen rings are a feature of the primary surfaces nearer the craters. In many places the definite rings of vegetation are being obscured as they coalesce and as shrubs, particularly *Coriaria arborea*, spread further on to the dome tops. All of these vegetation features of Tarawera have counterparts on Egmont but without the stamp of recency so obvious at Tarawera.

Mt Karioi is, like Kaitake, a long extinct and much dissected volcanic remnant located directly adjacent to the west coast of the North Island. The two mountains are situated approximately one degree of latitude apart. A comparison of the pattern of vegetation change through altitude, however, shows that, despite some major differences in species complement, there are considerable similarities in the floristics and structure of the vegetation. On Karioi a major changeover in species dominance occurs at about 550m. A lower altitude forest dominated by kohekohe (in which nikau, tawa, silver fern, pukatea and rewarewa are all prominent) is replaced by a higher altitude forest in which kamahi and quintinia dominate (and miro, *Pseudopanax edgerleyii*, soft tree fern and *Dracophyllum latifolium* are prominent). The equivalent altitude for this change in vegetation occurs at 460m on Kaitake and results in the replacement of a lowland forest in which kohekohe, tawa, rewarewa, pukatea and hinau are prominent by a kamahi dominated forest in which the major associate species are hinau, pigeonwood, toro, soft tree fern and miro. On Maungatautari and Pirongia, at a similar altitude to that on Karioi, a forest dominated by *Ixerba brexioides*, kamahi and quintinia replaces the lowland forest. Clayton-Greene (1976) emphasized fog level in explaining the critical altitude 550m on Karioi. It seems more appropriate, however, in view of the work of Van Steenis (1962, 1972), Grubb (1974) and others on tropical mountains to recognise this factor as only one of a number of factors including steepness of terrain, exposure and substrate characteristics which contribute to a change in the vegetation.

The small volcanic remnants, Kaitake and Karioi, both in close proximity to the sea, can thus be likened to the 'one-eyed kings' described by Van Steenis (1962, 1972). The dwarfed forest capping these mountains looks physiognomically similar to the goblin forests on the much higher mountains, Pouakai and Egmont. The similarity ends with the physiognomy and the overall dominance of kamahi, however, for the lower altitude forests have a quite different botanical composition. As Van Steenis (1962, 1972) describes, 'the woody and herbaceous plants of the high summits are not allured to low altitude by the one-eyed kings' (Van Steenis, 1972, p43). The equivalent change in vegetation type is higher on Karioi than on Kaitake and, as well, species common to both mountains always achieve a higher upper altitudinal limit on Karioi. This is probably accounted for by the climatic differences between the two mountains. Karioi, being one degree latitude north of Kaitake, has for any given altitude a slightly warmer climate.

It is tempting to apply the explanation of Van Steenis (1962) and Wood (1971) that the absence of mountain species from small tropical mountains results because of the lack of a zone of permanent establishment. This has already been attempted using New Zealand examples by Burrows (1964) and Clayton-Greene (1976) and the present author (Clarkson, 1981) has noted that *Ixerba brexioides* occurs on all volcanic remnants of the Waikato district higher than 760m. This is regardless of their proximity to the Kaimai Range, a supposed species refuge during the last glaciation. As has already been noted in the first section of this chapter, many species found in Egmont National Park distribute in the way outlined by Van Steenis (1962) and Wood (1971). Leatherwood, for example, is distributed on river banks and in disturbed sites on Egmont as low as 360m yet it is absent from Kaitake. Likewise kaikawaka, common at 690m in the Potaema Bog (Egmont) and as low as 480m on the banks of large rivers like the Manganui and Punehu Stream (Egmont), is absent from Kaitake. *Pseudopanax colensoi*, *Cordyline indivisa* and inaka are further species which exhibit similar distribution patterns. In all cases these species follow closely the pattern outlined by Van Steenis (1962, 1972) occupying sites where establishment is only temporary below the zone of permanent establishment. Seed dispersal down streams and rivers is the obvious mechanism for establishing the lower altitudinal limit of species. The explanation of Van Steenis (1962) and Wood (1971) may thus hold for many common and readily dispersed species so that as the sequence of mountain building and subsequent dissection and lowering of height proceeds, species may become extinct when the altitude of the highest peak falls below the critical lower limit of their zone of permanent establishment. Many species distributions do not conform to this pattern, however, and point to the importance of the stage of development of the vegetation on the mountains being compared. *Cyathea colensoi* and *Podocarpus nivalis*, for example, are both found on Pouakai but as yet have failed to colonise Egmont even though it has apparently suitable habitats.

The most commented upon species absence from Egmont National Park is that of beech (*Nothofagus* spp.), however, these species are also absent from most volcanic remnants in the North Island. In the case of the mountains cited in this discussion the forests are all of the podocarp-broadleaved type in which kamahi is particularly prominent. The closest localities to Egmont National Park in which the beech species are found at present are: Mt Messenger and vicinity (hard beech), Te Wera and vicinity (black beech) and Waitaanga and vicinity (silver beech). Black beech and hard beech are confined to sandstone ridge tops forming almost pure stands in many places. The silver beech forest at Waitaanga is of a more mixed composition with other species such as Hall's totara, kamahi, kahikatea and rimu often forming part of the top layer of the vegetation. In all cases however the beech forests of the Taranaki Upland can be considered as relict types in that they are confined to special sites and display no tendency to invade and displace the podocarp-broadleaved forests found throughout Taranaki.

Black beech and hard beech are able to tolerate the nutrient-poor, drought-prone soils of sandstone ridge caps while silver beech tolerates the boggy poorly drained soils of the Waitaanga plateau. The less favourable conditions encountered in these sites provide a 'competitive release' from the dominant podocarp-broadleaved forest. McGlone (1980), in describing the vegetation history of Taranaki, states that fossil silver beech dated at 30,000 years B.P. has been found near New Plymouth. Beech has therefore been absent from western Taranaki for a considerable period of time since being displaced probably by the change of climate, destruction by volcanic activity, or a combination of these factors. McGlone and Topping (1977) have cited these factors as causes for the present day pattern of *Nothofagus* distribution in the Tongariro region and they probably apply equally to the Taranaki region. The well documented poor dispersal ability of the beeches (Preest, 1963) would have prevented them from capitalising on any suitable habitats which became available later. The inability of the beech species to compete with and displace the surrounding podocarp-broadleaved forest in Taranaki under the present climatic regime means that they are doomed to remain relegated to special sites. Even if the beech species could disperse to the mountains of Egmont National Park it is debatable whether they would be able to successfully establish let along supplant the existing vegetation. Zotov (1938) suggested that the absence of *Nothofagus* spp. from some mountains in the North Island correlated with the prevailing climatic conditions notably high rainfall and the occurrence of frequent heavy fogs. These climatic conditions explained the absence of mountain beech from the Tararuas, Mt Egmont and a part of Westland. In the case of silver beech, Zotov (1938) cited the combination of high rainfall, frequent heavy fogs and the dense growth of rimu-rata forest as the reason for its absence from Mt Egmont and a part of Westland. Wardle (1979), however, describes the colonisation of parts of Westland National Park 'not much earlier than 1,000 B.C.' by silver beech from survival areas in the south. The performance of silver beech in these locations which have a similar climate to Mt Egmont suggests establishment would be possible on Mt Egmont if silver beech was at all capable of dispersing to these sites. Silver beech has been planted in a number of locations on the ring plain and near Mt Egmont since the days of European settlement, for example near the Meeting of the Waters Scenic Reserve. The planted trees have grown very successfully however the author is unaware of any successful regeneration.

Zotov (1938) ascribed the lower tree-line on Egmont to the absence of beech and Clarkson (1977) discussed this point and the possible consequences of the absence of beech on the performance of other montane species. As this study has shown, neither placed enough emphasis on the instability of the upper slopes or the recent history of volcanic disturbance in determining tree-line. This is regardless of the species which form the tree-line.

As the discussion above shows the absence of the beech species from the mountains of Egmont National Park is hardly surprising. Of much greater significance is the absence of forest trees such as *Quintinia serrata* noted earlier in the discussion which is not limited in dispersal ability to the same extent that the beech species are. The overwhelming dominance of kamahi in the upper altitude forests of Egmont National Park thus results not only because of the optimum climate and disturbance by volcanic activity but is also a function of a lack of competitors. On the volcanic remnants to the north kamahi only rarely achieves the degree of dominance it achieves in places on Egmont. On Pirongia, Maungatautari, and Edgecumbe, *Ixerba brexioides* and quintinia are both leading competitors with kamahi in the montane forest. *Ixerba brexioides* is absent from Karioi and quintinia is the main competitor. Only on Tarawera where the forests are still adjusting to the eruption of 1886 is kamahi still the clear overall dominant. There, quintinia and *Ixerba brexioides* are, as yet, uncommon components in the developing montane forest. Of the vegetation covering the mountains of Egmont National Park at least two-thirds is forest in which kamahi is prominent. A much more complete understanding of the ecology of kamahi particularly as it relates to volcanic disturbance is the key to understanding the pattern and process of the forests of Egmont National Park.

Appendix 1 Sampling sites on the Kaitake Range

Site No.	Location	Slope Angle	Aspect	Altitude Feet	Altitude Metres
1	Manders	30-35	292	650	198
2	Patuha	20-25	285	670	204
3	Davies	5-10	325	720	219
4	Patuha	30-40	283	780	238
5	Kirihau	10-60	350	800	244
6	Manders	5-15	292	850	259
7	Waimoku	7-12	175	870	265
8	Weld	10-25	235	900	274
9	Davies	5-15	310	920	280
10	Patuha	5-10	192	980	299
11	Kirihau	5-10	340	1000	305
12	Weld	5-20	195	1100	335
13	Davies	15	305	1110	335
14	Patuha	5-10	224	1180	359
15	Kirihau	20-40	5	1200	366
16	Manders	7-12	270	1200	366
17	Weld	5-10	165	1300	396
18	Davies	20-25	325	1320	402
19	Patuha	20-30	214	1380	420
20	Kirihau	30	60	1400	426
21	Manders	20-35	270	1400	426
22	Weld	20-25	265	1500	457
23	Waimoku	7-10	190	1510	460
24	Davies	20-30	5	1520	463
25	Patuha	10-15	178	1580	481
26	Kirihau	35-40	140	1600	487
27	Manders	25-28	270	1610	490
28	Weld	20-35	290	1700	518
29	Davies	30	85	1740	530
30	Patuha	5-10	192	1780	542
31	Kirihau	30-40	135	1800	548
32	Weld	15-20	100	1900	579
33	Manders	27-32	270	1920	585
34	Davies	40	110	1920	585

Appendix 1 continued

Site No.	Location	Slope Angle	Aspect	Altitude Feet	Altitude Metres
35	Kirihau	25-30	270	1980	603
36	Patuha	15-30	245	1980	603
37	Manders	22-27	270	2120	646
38	Davies	40	45	2120	646
39	Patuha	40-50	266	2180	664
40	Patuha	30-40	320	2190	667
41	Patuha	15-20	185	2210	673

Manders = Mander's Spur Track
Patuha = Sefton Ridge Track
Weld = Weld Road end of Davies Track
Kirihau = Kirihau Track
Waimoku = Waimoku Track
Davies = Davies Track

Appendix 2 Sampling sites on the Pouakai Range

Site No.	Location	Slope Angle	Aspect	Altitude Feet	Altitude Metres
1	Maude	12-17	280	1800	548
2	Maude	12-15	60	1800	548
3	Maude	5- 7	45	1860	567
4	Maude	7-10	290	1860	567
5	Mangorei	5- 7	0	1900	579
6	Maude	10-15	305	1945	593
7	Maude	5- 7	340	2080	634
8	Maude	7-12	305	2085	635
9	Mangorei	5- 7	0	2090	637
10	Henry	0- 5	0	2150	655
11	Maude	2- 5	320	2200	670
12	Maude	5	50	2240	682
13	Mangorei	7-10	350	2280	695
14	Dover	17	45	2300	701
15	Henry	20-25	0	2350	716
16	Maude	7-12	355	2400	731
17	Maude	10-12	15	2430	740
18	Mangorei	10-12	30	2480	756
19	Dover	25	25	2540	774
20	Henry	15-20	0	2600	792
21	Maude	5- 7	350	2600	792
22	Maude	10-15	45	2640	804
23	Mangorei	10-15	355	2660	810
24	Dover	20	65	2760	841
25	Henry	15-20	0	2780	847
26	Maude	9-15	350	2805	855
27	Dover	15	20	2980	908
28	Maude	9-15	350	2985	909
29	Mangorei	10-12	330	3000	914
30	Henry	22-27	45	3000	914
31	Henry	25-40	45	3200	975
32	Dover	15-20	30	3200	975
33	Mangorei	10-15	310	3220	981
34	Maude	12-15	350	3240	987

Appendix 2 continued

Site No.	Location	Slope Angle	Aspect	Altitude Feet	Altitude Metres
35	Ahukawakawa	35-40	20	3300	1005
36	Ahukawakawa	25-35	200	3300	1005
37	Henry	15-20	45	3400	1036
38	Dover	25	30	3420	1042
39	Henry	15-20	45	3450	1051
40	Mangorei	35-40	0	3460	1054
41	Ahukawakawa	25-30	0	3460	1054
42	Henry	15-20	45	3570	1088
43	Dover	25	50	3630	1106
44	Mangorei	15-20	85	3650	1112
45	Ahukawakawa	10-15	20	3660	1115
46	Henry	15-20	45	3770	1149
47	Dover	30-35	80	3830	1167
48	Mangorei	17-22	95	3850	1173
49	Henry	15-20	45	3960	1206
50	Ahukawakawa	5- 7	85	3960	1206
51	Dover	25-30	75	4040	1231

Maude = Maude Track
Mangorei = Mangorei Track
Henry = Henry Peak (Kaiauai Track)
Dover = Dover Track
Ahukawakawa = Ahukawakawa Track

Appendix 3 List of species recorded in the ground cover (above 1220m a.s.l.), Pouakai

DICOT TREES

Pseudopanax colensoi
Pseudopanax simplex

DICOT SHRUBS

Cassinia vauvilliersii
Coprosma depressa
C. 'paludosa'
C. pseudocuneata
C. pumila
C. 'taylorae'
Dracophyllum filifolium
Gaultheria antipoda
G. sp.unnamed
G. sp. unnamed x *Pernettya macrostigma*
Hebe odora "erect"
H. odora "prostrate"
H. stricta var. *egmontiana*
H. tetragona
H. venustula
Myrsine divaricata
Olearia arborescens
Pentachondra pumila
Pseudopanax anomalus
Senecio elaeagnifolius

PSILOPSIDS AND LYCOPODS

Lycopodium fastigiatum

FERNS

Blechnum capense agg. ("capense", "minus")
B. penna-marina
Hymenophyllum multifidum
Polystichum vestitum

ORCHIDS

Aporostylis bifolia

GRASSES

Chionochloa rubra
Hierochloe novae-zelandiae
Microlaena colensoi
Poa anceps
P. colensoi
Poa laevis
P. sp. *(breviglumis?)*
P. sp. "dwarf"
P. sp. *(pusilla?)*
Rytidosperma setifolium

SEDGES

Gahnia procera
Oreobolus pectinatus
Schoenus pauciflorus
Uncinia egmontiana
Uncinia sp. *(drucei?)*
U. sp. *(filiformis?)*
U. sp. *(involuta?)*

RUSHES

Luzula colensoi
Luzula migrata

MONOCOT HERBS (other than orchids, grasses, sedges, rushes)

Astelia sp. unnamed

Bulbinella hookeri

COMPOSITE HERBS

Abrotanella caespitosa

Celmisia glandulosa var. *latifolia*

C. gracilenta var.

C. setacea

Cotula squalida subsp. *squalida*

Helichrysum 'alpinum'

H. bellidioides

Lagenifera strangulata

Raoulia glabra

DICOT HERBS

Anisotome aromatica

Drapetes dieffenbachii

Epilobium sp.

Euphrasia cuneata

Forstera bidwillii var. *densifolia*

Galium perpusillum

Gentiana grisebachii

Geranium microphyllum

Geum leiospermum

Nertera depressa

Oreomyrrhis colensoi

Ourisia macrophylla var. *drucei*

O. macrophylla var. *macrophylla*

Oxalis lactea

Ranunculus nivicola

Viola cunninghamii

V. filicaulis

Wahlenbergia albo-marginata var.

MOSSES

Dendroligotrichum dendroides

Dicranaloma robustum

Racomitrium lanuginosum var. *pruinosum*

Sphagnum sp. *(cristatum?)*

Appendix 4 List of species recorded in sites at Ahukawakawa Swamp

GYMNOSPERM TREES AND SHRUBS

Libocedrus bidwillii
Podocarpus hallii

DICOT TREES AND SHRUBS

Griselinia littoralis
Pseudopanax colensoi
Pseudopanax simplex
Weinmannia racemosa var. *racemosa*

DICOT SHRUBS

Alseuosmia sp. *(pusilla?)*
Cassinia vauvilliersii
Coprosma grandifolia
C. 'paludosa'
C. 'taylorae'
C. tenuifolia
Dracophyllum filifolium
Hebe odora agg.
H. stricta var. *egmontiana*
H. venustula
Hymenanthera sp. unnamed
Pseudopanax anomalus
Pseudowintera colorata

PSILOPSIDS AND LYCOPODS

Lycopodium fastigiatum

FERNS

Blechnum capense agg. ("capense", "minus", "swamp")
B. fluviatile
B. penna-marina
Grammitis sp.
Hymenophyllum multifidum
Hymenophyllum sanguinolentum
H. spp.
Hypolepis millefolium
Leptopteris superba
Polystichum vestitum

ORCHIDS

Aporostylis bifolia
Corybas trilobus
Microtis oligantha
Pterostylis sp.

GRASSES

Chionochloa rubra
Hierochloe redolens
Microlaena avenacea

SEDGES

Gahnia procera
Scirpus habrus
Uncinia uncinata
Uncinia sp.

RUSHES

Luzula sp.

MONOCOT HERBS (other than orchids, grasses, sedges, rushes)

Astelia gragrans
A. sp. unnamed
Bulbinella hookeri
Libertia pulchella
Luzuriaga parviflora
Phormium tenax

COMPOSITE HERBS

Cotula squalida subsp. *squalida*
Lagenifera strangulata
Senecio rufiglandulosus var. *rufiglandulosus*

DICOT HERBS

Geranium microphyllum
Gonocarpus aggregatum
Ourisia macrophylla var. *macrophylla*
Oxalis lactea
Pratia angulata
Ranunculus rivularis
R. hirtus
Viola cunninghamii
V. filicaulis

MOSSES

Dendroligotrichum dendroides
Sphagnum sp. *(cristatum?)*

Other plants recorded in vicinity

Myrsine divaricata
Nertera balfouriana
Plantago triandra
Gunnera prorepens

Appendix 5 Site details for the eastern side of Mt Egmont

Site No.	Location	Slope Angle	Aspect	Altitude	
				Feet	Metres
1	North Egmont	26.0	NE	4565	1391
2	North Egmont	15.0	NE	4550	1386
3	York	5.0	E	4550	1386
4	Punehu-Skeet	7.5	SE	4530	1380
5	Dawson Falls	20.0	E	4500	1371
6	North Egmont	27.5	NE	4465	1360
7	York	2.5	E	4430	1350
8	York	22.0	ENE	4390	1337
9	Punehu-Skeet	8.5	SE	4360	1328
10	North Egmont	27.5	NE	4310	1313
11	Punehu-Skeet	12.5	SE	4260	1298
12	Punehu-Skeet	7.0	SE	4160	1267
13	York	15.0	E	4140	1261
14	North Egmont	27.5	NNE	4080	1243
15	Punehu-Skeet	5.0	SE	4050	1234
16	York	7.0	NE	4000	1219
17	North Egmont	35.0	NE	3960	1206
18	Punehu-Skeet	5.0	SSE	3930	1197
19	York	18.0	E	3860	1176
20	North Egmont	30.0	NE	3825	1165
21	Punehu-Skeet	10.0	SSE	3800	1158
22	York	4.0	E	3760	1145
23	Lake Dive	17.5	SE	3700	1127
24	North Egmont	25.0	NE	3660	1115
25	Lake Dive	7.5	SE	3625	1104
26	North Egmont	9.5	NE	3600	1097
27	Dawson Falls	11.0	E	3600	1097
28	York	30.0	NE	3570	1088
29	North Egmont	30.0	NNE	3500	1066
30	Dawson Falls	12.5	E	3500	1066
31	Lake Dive	16.0	SE	3500	1066
32	North Egmont	30.0	NNE	3410	1039
33	Lake Dive	17.5	SE	3400	1036
34	Dawson Falls	7.0	SE	3380	1030
35	North Egmont	30.0	N	3305	1007

Appendix 5 continued

Site No.	Location	Slope Angle	Aspect	Altitude Feet	Altitude Metres
36	Lake Dive	20	S	3300	1005
37	York	30	ENE	3280	999
38	Dawson Falls	8.5	E	3270	996
39	North Egmont	7.5	NNE	3200	975
40	Dawson Falls	8.5	ESE	3200	975
41	York	2	NE	3150	960
42	York	5	ESE	3150	960
43	Lake Dive	17.5	S	3150	960
44	Lake Dive	3.5	S	3100	944
45	Dawson Falls	19.5	SE	3065	934
46	York	5	E	3010	917
47	North Egmont	6	NNE	3005	915
48	York	20	E	2945	897
49	Lake Dive	10	SSE	2880	877
50	North Egmont	6	NNE	2865	873
51	North Egmont	12.5	NE	2680	816
52	Kaiauai	6	NE	2600	792
53	North Egmont	6	NE	2452	747
54	Kaiauai	6	NE	2400	731
55	North Egmont	1.5	NE	2232	680
56	North Egmont	2.5	NE	1929	588
57	North Egmont	2.5	NE	1805	550
58	North Egmont	7.5	NE	1575	480

North Egmont = (Razorback, Summit Track, Blundell's Track)

York = (York Track and Waipuku Track)

Dawson Falls = (Summit Track)

Lake Dive = (Lake Dive Track)

Kaiauai = (Near Kaiauai Hut)

Punehu-Skeet = (Punehu Track and Skeet Ridge)

Appendix 6 List of species recorded at Potaema Bog (including bog margins)

GYMNOSPERM TREES AND SHRUBS

Dacrycarpus dacrydioides
Dacrydium cupressinum
Libocedrus bidwillii
Podocarpus ferrugineus
P. hallii

MONOCOT TREES AND SHRUBS

Cordyline australis
(in adjacent bog only)
Cordyline indivisa

DICOT TREES

Beilschmiedia tawa
Carpodetus serratus
Elaeocarpus dentatus
E. hookerianus
Griselinia littoralis
Melicytus ramiflorus var. *ramiflorus*
Metrosideros robusta
Myrsine salicina
Nostegis cunninghamii
Pennantia corymbosa
Pittosporum tenuifolium subsp. *tenuifolium*
Pseudopanax arboreus
P. colensoi
P. crassifolius
P. edgerleyi
P. simplex
Schefflera digitata
Weinmannia racemosa var. *racemosa*

DICOT SHRUBS

Alseuosmia macrophylla
A. pusilla
Cassinia vauvilliersii
Coprosma areolata
C. robusta
C. 'taylorae'
C. tenuifolia
Cyathodes fasciculata
Dracophyllum lilifolium
Gaultheria antipoda
Geniostoma ligustrifolium
Hebe odora
Hebe stricta var. *egmontiana*
H. stricta var. *stricta*
Leptospermum scoparium
Neomyrtus pedunculata
Olearia arborescens
O. virgata var. *virgata*
Pittosporum kirkii
Pseudopanax anomalus
P. anomalus x *P. simplex*
Pseudowintera axillaris
P. colorata
Senecio elaeagnifolius
S. kirkii

MONOCOT LIANES

Ripogonum scandens

DICOT LIANES

Clematis paniculata
Metrosideros diffusa
Parsonsia capsularis
Rubus australis

PSILOPSIDS AND LYCOPODS

Lycopodium varium
Tmesipteris tannensis

FERNS

Asplenium falcatum
A. flaccidum
Blechnum capense agg. ("procerum", "minus", "swamp")
B. discolor
B. patersonii
Cardiomanes reniforme
Ctenopteris heterophylla
Cyathea smithii
Gleichenia dicarpa
Grammitis billardieri
Hymenophyllum dilatatum
H. multifidum
H. revolutum
H. sanguinolentum
Leptopteris superba
Pteridium aquilinum var. *esculentum*
Trichomanes venosum

ORCHIDS

Corybas sp. *(macranthus?)*
Dendrobium cunninghamii
Earina mucronata
Pterostylis sp. *(banksii?)*
Thelymitra longifolia
T. venosa

GRASSES

Microlaena avenacea

SEDGES

Baumea rubiginosa
B. tenax
Gahnia xanthocarpa
Lepidosperma australe
Scirpus habrus
Uncinia banksii
U. uncinata

RUSHES

Juncus bufonius

MONOCOT HERBS (other than orchids, grasses, sedges, rushes)

Astelia fragrans
A. grandis
A. solandri
Collospermum hastatum
C. microspermum
Libertia pulchella
Luzuriaga parviflora
Phormium tenax
Potamogeton suboblongus

DICOT HERBS

Drosera binata

Euphrasia cuneata

Gonocarpus aggregatum

Nertera sp. (unnamed; agg. *N. dichondraefolia*)

Ourisia macrophylla var. *macrophylla*

Pratia angulata

Viola filicaulis

LICHENS

Cladonia leptoclada

Usnea sp.

MOSSES

Dicranoloma robustum

Sphagnum sp. *(cristatum?)*

Appendix 7 List of species recorded in the ground cover (above 1220m a.s.l.), Mt Egmont

DICOT TREES

Pseudopanax colensoi
Pseudopanax simplex

DICOT SHRUBS

Cassinia vauvilliersii
Coprosma depressa
C. pseudocuneata
C. pumila
C. 'taylorae'
Coriaria plumosa
C. pteridioides
Cyathodes fraseri
Dracophyllum filifolium
Gaultheria antipoda
Gaultheria sp. unnamed
Hebe odora "erect"
Hebe stricta var. *egmontiana*
Muehlenbeckia axillaris
Myrsine divaricata
Olearia arborescens
Pentachondra pumila
Pimelea prostrata var. *prostrata*
Senecio elaeagnifolius

PSILOPSIDS AND LYCOPODS

Lycopodium fastigiatum

FERNS

Blechnum capense agg. ("capense", "minus")
B. penna-marina
Hymenophyllum multifidum
Polystichum vestitum

ORCHIDS

Aporostylis bifolia
Pterostylis venosa

GRASSES

Chionochloa rubra
Hierochloe redolens
Poa anceps
Poa colensoi
P. laevis var.
Poa sp. *(breviglumis?)*
P. sp. *(pusilla?)*
Rytidosperma clavatum
R. viride

SEDGES

Gahnia procera
Luzula sp.
Oreobolus pectinatus
Uncinia sp. *(drucei?)*
U. sp. *(filiformis?)*

MONOCOT HERBS (other than orchids, grasses, sedges, rushes)

Astelia sp. unnamed

COMPOSITE HERBS

Celmisia glandulosa var. *latifolia*

C. gracilenta

Helichrysum 'alpinum'

DICOT HERBS

Aciphylla squarrosa

Anisotome aromatica

Epilobium spp.

Euphrasia cuneata

Forstera bidwillii var. *densifolia*

Galium perspusillum

Gentiana grisebachii

Geranium microphyllum

Ourisia macrophylla var. *macrophylla*

Oxalis lactea

Ranunculus nivicola

Viola cunninghamii

V. filicaulis

Wahlenbergia albo-marginata var.

MOSSES

Campylopus sp.

Dendroligotrichum dendroides

Dicranaloma sp.

Hypnum sp.

Racomitrium lanuginosum var. *pruinosum*

Appendix 8 List of species recorded in moss-herbfield and allied vegetation (above 1500m a.s.l.), Mt Egmont

DICOT SHRUBS

Hebe odora "erect"
Coprosma depressa
C. pumila
Cyathodes fraseri
Gaultheria sp. unnamed
Muehlenbeckia axillaris
Pentachondra pumila

PSILOPSIDS AND LYCOPODS

Lycopodium australianum
Lycopodium fastigiatum

FERNS

Blechnum penna-marina
Grammitis armstrongii
Hymenophyllum multifidum
Hypolepis millefolium
Polystichum cystostegia

ORCHIDS

Aporostylis bifolia

GRASSES

Chionochloa rubra
Hierochloe redolens
Lachnagrostis sp.
((*b*) unnamed?)
Poa colensoi
Poa laevis
Poa novae-zelandiae
Rytidosperma clavata
R. viride

SEDGES

Carex pyrenaica var. *cephalotes*
Luzula colensoi
L. sp. (*migrata?*)
Oreolodus pectinatus
Uncinia drucei
U. sp.

RUSHES

Juncus novae-zelandiae
Juncus pusillus

COMPOSITE HERBS

Celmisia glandulosa var. *latifolia*
C. gracilenta var.
Helichrysum 'alpinum'
Raoulia glabra
R. tenuicaulis

DICOT HERBS

Anisotome aromatica

Colobanthus sp. unnamed

Drapetes dieffenbachii

Epilobium glabellum

E. pernitens

E. sp. *(chlorifolium?)*

E. sp.

Euphrasia cuneata

Forstera bidwillii var. *densifolia*

Gentiana grisebachii

Geranium microphyllum

Montia sp.

Oreomyrrhis colensoi

Ourisia macrophylla var. *macrophylla*

Oxalis lactea

Plantago novae-zelandiae

Ranunculus nivicola

Viola cunninghamii

Wahlenbergia albo-marginata var.

MOSSES

Campylopus sp.

Dicranaloma sp.

Hypnum sp.

Polytrichum sp.

Racomitrium crispulum

R. lanuginosum var. *pruinosum*

R. ptycophyllum

Appendix 9 Notes on the nomenclature of some species

' ' = informal name of another author, e.g. Druce (1977).

" " = informal name based on field observations used by this author.

1. *Astelia* sp. unnamed

   Druce (1973) - affinities with *Astelia nervosa*.

2. *Blechnum capense* agg.

   Used in reference to several distinct forms of *Blechnum capense* "procerum", "capense", "minus", and "swamp" which can be recognised in the field.

3. *Botrychium biforme*

   Braggins (1980) - was *Botrychium australe* var. *millefolium* (Allan, 1961).

4. *Carmichaelia arborea*

   Following Druce (1977) all the plants recorded are considered as varieties of *C. arborea*. The Mt Egmont var. was known as *Carmichaelia egmontiana* (Allan, 1961), and the plants recorded in inland Taranaki fit the description of *Carmichaelia cunninghamii* (Allan, 1961).

5. *Celmisia gracilenta* var.

   Druce (1973) - also known as *Celmisia major* var. *brevis* (Allan, 1961).

6. *Coprosma grandifolia*

   Druce (1977) - corrects mistake in (Allan, 1961)? where this species was renamed *Coprosma australis*.

7. *Coprosma 'paludosa'* and *Coprosma 'taylorae'*

   Druce (1977) - authors other than Druce have usually referred to both of these species as *Coprosma parviflora*.

8. *Gaultheria* sp. unnamed

   Druce (1973) - most other authors have used *Gaultheria depressa* var. *novae-zelandiae* for the plant found on Mt Egmont.

9. *Hebe odora* agg.

   Used in reference to two distinct forms of *Hebe odora* "erect" and "prostrate". The "prostrate" form was recorded on Pouakai only in tussock dominated vegetation. Individuals of *Hebe odora* "prostrate" grown by the author for over four years

9. *Hebe odora* agg. continued

have never become erect and show a marked tendency to spread by vegetative layering. Listed by Druce (1973) as a single species *Hebe* sp. (*a*) (*H. odora* agg.)

10. *Hebe stricta* var. *egmontiana*

Allan (1961) - Druce (1977) - lists this as an unnamed species *Hebe* sp. (*l*) (unnamed) var. *i*.

11. *Hebe tetragona* var.

Druce (1977) - also known as *Hebe subsimilis* var. *astonii* (Allan, 1961).

12. *Helichrysum 'alpinum'*

Druce (1973) - affinities with *H. bellidioides*, *Helichrysum 'alpinum'* of Cockayne (1928).

13. *Hymenanthera* sp. unnamed

Druce (1973, 1977) - similar to *Hymenanthera angustifolia*.

14. *Pimelea prostrata*

Two varieties have been noted in Taranaki var. *prostrata* the common variety found on Mt Egmont and on the road cuttings of inland Taranaki and var. *quadrifaria* the coastal variety.

15. *Pittosporum tenuifolium*

Two forms have been noted in Taranaki and following Druce (1977) they are subsp. *tenuifolium* and subsp. *colensoi*. *P. tenuifolium* subsp. *tenuifolium* is found on Egmont and Pouakai while *P. tenuifolium* subsp. *colensoi* is found in inland Taranaki. Both subspecies were recorded near Aotuhia but subsp. *tenuifolium* was probably introduced into the area as a cultivated shrub.

16. *Pseudopanax simplex*

Druce (1977) and Druce (pers. comm.) does not accept var. *sinclairii* on the grounds of continuous variation. Most other authors have used *Pseudopanax simplex* var. *sinclairii* for the plant found on Mt Egmont.

Appendix 10 List of common names used in text with scientific equivalents

black beech	*Nothofagus solandri* var. *solandri*
black maire	*Nestegis cunninghamii*
blackberry	*Rubus fruticosus* agg.
blue tussock	*Poa colensoi*
bracken fern	*Pteridium aquilinum* var. *esculentum*
broadleaf	*Griselinia littoralis*
crown fern	*Blechnum discolor*
everlasting daisy	*Helichrysum 'alpinum'*
filmy ferns	*Hymenophyllum* spp.
flax	*Phormium tenax*
forest oat grass	*Microlaena avenacea*
fuchsia	*Fuchsia excorticata*
Hall's totara	*Podocarpus hallii*
hangehange	*Geniostoma ligustrifolium*
hanging spleenwort	*Asplenium flaccidum*
hard beech	*Nothofagus truncata*
hinau	*Elaeocarpus dentatus*
hooked sedges	*Uncinia* spp.
inaka	*Dracophyllum filifolium*
kahikatea	*Dacrycarpus (Podocarpus) dacrydioides*
kaikawaka	*Libocedrus bidwillii*
kamahi	*Weinmannia racemosa* var. *racemosa*
kanuka	*Leptospermum ericoides*
karaka	*Corynocarpus laevigatus*
kawakawa	*Macropiper excelsum* var. *excelsum*
kidney fern	*Cardiomanes reniforme*
kohekohe	*Dysoxylum spectabile*
koromiko	*Hebe stricta* var. *egmontiana*
lancewood	*Pseudopanax crassifolius*
leatherwood	*Senecio elaeagnifolius* var.
mahoe	*Melicytus ramiflorus* var. *ramiflorus*
mangeo	*Litsea calicaris*
manuka	*Leptospermum scoparium*
marble leaf	*Carpodetus serratus*
matai	*Podocarpus spicatus*
miro	*Podocarpus ferrugineus*

Appendix 10 continued

mountain buttercup	*Ranunculus nivicola*
mountain cottonwood	*Cassinia vauvilliersii*
mountain flax	*Phormium cookianum*
mountain pepperwood	*Pseudowintera colorata*
ngaio	*Myoporum laetum* var. *laetum*
nikau	*Rhopalostylis sapida*
pate	*Schefflera digitata*
pigeonwood	*Hedycarya arborea*
pukatea	*Laurelia novae-zelandiae*
puriri	*Vitex lucens*
quintinia	*Quintinia serrata*
rata	*Metrosideros robusta*
red tussock	*Chionochloa rubra*
rewarewa	*Knightia excelsa*
ramarama	*Lophomyrtus bullata*
rimu	*Dacrydium cupressinum*
silver beech	*Nothofagus menziesii*
silver fern	*Cyathea dealbata*
silver tussock	*Poa laevis* var.
soft tree fern	*Cyathea smithii*
sphagnum moss	*Sphagnum* sp. *(cristatum?)*
supplejack	*Ripogonum scandens*
swamp maire	*Eugenia maire*
taurepo	*Rhabdothamnus solandri*
tawa	*Beilschmiedia tawa*
titoki	*Alectryon excelsus* var. *excelsus*
toro	*Myrsine salicina*
totara	*Podocarpus totara*
tutu	*Coriaria arborea* var. *arborea*
wheki	*Dicksonia squarrosa*
*hound's tongue fern	*Phymatosorus diversifolius*
mamaku	*Cyathea medullaris*
raurekau	*Coprosma grandifolia*

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