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A DETAILED HABITAT STUDY OF NORTH ISLAND KOKAKO IN PUKETI FOREST, NORTHLAND

by

H A Best and P J Bellingham

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A DETAILED HABITAT STUDY OF NORTH ISLAND KOKAKO IN PUKETI FOREST, NORTHLAND

by

H A Best[1] and P J Bellingham[2]

[1]Science and Research Division, Department of Conservation,
P O Box 10-420, Wellington

[2]Botany School, Cambridge University, Downing Street,
Cambridge CB2 3EA, United Kingdom

ABSTRACT

The document is primarily a resource document on kokako in Puketi Forest, their ecology, and how they use their habitat. It also contains a detailed the physical features of the vegetation of some kokako home ranges and a comprehensive flora of Puketi Forest.

READER'S GUIDE

This document is primarily a resource document on kokako in Puketi Forest, their ecology, and how they use their habitat. It also contains a detailed analysis of the physical features of the vegetation of some kokako home ranges in Puketi Forest. In addition, there is a comprehensive flora of Puketi Forest, and a section on the phenology of 58 species of indigenous forest plants.

Rather than lose this information by writing up only that of immediate relevance to the habitat use study it was decided to incorporate all the material in a document where it was available for reference. The value of this document is that it caters for a wide audience, from those who want to read only the salient points to those who want specific details on kokako or the vegetation of Puketi Forest. The document has been written as a series of distinct units so that readers can select what they want, according to their interest and the level of detail required.

1. The essential features of the entire study are given in The Summary (Section Seven), and the summaries of Sections Two - Five. The latter are placed at the beginning of their respective Sections and are printed on blue paper for easy access. Then read the Discussion (Section Six) and Recommendations (Sections 7 & 8). Background information for the study appears in the Introduction (Section One).

2. Physical features of the vegetation are described in Section Two (and finer details are in the Appendices to Section Two). A comprehensive vascular flora of Puketi Forest is given in Appendix 6.1 (Section Six). An account of the phenology (production of flowers, fruits and leaves) of 58 species of forest plants is provided in Section Three.

3. Information on kokako ecology and details on how birds use various components of their habitat are in Section Four. Topics in this Section have been approached at two levels. Firstly, an overall view is given (data from all home ranges have been pooled). This is accompanied by comparisons individual home ranges to highlight the influence that differences in habitat between home ranges have on kokako. These comparisons show that although the details of how individual kokako use components of their home range differ, they are all responding to same underlying factors.

4. An analysis of the degree of use that kokako make of vegetation groups and vegetation species for various activities is given in Section Five.

SECTION 1: INTRODUCTION

1.1 BACKGROUND AND RATIONALE FOR THE STUDY

The kokako, *Callaeus cinerea,* is one of three passerine species in the New Zealand endemic Wattlebird family (Callaeatidae), the others being the huia (*Heteralocha acutirostris*) and the saddleback (*Philesturnus carunculatus*). The kokako is the only surviving wattlebird on mainland New Zealand- the huia became extinct early this century and the saddleback (both subspecies) exists only on a few offshore islands (Mills and Williams 1978).

There has been a substantial decline in the numbers and distribution of kokako subsequent to European settlement in New Zealand. The South Island subspecies (*C. cinerea cinerea*) is extinct, or is very nearly so, and there are probably only 1400-1500 North Island kokako in existence (Rasch pers. comm.). Because its distribution is fragmented and its numbers continue to decline the kokako is now regarded as endangered (Bell 1986). The decline of kokako and extinction of local populations has resulted from loss of habitat (through logging, burning and clearing), predation, and the effects of introduced browsing mammals (by competition for and by habitat damage). The densest populations of kokako now occur in the central North Island forests (King Country-West Taupo-Bay of Plenty) and in Puketi Forest, Northland (Lavers 1978; 1984; Anderson 1984).

Puketi Forest held at least 100 kokako in November 1983 (Anderson 1984) which represented about 7% of the total estimated population. The significance of the Puketi Forest population was not known until November 1979 when the first surveys for kokako were made there. Logging for kauri was in progress at the time and the main kauri stands lay in the area where the kokako population was most concentrated. The survey revealed that three-quarters of the kokako population were in "not obviously modified" (i.e. unlogged) forest and that none were present in the most recent selectively logged forest (Anderson 1979).

A moratorium on logging in Puketi Forest was imposed by the New Zealand Forest Service (NZFS) in March 1980 for a five year period to enable an intensive study to be carried out on the habitat requirements of kokako, the importance of kauri forest to them and the possible impact of continued logging on the kokako population. The study was begun in May 1981 by R.G. Powlesland and taken over by H.A. Best in October 1982 who was joined in December 1982 by P.J. Bellingham (on contract to Auckland Conservancy, NZFS). Field work for the study was completed at the end of 1984.

The aims of the co-operative study on kokako and its habitat in Puketi Forest were to:

1. Record kokako ecology in a range of kauri and non-kauri forest assemblages (HAB)
2. Assess the seasonal availability of food to kokako by studying the phenology (production of leaves, flowers and fruits) of a wide range of plants that might feature in their diet (PJB).
3. Describe in detail the vegetation structure and composition of the kokako study home ranges (PJB).
4. Relate kokako habitat use to habitat types and define the most important species used for various kokako activities, especially the significance of kauri to kokako (HAB and PJB jointly).
5. Assess the likely impact of logging and browsing mammals on kokako (HAB and PJB jointly).

1.1.1 Previous studies

Until the 1970's, knowledge of kokako has been mostly anecdotal (e.g. Potts 1873, Reischek 1886, McKenzie 1951, Oliver 1955, St Paul 1966). Subsequently, there has been a considerable amount of attention focused on the species, especially in relation to the increased public outcry over the logging and destruction of the remnant lowland indigenous forest. Much of the work on kokako in the 15 years prior to this study has been directed towards surveys on distribution and relative abundance (Crook, Moran, and Lavers 1972, Crook 1975, Saunders 1983, O'Donnell 1984), but more recently, detailed studies on the biology of the bird have been undertaken.

Hay (1981, 1984), and Leathwick (1981) examined the habitats, habitat requirements, feeding and nesting of kokako in three study areas - Mapara State Forest (King Country), Pureora State Forest (West Taupo) and Rotoehu State Forest (Bay of Plenty) over a three year period. Hughes (1981) studied the vocal dynamics of the North Island kokako throughout its range. J.G. Innes (Forest Research Institute, Rotorua) has investigated the impact of predation on kokako nesting success and has devised methods for reducing this impact.

A major research programme on kokako has also been carried out by the Forest Research Institute, Ministry of Forestry (formerly part of NZFS), Rotorua, in relation to developing a 1080 poison bait for possum control that can be used in kokako-occupied forests, without placing the birds at risk of being killed (Innes, pers. comm.). Methods for assessing kokako numbers have been improved as a result of this programme.

1.1.2 Present studies

Forest Research Institute, MOF, and the Department of Conservation have initiated a comparative study to assess the impact of predators and browsers on the breeding performance of kokako on a mainland forest (Rotoehu State Forest), versus that on an island without major predators or browsers.

1.2 KOKAKO DISTRIBUTION

1.2.1 Historic distribution

Maori tradition holds that kokako were common and widespread in forests of North Island (Reischek 1886) and the distribution of sub fossil remains tends to support this (Lavers 1978). Kokako distribution was regarded by Buller (1892) as being somewhat disjointed in the late 1800's but locally dense populations existed in Northland, through Waikato, Bay of Plenty, Urewera, King Country, Taranaki and into Wairarapa.

The South Island kokako existed over a wide range of South Island (including Stephens, Durville and Resolution Islands) and Stewart Island. The distribution of the South Island kokako is less well known because it disappeared quite rapidly from many of its former haunts during last century. They were once plentiful in the forests of Banks Peninsula and in the scrub adjacent to some of the larger eastern river beds (Potts 1873). They occurred also from northwest Nelson to Fiordland.

1.2.2 Present distribution

Subsequent to the arrival of Europeans in New Zealand the range and numbers of kokako have declined markedly (Lavers 1978). The South Island kokako is either extinct, or very nearly so, and North Island populations (Fig 1.1) are concentrated centrally in forests of Northern Urewera, Bay of Plenty, King Country and Northern Taranaki (Lavers 1978, Saunders 1983, 1984). Isolated populations are present in Hunua Range (St Paul and McKenzie 1974), and Coromandel Range (Hughes 1981) - both of which have declined notably in recent years - and on Great Barrier Island (Ogle 1981, Hay *et al.* 1985) and in Northland (Ogle 1982). Few kokako have been recorded south of a line from Mt Taranaki to East Cape in the past 25 years (O'Donnell 1984).

The most significant causes for the decline in kokako numbers in the past 150 years have been related to the impact of European settlement, especially destruction of forest through fire, logging and clearfelling (Lavers 1978, Hay 1984). Predation (King 1984) and the effects of browsing mammals -through direct competition for food and by modifying habitat quality (e.g. by trampling, by reducing the understorey plants and the ability of the forest to maintain itself) -have contributed also to the reduction or extinction of local kokako populations (Leathwick, Hay and Fitzgerald1983). These factors may have operated singly or in combination on individual kokako populations.

Last century, kokako in Northland seem to have been comparatively plentiful in a number of localities (Buller 1885, Lavers 1978). Surveys carried out between December 1977 and January 1979 found kokako in only three forest tracts (Ogle 1982) - Puketi and Omahuta Forest, Maungataniwha Range (Raetea Forest) and Mataraua Forest (near the border with Waipoua Forest). The species is now known from only one out of the nine localities it was reported from between 1900 and 1965 (=Puketi and Omahuta Forest). The history of the other two current Northland kokako populations (Maungataniwha Range and Mataraua Forest) prior to 1977-79 is unknown. Nothing was known of population sizes until very recently, and these are still difficult to assess (Ogle 1982).

Kokako may exist in some of the other large remnant forest tracts in Northland that have not been surveyed adequately (e.g. Warawara, Marlborough).

Reported sightings of kokako were infrequent in Puketi Forest before 1979 (Anderson 1979). Surveys over much of the eastern two-thirds of the Forest in November 1979 (Anderson 1979, Hay 1979) revealed that at least 70 kokako were present, mostly (70%) in kauri-podocarp-hardwood forest, which was being logged at the time. Kokako were most plentiful (77%) in ‘not obviously modified’ (i.e. unlogged) forest, 13% were in areas that had been logged mainly between 1952 and 1975, but none were reported from the most recent selectively logged (for kauri) forest.

Another survey of the kokako population was made in November 1983, covering all of Puketi Forest (Anderson 1984). One hundred were recorded, including 83 birds from the area in which 73 were heard in 1979 (Anderson 1979). This did not necessarily reflect an increase in the number of kokako present over the period between surveys - some spurs and basins within the 1979 survey area were not traversed at that time; five birds counted in 1983 were on the edge of the 1979 survey area and may have been missed; and daily variability in kokako song performances could have influenced the number of birds reported from an area on either of the surveys.

1.2.3 Distribution of kokako in Puketi Forest

The bulk of the kokako population of Puketi Forest were found on the south flank of the Waipapa Catchment, especially in Canadian's Creek, mid-lower Waikape Stream, Stream and the head of Pukatea Stream (Fig.1.2). Most of the kokako on the north side of Waipapa River were in Camp Creek, or in immediately adjacent catchments. A notable feature for the group of birds centred about the plateau in the southwest part of the Forest was that each of their home ranges was situated where the terrain was dissected (i.e. near creeks), as in such places the habitat was more diverse than that of the surrounding, less broken country.

Overall, kokako were most plentiful in places where there has been minimal disruption of the vegetation by man and where kauri was most plentiful (Fig.1.3).

1.3 STUDY AREA

1.3.1 Location

Puketi Forest (latitude 35°13’S, longitude 173°44’E) lies 21 km N of Kaikohe and is one of 17 Forests in Northland State Forest Park (Fig.1.4). Omahuta Forest lies immediately west of Puketi Forest, while Otangaroa State Forest adjoins Puketi Forest north of the Mangakino River (Fig.1.5). The northern, eastern and southern flanks of Puketi Forest are bounded by farmland or by private land holdings.

1.3.2 Topography

Puketi Forest forms the greater part of the catchment of the Waipapa River which drains to the SW. The Waipapa catchment plus connected catchments in Omahuta Forest comprise one of the main runoffs feeding into Hokianga Harbour. Minor streams on the south side of Puketi Forest lead into Hokianga Harbour via the Waihoanga River, while those on the northern flanks of Mokau Ridge (on the Forest's northern boundary) drain into the Kaeo River and thence into Whangaroa Harbour.

Throughout the Forest, there are many rapid and local changes in topography (Sexton 1939). The high ground on the northern (Mokau and Mangehorehore Ridges) and southern sides (Pirau Ridge, and an elevated plateau in the SW) are flanked by many irregular and broken secondary ridges and spurs. Much of the country is rough, steep and accessible only on foot. Old alluvial terraces with steep drop offs characterise some of the mid and lower slopes. The steep feeder streams of the

Waipapa River have frequent waterfalls, the most spectacular being the Merumeru Falls (Willetts 1985).

By contrast, the bed of the Waipapa River is of gentle gradient, ranging in altitude from about 100m above sea level (asl) in the NE corner of the Forest, to 30 m asl where it joins the Mangapapa River in the west. The crests of Mokau (300-460m asl) and Pirau (360-460m asl) ridges are also of relatively gentle gradient and carry the principal road systems in the Forest (see Fig.1.3). The highest land in the Forest is on the SW plateau at 539m asl.

1.3.3 Weather / Climate

The climate of the district is as having very warm, humid summers, mild winters, annual rainfall of 1500-2540 mm per annum, prevailing wind from the SW but occasionally strong gales and heavy rain from the E or SE (McLintock, 1959).

Meteorological records from Kaikohe are analysed in Table 1.1 to show seasonal trends for the surrounding district (including Puketi Forest). All references to weather / climate pertain to Kaikohe unless otherwise stated.

Rainfall - least in summer (Dec-Feb), both in terms of precipitation and rain days, and greatest in winter (Jun-Aug). The rain gauge at the Forest Headquarters recorded a mean annual rainfall of 2308 mm for 1970-1974 (Willetts1985). This was 47% greater than Kaikohe on Table 1.1, and is attributable to Puketi Forest being on the highest ground between the west and east coasts.

Air Temperature - mean annual values ranged from a low of 10.7°C in June to a high of 19.1 °C in February - a difference of 8.4 °C. Maximum low and high temperatures in the same period were 0.5 °C and 30.5 °C respectively. Monthly maximum and minimum temperatures were typically about 10°C above or below the monthly mean. Air temperatures in Puketi Forest were likely to be milder than those recorded at Kaikohe owing to the mantling effect of tall woody vegetation.

1.3.4 Human history and influence

Puketi Forest was and remains a place of strong spiritual significance to the tangata whenua. There were many Maori settlements around Puketi Forest in pre-colonial times. Sexton (1939) recorded abandoned early Maori cultivation sites where taro was grown, and the forest provided naturally occurring food such as karaka fruit, the rhizomes of rahurahu (bracken) and the edible fronds of pikopiko (*Asplenium* spp.). The trees were a source of timber for carvings and dwellings. In later times three kauri trees from Puketi Forest were used in the war canoe which was built to mark the 1940 centenary of the signing of the Treaty of Waitangi.

In 1859, the Crown acquired most of Puketi Forest from its Maori owners for £240. A small State Forest was formed in 1906, but most of the area was administered by the Lands Department. The area was gazetted as provisional State Forest in 1922, and then State Forest in 1933. Some of the original Maori owners disputed the Crown's claim to the title of the Takapau Block (2294 ha) of the Forest. A ruling was made by a Royal Commission in favour of the Crown in 1948, but recrimination and arrests continued until 1952.

Commercial logging began in the 1860's, when a group of Canadians felled kauri along the banks of the Waipapa River for ships' spars (Fig.1.6). Extensive logging in the headwaters of the Waipapa River and Taita Stream continued intermittently from 1870-1915. Timber was flushed downstream using dams, the remains of which are still evident. Forest in the east was clear-felled from 1900-1910 around the head of Puketotara Stream and in a belt across the heads of Waikape and Puruwharawhara Streams. Timber from these areas was removed mostly by bullock teams and steam trains. Fires cleared an extensive area here as well. At the same time an area of forest north of Waihoanga Stream was clearfelled. Large areas of kauri and podocarp forest were felled in the Mangakino Stream and Collin's Creek catchments, and the timber was flushed downstream until it eventually reached Hokianga Harbour.

Table 1.1 Climate Summary.
Kaikohe, Lat 35°25'S, Long 173°49'E. Altitude 204 m.
(Source: New Zealand Meteorological Service)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Rainfall (mm) 1956-78													
Highest Monthly/Annual Total	319	328	246	582	304	313	342	332	306	257	179	212	2127
Mean	92	123	107	130	147	168	164	170	145	135	93	99	1573
Lowest Monthly/Annual Total	5	23	5	24	51	55	52	72	38	21	36	37	1217
Average Raindays, 1.0 mm or more.	8	9	10	11	14	15	15	17	14	12	9	11	145
Air Temperature (°C) 1973-1980	30.5	30.5	26.5	24.0	23.1	20.4	17.4	18.4	19.6	22.0	24.2	27.6	30.5
Highest Recorded	18.9	19.1	18.2	15.9	13.5	11.7	10.7	11.1	11.9	13.4	15.2	16.8	14.7
Mean	8.8	8.3	7.1	6.3	1.4	0.5	2.0	1.6	2.5	4.0	5.0	7.8	0.5
Lowest Recorded													
Relative Humidity (%) 1973-1980 **(Average at 9am.)**	81	85	84	86	97	89	88	87	84	79	83	80	84

The Forest Service established a headquarters near Manginangina in 1929 and employed a Forest caretaker. During the Depression years, many people worked in the Forest, living in shanties and tent camps. Tracks were formed, and in 1938 work commenced from Forest Road on a road to follow along the length of the Waipapa River bed and thence on to Kaeo. When the project was abandoned at the outbreak of World War II, the road extended 10km into the Forest and three bridges had been built, which are now dilapidated. Many of the people in the Forest at that time fossicked for kauri gum. Fossil gum had been sought for many years, and in the 1920's licences were issued for particular areas. Later, bleeding of live trees was commonplace until the practice was outlawed in 1952 (Halkett 1979).

Many mature trees were badly mutilated in this way; pathogens gained entry and rot has badly debilitated some trees and killed others. Locally, fire caused damage to the forest at old campsites; most of these areas are now regenerating.

Little timber felling took place in Puketi Forest during World War II, but adjacent Omahuta Forest was logged extensively from this time until the mid-1950's. A major inventory of the timber resources of Puketi Forest was undertaken in 1938-39 by A.N. Sexton. On the basis of this and subsequent work plans, felling of timber proceeded from 1952. From then until 1962, timber felling occurred in sawmill sale areas from north of Mokau Ridge to areas in the headwaters of the Onekura Stream and the Waipapa River (Fig.1.6). Most of this logging was for podocarps and a substantial volume of taraire; little kauri was taken. In 1959, a major cyclone battered Puketi Forest and destroyed large areas of podocarp and kauri forest. Salvage of fallen timber was carried out in the Onekura Stand and on Bramley's Ridge, and a road was developed from Puketi Road to Pirau Ridge to allow salvage in the Walnut Stand near Merumeru Falls. These access roads were the basis of most subsequent logging. Many of these are now overgrown.

The area of Puketi Forest was consolidated by the Forest Service in the 1960's. In 1977, 612 ha were transferred to Otangaroa State Forest in 1977. Two areas totalling 106 ha in the east of the Forest have been cleared and planted in exotic tree species. An area east of Forest Headquarters was planted mostly in southern pines in the late 1940's, which have since been cleared and the area replanted mostly with radiata pine (this area is now administered by Forest Corp). An area at the head of Waihoanga Stream was cleared in 1982 and planted in radiata pine.

Logging primarily of kauri continued in the head of the Waipapa River and in the Puruwharawhara catchment from 1965 to 1973. The process of logging changed from clearfelling to leaving trees under 100cm diameter by the end of this time. Logging of Bramley's and Totara Ridges, east of Canadian's Creek, coincided with the announcement of the 1973 Kauri Policy and a commitment to selection logging for mature kauri. This was conducted in Puketi Forest on the basis of selection of individual trees on merit (Halkett 1979). The areas logged after 1973 were west of Mreumreu Stream for podocarps and for kauri. From 1976 to 1979, the Walnut Stand was selectively logged for kauri using ground hauling techniques. The operation was suspended in pending results from the kokako habitat use study. Since then, the revised Kauri Policy of 1985 has precluded the felling of mature kauri in State Forests except for specific cultural purposes, with Ministerial approval necessary.

In the early 1980's, some areas of the Forest were subject to silvicultural tending. These areas were the shrublands and regenerating forest communities which were reverting after past logging and burning, mostly in the north and east of the Forest. In some areas, ringbarking of species other than regenerating kauri and podocarps has been carried out. In other areas, kauri raised in nurseries have been planted under regenerating canopies, initially in lines but subsequently in scattered small groups. Since 1979, these regenerating communities have also been subjected to salvage of kauri headlogs left behind in the original logging operations and cut up on portable saw mills.

The outstanding floristic and wildlife values of Puketi Forest have been recognised only in recent years (e.g. in Ogle 1982). The Onekura Ecological Area was set up to reserve some of these features, in particular the landforms and mature kauri forest (Nicholls 1979). The Ecological Area incorporates a range of vegetation from highly modified to unmodified condition (Willetts 1985).

Similarly, there has been an increased appreciation of the high recreation value of the Forest over the last two decades. Walking tracks have been developed through much of the Forest, along with picnic sites, camping grounds and a trampers' hut. The proximity of Puketi Forest to holiday centres in the Bay of Islands makes it a popular place for tourists. In 1984, it was gazetted as part of the Northland Forest Park, along with sixteen other Northland indigenous forests. Administration and management of Puketi Forest is now undertaken by the Department of Conservation.

1.3.5 Introduced mammals in Puketi Forest

Goats have been present in low numbers in the Forest since 1935 (Willetts 1985). Sexton (1939) highlighted their damage to the Forest and listed a number of plant species which had been killed by goat browse. He observed that where numbers were high, the undergrowth was destroyed and erosion was occuring on steep hillsides. In the 50 years since his report, successive Forest Service culling parties have restricted the distribution and maintained the population at a low level. During the present kokako study, goats were never observed on the true right of the Waipapa River. The highest numbers were seen in the middle reaches of Pukatea Stream, particularly in Flavell’s Creek catchment, and on the bluffs south of Pukatea Stream. The understorey was very open in these areas and adventive plants, especially *Argeratina* species, have colonised some parts. Goats were also present in the Merumeru,Waikape and Canadian's Creek Catchments, and appeared to be invading the Forest from the south and east. In 1984, goats were seen frequently on old logging roads. This was cause for concern as it was highly likely these were escapees from recently developed goat farms nearby.

Wild cattle were present in small numbers in an area south and west of Mangahorehore. However, they were quite destructive because they ate a wide range of plant species in the Forest and their trampling caused considerable damage to soil and ground cover vegetation, particularly in the vicinity of streams. Stray cattle from farms occasionally ventured into the Forest. Ministerial approval has been given to shoot cattle in the Forest (Willetts 1985).

Pigs were widespread in moderate numbers (NZFS 1985) throughout mature and regenerating forest. Locally, large areas of earth, roots and ground cover have been churned up by rooting and wallowing. Many smashed shells of the rare kauri snail (*Paryphanta busbyi busbyi*) were found throughout the course of the study, likely a result of pig predation (Ogle 1982). Control of pigs has been primarily by recreational hunting.

Possums probably posed the greatest current threat to the vegetation. Numbers was estimated as low to moderate (NZFS 1985). Their arrival in the Forest has been relatively recent, and their numbers appeared to have increased. Possums were liberated in the vicinity of Dargaville in the early 1920's and at Kerikeri (near Puketi Forest) in 1946 (Pracy 1962). Sexton (1939) made no mention of possums in Puketi Forest. The spread and increase of numbers in Northland was initially apparently slow, reaching Puketi Forest in the mid-1970's (Willetts 1985). They were now found throughout the forest during the kokako study, but appeared to be most plentiful along the forest margins. Logging roads along axial ridges provided access into the forest. During the course of the kokako study, it was evident that possum damage was increasing. In 1982, browsing sign was seen infrequently, but by late 1984 some plants appeared to have been killed by repeated browsing (see Section Ten: Summary, for details). Possums may also be predators of bird nestlings and invertebrate fauna (Hay 1981). Very little control of possums has been undertaken in the Forest. Skins from Northland are inferior in quality to those from other parts of New Zealand so there is little likelihood of commercial trapping being an effective control.

Predatory mammals known from the Forest include ship rats, stoats and cats. Ship rats have been caught in traps set to protect a kokako nest, and the other animals have been seen. Their impact on native wildlife has been well documented, and populations of rare birds such as kokako are particularly vulnerable to their activities (King 1984).

1.3.6 Previous studies of the vegetation of Puketi Forest

The first and most comprehensive survey of the vegetation of Puketi Forest was by Sexton (1939). Sexton's work and a later report by Halkett (1979) focused primarily on merchantable timber stands, particularly on kauri or podcarp-dominated vegetation. Willetts (1985) surveyed the Onekura Ecological Area, which lies entirely within Puketi Forest. These authors separated physiognomically distinct vegetation types, and prepared broad vegetation maps on the basis of these. The four basic vegetation types identified by these authors were:

a) mature kauri-softwood-hardwood (B6 of Nicholls 1976)

b) stands of small or pole kauri or softwood

c) low altitude palocarp-hardwood forest (E2 and E3 of Nicholls 1976)

d) manuka/pole softwood shrubland

Also identified in the course of reconnaissance in the forest during the present study were:

e) high altitude podocarp-hardwood forest

f) low manuka and sedge-dominated heathland (gumland).

Types (a) and (b) were found almost exclusively (Figure 1.7) on or near ridge crests in the most sharply dissected parts of the forest, and occasionally on small ridge plateaux (e.g. Takapau Stand, Onekura Stand and Manginangina Scenic Reserve). The mature kauri stands have been the best known feature of Puketi Forest and, as Nicholls (1979) said: "the occurrence of old-growth kauri forest less than 150m asl as some of these are, in an extensive forest environment cannot be matched elsewhere in the (Maungataniwha) District and extremely rarely outside it". The mature stands of kauri have been the subject of quantitative stand descriptions by Latter (1932). Similar stands to those measured by Latter formed the basis of studies on seedling population sizes and models for gap-phase regeneration in kauri-dominated forest (Odgen, Wardle & Ahmed 1987). Studies by Ahmed and Ogden (1987) employed data gathered from Puketi Forest on the population structures and growth rates of kauri. Similarly, these mature stands contained sites used for dendrochronological studies by Ahmed and Ogden (1985) and Wardle (1984).

Type (c) was the most extensive in the Forest and occurred on gently rolling ridges, ridge flanks, in gullies and on alluvial terraces. Type (d) was distributed in the most heavily modified parts of the Forest, especially in the areas logged most heavily, in the north and east.

Type (e) was distributed on the upland massif in the southern third of the Forest, at the headwaters of Creek and Te Rereatuoro Stream. Type (f) occurred in isolated areas at the eastern fringe of the Forest, particularly in the headwaters of the Waipapa River and the Stream.

In contrast to the kauridominated vegetation, the last four vegetation types have received very little attention to date in scientific studies.

Fig. 1.1 Past and present distributionof North Island kokako (after Lavers, 1978)

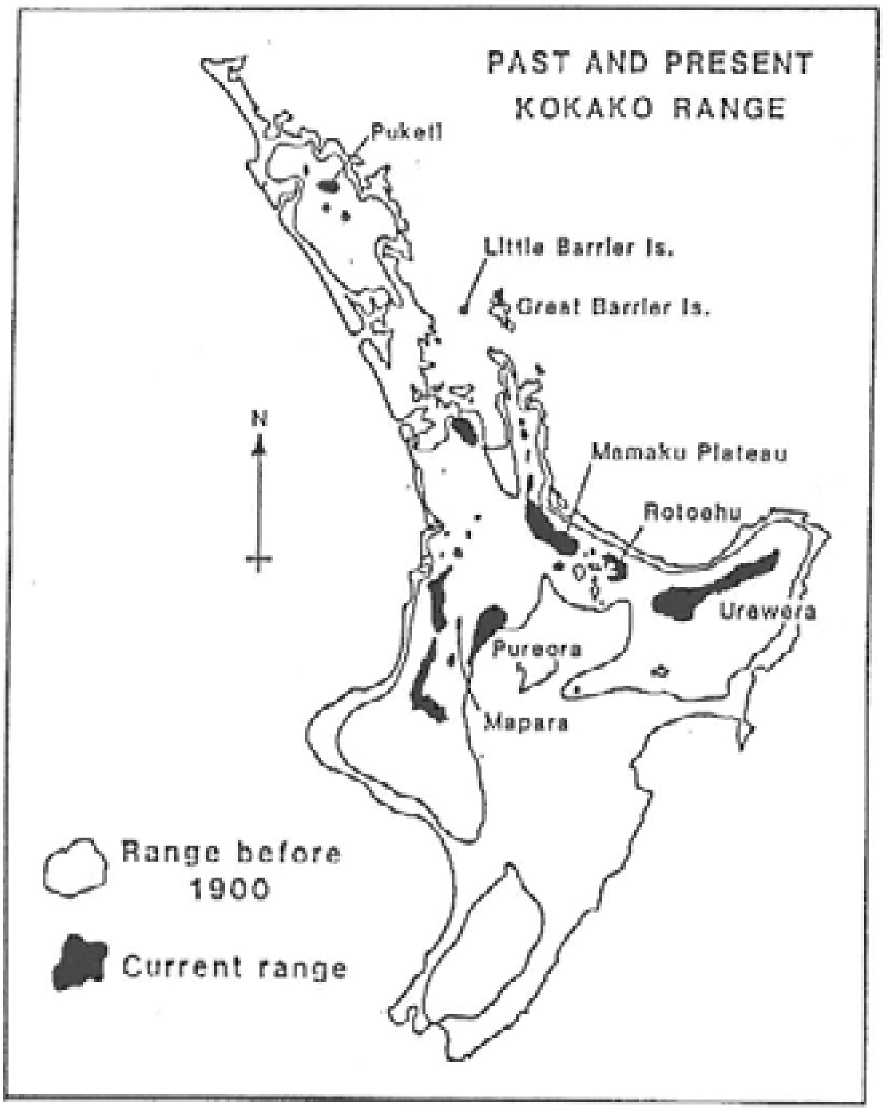
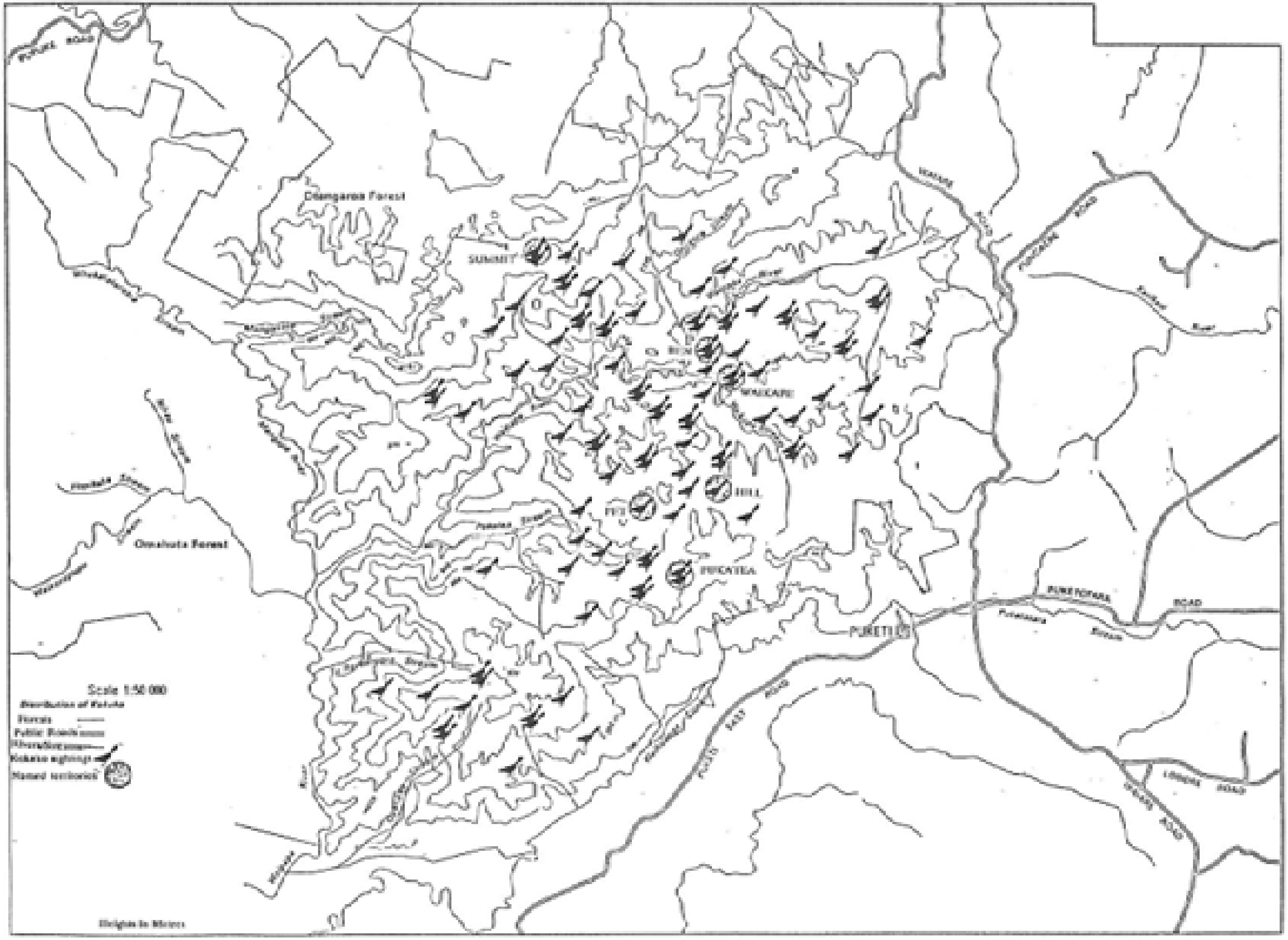


Fig. 1.2 **Kokako distribution in Puketi Forest (after Anderson 1984) and location of the six kokako home ranges used in this study**



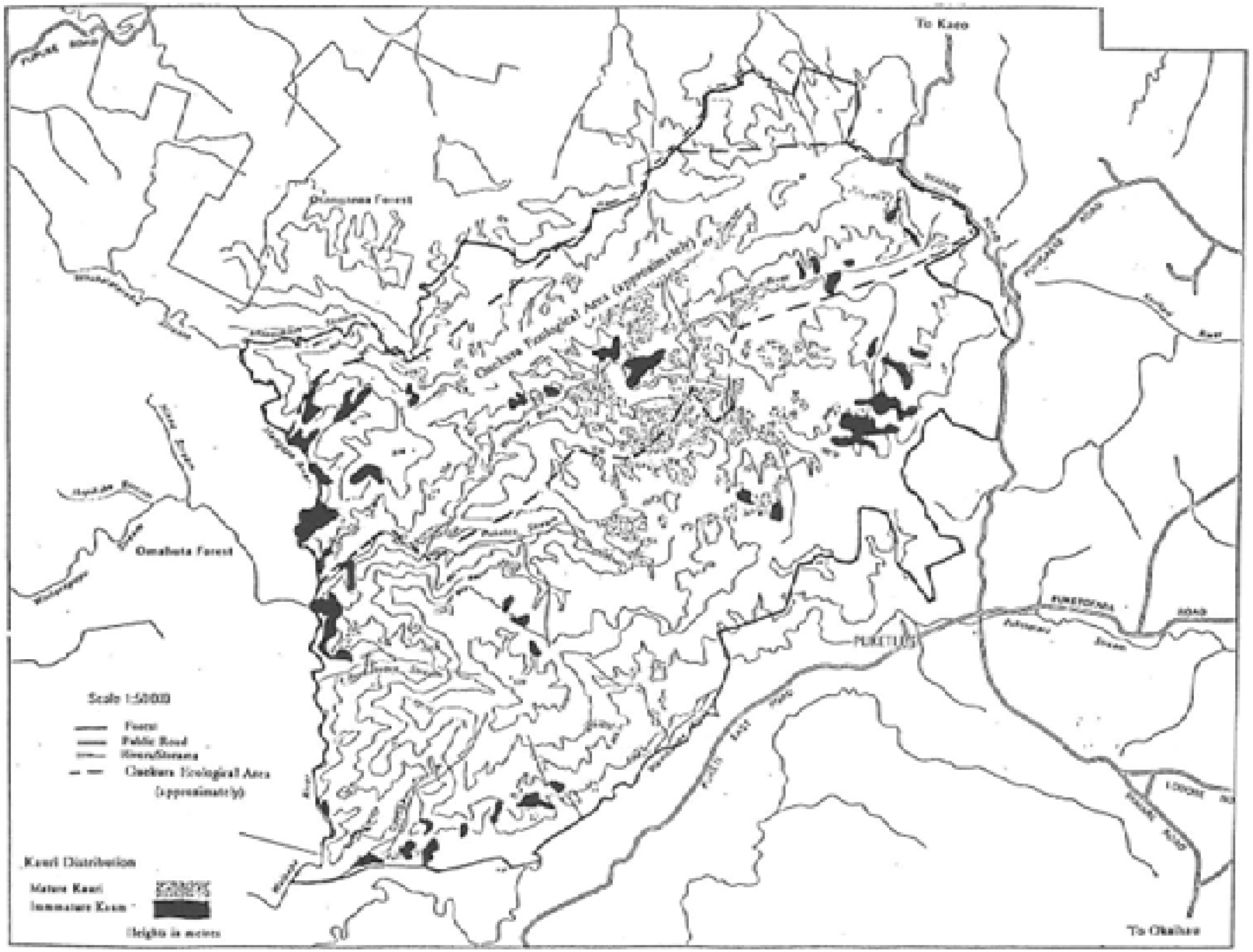


Fig. 1.3 Distribution of kauri stands in Puketi Forest, and location of the Onekura Ecological Area.

Fig. 1.4 Location map of Puketi Forest and other Northland sites mentioned in the text

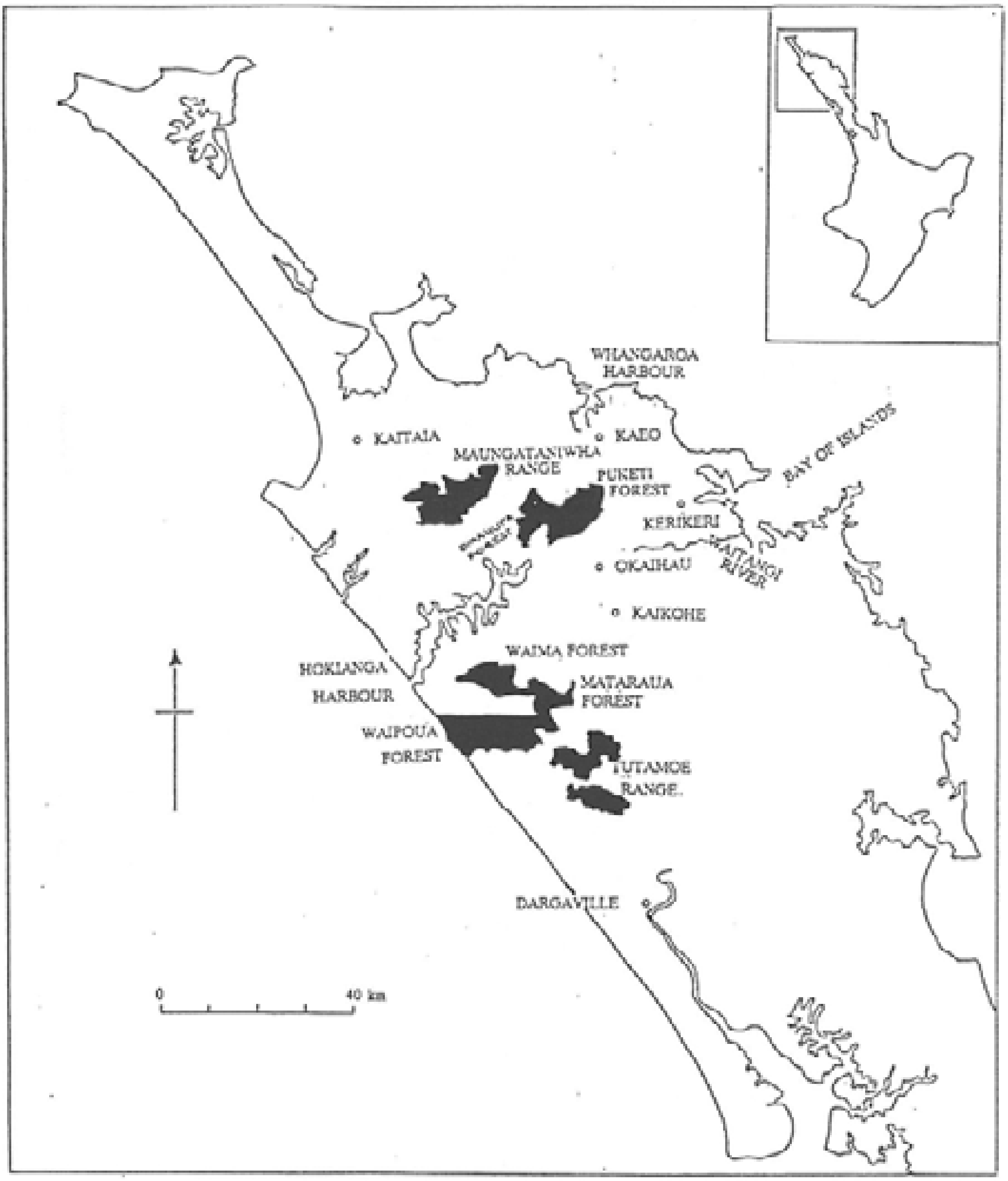


Fig. 1.5 Map of Puketi Forest showing place names used in text

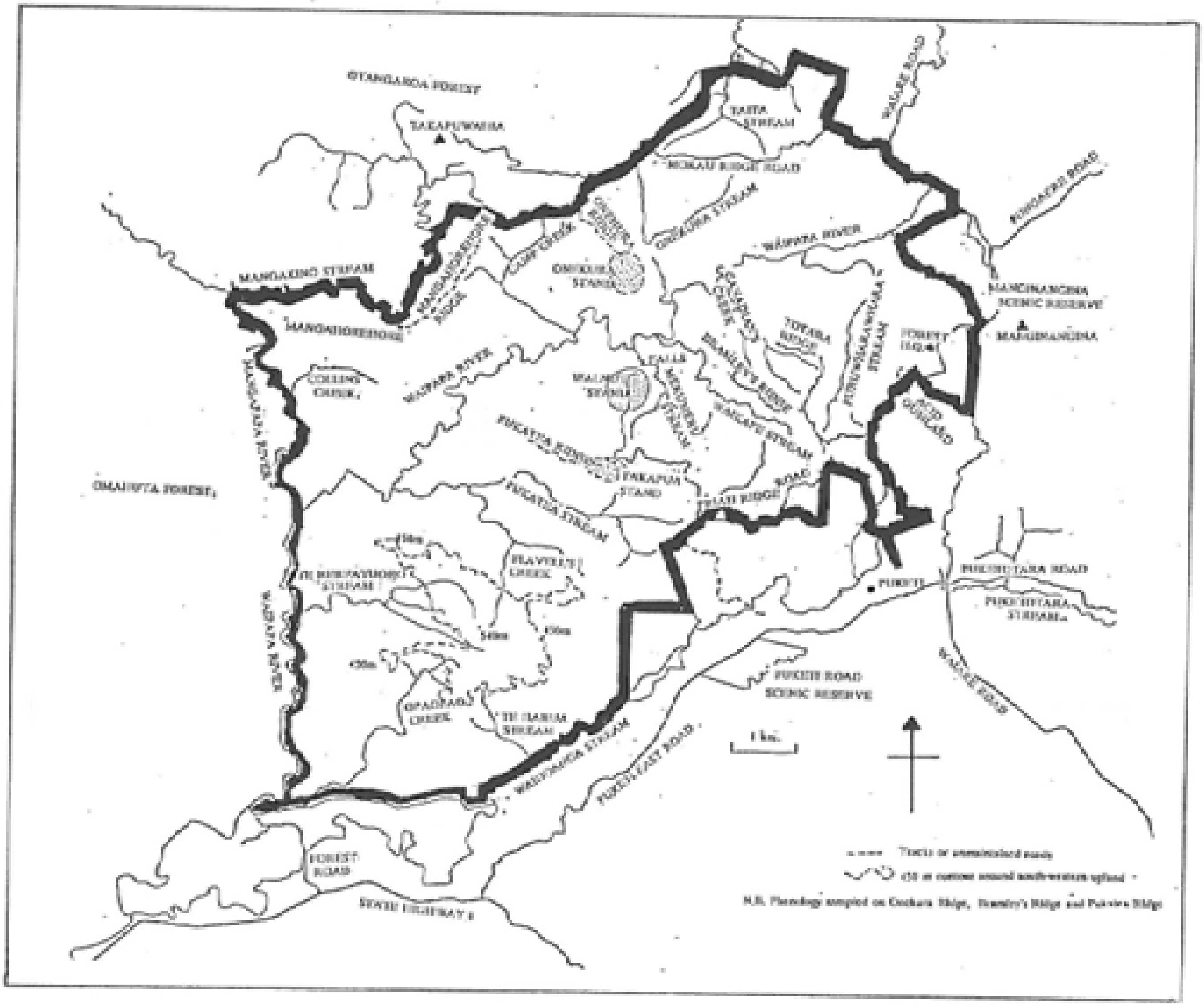
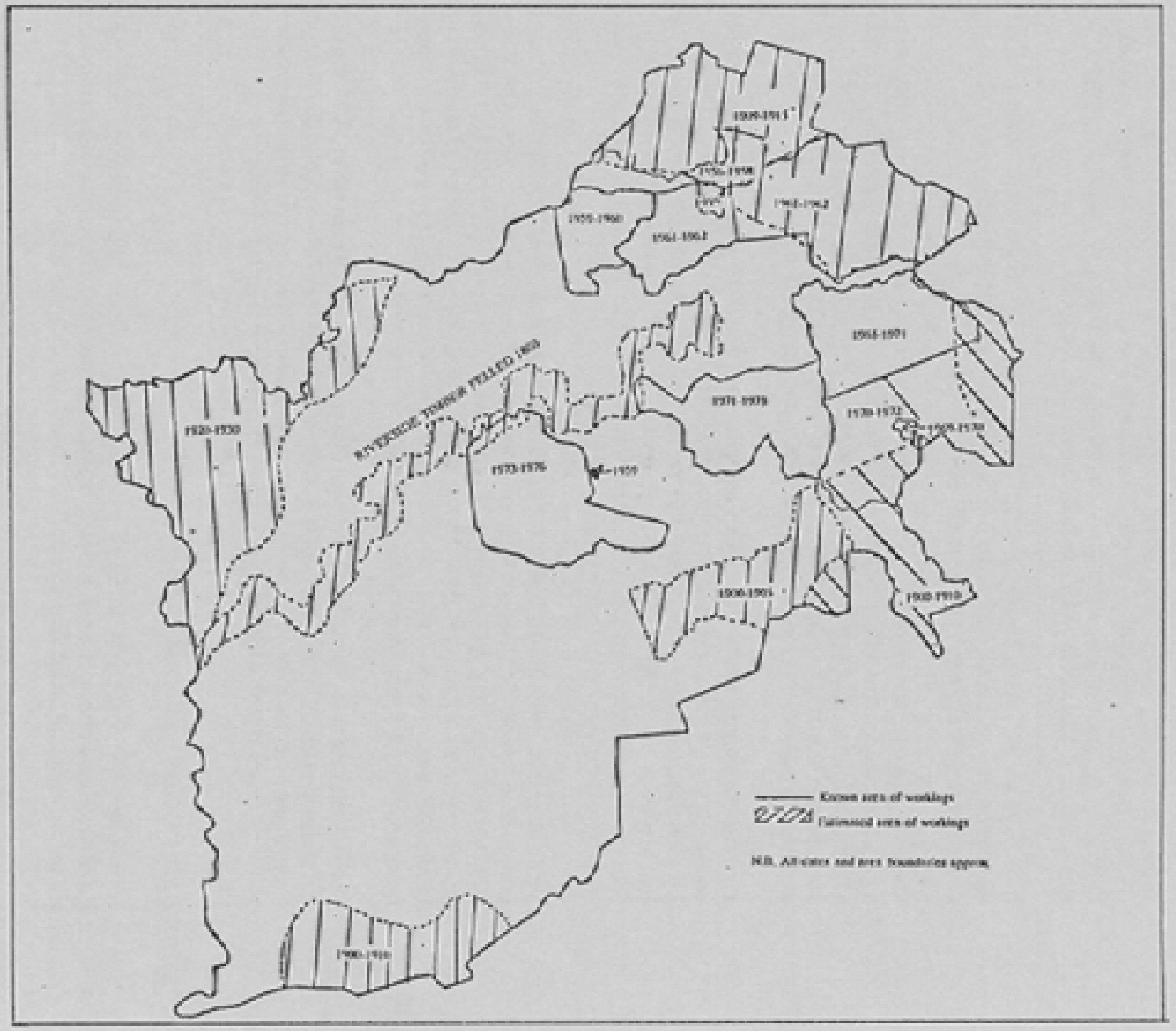


Fig. 1.6 Logging history of Puketi Forest (after Willetts 1985)



SECTION TWO :VEGETATION STRUCTURE AND COMPOSITION IN KOKAKO HOME RANGES IN PUKETI FOREST

SUMMARY

a) The vegetation structure and composition were studied in six kokako home ranges in Puketi Forest. The home ranges chosen covered a variety of forest assemblages inhabited by kokako, in terms of apparent differences in forest composition, the degree of disturbance (natural or man-made) and geographic and altitudinal range within the forest.

b) Like most kokako home ranges in Puketi Forest, the study ranges were situated in the headwaters of side catchments of the Waipapa River, each usually being on an axial ridge flanked by one or more gully systems. Most covered about 6ha.

c) There was considerable diversity in the vegetation, both within and between the study home ranges. The main factor influencing the vegetation across the home ranges was interpreted as reflecting a change in topography from gully bottoms, to ridge flanks and gently rolling ridge tops, through to sharply dissected ridge systems. Along this sequence, there were marked changes in moisture, drainage, shelter, shade and site fertility.

d) Eight vegetation groups were identified along this gradient. The vegetation in gully bottoms was composed mainly of pukatea, supplejack, and kohekohe, while rimu, taraire and kohekohe were dominant on lower ridge flanks. Mid to upper ridge flanks and rolling ridge tops were clad mainly in towai, taraire, kohekohe and tawa, with Hall's totara being common locally. Ridge top sites in the most dissected terrain were characterised by Hall's totara with kauri subdominant, or kauri with Hall's totara subdominant.

e) While this basic gradient was common to all home ranges, there was variation in vegetation composition between them, resulting from differences in site factors. One home range lacked vegetation groups typical of the crowns of sharply dissected ridges. Others lacked vegetation of extreme gully bottom sites. Additionally, altitudinal gradients were apparent in plant species composition, with species common in higher altitude home ranges being absent from home ranges at lower altitude and vice versa.

f) The vegetation in some home ranges had been disturbed more than that in others. Disturbance had a considerable influence on the vegetation structure and often affected species composition - weeds and successional species were a common feature of these disturbed sites. Disturbance was either natural (e.g. wind damage, slips) or man-induced (logging, roading).

2.1 INTRODUCTION

This study was designed specifically to facilitate integration of data on kokako ecology and vegetation, collecting both data sets within a common sampling matrix. This provided a description of the forest that kokako inhabit and the way that they used their habitat (after Rotenbury & Weins 1981).

As in previous studies of forest bird habitat (e.g. James 1971), the vegetation was sampled in such a way that identifiable features of it could be defined, i.e. that zones of similar vegetation could be classified into groups which could be recognised both within and between kokako home ranges.

Several studies outside New Zealand (e.g. Cyr 1977, Noon 1981) have stressed the importance of assessing three- dimensional forest structure in quantifying the way in which birds use their habitat. In New Zealand, previous studies of kokako (Hay 1981, Leathwick 1981) have shown the need for understanding the influence of forest structure upon kokako when conserving the bird. This section of the study quantifies both the three-dimensional forest structure and species composition of selected kokako home ranges in Puketi Forest.

2.2 METHODS

Six kokako home ranges were chosen for study (Ben, Hill, Pet, Pukatea, Summit and Waikape); see Fig 1.2 for their location in the forest. The home ranges covered a wide range of the forest inhabited by the birds in the Forest, in terms of their distribution in the Forest, different forest composition, and the extent of vegetation disturbance (natural and man-induced). The limits of these six kokako home ranges (containing paired and single birds) were established after several months of field observations.

Five of the study home ranges averaged 6ha (range 3.8-7.4 ha). The full extent of the sixth home range (Waikape) was not ascertained owing to the residents' elusive nature and the broken terrain they inhabited. Only of this home range was examined, centred upon their main song ridge. Once the extent of the home ranges had been determined, they were gridded into contiguous, permanently-marked 40 x 40m plots. This plot size was judged to be the most convenient to allow both the bird observations and forest description. The grid system in each home range was aligned with the 'grain' of the landscape. Maps of each gridded home range, showing major landform features, appear in Appendices 2.1 - 2.6.

Forest descriptions of these bounded plots were based on the standardised procedure of Allen and McLennan (1983). One modification of this procedure was incorporated, i.e. both overall tier densities and individual species densities within tiers were assigned cover value scores (after Bailey and Poulton 1968). These were:

1) 0-1 % cover
2) 1-5 % cover
3) 5-25 % cover
4) 25-50 % cover
5) 50-75 % cover
6) 75-95 % cover
7) 95-100 % cover

Unlike Allen and McLennan (1983) however, tiers were given absolute overall percentage cover values, but the relative cover values of species within tiers (=species covers) were summed to 100% per tier, regardless of the overall tier density. An attempt was made to obtain a complete enumeration of all species in all tiers within each grid square. Because the grid squares were of constant size, species cover values and tier density values between grid squares were directly comparable.

A major shortcoming of this technique was the inability to quantify either abundance or density of epiphytes. Epiphytes were recorded in each grid square only as a list of those "present" with no indication of abundance. As a consequence, species of comparatively large biomass, e.g. *Collospermum hastatum* were given the same ranking of those of small biomass, e.g. *Hymenophyllum revolutum.* However, in the absence of relatively quick and non-destructive sampling techniques, the information gained by this method was considered the best possible.

Non-vascular flora have been omitted entirely from the forest description. Locally, these species contributed greatly to ground cover (bryophytes) and epiphyte flora (bryophytes and lichens), and, in the case of epiphytes were an important component in the diet of kokako.

2.2.1 Analysis

The field data were entered onto the NZFS Forest Research Institute (FRI) computer using the standardised reconnaissance plot format (Allen and McLennan 1983). These data files were run through FRI’s Protection Forestry Division's package RECCECHECK, and errors were corrected. A single importance value was then calculated for each species by combining the raw multi-tier data using the formula:

$$IVi = \sum_{j=1}^{i} (SPCOij \;.\; TIWTj)$$

where IVi = Importance Value of Species i
SPCOij = Cover value of species I in tier j
TIWTj = Tier weight of tier j

The tier weights for the seven tiers were assigned on the basis of a subjective assessment of the relative importance of each, based on tier height. These were:

Tier 1: >canopy height : 30
Tier 2: 12m- canopy height : 20
Tier 3: 5m -12m : 12
Tier 4: 2m – 5m : 5
Tier 5: 30cm – 2m : 2
Tier 6: 0cm – 30 cm : 1
Tier 7: Epiphytes : 1

The multivariate analysis techniques of ordination and classification were used to the structure and composition of the vegetation of kokako home ranges. These two techniques have different but complimentary aims. In ordination, plots and species were allocated scores along indirect floristic gradients, emphasising the continuous nature of data sets. Classification, by contrast, grouped plots of similar vegetation composition or species of similar distribution, emphasising discontinuities in the data.

The ordination technique used in this study was detrended correspondence analysis, or DCA (Hill & Gauch 1980) as implemented in the Cornell University package DECORANA (Hill 1979a). Relationships among plots and species along floristic gradients were represented by the ordination axes. Results of ordination were summarised as scatter graphs of the scores of plots, and of the scores of more common species on the first two ordination axes (i.e. the two axes which explained most of the variance in the data set).

Simultaneous classification of plots and species was carried out using the technique of Indicator Species Analysis as implemented in the Comell University package TWINSPAN (Hill 1976). Results were displayed as a table partitioning species and plots, with a dendrogram to show the hierarchy of division. groups have also been depicted on the plot ordination diagrams to show the relationships between the classification results and the main floristic gradients. Data from the various plots in each vegetation group were summarised to give mean percentage cover of tiers, of species within tiers, and the percentage of plots in which species occurred applied to each tier and each species within each tier.

2.3 RESULTS

Analysis and interpretation of kokako habitat at Puketi Forest was undertaken at two levels - for all home ranges and within individual home ranges.

2.3.1 Analysis of vegetation patterns across all kokako home ranges studied

2.3.1.1 Ordination of plots and species of all kokako home ranges. Ordinations of plots (Fig.2.1) and plant species (Fig.2.2) along the first two axes of ordination have been depicted graphically. These ordinations were interpreted as follows. The first ordination axis was associated clearly with a change in topography, from gully bottom sites to ridge top sites, and its associated changes in features. Plots with high Axis 1 scores, regardless of the home range they came from, were invariably ridge top sites dominated by kauri associations (e.g. F6 of Waikape home range, D9 of Ben home range and El of Pet home range). Plots with low Axis 1 ordination scores were always those of extremely wet gully sites (e.g. D2 of Summit home range, F6 of Hill home range and D4 of Pukatea home range). Plots with medium Axis 1 scores (e.g. D5 of Ben home range, G10 of Pukatea home range and C3 Pet home range) were generally plots of ridge flanks. The gully bottom sites were moist, shaded and sheltered and usually had deep litter and presumably more fertile soils (owing to their organic content). In contrast, ridge top sites were more exposed, better lit, and had drier skeletal soils with less litter; those under kauri had typically podsols with acid litter.

Species with high Axis 1 scores (e.g. kauri, *Metrosideros albiflora,* mairehau and kanuka) were characteristic of dry ridge top sites, whereas species with low Axis 1 scores (e.g. parataniwaha, pukatea, and kotukutuku) were characteristic of damp, shaded gully bottom sites. Species which had medium scores on this axis are either ubiquitous species (e.g. kiekie, heketara), or were characteristic of ridge flank sites, (e.g. tawa and hinau).

The second ordination axis accounted for a lesser amount of the total variance. Plots from Ben home range and Waikape home range had the lowest scores, Hill home range had intermediate scores and Pet home range, Pukatea home range and Summit home range had the highest scores. Along this sequence there was an increase in altitude from c.200m asl (Ben home range) to c.350m asl (Hill home range) to c.420m asl (Summit home range). On the species ordination, those having high Axis 2 scores (e.g tawari and *Dicksonia* sp. (aff *D. lanata*)) occurred mostly at high altitude, despite there being apparently suitable habitat at lower altitude. Species which had low Axis 2 scores tended to be more abundant at lower altitude, particularly widespread species. Plants indicative of disturbed sites had high Axis 2 scores (especially opportunist weed species). This was because the high attitude home ranges were relatively more disturbed than low altitude home ranges.

2.3.1.2 Changes in forest composition and structure along the dominant floristic gradient.

In order to better determine the extent that kokako used parts of the main floristic gradient (i.e. DCA Axis 1, Figs 2.1 & 2.2), the vegetation data were split into groups of plots along the axis, broadly following a sequence from gully bottoms to ridge tops. Eight such vegetation groups were defined, the dominant species in which were:

a) Puketea-supplejack-kohekohe-taraire
b) Rimu-kohekohe-towai-taraire-supplejack
c) Rimu-taraire-kohekohe-towai
d) Towai-taraire-kohekohe
e) Towai-taraire-kohekohe-tawa
f) Hall’s totara-kiekie-towai-taraire
g) Hall’s totara-kauri-miro-northern rata-kiekie-towai-taraire
h) Kauri-Hall’s totara-miro-towai-kiekie

The locations of these groups within each of the study home ranges have been depicted in Figure 2.3. There were differences in the distribution of vegetation groups between the home ranges. Group (i) was plentiful in Summit home range compared with the other home ranges. There was a preponderance of groups (iv) and (v) in Pukatea home range. Group (viii) occurred predominantly in Ben and Hill home ranges, on the sharp ridges and steep flanks which characterised these two home ranges. Conversely, Summit home range lacked vegetation of group (viii), while groups (vi), (vii) and (viii) were absent from Pukatea home range. At the other end of the scale, Pet home range lacked vegetation of group (i) and the small gridded portion of Waikape home range lacked most groups (i) to (v).

Changes in species composition between the eight vegetation groups of the main floristic gradient have been shown by displaying the mean importance values of six tree species (present in each of the study home ranges and common in most) in each of the eight vegetation groups (Fig. 2.4). Species with highest scores in groups (i) and (ii), e.g. pukatea, were most abundant in moist, sheltered, fertile gully bottoms. Those with their highest scores in groups (iv) and (v), e.g. towai and taraire, were characteristic of ridge flanks and gently rolling ridge tops. Species with their highest scores in groups (vii) and (viii) were characteristic of dry, exposed ridge tops with podsolised or skeletal soils, e.g. kauri and Hall's totara.

Representations of the mean tier densities per tier in the eight vegetation groups have also been included on Figure 2.4. Canopy cover was relatively less dense in gully bottoms, most dense on ridge flanks or gently rolling ridge tops and, again, relatively less dense on ridge tops. Conversely, the lower tiers were most dense in gully bottoms and on ridge tops, and least dense on ridge flanks or gently rolling ridge tops.

2.3.1.3 Descriptions of the eight vegetation groups for all home ranges combined. Graphic representations of forest structure incorporating the most common constituent species of each vegetation group have been shown in Figures 2.5 to 2.12.

Group (i) pukatea-supplejack-kohekohe-taraire
Characteristic of gully bottoms. The sites were shaded, sheltered and very damp, often having rivulets or stream headwaters running through them. The sites were usually gently sloping and of moderate to poor drainage. Away from water courses, the ground comprised moist clay banks and sometimes rocky ground or outcrops. Deep litter and rotting plant debris covered the ground. Herbs and were rare, but were liverworts were common.

This group was most common in Summit home range, though smaller areas of it were present in Ben, Hill and Pukatea home ranges.

The forest structure of this group has been depicted in Figure 2.5. Other ground species common in this group included *Asplenium bulbiferum* s.s., *Lastreopsis hispida*, *Blechnum membranaceum*, *Hymenophyllum demissum*, the sedge *Uncinia uncinata*, and the grass *Microlaena avenacea*.

Epiphytes were abundant. These included ubiquitous species such as the ferns *Asplenium flaccidum,* kidney fern, *Phymatosorus diversifolius, Hymenophyllum demissum, H. revolutum* and *H. sanguinolentum,* the orchids *Earina autumnalis, E. mucronata* and *Dendrobium cunninghamii,* the shrub puka, the lilies *Collospermum hastatum* and *Astelia solandri.* There were also species characteristic of moist shaded sites, e.g. the filmy ferns *Hymenophyllum ferrugineum, Trichomanes endlicherianum* and *T. venosum.*

Group (ii) rimu-kohekohe-towai-tamire-supplejack
Found away from the most extreme gully sites on slightly better drained terraces and flanks. This group occupied shaded, moist sites of gentle slope and good drainage. There was deep litter and bare clay banks, with small amounts of bryophytes and small herbs.

This group occurred in gully heads and terraces in most home ranges, but was most common in the gently sloping gully system of Pukatea home range at the headwaters of Pukatea Stream.

The forest structure of this group has been depicted in Figure 2.6. Other common ground species included *Pneumatopteris pennigera, Asplenium bulbiferum* s.s., *Lastreopsis hispida* and *Blechnum fraseri.*

Epiphytes were abundant. In addition to the ubiquitous species described in group (i), species typical of moist shaded gully sites were common, e.g. *Hymenophyllum ferrugineum, Trichomanes endlicherianium, T. venosum* and *Tmesipteris lanceolata.*

Group (iii) rimu-taraire-kohekohe-towai
Located in gully heads and the lower parts of ridge flanks. These sites were of moderate slope and were fairly well-drained. The ground surface was covered in deep litter with bare clay banks on steeper parts. Both vascular and non-vascular ground cover was sparse.

The group was present in all home ranges studied, mostly above stream systems at heads of gullies, although it occurred also on damp ridge sites in Ben, Pet and Pukatea home ranges.

The forest structure of this group has been depicted in Figure 2.7. Common ground cover species include *Pneumatopteris pennigera, Asplenium bulbiferum* s.s., *Blechnum fraseri, Trichomanes elongatum* and *Microlaena avenacea.* Around some disturbed sites, e.g. slips, *Blechnum* sp. (*B. capense* agg. Common lowland species) and *Gahnia setifolia* were locally common.

Epihytes were abundant and included some species characteristic of ridge flanks, e.g. Blechnum filiforme, and others characteristic of gullies, e.g. *Phymatosorus scandens* and *Tmesipteris lanceolata.*

Group (iv) towai-tataire-kohekohe
Occurred primarily on ridge flanks, occasionally on side ridges and rarely in gully heads, mostly on steep, drained sites. Where it could accumulate, there was a deep litter layer, while the steepest sections had exposed clay banks. There was a moderate amount of vascular and non-vascular ground cover.

This group was most common along the ridge flanks and side ridges of Pukatea home range, above the headwaters of Pukatea Stream, and also quite commonly on the mid-slop of Hill home range, above headwaters of Waikape Stream.

The forest structure of this group has been shown in Figure 2.8. Among the more common ground cover species were *Microlaena avenacea, Uncinia uncinata* and *Blechnum fraseri*, while parataniwha was common locally around gully heads.

Epiphytes were common and included species characteristic of shaded ridge flank sites, especially *Tmesipteris sigmatifolia* and *Blechnum filiforme.*

Group (v) towai-taraire-kohekohe-tawa
Characteristic in most home ranges of sites adjoining podocarp-dominated ridges on upper ridge flanks. However, in Pukatea home range, group (v) vegetation occupied gently rolling ridge tops. occupied by this group were well-drained and ranged from gently-sloping to steep. There was generally a deep litter over the ground, but little herbaceous or bryophyte flora. Dry clay banks were a feature of steeper sites.

This group was most common in Pukatea home range, with lesser amounts on the ridge flanks of most other home ranges.

The forest structure for this group has been shown in Figure 2.9. The ground cover was generally sparse with only *Blechnum fraseri* being common.

Epiphytes were common and included shade-preferring species such as *Blechnum filiforme*, *Anarthropteris lanceolata* and *Tmesipteris elongata.*

Group (vi) Hall's totara-kiekie-towai-taraire
Characteristic of ridge tops and upper ridge flanks away from exposed knolls. Most plots containing this vegetation group were north-facing, steep and well-drained. The ground was covered in a fine layer of litter on less steep sites, and there were clay banks on the steeper sites. Both herbaceous and bryophyte flora were common as ground cover.

This group was found on, or near ridge systems in all home ranges studied except Pukatea home range, where it was absent.

The forest structure of this group has been shown in Figure 2.10. Both tiers 5 and 6 contained a wide range of species, amongst which the major elements were *Gahnia xanthocarpa, Blechnum fraseri, B.* sp. (*B. capense* agg., common lowland species), and also toropapa, *Alseuosmia* x *quercifolia* and *Microlena avenacea.*

Epiphytes were common. In addition to species typical of shaded sites on ridge flanks (e.g. *Tmesipteris elongata* and *Anarthropteris lanceolata*), there were light-preferring species such as *Drymoanthus adversus.*

Group (vii) Hall's totara-kauri-miro-northern rata-kiekie-towai-taraire
Present on ridge knolls and steep side spurs, and in some cases on steep ridge flanks. The sites were mainly north-facing, usually steep, and well- to excessively well-drained. A fine litter layer covered the ground and there were often bare clay sites, especially on the tops of knolls and on banks.

This podocarp-dominated group was scattered in most home ranges, hut was absent in both Pet and Pukatea home ranges. It was most prominent on the finely dissected ridge systems of Ben and Hill home ranges.

The forest structure of this group has been portrayed in Figure 2.11, including the major ground species. Epiphytes were common and epiphytic shrubs were frequent, e.g. Kirk's daisy, fivefinger and *Pittosporum cornifolium.*

Group (viii) kauri-Hall's totara-miro-towai-kiekie
Found principally on the most prominent knolls and side spurs, on the most finely dissected ridge systems, and, in one case, on a raised plateau. Most of the sites were excessively well-drained although those on the plateau appeared to have a high water table. Most of the plots in which this group occurred were gently sloping and north-facing, although in some sites it occurred off ridge tops on steeply-sloping ridge flanks. Though deep, acid litter (pukahu) accumulated around the bases of kauri trees, there were considerable areas of bare ground, particularly on ridge crests, which dried excessively during the summer. Considerable disturbance had occurred to this vegetation group in many home ranges. In particular, in Pet and Hill home ranges on Pirau Ridge, sections of this group's canopy had been destroyed by a hurricane in 1959. Part of this storm-damaged area in Pet home range had been logged subsequently. Regeneration to the former canopy composition appeared to be taking place in both of these home ranges.

The group was distributed locally. It was absent from Summit and Pukatea home ranges, confined to side spurs in Ben home range, and was a major feature of the axial ridges of Waikape and Hill home ranges. Part of Pet home range incorporated a portion of a large kauri grove (the Takapau stand) on an upland plateau.

The forest structure of this group has been depicted in Figure 2.12. This composite included both mature and regenerating stands, and there were idiosynchracies in the composition of all stands. For example, in tier 3, the dominant subcanopy tree beneath tall kauri in Pet home range was tawari, while in Hill home range it was either towai or tawa. Ben and Waikape home ranges lacked a major subcanopy other than scattered tall shrubs, but instead had Hall's totara and miro subdominant to kauri in the canopy.

In the lowest tiers, the proportions of the major species shown in Figure 2.12 varied between home ranges. In Ben and Waikape home ranges, *Astelia trinervia* was more common than *Gahnia xanthocarpa,* while the reverse was true in Hill and Pet home ranges. Some ground cover species appeared to be restricted to this group, including the fern *Schizea dichotoma* and the orchid *Pterostylis graminea* var. *rubicaulis,* both of which were common.

Epiphytes were relatively uncommon. Except for epiphytic shrubs (e.g. puka and *Pittosporum cornifolium*) and some orchids (e.g. *Bulbophyllum pygmaeum*), kauri trees supported generally very few epiphyte species. Most epiphytic orchids, ferns and lilies and most lianes were in the crowns of the crowns of the podocarps or subcanopy trees in this group.

2.3.2 Analysis of vegetation patterns in individual kokako home ranges

In all the home ranges, the main floristic gradient identified by the DCA ordination was associated with a change in topography, i.e. from gully bottoms to ridge tops. The associated changes from moist, sheltered often poorly drained sites in gullies with organic soils and deep litter, to drier, more exposed sites having very good drainage and skeletal podsolised soils on ridges, were major influences on the flora on this same gradient. In almost all instances, the second most important floristic gradient reflected the level of disturbance (i.e. a transition from undisturbed mature forest to a canopy disrupted by natural or man-induced causes, often with shrub regrowth or weed colonisation). In one home range (Summit), the second most important floristic gradient appeared to reflect a drainage gradient, from poorly drained to well-drained sites, but this gradient was associated closely with disturbance (disturbed sites being poorly drained whereas many undisturbed sites were well drained).

Six TWINSPAN classification groups were identified in each of the study home ranges, except for Waikape which was only partly gridded and contained only three vegetation groups. These groups principally reflected the influence of topography on the vegetation but, in some cases, also recognised the influence of disturbance on the vegetation. Detailed descriptions and forest structure diagrams of logged and adjacent intact forest vegetation groups within a kokako home range have been provided in Appendix 2.4 (Pet home range, groups (iv) and (vi)). Similarly, detailed descriptions of forest groups showing historic hurricane damage and nearby intact forest groups within a kokako home range can be compared in Appendix 2.2 (Hill home range, groups (vi) and (iv)).

Figure 2.2 Graph depicting ordination scores of a selection of species from the 173 40 x 40m vegetation plots (encompassing all of the kokako home ranges studied), along the two environmental gradients detected. The first gradient (Axis 1) corresponds with changes in topography. Species with low Axis 1 scores (e.g. LAUnov = pukatea) are characteristic of gully bottom sites while those with high Axis 1 scores (e.g. LEPeri = manuka) are characteristic of ridge crest sites. The second gradient (Axis 2) corresponds with changes in altitude. Species with low Axis 2 scores (e.g. ELArug = parataniwha) are characteristic of low altitude sites while those with high Axis 2 scores (e.g. QUIser = tawheowheo) are characteristic of higher altitude sites. Species points are listed.

Key to species

ACKros - makamaka
ASPbul - *Asplenium bulbiferum*
BEItaw - tawa
CYAdea - ponga
CYAsmi - *Cyathea smithii*
DICIan - *Dicksonia* sp. (aff. *D. lanata*)
ELArug - parataniwha
GAHxan - *Gahnia xanthocarpa*
IXEbre - tawari
LAUnov - pukatea
LIBplu - kawaka
MELram - mahoe
METful - *Metrosideros fulgens*
NESmon - *Nestigus montana*
PHYtri - tanekaha
PSEcra - lancewood
PODhal - Hall's totara
RHOsap - nikau
SENkir - Kirk's daisy

AGAaus - kauri
ASTtri - Astelia *trinervia*
COPgra - raurekau
CYAfas - mingimingi
DACcup - rimu
DICsqu - wheki
FREbau - kiekie
GENlig - hangehange
JUNeff - *Juncus* sp. (*J. effusus* agg.)
LEPeri - manuka
LOTped - *Lotus pedunculatus*
METalb - *Metrosideros albiflora*
METper - *Metrosideros perforata*
OLEran - heketara
PNEpan - *Pneumatopteris pennigera*
PODdac - kahikatea
QUIser - tawheowheo
RIPsca - supplejack
VITluc - puriri

ALSmac -toropapa
BEItar - taraire
CORbud - korokoro
CYAmed - mamaku
DACkir - manoao
DYSspe - kohekohe
FUCexc - kotukutuku
HEDarb - pigeonwood
KNIexc - rewarewa
LEPsco - kanuka
MELmac - *Melicytus macrophyllus*
METdif - *Metrosideros diffusa*
METrob - northern rata
PHEnud - mairehau
PSEarb - fivefinger
PODfer - miro
RHAsol - waiuatua
SCHdig - pate
WEIsil - towai

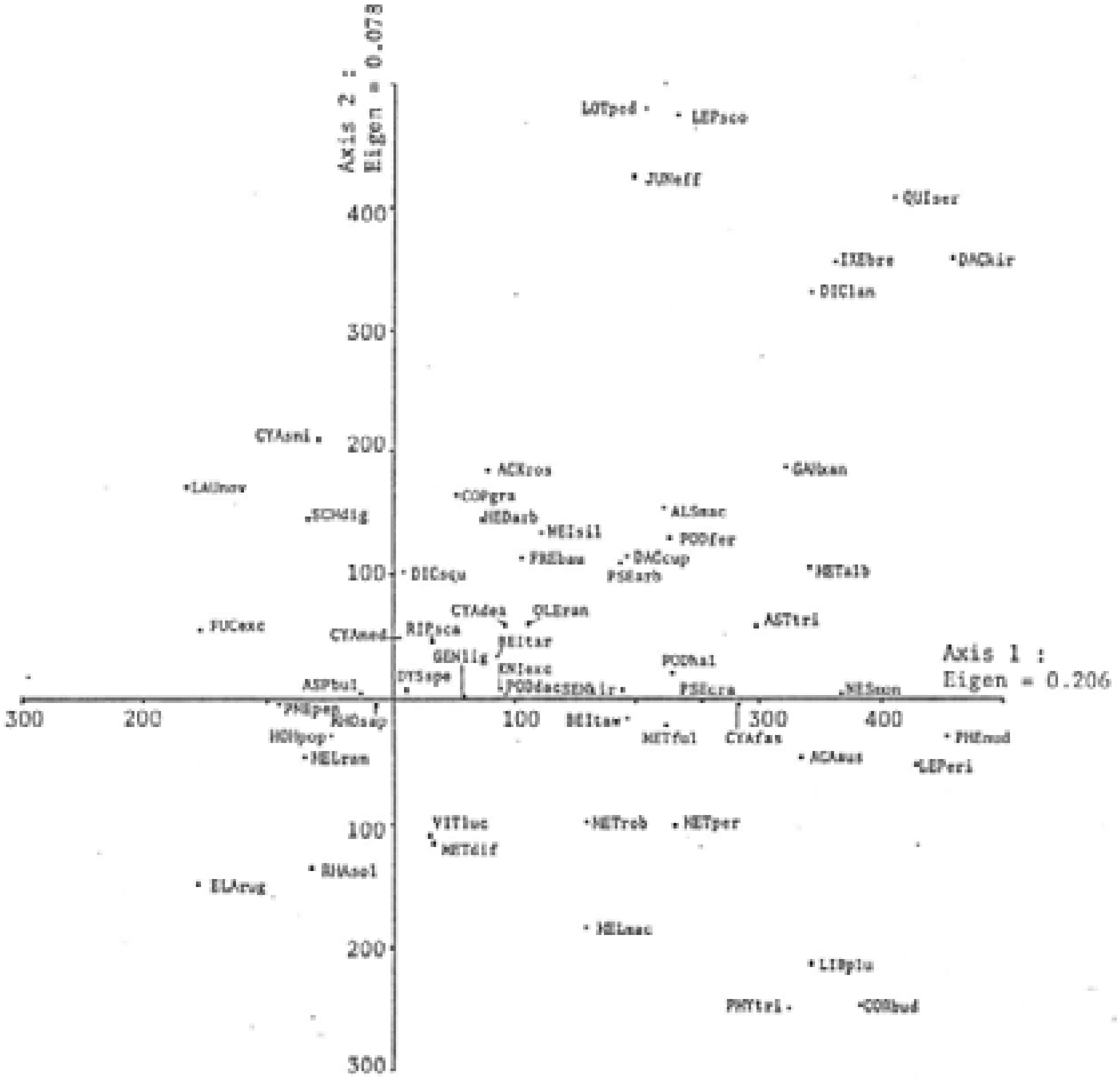


Figure 2.1 Ordination scores of the one hundred and seventy three 40 x 40m plots in all of the kokako home ranges, plotted for the two principle environmental gradients detected. The first gradient (Axis 1) corresponds with changes in topography from gully bottoms (the lowest scores) to ridge crests (the highest scores). The second gradient (Axis 2) corresponds largely with the changes in altitude, from lowest altitude (lowest scores) to highest altitude (highest scores). Superimposed upon the ordination of plots are eight vegetation groups defined by classification of plots. The first characters at each point identify a particular vegetation plot, while the last (alphabetic) characters identify the home range (namely B = Ben, H = Hill, K = Waikape, P = Pet, PU = Pukatea, S = Summit)

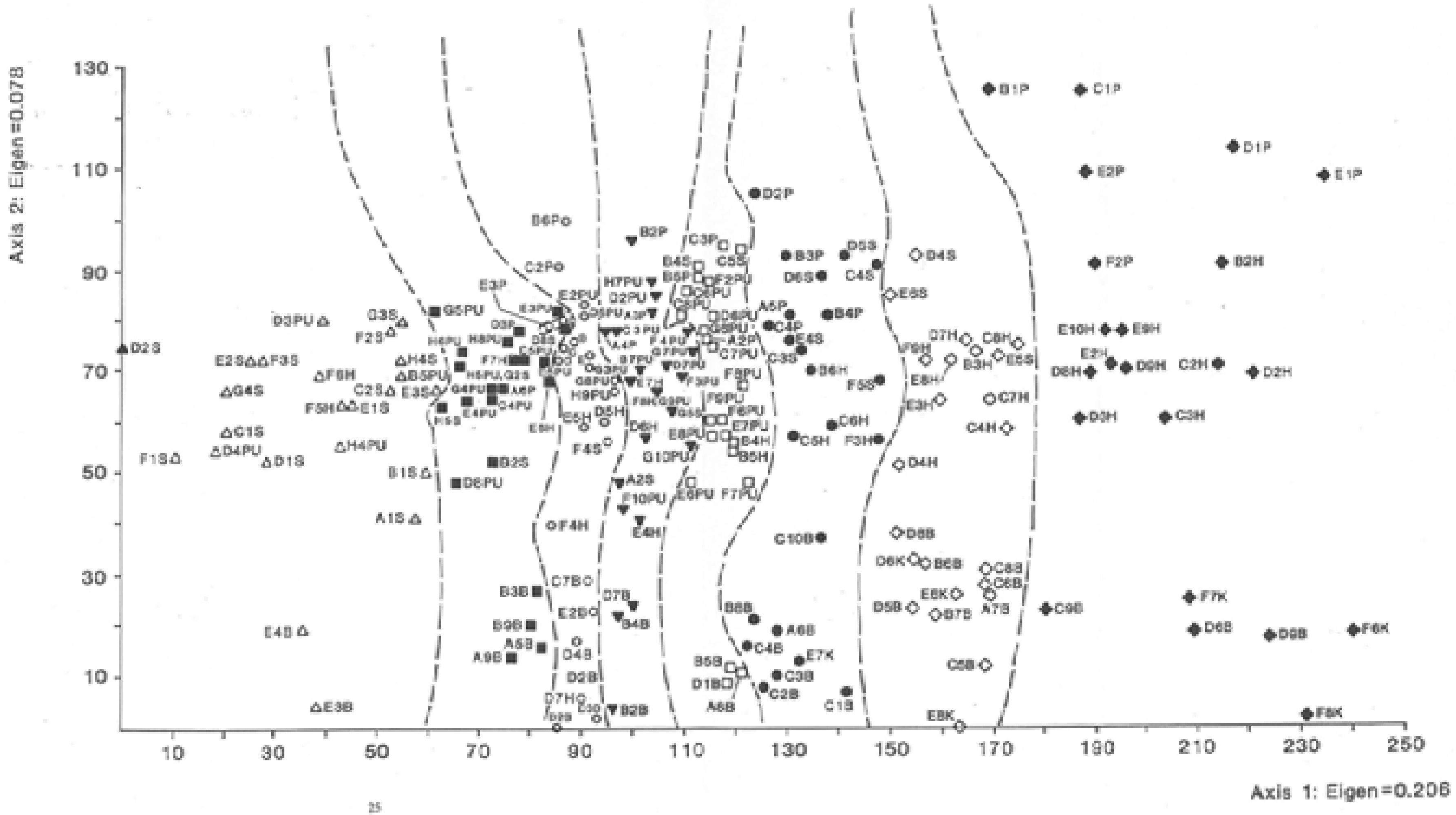


Figure 2.3 Distribution of eight vegetation groups across the kokako study home ranges. Scale: each grid square is 40 x 40m.

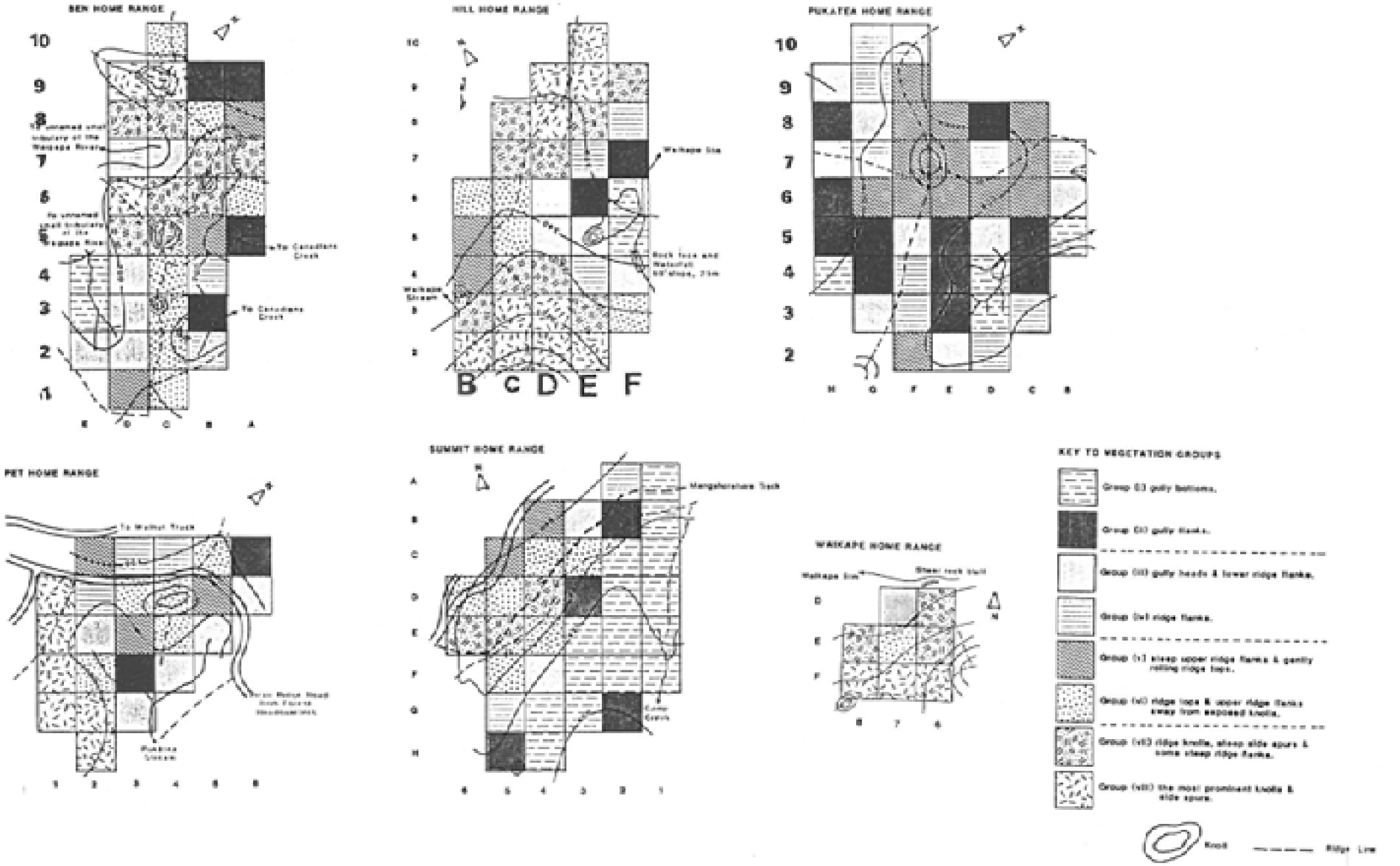


Figure 2.4a Mean importance values of six common tree species in eight composite vegetation groups (derived from Axis 1 of DECORANA of all vegetation plots transformed [log tier ht + 1] x cover value).

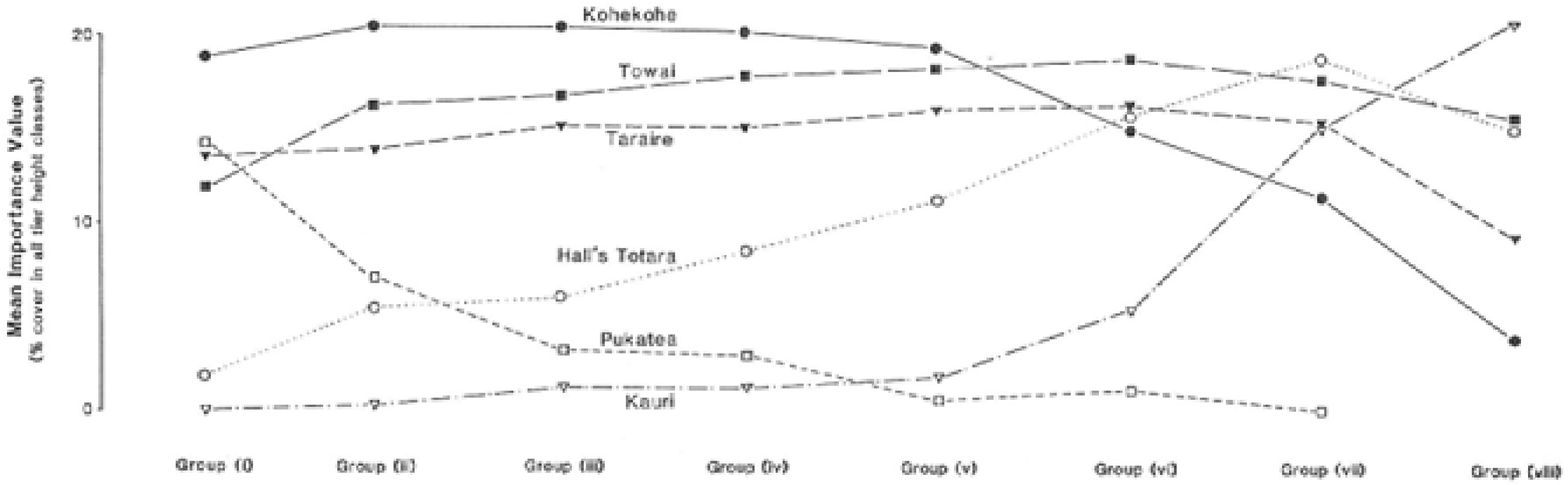


Figure 2.4b Mean cover abundance per forest tier in each of the eight composite vegetation groups defined for all of the kokako study home ranges combined. The forest tiers depicted are (bottom to top): Tier 6 = 0-0.3m high, Tier 5 = 0.3-2m, Tier 4 = 2-5m, Tier 3 = 5-12m, Tier 2 = canopy vegetation, Tier 1 = emergent vegetation.

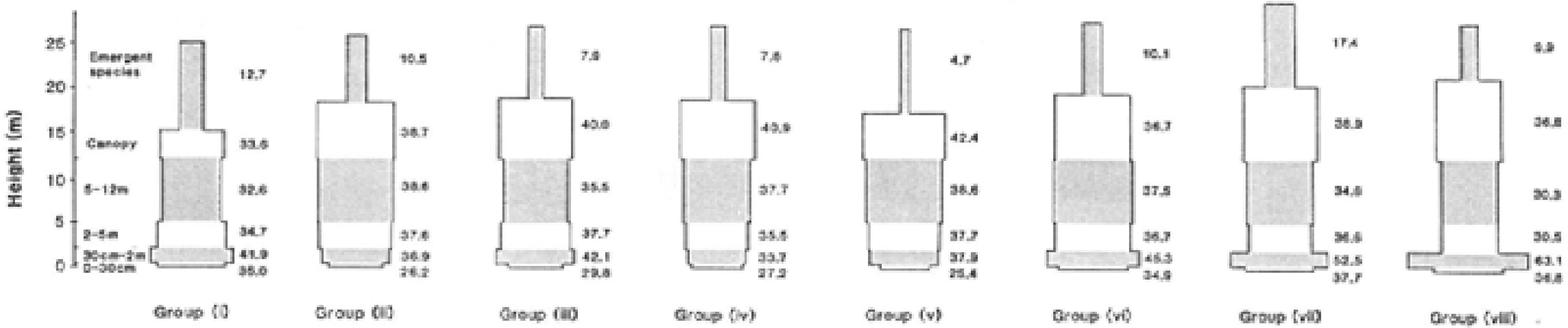


Figure 2.5 Structural representation of vegetation group (i) [pukatea-supplejack-kohekohe-taraire] determined from classification analysis of vegetation plots in six kokako home ranges.
Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = >15m; Tier 2: canopy vegetation = 12-15m; Tier 3 and tier 4: subcanopy vegetation = 5-12m & 2-5m respectively; Tier 5 and tier 6: ground plants = 0.3-2m & 0-0.3m respectively.

Mean percentage abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (i) vegetation was present in the following plots;
Ben home range E3,E4; Hill home range F5,F6; Pukatea home range B5,D3,D4,H4; Summit home range A1,B1,C1,C2,D1,D2,E1,E2,E3,F1,F2,F3,G3,G4,H4

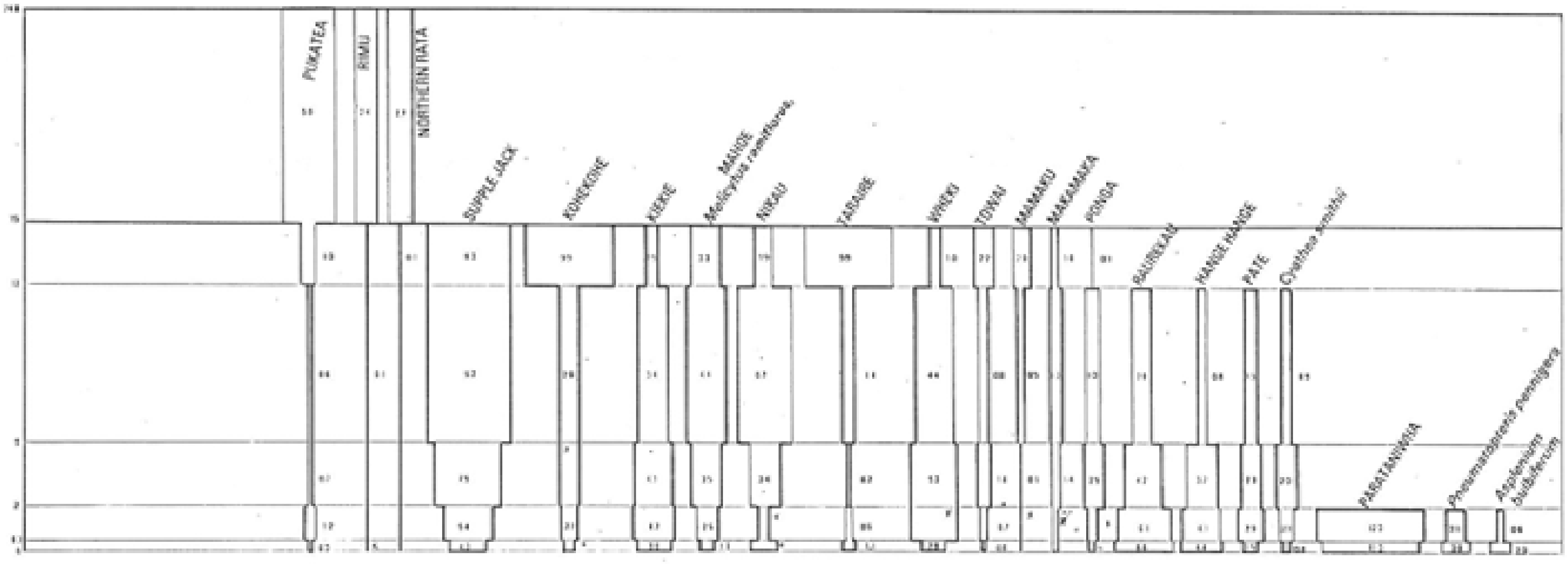


Figure 2.6 Structural representation of vegetation group (ii) [rimu-kohekohe-towai-taraire-supplejack] determined from classification analysis of vegetation plots in six kokako home ranges.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = >18.2m; Tier 2: canopy vegetation = 12-18.2m; Tier 3 and tier 4: subcanopy vegetation = 5-12m & 2-5m respectively; Tier 5 and tier 6: ground plants = 0.3-2m & 0-0.3m respectively.

Mean percentage abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (ii) vegetation was present in the following plots;
Ben home range A5,A9,B3,B9; Pet home range A6,D3; Pukatea home range C4,C5,D8,E3,E4,E5,G4,G5,H5,H6,H8; Summit home range B2,D3,G2,H5

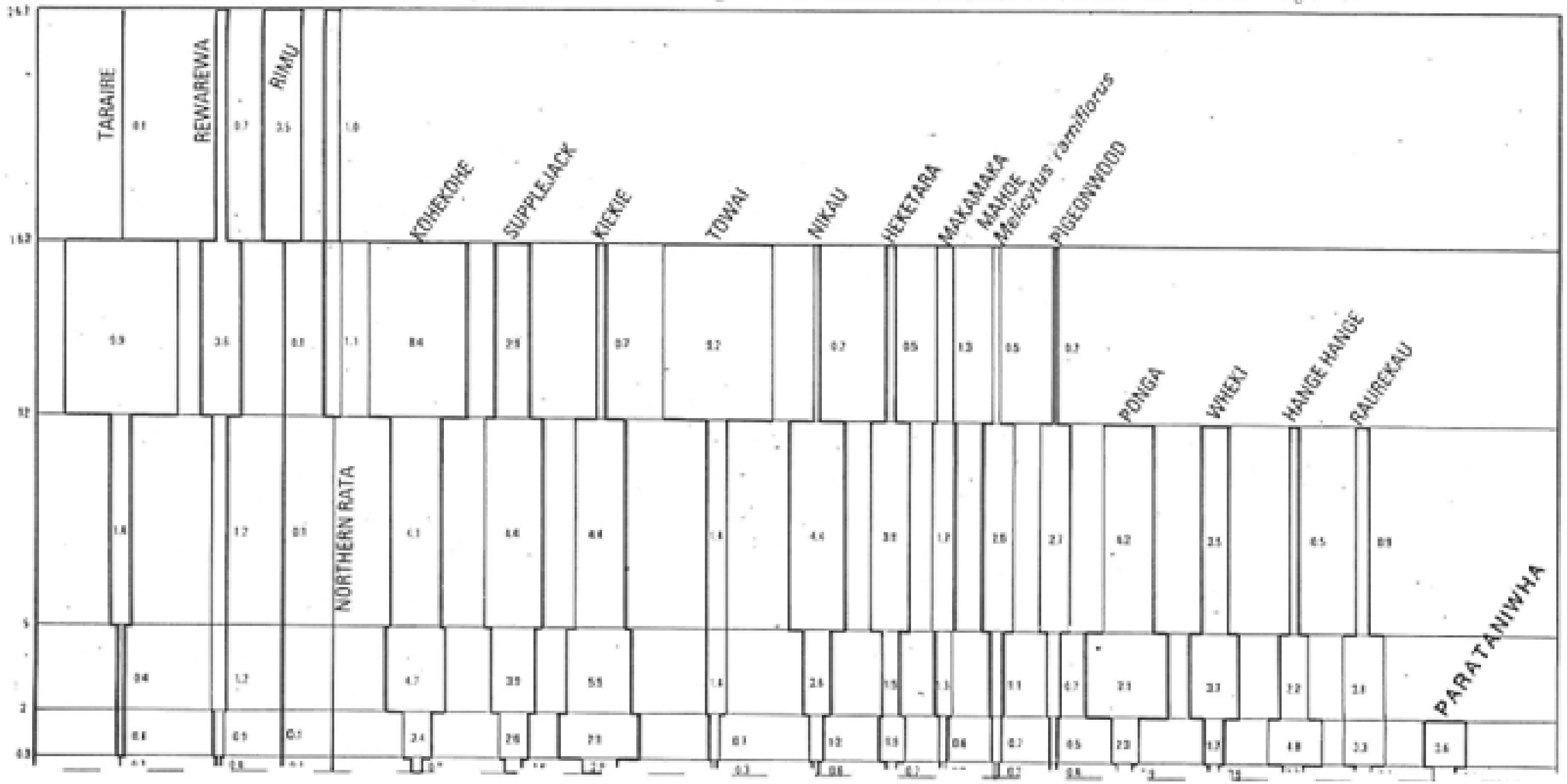


Figure 2.7 Structural representation of vegetation group (iii) [rimu-taraire-kohekohe-towai] determined from classification analysis of vegetation plots in six kokako home ranges.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = >18.2m; Tier 2: canopy vegetation = 12-18.2m; Tier 3 and tier 4: subcanopy vegetation = 5-12m & 2-5m respectively; Tier 5 and tier 6: ground plants = 0.3-2m & 0-0.3m respectively.

Mean percentage abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (iii) vegetation was present in the following plots;
Ben home range C7,D2,D3,D4,E2; Hill home range D5,E5,F4; Waikape home range D7; Pet home range B6,C2,C5,D4,E3; Pukatea home range B6,D5,E2,F5,G3,G8,H9; Summit home range B3,F4

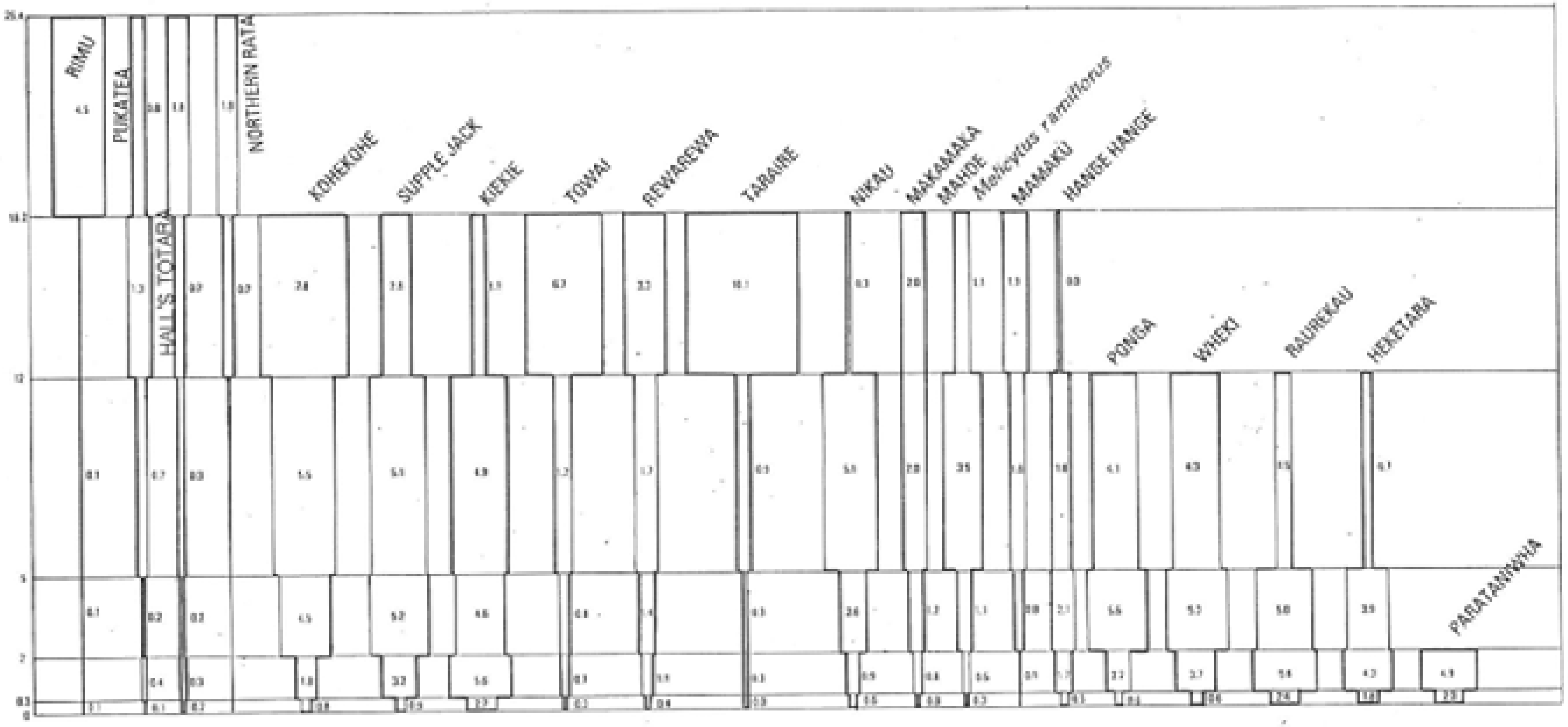


Figure 2.8 Structural representation of vegetation group (iv) [towai-taraire-kohekohe] determined from classification analysis of vegetation plots in six kokako home ranges.
Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = >18.4m; Tier 2: canopy vegetation = 12-18.4m; Tier 3 and tier 4: subcanopy vegetation = 5-12m & 2-5m respectively; Tier 5 and tier 6: ground plants = 0.3-2m & 0-0.3m respectively.

Mean percentage abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (iv) vegetation was present in the following plots;
Ben home range B2,B4,D7; Hill home range D6,E4,E7,F8; Pet home range A3,A4,B2; Pukatea home range B7,C3,D2,D7,F3,F4,F10,G7,G9,G10,H7; Summit home range A2,G5

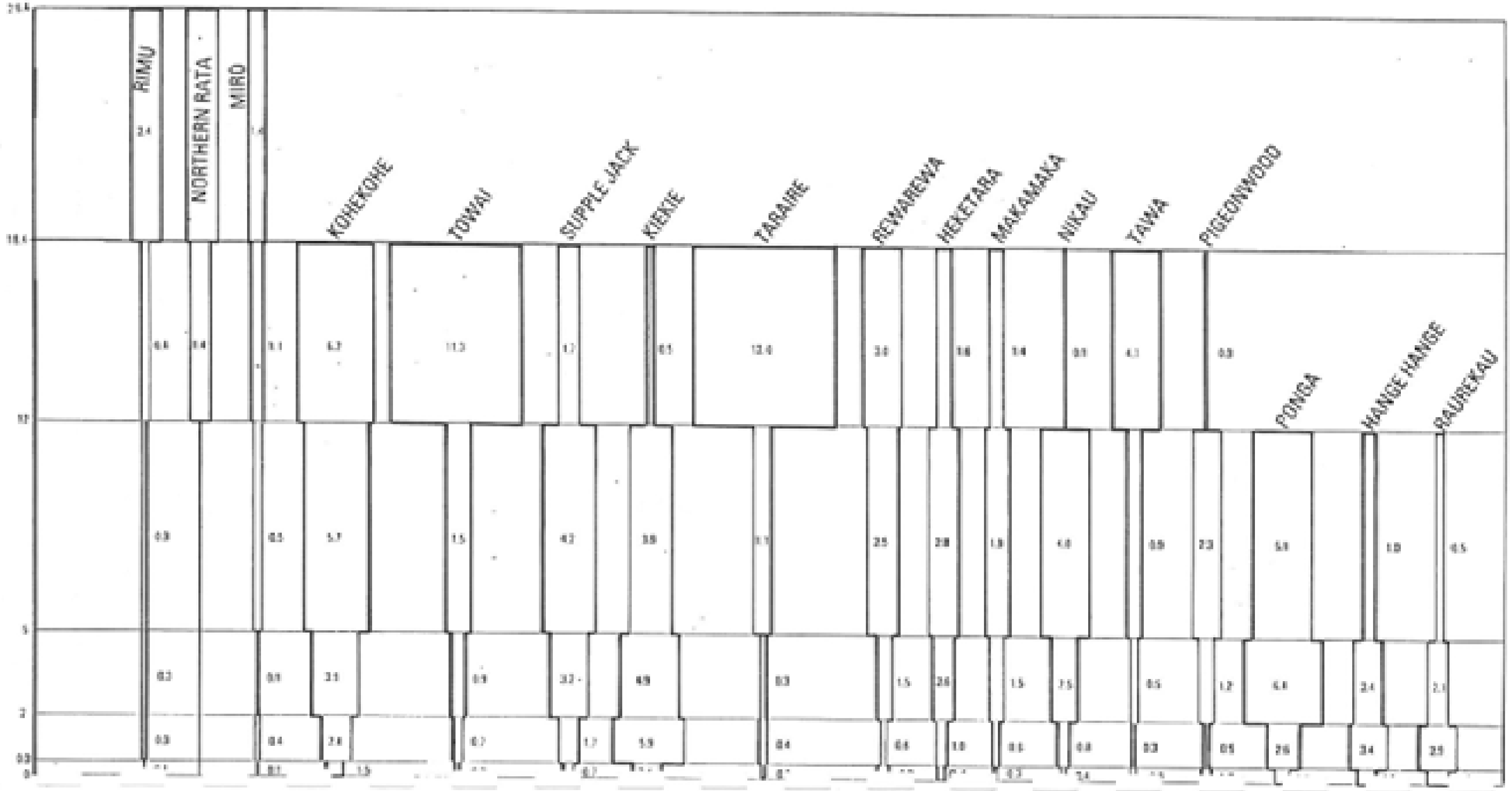


Figure 2.9 Structural representation of vegetation group (v) [towai-taraire-kohekohe-tawa] determined from classification analysis of vegetation plots in six kokako home ranges.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = >17m; Tier 2: canopy vegetation = 12-17m; Tier 3 and tier 4: subcanopy vegetation = 5-12m & 2-5m respectively; Tier 5 and tier 6: ground plants = 0.3-2m & 0-0.3m respectively.

Mean percentage abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (v) vegetation was present in the following plots;
Ben home range A8,B5,D1; Hill home range B4,B5; Pet home range A2,B5,C3; Pukatea home range C6,C7,C8,D6,E6,E7,E8,F2,F6,F8,F9,G6; Summit home range B4,C5

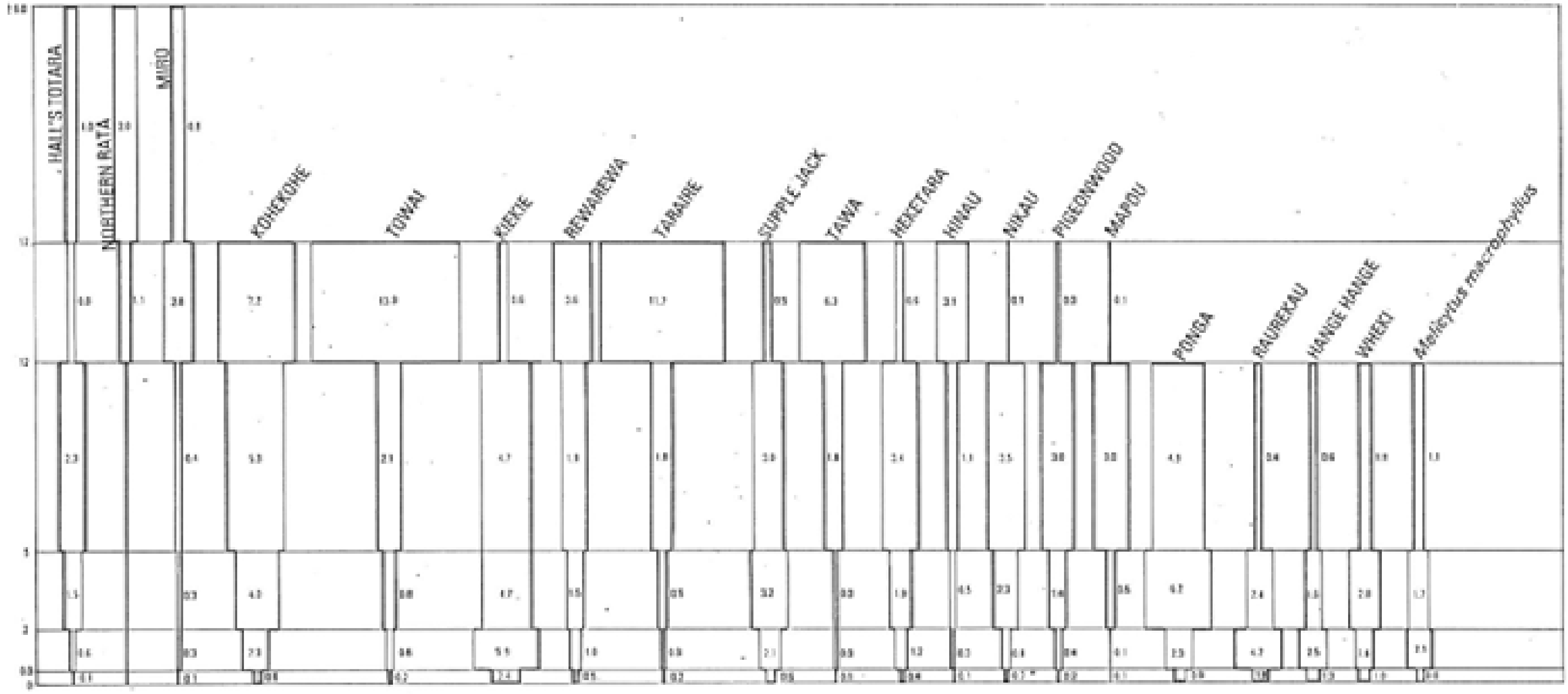


Figure 2.10 Structural representation of vegetation group (vi) [Hall's totara-kiekie-towai-taraire] determined from classification analysis of vegetation plots in six kokako home ranges.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = >18.5m; Tier 2: canopy vegetation = 12-18.5m; Tier 3 and tier 4: subcanopy vegetation = 5-12m & 2-5m respectively; Tier 5 and tier 6: ground plants = 0.3-2m & 0-0.3m respectively.

Mean percentage abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (vi) vegetation was present in the following plots;
Ben home range B8,C1,C2,C3,C4,C10; Hill home range B6,C5,C6,F3; Waikape home range E7; Pet home range A5,B3,B4,C4,D2; Summit home range C3,C4,D5,D6,E4,F5

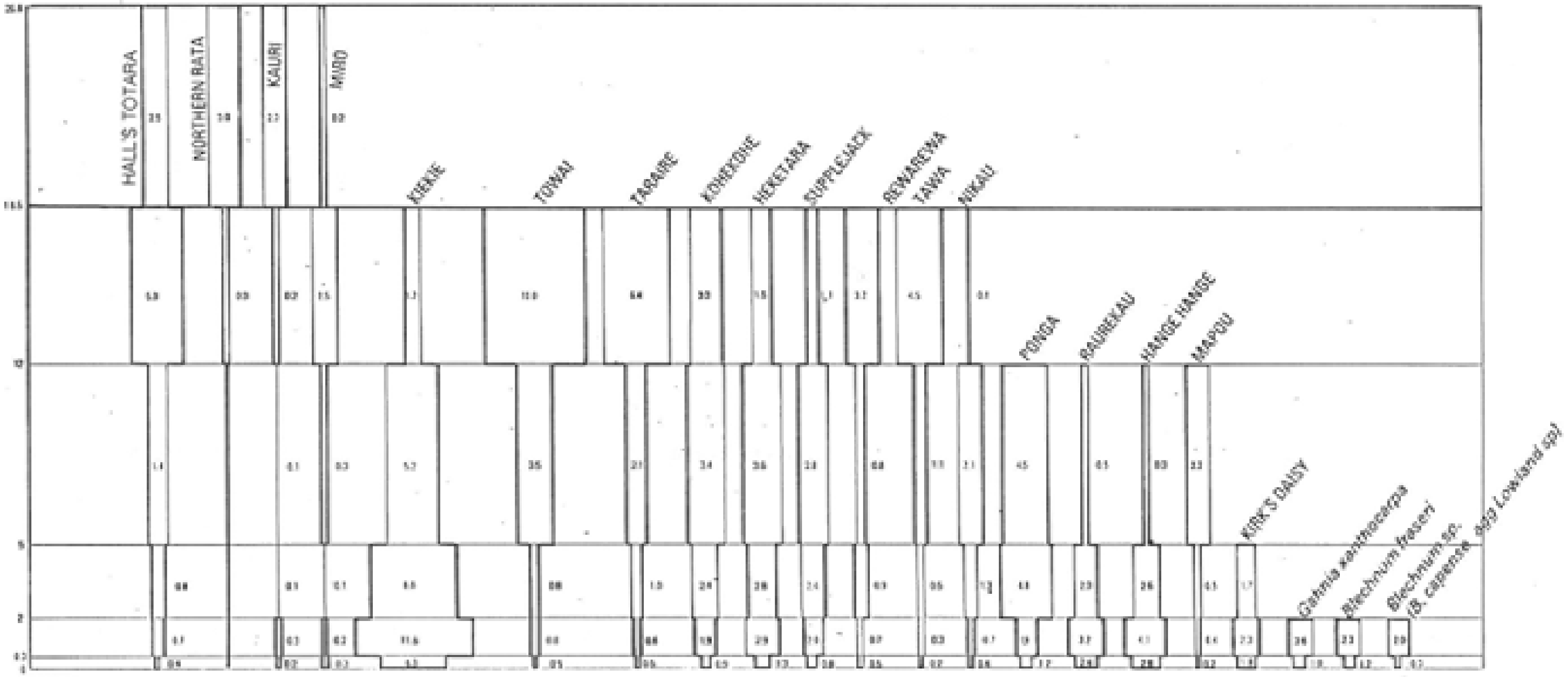


Figure 2.11 Structural representation of vegetation group (vii) [Hall's totara-kauri-miro-northern rata-kiekie-towai-taraire] determined from classification analysis of vegetation plots in six kokako home ranges.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = >20m; Tier 2: canopy vegetation = 12-20m; Tier 3 and tier 4: subcanopy vegetation = 5-12m & 2-5m respectively; Tier 5 and tier 6: ground plants = 0.3-2m & 0-0.3m respectively.

Mean percentage abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (vii) vegetation was present in the following plots;
Ben home range A7,B6,B7,C5,C6,C8,D5,D8; Hill home range B3,C4,C7,C8,D4,D7,E3,E8,F9; Waikape home range D6,E6,E8; Summit home range D4,E5,E6

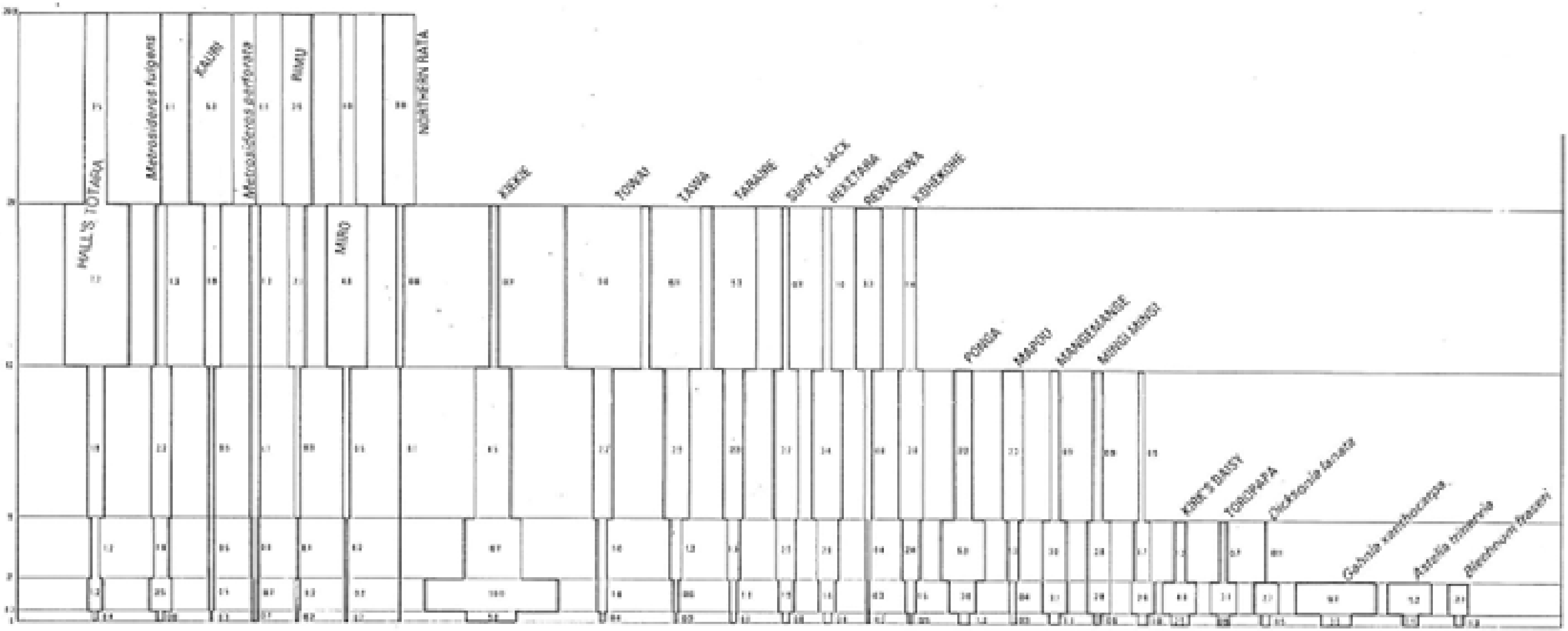
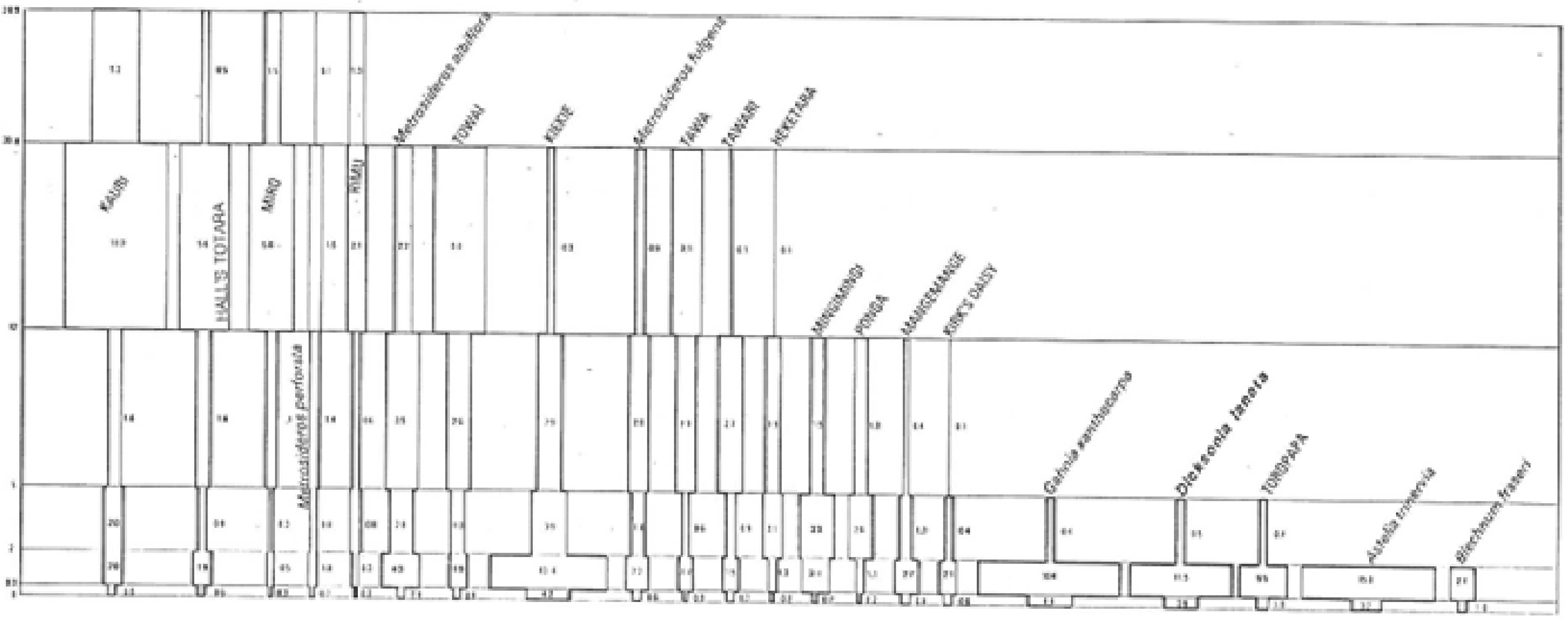


Figure 2.12 **Structural representation of vegetation group (viii) [kauri-Hall's totara-miro-towai-kiekie] determined from classification analysis of vegetation plots in six kokako home ranges.**

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = >20.8m; Tier 2: canopy vegetation = 12-20.8m; Tier 3 and tier 4: subcanopy vegetation = 5-12m & 2-5m respectively; Tier 5 and tier 6: ground plants = 0.3-2m & 0-0.3m respectively.

Mean percentage abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (viii) vegetation was present in the following plots;
Ben home range C8,D6,D9; Hill home range B2,C2,C3,D2,D3,D8,D9,E2,E9,E10; Waikape home range F6,F7,F8; Pet home range B1,C1,D1,E1,E2,F2



APPENDIX 2.1

DESCRIPTION OF BEN KOKAKO HOME RANGE

Gridded area: 5.6ha (Fig.2.1.3). Centred on grid reference 654N794E, NZMS 260, Sheet 05. Altitude range: 180-220m asl. Located at the western end of Bramley's Ridge, on an axial ridge between side catchments of Canadian's Creek (to the north), and headwaters of a small unnamed tributary of the Waipapa River (to the south). The terrain was finely dissected. A series of knolls and saddles occurred along the axial ridge and there were numerous side spurs and small gully heads. Some wind damage was evident on the knolls, and there was a slip in one of the gullies. The area adjoining to the east was salvage logged after storm damage in 1959.

1. Interpretation of Ordination

The main floristic gradients in the home range have been determined from the ordination of plots and species. The ordination scores on the two main axes (1 and 2) were plotted for selected species (Fig.2.14) and for plots (Fig.2.15).

Axis 1 corresponded to the main floristic gradient identified in the home range. It was a complex gradient which coincided with the change in topography from gully bottoms to ridge tops, and associated gradients from relatively poorly drained, damp, sheltered sites of apparently high fertility to well-drained, dry, exposed sites with skeletal, podsolised soils. Species that were confined largely to ridge top sites (e.g. kauri, *Metrosideros albiflora and Gahnia xanthocarpa*) scored highest on this axis, while species confined to moist gully bottoms (e.g. parataniwha, pukatea and kotukutuku) scored lowest. The species clustered in the middle of Axis 1 were either ubiquitous, or were characteristic of ridge flanks in this home range (e.g. taraire, kiekie and towai). Similarly, ridge top plots had the highest ordination scores and gully bottom plots had the lowest scores, while plots on the ridge flanks had intermediate scores.

The second axis of the ordination graph of species (Fig. 2.14) accounted for a much smaller amount of variability in the data set. The floristic gradient that it detected was coincident with a trend from undisturbed to disturbed plots in the home range. Species with high scores on this axis were weeds, such as Australian and Scotch thistle, or successional species, such as kanuka, or plants characteristic of forest margins, e.g. puawhananga and *Rubus australis.* Species such as matai, *Metrosideros carminea* and puriri (which were on undisturbed sites in the home range) scored lower on this axis.

Similarly, the ordination of plots on this axis yielded readily interpretable results. Among the plots that scored highly on Axis 2, plot C5 was on an exposed knoll which had been considerably wind-damaged; the canopy had collapsed, and a dense thicket of regenerating shrubs, lawyer and puawhananga had developed there. Plot B2 contained a large slip, the hare clay of which was being colonised by weeds. Plot C1 was on the fringe of logging damage following salvage of windthrown trees and contained some logging debris.

2. Interpretation of Classification

TWINSPAN analysis identified six vegetation groups. Superimposing these groups onto the ordination of plots (Fig.2.15) showed that they, too, corresponded with tbe main floristic gradient. Plots with low ordination scores on Axis 1 were those of gully sites, while plots with high Axis 1 scores were those of well-drained, open ridge top sites. 'The six vegetation groups identified by plot classification were:

a) supplejack-kohekohe-mahoe
b) kohekohe-taraire-rewarewa-(Hall's totara)
c) kohekohe-taraire-towai-tawa-kiekie-northern rata
d) Hall's totara-kauri-northern rata-taraire-tawa-towai-rewarewa-kiekie
e) Hall's totara-kauri-tawa-towai-taraire-miro-rimu
f) kauri-Hall's totara-northern rata-*Metrosideros albiflora*

Group (i) lay in gully bottoms, groups (ii) and (iii) were on ridge flanks and groups (iv), (v) and (vi) were on ridge tops. The locations of these vegetation associations in the home range have been shown in Figure 2.16.

Group (i) supplejack-kohekohe-mahoe
Occurred in predominantly-NW facing gully bottom, at headwaters of a small, unnamed side catchment of the Waipapa River. The site was of gentle slope and moderate drainage. Deep accumulations of litter were present, but near the stream there were damp clay banks and broken rock. Rotting logs and vegetation covered most of the ground. The canopy had collapsed in one place allowing local colonisation of weed species on damp banks.

The structure and composition of this group has been depicted in Figure 2.17. Parataniwha was abundant in the lowest tiers. Other common ground cover species included *Uncinia uncinata* and the ferns *Pneumatopteris pennigera, Lastreopsis hispida* and *Blechnum* sp (*B. capense* agg., lowland sp.). Epiphytes were common. Ferns characteristic of shaded damp sites were present (such as *Trichomanes endlicheranum, T. venosum* as well as the fern ally *Tmesipteris lanceolata*) and ubiquitous species such as *Asplenium flaccidum, Phymatosorus diversifolius,* kidney fern and puka.

Group (ii) kohekohe-taraire-rewarewa-(Hall's totara)
Present just above the gully bottom sites occupied by group (i) vegetation. Characteristic of side catchment headwater sites; on ridge flanks and gully heads with good to moderate drainage and steep slopes. Ground cover comprised deep, rich litter where it could accumulate and damp clay banks on steep areas.

The structure and composition of this group has been depicted in Figure 2.18. Parataniwha and were abundant in the lower tiers. Other common species in tiers 5 and 6 included the shrub waiuatua and the ferns *Asplenium bulbiferum* s.s. and *Pneumatopteris pennigera.*

Epiphytes were profuse, including common species in group (i) as well as other widespread species such as the epiphytic orchids *Earina autumnalis, E. mucronata* and *Dendrobium cunninghamii.* Other epiphytes characteristic of this group included *Blechnum filiforme, Phymatosorus scandens* and the fern ally *Tmesipteris sigmatifolia.*

Group (iii) kohekohe-taraire-towai-tawa-(northern rata)
Located on ridge flanks above gully heads, on gentle side spurs and in saddles between prominent knolls on the axial ridge of this home range. It occurred on ridge flanks on steep, well-drained slopes and on a range of aspects. Although drained, the sites were not excessively dry, and there was usually a deep accumulation of litter, with much herbaceous material.

The structure and composition of this group has been shown in Figure 2.19. Parataniwha was rare. The more common ground cover species included *Cordyline pumilio, Uncinia uncinata* and *Blechnum fraseri.*

Epiphyles were abundant and included not only the ubiquitous filmy fern species *Hymenophyllum demissum, H. revolutum, H. rarum,* and *H. sanguinolentum,* but also the moisture-preferring species such as *H. dilatatum and H. scabrum.*

Group (iv) Hall's totara-kauri-northern rata-taraire-tawa-towai-rewarewa-kiekie
Characteristic of major knolls of the main axial ridge of Ben kokako home range and also of some of the side ridges. It occurred also on the steep flanks of these knolls. The sites were well-drained to excessively well-drained in summer months. Most of the plots in which this group occurred were steep and faced a range of aspects. Locally, litter accumulated deeply, but there were many clay banks.

The structure and composition of this group has been depicted in Figure 2.20. Kiekie was the most conspicuous feature of the forest tiers. Tier 6 contained a wide range of seedlings, shrub species and ground cover species amongst which *Blechnum fraseri, Astelia trinervia, Gahnia setifolia* and *G. xanthocarpa* were the more common.

Epiphytes were common, comprising mostly ubiquitous species with moisture-preferring species being rare. The light-demanding orchids *Bulbophyllum pygmaeum* and *Drymoanthus adversus* were common.

Group (v) Hall's totara-kauri-tawa-towai-taraire-mire-rimu
Located on and about the flanks of a major knoll at the western end of the home range. The site was generally steep and well-drained to excessively well-drained in the summer. The group had a predominantly south-west aspect. Locally, there was a dense accumulation of litter about the bases of the kauri trees, and away from the top of the knoll there was an even distribution of deep litter and a profusion of vascular and non-vascular ground species.

The structure and of this group has been depicted in Figure 2.21. The most abundant species in the lower tiers were kiekie, mangemange, and *Astelia trinervia*. There was a wide range of species in Tier 6, tree seedlings, lianes and shrubs, and low plants such as *Blechnum fraseri, B. discolour, Gahnia xanthocarpa* and *G. setifolia* were the most common.Ground cover species particularly associated with kauri were present as well, e.g. *Schizaea dichotoma* and *Pterostylis graminea* var. *rubricaulis.*

Epiphytes were common; they were primarily ubiquitous species, although *Hymenophyllum multifidum* and *Tmesipteris tannensis* were conspicuous.

Figure 2.13: Ben kokako home range, Puketi Forest. Location: NW end of Bramley's Ridge, about a small unnamed tributary of the Waipapa River. Scale: each square is 40 x 40m. Approximate altitudinal contours at 20m intervals.

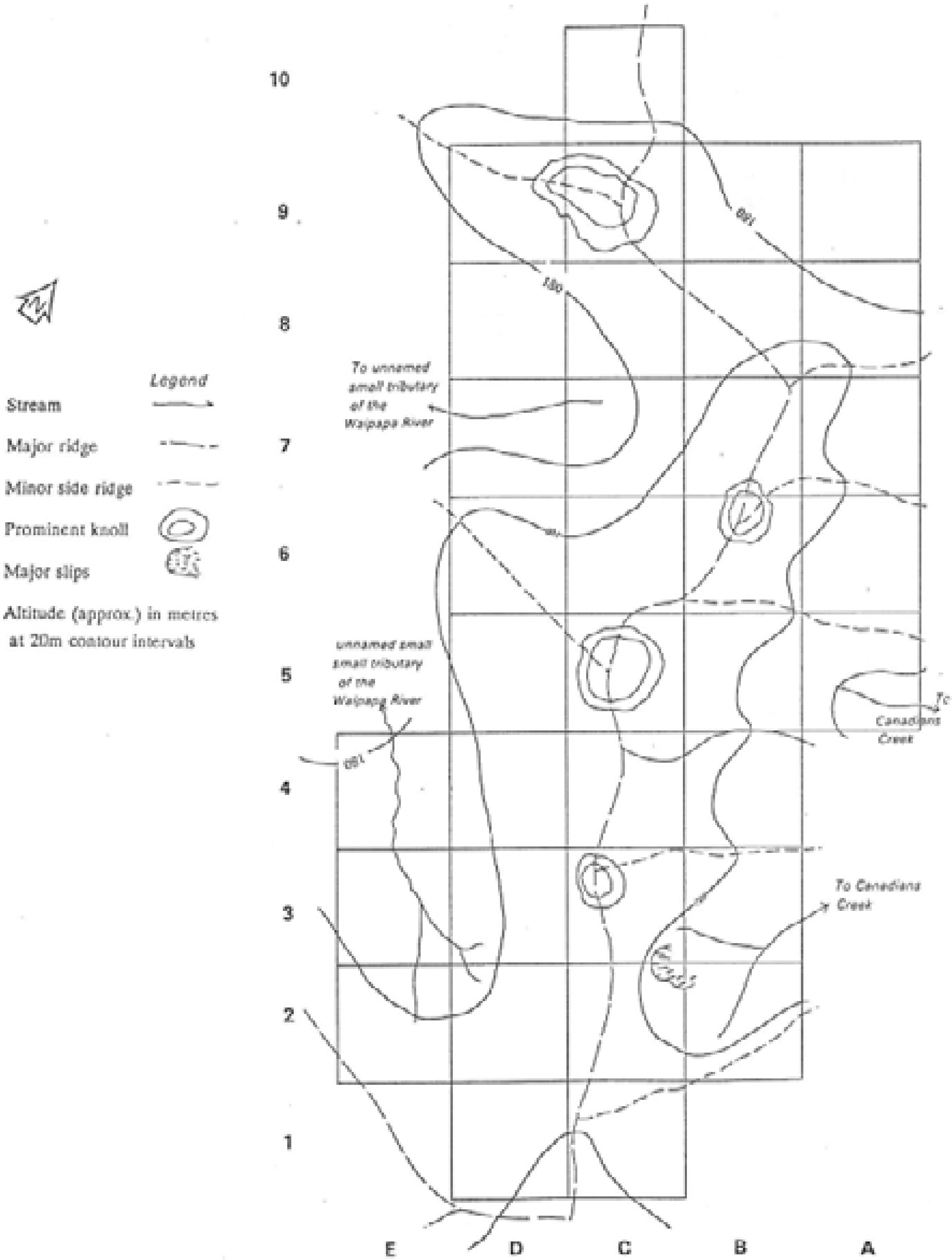


Figure 2.14: Graph depicting ordination scores of a selection of species from the thirty five 40x40m vegetation plots in Ben kokako home range, along the two principle floristic gradients detected. The first gradient (Axis 1) corresponds with changes in topography. Species with low Axis 1 scores (e.g. ELArug = parataniwha) are characteristic of gully bottom sites, while those with high Axis 1 scores (e.g. AGAaus = kauri) are characteristic of ridge crest sites. The second gradient (Axis 2) corresponds with the degree of disturbance. Species with low Axis 2 scores (e.g. VITluc = puriri) are characteristic of less disturbed sites while those with high Axis 2 scores (e.g. LEPeri = kanuka) are characteristic of more disturbed sites. Species points are listed.

Key to species

ACKros - makamaka
BEItar - taraire
COPgra - raurekau
CYAmed - mamaku
DYSspe - kohekohe
FREbau - kiekie
HEDarb - pigeonwood
LAUnov - pukatea
METful - *Metrosideros fulgens*
PHYtri - tanekaha
PODfer - miro
RHOsap - nikau
SENkir - Kirk's daisy

AGAaus - kauri
BEItaw - tawa
CYAdea - ponga
DACcup - rimu
ELAden - hinau
GAHpau - *Gahnia pauciflora*
HOHpop - lacebark
LEPeri - manuka
METrob - northern rata
PITten - kohuhu
PODhal - Hall's totara
RIPsca - supplejack
WEIsil - towai

ALSmac - toropapa
BRArep - rangiora
CYAfas - mingimingi
DICsqu - wheki
ELArug - parataniwha
GENlig - hangehange
KNIexc - rewarewa
MELram - mahoe
OLEran - heketara
PODdac - kahikatea
PSEcra - lancewood
SCHdig - pate

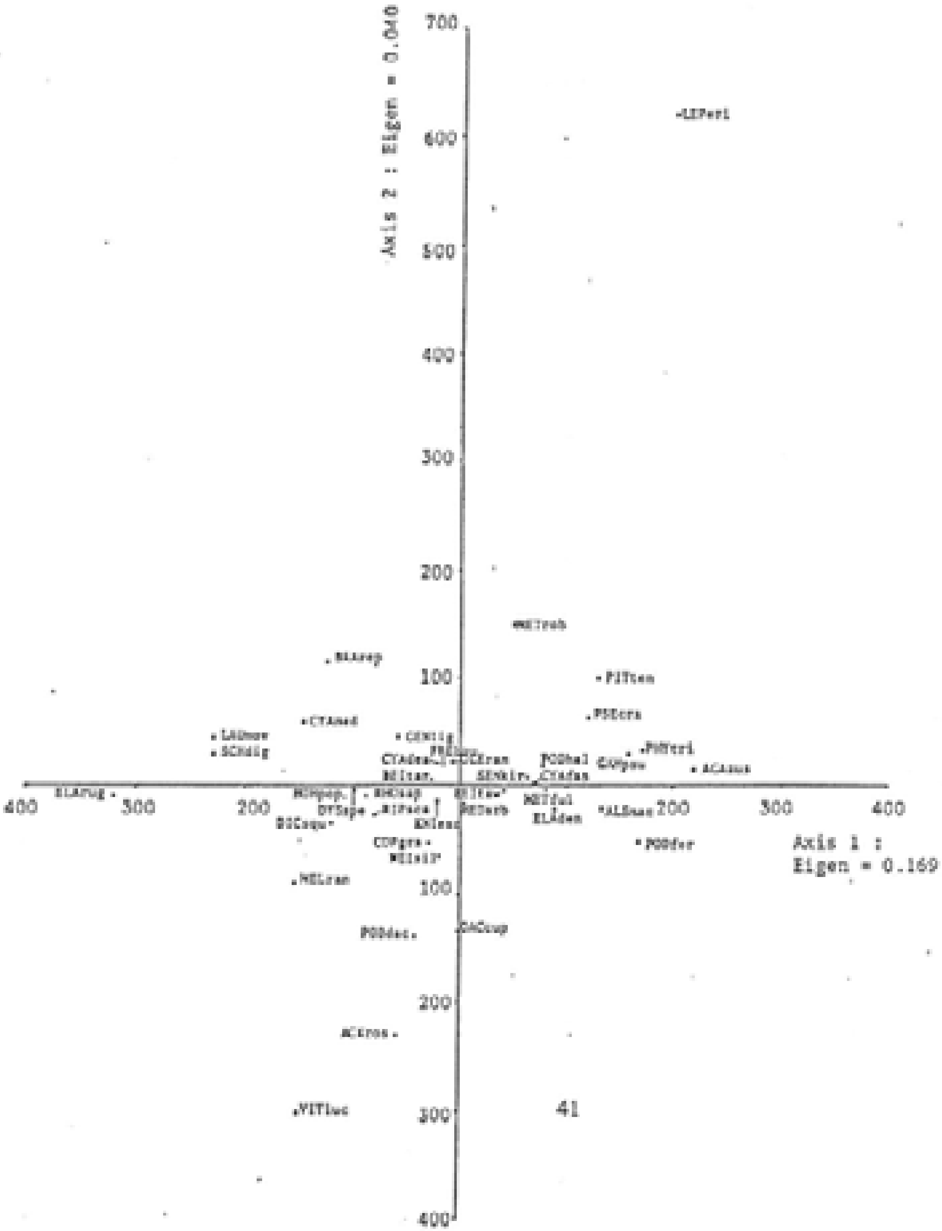


Figure 2.15: Ordination scores of the thirty five 40x40m vegetation plots in Ben kokako home range plotted for the two principle floristic gradients detected. The first gradient (Axis 1) corresponds with changes in topography from gully bottoms (the lowest scores) to ridge crests (the highest scores). The second gradient (Axis 2) corresponds with the degree of disturbance, from least disturbed (lowest scores) to most disturbed (highest scores). Superimposed upon the ordination of plots are six vegetation groups defined for this home range by classification of plots. These are:

▲ supplejack-kohekohe-mahoe
■ kohekohe-taraire-rewarewa-(Hall's totara)
◻ kohekohe-taraire-towai-tawa-kiekie-northern rata
▼ Hall's totara-kauri-northern rata-taraire-tawa-towai-rewarewa-kiekie
▣ Hall's totara-kauri-tawa-towai-taraire-miro-rimu
● kauri-Hall's totara-northern rata-*Metrosideros albiflora*

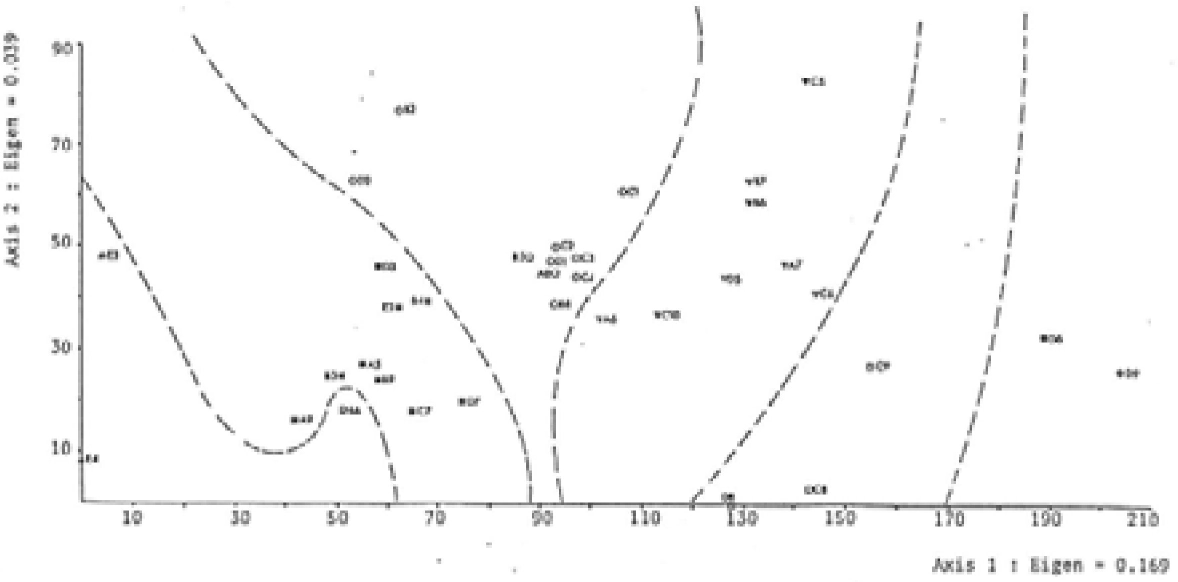


Figure 2.16: Location of six vegetation groups in Ben kokako home range. The groups were defined by classification, and reflect primarily the transition from gully to ridge crest sites. The six groups are listed below and are shown for the appropriate grid squares. Scale : each square is 40 x 40 m.

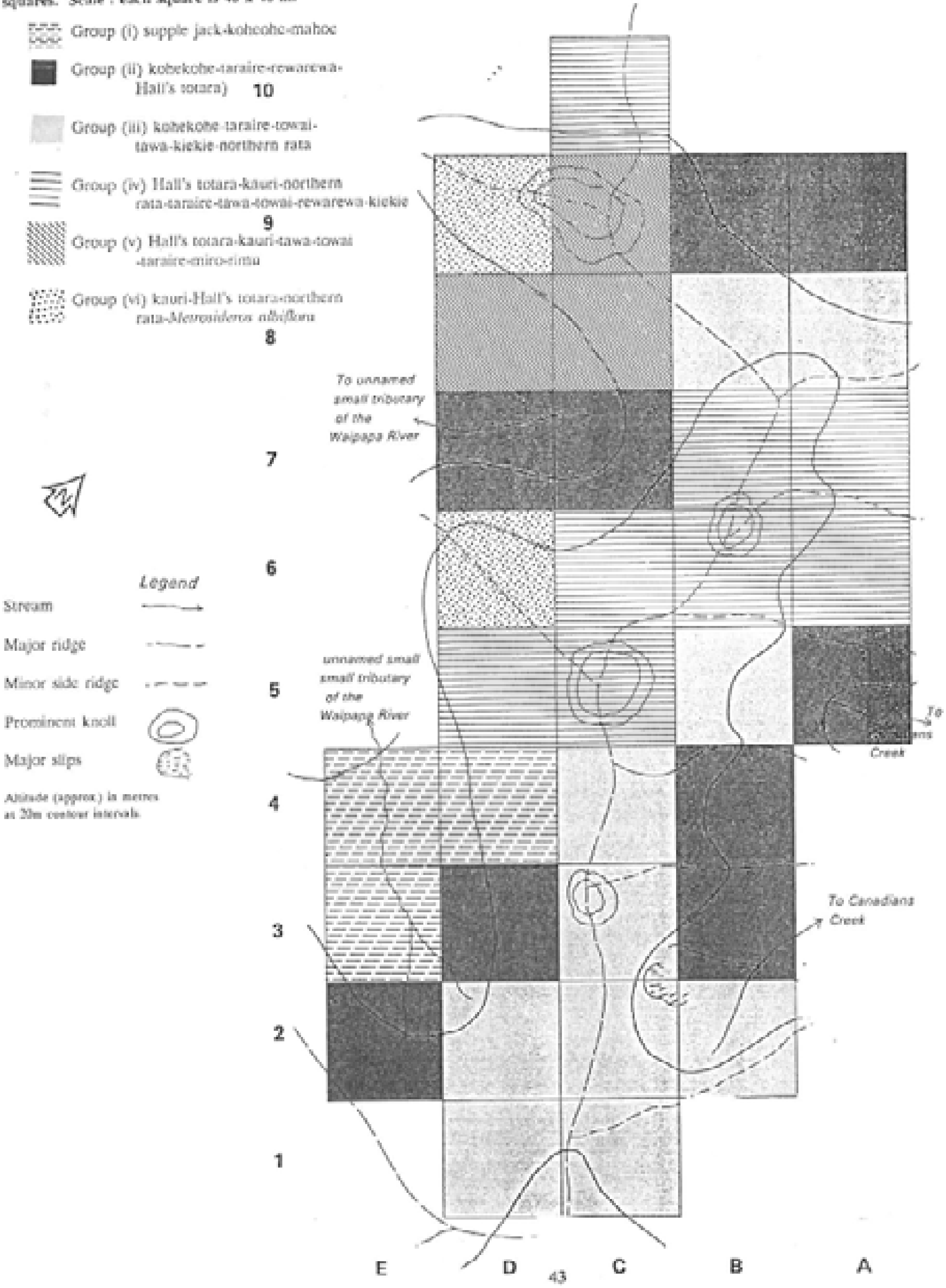


Figure 2.17: Structural representation of vegetation group (i) supplejack-kohekohe-mahoe determined from classification analysis of vegetation plots in Ben kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 19-28m; Tier 2: canopy vegetation = 12-19m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively; Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (i) vegetation was present in the following plots; D4,E3,E4.

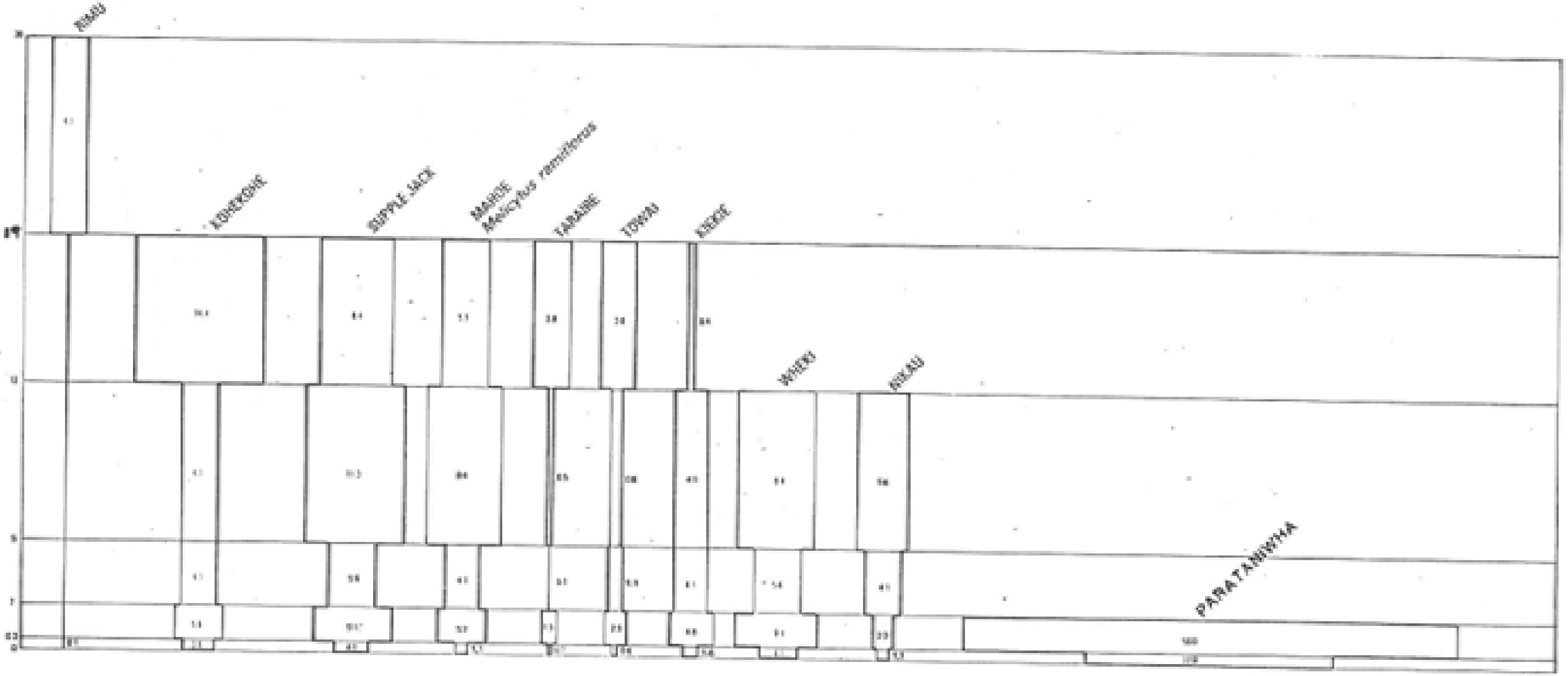


Figure 2.18: **Structural representation of vegetation group (ii) kohekohe-taraire-rewarewa-(Hall's totara) determined from classification analysis of vegetation plots in Ben kokako home range.**

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 22-32m; Tier 2: canopy vegetation = 12-22m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively; Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (ii) vegetation present in the following plots; A5,A9,B3,B4,B9,C7,D3,D7,E2.

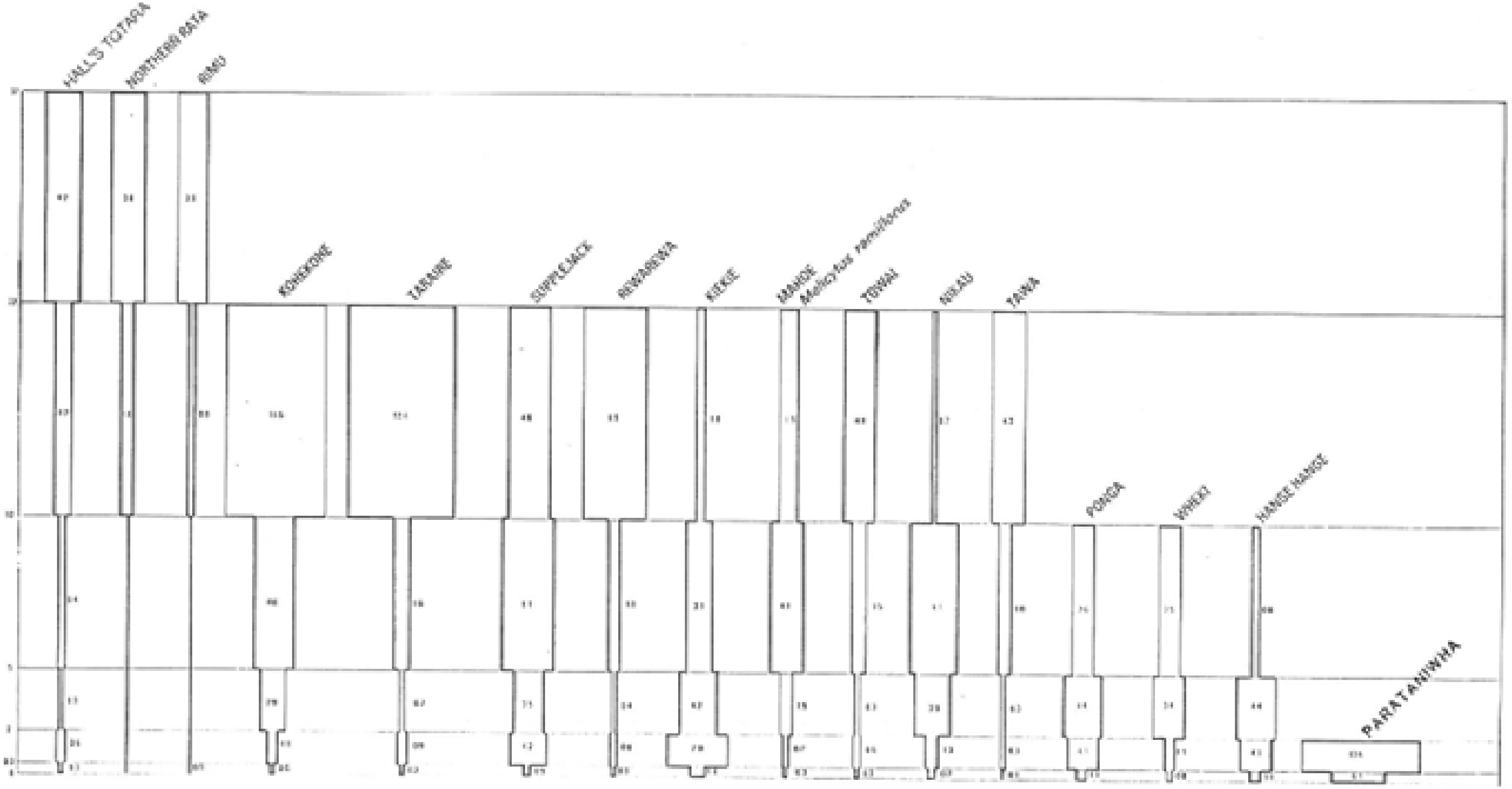


Figure 2.19: **Structural representation of vegetation group (iii) kohekohe-taraire-towai-tawa-kiekie-northern rata determined from classification analysis of vegetation plots in Ben kokako home range.**

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 20-30m; Tier 2: canopy vegetation = 12-20m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively; Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (iii) vegetation was present in the following plots; A8,B2,B5,B8,C1,C2,C3,C4,D1,D2,

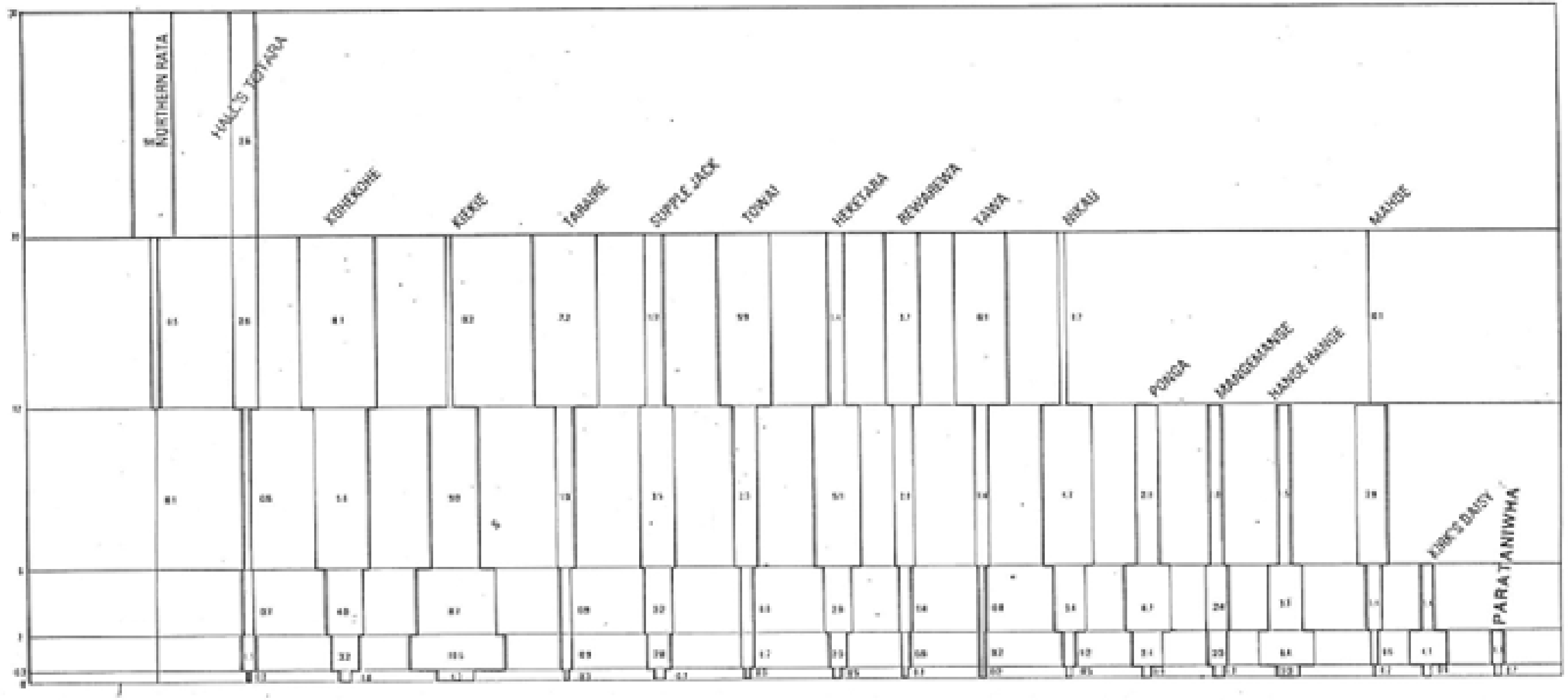


Figure 2.20: **Structural representation of vegetation group (iv) Hall's totara-kauri-northern rata-taraire-tawa-towai-rewarewa-kiekie determined from classification analysis of vegetation plots in Ben kokako home range.**

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 20-31m; Tier 2: canopy vegetation = 12-20m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively; Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (iv) vegetation was present in the following plots; A6,A7,B6,B7,C5,C6,C10,D5

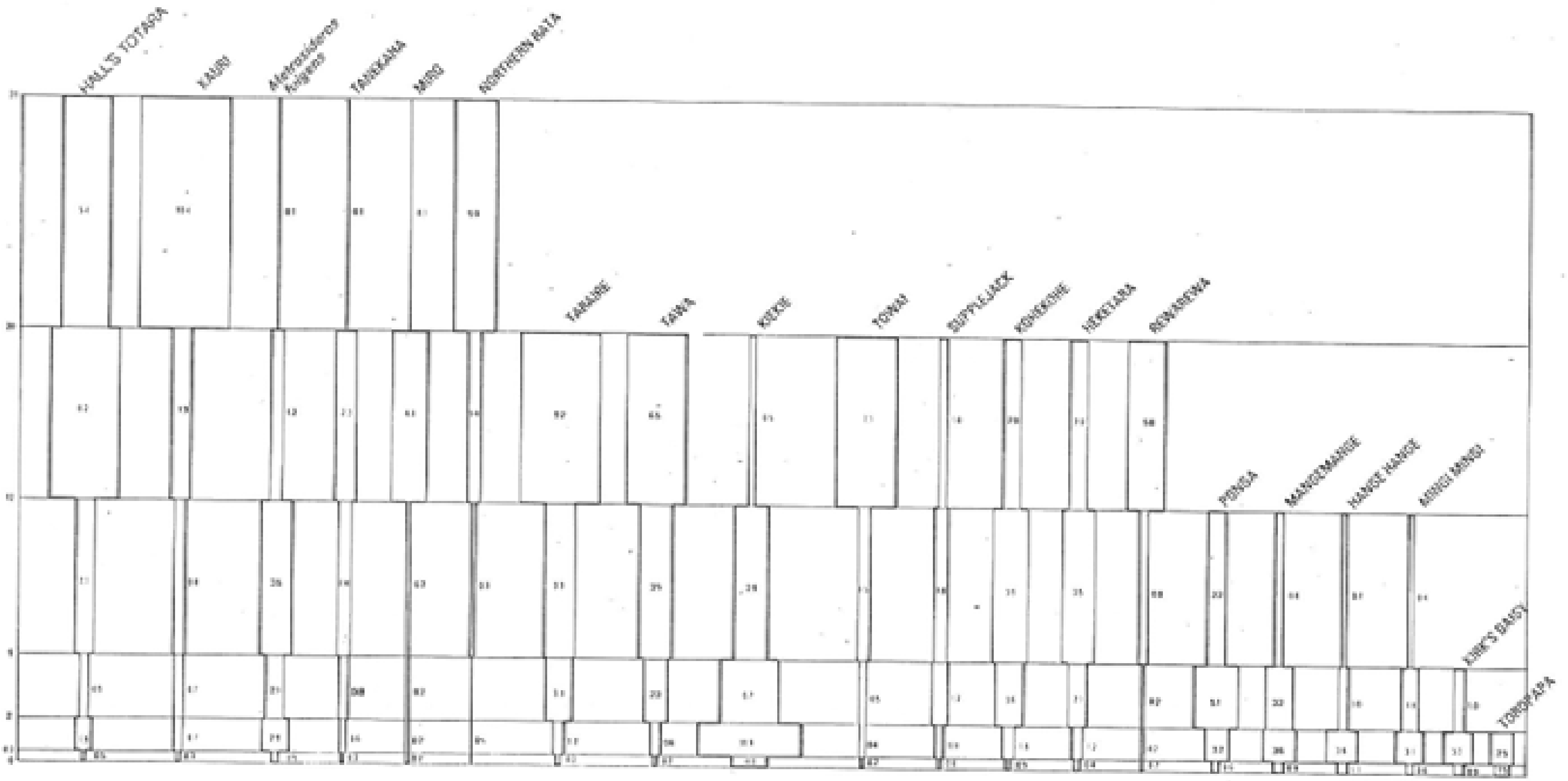


Figure 2.21: Structural representation of vegetation group (v) Hall's totara-kauri-tawa-towai-taraire-miro-rimu determined from classification analysis of vegetation plots in Ben kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 24-32m; Tier 2: canopy vegetation = 12-24m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively; Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (v) vegetation was present in the following plots; C8,C9,D8.

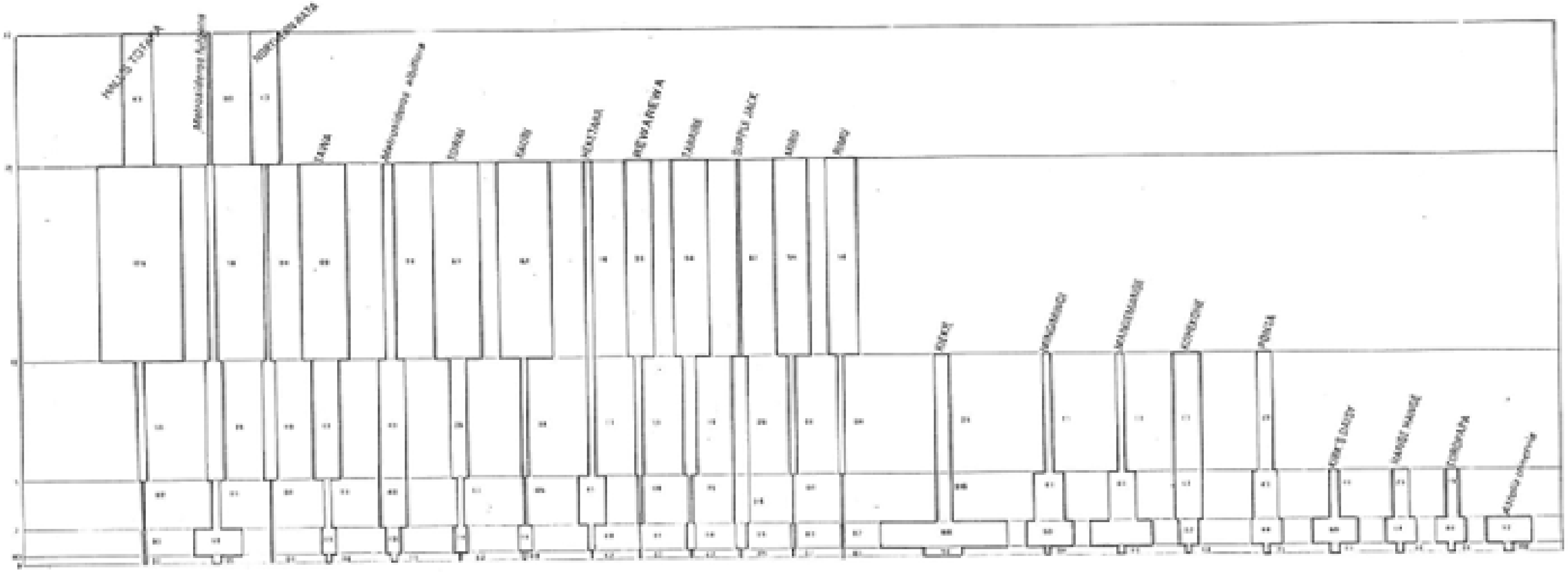
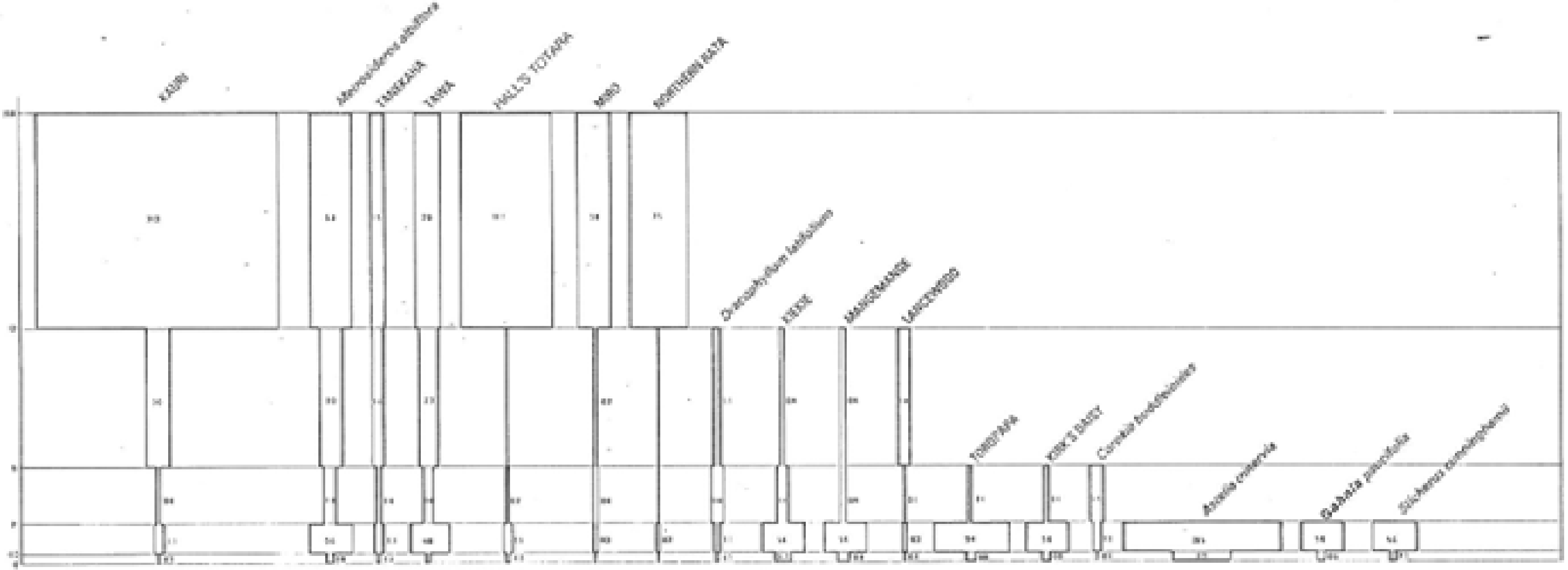


Figure 2.22: Structural representation of vegetation group (vi) kauri-Hall's totara-northern rata-*Metrosideros albiflora* determined from classification analysis of vegetation plots in Ben kokako home range.

Tier height classes are depicted to scale, namely
Tier 2: canopy vegetation = 12-23.8m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively; Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (vi) vegetation was present in the following plots; D6,D9.



APPENDIX 2.2

DESCRIPTION OF HILL KOKAKO HOME RANGE

Gridded area: 5.76 ha (Fig. 2.23). Centred on grid reference 634N NZMS 206, Sheet P 05. Altitude range: 310-390m asl. Situated on a side ridge leading north of Pirau Ridge, dividing two headwater catchments of the Waikape Stream to the east and to the west. The home range extended from a small plateau knoll at its highest point, down a single main ridge with a small side ridge near its lowest (northern) end. The terrain dropped steeply from the highest point, particularly into a gully in the east, where a branch of Waikape Stream headwaters plunged over a 20m waterfall. The lower portions of the home range had more gentle gradients. Severe storm damage was evident locally, as a result of a hurricane in 1959. There was a small slip on the gully flank, downstream of the 20m waterfall mentioned above.

Interpretation of ordination

The ordination of species (Fig.2.24) and plots (Fig.2.25) by DCA was easily interpreted. The first axis on Figure 2.25 detected the main floristic gradient in the home range which appeared to correspond with a change in topography from ridge top sites to gully bottom sites. Associated with it were changes in microenvironment, i.e. from drier, more exposed sites with acid litter and podsolised soils under kauri to moist, sheltered, shaded sites with deep humic litter and organic soils. The ordination of species (Fig.2.24) showed that those with high Axis 1 scores, such as pukatea, pate, mahoe and *Cyathea smithii* were characteristic of moist, shaded, relatively poorly-drained gully sites. Species with low Axis 1 scores included manoao, tanekaha, toru and kauri (which were characteristic of dry ridge top sites). Clustered about the middle were ubiquitous species and also those characteristic of ridge flanks, e.g. white maire, tawa and *Mida salicifolia.* Comparison of the plot ordination (Fig.2.25) with the map of the home range (Fig.2.23) gave further indication that the detected floristic gradient coincided with a change in topography, i.e. plots at the bottom of the gully (F5, F6) had high Axis 1 scores, plots on the ridge flanks (e.g. B4, B5, C5) had intermediate scores and those at the top of ridges (e.g. B2, C2, D2) had low Axis 1 scores.

Ordination of species and plots along Axis 2 detected an floristic gradient of secondary importance to the main gradient described above. It could be interpreted as a gradient that coincided with a change from disturbed to relatively undisturbed forest. Two major factors caused disruption of the canopy and have had a major impact on ground cover composition in the home range. There has been a substantial slip in the gully bottom (grid E5), exposing a clay bank which has colonised by species such as broad-leaved fleabane, Australian fireweed and *Paesia scaberula*. These species had low Axis 2 scores and high Axis 1 scores. The effect of the 1959 hurricane that devastated parts of Puketi Forest was most apparent on the ridge top. The major damage in this home range has at the highest point along the axial ridge, and comparatively less at the bottom. Species with low Axis 2 scores and low Axis 1 scores were indicative of regeneration after this wind destruction (e.g. kanuka, toru and *Rytidosperma gracile*).

Interpretation of TWINSPAN classification

Because the main floristic gradient detected by ordination coincided with changes in topography in this home range, it was not surprising that classification of plots also appeared to coincide with changes in topography. When six groups were superimposed onto the ordination of plots (Fig.2.25) this relationship with the main floristic gradient could be seen easily. Two groups were separated by classification with low Axis 1 scores. These plots were separated on apparently the same basis that plots were ordinated on Axis 2 (i.e. a floristic gradient reflecting the degree of disturbance). Plots receiving the most damage from the 1959 hurricane at the upper area of the axial ridge were distinguished as belonging to a different group from those lower down the axial ridge that were less affected. Locations of the six classification groups in the home range have been depicted in Fig.2.26. The vegetation groups identified were:

a) Kohekohe-taraire-supplejack-(pukatea)
b) Towai-supplejack-kohekohe-kiekie
c) Northern rata-taraire-towai-kohekohe
d) Rimu-northern rata-towai-taraire-miro-tawa-kiekie
e) Kauri-towai-taraire-miro-tawa-kiekie
f) Kauri-towai-miro-kiekie-*Metrosideros albiflora*

Group (i) occurred in gully bottoms, groups (ii)-(iv) on ridge flanks, and groups (v) and (vi) on ridge top sites (with group (v) being relatively less disturbed than group (vi)).

Group (i) kohekohe-taraire-supplejack-(pukatea)

Present in the gully at the head of the Waikape Stream. Drainage was medium to poor, with the stream cutting through the plots, and dropping over a steep rock face c.20cm high in one plot. The other plots sloped gently, forming the stream banks. Seepage points extended through two of the plots. The ground surface consisted of damp clay banks and rock faces near the falls and broken rock around them. A deep layer of litter and rotting vegetation was found on the more gently sloping plots. Disturbance was an important feature locally. Slip debris had ploughed through two plots and toppled several trees, leaving a comparatively open canopy over rotting logs and a dense regrowth of species characteristic of disturbance e.g. *Rubus australis.*

The structure and composotion of this group has been depicted in Figure 2.27. The ferns *Asplenium bulbiferum* s.s., *Pneumatopteris pennigera* and *Blechnum* sp. (*B. capense* agg) were common in tiers 5 and 6. Other common ground cover species included *Blechnum membranaceum, Lastreopsis hispida* and *Uncinia uncinata.*

Epiphytes were common on the relatively few trees present, particularly on tree ferns. Beside the ubiquitous species, there were also those characteristic of very dark, moist sites, e.g. *Tricgomanes endlicherianum.*

Group (ii) towai-supplejack-kohekohe-kiekie

Located away from the extreme gully bottom sites and the stream, on gently sloping, east-facing flanks of the main ridge system. Drainage was moderate to good, and the ground was covered mainly in dense litter, except for one large area of bare clay. Disturbance was a major feature of this group, particularly in one plot where most of the vegetation and surface soil had slipped into the gully below, leaving a large open clay bank which was being recolonised.

The structure and composition of this group has been shown in Figure 2.28. In tiers 5 and 6, *Blechnum* sp (*B. capense* agg) and *Gahnia setifolia* were locally dense around the slip site and weeds, such as Australian fireweed, broad-leaved fleabane and Scotch thistle were present there also. Elsewhere, common ground cover species included *Blechnum fraseri, Lastreopsis hispida* and *Asplenium bulbiferum* s.s.

Epiphytes were common, including species characteristic of moist shaded sites such as *Trichomanes venosum, Hymenophyllum scabrum* and *Tmesipteris lanceolata.*

Group (iii) northern rata-taraire-towai-kohekohe

Found on the steep gully head flanks on both sides of the central axial ridge. The sites were well-drained, having a deep accumulation of litter and some banks of bare soil. The vegetation was relatively undisturbed.

The structure and composition of this group has been shown in Figure 2.29. Other common ground cover species included *Blechnum fraseri, Gahnia xanthocarpa, Uncinia uncinata* and *Microlaena avenacea.*

Epiphytes were very common and included those characteristic of cool, shaded though not necessarily damp ridge flanks (e.g. *Tmesipteris sigmatifolia* and *Phymatosorus scandens*).

Group (iv) rimu-northern rata-towai-taraire-miro-tawa-kiekie

Distributed on steep flanks and on the steepest part of the main axial ridge above the gully systems. The plots were usually very well drained and occurred at a variety of aspects above the main gully systems. Litter accumulated deeply at some points, but the ground was often bare on steep banks. Some of the sites had been quite disturbed as a result of the 1959 hurricane, particularly those at the upper part of the home range, where the canopy had been quite depleted and trunks of fallen trees strewn about.

The structure and composition of this group has been shown in Figure 2.30. Epiphytes were common, and included such shade and moisture preferring species as *Hymenophyllum dilatatum* and *Anarthropteris lanceolata.*

Group (v) kauri-towai-miro-tawa-kiekie

Occurred mainly at the lower end of the main ridge of this home range, on the crest and upper ridge flanks. Drainage from the ridge was very good and the group was present mostly in plots of moderate slope. Ground cover comprised locally dense kauri litter and associated vascular and non-vascular plant species, or dry clay banks. Some plots featured a larger degree of disturbance than others. Plots mast exposed to the southerly wind of the 1959 hurricane (e.g. plots D7, E8) had their canopies destroyed to some extent while others less exposed (e.g. plot E10) were relatively unaffected.

The structure and composition of this group has been shown in Figure 2.31. Epiphytes were relatively less common here than they were in the preceeding groups. Beside ubiquitous species, light-demanding species such as *Bulbophyllum pygmaeum* were common. The fern ally *Tmesipteris sigmatifolia* was common on the trunks of *Dicksonia* sp. (aff. *D. lanata*).

Group (vi) kauri-towai-miro-lielie-*Metrosideros albiflora*

Present on the plateau and very steep north facing slopes flanking it at the highest part of this home range's axial ridge. The area was well to extremely well-drained. Where it was less steep, there was a deep bed of kauri litter with associated ground cover species, but on tbe slopes there were many dry banks. The area occupied by this group was affected severely by the 1959 hurricane, and while vestiges of a canopy remained intact, a dense thicket of regenerating canopy species and a very dense ground cover were the most conspicuous features.

The structure and composition of this group has been depicted in Figure 2.32. Epiphytes were relatively uncommon in this group; *Tmesipteris tannensis* was conspicuous in addition to the ubiquitous species.

Figure 2.23: Hill kokako home range, Puketi Forest. Location: side ridge north of Pirau Ridge, at headwaters of Waikape stream. Scale: each square is 40 x 40m. Approximate altitudinal contours at 20m intervals.

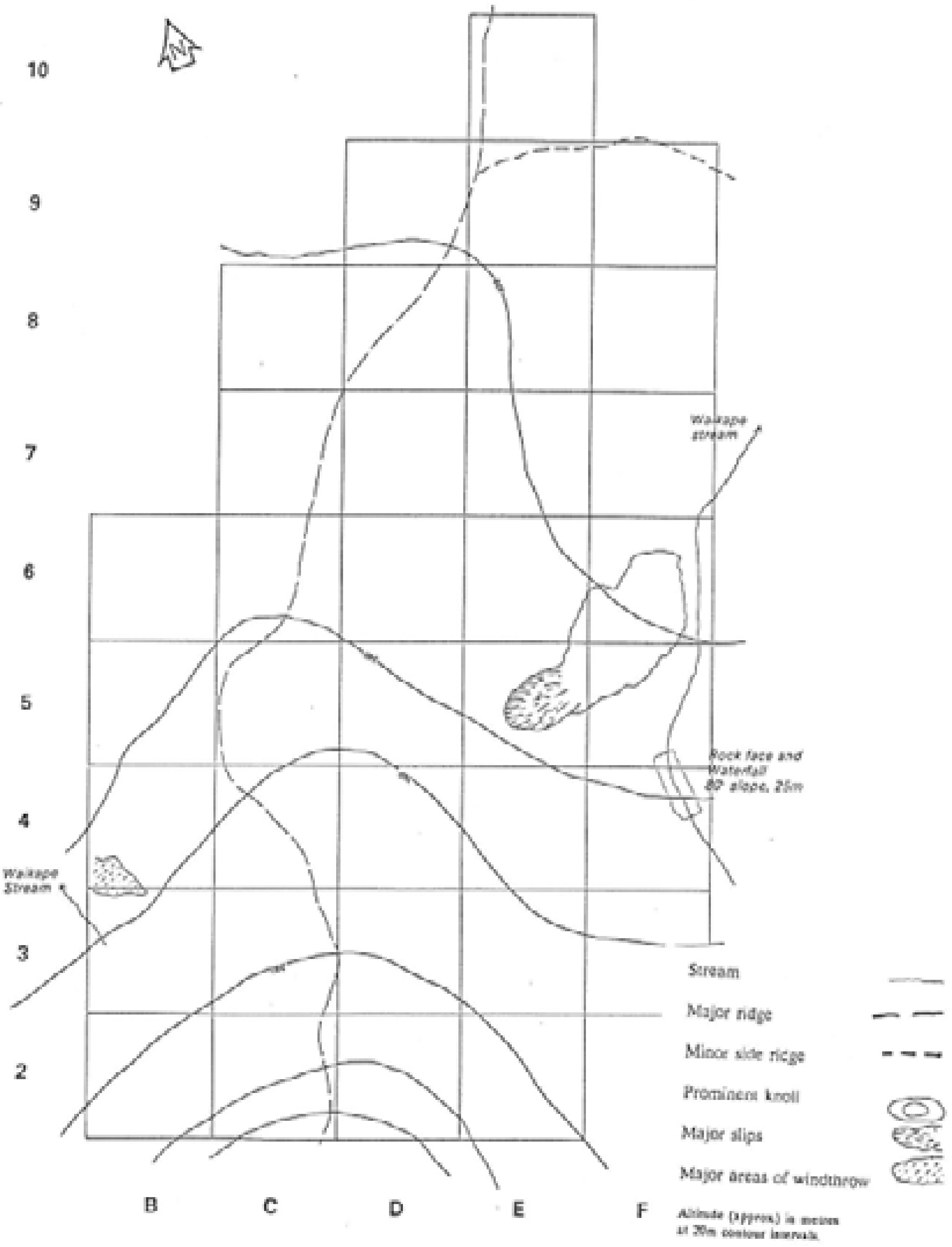


Figure 2.24: Graph depicting ordination scores of a selection of species from the thirty six 40x40m vegetation plots in Hill kokako home range, along the two principle floristic gradients detected. The first gradient (Axis 1) corresponds with changes in topography. Species with low Axis 1 scores (e.g. DACkir = manoao) are characteristic of ridge crest sites, while those with high Axis 1 scores (e.g. FUCexc = kotukutuku) are characteristic of gully bottom sites. The second gradient (Axis 2) corresponds with the degree of disturbance. Species with low Axis 2 scores (e.g. LEPeri - kanuka) are characteristic of more disturbed sites, while species with high Axis 2 scores (e.g. METrob = northern rata) are characteristic of less disturbed sites. Species points are listed below:

Key to Species

ACKros - makamaka
ASTtri - *Astelia trinervia*
BLEcap - *Blechnum sp.(B.capense agg.)*
COPgra - raurekau
CYAfus - mingimingi
DACkir - monoao
DRAlat - neinei
ELAden - hinau
GAHxan - *Gahnia xanthocarpa*
HEDarb - pigeonwood
LAUnov - pukatea
LYGart - hangehange
METdif - *Metrosideros diffusa*
MIDsal - toro
PHYtri - tanekaha
PODfer - miro
PSEcra - lancewood
RIPsca - supplejack
VITluc - puriri

AGAaus - kauri
BEItar - taraire
BLEfra - *Blechnum fraseri*
CYAdea - ponga
DACcol - silver pine
DIClan - *Dicksonia sp.(aff. D.lanata)*
DYSspe - kohekohe
FREbau - kiekie
GENlig - hangehange
IXEbre - tawari
LEPeri - kanuka
MELmac - *Melicytus macrophyllus*
METful - *Metrosideros fulgens*
OLEran - heketara
PITten - kohuhu
PODhal - Hall's totara
QUIser - tawheowheo
RUBaus - *Rubus australis*
WEIsil - towai

ALSmac - toropapa
BEItaw - tawa
BRArep - rangiora

DACcup - rimu
DICsqu - wheki

FUCexc - kotukutuku
GRIluc - puka
KNIexc - rewarewa
LIBplu - kawaka
METalb - *Metrosideros albiflora*
METrob - northern rata
PAEsca - *Paesia scaberula*
PNEpen - *Pneumatopteris pennigera*
PSEarb - fivefinger
RHOsap - nikau
SENkir - Kirk's daisy

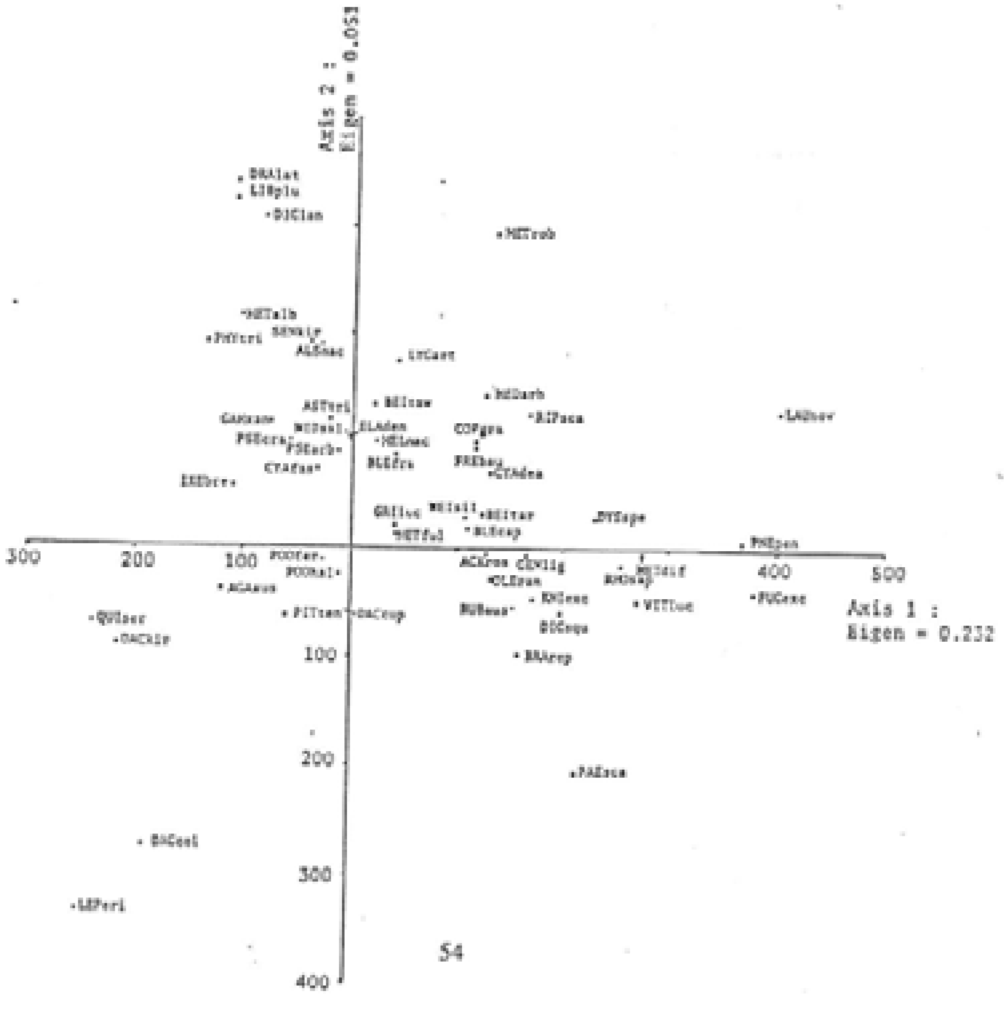


Figure 2.25: Ordination scores of the thirty six 40x40m vegetation plots in Hill kokako home range plotted for the two principle floristic gradients detected. The first gradient (axis 1) corresponds with changes in topography from ridge crests (the lowest scores) to gully bottoms (the highest scores). The second gradient (Axis 2) corresponds with the degree of disturbance from most disturbed sites (the lowest scores) to the least disturbed sites (the highest scores). Superimposed on this ordination of plots are six vegetation groups defined for this home range by classification of plots. These are:

▲ kauri-towai-miro-kiekie-*Metrosideros albiflora*
■ kauri-towai-miro-tawa-kiekie
○ rimu-northern rata-towai-taraire-miro-tawa-kiekie
▼ northern rata-taraire-towai-kohekohe
□ towai-supplejack-kohekohe-kiekie
✱ kohekohe-taraire-supplejack-(pukatea)

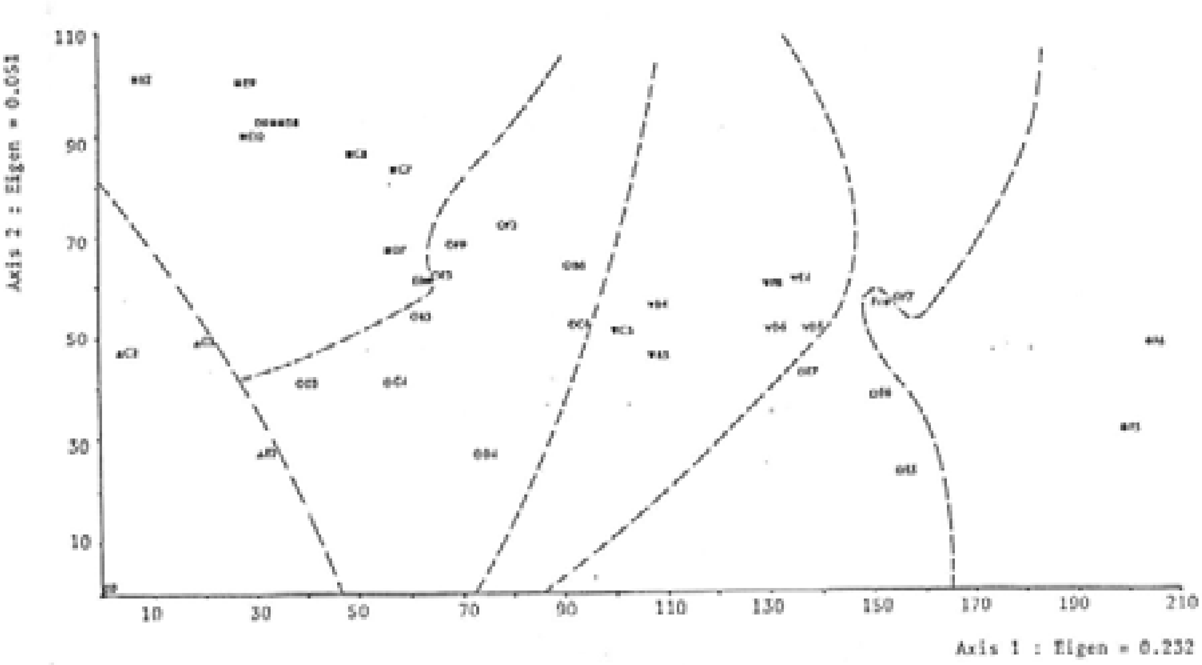


Figure 2.26: **Location of six vegetation groups defined for Hill kokako home range.** The groups were defined by classification, and reflect primarily the transition from gully bottom to ridge crest sites, though the degree of damage by wind is also a major influence. The six groups defined are listed below, and are shown for the appropriate grid square on the home range map. Scale: each square is 40 x 40m. Approximate altitudinal contours at 20m intervals.

Group (i) kohekohe-taraire-supplejack-(pukatea); Group (ii) towai-supplejack-kohekohe-kiekie; Group (iii) northern rata-taraire-towai-kohekohe; Group (iv) rimu-northern rata-towai-taraire-miro-tawa-kiekie; Group (v) kauri-towai-miro-tawa-kiekie; Group (vi) kauri-towai-miro-kiekie-*Metrosideros albiflora*

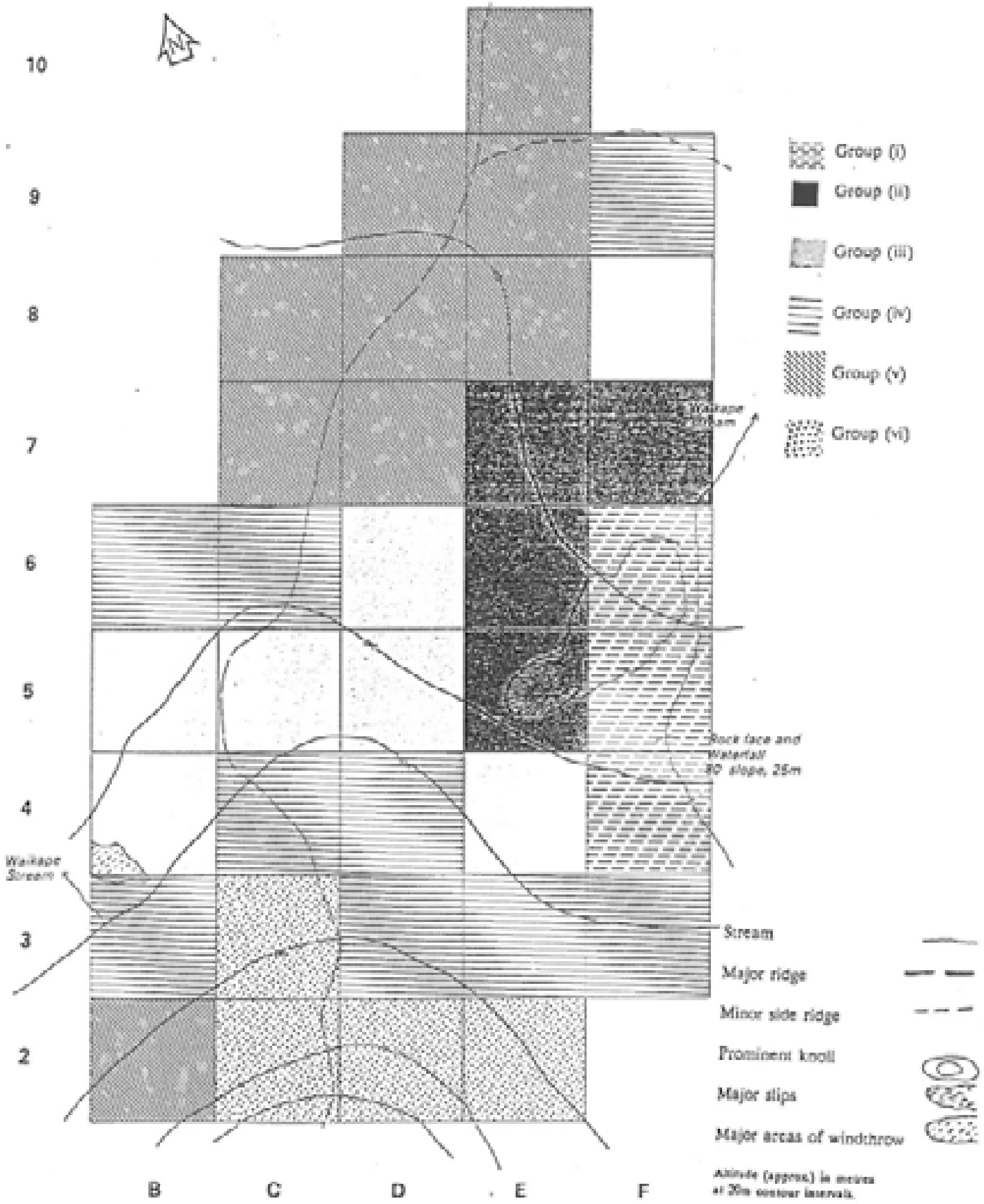


Figure 2.27: Structural representation of vegetation group (i) kohekohe-taraire -supplejack-(pukatea) determined from classification analysis of vegetation plots in Hill kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 16.7-25m; Tier 2: canopy vegetation = 12-16.7m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively; Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (i) vegetation was present in the following plots; F4,F5,F6.
Note: *Blechnum* sp. (*B.capense* agg. Lowland sp.) is now named *B.procerum* (see Appendix 6.1)

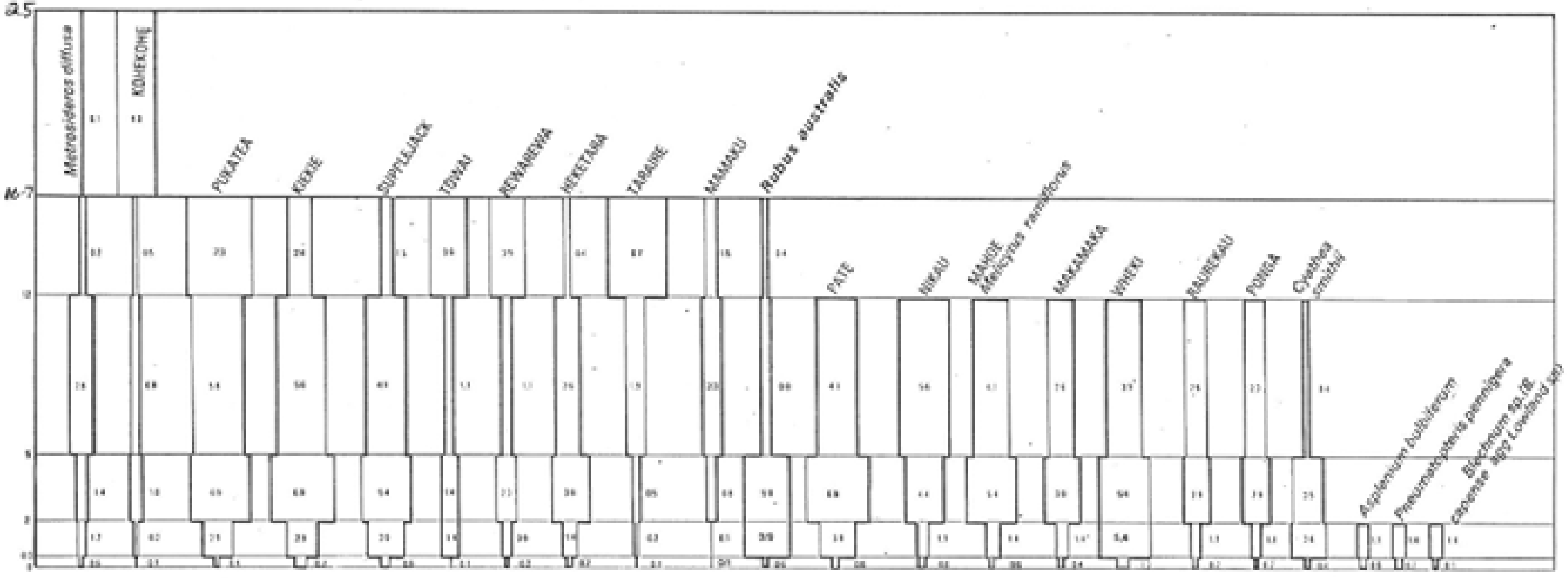


Figure 2.28: Structural representation of vegetation group (ii) towai-supplejack-kohekohe-kiekie determined from classification analysis of vegetation plots in Hill kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 16.5-27m; Tier 2: canopy vegetation = 12-16.5m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively; Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (ii) vegetation was present in the following plots; E5,E6,E7,F7.
Note: *Blechum sp.* (*B.capense* agg. Lowland sp.) is now named *B.procerum* (Appendix 6.1)

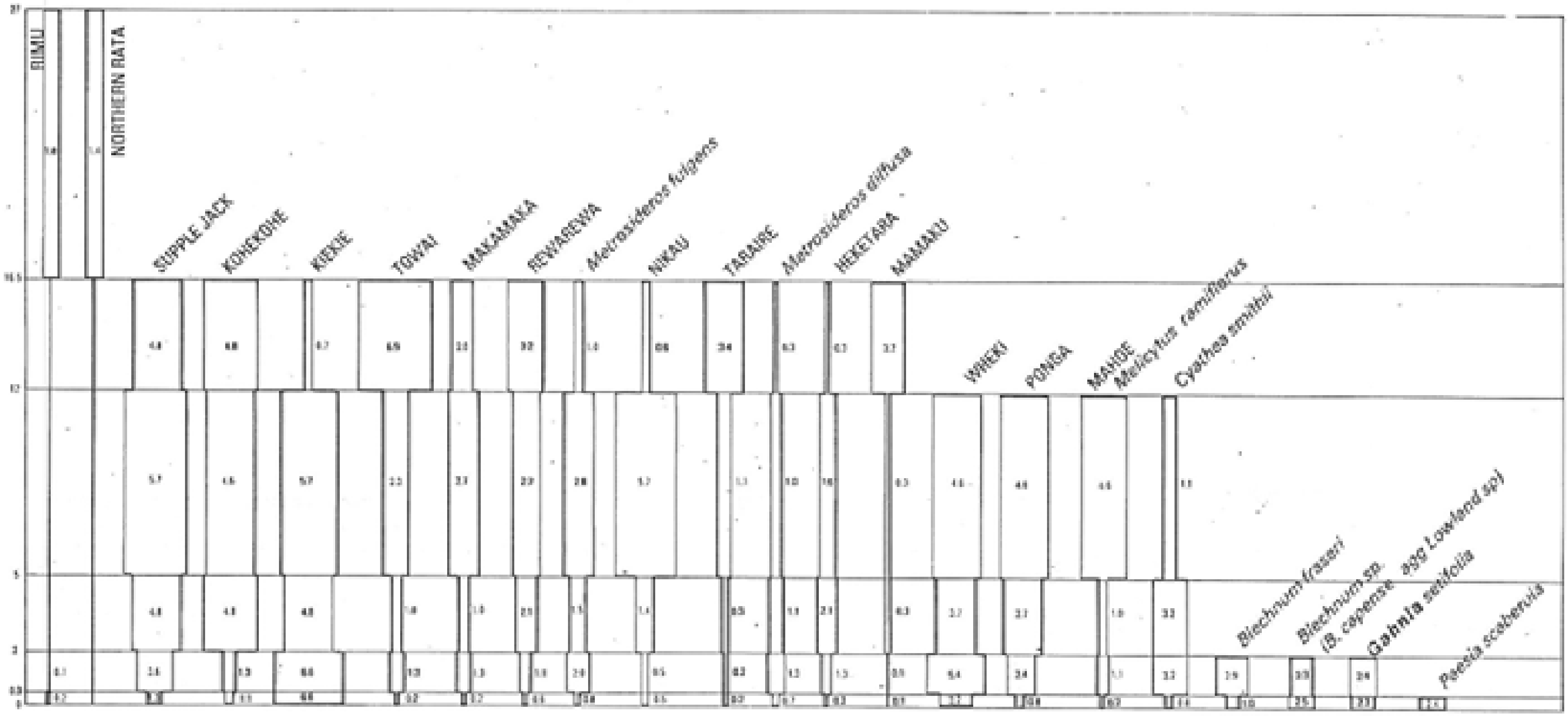


Figure 2.29: **Structural representation of vegetation group (iii) northern rata-taraire-towai-kohekohe determined from classification analysis of vegetation plots in HH kokako home range.**

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 20.3-29.3m; Tier 2: canopy vegetation = 12-20.3m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively; Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (iii) vegetation was present in the following plots: B4,B5,C5,D5,D6,E4,F8.

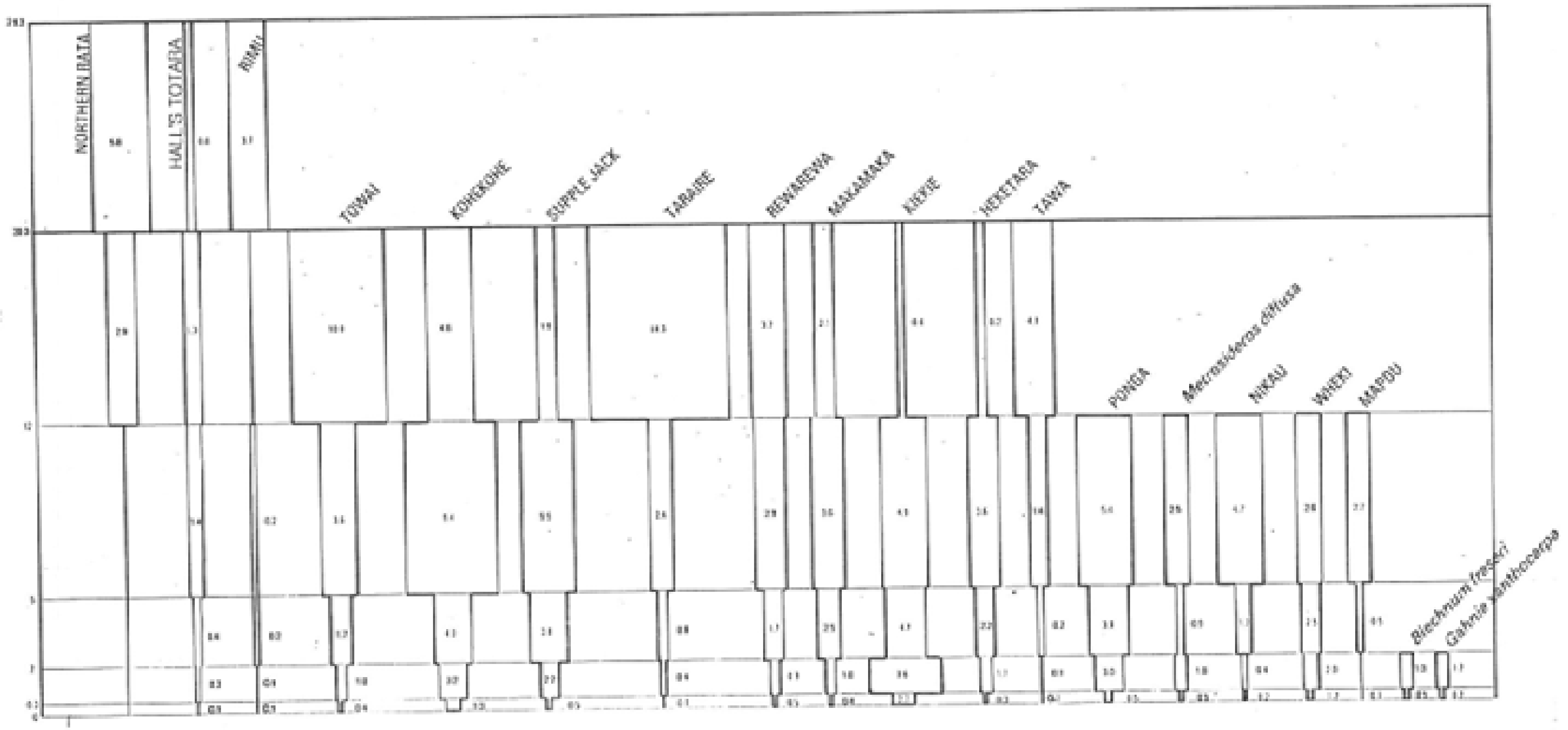


Figure 2.30: **Structural representation of vegetation group (iv) rimu-northern rata-towai-taraire-miro-tawa-kiekie determined from classification analysis of vegetation plots in Hill kokako home range.**

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 19.7-27m; Tier 2: canopy vegetation = 12-19.7m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively; Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (iv) vegetation was present in the following plots; B3,B6,C4,C6,D3,D4,E3,F3,F9.

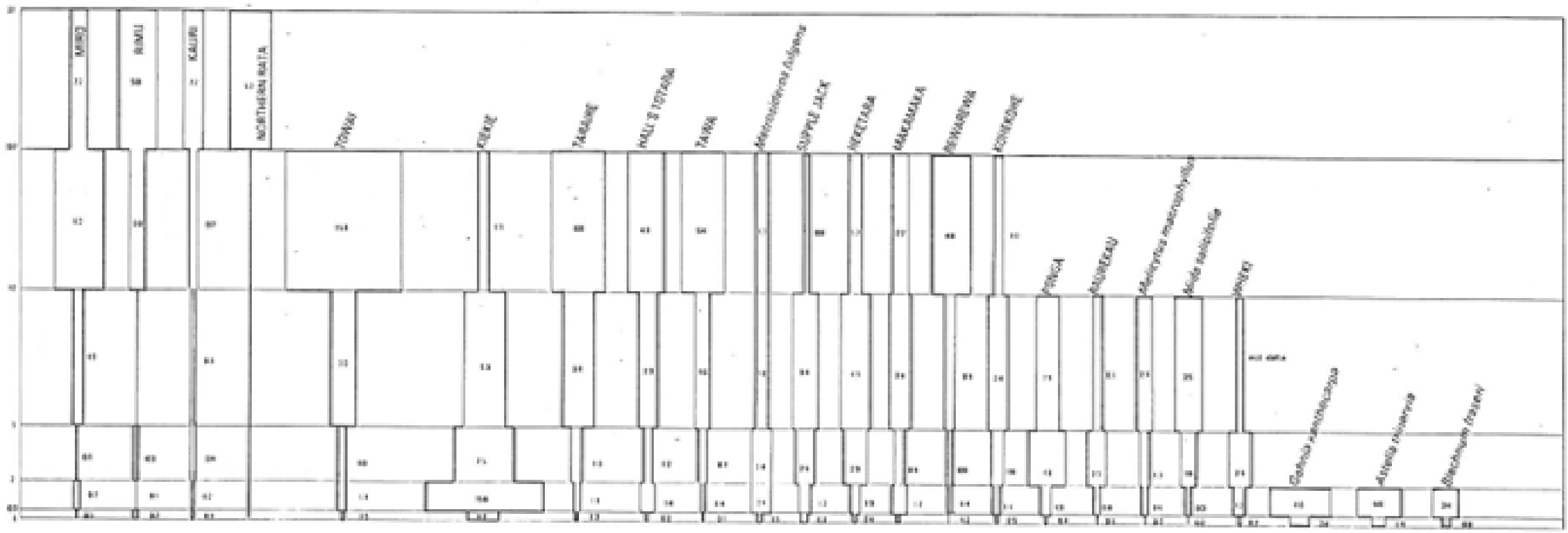


Figure 2.31: **Structural representation of vegetation group (v) kauri-towai-miro -tawa-kiekie determined from classification analysis of vegetation plots in Hill kokako home range.**

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 21.7-30.3m; Tier 2: canopy vegetation = 12-21.7m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively; Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (v) vegetation was present in the following plots; B2,C7,C8,D7,D8,D9,E8,E9,E10.

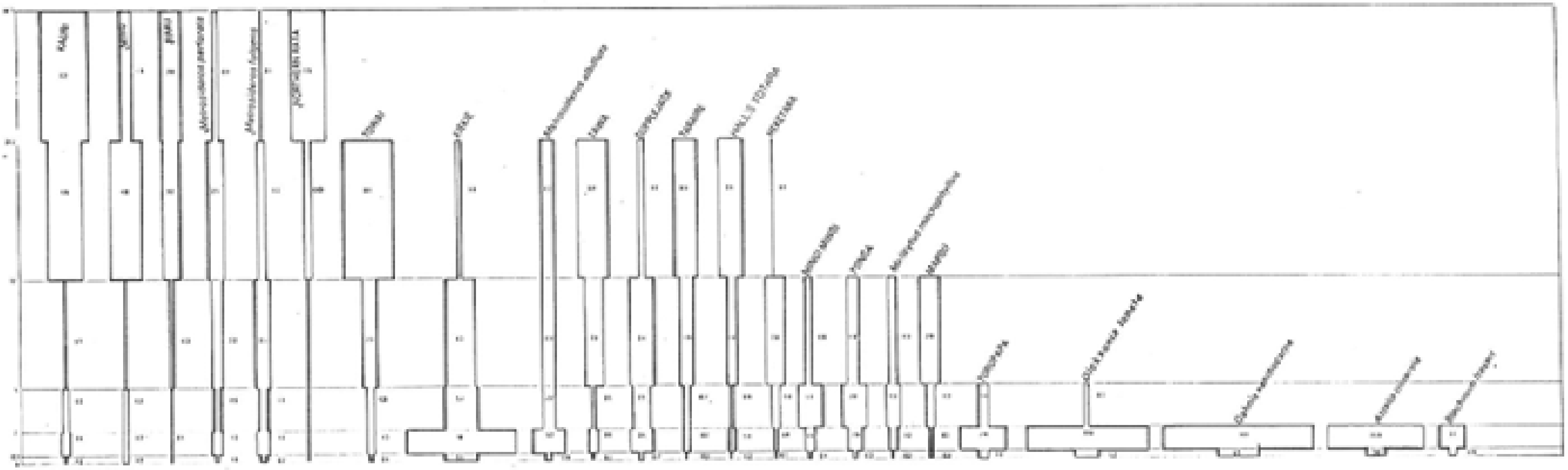
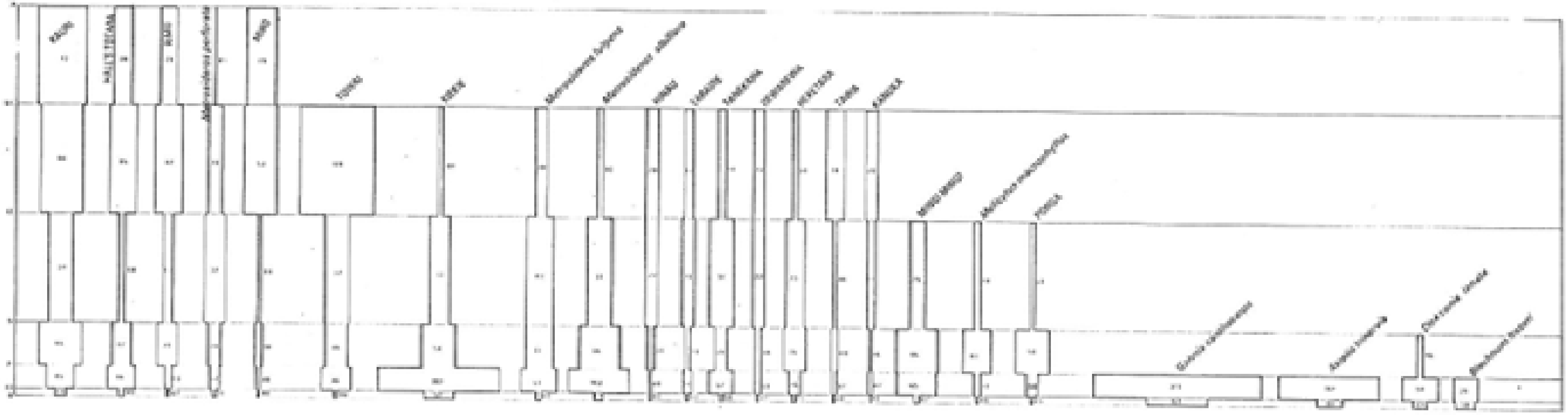


Figure 2.32: Structural representation of vegetation group (vi) kauri-towai-miro-kiekie-*Metrosideros albiflora* determined from classification analysis of vegetation plots in Hill kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = >19.5m; Tier 2: canopy vegetation = 12-19.5m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively; Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (vi) vegetation was present in the following plots; C2,C3,D2,E2.



APPENDIX 2.3

DESCRIPTION OF WAIKAPE KOKAKO HOME RANGE

Gridded area: 1.28ha (Fig.2.33). Centred on grid reference 647N797E, NZMS 260, Sheet P 05. Altitude range: 230-280m asl. Located on a sharply dissected axial ridge between the main course of Waikape Stream (to the south) and a small side catchment of it (to the north), just east of a series of waterfalls on the Waikape Stream.

The main axial ridge had two steeply sloping side ridges ending in bluffs that enclosed a small gully head to the north.

Interpretation of ordination

Ordination by DCA along the first two axes were depicted as graphs for species (Fig.2.34) and for plots (Fig.2.35). The main floristic gradient detected along Axis 1 corresponded with changes in topography (i.e. from ridge top to gully bottom sites) and with associated changes from dry, well-lit exposed sites having skeletal soils to damp, shaded, sheltered sites having more fertile soils. Species with high Axis 1 scores (e.g. *Metrosideros diffusa,* pate and parataniwha) were characteristic of gully sites, while those with low Axis 1 scores (e.g. *Metrosideros albiflora*, and mairehau and *Cyathodes juniperina*) were characteristic of dry ridge-top sites. Species clustered about the middle were either ubiquitous (including kauri in this home range), or were found primarily on ridge flanks (e.g. tawa). The ordination of plots, when compared alongside the map of the home range (Fig.2.33) indicated that the floristic gradient detected coincided with the topgraphic changes in the home range (i.e. the plot at the bottom of the gully (D7) had the highest score while the driest ridge top plot (F6) had the lowest score).

The floristic gradient detected along Axis 2 was not readily interpretable. It may have been that no other major environmental factor was influencing vegetation over such a small area.

Interpretation of TWINSPAN classification

Three TWINSPAN groups were identified. These classification groups have been superimposed on the ordination of plots (Fig.2.35). Again the classification coincided with the main floristic gradient; i.e. it appeared to reflect changes in topography which occurred in the home range. The three vegetation groups identified were:

a) Kauri-rimu-kohekohe-tawa-taraire
b) Kauri-tawa-Hall's totara-taraire
c) kauri-Hall's totara-miro-northern rata-*Metrosideros albiflora*

Group (i) kauri-rimu-kohekohe-tawa-taraire

Found on the lower ridge flanks and in a small gully head of a sidestream of the Waikape Stream; on north-facing, generally well-drained, moderate slopes. The ground was covered in a deep litter layer over much of the area, but on some steeper parts there were dry clay banks, and, at one point, a rock bluff.

The composition and structure of this group has been shown in Figure 2.37. Tiers 5 and 6 contained a wide range of seedlings and saplings and ground cover species, of which the more common species included Kirk's daisy, *Blechnum fraseri, Lastreopsis hispida* and *Asplenium bulbiferum* s.s.

Epiphytes were common and in addition to ubiquitous species, shade and moisture-preferring species such as *Tmesipteris lanceolata* and *Hymenophyllum dilatatum* were common.

Group (ii) kauri-tawa-Hall's totara-taraire

Located on side spurs above a small gully head that was clad in group (i) vegetation (above). The spurs were steep and their flanks were steeper still. The sites were extremely well drained and quite arid in summer. Litter was quite deep where it could accumulate. Dry clay banks occurred, particularly on the flanks of the spurs.

The composition and structure of this group has been depicted in Figure 2.38. Other common species in tier 5 included the sedges *Gahnia lacera, G. pauciflora*, and *G. xanthocarpa*, the shrub waiuatua and the fern *Blechnum* sp. (*B. capense* agg).

Common ground cover species in tier 6 included *Blechnum discolor*, and *Uncinia uncinata* and *U. banksii.*

Epiphytes were common and included species characteristic of shaded ridge flank sites, e.g. *Anarthropteris lanceolata, Tmesipteris elongata* and *T. sigmatifolia.*

Group (iii) kauri-Hall's totara-miro-northern rata-*Metrosideros albiflora*

Situated along the main axial ridge and its predominantly north-facing flanks. The site was of moderate slope and very well drained. There were no obviously emergent trees, but rather a high, even canopy. Litter accumulated deeply around the bases of kauri trees, and there were some bare clay banks.

The composition and structure of this group has been depicted in Figure 2.39. Conspicuous components of tiers 5 and 6 included *Gahnia pauciflora, Blechnum discolor* and mangemange. Ground cover species in tier 6 included those characteristic of kauri-dominated sites, e.g. *Schizaea Dichotoma, Acianthus reniformis, Pterostylis trullifolia* and the rare fern *Grammitis rawlingsii.*

Epiphytes were relatively infrequent; primarily they were ubiquitous species and light-demanding species such as *Bulbophyllum pygmaeum.*

Figure 2.33: **Waikape kokako home range, Puketi Forest. Location:** adjacent to a side ridge on west flank of the lower part of Bramley's Ridge. Scale: each square is 40 x 40m. Approximate altitudinal contours at 20m intervals.

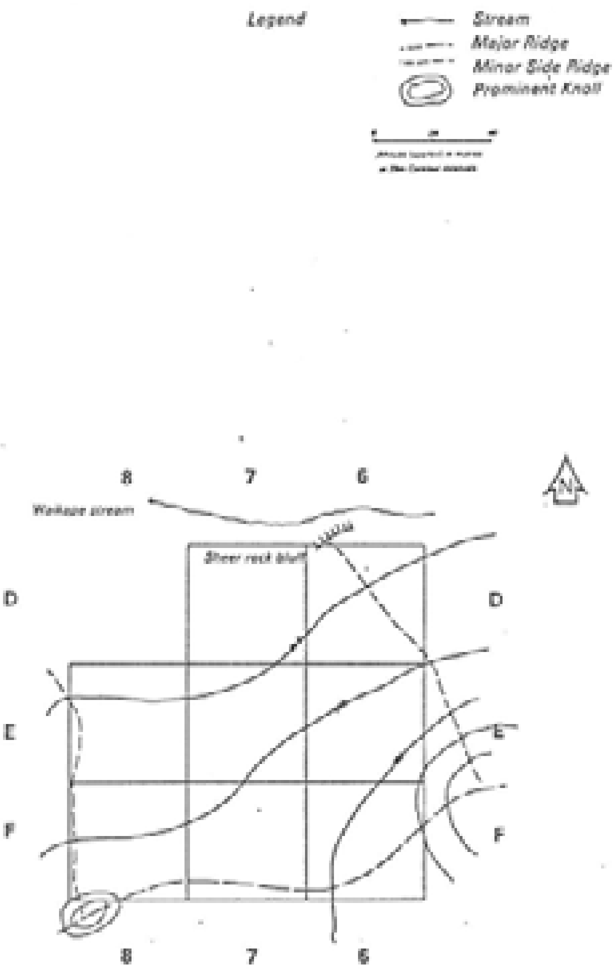


Figure 2.34: Graph depicting ordinaton scores of a selection of species from the eight 40x40m vegetation plots in Waikape kokako home range, along the the two principle floristic gradients detected. The first gradient (Axis 1) corresponds with changes in topography. Species with low Axis 1 scores (e.g. CORbud = korokio) are characteristic of ridge crest sites, while those with high Axis 1 scores (e.g. ELArug = parataniwha) are characteristic of gully bottom sites. The second gradient (Axis 2) is not readily interpretable. Species points are listed below:

Key to Species

ACKros - makamaka
BEItar - taraire
CORbud - korokio
CYAjun - *Cyathodes juniperina*
DYSspe - kohekohe
FREbau - kiekie
HEDarb - pigeonwood
MELram - mahoe
METful - *Metrosideros fulgens*
OLEran - heketara
PHYtri - tanekaha
PODhal - Hall's totara
RIPsca - supplejack

AGAaus - kauri
BEItaw - tawa
CYAdea - ponga
DACcup - rimu
ELAden - hinau
GAHxan - *Gahnia xanthocarpa*
KNIexc - rewarewa
METalb - *Metrosideros albiflora*
METper - *Metrosideros perforata*
PHErud - mairehau
PITten - kohuhu
PSEcra - lancewood
SENkir - Kirk's daisy

ASTtri - *Astelia trinervia*
COPgra - taurekau
CYAfas - mingimingi
DRAlat - neinei
ELArug - parataniwha
GENlig - hangehange
LYGart - mangemange
METdif - *Metrosideros diffusa*
METrob - northern rata
PHYgla - toatoa
PODfer - miro
RHOsap - nikau
WEIsil - towai

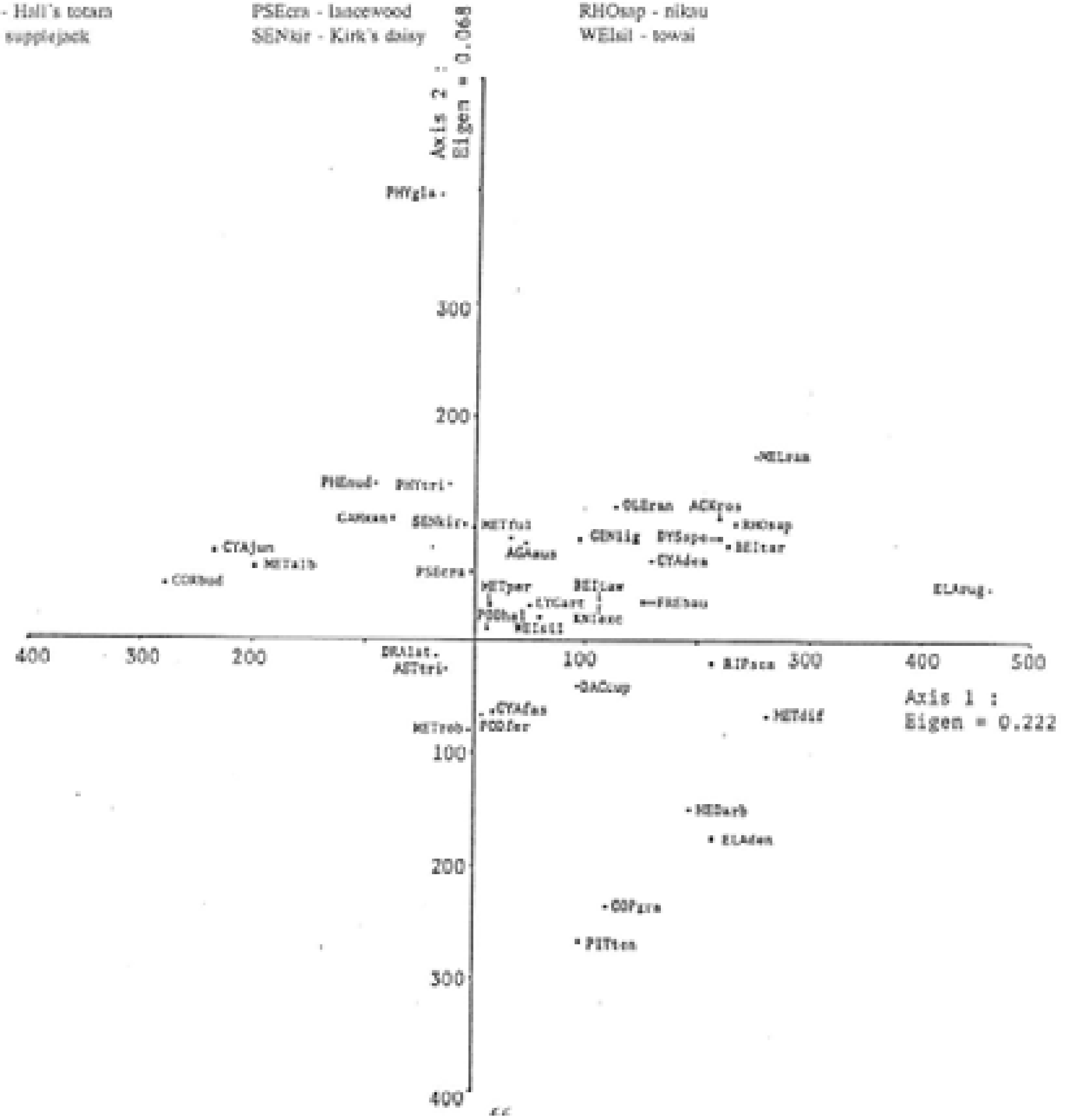


Figure 2.35: Ordination scores of the eight 40x40m vegetation plots in Waikape kokako home range plotted for the two principle floristic gradients detected. The first gradient (Axis 1) corresponds with changes in topography from ridge crests (the lowest scores) to gully bottoms (the highest scores). The second gradient detected (Axis 2) is not readily interpretable. Superimposed on this ordination of plots are three vegetation groups defined for this home range by classification of plots These are:

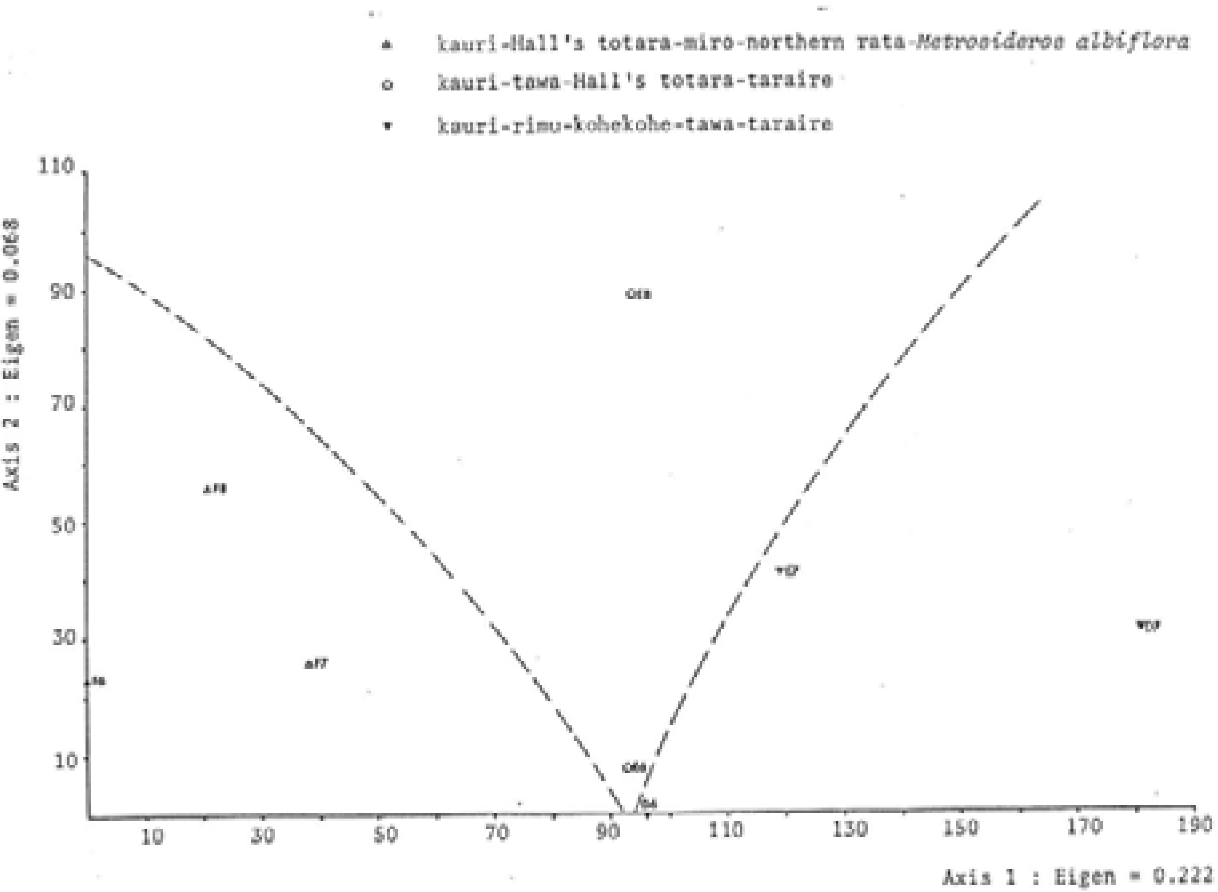


Figure 2.36: Location of three vegetation groups as defined for Waikape kokako home range. The groups were defined by classification and reflect the transition from gully bottom to ridge crest sites. The three groups are listed below, and are shown for appropriate grid squares on the home range map. Scale: each square is 40 x 40m. Approximate altitudinal contours at 20m intervals.

Group (i) kauri-rimu-kohekohe-tawa-taraire; Group (ii) kauri-tawa-Hall's totara-taraire; Group (iii) kauri-Hall's totara-miro-northern rata-*Metrosideros albiflora*

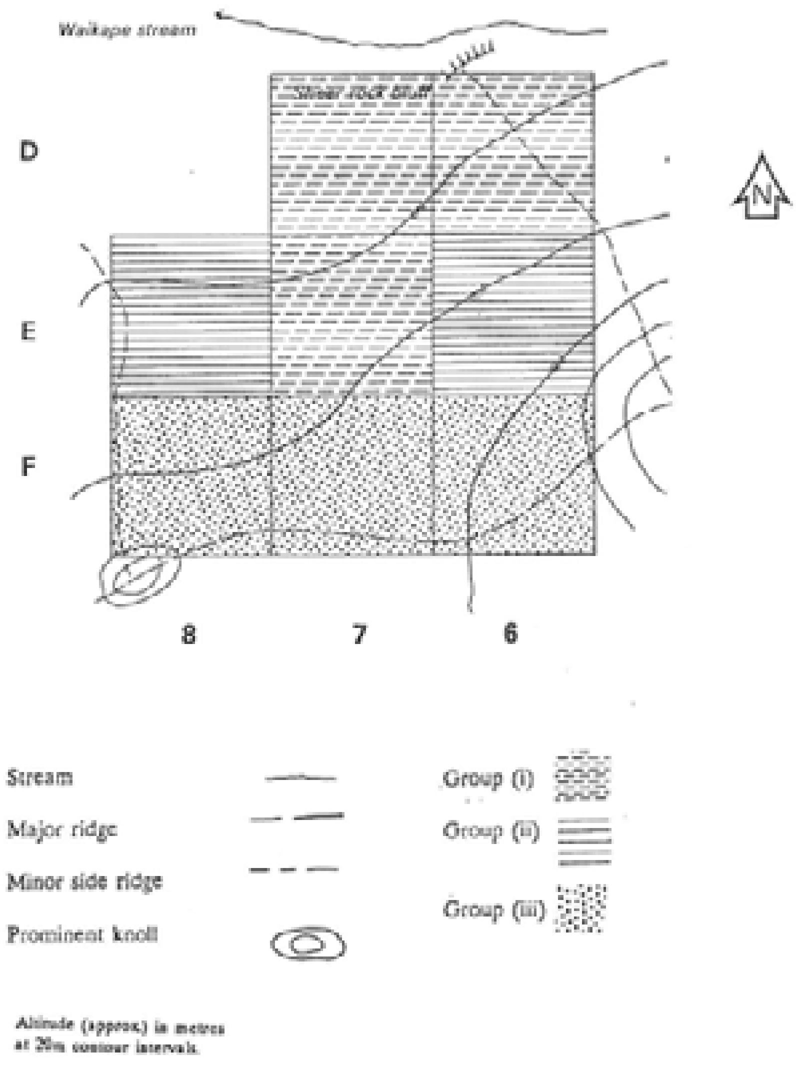


Figure 2.37: Structural representation of vegetation group (i) kauri-rimu-kohekohe-tawa-taraire determined from classification analysis of vegetation plots in Waikape kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 24-29.7m
Tier 2: canopy vegetation = 12-24m
Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively
Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (i) vegetation was present in the following plots; D6,D7,E7.
Note: *Leucopogon fascicularis* is now named *Styphelia fasciculatus* (see Appendix 6.1)

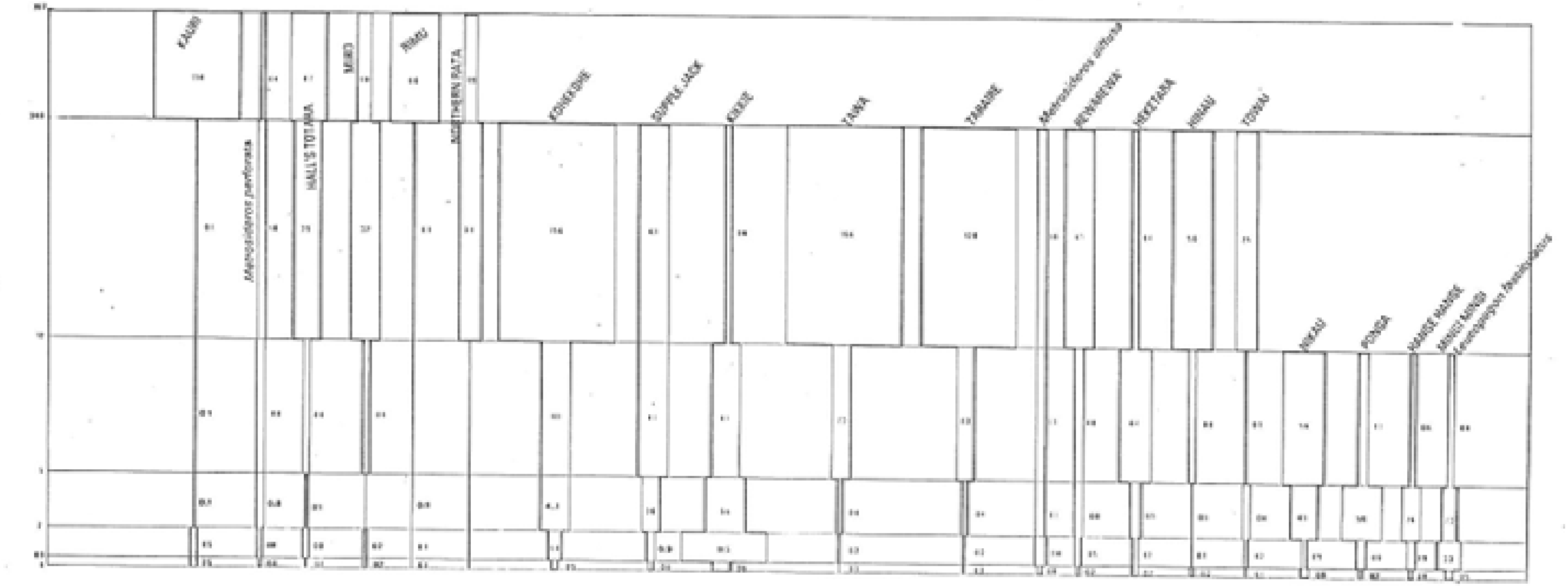


Figure 2.38: Structural representation of vegetation group (ii) kauri-tawa-Hall's totara-taraire determined from classification analysis of vegetation plots in Waikape kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 20-27m; Tier 2: canopy vegetation = 12-20m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively
Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (ii) vegetation was present in the following plots; E6,E8.

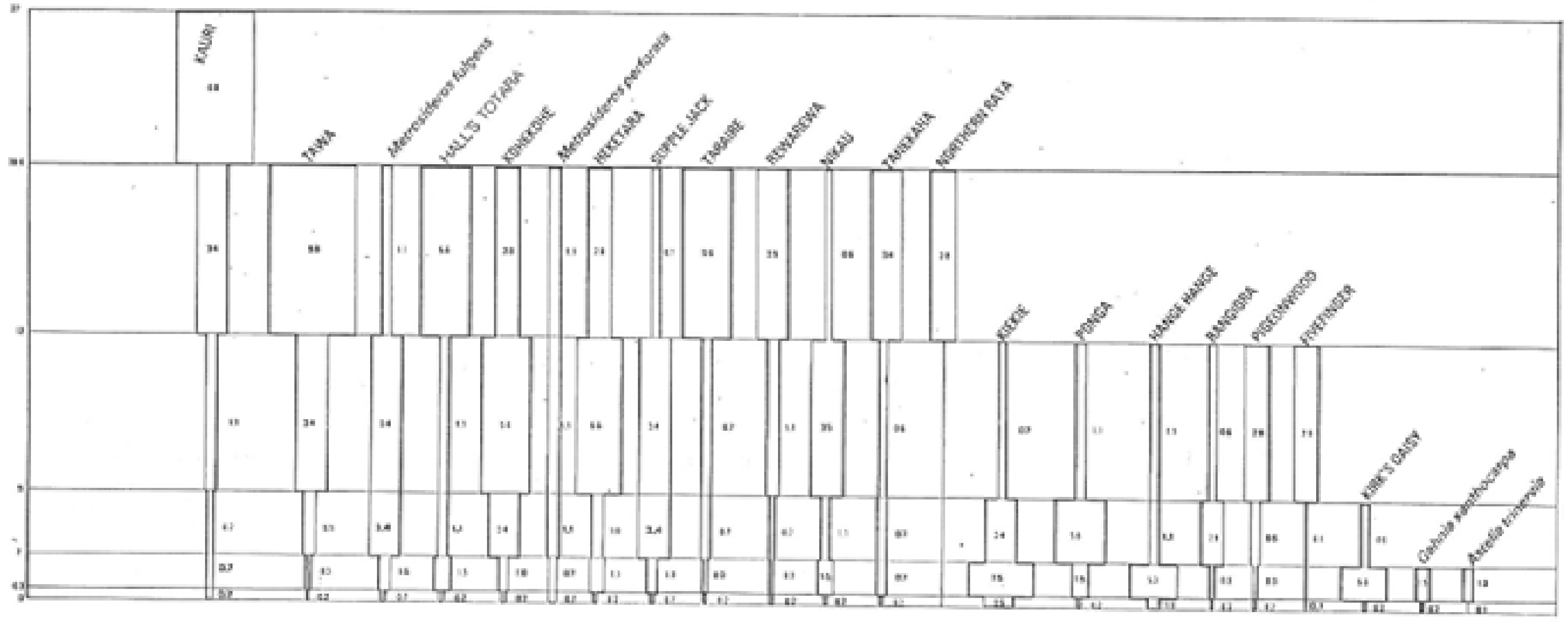
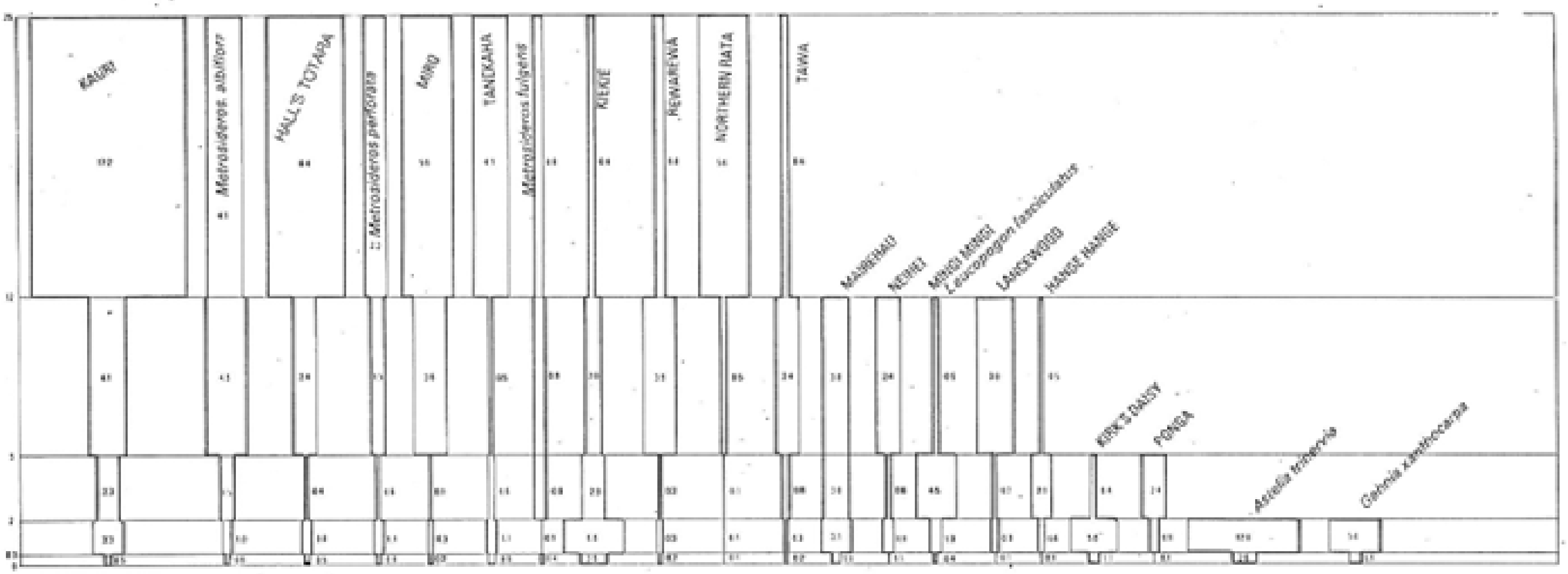


Figure 2.39: **Structural representation of vegetation group (iii) kauri-Hall's totara-miro-northern rata-*Metrosideros albiflora* determined from classification analysis of vegetation plots in Waikape kokako home range.**

Tier height classes are depicted to scale, namely
Tier 2: canopy vegetation = 12-25m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively; Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (iii) vegetation was present in the following plots; F6,F7,F8
Note: *Leucopogon fascicularis* is now named *Styphelia fasciculatus* (see Appendix 6.1)



APPENDIX 2.4

DESCRIPTION OF PET KOKAKO HOME RANGE

Gridded area: 3.84ha (Fig.2.40). Centred on grid reference 632N82E, NZMS 260, Sheet P 05. Altitude range: 390-410m asl. Situated on Pirau Ridge, between Pukatea Stream catchment (to the south) and Merumeru Stream catchment (to the north). The home range enclosed a small gully system at the head of Pukatea Stream, and contained minor side ridges. The axial ridge became a raised plateau at the western end of the home range.

Part of the axial ridge crest was denuded (a result of the Pirau Ridge logging road being installed). The north-west corner of the home range was damaged severely by the 1959 hurricane and subsequent salvage logging. The Takapau tramping track cut through the western end of the home range.

Interpretation of ordination

ordination of species and of plots have been shown in Figure 2.41 and 2.42 respectively. The main floristic gradient in the home range (Axis 1) was readily interpretable as a complex gradient which corresponded with a change in topography, from gully bottom sites to ridge top sites. Associated with this was a change in microenvironment from sheltered, shaded, moist, fertile sites to the drier, more exposed, better lit sites of the ridges with acid litter and podsolised soils. The ordination of species showed that the highest scoring species on Axis 1 were characteritic of ridge-top sites (e.g. kawaka, kauri, mairehau and tawari), while ubiquitous species and species of ridge flanks (e.g. kiekie, raurekau and *Melicytus macrophyllus*) had intermediate scores, and species characteristic of gully bottom sites (e.g. pukatea, mahoe and *Pneumatopteris pennigera*) had low scores. The ordination of plots (Fig.2.42) gave further credance to this interpretation, when seen alongside map of the home range (Fig.2.40), i.e. the plots nearest the axial ridge (where the vegetation was intact; e.g. D1, E1) had the highest scores, while those on ridge flanks (e.g. A5, C4) had intermediate scores and those in gullies (e.g. D3, A6) had low scores.

Although Axis 2 accounted for a lesser proportion of the data's variability, the floristic gradient it detected was interpretable, nonetheless. Most species with high Axis 2 scores had scores in the middle to lower part of Axis 1, i.e. they were species primarily of gullies or ridge flanks. It was clear that the complex floristic gradient along Axis 2 coincided with a change from relatively undisturbed to highly disturbed sites. Species with high Axis 2 scores included gorse, broad-leaved flebane, pampas grass and sweet vernal, which were characteristic of highly disturbed sites; they were colonising bare clay along the road margins. Species with low Axis 2 scores included pukatea, *Pneumatopteris pennigera* and *Trichomanes endlicherianum,* and all of which were present in the relatively undisturbed gully bottom. Plots with high Axis 2 scores included (which had its canopy virtually destroyed by the 1959 hurricane and subsequent salvage logging), and also those (A2, A3, A4, A5, B5, B6) which had part of their canopy removed in the formation of a logging road. This clay road provided a habitat for many weed species, and shrubs have flourished at the forest margin. The ridge-top vegetation along this part of the axial ridge has been virtually eliminated. Plots with low Axis 2 scores (e.g E3, D4, D3) were on relatively undisturbed sites in the gully bottom.

Interpretation of TWINSPAN classification

TWINSPAN classification has separated six vegetation groups, the boundaries of which have been superimposed onto ordination of plots in Figure 2.42. The classification of plots mirrored the floristic gradients detected in ordination, those associated with changes in topography and with degrees of disturbance. The groups were :

a) taraire-towai-kohekohe-supplejack-kiekie
b) taraire-towai-kiekie
c) kauri-miro-towai-taraire
d) towai-kohuhu-fivefinger-mamaku-*Rubus australis-Gahnia xanthocarpa*
e) kauri-miro-towai
f) kauri-tawari-kiekie-Hall's totara

The positions of these vegetation groups in the home range have been shown in Figure 2.43. They occurred in the following sites:

group (i) in undisturbed gully bottoms,
group (ii) in gully heads, considerably modified,
group (iii) on ridge flanks, relatively unmodified,
group (iv) on a ridge top, severely modified,
group (v) on upper ridge flanks, unmodified
group (vi) on a ridge top, unmodified.

Group (i) taraire-towai-kohekohe-supplejack-kiekie
Found at the bottom of the small gully from which the headwaters of a small side branch of Pukatea Stream began to flow, and also north of the axial ridge, near the headwaters of Merumeru Stream. Most of the site was of moderate slope and faced predominantly to the south; drainage was medium to poor. The ground was covered in deep litter. Herbaceous and bryophyte ground cover was abundant. Damp clay banks occurred nearer the stream course.

The composition and structure of this group has been depicted in Figure 2.44. Common ground cover species included *Asplenium bulbiferum* s.s., *Microlaena avenacea* and *Blechnum fraseri.*

Epiphytes were abundant and included species characteristic of moist, shaded gully sites, e.g. *Tmesipteris lanceolata* and *Trichomanes venosum*, and less commonly *Trichomanes endlicherianum* and *Hymenophyllum ferrugineum.*

Group (ii) taraire-towai-kiekie
Found on both the north and south flanks and gully heads of the axial ridge separating the Pukatea and Merumeru catchments. The sites were of moderate to steep slope. The vegetation along the axial ridge had been cleared for a clay logging road, which cut a swathe c.10m wide through the forest; rank growth of many species occurred along its margin. Drainage on the flanks was generally good. There was a deep litter layer and ground cover under the forest canopy, while road area was a generally well-drained, clay surface.

The composition and structure of this group has been illustrated in Figure 2.45. Common ground cover species under forest cover included *Blechnum fraseri, Aspolenium bulbiferum* s.s. and *Microlaena avenacea*. A wide range of weeds and species characteristic of disturbed sites grew at the edge of the forest and along the road margins, the more common of these including *Paesia scaberula, Dianella nigra, Centella uniflora, Microlaena stipoides*, browntop and sweet vernal.

Epiphytes were common under the forest particularly those that were characteristic of shaded ridge flank sites, e.g. *Blechnum filiforme* and *Anarthropteris lanceolata.*

Group (iii) kauri-miro-towai-taraire
Located on the moist shaded lower ridge flanks adjoining the Pukatea Stream headwaters. The sites were moderately drained and of moderate slope, and, compared with the previous group, were quite undisturbed. There was a deep litter layer, and herbaceous and bryophyte ground cover was common.

The composition and structure of this group has been depicted in Figure 2.46. Common ground cover species of both tiers 5 and 6 included *Astelia trinervia, Gahnia xanthocarpa* and *Asplenium bulbiferum* s.s.

Epiphytes were common and included species of moist shaded flanks, e.g. *Anarthropteris lanceolata* and *Hymenophyllum ferrugineum.*

Group (iv) towai-kohuhu-fivefinger-mamaku-*Rubus australis-Gahnia xanthocarpa*
Occupied a small area on the axial ridge of the home range. Formerly, the site was clad probably in group (vi) vegetation (i.e. kauri-tawari-kiekie-Hall's totara), which had been damaged by the 1959 and subsequent salvage logging to such an extent that only a low, sparse, regenerating canopy remained over a very dense shrub tier.

The terrain was gently sloping, of north-east aspect, and well-drained. The ground had a dense litter layer, and clay banks were present on more exposed sites (e.g. next to the Takapau tramping track, which cut through this group).

The composition and structure of this group has been shown in Figure 2.47. Tier 4 (2-5m) was extremely dense beneath a sparse canopy predominantly of towai. It consisted of scattered shrubs and a dense tangle of lianes, in particular *Rubus australis.* Beneath this lay a dense thicket of *Gahnia xanthocarpa.* Ground cover under the most dense vegetation was almost non-existent. Species associated with disturbance were common alongside the margins of the tramping track, e.g. *Paesia scaberula, Dianella nigra* and Microlaena stipoides.

Epiphytes were uncommon in the few canopy trees present and were light-preferring species such as *Bulbophyllum pygmaeum.*

Group (v) kauri-miro-towai
Existed in a small area on an east-facing ridge flank and ridge crest. The site sloped steeply and was of moderate drainage. One part had been disturbed slightly by the wind and logging damage which affected the previous group, but to no great extent. The ground was covered in deep litter and common herbaceous species. Bryophytes were particularly common.

The composition and structure of this group has been depicted in Figure 2.48. A range of seedlings and saplings contributed to tiers 5 and 6. *Blechnum* sp. (*B. capense* agg) was conspicuous, but *Astelia trinervia* and *Gahnia xanthocarpa* were relatively uncommon.

Epiphytes were common and included species characteristic of moist flanks, e.g. *Hymenophyllum dilatatum,* and *Tmesipteris sigmatifolia* was common on the trunks of *Dicksonia* aff. *lanata.*

Group (vi) kauri-tawari-kiekie-Hall's totara
Present on a gently sloping plateau east of the axial ridge of the home range; it formed the fringes of the large Takapau kauri stand. Surface drainage was good, but the water table appeared to be high. The site was mostly east to south-east facing. Deep litter had accumulated around the bases of large kauri trees. In one place, the canopy had collapsed leaving a few kauri and rimu trees as emergents over dense gymnosperm regeneration. Elsewhere, kauri formed the bulk of a high, even canopy, with a tall understorey dominated by tawari.

The composition and structure of this group has been illustrated in Figure 2.49. Other common in tiers 5 and 6 included *Alseuosmia* x *quercifolia* and *Blechnum fraseri;* other common ground cover species included *Lindsaea trichomanoides* and *Asplenium oblongifolium.*

Epiphytes were uncommon, particularly in the crowns of kauri trees where only puka and *Pittosporum cornifolium* were common. Their lower trunks were coated in young *Metrosideros* spp. lianes and the fern *Grammitis pseudociliata.* Epiphytes were more common on other tree species in this group.

Figure 2.40: Pet kokako home range, Puketi Forest. Location: about a small headwater catchment of Pukatea Stream, south side of Pirau Ridge Road and including the edge of the Takapau Kauri Stand. Scale: each square is 40 x 40m. Approximate altitudinal contours at 20m intervals.

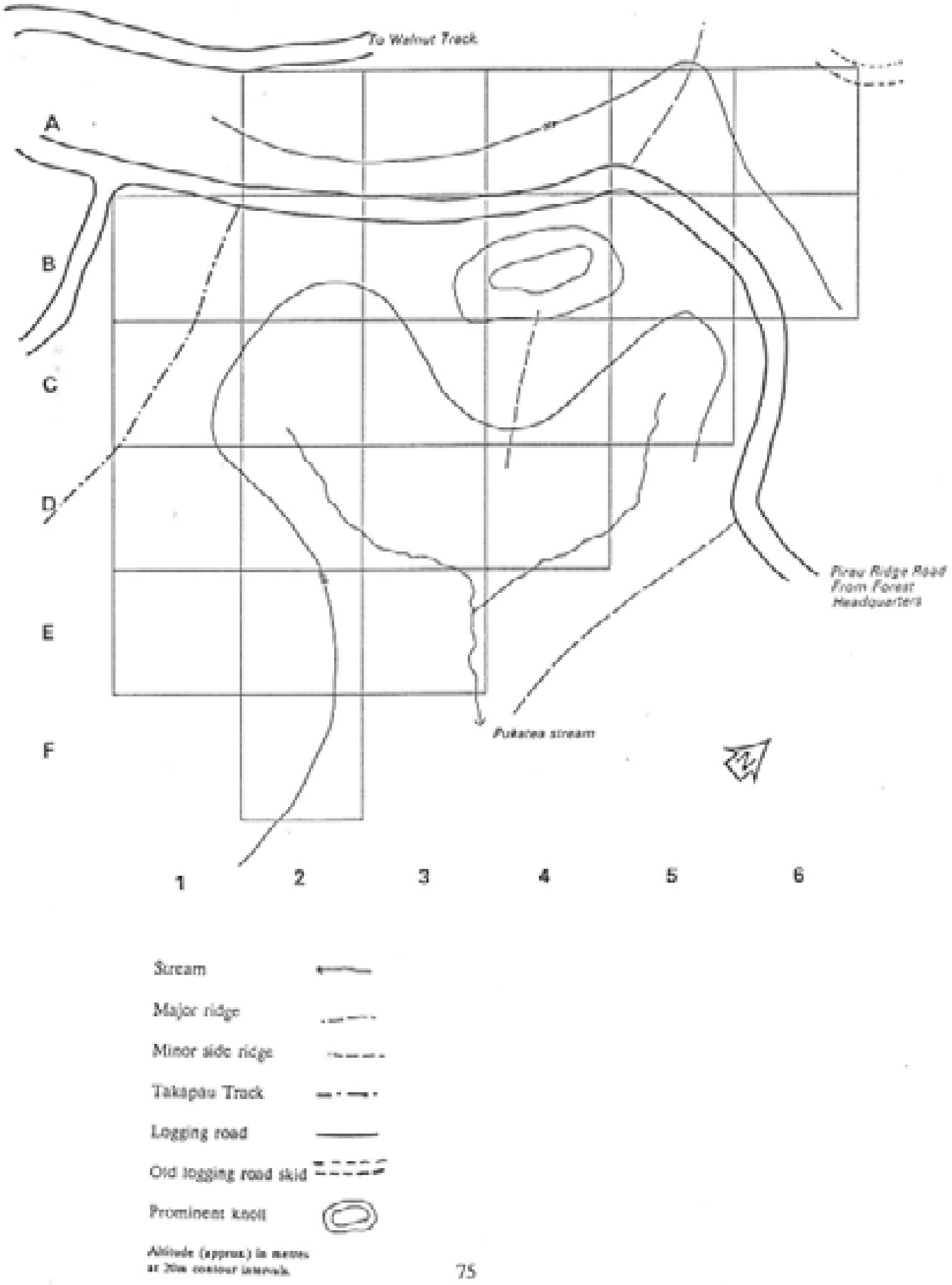


Figure 2.41: Graph depicting ordination scores of a selection of species from the twenty four 40x40m vegetation plots in Pet kokako home range along the two principle floristic gradients detected. The first gradient (Axis 1) corresponds with changes in topography. Species with low Axis 1 scores (e.g. MELram = mahoe) are characteristic of gully bottom sites, while those with high Axis 1 scores (e.g. CORbud = korokia) are characteristic of ridge crest sites. The second gradient (Axis2) corresponds with the degree of disturbance. Species with low Axis 2 scores (e.g. PNEpne = *Pneumatopteris pennigra*) are characteristic of least disturbed sites, while those with high Axis 2 scores (e. g. ANTodo = sweet vernal) are characteristic of highly disturbed sites. Species points are listed below:

Key to species

ACKros - makamaka
ANTodo - sweet vernal
BEItaw - tawa
BLEfra - *Blechnum fraseri*
CYAdea - ponga
DYSspe - kohekohe
GAHxan - *Gahnia xanthocarpa*
HYPrat - catsear
LAUnov - pukatea
METalb - *Metrosideros albiflora*
METrob - northern rata
PHEnud - mairehau
PODfer - miro
QUIser - tawheowheo
RIPsca - supplejack

AGAaus - kauri
ASTtri - *Astelia trinervia*
BLEcap - *Blechnum* sp.(*B.capense* agg)
COPgra - raurekau
DACcup - rimu
FREbau - kiekie
GENlig - hangehange
IXEbre - tawari
LYGart - mangemange
METdif - *Metrosideros diffusa*
MICsti - *Microlaena stipoides*
PITten - kohuhu
PODhal - Hall's totara
RHOsap - nikau
SCHdig - pate

ALSmac - toropapa
BEItar - taraire

CORbud - korokio
DRAlat - neinei
GAHset - *Gahnia setifolia*
HEDarb - pigeonwood
KNIexc - rewarewa
MELram - mahoe
METful - *Metrosideros fulgens*
OLEran - heketara
PNEpen - *Pneumatopteris pennigera*
PSEedg - raukawa
RHOsap - nikau
WEIsil - towai

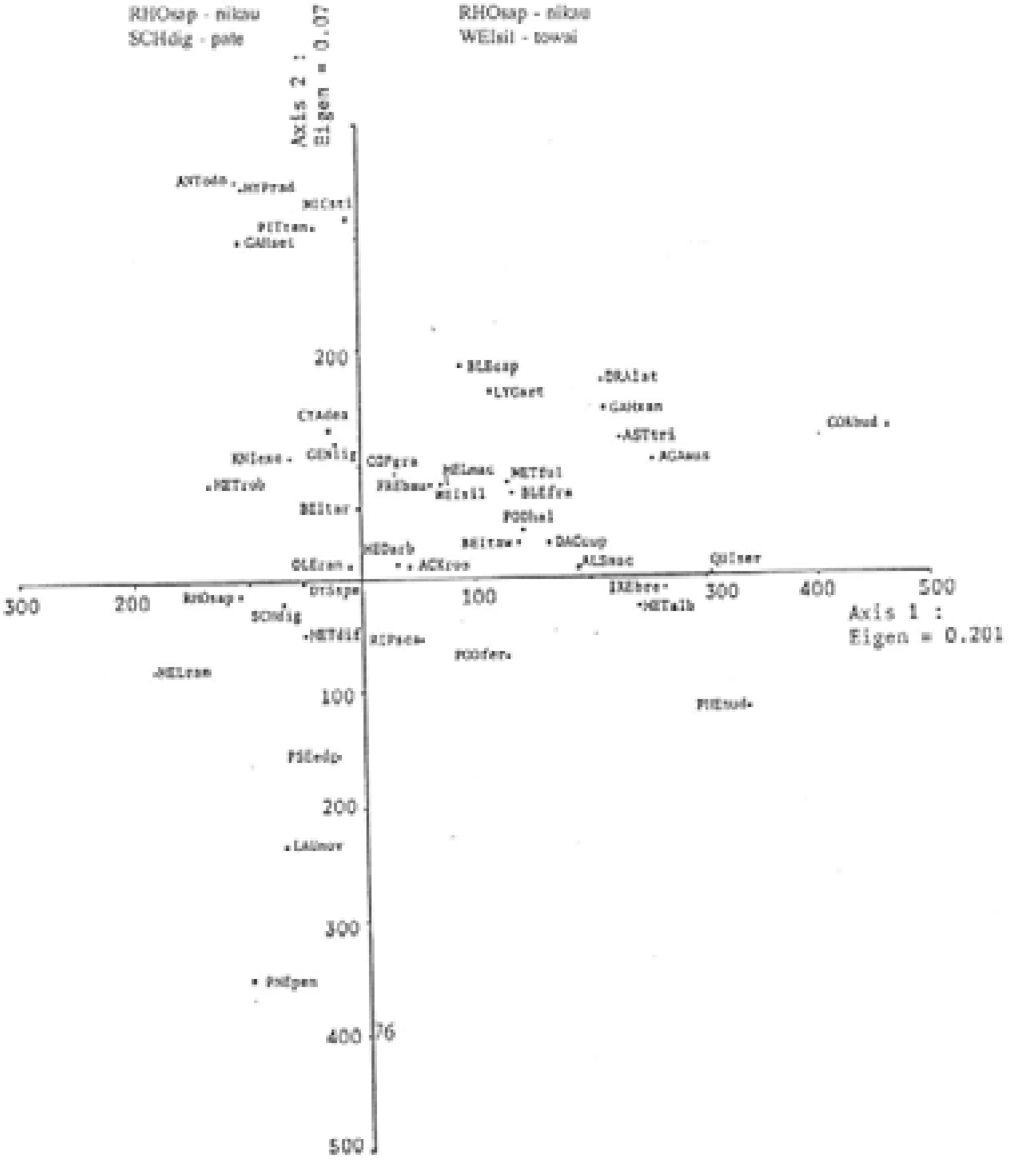


Figure 2.42: Ordination scores of the twenty four 40x40m vegetation plots in Pet kokako home range plotted against the two floristic gradients detected. The first gradient (Axis 1) corresponds with changes in topography from gully bottoms (the lowest score) to ridge tops (the highest scores). The second gradient (Axis 2) corresponds with the degree of disturbance, with the least disturbed plots having the lowest Axis 2 scores and the most disturbed plots having the highest scores. Superimposed on this ordination of plots are six vegetation groups defined for this home range by classification. These are:

▲ taraire-towai-kohekohe-supplejack-kiekie
■ taraire-towai-kiekie
○ kauri-miro-towai-taraire
▼ towai-kohuhu-five-finger-mamaku-*Rubus australis*-*Gahnia xanthocarpa*
□ kauri-miro-towai
● kauri-tawaire-kiekie-Hall's totara

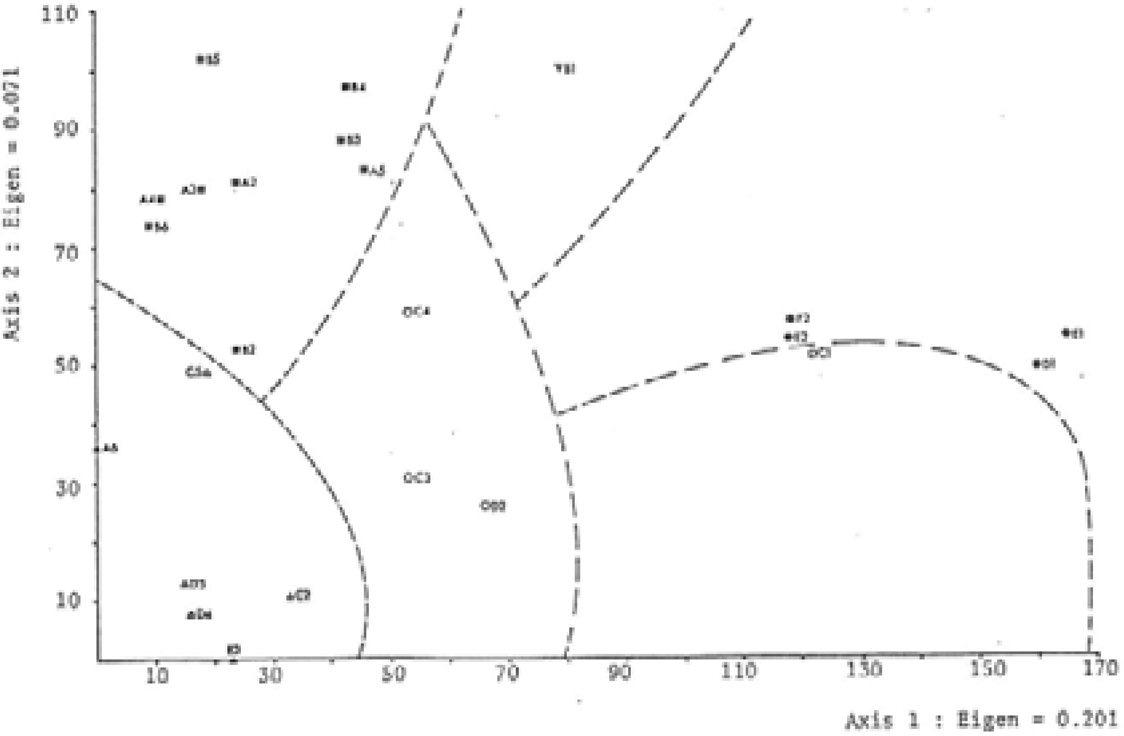


Figure 2.43: Location of six vegetation groups defined for Pet kokako home range. The groups were defined by classification and reflect primarily the transition from gully bottom to ridge top, although damage to the vegetation by storms and by logging is also a major influence. The six groups defined are listed below, and are shown for the appropriate grid square on the home range map. Scale: each square is 40 x 40m. Approximate altitudinal contours at 20m intervals.

Group (i) taraire-towai-kohekohe-supplejack-kiekie; Group (ii) taraire-towai-kiekie
Group (iii) kauri-miro-towai-taraire; Group (iv) towai-kohuhu-fivefinger-mamaku-*Rubus australis*-
Gahnia xanthocarpa; Group (v) kauri-miro-towai; Group (vi) kauri-tawari-kiekie-Hall's totara

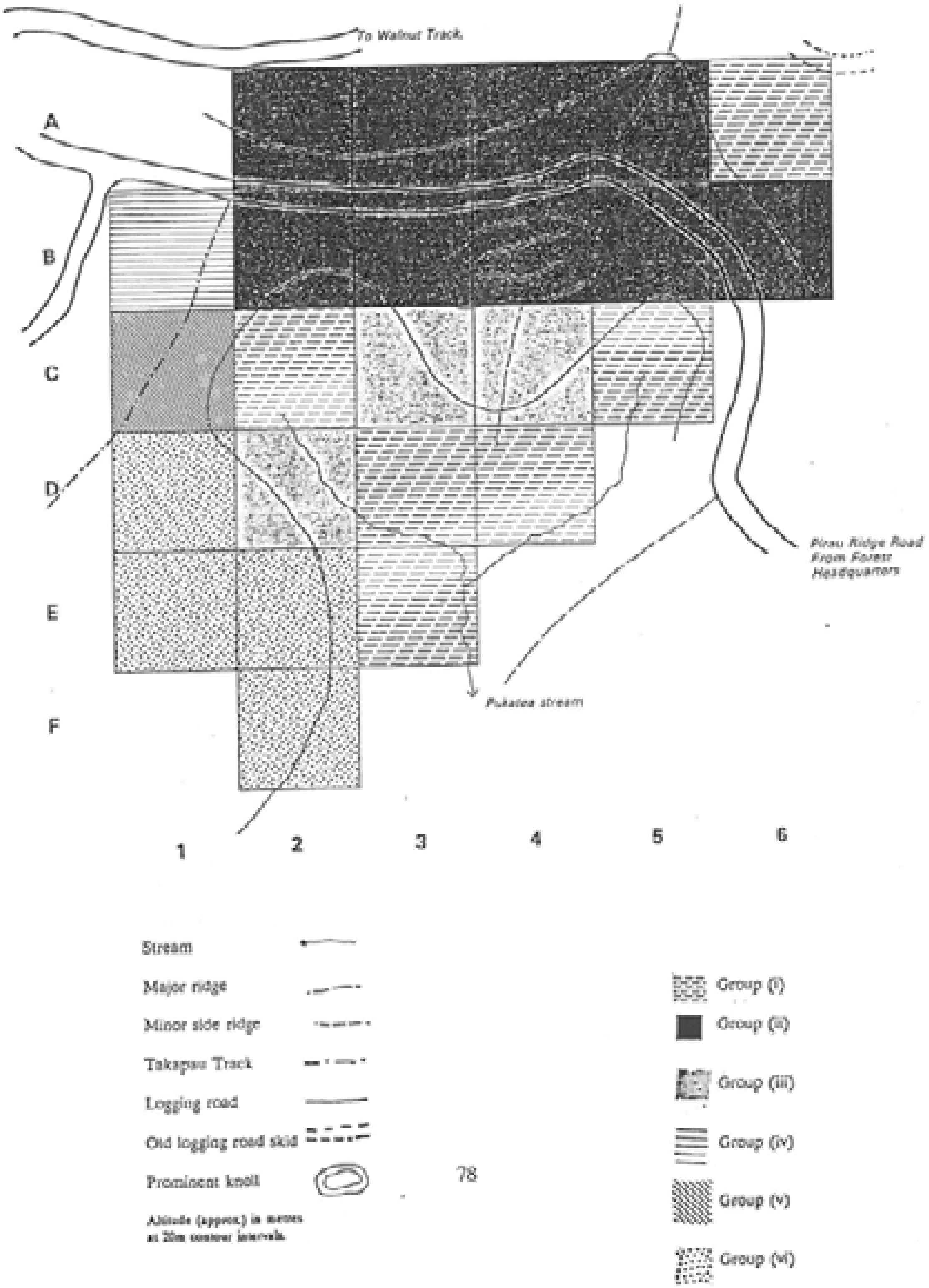


Figure 2.44: Structural representation of vegetation group (i) taraire-towai-kohekohe-supplejack-kiekie determined from classification analysis of vegetation plots in Pet kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 17-22.5m; Tier 2: canopy vegetation = 12-17m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively
Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (i) vegetation was present in the following plots; A6,C2,C5,D3,D4,E3.

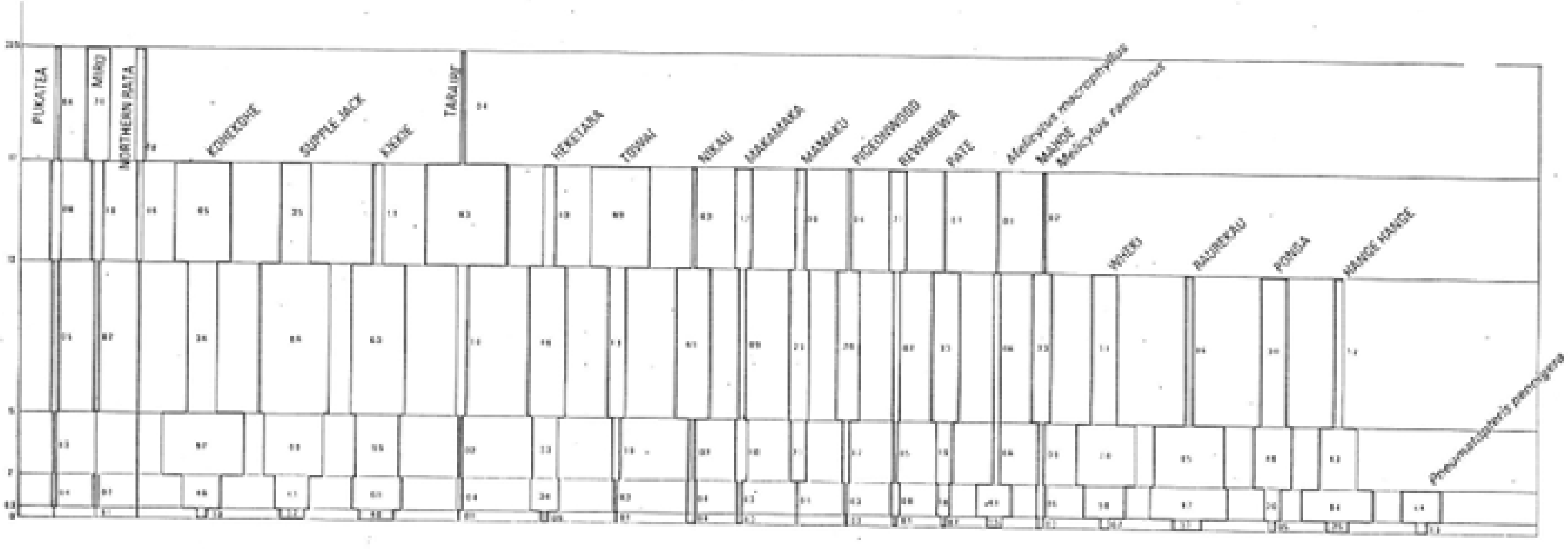


Figure 2.45: Structural representation of vegetation group (ii) taraire-towai-kiekie determined from classification analysis of vegetation plots in Pet kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 15.7-30m; Tier 2: canopy vegetation = 12-15.7m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively
Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (ii) vegetation was present in the following plots; A2,A3,A4,A5,B2,B3,B4,B5,B6.

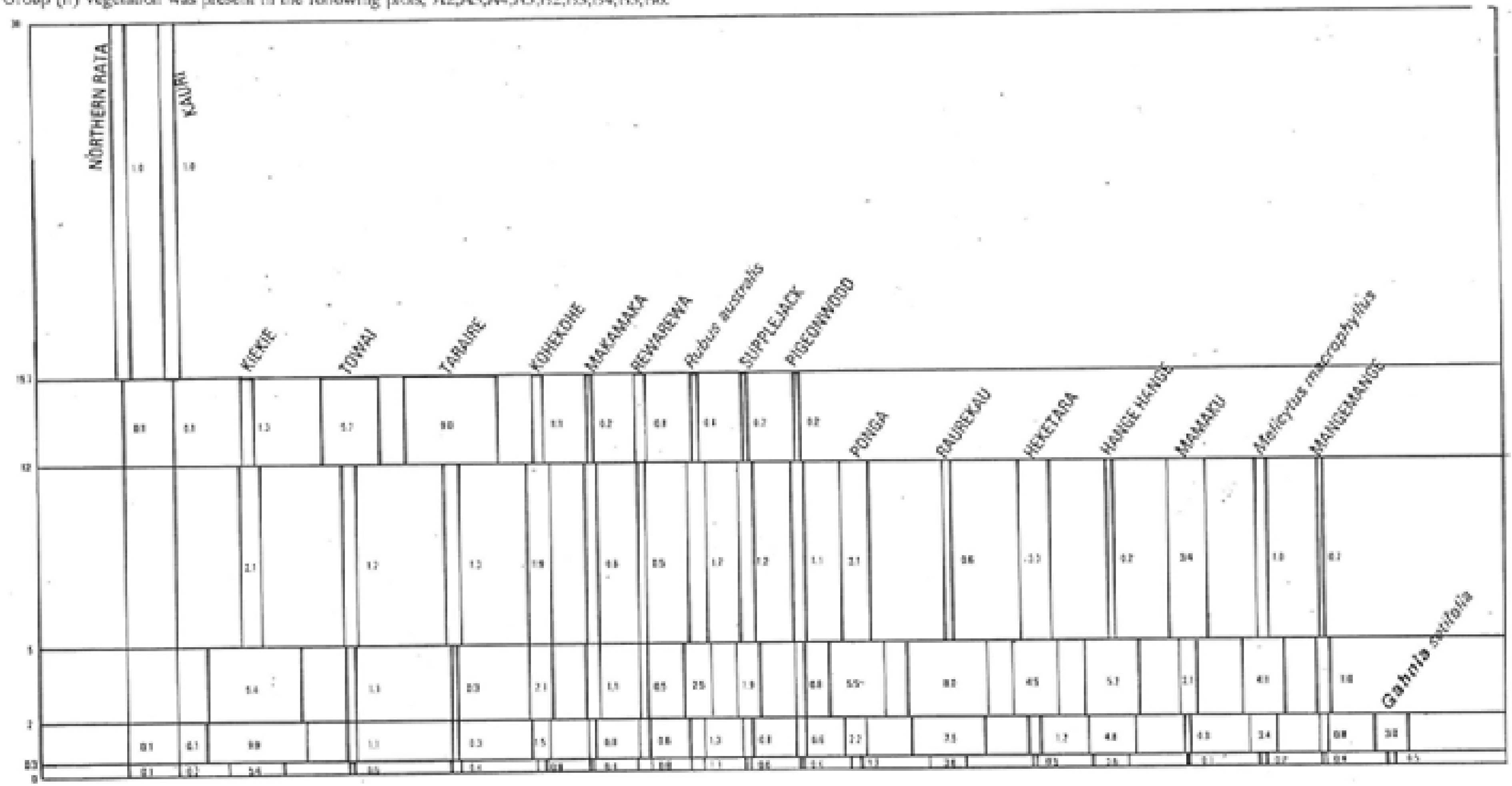


Figure 2.46: Structural representation of vegetation group (iii) kauri-miro-towai-taraire determined from classification analysis of vegetation plots in Pet kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 17.3-21.7m; Tier 2: canopy vegetation = 12-17.3m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively
Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (iii) vegetation was present in the following plots; C3,C4,D2.

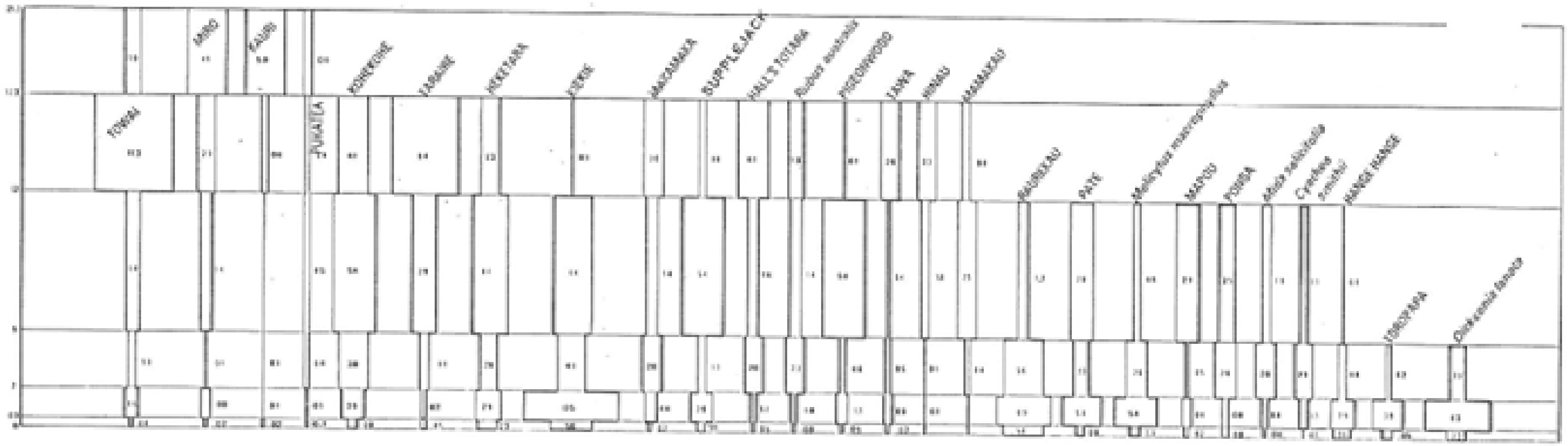


Figure 2.47: Structural representation of vegetation group (iv) towai-kohuhu-fivefinger-mamaku-*Rubus australis*-*Gahnia xanthocarpa* determined from classification analysis of vegetation plots in Pet kokako home range.

Tier height classes are depicted to scale, namely
Tier 2: canopy vegetation = 12-16m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively; Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (iv) vegetation was present in the following plots; B1.
Note: *Leucopogon fascicularis* is now named *Styphelia fasciculatus* (see Appendix 6.1)

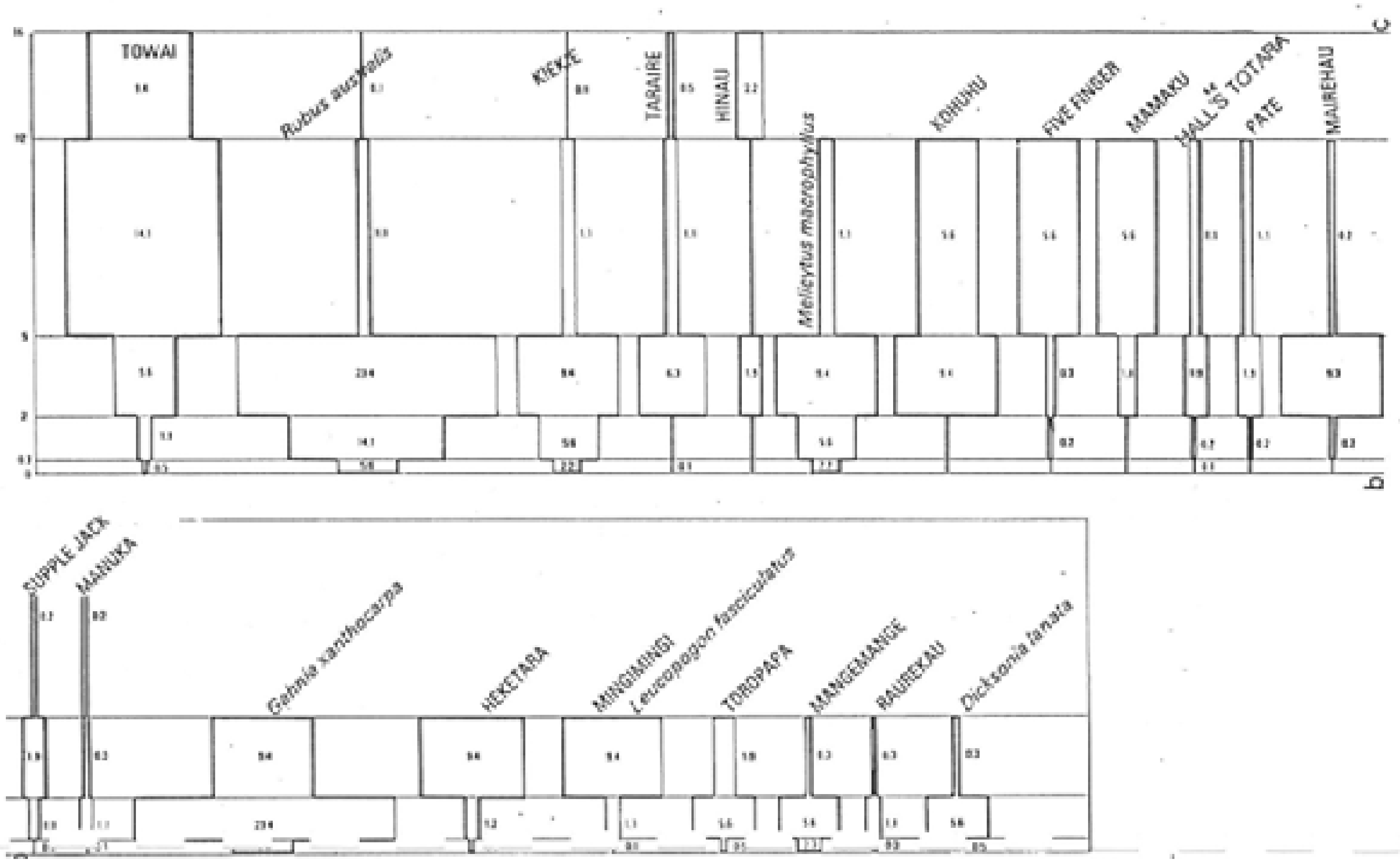


Figure 2.48: **Structural representation of vegetation group (v) kauri-miro-towai determined from classification analysis of vegetation plots in Pet kokako home range.**

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 18-25m; Tier 2: canopy vegetation = 12-18m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively
Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (v) vegetation was present in the following plots; C1.
Note: *Blechnum* sp. (*B.capense* agg. Lowland sp.) is now named *B.procerum* (see Appendix 6.1)

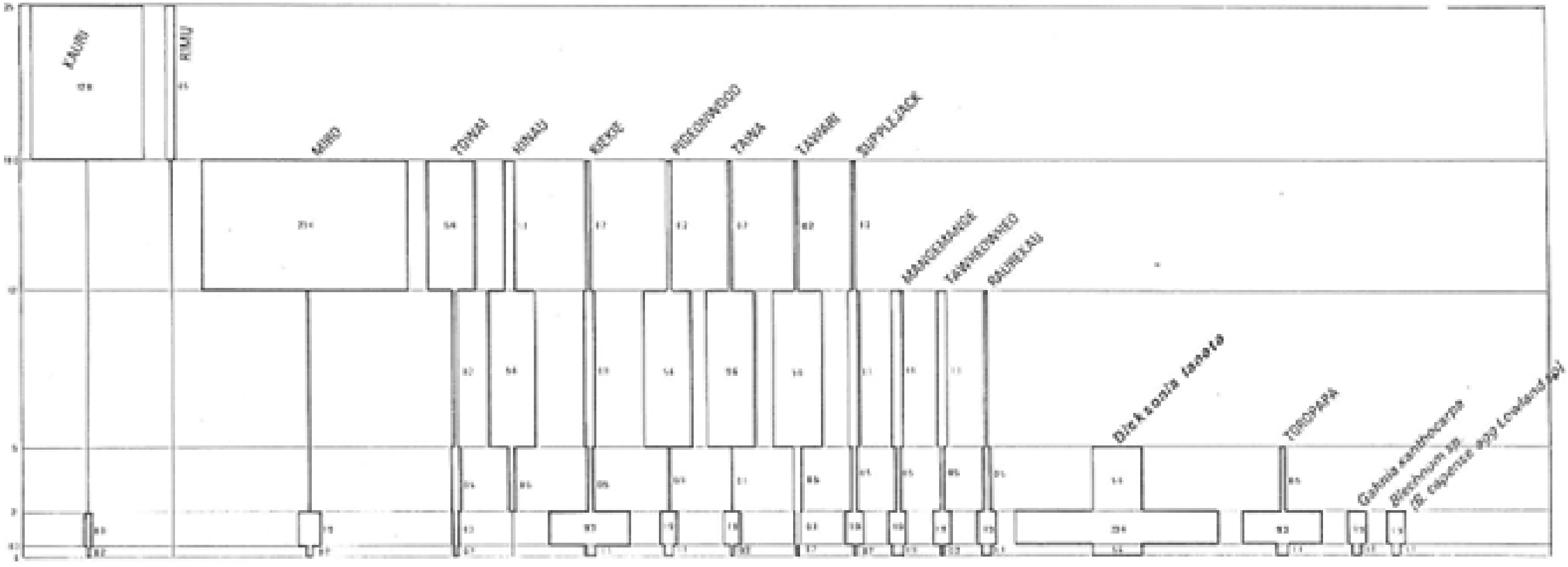
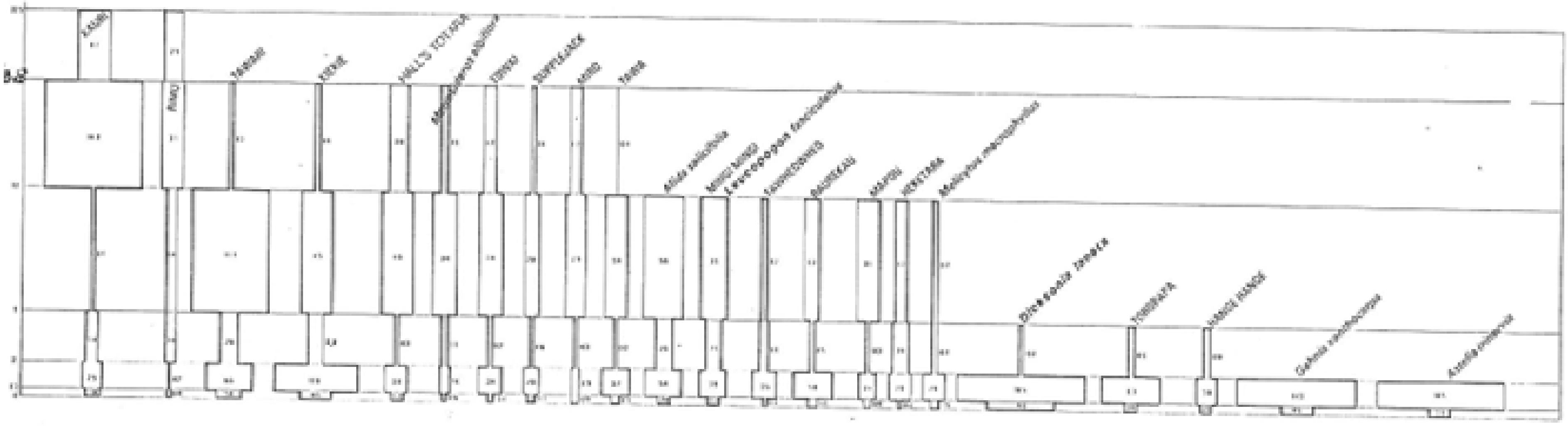


Figure 2.49: Structural representation of vegetation group (vi) kauri-tawari-kiekie-Hall's totara determined from classification analysis of vegetation plots in Pet kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 18.3-22.5m; Tier 2: canopy vegetation = 12-18.3m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively
Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (vi) vegetation was present in the following plots; D1,E1,E2,F2.
Note: *Leucopogon fasciculatus* is now named *Styphelia fasciculatus* (see Appendix 6.1)



APPENDIX 2.5

DESCRIPTION OF PUKATEA KOKAKO HOME RANGE

Gridded area: 7.36ha (Fig.2.50). Centred on grid reference 622N788E, NZMS 260, Sheet P 05. Altitude range: 380-410m asl. Situated on a major side ridge south of Pirau Ridge, between two headwater branches of Pukatea Stream, on gently rolling topography. There was a prominent knoll on the axial ridge which gave rise to side ridges that extended to the north and south. The home range enclosed one gently sloping sub-catchment. Some wind damage was evident on flanks of ridges exposed to the north-east.

Interpretation of ordination

Ordination of plots and species have been shown on Figures 2.51 and 2.52 respectively. Many canopy species were ubiquitous and dominant at most of the sites examined (e.g. towai, taraire and kohekohe) and thus had intermediate scores on both Axes 1 and 2 of the ordination. Consequently, interpretation of this fairly homogeneous vegetation relied on distribution of less physiognomically prominent species, compared with the other study home ranges. Nonetheless, the floristic gradients detected by DCA in this home range were readily interpretable.

The main floristic gradient detected by Axis 1 of ordination was associated with a change in topography (i.e. from ridge top sites to those in gully bottoms) with associated changes in microenvironment from less sheltered, drier sites to sheltered, moist, shaded sites. The species ordination reflected this change. Species such as *Gahnia pauciflora,* lancewood and mapou, (which were primarily on ridge tops in this home range) had low Axis 1 scores, while gully-preferring species such pukatea, kotukutuku and parataniwha had high Axis 1 scores. Species with intermediate scores included those that were most plentiful on ridge flank sites, e.g *Uncinia uncinata* and *Tmesipteris sigmatifolia.* The ordination of plots (Fig.2.51), when seen alongside the map of the home range (Fig.2.50), reinforced this interpretation, i.e. plots on the highest points of the axial ridge (e.g. F7) had low Axis 1 scores, while those at the bottom of the gully (e.g. D4) had the highest Axis 1 scores.

Axis 2 ordination was not so easy to interpret. Species which had high Axis 2 scores (e.g. kauri, *Metrosideros albiflora* and mingimingi) were rare in the home range, while those with low Axis 2 scores (e.g. lacebark, pukatea, and puriri) were comparatively common. Kauri and the other species with high Axis 2 scores were on exposed north-facing slopes while pukatea and puriri occurred primarily in sheltered sites. Furthermore, sites occupied by species with high Axis 2 scores had been quite badly damaged by wind from the north-east, and dense sapling regrowth had arisen subsequently. However, the canopy gaps were not of sufficient size, nor the scale of destruction sufficient for colonisation by weed or seral species to have followed. Therefore, the complex floristic gradient detected along Axis 2 appeared to coincide with a change from undisturbed sites, to relatively more-disturbed sites. Examination of the ordination of plots (Fig.2.51) alongside the map of the home range (Fig.2.50) again was indicative of this. Plots with high Axis 2 scores faced north or north-east, at the end of the side ridge arising from the axial ridge (Plots C5, C6, B7). These plots had suffered from wind damage to some extent; fallen logs and a dense thicket of secondary growth were a feature of plot B7 in particular. Plots which had low Axis 2 scores were predominantly south-facing, and had not been affected by wind damage to any great extent.

Interpretation of TWINSPAN classification

Superimposition of six TWINSPAN classification groups on the ordination of plots (Fig.2.51) showed that the same floristic gradient as detected on Axis 1 was most influential on these groupings; i.e. classification identified these groups from gully bottoms to ridge tops. Because of the relative homogeneity of canopy composition, there was quite an intergrading of these groups along Axis 1 of ordination. To the level of divisions used in the floristic gradient detected by Axis 2 (associated with the degree of disturbance) had not influenced the plot classification; however finer divisions split the ridge flank vegetation group into a north-facing, relatively disturbed group and a south-facing, relatively undisturbed group. The influence of topography was apparent when the six vegetation groups were superimposed on the map of the home range (Fig.2.53). The vegetation groups detected were:

(i) Pukatea-taraire-towai-kohekohe-supplejack
(ii) Rimu-taraire-kohekohe-supplejack-towai
(iii) Rimu-towai-taraire-kohekohe-tawa-makamaka
(iv) Towai-taraire-kohekohe
(v) Towai-taraire-tawa-kohekohe
(vi) Towai-taraire-kohekohe-tawa-hinau-miro-rewarewa

The groups followed a sequence from gully bottom sites (i), to gully heads ((ii) and (iii)), to ridge flanks (iv), to ridges (v), and the knoll on the ridge (vi).

Group (i) pukatea-taraire-towai-kohekohe-supplejack
Found at the bottom of a small gully system that a sidebranch headwater of Pukatea Stream. The site was predominantly north-facing and sloped gently. Drainage was moderate to with rivulets the head of the stream passing through most of the site. ground consisted of damp clay banks (usually nearest the stream course) and occasionally rocky substrate in the water channels, or was covered in deep, damp litter and rotting logs.

The composition and structure of this group has been illustrated in Figure 2.54. Common components of both tiers 5 and 6 included *Blechnum* sp (*B. capense* agg), *Pneumatopteris pennigera* and *Asplenium bulbiferum* s.s.

Epiphytes were very common, and included species characteristic of the darkest, dampest sites such as *Trichomanes endlicherianum.*

Group (ii) rimu-taraire-kohekohe-supplejack-towai
Occurred in gently sloping gully heads above headwaters of Pukatea Stream, rather than the steeper gully heads which were characteristic of the following group. Drainage was moderate. The ground was covered in a deep litter layer and herbaceous and bryophyte vegetation, with some areas of bare soil.

The composition and structure of this group has been depicted in Figure 2.55. Ground cover species also included *Pneumatopteris pennigera, Asplenium bulbiferum* s.s. and *Blechnum fraseri.*

Epiphytes were very common, especially the ubiquitous species and also those that were characteristic of gully sites, such as *Phymatosoros scandens* (which did not need excessively damp conditions). The higher altitude of this home range compared with others described so far was evident in the epiphyte flora. *Collospermum microspermum* was as frequent here as th common lowland species *C. hastatum*; at lower altitudes it was uncommon. The epiphytic fern which was infrequent in similar sites at lower altitude was abundant here.

Group (iii) rimu-towai-taraire-kohekohekohe-tawa-makamaka
Located in a gully head in north-facing headwaters of Pukatea Stream. This area lay immediately above a gully bottom which was clothed in group (i) vegetation. The site varied from gently sloping (where there was a deep accumulation of litter), to steep ridge flanks. There were moist clay banks about the points where small rivulets formed stream headwaters. Drainage of the site varied from good to moderate.

The composition and structure has been shown in Figure 2.56. Common ground species included *Pneumatopteris pennigera, Asplenium bulbiferum* s.s. and *Blechnum fraseri.*

Epiphytes were abundant, comprising a wide range of species. Beside ubiquitous species, filmy ferns of moist sheltered sites such as *Hymenophyllum ferrugineum* and *H. scabrum* were common, as they were in the previous two groups.

Group (iv) towai-taraire-kohekohe
This was the major vegetation group of Pukatea home range, and was found predominantly on the flanks of the central ridge system. It occurred mainly above gully heads and away from the prominent knolls of the ridges. It grew on a range of aspects, usually on terrain of moderate slope and good drainage. There was a deep litter layer over most of the site, with bare earth banks at steeper points. The canopy in some sites has sustained considerable wind damage, particularly in

plots most exposed to the east and to the north-east. In these plots, there was a dense regenerating understorey beneath the damaged canopy.

The composition and structure of this group has been shown in Figure 2.57. Common ground cover species included *Uncinia uncinata, Microlaena avenacea* and *Blechnum fraseri.*

Epiphytes were very common and included such shade and damp-preferring species as *Tmesipteris lanceolata.*

Group (v) towai-taraire-tawa-kohekohe
Found on ridge sites and their adjacent flanks away from the prominent knoll and the saddles on the ridges of this home range. The sites were gently sloping and well drained. There was copious litter with some bare soil, and little vegetative ground cover (vascular or non-vascular) apart from a few seedlings and some *Blechnum fraseri.*

The composition and structure of this group has been shown in Figure 2.58. Epiphytes were common, though not as common as in gully sites. The epiphyte flora of ridges in this home range were most similar to that of shaded ridge flanks in the other home ranges studied, i.e. *Tmesipteris simatifolia, Blechnum filiforme,* and the filmy fern *Hymenophyllum lyalli* were common, as well as ubiquitous species.

Group (vi) towai-taraire-kohekohe-tawa-hinau-miro-rewarewa
Distributed on and about a prominent knoll which marked the highest point along the main ridge, on which the home range was centred. Unlike ridge sites in the other home ranges studied, this axial ridge was gently rolling and its flanks were moderately sloping. The site was well drained, although not excessively so (compared with ridge top sites in the other home ranges). Deep litter covered most of the ground, but there were some patches of bare earth, and little ground vegetation (vascular or non-vascular).

The structure and composition of this group has been illustrated in Figure 2.59. There were very few ground cover species - only *Blechnum fraseri, Alseuosmia banksii* and *A.* x *quercifolia* were common.

Epiphytes were common, and unlike dry, sharply-dissected ridge top sites, some of the species in this group were shade and moisture preferring species, e.g. *Anarthropteris lanceolata, Blechnum filiforme* and *Tmesipteris elongata*. The light-demanding fern *Pyrrosia serpens* was also common in this group.

Figure 2.50: Pukatea kokako home range, Puketi Forest. Location: on a main side ridge of Pirau Ridge that runs down the axis of the upper-mid part of Pukatea Stream catchment. Scale: each square is 40 x 40m. Approximate altitudinal contours at 20m intervals.

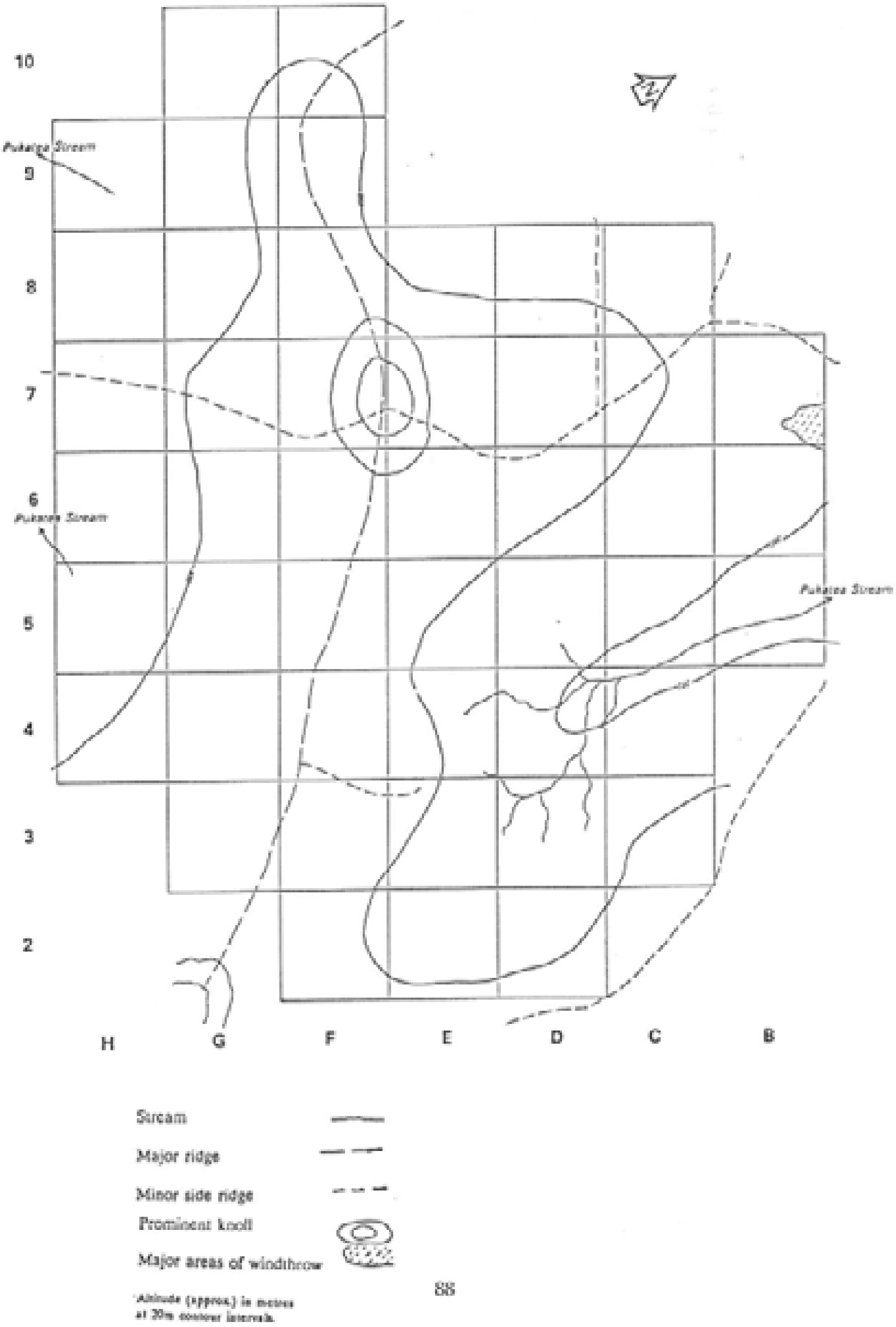


Figure 2.51: Ordination scores of the forty six 40x40m vegetation plots in Pukatea kokako home range plotted against the two floristic gradients detected. The first gradient (Axis 1) corresponds with changes in topography from gully bottoms (the lowest score) to ridge tops (the highest scores). The second gradient (Axis 2) corresponds with the degree of disturbance, with the least disturbed plots having the lowest Axis 2 scores and the most disturbed plots having the highest scores. Superimposed on this ordination of plots are six vegetation groups defined for this home range by classification. These are:

- ▲ towai-taraire-kohekohe-tawa-hinau-miro-rewarewa
- ■ towai-taraire-tawa-kohekohe
- ○ towai-taraire-kohekohe
- ▼ rimu-towai-taraire-kohekohe-tawa-makamaka
- ◎ rimu-taraire-kohekohe-supplejack-towai
- ✱ pukatea-taraire-towai-kohekohe-supplejack

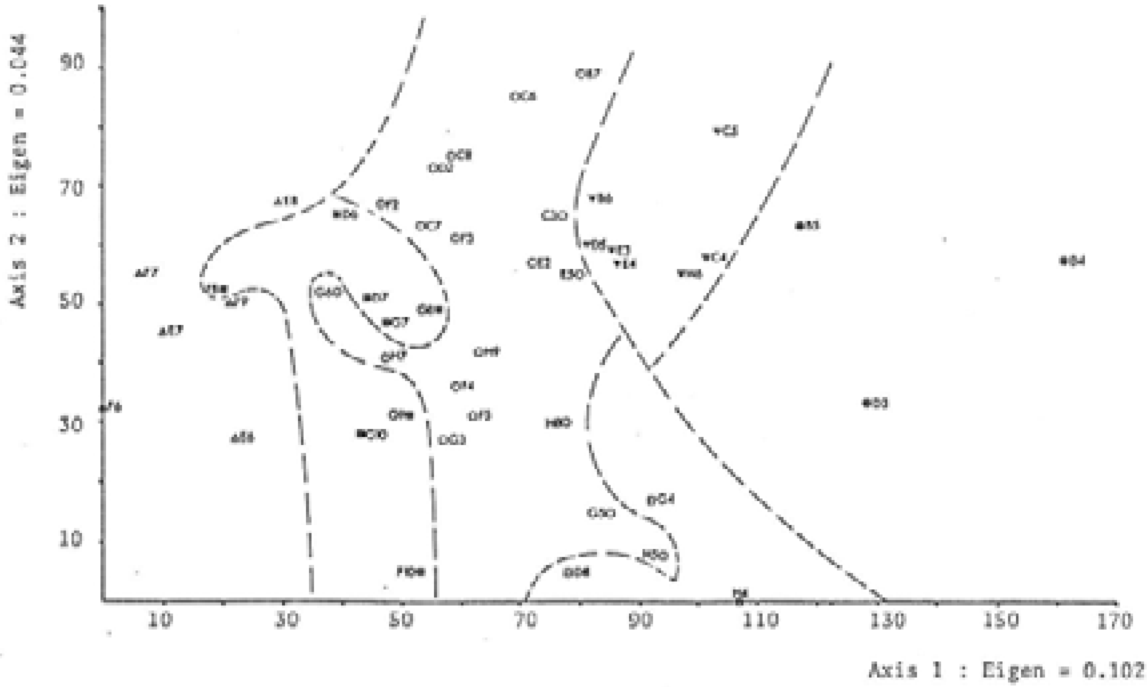


Figure 2.52: Graph depicting ordination scores of a selection of species from the forty six 40x40m vegetation plots in Pukatea kokako home range along the two principle floristic gradients detected. The first gradient (Axis 1) corresponds with changes in the topography. Species with low Axis 1 scores (e.g. LITcal = mangeao) are characteristic of gully bottom sites. The second gradient (Axis 2) corresponds with the degree of disturbance. Species with low Axis 2 scores (e.g. VITluc = puriri) are characteristic of the least disturbed sites, while species with high Axis 2 scores (e.g. CYAfas = mingimingi) are characteristic of more disturbed sites . Species are listed below:

<u>Key to species</u>

ACKros - makamaka
BEItar - taraire
COPgra - raurekau
CYAmed - mamaku
DICsqu - wheki
ELArug - parataniwha
GAHxan - *Gahnia xanthocarpa*
KNIexc - rewarewa
MELmac - *Melicytus macrophyllus*
METpre - *Metrosideros perforata*
PODfer - miro
PSEedg - raukawa
SCHdig - pate

ASPbul - *Asplenium bulbiferum s.s.*
BEItaw - tawa
CYAdea - ponga
CYAsmi - *Cyathea smithii*
DYSspe - kohekohe
FREbau - kiekie
GENlig - hangehange
LAUnov - pukatea
MELram - mahoe
OLErau - heketara
PODhal - Hall's totara
RHOsap - nikau
VITluc - puriri

ASTtri - *Astelia trinervia*
BLEfra - *Blechnum fraseri*
CYAfas - mingimingi
DACcup - rimu
ELAden - hinau
FUCexc - kotukutuku
HEDarb - pigeonwood
LITcal - mangeao
METdif - *Metrosideros diffusa*
PNEpen - *Pneumatopteris pennigera*
PSEarb - fivefinger
RIPsca - supplejack
WEIsil -towai

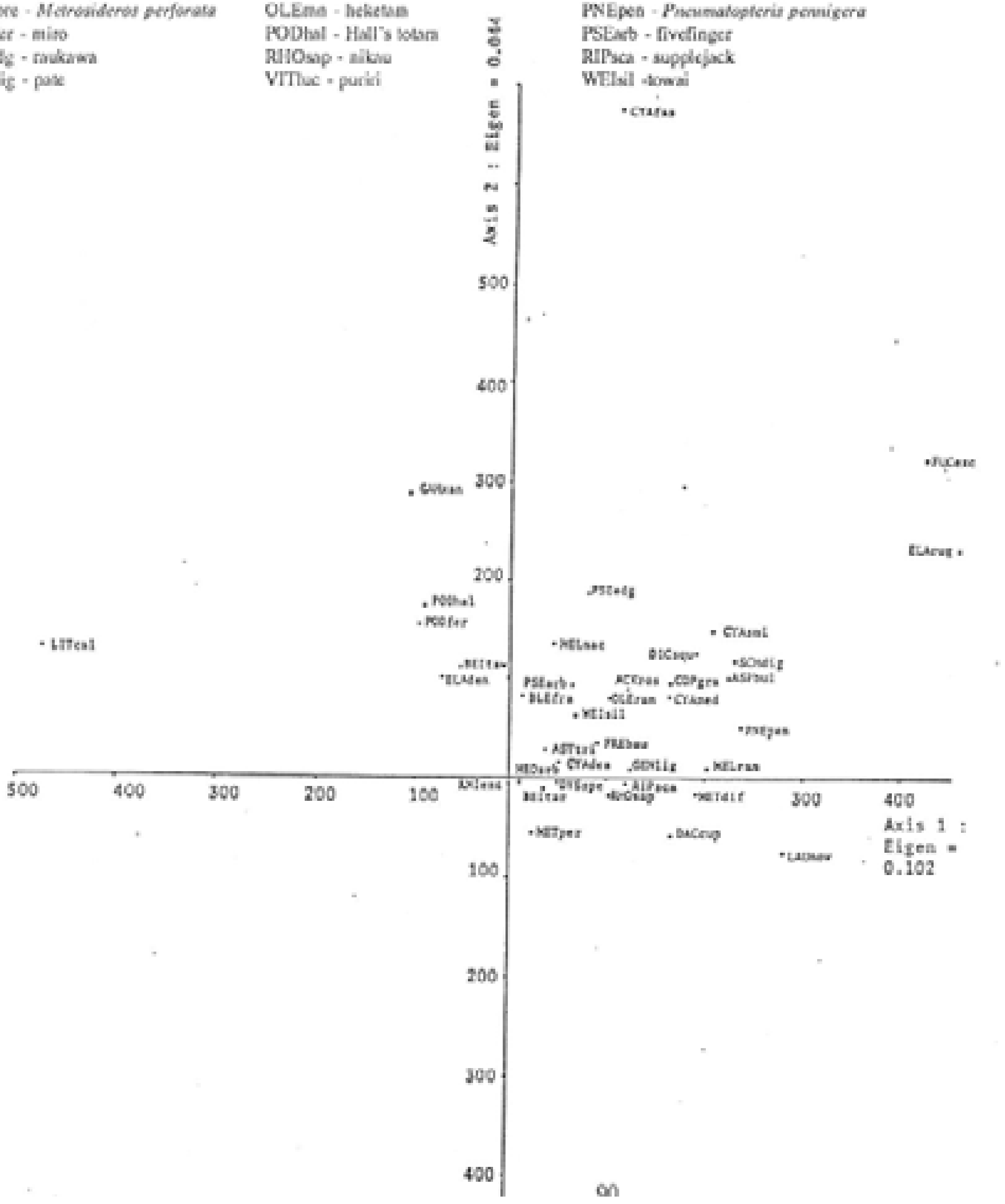


Figure 2.53: Location of six vegetation groups defined for Pukatea kokako home range. The groups were defined by classification and reflect primarily the transition from gully bottoms to ridge tops. The six groups are listed below , and are shown on the appropriate grid square on the home range map. Scale: each square is 40 x 40m. Approximate altitudinal contours at 20m intervals.

Group (i) pukatea-taraire-towai-kohekohe-supplejack; Group (ii) rimu-taraire-kohekohe-supplejack-towai; Group (iii) rimu-towai-taraire-kohekohe-tawa-makamaka; Group (iv) towai-taraire-kohekohe; Group (v) towai-taraire-tawa-kohekohe; Group (vi) towai-taraire-kohekohe-tawa-hinau-miro-rewarewa

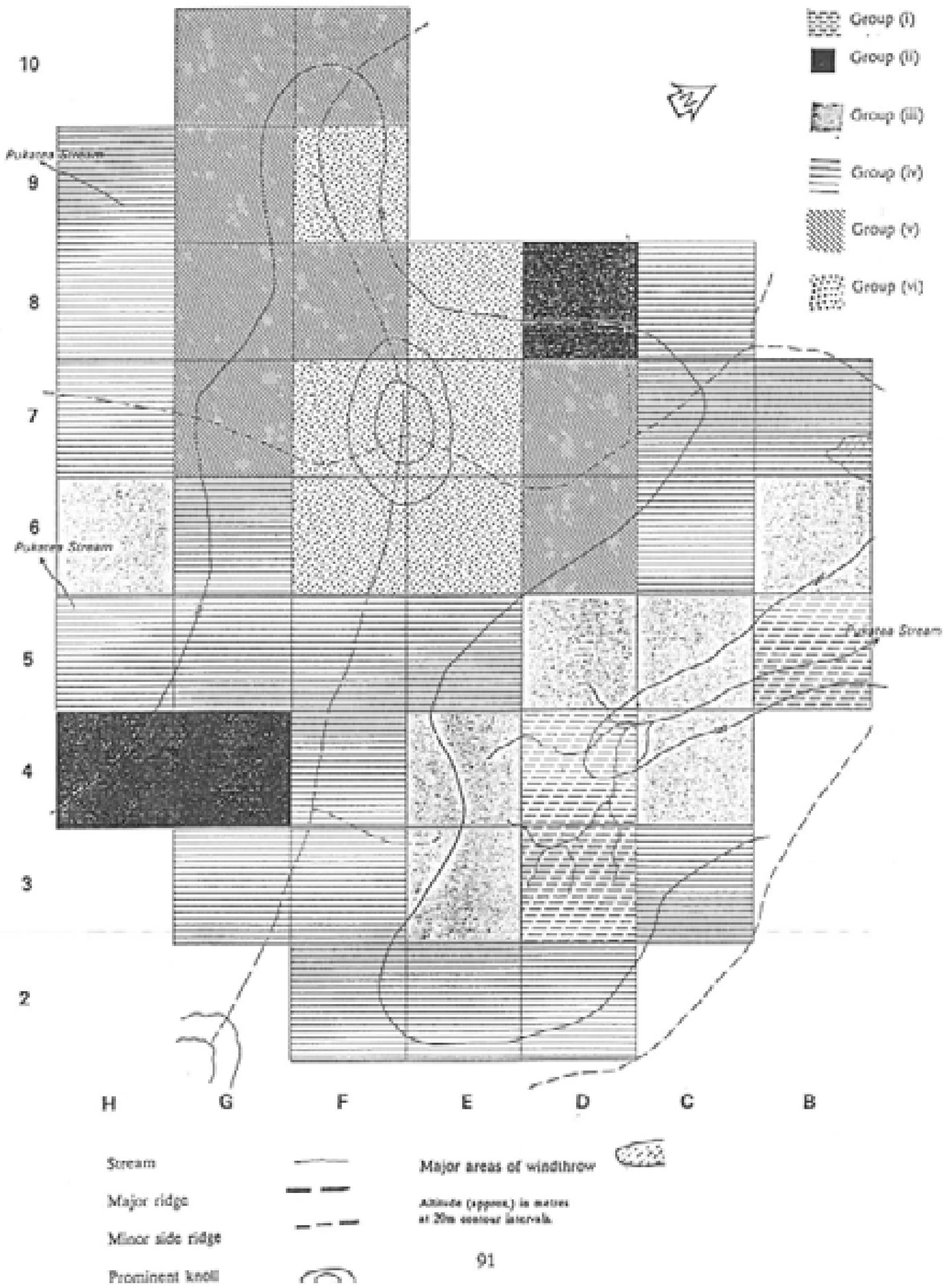


Figure 2.54: Structural representation of vegetation group (i) pukatea-taraire-towai-kohekohe-supplejack determined from classification analysis of vegetation plots in Pukatea kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 16.7-22m; Tier 2: canopy vegetation = 12-16.7m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively
Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (i) vegetation was present in the following plots; D5,D3,D4.

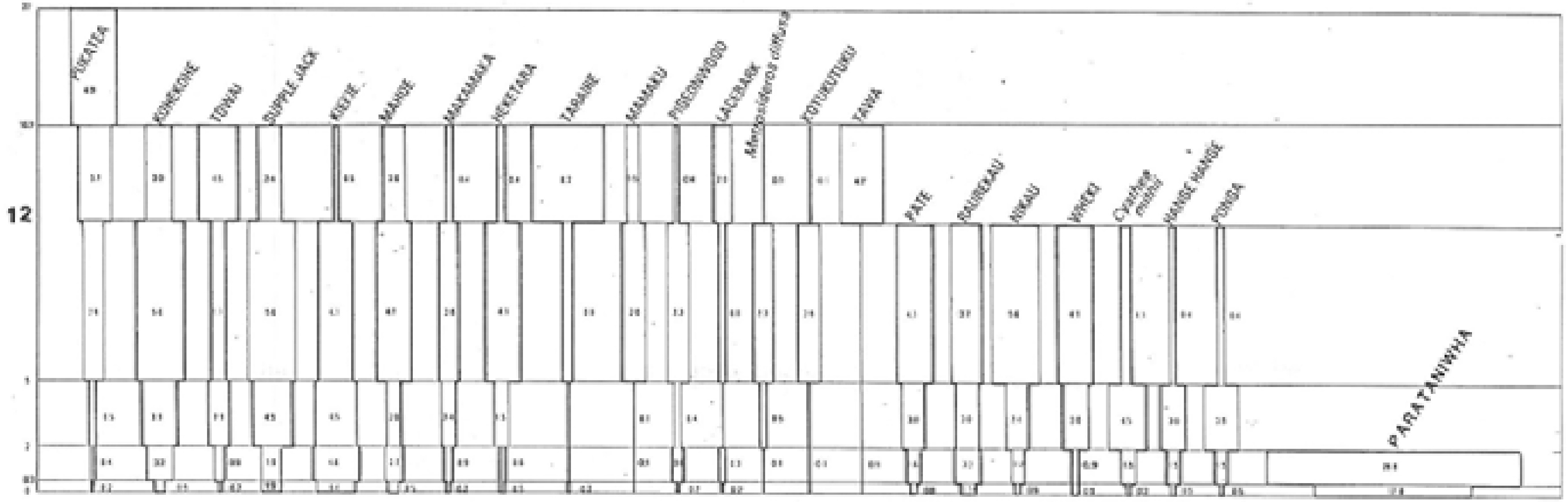


Figure 2.55: Structural representation of vegetation group (ii) rimu-taraire-kohekohe-supplejack-towai determined from classification analysis of vegetation plots in Pukatea kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 18.8-22.7m; Tier 2: canopy vegetation = 12-18.8m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively
Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (ii) vegetation was present in the following plots; D8,G4,H4.

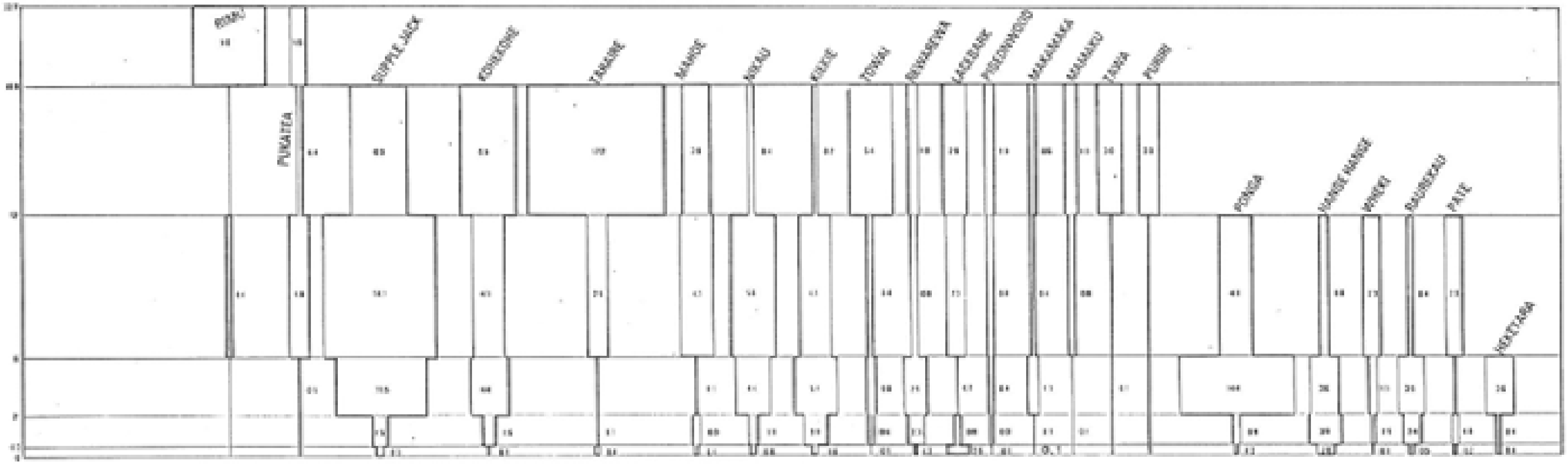


Figure 2.56: Structural representation of vegetation group (iii) rimu-towai-taraire-kohekohe-tawa-makamaka determined from classification analysis of vegetation plots in Pukatea kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 19.1-24.3m; Tier 2: canopy vegetation = 12-19.1m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively
Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (iii) vegetation was present in the following plots; B6,C4,C5,D5,E3,E4,H6.

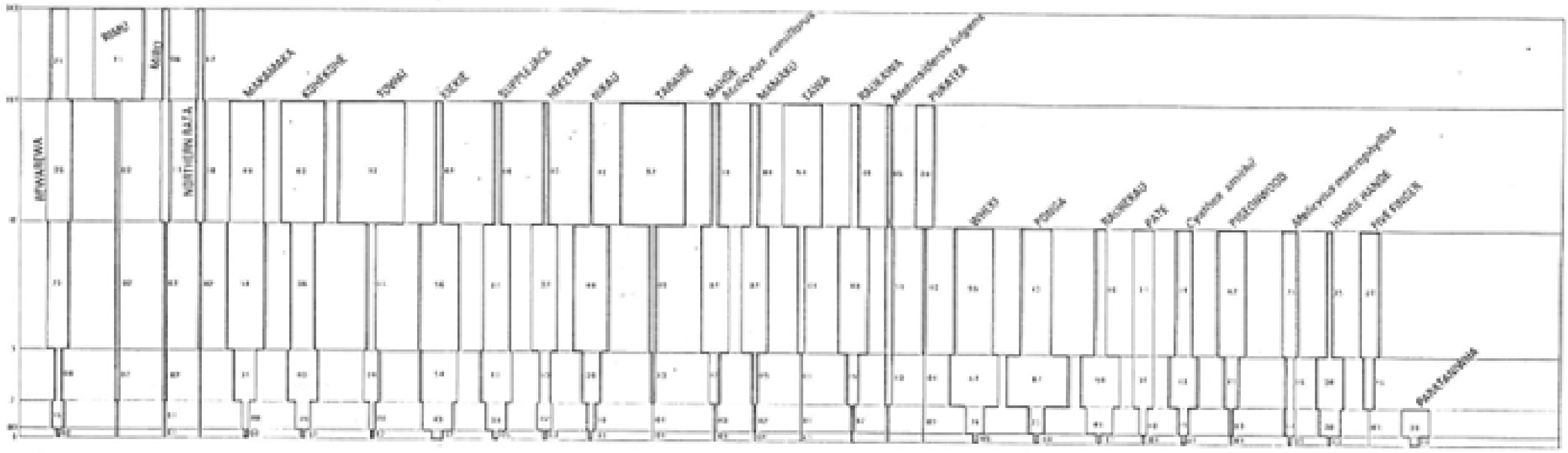


Figure 2.57: Structural representation of vegetation group (iv) towai-taraire-kohekohe determined from classification analysis of vegetation plots in Pukatea kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 16.7-24.8m; Tier 2: canopy vegetation = 12-16.7m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively
Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (iv) vegetation was present in the following plots;B7,C3,C6,C7,C8,D2,E2,E5,F2, F3,F4,F5,G3,G5,G6,H5,H7,H8,H9.

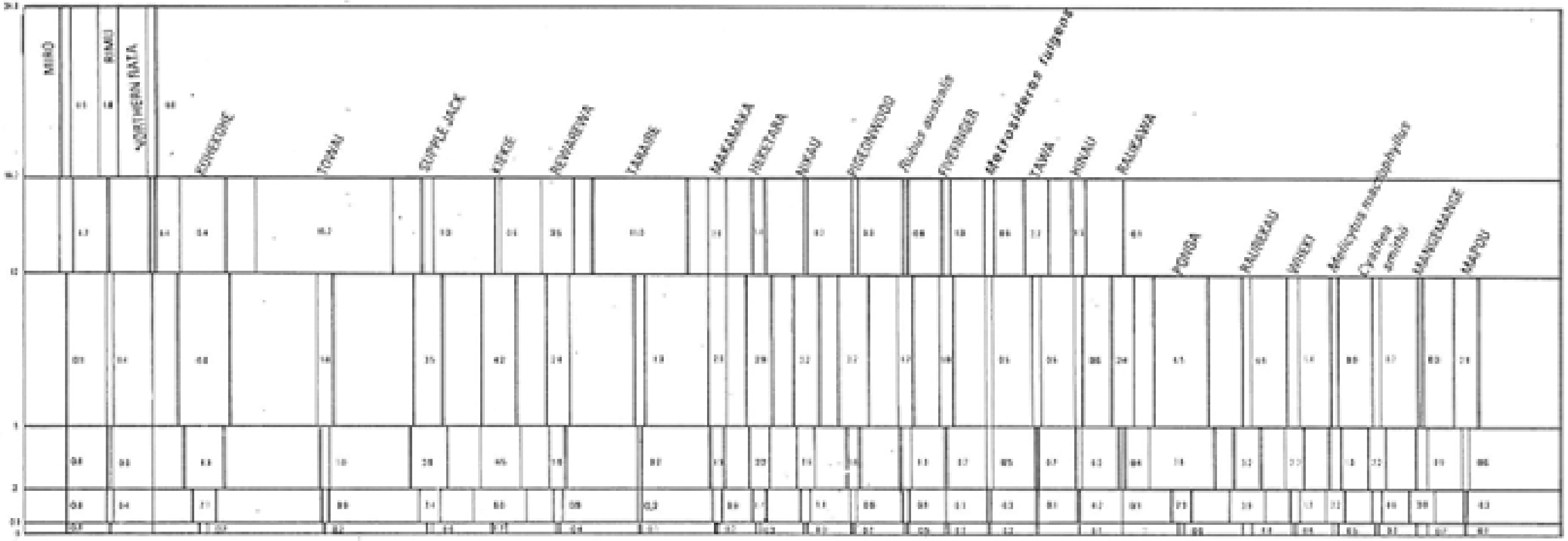


Figure 2.58: **Structural representation of vegetation group (v) towai-taraire-tawa-kohekohe determined from classification analysis of vegetation plots in Pukaten kokako home range.**

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 17.3-21.5m; Tier 2: canopy vegetation = 12-17.3m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively
Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (v) vegetation was present in the following plots; D6,D7,F8,F10,G7,G8,G9,G10.

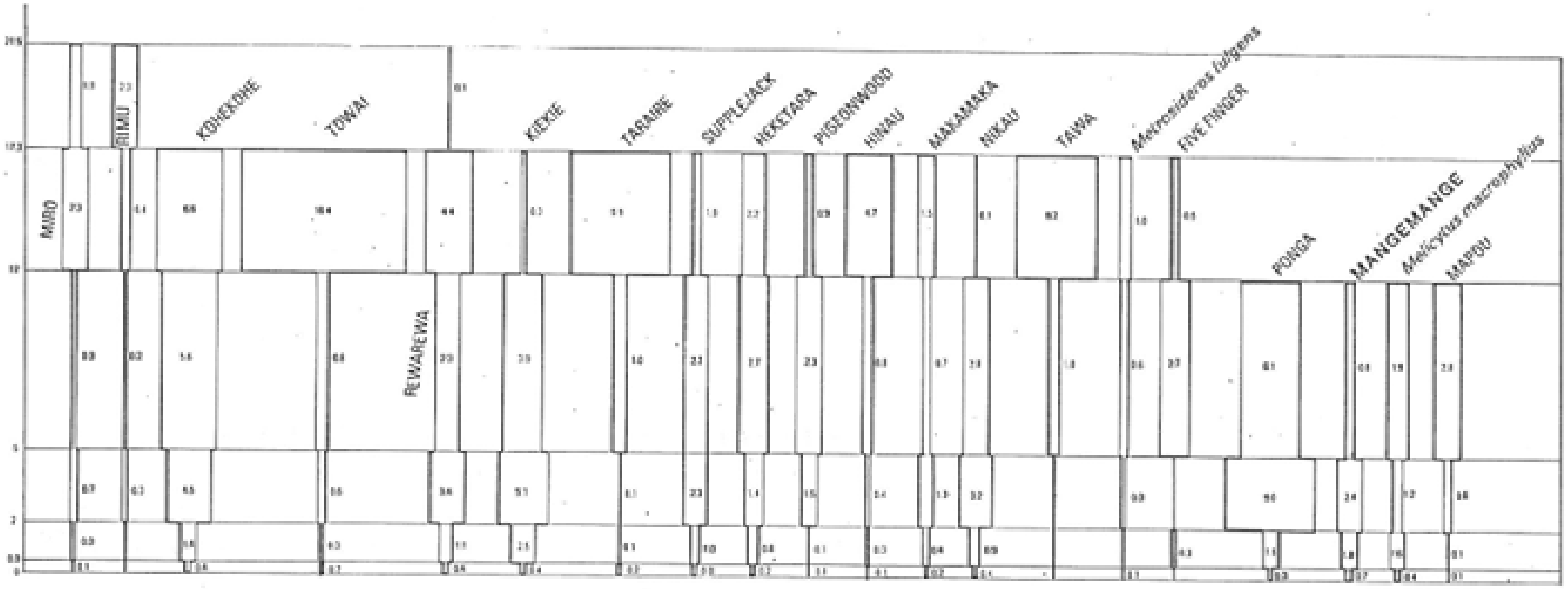
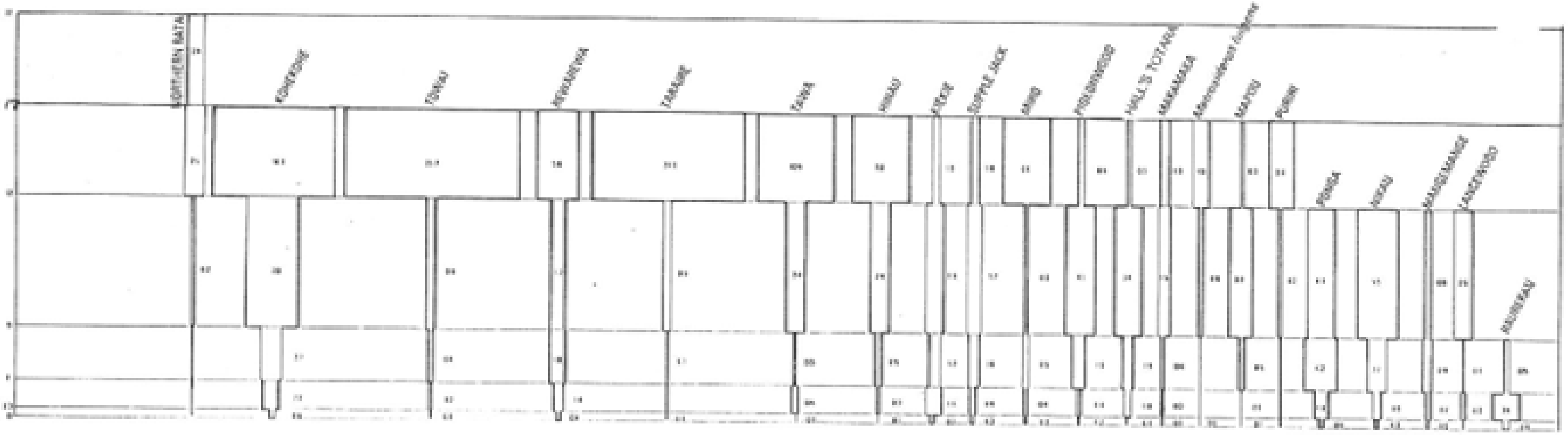


Figure 2.59: Structural representation of vegetation group (vi) towai-taraire-kohekohe-tawa-hinau-miro-rewarewa determined from classification analysis of vegetation plots in Pukatea kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 17-22m; Tier 2: canopy vegetation = 12-17m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively
Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (vi) vegetation was present in the following plots; E6,E7,E8,F6,F7,F9.



APPENDIX 2.6

DESCRIPTION OF SUMMIT KOKAKO HOME RANGE

Gridded area: 5.44ha (Fig.2.60). Centred on grid reference 670N770E, NZMS 260, Sheet P 05. Altitude range: 400-440m asl. Situated on Mokau Ridge. The southern flanks of the axial ridge dropped steeply to a broad, flat gully head at the headwaters of Camp Creek. Two steep side ridges enclosed this basin. The north side of Mokau Ridge comprised a plateau, sloping gently to the north-west. An old, overgrown logging road cut through the north-west corner of the home range, north of the axial ridge. The Mangahorehore tramping track followed the crest of the axial ridge through the home range.

Interpretation of the ordination

Scatter graphs of plots (Fig.2.61) and selected species (Fig.2.62) showed ordination along the first two Axes, both of which were readily interpretable. The main floristic gradient detected by Axis 1 was a complex one which corresponded with changes in topography in the home range from gully bottom sites to ridge top sites. Associated with this were changes in microenvironment from sheltered, shaded, damp sites having deep, humic soils and litter through to more exposed, better lit, drier sites with skeletal soils. Species such as kauri, *Gahnia xanthocarpa* and *Phormium cookianum* (which occurred on the crest of the axial ridge) had the highest Axis 1 scores. Species such as tawa, rewarewa and hinau (which were found primarily on steep ridge flanks) had intermediate Axis 1 scores, along with ubiquitous species such as raurekau and hangehange. Species such as pukatea, mahoe and parataniwha (which were characteristic of gully bottom sites) had low Axis 1 scores. Similarly, an examination of the ordination of plots alongside the map of the home range showed that plots at the crest of the axial ridge (e.g. C4, D4, E5) had the highest scores, those on the steep ridge (e.g. F4, G5) had intermediate scores, and those at the bottom of the gully (e.g. F1, D2, E2) had low Axis 1 scores.

Axis 2 accounted for a lesser proportion of the variability in the data set; it detected a complex floristic gradient which reflected primarily changes in drainage from poorly-drained to well-drained sites, but also reflected the extent of disturbance in some cases. At the ridge top (i.e. species with high Axis 1 scores), species which also had low Axis 2 scores (e.g. selfheal and *Juncus* spp) were typical of the most disturbed area (the logging road which cut through the home range), which was also a poorly drained ridge-top site. Species with low Axis 1 scores (= gully bottom plants), that also had low Axis 2 scores (e.g. *Carex dissita* and *Callitriche muelleri*) were usually found on poorly-drained sites, and also included weeds such as mist flower, which had colonised light wells after wind throw. Species with high Axis 2 scores (e.g. waiuatua and tawa) grew generally on the best-drained, undisturbed sites. Plots with high Axis 1 scores and low Axis 2 scores (e.g. B4, C5, D6) were those which included the old road while plots with both low Axis 1 and 2 scores were mostly from the poorest drained sites (e.g. E1, H4) and in the case of some (e.g. E1) their canopies had collapsed from windthrow. Plots with high Axis 2 scores were generally in well-drained, undisturbed sites.

Interpretation of the TWINSPAN classification

Six classification groups have been separated out. These were:

(i) Supplejack-kohekohe-taraire-(pukatea)
(ii) Pukatea-northern rata-rimu-supplejack-taraire
(iii) kohekohe-tawa-taraire
(iv) Hall's totara-miro-towai-kiekie
(v) towai-Hall's totara-kiekie-wheki-ponga
(vi) towai-Hall's totara-kiekie-ponga

The groups have been superimposed on the ordination scattergraph of vegetation plots in Figure 2.61. It was clear they were affected primarily by floristic gradient detected by Axis 1, i.e. a transition from gully bottom sites to ridge top sites. Gully bottom vegetation was split into two groups [(i) and (ii)] which appeared to be influenced by the same floristic gradient detected by Axis 2, i.e. a change from poorly-drained sites [occupied by group (ii)], to better drained sites [occupied by group (i)]. The ridge top sites were occupied by three groups [(iv) to (vi)] which were the most easily interpreted in terms of the extent of disturbance as well as drainage. Group (iv) was undisturbed and well-drained. Group (v) had its canopy damaged considerably by the road formation which cut through it, leaving a dense shrub regrowth, and the site was poorly-drained. Group (vi) had a wind-damaged canopy, but the site was well-drained. The location of these groups in the home range has been shown in Figure 2.63.

Group (i) supplejack-kohekohe-taraier-(pukatea)
Occurred at the bottom of steep ridge flanks and side ridges, in a broad gully head, from which part of the headwaters of Camp Creek began to flow. The ridge flanks sloped steeply and were predominantly south-east facing, while the gully bottom sloped gently. A small headwater rivulet flowed through one part of the site occupied by this group. Drainage was medium to good. Much of the ground was either bare soil or loose broken rock, while locally ground cover was dense and covered in deep litter, or damp rotting vegetation. The canopy had collapsed in some places, usually from windthrow of old trees, resulting in a dense regrowth of some species, e.g. wineberry.

The composition and structure of this group has been depicted in Figure 2.64. Supplejack and parataniwha, in particular, were very dense in the tiers that they occupied. Common ground cover species included *Lastreopsis hispida, Blechnum membranaceum, Hymenophyllum demissum* and *Phymatosorus scandens.*

Epiphytes were abundant; beside the ubiquitous species, there are those typical of moist, shade sites such as *Trichomanes venosum* and *Tmesipteris lanceolata.*

Group (ii) pukatea-northern rata-rimu-supplejack-taraire
Situated in the broad gully head away from freer draining sites and the stream headwaters of the previous group. The site faced south to south-east and was of gentle slope. Drainage was medium to poor, and surface water lay in depressions on the ground, particularly during winter months. The ground was covered mainly in bare soil with only a little broken and relatively little litter and herbaceous or bryophyte ground cover. As in the previous group, the canopy had collapsed in places as a result of windthrow of old trees, which lead to dense regrowth of shrub species in the resultant light wells.

The composition and structure of this group has been illustrated in Figure 2.65. Supplejack liane formed extremely dense tangles in and beneath the canopy, while parataniwha extremely dense ground cover locally. Ground cover species also included *Asplenium bulbiferum* s.s., *Lastreopsis hispida, Hymenophyllum demissum* and *Microlena avenacea.*

Epiphytes were abundant and included species which occurred only in the most moist, shaded sites, e.g. *Hymenophyllum ferrugineum.*

Group (iii) kohekohe-tawa-taraire
Found on the mid-slopes flanking the axial ridge, and on part of the gently-sloping, north-facing plateau. On the plateau, there was deep litter and ground cover vegetation, while on the steep flanks there was much bare soil, broken rock and some large rock surfaces. There was some disruption of the canopy usually resultant from isolated wind damage.

The composition and structure of this group has been depicted in Figure 2.66. Parataniwha was dense locally, but found only on the lower part of the steep ridge flanks. A wide range of ground cover species were present, including many seedlings. *Blechnum fraseri, B. discolour, Trichomanes elongatum, Pneumatopteris pennigera, Cordyline pumilio* and *Microlena avenacea* were common ground cover species.

Epiphytes were abundant and included species characteristic of ridge flanks, such as *Tmesipteris sigmatifolia,* while moisture-preferring, filmy fern species were much less common.

Group (iv) Hall's totara-miro-towai-kiekie
Located on the steep upper ridge flanks and on the crest of the axial ridge. There was a very steep drop down the ridge flanks to the gully bottom; this group extended about halfway down the c.30m drop. The site was predominantly south-east facing, and although well drained, it was not excessively so. A thin litter layer covered most of the ground, and although there were numerous clay banks, there was also a substantial amount of vascular and non-vascular ground cover.

The compostion and structure of this group has been shown in Figure 2.67. Common ground cover species included *Blechnum* sp (*B. capense* agg), *B. fraseri, Alseuosmia x quercifolia, Microlena avenacea* and *Gahnia pauciflora.*

Epiphytes were fairly common. Beside ubiquitous species, others such as *Pittosporum cornifolium* Kirk's daisy and *Lycopodium varium* were common in podocarp crowns. The filmy fern *Hymenophyllum lyalli* was common on ponga trunks.

Group (v) towai-Hall's totara-kiekie-wheki-ponga

This and the next group occurred adjacent to each other, on the gently sloping plateau, north-east of the axial ridge in this home range. The ground in both groups was covered in dense litter with vascular and non-vascular ground-cover plants, and relatively little bare ground. The major difference between the two groups was the extent of disturbance. In group (v), compared with group (vi), part of the canopy had been destroyed when a logging road was installed. This clay road has overgrown with a dense shrub layer and some regenerating canopy species. Drainage was very poor and surface water was usually present in the vicinity of the old road. The canopy was low and there were no emergent trees. Wheki and regenerating towai were particularly common in the vicinity of the old road.

The composition and structure of this group has been shown in Figure 2.68. Among the ground cover species, kiekie was most abundant in the areas not affected by man-induced damage, while *Blechnum* sp. was abundant along the margins of the old road. On the old road surface, there was a wide variety of species in tier 6, especially selfheal, *Paesia scaberula,* many *Juncus* species and many herb species.

Epiphytes were fairly common, particularly those which throve on the trunks of tree ferns (e.g. towai, fivefinger, *Tmesipteris* species and many species of filmy fern).

Group (vi) towai-Hall's totara-kiekie-ponga

Occurred on the same locale as group (v). While the canopy of group (v) had been destroyed by roading, canopy damage in group (vi) was localised and a result of wind. The canopy was low and appparently wind-shorn, and there were no emergent trees. Absence of roading meant that site drainage was good, compared with group (v). In most other respects, the site was similar to that of group (v).

The composition and structure of this group has been shown in Figure 2.69. Other common species of tier 5 and 6 included toropapa, *Alseuosmia x quercifolia*, *Blechnum discolor* and *Microlena avenacea.*

Epiphytes were common. The epiphyte flora were not of the dry, sharply-dissected ridge crests of some of the other home ranges, but included such shade-preferring species as *Tmesipteris elongata, Anathropteris lanceolata* and *Grammitis pseudociliata.*

Figure 2.60: Summit kokako home range, Puketi Forest. Location: on the summit of Mokau Ridge, including the headwater basin of Camp Creek. Scale: each square is 40 x 40m. Approximate altitudinal contours at 20m intervals.

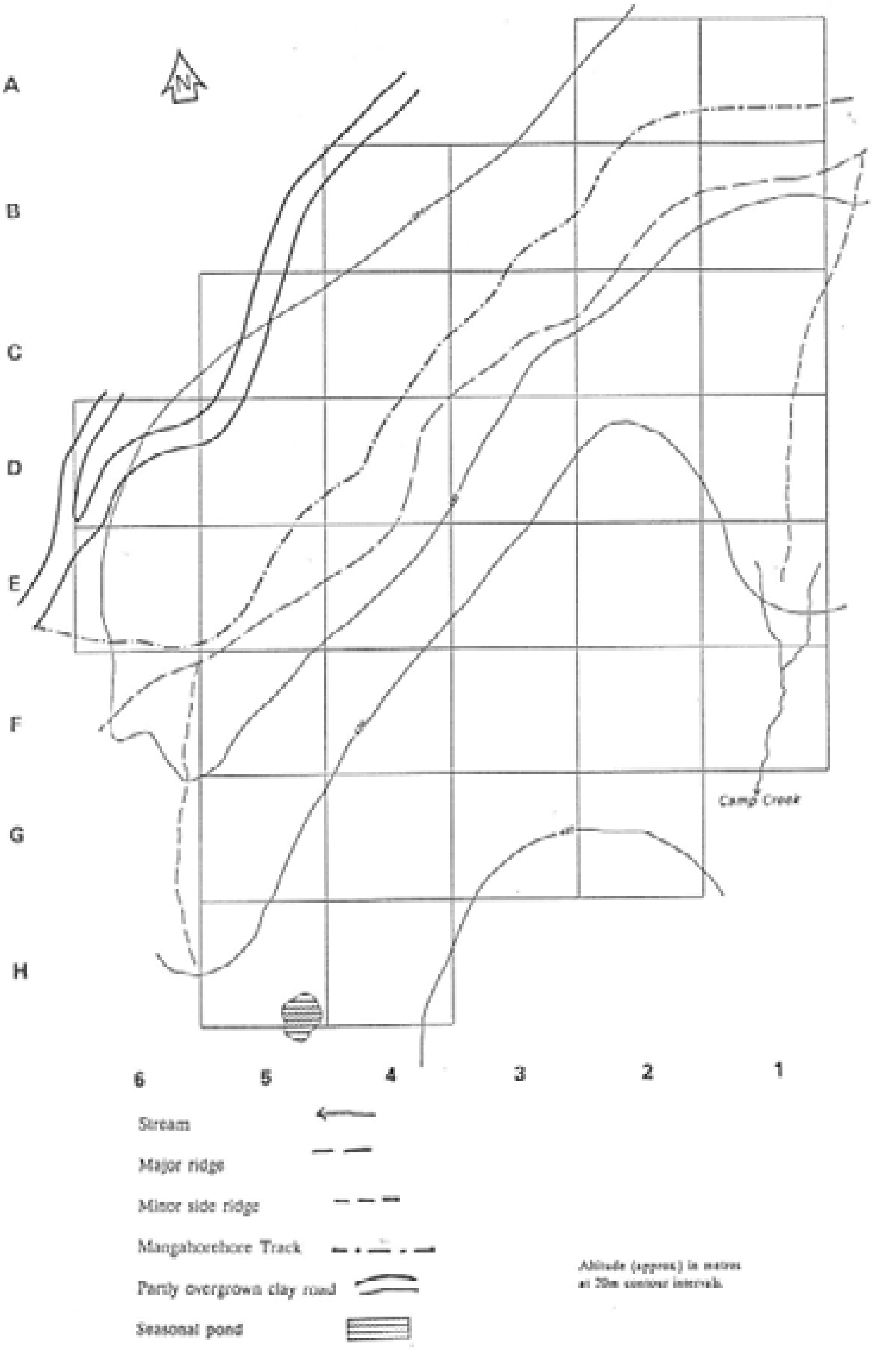


Figure 2.61: **Ordination scores of the thirty four 40x40m vegetation plots in Summit kokako home range are plotted for the two principle floristic gradients detected.** The first gradient (Axis 1) corresponds with changes in topography from gully bottoms (the lowest scores) to ridge crests (the highest scores). The second gradient (Axis 2) corresponds with a gradient in site drainage , which is intimately associated with the degree of disturbance. Poorly drained, disturbed sites have low Axis 2 scores while well-drained undisturbed sites have high Axis 2 scores. Superimposed on this ordination graph are the six vegetation groups defined for this home range by classification. These are:

▲ supplejack-kohekohe-taraire-(pukatea)
■ pukatea-northern rata-rimu-supplejack-taraire
○ kohekohe-tawa-taraire
▼ Hall's totara-miro-towai-kiekie
◎ towai-Hall's totara-kiekie-wheki-ponga
● towai-Hall's totara-kiekie-ponga

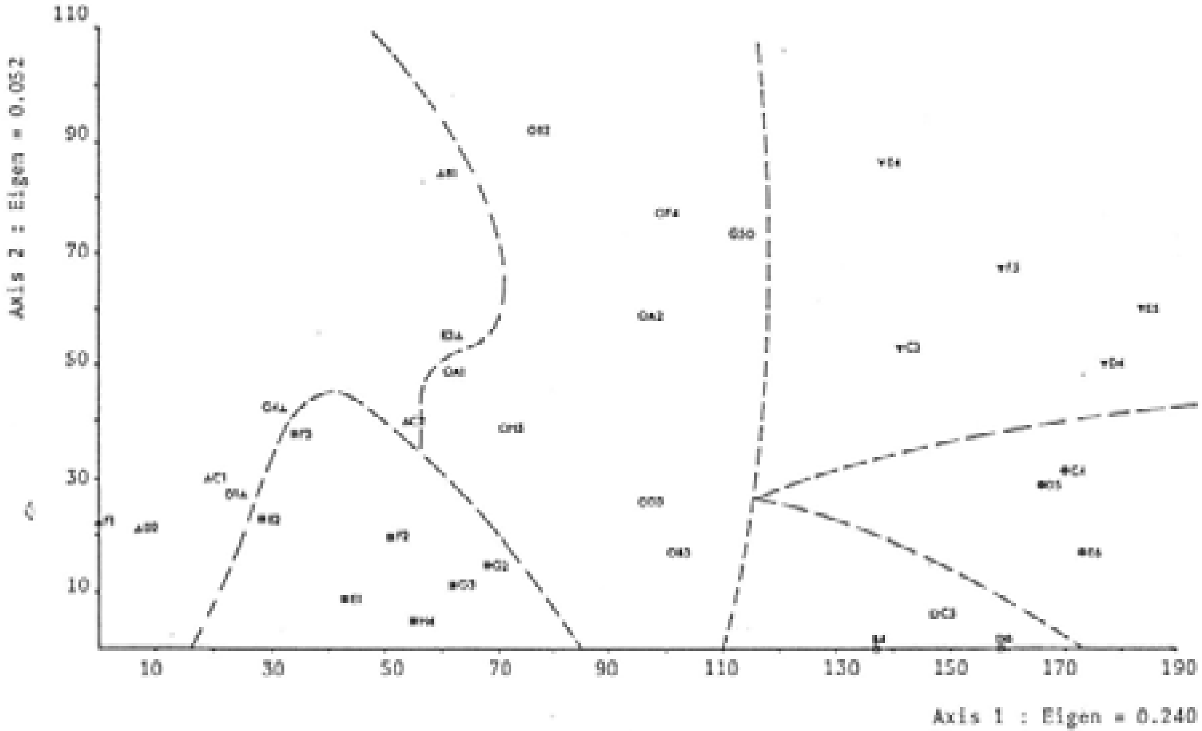


Figure 2.62: Graph depicting ordination scores of a selection of species from the thirty four 40x40m vegetation plots in Summit kokako home range along the two floristic gradients detected. The first gradient (Axis 1) corresponds with changes in topography. Species with low Axis 1 scores (e.g. LAUnov = pukatea) are characteristic of gully bottom sites while those with high Axis 1 (e.g. AGAaus = kauri) are characteristic of ridge top sites. The second gradient (Axis 2) reflects primarily differences in site drainage , but this is intimately associated with the degree of disturbance. Species with low Axis 2 scores (e.g. JUNeff = *Juncus effusus* agg.) are characteristic of poorly drained, disturbed sites, while species with high Axis 2 scores (e.g. RHAsol = waiuatua) are characteristic of well-drained, undisturbed sites. Species are listed below:

Key to species

ACKros - makamaka
ALSque - *Alseuosmia x quercifolia*
BEItar - taraire
COPgra - raurekau
CYAmed - mamaku
DYSspe - kohekohe
FREbau - kiekie
HEDarb - pigeonwood
JUNeff - *Juncus* sp (*J. effusus* agg.)
LAUnov - pukatea
MELmac - *Melicytus macrophyllus*
METdif - *Metrosideros diffusa*
MYRaus - mapou
PNEpen - *Pneumatopteris pennigera*
PODhal - Hall's totara
RHOsol - waiuatua
SCHdig - pate

AGAaus - kauri
ARIser - wineberry
BEItaw - tawa
COPspa - *Coprosma spathulata* s.s.
CYAsmi - *Cyathea smithii*
ELAdea - hinau
FUCexc - kotukutuku
HOHpop - lacebark
KNIexc - rewarewa
LOTped - *Lotus pedunculatus*
MELram - mahoe
METful - *Metrosideros fulgens*
OLEran - heketara
PODdac - kahikatea
PSEarb - fivefinger
RHOsap - nikau
SENkir - Kirk's daisy

ALSmac - toropapa
ASPbul - *Asplenium bulbiferum* s.s.
BLEcap - *Blechnum* sp.(*B.capense* agg.)
YAdea - ponga
ACcup - rimu
ELArug - parataniwha
GENlig - hangehange
HYPrad - catsear
LASbis - *Lastreopsis hispida*
LYGart - mangemange
MELsim - *Melicope simplex*
METrob - northern rata
PITten - kohuhu
PODfer - miro
PSEcra - lancewood
RIPsca - supplejack
WEIsil - towai

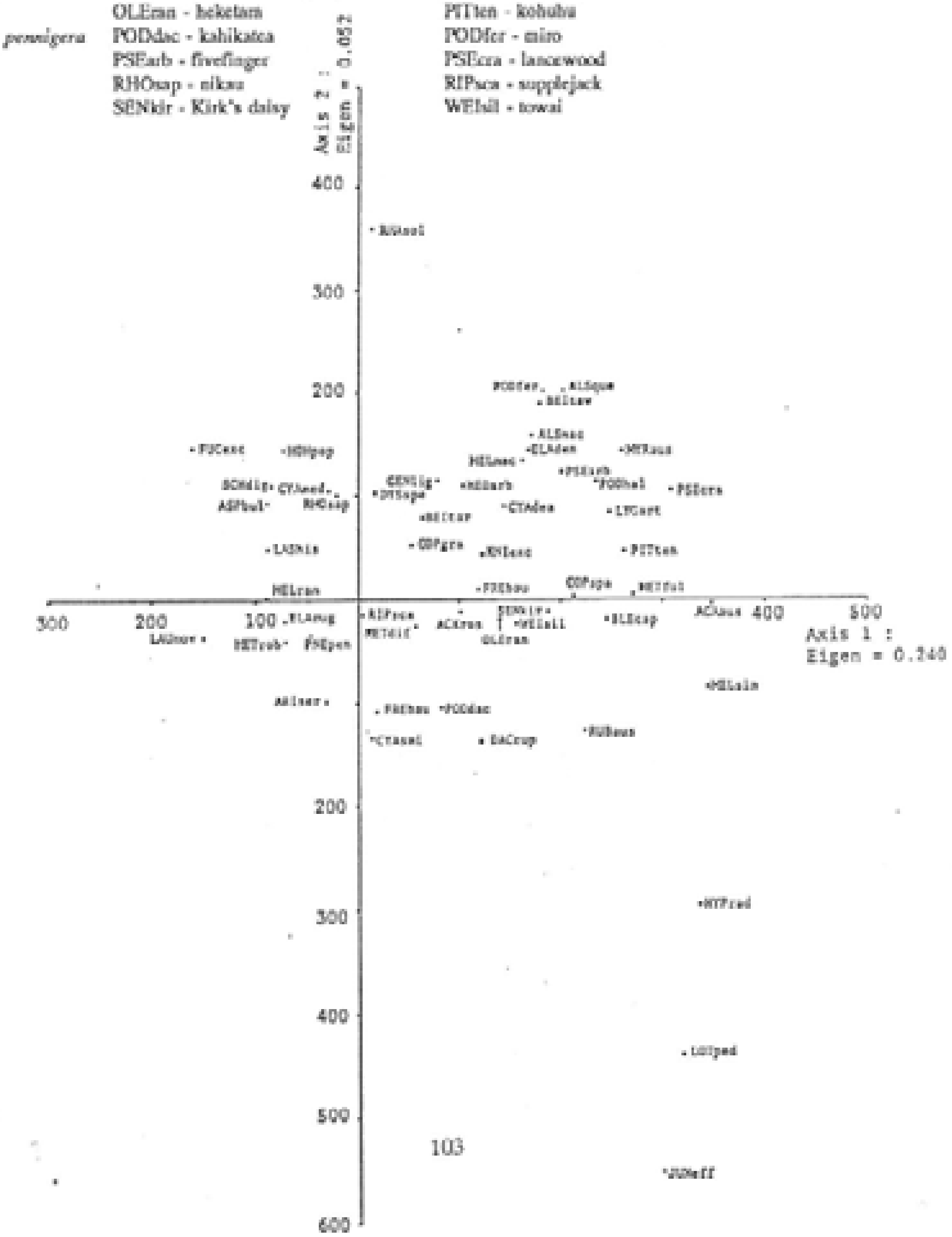


Figure 2.63: **Location of six vegetation groups defined for Summit kokako home range.** The groups were defined by classification and reflect primarily the transition from gully bottoms to ridge tops, and also the extent of disturbance and of drainage gradients. The six groups defined are listed below, and are shown for the appropriate grid square on the home range map. Scale: each square is 40 x 40m. Approximate altitudinal contours at 20m intervals.

Group (i) supplejack-kohekohe-taraire-(pukatea); Group (ii) pukatea-northern rata-rimu-supplejack-taraire; Group (iii) kohekohe-taraire-tawa; Group (iv) Hall's totara-miro-towai-kiekie; Group (v) towai-Hall's totara-kiekie-wheki-ponga; Group (vi) towai-Hall's totara-kiekie-ponga

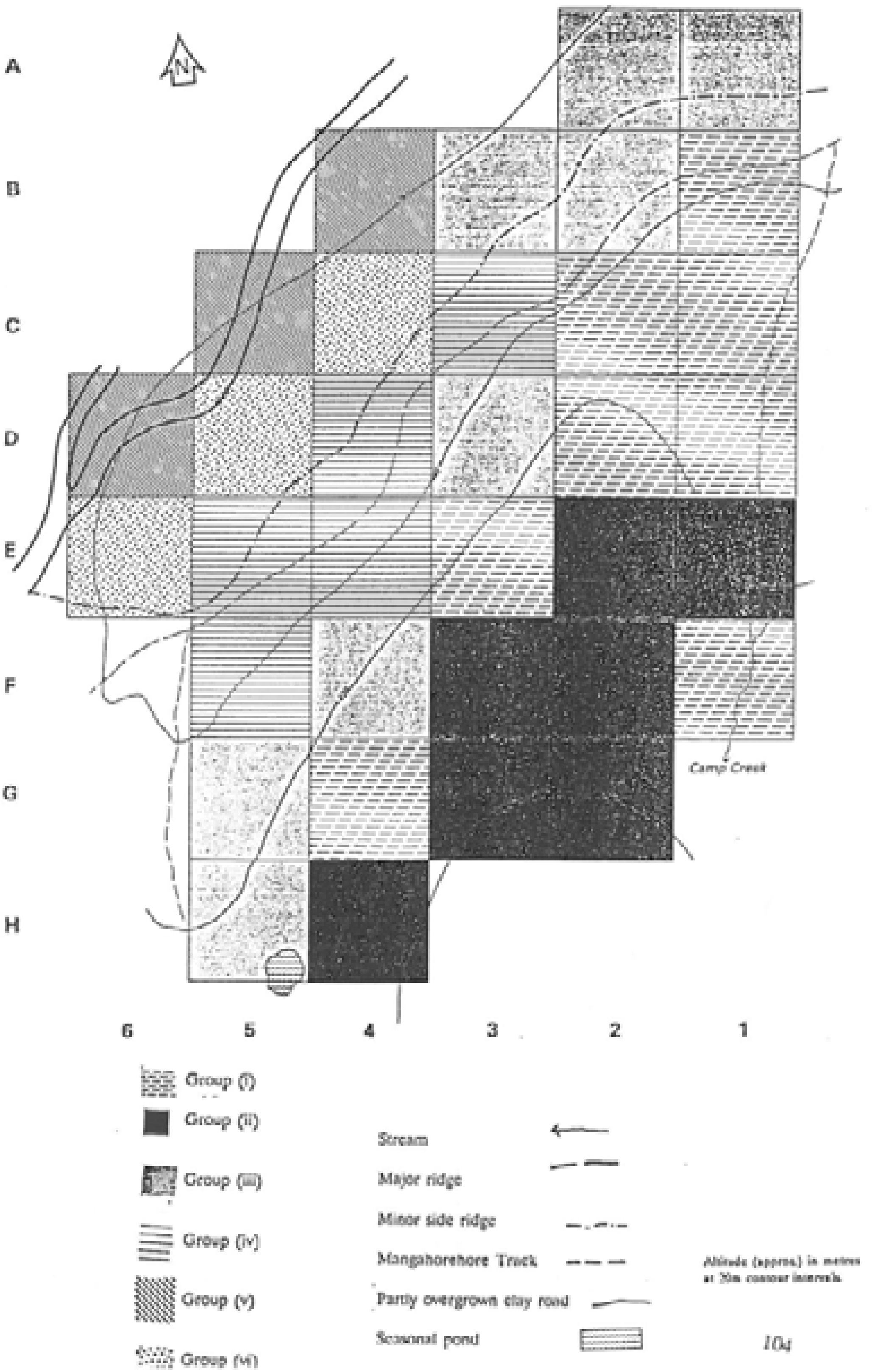


Figure 2.64: Structural representation of vegetation group (i) supplejack-kohekohe-taraire-(pukatea) determined from classification analysis of vegetation plots in Summit kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 14-23.7m; Tier 2: canopy vegetation = 12-14m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively
Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (i) vegetation was present in the following plots; B1,C1,C2,D1,D2,E3,F1,G4.

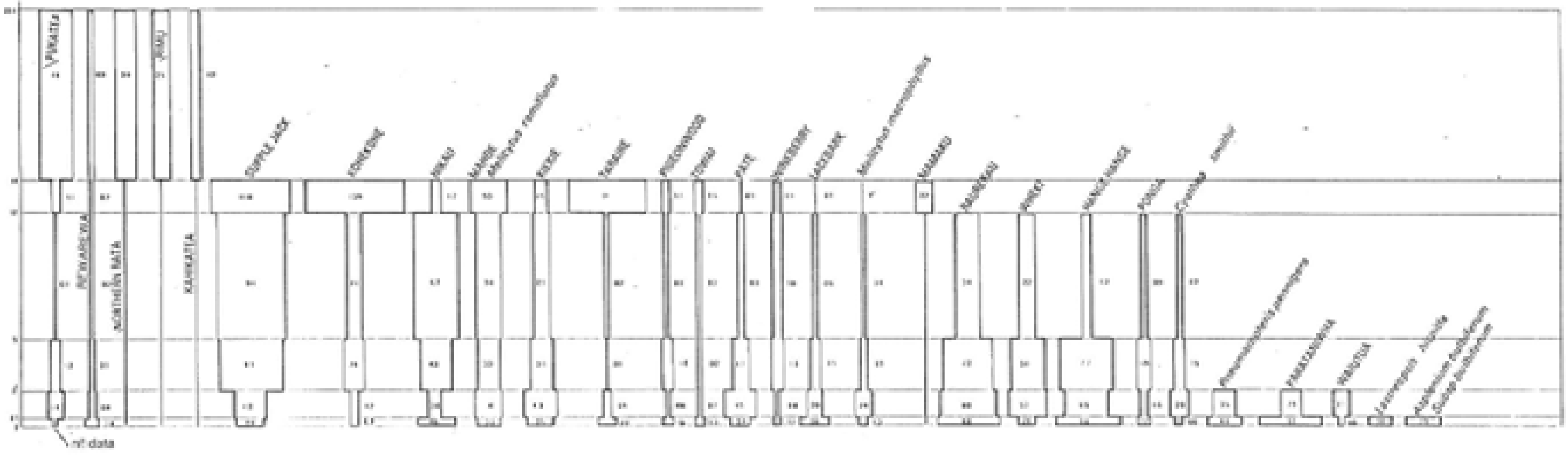


Figure 2.65: **Structural representation of vegetation group (ii) pukatea-northern rata-rimu-supplejack-taraire determined from classification analysis of vegetation plots in Summit kokako home range.**

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 14.7-23.5m; Tier 2: canopy vegetation = 12-14.7m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively
Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (ii) vegetation was present in the following plots; E1,E2,F2,F3,G2,G3,H4.

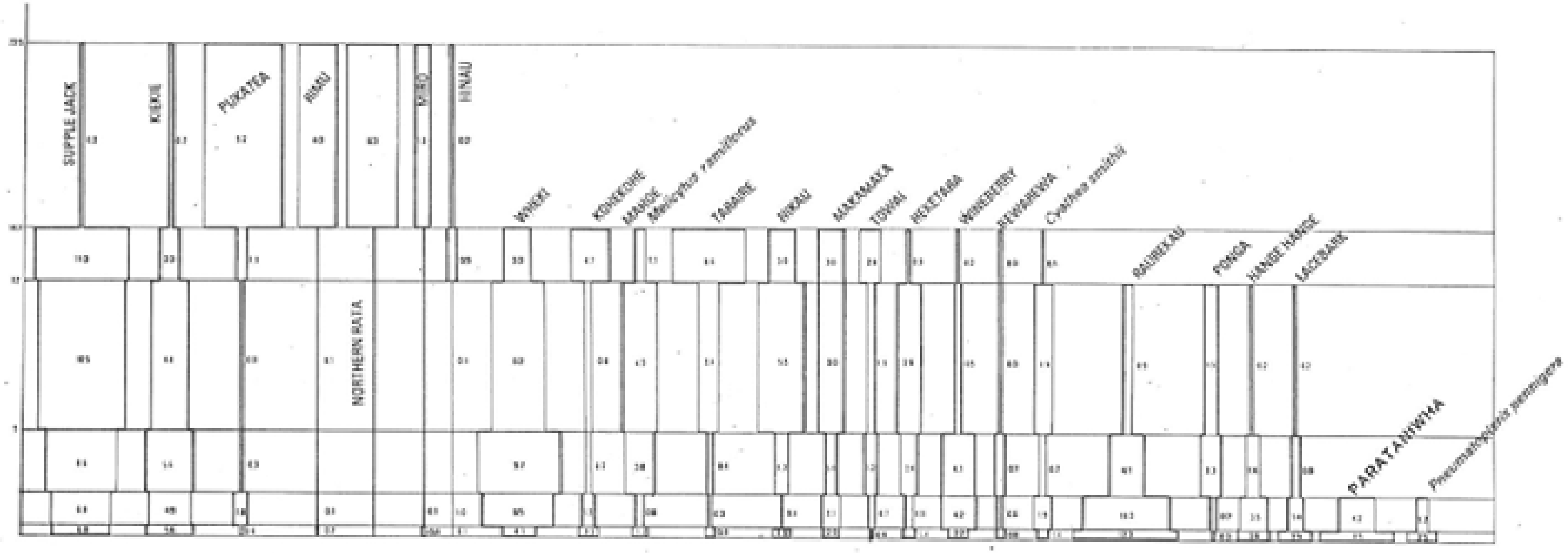


Figure 2.66: Structural representation of vegetation group (iii) kohekohe-towai-tawa determined from classification analysis of vegetation plots in Summit kokako home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 15.3-22.8m; Tier 2: canopy vegetation = 12-15.3m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively
Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (iii) vegetation was present in the following plots; A1,A2,B2,B3,D3,F4,G5,H5.

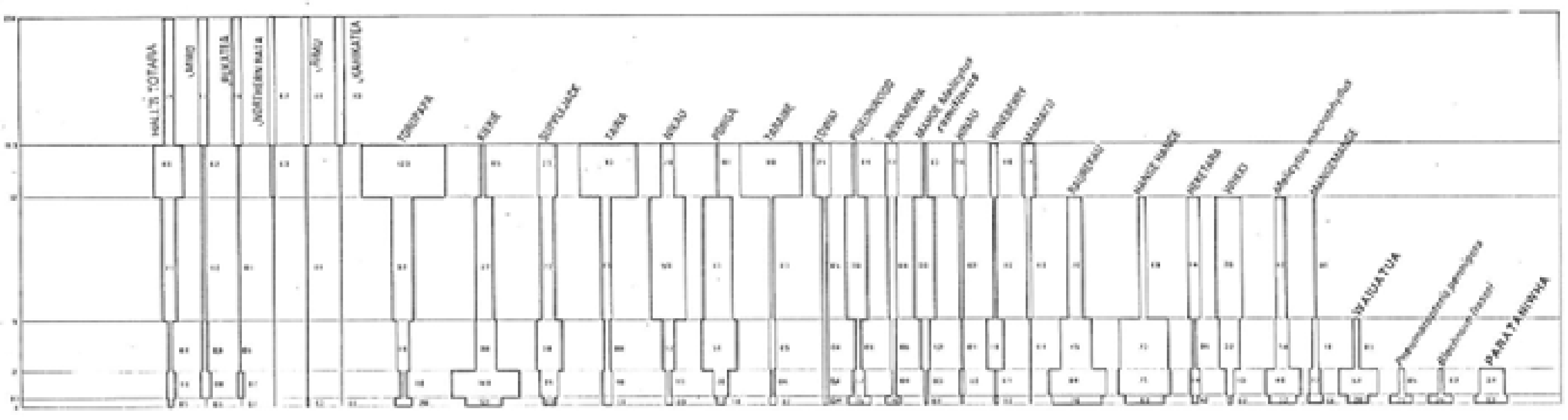


Figure 2.67: Structural representation of vegetation group (iv) Hall's totara-miro-towai-kiekie determined from classification analysis of vegetation plots in Summit home range.

Tier height classes are depicted to scale, namely
Tier 1: emergent vegetation = 16.4-23.3m; Tier 2: canopy vegetation = 12-16.4m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively
Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (iv) vegetation was present in the following plots; C3,D4,E4,E5,F5.
Note: *Blechnum* sp. (*B.capense* agg. Lowland sp.) is now named *B.procerum* (see Appendix 6.1)

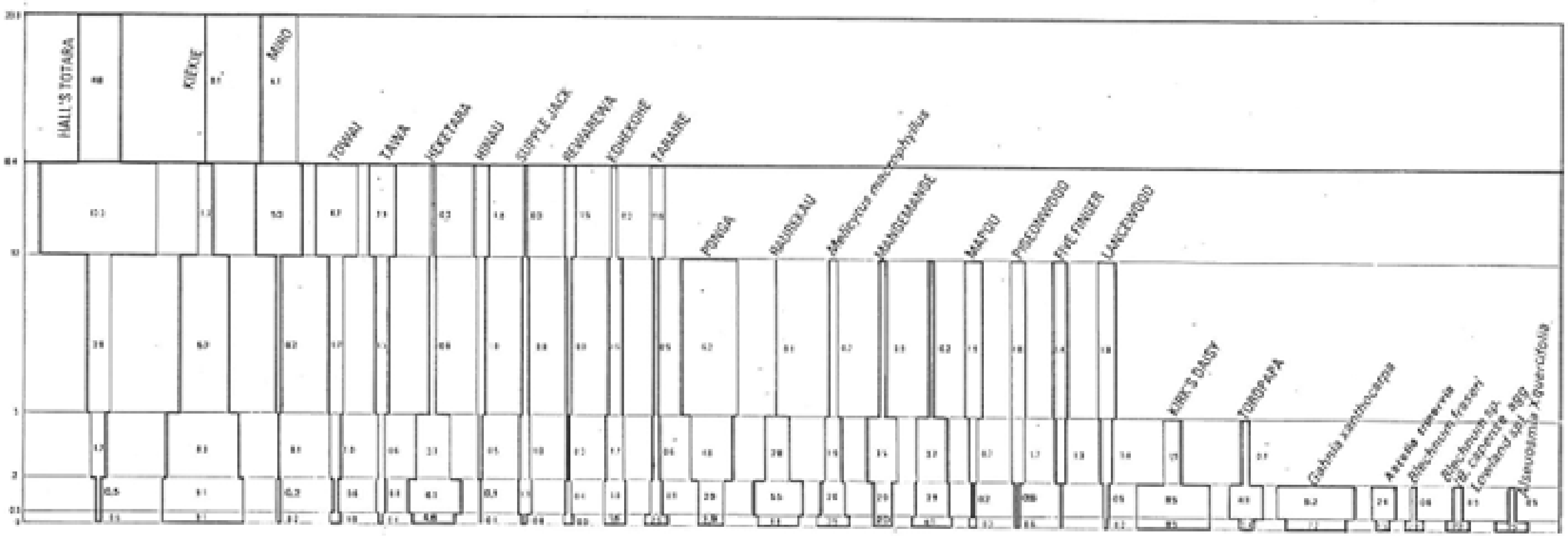


Figure 2.68: Structural representation of vegetation group (v) towai-Hall's totara-kiekie-wheki-ponga determined from classification analysis of vegetation plots in Summit kokako home range.

Tier height classes are depicted to scale, namely
Tier 2: canopy vegetation = 12-13.67m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively; Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (v) vegetation was present in the following plots; B4,C5,D6.
Note: *Blechnum* sp. (*B.capense* agg. Lowland sp.) is now named *B.procerum* (see Appendix 6.1)

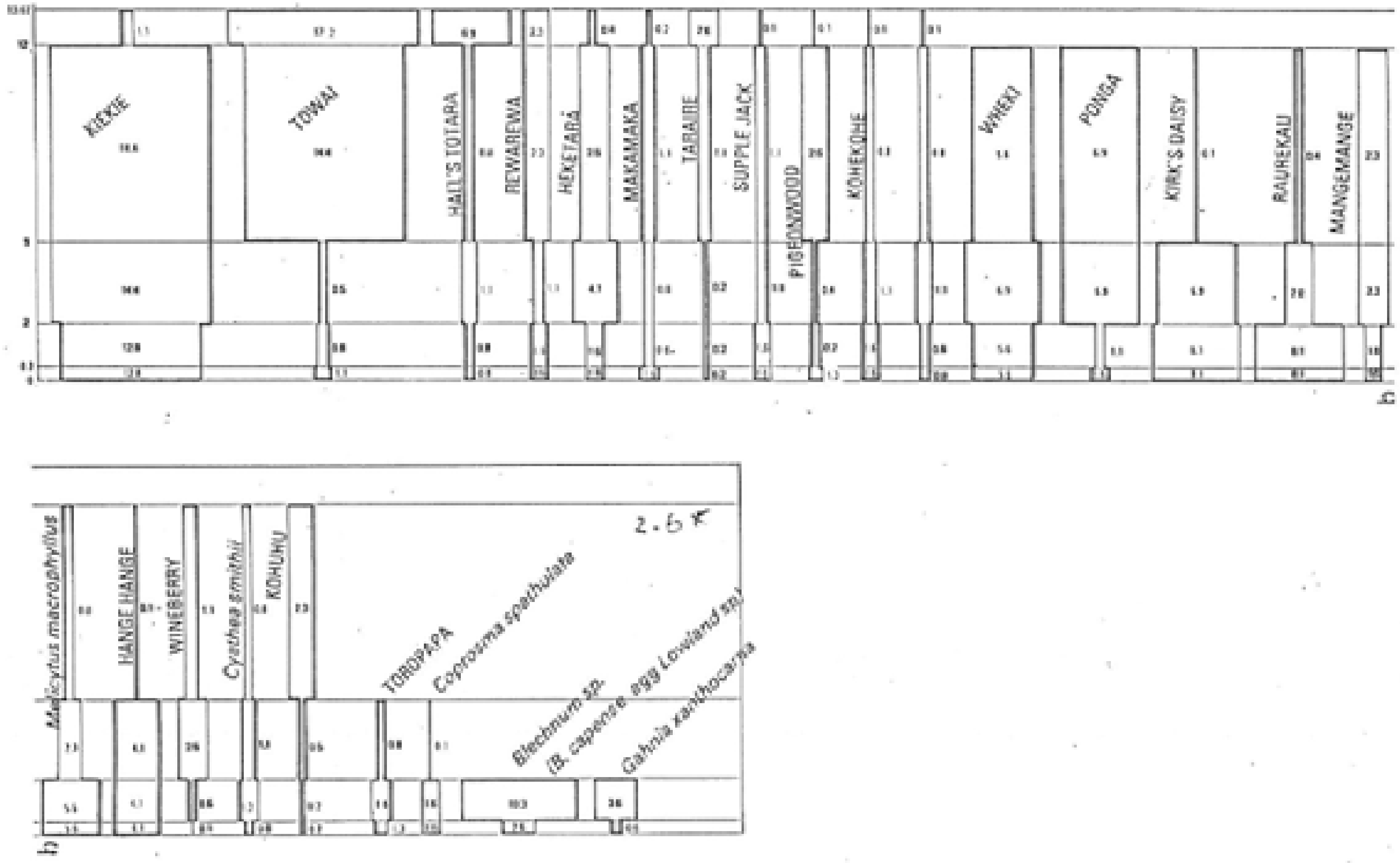
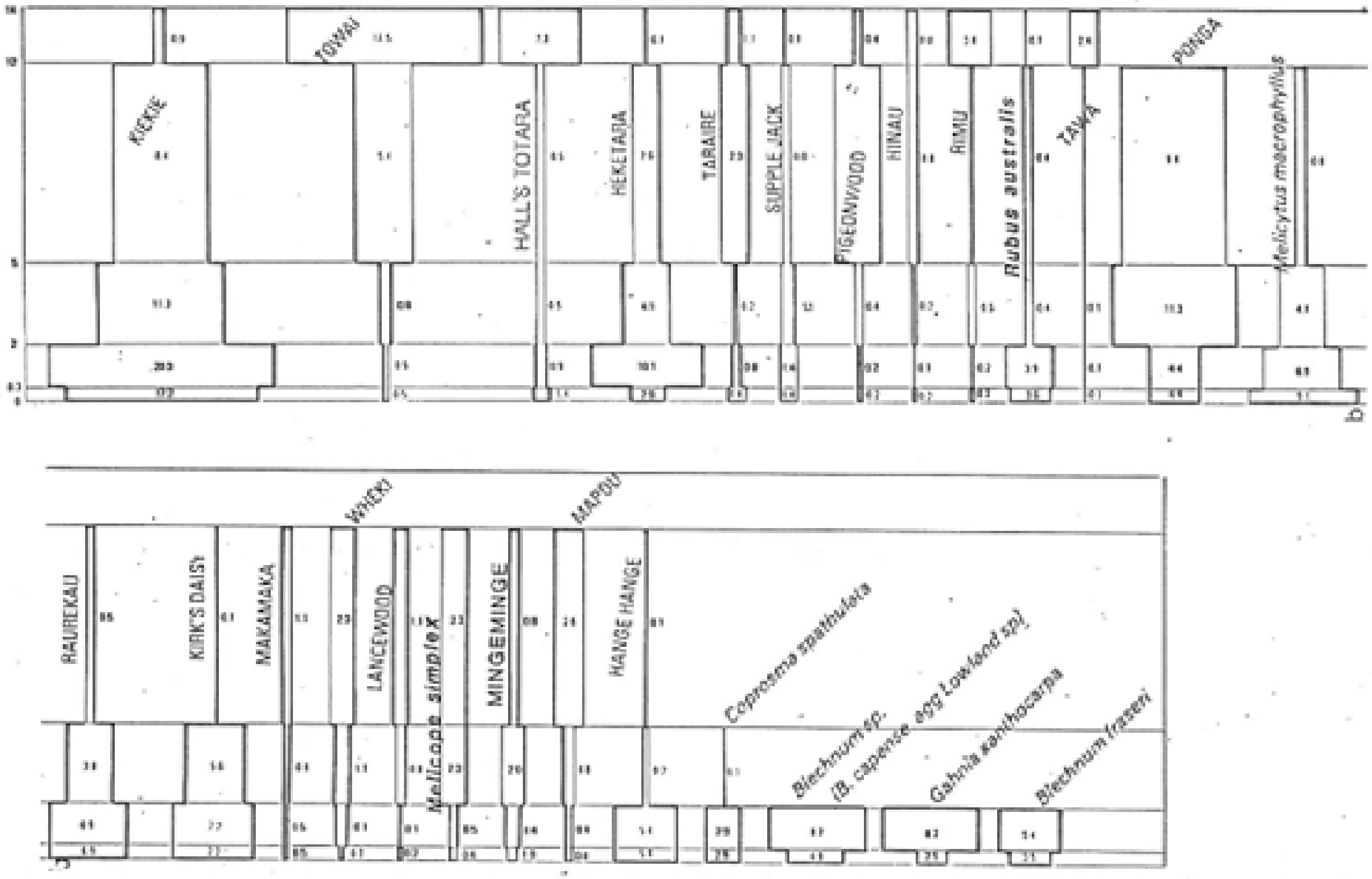


Figure 2.69: Structural representation of vegetation group (vi) towai-Hall's totara-kiekie-ponga determined from classification analysis of vegetation plots in Summit kokako home range.

Tier height classes are depicted to scale, namely
Tier 2: canopy vegetation = 12-14m; Tier 3 and 4: subcanopy vegetation = 5-12m and 2-5m respectively; Tier 5 and 6: ground plants = 0.3-2m and 0-0.3m respectively.

Mean percent cover abundance in each tier class is shown for various common species, where the width in each tier class is proportional to the species abundance.

Group (vi) vegetation was present in the following plots; C4,D5,E6.
Note: *Blechnum* sp. (*B.capense* agg. Lowland sp.) is now named *B.procerum* (see Appendix 6.1)



SECTION THREE: PHENOLOGY STUDIES

SUMMARY

a) The flowering, fruiting and leaf production cycles of fifty three species of trees, shrubs, lianes and epiphytes, which were common in Puketi Forest, were studied to determine the relationship between kokako diet and food availability.

b) Nearly all species produced most of their leaves in spring to early summer, and a few also had a secondary flush in autumn. The majority of spring-flowering species had a flush of leaves after flowering.

c) Most species flowered in spring and some in summer. Some spring-flowering plants produced flower buds in winter, but others budded in autumn or even earlier. Few species flowered in autumn or in winter. Some winter-flowering species had very long flowering periods. Some populations of species had protracted flowering periods. Individual puriri trees flowered profusely through most of the year.

d) Timing of fruit ripening bore little relationship to the time of flowering. The fruit of some species ripened within a month, while that of other species took more than a year to ripen. Ripe fruit were mast abundant in autumn, and scarcest in spring.

e) The study was of insufficient duration to make detailed conclusions about changes in productivity between years. For most plants, a moderate level of flowering and fruiting was evident in 1982, 1983, and 1984. Of the species whose output changed between years, more species had higher levels of fruit production resulting from 1983 flowering than either of the other years.

3.1 INTRODUCTION

Astudy of the phenology of 53 common trees, shrubs, lianes and epiphytes was undertaken concurrent with the study of use of habitat by kokako in Puketi Forest, Northland. The principle reason for the study was to assess the availability of food to kokako throughout the year. Previous studies (e.g. St Paul 1966, Hay 1981) have shown that kokako are predominantly foliage and fruit eating birds. Consequently, monitoring the availability of particular food items should help to account for seasonal changes in the species composition of the diet.

The phenology study was also the first to be undertaken in a northern New Zealand forest. Previous information regarding the phenology of species in these forests has been largely anecdotal, and attempts to derive information from herbarium material, as pointed out by Leathwick (1981) must be tempered with knowledge that such examples often represent atypical material gathered outside their usual periods of flowering and fruiting. Studies of the phenology of New Zealand lowland forests have been very few (e.g. Fitzgerald 1976, Leathwick 1984). The information derived from this study broadens the understanding of phenological patterns of species that occur in such forests, as well as providing regional knowledge.

Two aspects of the growth of each plant species studied were examined; namely

i) the time of year that certain stages of growth in particular leaf, flower and fruit production

ii) differences in levels of production of leaves, flowers and fruit between the two years of the study

3.2 METHODS

The method described by Fitzgerald (1976) formed the basis to this study. The following stages of plant growth were assessed:

a) Vegetative growth

(i) leaf buds - especially resting buds
(ii) expanding leaf buds - from the of breaking from a resting bud to the partial formation of new leaves
(iii) new leaves - when expanding buds have resulted in the complete or near-complete formation of new leaves

b) Flowering

(i) flower buds - the first appearance of either flower bud initials or, in the case of gymnosperms, the first appearance of cones of either sex
(ii) expanding flower buds or cones
(iii) flowers - included fully developed ones in the gymnosperms and pollination by male cones of ovules (usually inferred rather than seen)
(iv) petal fall - where this could be detected. This also included the shedding of male cones following anthesis.

c) Fruiting

(i) unripe fruit - all stages of development until ripeness. This could render some results difficult to interpret, especially when fruit of some species took more than a year to ripen and unripe fruit from one year's flowering were indistinguishable from those of the previous year. It was necessary to interpret these results alongside descriptive notes taken in the field
(ii) ripe fruit - where this could be detected. In many species a change in colour occurred with ripening, but this was not always the case, and in some species there was a very gradual change from unripe to ripe fruit such that no definite boundary existed between the two stages
(iii) seed fall - included fruit fall, shattering of cones, dehiscing of capsules, etc.

About 550 adult plants of 53 species were tagged for study. Up to 13 individuals of each species were tagged, and, in the case of dioecious plants, up to 12 plants of either sex were tagged. This applied only to strictly dioecious plants - in gynodioecious species and those exhibiting a between male and female plants (e.g. fivefinger, *Pseudopanax arboreus*), no attempt was made to separate the two sexes.

Three sites were selected for study. They were in forest of intact, or nearly intact mature canopy alongside old logging roads, and were either contiguous with, or ran through parts of kokako home ranges. The sites were located on

i) Pirau Ridge, near the Takapau kauri stand,
ii) Bramley's Ridge, and
iii) a disused road leading from Mokau Ridge to Onekura Bluff.

Areas of forest next to logging roads were chosen for study, so that crowns of individual trees could be scanned adequately, a task that was not practical from beneath the canopy of unmodified forest. However, the phenology specimens were generally more exposed to sun, wind and rain than their counterparts within or beneath the forest mantle. Consequently, phenology specimens may have flowered or fruited earlier, and to a different degree than plants of the same species on more sheltered sites. Furthermore, because logging roads in Puketi Forest were almost invariably along ridges, there was a preponderance of species which were more common on ridge tops and gully heads, and thus species predominantly frequenting gully bottoms (e.g. kahikatea and pukatea) have not been included in the study. The species selected for study were chosen to represent the most common species in the forest (based on initial field reconnaissance and on a report by Sexton 1939), and also to include species considered important in kokako diet in Puketi Forest. This latter information was supplied by Dr R.G. Powelsland on the basis of observations of kokako in Puketi Forest in 1982.

The three study sites were visited each month from March 1983 to October 1984, inclusive. The crowns of tagged trees and shrubs were scanned thoroughly using 7 x 35 binoculars, and the phenological stages present noted. The abundance of each phenological stage was assessed on a numerical scale from 1 to 10 (1 = barely present, 5 = common, 10 = superabundant). This index of abundance was applied in the field relative to the size of the plant - an important point to consider when comparing an abundance of flowering in a small epiphytic orchid (e.g. *Dendrobium cunninghamii*) to that of relatively low level of fruit production in podocarps.

Two species examined provided no useful data: kiekie and tanekaha. The 12 lianes examined never flowered and leaf production was impossible to detect. Flowers and fruit were very seldom seen in the forest in the course of the study, and these were usually on low trailing tangles rather than in high lianes like those that were studied. Of the five tanekaha trees examined, the one male had cones that ripened in the spring of 1983, but had none in 1984. The remaining tanekaha were of indeterminate sex, as it was impossible to distinguish development of either male cones or ovules in their crowns.

For each species, plots were made of the mean scores of abundance per month of each of the ten phenological stages studies over 20 months. These results appear as graphs in Appendix 3.1 along with a description of the cycle of growth observed over the duration of the study.

Although data on the reproductive phases of growth (i.e. of flowering and of fruiting) were collected on a monthly basis, they were analysed seasonally to coincide with the collection of kokako habitat use. The seasons were grouped as follows:

Summer = December, January, February
Autumn = March, April, May
Winter = June, July, August
Spring = September, October, November

3.3 Results

Table 3.1 summarises the reproductive phases of growth (i.e. flowering and fruiting). The species listed for each of the four seasons were those which had maximal production of one of the following phenological stages: flower buds (including expanding flower buds), flowers, unripe fruit, and ripe fruit. Species which had a relatively constant level of production in more than one season have been listed for each of these seasons. Some species had a sharp flush of production of flowers and subsequently of fruit (e.g. heketara = *Olearia rani*). Other species had quite protracted periods of flowering and fruiting, so that flowers and fruit were often present in seasons other than those listed below (e.g. in the case of towai = *Weinmannia silvicola*). Protracted flowering and/or fruiting was exhibited by individual plants as well as being a feature of populations.

3.3.1 Vegetative Growth

Most species produced new foliage in spring and a few had a secondary flush of production in autumn. Very few species had maximal leaf production in summer (e.g. northern rata, miro and lancewood). Many species that had a pronounced leaf flush in spring, were also spring-flowering. Leaf flush usually just followed flowering (e.g. in taraire, hinau and tawari) and less frequently just preceded flowering (e.g. in tawa and supplejack. In addition to their having peak seasons for leaf production, many species produced minor amounts of leaves all year round, and a few (e.g. hangehange, mingimingi and Kirk's daisy) produced a substantial amount of leaves in all seasons. Two species (wineberry and kotukutuku) were wholly or partially deciduous, having a short period of leaf fall in late autumn/early winter with a major flush of leaves subsequently.

3.3.2 Flowering

Most species produced flower buds in autumn, or winter and flowered in spring. Very few species (e.g. tawari) formed flower buds in summer. Of the podocarps, miro formed male cones in the autumn which ripened in the spring, while others produced male cones in late winter. Ovules for all of the podocarps developed over longer periods. Cones on kauri appeared in autumn, and were fully developed by spring. Some species formed flower buds in spring, just after the peak of leaf production, for flowering in the summer (e.g. in tawa, mahoe and towai).

Relatively few species flowered in autumn or winter. Autumn-flowerers formed buds in mid or late sumner and flowered mostly in early autumn (e.g. raurekau, lancewood and pate). Winter-flowering plants occurred as two types; those that produced flower buds in autumn for a protracted period of winter-flowering (e.g. kohekohe, fivefinger and kotukutuku) and those that had flower buds which developed rapidly from early winter for a flush of flowering in late winter, just in advance of the major buildup to spring-flowering (e.g. *Pittosporum cornifolium* and toro). Very few plants flowered throughout the year. Although some (e.g. northern rata and fivefinger) had protracted flowering periods within a population, generally only a few plants were flowering at one time. Puriri was a notable exception in that flower buds and flowers were produced all year round, with a relative decline only in summer.

3.3.3. Fruiting

It was difficult to generalise about fruit production. Ripe fruit were present on a range of species at mast times of the year. The main patterns in fruiting that occurred were thus; ripe fruit appeared -

1. Two to three months after pollination. This happened with summer-flowering towai and raukawa, autumn-flowering pate, winter-flowering Kirk's daisy and spring-flowering rangiora, puawhananga, heketara and *Rubus australis.*

2. Four to seven months after pollination. This was the most wmmon pattern observed from the study plants. Many spring-flowering plants had fruit that ripened in autumn or winter (e.g. toropapa, hinau, puka, tawari, rewarewa, Hall's totara and kohuhu).

3. Seven to nine months after pollination: a small number of species. Examples included spring-flowering *metrosideros albiflora* and taraire, both of which lost their seeds of fruit in winter, and summer-flowering nikau whose fruit ripened in late winter/early spring.

4. Twelve months after pollination. In these cases, ripe fruit from the previous year's flowering were apparent at the same time as unripe fruit of the current year. This occurred with autumn-flowering raurekau, winter-flowering *Pittosporum cornifolium* and spring-flowering *Coprosma lucida* and pigeonwood.

5. More than twelve months after pollination. This applied mainly to gymnosperms, but also included a few angiosperms. As an example, ripe supplejack fruit were most abundant in summer, 14 months after flowering. Likewise, the seed in female kauri cones took about 14 months to ripen after spring fertilisation. Fruit of the podocarps miro and rimu ripened in autumn, about 18 months after pollination, and sometimes remained on trees up to 20 months after pollination.

6. Over a protracted period. For mapou and fivefinger, a portion of the fruit ripened within two or three months of flowering, while other fruit did not ripen until more than a year after flowering. Protracted ripening of fruit sometimes resulted from protracted flowering (e.g. for kotukutuku and fivefinger), but not in the case of mapou which had a short flowering period. Similarly, while the fruiting species was seasonal, ripe fruit persisted in small quantities on some species at most times of the year (e.g. *Melicytus macrophyllus* fruit ripened mainly about five months after flowering but some ripe fruit wuld still be present one year later).

The production of ripe fruit varied between the two years of the study. Unfortunately, the study did not extend for sufficient time to make comparisons between years for some species (i.e. only one complete flowering and fruiting cycle was observed), and in other instances, levels of fruit production were inferred from the level of flowering or unripe fruit production.

Comparisons of ripe fruit production between years could be made for 45 of the 53 species studied, including 28 species between 1982 and 1983 (in the case of fruit with long ripening periods) and 33 species between 1983 and 1984.

(a) 1982/1983 comparisons:
Eight (29%) of the 28 species that allowed comparison between these years showed differences in levels of fruit production.

- Three species fruited more heavily from the 1982 flowering period than from the 1983 flowering period (pigeonwood, Kirk's daisy and towai).

- Five species had greater levels of fruit production from the 1983 flowering period than from the 1982 flowering period (kauri, tawa, *Metrosideros albiflora, Pittosporum cornifolium* and kohuhu).

(b) 1983/1984 comparisons:
Thirteen (39%) of the 33 species that allowed comparison between these years showed differences in levels of production.

Nine species had greater levels of fruit production from the 1983 flowering period than from the 1984 period. They were makamaka, taraire, mamangi, neinei, mahoe *Melicytus macrophyllus, Metrosideros albiflora,* heketara and kohuhu.

Four species had greater levels of fruit production from the 1984 flowering period than from the 1983 flowering period (wineberry, pigeonwood, tawari and lancewood).

In conclusion, most species showed a similar level of fruit production between 1982/83 and 1983/84. However, for the species that showed different fruit production levels these years, more species had higher levels of fruit production arising from the 1983 flowering season, than from 1982 or 1984.

Table 3.1 Main production seasons of flower buds, flowers, unripe fruit and fruit for 53 species in Puketi Forest noted over a study from Autumn 1983 - Spring 1984.

From 1 to 13 individuals of each species were observed throughout the study. Where long ripening periods occur (i.e. more than 1 year), no attempt has been made here to distinguish between unripe fruit produced in different years.

Attribute	Summer (Dec,Jan,Feb)	Autumn (Mar,Apr,May)	Winter (June,July,Aug)	Spring (Sept,Oct,Nov)
Flower buds (including unripe cones of gymnosperms)	*Collospermum hastatum* *Earina autumnalis*, tawari, mahoe, northern rata, fivefinger, lancewood, nikau, pate, puriri	makamaka, raurekau, rimu, kohekohe, hinau, kotukutuku, hangehange, tawari, mingimingi, mapou, *Metrosideros fulgens* Hall's totara, miro, fivefinger, Kirk's daisy, puriri towai	makamaka, kauri, toropapa, taraire, rangiora, puawhananga, *Coprosma lucida*, *Coprosma robusta*, rimu, *Earina mucronata*, hinau, kotukutuku, hangehange, puka, *Ileostylus micranthus*, pigeonwood, tawari, rewarewa, mingimingi, *Melicytus macrophyllus*, *Metrosideros albiflora*, *Mida salicifolia*, mapou, toro, heketara, *Pittosporum cornifolium*, kohuhu, Hall's totara, miro, puriri	kauri, wineberry, taraire, tawa, mamangi, ti ngahere, ti kouka, neinei, *Dendrobium cunninghamii* kotukutuku, puka, pigeonwood, rewarewa, mahoe, northern rata, *Metrosideros albiflora*, Hall's totara, miro raukawa, supplejack, *Rubus australis*
Flowers (including ripe cones gymnosperms)	kauri, tawa, *Collospermum hastatum*, ti kouka, rimu *Dendrobium cunninghamii*, neinei, mahoe, northern rata, raukawa, nikau, towai	raurekau, lancewood, *Earina autumnalis*, *Metrosideros fulgens*, pate, puriri, towai	kohekohe, kotukutuku, *Metrosideros fulgens*, mapou, toro, *Pittosporum cornifolium*, fivefinger, Kirk's daisy, puriri	makamaka, wineberry toropapa, taraire, rangiora, puawhananga, mamangi, ti ngahere, *Coprosma lucida*, *Coprosma robusta*, rimu, hinau, *Earina mucronata*, kotukutuku, hangehange, *Ileostylus micranthus*, puka, pigeonwood, tawari, rewarewa, mingimingi, mahoe, *Melicytus macrophyllus*, *Metrosideros albiflora*, *Mida salicifolia*, heketara, kohuhu, Hall's totara, miro, supplejack, *Rubus australis*, puriri
Unripe fruit	kauri, toropara taraire, *Coprosma ludica*, *Coprosma robusta*, ti ngahere, ti kouka, rimu, neinei, *Dendrobium cunninghamii*, kohekohe, hinau, kotukutuku, hangehange, *Ileostylus micranthus*, puka, pigeonwood, tawalri, rewarewa, *Metrosideros albiflora*, northern rata, mapou, *Mida salicifolia*, *Pittosporum cornifolium*, kohuhu, Hall's totara, miro, raukawa, supplejack, *Rubus australis*, puriri	kauri, taraire, tawa, *Coprosma lucida*, *Collospermum hastatum*, rimu, neinei, *Earina autumnalis*, hinau pigeonwood, *Ileostylus micranthus*, *Metrosideros albiflora*, *Pittosporum cornifolium*, kohuhu, Hall's totara, lancewood, nikau, supplejack, pate, puriri, towai	kauri, tawa, raurekau, rimu, koheohe, pigeonwood, *Metrosideros fulgens*, mapou, Hall's totara, fivefinger, lancewood, nikau, supplejack, pate, Kirk's daisy	makamaka, kauri, wineberry, toropapa, rangiora, puawhananga, raurekau, rimu, kohekohe, kotukutuku, *Earina mucronata*, puka, mingimingi, *Melicytus macrophyllus*, *Metrosideros fulgens*, *Mida salicifolia*, mapou, toro, heketara, *Pittosporum cornifolium*, kohuhu, Hall's totara, miro, fivefinger, nikau, *Rubus australis*, puriri

Attribute	Summer (Dec, Jan, Feb)	Autumn (Mar,Apr, May)	Winter (June,July, Aug)	Spring (Sept,Oct,Nov)
Ripe fruit	makamaka, wineberry, toropapa, tawa, rangiora, puawhananga, raurekau, kotukutuku, rewarewa, mingimingi, *Melicytus macrophyllus*, *Meterosideros fulgens*, *Mida salicifolia*, mapou, supplejack, *Rubus australis*, puriri	kauri, toropapa, *Collospermum hastatum*, raurekau, *Coprosma robusta*, ti ngahere, ti kouka, rimu, neinei, *Dendrobium cunninghamii*, kohekohe, hinau, *Earina autumnalis*, hangehange, puka, *Ileostylus micranthus*, tawari, rewarewa, *Melicytus macrophyllus*, northern rata, mapou, *Mida salicifolia*, kohuhu, Hall's totara, miro, raukawa, towai	taraire, hinau, *Collospermum hastatum*, hinau, puka, *Metrosideros albiflora*, mapou, kohuhu, *Pittosporum cornifolium*, lancewood, nikau, pate, puriri	makamaka, taraire, tawa, puawhananga, *Coprosma lucida*, *Earina mucronata*, kotukutuku, pigeonwood, *Metrosideros fulgens*, mapou, heketara, *Pittosporum cornifolium*, fivefinger, lancewood, nikau, puriri

APPENDIX 3.1 NOTES ON TEE PHENOLOGY OF PARTICULAR SPECIES

(note: figures follow text on page 130)

(1) *Ackama rosifolia* – makamaka[1] (n=11)
Leaf buds and expanding leaf buds were a feature of makamaka for most of the year, with maximum leaf production occuring in late spring and early summer, after the peak of flowering. Flowering occurred over a protracted period, with flower buds first appearing in late summer. The panicles expanded soon after, with a small amount of flowers present through most of autumn and winter (particularly in 1984). The bulk of flowering occurred in late winter, however. Fruit development and ripening was rapid, with seed fall occuring predominantly in late spring after flowering.

Flowering was slightly heavier but extended over a period in 1983, compared to 1984.

(2) *Agathis australis* - kauri[1] (n=12)
Leaf production was evident on most trees examined for only a brief period in late spring, when the trees were flushed with glaucous-green new foliage. Leaf buds apparently overwintered but their expansion before leaf production was almost impossible to see in the tall crowns of these trees. Male cone development was also extremely difficult to detect in its initial stages, occurring as it does just back from the branchlet tips inset among the previous season's leaves. Sando (1936) noted initialising of male cones in February. However the earliest that male cones were detected was in early winter, and they developed to shed pollen in late spring/early summer, after which they soon fell from the crowns. Female cones were initialised in summer and developed in the crowns for most of the following year, expanding rapidly in late spring, when they were pollinated. They then developed to mature cones with unripe seeds through the whole of the following year, shattering to release seed in late summer (i.e. 14 months after pollination).

Considerably more cones bearing unripe seed resulted from pollination in late 1983 than had resulted from pollination in 1982.

(3) *Aristotelia serrata* - makomako, wineberry[1] (n = 9 (male), 13 (female))
Trees of both sexes remained in bud through most of autumn and winter; some late leaf production occurred in autumn. The trees were partially deciduous and crowns were quite sparse by the end of winter. The overwintering buds began to expand rapidly in late winter to reach a peak of leaf production in late winter. Flower bud development began slightly earlier in male trees than in females during early spring and developed quickly in both sexes to a peak of flowering in October. Fruit development and ripening was rapid, with a peak of ripe fruit in mid-summer.

Flower production was greater in 1984 compared to 1983 and it can be surmised that more fruit production would have thus eventuated. Heavy and debilitating possum browse was noted on two male trees in 1984 which resulted in lesser leaf production and no flower production in that year.

(4) *Alseuosmia macrophylla* – toropapa[1] (n = 6)
Leaf production occurred in small amounts all year round on the plants observed, reaching peak production in spring. Flowering was protracted in toropapa, with buds appearing in early winter and producing flowers frnm mid-winter to late spring, but with peak production in both years in September. Fruit production resulted from flowers produced from September onward, ripening predominantly in late summer/early autumn.

Neither flowering nor fruiting were very heavy in either of the two years of the study.

(5) *Beilschmiedia taraire* – taraire[1] (n=13)

Trees remained in bud most of the year - the buds were large, conspicuous and covered in brown tomentum, and although sparse leaf production occurred for most of the year, there was a major flush of leaf production in late spring. Flower buds were first detected in late autumn. They expanded through the winter for a peak of flowering in mid-spring, just before the leaf flush. The

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[1] Monthly abundance rating scale 0 to 10, where 1 = absent,1 = barely present, 5 = common, and 10 = superabundant.

unripe fruit grew rapidly in size to the full-sized glaucous coloured drupe by early autumn. A gradual ripening of fruit to its indigo colour and subsequent seed fall occurred from early winter until the end of spring in the year that followed their formation. No noticeable peak of ripe fruit production was evident in either of the years that records were taken.

Flowering was noticeably heavier in 1983 than in 1984.

(6) *Beilschmiedia tawa* – tawa[1] (n=12)
A small amount of leaf production occurred in tawa for most of the year, but the majority of new leaf production was from late winter until late spring. Flower buds were first detected in late winter and rose to a sharp peak of flowering in early summer, just after the bulk of leaf production. Despite heavy flowering, only a relatively small amount developed as fruit, in the one season that both flowering and fruiting were observed. The unripe fruit developed in size to full-sized, green fruit by early winter. They ripened to a purple colour over a protracted period, from mid-winter onwards to a peak the summer after their formation.

Neither 1983 nor 1984 had heavy crops of tawa fruit, although that of 1984 (resulting from flowering in 1983) was heavier than that of the previous year.

(7) *Brachyglottis repanda* – rangiora[1] (n=12)
Rangiora produced low levels of new leaves most of the year round, but had a definite flush of new leaf production from early spring until mid-summer. Flower buds appeared first in early or mid-winter and developed for a peak of flowering in early spring. The florets soon formed unripe seed which ripened and scattered soon after by early summer. There were considerable differences between plants in their flowering - some individuals flowered heavily in both years, while others produced only a meagre amount of flowers.

Overall, a low level of flowering and of seed production was observed in both years.

(8) *Clematis paniculata* – puawhananga[1] (n = 1 (male), 1 (female))
Leaf production in both sexes was strongly seasonal from a marked expansion of buds in late winter, to a major flush of leaf growth in the spring (the male exhibited a second flush of growth in late autumn). Flowering and fruiting occurred rapidly and in profusion. Flower buds were evident in mid-winter and expanded rapidly, with flowering ensuing in early spring. The flowers went quickly to seed which ripened in late spring, and were scattered over the summer months.

The male plant flowered extremely profusely in both years of the study, but the female, which flowered abundantly in 1983 did not flower in 1984, although it remained healthy in appearance.

(9) *Collospermum* hastatum[1] (n=2 (male), 2 (female), 8 others examined sex indeterminate)
New leaf production was not detected in any of the plants examined. Because flower buds were formed in the centre of these lilies perched high up in trees they were impassible to detect. Expanding flower buds became visible in early summer, rising to a peak of flowering in mid-summer. Fruit production and ripening was protracted in 1983 but took place over a relatively shorter period in 1984, i.e. ripe fruit fell in late winter in 1983 and in early autumn in 1984. Only a small proportion of the *Collospermum* plants examined exhibited any flowering over the duration of the study - two-thirds of the plants examined produced no observable phenological traits.

(10) *Coprosma arborea* – mamangi[1] (n=2 (male))
Only two male plants were observed in the study, so no information on fruiting was gathered. Sporadic leaf production was noted through most of the year, with the greatest amount being produced in mid-spring, although scarcely a noticeable peak. Flowering of the two male plants was extremely heavy in 1983, but none was detected in 1984. Flower buds were first noted in late winter and flowering followed soon after, in early spring.

(11) Coprosma grandifolia – raurekau[1](n=11 (male), 13 (female))
Leaf production occurred most of the year round, but had a distinct peak in both sexes from early spring to mid-summer. Flower production was greater and there was a distinct peak of flowering in

male plants, compared with female plants, which had a more protracted flowering period. Flower buds were produced from early autumn, with a peak of flowering in May-June (late autumn). Fruit on the female plants developed to full size by mid-winter but were green and ripened over a protracted period from then on -a small amount of ripe fruit was produced all year but the bulk of ripe fruit appeared from mid-summer until early autumn, (10 months after pollination).

Similar levels of flower and fruit production were in both years of the study - the protracted nature of ripening of fruit was much more evident in 1984 than in 1983.

(12) *Coprosma lucida* – karamu[1] (n = 11 (male), 9 (female))
Although moderate amounts of leaves were produced most of the year round, the majority appeared from mid-winter to early summer. Flower buds were first noted in mid-winter and developed rapidly to a peak of flowering in early spring - large numbers of flowers were produced on both sexes, although more were produced by male plants. Fruit production and ripening was extremely protracted in *Coprosma lucida.* Unripe fruit formed and developed to full size by early summer. Ripe fruit were evident from early autumn, reaching a peak in late winter/early spring the year after their formation, but were still present until early summer (14 months after their formation).

Similar moderate levels of flowering and fruit production were evident in both years of the study.

(13) *Coprosma robusta* – karamu[1] (n = 1 (male), 1 (female))

High levels of leaf production occurred throughout most of the year, peaking in early spring. Leaf buds were evident throughout most of the year. Flower buds in both sexes developed quickly from mid- to late winter, to reach a peak of flowering in early spring; heavy flowering being a feature of the species. Unripe fruit developed quickly and also in high numbers through the summer and ripened in autumn. Most fruit had fallen by mid-winter.

While similar flowering patterns at similar levels were observed in both years on the male plant, after two years of high fruit production from flowering in 1982 and 1983, the female did not flower in 1984.

(14) *ordyline banksii* – ti ngahere (n = 4)
Leaf production was spasmodic among the individuals examined; each plant either flowered profusely or not at all. Mean values presented in the accompanying Figure do not therefore give a true indication of the levels of abundance of the traits examined. Leaf development usually occurred as single leaves with a bud unfurling and expanding. This happened at all times of the year. Flowering, by contrast, was synchronous among those individuals examined, with the panicle appearing at the apex in early spring. The panicle was displaced axially by expanding leaf buds. Flowering peaked in mid-spring, and fruit development occurred soon after; only a small proportion of the flowers gave rise to fruit. The fruit ripened quickly and fell through summer until early autumn.

Meaningful comparisons between levels of flowering and fruiting in the two years cannot be drawn; one individual flowered in 1983 but not in 1984, one flowered in 1984 and not in 1983, one flowered in both years and the last in neither year.

(15) *Cordyline pumilio* - ti kouka[1] (n = 4, later 3 due to accidental death of one)
Leaf production was spasmodic and occurred as single leaves produced on individuals, which occurred at all times of the year. Flowering was synchronous and individuals either flowered heavily, or not at all. The panicle was produced in mid-spring and flowering occurred in early summer. The resultant fruit ripened quickly over autumn and had fallen by winter. A higher proportion of flowers resulted in fruit formation in ti kouka than in ti ngahere.

Only one season's flowering/fruiting cycle was observed in the study, so inter-seasonal comparisons cannot be made.

(16) *Dacrydium cupressinum* – rimu[1] (n = 4 (male), 6 (female))
No resting buds were formed in rimu (Franklin 1968), consequently [as explained by Leathwick

(1984)] it was extremely difficult to distinguish old and new vegetative growth in individuals. No attempt was made in this study to quantify it. Hence only features of rimu's reproductive biology have been depicted in the accompanying Figure. Franklin (1968) reported that both male and female cones were in autumn, but they only became apparent in this study in early winter for both sexes. Male wnes developed to maturity in spring, shedding their pollen in late spring and fell soon after. Female cones, visible as upturned branchlet tips, developed concurrently and ripened in late spring/early summer. The pollinated cones formed unripe fruit that ripened in late summer and throughout autumn (14 - 18 months after pollination). Ripe fruit were very seldom seen in the crowns of trees in the study - the best indication of the presence of ripe fruit was the occurrence of fallen seeds or branchlets with ripe fruit that had fallen from the crowns.

Only moderate levels of seed production were observed in the two seasons of the study (resulting from pollination in 1981 and in 1982).

(17) *Dendrobium cunninghammii*[1] (n = 3)
It was not possible to distinguish any stages of vegetative growth in this epiphytic orchid during the study, and thus only aspects of its reproduction were depicted in the accompanying Figure. Flower buds first became apparent in late spring and developed rapidly to a peak of flowering in mid-summer. The resultant capsules enlarged rapidly through late summer and early autumn, ripening to a light brown and dehiscing to release seeds in mid-autumn.

Only one cycle of flower and fruiting was observed in the course of the study.

(18) *Dracophyllum latifolium* – neinei[1] (n=9)
Leaf buds were extremely difficult to observe and it was apparent that a low level of leaf production occurred all year round. Similarly, it was impossible to detect when flower buds commenced development, amidst the dense foliage at the end of each branch. However, once the panicle began to expand in early summer, development was rapid, and the woody capsules ripened to release seed in early and mid-autumn.

Although the 1983 flowering cycle was not observed fully, it was more productive than that of 1984.

(19) *Dysoxylum spectabile* – kohekohe[1] (n = 12)
Leaf production occurred most of the year round, although there was a definite peak of production from late winter to early summer. Flower buds (i.e. initials of panicles), were usually cauliflorous. They appeared first in late summer, and lengthened rapidly, with flowering occurring from mid-autumn to mid-winter. Although a moderate level of flowering occurred in both years, very few fruit eventuated in either year of the study, and some of the set fruit failed to develop. Fruits that were not aborted increased slowly in size to reach full sue in spring and ripened in early autumn of the year following their formation. It was difficult to detect when the fruit were ripe - some capsules remained green while others turned light brown, but both split to reveal the orange around the seed when they were ripe.

A very low level of fruit production occurred in both years of the study. Several of the study trees were severely debilitated by possum browse. Very few old leaves remained on these trees and new growth was constantly browsed. These individuals appeared to flower less than other kohekohe that were relatively unbrowsed.

(20) *Earina autumnalis*[1] (n = 4)
Only a very low amount of leaf production was observed on this epiphytic orchid. New leaves developed slowly from buds produced in early spring to appear in early summer. Flower bud production occurred soon after in late summer and a peak of flowering followed in early autumn. The unripe capsules developed rapidly and reached full sue and ripened in late autumn. The light brown ripe capsules split to release seed in early winter.

Similar common amounts of flowering and seeding were observed in both years of the study.

(21) *Emina mucronata*[1] (n = 7)
As in *E. autumnalis,* a very low level of leaf production was observed in the course of the study, only on plants that were not flowering in that season. The leaf buds appeared in late winter, resulting presumably from leaf production in spring, although no new leaves were actually

detected. Flower buds were produced in mid-winter and developed more slowly than those of *E. autumnalis* to a peak of flowering in late winter/early spring. Rapid formation, enlargement and ripening of capsules ensued, with the capsules splitting to release seed in late spring/early summer.

Similar levels of flowering and biting were observed in both years of the study.

(22) *Elaeocarpus dentatus* – hinau[1] (n = 12)
Resting leaf buds were evident most of the year round, with buds expanding rapidly for a major flush of new leaves in late spring/early summer. There was a very low level of leaf production before and after the major flush of growth, but leaf production was very common during the major flush of growth which occurred just after flowering. Flower buds first appeared in mid-autumn and developed slowly through the winter and spring for a sharply defined peak of flowering in late spring. Only one season's flowering was recorded at which time flowering was profuse. Fruit development followed with quick development to full size. It was very difficult to differentiate ripe from unripe as the fruit generally remained the same dull green colour, and the only real guide to when fruit were ripe was when they began to fall. Fruit developed through summer and began to fall from early autumn until late winter. Moderate amounts of fruit were produced in both years of the study (from 1982 and 1983 flowering seasons respectively).

(23) *Fuchsia excorticata* – kotukutuku[1] (n = 12-10)
Kotukutuku was distinctly deciduous in the forest; although some individuals retained leaves all year round, albeit with a sparser crown, others lost all leaves. Leaf fall was recorded only in the second year of the study (see adjacent Figure), during late autumn/early winter. Leaf bud production commenced immediately after, however. These buds expanded rapidly, but actual leaf production gradually reached a peak in early spring. Flowering in kotukutuhu was extremely protracted, with flower buds first appearing mid-winter, just after leaf fall and a few flowers appearing immediately after. Flowering reached a peak in spring, but continued on into early summer. Similarly fruit production was protracted, with the first unripe fruit appearing in late winter, reaching a peak in late spring, with a peak of dark ripe fruit apparent in mid-summer.

Flowering and fruiting were common in both years on those plants examined. Possum browse was noted on many of the plants, usually quite light, but two trees appeared to be killed by repeated browsing.

(24) *Geniostoma rupestre* var. *lingustrifolium – hangehange*[1] (n = 12)
Leaf production in hangehange occurred all year round with an abundance of expanding buds and new leaves. A peak of leaf production occurred from mid-winter to early summer, with a marked drop in new leaf production in late autumn. Flower bud production began in late autumn and the buds expanded rapidly through winter to a definite peak of flowering in mid-spring. Fruit development began rapidly soon after flowering. It was difficult to differentiate ripe from unripe fruit as ripening progressed. However, by mid- summer the ripe capsules began to split and seed was released in late autumn.

Flowering occurred at a high level in both years of study. Seed production from flowering in 1982 was at a similar level to that which resulted from 1983 flowering.

(25) *Ileostylus (=Loranthus) micranthus*[1] (n = 1)
Only one plant of this species was observed, growing as a parasite on Hall's totara. New leaves were produced most of the year round with a peak of production from late winter until mid-spring. Flower buds were evident initially in early winter, with flowering peaking in early spring. Fruit formed and developed to full size rapidly over summer. The fruit were dull orange in colour could not be distinguished from ripe fruit. Presumably the fruit ripened by late autumn because they had disappeared by early winter.

Although more flowers were produced in 1983 than in 1984, a similar amount of fruit was produced in both years.

(26) *Griselinia lucida* – puka[1] (n = 6 (male), 5 (female))
New leaves were produced by both sexes all year round, but with a peak of production in early spring and a relative lull in production during summer and autumn. Flower buds first appeared in mid-winter in both sexes, with the panicles expanding for full flowering which peaked sharply in

mid-spring. Male plants produced substantially more flowers than their female counterparts in both years of the study. Fruit developed rapidly and ripened over a protracted period from mid-summer to mid-winter, peaking in mid-autumn.

Similar moderate amounts of fruit were produced in both years of the study (from 1982 and 1983 flowering seasons respectively).

(27) *Hedycarya arborea* – porokaiwhiri, pigeonwood[1] (n = 7(male), 5(female))
While a low level of leaf production was evident throughout most of the year, there was a definite peak of leaf production in early spring in both sexes (more pronounced in 1983 than in 1984). Flower buds in males appeared first during late autumn, and in early winter in females. developed through winter and early spring to a peak of flowering in mid-spring. Fruit developed fairly quickly to full size, but remained as green unripe fruit for 13 months following flowering. Peak production of ripe orange fruit occurred in late spring.

There were marked differences in levels of flowering and fruiting between years. Flowering was markedly heavier in 1984 than in 1983, particularly for the males. Fruit production arising from the 1982 flowering season (ripening in spring 1983), was much higher than that derived from the 1983 flowering season. A higher level of fruit production may have resulted from the comparatively heavy flowering of 1984.

(28) *Ixerba brexioides* – tawari[1] (n= 5)
Marked seasonality was a notable feature of most aspects of the phenology of tawari. It seems likely that resting leaf buds were present for most of the year, but it was very difficult to see buds in the crowns of these trees. A rapid synchronous flush of new leaves was apparent in late spring/early summer, but new leaves were not produced at other times of the year. Flower buds were produced in mid-summer, immediately after the flush of new leaves and the previous season's flowering, and they expanded rapidly to full-sized flower buds by early autumn. These expanded flower buds remained on the trees throughout autumn and winter, with a few rarely expanding to flower. The majority, however, burst simultaneously into flower through mid- to late spring. The resultant fruit developed rapidly to full-sued capsules which split to reveal dark seeds and orange arils from late summer to mid-autumn.

Only one season's flowering and fruiting was observed fully; both new leaves and flowers were produced in abundance in 1983. An even greater amount of flower buds produced in 1984 suggested an even higher level of flowering and fruiting would occur that year.

(29) *Knightia excelsa* – rewarewa[1] (n=12)
There was notable seasonality in the production of new leaves. Resting buds were evident through most of the year, but expanded rapidly in early spring to produce a flush of new leaves in late springiearly summer, whereafter there was a dramatic decline in leaf production. New resting buds were formed, though new leaves were not produced until the following spring. Flower buds were formed in late autumn but did not expand until late winter, leading to a peak of flowering in late spring. The resultant follicles (seed pods) developed rapidly to full size and were coated in brown tomentum. They ripened to split and discharge their seeds from mid-summer to late autumn.

Fruit production in both years of the study (i.e. that resulting from the 1982 and 1983 flowering seasons) was at moderate levels.

(30) *Leucopogon fasciculatus* – mingimingi[1] (n=11)
Production of new leaves occurred all year round in this species, with a slight increase in production during late spring. Flower buds appeared first in mid-autumn and over-wintered, increasing in size in mid- to late winter to reach a peak of flowering in early spring. Unripe fruit developed in sue quickly, and ripened to a red colour through the summer.

A similar high level of flowering occurred in both years of the study, and a similar moderate level of fruit production resulted in both years.

(31) *Melicytus ramiflorus* - mahoe[1] (n = 8 (male))
Leaf production occurred at low levels throughout most of the year, but with a definite peak of leaf production through spring and early summer. Unfortunately, when selection of individuals for the study was made, the plants chosen were neither flowering or fruiting, and it transpired that all the individuals chosen for the study were male plants. Powlesland (1984) reported that there were significantly more males than females in a population studied in the South Island. An imbalanced ratio of the sexes suggested that the selection of all male plants in this study was not due to chance.

Flower buds appeared on the plants on old wood in early spring and developed rapidly. The "pulsing" of flowering observed by Powlesland (1982) was quite apparent; the largest "pulse" by far was in mid-spring, with much lesser amounts in mid-summer and in early autumn. As only male plants were examined, no information was available on fruiting from the study.

Flowering was at a much greater level in 1983 than 1984.

(32) *Melicytus macrophyllus*[1] (n = 12 (male), 12 (female))
A low level of leaf production occurred most of the year round, but there was a distinct flush of new leaves from late winter to early summer. As in *M. ramiflorus,* flower buds were produced on old wood beneath leaves produced in that season, with most flower buds on the wood of the previous year. Flower buds developed on males slightly in advance of females, appearing first in early winter and developing through winter for a peak of flowering in early spring. Unlike *M. ramiflorus,* flowering occurred for only a brief period, with all individuals flowering simultaneously. Pale, unripe fruit developed rapidly after flowering and ripened to a deep purple colour, the majority ripening from mid-summer to early autumn. However, a diminishing amount of ripe fruit persisted on plants for most of the year following flowering, and some persisted through to the next year's flowering.

Only one full flowering/fruiting cycle was observed in the course of the study. Flowering was abundant for both sexes in both years, in slightly higher quantities in 1983 than in 1984.

(33) *Metrosideros albiflora*[1] (n=6)
Dawson (1968) noted that dormant buds in this species were small and difficult to detect. In this study, it was only possible to observe them during their expansion over the main growing season. Leaf production peaked in early to mid-spring and tapered off by early autumn, with little leaf production in autumn or winter. Flower buds appeared first in early winter and over-wintered, developing rapidly in spring for a sharp peak of flowering in mid-spring, although some buds broke into flower before this. The fruiting capsules developed quickly to full size by early summer and remained closed until mid-autumn when they split to release their seeds.

Flowering was much heavier in 1983 than in 1984; in 1983 flowering was superabundant. Similarly fruit production from the 1982 flowering season was considerably less than that resulting from the 1983 flowering season.

(34) *Metrosideros fulgens*[1] (n = 7)
As in *M. albiflora*, it was difficult to detect dormant buds, and most of the vegetation growth phases of *M. fulgens* were obvious only when these buds began to expand. Leaf production was strongly seasonal, with expanding in late winter for a flush of new leaf production from early spring until mid-summer. Flower buds first appeared in late summer. Flowering commenced in early autumn and continued through into mid-winter. The resultant fruit developed quickly to full sized capsules. It was difficult to distinguish ripe from unripe capsules but it was apparent that most of the fruit ripened from mid-spring until early summer.

Because the flowering season is extended, few flowers were seen at any given time in either of the two years studied. However, cumulatively, a moderate amount of flowers and fruit were produced in both years.

(35) *Metrosideros robusta* - northern rata[1] (n = 12)
Northern rata distinctive resting buds (Dawson 1968). However, it was often very difficult to detect these in the crowns of the tall study trees. While some trees produced new leaves most of the year round, others had a definite flush of new leaves in early to mid-autumn. Individual trees were quite

Idiosynchratic when flowering, a feature that the mean indices of abundance presented in the accompanying Figure disguises. Some had lengthly flowering periods, in which few flowers were produced, while others had sharp peaks of relatively heavy flowering. Individual trees could flower at any time of the year from late autumn, through to late summer of the following year. The majority followed a pattern of flower bud formation in early spring which expanded in early summer for flowering in mid-summer. Fruit developed and ripened soon after, with a peak of ripe capsules in early autumn.

Only one cycle of major flowering and fruit production was observed in the course of the study. Leaf production in early 1983 was much greater than that of early 1984. Major possum browse was noted on the younger foliage of one of the study trees during the study.

(36) *Mida salicifolia*[1] (n = 4)
Leaf production occurred most of the year round, but with greatest production during spring and summer, and with noticeably less during winter. Flower buds first appeared in early to mid-winter, followed soon after by flowering in late winter and early spring. The unripe green fruit developed rapidly in size and ripened to a red colour by mid- to late summer.

Only one complete flowering and fruiting cycle was observed in the course of the study. All individuals were browsed heavily by possums during the study (particularly their new foliage) and some were reduced to having only leaf buds by the end of the study. The effect of this browsing was sufficiently debilitating that the only tree to form flower buds in 1984 either shed them or they were browsed before they could develop.

(37) *Myrsine australis* – mapou[1] (n = 6 (male), 6 (female))
Leaf production occurred peak of production from late winter until late spring. Flowering occurred over a protracted period, particularly with male plants. Flower buds formed in early autumn on old wood below the foliage at branch tips and developed rapidly from early autumn onwards. Flower buds continued to be produced throughout winter and even into spring, particularly in males. Flowering occurred from early autumn until late spring in males, but only until mid-winter in females. Fruit developed soon after flowering and while some fruit ripened quickly, others did so over a much longer period. This resulted in there being a constant transition of unripe, light fruit through to purple, ripe fruit most of the year round, with a new influx of unripe fruit from late autumn onward from the protracted flowering.

A similar, moderate amount of fruiting and flowering was observed in both years of the study.

(38) *Myrsine salicina* – toro[1] (n=4)
Obvious resting buds were a feature of this species. Leaf production from these resting buds was strongly seasonal, the bulk of new leaves being formed in early spring, and with a flush of leaves in late summer. Flower buds formed in mid-autumn on old wood near branchlet tips and over-wintered to flower in late winter. No fruit were formed from the 1983 flowering season and only a small amount of fruit were generated from the 1984 flowering There was no information for ripening of, or seed fall from the fruit of toro owing to the absence of fruit formation in 1983.

Flowering was at a similar, low level in both years of the study.

(39) *Olearia rani* – heketara[1] (n = 12)
A low level of leaf production was maintained throughout most of the year, with obvious resting buds a feature, especially in winter. The bulk of leaf production occurred from late winter until early summer. Flower buds appeared first in mid-winter, and the panicles developed for a sharp peak of flowering in mid-spring. The composite florets went quickly to seed which ripened soon after (by late spring/early summer), and then scattered rapidly.

1983 flowering season for heketara was remarkable through much of Northland; almost trees had superabundant flowering and subsequent seed production. In fact, some of the study trees that flowered so heavily in 1983 experienced noticeable dieback in the crowns in the following year. Flowering in 1984 was at a moderate level only.

(40) *Pittosporum cornifolium*1 (n=4 (male), 5-4 (female))
This predominantly epiphytic species produced resting buds that were protected by scales. A low level of leaf production occurred throughout the year, hut the major flush of leaf production occurred in late winter until late spring, just after the flowers had been produced, and a secondary smaller flush occurred in both sexes in late autumn. Flowering was synchronous, peaking sharply and concurrently for both sexes; flowerbuds broke through the resting buds in mid-winter and expanded rapidly to a peak of flowering in late winter. Considerably more flowers were produced on male plants than on females. The fruit developed to full size fairly quickly but remained green throughout most of the following year. Upon ripening, the capsules darkened and split to reveal a scarlet interior with black seed. Ripening was slow and non-synchronous; a small amount of ripening fruit was evident from early winter until mid-spring of the year following their formation.

Similar abundant levels of flowering were observed in both years on male plants, but noticeably fewer female flowers were observed in 1984, compared to 1983.

(41) *Pittosporum tenuifolium* – kohuhu[1] (n = 5(male), 5 (female))
Like *Pittosporum cornifolium*, kohuhu produced resting buds, protected by scales through most of the year. A moderate level of leaf production occurred throughout the year, particularly in the crowns of trees away from where flowering and fruiting occurred. The major flush of leaf growth (particularly evident in male plants) occurred in early to mid-spring, with a smaller flush in late summer.

As with *Pittosporum cornifolium,* flowering was strongly synchronous - flower buds first became apparent in mid-winter and developed quickly to a peak of flowering in early spring. Male kohuhu plants produced substantially more flowers than their female counterparts. The fruit developed slowly to a grey-green tomentose fruit by mid-summer, and began to ripen in early to mid autumn, splitting to reveal a yellow interior and black viscid seeds. Though most fruit ripened and shed their seed at this time, some ripe fruit were still present in mid-winter.

Male flowers were superabundant in 1983 and slightly less common in 1984, while female flower production was at a similar level in both years. Considerably more fruit eventuated from the 1983 flowering season compared to the 1982 flowering season.

(42) Podocarpus hallii - Hall's totara[1] (n = 7(male), 3(female))
Hall's totara had obvious resting buds throughout most of the year, which expanded in late winter for a major flush of growth in spring and early summer (distinctly in early summer in the male plants and more protracted in the female plants). In the first autumn of the study there was a flush of leaves that was not apparent in either sex in the second autumn of the study. Leaf production in 1984 had not commenced in either sex by the end of the study. Male cones first became apparent in mid- to late winter as club-shaped shoots below the previous season's leaf growth. These developed rapidly in spring, the cones breaking through the protective buds in spring and enlarging rapidly to shed their pollen in early summer. Ovules are apparently first produced in spring at the base of the new season's growth (A.E. Beveridge pers. comm.), but I was only able to detect young ovules from early autumn onward - they were deceptively leaf-like from a distance. The ovules expanded prior to pollination through the spring, and after pollination in early summer the majority developed to ripe fruit in late summer/early autumn. A high proportion either ripened later in the year, or were aborted in development and remained on the tree through the rest of the year following pollination. Distinguishing these aborted or unripe fruit from developing ovules became progressively more difficult as the next year's ovules became conspicuous.

Male trees produced moderate amounts of strobili (cones) in both years of the study, and while fairly high amounts of ovules were produced on female trees, only a very small proportion appeared to develop to ripe fruit from either the 1982 or 1983 ovules.

(43) *Prumnopitys ferruginea* (=*Podocarpus ferrugineus*) – miro[1] (n=5(male), 6(female))
Leaf production in was strongly seasonal, occurring after pollination. Trees developed resting buds through most of the year, which began to expand in late spring for a flush of new growth in early to mid-summer. A secondary flush in the first autumn of the study was also apparent, and a very small level of leaf production occurred in a few females through the first year of study. Male cones first became apparent in early autumn, and expanded rapidly in late winter to shed their pollen in mid-

spring. Small, glaucous ovules first became apparent in early spring, although they actually first appear on the plants the previous spring (A.E. Beveridge pers. comm.). The ovules grew in size during early spring and were in late spring. Little change in size followed fertilisation, until the following spring. By mid-summer, the fruit had developed to full size but remained green. Most fruit ripened from late summer until the end of autumn, though ripe fruit remained on some trees until mid-winter (up to 20 months after ovule fertilisation).

As noted by Leathwick (1984), a number of branches on some predominantly male trees bore ovules and later fruit, particularly on lower branches in the crown. High production of ripe fruit (i.e. that resulting from pollination in 1981 and 1982) occurred in both years of the study, and indications from the 1983 pollination season were that high fruit production would ensue.

(44) *Pseudopanax arboreus* - whauwhaupaku, fivefinger[1] (n = 11 – 10)
Although a low level of leaf production occurred most of the year round, there was a pronounced flush of new leaf production from early spring until early summer. Resting buds were produced for much of the remainder of the year. As by Leathwick (1984), whauwhaupaku is not truly dioecious; a continuum is evident between predominantly male to predominantly female plants, but with no plants examined exclusively of one sex. Flowering occurred over a protracted period - flower buds were produced in early summer and expanded through autumn, and while a small amount of flowering occurred in autumn, most flowering occurred through winter and early spring, tapering off as leaf production commenced. Swarms of small insects were evident around inflorescences in full flower. Fruit formed soon after flowering and developed quickly to full size from autumn until early spring; the majority of fruit ripened to a dark colour throughout spring and summer following the protracted flowering period, but ripe fruit were present on trees in low numbers through the following autumn and into winter.

Moderate levels of flowering and of fruit production occurred in both years of the study. Possum browse was evident on several individuals, both on leaf buds (which caused surrounding leaves to fall) and on flower buds. Repeated browse of one individual was sufficiently debilitating that no flowering occurred in 1984 and the tree appeared dead by the end of the study.

(45) *Pseudopanax edgerleyi* - raukawa (n =1(female))
Raukawa produced resting buds for most of the year which expanded for a peak of leaf production in mid- to late spring, with a secondary flush of leaves in late summer. Leaves were not produced at other times of the year. Flower buds first appeared in mid-spring and expanded to what presumably was a peak of flowering in early summer. Fruit developed rapidly afterwards to a bright green fruit in mid- to late summer. As in the other *Pseudopanax* species examined, it was difficult to determine when the fruit had ripened fully, but presumably this was by early autumn as none was evident after this.

Only one flowering and fruiting season was observed in the course of the study.

(46) *Pseadopanax crassifoloius* – horoeka, lancewood[1] (n=9 (sex indeterminate), 4 (female)
Like the other *Pseudopanax* species studied, horoeka had resting buds throughout most of the year, and leaf production occurred as a synchronous flush in late spring/early summer, with a minor production of leaves in early autumn. Curiously, of the individuals for the study, very few flowered and all that did were female. Flower buds appeared in mid-summer, just after the bulk of leaf production had finished, and expanded quickly to a peak of flowering from early to mid-autumn. As noted by Leathwick (1984), the flowers appeared particularly attractive to insect pollinators, which swarmed about them. The resulting fruit developed slowly, and ripened over a protracted period from early winter until early spring.

Slightly greater flowering and fruiting was evident in 1984, compared to 1983. The individuals that flowered in 1983 did not do so in 1984 and vice versa.

(47) *Rhopalostylis sapida* - nikau[1] (n=12)
Leaf production (i.e. of single leaves) appeared to occur infrequently and at any time of the year. Bud formation was virtually impossible to detect in the densely foliated crowns of these palms. Flowering, too, appeared quite idiosynchratic -individuals flowered either profusely or not at all, and it appeared that individuals flowering in one year would not do so the next, although the study ceased before this hypothesis could be tested fully. Spathes (containing flower buds) first appeared

in early summer and expanded rapidly for a flowering period that was quite short for individuals but overall extended from early summer to early autumn in 1984 and as late as early winter in 1983. Fruit produced from a particular flowering season developed fairly quickly to full sue and remained dark green. A very small amount ripened to bright red colour during the year of flowering, but most ripened from late summer to mid-autumn the year after flowering.

Overall, the level of flowering and of fruit production was quite low in both years of the study.

(48) *Ripogonum scandens* - supplejack, kareao[1] (n = 12)
Production of leaves and trailing stems was quite seasonal - buds broke in early spring for a peak of leaf production in mid-spring that decreased through summer, with a small secondary peak in late summer. Flower buds first appeared in early spring and the inflorescences expanded rapidly with a peak of flowering occurring in late The resultant fruit developed quite slowly in size over the next year, reaching full size in autumn but remaining green and ripened to a bright red colour over a protracted period from early spring to early autumn with a peak in early summer 13 months after flowering. However, fruit ripened on the lianes well before spring in small numbers, and a small quantity of ripe fruit persisted on the lianes until winter, as much as 18 months after the flowering that had produced them.

Similar, moderate amounts of fruit were present in both 1983 and 1984 (i.e. from 1982 and 1983 flowering seasons) and indications were that the 1984 flowering season would be of a similar order of magnitude.

(49) *Rubus australis* - bush lawyer, tataramoa[1] (n = 8(male), 4(female))
Although a moderate amount of new stems and leaves were produced most of the year around, there was a definite peak of production in early spring and a marked lull in winter. Flower buds in both sexes first appeared in early spring, and the panicles expanded rapidly to a peak of flowering from mid- to late spring. The resultant colourless berries developed in sue quickly and ripened to a bright red colour in mid-summer and fell soon after.

Only one full-flowering and fruiting cycle was observed in the course of the study.

(50) *Schefflera digitata* – pate[1] (n = 12)
Leaves were produced most of the year round, but there was a definite peak in production from mid-winter until early summer with a marked decrease in production through autumn and early winter. Resting buds were apparent at times of relatively less leaf production. Flower buds were evident from mid-winter in 1984 and from late spring in 1983, but the panicles only began to expand in the summer months after the peak of leaf production for a protracted period of flowering which peaked in early to mid-autumn. Green unripe fruit developed rapidly following flowering and ripened over about a month to a dark purple wlour. The flowering and subsequent fruiting seasons were protracted; ripe fruit being apparent from mid-autumn until late winter with a peak in mid-winter.

Leaf production was abundant in 1983 and less so in 1984. Both flowering and fruiting occurred at a similar, moderate level in both years.

(51) *Urostemom kirkii* [now *Brachyglottis* sp. (*Senecio kirkii* Hook. f. var. *angustior Allan*] -
Kirk's daisy[1] (n= 12)
A high level of leaf production was apparent throughout must of the study. Although a peak of production occurred in spring 1983 (when no flowering took place), there was a marked drop in the numbers of new leaves seen in the following spring when flowering occurred. Flower buds first became evident in early summer but although these expanded through early autumn no flowering eventuated from these buds. Buds again in early winter; these expanded and flowered in mid-winter, and set seed soon afterwards (ripe seed being evident during late winter and early spring).

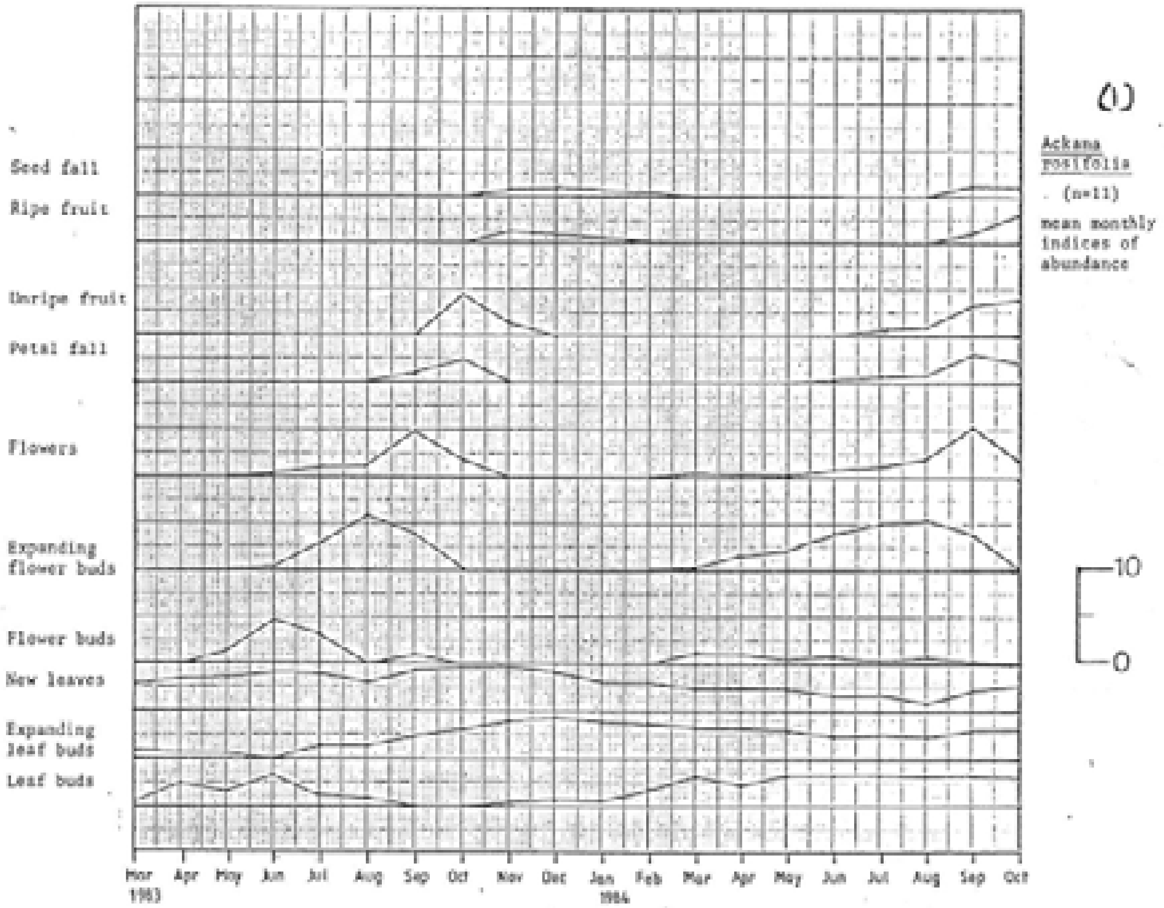
Within the individuals studied, very different flowering patterns occurred from year to year. When the study shrubs were selected, they all had many florets that had set seed heavily from the 1982 flowering season. None flowered in 1983 and they appeared to consolidate vegetative growth instead. In 1984, meagre flowering took place on only a few branchlets of some plants. Elsewhere in the forest in 1984, isolated individuals were seen flowering sparsely at most times of the year.

(52) *Vitex lucens* – puriri[1] (n = 1)
Leaf production was strongly seasonal; leaves were produced only from mid-winter until mid-summer, with a peak of production in early summer. Flowering and fruit production was ongoing and, compared with most trees studied, quite spectacular. Flower buds were formed throughout mast of the year, except when leaf production was at a maximum (i.e. they were produced from mid-summer until mid-winter). They expanded to flower very quickly, and flowers appeared to be quite long-lived. Flowers could be found at a fairly constant high level throughout the year except at the peak of leaf production in late spring/early summer. Successive bursts of bud development and flowering gave rise to a presence of fruit in various stages of development. Following pollination, fruit developed rapidly to full size and ripened over a period of about four to six months to a red colour.

No marked differences in production of either flowers or fruit were noted between the two years of the study.

(53) *Weinmannia silvicola* – towai[1] (n = 13)
While a low level of leaf production occurred most of the year round, there was a definite peak of production from early spring to mid-summer, accompanied by a secondary peak in mid-autumn. At other times of the year, resting buds or partly developed buds were a feature, particularly during the winter months. The flowering season of towai was extremely protracted. The majority of flower buds developed at the peak of leaf production in late spring, and the racemes expanded quickly for a peak of flowering in late summer. Flower buds continued to be produced, and flowering wntinued until late winter of the following year, albeit at a very low level. The flowers set seed quickly, and the fruit developed rapidly over a month after flowering, resulting in the maximum levels of ripe fruit being available from early autumn until early winter. Fruit arising from later-produced flowers took slightly longer to ripen. The protracted nature of the flowering ensured that unripe or ripe were present on trees at most times of the year.

Only one full flowering cycle was observed in the course of the study. However, there was considerably more fruit present in 1983 than there was in 1984, from which it can be inferred that flowering in 1982 was heavier than that in 1983.

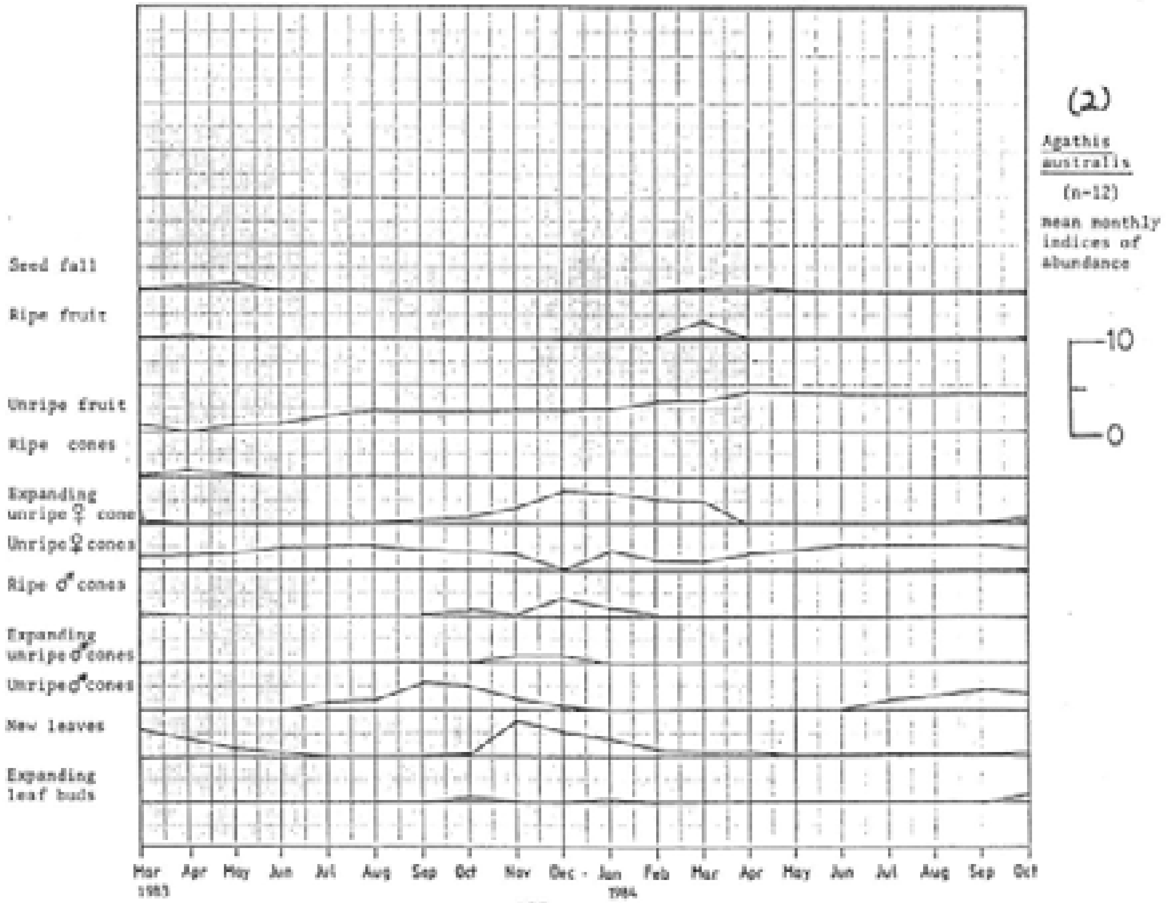


(1)

Ackana rosifolia

(n=11)

mean monthly indices of abundance

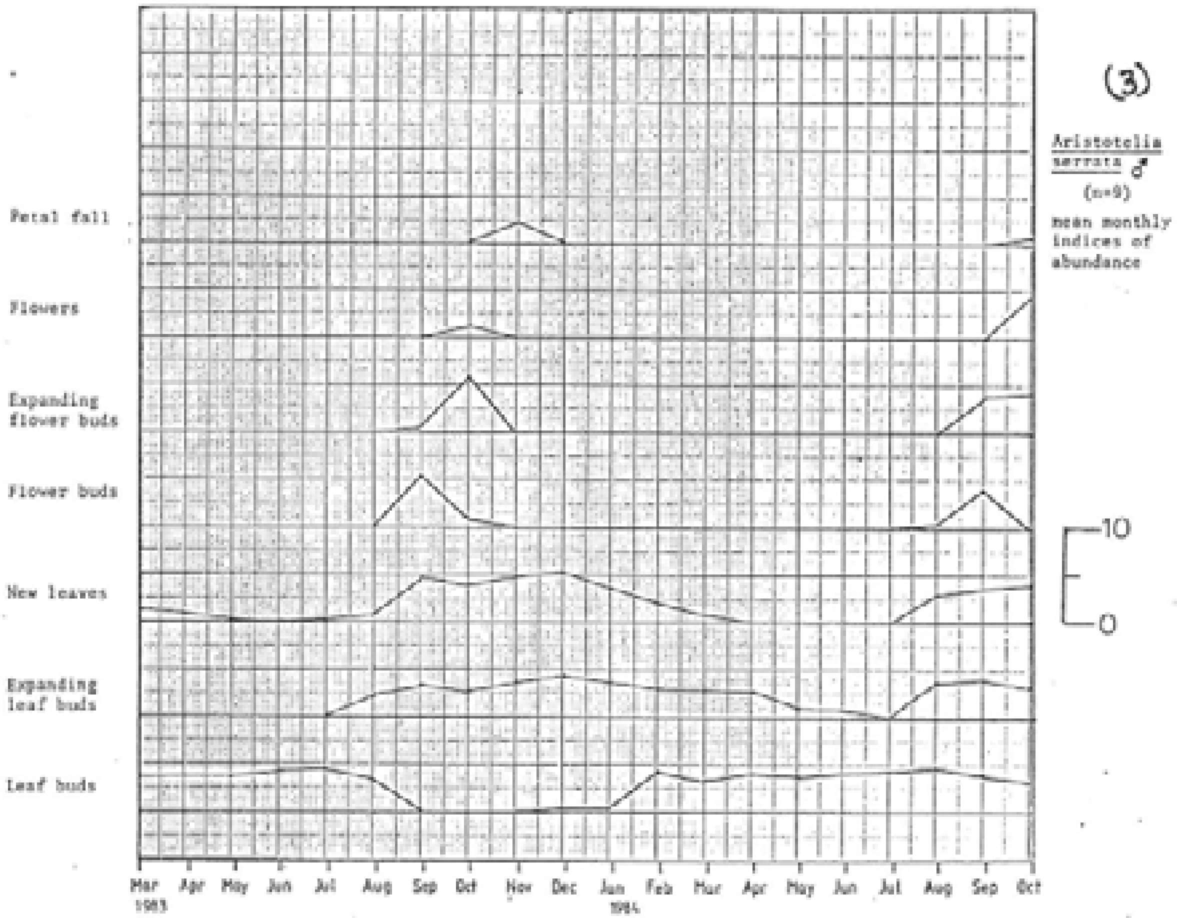


(2)

Agathis australis

(n=12)

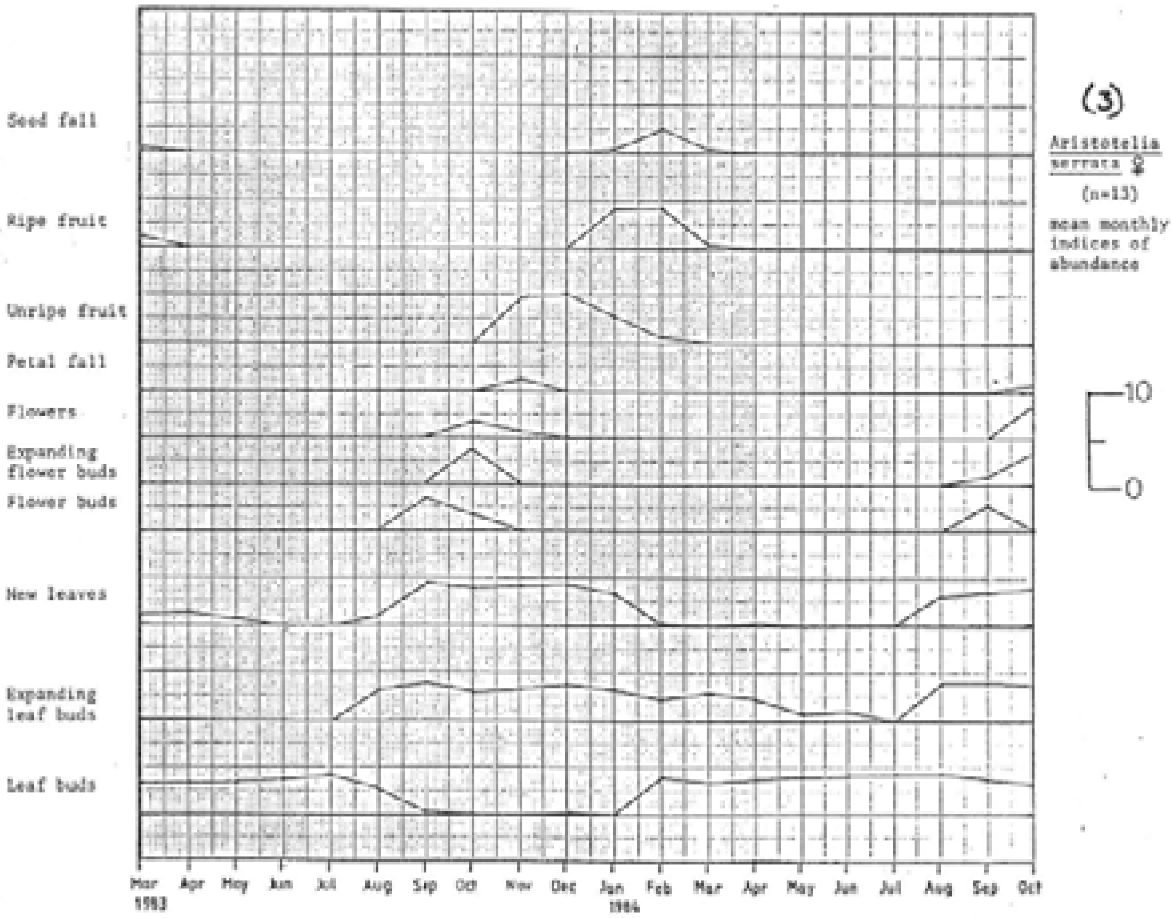
mean monthly indices of abundance


(3)

Aristotelia serrata ♂

(n=9)

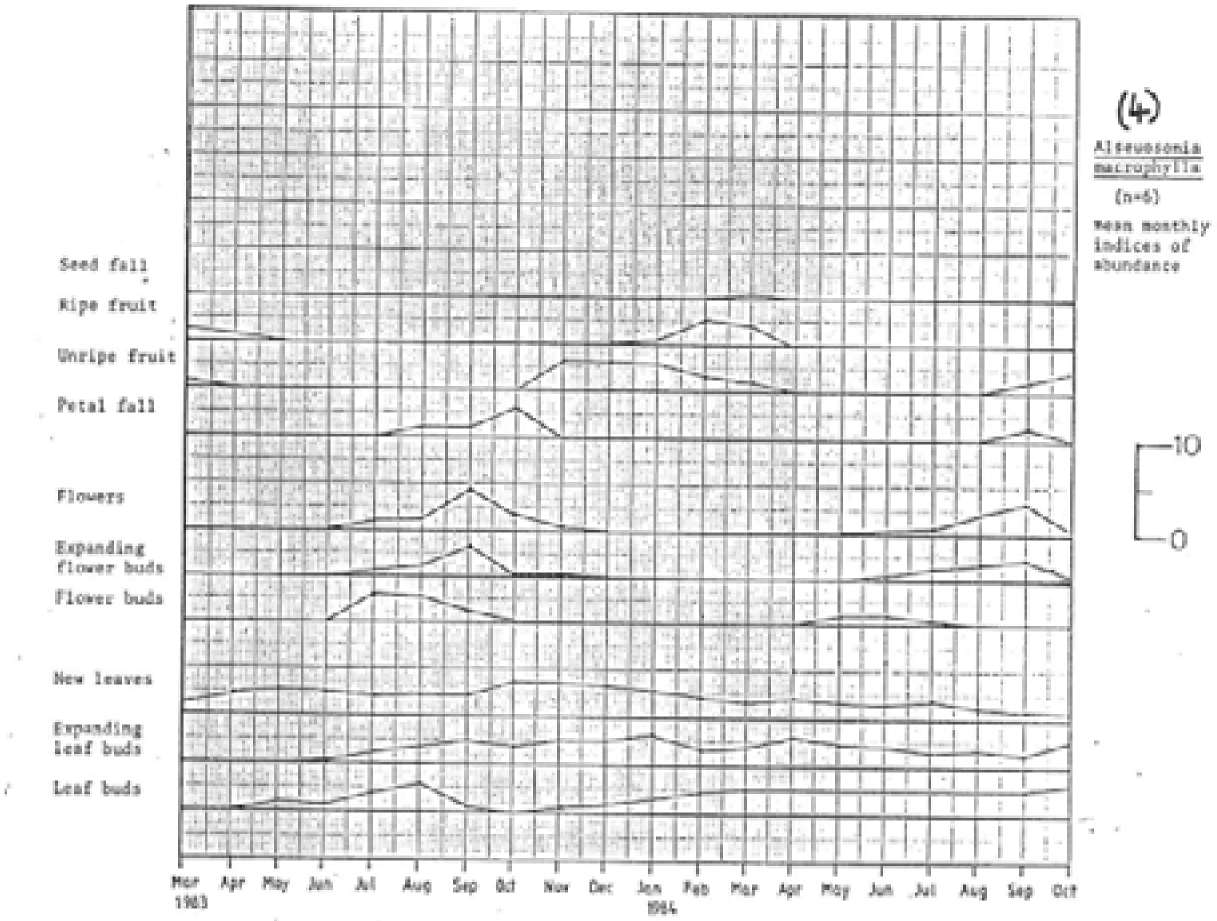
mean monthly indices of abundance


(3)

Aristotelia serrata ♀

(n=13)

mean monthly indices of abundance

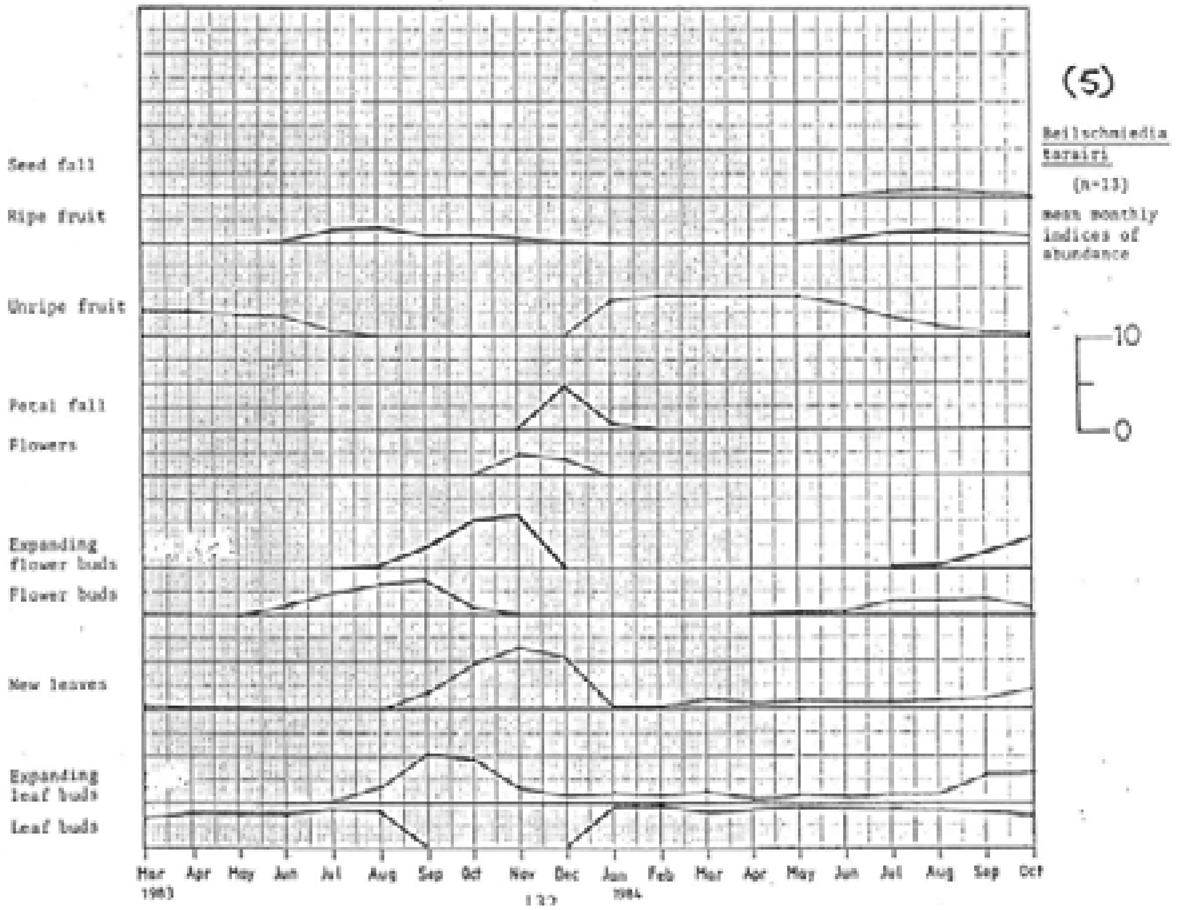


(4)

Alseuosmia macrophylla

(n=6)

mean monthly indices of abundance

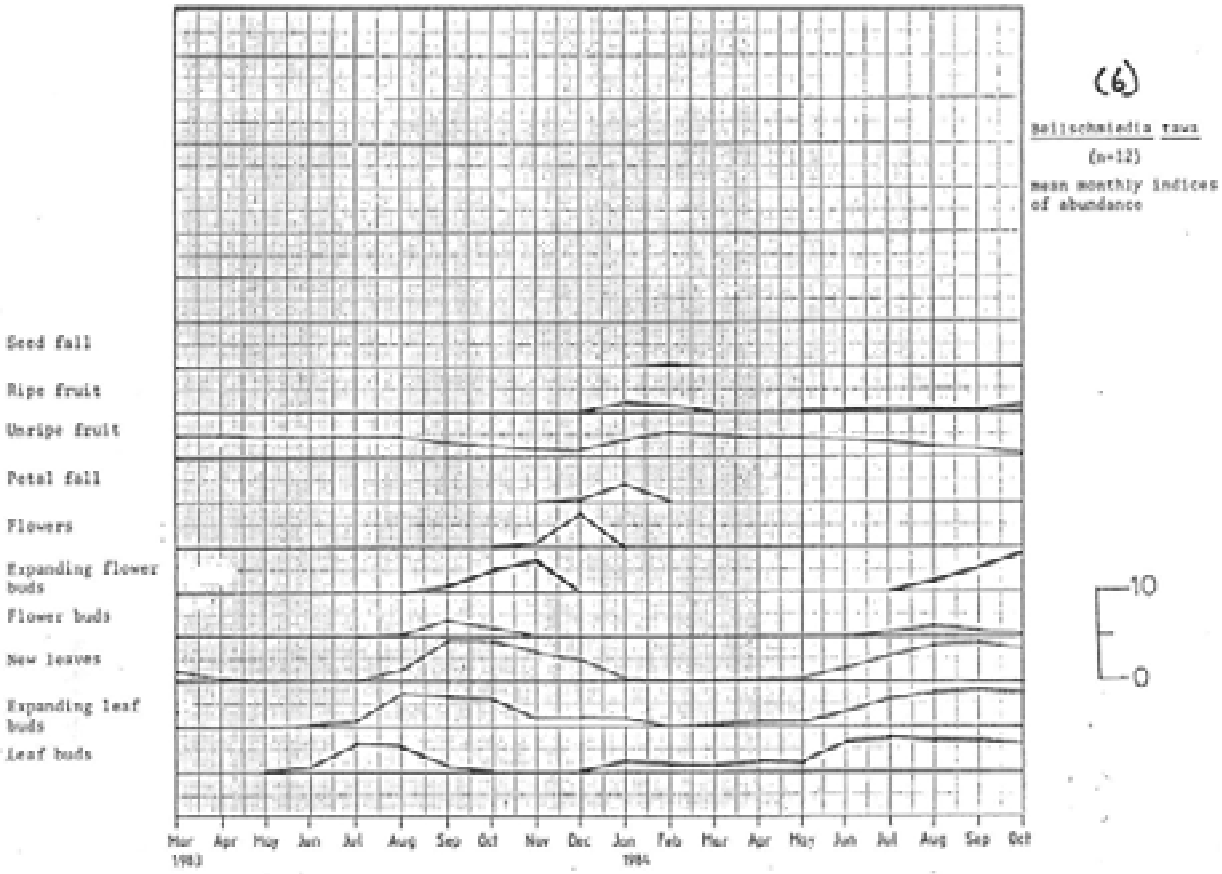


(5)

Beilschmiedia tarairi

(n=13)

mean monthly indices of abundance

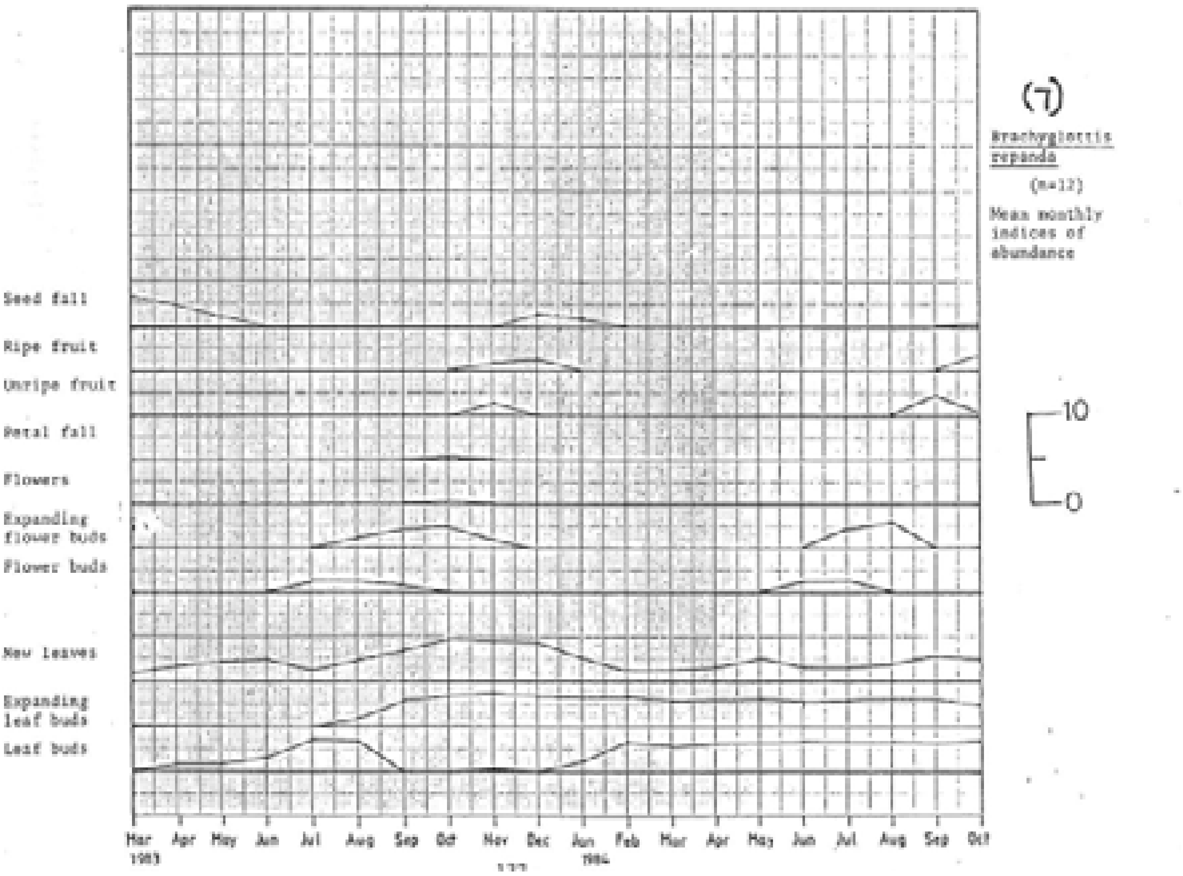


(6)

Beilschmiedia tawa

(n=12)

mean monthly indices of abundance

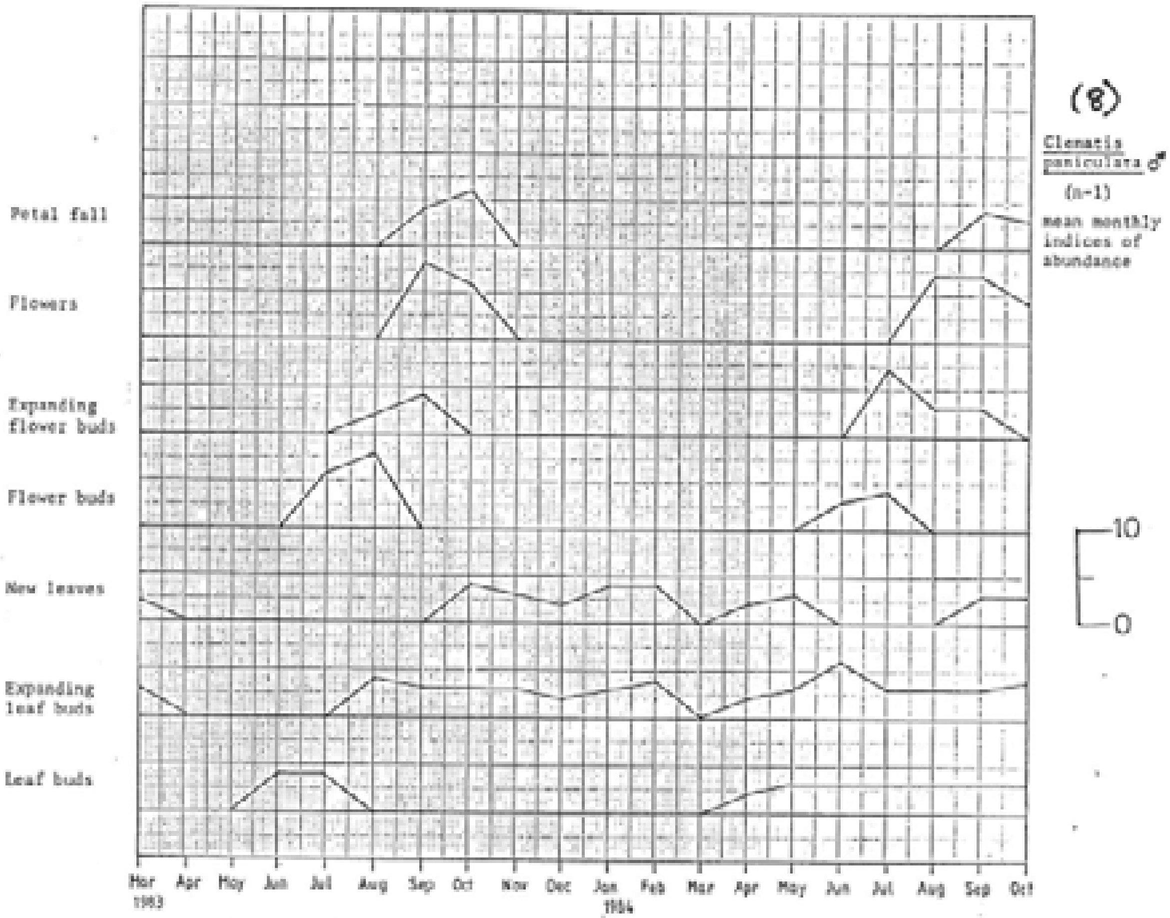


(7)

Brachyglottis repanda

(n=12)

Mean monthly indices of abundance

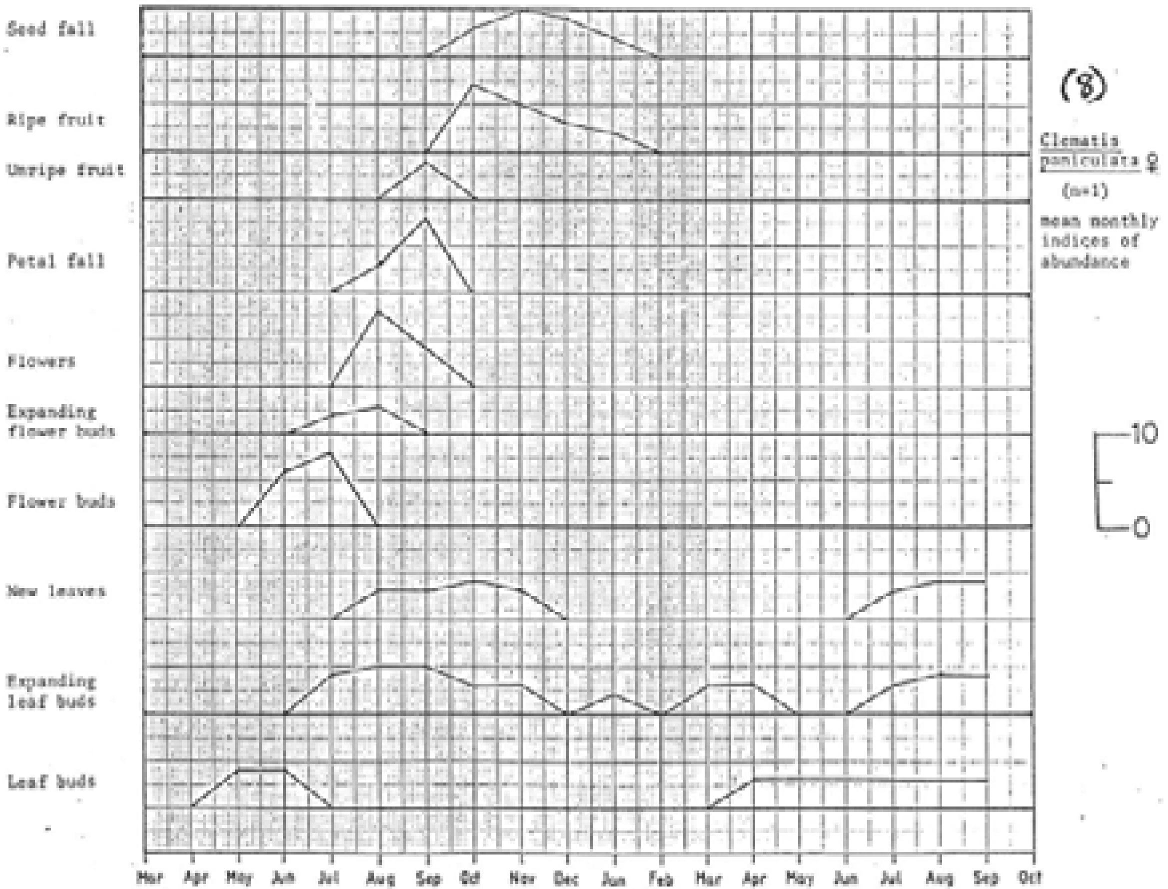


(8)

Clematis paniculata ♂

(n=1)

mean monthly indices of abundance

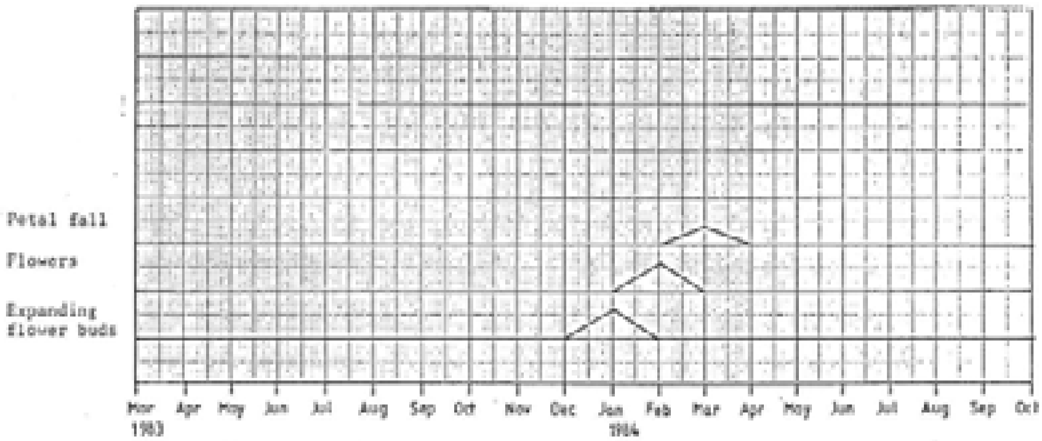


(8)

Clematis paniculata ♀

(n=1)

mean monthly indices of abundance

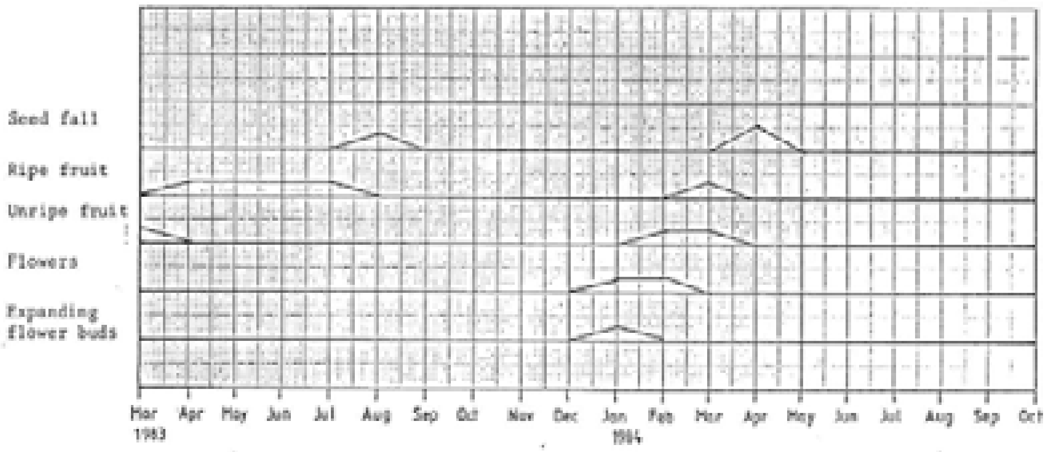


(9)

Collospermum hastatum ♂

(n=2)

mean monthly indices of abundance

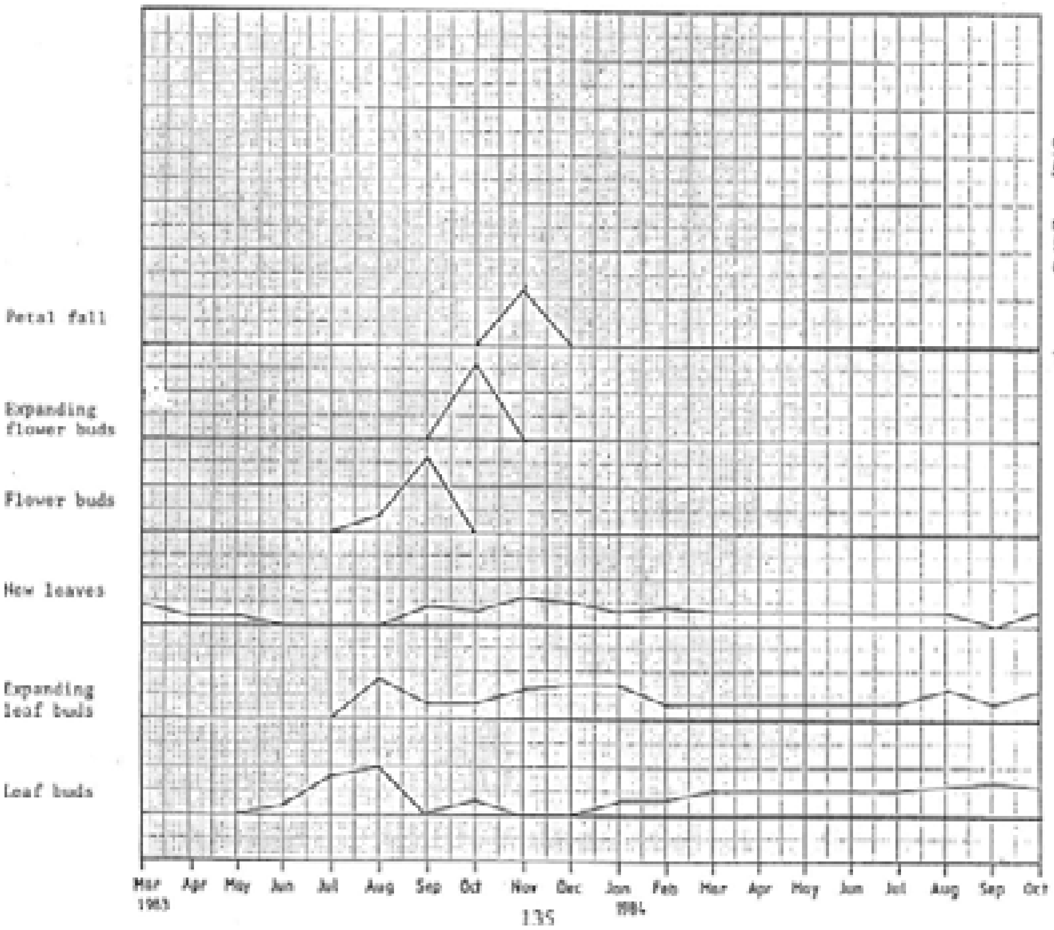


(9)

Collospermum hastatum ♀

(n=2)

mean monthly indices of abundance

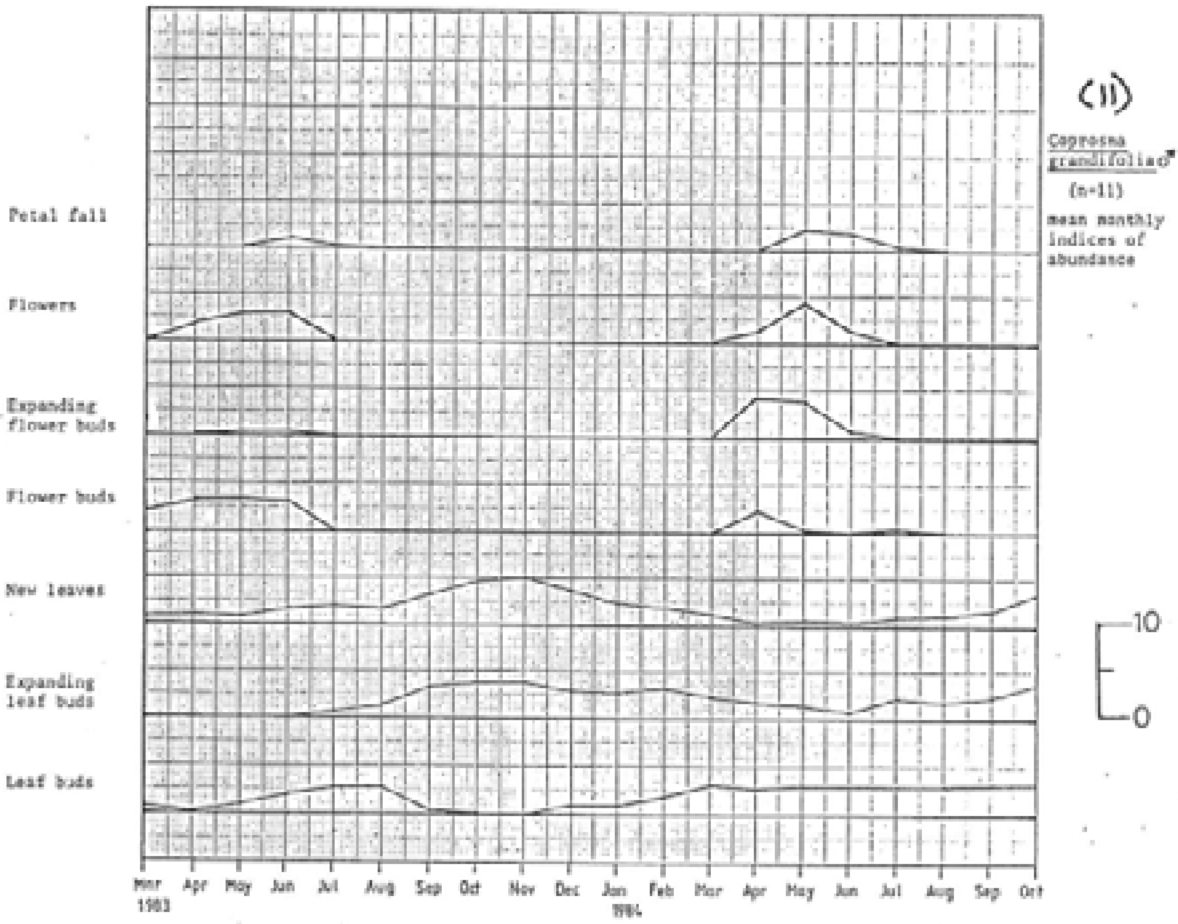


(10)

Coprosma arborea ♂

(n=2)

mean monthly indices of abundance

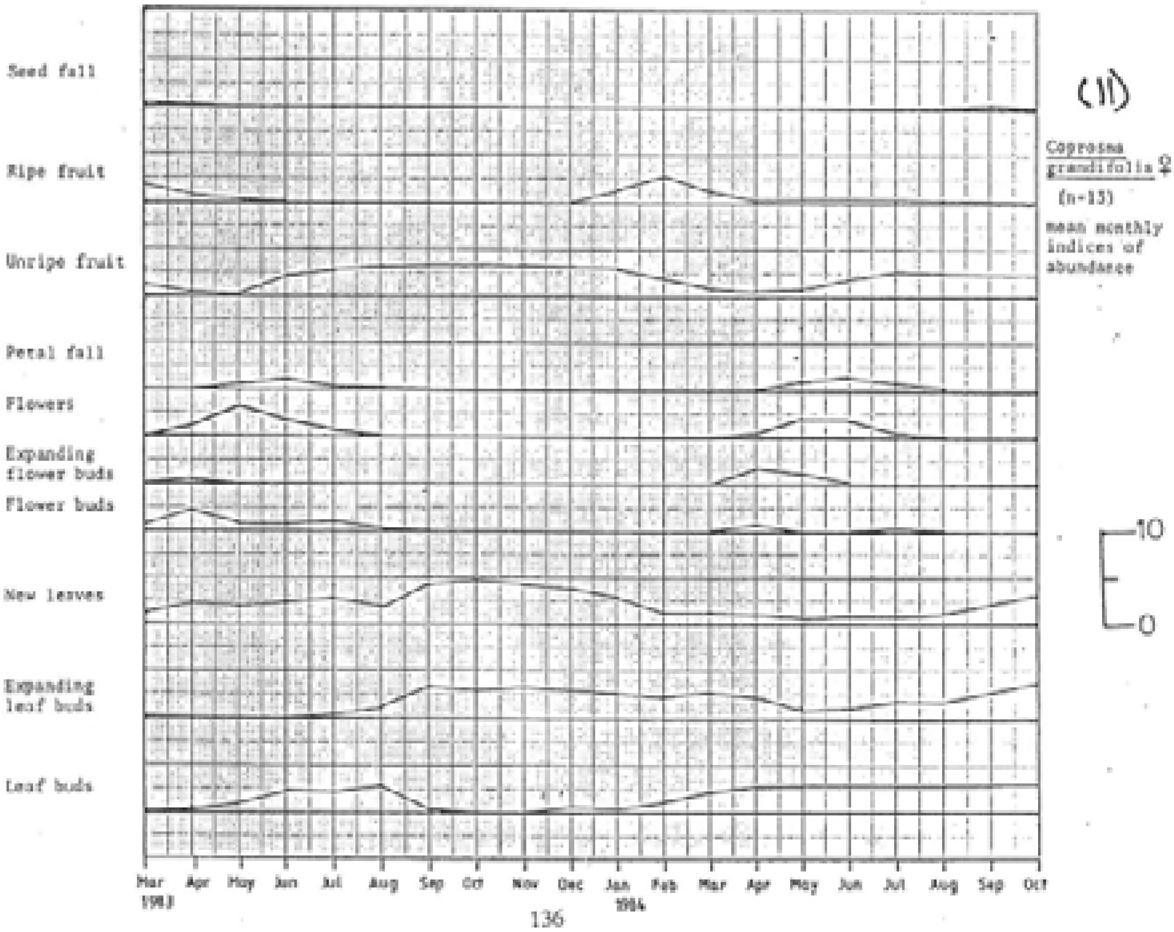


(11)

Coprosma grandifolia ♂

(n=11)

mean monthly indices of abundance

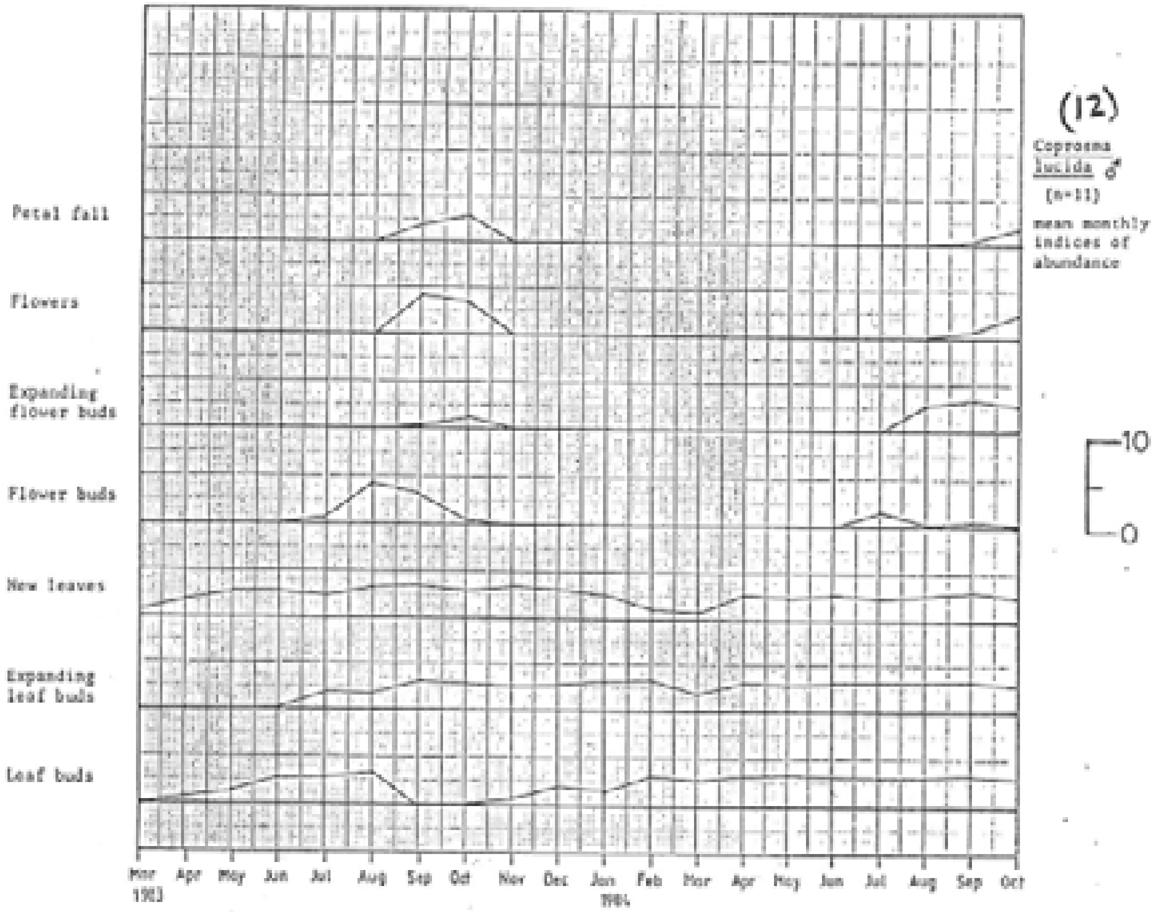


(11)

Coprosma grandifolia ♀

(n=13)

mean monthly indices of abundance

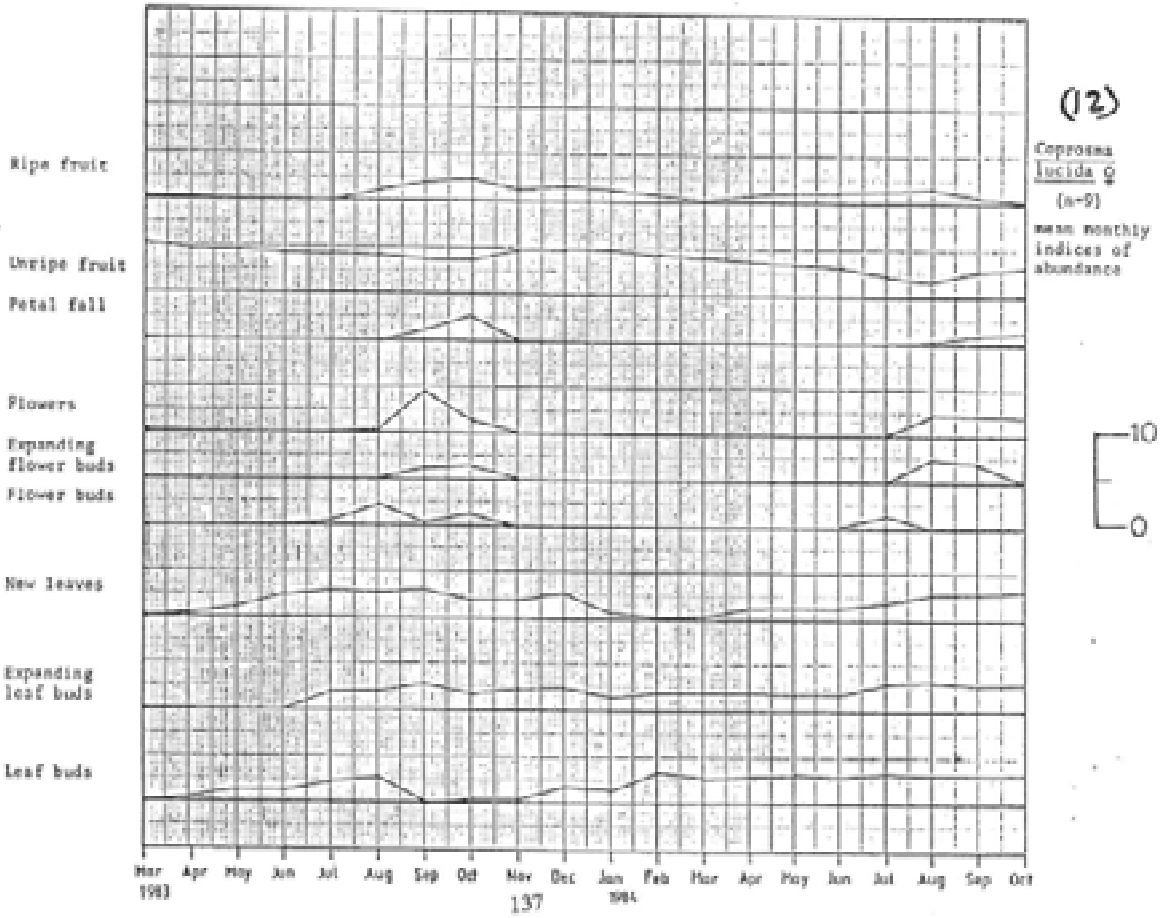


(12)

Coprosma lucida ♂

(n=11)

mean monthly indices of abundance



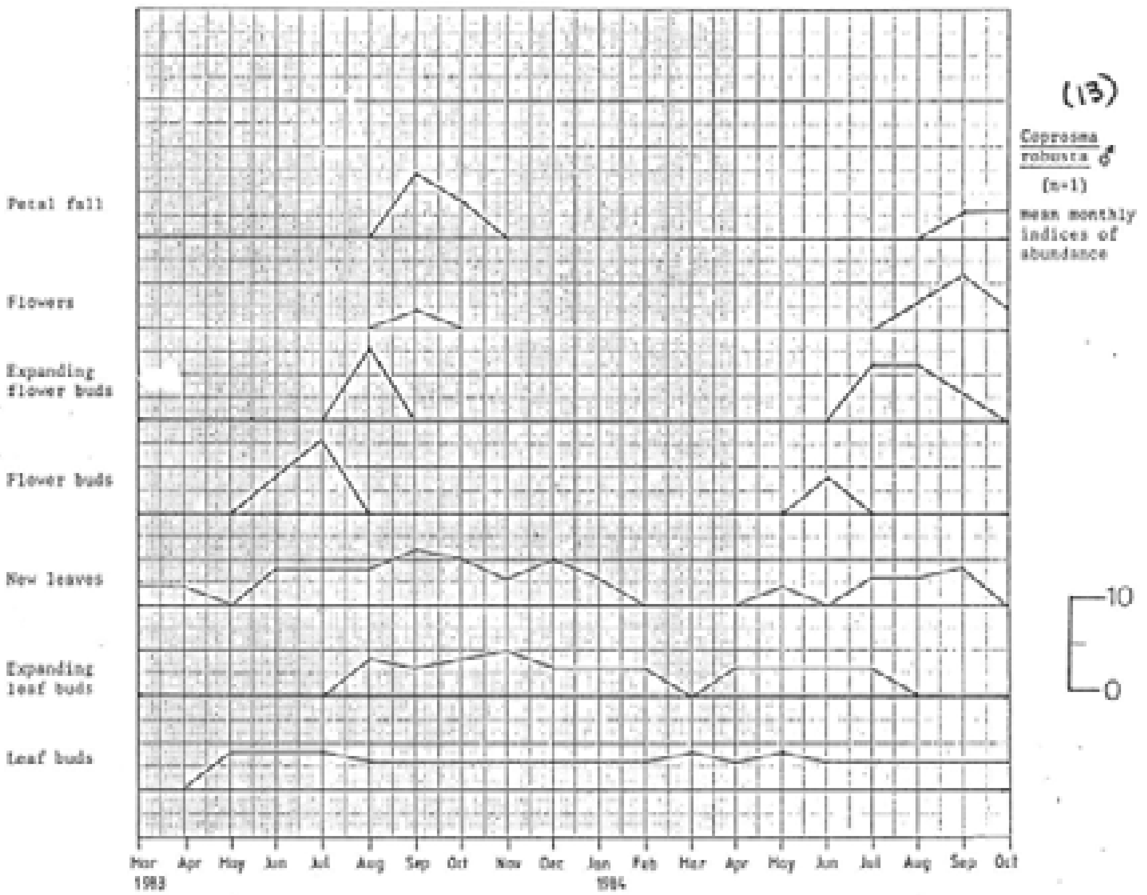
(12)

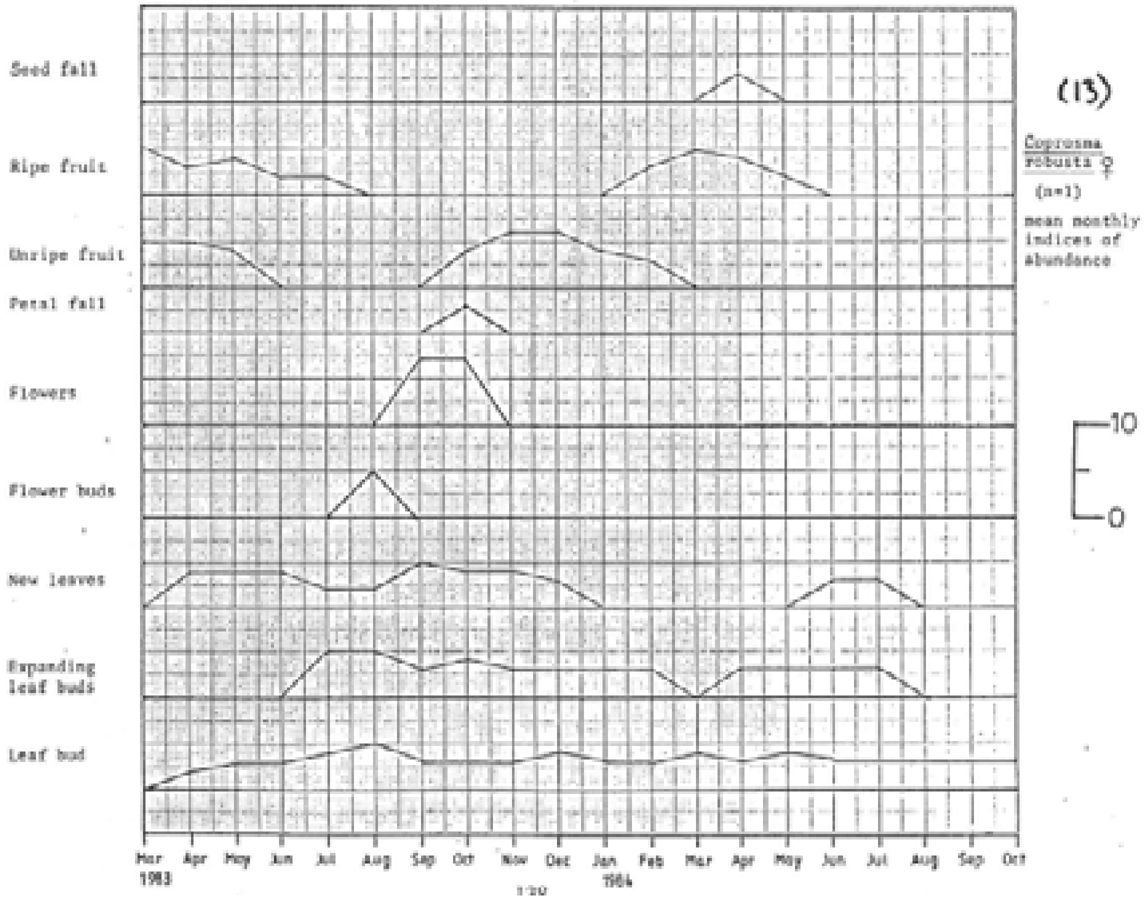
Coprosma lucida ♀

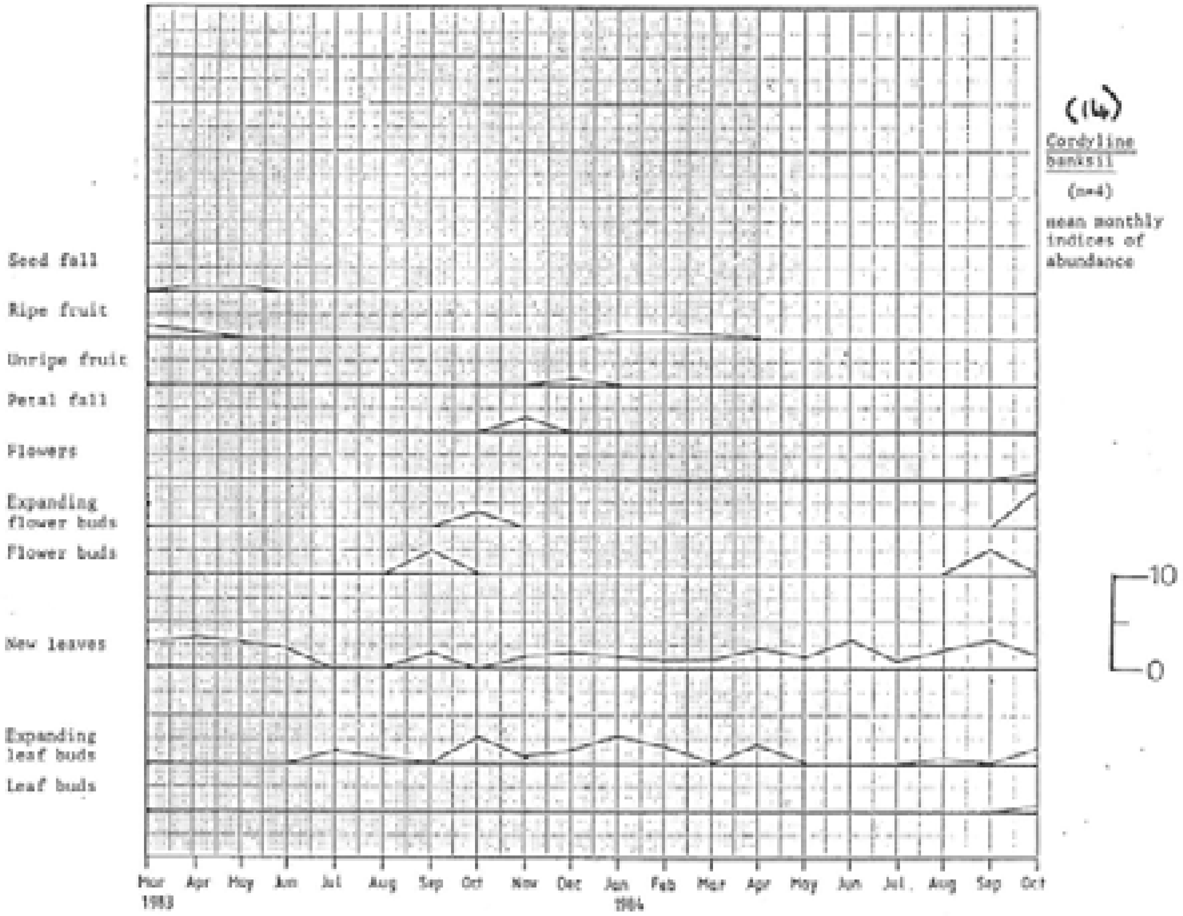
(n=9)

mean monthly indices of abundance

137


(13)
Coprosma robusta ♂
(n=1)
mean monthly indices of abundance
Petal fall
Flowers
Expanding flower buds
Flower buds
New leaves
Expanding leaf buds
Leaf buds
10
0
Mar 1983
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 1984
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct


(13)
Coprosma robusta ♀
(n=1)
mean monthly indices of abundance
Seed fall
Ripe fruit
Unripe fruit
Petal fall
Flowers
Flower buds
New leaves
Expanding leaf buds
Leaf bud
10
0
Mar 1983
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 1984
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct

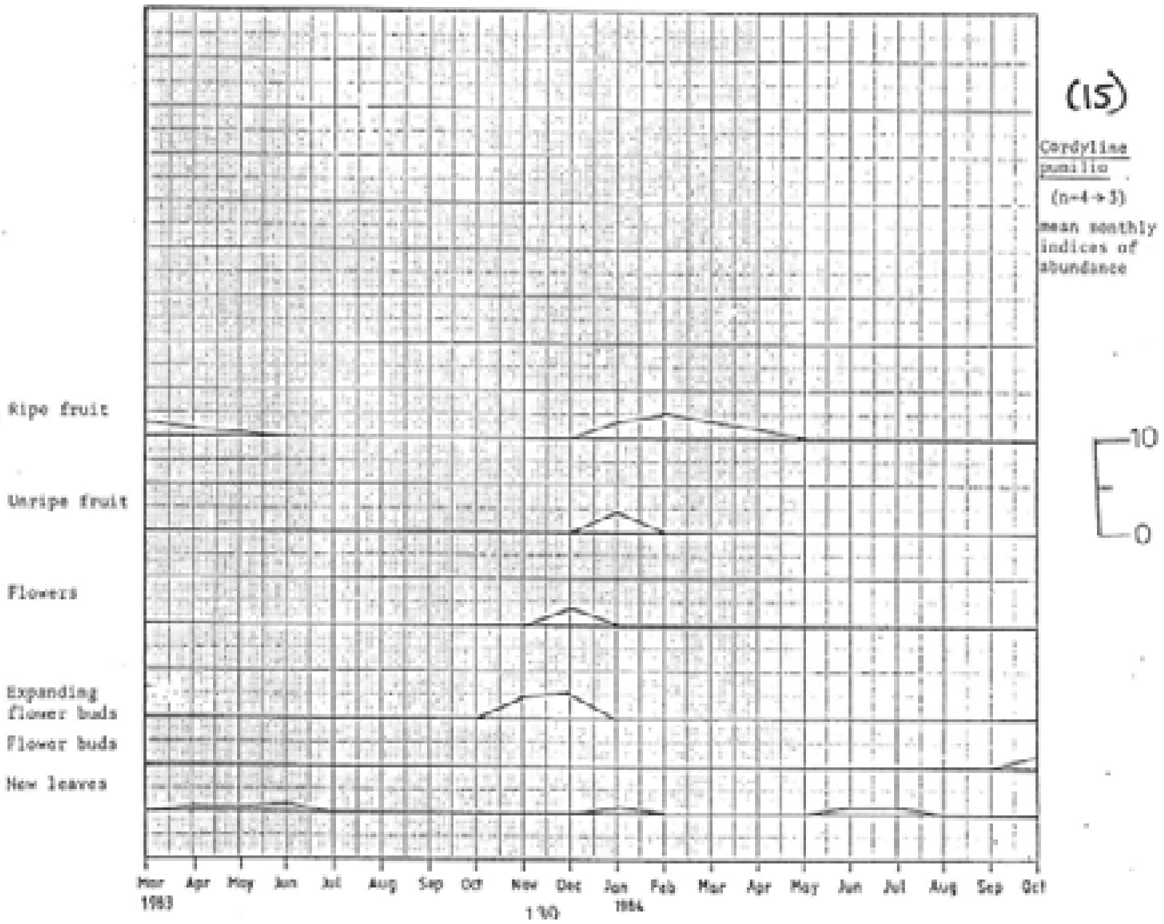


(14)

Cordyline banksii

(n=4)

mean monthly indices of abundance

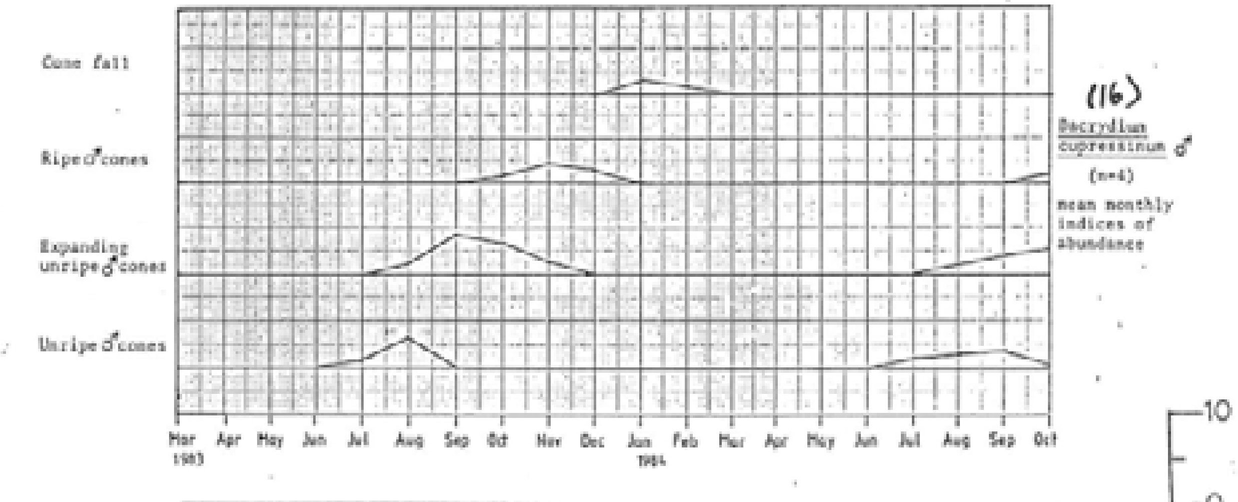


(15)

Cordyline pumilio

(n=4→3)

mean monthly indices of abundance

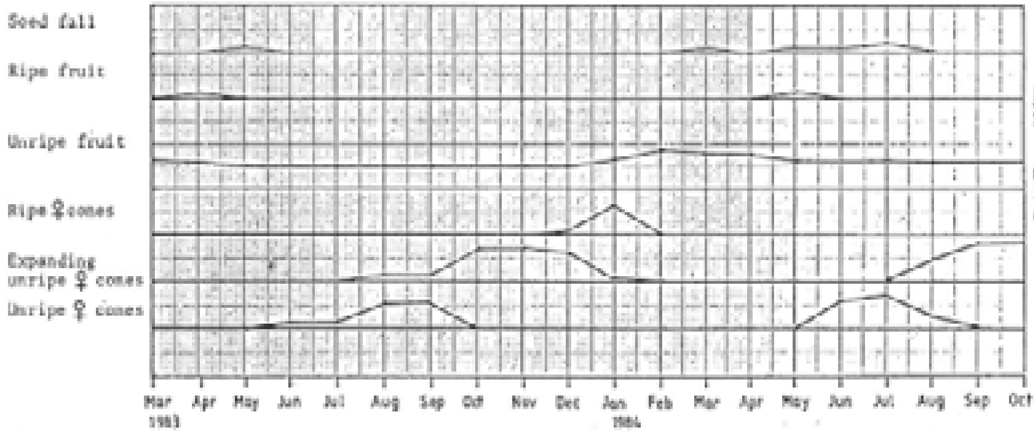


(16)

Dacrydium cupressinum ♂

(n=4)

mean monthly indices of abundance

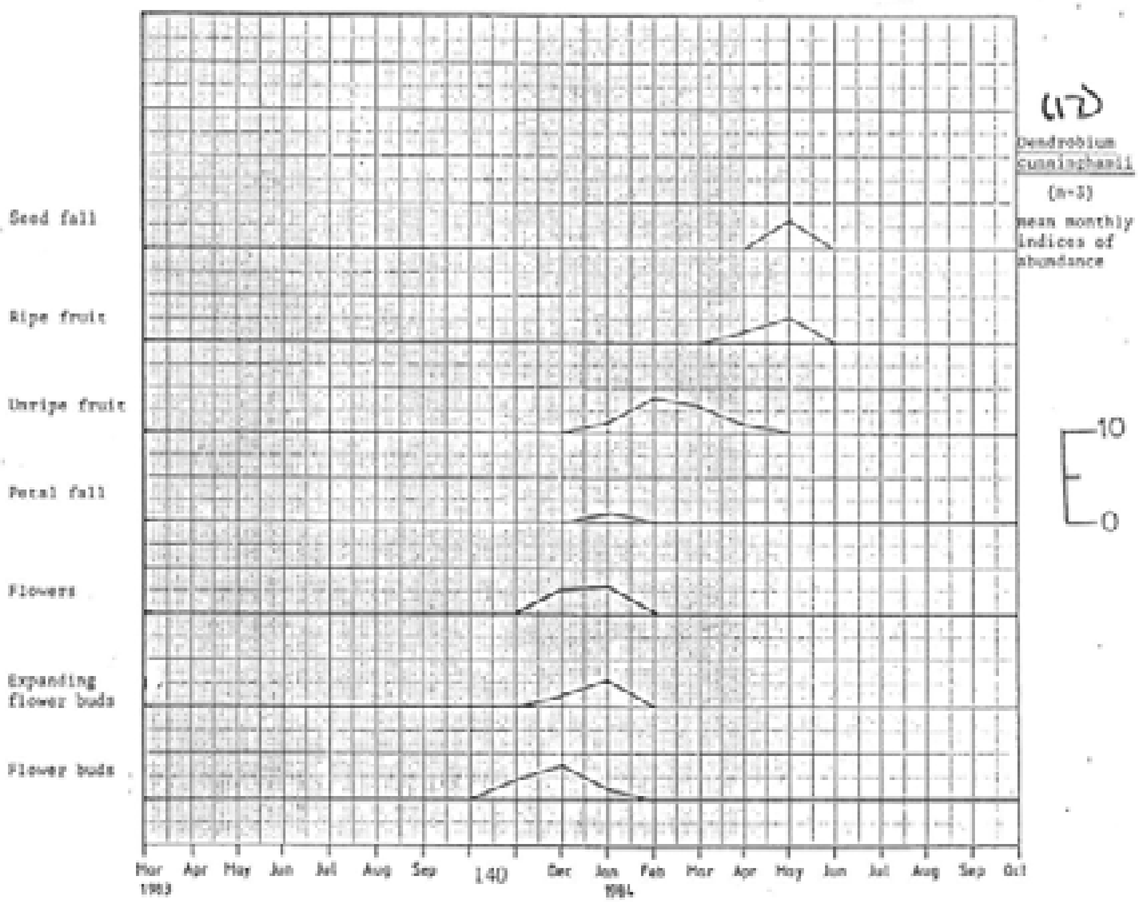


(16)

Dacrydium cupressinum ♀

(n=6)

mean monthly indices of abundance

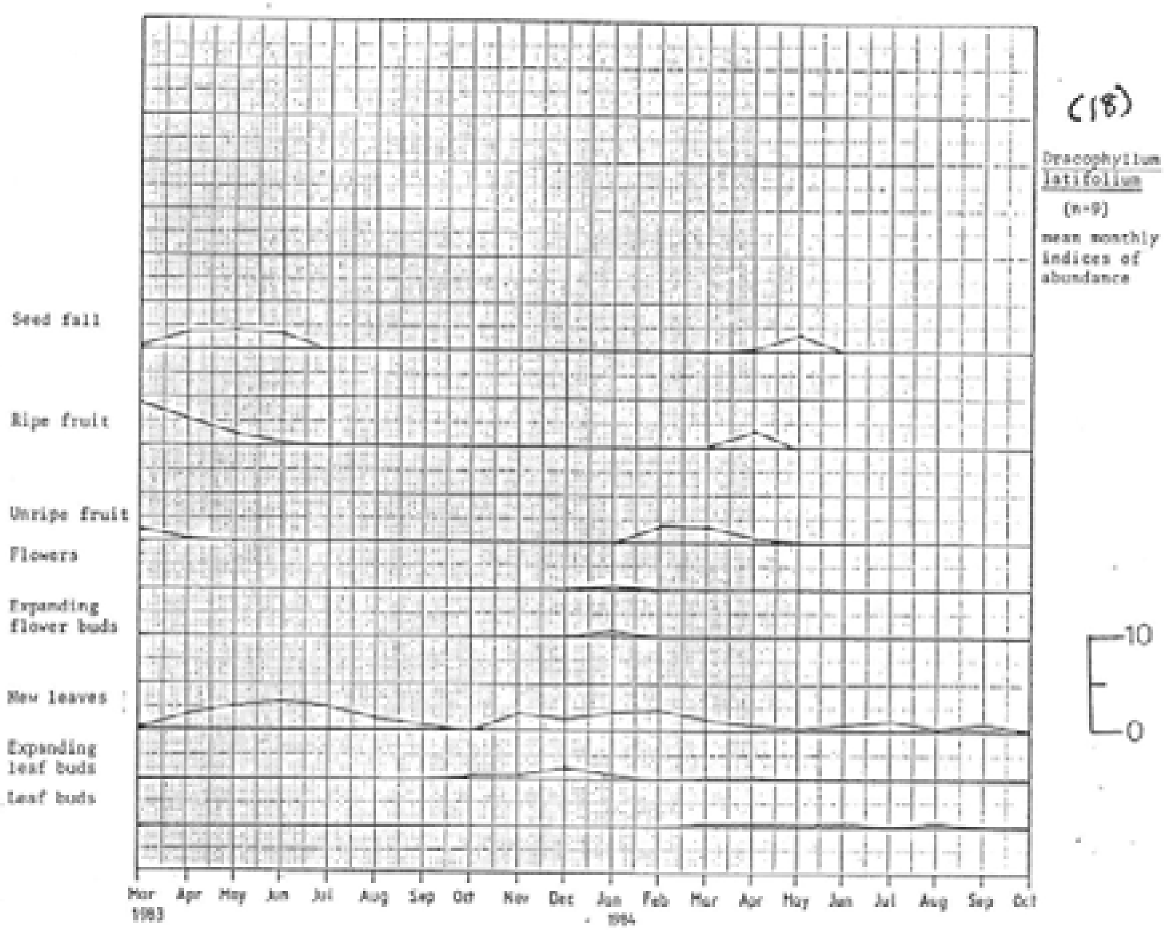


(17)

Dendrobium cunninghamii

(n=3)

mean monthly indices of abundance

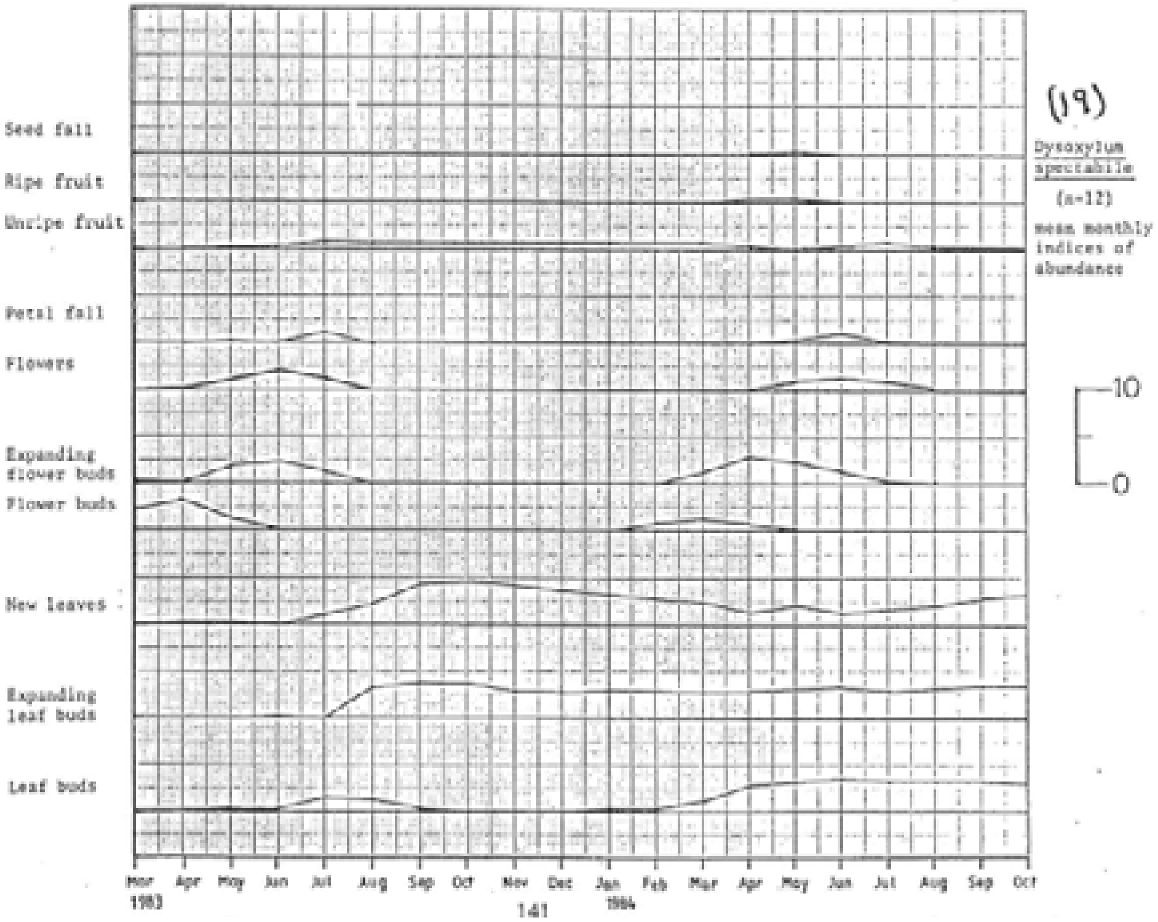


(18)

Dracophyllum latifolium

(n=9)

mean monthly indices of abundance



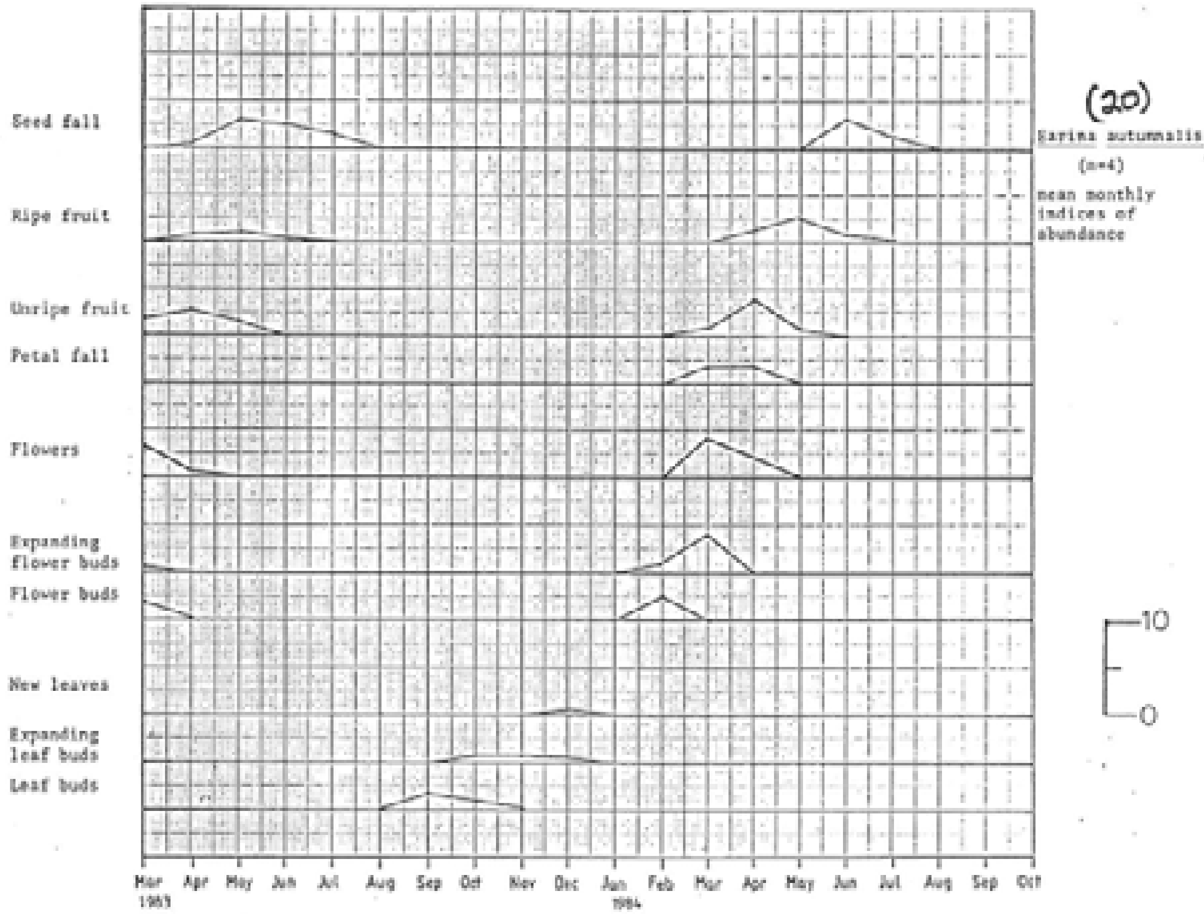
(19)

Dysoxylum spectabile

(n=12)

mean monthly indices of abundance

(20)

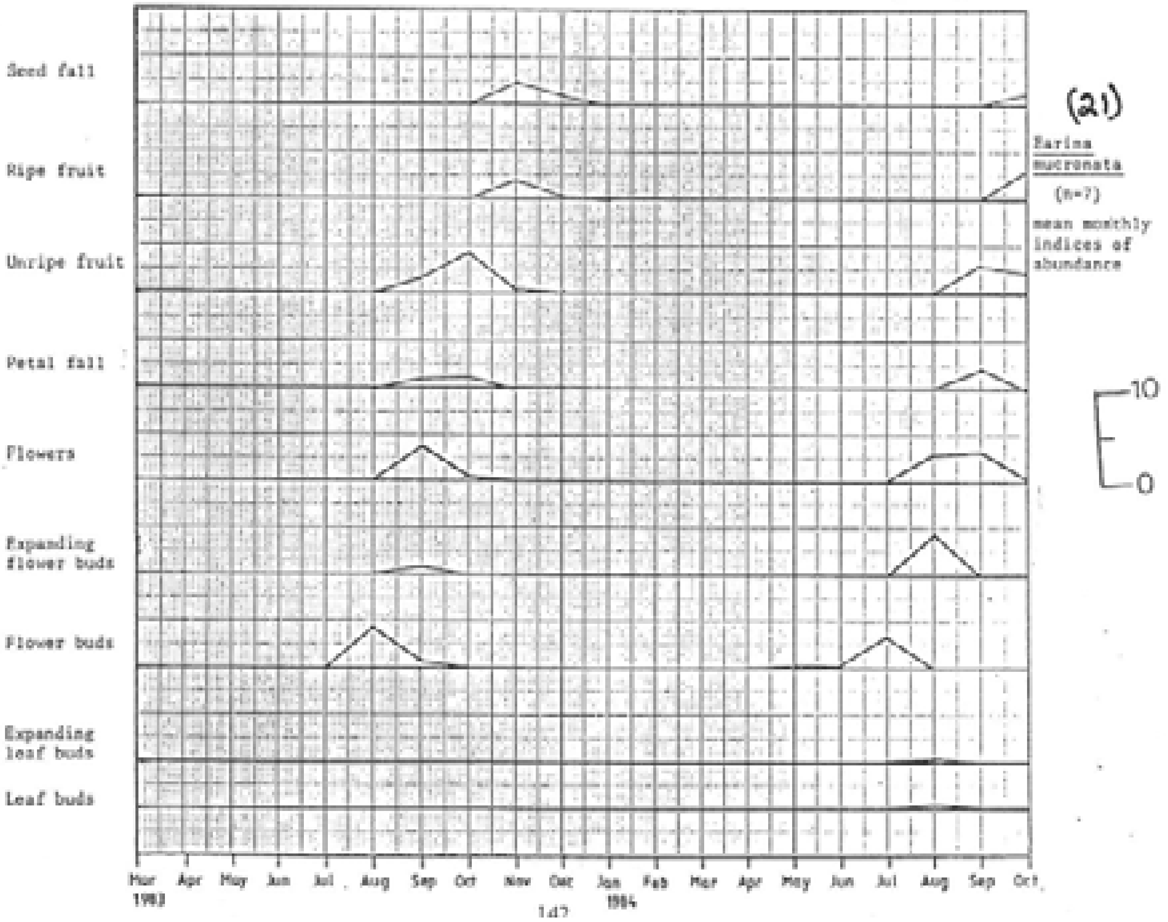


Sarina autumnalis

(n=4)

mean monthly indices of abundance

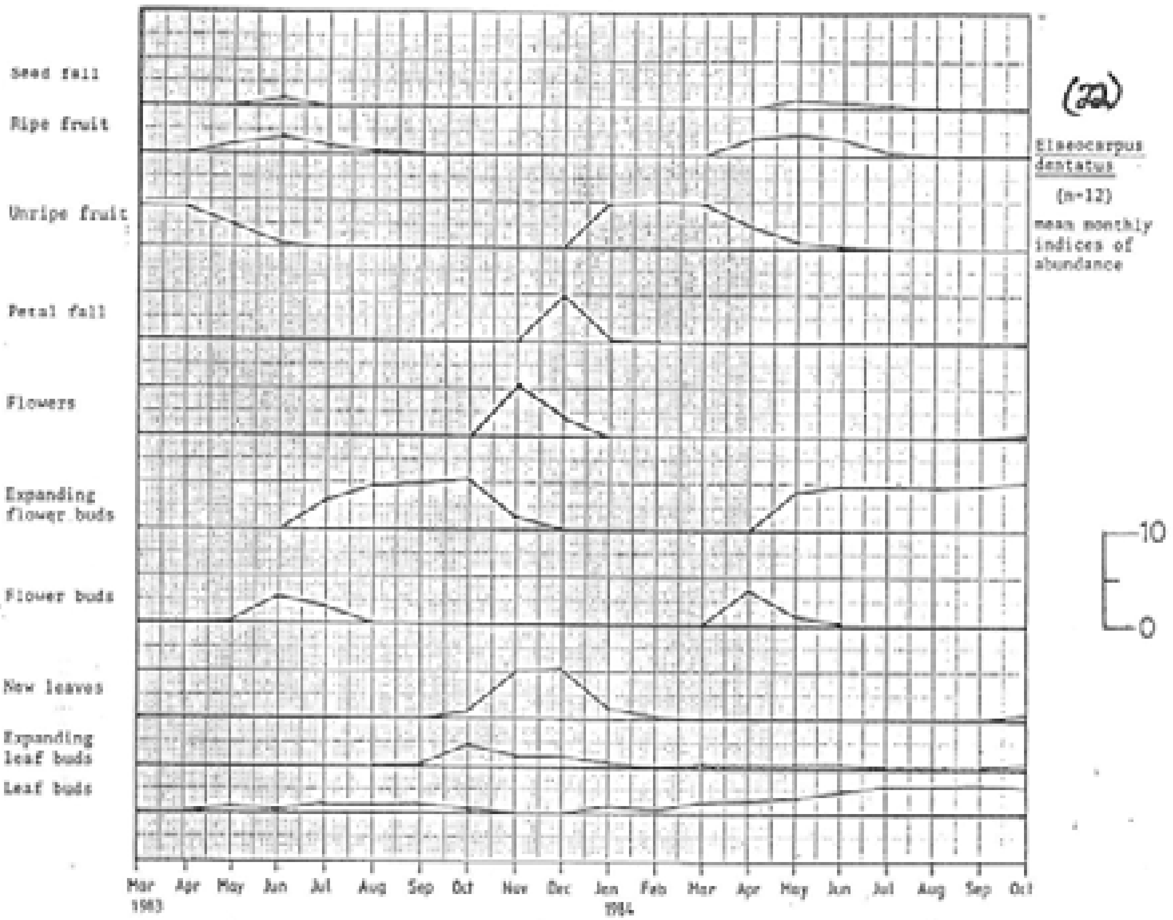
(21)



Sarina mucronata

(n=7)

mean monthly indices of abundance

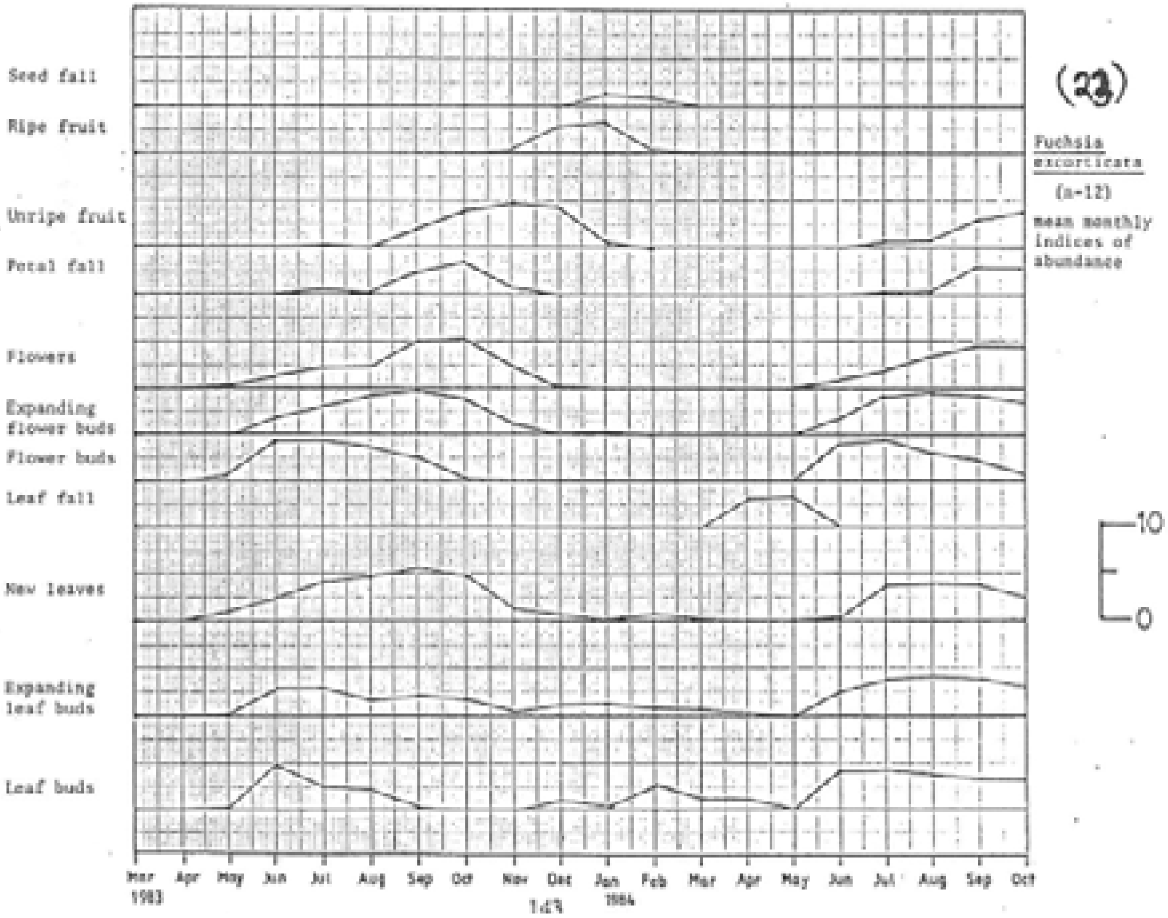


(22)

Elaeocarpus dentatus

(n=12)

mean monthly indices of abundance

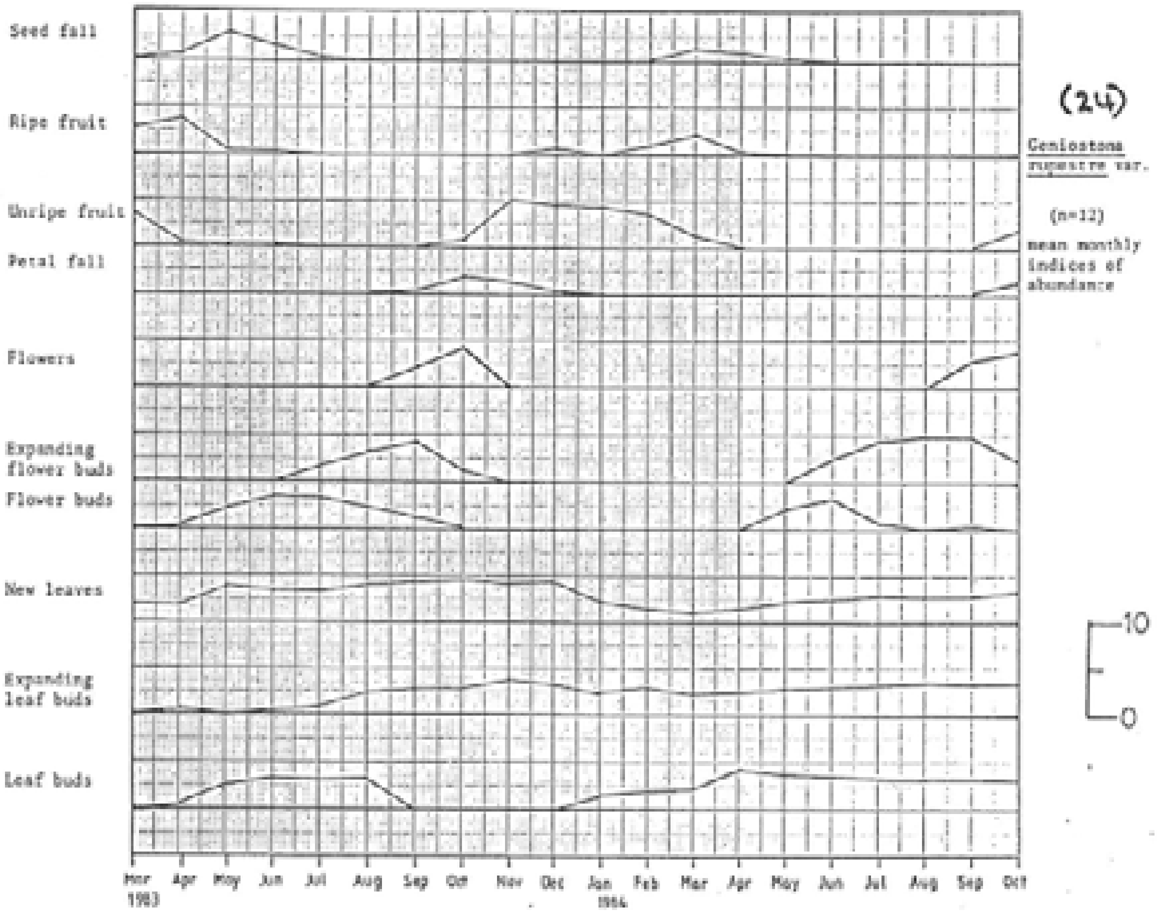


(23)

Fuchsia excorticata

(n=12)

mean monthly indices of abundance

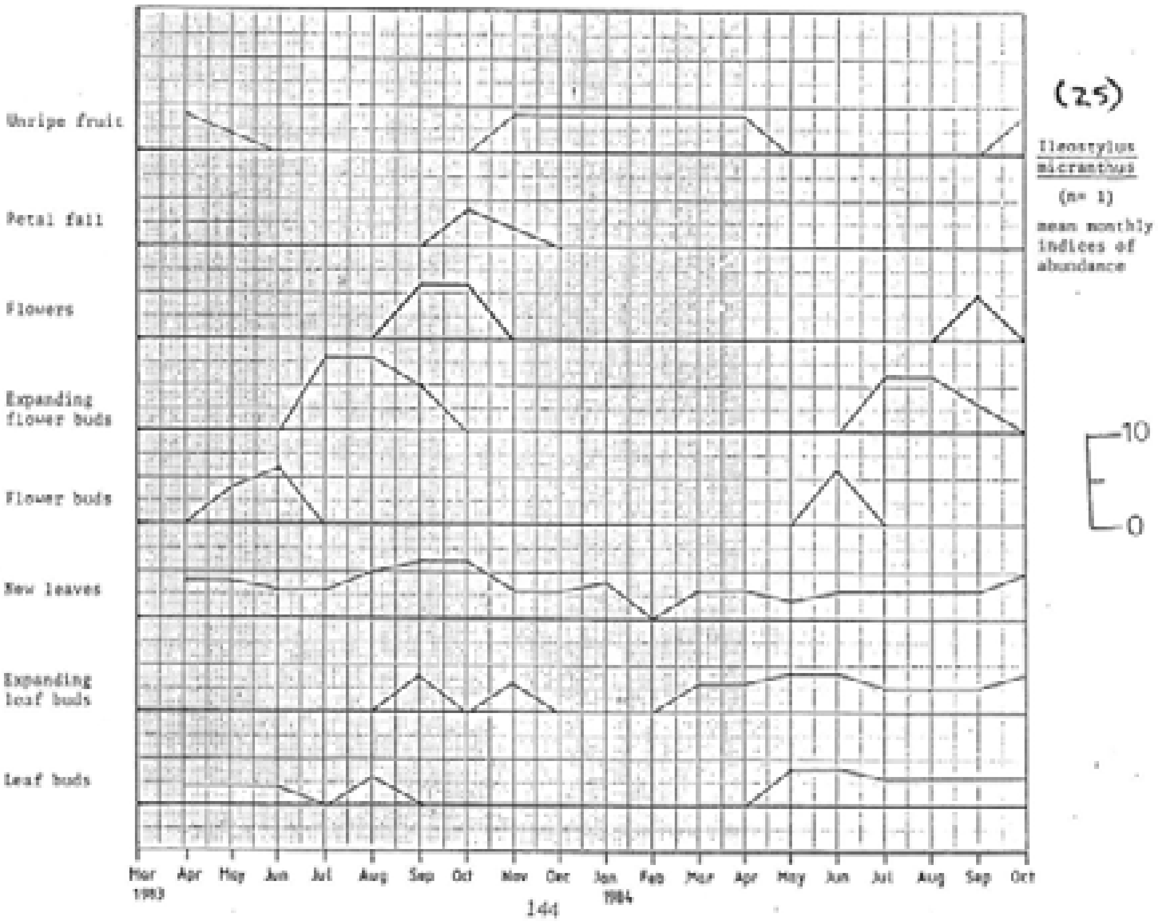


(24)

Geniostoma rupestre var.

(n=12)

mean monthly indices of abundance

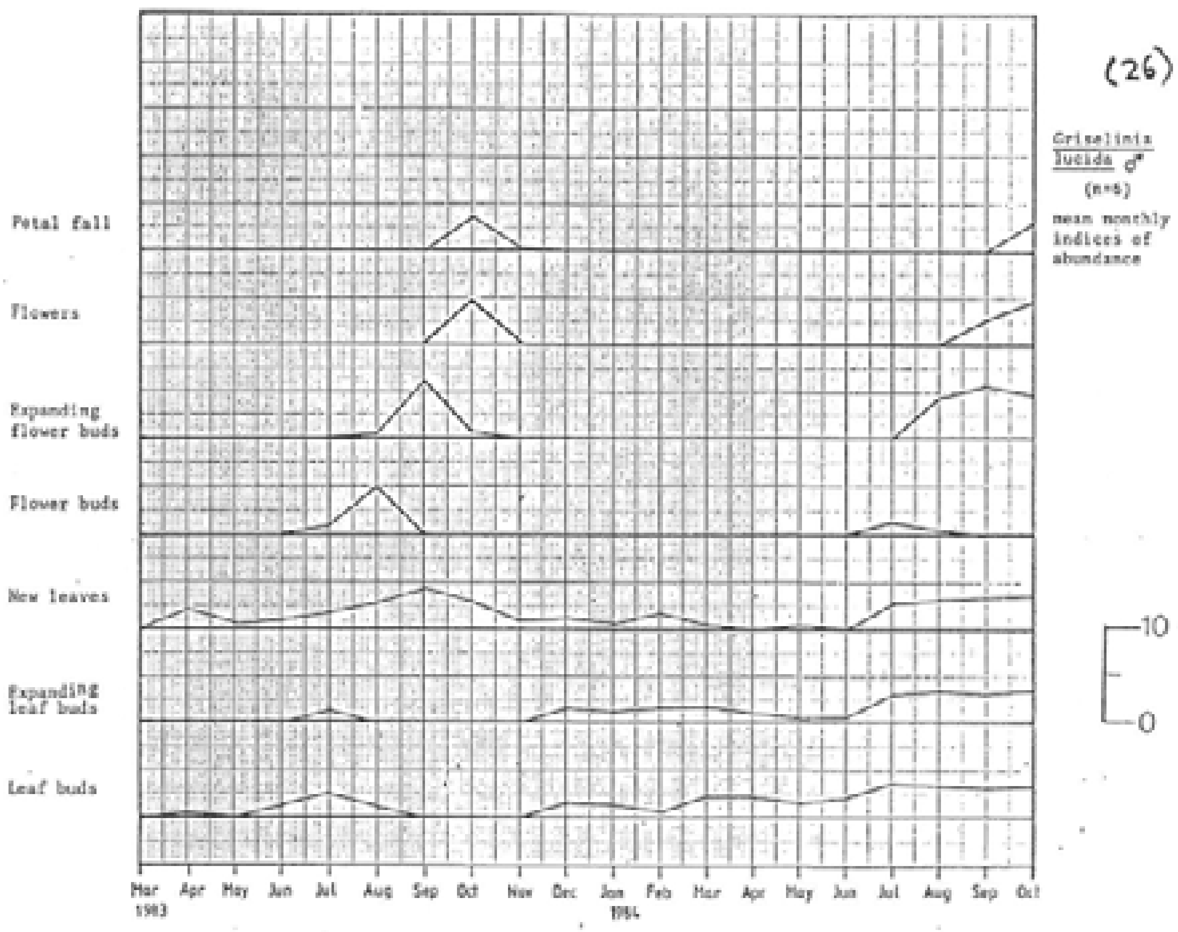


(25)

Ileostylus micranthus

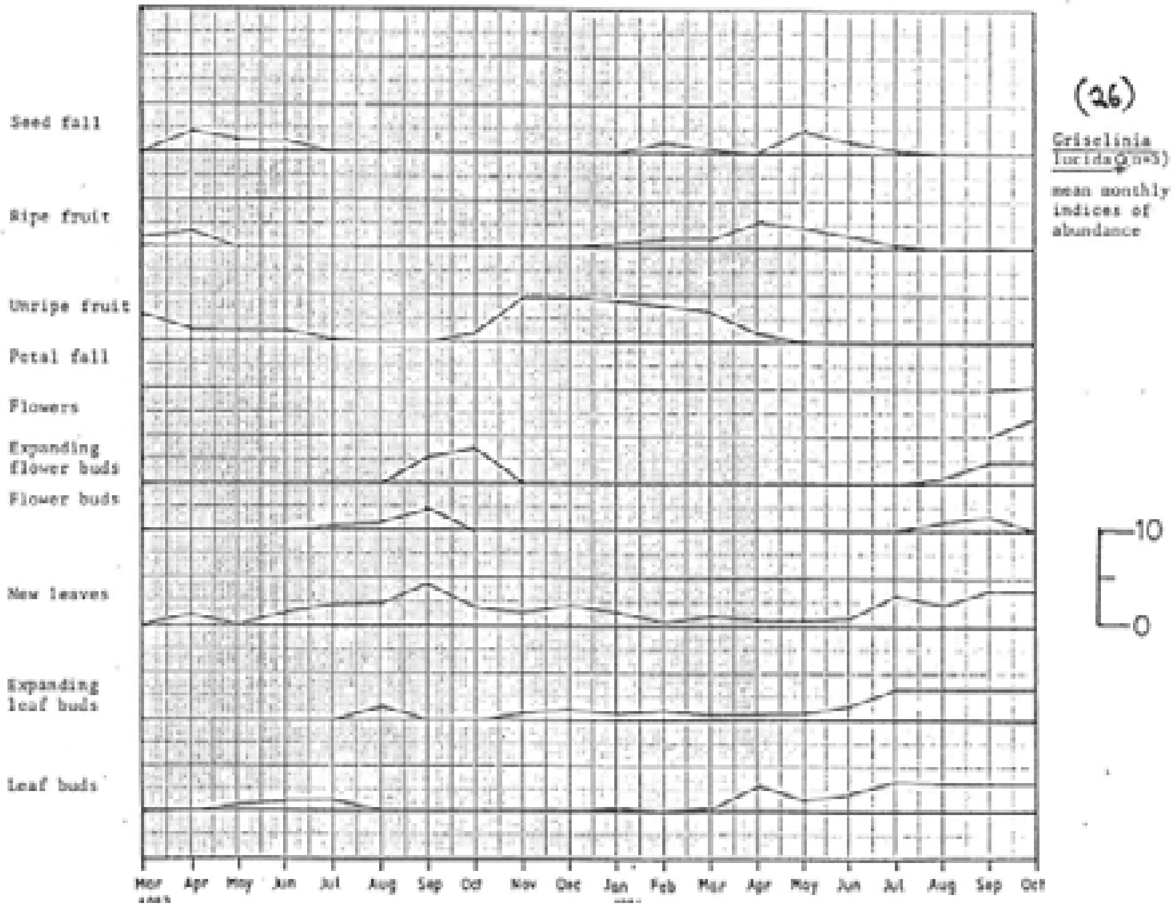
(n= 1)

mean monthly indices of abundance



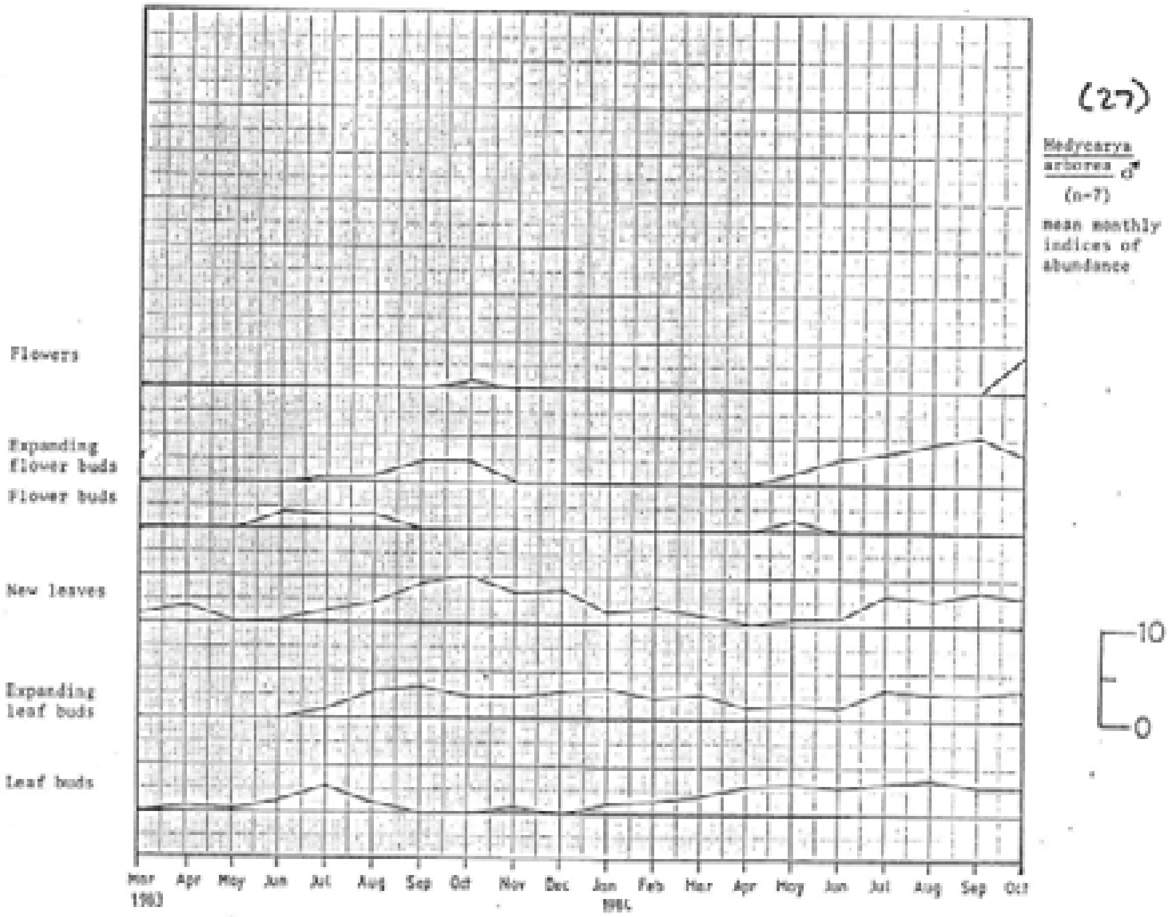
(26)

Griselinia lucida ♂
(n=6)
mean monthly indices of abundance



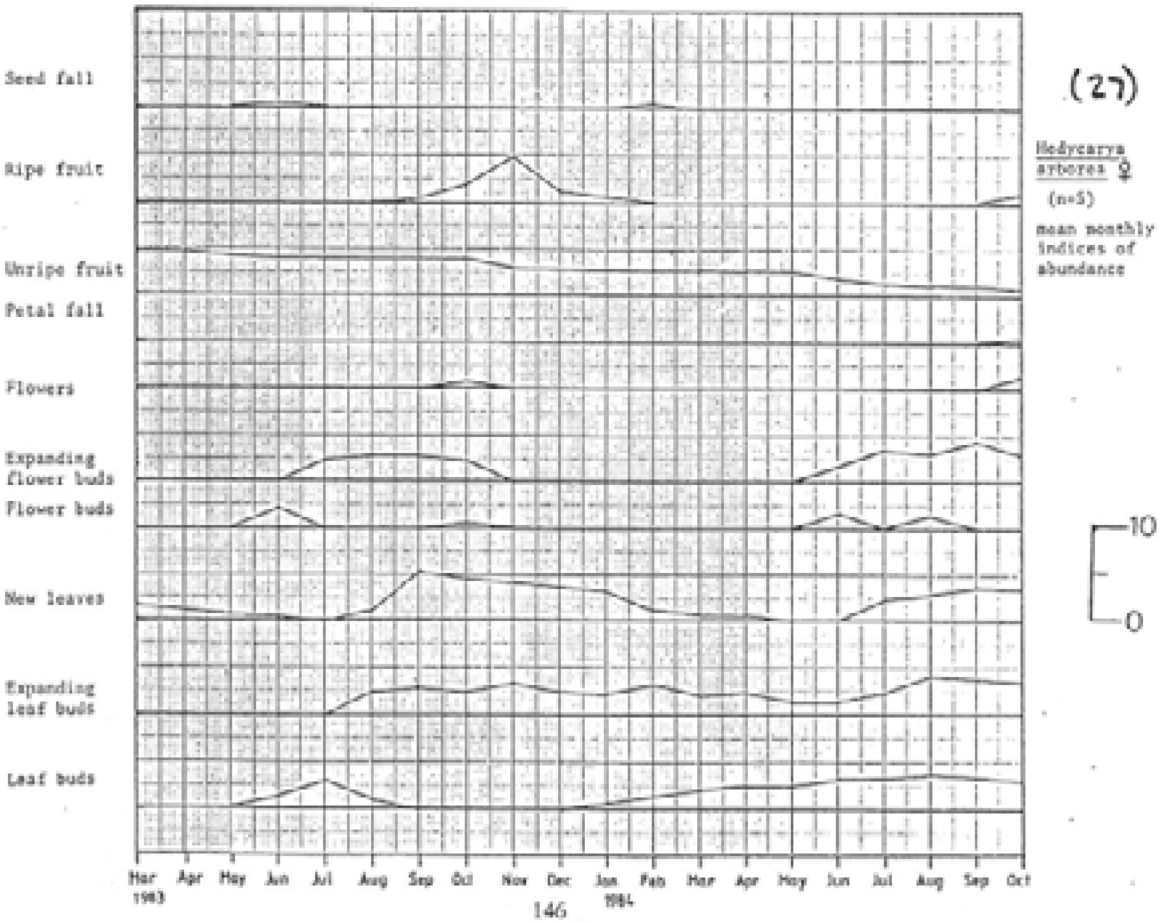
(26)

Grisclinia lucida ♀ (n=5)
mean monthly indices of abundance



(27)

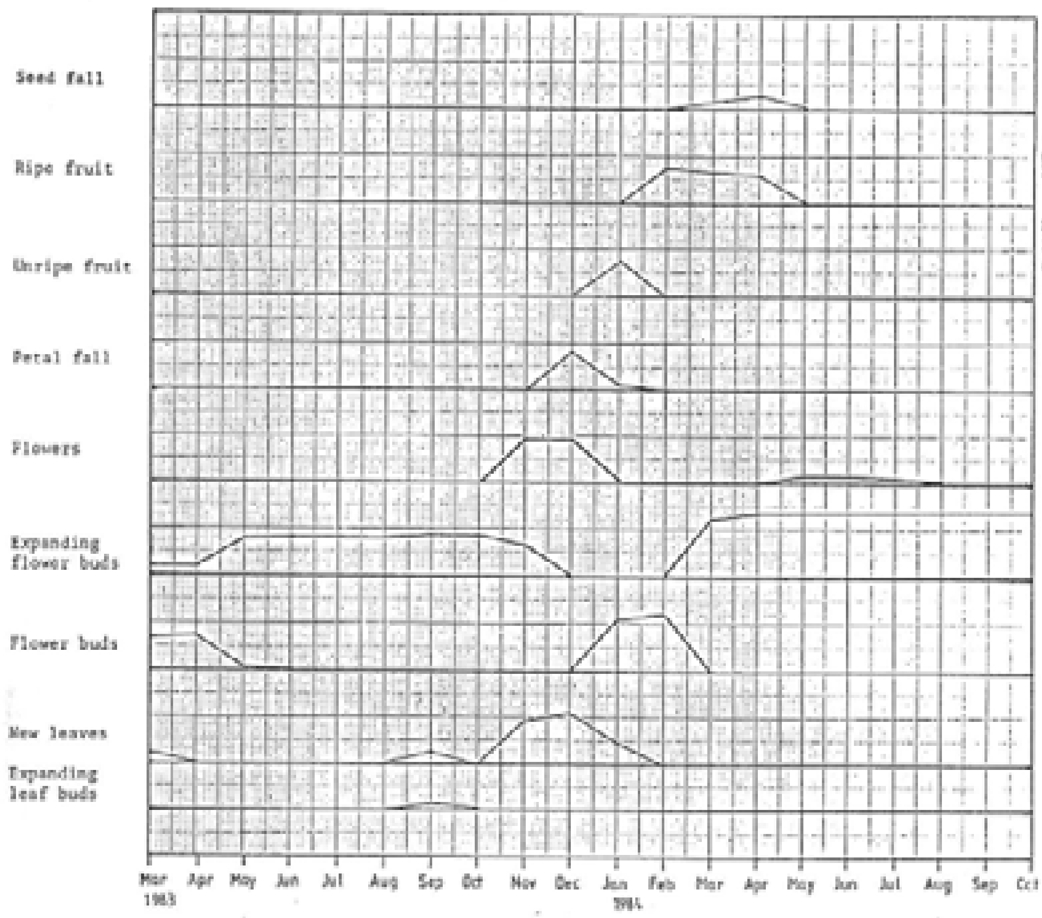
Hedycarya arborea ♂
(n=7)
mean monthly indices of abundance



(27)

Hedycarya arborea ♀
(n=5)
mean monthly indices of abundance

(28)

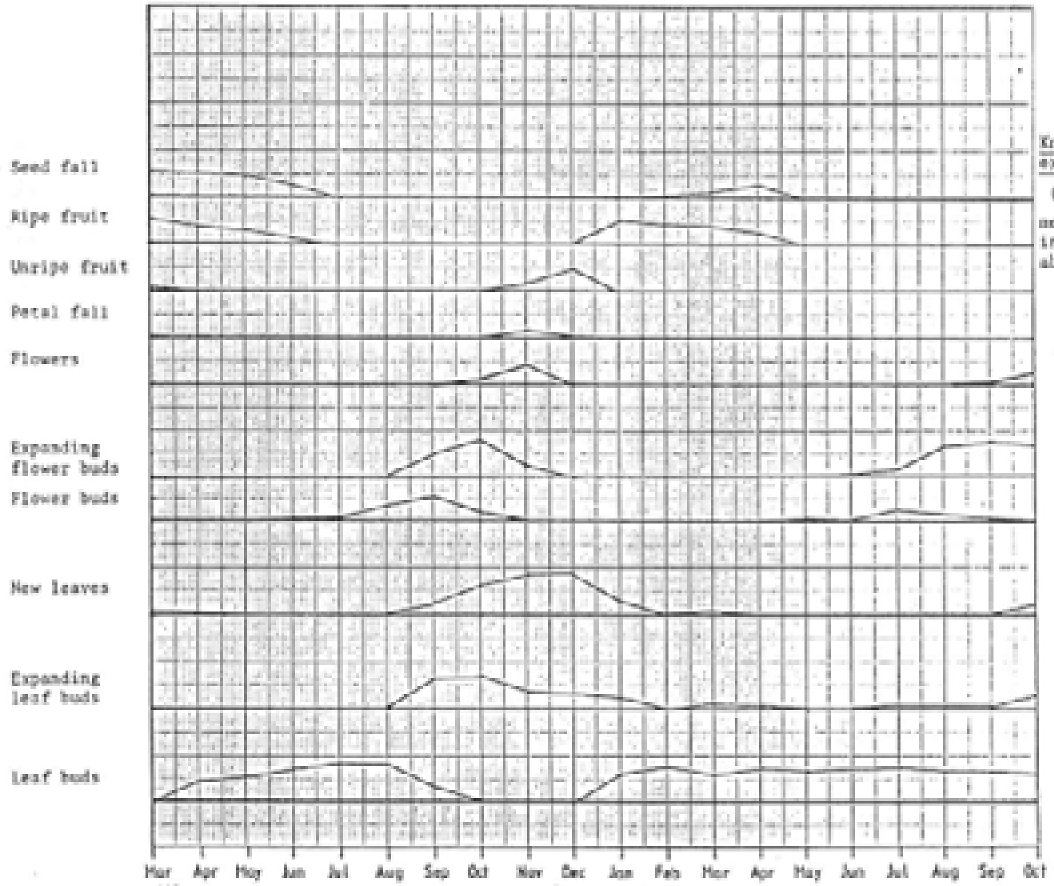


Ixerba brexioides

(n=5)

mean monthly indices of abundance

(29)

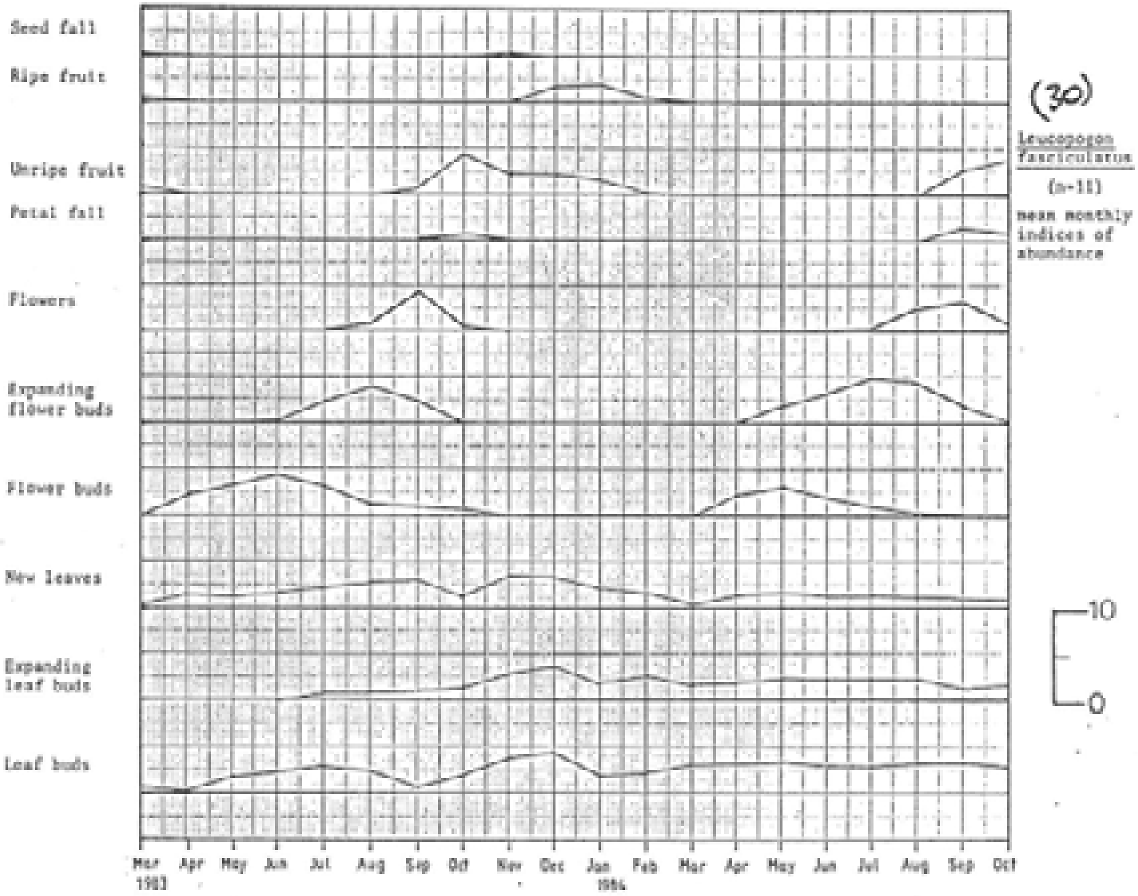


Knightia excelsa

(n=12)

mean monthly indices of abundance

147

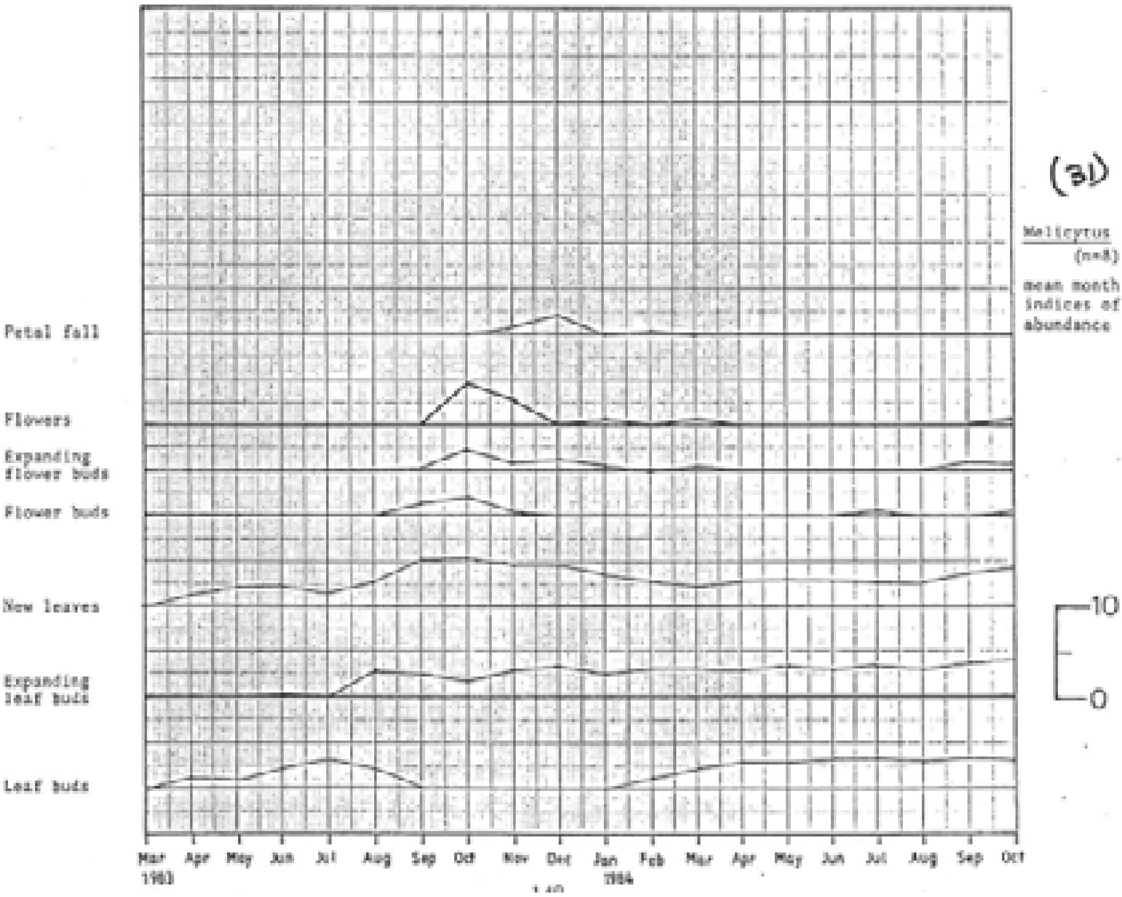


(30)

Leucopogon fasciculatus

(n=11)

mean monthly indices of abundance

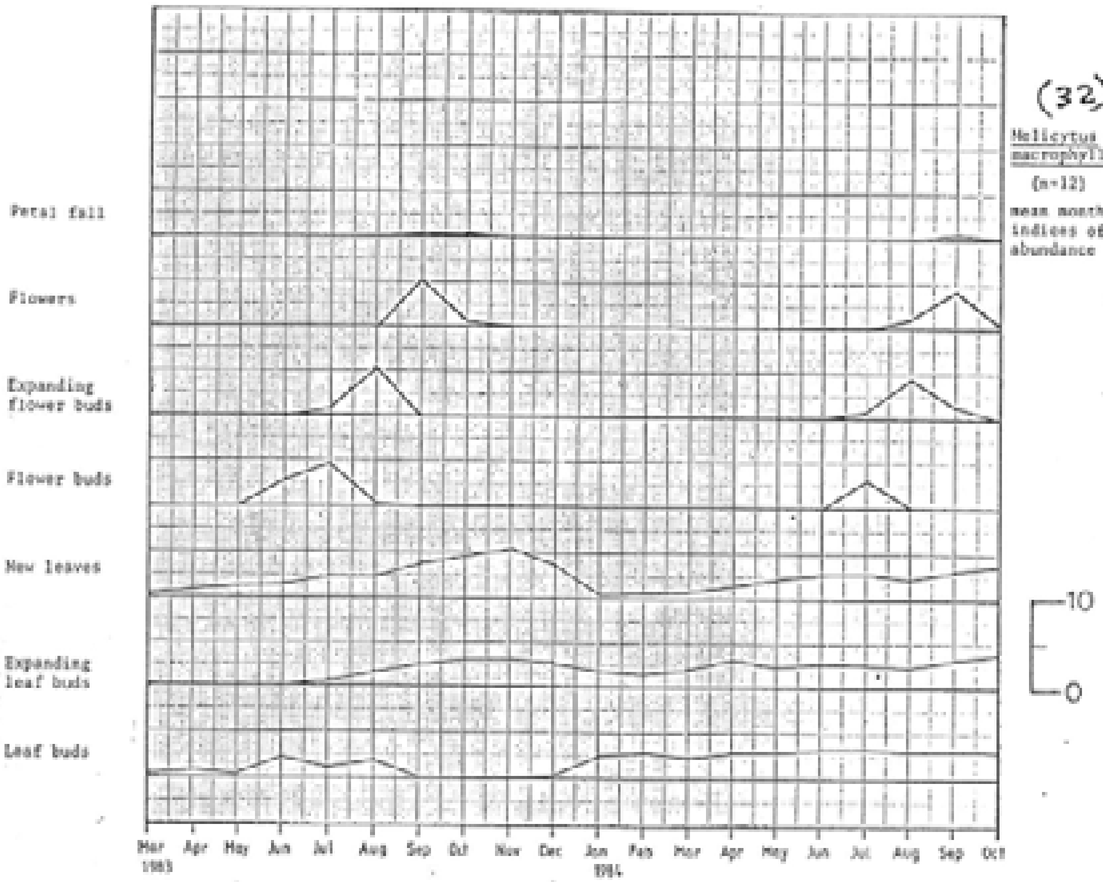


(31)

Melicytus ramiflor

(n=8)

mean monthly indices of abundance

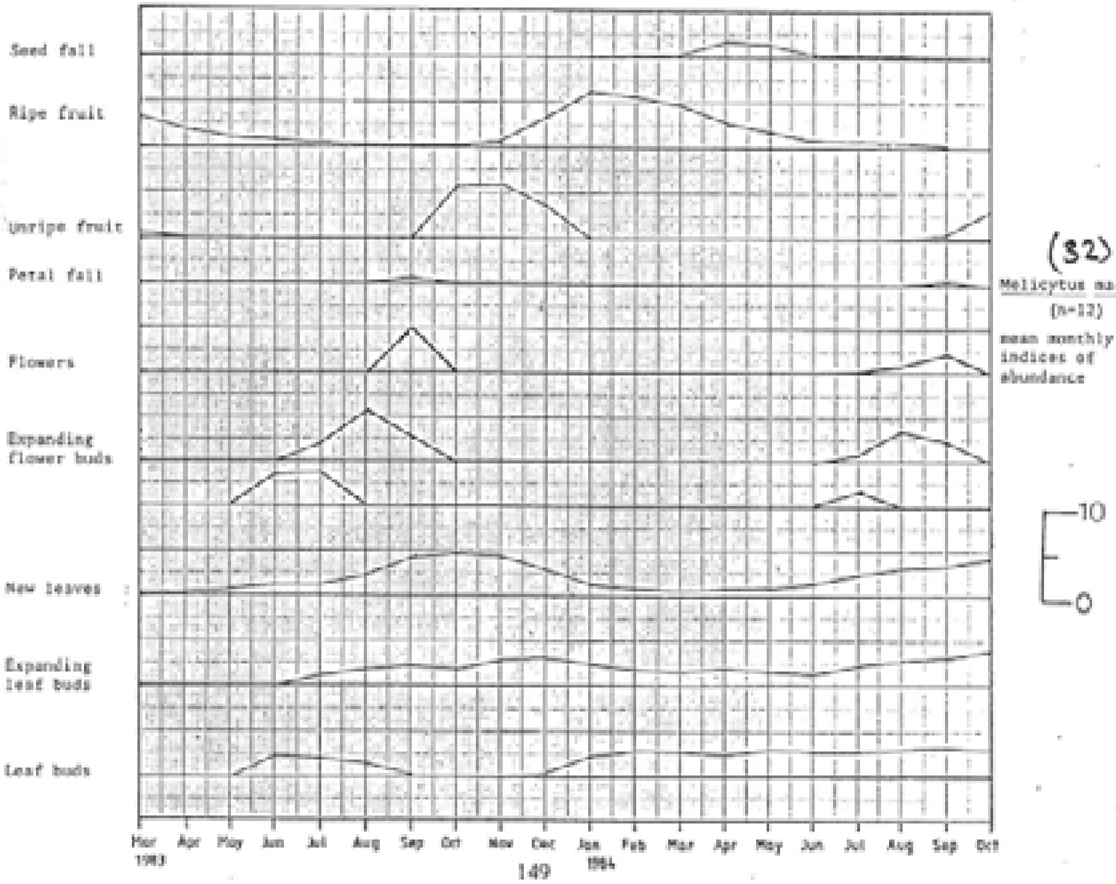


(32)

Melicytus macrophyllus ♂

(n=12)

mean monthly indices of abundance

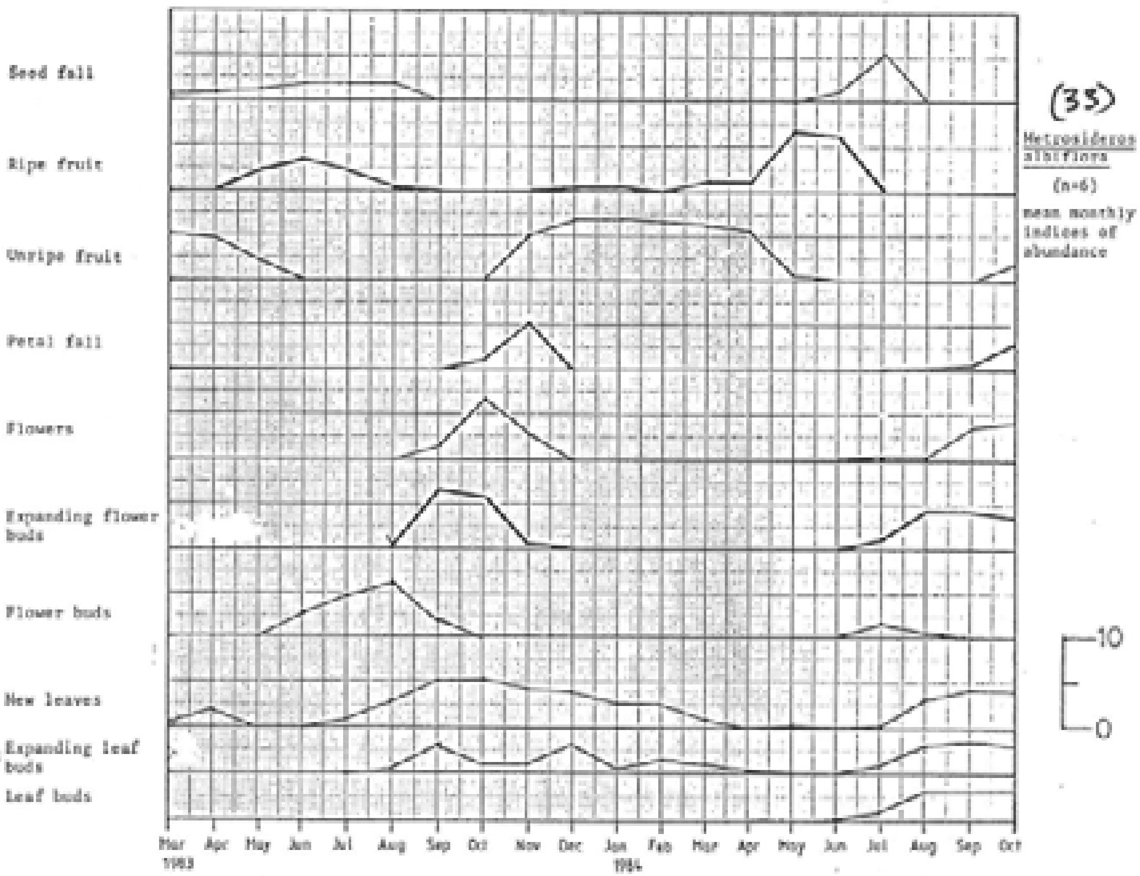


(32)

Melicytus macrophyllus

(n=12)

mean monthly indices of abundance

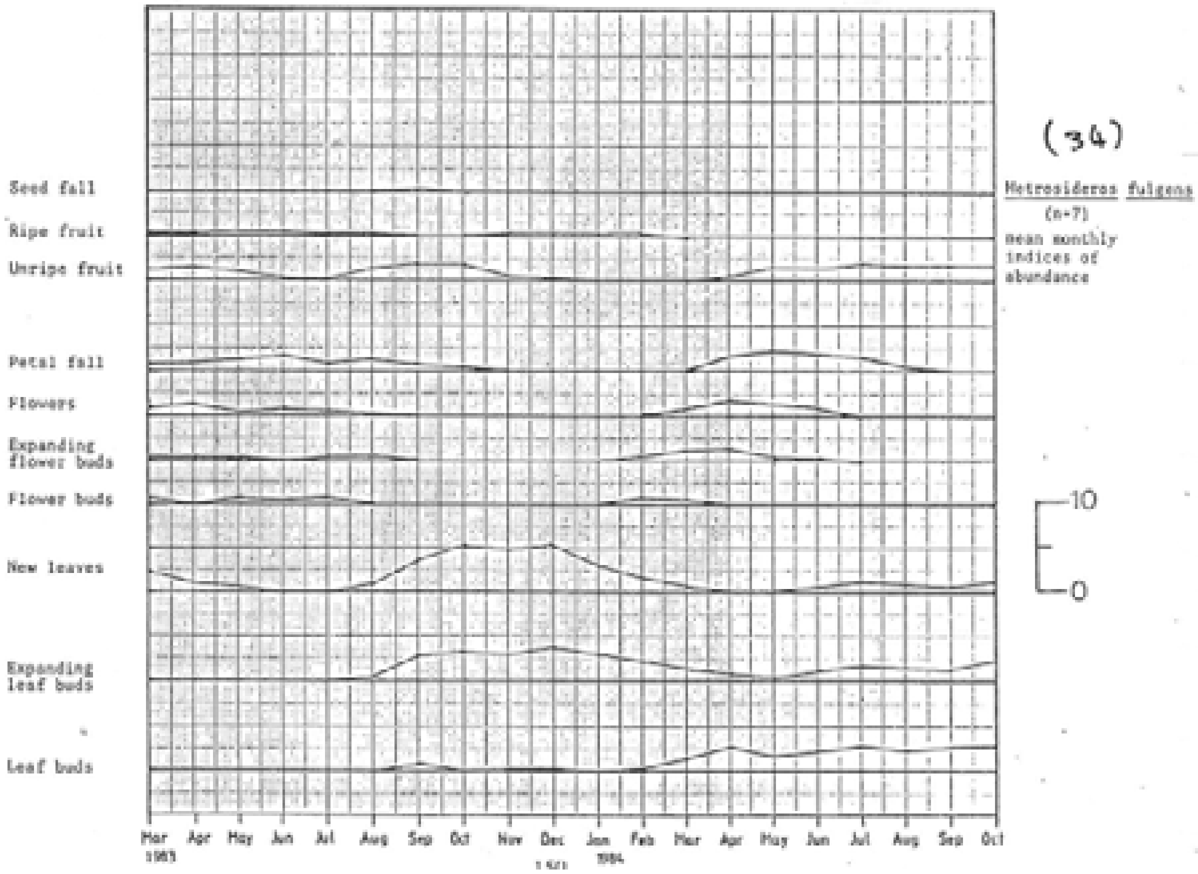


(33)

Metrosideros albiflora

(n=6)

mean monthly indices of abundance



(34)

Metrosideros fulgens

(n=7)

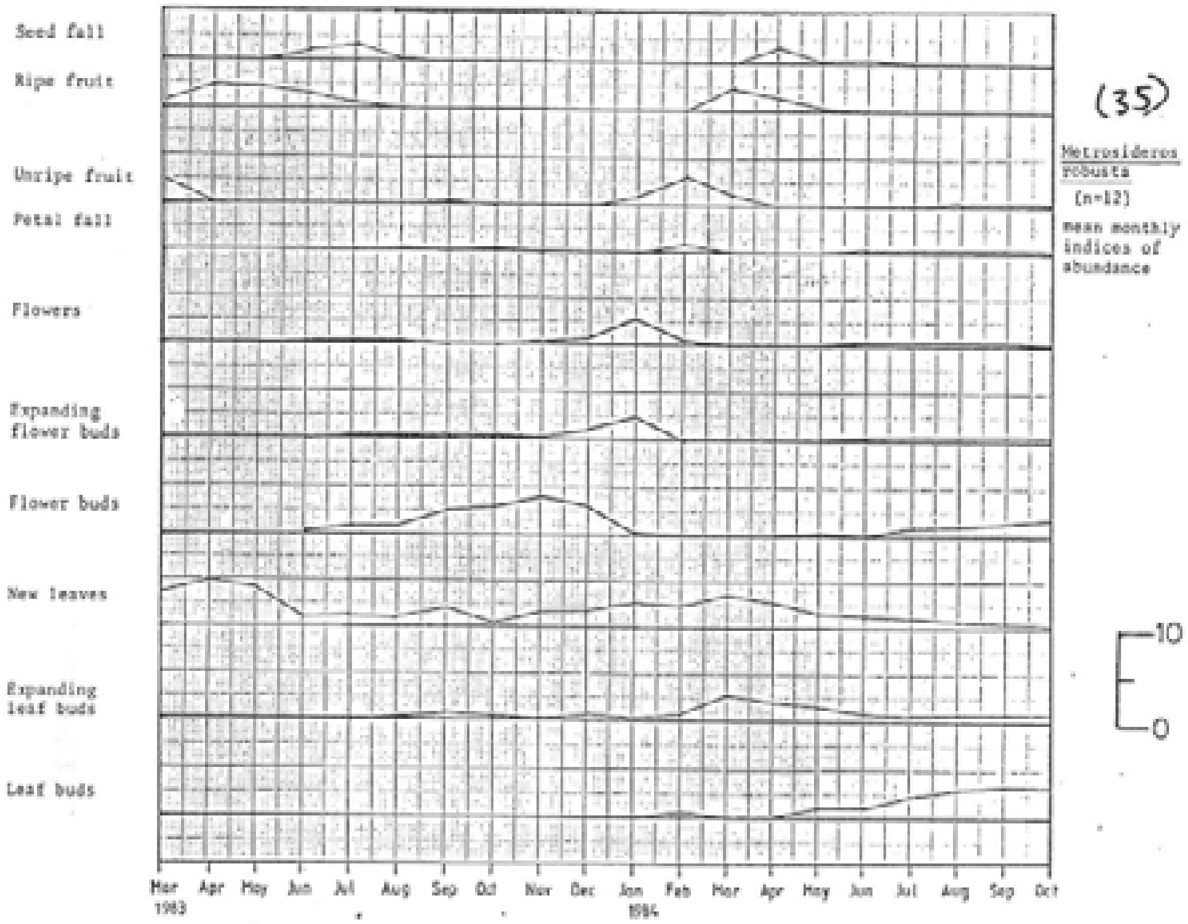
mean monthly indices of abundance

(35)

Metrosideros robusta

(n=12)

mean monthly indices of abundance

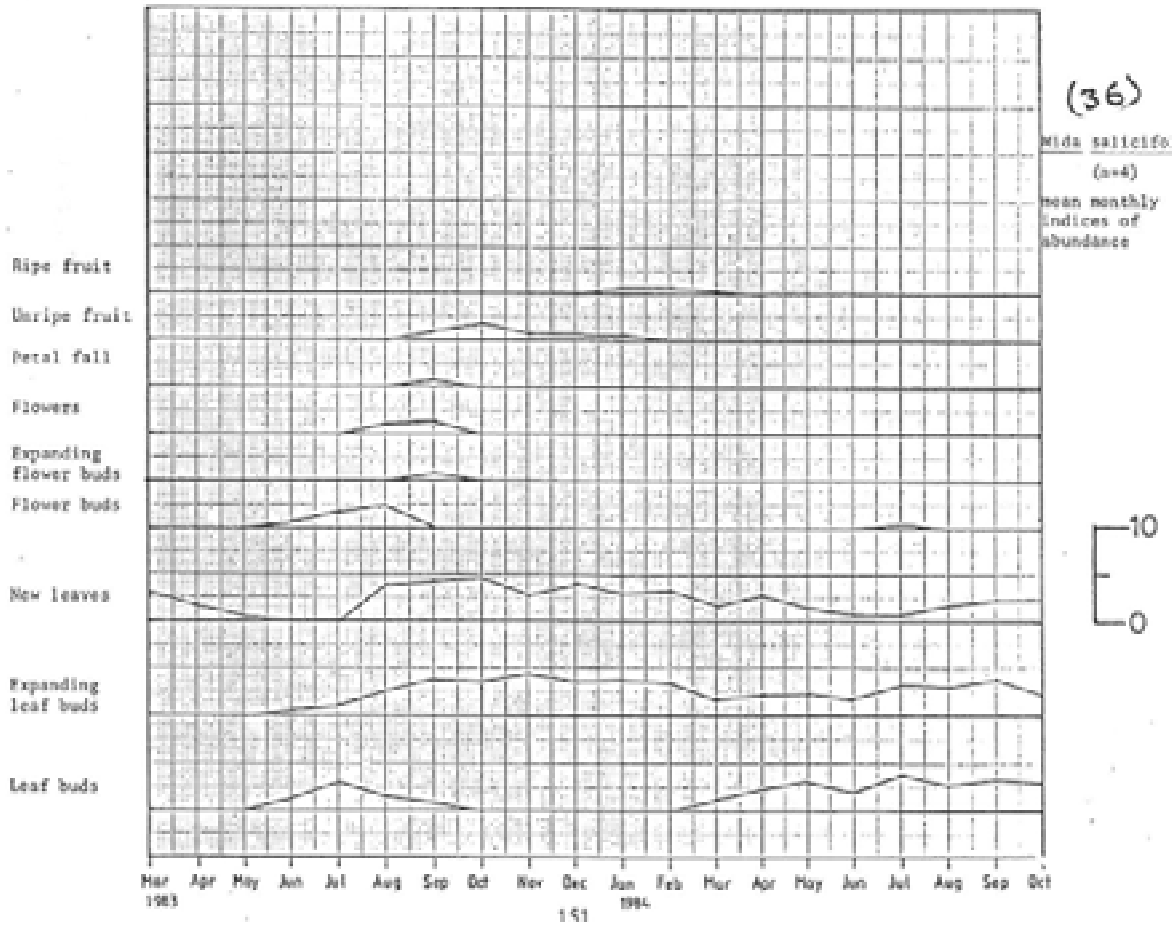


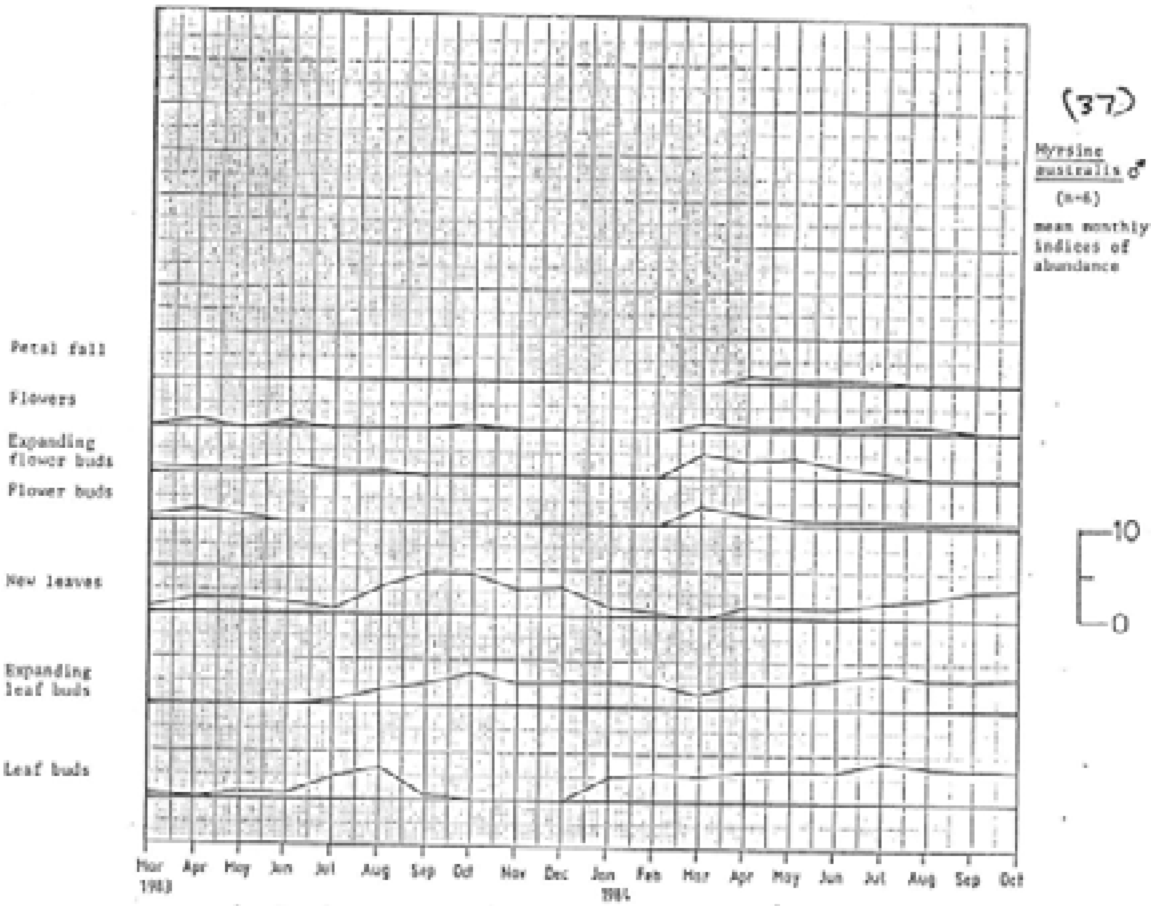
(36)

Wida salicifolia

(n=4)

mean monthly indices of abundance



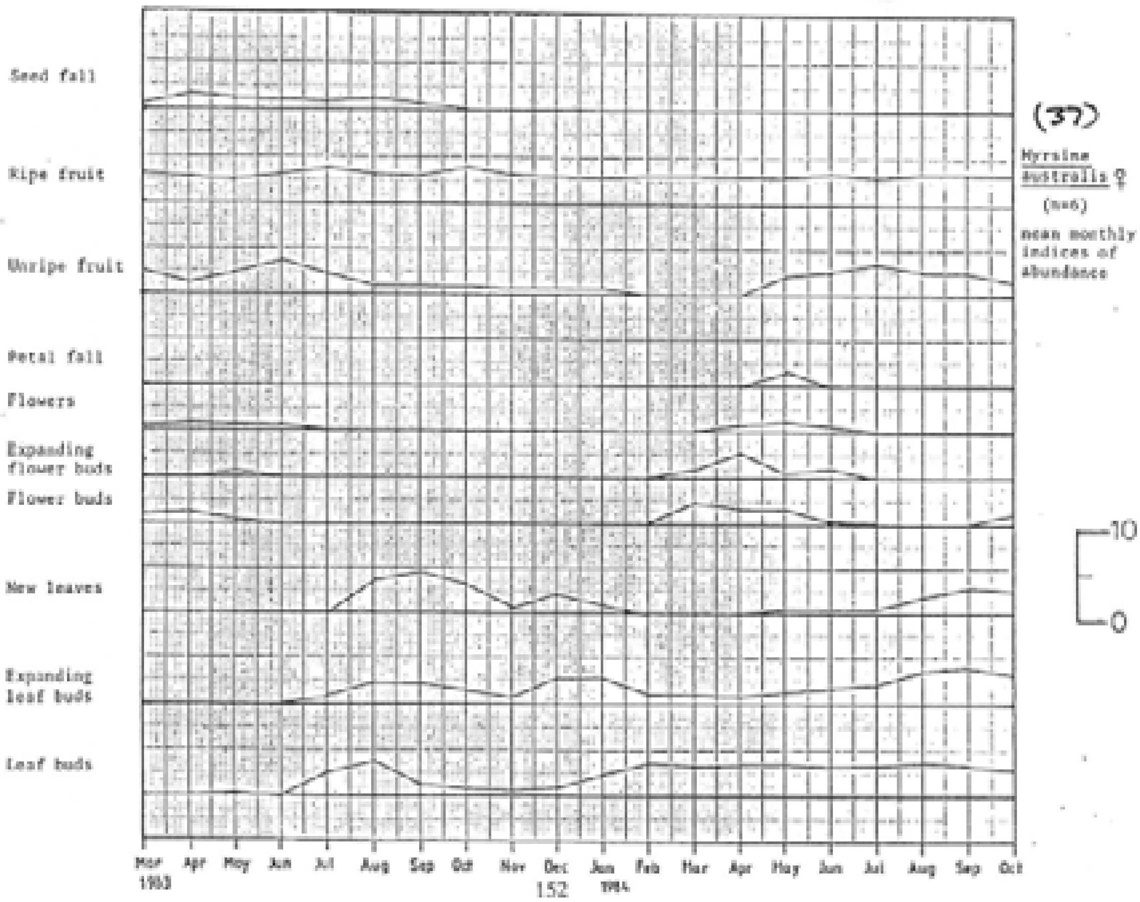


(37)

Myrsine australis ♂

(n=6)

mean monthly indices of abundance



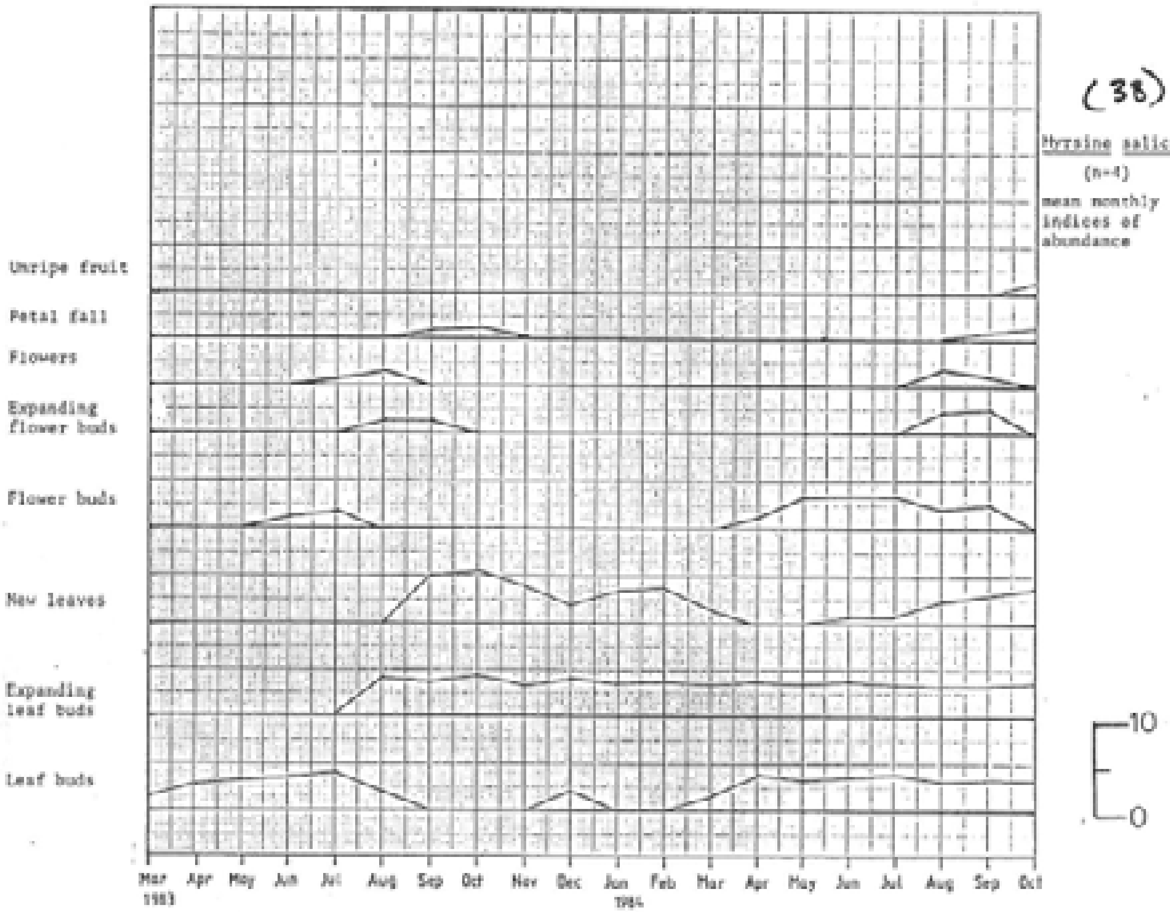
(37)

Myrsine australis ♀

(n=6)

mean monthly indices of abundance

(38)

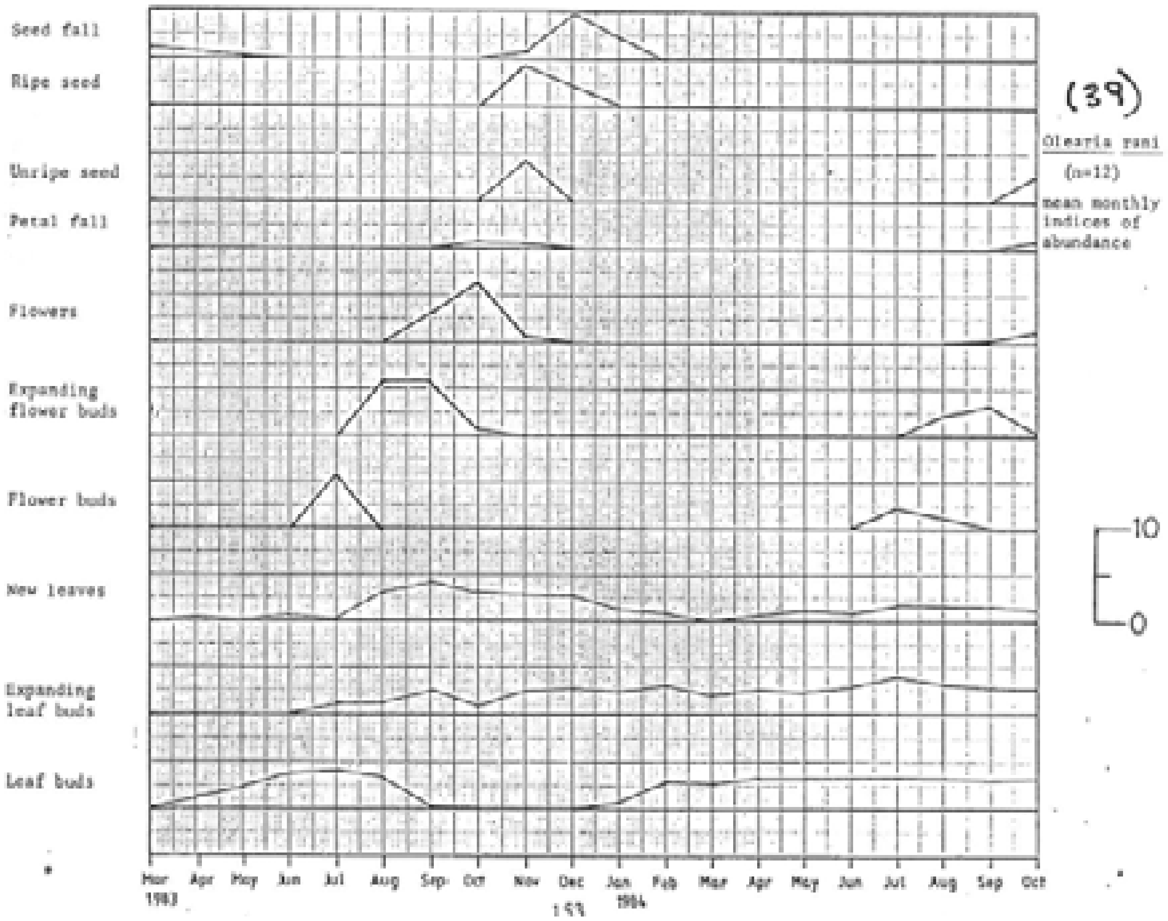


Myrsine salicina

(n=4)

mean monthly indices of abundance

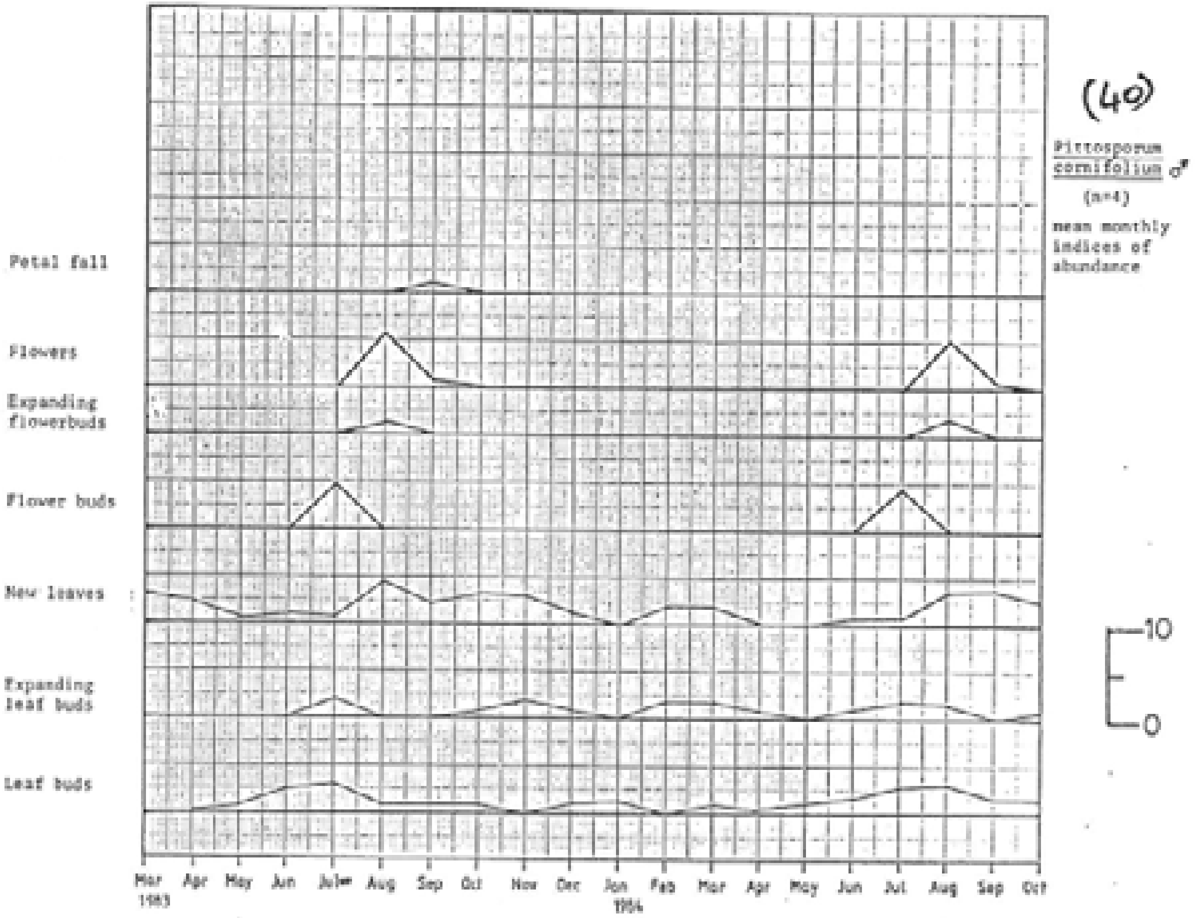
(39)



Olearia rani

(n=12)

mean monthly indices of abundance

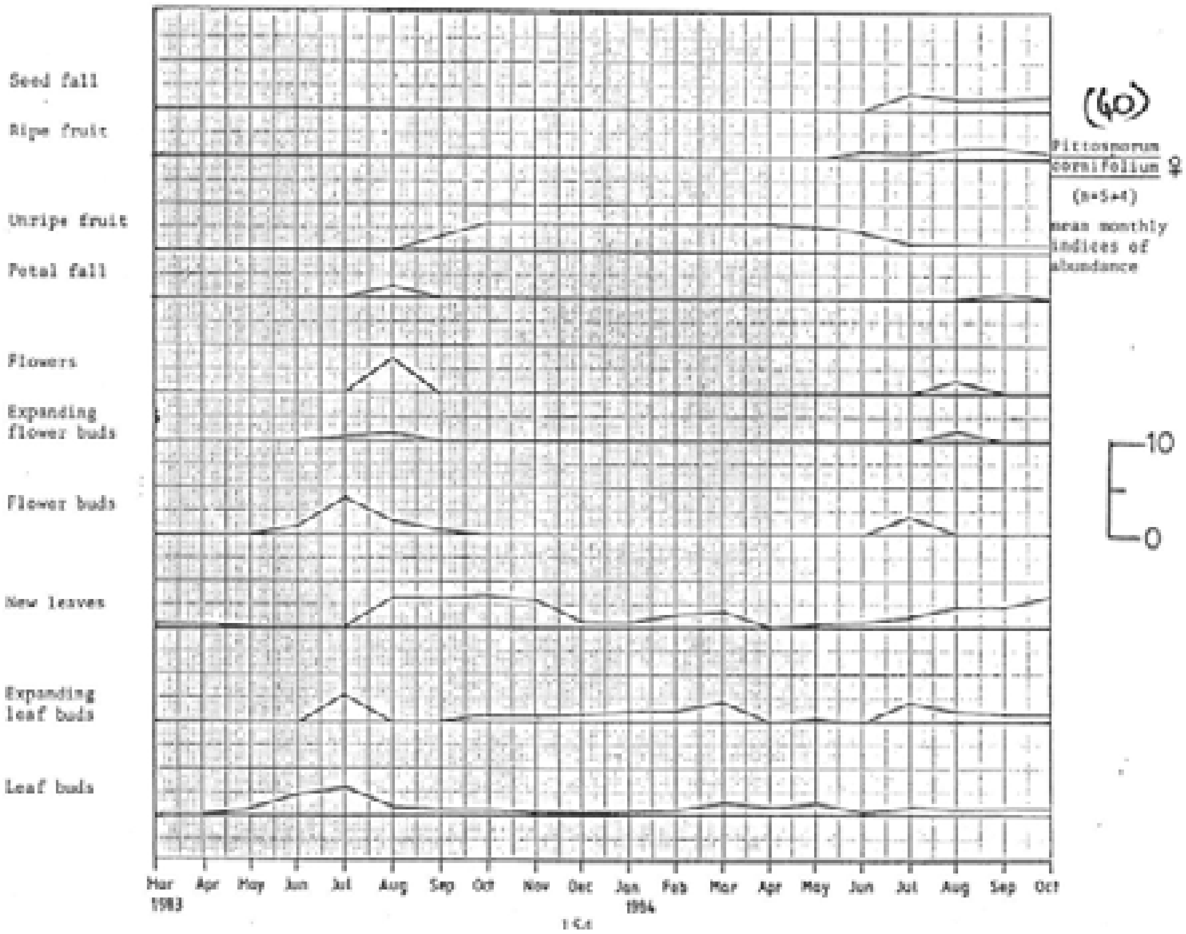


(40)

Pittosporum cornifolium ♂

(n=4)

mean monthly indices of abundance

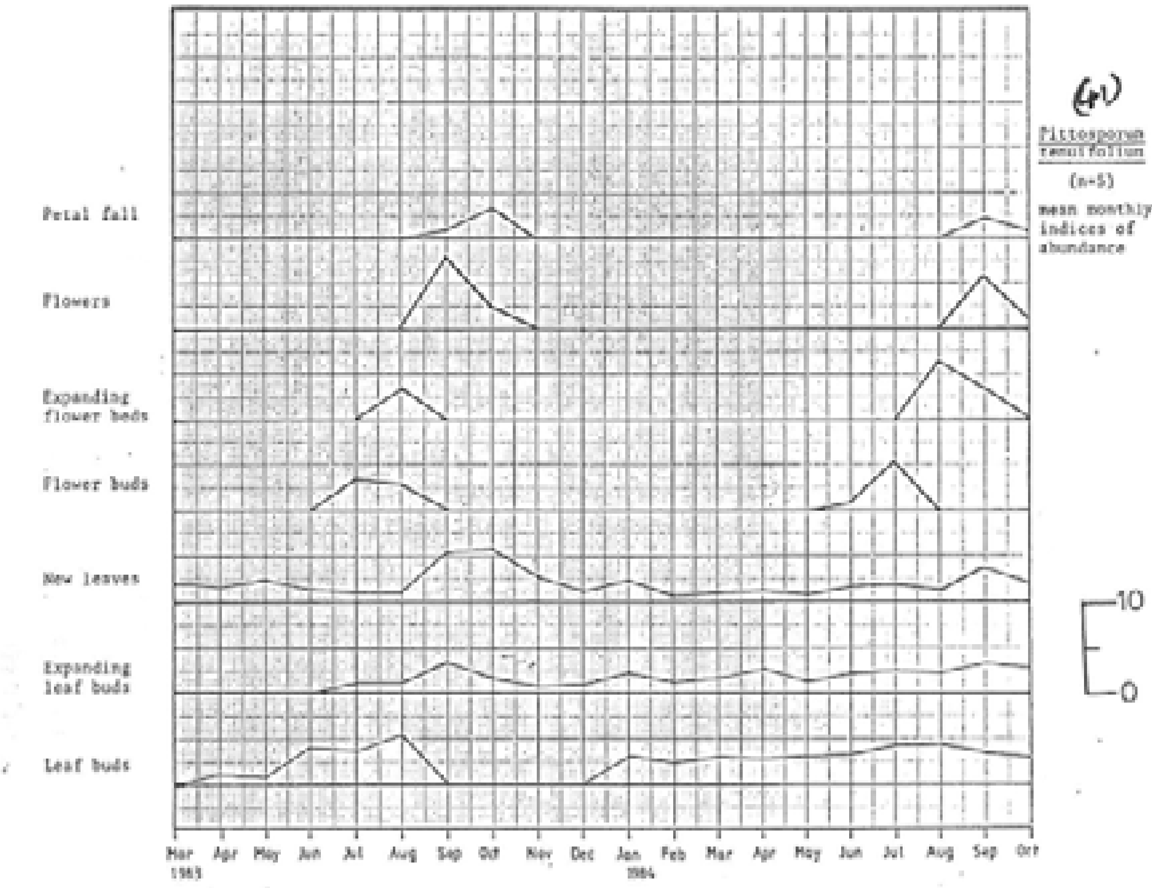


(40)

Pittosporum cornifolium ♀

(n=5+4)

mean monthly indices of abundance

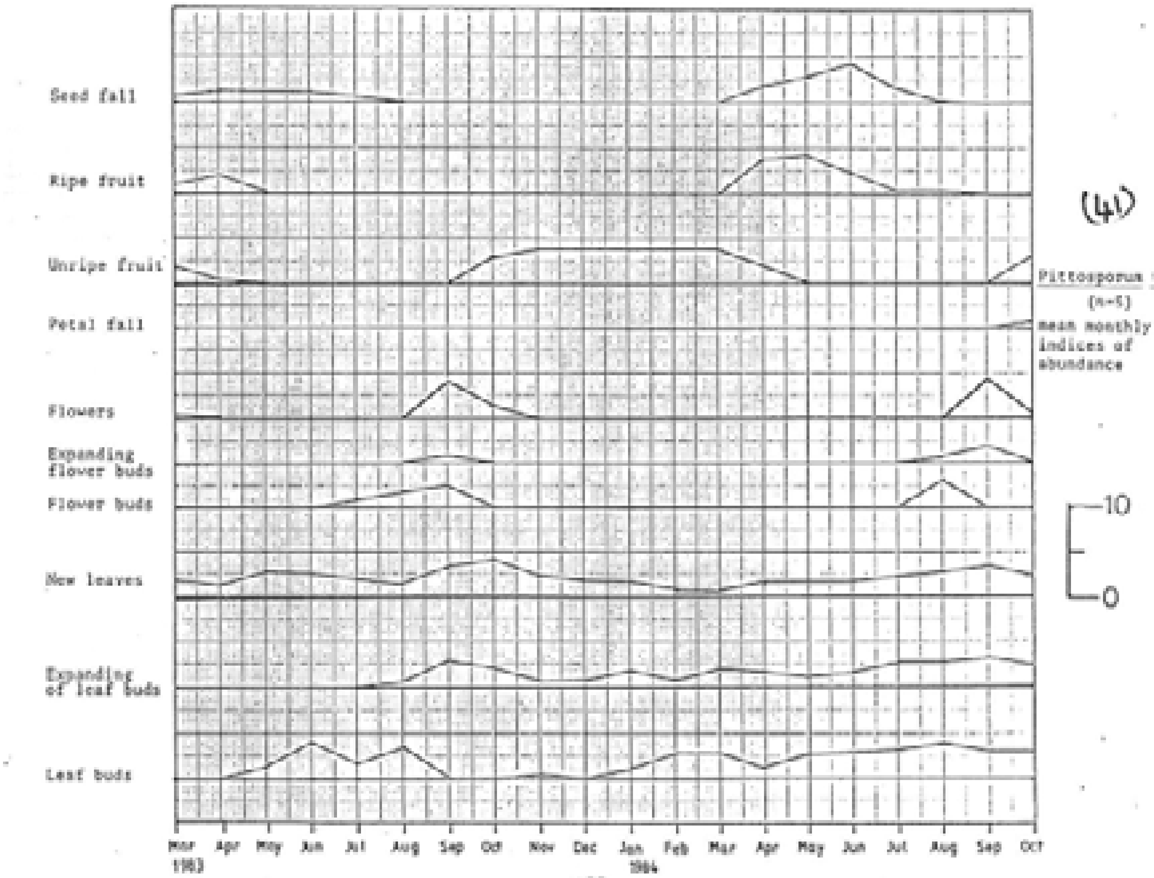


(41)

Pittosporum tenuifolium ♂

(n=5)

mean monthly indices of abundance

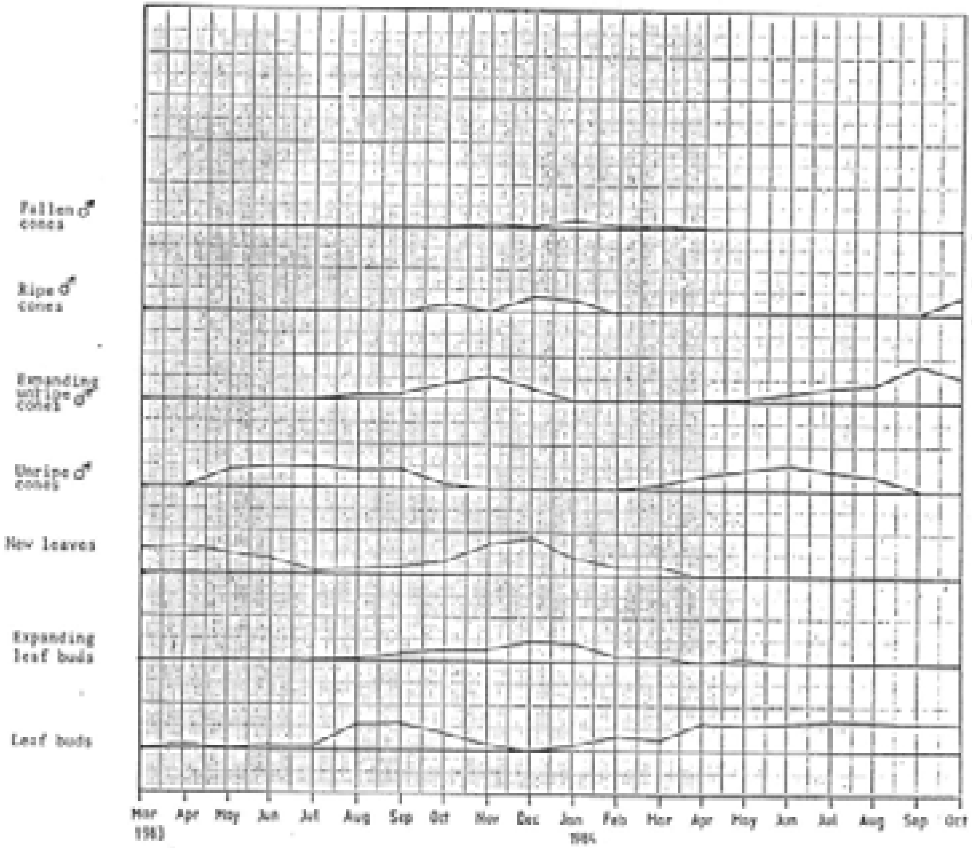


(41)

Pittosporum tenuifolium

(n=5)

mean monthly indices of abundance

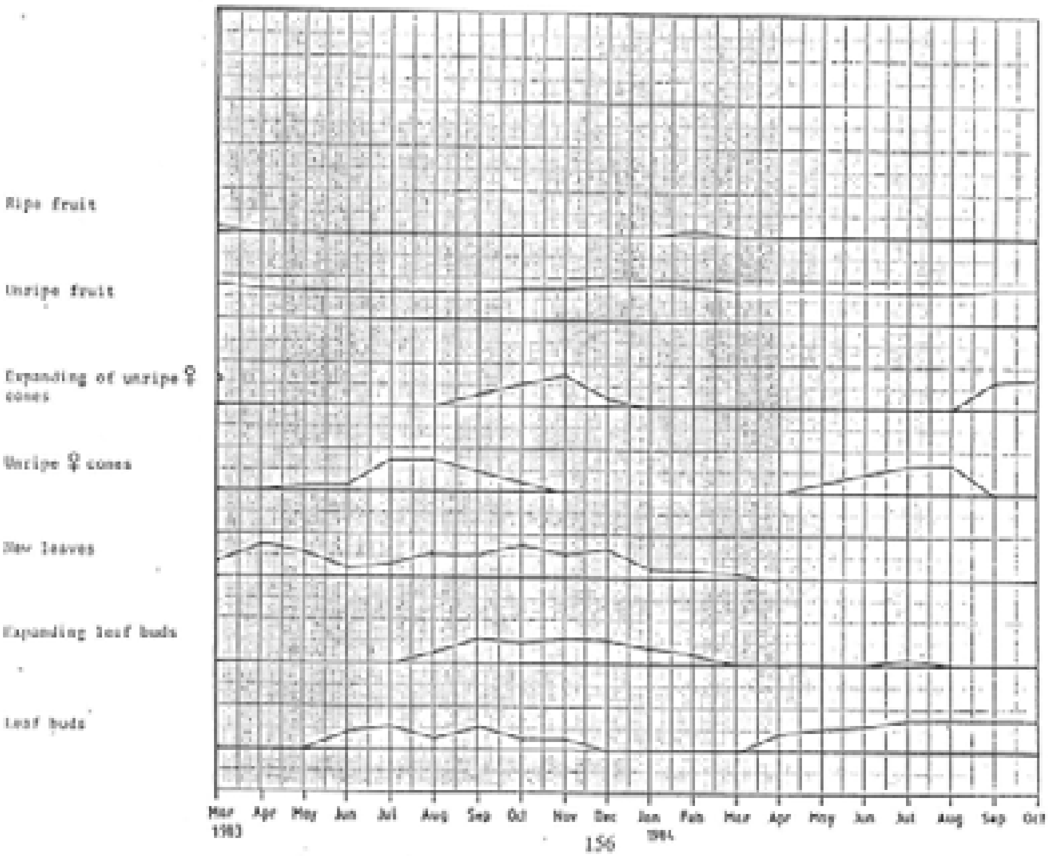


(42)

Podocarpus halli ♂

(n=7)

mean monthly indices of abundance



(42)

Podocarpus hal

(n=3)

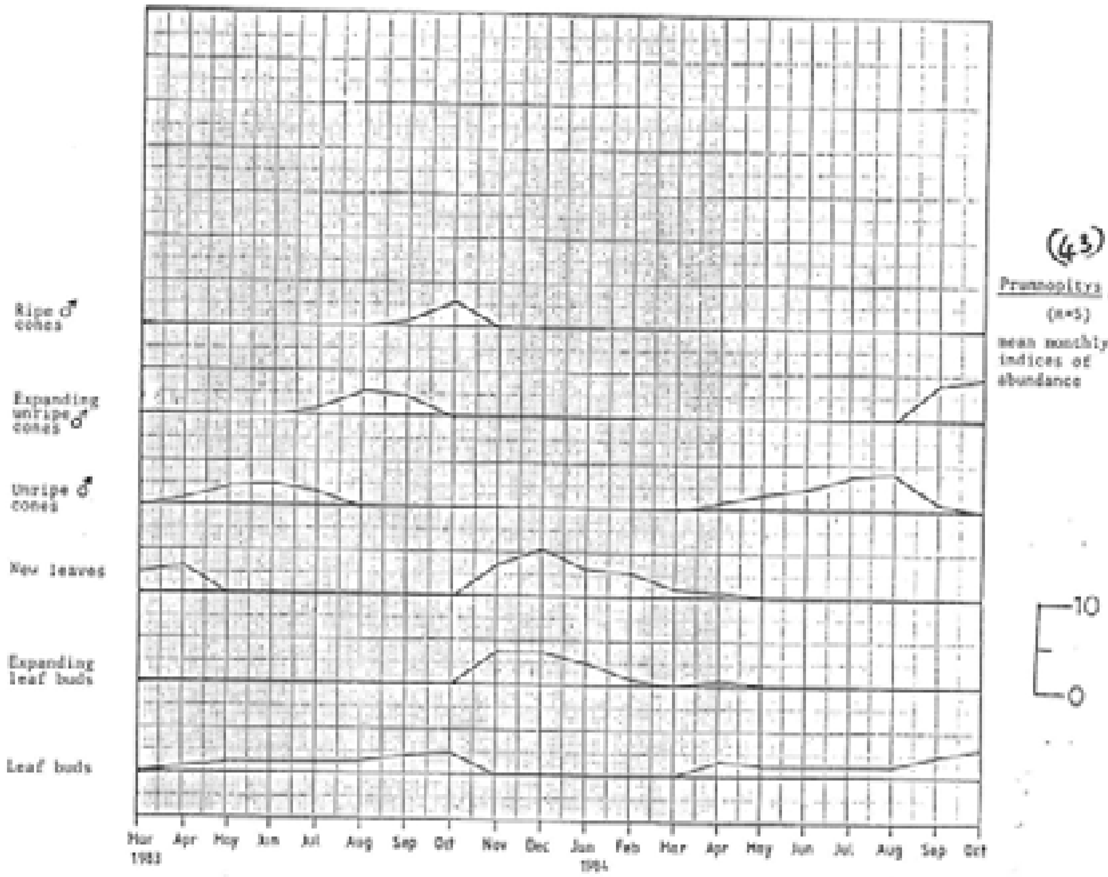
mean monthly [illegible]
of abundance

(43)

Prumnopitys ferruginea

(n=5)

mean monthly indices of abundance

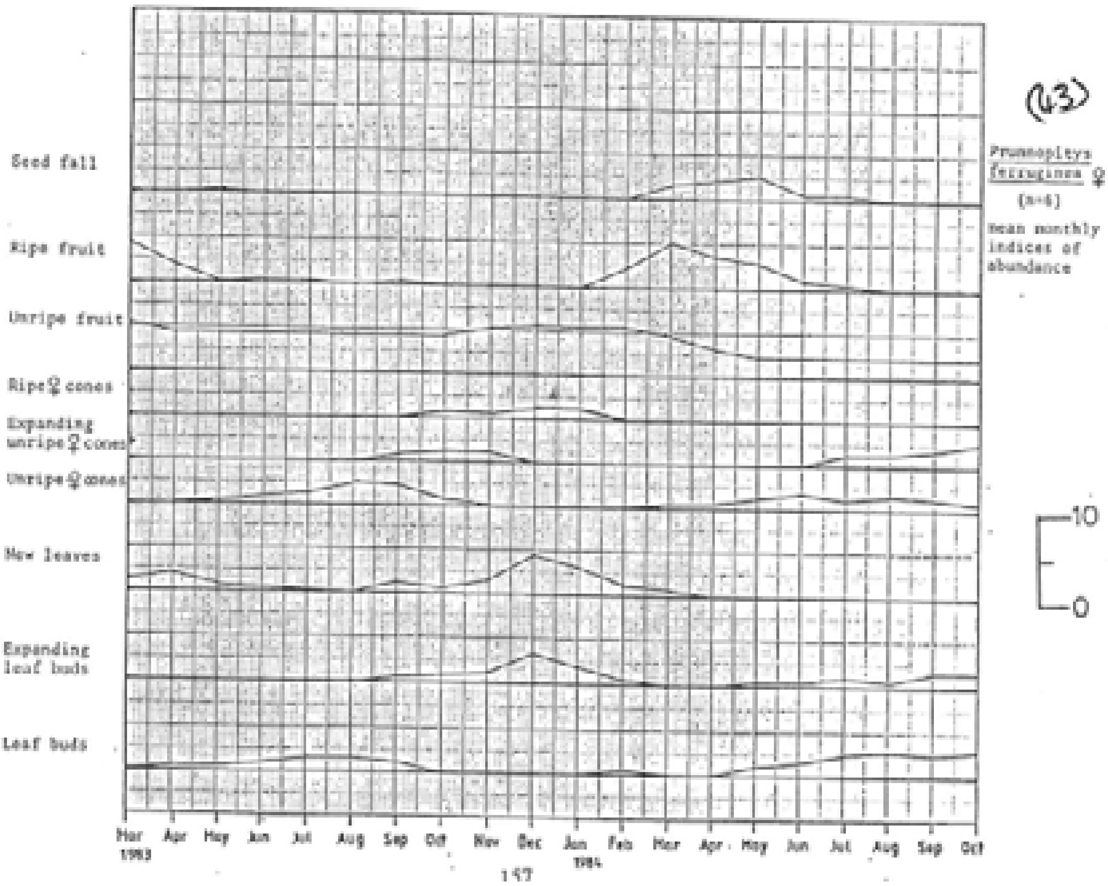


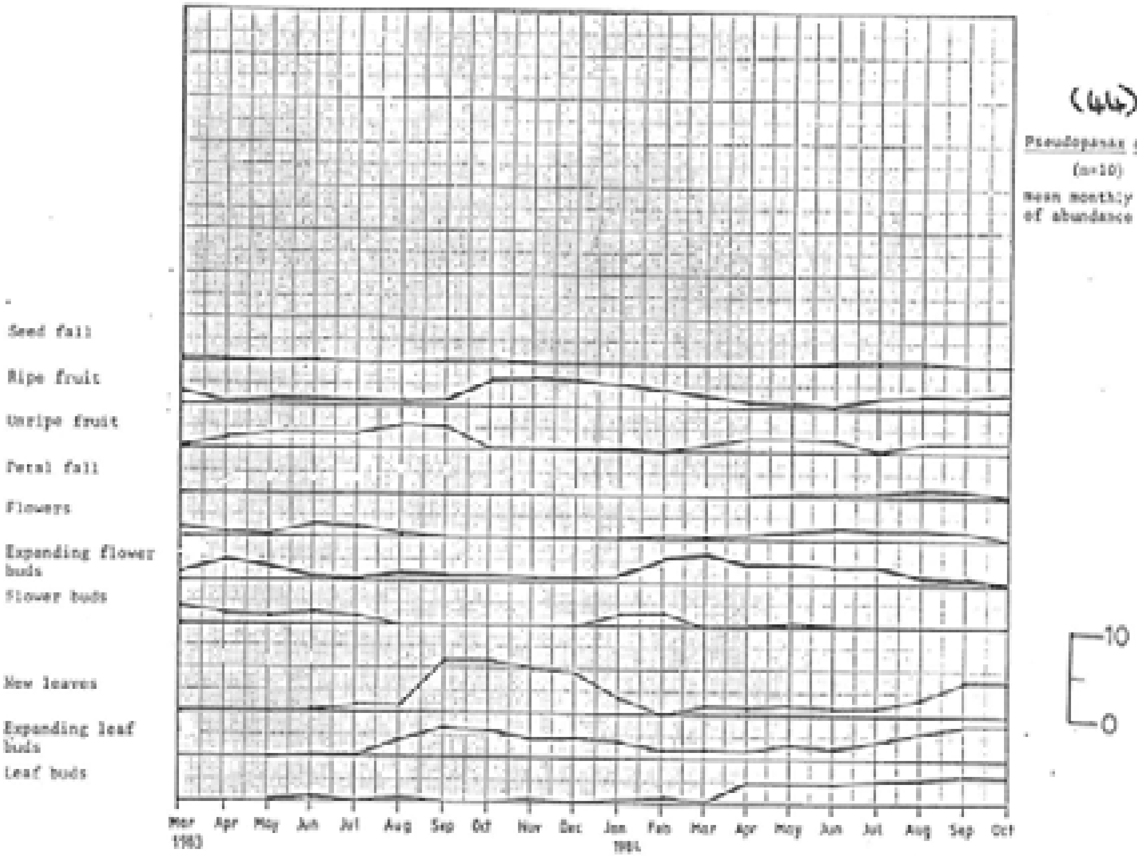
(43)

Prumnopitys ferruginea ♀

(n=6)

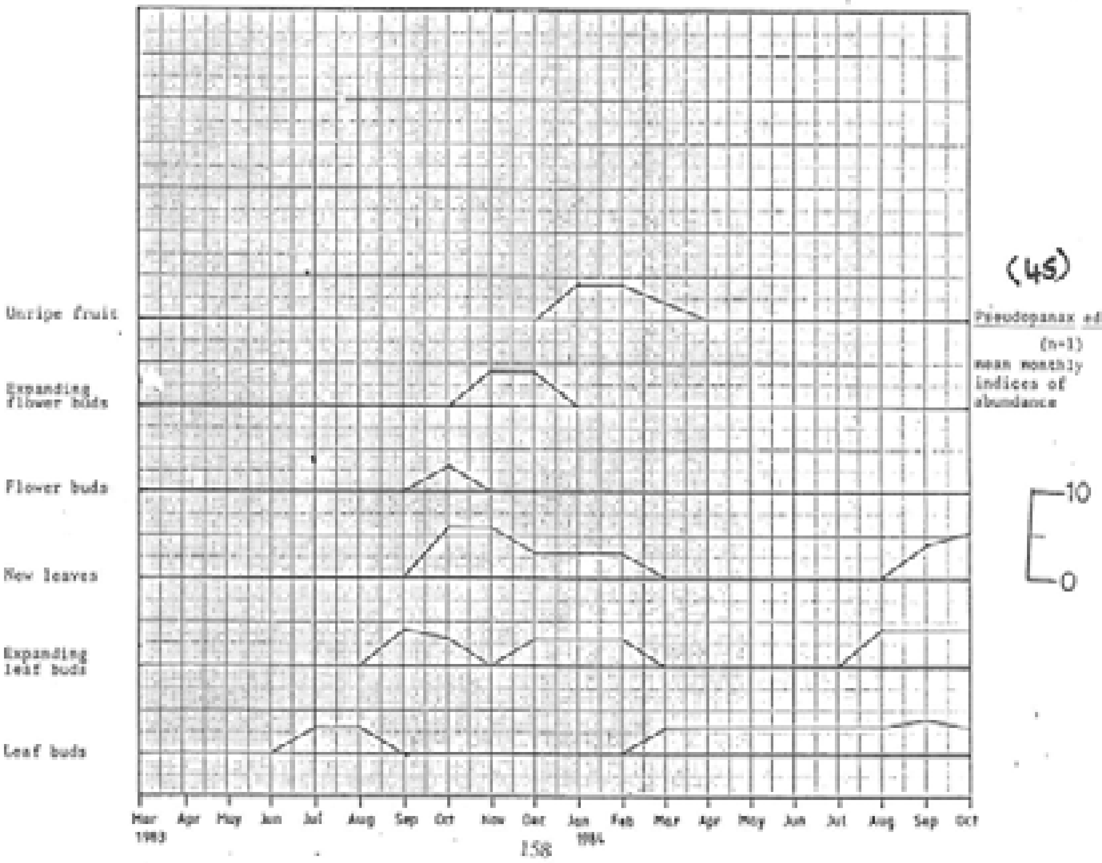
mean monthly indices of abundance





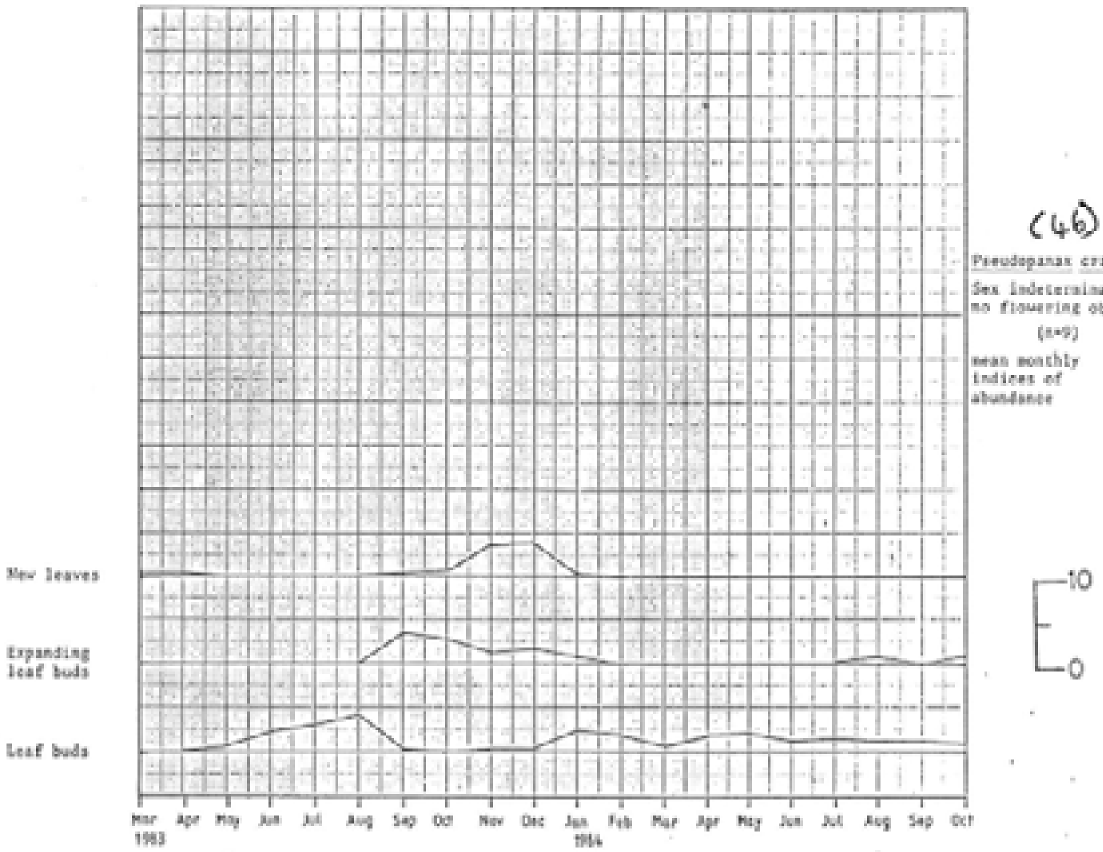
(44)

Pseudopanax arboreu
(n=10)
mean monthly indices of abundance



(45)

Pseudopanax edgerle
(n=3)
mean monthly indices of abundance



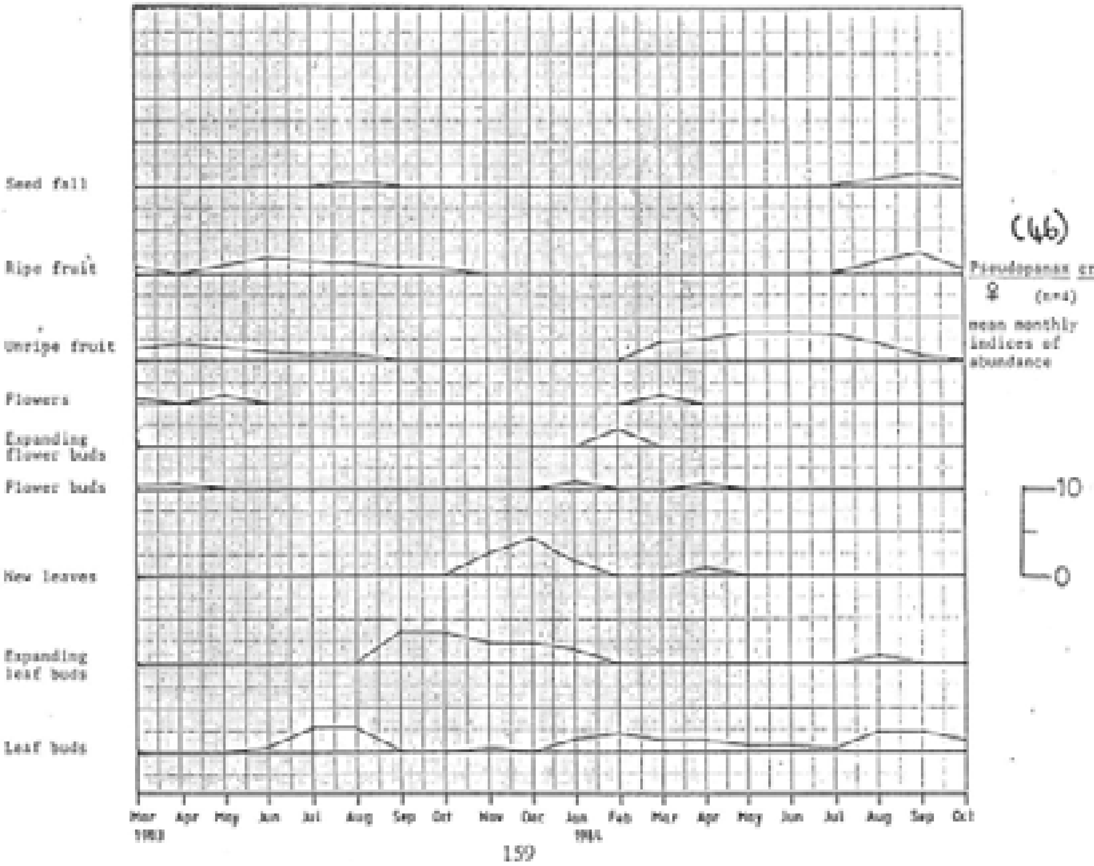
(46)

Pseudopanax crassifolius

Sex indeterminate - no flowering observed

(n=9)

mean monthly indices of abundance

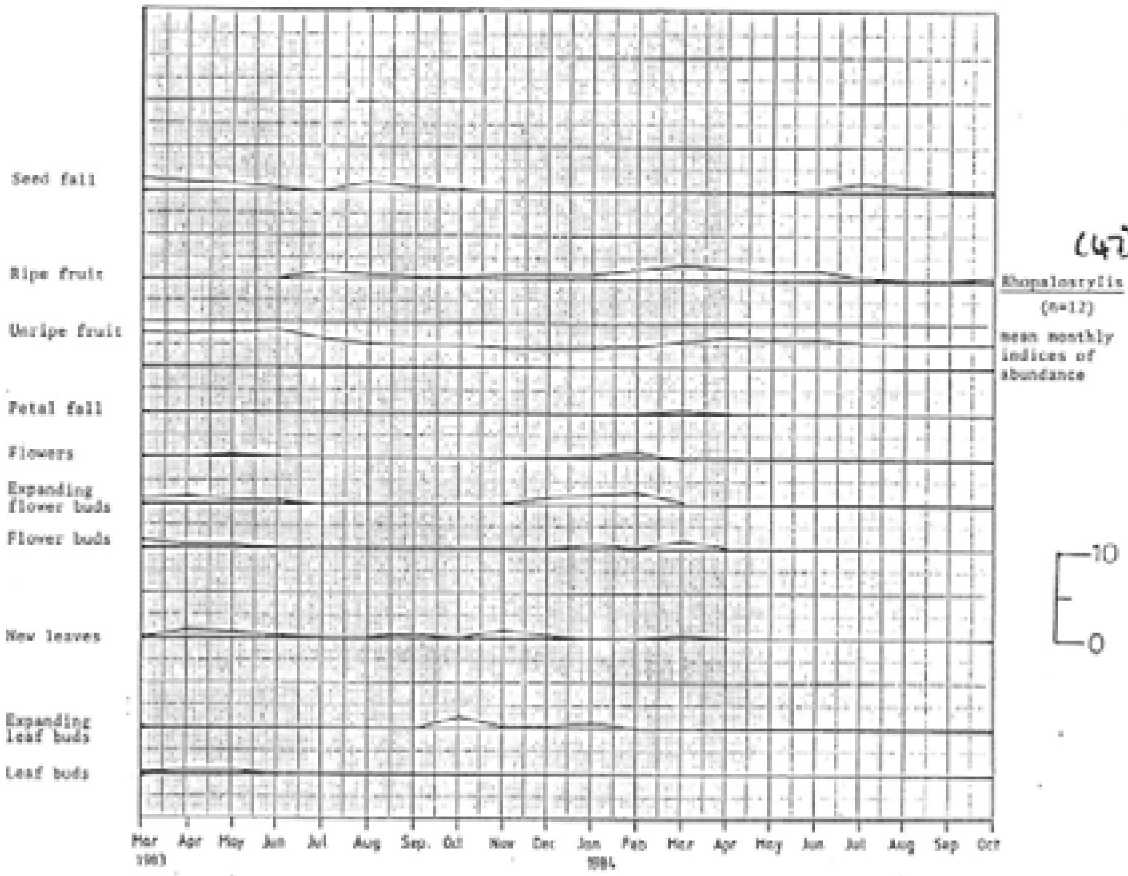


(46)

Pseudopanax crassifolius

♀ (n=4)

mean monthly indices of abundance

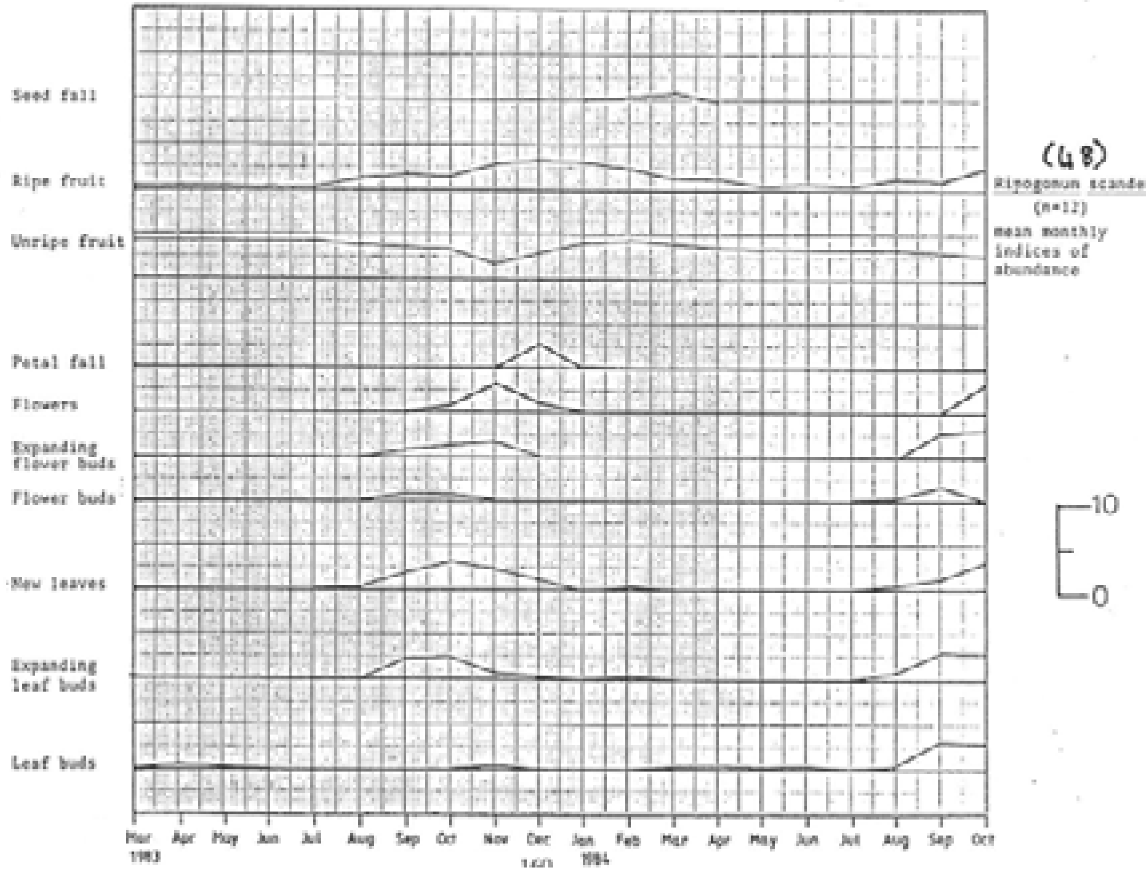


(47)

Rhopalostylis sapida

(n=12)

mean monthly indices of abundance

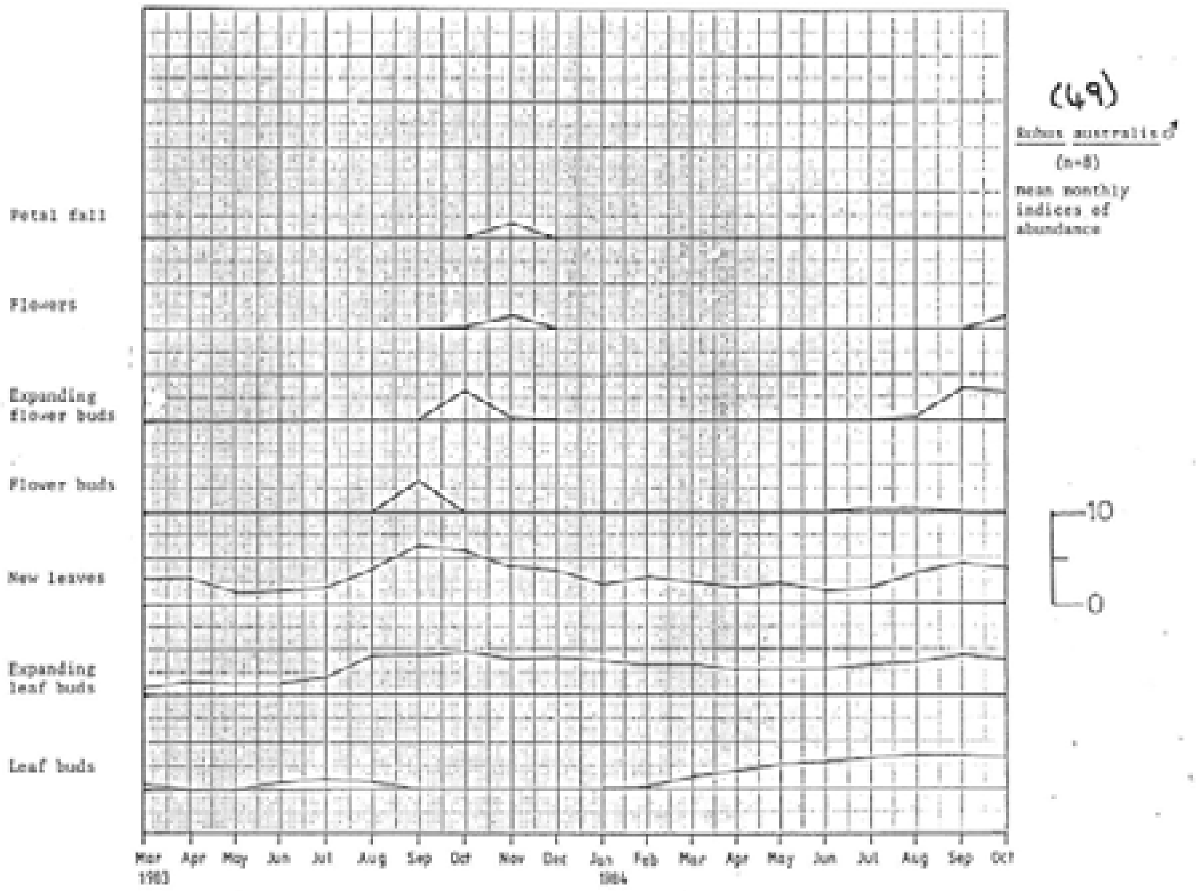


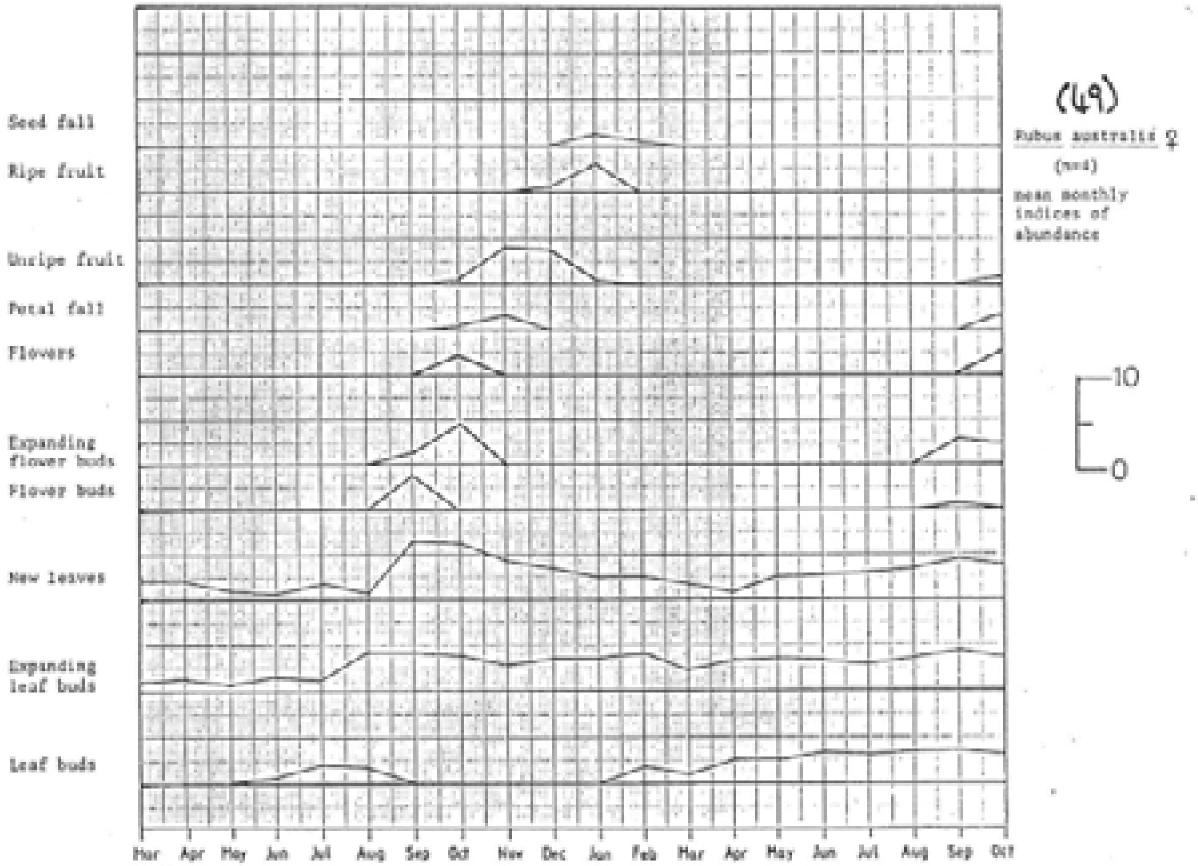
(48)

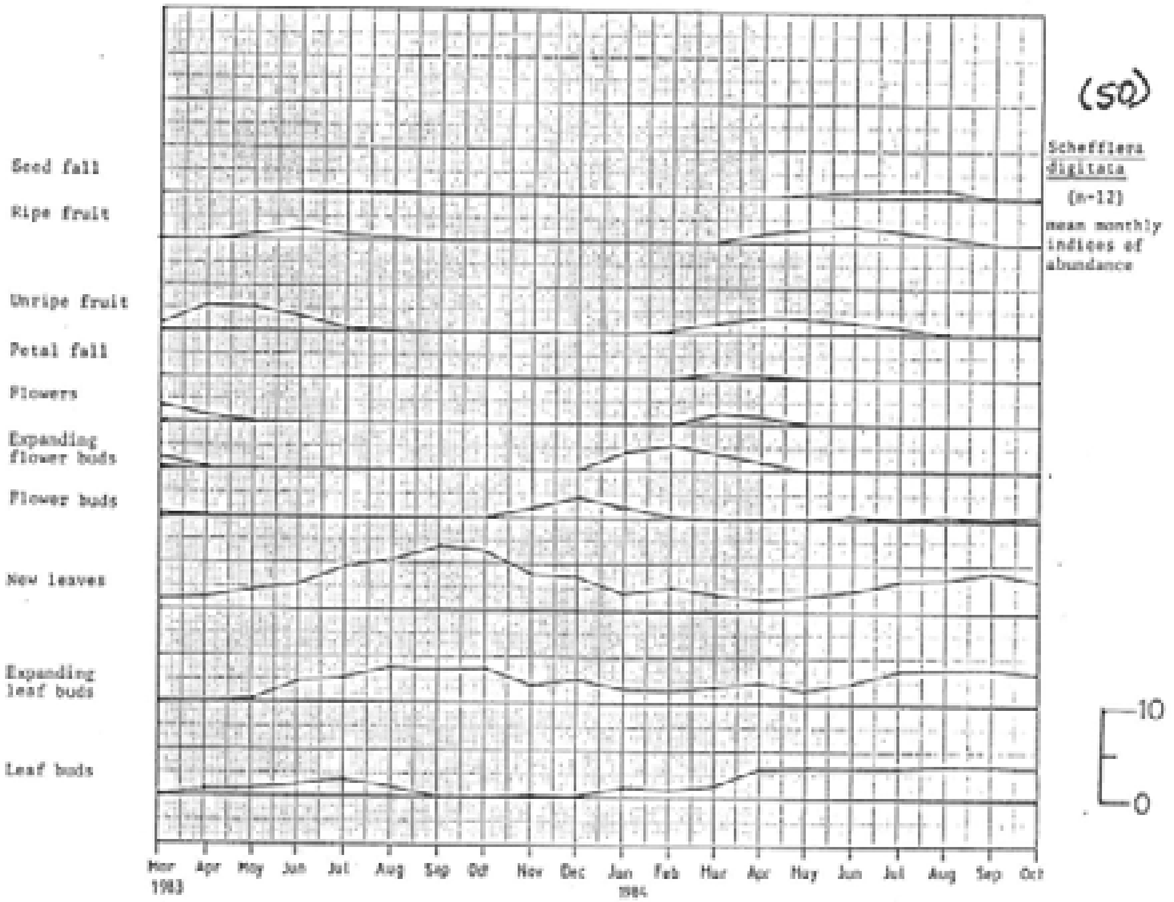
Ripogonum scandens

(n=12)

mean monthly indices of abundance


(49)
Rubus australis ♂
(n=8)
mean monthly indices of abundance
Petal fall
Flowers
Expanding flower buds
Flower buds
New leaves
Expanding leaf buds
Leaf buds
10
0
Mar 1983
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 1984
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct


(49)
Rubus australis ♀
(n=4)
mean monthly indices of abundance
Seed fall
Ripe fruit
Unripe fruit
Petal fall
Flowers
Expanding flower buds
Flower buds
New leaves
Expanding leaf buds
Leaf buds
10
0
Mar 1983
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 1984
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct

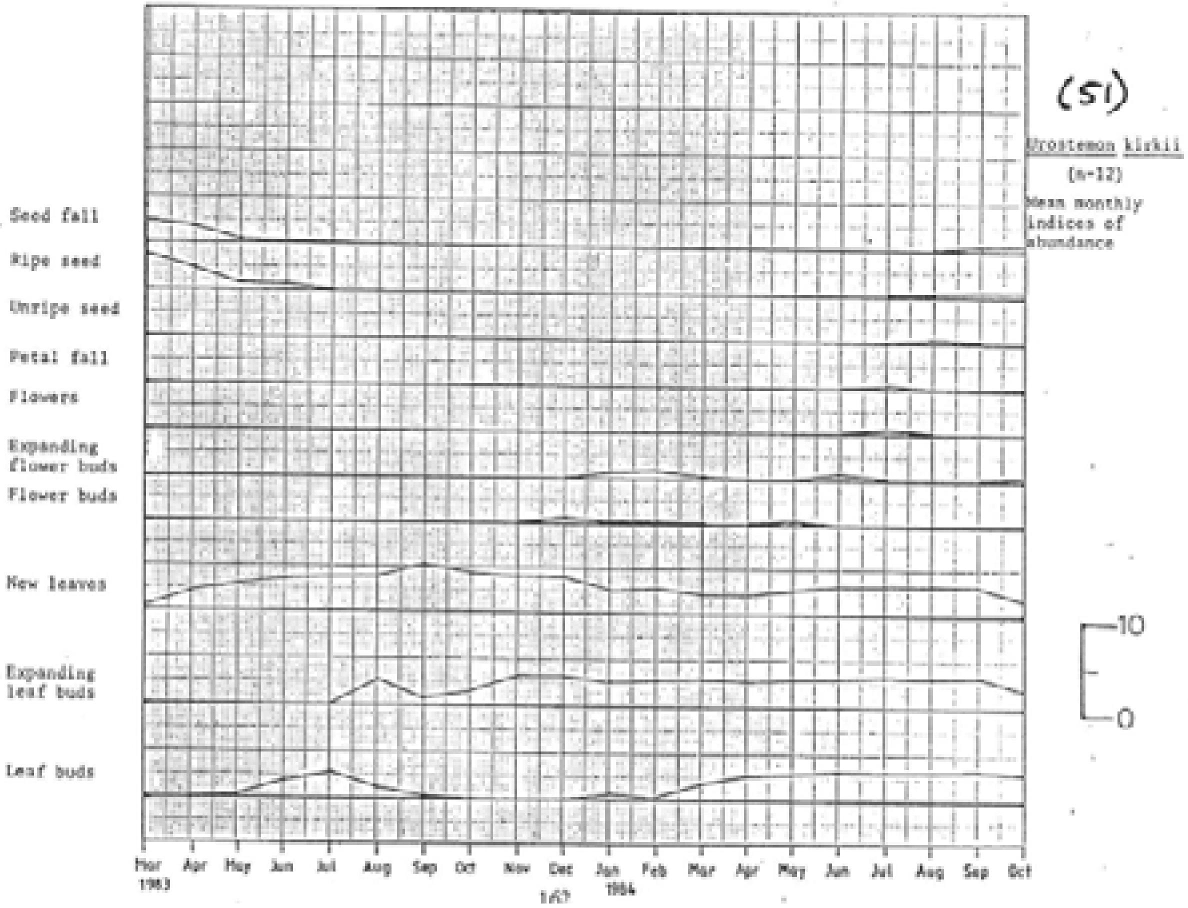


(50)

Schefflera digitata

(n=12)

mean monthly indices of abundance

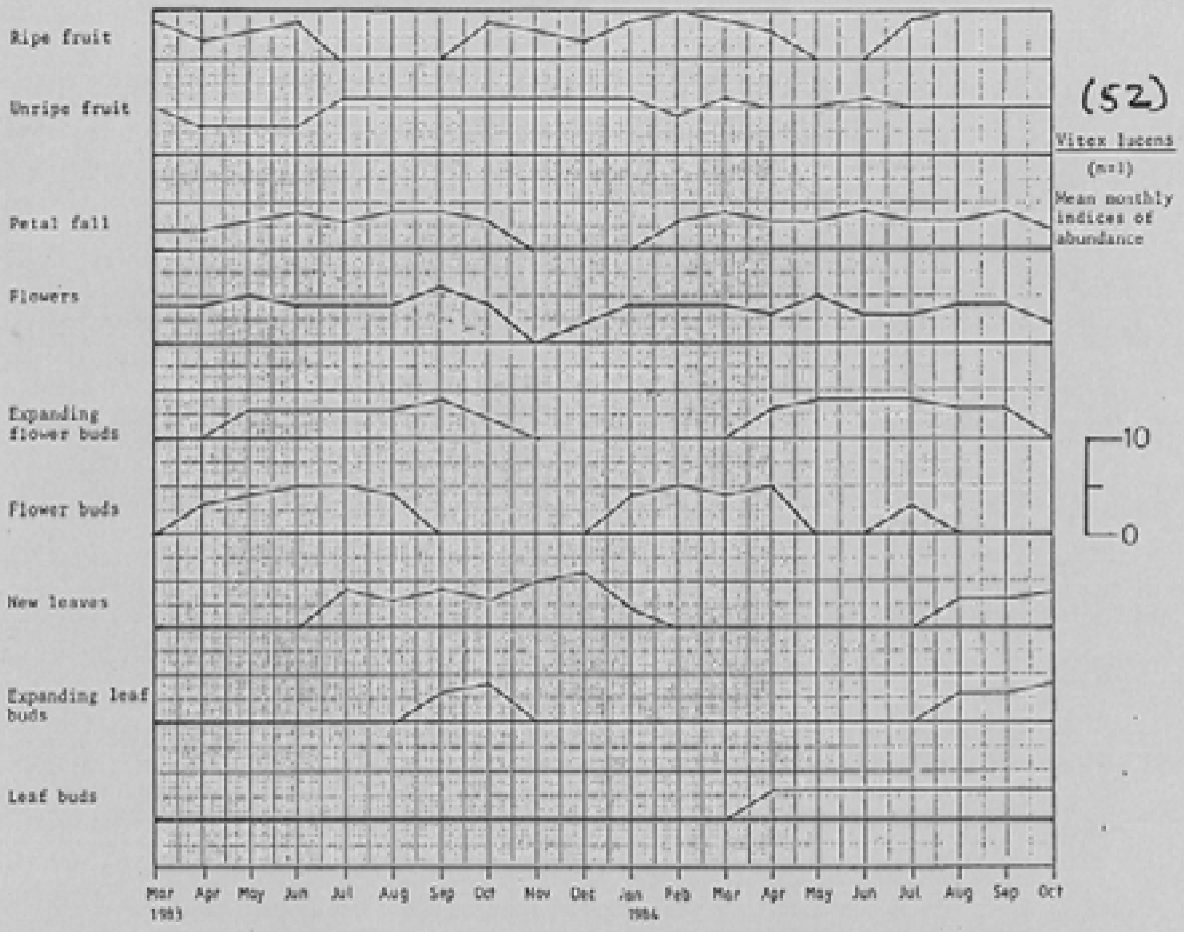


(51)

Urostemon kirkii

(n=12)

mean monthly indices of abundance

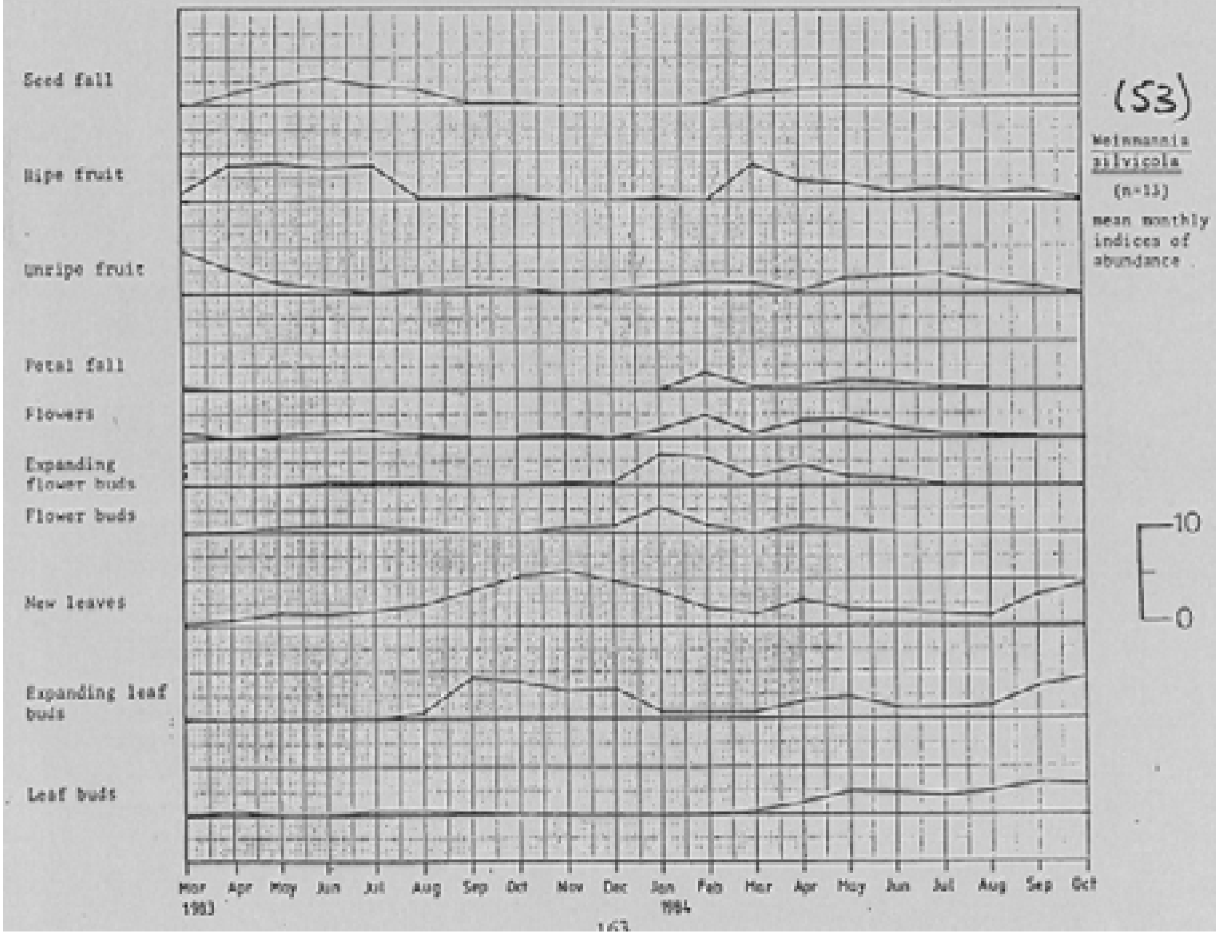


(52)

Vitex lucens

(n=1)

Mean monthly indices of abundance



(53)

Weinmannia silvicola

(n=13)

mean monthly indices of abundance

SECTION FOUR: THE ECOLOGY OF KOKAKO

SUMMARY

a) A study was carried out on the diet, time energy budgets and features of the habitat used by kokako in Puketi Forest, Northland, from December 1982 to September 1984. The work was centred on five study home ranges which were chosen for their geographical location (occupying different parts of the main watershed of the Forest) and the range of vegetation assemblages they contained.

b) More than 85 species of food were taken by kokako during this study. The diet of kokako (in terms of species, parts of species consumed, and species class) altered with season. There were also large differences in the composition of the diet between home ranges, even in the same season. high degree of variability was related to changes in food supply, and the individual nature of the vegetation structure and composition of each home range.

c) Overall, shrub hardwoods were the principle providers of food for kokako. Podocarps, epiphytes and lianes were the next most frequently eaten foods, depending on the season. Foods from tree hardwoods (the main canopy forming species over much of Puketi Forest) were taken to a lesser degree. However, the importance of tree hardwoods as a supplier of kokako foods was elevated greatly when records for epiphyte, liane and invertebrate species were assigned to their respective hosts. Under this regime, tree hardwoods vied with shrub hardwoods as the dominant food supplying class of vegetation.

d) Seventy percent of the epiphyte foods taken by kokako came from tree hardwoods (30% being from kohekohe and 19% from taraire), and 19% from podocarps (11% from Hall's totara, and 5% from miro). These figures reflected the general abundance of canopy species in Puketi Forest. Shrub hardwoods (6% use) and the remaining epiphyte host species (5% use) were utilised only to a minor degree.

e) The principle liane and invertebrate host food species used by kokako were similar to that for epiphytes. Most liane and invertebrate foods were obtained from tree hardwoods (59% and 79% respectively), especially kohekohe (20%), towai (15%) and taraire (11%) for lianes; and towai (38%), taraire (21%) and tawa (16%) for invertebrates.

f) Feeding on kauri was negligible throughout the study (0.1% use on its own, 0.4% use with its attendant species).

g) The activity patterns of kokako varied seasonally and diurnally. These activities revolved principally around feeding, home range maintenance (= singing) and roosting-preening. Feeding activity per hour was greatest during the colder months of the year (39-48% of all activities in June-September) when the food supply was limited, and was least during summer (17% and 21% of all activities in the two seasons sampled) when the range of foods available was much greater. Singing was prominent in spring, summer and early autumn (prior to and during breeding), especially in late October-early December. Roosting and preening activities were greatest in summer-early autumn (during the moult).

Generally, singing took place most often in the first and last two or three hours of daylight, whilst feeding and the remaining activities occurred mostly during the intervening daytime period. Diurnal activity patterns were highly variable, however.

h) The type of perch used by kokako depended on the activity being undertaken. Feeding occurred mainly beneath the canopy amongst twigs and outer branches as this was where most food was located. Singing took place. almost exclusively from outer branches as these provided elevated, unobstructed perches to sing and listen from - hence also the favouring of emergent trees. Calling and moving activities were mainly accessory to feeding and singing and thus took place on similar perches and tiers (emergent and canopy) to the latter activities. Roosting and preening birds chose mid-branches and inner branches on canopy trees (in preference to emergents) probably as these sites gave a greater degree of shelter from harriers patrolling above the canopy.

i) Kokako sang mostly from kauri, podocarps and tree hardwoods probably as these classes pmvided the tallest trees in the forest. The trees used most for song posts were those which rose above the general canopy level (especially if situated on top of prominent landforms) and were not too densely foliaged as this interfered with sound transmission. Use of individual trees was related to the abundance of tall trees in each home range. However, kauri and northern rata were used particularly when present, as both grew typically to large proportions, had massive crowns that towered above the general canopy level, and had long spindly branches that were relatively free of foliage.

j) Use of various vegetation classes by kokako in each home range for calling, moving and roosting-preening was related to the overall abundance of species. Tree hardwoods and were used most often as they were the main components of the canopy. Likewise, use of individual canopy tree species in each home range was related to their abundance within the areas frequented most often by the birds.

k) Kokako particular height zones of the forest for each activity. Most singing took place from the uppermost tiers of vegetation, usually well above the canopy level. In comparison, feeding, moving, calling, roosting-preening and incidental activities were distributed closely about the canopy profile (bird heights being typically 2-4m lower than canopy height).

l) Height profiles of feeding birds changed with season in relation to the vegetation class and varied considerably between home ranges. Median feeding heights were lowest when most of the diet comprised products from lianes and shrub hardwoods (typically in summer), and highest when feeding on puka fruit in the tops of emergents (typically in winter). Feeding on the ground occurred mainly in winter-early spring (up to 4.8% of all feeding observations in Summit home range in Winter 1983) and was probably related to birds having to prospect more for food then than in other seasons.

m) Kokako occupied discrete home ranges throughout the year, but different parts were used with season. In some seasons, relatively compact portions of their home range were used (generally in summer and autumn for the home ranges studied). At other times (e.g. late winter-early spring) birds were active over most of their home range.

n) In each home range, the area frequented most during a season was generally similar for all activities (except perhaps for singing) and was related to the distribution of food resources at that time. For all of the home ranges studied, the amount of feeding in an individual area was likely to depend not only on the foods it contained, but also on the availability of food in adjacent areas. Small, individual areas were likely to be under-utilised in relation to their food availability if they were some distance from a larger area that had a comprehensive range of foods.

o) Although singing was sometimes centred in different parts of the home range to those used for all other activities, it tended to take place nearby. In most instances, birds used the closest prominent trees available to them; they did not move habitually to a specific tree if it were some distance from the area they were occupying at the time.

Note: Figures and large tables follow text starting page 181.

4.1 INTRODUCTION

The following aspects of kokako ecology were studied in Puketi Forest:

1) Diet.
2) Daily and seasonal activity patterns.
3) Use of components of the habitat.
4) Home range use.

4.2 METHODS

Initially, suitable home ranges were found by listening from logging roads for birds singing at dawn and dusk, in areas where Anderson's 1979 survey had shown them to be present. When kokako song was heard within of the road, the observer went to the place where birds were singing and tried to follow them for as long as possible. Additionally, song and/or call tapes were played in areas where kokako had been noted previously (e.g. Anderson 1979) in the hope of attracting buds. The most productive periods for this were during spring to autumn, especially 1-3 hours after dawn, and similarly before dusk, on fine days with little wind. Sometimes, however, birds sang spontaneously at any time of the day, especially during changes in weather at the beginning of, or after a shower of rain). The response of kokako to taped song or calls was highly variable, ranging from little or none nearly all of the time, to highly responsive on most occasions. Sometimes, it took several attempts to locate a suitable home range. Occasionally, the presence of birds that were not otherwise responsive was discerned by just sitting still, or moving about quietly, for an hour or two.

None of the kokako in the study were banded, but individuals could be recognised by characteristic markings, features of their song, or the solo status of some throughout the study. One individual (the resident of Pet home range) was remarkably tame and particularly responsive to song tapes, hand claps, or the sound of an approaching vehicle. Observation of these particular birds showed that kokako stayed in the same general area during the year. Initial mapping of home ranges was carried out by following individuals for periods of several hours.

Fifteen home ranges were visited in the first year of the study, but from March 1984 observations were confined largely to five home ranges that had been gridded into 40 x 40 m grid squares (Ben, Hill, Pet, Pukatea, Summit). These home ranges were chosen on the basis of ease of access and observation, and the vegetation assemblages they contained. Essential vegetation characteristics included the presence or absence of kauri, and whether logging had occurred in or immediately adjacent to a home range. A sixth home range (Waikape) was partly gridded, but the work was not completed because of continual difficulties in finding the buds.

With experience, the main study kokako became relatively easy to find. Birds were found by going to the middle of their home range, or to one of their favoured areas, and listening and looking for sign of them. Invariably a soft call, a movement, or the patter of food falling from the canopy revealed their whereabouts. If the kokako were not found after 5-10 minutes, taped calls were played judiciously (usually a solitary 'mew' call [Hughes 1981] at soft to moderate volume) or whistled imitations of close-range contact calls were given. Sometimes, an answering call from the bird was not heard until a minute or two later. If there was no response, the procedure was repeated two or three times over 10-15 minutes. If there was still no reply, another attempt was made elsewhere - usually 75m or so away along a main ridge. By using this low-key approach, birds were found generally within 10-20 minutes, without modifying their behaviour, or attracting them from the place they were using at the time.

At times, birds could not be found readily at all. This was often the case in Ben home range subsequent to Autumn 1983, when it could take more than an hour to locate the resident pair. Even then they were not easy to follow for extended periods as they had a habit of moving rapidly to another part of the home range and not being very responsive to attempts to call them up.

Only rarely were song tapes played loudly in a study home range to attract a response from kokako. Though this technique was useful for determining where home ranges were located initially, it often resulted in birds going to the highest trees and singing.

Kokako were generally indifferent to people moving about or talking nearby. However, it was important to keep quiet and alert at all times when following them, as they could disappear from sight behind a screen of vegetation, and any movement or sounds were crucial clues as to their whereabouts.

4.2.1 Data collection

The sampling technique used in this study was identical to that devised by Hay (1981) in his study of kokako in the central North Island. The method comprised

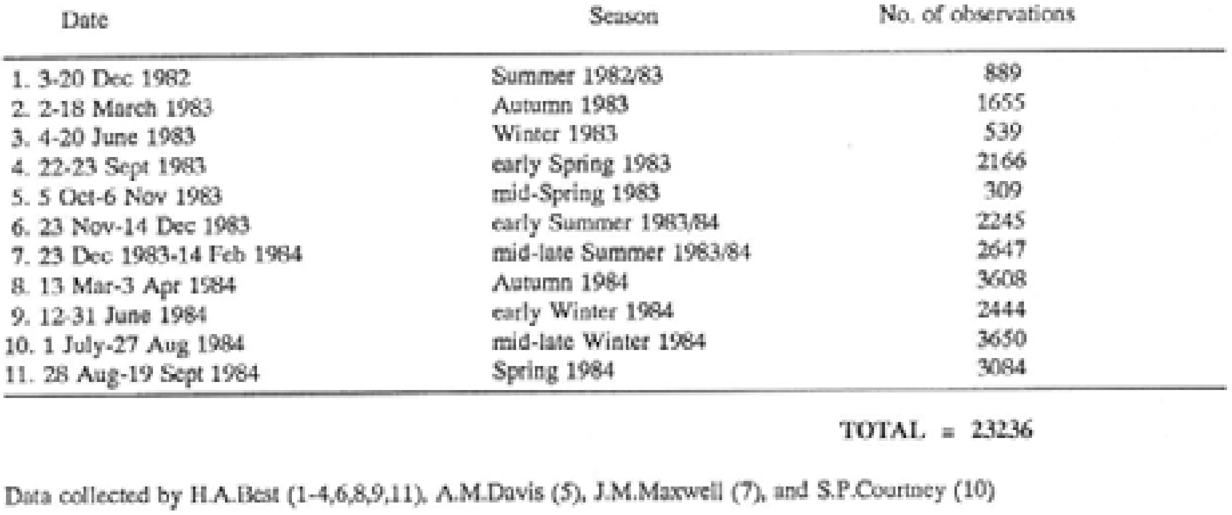
- locating a bird or pair of birds in a study home range; commencing observations as soon as the birds were found, and reporting the information onto a pocket-sized tape recorder;

- at the start of each sampling period the home range name, date, weather conditions and air temperature were recorded. Then the following details were noted at one minute intervals: time of day, bird activity (predominant behaviour observed during a 10 second period), height of the bird and canopy above the ground, tier class that the bird was present in, perch type, food type and source (if feeding), and topography (see coding sheet in Appendix 4.1 and 4.2 for full details). The information was coded later onto computer data sheets for punching.

From December 1982 to September 1983, the birds in Summit home range were followed at various periods over a number of days, to obtain a composite dawn-to-dusk record of activities in each sampling season (Table 4.1). Other study home ranges were sampled as intensively as time allowed. By March 1984, data had increased to a level where it was possible to obtain dawn-to-dusk records in all the five home ranges, weather permitting.

Birds were followed for as long as possible in each Initially, 2 or 3 hour sessions were all that could be handled. In the latter half of the study, monitoring sessions of 5-6 hours duration were common, the longest being 9 hours.

Table 4.1 Periods when data were gathered on kokako in Puketi Forest



Date	Season	No. of observations
1. 3-20 Dec 1982	Summer 1982/83	889
2. 2-18 March 1983	Autumn 1983	1655
3. 4-20 June 1983	Winter 1983	539
4. 22-23 Sept 1983	early Spring 1983	2166
5. 5 Oct-6 Nov 1983	mid-Spring 1983	309
6. 23 Nov-14 Dec 1983	early Summer 1983/84	2245
7. 23 Dec 1983-14 Feb 1984	mid-late Summer 1983/84	2647
8. 13 Mar-3 Apr 1984	Autumn 1984	3608
9. 12-31 June 1984	early Winter 1984	2444
10. 1 July-27 Aug 1984	mid-late Winter 1984	3650
11. 28 Aug-19 Sept 1984	Spring 1984	3084

TOTAL = 23236

Data collected by H.A.Best (1-4,6,8,9,11), A.M.Davis (5), J.M.Maxwell (7), and S.P.Courtney (10)

4.2.2 Data analysis

The data were analysed using SAS based sorting programmes. A SAS graphics package was used to produce 3-dimensional bar graphs of home range use (see Section 4.2.4). Initial runs of analysed data were compared against manually derived examples that had been double checked for accuracy. These comparisons revealed discrepancies in the coded data sets. Detailed error detection programmes were then written which identified incorrectly coded lines of data. The final data analyses were not run until the entire data set (23,236 observations made at one minute intervals) bad been screened, and all the discrepancies had been corrected and rechecked as being acceptable.

During the joint analysis (Section 5) it was found that estimates of tree heights differed, the latter's being about 15% greater than those of the former. The arose probably from differences in field procedures. Because birds were often moving, tree heights. However, more time could be spent in gauging tree heights during the botanical sampling work (by PJB). The source of error small for heights of 10m or less (e.g. PJB 10m = HAB 11-12m) but was numerically greater at the highest levels where it was increasingly difficult to gauge tree heights accurately without a measuring device (PJB 30m = HAB 33-35m). The outcome though made little difference to the interpretation of the results as the height use data were grouped, and only broad comparisons were made in the use of different height classes. The bird and height use profile diagrams (e.g. Fig.4.15) can be 'corrected' by regarding the 3m intervals as corresponding to 2.6m intervals.

4.3 RESULTS

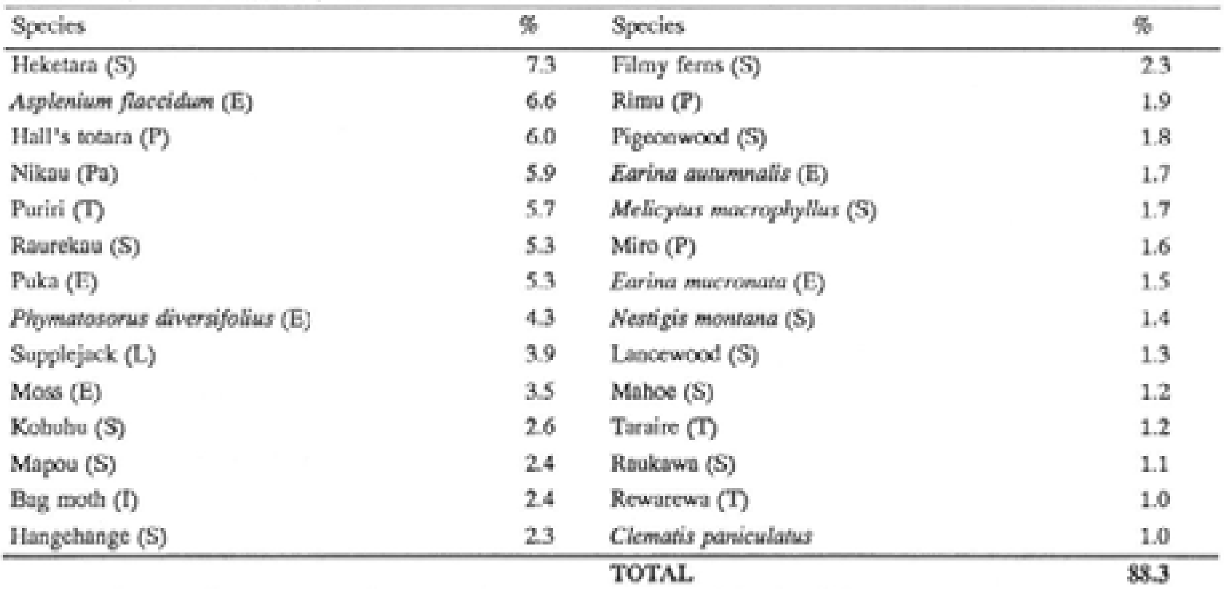
4.3.1 Part One: Diet

The diet of kokako was examined with respect to:
A. Species composotion
B. The type of food (leaves, fruit, flowers, etc).
C. The class of food (epiphyte, liane, podocarp, nikau palm, etc).
D. The host vegetation class from which epiphyte, liane, and invertebrate foods were obtained.
E. The species of vegetation that were hosts of epiphyte, liane, and invertebrate foods.

4.3.1A Species composition of the diet

Kokako ate more than 85 species of plants and invertebrates during the study (Appendix 4.3). Most of the diet was obtained from a few species (49.6% of the food was provided by the first ten species listed on Table 4.2). Although other species eaten by kokako represented minor portions of the diet, they could be seasonally important sources of food within home ranges.

Table 4.2. **Species composition of kokako diet, Puketi Forest, December 1982 - September 1984 (for species comprising 1.0% or more of the diet overall).**



Species	%	Species	%
Heketara (S)	7.3	Filmy ferns (S)	2.3
Asplenium flaccidum (E)	6.6	Rimu (P)	1.9
Hall's totara (P)	6.0	Pigeonwood (S)	1.8
Nikau (Pa)	5.9	*Earina autumnalis* (E)	1.7
Puriri (T)	5.7	*Melicytus macrophyllus* (S)	1.7
Raurekau (S)	5.3	Miro (P)	1.6
Puka (E)	5.3	*Earina mucronata* (E)	1.5
Phymatosorus diversifolius (E)	4.3	*Nestigis montana* (S)	1.4
Supplejack (L)	3.9	Lancewood (S)	1.3
Moss (E)	3.5	Mahoe (S)	1.2
Kohuhu (S)	2.6	Taraire (T)	1.2
Mapou (S)	2.4	Raukawa (S)	1.1
Bag moth (I)	2.4	Rewarewa (T)	1.0
Hangehange (S)	2.3	*Clematis paniculatus*	1.0
		TOTAL	88.3

Note: E=epiphyte, I=invertebrate, L=liane, P=podocarp, Pa=palm, S=shrub hardwood, T=tree hardwood.

Detailed information on the species eaten in each home range per season and for each season overall has been listed in Appendix 4.4 to 4.14. To simplify interpretation, the data have been arranged in two formats to illustrate changes in diet composition; namely

i) variation in consumption of 11 of the more commonly eaten food species as examples of some of the patterns of food use;

ii) comparison of the main food items (expressed as the ten most commonly eaten food species) between
a) one home range over a number of seasons, and
b) several home ranges in one season.

i) Seasonal variation of intake of food species
The frequency of feeding on 11 plant species during the study has been depicted in Figure 4.1. The main feeding patterns were:

a) maximal use of some species occurred at different times of the year to that of others. For example, supplejack and fivefinger were taken mainly in summer (both years), miro and Hall's totara in autumn, heketara in winter and *Asplenium flaccidum* in spring.

b) maximal use levels of seasonally predictable foods changed from year to year - see graphs for heketara, miro, rimu and supplejack. The level of feeding on *Asplenium flaccidum* was the most consistent in the two annual cycles studied.

c) some species were fed on intensively for short periods (supplejack, fivefinger), while maximal feeding periods on others were more gradual and extended over longer periods (puka, Hall's totara, rimu). Raurekau and nikau had especially extended maximal use periods, but not in the same years.

d) different parts of some plants were eaten at different times of the year (puka, puriri, raurekau). For example, feeding on puka ranged between 1.5 and 9.2% of the diet (except for 0% in Summer 1982/3). This comprised mainly fruit during Autumn-Winter 1983, leaves in Spring 1983, flowers in early Summer 198314, fruit from mid-late Summer 198314 to early Winter 1984 and increasing use of leaves in mid-late Winter to Spring 1984.

ii) Comparison of diet between home range within a season
There were large differences in the composition of the diet between home ranges in the same season (as in Autumn 1984, Fig.4.2). Of the total 25 species depided, none rated in the ten most commonly eaten foods for all five home ranges. However, six species rated in four home ranges (fivefinger, Hall's totara, heketara, *Melicytus macrophyllus,* miro, nikau). An additional three species rated in three home ranges (hangehange, raurekau, supplejack), while bag moth, mahoe, moss and rimu ranked in the ten most commonly eaten foods in only two home ranges.

iii) Comparison of diet in one home range over a number of seasons
The ten most commonly eaten food species each season in Summit home range, between early Summer 1983/4 and Spring 1984, have been shown in Figure 4.3. Although 24 species were important seasonally, Hall's totara was the only major food in all the seasons depicted. Some of the other 23 species were taken relatively commonly (e.g. puka, heketara and nikau in four seasons; *Asplenium flaccidum, Phymatosorus diversifolius,* pate and raurekau in three seasons). The remaining 16 species were taken less frequently (in one or two seasons).

4.3.1.B Type of food
i) Differences between seasons
The types of food eaten during the study changed seasonally (Fig.4.4, and see Appendix 4.15 for tabulated data). and leaves were the principal items of the diet, supplimented by flowers, moss (foliage and capsules), invertebrates, bark, and dead plant material. Changes in diet with season were related to the abundance of foods. Fruit was taken mostly in summer and autumn, and declined steadily to its lowest levels in spring. Similarly, flowers were eaten mostly in summer and declined progressively in the diet thereafter.

Kokako fed on leaves mast often in winter and spring when flowers and fruits were least abundant (see Section 3.2.1 to 3.2.3, Phenology Study).

ii) Differences between home ranges

The types of food eaten in each of the five main study home ranges from Autumn 1984, to Spring 1984 (Fig. 4.5, App 4.16) followed the trend illustrated over the same period in Figure 4.4. The major difference was that the kokako in Ben and Summit home ranges ate more fruit in Autumn 1984 than their counterparts in the other home ranges. Flowers were eaten most of all in Hill home range, this being almost entirely from puriri.

4.3.1.C. Class of food

Feeding records have been grouped into classes, namely - kauri, podocarp, tree hardwood, shrub hardwood, nikau palm, epiphyte, liane, invertebrate, and tree fern-ground plant-other. A full list of the species comprising each class is given in Appendix 4.17.

i) Seasonal use of food classes (Fig.4.6, App 4.18).

Shrub hardwoods were the major food class eaten throughout the study (26.6% to 67.3% of the diet). They were fed on most of all in summer and least in winter-spring, the exception being in Winter 1983 (see Discussion).

Feeding on podocarps was greatest in autumn, mainly for fruit; on epiphytes in late winter-spring, for foliage; and on lianes during summer, mostly for supplejack leaves, flowers and fruit. The only other species classes that contributed more than 5%to the diet in any one season were tree hardwoods and nikau palms. Consumption of tree hardwood foods fluctuated between 6.8% and 21.1%. Nikau fruit comprised less than 1% of kokako diet in the first year of the study, but formed between 2.1% and 11.2% of the diet from January 1984 until September 1984.

Invertebrates, kauri, tree ferns, ground plants and ‘other’ (dead tree, self-entwined supplejack and kiekie liane thickets, and unknown), contributed minor amounts to the diet. Feeding on kauri was seen only in Spring 1983 and Autumn 1984, when it comprised less than 0.5% of the diet. Invertebrates made up 0.2% to 3.5% of the diet per season.

ii) Use of food classes between home ranges

There were small, but distinct differences between home ranges, in the proportion of the diet obtained from each food class (Fig. 4.7, App 4.19) between Autumn 1984 and Spring 1984. Feeding on shrub hardwoods increased steadily from Autumn to Spring 1984 in Ben home range, but remained almost in Hill home range, and declined in Pet, Pukatea and Summit home ranges. Epiphytes were the dominant food in Pukatea home range in all four periods, and were the prime food class in Pet and Summit home ranges in Spring 1984. were eaten mostly in Ben home range, tree hardwoods in Hill home range, lianes and invertebrates in Pet and Pukatea home ranges, and nikau palm mostly in Summit home range.

4.3.1.D. Food hosts

Records of feeding on epiphytes, lianes and invertebrates have been grouped according to their respective hosts to highlight the importance of each food host to kokako.

The data have been analysed to illustrate:

i) Seasonal use of food hosts

There was a marked increase in the importance of tree hardwoods as a food source when their role as hosts of epiphyte, liane and invertebrate foods was taken into account (cf Fig.4.8 with Fig 4.6). Tree hardwoods were the dominant food host in four sampling periods (Spring 1983, early Winter 1984, mid-late Winter 1984, Spring 1984) principally as these trees had the greatest loadings of epiphytes, and feeding on epiphytes was greatest during these periods. Tree hardwoods were the second most utilised host food class in four out of the other six sample periods.

The incorporation of feeding records from dependant species increased

- podocarp use by about 6% for most seasons (highest additional useage occurring in Spring 1983 (7.9%) and Winter 1983 (12.1%)).
- shrub hardwood use by less than 5% in most seasons (except during early and mid-late Summer when it increased to 18.9% and 11.9% respectively, mainly owing to feeding on supplejack).

Kokako obtained little food from the remaining food hosts (i.e. kauri, nikau, 'other'). Kauri was taken during three seasons (comprising less than 1%of the diet for each), and nikau showed less than 2% increase per season when feeding on its dependant species was included (cf. Appendix 4.20 with Appendix 4.18). In some seasons, there were appreciable increases in the use of 'other' food host, e.g. in Winter 1983 when kokako fed from the ground on unripe supplejack fruits and other foods that had been blown out of the canopy by storms, and also in mid-late Summer 1983/4 when birds were perched on tree ferns and dead standing trees while feeding on ripe supplejack fruit.

ii) Use of food hosts between home ranges
There were differences in the relative importance of food hosts between kokako home ranges with season. The increase in importance of tree hardwoods as food hosts was mast pronounced in Pukatea home range (cf Fig.4.9 with Fig.4.7). Podocarps were the dominant food hosts in Ben home range during Autumn 1984, but in Winter and Spring 1984 this position was taken over by shrub hardwoods. Tree hardwoods were the main food hosts during one or more seasons in the other four home ranges (e.g. Hill in Spring 1984, Pet and Summit in Winter and Spring 1984, Pukatea in all three seasons depicted).

4.3.1.E. Host species of epiphyte, liane and invertebrate foods
The species which hosted epiphyte, liane and invertebrate foods during the study have been summarised on Table 4.3. (see page 222)

i) Epiphytes
Seventy percent of the epiphyte foods eaten by kokako came from tree hardwoods, especially from kohekohe (29.7% use overall; range 7.4% to 39.6% between home ranges) and taraire (19.4% overall, range 10.3% to 29.3%). A further 20.6% of the epiphyte foods were obtained from nine species of tree hardwoods (ranging from 0.1% to 5.8% use overall).

Podocarpswere the second most common hosts of epiphyte foods (18.8% use overall; range 8.0% to 37.0% between home ranges), the main species being Hall's totara (10.8% use overall; range 0% to 24.7%) and (5.4% use overall; range 2.0% to 11.0%). Kauri (0.4% use overall), shrub hardwoods (6.1% use overall) and the remaining vegetation classes housing epiphytes (3.4% use overall) were minor food hosts.

ii) Lianes
Most liane foods came fmm tree hardwoods, particularly kohekohe (20.3%), towai (15.0%) and taraire (10.5%). Shrub hardwoods hosted 32.0% of the food taken from lianes, especially mahoe (7.4%), heketara (6.6%) and pigeonwood (6.2%). None of the other 25 host species in Table 4.3 (page 222) provided more than 5% of the liane foods eaten by kokako.

iii) Invertebrates
Tree hardwoods were also the prime source of invertebrate foods (79.5%), mainly towai (37.5%), taraire (21.5%) and tawa (16.3%). Bag moths were the major invertebrate prey (78.9%), followed by scale insects (7.4%). Invertebrates totalled 3.0% of all foods taken in this study.

4.3.1.F. Discussion
The diet of kokako changed considerably with season, and between home ranges in the same season, because of changes in the food supply (see Phenology Study, Section Three) and differences in the relative abundance of food classes between home ranges (see home range descriptions in Section Two). Feeding patterns could be disrupted by stormy weather. Persistent easterly storms in Winter 1983 had a profound effect on the data gathered compared with that obtained during the

following year (i.e. early Winter 1984). Eighty three percent of the 539 observations during Winter 1983 were obtained from one home range (Summit), as the roads to the other study home ranges were not negotiable in the available vehicle. During this season, the kokako in Summit home range resided in the only part of their home range that was sheltered from the prevailing weather. This small area was dominated by shrub hardwoods and received little use at any other time of the study – see Section 4.2.4, Home range use. Thus a greater percentage of shrub hardwoods were eaten then than in the following winter, and there was no feeding on puka fruit (which was usually most plentiful in the exposed crowns of emergents), or winter flowering kohekohe or puriri. The stormy weather resulted also in large quantities of leaves and fruits being blown out of the crowns of trees and probably accounted for the higher than usual incidence of feeding at ground level (on material torn out of the canopy).

Shrub hardwoods were the top ranking food class over the study, probably as there were more species in this group (see Appendix 4.17) than in any of the other food classes. In addition, leaves, fruits and flowers of shrub hardwoods were eaten. By contrast, podocarps and tree hardwoods comprised relatively few species and only the flowers or fruits were fed on to any degree.

Changes were likely to occur in the use of food classes from year to year. The use of a particular food class depended on the production of certain key species (e.g. for tree hardwoods, the fruiting of hinau, tawa, or taraire, or the flowering of puriri) and may have been influenced also by the amount of food available (e.g. podocarp fruits) from species in other classes.

Tree were the major food hosts because they comprised the dominant canopy plants in the kokako home ranges studied, particularly in Pukatea home range. Podocarps and shrub hardwoods were less important as food hosts; the former were of large stature (and thus each tree could support large loadings of attendant species) but less numerous than tree hardwoods, whereas shrub hardwoods were of smaller form but relatively more plentiful. Kauri, nikau, tree ferns, and dead trees bore small amounts of attendant species. Kauri were generally very clean trunked and limbed (possibly a result of their bark being shed in large flakes), while nikau and tree ferns comprised a relatively small fraction of the vegetation in home ranges, and were of small size and devoid of branches.

Kokako ate relatively few invertebrates throughout this study (3.0% overall; seasonal range 0.7%-5.5%). This contrasted with (1987) result of 8% overall (range 0-29.2%) from Puketi Forest and that of 15.9% by Hay 1981 for (Pureora State Forest). Powlesland and Hay reported that sixpenny scale insect *Ctenochiton viridis* was the main invertebrate prey (in Hay's study, scale insect provided up to 77% of the diet in some seasons, from one of his study areas). However, only 16 records (0.2%) of feeding on this prey were made during my study. The principle invertebrate prey taken during my study in Puketi Forest was the bag moth (*Liothula omnivorus*) which Hay reported as comprising 0.5% of the diet overall for Rotoehu, 3.8% for Pureora and 4.4% at Mapara. These figures lie within the range given above for my study. The large differences in seasonal and annual use of invertebrates, especially of sixpenny scale insect were probably related to their abundance. Powlesland found sixpenny scale to be plentiful in the seasons that kokako fed on them, whereas I had great difficulty in finding any during frequent checks of likely host plant leaves (pate, fivefinger, puka).

4.3.2 Part Two: Activity patterns

The amount of time that kokako spent feeding, singing, calling, moving, roosting and preening varied seasonally and diurnally.

4.3.2.A Seasonal activity patterns (Fig. 4.10, App. 4.22)

Three broad patterns were apparent, namely -

(i) The amount of time spent feeding per hour was greatest during the colder parts of the year and was least during summer.

(ii) Singing, roosting-preening and incidental[1] activities occurred most frequently during the warmer months of the year. Singing was greatest in spring, summer and autumn, roosting-

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[1] see Definition of Terms, Appendix 4.2.

preening was most common in summer and autumn (during moult) and incidental activities (most of which were related to breeding, such as gathering nest material) peaked in spring and summer.

(iii) The amount of time spent moving and calling changed relatively little with season in comparison to the activities above.

4.3.2.B Diurnal activity patterns
The frequency of each activity per hour of daylight for Summer 198314 and for Winter 1984 have shown in Figure 4.11 and Appendix 4.23. The hourly activity patterns depicted for Summer 198314 showed that singing was the dominant activity in the first and last quarter of the day, and was heard rarely in the middle of the day. By contrast, feeding, moving, roosting-preening and incidental activities were most common in the middle half of the day. During Winter 1984, the amount of time spent singing more than halved and there was a corresponding increase in feeding compared to that in summer. There was also a reduction in moving and roosting-preening activities per hour during Winter 1984 compared to Summer 1983/4.

4.3.2.C Discussion
The activities of kokako revolved principally around feeding and home range maintenance (i.e. singing). Moving and calling activities were accessory to feeding and singing. Birds moved to search for food and to find suitable song posts. Calling often preceeded bouts of singing, or was given during intervals in song periods, or as a song session was winding down. Birds also called to their mates if they became separated while feeding. On occasions, birds called spontaneously for several minutes, regardless of whether single or paired, its mate was nearby or some distance away, or whether there was a reply or not.

Singing may have declined over winter to allow more time for feeding during the shorter period of daylight. The abundance of food was less in winter and spring than that in summer and autumn.

Roosting and preening activities were greatest in summer when birds were moulting. Buds often preened for more than 20 or 30 minutes at a time. Roosting took place usually after birds had been feeding intensively for 10-20 minutes or more. After long feeding sessions, buds were probably quite full and needed to rest until their digestive systems could process the food. At times, kokako fed until their necks were swollen and they had difficulty with cramming in the last items of food. was often the case when feeding on nikau or supplejack fruit, which had a thin fleshy exocarp covering a bulky hard seed and as a consequence much of the gut would be filled with indigestive seeds.

4.3.3 Part Three: Use of habitat

Information on how kokako use structural components of their habitat has been grouped under the following categories:
A. Use of perches
B. Use of vegetation tiers
C. Use of vegetation classes
D. Vertical use of the forest

4.3.3.A. Use of perches (definitions in Appendix 4.2)
Feeding birds perched mostly on twigs (26.5%) and outer branches (25.8%), but mid-branches (19.3%) and trunks (11.8%) were also important (Fig.4.12). The majority of feeding from trunks took place when eating nikau fruit (birds perched mainly on nikau flower stalks which arose directly from the trunk).

Most singing on outer branches (83.4%). Calling buds perched mainly on outer and mid-branches (44.2% and 32.7% respectively), and likewise with moving (32.1% and 35.3% respectively). However, roosting and preening took place primarily on mid-(47.7%) and inner branches (30.2%). Incidental activities were centred on mid-branches (34.5%), followed by outer branches (16.9%), trunks (14.2%) and epiphytes (13.6%).

4.3.3.B. Use of vegetation tiers
Nearly all kokako activities took place in canopy forming trees (65.9-85.9%) except during singing when emergents (81.5%) were the prime sites (Fig.4.13). Understorey and ground tier plants

received minimal use by kokako (5.5% and 0.8% respectively overall).

4.3.3.C. Use of vegetation

i) For the study overall

Kokako used vegetation classes in different ways for different activities (Fig.4.14).

Feeding was concentrated in shrub and tree hardwoods (including their associated epiphytes, lianes and invertebrates) and to a lesser degree in podocarps.

Nearly all singing (98.2%) took place from tree hardwoods, podocarps and kauri.

Most calling (91.1%) and moving (90.1%) were recorded from tree hardwoods, podocarps and shrub hardwoods.

Almost three-quarters (70.1%) of roosting and preening occurred in tree hardwoods.

The most common activity on the ground was incidental (4.5%), followed by moving (2.4%), calling (0.9%) and feeding (0.5%). Singing and roosting-preening were not seen on the ground.

ii) Between home ranges

The amount of singing, calling, moving, and roosting-preening in each vegetation class between home ranges has been shown in Figure 4.15 A-D and on Tables 4.4 to 4.7 (see page 225-232). Use of vegetation classes for feeding has been covered previously (see Section 4.2.1.B & C).

a) Singing

Kauri, podocarps and tree hardwoods were used to varying degrees between home ranges (Fig.4.15A).

More than a quarter of all singing in Ben, Hill, and Pet home ranges came from kauri, but only 9.0% from Summit home range. There were no kauri in the parts of Pukatea home range frequented by kokako in this study.

Podocarps were the most popular song trees in Summit home range (60.7%), but they were sung from much less in the other four home ranges; 14.3% (Pukatea home range) to 33.5% (Ben home range).

Singing from tree hardwoods was most common in Pukatea home range (85.0%). Tree hardwoods were used between 30.3% and 53.4% of the time in the other four home ranges.

The principle species used for singing were:

- kauri (Ben, Hill, Pet home ranges)
- rimu (Ben, Hill, Pet and Summit home ranges)
- miro (Hill, and Pukatea home ranges)
- Hall's totara (Ben, Pet, Summit home ranges)
- northern rata (particularly in Ben and Hill home ranges, but also in Pet home range)
- towai (Hill, Pet, and especially in Pukatea home range).

These species acted as song posts in at least four of the five study home ranges (Table 4.4, page 225). Other species were important also, but only in single home ranges; namely

- kahikatea (a single, very prominent specimen in Summit home range)
- rewarewa (in Pukatea home range)

- pukatea (in Summit home range).

The 9.0% use of kauri in Summit home range was also noteable; there was only one emergent sized kauri in the home range. This emergent was sung from in preference to adjacent miro and Hall's totara of similar size and stature.

b) Calling, moving, roosting-preening
The relative importance of vegetation classes within each home range for calling, roosting and roosting-preening (Fig.4.15) was similar to the overall pattern on Figure 4.14. However, as with singing, there were variations on this theme between home ranges. Tree hardwoods were used most of all in Pukatea home range, mostly in Ben and Hill home range, and shrub mainly in Pet and Summit home ranges. The species used most commonly between home ranges for calling, moving, and roosting-preening were Hall's totara, kohekohe, taraire and towai (Tables 4.5 to 4.7, page 227-232).

4.3.3.D. Vertical use of the forest

i) For the study overall (Fig.4.16)

Singing was concentrated in the uppermost vegetation of the forest (median song height for birds = 25m above ground level, compared to the median canopy height of 15m). The other five activities occurred near canopy level (bird height profiles generally being 2-4m lower than canopy height profiles).

The lower third of the profile for was used most for feeding and incidental activities (median bird height of 10m and 8m respectively). Calling, moving and roosting-preening were concentrated at higher elevations (median bird heights being 19m, 12m and 12m respectively).

ii) Differences in song height profiles between home ranges

The extent that birds sang above the canopy differed between home ranges (Fig.4.17). Median heights for singing varied from 6m above median canopy height in Pukatea home range, to 13m above the canopy in Ben home range.

There were also differences in the shapes of song height profiles between home ranges. For instance, the song height profile in Ben home range peaked strongly between 22-30m, whereas the majority of singing in Pukatea home range was spread more evenly around the median value. Differences in song height profiles between home ranges were related to differences in habitat (see Discussion).

iii) Differences in height profiles For calling, moving and roosting-preening between home ranges

Differences in bird height profiles between home ranges for each of these activities (Figs 4.18 to 4.20) were minor in comparison to those for singing (Fig.4.17) and were mainly as follows. The profiles for calling, moving and roosting-preening from Hill, Pet and Summit home ranges were biassed towards lower levels whereas profiles from Ben (except for roosting-preening which had a downward bias) and Pukatea were distributed more evenly towards the middle of the height range.

iv) Differences in height profiles of feeding kokako

a) Seasonal differences (Fig.4.21)

Median heights of feeding birds were lowest in summer (6m for Summer 1982/3 and 7m for early Summer 1983/4) and highest in winter (10m for Winter 1983; 15m for early Winter 1984). In all seasons, the bird height profiles were biased towards lower levels except in early Winter 1984 when the profile was distributed relatively evenly to either side of the median bird and canopy height values (Appendix 4.24).

Feeding on the ground occurred in winter and spring of both years and also to a minor degree (<1%) in early and mid-late Summer 1983/4. The greatest amount of ground feeding recorded was in Winter 1983 (4.8% of the feeding in that home range) when the birds in Summit home range were feeding on material that had been blown from the canopy during prolonged stormy weather.

b) Differences between home ranges

> Seasonal changes were apparent in the median bud and canopy heights[2] in each of the home ranges (Fig.4.22). The median values for bird and canopy heights in Hill, Pukatea and Summit home ranges conformed to the overall pattern shown in Figure 4.21, i.e. bird and canopy median heights were lowest during summer and highest in winter. However, median bud and canopy heights varied little in Pet home range, and there was a decline in median heights in Ben home range over the period depicted. Feeding on the ground was most common in Summit home range (winter and spring of both years). It was recorded also in Spring 1983 and mid-late Winter 1984 from Pet home range, but only in mid-late Winter 1984 from Ben and Pukatea home ranges. Feeding was not seen on the ground in Hill home range.

4.3.3.E. Discussion

i) Perches.

Feeding birds used twigs and outer branches mainly as most of the food was located there (i.e. flowers, fruits, leaves and invertebrates). Birds perched on trunks and limbs (mid to inner branch) mainly when feeding on epiphytes. Singing took place almost exclusively from outer branches, as these provided elevated, unobstructed perches to sing and listen from - hence also the favouring of emergent trees (especially on ridges, see Section 5.1.2).

Calling and moving activities were mainly accessory to feeding and singing, and thus took place on similar perches and tier types (emergent and canopy) to the latter activities. Kokako used mid-branches more than twigs or outer branches when moving. Birds tended to search through the canopies of trees from mid-branches and move outwards when food was seen.

Incidental activities (principally displaying, and gathering nesting material) occurred on, or near the ground, or on parts of trees where there were mosses, filmy ferns or accumulated litter (e.g. crotches of branches, or amongst foliage of epiphytic *Collospermum* or asteliads). Roosting and preening birds perched on mid branches and inner branches of canopy trees (rather than emergents), probably as these sites gave the greater degree of visual screening and mechanical protection against any harriers (*Circus approximans*) that may have been patrolling overhead.

Kokako were usually extremely alert to harriers. One harrier attack was seen on a roosting kokako. A harrier was cruising 10-15m above the canopy. The kokako was roosting on a deeply shaded mid-branch about below canopy level where it would have been quite inconspicuous. The harrier must have noticed the kokako on its first pass overhead as it wheeled around quickly and made two more passes into the wind. The first of these passes was about 5m above the canopy, and on the final pass it stooped suddenly when directly above the kokako (which was alerted only as the harrier broke through the canopy). On other kokako usually hid in places concealed from above as soon as a harrier was seen, and stayed there for several minutes afterwards.

ii) Use of vegetation classes and species for various activities

As most neighbouring kokako were situated several hundred metres apart, singing was the only way they could communicate with one another. The best places for broadcasting song over long distances, and to listen for answering song, were tall trees that rose above the general canopy level, especially if situated on top of prominent high points, densely foliated as this reduced sound transmission. The tallest trees in the forest were kauri, and tree hardwoods.

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[2] The canopy height data were gathered in the immediate proximity of the bird (either the height of the tree that the bird was in if it were a canopy species, or the height of the canopy tree nearest to the bird if it were in emergent or understorey vegetation, or on the ground - see Appendix 4.1). As a result, canopy height profiles may change with depending on the places that kokako used (e.g. clad mostly in low shrub hardwoods, or in taller podocarps). The canopy height profiles were not a direct measure of the distribution of canopy heights over an entire home range.

Generally, kokako sang from the highest trees available in the part of the home range frequented at the time, or in those parts of the home range that faced neighbouring birds. Use of individual tall tree species was related to their general abundance. Prominent kauri and northern rata trees were mast plentiful in Ben, Hill and Pet home ranges; miro was the only podocarp of consequence in Pukatea home range; the only outstanding specimen of kahikatea was in Summit home range. Kauri and northern rata were favoured particularly (when present) as both grew to large proportions and had massive crowns with long, spindly limbs and branches that were relatively free of foliage. These perches gave unobstructed views over the surrounding terrain and were thus ideal places to listen and to be heard from.

Vegetation classes were used for calling, moving and roosting-preening in proportion to their overall abundance in the canopy (except for roosting-preening in Ben home range[3]). And likewise for use of individual species was mast plentiful in Hill home range; tawa in Pukatea and Ben home ranges (see vegetation profiles, Appendix 2.2, 2.6 and 2.1 respectively).

iii) Height profiles

Changes in height profiles between home ranges for each activity were related to differences in habitat. Taking singing as an illustration;

1. Pukatea home range contained very few emergent trees, hence median song height was only a few (6) metres above median canopy level.
2. Ben home range contained a large selection of tall emergents distributed along the main ridges. Consequently, the median song height was well above the median canopy height.
3. In Hill home range, the emergent trees in one area were the remnants of a former canopy that had been devastated by a violent storm in 1959, and were of lower stature than tall kauri and northern rata sung from elsewhere.
4. Pet bird sang from two areas, one of which contained 25-35m high kauri and northern rata, while the second was clad in 15-20m high podocarps emergent over a low shrub and tree hardwood canopy.
5. Summit home range contained a wide range of emergents projecting above a canopy of highly variable height (mainly between 5-20m). Nearly all the singing at 34-36m took place from the top of a particularly large, lone kahikatea tree (see Table 4.4, page 225).

Similarly, differences between home ranges in median heights of buds and canopy for calling, moving, roosting-preening were related to habitat type. Median heights for birds were higher in Pukatea and Ben home ranges than for the other three home ranges because of a greater degree of feeding (and associated activities) in podocarps and/or tree hardwoods (predominantly taller trees). Shrub hardwoods were frequented more in the other three study home ranges (resulting in lower median bud and canopy heights).

For the study overall, changes in feeding height profiles with season were related to the vegetation class being fed in. Median feeding heights were lowest in summer when much of the diet comprised products from and shrub hardwoods and highest in winter when birds were feeding on epiphytes in the crowns of emergents. Feeding on the ground in winter-spring was probably related to buds having to prospect more for food then than in other seasons. Median feeding heights were lower in Winter 1983 than for Winter 1984 (Fig.4.21) because of stormy weather. The buds in the only home range that could be visited readily in Winter 1983 were living in the only place in their home range that was sheltered from the prevailing winds. This area was clad predominately in low shrub hardwoods. The birds did not spend as much time in this area in any other study season (see Fig.4.24A versus Fig.4.24B-G).

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[3] In Ben home range, the predominant use of tree hardwoods may have resulted from two factors - (i) not to roost or preen on ridge crests (where birds would be more exposed to wind and to harriers), and (ii) tree hardwoods in this home range grew mainly on the steep terrain flanking ridges, while and kauri were concentrated on ridges. Kauri was avoided generally for calling, moving or roosting-preening as it was not a good place to find food (calling and moving being accessory activities to feeding) and provided less concealment or shelter than tree hardwoods.

4.3.4. Part Four: Home range use

Each of the five study home ranges was marked into 40 x 40m grids (see Methods, Section Two). This provided a means of recording a bud's location in its home range for each observation. Examples of how kokako use their home ranges have been presented below.

4.3.4.A. Activity centres of home ranges

Kokako did not use all parts of their home ranges equally. In Summit home range, bud activities were concentrated centrally (Fig.4.23 A). However, in Pet home range, most activities were centred in the (Fig.4.23 B). Nearly all of the activities that were listed from unknown grids in Pet home range, took place in the Takapau kauri stand (subsequently squares C1,D1,D2,E1,F1) which had not been marked out at the time the observations were made (Spring 1983).

4.3.4.B. Seasonal use of home range

Changes in use of home range with season have been depicted for Summit home range (the home range that was gridded first and for which there was the largest pool of seasonal see Fig.4.24 A-G). In some seasons (e.g. Winter 1983 and early Summer 1983/4) the resident kokako used relatively compact areas (13 and 16 squares respectively), hut at other times their activities were spread more widely (e.g. mid-late Winter 1984, when 30 squares were used). Changes in use of grid squares were apparent even between early Winter 1984, mid-late Winter 1984, and Spring 1984, a period which was sampled continuously from early June to late September. Greater changes in home range use occurred in other home ranges between early Winter 1984 - Spring 1984 - see maps of Pet and Pukatea home range in Appendix 4.26 and 4.27.

4.3.4.C. Differences in use of home ranges with activity.

Centres of activity for i) feeding, ii) calling, moving, roosting-preening and incidental activities, and ii) singing in Pet, Pukatea and Summit home ranges have been shown in Figures 4.25, 4.26 and 4.27 respectively. In all three home ranges calling, moving, roosting-preening and incidental activities were clumped around the areas where feeding was most frequent, but singing sometimes tended to be concentrated in a different suite of squares.

4.3.4.D. Discussion

Changes in the occupancy of parts of kokako home ranges were related to changes in food availability, as outlined below for Summit home range over a number of seasons.

1. Early Summer 1983/84. The diet comprised mostly shrub hardwoods and lianes which were plentiful in the grids where the birds fed mast often (D3,E2,F3,G3,G4 - see Fig.4.24 A, Fig.4.3 and vegetation profiles in Appendix 2.6).

2. Autumn 1984. Birds fed mainly in grids B2, D3 and E3 which contained the major foods - podocarps (rimu and Hall's totara) and nikau as well as a range of shrub hardwoods (see Fig.4.24 B, Fig.4.3 and Appendix 2.6).

3. Early Winter 1984. Most feeding took place in grids B3, C1,C4,D3,D4,F2,F3 and G3 (Fig.4.24 C) forpodocarps (Hall's totara), tree hardwoods (kohekohe, hinau, puriri), shrub hardwoods (heketara, kohuhu, nikau) and epiphytes (puka and ferns).

4. Spring 1984. Feeding was concentrated in grids C1,C2,C3,D2,D3,E1,E2,E3,E4 and F3 (Fig.4.24 D) mostly for epiphytes (puka and ferns) and nikau, but podocarps (Hall's totara), tree hardwoods (puriri) and shrub hardwoods (raurekau and heketara) were taken to a lesser degree (Fig.4.3).

Use of an indiviudal grid square for feeding within any of the study home ranges for feeding was likely to depend not only on the foods it contained at the time, but also on the availability of food in adjacent squares. Individual squares were likely to be in relation to their food availability if they were some distance from a cluster of squares that had a comprehensive range of foods. For example, the only puriri tree available to Summit pair was located on the very periphery of their home range (on the outer edge of grid C1). This tree was used only when the birds frequented that general area of their home range (early Winter 1984-Spring 1984).

In Hill home range, however, puriri was an important food during most seasons (e.g. see Fig.4.2) because the three trees present were situated centrally (in squares C5,C6 and F5, Appendix 2.2).

Differences in the use of home range between singing versus activities (as shown in Figs 4.25 to 4.27) were related to the distribution of resources. In Pet home range, for example, feeding and associated activities were centred on grid squares B2-B4 and 2-C3 because these contained the most diverse assemblage of food producing plants in the home range. Singing though took place in the tallest trees, such as kauri (grid squares A2,D1,D2,E1 and E2), tall rimu and northern rata emergents (E3), miro and a large northern rata (B2), pukatea (3 trees clumped together on the C2 and C3 border), Hall's totara (B3), and towai on the highest land point of the home range (B4).

Storms could have a large influence on the sector of a home range used by kokako. During Winter 1983 the kokako in Summit home range lived in the area most sheltered from the prevailing easterly storms. Their activities were restricted to 13 grid squares (Fig.4.24 A). Three of these received 62.4% use overall and another four (B2,B4,B5 and C5) were seldom visited at any other time during the study. During the following winter the weather was calmer and the birds ranged more widely (25 squares in early Winter 1984 and 30 squares in mid-late Winter 1984) - See figure 4.24 E & F.

4.4 CONCLUDING COMMENTS.

A. Each of the eighteen kokako home ranges visited contained different habitat, even where home ranges were immediately adjacent. This was a consequence of variations in terrain and its influence on vegetation patterns. The outcome of this was that the details of how birds used their habitat in any season varied considerably between home ranges. However, the factors influencing the way that kokako used their habitat were the same between home ranges. Birds went where the food was most plentiful at the time (in terms of vegetation classes and species, height zones, and parts of the home range) and when singing they usually moved to the most suitable tall, prominent platforms nearby.

B. Although kokako ate a wide variety of foods during the study (more than 85 species) only a fraction of these were available at any one time. Fifteen species each contributed more than 2% of the total diet during the study (seven of these provided more than 5% each of the total food during the study). Thus a small group of species comprised the bulk of the diet, while the remainder were taken as the opportunity arose. Some of the plant species eaten bore food in abundance only intermittently. This characteristic was typical of many New Zealand plants (see Brockie 1988) which had mass fruitings once every three or four years or so. A basic requirement for kokako then appeared to be

i) a wide variety of food species to provide sustenance throughout the year, and
ii) more than enough food at any one time of the year to accommodate irregular production of many of the foods eaten by kokako (this is provided for better in a larger area than in a smaller area, all other factors being equal). The diet needed to be adequate to meet different nutritional requirements of the birds throughout the year (e.g. breeding in spring-summer, moulting in summer-autumn).

C. Access to terrain of differing aspect could also be important to kokako as it provided shelter from storms, regardless of wind direction. Storms (such as the strong NE winds experienced for most of June 1983) had both an immediate and a delayed effect on kokako and their food supply. The immediate effect was that tree tops were buffetted about considerably, and foods in the crowns of emergent and canopy forming trees on exposed sites were damaged or shaken from the trees. The delayed effect was that the abundance of developing foods (that were not ready for eating until some weeks or months later) was also reduced.

D. Microclimate regimes within each home range may have influenced the period over which specific foods were available. In Autumn 1984, the kokako in Ben home range fed heavily on nikau fruit, hut not in subsequent seasons. In the other four main study home ranges of nikau fruit peaked later. The kokako in Ben home range spent most of their time during Autumn 1984 in areas that lay open to the sun, and in which nikau fruits were noticeably riper than in adjacent gullies of different aspect.

In general then, foods may be available earlier on warm, sheltered, sunny sites than elsewhere in a home range and present last of all on the sites receiving the least amount of sun (but which do not dry out as much during the hottest periods of the year). A diverse home range (in terms of terrain and thus its vegetation cover) may provide a richer supply of foods than a less diverse one, not only because of species diversity, but possibly also by extending the seasonal availability of foods through favourable microclimatic conditions.

The kokako study home ranges did not have fixed boundaries but rather were a zone of occupation around a geographical point. Typically, there were gaps of several hundred metres between neighbouring home ranges (Fig.1.2) even where kokako numbers were relatively dense. This was a result of deep valleys separating the sites of high ground occupied by neighbouring kokako. Spacing between home ranges increased in areas where there had been extensive wind damage along ridge tops, logging (e.g. the east portion of Puketi Forest) or where the terrain was least dissected (e.g. the tableland in the SW portion of the Forest). However, some kokako home ranges abutted onto one another. Usually the occupants of such home ranges stayed almost entirely within their own area though the odd incursion into neighbouring forest occurred.

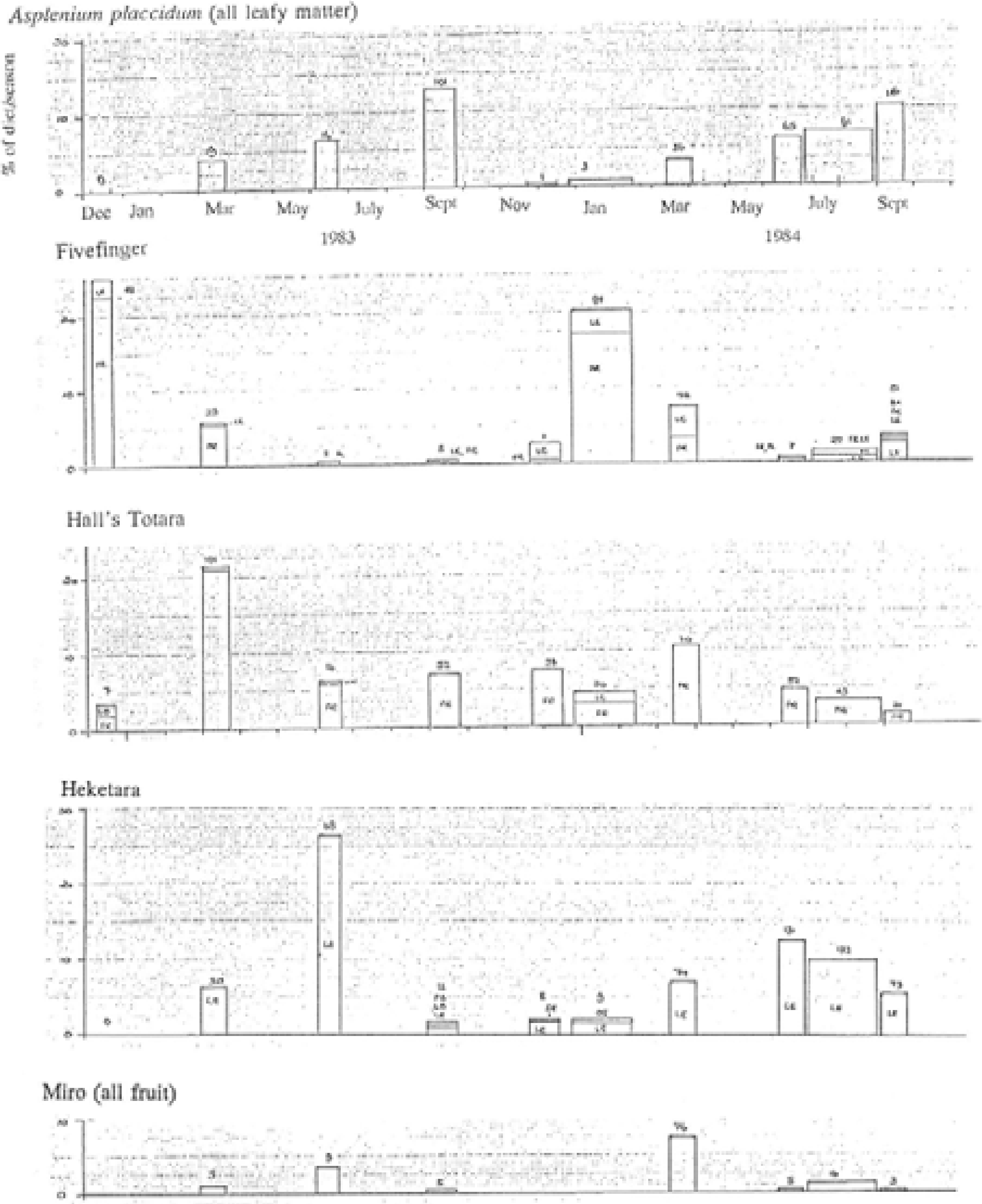
Changes took place in the birds that were resident in one gridded home range (namely Ben). A resident pair of kokako were invariably present in the gridded area (one of which had characteristic, semi-pendulous wattles) from December 1982 to September 1983. Subsequently there was a change. In December 1983 to January 1984, the pair were found in a relatively restricted part of the gridded area alongside the main axial ridge, while another bird was heard calling some 100m further down the ridge crest from an area that the pair occupied formerly. Both parties kept their distance. In March 1984, the pair were living on a neighbouring ridge that lay just outside the gridded area (just W of grid G7, Appendix 2.1), and thereafter only a lone bird (not one from the original pair) was seen in the gridded area. This bird frequented the area that the pair was seen in most often prior to December 1983.

One adult bird disappeared from Pukatea home range during the study. A pair of kokako were resident in the home range when it was first visited in September 1983. They were acting secretively and began nesting a week later. In late November-early December 1983, it was difficult to determine the number of birds present - other than there was a fledgling that was being fed by at least one furtive adult. On the next season's visit to Puketi (march/Autumn 1984), and subsequently, only one adult was seen in this home range. It was not known whether this bird was a member of the original pair, or a newcomer.

The impression obtained during this study was that kokako had strong bonds to their home ranges. A case of this was given by the occupant of Pet home range. When this home range was discovered in late 1979, a pair of birds were nesting and tape recordings were obtained of one bird's song. Soon afterwards, the nest failed and only one bird remained - this bird has been an ardent songster, has often approached vehicles or people on the roadside near the centre of its home range, and has responded strongly to song tapes and to a dummy kokako (whenever this has been displayed).

In addition, the song recorded in 1979 is identical to that sung during our study and is different to that of neighbouring kokako (HAB pers. obs.). Presumably this lone bird has been keen to obtain a mate, but has stayed in its home range for at least eleven years (still alive in 1990) rather than going to find a companion. The best way for a kokako to obtain and bold a mate may be to establish a home range and to advertise the fact. Living in one place (a home range) for a relatively sedentary bird such as kokako may also increase an individual's chances of survival for with time it obtains an intimate knowledge of the resources of an area and their seasonal availability. This relationship with a particular piece of forest may be especially important for breeding as a pair of birds must know how to obtain enough food to feed themselves and to provide for their young, who (J.G. Innes pers. comm.) may be dependent for several months.

Figure 4.1: Seasonal use of eleven species of food eaten by kokako.
LB = leafbuds, Le = leaves, Fr = fruit, Ba = bark, Fl = flowers, Fb = flower buds, Ne = nectar, Dm = dead material. Numbers on top of bars = no. of feeding observations per season.



Asplenium placcidum (all leafy matter)

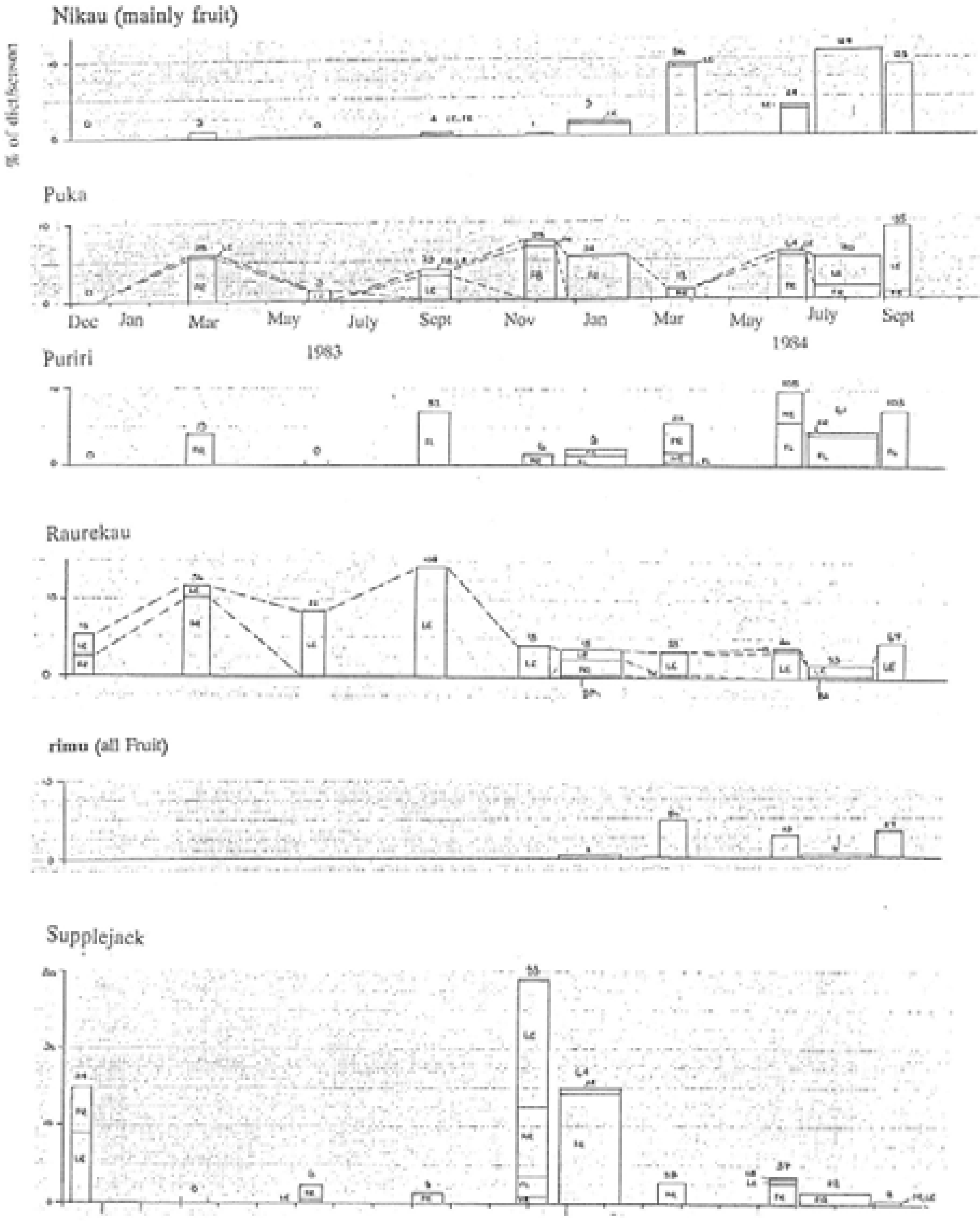
Fivefinger

Hall's Totara

Heketara

Miro (all fruit)

Figure 4.1 (cont'd)



Nikau (mainly fruit)

Puka

Puriri

Raurekau

rimu (all Fruit)

Supplejack

Figure 4.2: The ten most commonly eaten food species in five kokako home ranges in Autumn 1984. More than ten species have been depicted in cases where there was a tie for the tenth most commonly eaten species.

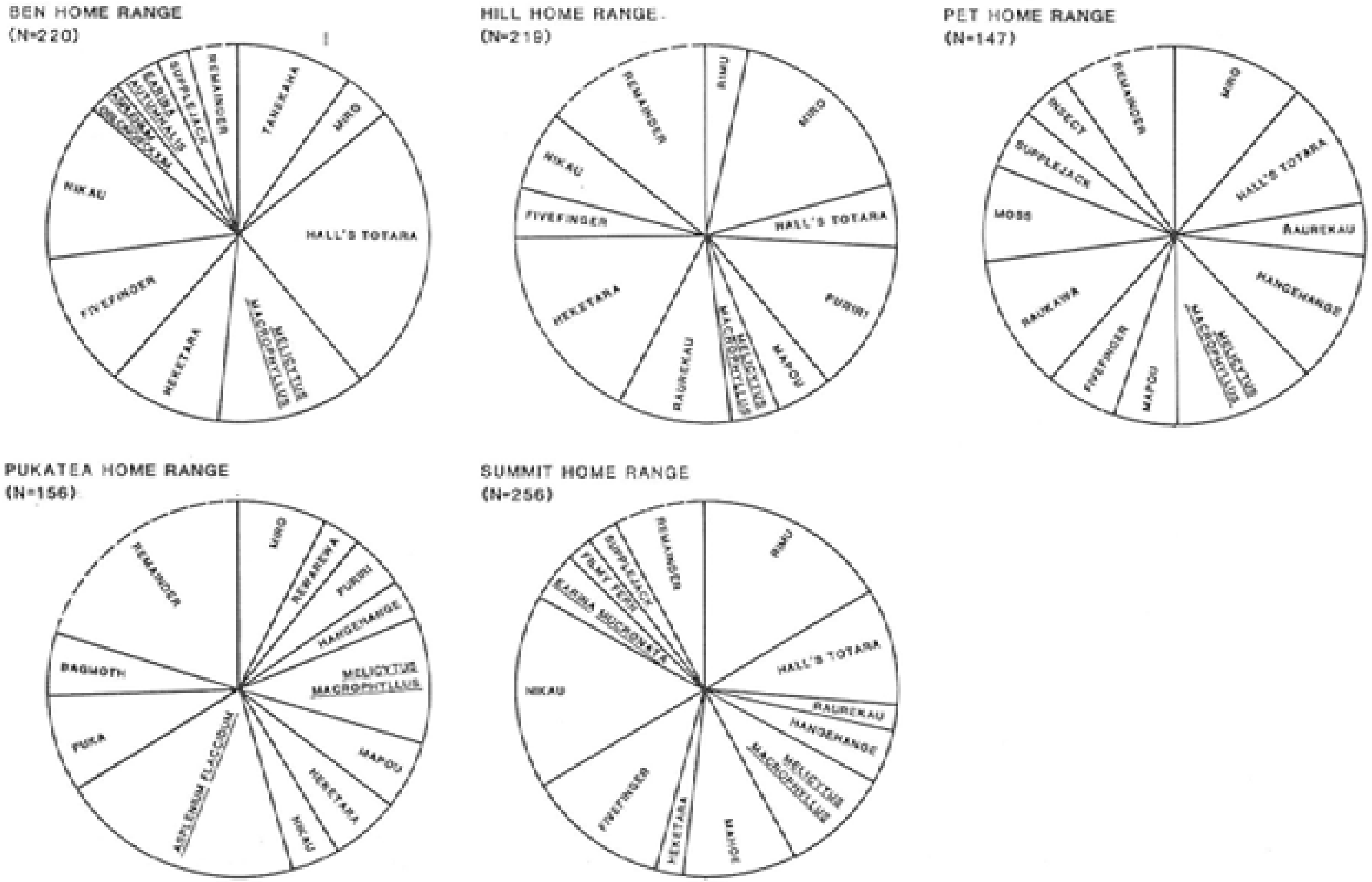

BEN HOME RANGE (N=220)
HILL HOME RANGE. (N=219)
PET HOME RANGE (N=147)
PUKATEA HOME RANGE (N=156)
SUMMIT HOME RANGE (N=256)

Figure 4.3: The ten most commonly eaten food species in Summit kokako home range between early Summer 1983/84 and Spring 1984.

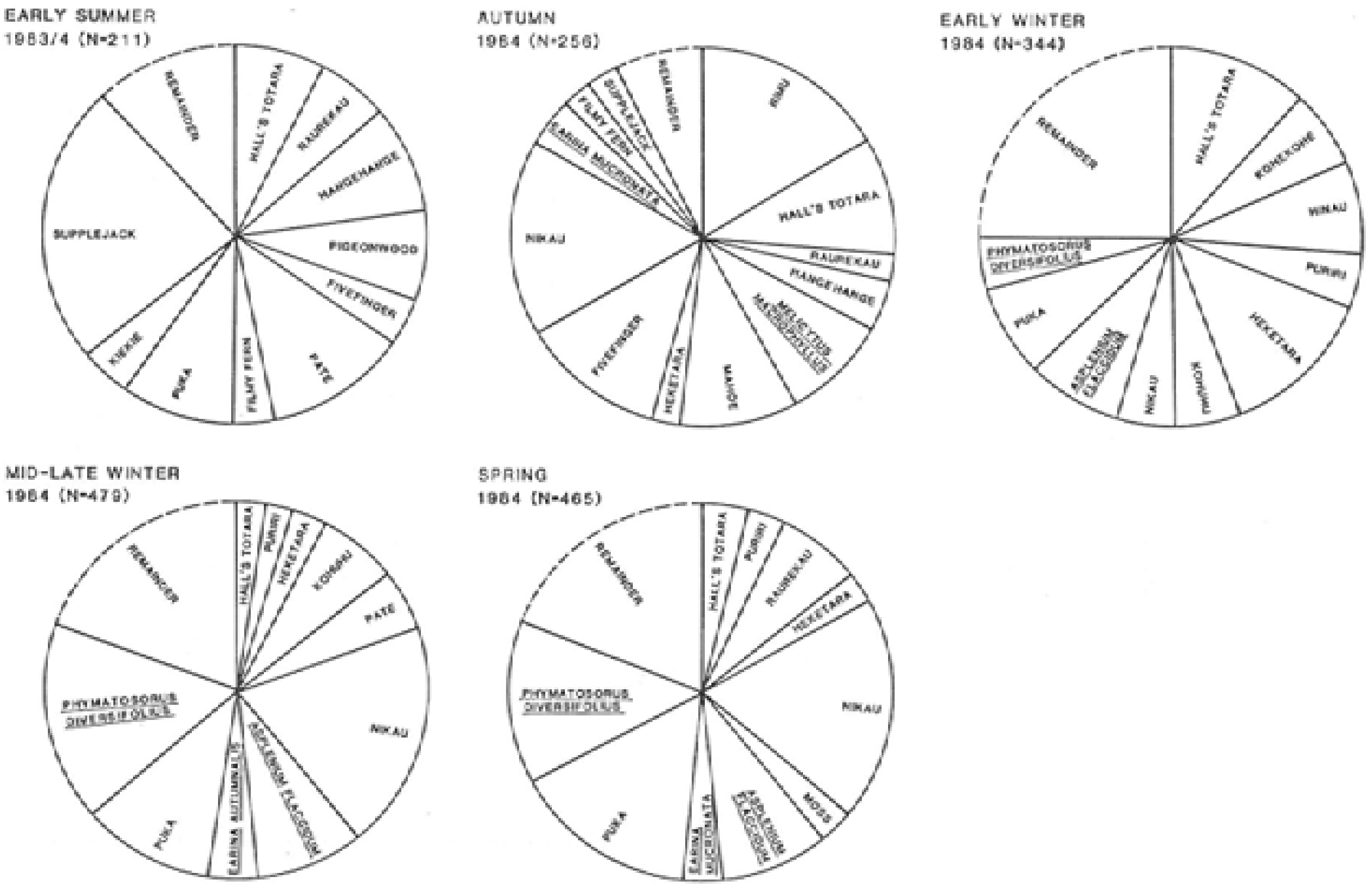


Figure 4.4: Seasonal use of food types by kokako during the study.

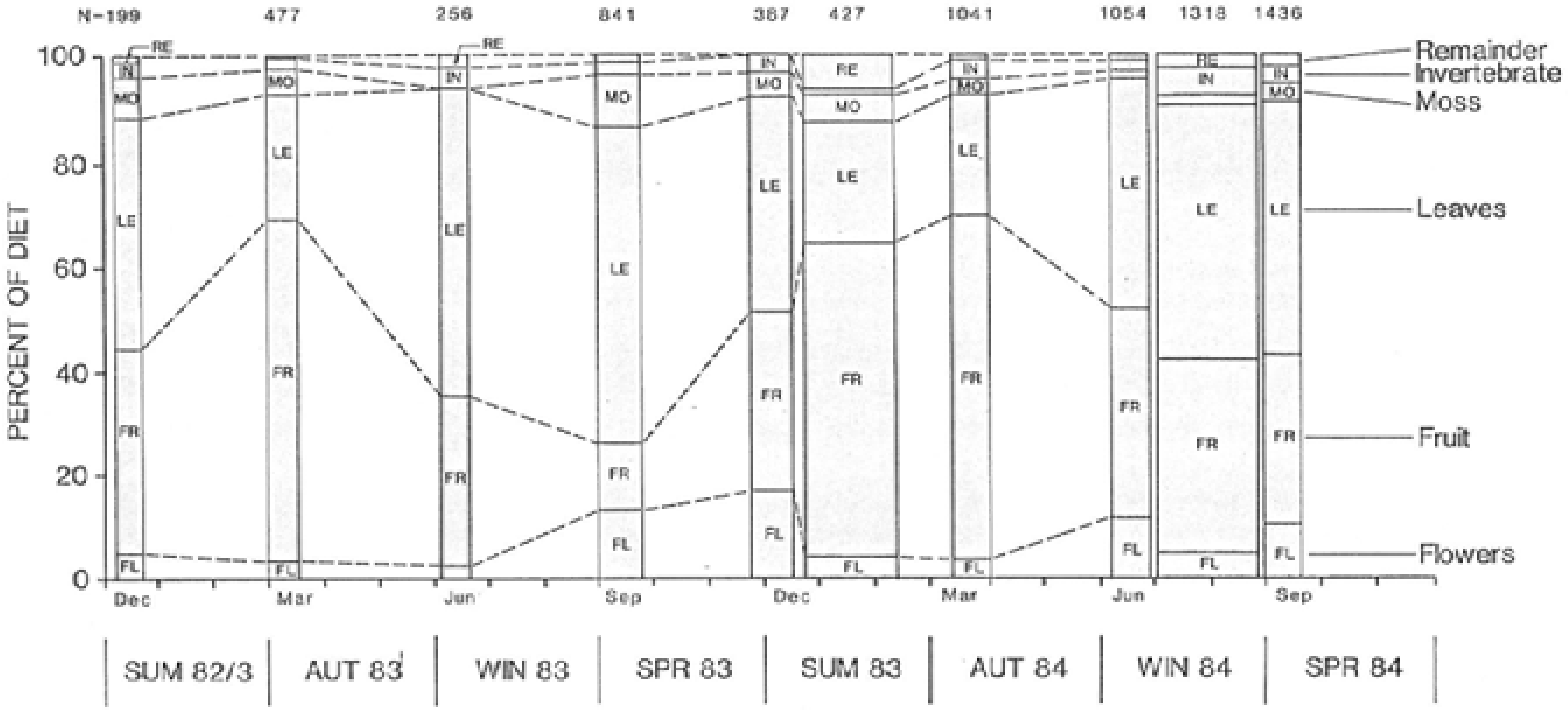


Figure 4.5: Use of food types in five kokako home ranges over three seasons.
BA = bark, FL = flowers, FR = fruit, LE = leaves, MO = moss, IN = invertebrate, OT = other.

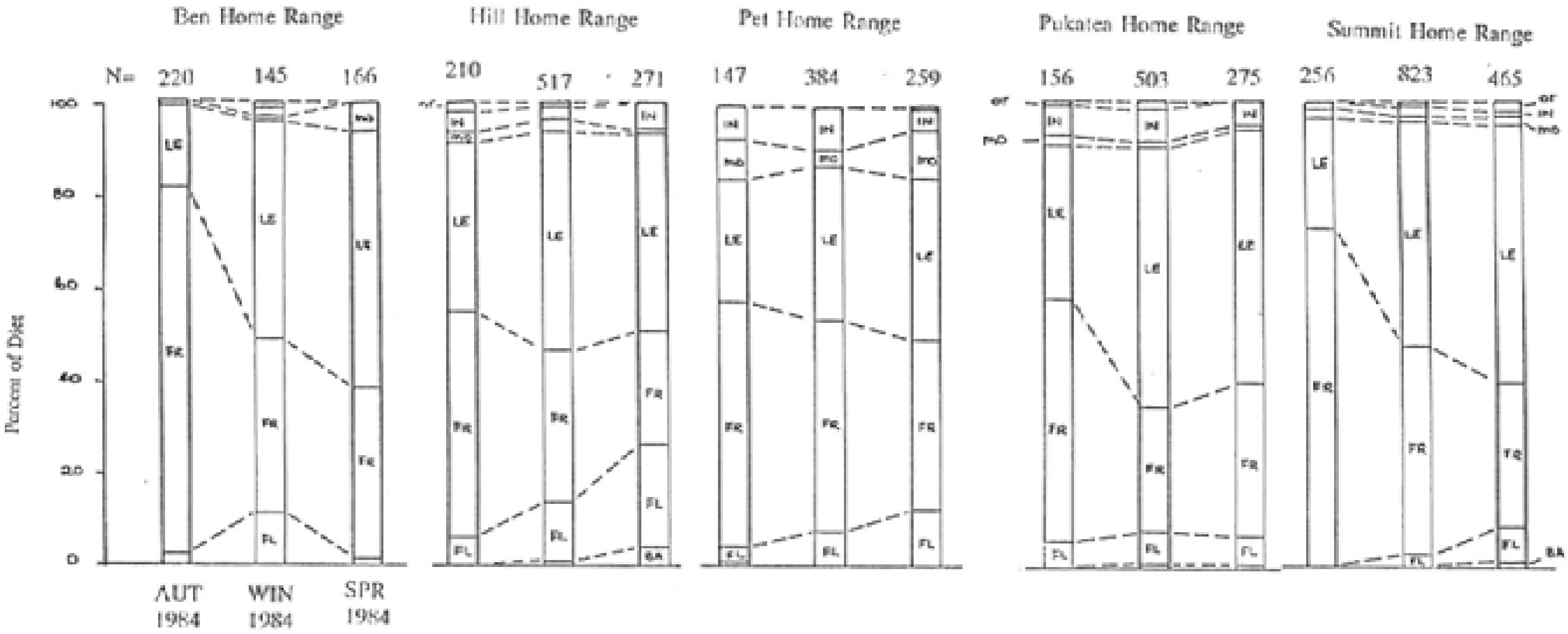
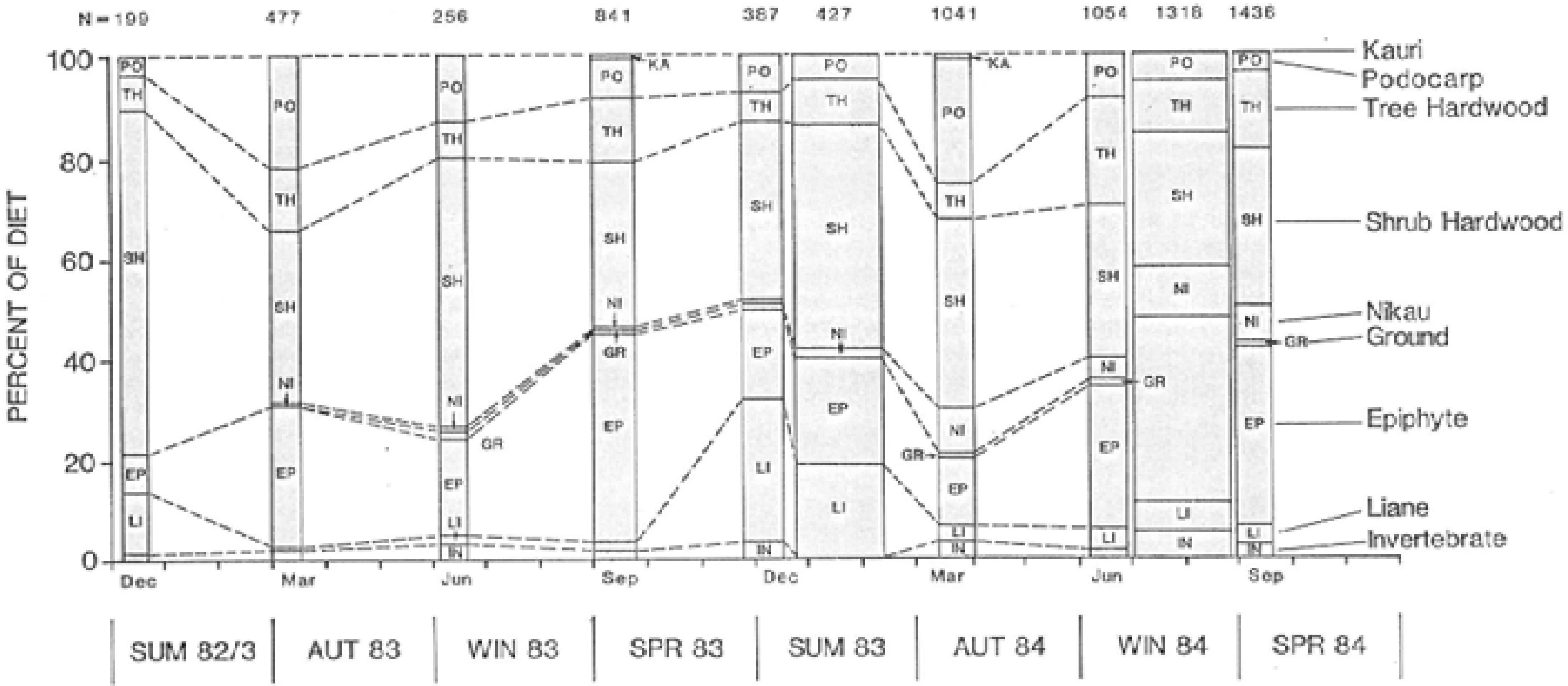


Figure 4.6: Seasonal use of food classes by kokako over the study.



igure 4.7: **Use of food classes in five kokako home ranges over three seasons.**
A = kauri, PO = podocarps, TH = tree hardwood, SH = shrub hardwood, NI = nukau palm, EP = epiphyte, LI = liane, IN = invertebrate, OT = other

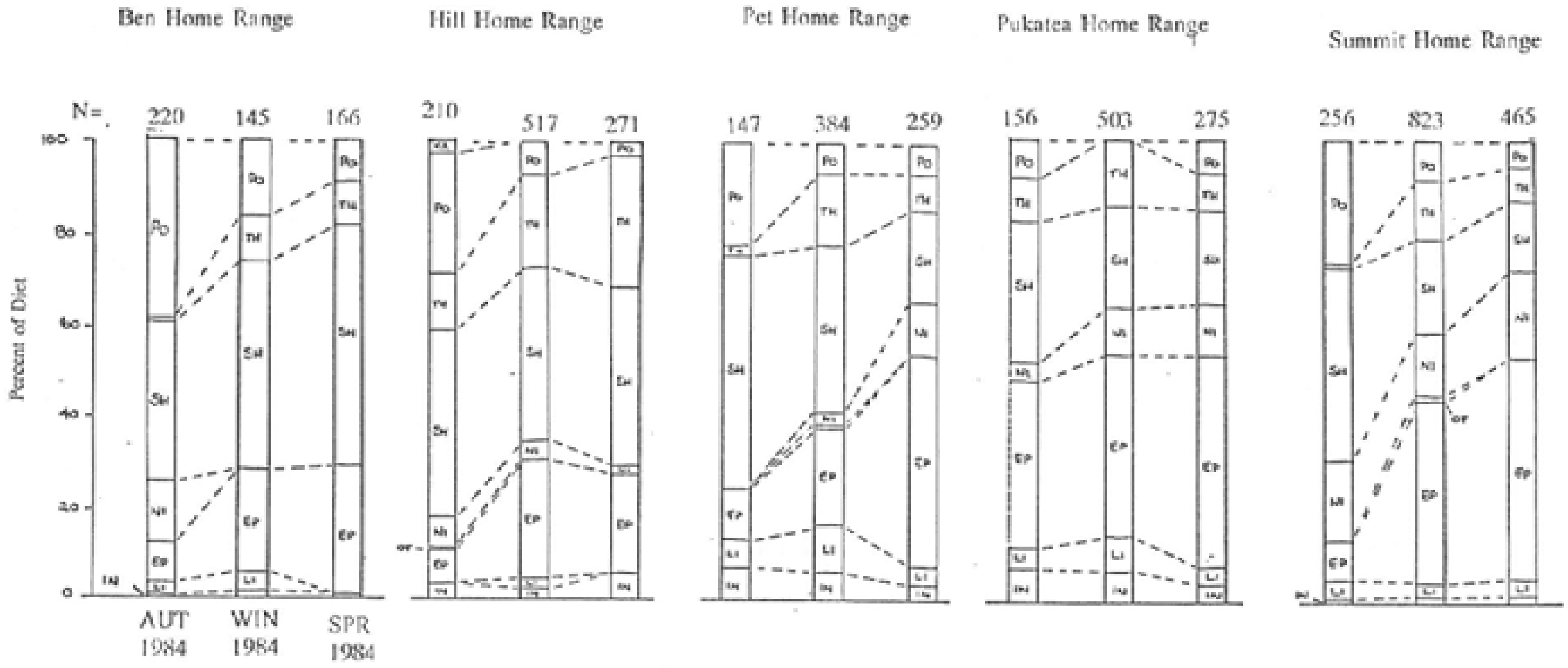


Figure 4.8: Seasonal use of food hosts by kokako during the study.

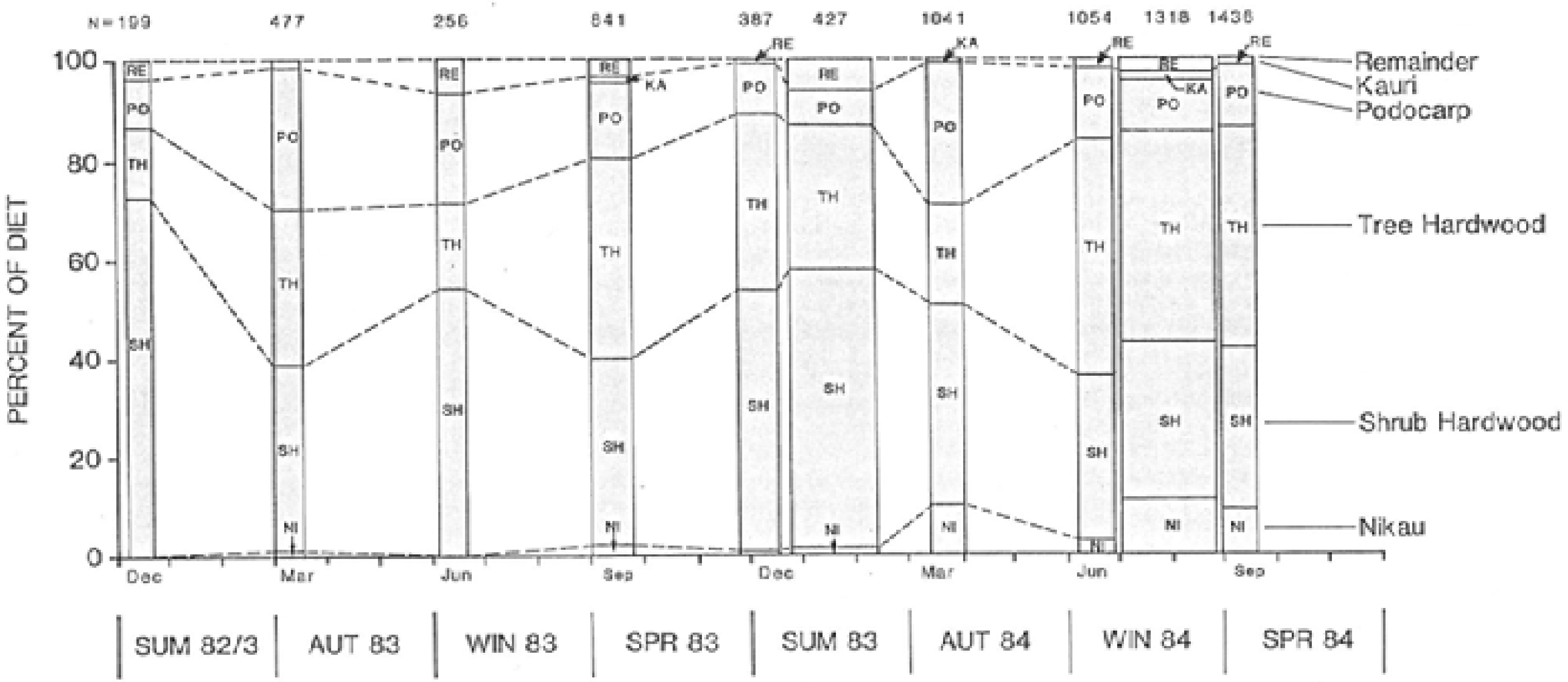


Figure 4.9: Use of food hosts by kokako in five home ranges over three seasons.
KA = kauri, PO = podocarps, TH = tree hardwood, SH = shrub hardwood, NI = nukau palm, OT = other

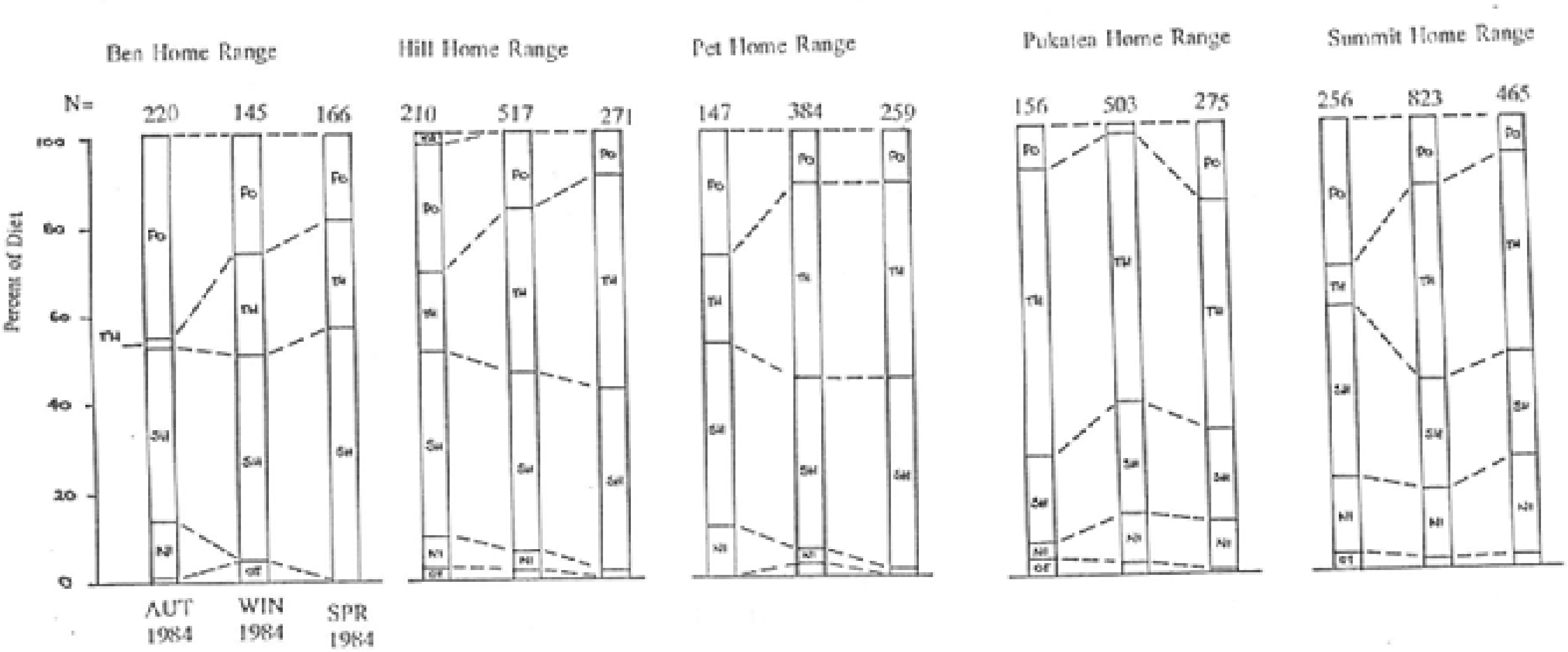


Figure 4.10: Seasonal variation in kokako activities (N = 23236).

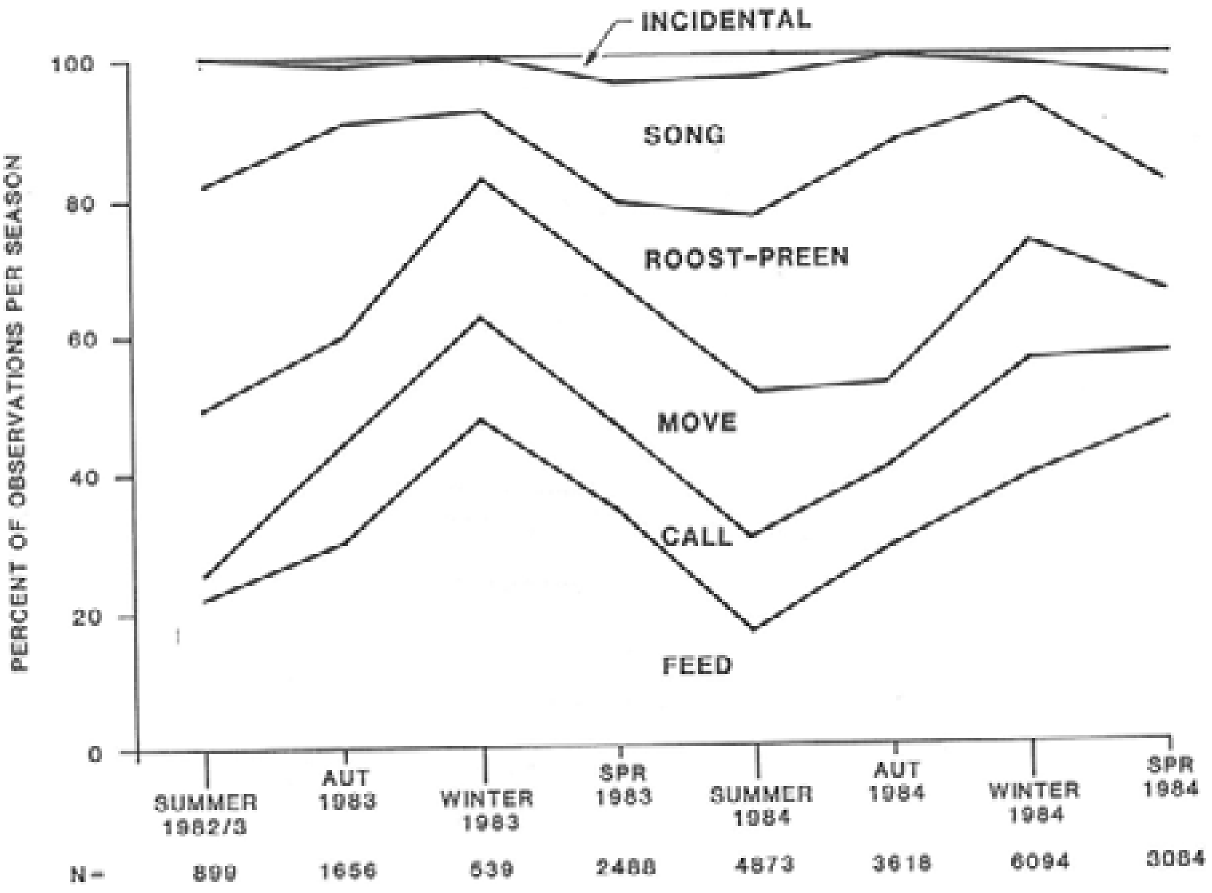


Figure 4.11: Comparison of diurnal activity patterns of kokako between summer and winter.

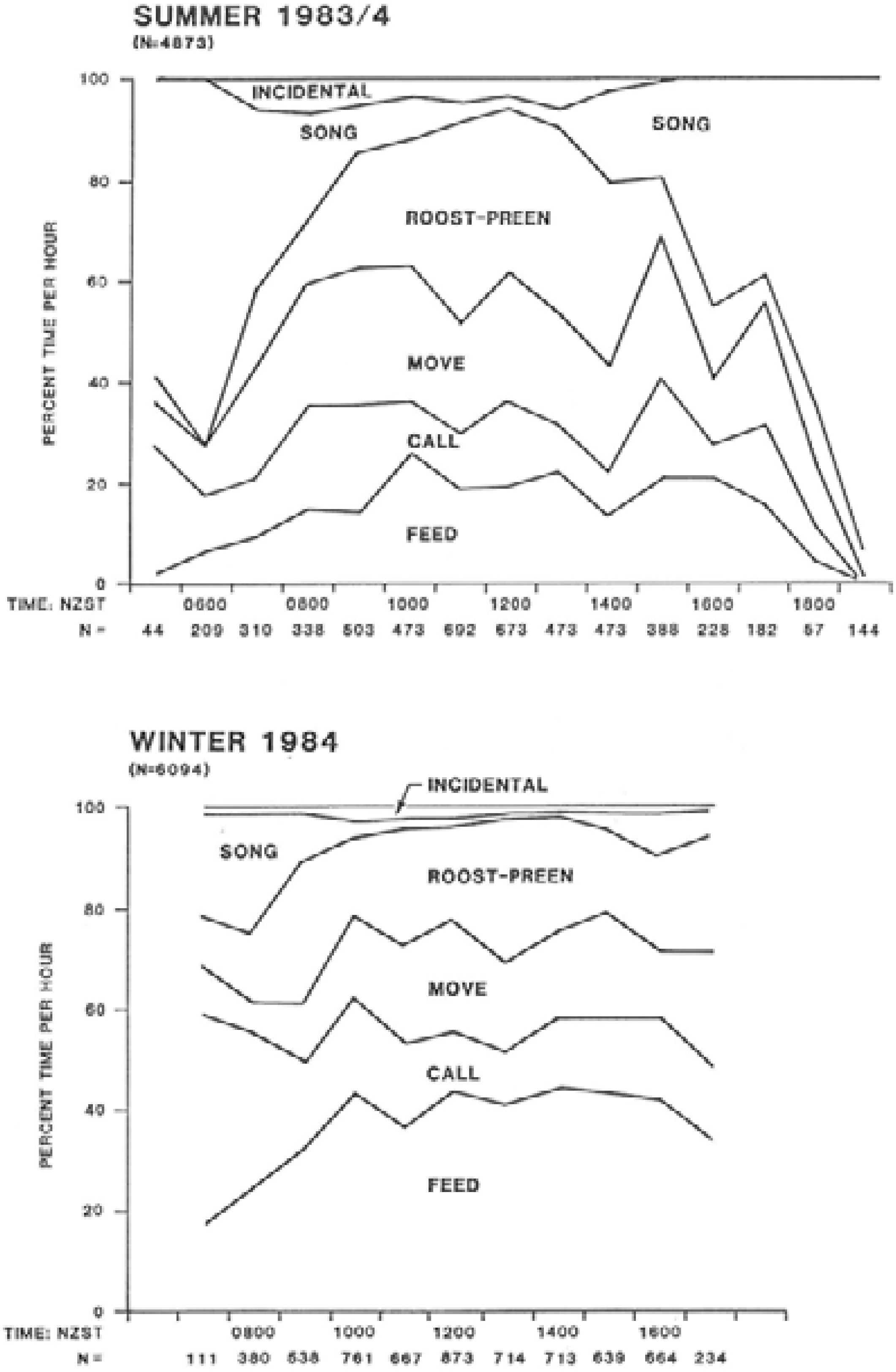


Figure 4.12: Use of perches by kokako for various activities. For Remainder (Feeding): epiphytes were perched on 5.8% of the time, and lianes 3.6%. For Remainder (Incidental); birds perched mainly on epiphytes (13.6% of the time), or on the ground (4.8%).

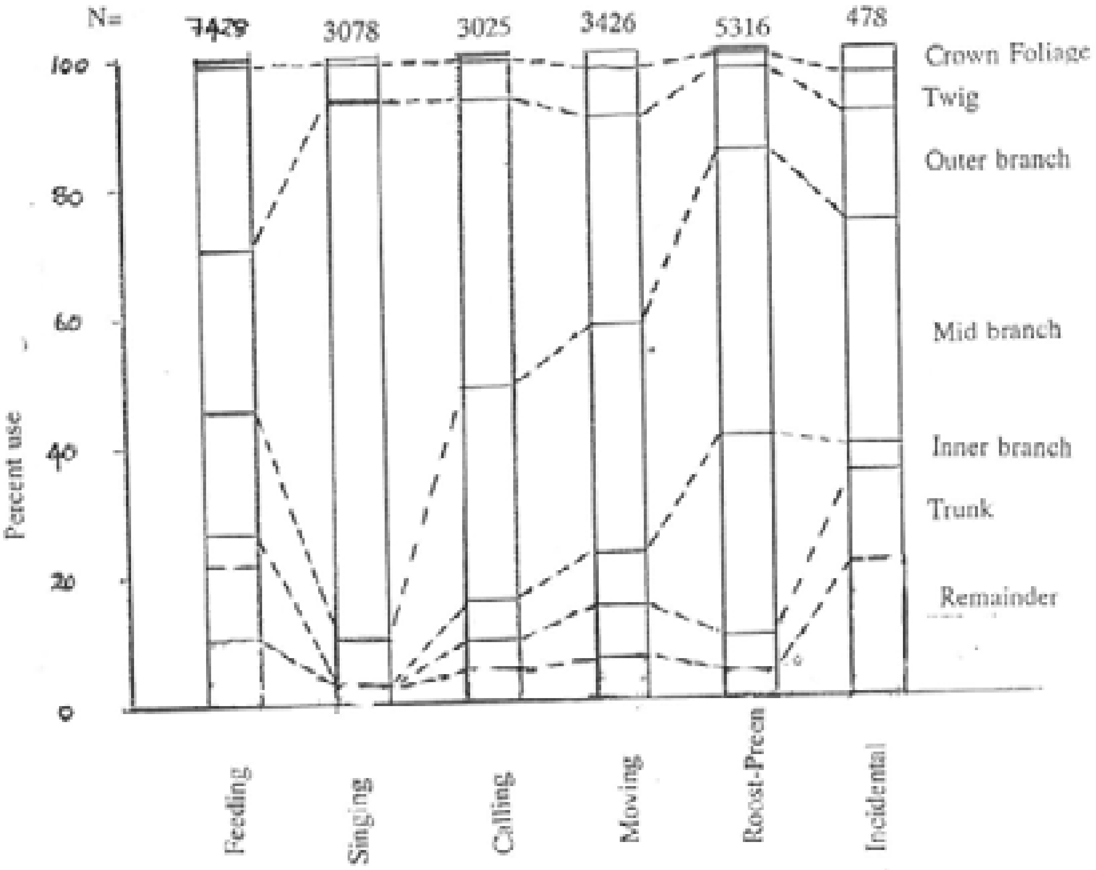


Figure 4.13: Use of vegetation tiers by kokako for various activities.

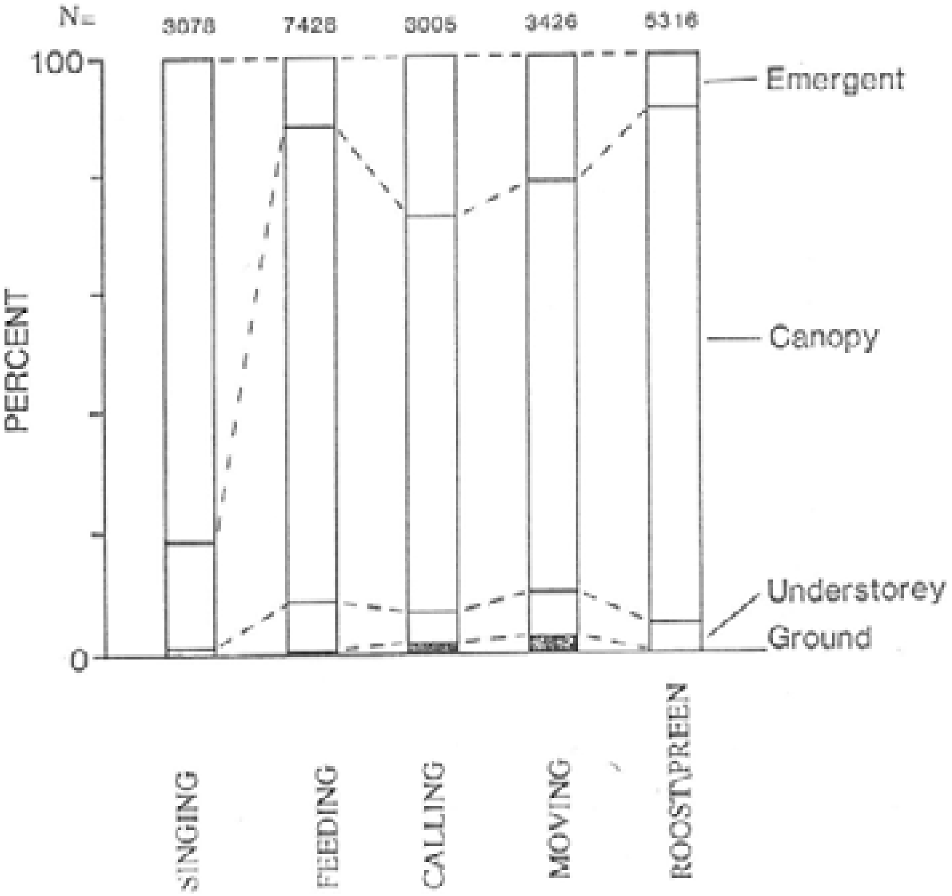


Figure 4.14: Use of vegetation classes by kokako for various activities. Note: Other = nikau, tree fern, ground, liane (as self-entwined thickets, not obviously attached to a single host tree), dead tree and unidentified.

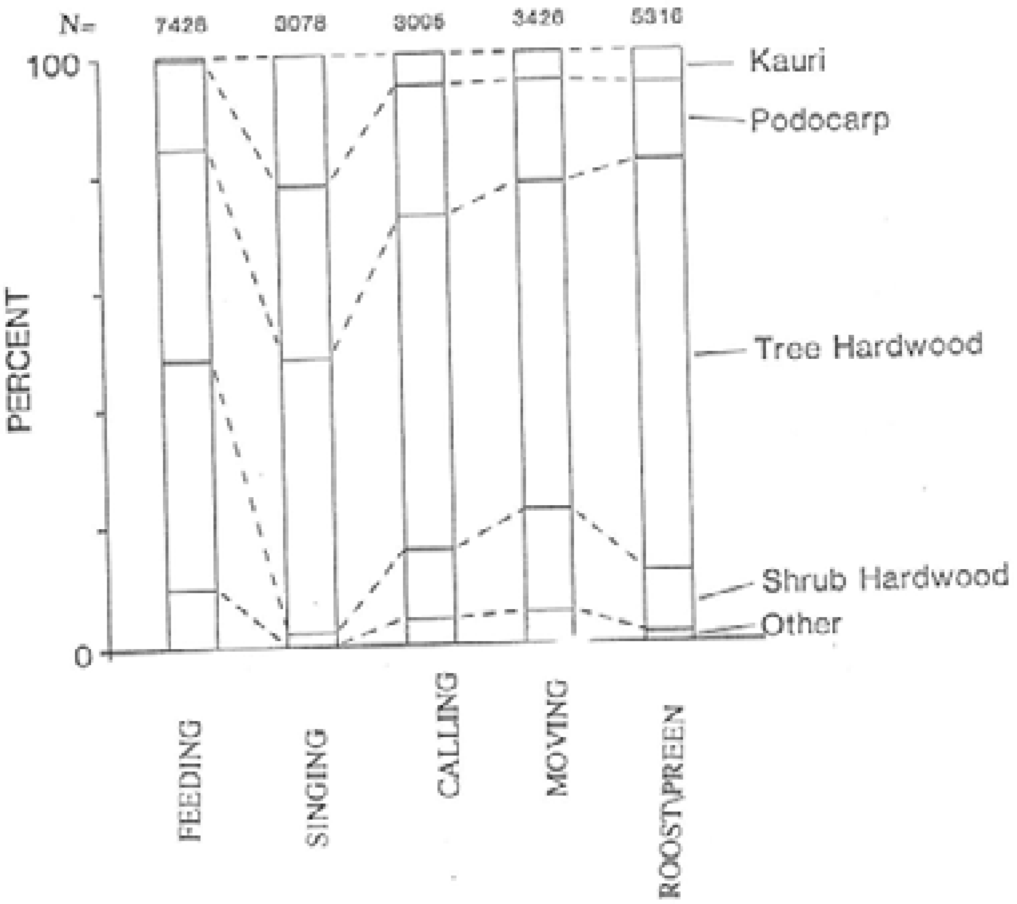


Figure 4.15: Use of vegetation classes in five kokako home ranges for singing,calling, moving, and roosting-preening. Note: Other = nikau, tree fern, ground, liane (as self-entwined thickets not obviously attached to a single host tree), dead tree and unidentified.

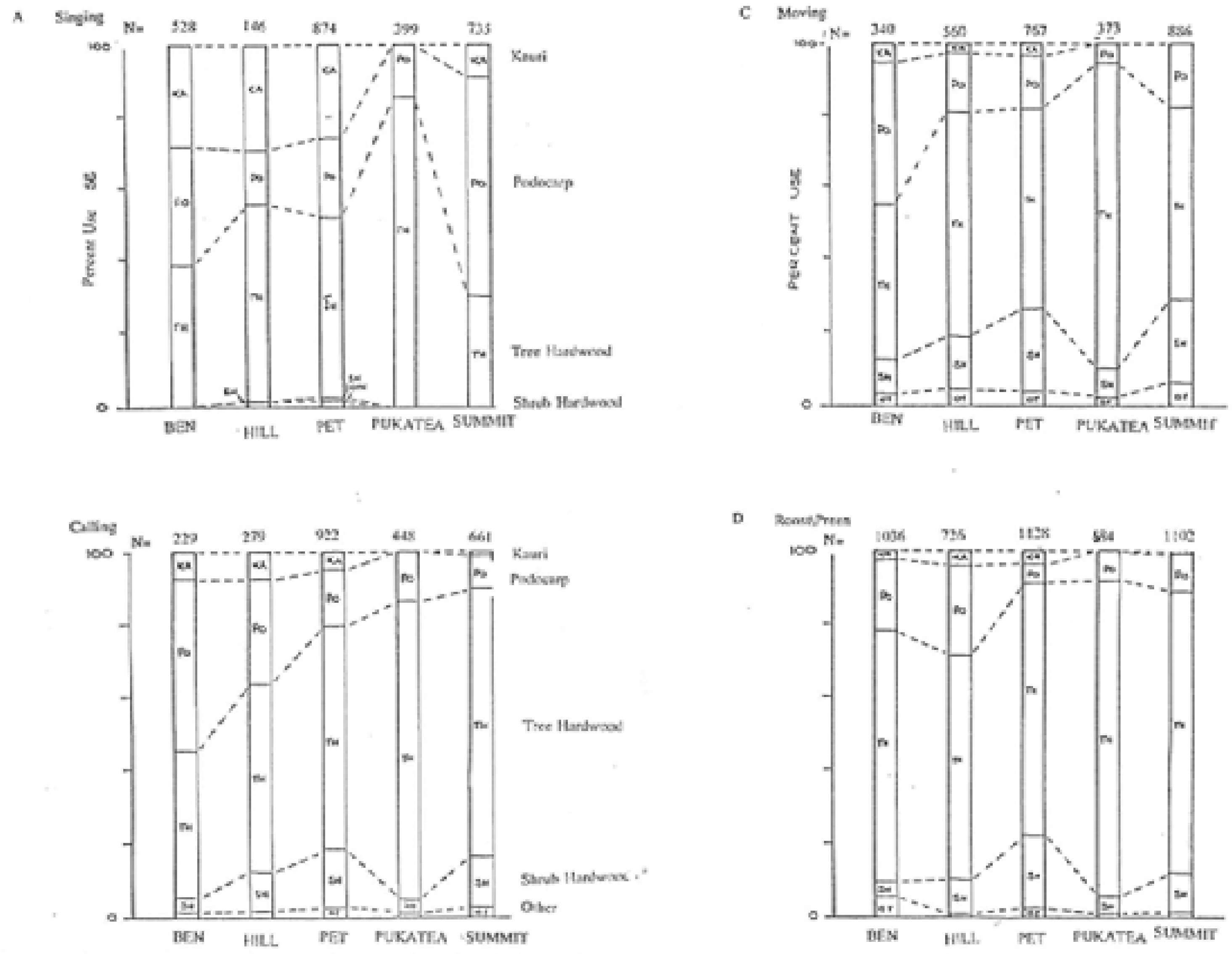


Figure 4.16: Use of forest height levels by kokako for various activities.

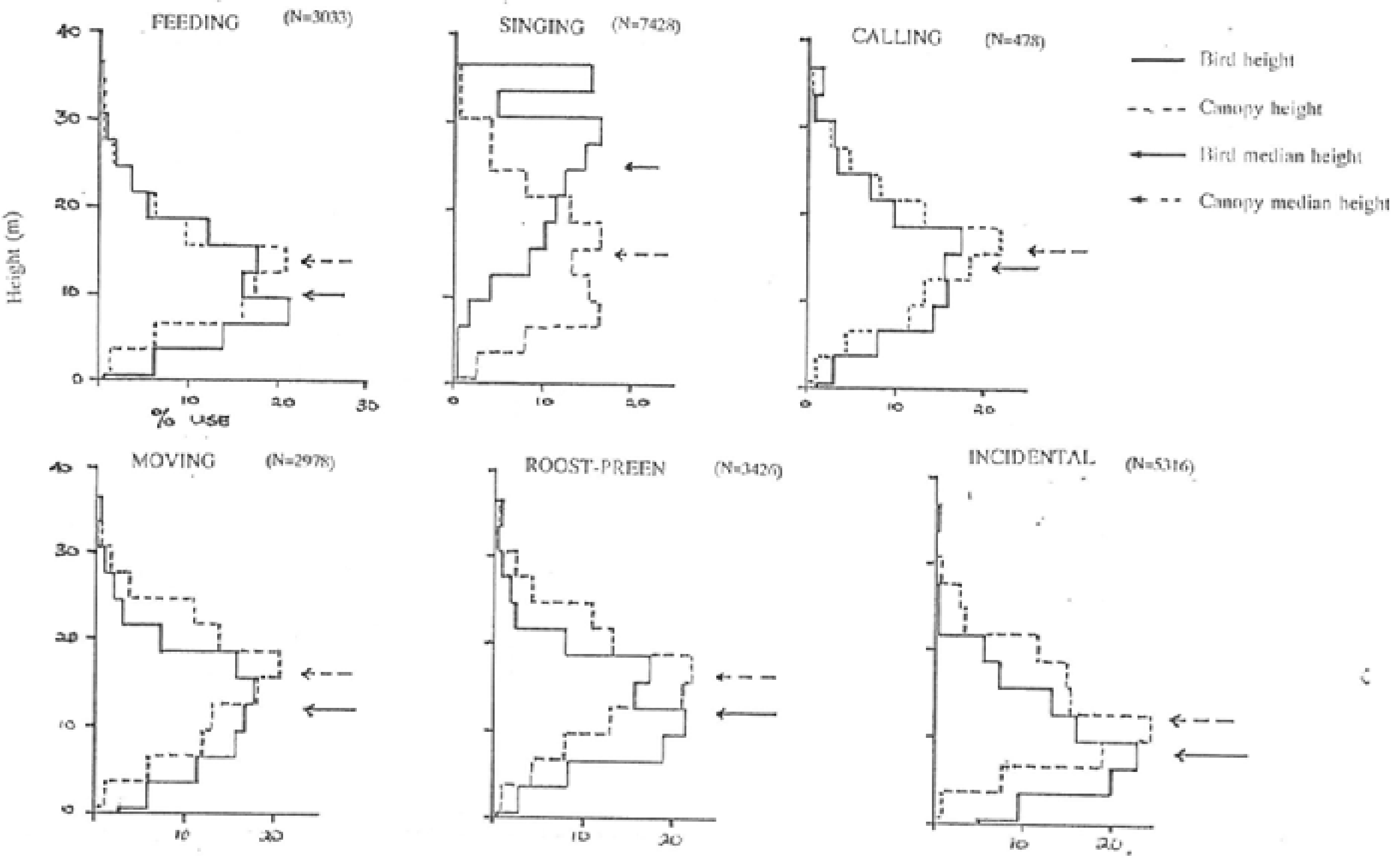


Figure 4.17: Use of forest height levels for singing in five kokako home ranges.

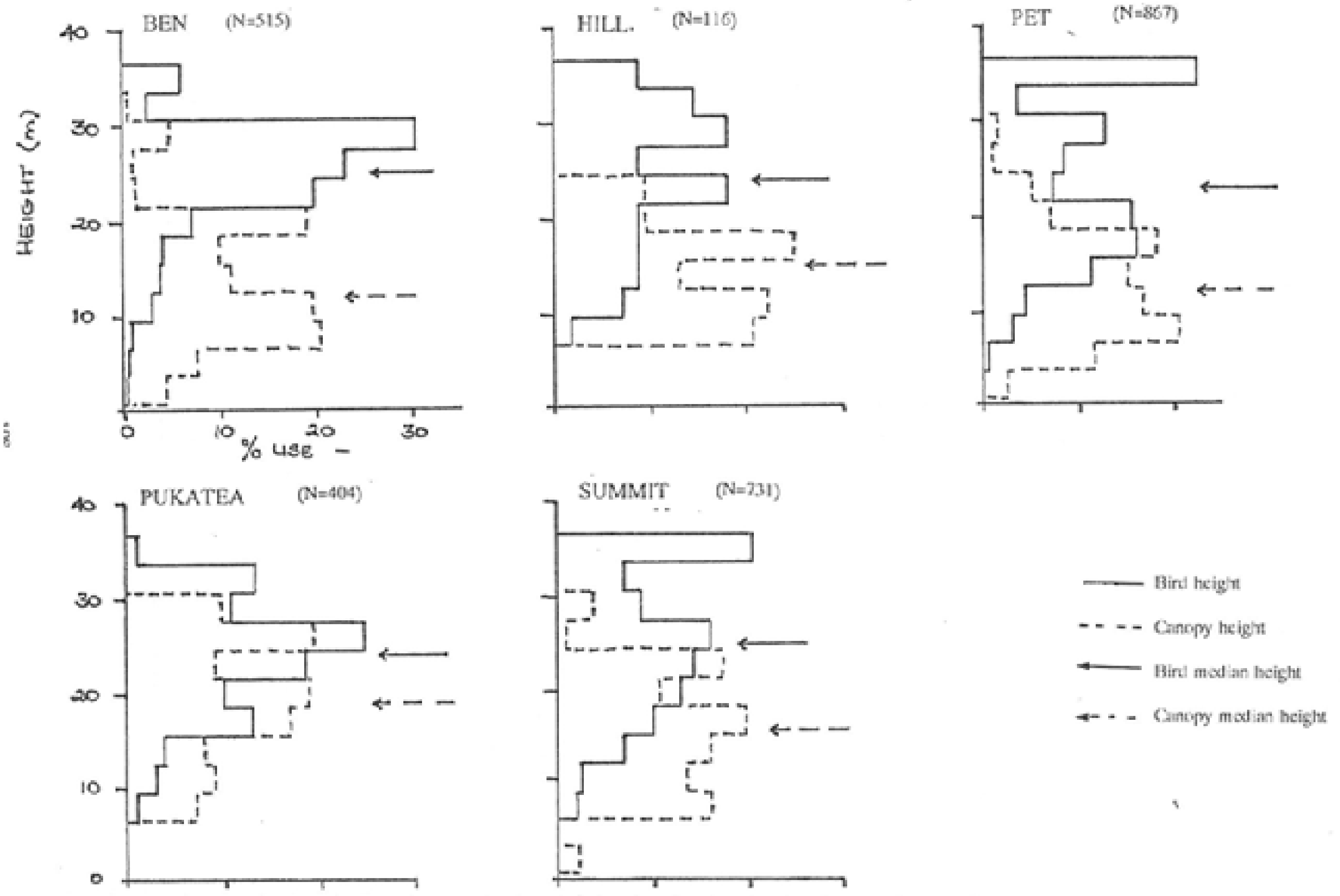


Figure 4.18: Use of forest height levels for calling in five kokako home ranges.

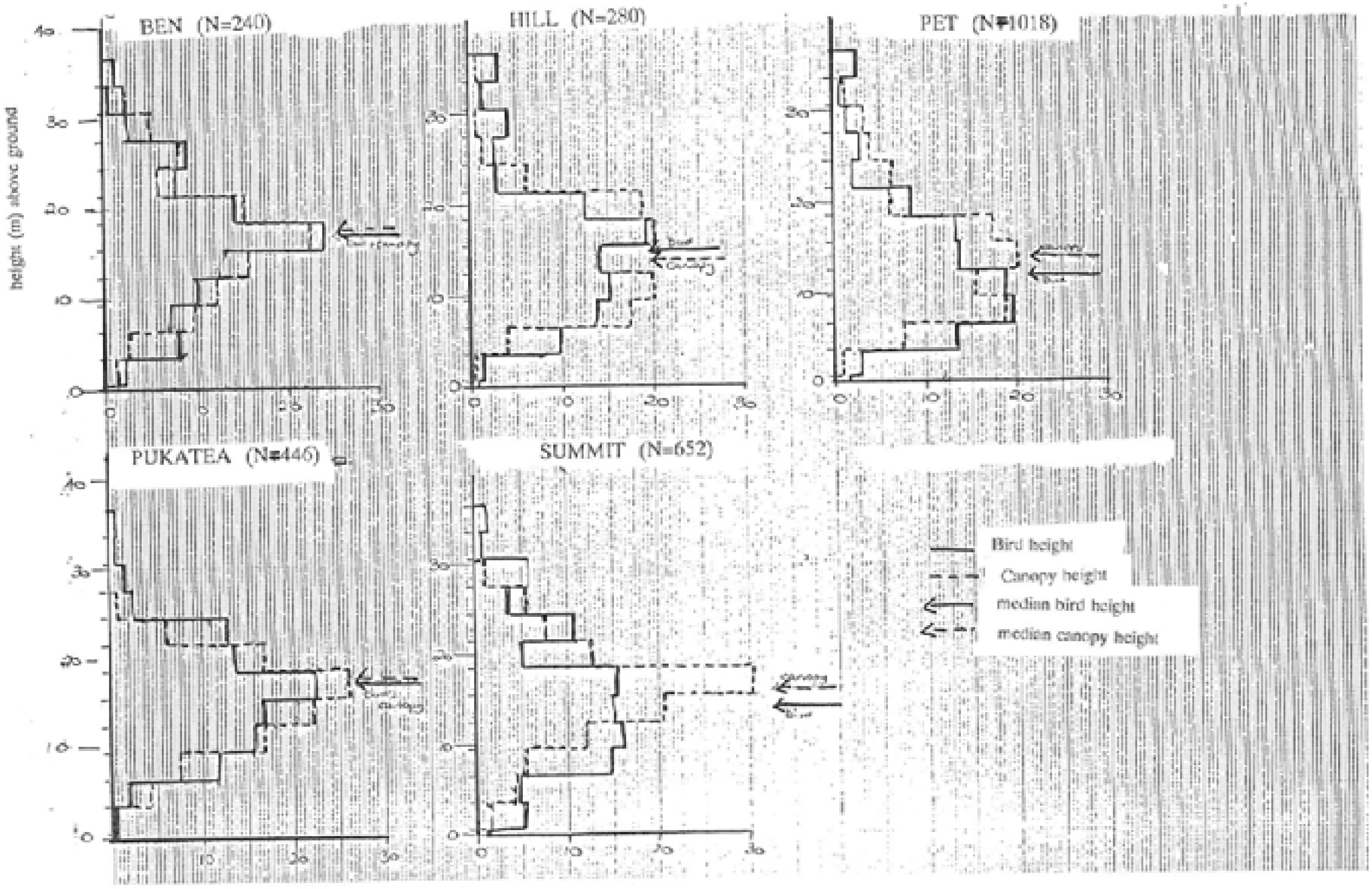


Figure 4.19: Use of forest height levels for moving in five kokako home ranges.

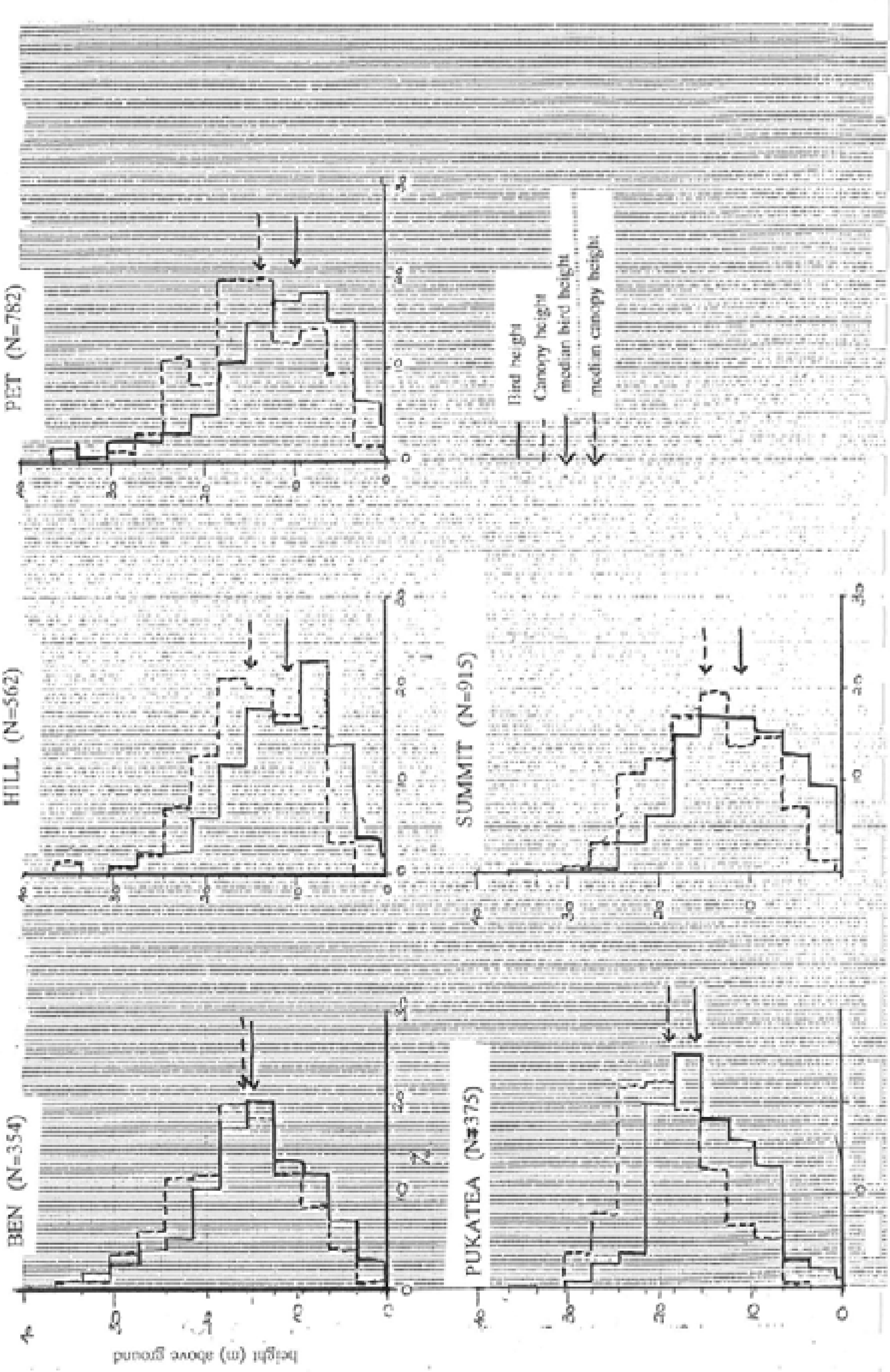


Figure 4.20: Use of forest height levels for roosting-preening in five kokako home ranges.

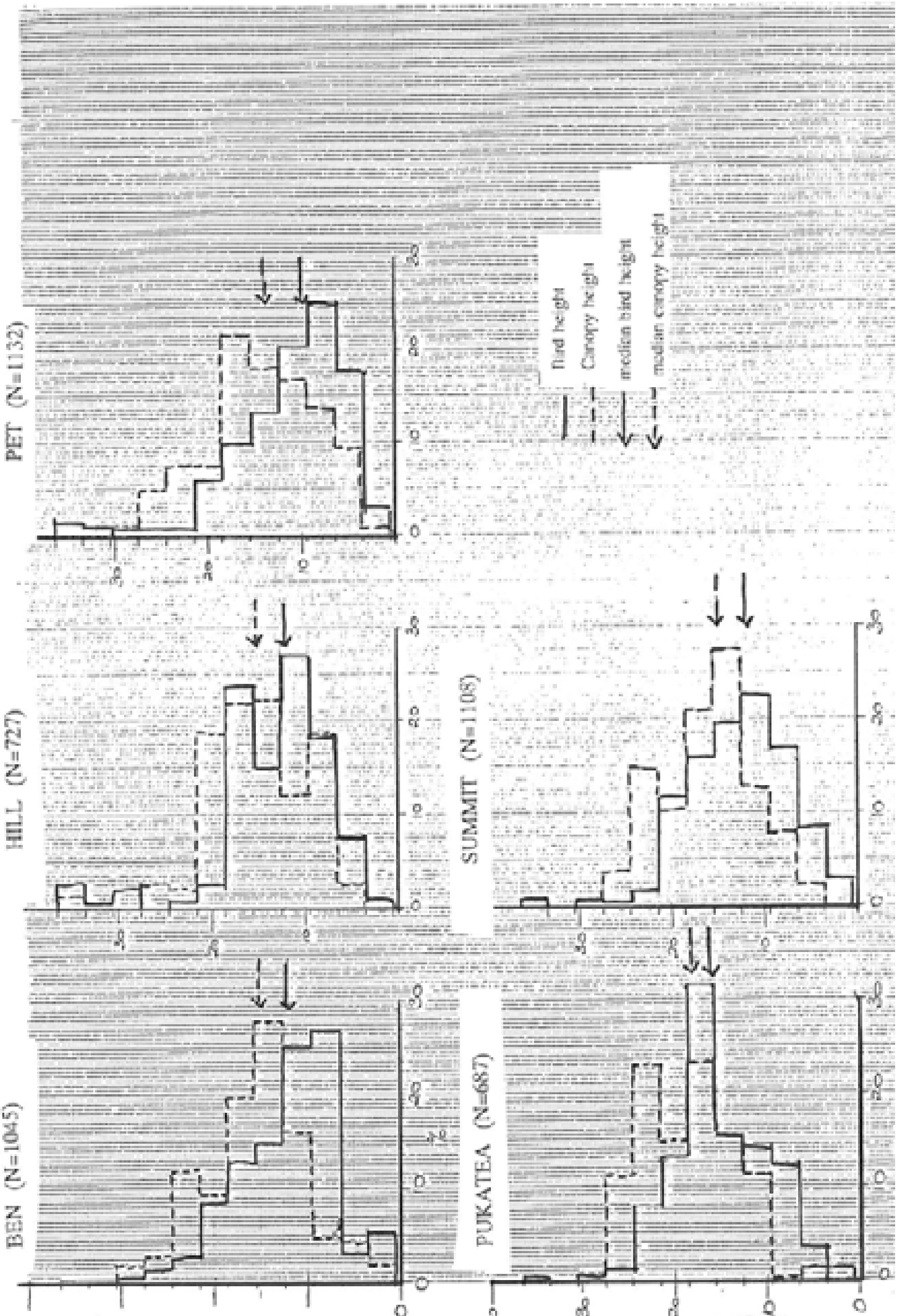


Figure 4.21: Variation in median feeding heights of kokako with season.

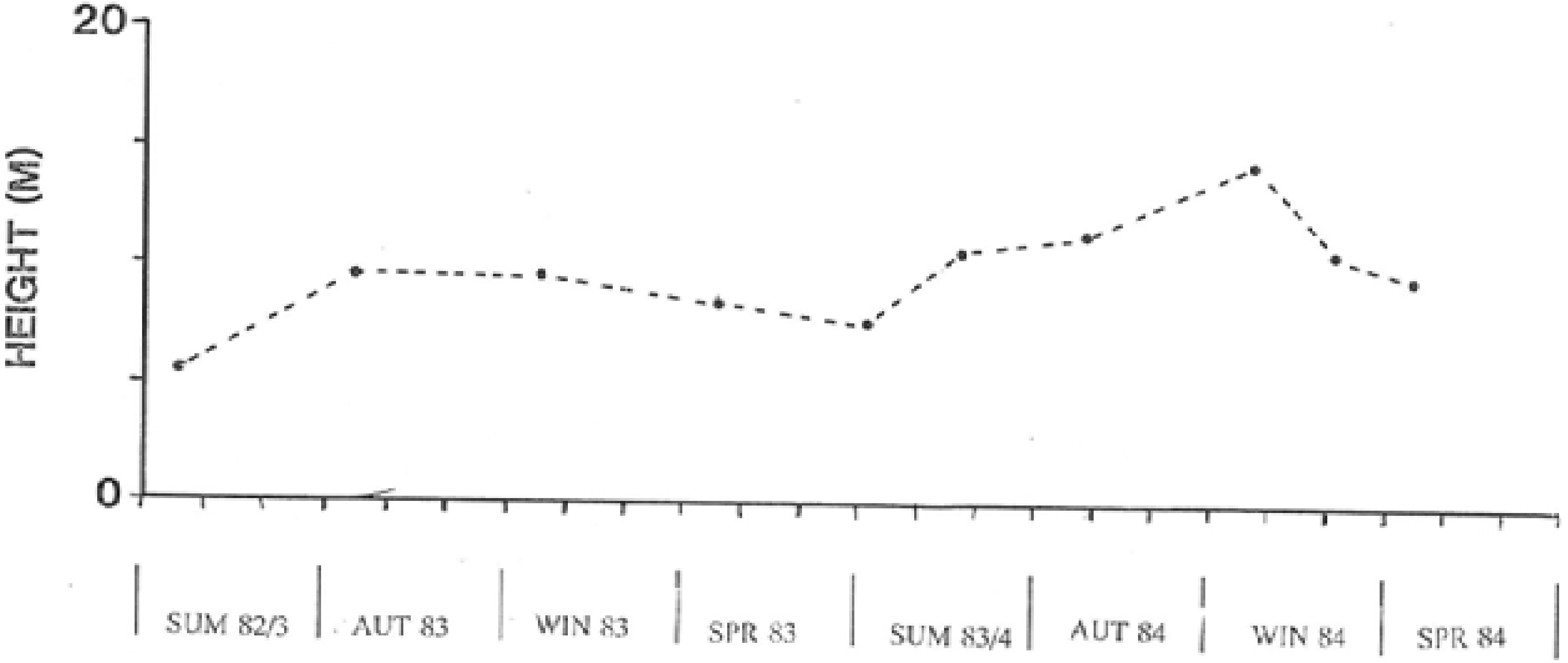


Figure 4.22: Seasonal variation in median feeding heights in five kokako home ranges. For changes in canopy height with season, see footnote, Section 4.2.3.D(iv)b

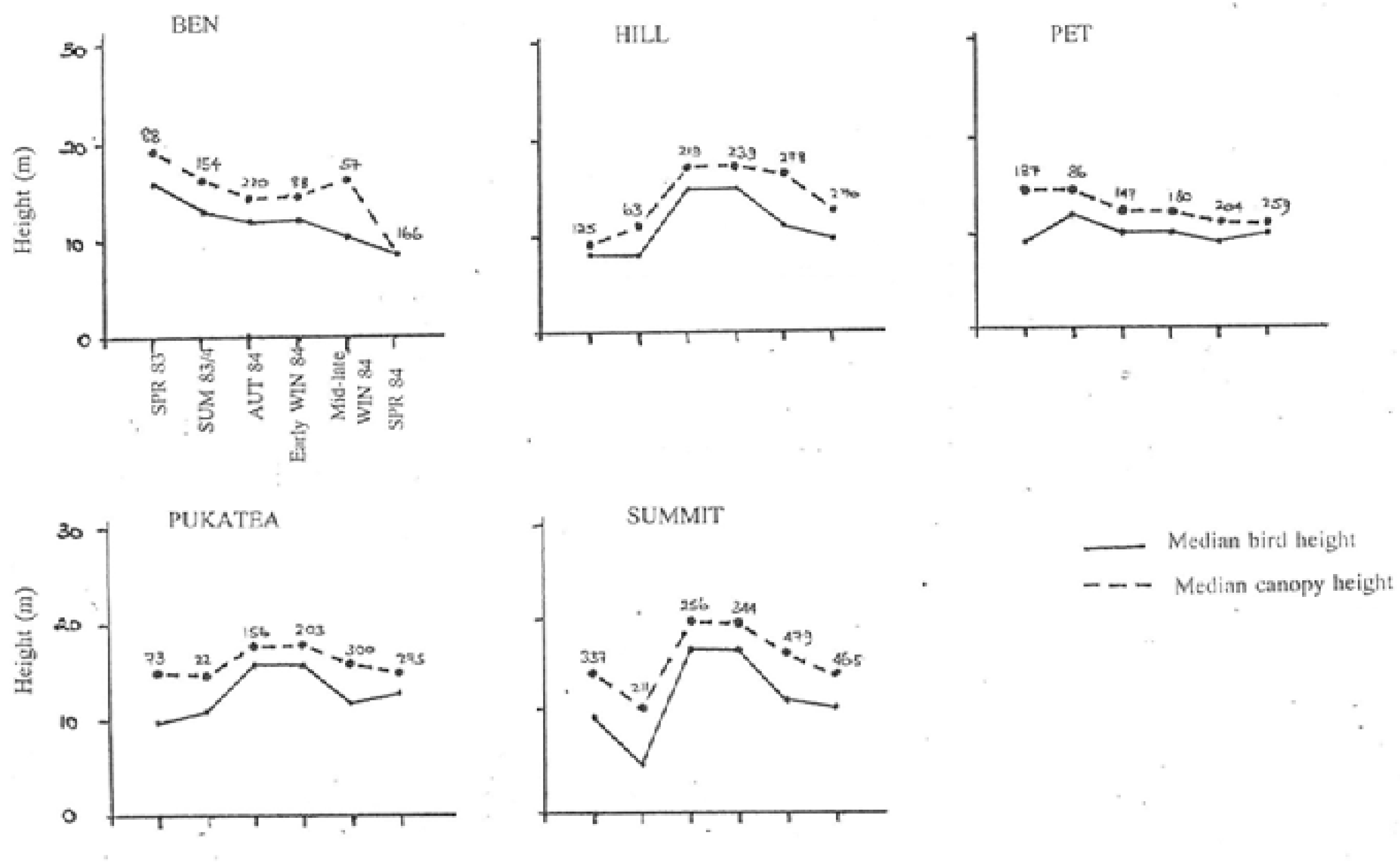


Figure 4.23: A. Distribution of all activities in Summit kokako home range from Winter 1983 to Spring 1984 (N = 5575). Scale: squares are 40 x 40m. Perimeter of the gridded portion of the home range marked by heavy black line. Numbers at base of bars are percent frequencies.

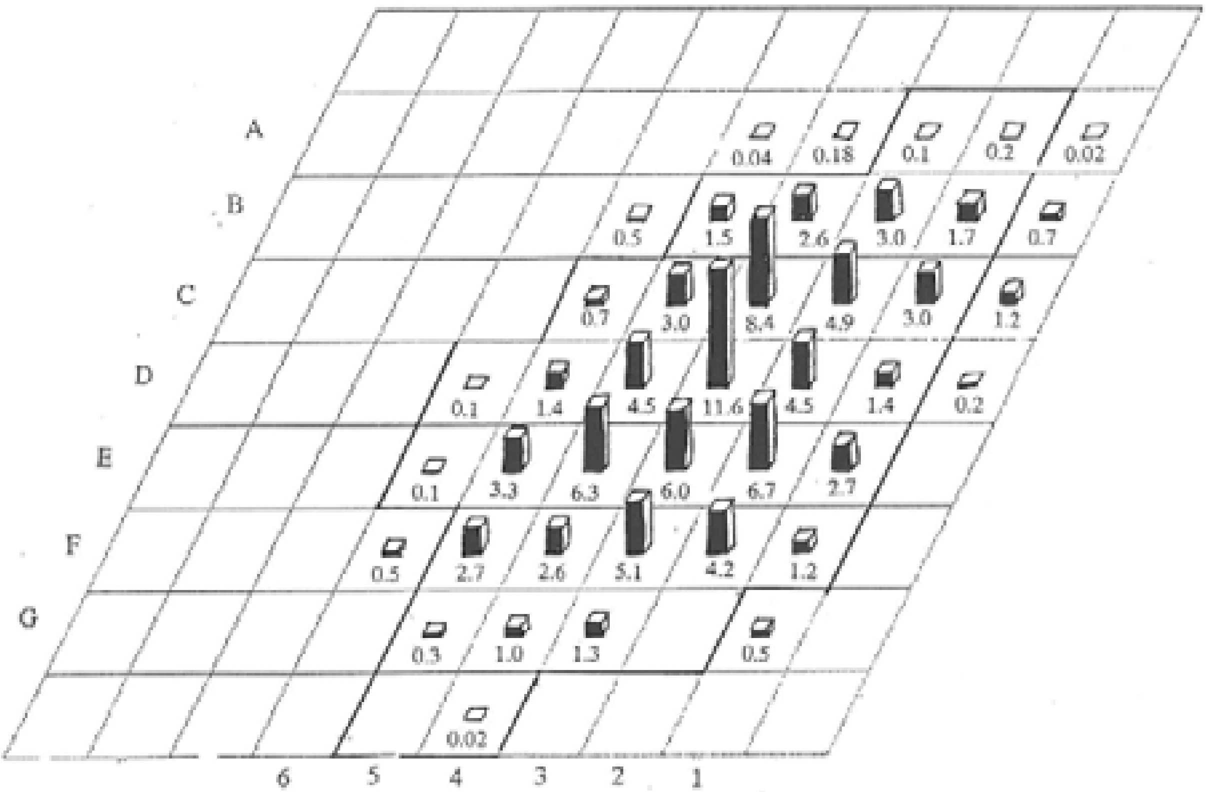


Figure 4.23: B. Distribution of all activities in Pet kokako home range from Spring 1983 to Spring 1984 (N = 4307). Scale: squares are 40 x 40m. Perimeter of the gridded portion of the home range marked by heavy black line. Numbers at base of bars are percent frequencies. Most of the activities recorded from unknown grids occurred during Spring 1983 in grids C1, D1, D2, E1, F1, which were not marked out at that time.

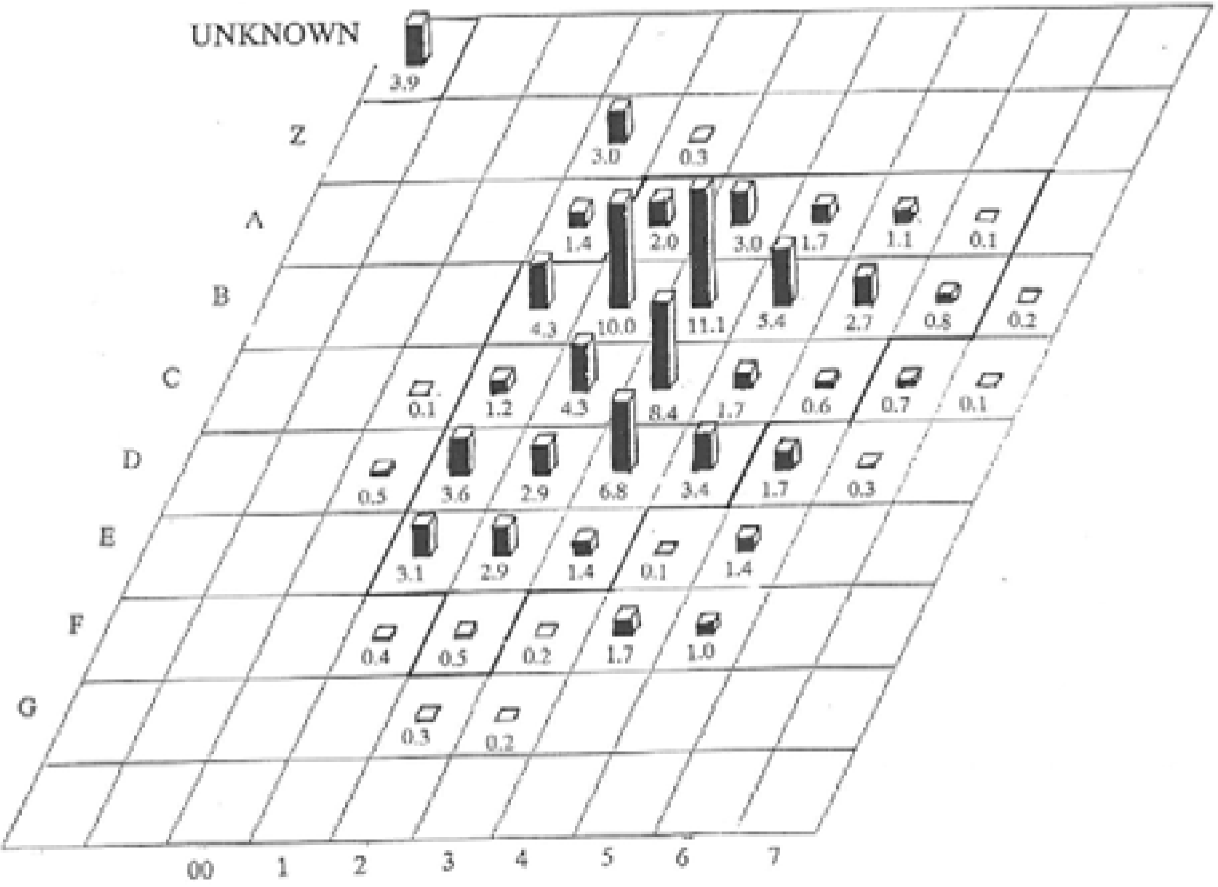


Figure 4.24: Seasonal distribution of all kokako activities in Summit home range. Scale: squares are 40 x 40m. Perimeter of the gridded portion of the home range marked by heavy black line. Numbers at base of bars are percent frequencies.
A. Winter 1983 (N = 447).

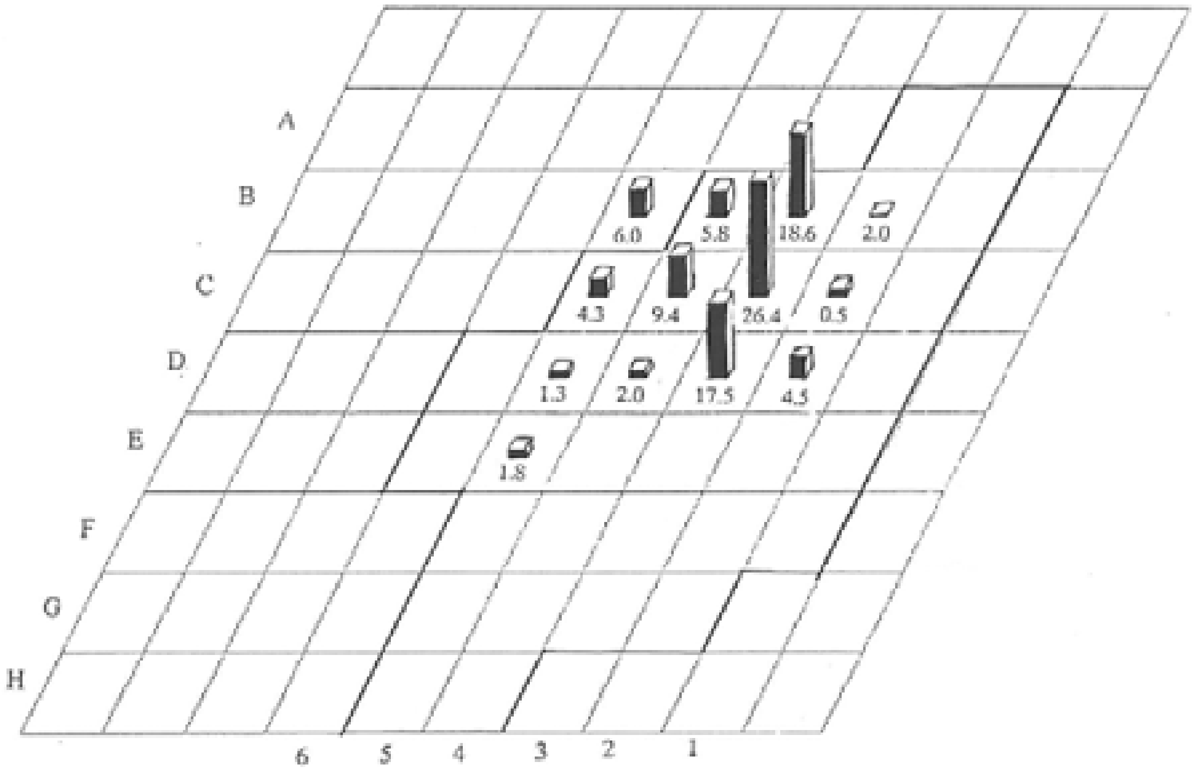


Figure 4.24: B. Spring 1983 (N = 828).

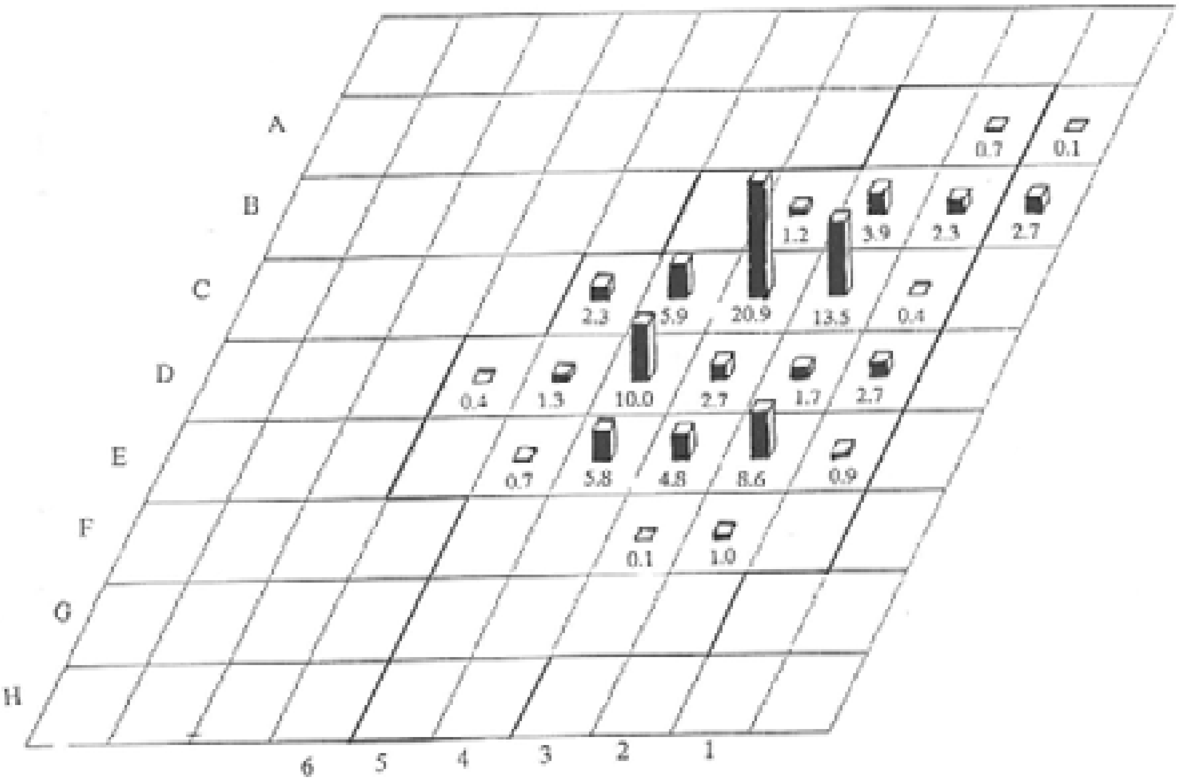


Figure 4.24: C. Summer 1983/84 (N = 733).

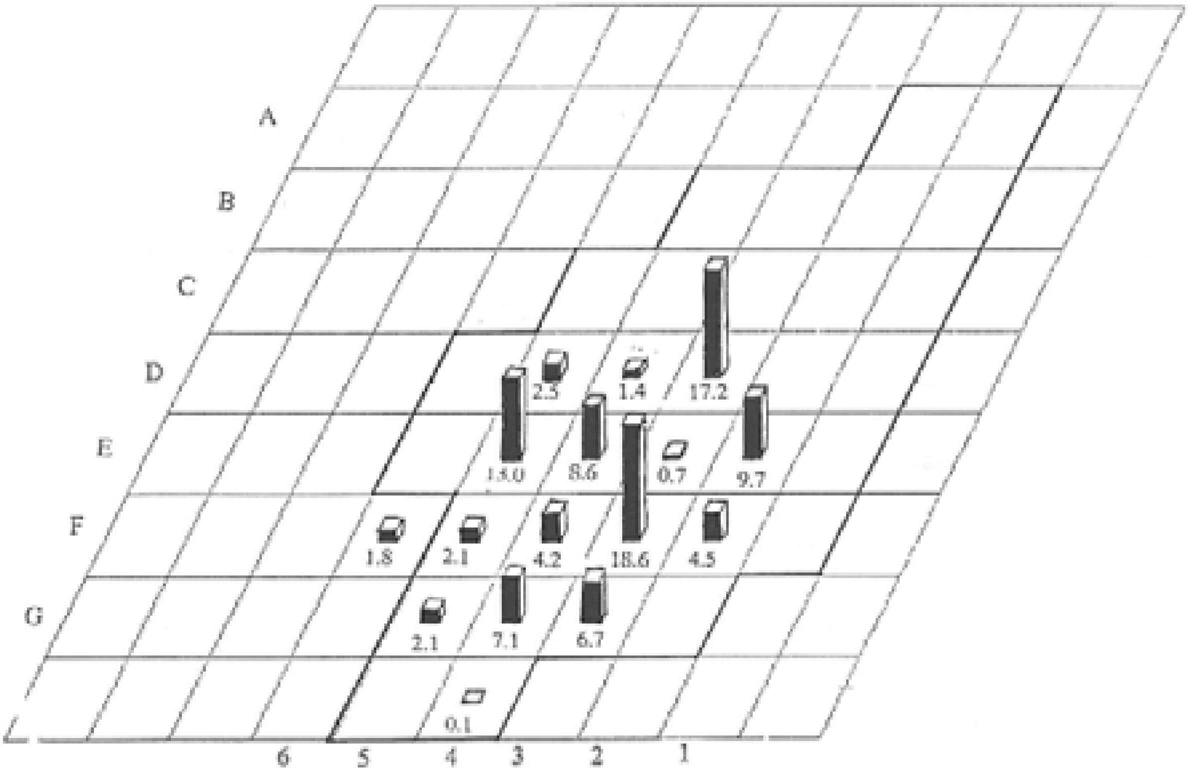


Figure 4.24: D. Autumn 1984 (N = 702).

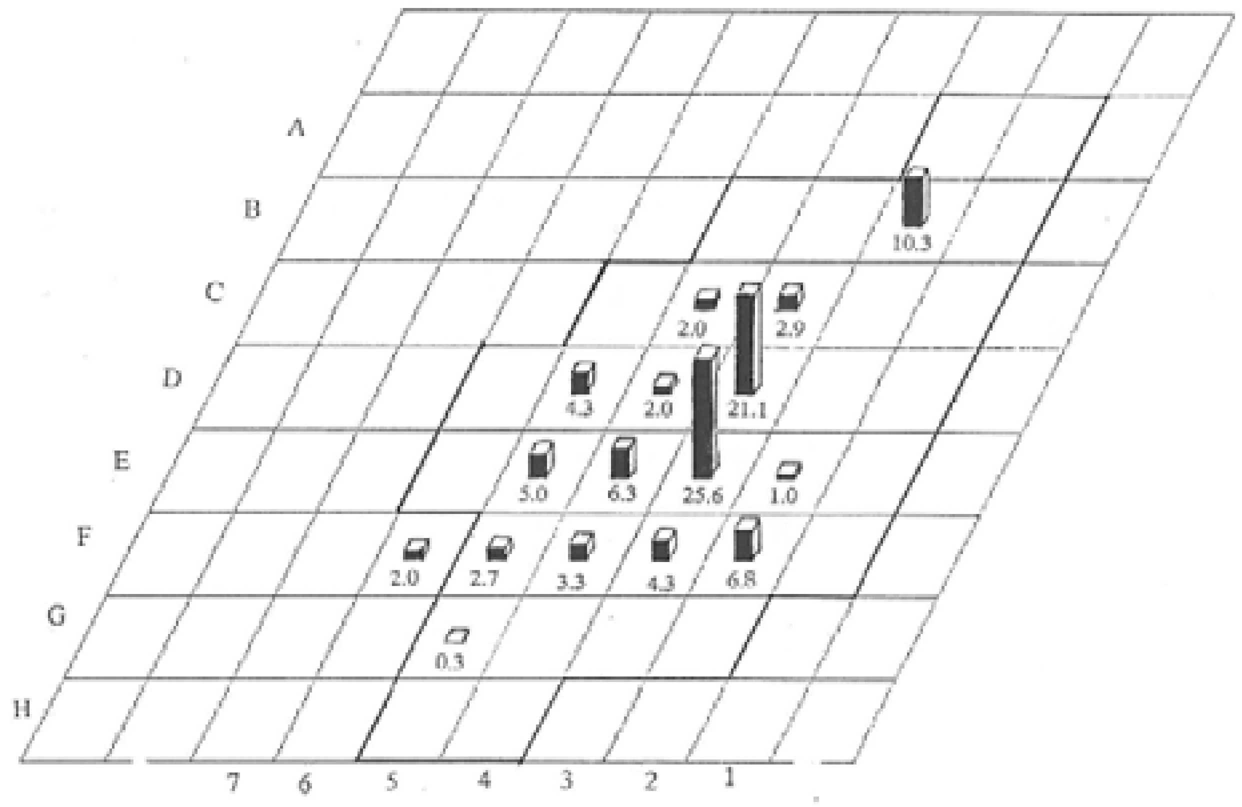


Figure 4.24: E. Early Winter 1984 (N = 708).

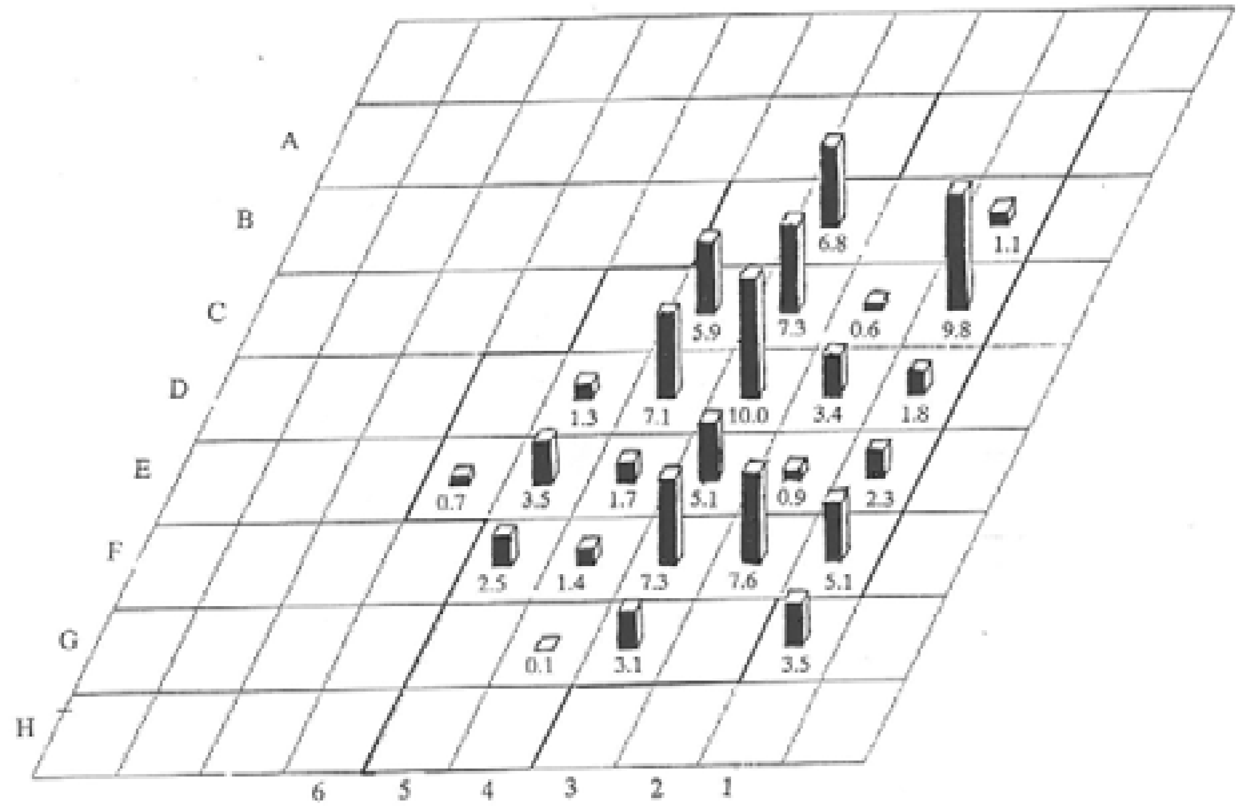


Figure 4.24: F. Mid to late Winter 1984 ($N = 1264$).

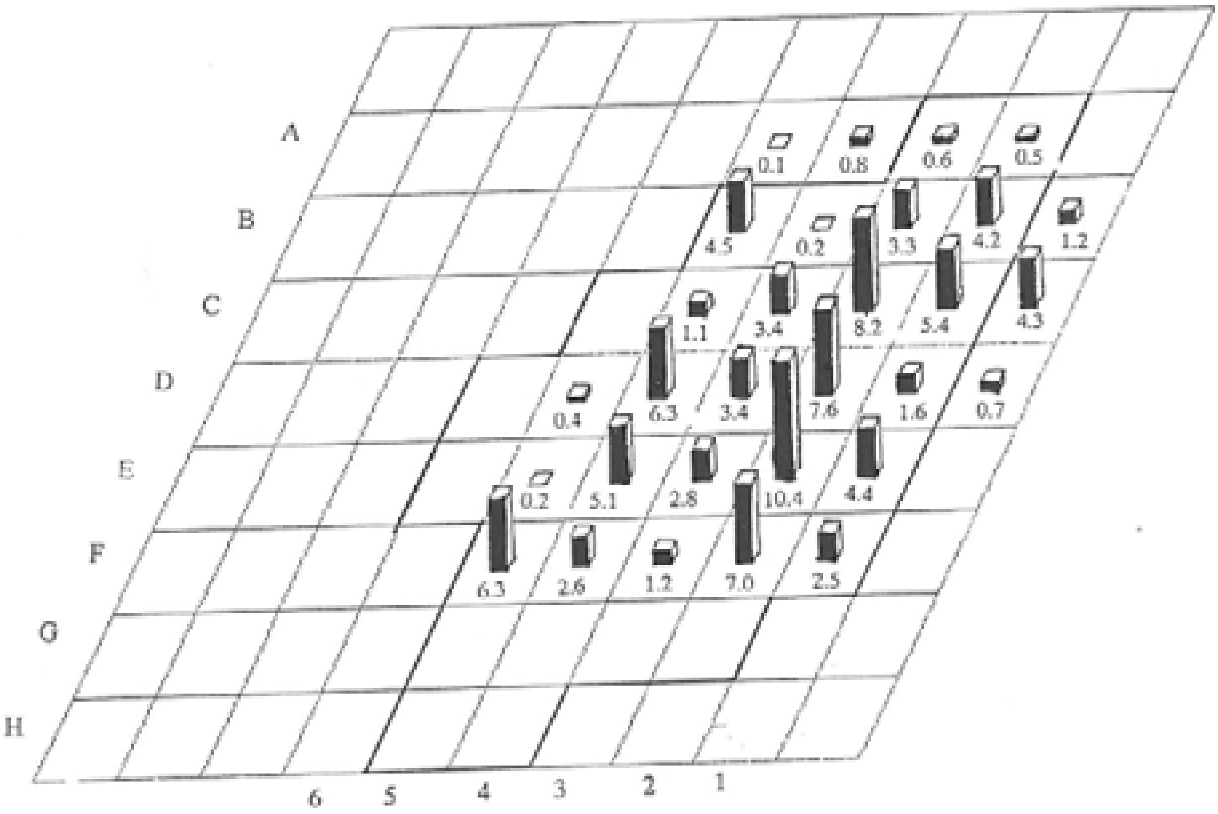


Figure 4.24: G. Spring 1984 (N = 893).

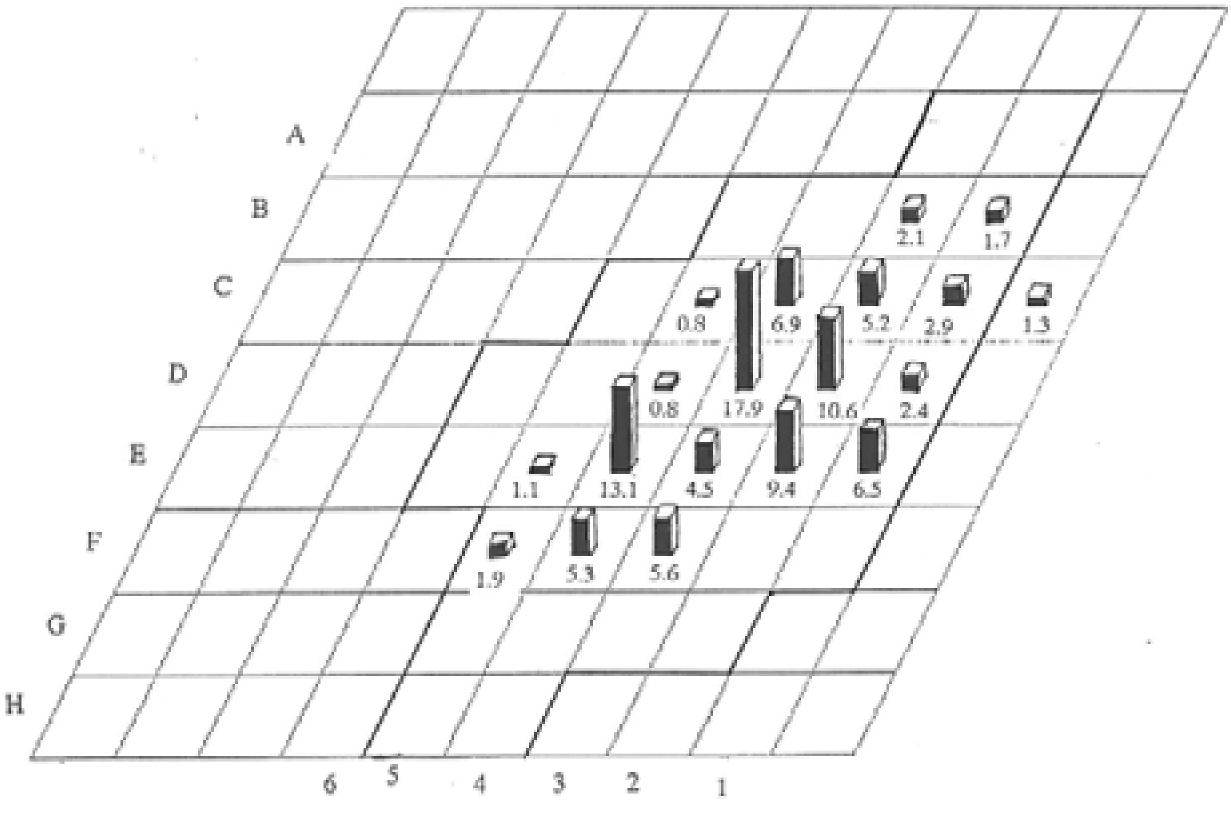


Figure 4.25: Distribution of activities in Pet kokako home range between Spring 1983 and Spring 1984. Scale: squares are 40 x40m. Perimeter of the gridded portion of the home range marked by heavy black line. Numbers at base of bars are percent frequencies. Most of the activities recorded from unknown grids occurred during Spring 1983 in grids C1, D1, D2, E2, F1 which were not marked out at the time.
A. Feeding (N = 1063).

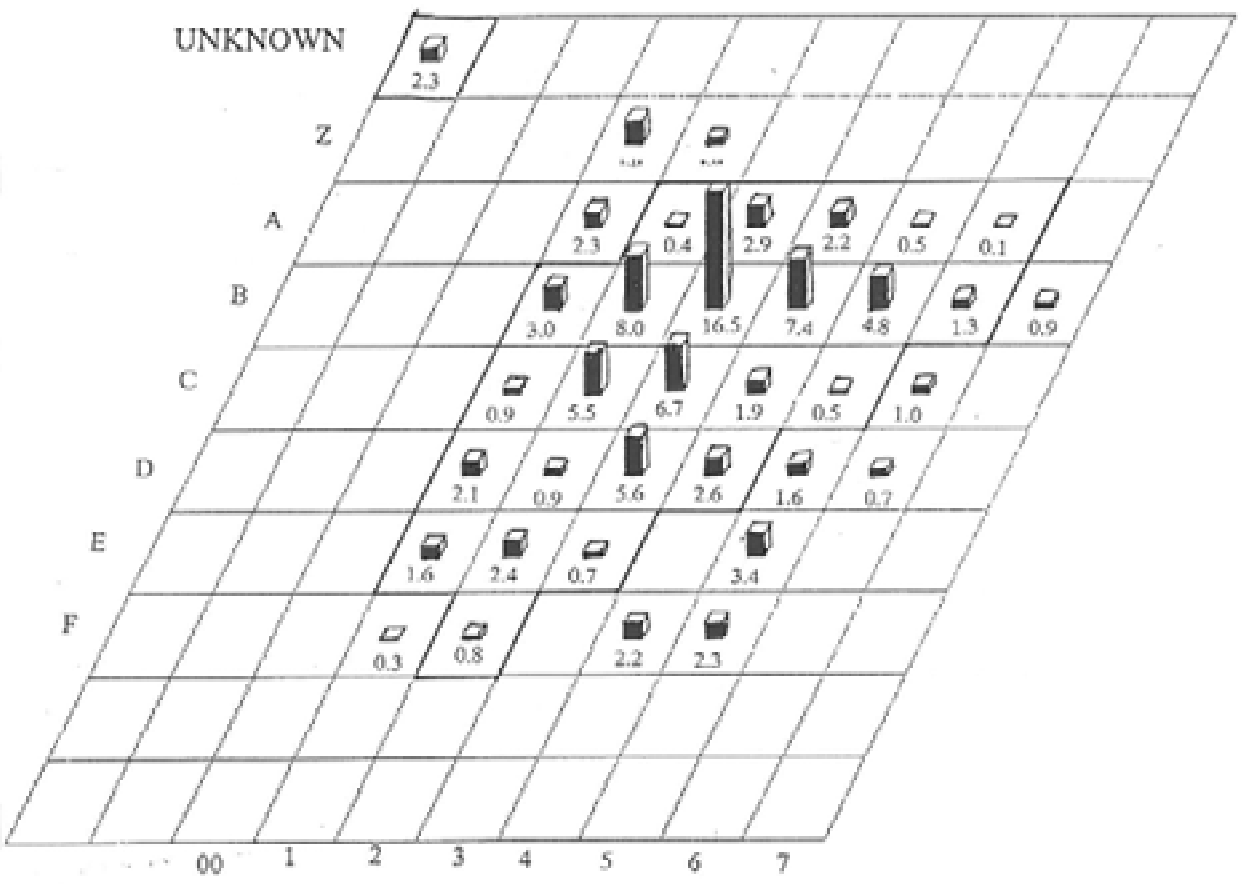


Figure 4.25: B. Calling, Moving, and Roosting-Preening (N = 2473).

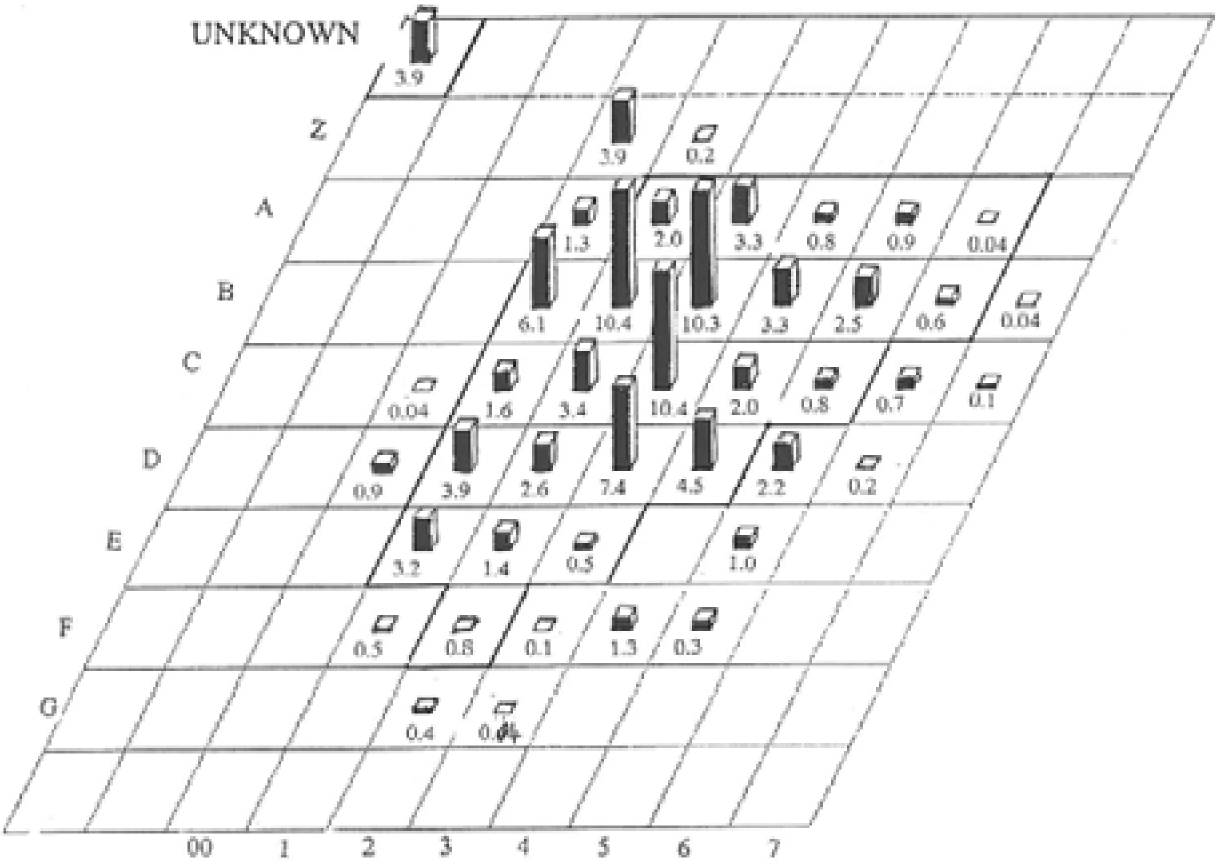


Figure 4.25: C. Singing (N = 771).

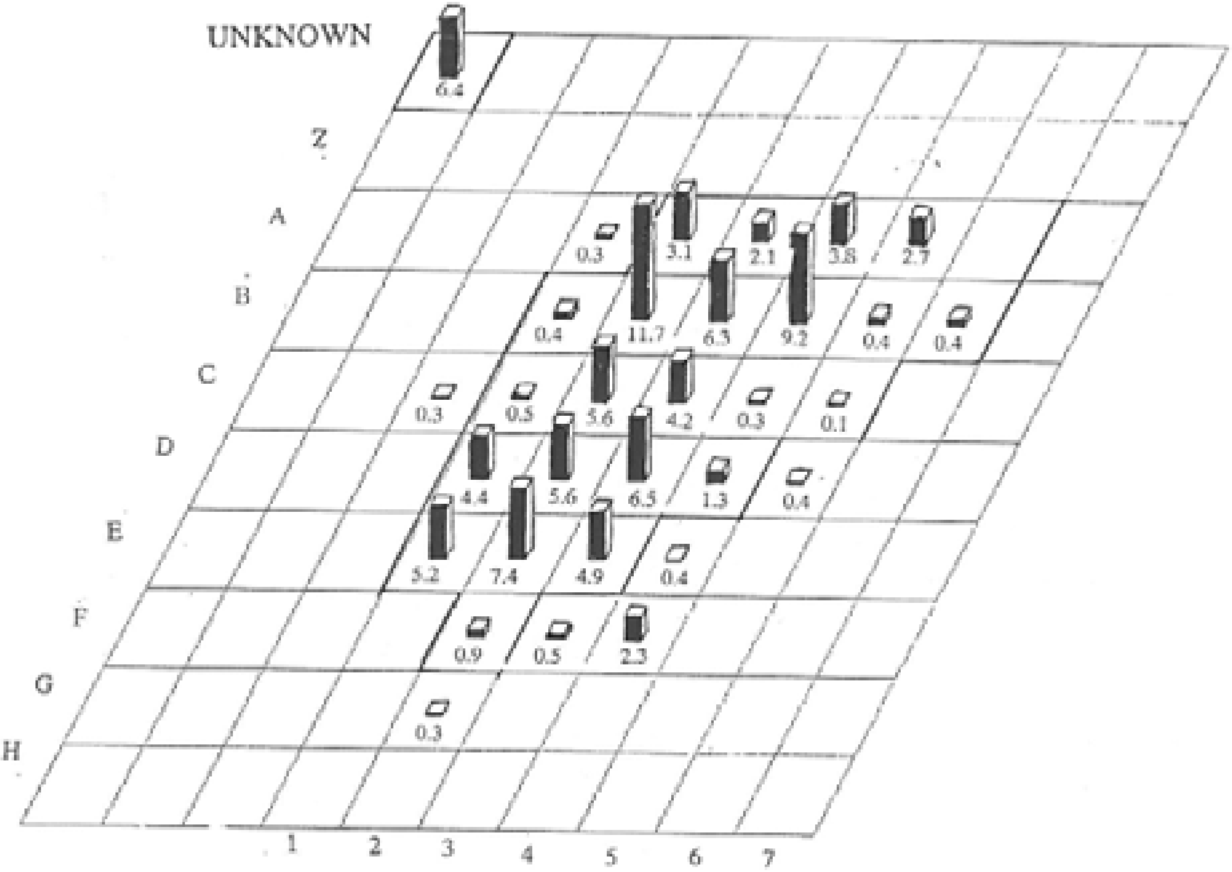


Figure 4.26: Distribution of activities in Pukatea home range. Scale: squares are 40 x 40m. Perimeter of the gridded portion of the home range marked by heavy black line. Numbers at base of bars are percent frequencies.

A. Feeding (N = 983).

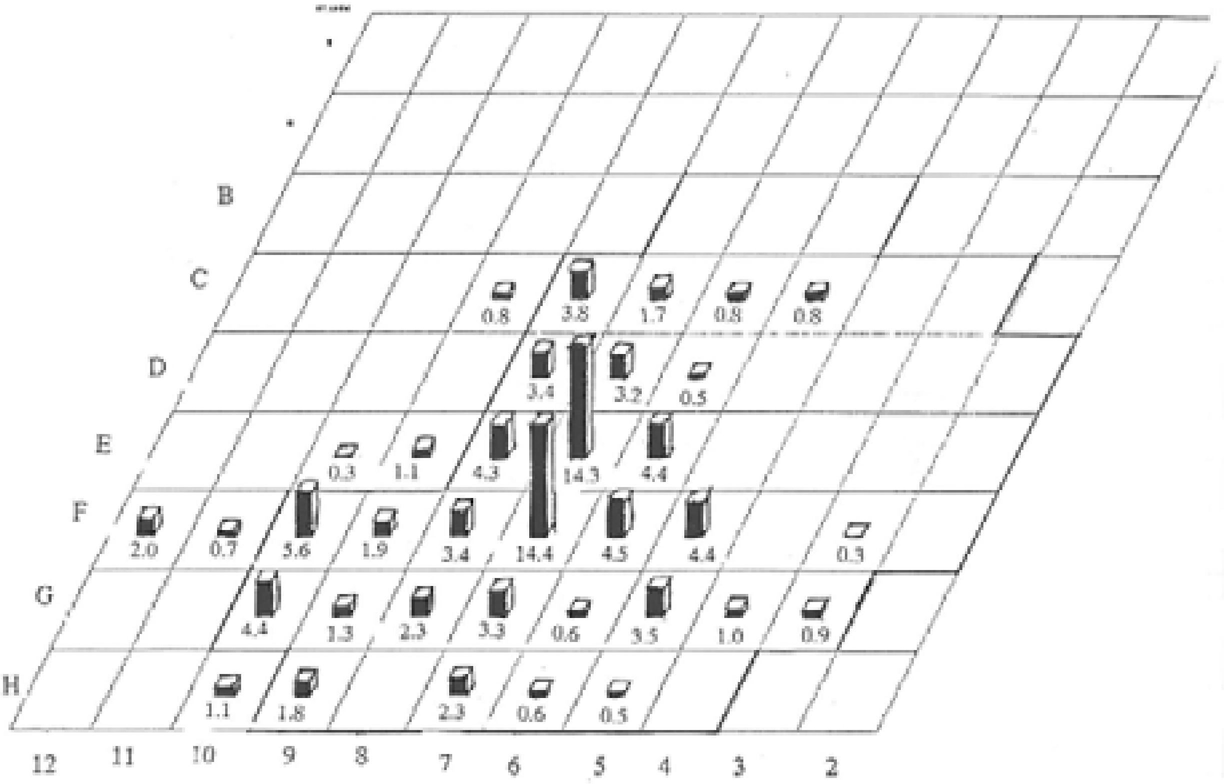


Figure 4.26: B. Singing (N = 363).

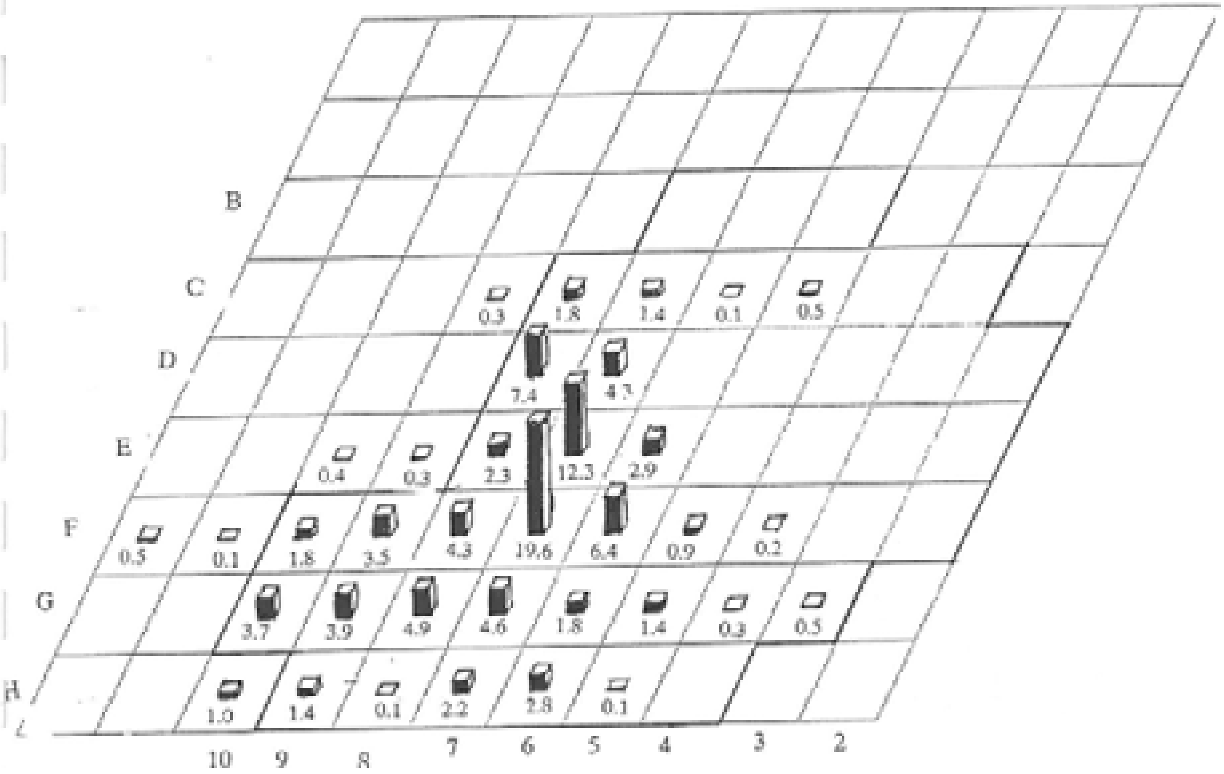


Figure 4.26: C. Calling, Moving, and Roosting-Preening (N = 1530).

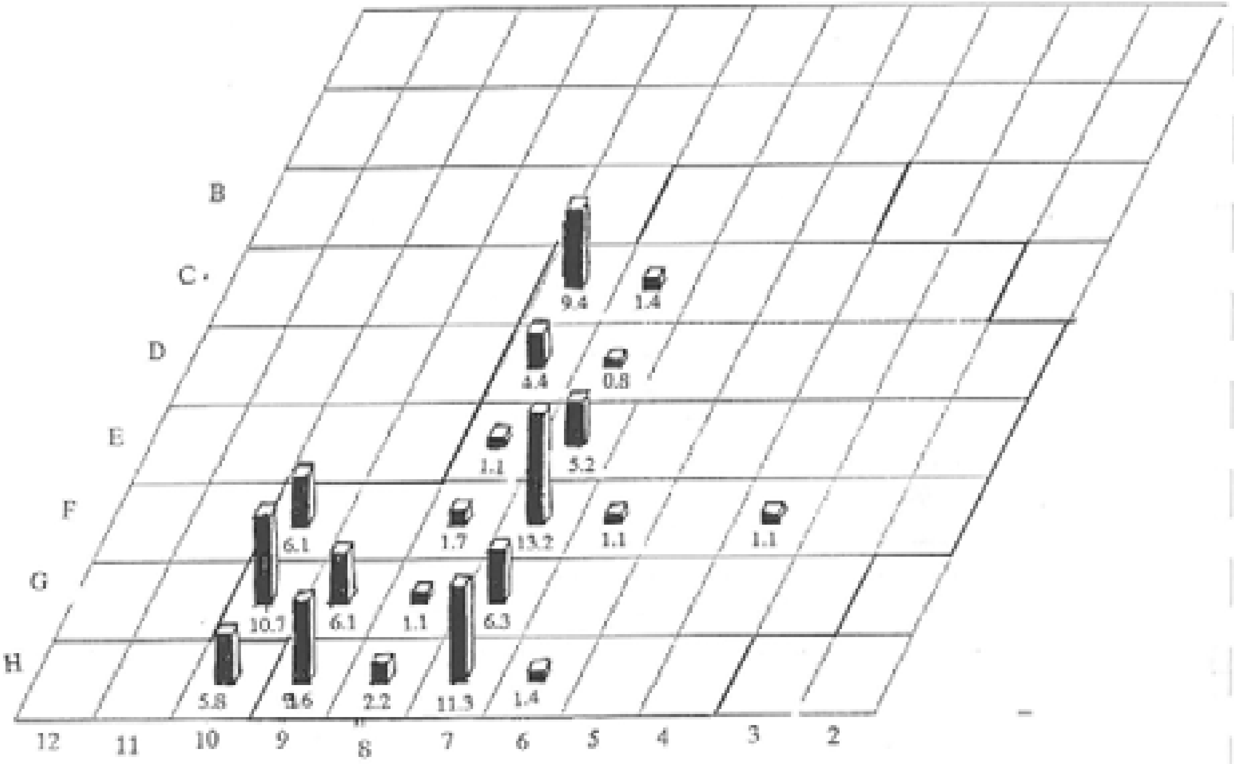


Figure 4.27: Distribution of activities in Summit home range between Winter 1983 and Spring 1984. Scale: squares are 40 x 40m. Perimeter of the gridded portion of the home range marked by heavy black line. Numbers at base of bars are percent frequencies.

A. Feeding (N = 2302).

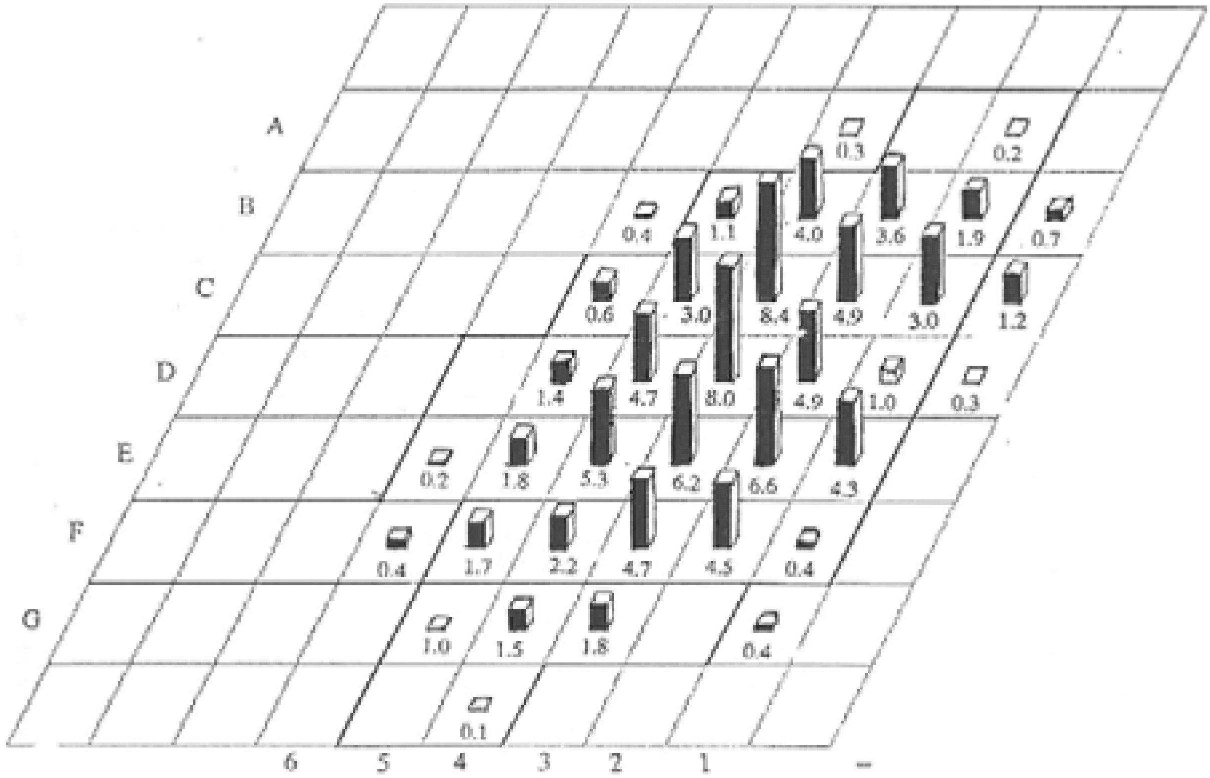


Figure 4.27: B. Calling, Moving, and Roosting-Preening (N = 2564).

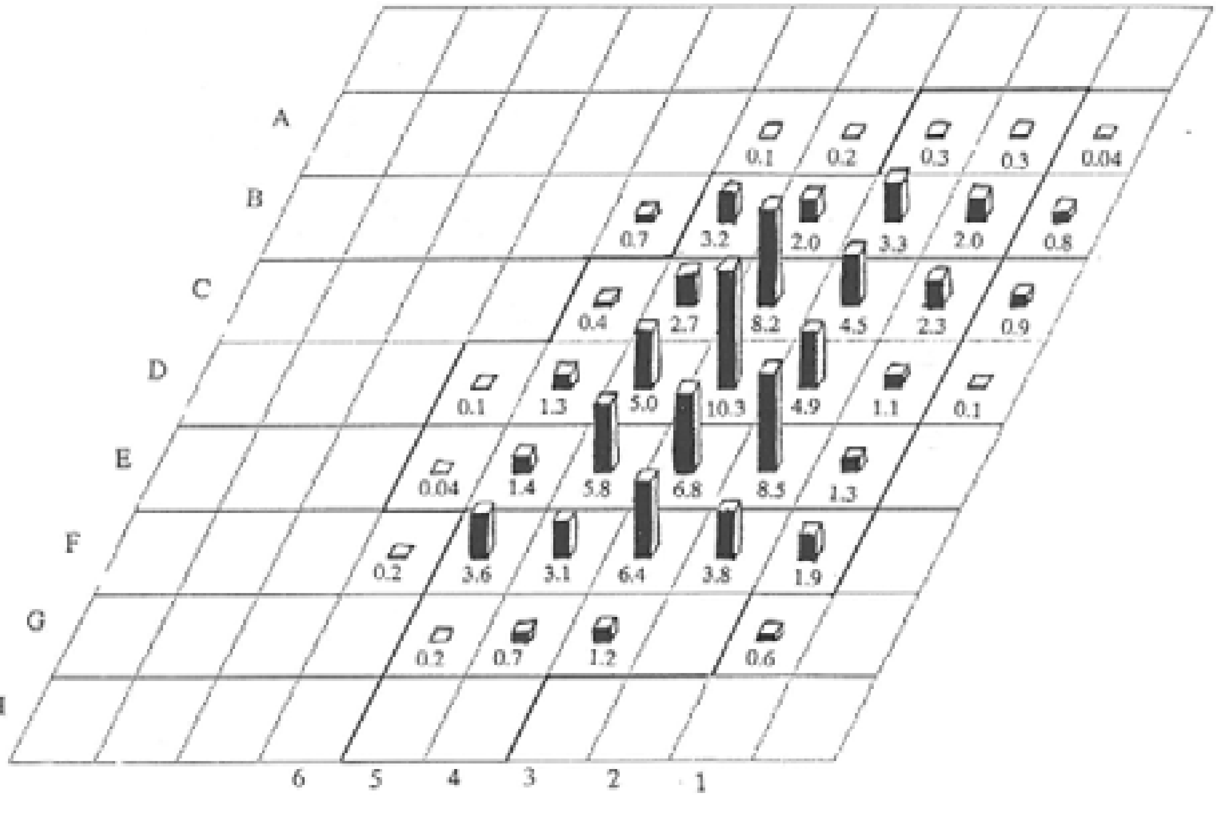


Figure 4.27: C. Singing (N = 709).

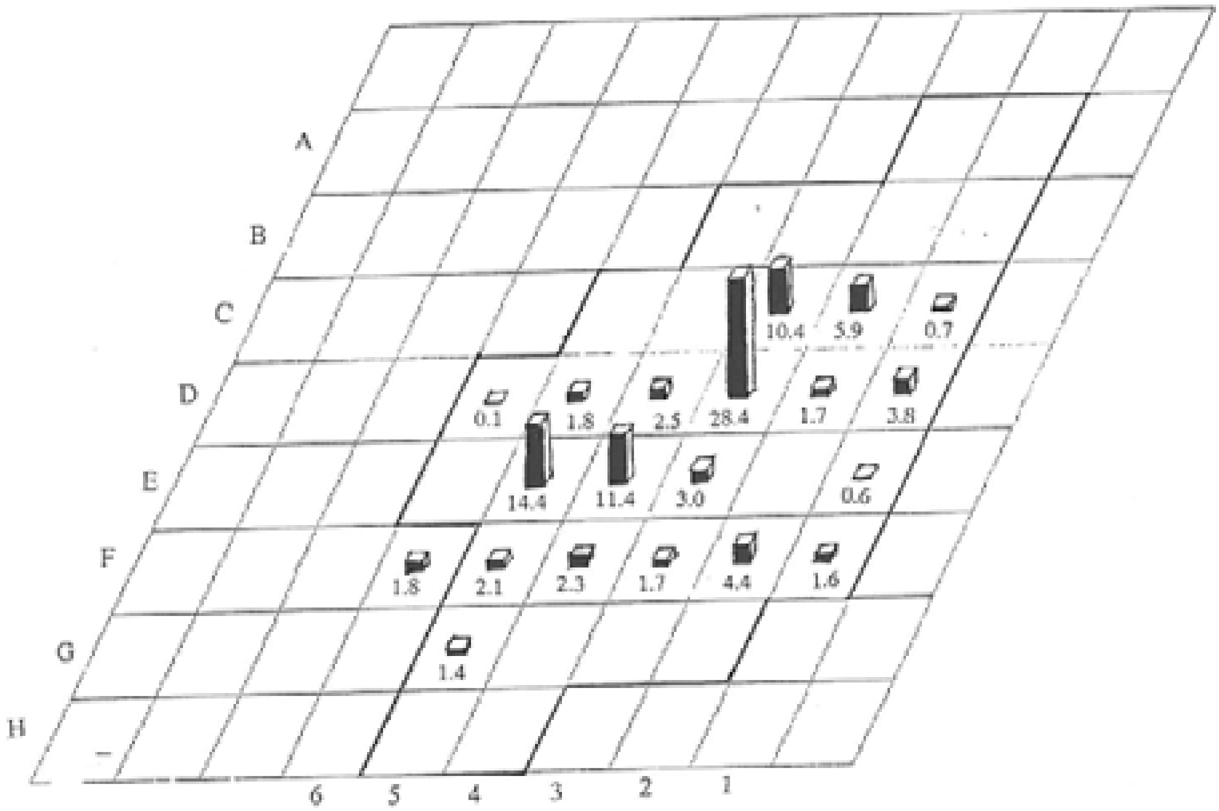


Table 4.3: Percent use of host species for epiphyte, liane and invertebrate foods eaten by kokako

	EPIPHYTE HOST						LIANE HOST	INVERTEBRATE HOST
HOME RANGE	Ben	Hill	Pet	Pukatea	Summit	Study Overall	Study Overall	Study Overall
N =	243	245	298	410	863	2109	439	216
Kauri	0	1.6	1.0	0	0.2	0.4	0	0
Podocarp								
Hall's totara	*24.7	*13.5	*13.4	0	*11.0	*10.8	2.7	3.2
Miro	7.4	11.0	*6.7	*8.0	2.0	*5.4	0.2	1.9
Rimu	4.9	*6.5	2.0	0	2.1	2.5	0.6	0.5
Tanekaha	0	0.4	0	0	0	0.1	0	0
	37.0	31.4	22.1	8.0	15.1	18.8	3.5	5.6
Tree hardwood								
Hinau	0	0	0	0	0.9	0.4	2.1	0
Kohekohe	*20.7	*21.2	*7.4	*38.4	*39.6	*29.7	20.3	0
Makamaka	0	0	0.3	0	0	0.1	1.4	2.3
Mangeao	0	0	0	0.2	0	0.1	0	0
Northern rata	*16.1	0	*6.7	0	0.9	3.3	0	0
Pukatea	0	0	*7.4	0	*5.2	3.2	3.6	0
Puriri	0	2.0	0.7	4.9	0	1.3	0.7	1.4
Rewarewa	0	3.7	1.3	1.2	0.2	1.0	3.6	0.5
Taraire	*10.3	*12.7	*29.3	*28.3	*15.8	*19.4	*10.5	*21.5
Tawa	3.7	*7.8	4.0	*9.5	4.1	*5.4	1.8	*16.3
Towai	0.8	*8.6	*14.5	*6.1	3.1	*5.8	*15.0	*37.5
	51.6	56.0	71.6	88.6	69.8	69.7	59.0	79.5

Table 4.3 (cont'd)

HOME RANGE	EPIPHYTE HOST Ben	Hill	Pet	Pukatea	Summit	Study Overall	LIANE HOST Study Overall	INVERTEBRATE HOST Study Overall
N =	243	245	298	410	863	2109	439	216
Shrub hardwood								
Fivefinger	0	0	0.7	0	0	0.1	0.9	0.5
Hangehange	0	0.4	0	0	0	0.1	0	0
Heketara	0.8	0.8	0.3	0.5	0	0.5	*6.6	1.9
Kotukutuku	0	0	0	0	1.4	0.6	0	0
Mahoe	0	0.8	0.3	0	*7.3	3.3	*7.4	0.5
Mapou	0	0	0	0	0.2	0.1	0	0
~~Matipe~~ Kohuhu	0	0	0	0	0	0	0.5	0.5
Melicytus macrophyllus	0	0	0	0	0	0.1	0	0
Melicytus micranthus	0	0	0	0	0	0	0.5	0
Mingimingi	0	0	0	0	0	0	0	0.2
Pate	0	0	0	0	0	0	0.5	3.2
Pigeonwood	0	2.5	0.3	0	0	0.5	*6.2	3.2
Raukawa	2.9	0	0.3	0	0	0.4	0.7	2.3
Raurekau	0	0	0	0	0.1	0.1	0.5	0
Tawari	0	0	0	0	0	0	4.3	0
Toro	0	0	0	0	0	0	0	0.5
White maire	0	0	0	0	0	0	1.4	0
Wineberry	1.6	0	0	0	0.2	0.3	2.5	0
	5.3	4.5	2.6	0.5	9.2	6.1	32.0	13.5
Nikau Palm	0	1.6	0	0	4.6	2.1	0.5	0.9

Table 4.3 (cont'd)

	EPIPHYTE HOST						LIANE HOST	INVERTEBRATE HOST
HOME RANGE	Ben	Hill	Pet	Pukatea	Summit	Study Overall	Study Overall	Study Overall
N =	243	245	298	410	863	2109	439	216
Other								
Puka	0	0	0	0	0.1	0.1	0	0
Dead tree	1.2	0	0.7	1.0	0.7	0.8	0	0
Ground	0	0	0	0	0	0	3.2	0
Kiekie	0	0	0.7	1.0	0.1	0.4	0.2	0
Metrosider~~f~~os diffusa	0	0	0	0	0	0	0.5	0
Rubus australis	0	0	0	0.2	0	0.1	0	0
Supplejack	0	0	0	0	0	0	0.2	0
Tree fern	4.5	4.9	1.3	0.7	0.2	1.5	0.9	0.5
	5.7	4.9	2.7	2.9	1.1	2.9	5.0	0.5
TOTAL	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

* = host species contributing 5% or more of the records for feeding on epiphyte, liane or invertebrate foods.

Note 1: Record for Melicytus macrophyllus came from home range other than the five main study home ranges.

Note 2: Supplejack and kiekie (both lianes) listed under 'other' where the species formed dense, self-entwined thickets not obviously attached to any single host tree species.

Table 4.4: Percent use of tree species for singing in five kokako home ranges

HOME RANGE	Ben	Hill	Pet	Pukatea	Summit
N =	528	146	874	399	735
Kauri	*27.5	*29.4	*25.9	0	*9.0
Podocarp					
Hall's totara	*15.6	1.4	*9.3	0.3	*19.0
Kahikatea	1.1	0	0	0	*21.0
Matai	1.1	0	0	0	0
Miro	1.3	*7.5	5.7	*11.0	6.1
Rimu	*11.9	*6.2	*6.9	3.0	*14.6
Tanekaha	*2.5	0	0	0	0
	33.5	15.1	21.9	14.3	60.7
Tree hardwood					
Hinau	0	0	1.1	3.8	3.8
Kohekohe	0	0	0.1	1.5	1.1
Northern rata	*37.6	*38.3	*12.3	1.8	7.2
Pukatea	0	0	2.6	2.0	*10.1
Puriri	0	0	1.5	*5.5	0
Rewarewa	0	2.7	6.4	*22.6	3.0
Taraire	0.8	1.4	6.5	*14.0	0.3
Tawa	0	2.1	0	0.8	1.5
Towai	0.6	*8.9	*18.9	*33.0	3.3
	39.0	53.4	49.4	85.0	30.3

Table 4.4 (cont'd)

HOME RANGE	Ben	Hill	Pet	Pukatea	Summit
N =	528	146	874	399	735
Shrub hardwood					
Heketara	0	0	0	0.7	0
~~Matipo~~ Kohuhu	0	0	0.2	0	0
Pigeonwood	0	0	0.2	0	0
Tawari	0	0	0.6	0	0
Toro	0	2.1	0	0	0
	0	2.1	1.0	0.7	0
Other					
Dead tree	0	0	1.8	0	0
	0	0	1.8	0	0
TOTAL	100·0	100·0	100·0	100·0	100·0

* = top 5 species in each home range

The dominant species used for singing (rating in top 5 species in 2 or more home ranges) were **kauri, Hall's totara, miro, rimu, Northern rata and towai.**

Table 4.5: Percent use of tree species for calling in five kokako home ranges

HOME RANGE	Ben	Hill	Pet	Pukatea	Summit
N =	229	279	922	448	661
Kauri	*7.0	*7.5	4.7	0	0
Podocarp					
Hall's totara	*34.5	*11.5	*8.0	0	*14.6
Kahikatea	0.4	0	0	0	0.3
Miro	*7.4	*12.5	*6.0	*10.6	2.1
Rimu	3.1	4.3	0	0	*12.8
Tanekaha	0.9	0	0	0	0
	46.3	28.3	15.4	13.2	29.8
Tree hardwood					
Hinau	0.4	1.1	1.1	4.5	2.1
Kohekohe	3.9	*12.5	*6.0	*14.7	*12.5
Makamaka	0	1.1	3.0	0.4	0.9
Northern rata	*13.1	2.2	1.4	*6.5	2.0
Pukatea	0	0	1.2	0.2	4.2
Puriri	0	2.2	0.9	2.2	0.3
Rewarewa	3.1	3.6	6.5	3.1	1.5
Taraire	5.2	*8.1	*18.3	*20.0	*11.4
Tawa	4.4	3.6	0.5	3.8	2.6
Towai	*10.5	*16.8	*22.1	*25.9	*14.8
	40.6	51.2	61.0	81.3	73.0

Table 4.5 (cont'd)

HOME RANGE	Ben	Hill	Pet	Pukatea	Summit
N =	229	279	922	448	661
Shrub hardwood					
Heketara	1.3	1.4	2.6	0.4	0.5
Lancewood	2.2	0	0	0	1.1
Mahoe	0	2.2	0.5	0	3.9
Neinei	0.4	0	0	0	2.0
Pate	0	0.6	3.7	0	0
Pigeonwood	0	3.9	2.6	2.5	1.5
†Remaining 16 species	0.4	2.9	6.8	0.6	9.0
	4.1	11.0	16.2	3.5	14.2
Nikau	0.4	0	0	0	0.6
‡ Other	1.4	2.0	2.9	1.7	3.1
TOTAL	100·0	100·0	100·0	100·0	100·0

* = top 5 species in each home range

The dominant species used for calling (rating in top 5 species in 2+ or more home ranges) were **Hall's totara, miro,** kohekohe, Northern **rata, toraire and towai**.

\+ Species which were used less than 1% in any one home range for calling

\# Other = tree fern, dead tree, ground, unknown, liane

Table 4.6: Percent use of tree species for moving in five kokako home ranges

HOME RANGE	Ben	Hill	Pet	Pukatea	Summit
N =	340	560	767	373	886
Kauri	*5.9	3.2	4.0	0	0
Podocarp					
Hall's totara	*28.5	*7.3	*8.5	1.3	*14.0
Kahikatea	1.8	0	0	0	0.5
Matai	0.9	0	0	0	0
Miro	3.8	*6.8	*5.3	3.2	0.7
Rimu	0	2.1	1.3	1.1	2.5
Tanekaha	*4.7	0.4	0	0	0
	39.7	16.6	15.1	5.6	17.7
Tree hardwood					
Hinau	0.9	1.3	0.9	2.4	2.7
Kohekohe	*14.7	*18.1	*6.4	*20.1	*21.0
Makamaka	0	3.2	2.6	1.9	0.6
Northern rata	3.2	0.5	1.2	0	0.1
Pukatea	0	0.2	0.3	0	0.9
Puriri	0.9	2.9	1.3	*4.0	0.3
Rewarewa	2.6	0.9	0.5	2.9	1.0
Taraire	*11.5	*13.7	*19.8	*25.4	*14.6
Tawa	3.2	3.2	2.5	*11.0	3.3
Towai	4.4	*17.0	*18.5	*15.7	*7.9
	41.4	61.0	54.0	83.4	52.4

Table 4.6 (cont'd)

HOME RANGE	Ben	Hill	Pet	Pukatea	Summit
N =	340	560	767	373	886
Shrub hardwood					
Fivefinger	1.2	0.9	3.1	0.6	0.7
Heketara	4.4	2.0	2.0	1.3	1.0
Mahoe	1.8	4.3	0.7	0.8	*6.8
Mapou	0.6	0.7	1.3	0	0.2
Melicytus macrophyllus	0	0	1.0	0	1.6
Pate	0	0.4	4.4	0.6	1.2
Pigeonwood	0	2.5	3.9	2.9	4.7
Raurekau	0	0.5	1.3	0.5	1.1
Tawari	0	0	1.6	0	0
Wineberry	0	0	0.1	0	1.5
White maire	0	1.3	0.3	0	0
†Remaining 20 species	1.5	1.7	2.7	1.5	3.4
	9.5	14.3	22.4	8.2	22.2
Nikau	0	0.4	0.1	1.1	0.8
‡ Other	3.5	4.9	4.5	2.8	7.1
TOTAL	100·0	100·0	100·0	100·0	100·0

* = top 5 species in each home range

The dominant species used for moving (rating in top 5 species in 2 or more home ranges) were Hall' totara, miro, kohekohe, taraire and towai.

+ Species which were used less than 1% in any one home range for calling

Other = tree fern, dead tree, ground, unknown, liane

Table 4.7: Percent use of tree species for roosting & preening in five kokako ranges

HOME RANGE	Ben	Hill	Pet	Pukatea	Summit
N =	1036	726	1128	684	1102
Kauri	2.6	4.0	3.7	0	0.5
Podocarp					
Hall's totara	*16.3	*12.4	*3.7	3.2	*8.4
Miro	0.3	*9.9	2.0	3.4	0.1
Rimu	0.2	0.3	0.1	0.6	2.3
Tanekaha	2.2	0	0	0	0
	19.0	22.6	5.8	7.2	10.8
Tree hardwood					
Hinau	0	0.3	1.6	*4.7	2.3
Kohekohe	*36.0	*22.5	*15.5	*24.7	*29.5
Makamaka	0	*7.2	1.2	0	0.1
Northern rata	0.4	0.6	0.1	0.1	0
Pukatea	0	0.1	0	0	0.7
Puriri	0.2	0.3	0.4	1.6	0.1
Rewarewa	3.8	2.3	1.4	0.6	0.2
Taraire	*6.9	6.4	*28.0	*23.5	*25.5
Tawa	*12.6	1.5	3.6	*14.2	3.4
Towai	*8.6	*20.3	*17.6	*15.4	*14.8
	68.4	61.5	69.4	84.8	76.6

Table 4.7 (cont'd)

HOME RANGE	Ben	Hill	Pet	Pukatea	Summit
N =	340	560	767	373	886
Shrub hardwood					
Fivefinger	0.5	0.1	0.8	0	1.1
Heketara	2.0	1.8	1.5	1.3	0.6
Mahoe	0.1	2.3	1.2	0	*3.9
Mapou	0	0.8	0.3	1.3	0.5
Pate	0	0	*5.6	0	0
Pigeonwood	0	4.0	3.5	1.0	3.1
Pseudopanax edgerleyi	0	0	1.8	0	0
Toro	0	0	1.0	0	0
Wineberry	0	0	0	2.5	0
†Remaining 12 species					
	4.4	9.8	20.1	4.8	10.9
Nikau	0	0	0	0	0.8
‡ Other	5.6	0.6	2.6	0.7	1.2
TOTAL	100·0	100·0	100·0	100·0	100·0

* = top 5 species in each home range

The dominant species used for calling (rating in top 5 species in 2 or more home ranges) were **Hall's totara, kohekohe, taraire, tawa and towai**

+ Species which were used less than 1% in any one home range for calling

Other = tree fern, dead tree, ground, unknown, liane

APPENDIX 4.1 DATA COLLECTION

CODES FOR COMPUTER DATA SHEETS

(* For definitions of terms see Appendix 4.2).

1. HOME RANGE NAME Columns 1-3

2. DATE
Record as year:month:date e.g. 26th of March 1983 is coded as 830326 Columns 4-9

3. OBSERVER
Record three initials, e.g. HAB for H. A. Best Column 10-12

4. WIND*
Record as either light (L), moderate (M) or strong (S) Column 13

5. RAIN*
Record as either absent (A); some (S); Heavy (H) Column 14

6. CLOUD COVER*
Record as either sunny (S): partly clouded (P); overcast (O) Column 15

7. TIME
Record in NZ Standard Time, on 24 hour clock, e.g. 1.15 pm is recorded as 1315 Columns 16-19

8. ACTIVITY

A. FEEDING Column 20-23
Feeding = FEED
Feed and Song = FESO
Feed and Call = FECA
Courtship Feed = FECO

B. SINGING
Singing = SONG
Move and Sing = MOSO
Display and Sing = DISO

C. CALLING
Calling = CALL
Display and Call = DICA
Preen and Call = PRCA
Move and Call = MOCA

D. MOVING
Moving = MOVE
Flight = FLIT

E. ROOSTING-PREENING
Preening = PREN
Mutual Preening = MUPR
Roost =ROST

F. INCIDENTAL
Display = DISP
Gathering Nest Material = NEMA
Interspecific Interaction = INAG
Kokako - Kokako Interactions = KOAG
Bathe = BATH
Drink = DRNK
Unknown = UNKN

9. BIRD HEIGHT Columns 24-25
Record the height of the bird above the ground; in metres. If the tree perched in is on a steep slope, ground level is taken to he the point at which the tree trunk emerges from the ground.

10. CANOPY HEIGHT Columns26-28
Record the vertical height of the canopy from the base of the trunk at ground level to the canopy crown directly above the birds position. If the bird is not in a canopy species at the time of observation, record the height of the canopy plant closest to the bird.

11. BIRD STATION* Columns 28-29
Record as either Emergent (EM), Canopy (CA), Understorey, or Ground (GR)

12. MAIN PERCH SPECIES Columns 30-35
the first three letters of the genus and species of vegetation that a bird is perched in. For example *Myrsine australis* is coded as MYRAUS. Dead tree = DEATRE, Ground = GROUND.

13. PERCH SPECIES, EPIPHYTE OR LIANE Column 36-41
Record the first three letters of the genus and species of epiphyte or liane that a bird is perched upon. When a bird is perched on an epiphyte or liane, record the name of the host species also; if a bird was perched on supplejack liane entwined in a towai tree, record WEISILRIPSCA in columns 30-41.

If a bird is in a dense thicket of supplejack or kiekie not obviously attached to just one host plant, then record RIPSCARIPSCA or FREBAUFREBAU in columns 30-41.

14. PERCH TYPE Columns 42-43
Record as either of crown foliage (CF), Branch inner (BI), Branch mid (BM), Branch outer (BO), Trunk (TK), Twig (TW), Liane (LI), Epiphyte (EP), Ground (GR), or Unknown (UN).

15. GRID SQUARE Columns 44-46
Record the grid square the bird is in at the time the observation was made - this comprises a single alphabetical character followed by two numerical characters. Grid E-two is coded E02.

16. FOOD TAKEN Column 47-48
Record as either Petiole (PE), Fruit (FR), Flower (FL), Flower Bud (FB), Leaf (LE), Leaf Bud (LB), Lichen (LI), Moss (MO), Moss Capsules (CA), Dead Plant Material (DM), Nectar (NE), Invertebrate (IN), Seed (SE), Bark (BA), or Exudate (EX).

Dead plant material = dead twigs, dead wood, dried leaves or cones.

Exudate = gum, resin or any other plant sap or juice.

Leaf = also includes fern fronds.

17. FOOD SOURCE* Columns 49-50
Record the source of the food taken as either of Kauri (KA), Podocarp (PO), Tree Hardwood (TH), Shrub Hardwood (SH), Nikau (NI), Epiphyte (EP), Liane (LI), Ground Plant (GS), Ground (GR), or Unknown (UN).

For invertebrate foods, record which of the above sources the food came from (i.e. was host to the invertebrate food).

18. FOOD SPECIES Columns 51-56
Record the first three letters of the genus and species of plant or animal food taken. Note: Scale insect = SCAINS, spider egg case = SPIEGG, insect grub = INSGRU, bagmoth = BAGMOT, moss = MOSUNK, filmy fern = FILFER, Lichen = LICHEN

19. TERRAIN* Columns 57-59
For columns 57-58: record as either of Ridge Crest (RC), Ridge Flank (RF), Valley Side (VS), or Valley Bottom (VB).
For column 59: record as either of Flat slope (F), Moderate slope = 30 degrees or less (M); or Steep slope = more than 30 degrees (S).

20. NUMBER OF BIRDS Column 60
Record the number of birds usually resident in the home range.

21. AIR TEMPERATURE Columns 61-52
Record air temperature at start of the observation period and each 20-30 minutes subsequently. Hang thermometer supplied to the outside of your day pack where it will not be affected by your body temperature.

22. HOST SPECIES OF FOOD TAKEN Column 63-68
When invertebrate, liane or epiphyte foods are taken, record the name of the host plant (first three letters of genus and species). To take a complex example - a bird may be standing on a kiekie liane (columns 36-41) in a miro tree (columns 30-35) and feeding on leaves of *Clematis* liane (columns 51-56) in a towai tree (columns 63-68).

APPENDIX 4.2 DATA COLLECTION DETAILS

DEFINITION OF TERMS

In order of first mention in Appendix 4.1, "Codes for Computer Data Forms".

1. Wind
Light -minimal to intermittent movement of tree tops giving rise to negligible background noise.
Moderate - tree tops in gentle motion most of the time the noise of which partly obscures bird calls
Strong - tree tops in constant motion, significant noise levels from shaking of vegetation drowning all but the loudest bird calls.

2. Rain
Some – drizzle, light rain, moderate rain, slight noise detected.
Heavy - persistent and concerted; noise levels sufficient to obscure most bird calls.

3. Cloud Cover Sunny
Sunny - less than a quarter of the sky clouded.
Part Cloud - between ¼ and ¾ of the sky clouded.
Overcast -more than ¾ of the sky clouded.

4. Activity
Feeding - the plucking, holding, manipulation and devouring of items, but not the searching for them.
Singing - loud of distinct, complex, sonorous character usually given for sustained period from prominent perches above the canopy.
Calling – vocalisations other than song, typically comprising one or a few notes. May be given from any perch site and usually not for sustained period.
Moving – locomotion involving use of legs or wings (e.g. running, hopping, flight).
Preening - manipulation of feathers with the mandibles.
Roosting - bird perched in a passive state, not engaged in any other activity.
Display - "bow-wing flap" (Hughes 1981) - bird adopts an upright stance, fans its tail, flaps it fully opened wings up and down, bows and emits a wheezy “hoch” (as pronounced in Gaelic "loch") followed by “tuk-tuk-too". The wings make a distinctive slapping sound as they strike together at the top of each upstroke.
Gathering nest material -the gathering, holding, or carrying of any non-food material between the mandibles.
Interspecific interaction - any direct confrontation between a kokako and bird of another species that involves aggressive behaviour. Usually involves a tui.
Kokako -kokako interaction - any direct encounter between two or more kokako that involves aggressive behaviour.
Bathe - the repeated wetting of plumage by brief immersions in standing water or by the splashing of water over the body by flapping of the wings.
Drink - gathering and swallowing of water, from pools, from drops adhering to the foliage of filmy ferns and mosses, or most commonly by ripping holes in the bases of *Collospermum hastatum* leaves to release water trapped therein.
Unknown - activity not identified.

5. Bird Station
Emergent - plant whose crown stands prominently above the general surrounding vegetation mantle
Canopy - non-emergent plant with more than 50% of its crown exposed to the sky.
Understorey -plant with less than 50% of its exposed to the sky, but taller than 1 m.
Ground - less than 1 m above the ground.

6. Perch type
Crown foliage - bird on tree fern, or on leaves at the tips of twigs.
Twigs - woody parts of a tree, less than 6mm in diameter.
Branch outer - outer third of a branch.

Branch mid - middle third of a branch.
Branch inner - inner third of a branch.
Branch -woody parts of a tree greater than 6mm in diameter which extend from the trunk.
Trunk - principal stem of a woody plant arising from the ground.
Ground - the ground itself, covered in soil, rock, litter, humus or in the recumbant portions of dead trees.

7. Food Source
Podocarp - members of the family Podocarpaceae.
Tree hardwood - species capable of forming canopy forest in height.
Shrub hardwood - species rarely attaining more than 12m in height and often present as an understorey species.
Epiphyte - plant growing (but not parasitically) on another plant.
Liane - climbing plant with long, rope-like, woody stems.
Invertebrate -animal lacking a vertebral (spinal) column e.g. spiders, insects, worms.
Ground plant - a plant less than lm high but standing above ground level.
Ground -the ground level, including litter, rock, humus or recumbant portions of dead trees.

8. Terrain
Ridge - a long narrow raised landform with sloping sides
Ridge crest - the highest portion of a ridge, extending along a ridge axis.
Ridge flank - the upper most slopes flanking a ridge, adjacent to the ridge crest and extending no more than 10 m vertically below the ridge crest.
Valley - a long depression in the landscape usually containing a stream or other form of runoff channel.
Valley side - the sloping ground on either side of a ridge, below the ridge flank.
Valley bottom - the lowest portion of a valley, along which surface runoff is channelled.
Minor spurs extending down valley sides are regarded as valley side as also are small gullies.

Appendix 4.3: Compnents and percent species composition of kokako diet in Puketi Forest from December 1982 to September 1984.

	Fruit	Flower	Flower bud	Nectar	Leaf	Petiole	Leaf, stem, stalks (non-petiole)	Leaf bud	Lichen	Moss	Moss capsule	Bark	Dead plant material	Exudate	Invertebrate	Unknown	TOTAL
N=	3046	444	74	68	2965	59	49	92	13	137	125	31	19	2	224	80	7428
PODOCARP																	
Hall's totara	5.2							0.7								0.03	6.0
Kahikatea	0.04																0.04
Matai	0.05																0.05
Miro	1.6																1.6
Rimu	1.8																1.8
Tanekaha	0.3																0.3
TREE HARDWOOD																	
Hinau	0.9	0.01															0.9
Kohekohe	0.6	0.08			0.2	0.01											0.9
Makamaka		0.08															0.08
Northern rata		0.03															0.03
Pukatea	0.03				0.01												0.04
Puriri	1.1	3.7		0.9													5.7
Rewarewa	0.9	0.1															1.0
Taraire	0.9	0.2			0.01			0.09								0.01	1.2
Tawa	0.7	0.01			0.09								0.03				0.8
Towai		0.1	0.04		0.08	0.03		0.01								0.04	0.3

	Fruit	Flower	Flower bud	Nectar	Leaf	Petiole	Leaf, stem, stalks (non-petiole)	Leaf bud	Lichen	Moss	Moss capsule	Bark	Dead plant material	Exudate	Invertebrate	Unknown	TOTAL
SHRUB HARDWOOD																	
Alseuosmia macrophylla					0.2												0.2
Coprosma arborea	0.07				0.02												0.1
C. parviflora					0.2												0.2
C. spathulata					0.2												0.2
Fivefinger	2.7	0.05			1.7		0.01					0.09					4.6
Hangehange	0.4	0.01	0.2		1.6		0.03	0.07									2.3
Heketara	0.04		0.07		6.5	0.6		0.07									7.3
Kohuhu	1.7				0.9												2.6
Kotukutuku	0.05	0.05			0.05												0.2
Lancewood	1.2				0.08												1.3
Mahoe	0.6	0.01			0.6		0.01										1.2
Mapou	2.1		0.1		0.1		0.03										2.4
Melicytus macrophyllus	1.5				0.2												1.7
M. micranthus					0.07												0.07
Mida salicifolia					0.1												0.1
Mingimingi	0.05				0.3												0.4
Neinei												0.03					0.03
Nestegis montana					0.08												0.08
Pate	0.7		0.07		0.5							0.05	0.08				1.4
Pigeonwood	1.6				0.2			0.04									1.8
Pittosporum virgatum	0.04																0.04

	Fruit	Flower	Flower bud	Nectar	Leaf	Petiole	Leaf, stem, stalks (non-petiole)	Leaf bud	Lichen	Moss	Moss capsule	Bark	Dead plant material	Exudate	Invertebrate	Unknown	TOTAL
Ramarama	0.2																0.2
Rangiora													0.01				0.01
Raukawa	0.8		0.01		0.3												1.1
Raurekau	1.0	0.04			4.2			0.01				0.04	0.01	0.03			5.3
Tawari		0.04															0.04
Toro	0.05				0.05												0.1
Toru	0.01	0.08															0.09
White maire					0.04			0.03									0.07
Wineberry					0.04												0.04
NIKAU PALM	5.6				0.3												5.9
TREE, FERN, GROUND PLANT, OTHER																	
Dead tree												0.03					0.03
Gahnia pauciflora	0.01																0.01
Ponga					0.07												0.07
Uncinia sp.					0.04												0.04
Unknown					0.08											1.0	1.1
EPIPHYTE																	
Anarthropteris lanceolata (F)					0.2												0.2
Asplenium bulbiferum (F)					0.03												0.03
A. flaccidum (F)					6.6												6.6
A. oblongifolium (F)					0.01												0.01

	Fruit	Flower	Flower bud	Nectar	Leaf	**Petiole**	Leaf, stem, stalks (non-petiole)	Leaf bud	Lichen	Moss	Moss capsule	Bark	Dead plant material	Exudate	Invertebrate	Unknown	TOTAL
A. polyodon (F)					0.9												0.9
Astelia solandri (H)	0.2	0.03			0.01	0.03											0.3
Blechnum filiforme (F)					0.07												0.07
Bulbophyllum pygmaeum (F)					0.03												0.03
Ctenopteris heterophylla (F)					0.1												0.1
Collospermum hastatum (H)	0.05				0.07												0.1
Dendrobium cunninghamii (H)			0.03		0.4		0.3										0.7
Drymoanthus adversus (H)					0.05												0.05
Earina autumnalis (H)	0.3	0.4			0.9	0.05	0.01										1.7
E. mucronata (H)	0.2	0.5	0.03		0.6		0.2										1.5
Filmy fern					1.9												1.9
Kirk's daisy (S)					0.2												0.2
Lichen									0.2								0.2
Lycopodium varium (H)					0.01												0.01
Moss										1.8	1.7						3.5
Phymatosorus diversifolius (F)					4.3												4.3
Pittosporum cornifolium (F)	0.3	0.03			0.2												0.5
P. sp. (S)	0.05																0.05
Pyrrosia eleagnifolia (F)					0.03												0.03
Puka (S)	2.2		0.4		2.5		0.1	0.09									5.3

	Fruit	Flower	Flower bud	Nectar	Leaf	Petiole	Leaf, stem, stalks (non-petiole)	Leaf bud	Lichen	Moss	Moss capsule	Bark	Dead plant material	Exudate	Invertebrate	Unknown	TOTAL
LIANE																	
Clematis paniculata	0.08	0.04	0.01		0.8	0.1											1.0
Kiekie		0.01			0.01		0.03					0.2	0.1				0.4
Mangemange					0.03												0.03
Metrosideros diffusa					0.03												0.03
M. perforata		0.04			0.1												0.1
Rubus australis	0.2				0.05												0.2
R. cissoides	0.05																0.05
Supplejack	2.8	0.2	0.04		0.8			0.04									3.9
INVERTEBRATES																	
Bag moth															2.4		2.4
Insect cocoon															0.04		0.04
Insect grub															0.2		0.2
Unidentified insect															0.1		0.1
Scale insect															0.2		0.2
Spider egg cluster															0.04		0.04
TOTAL	**41.0**	**5.9**	**1.0**	**0.9**	**40.1**	**0.9**	**0.6**	**1.2**	**0.2**	**1.8**	**1.7**	**0.4**	**0.2**	**0.03**	**3.0**	1.1	**100.0**

Note:
1. (F) = fern (H) = herb (S) = shrub
2. * includes <u>Hymenophyllum</u> <u>demissum</u>, <u>H</u>. <u>dilatatum</u>, <u>H</u>. <u>sanguinolentum</u>
3. For values of less than 0.1% occurence, the frequency figure is expressed to the nearest 0.01%
4. Eight records of unknown items were from kauri
5. Leaf stems, stalks : for ferns this was the rachi, but not the stipe; for <u>Dendrobium</u>, <u>Earina</u> and other plants it was the fleshy green twigs.

Appendix 4.4 : Components and percent species composition of kokako diet in summer 1982/3 (3-20 December)

	Fruit	Flower	Leaf +	Leaf bud	Moss	Bark	Invertebrate	TOTAL
N =	76	11	80	3	14	2	4	191
PODOCARP								
Halls'totara	3.7							3.7
TREE HARDWOOD								
Hinau		0.5						0.5
Taraire		4.2	0.5					4.7
Towai		1.1	0.5					1.6
SHRUB HARDWOOD								
Alseuosmia macrophylla			6.2					6.2
Fivefinger	22.5		2.6					25.1
Hangehange			4.2	1.6				5.8
Kotukutuku	2.1							2.1
Lancewood			3.1					3.1
Mahoe			11.0					11.0
Melicytus macrophyllus			0.5					0.5
Neinei						1.1		1.1
Pate			3.7					3.7
Pigeonwood			2.1					2.1
Raurekau	2.6		2.6					5.2
Toro			1.1					1.1
Wineberry			0.5					0.5
EPIPHYTE								
Moss					7.3			7.3
LIANE								
Supplejack	8.9		3.7					12.6
INVERTEBRATE								
Scale insect							2.1	2.1
TOTAL	39.8	5.8	42.3	1.6	7.3	1.1	2.1	100

\+ includes leaf, petiole, green stems, fern foliage

Appendix 4.5 : Components and percent species composition of kokako diet in autumn 1983 (2-18 March)

	Fruit	Flower	Leaf +	Lichen	Moss	Invertebrate	Unknown	TOTAL
N =	312	16	110	1	25	10	3	477
PODOCARP								
Hall's totara	21.2							21.2
Miro	1.1							1.1
TREE HARDWOOD								
Kohekohe			0.6					0.6
Puriri	4.0							4.0
Rewarewa	5.9	0.4						6.3
Towai			0.8					0.8
SHRUB HARDWOOD								
Fivefinger	5.7		0.2					5.9
Hangehange	0.4		1.9					2.3
Heketara			6.3					6.3
Mahoe			1.1					1.1
Mapou	3.8							3.8
Kohuhu			0.2					0.2
Melicytus macrophyllus	1.9		0.4					2.3
Mida salcifolia			1.1					1.1
Raukawa	4.4							4.4
Raurekau	10.3		1.5					11.8
NIKAU PALM	0.6							0.6
EPIPHYTE								
Asplenium flaccidum			4.0					4.0
Dendrobium cunninghamii			0.4					0.4
Earina autumnalis		3.0	0.4					3.4
E. mucronata			1.7					1.7
Filmy fern			1.9					1.9
Lichen				0.2				0.2
Moss					5.2			5.2
Phymatosorus diversifolius			0.2					0.2
Puka	5.7		0.2					5.9

Appendix 4.5 (cont'd)

	Fruit	Flower	Leaf +	Lichen	Moss	Invertebrate	Unknown	TOTAL
LIANE								
Metrosideros perforata			0.2					0.2
Rubus australis	0.6							0.6
INVERTEBRATE								
Bagmoth						1.9		1.9
Insect grub						0.2		0.2
UNKNOWN							0.6	0.6
TOTAL	65.4	3.4	23.1	0.2	5.2	2.1	0.6	100

\+ includes leaf, petiole, green stems, fern foliage

Appendix 4.6 : Components and percent species composition of kokako diet in winter 1983
(4-20 June)

	Fruit	Flower	Leaf +	Invertebrate	Unknown	TOTAL
N =	81	8	150	9	8	256
PODOCARP						
Hall's totara	5.5				0.8	6.3
Miro	3.5					3.5
TREE HARDWOOD						
Hinau	3.9					3.9
Kohekohe	0.4					0.4
Rewarewa	1.2					1.2
Taraire					0.4	1.4
Towai					1.2	1.2
SHRUB HARDWOOD						
Coprosma spathulata			2.0			2.0
Fivefinger		0.8				0.8
Hangehange			3.1			3.1
Heketara			26.3			26.3
Mahoe			0.8			0.8
Mapou			0.4			0.4
Kohuhu		12.0				12.0
Melicytus micranthus			2.0			2.0
Mida salicifolia			0.4			0.4
Raukawa	0.4					0.4
Raurekau			8.5			8.5
UNKNOWN					0.8	0.8
EPIPHYTE						
Anarthropteris lanceolata			0.4			0.4
Asplenium flaccidum			6.3			6.3
Dendrobium cunninghamii			2.0			2.0
Earina autumnalis	1.6	2.3	2.0			5.9
Filmy fern			2.3			2.3
Phymatosorus diversifolius			0.8			0.8
Puka	1.2					1.2
LIANE						
Mangemange			0.8			0.8
Supplejack	2.0		0.4			2.4
INVERTEBRATE						
Bag moth				3.5		3.5
TOTAL	31.6	3.1	58.6	3.5	3.2	100

+ = includes leaf, petiole, green stems, fern foliage

Appendix 4.7 : Components and percent species composition of kokako diet in early spring 1983 (2-23 September)

	Fruit	Flower	Flower bud	Leaf	Leaf bud	Moss	Moss capsule	Invertebrate	Unknown	TOTAL
N =	170	64	25	408	24	15	48	13	11	778
PODOCARP										
Hall's totara	6.9									6.9
Miro	0.7									0.7
TREE HARDWOOD										
Hinau	0.1				0.1					0.2
Kohekohe	0.3									0.3
Makamaka		0.5								0.5
Pukatea				0.1						0.1
Puriri		6.7								6.7
Taraire	0.6				0.5					1.1
Tawa				0.8						0.8
Towai		0.1								0.1
SHRUB HARDWOOD										
Fivefinger	0.1			0.5						0.6
Hangehange		0.1	1.2	0.9	0.3					2.5
Heketara			0.5	0.6	0.5					1.6
Lancewood	0.6									0.6
Mahoe		0.1		1.3	0.2					1.5
Mapou	1.0		1.2	0.3	0.1					2.6
Kohuhu	2.6			0.1						2.7
Pate	1.0			0.3						1.3
Pigeonwood	5.1			0.3	0.4					5.8
Pittosporum virgatum	0.4									0.4
Raukawa				0.6						0.6
Raurekau				14.0						14.0
Tawari				0.1						0.1
White maire					0.3					0.3
NIKAU PALM	0.5			0.3						0.8
GROUND PLANT, OTHER										
Uncinia sp.				0.1						0.1
Unknown									1.4	1.4

Appendix 4.7 (cont'd)

	Fruit	Flower	Flower bud	Leaf +	Leaf bud	Moss	Moss capsule	Invertebrate	Unknown	TOTAL
N =	170	64	25	408	24	15	48	13	11	778
EPIPHYTE										
Anarthropteria lanceolata				1.4						1.4
Asplenium bulbiferum				0.3						0.3
A. flaccidum				13.0						13.0
A. polyodon				0.8						0.8
Blechnum filiforme				0.5						0.5
Dendrobium cunninghamii			0.3							0.3
Earina autumnalis				1.2						1.2
E. mucronata		0.6		0.8						1.4
Filmy fern				4.0						4.0
Kirk's daisy				0.1						0.1
Lycopodium varium				0.1						0.1
Moss						1.9	6.2			8.1
Phymatosorus diversifolius				6.2						6.2
Pittosporum sp.	0.5									0.5
Puka			0.1	2.8	0.8					3.7
LIANE										
Metrosideros perforata				0.8						0.8
Rubus australis				0.3						0.3
Supplejack	1.3									1.3
INVERTEBRATE										
Bag moth								1.7		1.7
TOTAL	21.7	8.1	3.3	52.6	3.1	1.9	6.2	1.7	1.4	100

+ = includes leaf, petiole, green steams, fern foliage

Appendix 4.8 : Components and percent species composition of kokako diet in mid-spring 1983 (5 October - 6 November)

	Fruit	Flower	Leaf	Lichen/Moss	Invertebrate	Unknown	TOTAL
N =	11	15	25	5	5	2	63
PODOCARP							
Kahikatea	3.2						3.2
Rimu	1.6						1.6
TREE HARDWOOD							
Kohekohe			4.8				4.8
Puriri		22.1					22.1
Rewarewa		1.6					1.6
Tawa	1.6		1.6				3.2
SHRUB HARDWOOD							
Heketara			1.6				1.6
Mingimingi	1.6						1.6
Raurekau	9.5						9.5
UNKNOWN *						3.2	3.2
EPIPHYTE							
Asplenium flaccidum			17.4				17.4
Filmy fern			12.6				12.6
Lichen				3.2			3.2
Moss				4.8			4.8
Phymatosorus diversifolius			1.6				1.6
INVERTEBRATE							
Insect grub					6.4		6.4
Scale insect					1.6		1.6
TOTAL	17.5	23.7	38.6	8.0	8.0	3.2	100.0

*Both records were of food taken from kauri tree.

Appendix 4.9 : Components and percent species composition of kokako diet in early summer 1983/4 (23 November - 14 December)

	Fruit	Flower	Flower bud	Leaf	Leaf bud	Moss	Moss capsule	Invertebrate	TOTAL
N =	131	32	33	157	1	13	7	13	387
PODOCARP									
Hall's totara	7.5								7.5
TREE HARDWOOD									
Kohekohe			0.5						0.5
Puriri	1.6								1.6
Rewarewa		1.8							1.8
Taraire	1.0								1.0
Tawa	0.5								0.5
Towai				0.5	0.3				0.8
SHRUB HARDWOOD									
Coprosma arborea	0.5								0.5
Fivefinger	0.8			2.0					2.8
Hangehange			0.8	5.4					6.2
Heketara	0.3			1.8					2.1
Mahoe				0.5					0.5
Kohuhu				0.8					0.8
Mingimingi	0.8								0.8
Pate				6.4					6.4
Pigeonwood	8.6			1.6					10.2
Raukawa	0.5		0.3						0.8
Raurekau				3.9					3.9
Tawari		0.8							0.8
Wineberry				0.5					0.5
NIKAU PALM	0.3								0.3
TREE FERN, GROUND PLANT, OTHER									
Ponga				0.8					0.8
Uncinia species				0.5					0.5
Unknown				0.3					0.3
EPIPHYTE									
Asplenium flaccidum				0.3					0.3
Astelia solandri		0.5							0.5
Filmy fern				3.1					3.1
Moss						3.4	1.8		5.2
Puka	0.8		6.7						7.5
LIANE									
Clematis paniculata	1.6								1.6
Kiekie		2.3							2.3
Metrosideros perforata				0.3					0.3
Supplejack	9.0	2.8	0.8	11.4					24.0
INVERTEBRATE									
Bag moth								0.5	0.5
Scale insect								2.8	2.8
TOTAL	33.9	8.2	8.6	40.7	0.3	3.4	1.8	3.3	100

Appendix 4.10 : Components and percent species composition of kokako diet in mid-late summer 1983/4 (23 December - 14 February)

	Fruit	Flower	Leaf +	Lichen/Moss	Moss Capsule	INvertebrate	Dead plant material	Unknown	TOTAL
N =	260	16	99	19	3	2	17	11	427
PODOCARP									
Hall's totara	4.7								4.7
Kahikatea	0.2								0.2
Rimu	0.5								0.5
Tanekaha			0.2						0.2
TREE HARDWOOD									
Hinau	0.2								0.2
Kohekohe			0.2						0.2
Northern rata		0.5							0.5
Puriri	0.7	1.4							2.1
Tawa	0.7	0.2							0.9
Towai		1.6	0.2						1.8
SHRUB HARDWOOD									
Coprosma arborea	0.7		0.5						1.2
Fivefinger	17.3		3.0						20.3
Heketara	0.5		1.6						2.1
Mahoe	0.2		0.2						0.4
Mapou			0.9						0.9
Melicytus macrophyllus	4.7		1.2						5.9
Mingimingi			6.0						6.0
Pate			0.2				1.4		1.6
Pigeonwood	1.2		0.2						1.4
Rangiora							0.2		0.2
Raukawa	3.8								3.8
Raurekau	2.1		1.2				0.2		3.5
NIKAU PALM	1.6		0.5						2.1
UNKNOWN			0.2					2.6	2.8
EPIPHYTE									
Asplenium flaccidum			0.7						0.7
Astelia solandri			0.2						0.2
Earina mucronata			0.2						0.2
Filmy fern			4.6						4.6
Lichen				1.2					1.2
Moss				3.3	0.7				4.0
Phymatosorus diversifolius			0.2						0.2
Puka	5.6								5.6

Appendix 4.10 (cont'd)

	Fruit	Flower	Leaf+	Lichen/Moss	Moss Capsule	Invertebrate	Dead plant material	Unknown	TOTAL
N =	260	16	90	19	3	2	17	11	417
LIANE									
Kiekie							2.2		2.2
Metrosideros diffusa			0.2						0.2
Rubus australis	1.9								1.9
Supplejack	14.3		0.7						15.0
INVERTEBRATE									
Bag moth						0.5			0.5
TOTAL	60.9	3.7	23.1	4.5	0.7	0.5	4.0	2.6	100

+ = includes leaf, petiole, green stems, fern foliage

Appendix 4.11 : Components and percent species composition of kokako diet in autumn 1984
(13 March - 3 April)

	Fruit	Nectar	Flower	Flower bud	Leaf^{+}	Lichen/Moss	Moss capsule	Invertebrate	Bark	Unknown*	TOTAL
N =	691	13	18	5	238	26	7	34	2	7	1041
PODOCARP											
Hall's totara	10.5										10.5
Miro	7.2										7.2
Rimu	4.7										4.7
Tanekaha	2.0										2.0
TREE HARDWOOD											
Pukatea	0.2										0.2
Puriri	3.8	1.2	0.5								5.5
Rewarewa	0.8										0.8
Tawa	0.3										0.3
SHRUB HARDWOOD											
Fivefinger	3.3				4.1						7.4
Hangehange	2.3				0.8						3.1
Heketara					7.1						7.1
Mahoe	4.1				0.1						4.2
Mapou	2.6										2.6
Kohuhu	0.5				0.2						0.7
Melicytus macrophyllus	7.7				0.4						8.1
Pate				0.5	0.1						0.6
Pigeonwood	0.1										0.1
Raukawa	1.6										1.6
Raurekau	0.3				2.9						3.2
Toru	0.1										0.1
NIKAU PALM	8.7				0.5						9.2
TREE FERN, OTHER											
Ponga					0.1						0.1
Unknown										0.7	0.7
EPIPHYTE											
Anarthropteris lanceolata					0.1						0.1
Asplenium flaccidum					3.3						3.3
A. polyodon					0.8						0.8
Collospermum hastatum	0.4										0.4

Appendix 4.11 (cont'd)

	Fruit	Nectar	Flower	Flower bud	Leaf+	Lichen/Moss	Moss capsule	Invertebrate	Bark	Unknown*	TOTAL
N =	691	13	18	5	238	26	7	34	2	7	1041
Dendrobium cunninghamii					0.4						0.4
Earina autumnalis			0.8		0.5						1.3
E. mucronata	1.0		0.2		0.2						1.4
Filmy fern					1.1						1.1
Kirk's daisy					0.1						0.1
Lichen						0.3					0.3
Moss						2.2	0.7				2.9
Puka	1.3										1.43
LIANE											
Kiekie					0.1				0.2		0.3
Metrosideros perforata			0.3								0.3
Supplejack	2.7										2.7
INVERTEBRATE											
Bag moth								2.0			2.0
Insect grub								0.3			0.3
Insect unknown								0.9			0.9
Spider egg								0.1			0.1
TOTAL	66.2	1.2	1.8	0.5	22.9	2.5	0.7	3.3	0.2	0.7	100

* = unknown, 6 records from within kauri tree

\+ = includes leaf, petiole, green stems, fern foliage

Appendix 4.12 : Components and percent species composition of kokako diet in early winter 1984 (12-31 June)

	Fruit	Nectar	Flower	Flower bud	Leaf^{+}	Leaf bud	Lichen, moss moss capsule	Invertebrate	Bark	Unknown	TOTAL
N =	423	42	72	3	462	6	16	19	2	9	1054
PODOCARP											
Hall's totara	4.8										4.8
Miro	0.5										0.5
Rimu	2.7										2.7
TREE HARDWOOD											
Hinau	4.5										4.5
Kohekohe	2.3		0.6								2.9
Puriri	0.2	4.0	5.8								10.0
Rewarewa	2.0										2.0
Taraire						0.3					0.3
Tawa	0.5										0.5
Towai				0.3							0.3
SHRUB HARDWOOD											
<u>Coprosma parviflora</u>					1.4						1.4
<u>C. spathulata</u>					0.7						0.7
Fivefinger	0.5		0.2								0.7
Hangehange					2.0						2.0
Heketara					12.3						12.3
Lancewood	2.4										2.4
Mapou	2.7										2.7
Kohuhu	1.9					2.3					4.2
<u>Melicytus macrophyllus</u>	0.1										0.1
Pate	0.6										0.6
Raukawa	0.4				0.2						0.6
Raurekau			0.3		3.5						3.8
Toro	0.3										0.3
White maire					0.1						0.1
NIKAU PALM	3.4				0.8						4.2
TREE FERN, OTHER											
Dead tree									0.2		0.2
Ponga					0.1						0.1
Unknown					0.3					0.9	1.2

Appendix 4.12 (cont'd)

	Fruit	Nectar	Flower	Flower bud	Leaf +	Leaf Bud	Lichen, moss moss capsule	Invertebrate	Bark	Unknown	TOTAL
N =	423	42	72	3	462	6	16	19	2	9	1054
EPIPHYTE											
Asplenium flaccidum					6.2						6.2
A. polyodon					1.1						1.1
Astelia solandri	0.6										0.6
Blechnum filiforme					0.1						0.1
Collospermum hastatum					0.1						0.1
Ctenopteris heterophylla					0.2						0.2
Dendrobium cunninghamii					1.2						1.2
Earina autumnalis	1.4				1.0						2.4
E. mucronata	0.1				0.8						0.9
Filmy fern					1.8						1.8
Kirk's daisy					0.2						0.2
Lichen							0.2				0.2
Moss							1.3				1.3
Phymatosorus diversifolius					4.6						4.6
Pittosporum cornifolium					0.9						0.9
Puka	5.5				0.6						6.1
LIANE											
Clematis paniculata					0.7						0.7
Supplejack	2.7				0.6	0.3					3.6
INVERTEBRATE											
Bag moth								1.6			1.6
Insect grub								0.2			0.2
TOTAL	40.1	4.0	6.8	0.3	43.8	0.6	1.5	1.8	0.2	0.9	100

\+ = includes leaf, petiole, green stems, fern foliage

Appendix 4.13 : Components and percent species composition of kokako diet in mid to late winter 1984 (1 July - 27 August)

	Fruit	Nectar	Flower	Flower bud	Leaf+	Leaf bud	Moss	Moss capsule	Invertebrate	Bark	Dead plant material	Unknown	TOTAL
N =	484	13	50	4	626	4	11	18	73	3	2	18	1318
PODOCARP													
Hall's totara	3.3												3.3
Miro	1.2												1.2
Rimu	0.5												0.5
TREE HARDWOOD													
Hinau													
Kohekohe	1.1												1.1
Puriri	0.7	1.0	3.0										4.7
Rewarewa	0.5												0.5
Taraire	1.3												1.3
Tawa	0.9										0.2		1.1
SHRUB HARDWOOD													
Fivefinger	0.7				0.8								1.5
Hangehange					1.3								1.3
Heketara				0.1	9.7	0.1							9.9
Lancewood	1.3												1.3
Mapou	2.2					0.1							2.3
Kohuhu	2.1				1.9								4.0
Melicytus macrophyllus	0.2												0.2
Nestegis montana					0.5								0.5
Pate	3.0												3.0
Pigeonwood	0.2				0.1								0.3
Ramarama	0.2												0.2

Appendix 4.13 (cont'd)

	Fruit	Nectar	Flower	Flower bud	Leaf^{+}	Leaf bud	Moss	Moss capsule	Invertebrate	Bark	Dead plant material	Unknown	TOTAL
N =	484	134	50	4	626	4	11	18	73	3	2	18	1318
Raukawa					0.3								0.3
Raurekau	0.1				1.4	0.1				0.2			1.8
Toro	0.1												0.1
White maire					0.2								0.2
NIKAU PALM	10.9				0.2								11.1
GROUND **PLANT, OTHER**													
Gahnia pauciflora	0.1												0.1
Unknown					0.1				0.1			1.3	1.5
EPIPHYTE													
Asplenium flaccidum					6.8								6.8
A. oblongifolium					0.1								0.1
A. polyodon					1.8								1.8
Astelia solandri	0.5												0.5
Bulbophyllum pygmaeum					0.2								0.2
Ctenopteris heterophylla					0.5								0.5
Dendrobium cunninghamii					1.0								1.0
Drymoanthus adversus					0.3								0.3
Earina autumnalis	0.4				2.4								2.8
E. mucronata	0.5		0.5	0.2	1.4								2.6
Filmy fern					0.7								0.7
Kirk's daisy					0.2								0.2
Moss							0.8	1.4					2.2
Phymatosorus diversifolius					9.3								9.3
Pittosporum cornifolium	0.9		0.2		0.2								1.3
Puka	1.6				3.6	0.1							5.3

Appendix 4.13 (cont'd)

	Fruit	Nectar	Flower	Flower bud	Leaf[+]	Leaf bud	Moss	Moss capsule	Invertebrate	Bark	Dead plant materia	Unknown	TOTAL
N =	484	134	50	4	626	4	11	18	73	3	2	18	1318
LIANE													
Clematis paniculata			0.2	0.1	3.2								3.5
Metrosideros diffusa					0.1								0.1
Rubus cissoides	0.3												0.3
Supplejack	1.7												1.7
INVERTEBRATE													
Bag moth									4.9				4.9
Insect grub									0.4				0.4
Spider egg case									0.2				0.2
TOTAL	36.5	1.0	3.9	0.4	48.3	0.4	0.8	1.4	5.6	0.2	0.2	1.3	100

+ = includes leaf, petiole, green stems, fern foliage

Appendix 4.14 : Components and percent species composition of kokako diet in spring 1984
(28 August - 19 September)

	Fruit	Flower	Flower bud	Leaf^{+}	Moss	Moss capsule	Invertebrate	Bark	Exudate	Unknown	TOTAL
N =	460	142	4	703	6	44	42	22	2	11	1436
PODOCARP											
Hall's totara	1.5										1.5
Matai	0.3										0.3
Miro	0.2										0.2
Rimu	3.3										3.3
TREE HARDWOOD											
Makamaka		0.1									0.1
Kohekohe	0.1			0.2							0.3
Puriri	0.1	7.0									7.1
Taraire	3.0	0.5									3.5
Tawa	1.6										1.6
SHRUB HARDWOOD											
Alseuosmia macrophylla											
Fivefinger	0.4			2.7				0.5			3.6
Hangehange	0.1		0.3	1.3							1.7
Heketara				5.5							5.5
Kotukutuku		0.3		0.2							0.5
Lancewood	2.9										2.9
Mapou	3.1		0.2								3.3
Kohuhu	1.5			0.8							2.3
Mida salicifolia				0.5							3.3
Pate								0.3			0.3
Pigeonwood	2.4										2.4
Ramarama	1.0										1.0
Raukawa				0.6							0.6
Raurekau				4.5					0.1		4.6
Toro				0.1							0.1
Toru		0.4									0.4
NIKAU PALM	8.9			0.1							9.0
TREE FERN, GROUND PLANT, OTHER											
Unknown										0.8	0.8

Appendix 4.14 (cont'd)

	Fruit	Flower	Flower bud	Leaf+	Moss	Moss capsule	Invertebrate	Bark	Exudate	Unknown	TOTAL
N =	423	42	72	3	462	6	16	19	2	9	1054
EPIPHYTE											
Anarthropteris lanceolata				0.1							0.1
Asplenium flaccidum				10.2							10.2
A. polyodon				0.9							0.9
Collospermum hastatum				0.3							0.3
Ctenopteris heterophylla				0.1							0.1
Dendrobium cunninghamii				1.0							1.0
Earina autumnalis				0.5							0.5
E. mucronata		1.5		0.6							2.1
Filmy fern				1.5							1.5
Kirk's daisy				0.4							0.4
Moss					0.4	2.9					3.2
Phymatosorus diversifolius				6.5							6.5
Pittosporum cornifolium	0.5			0.2		0.2					0.9
Puka	0.8			0.6							9.4
Pyrrosia eleagnifolia				0.1							0.1
LIANE											
Clematis paniculata				1.3							1.3
Kiekie				0.1				0.7			0.8
Rubus australis				0.1							0.1
Supplejack	0.4			0.1							0.5
INVERTEBRATE											
Bag moth							2.6				2.6
Insect cocoon							0.2				0.2
Insect grub							0.1				0.1
TOTAL	32.1	9.8	0.3	49.0	0.4	3.1	2.9	1.5	0.1	0.8	100

+ = includes leaf, petiole, green stems, fern foliage

Appendix 4.15: Seasonal use of food types by kokako

						early	mid-late		early	mid-late		
		Sumr 1982/3	Autm 1983	Wint 1983	Spr 1983	Sum 1983/4	Sum 1983/4	Autm 1984	Win 1984	Win 1984	Spr 1984	Total
N =		191	477	256	841	387	427	1041	1054	1318	1436	7428
					*		***	*	*	***		
1.	Bark	1.0	0	0	0	0	0	0.2	0.2	0.2	1.5	0.4
	Dead material	0	0	0	0	0	4.0	0		0.2	0	0.3
			***	**	***	***	**	***	***	***	***	
2.	Flower	5.8	3.4	3.1	9.4	8.3	3.7	1.7	6.8	3.8	9.9	6.0
	Flower bud	0	0	0	3.0	8.5	0	0.5	0.3	0.3	0.3	1.0
	Nectar	0	0	0	0	0	0	1.2	4.0	1.0	0	0.9
			***	***	***	**	***	***		**	***	
3.	Fruit	39.8	65.4	31.6	13.2	32.0	60.0	66.3	39.9	32.6	30.0	39.5
	Seed	0	0	0	0	1.8	0.5	0	0.2	4.1	2.0	1.3
			***	***	***		***	***		***	***	
4.	Leaf	41.9	23.1	42.7	51.5	40.0	23.4	22.9	42.3	47.5	46.5	39.9
	Leaf Bud	1.6	0	0	9.3	0.3	0	0	0.6	0.3	0	1.2
	Peticle	0	0	16.0	0	0	0.2	0	0.2	0.9	0	0.8
	Stem	0.5	0	0	0	0.5	0	0	1.2	0	2.4	0.7
		*		***	***				***	***		
5.	Lichen	0	0.2	0	0.2	0	1.2	0.3	0.2	0	0	0.2
	Moss	7.3	5.2	0	2.1	3.4	3.3	2.2	1.2	0.8	0.4	1.8
	Moss Capsule	0	0	0	7.6	1.8	0.7	0.7	0.1	1.4	3.1	1.9
							**		*	**		
6.	Invertebrate	2.1	2.1	3.5	2.0	3.4	0.7	3.3	1.8	5.5	2.9	3.0
				**		*	**					
7.	Other		0.6	3.1	1.5	0	2.6	0.7	0.9	1.4	0.9	1.1
		100	100	100	100	100	100	100	100	100	100	100

Chi-squared test significance levels * = P<0.05 ** = P<0.01 *** = P<0.001

Appendix 4.16 Seasonal use of food types between five kokako home ranges

	Autumn 1984					Winter 1984					Spring 1984				
	Ben	Hill	Pet	Pukatea	Summit	Ben	Hill	Pet	Pukatea	Summit	Ben	Hill	Pet	Pukatea	Summit
N=	220	219	147	156	256	145	517	384	0503	823	166	271	259	275	465
												***	*		
1. Bark	0	0	1.4	0	0.2	0	0.6	0.5	0.4	0	0	4.0	0	0.7	1.9
		**		*	***		***			***	***	***		*	**
2. Flower	1.8	7.0	3.4	5.8	0	11.1	13.2	9.6	7.6	3.0	1.2	22.5	13.1	6.1	6.9
	***	***		***	***		*	***	***	***		**			
3. Fruit	80.5	48.9	72.8	51.9	73.8	37.9	33.5	45.8	23.4	45.0	37.3	24.7	36.7	32.7	31.4
	**	***	***	***				***	***			*	***	*	**
4. Leaf	17.3	36.1	6.8	32.7	23.0	46.8	46.5	33.3	55.6	47.7	54.8	42.0	35.5	54.6	55.1
	**	**	***								*	**	***	*	
5. Moss	0	2.7	8.2	1.9	2.0	1.4	2.5	0.3	1.6	1.2	6.6	0.4	9.7	1.1	2.2
								**	***	**	*	***		*	***
6. Invertebrates	0.5	3.7	7.5	7.1	1.2	1.4	2.5	0.7	6.8	2.2	0	6.3	4.2	4.7	0.2
															***
7. Other	0	2.7	0	0.6	0.7	1.4	1.2	1.0	1.6	0.9	0	0	0.8	0	2.4
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Chi-squared test significance levels * = P<0.05 ** = P<0.01 *** = P<0.001

Appendix 4.17: Species composition of food classes used by kokako

1. KAURI

   Agathis australis

2. PODOCARPS

   Dacrycarpus dacrydioides: kahikatea
   Dacrydium cupressinum: rimu
   Halocarpus kirkii: manoao
   Phyllocladus trichomanoides: tanekaha
   Podocarpus hallii: Hall's totara
   Prumnopitys ferruginea: miro
   P. taxifolia: matai

3. TREE HARDWOODS

   Ackama rosifolia: makamaka
   Beilschmiedia tarairi: taraire
   B. tawa: tawa
   Corynocarpus laevigatus: karaka
   Dysoxylum spectabile: kohekohe
   Elaeocarpus dentatus: hinau
   Knightia excelsa: rewarewa
   Laurelia novaezelandiae: pukatea
   Litsea calicaris: mangeao
   Metrosideros robusta: northern rata
   Vitex lucens: puriri
   Weinmannia silvicola var. silvicola: towai

4. SHRUB HARDWOODS

   Alseuosmia macrophylla
   Aristotelia serrata: wineberry
   Brachyglottis repanda: rangiora
   Carpodetus serratus: putaputaweta
   Coprosma arborea
   C. grandifolia: raurekau
   C. parviflora
   C. spathulata subsp. spathulata
   Dracophyllum latifolium
   Fuchsia excorticata: kotukutuku
   Geniostoma rupestre var. ligustrifolium: hangehange
   Hedycarya arborea: pigeonwood
   Hoheria populnea var. populnea: lacebark
   Ixerba brexioides: tawari
   Lophomyrtus bullata: ramarama
   Macropiper excelsum var. excelsum: kawakawa
   Melicytus macrophyllus
   M. micranthus
   M. ramiflorus subsp. ramiflorus: mahoe
   Mida salicifolia: maire
   Myrsine australis: mapou
   M. salicina: toro
   Nestegis lanceolata: white maire
   Olearia rani var. rani: heketara
   Phebalium nudum: mairehau
   Pittosporum tenuifolium: kohuhu
   P. virgatum
   Pseudopanax arboreus var. arboreus: fivefinger
   P. crassifolius: lancewood
   P. edgerleyi: raukawa
   Schefflera digitata: pate
   Styphelia fasciculata: mingimingi
   Toronia toru: toru

5. NIKAU

   Rhopalostylis sapida

6. TREE FERN

   Cyathea dealbata: ponga
   C. medullaris: mamaku
   C. smithii

7. OTHER

   Dead tree
   Ground
   Uncinia species (probably U. uncinata)
   Unknown

8. EPIPHYTES

   Anarthropteris lanceolata
   Asplenium bulbiferum
   A. flaccidum subsp. flaccidum
   A. oblongifolium
   A. polyodon
   Astelia solandri
   Blechnum filiforme
   Brachyglottis sp. (Senecio kirkii var. angustior): Kirk's daisy
   Bulbophyllum pygmaeum
   Ctenopteris heterophylla
   Collospermum hastatum
   Dendrobium cunninghamii
   Earina autumnalis
   E. mucronata
   Filmy ferns (especially Hymenophyllum demissum, H. dilatatum and H. sanguinolentum)
   Griselinia lucida: puka
   Lichen
   Lycopodium varium
   Lygodium articulatum
   Moss
   Phymatosorus diversifolius
   Pittosporum cornifolium
   Pyrrosia eleagnifolia

9. LIANES

   Clematis paniculata
   Freycinetia baueriana subsp. banksii: kiekie
   Metrosideros diffusa
   M. perforata
   Ripogonum scandens: supplejack
   Rubus australis: bush lawyer
   R. cissoides: bush lawyer

10. INVERTEBRATES

   Bagmoth
   Insect grub
   Insect cocoon
   Insect (unknown type)
   Scale insect
   Spider eggs

Appendix 4.18: Seasonal use of food classes by kokako

					early	mid-late		early	mid-late		
	Sumr 1982/3	Autm 1983	Wint 1983	Spr 1983	Sum 1983/4	Sum 1983/4	Autm 1984	Win 1984	Win 1984	Spr 1984	Total
N =	191	477	256	841	387	427	1041	1054	1318	1436	7428
Kauri	0	0	0	0.2	0	0	0.6	0	0	0	0.1
Podocarp	** 3.7	*** 22.2	9.6	* 7.7	7.5	** 5.6	*** 24.6	* 8.3	*** 5.2	*** 5.2	10.0
Tree hardwood	* 6.8	12.4	* 7.4	12.4	** 7.0	* 8.2	*** 6.9	*** 21.1	10.2	* 13.5	11.8
Shrub hardwood	*** 67.3	39.0	*** 53.1	33.4	35.1	*** 44.3	38.7	31.4	*** 26.6	*** 29.6	34.5
Nikau palm	*** 0	*** 0.6	*** 0.4	*** 0.7	*** 0.3	*** 2.1	*** 9.2	* 4.2	*** 11.2	*** 9.0	5.9
Epiphyte	*** 7.3	** 22.9	** 16.8	*** 41.0	*** 18.3	*** 20.4	*** 13.3	28.2	*** 35.7	*** 36.9	28.4
Liane	*** 12.6	*** 0.8	* 2.0	*** 2.0	*** 27.9	*** 19.2	*** 3.3	** 4.2	5.6	*** 3.1	5.9
Invertebrate	2.1	2.1	3.5	* 1.9	3.4	** 0.2	3.3	* 1.7	*** 5.5	2.7	2.9
Other#	0	0	1.6	0.6	1.3	0	0.1	1.0	0	0.2	0.5
	100	100	100	100	100	100	100	100	100	100	100

Other = tree ferns, ground, dead tree, unknown

Chi-squared test significance levels * = P < 0.05 ** = P < 0.01 *** = P < 0.001

Appendix 4.19: Seasonal use of food classes between five kokako home ranges

Autumn 1984	Ben	Hill	Pet	Pukatea	Summit
N =	220	219	147	156	256
Kauri	0	2.7	0	0	0
Podocarp	*** 39.1	26.0	22.4	*** 8.3	26.5
Tree hardwood	** 0.9	*** 12.8	2.7	*** 9.6	*** 0.8
Shrub hardwood	35.0	40.6	50.3	** 30.8	42.2
Nikau palm	* 13.2	6.8	*** 0	* 3.8	*** 16.8
Epiphyte	* 8.6	*** 6.8	10.9	*** 35.9	9.8
Liane	2.7	** 0	* 6.1	4.5	2.7
Invertebrate	** 0.5	3.7	** 7.5	** 7.1	* 1.2
Other#	0	0.5	0	0	0
	100	100	100	100	100

Other = tree ferns, ground, dead tree, unknown

Chi-squared test significance levels * = P < 0.05 ** = P < 0.01 *** = P < 0.001

	Ben	Hill	Pet	Pukatea	Summit
Early & mid-late Winter 1984					
N =	145	517	384	503	823
Kauri	0	0	0	0	0
Podocarp	16.6***	7.4	6.8	0***	8.5*
Tree hardwood	10.3***	20.6	15.9	14.3	12.5*
Shrub hardwood	45.5***	38.2***	36.2***	22.0***	20.5***
Nikau palm	0***	3.9***	2.6***	10.3*	13.3***
Epiphyte	22.1**	25.2***	21.0***	39.0***	39.3***
Liane	4.1	2.2***	10.2***	7.6**	2.8***
Invertebrate	1.4*	2.5	6.5**	6.8***	2.9***
Other#	0	0	0.8	0	1.2
Spring 1984					
N =	166	271	259	275	465
Kauri	0	0	0	0	0
Podocarp	9.0*	2.6*	3.5	7.3	5.2
Tree hardwood	9.6	29.5***	16.2	8.0***	7.3***
Shrub hardwood	53.0***	38.8***	41.3***	20.0***	15.1***
Nikau palm	0***	1.8***	1.9***	11.3	18.9***
Epiphyte	27.2**	21.0***	30.5*	45.4**	48.2***
Liane	1.2	0**	2.7	3.6	5.4
Invertebrate	0*	6.3***	3.9	4.4	0***
Other#	0	0	0	0	0
	100	100	100	100	100

Other = tree ferns, ground, dead tree, unknown

Chi-squared test significance levels * = P < 0.05 ** = P < 0.01 *** = P < 0.001

Appendix 4.20: Seasonal use of food hosts by kokako

					early	mid-late		early	mid-late		
	Sumr 1982/3	Autm 1983	Wint 1983	Spr 1983	Sum 1983/4	Sum 1983/4	Autm 1984	Win 1984	Win 1984	Spr 1984	Total
N =	191	474	256	841	387	427	1041	1054	1318	1436	7428
Kauri	0	0	0	0.2	0	0	0.5	0	0.2	0	0.1
Podocarp	* 9.4	*** 27.9	** 21.9	15.6	** 9.3	*** 6.1	*** 29.0	14.3	*** 11.0	*** 11.5	15.7
Tree hardwood	*** 14.1	* 31.2	*** 16.4	** 40.3	35.1	** 29.7	*** 20.1	*** 46.7	*** 42.3	*** 44.6	36.6
Shrub hardwood	*** 71.4	39.4	*** 54.3	37.5	*** 54.0	*** 55.5	40.2	*** 32.3	*** 30.8	*** 32.8	38.5
Nikau palm	*** 0	*** 0.8	*** 0	*** 2.5	*** 0.3	*** 2.1	*** 9.2	** 4.5	*** 12.4	*** 9.9	6.5
Other#	*** 4.7	0.6	*** 7.4	*** 3.9	*** 1.3	*** 6.6	*** 1.0	*** 1.3	*** 3.3	*** 1.2	2.6
	100	100	100	100	100	100	100	100	100	100	100

Other = tree ferns, ground, dead tree, unknown

Chi-squared test significance levels * = P < 0.05 ** = P < 0.01 *** = P < 0.001

Appendix 4.21: Sesonal use of food hosts between five kokako home ranges

Autumn 1984	Ben	Hill	Pet	Pukatea	Summit
N =	220	219	147	156	256
Kauri	0	2.3	0	0	0
Podocarp	*** 45.8	28.8	27.8	*** 9.0	31.6
Tree hardwood	*** 2.3	18.3	19.7	*** 53.9	*** 9.0
Shrub hardwood	38.2	40.6	40.9	* 29.5	38.3
Nikau palm	* 13.2	6.8	*** 0	* 3.8	*** 16.8
Other#	** 0.5	*** 3.2	*** 11.6	3.8	4.3
	100	100	100	100	100

Other = tree ferns, ground, dead tree, unknown

Chi-squared test significance levels * = $P < 0.05$ ** = $P < 0.01$ *** = $P < 0.001$

Early & mid-late Winter 1984	Ben	Hill	Pet	Pukatea	Summit
N =	145	517	384	503	823
Kauri	0	0	0.8	0	0
Podocarp	*** 26.9	*** 16.8	10.7	*** 1.8	* 14.6
Tree hardwood	*** 23.4	*** 37.0	43.8	*** 59.8	43.2
Shrub hardwood	*** 45.5	*** 39.7	** 38.2	*** 25.0	*** 24.4
Nikau palm	*** 0	*** 3.9	*** 2.9	10.4	*** 15.4
Other#	4.2	1.2	1.8	3.0	2.4
	100	100	100	100	100

Other# = tree ferns, ground, dead tree, unknown

Chi-squared test significance levels * = P < 0.05 ** = P < 0.01 *** = P < 0.001

Spring 1984

N =	166	271	259	275	465
Kauri	0	0	0	0	0
Podocarp	*** 19.3	9.6	11.2	** 16.4	*** 7.1
Tree hardwood	*** 25.3	48.0	44.4	** 51.6	45.6
Shrub hardwood	*** 55.4	** 40.2	*** 42.1	*** 20.0	*** 22.8
Nikau palm	*** 0	*** 2.2	*** 1.9	11.3	*** 21.5
Other#	0	0	0.4	0.7	2.9
	100	100	100	100	100

Other = tree ferns, ground, dead tree, unknown

Chi-squared test significance levels * = P < 0.05 ** = P < 0.01 *** = P < 0.001

Appendix 4.22: Seasonal variation in kokako activities at Puketi Forest

	SUM'R 1982-3	AUTH 1983	WINT 1983	SPR. 1983	SUM 1983-4	AUTH 1984	WIN 1984	SPR 1984	TOTAL
N =	899	1656	539	2475	4892	3608	6094	3084	23236
	***	**	***	*	***	***	***	***	
FEED	21.2	28.8	47.5	34.4	16.7	28.4	38.9	46.4	32.0
	***	***	***	***	***		***	**	
SONG	18.3	9.0	7.2	17.7	19.8	13.6	5.5	15.1	13.2
	***	**				***	***	***	
CALL	3.7	15.3	15.0	12.2	13.1	10.9	16.5	10.2	12.9
	***	*		***	***	***		***	
MOVE	24.1	15.2	19.3	21.1	22.0	12.7	16.7	9.1	16.9
	***	***	***	***	***	***	***	***	
ROOST-PREEN	32.7	30.8	10.4	10.7	25.2	33.5	21.1	15.7	22.9
	***	***	*	***	***	***	***	***	
INCIDENTAL	0	0.9	0.6	3.9	3.2	0.7	1.3	3.3	2.1
TOTAL	100	100	100	100	100	100	100	100	100

Chi-squared test significance levels * = P < 0.05, ** = P < 0.01, *** = P < 0.001

Appendix 4.23: Diurnal variation in kokako activities during summer 1983/84 and winter 1984

TIME OF DAY* (NZST)

Early-late Summer 1983/4

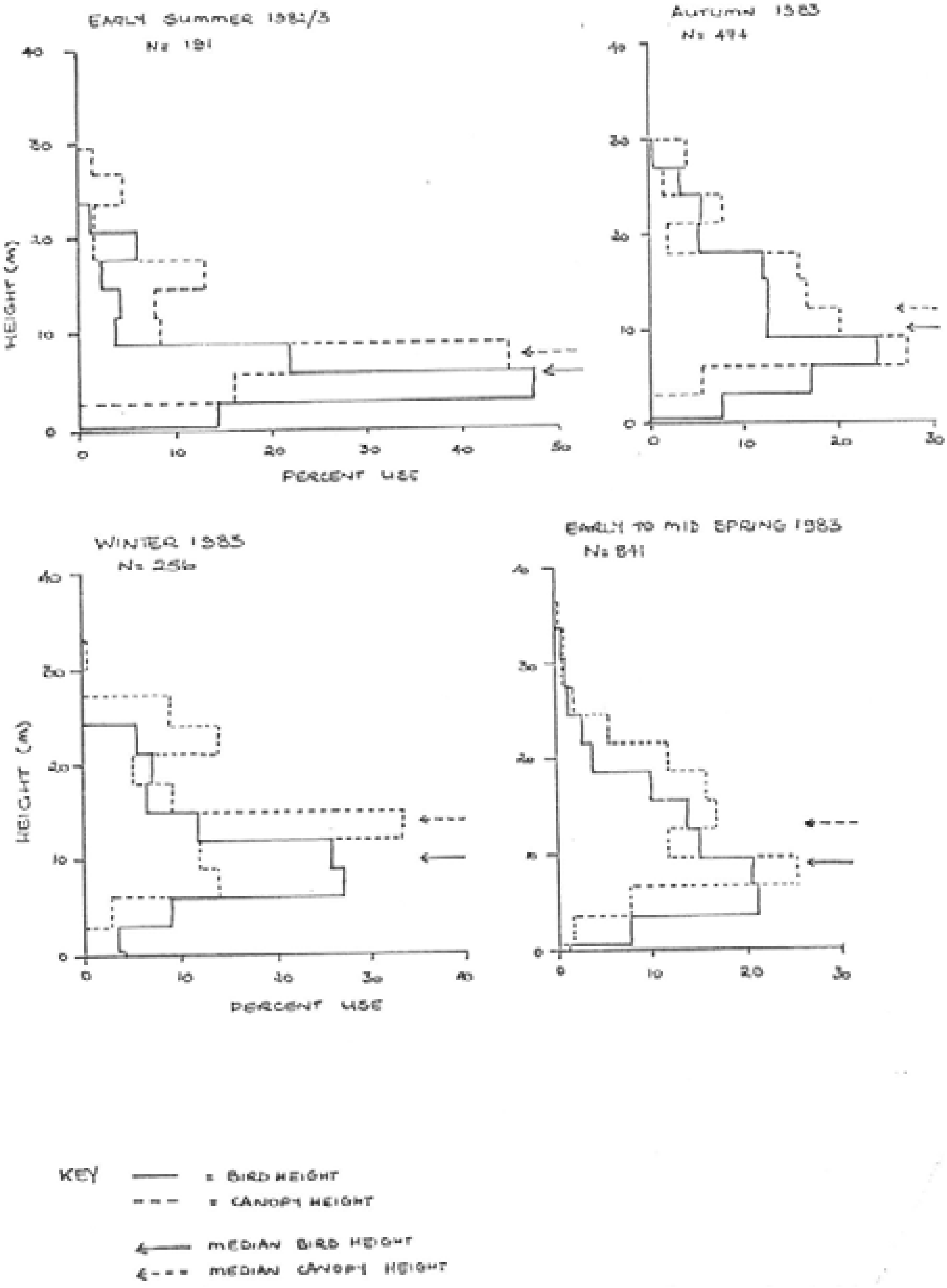
	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19 plus	Total
N =	44	209	310	338	503	473	692	673	473	388	228	182	57	144	159	4892
Feed	2.3	6.7	9.7	14.8	14.5	26.0	18.8	19.3	22.4	13.7	21.1	20.9	15.8	4.9		16.7
Song	59.1	73.2	36.4	21.3	8.7	8.0	4.3	2.5	3.6	18.6	18.9	45.6	38.5	63.9	92.4	19.8
Call	25.0	11.5	11.0	20.4	21.5	10.6	11.1	17.2	8.7	8.2	19.7	6.6	15.8	6.9		13.1
Move	9.1	8.6	21.6	24.3	27.2	27.7	21.4	25.7	22.8	21.1	28.9	12.1	24.6	11.8	1.2	22.0
Roost																
-preen	4.5	0	16.1	13.0	23.3	24.5	40.3	32.5	37.0	36.6	11.4	14.8	5.3	12.5	6.3	25.2
Incidental	0	0	5.2	6.2	4.8	3.2	4.2	2.8	5.5	1.8	0	0	0	0		3.2
	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

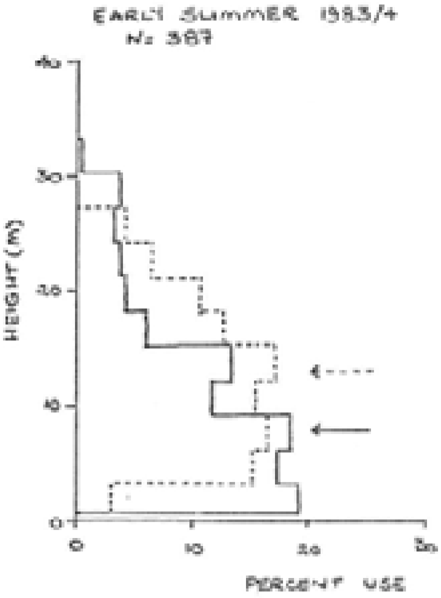
Early-late Winter 1983/4

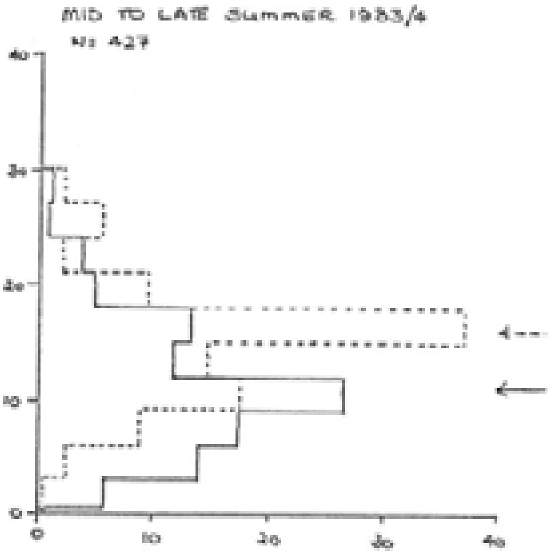
	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19 plus	Total
N =			111	380	538	761	667	673	714	713	639	664	234			6094
Feed			17.1	24.7	32.4	43.3	36.4	43.4	40.4	43.9	42.4	41.0	32.9			38.9
Song			20.8	24.5	10.6	3.5	1.6	2.2	1.0	1.1	3.8	8.6	5.6			5.5
Call			41.4	31.1	17.3	19.2	16.6	12.0	10.5	13.9	14.9	15.1	14.5			16.5
Move			9.9	5.5	11.0	16.4	19.0	22.0	17.5	17.0	21.1	13.4	22.7			16.7
Roost																
-preen			9.9	13.9	28.3	15.1	23.5	18.6	23.8	23.4	16.9	19.5	23.9			21.1
Incidental			0.9	0.3	0.4	2.5	2.7	1.8	0.8	0.7	1.1	1.4	0.4			1.3
			100	100	100	100	100	100	100	100	100	100	100			100

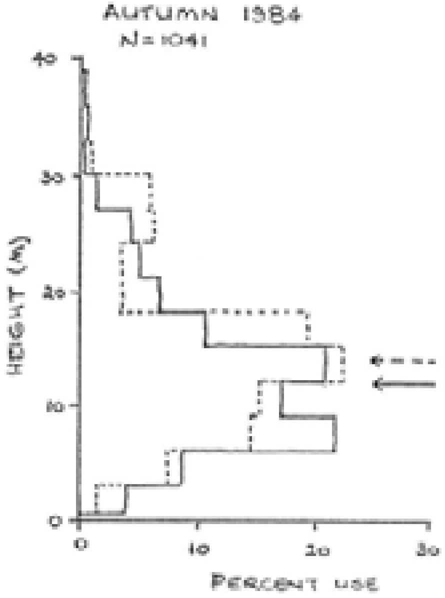
*Time of Day: 05 signifies 0500-0559, 06 = 0600-0659, etc. 1900 plus = 1900 and subsequently

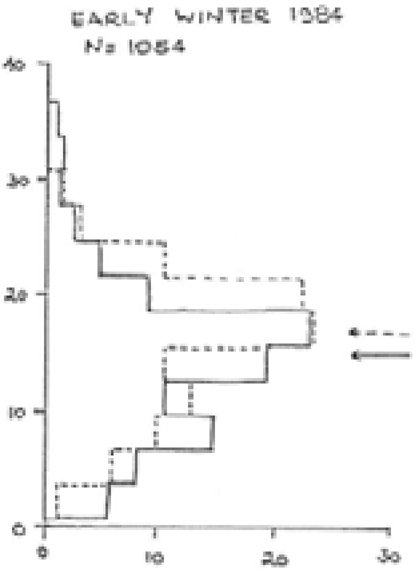
Appendix 4.24: Changes in height profiles of feeding kokako with season

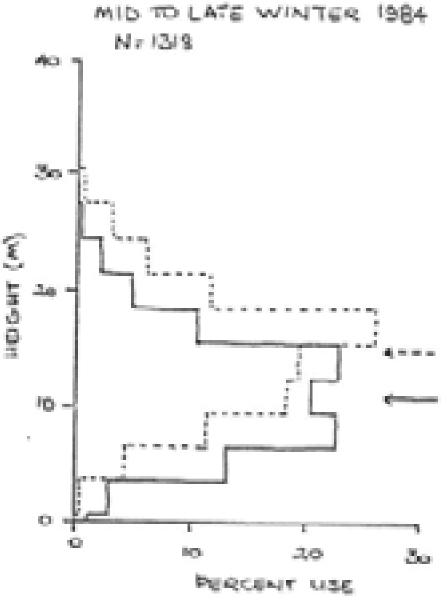


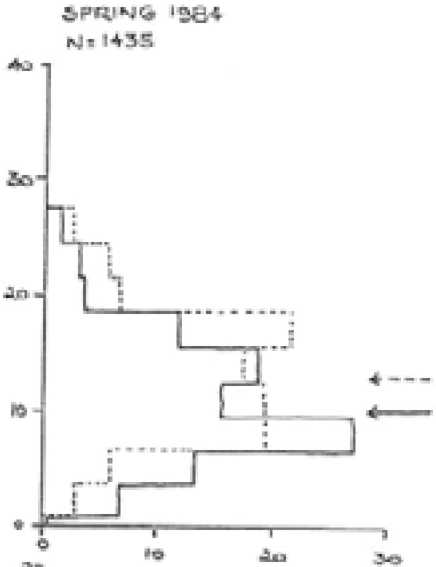

EARLY SUMMER 1983/4
N= 387
HEIGHT (M)
40
30
20
10
0
0
10
20
30
PERCENT USE


MID TO LATE SUMMER 1983/4
N= 427
40
30
20
10
0
0
10
20
30
40


AUTUMN 1984
N= 1041
HEIGHT (M)
40
30
20
10
0
0
10
20
30
PERCENT USE


EARLY WINTER 1984
N= 1084
40
30
20
10
0
0
10
20
30


MID TO LATE WINTER 1984
N= 1318
HEIGHT (M)
40
30
20
10
0
0
10
20
30
PERCENT USE


SPRING 1984
N= 1435
40
30
20
10
0
0
10
20
30

SECTION FIVE: KOKAKO USE OF FOREST SUMMARY

SUMMARY

1. Use of vegetation groups and floristic gradients

(a) Kokako lived in home ranges all year round. In Puketi Forest, the home ranges were situated mostly at the headwaters of side catchments of the Waipapa River, where the terrain was divided into ridges and gullies.

(b) At a combined home range level

(i) The primary floristic gradient was associated with changes in topography from gully bottom to ridge top. Within individual home ranges, there were usually floristic gradients associated with disturbance, either natural or man-induced.

(ii) Kokako made significantly greater use of particular vegetation groups which were common to all home ranges studied. There were clear seasonal trends, e.g. toward kauri-dominated vegetation (in home ranges having this vegetation) in Summer 1983-84, and toward podocarp-dominated vegetation in Autumn 1984. Both of these were ridge top communities.

(iii) Some vegetation groups were used significantly more than others. Vegetation of upper ridge flanks and gently rolling ridge tops were favoured most consistently for all kokako activities. These sites were characterised by towai, taraire, kohekohe and tawa. Hall's totara was also a major element.

(iv) The next most utilised vegetation group for feeding was that of gully bottoms, while for singing it was the forested crowns of dissected ridges.

(c) At an individual home range level

(i) Primary floristic gradients paralleled the topographic gradient identified across all home ranges. Secondary floristic gradients were usually associated with disturbance, either natural or man-induced.

(ii) There were also significant trends apparent in the use of vegetation made by kokako with respect to the degree of disturbance. Most of the birds studied made significantly greater use of undisturbed vegetation and only rarely used disturbed vegetation. One kokako used vegetation damaged by an historic cyclone, but birds avoided man-damaged vegetation in home ranges where this was present.

2. Use of Plant Species

a) Kokako activities took place mostly in the upper tiers of the forest. Feeding occurred principally in tiers 2 (12m-canopy height), 3 (5m-12m) and 7 (epiphytes). Singing was undertaken mainly in tier 1 and in tier 2.

b) Overall, kokako used common plant species generally in proportion to their abundance, especially for preening, moving and calling.

c) However, the frequency of use of some plant species showed only weak correlation with individual species abundance, indicating that some species were selected significantly more than others for these activities.

d) The species that were used for feeding changed markedly with season.

e) In any given season, most of the species fed on bore either flowers or ripe fruit at the time. But some of these were fed on to a significantly greater extent than others. In some seasons, the amount of feeding on species was proportional to their relative abundance, but in others, items from relatively uncommon species were eaten in greater quantities than those from more common food species.

f) Singing activity varied throughout the year, summer singing being several times greater than that in winter. The use of tree species as song posts in tier 1 (emergents) was related to their general abundance, but in tier 2 (12m-canopy) some species were used significantly more than others. Use of plant species for song posts varied seasonally in tier 2. During summer, kauri was the song post used most frequently in the home ranges where it was present.

5.1 INTRODUCTION

5.1.1 Preamble

Vegetation structure and composition has long been as an important factor in habitat selection of forest birds (e.g. MacArthur and MacArthur 1961). North Island kokako primarily inhabit mature lowland forest (Lavers 1978, O'Donnell 1984). This section examines how kokako use their habitat in relation to vegetation features in Puketi Forest (based on the studies in Section 2 and 4 of this report). Specific attention has been made to the use of particular forest groups and floristic gradients (defined in Section 2), and also for preferences of particular plant species in relation to their abundance.

Six kokako home ranges were marked into grid squares. This provided a common framework on which (i) standardised vegetation descriptions could be made, (ii) aspects of kokako behaviour and habitat use could be evaluated against particular forest groups and floristic gradients, and (iii) the degree of selection or non-selection by kokako for individual plant species could be assessed. Grid systems have been used in similar studies overseas involving quantification of bird habitat use (e.g. Noon 1981).

5.1.2 General methods

Techniques for collecting data on kokako activities have been outlined in Section 4.1.1. Data collection and analysis methods for describing the vegetation have been provided in Section 2.1.0 and 2.1.1.

5.1.3 Analysis

The analysis was conducted to two aspects of use of the forest by kokako:

A. Use of vegetation groups and floristic gradients. This was conducted at two levels:

i) for all kokako home ranges combined; to determine general trends in forest use, and

ii) within individual home ranges. Trends for use of particular home ranges were examined to compare differences in behaviour of individual kokako (as noted in Section 4) with differences in vegetation between their home ranges (see Section 2 and Appendix 2.1 to 2.6).

B. Use of species. This was conducted to the species that appeared to be important for a range of kokako activities at certain times of the year. Only general trends were described here (i.e. data from all home ranges were combined).

5.2 USE OF VEGETATION GROUPS AND FLORISTIC GRADIENTS BY KOKAKO

5.2.1 Preamble

Studies overseas (e.g. James 1971, Smith 1977) have shown niche separation of species along floristic gradients. The present study sought to define preferred habitat for kokako along floristic gradients in the forest they inhabit. The aim was to elucidate trends in use of forest by kokako for various activities.

Vertical stratification of forest has been used as a key to interpreting bird habitat use (e.g. Cyr 1977, James and Warner 1982). Previous studies of kokako (e.g. Hay 1981) have shown that they require and utilise the complex forest structure fully. This section also examined the extent that tiers of the forest were used to the forest habitat.

Within each season, counts were made of eight variables plow) for each grid square:

(i) frequency of all kokako activities

(ii) frequency of feeding

(iii) frequency of singing

(iv) frequency of other activities (calling, moving, and preening)

where the total of "feeding", "singing" and "other activities" was equal to the total of "all activities" in each grid square.

(i) frequency of use of tiers 1 and 2 ("emergents and canopy" i.e. >12m)

(ii) frequency of use of tiers 3 and 4 ("subcanopy", i.e. 5m-12m)

(iii) frequency of use of tiers 5 and 6 (“ground level", i.e. 0-2m)

(iv) frequency of use of tier 7 (epiphytes)

again where the total of counts (v) to (viii) was equal to the total of "all activities" in each grid square.

This data file was edited further to include ordination scores for each grid square from Axes 1 and 2 (the scores for grid squares along the two main floristic gradients, see Section 2.2.1.A), and the forest group of each grid square, as by classification (see Section 2.2.1.B). Two sets of ordination scores and vegetation groups were assigned to each grid square:

- its ordination scores and DCA groups of all home ranges, the floristic gradients detected for all home ranges combined (see Section 2.2.1A & B), and

- its ordination scores and TWINSPAN classification groups noted from analysis of individual home ranges (see Section 2.2.2 and Appendix 2.1-2.6).

The statistical computer package GENSTAT (Alvey *et al.*1983) was used to analyse data on the Forest Research Institute computer. Non-parametric statistical methods were used to test for significant trends in kokako use of forest habitat.

Use of floristic gradients. The response of kokako to floristic gradients in their ranges was assessed by carrying out rank correlations on the frequency use of grid squares versus the ordination scores of grid squares. The statistical significance of these correlations was determined from t-tests. The correlations were calculated for all home ranges and also within home ranges, at given seasons. There were no suitable non- parametric statistics available for making between-season comparisons of use of these floristic gradients.

Use of vegetation groups A much-modified version of GENSTAT'S non-parametric, one-way analysis of variance (ANOVA); namely, the Kruskal-Wallis ANOVA adjusted for tied ranks (Zar 1974), was used to ascertain preferences for particular vegetation groups by kokako for a range of activities in each season. These tests were undertaken for all home ranges combined and within individual home ranges. Two-way ANOVAs were used to establish trends in the use of vegetation groups, both within home ranges and also for all home ranges combined. In the apparent absence of suitable non-parametric, two-way ANOVA techniques, an approximation was used in which a parametric two-way ANOVA was conducted on ranked variables. Imam (1974) considered this method to be both robust and powerful.

5.2.2 Results

A. For all home ranges combined

i) Interseasonal comparisons
The main floristic gradient detected across all of the kokako home ranges studied corresponded with a change in topography from gully bottoms (with poorly drained, moist, sheltered, more fertile sites) to ridge tops (with well-drained, drier, more exposed sites having skeletal podsolised soils; see Section 2.2.1.C).

Statistical t-tests, showing the significance of correlations of frequency of use of grid squares versus ordination scores on the first two ordination Axes, have been tabulated in Appendix 5.1. Statistical H-values derived from Kruskal-Wallis ANOVAs of use of vegetation groups, and their levels of statistical significance, have tabulated also in Appendix 5.1.

Significant trends were noted in the use of the main floristic gradient as follows:

a) Gully vegetation.

> In Spring 1983, ANOVAs showed that all the birds made significantly greater use ($P<0.05$) of gully bottom vegetation groups, particularly epiphytes in pukatea-supplejack-kohekohe-taraire (almost certainly as food).
>
> In Summer 1983-84, ANOVAs showed significantly greater use ($P<0.05$) of the ground tiers (<2m) of the pukatea-supplejack-kohekohe-taraire group.

b) Ridge flank vegetation

> In Spring 1984, ANOVAs showed that kokako made significantly higher use ($P<0.05$) of the ground tiers (<2m) of the Hall's totara-kiekie-towai-taraire vegetation group.

c) Ridge crest vegetation

> In Summer 1983-84, correlations showed a significant trend ($P<0.05$) to use of the canopy tiers of ridge crest vegetation (particularly kauri-dominated vegetation groups). Use of kauri-dominated sites corresponded with the annual peak of song activity (see Section 4.2.1.A) and there was strong selection of kauri trees as song posts (see Section 4.2.3 and Section 5.2.2.B).
>
> In Autumn 1984, correlation of use of grid squares along the main floristic gradient showed a significant trend towards use of ridge top forest for "all activities" ($P<0.001$), feeding ($P<0.05$), singing ($P<0.05$) and use of the canopy ($P<0.01$). This represented a significant trend towards use of podocarp-dominated sites on, or just off ridge crests, at a time when ripe fruit of these species (e.g. miro) was most plentiful (see Table 3.1) and formed a substantial part of the diet (see Fig. 4.6).

The second ordination axis reflected a complex floristic gradient that was associated with changes in floral composition and structure, from home ranges at lowest altitude to those at higher altitude (see Section 2.2.1.A). Statistically significant trends occurred in a number of seasons in correlation of frequency of grid square use with the ordination scores of grid squares on the second axis. However, these represented mostly differences in the mount of data collected from each home range in a given season. Positive, significant correlations (i.e. towards home ranges at higher altitude) were apparent because kokako in the higher altitude home ranges were more amendable to study, compared with their counterparts at low altitude, which contributed comparatively less data. Consequently, interpretation of significant correlations along this axis was spurious.

(ii) Intraseasonal comparisons
Parametric two-way ANOVAs, using ranked variables, were used to establish intraseasonal use of certain vegetation groups, for all home ranges combined. Statistical F-values were calculated (see Appendix 5.2).

Significant seasonal differences were noted in the frequencies of "all activities", feeding, and use of epiphytes. may have corresponded to real seasonal differences in time spent on some of these activities, but are much more likely to represent the differing amounts of data collected in each season.

Over all of the home ranges studied, kokako made statistically greater use of specific vegetation groups for "all activities" ($P<0.001$), feeding ($P<0.001$), singing ($P<0.001$) and use of epiphytes ($P<0.05$).

The order of use of vegetation groups by kokako for “all activities", feeding, singing, and use of epiphytes has been shown on Figure 5.1. No statistically significant interactions were detected in the use of vegetation groups with season (but this occurred "Within individual home ranges", see below).

A feature of kokako habitat use was that whenever significant differences occurred between vegetation groups, the greatest use in all cases was those of upper ridge flanks and gently rolling ridge tops. Singing was primarily in ridge top vegetation groups, while gully bottom groups were important sites for feeding and for use of epiphytes.

B. Within individual home ranges

Use of floristic gradients and vegetation groups within home ranges was examined applying the same statistical procedures adopted for all home ranges Only five home ranges were examined in detail as insufficient data were collected from the sixth (Waikape).

First of all, non-parametric Spearman's correlation coefficients were calculated to determine correlations frequency use of individual grid squares, and the ordination scores of those grid squares on the first two ordination axes (Appendix 5.3). The first ordination axis in all home ranges was a complex floristic gradient which coincided with a change in topography from gully bottoms to ridge tops, with associated changes in microenvironment. The second ordination axis in most home ranges was a floristic gradient linked closely with disturbance (i.e. a transition from undisturbed mature canopy to disrupted canopies with shrub regrowth or weed colonisation). In Summit home range, the second ordination axis floristic gradient corresponded with changes in drainage, from well-drained to poorly-drained sites (sites disturbed by logging were also poorly-drained, however).

Secondly, non-parametric Kruskall-Wallis ANOVAs were conducted for each season to determine whether significantly greater use was made of certain vegetation groups within individual home ranges. A two-way, parametric on ranked variables was applied to detect whether the use of groups changed with season (Appendix 5.3). Descriptions of the vegetation in each home range have been detailed in Appendix 2.1-2.6.

In general, use of the main floristic gradient by individual kokako reinforced trends detected for all home ranges combined.

> In Winter 1983, there was a significant trend towards use of ridge top vegetation in Summit home range (the only home range that could be studied at the time).
>
> The trend towards use of ridge top vegetation was significant also in Summer 1983-84 within individual home ranges. This was evident particularly in Pet home range, where the resident bird frequented ridge top kauri groups, using kauri in the canopy as song posts and feeding on tawari flowers in the subcanopy. At the same time, the pair of kokako in Summit home range used ridge top Hall's totara-dominated vegetation extensively.
>
> In Autumn 1984, significant movements toward ridge top groups were apparent in mast home ranges, but was notable particularly in Summit home range where extensive use was made of ridge top Hall's totara-dominated vegetation.

> The kokako in Pukatea home range used mostly ridge top groups in all seasons for all activities, and moved about the home range far less than birds in the other home ranges.

All home ranges contained some degree of disturbance - either natural or man-induced. During Summer 84, there was significant avoidance of disturbed areas in Pet and Summit home ranges, and in Autumn 1984, the birds of Pukatea and Summit home ranges lived in undisturbed areas. The only significant use of disturbed areas occurred in Hill home range. The disturbed areas used in this home range were struck by a hurricane in 1959. There were no trends towards use of man-disturbed areas in any study home range, in any season. Indeed, in some seasons, vegetation in areas which had been man-disturbed were actively avoided, and similar sites with undisturbed vegetation were used instead (e.g. in Pet home range in Summer 1983-84 and Summit home range in Summer 1983-84 and Autumn 1984).

5.3 USE OF PLANT SPECIES BY KOKAKO

5.3.1 Preamble

Kokako utilised the upper tiers of forest for most of their activities [Section 4.2.3.B). This section examined the extent that kokako utilised particular plant species in the upper tiers, whether this changed with season, and the preferences shown for different species for various activities.

The analysis was based on the seasonal use that kokako made of grid squares in different home ranges. A series of editing procedures and simple counting programs were used to derive a set of kokako data which recorded:

- the season
- the grid square
- the plant species used
- the height of the plant species used; namely tier 1 (emergents), tier 2 (12m-canopy height), tier 3 (5-12m) and tier 7 (epiphytes).
- Cumulative frequencies of plant species in a particular season, grid square and tier by kokako in four activity classes, i.e. “all activities”, feeding, singing and “other” (=calling, moving, roosting, preening), where the combined total of feeding, singing and "other" equals that of "all activities".

These data were combined with the vegetation data (which had been edited to exclude all vegetation below 5m). For each season, the vegetation data were scanned to check whether a plant species recorded as used by kokako occurred in the same grid square and tier as that recorded in the kokako data. Where a successful match was found, the data were recorded on a second file, that was of similar format to the kokako data file, but which also included a cover abundance value for each plant species. The second file also contained records of plant species in each grid square and tier that were not used by kokako, with the count of activities being set to zero.

When a plant species recorded as used by kokako in a particular grid square and tier did not match data from the vegetation data, this was recorded on another output file. Some records on this file of unmatched data could be reconciled, e.g. use of a prominent tree growing close to the boundary of two grid squares, that was situated in a square adjacent to the one it was attributed to. After these corrections were made, the amount of kokako data which could not be matched with vegetation data was never more than 5% of the total observations in any tier. The file of matched kokako and vegetation data provided the base for statistical analysis of kokako use of plant species.

The analysis was carried out in two stages. First, correlations were made between use of plant species by kokako in various forest tiers and the cover abundance of the same species in those tiers. A strong correlation between the frequency of plant species use and species abundance indicated that the birds were generalists, exhibiting no particular preferences. But if species use and species abundance were weakly correlated, then there was a degree of selection, independant of any general trend. Spearman correlation coefficients were calculated to measure the extent of correlation, and t-tests attached a level of statistical significance to these coefficients. Tests of correlation were possible only in tiers 1,2 and 3, because no estimates of species abundance were made in tier 7 [epiphytes). Correlations in each tier were measured for "all activities", feeding and singing.

Secondly, tests were conducted to determine whether kokako used some plant species in each of the four tiers proportionally more than others for "all activities", feeding and singing. Non-parametric Kruskal-Wallis 1-way ANOVAs were used to identify highly used plant species, and the level of statistical significance was calculated by using a statistical H-value, adjusted for tied ranks. Significant H-values indicated that differences detected between species that were used frequently, versus those that were used less often, were not a result of chance.

5.3.2 Results

A. Correlation between frequency of use of species for various kokako activities and plant species abundance.

Correlations between the frequency of use of various plant species by kokako and the relative abundance of the species in the home ranges have been shown in Appendix 5.4. Correlations were calculated for the use that kokako made of plants in most tiers of the forest except for epiphytes, where no estimate of their cover abundance was made.

Use of individual plant species was correlated positively with individual species abundance for all kokako activities, i.e. the birds tended to use common species more than rare species. However, the level of correlation differed greatly between kokako activities.

There was almost always strong correlation between the use of individual plant species by kokako for "all activities", and plant species abundance, in all tiers (Spearman coefficient = c.0.6, usually $P<0.001$). This was because activities other than feeding and singing occurred mainly in the more common tree species. For example, kokako often moved about in, or called from the nearest convenient tree, which was most likely to be a common species (see also Section 4.2.3.C).

By contrast, the plant species fed on by kokako in a given season were much less strongly correlated with species density (Spearman coefficient = c.0.3, usually $P<0.05$). Feeding occurred mostly in tiers 2, 3 and 7 (Section 4.2.3.B). The weaker correlation between species use and species abundance suggested that kokako were more selective when feeding, than they were when singing or engaged on other activities.

Singing occurred primarily in tiers 1 and 2 (Section 4.2.3.B). The amount of time spent singing varied considerably with season (Section 4.2.2.A). In tier 1 (emergents), the correlation coefficients for use of individual plant species as song posts versus plant species abundance varied seasonally, but was generally strongly correlated (Spearman coefficient = c.0.6, usually $P<0.01$), i.e. there was a strong tendency to use the common emergent trees as song posts. Field observations of use of emergent tree song posts indicated that emergent trees were selected with respect to topography, i.e. vantage points from which song could be heard as widely as possible. In tier 2 (12m-canopy height), there was a much weaker correlation between the use of individual plant species as song posts versus plant species abundance (Spearman coefficient = c.0.3, usually $P<0.05$), suggesting that selection of particular tree species as song posts may have occurred.

B. Use of particular plant species

For each season, non-parametric 1-way ANOVAs were out on species use in the three activity classes ("all activities", feeding, and singing), over the four main tiers used (Tiers 1,2,3 and 7). The data in Appendix 5.5 provide rankings of the most abundant plants available to kokako in each of the four tiers per season, against rankings of the most frequently used plant species in each of the three activity classes. A test statistic (an H value adjusted for tied ranks) denoted whether there was significantly greater use made by kokako of the plant species with the highest rankings. These rankings also showed changes in use of plant species with season. Unfortunately, there was no suitable non-parametric test available which could be used to quantify apparent interseasonal differences in the use of plant species.

Tier 1 (emergent trees and lianes above canopy height).

The majority of "all activities" in emergents consisted of singing (see Appendix 5.5 A). Plant species were used in relation to their overall abundance, in nearly all seasons. However, kauri received proportionally more use than other species for "all activities", primarily for singing (P<0.01) in Summer 1983-84. Note though that the species preference comparisons were applied for all the kokako home ranges studied, including one which had no kauri, and another which contained only two kauri trees. Thus, kauri was used to an even greater extent in the three remaining study home ranges. The degree to which kokako used kauri in this tier over the study period has been illustrated in Figure 5.2. Frequent use of kauri as a song post in summer coincided with the peak period of kokako singing (Section 4.2.2).

Tier 2 (12m-canopy height)

There was a high degree of species selection by kokako for all activity classes in this tier (usually P<0.001). Although the range of species used for "all activities" in each season usually included relatively common plants (Appendix 5.5 B), some of those fed upon were uncommon (e.g. heketara in Winter 1983, and puriri between Spring 1983 and Spring 1984).

Marked changes in the use of food species occurred with season. Kokako tended to feed upon plant species when they were in flower, or bearing ripe fruit (compare favoured food species per season in Appendix 5.5 B, with lists of flowering or ripe fruiting periods of species on Table 3.1, Section Three). Even so, some species were favoured over others. For example, during Autumn 1984, ripe fruit was the most common food eaten in tier 2, yet miro was only a moderately common species there. By contrast, ripe fruits of the most abundant species in tier 2 (towai) were never taken (see Appendix 4.3, Section Four). Kokako also appeared to select particular species as song posts in this tier which changed seasonally. At the peak of singing in summer 1983-1984, kauri was used especially as a song species in this tier, as it was also in tier 1.

Tier 3 (5m-12m).

Significantly greater use (usually P,0.001) of particular plant species was evident for "all activities" and for feeding. Although singing occurred infrequently in this tier, some plant species were used more than others also.

As in tier 1, the most abundant species were used most frequently for "all activities" (see Appendix 5.5 C). By contrast, species abundance had far less bearing on the significantly greater use of certain species for feeding, as expected from the weaker correlation between the two. The species that were fed upon most changed markedly from season to season. As in tier 2, the phenology of species had a strong influence on their use as food (compare species fed on most frequently in Appendix 5.5 C, with flower or fruit availability listed in Table 3.1, Section Three). But again, certain species appeared to be selected when a range of other food items were available (e.g. heketara leaves were fed on most often from tier 3 in both winters of this study when the species was neither flowering or seeding, while species such as pate, which bore abundant fruit at the time, were eaten much less often). There was a noteable avoidance of tree ferns (e.g. ponga and wheki), which were major constituents of this tier, by kokako for any activity.

Tier 7 (epiphytes).

Feeding was by far the most common kokako activity amongst epiphytes, and this was reflected by the high use of particular species in most seasons (P<0.001) for "all activities" (see Appendix 5.5 D). Singing occurred very rarely in this tier and no statistically significant selection was apparent in the use of species. Marked changes occurred in highly utilised species from season to season for "all activities", and feeding. For example, the epiphytic fern *Aspleniumm flaccidum* was eaten frequently in all seasons except in Summer 1983-84, while *Phymatosorus diversifolius* (another epiphytic fern) was an important food item in both winters and springs of summer and autumn. Seasonal use of these two species may have been related to the emergence of new fronds (no phonological data were collected from them). Flowering plants such as puka and *Pittosporum cornifolium* were important food items seasonally, and were eaten mostly when flowers or ripe fruit were present (compare species use in various seasons in Appendix 5.5 D with availability of flowers or fruit in Table 3.1, Section Three).

A more detailed illustration of the relationship between species use versus species abundance has been provided in Figure 5.3, for Winter 1984. This season was chosen as it was the one in which the greatest amount of data on kokako activities was collected. There was a strong correlation between the use and relative abundance of plant species in all tiers, for "all activities". However, a noteable exception occurred with kiekie, an abundant liane species in both tiers 2 and 3, which was very seldom used.

Singing in tier 1 showed a high correlation between frequency of use of plant species and their relative abundance. The correlation was much weaker in tier 2, and some species were used significantly more than others ($P<0.001$) for song posts; especially towai (abundant), rewarewa (common) and rimu (uncommon). Singing was uncommon in tier 3. Kokako sang less in this season than at other times of the year.

Selection of plant species by kokako was most evident for feeding, particularly in tiers 2 and 3 . In both tiers, significantly greater use ($P<0.001$) was made of certain plant species. For example, puriri and heketara were uncommon in tier 2 (see Figs 2.5-2.12), but they were the main plant species eaten. In tier 3, heketara and nikau were common and were highly used as food species ($P<0.001$).

Figure 5.1: Rank order of use of vegetation groups by kokako for various activities.

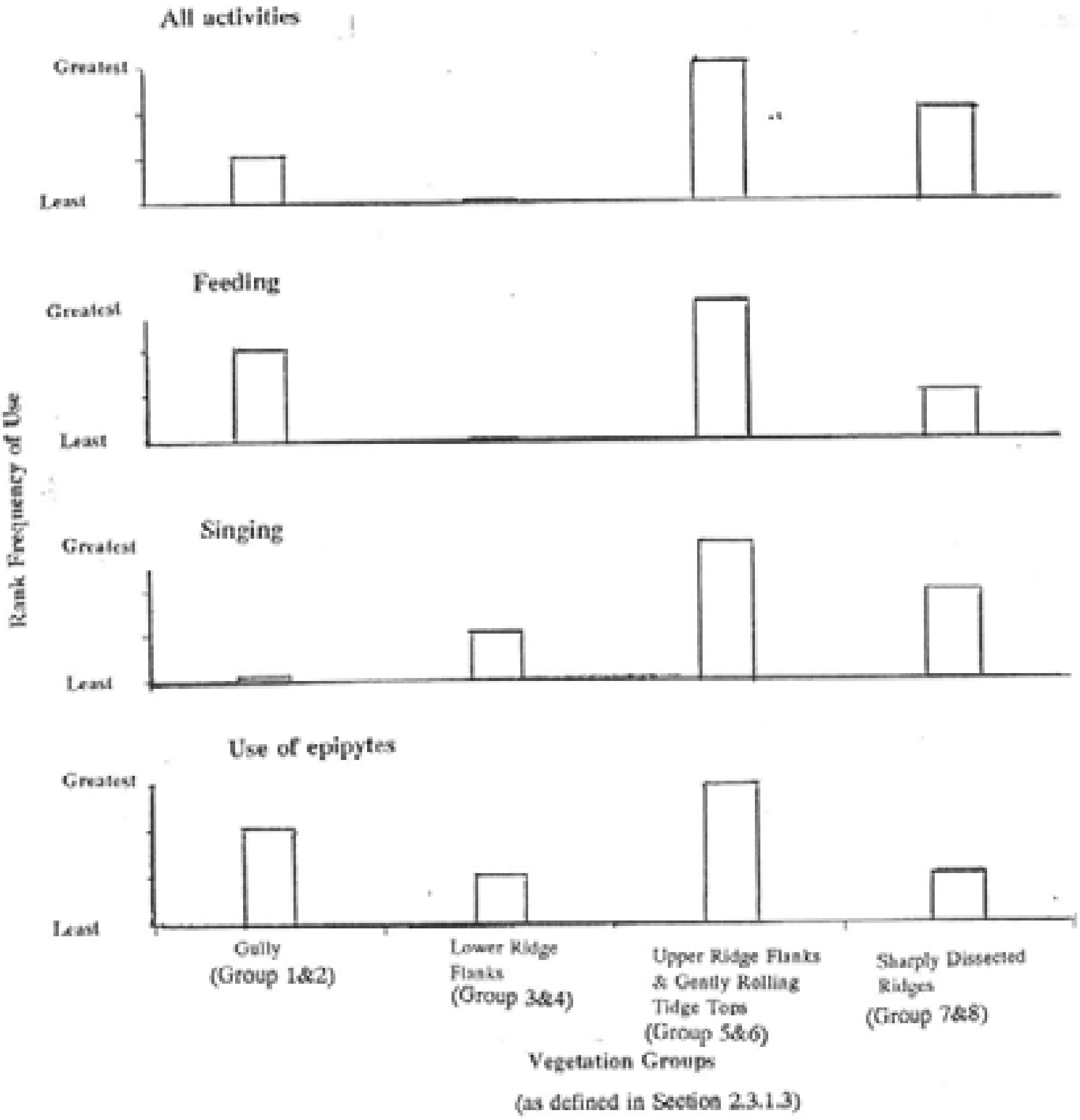


Figure 5.2: Seasonal use of kauri by kokako.

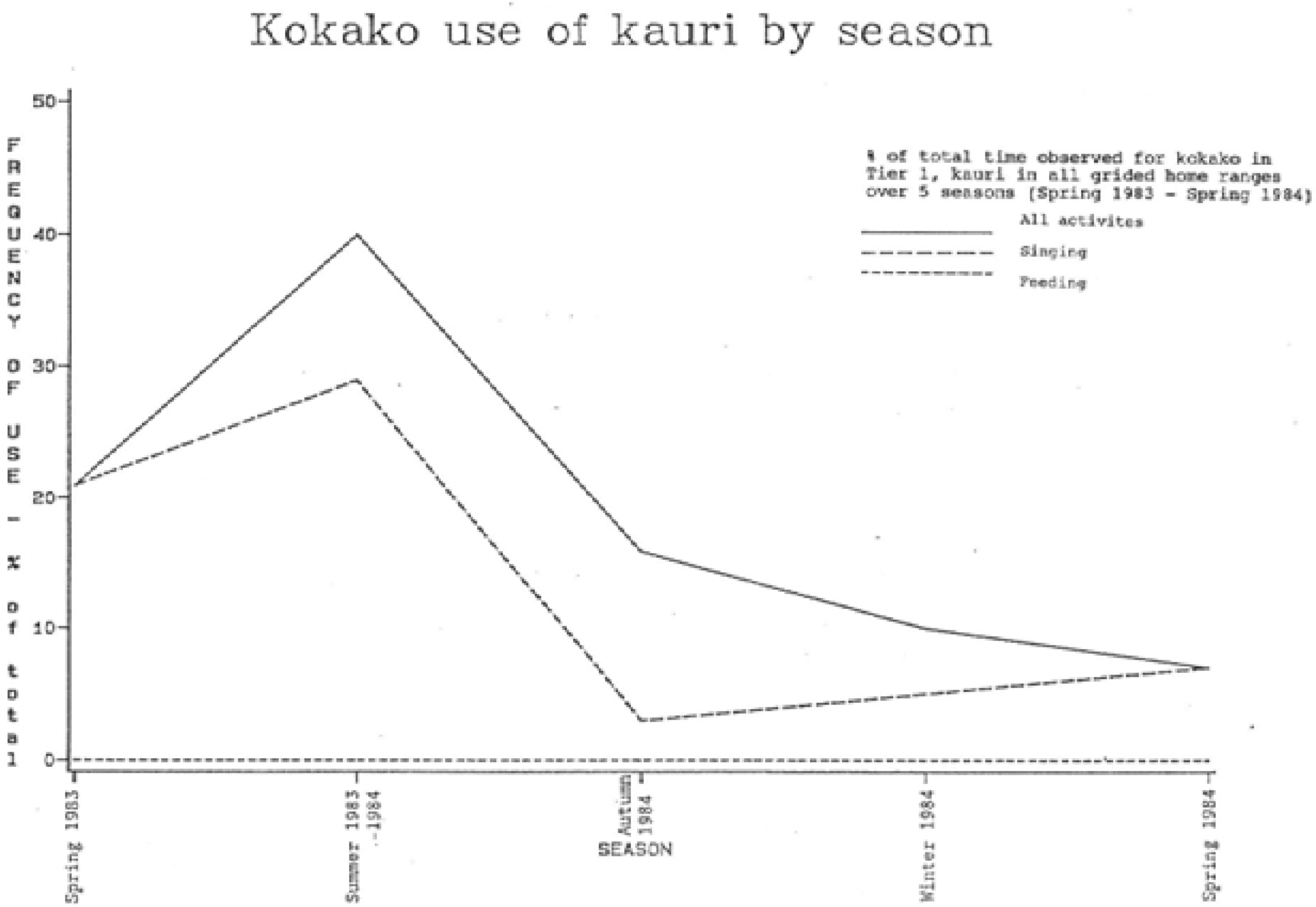
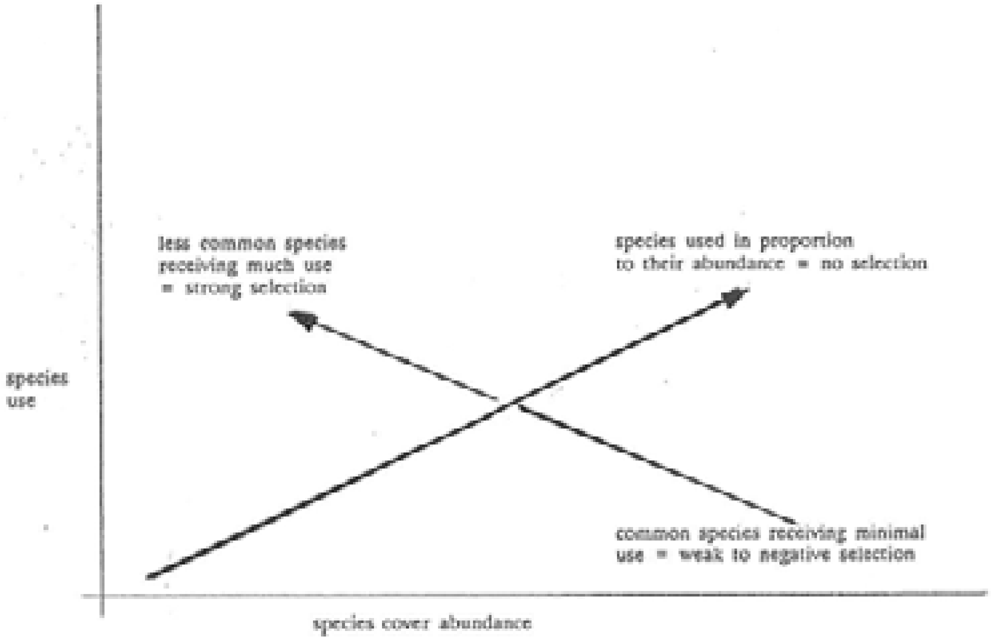


Figure 5.3: Use of a range of plant species in the upper three tiers of forest by kokako, in relation to their relative cover abundance during winter (June-August)1984. The degree of selection by kokako for individual species in each tier is outlined in the diagram below.

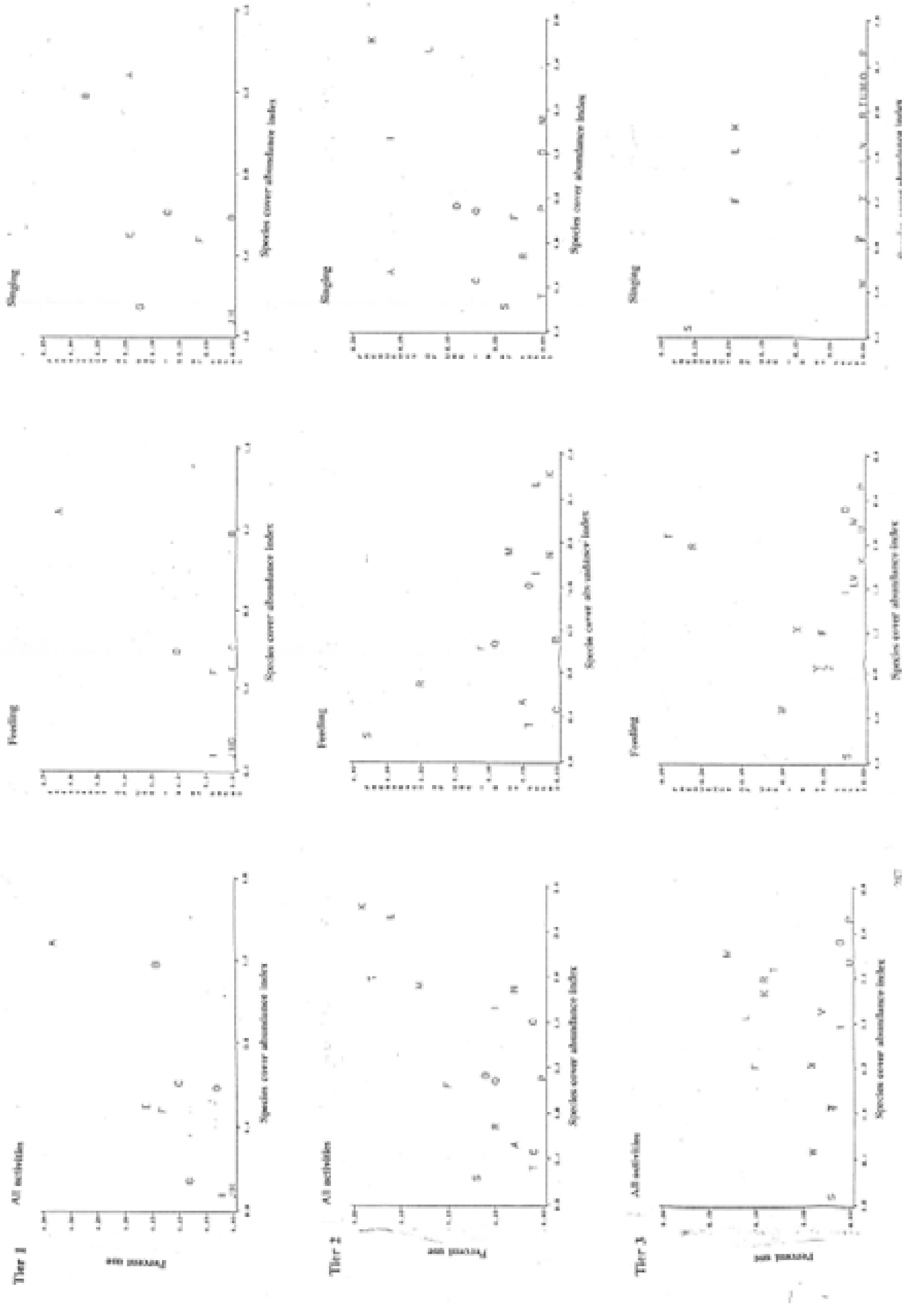


Frequency of use is expressed as a percentage of total observations of each activity [i.e. of all activities, of feeding, and of singing]. Cover abundance is expressed as an index of percentage cover. The species examined at each tier are denoted by letter symbols, as identified below:

A = rimu
B = northern rata
C = kauri
D = miro
E = pukatea
F = Hall's totara
G = kahikatea
H = *Metrosideros perforata*
I = rewarewa

J = *Metrosideros fulgens*
K = towai
L = taraire
M = kohekohe
N = tawa
O = supplejack
P = kiekie
Q = hinau
R = heketara

S = puriri
T = nikau
U = ponga
V = pigeonwood
W = kohuhu
X = mapou
Y = lancewood
Z = pate

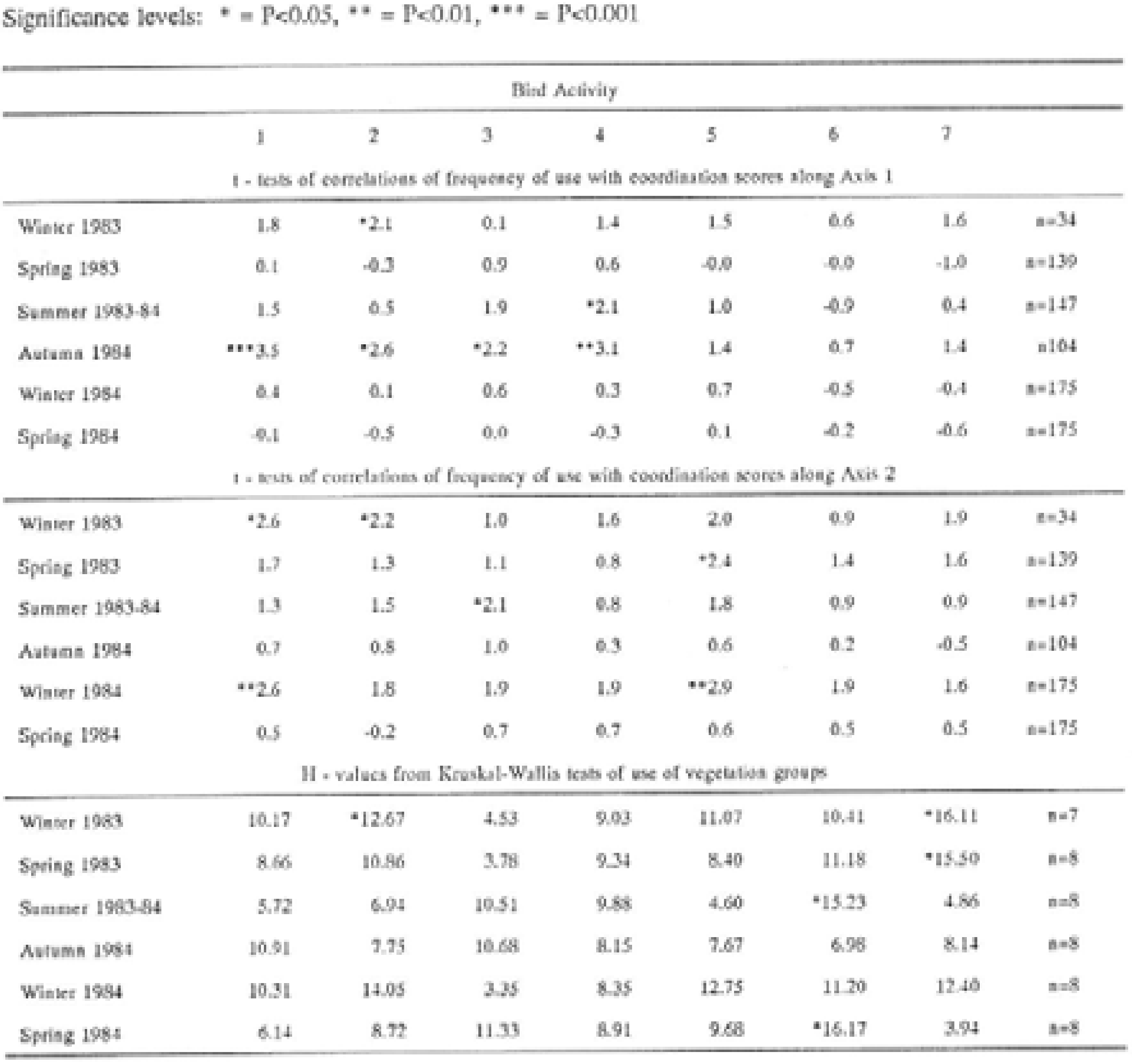

Tier 1
Tier 2
Tier 3
All activities
Feeding
Singing
Percent use
Species cover abundance index

APPENDIX 5.1: INTERSEASONAL COMPARISONS OF USE OF VEGETATION AND FLORISTIC

GRADIENTS OF ALL KOKAKO STUDIED.

Seven aspects of kokako behaviour were examined with respect to use of floristic gradients and vegetation groups, i.e. (1) all activities, (2) feeding, (3) singing, (4) use of canopy, (5) use of subcanopy, (6) use of ground tiers and (7) use of epiphytes.

Spearman correlation coefficients were tabulated for the correlations between frequency of use of grid squares for these seven behavioural attributes and ordination scores of these grid squares along the two main floristic gradients. Statistical t-tests were applied to ascribe significance levels to these coefficients. Those found to be significant have been marked below with asterisks. Statistical H-values ascribed statistical significance to use of particular vegetation groups assigned along the principle floristic gradient.



Significance levels: * = P<0.05, ** = P<0.01, *** = P<0.001

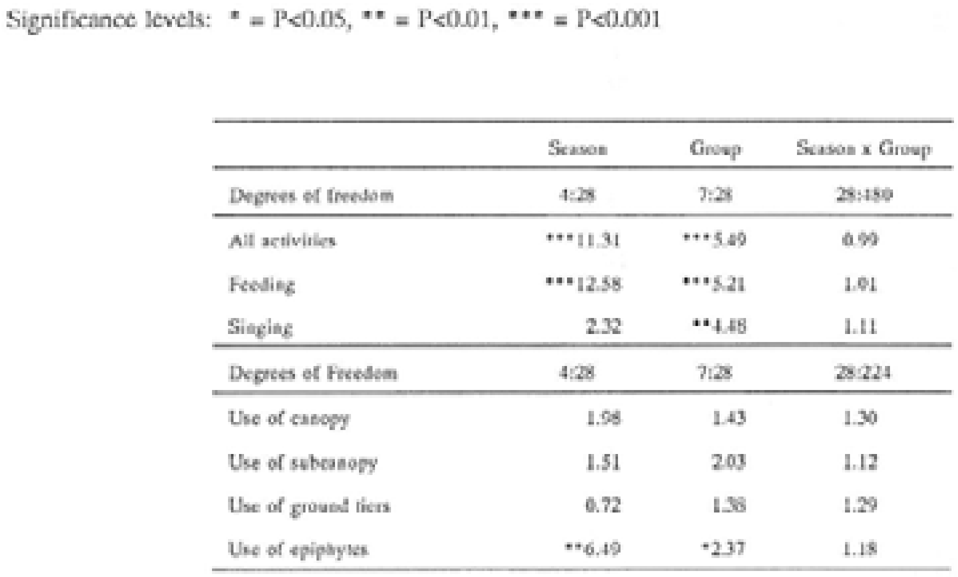
	Bird Activity							
	1	2	3	4	5	6	7	
	t - tests of correlations of frequency of use with coordination scores along Axis 1							
Winter 1983	1.8	*2.1	0.1	1.4	1.5	0.6	1.6	n=34
Spring 1983	0.1	-0.3	0.9	0.6	-0.0	-0.0	-1.0	n=139
Summer 1983-84	1.5	0.5	1.9	*2.1	1.0	-0.9	0.4	n=147
Autumn 1984	***3.5	*2.6	*2.2	**3.1	1.4	0.7	1.4	n104
Winter 1984	0.4	0.1	0.6	0.3	0.7	-0.5	-0.4	n=175
Spring 1984	-0.1	-0.5	0.0	-0.3	0.1	-0.2	-0.6	n=175
	t - tests of correlations of frequency of use with coordination scores along Axis 2							
Winter 1983	*2.6	*2.2	1.0	1.6	2.0	0.9	1.9	n=34
Spring 1983	1.7	1.3	1.1	0.8	*2.4	1.4	1.6	n=139
Summer 1983-84	1.3	1.5	*2.1	0.8	1.8	0.9	0.9	n=147
Autumn 1984	0.7	0.8	1.0	0.3	0.6	0.2	-0.5	n=104
Winter 1984	**2.6	1.8	1.9	1.9	**2.9	1.9	1.6	n=175
Spring 1984	0.5	-0.2	0.7	0.7	0.6	0.5	0.5	n=175
	H - values from Kruskal-Wallis tests of use of vegetation groups							
Winter 1983	10.17	*12.67	4.53	9.03	11.07	10.41	*16.11	n=7
Spring 1983	8.66	10.86	3.78	9.34	8.40	11.18	*15.50	n=8
Summer 1983-84	5.72	6.94	10.51	9.88	4.60	*15.23	4.86	n=8
Autumn 1984	10.91	7.75	10.68	8.15	7.67	6.98	8.14	n=8
Winter 1984	10.31	14.05	3.35	8.35	12.75	11.20	12.40	n=8
Spring 1984	6.14	8.72	11.33	8.91	9.68	*16.17	3.94	n=8

APPENDIX 5.2: INTRASEASONAL COMPARISONS OF USE OF VEGETATION GROUPS ACROSS

ALL HOME RANGES.

Seven aspects of behaviour of all kokako studied were examined with respect to use of vegetation groups for all activities, feeding, singing, use of canopy, use of use of ground tiers, and use of epiphytes.

Analysis was by parametric two-way ANOVAs of ranked variables. F-values were tabulated for overall seasonal differences, overall differences in use of vegetation groups, and for season by group interactions. Degrees of freedom associated with each test have been listed also. The levels of significance associated with each test were determined from the F-values and degrees of freedom.



Significance levels: * = P<0.05, ** = P<0.01, *** = P<0.001

	Season	Group	Season x Group
Degrees of freedom	4:28	7:28	28:180
All activities	***11.31	***5.40	0.99
Feeding	***12.58	***5.21	1.01
Singing	2.32	**4.48	1.11
Degrees of Freedom	4:28	7:28	28:224
Use of canopy	1.98	1.43	1.30
Use of subcanopy	1.51	2.03	1.12
Use of ground tiers	0.72	1.38	1.29
Use of epiphytes	**6.49	*2.37	1.18

WITHIN INDIVIDUAL HOME RANGES

1. BEN HOME RANGE

a) Interseasonal trends (Table 5.1)

The main floristic gradient with changes in topography. The second most important floristic gradient in the home range corresponded with changes from undisturbed sites to more disturbed sites. Classification of plots reflected mainly the principle floristic gradient (See Appendix 2.1). No significant trends were found. There were no significant correlations of this pair's use of vegetation with respect to either gradient, so no assertions can be made about selection of forest habitat on the basis of these tests. Similarly there were no significant results from Kruskal-Wallis ANOVAs of use of forest groups for any kokako activity, so it is uncertain whether these birds showed preferences for use of particular vegetation groups.

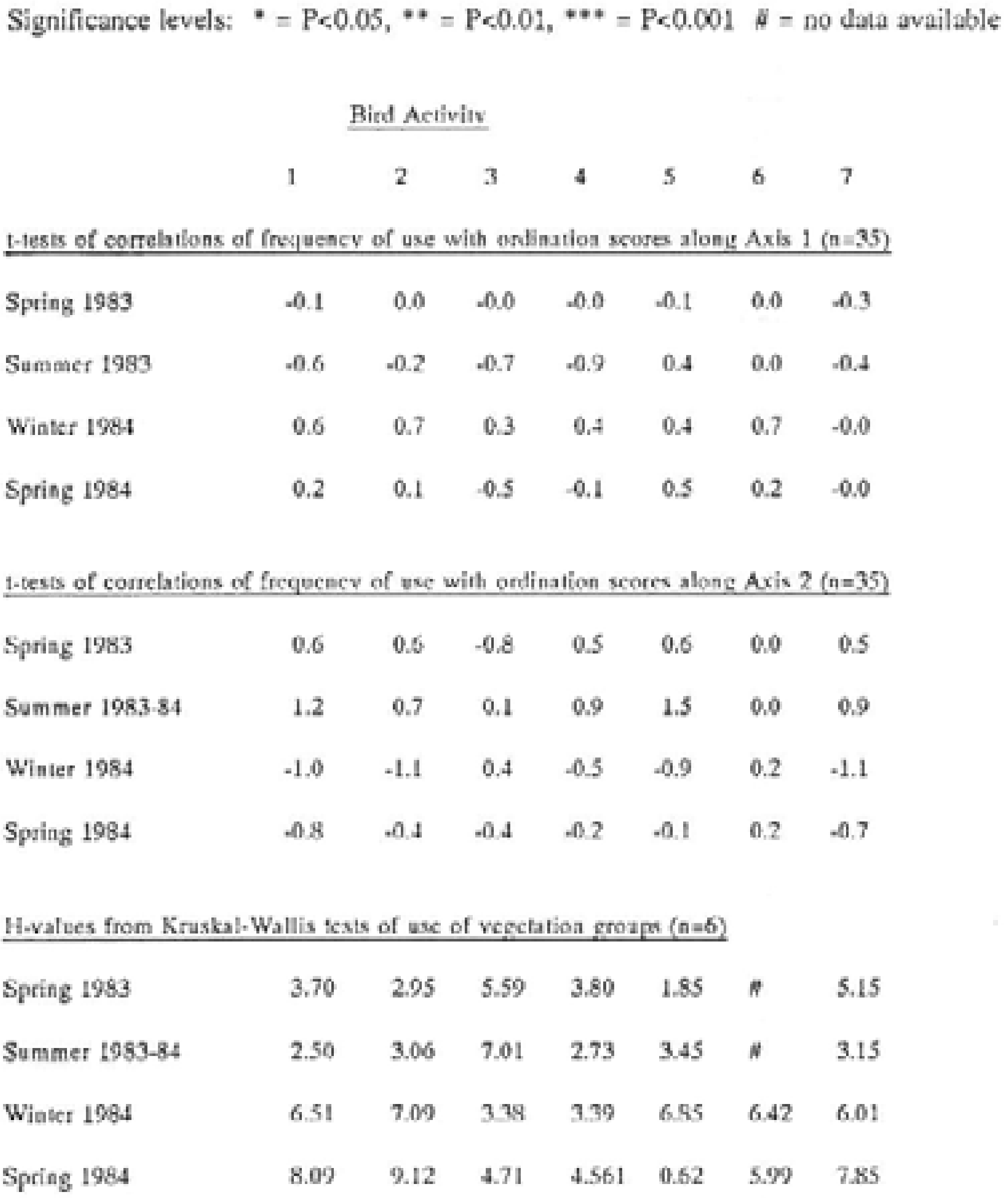
b) Intraseasonal trends (Table 5.2)

Almost all the results of the two-way ANOVAs of the use of forest groups were not significant. The sole exception was in the use of ground tiers where a significant season by group interaction ($P<0.05$) was identified, which is not surprising as this pair used the lowest tiers of the forest only in the latter stages of the study. Other than this, no assertions can be made about these birds' use of vegetation groups.

Table 5.1: Interseasonal comparisons of use of vegetation groups and major floristic gradients in Ben home range.

Seven aspects of kokako behaviour were examined with respect to their use of floristic gradients and vegetation groups identified in this home range, i.e. (1) all activities, (2) feeding, (3) singing, (4) use of canopy, (5) use of subcanopy, (6) use of ground tiers, and (7) use of epiphytes.

Spearman correlation coefficients were tabulated for the correlation between frequency of use by kokako of grid squares for these seven behavioural attributes and ordination scores of these grid squares along the two floristic gradients detected in this home range. Statistical t-tests were applied to ascribe significance levels to these two coefficients. Those found to be significant have been marked below with asterisks. Statistical ascribed statistical significance to use of particular vegetation groups in this home range.



Significance levels: * = P<0.05, ** = P<0.01, *** = P<0.001 # = no data available

Bird Activity

	1	2	3	4	5	6	7
t-tests of correlations of frequency of use with ordination scores along Axis 1 (n=35)							
Spring 1983	-0.1	0.0	-0.0	-0.0	-0.1	0.0	-0.3
Summer 1983	-0.6	-0.2	-0.7	-0.9	0.4	0.0	-0.4
Winter 1984	0.6	0.7	0.3	0.4	0.4	0.7	-0.0
Spring 1984	0.2	0.1	-0.5	-0.1	0.5	0.2	-0.0
t-tests of correlations of frequency of use with ordination scores along Axis 2 (n=35)							
Spring 1983	0.6	0.6	-0.8	0.5	0.6	0.0	0.5
Summer 1983-84	1.2	0.7	0.1	0.9	1.5	0.0	0.9
Winter 1984	-1.0	-1.1	0.4	-0.5	-0.9	0.2	-1.1
Spring 1984	-0.8	-0.4	-0.4	-0.2	-0.1	0.2	-0.7
H-values from Kruskal-Wallis texts of use of vegetation groups (n=6)							
Spring 1983	3.70	2.95	5.59	3.80	1.85	#	5.15
Summer 1983-84	2.50	3.06	7.01	2.73	3.45	#	3.15
Winter 1984	6.51	7.09	3.38	3.39	6.85	6.42	6.01
Spring 1984	8.09	9.12	4.71	4.561	0.62	5.99	7.85

Table 5.2: Intraseasonal comparisons of use of vegetation groups in Ben home range.

Seven aspects of behaviour were examined in this home range with respect to the use of vegetation groups, i.e. all activities, feeding, singing, use of canopy, use of subcanopy, use of ground tiers and use of epiphytes.

Analysis was by two-way ANOVAs of ranked variables. Statistical F-values were tabulated for overall seasonal differences, overall differences in use of groups, and for season by group interactions. Degrees of freedom with each test have been listed also. The levels of statistical significance associated with each test were determined from the F-values and degrees of freedom.

Significance levels: * = P<0.05, ** = P<0.01, *** = P<0.001

	Season	Group	Season x Group
Degrees of freedom	3:15	5:15	15:116
All activities	1.21	0.48	1.17
Feeding	0.30	1.14	1.13
Singing	0.91	0.73	1.23
Degrees of Freedom	3:8	5:8	8:26
Use of canopy	1.43	1.84	1.02
Use of subcanopy	0.91	2.73	1.02
Use of ground tiers	1.99	1.24	*2.165
Use of epiphytes	2.75	1.47	1.42

2. HILL HOME RANGE

a) Interseasonal trends (Table 5.3)
Axis 1 of the ordination of plots detected a floristic gradient which coincided with changes in topography. Axis 2 of the ordination appeared to be linked closely to changes from disturbed to undisturbed sites. Classification of plots recognised primarily the floristic gradient associated with topography, but also split two vegetation groups from the ridge top kauri-dominated sites on the basis of the extent of damage to the canopy resulting from a cyclone in 1959 (see Appendix 2.2). Only two seasons' data could be tested from this home range as it was not gridded fully until late in the study. No significant correlations were noted for either season on kokako use of the gradient associated with topographic changes. Likewise there were no significant results in the ANOVAs of use of groups, so no preferences could be shown in the use of vegetation groups by this bird.

However, some significant correlations were noted in the resident bird's use of the floristic gradient linked with the extent of disturbance. In Winter 1984, therewere significant trends (P<0.05) in both feeding and use of subcanopy tiers towards use of disturbed vegetation (e.g. in wind-damaged sites and an area around a slip). The most heavily disturbed areas, however, were not used.

b) Intraseasonal trends (Table 5.4)
Some significant results were obtained in two-way on seasonal in use of groups. was a significant seasonal difference (P<0.05) in the amount of singing from the resident kokako; it sang appreciably more in Spring 1984 than in Winter 1984. There was also a significant difference between seasons in the use of ground tiers (P<0.05) in use of forest groups. The bird used the lowest tiers of the northern rata-taraire-towai-kohekohe group in Winter 1984, but changed over to the lowest tiers of the towai-taraire-miro-tawa-kickie group in Spring 1984.

Table 5.3: Interseasonal comparisons of use of vegetation groups and major floristic gradients in Hill home range.

Seven aspects of kokako behaviour were examined with respect to use of floristic gradients and vegetation groups identified in this home range, i.e. (1) all activities, (2) feeding, (3) singing, (4) use of canopy, (5) use of subcanopy, (6) use of ground tiers, and (7) use of epiphytes.

Spearman correlation coefficients were tabulated for the correlations between frequency of use of grid squares for these seven behavioural attributes and ordination scores of these grid squares along the two floristic gradients detected in this home range. Statistical t-tests were applied to ascribe significance levels to these co-efficients. Those found to be significant have been marked below with asterisks. Statistical H-values ascribe statistical significance to use of particular vegetation groups in this home range.

Significance levels: * = P<0.05, ** = P<0.01, *** = P<0.001

	Bird Activity						
	1	2	3	4	5	6	7
t-tests of correlations of frequency of use with ordination scores along Axis 1 (n=36)							
Winter 1984	-0.2	0.5	-0.7	0.0	-0.3	0.1	0.5
Spring 1984	1.4	1.0	0.0	1.4	1.3	0.2	0.5
t-tests of correlations of frequency of use with ordination scores along Axis 2 (n=36)							
Winter 1984	-1.3	*-2.2	0.3	-0.8	*-2.1	-0.1	-1.0
Spring 1984	-1.7	-0.2	0.1	-1.9	-1.2	0.2	0.1
H-values from Kruskal-Wallis tests of use of vegetation groups (n=6)							
Winter 1984	2.58	3.52	3.99	3.47	5.61	4.14	6.15
Spring 1984	0.72	3.13	2.62	2.37	1.08	6.18	3.36

Table 5.4: Interseasonal comparisons of use of vegetation groups in Hill home range.

Seven aspects of kokako behaviour were examined with respect to use of vegetation groups, i.e. (1) all activities, (2) feeding, (3) singing, (4) use of canopy, (5) use of subcanopy, (6) use of ground tiers and (7) use of epiphytes.

Analysis was by two-way parametric ANOVAs of ranked variables. Statistical F-values were tabulated for overall seasonal differences, overall differences in use of groups, and for season by group interactions. Degrees of freedom associated with each test have also been listed. The levels of statistical significance associated with each test were determined from the F-values and degrees of freedom.

Significance levels: * = P<0.05, ** = P<0.01, *** = P<0.001

	Season	Group	Season x Group
Degrees of freedom	1:5	5:5	5:60
All activities	1.63	0.61	0.39
Feeding	4.45	1.12	0.56
Singing	*14.00	5.06	0.22
Degrees of Freedom	1:5	5:5	5:33
Use of canopy	2.57	0.17	1.49
Use of subcanopy	3.66	0.47	1.49
Use of ground tiers	0.16	0.48	*2.71
Use of epiphyses	0.72	1.75	1.47

3. PET HOME RANGE

a) Interseasonal trends (Table 5.5)

The main floristic gradient in this home range was associated with changes in topography. The important floristic gradient in the home range coincided with changes from undisturbed sites to disturbed sites (in which the canopy has been destroyed mostly by logging and to a lesser extent by wind). Classification of vegetation recognised both these influences (see Appendix 2.4). There were no significant results from ANOVAs of use of vegetation groups, so assertions cannot be made about this bird's preferences of the groups identified. However, there were some highly trends apparent from correlations of the resident kokako's activities with the main floristic gradients.

In summer 1983-84 highly significant trends were evident from correlation with the floristic gradient related to topography. This was toward ridge top vegetation for "all activities" ($P<0.01$), singing ($P<0.01$), use of canopy ($P<0.05$), and use of the subcanopy ($P<0.05$). This represented a significant movement in that season to the kauri-tawari-kiekie-Hall's totara group which coincided with a peak of use of kauri in the canopy, at the peak of singing activity (see Section 4.2.2, Fig.5.2), and feeding in the subcanopy on the flowers of tawari which bloomed at this time (see Table 3.1).

At the same time, there was also a significant correlation of kokako activity with the floristic gradient associated with the extent of disturbance. There was a significant trend in use of epiphytes (almost certainly as food items) ($P<0.05$) and towards use of undisturbed vegetation. The intact mature canopy of the kauri-tawari-kiekie-Hall's totara group was used extensively by the bird in this home range at this time, while adjacent areas of previously similar stand structure and composition which have been damaged by logging or wind were avoided.

b) Intraseasonal trends (Table 5.6)

Two-way ANOVAs have detected some significant trends. Significant seasonal differences in use of canopy and subcanopy were noted, and while these may have reflected real differences in the amount of spent in either of these tiers between seasons it was more likely they reflected the different amounts of data collected from within this home range in different seasons.

Significant differences in use of vegetation groups were noted over the whole study in:

- use of canopy tiers ($P<0.05$). Ridge top vegetation groups were used most consistently of all, followed by gully bottom vegetation;

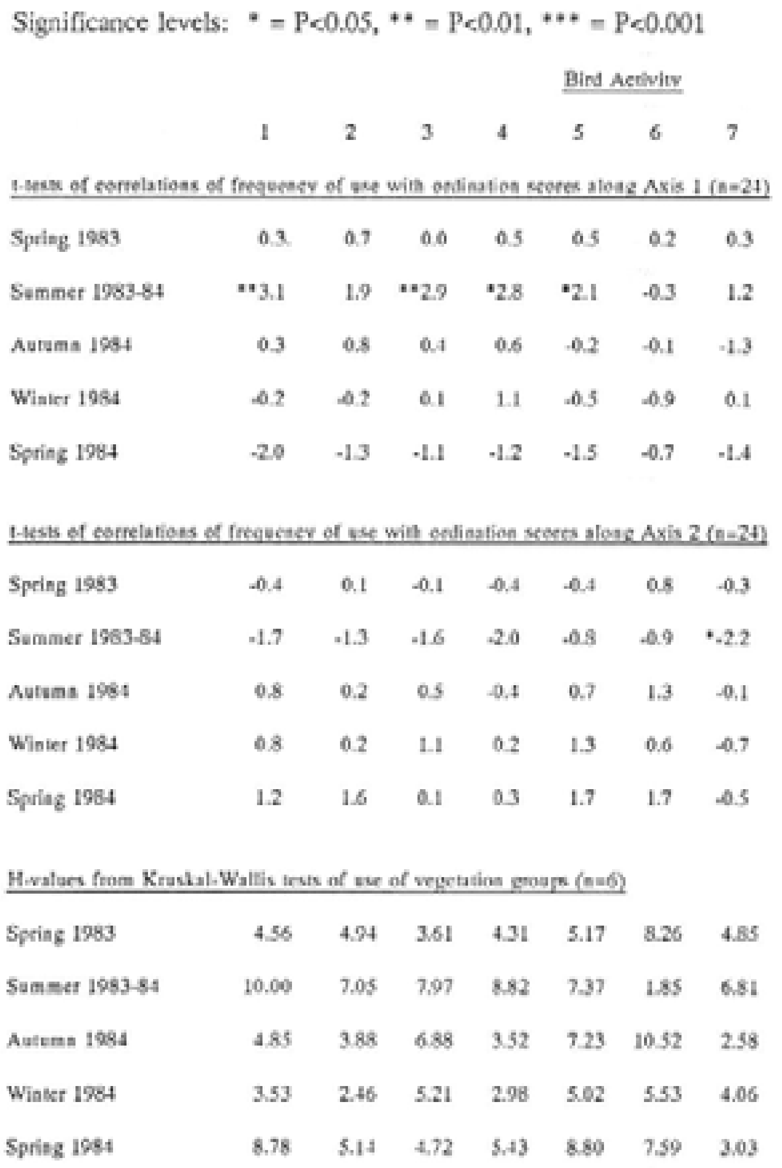
- use of subcanopy tiers ($P<0.001$). Use of ridge flank vegetation predominated (especially the kauri-miro-towai-taraire group) followed by groups of the ridge tops;

- use of ground tiers ($P<0.05$). The most favoured vegetation groups were those of ridge flanks, followed by those in gully bottoms.

Table 5.5: Interseasonal comparisons of use of vegetation groups and major floristic gradients in Pet home range.

Seven aspects of kokako behaviour were examined with respect to use of floristic gradients and vegetation groups identified in this home range, i.e. (1) all activities, (2) feeding, (3) singing, (4) use of canopy, (5) use of subcanopy, (6) use of ground tiers, and (7) use of epiphytes.

Spearman correlation coefficients were tabulated for correlations between frequency of use of grid squares along the two floristic gradients detected in this home range. Statistical t-tests were applied to ascribe significance levels to these coefficients. Those found to be significant have been marked below with asterisks. Statistical H-values ascribed statistical significance to use of particular vegetation groups in the home range.



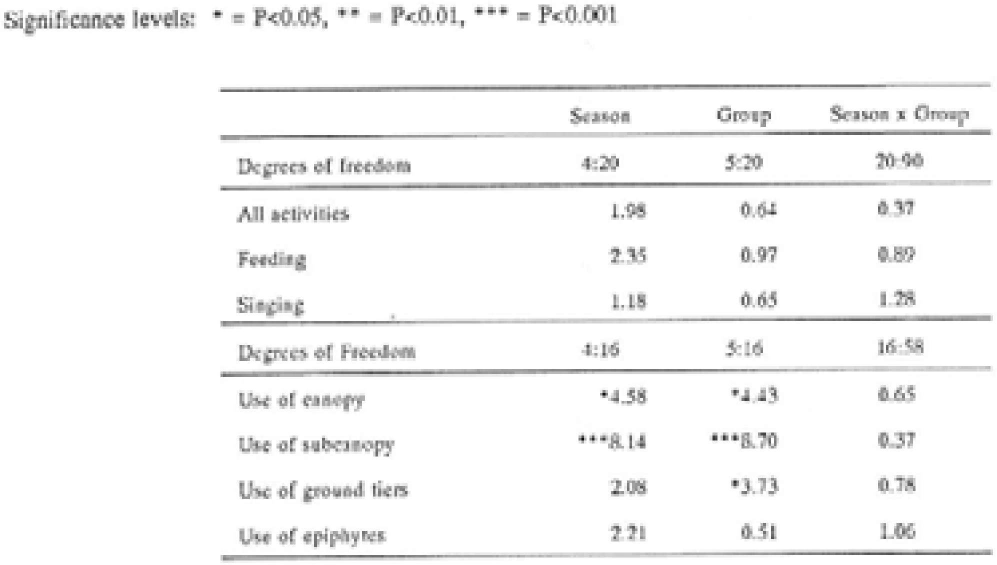
Significance levels: * = P<0.05, ** = P<0.01, *** = P<0.001

	Bird Activity						
	1	2	3	4	5	6	7
t-tests of correlations of frequency of use with ordination scores along Axis 1 (n=24)							
Spring 1983	0.3	0.7	0.0	0.5	0.5	0.2	0.3
Summer 1983-84	**3.1	1.9	**2.9	*2.8	*2.1	-0.3	1.2
Autumn 1984	0.3	0.8	0.4	0.6	-0.2	-0.1	-1.3
Winter 1984	-0.2	-0.2	0.1	1.1	-0.5	-0.9	0.1
Spring 1984	-2.0	-1.3	-1.1	-1.2	-1.5	-0.7	-1.4
t-tests of correlations of frequency of use with ordination scores along Axis 2 (n=24)							
Spring 1983	-0.4	0.1	-0.1	-0.4	-0.4	0.8	-0.3
Summer 1983-84	-1.7	-1.3	-1.6	-2.0	-0.8	-0.9	*-2.2
Autumn 1984	0.8	0.2	0.5	-0.4	0.7	1.3	-0.1
Winter 1984	0.8	0.2	1.1	0.2	1.3	0.6	-0.7
Spring 1984	1.2	1.6	0.1	0.3	1.7	1.7	-0.5
H-values from Kruskal-Wallis tests of use of vegetation groups (n=6)							
Spring 1983	4.56	4.94	3.61	4.31	5.17	8.26	4.85
Summer 1983-84	10.00	7.05	7.97	8.82	7.37	1.85	6.81
Autumn 1984	4.85	3.88	6.88	3.52	7.23	10.52	2.58
Winter 1984	3.53	2.46	5.21	2.98	5.02	5.53	4.06
Spring 1984	8.78	5.14	4.72	5.43	8.80	7.59	3.03

Table 5.6: Interseasonal comparisons of use of vegetation groups in Pet home range.

Seven aspects of kokako behaviour were examined with respect to use of vegetation groups, all activities, feeding, singing, use of canopy, use of subcanopy, use of ground tiers and use of epiphytes.

Analysis was by parametric two-way ANOVAs of ranked variables. Statistical F-values were tabulated for overall seasonal differences, overall differences in use of groups, and for season by group interactions. Degrees of freedom associated with each test have been listed also. The levels of statistical significance with each test were determined from the F-values and degrees of freedom.



Significance levels: * = P<0.05, ** = P<0.01, *** = P<0.001

	Season	Group	Season x Group
Degrees of freedom	4:20	5:20	20:90
All activities	1.98	0.64	0.37
Feeding	2.35	0.97	0.89
Singing	1.18	0.65	1.28
Degrees of Freedom	4:16	5:16	16:58
Use of canopy	*4.58	*4.43	0.65
Use of subcanopy	***8.14	***8.70	0.37
Use of ground tiers	2.08	*3.73	0.78
Use of epiphytes	2.21	0.51	1.06

4. PUKATEA HOME RANGE

a) Interseasonal trends (Table 5.7)

The kokako in Pukatea home range spent most of their time in a relatively small area. The vegetation of this home range was considerably more uniform than that in the other study home ranges (see Fig 2.3). The main floristic gradient coincided with a change in topography, and the vegetation groups identified also reflect this gradient. The second most important floristic gradient coincided with a change from undisturbed areas to wind-damaged areas (see Appendix 2.5).

There were strong and consistent trends during most seasons in the use of vegetation groups which mirrored the main floristic gradient (Axis 1). These were:

- in Summer 1983-84. There was a significant trend towards use of ridge top vegetation for "all activities" (P<0.01), use of canopy tiers (P<0.05) and use of subcanopy tiers (P<0.05). These significant correlations coincided with the high degree of use of the towai-taraire-kohekohe-tawa-hinau-miro-rewarewa group at the knoll marking a local high point on the axial ridge, followed by towai-taraire-tawa-kohekohe group of the ridge and upper ridge flanks. ANOVAs showed there was a preference for "all activities" (P<0.01), feeding (P<0.01), and use of canopy (P<0.01).

- in Autumn 1984, correlations indicated preferences for ridge top vegetation for "all activities" (P<0.001), feeding (P<0.01), use of canopy (P<0.001) and use of epiphytes, almost certainly as food (P<0.05). Kruskal-Wallis ANOVAs showed a significant preference for the ridge knoll group, followed by that of ridges and upper flanks for these same aspects of behaviour (except for use of epiphytes).

in Winter 1984, correlations and indicated that the knoll vegetation, followed by that of ridges and upper flanks was preferred significantly for "all activities" (P<0.001), feeding (P<0.01), use of canopy (P<0.001), use of subcanopy (P<0.001) and use of epiphytes (P<0.01). The most favoured groups for singing were the ridge and upper flank groups followed, by that of the knoll ($P<0.05$).

- in Spring 1984, correlations indicate there was preference for ridge top vegetation, and showed that the knoll group was preferred significantly for ""all activities" ($P<0.01$), feeding ($P<0.001$), use of canopy ($P<0.001$), use of subcanopy ($P<0.05$) and use of epiphytes (almost certainly as food, $P<0.001$).

There were also significant trends in use of the second most important floristic gradient (Axis 2) i.e. associated with changes from undisturbed to wind-damaged sites. These were:

- in Autumn 1984 undisturbed sites appeared to be favoured for "all activities" ($P<0.01$), and in the use of the canopy ($P<0.05$). The areas favoured were on the southern side of the knoll on the main ridge.

- in Spring 1984 the same trend was significant for "all activities" ($P<0.01$), feeding ($P<0.01$), and in use of the canopy ($P<0.01$).

b) Intraseasonal trends (Table 5.8)
The significant seasonal differences shown for "all activities", feeding, singing and use of epiphytes probably reflected the different amounts of data collected at different more than real in levels of activity.

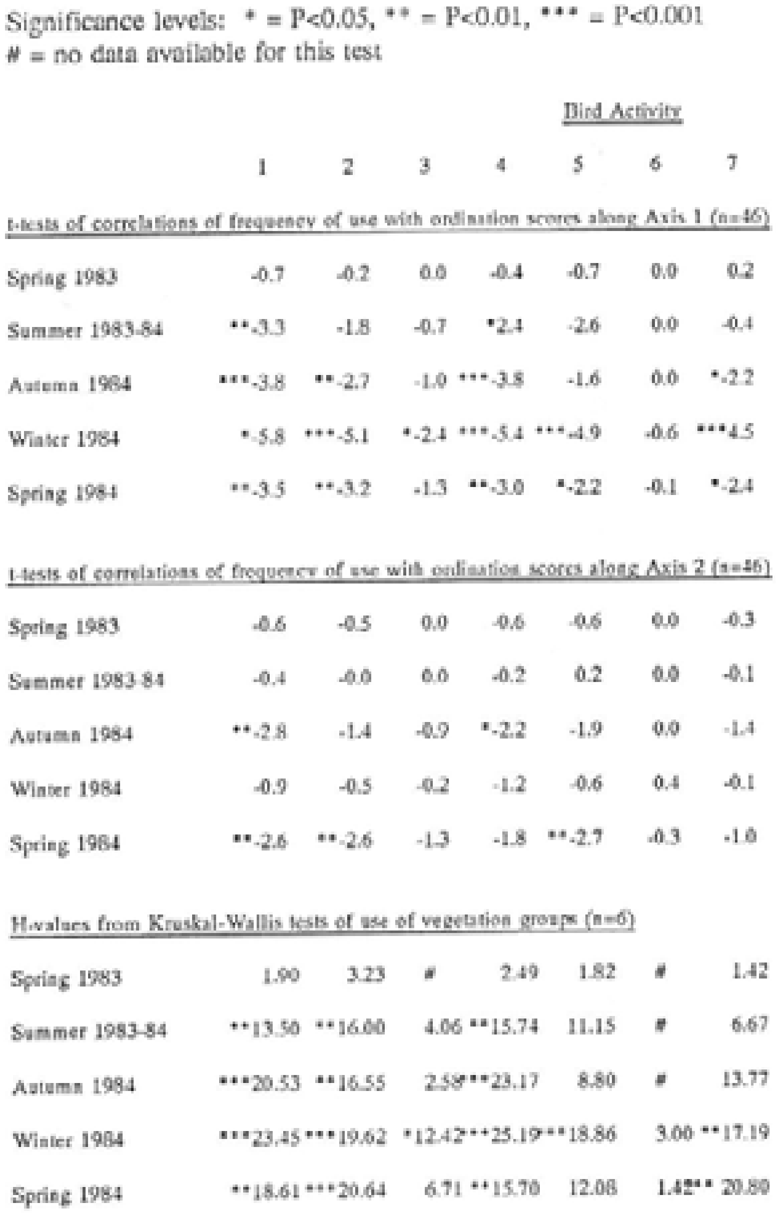
Given the strong and apparently consistent trends to use of knoll vegetation shown above, it was not surprising that significant differences in the use of groups were apparent over the whole study. The knoll group was consistently the most preferred group for "all activities" ($P<0.001$), followed by that of ridges and upper flanks. The knoll group was favoured consistently for feeding ($P<0.001$). Vegetation of the ridges and flanks was favoured most for singing, followed by that of the knoll ($P<0.01$).

There was a significant difference in the use of groups by season for feeding ($P<0.05$). Although the knoll group was favoured most consistently, the next most favoured group in Spring 1983 was that of lower flanks (towai-taraire-kohekohe), while in Summer, Autumn and Winter of 1984 it was that of ridges and upper flanks, and in Spring 1984, it was that of gullies (rimu-taraire-kohekohe-supplejack-towai).

Table 5.7: Interseasonal comparisons of use of vegetation groups and major floristic gradients in Pukatea home range.

Seven aspects of kokako behaviour were examined with respect to use of floristic gradients and vegetation groups identified in this home range, i.e. (1) all activities, (2) feeding, (3) song, (4) use of canopy, (5) use of subcanopy, (6) use of ground tiers and (7) use of epiphytes.

Spearman correlation coefficients were tabulated for correlations between frequency of use of grid squares for these seven aspects of and ordination scores of these grid squares along the two floristic gradients detected in this home range. Statistical t-tests were applied to ascribe significance levels to coefficients. Those found to be significant have been marked below with asterisks. Statistical H-values ascribed significance to use of particular vegetation groups in the home range.



Significance levels: * = P<0.05, ** = P<0.01, *** = P<0.001
= no data available for this test

Bird Activity

t-tests of correlations of frequency of use with ordination scores along Axis 1 (n=46)

	1	2	3	4	5	6	7
Spring 1983	-0.7	-0.2	0.0	-0.4	-0.7	0.0	0.2
Summer 1983-84	**-3.3	-1.8	-0.7	*2.4	-2.6	0.0	-0.4
Autumn 1984	***-3.8	**-2.7	-1.0	***-3.8	-1.6	0.0	*-2.2
Winter 1984	*-5.8	***-5.1	*-2.4	***-5.4	***-4.9	-0.6	***4.5
Spring 1984	**-3.5	**-3.2	-1.3	**-3.0	*-2.2	-0.1	*-2.4

t-tests of correlations of frequency of use with ordination scores along Axis 2 (n=46)

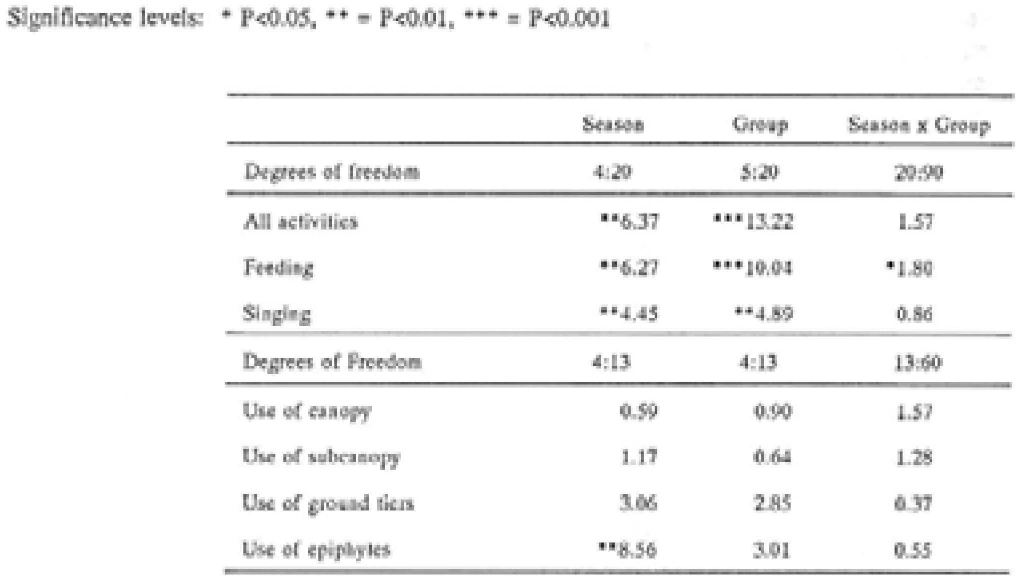
	1	2	3	4	5	6	7
Spring 1983	-0.6	-0.5	0.0	-0.6	-0.6	0.0	-0.3
Summer 1983-84	-0.4	-0.0	0.0	-0.2	0.2	0.0	-0.1
Autumn 1984	**-2.8	-1.4	-0.9	*-2.2	-1.9	0.0	-1.4
Winter 1984	-0.9	-0.5	-0.2	-1.2	-0.6	0.4	-0.1
Spring 1984	**-2.6	**-2.6	-1.3	-1.8	**-2.7	-0.3	-1.0

H-values from Kruskal-Wallis tests of use of vegetation groups (n=6)

	1	2	3	4	5	6	7
Spring 1983	1.90	3.23	#	2.49	1.82	#	1.42
Summer 1983-84	**13.50	**16.00	4.06	**15.74	11.15	#	6.67
Autumn 1984	***20.53	**16.55	2.58	**23.17	8.80	#	13.77
Winter 1984	***23.45	***19.62	*12.42	**25.19	**18.86	3.00	**17.19
Spring 1984	**18.61	***20.64	6.71	**15.70	12.08	1.42	** 20.80

Table 5.8: Interseasonal comparisons of use of vegetation groups in Pukatea home range. Seven aspects of behaviour were examined with respect to kokako use of vegetation groups, i.e. (1) all activities, (2) feeding, (3) singing, (4) use of canopy, (5) use of subcanopy, (6) use of ground tiers, and (7) use of epiphytes.

Analysis was by parametric two-way ANOVAs of ranked variables. Sratisrical F-values were for overall seasonal differences, overall differences in use of groups, and for season by group interactions. Degrees of freedom with each test have been listed also. The levels of significance associated with each test were derermined from the F-values and degrees of freedom.



Significance levels: * P<0.05, ** = P<0.01, *** = P<0.001

	Season	Group	Season x Group
Degrees of freedom	4:20	5:20	20:90
All activities	**6.37	***13.22	1.57
Feeding	**6.27	***10.04	*1.80
Singing	**4.45	**4.89	0.86
Degrees of Freedom	4:13	4:13	13:60
Use of canopy	0.59	0.90	1.57
Use of subcanopy	1.17	0.64	1.28
Use of ground tiers	3.06	2.85	0.37
Use of epiphytes	**8.56	3.01	0.55

5. SUMMIT HOME RANGE

a) Interseasonal trends (Table 5.9)

The main floristic gradient in this home range was associated with changes in topography, while the second most important floristic gradient reflected changes in drainage from well-drained to poorly drained sites, with a secondary influence from undisturbed to disturbed sites. The classification of plots reflected both of these gradients (see Appendix 2.6).

Along the main floristic gradient, significant trends were apparent:

- in Winter 1983, there was significantly higher use of ridge top vegetation for "all activities" (P<0.05) and feeding (P<0.05). These activities occurred primarily in the vegetation of the ridge top plateau.

- in Spring 1983, ANOVAs showed that use of canopy tiers occurred primarily in the group of the Hall’s totara-miro-towai-kiekie group in the upper ridge flanks (P<0.05).

- in Winter 1984, ANOVAs show that use of epiphytes, almost certainly as food, focused on the upper ridge flank group (P<0.05).

There were also significant trends in the use of the second most important floristic gradient:

- in Summer 1983-84, there was a significant trend toward use of better-drained sites for song ANOVAs showed that the Hall's tatara-miro-towai-kiekie group of well-drained, undisturbed upper ridge flanks was favoured significantly for singing (P<0.05).

- in Autumn 1984, the birds made significantly greater use of well-drained, undisturbed sites for "all activities" ($P<0.01$), feeding ($P<0.05$), use of canopy tiers ($P<0.05$), subcanopy tiers ($P<0.05$) and ground tiers ($P<0.05$). ANOVAs showed that upper ridge flank vegetation was favoured significantly for singing ($P<0.05$).

- in Spring 1984, there was significantly greater use made of vegetation of better drained sites for the use of subcanopy tiers ($P<0.05$)

b) Intraseasonal trends (Table 5.10)
Significant seasonal differences detected in levels of "all activities" and feeding probably were indicative of different sized data sets in each season.

Significant differences in use of groups over the whole study were evident in:

- “all activities" ($P<0.01$), in which the upper ridge flank group (Hall's totara-miro-towai-kiekie) was consistently the most favoured, followed by gully groups.

- feeding ($P<0.05$), which also occurred primarily in the upper ridge flank group, followed by gully groups, then those of the plateau ridge top.

- singing ($P<0.001$) was centred also on upper ridge flank vegetation, followed by groups of lower ridge flanks and gullies.

A significant difference in use of groups by season was apparent for the use of epiphytes ($P<0.05$), which were used primarily for food. Ridge top and flank groups were favoured in Winter 1983, gully groups were preferred over those of flanks in Spring 1983 and Summer 1983-83-4, ridge top groups were preferred in Autumn 1984, ridge flank groups were preferred in Winter 1984, and gully vegetation groups were preferred sites for use of epiphytes in Spring 1984.

Table 5.9: Interseasonal comparisons of use of vegetation groups and major floristic gradients in Summit home range.

Seven aspects of kokako behaviour were examined with respect to use of floristic gradients and vegetation groups identified in this home range, i.e. (1) all activities, (2) feeding, (3) song, (4) use of canopy, (5) use of subcanopy, (6) use of ground tiers and (7) use of epiphytes.

Spearman correlation coefficients were tabulated for correlations between frequency of use of grid squares for these seven aspects of and ordination scores of these grid squares along the two floristic gradients detected in this home range. Statistical t-tests were applied to ascribe significance levels to coefficients. Those found to be significant have been marked below with asterisks. Statistical H-values ascribed significance to use of particular vegetation groups in the home range.

Significance levels: * = P<0.05, ** = P<0.01, *** = P<0.001

	Bird Activity						
	1	2	3	4	5	6	7
t-tests of correlations of frequency of use with ordination scores along Axis 1 (n=34)							
Winter 1983	*2.1	*2.3	0.2	1.6	1.6	0.7	1.8
Spring 1983	0.5	-0.3	1.3	0.6	-0.7	0.1	-0.5
Summer 1983-84	0.3	-0.1	1.9	1.1	-0.1	-0.9	0.2
Autumn 1984	1.7	1.4	1.5	1.4	1.3	1.0	1.7
Winter 1984	-1.5	-1.4	-0.5	-1.7	-0.5	-0.3	-1.6
Spring 1984	-1.1	-1.2	-0.1	-1.2	-0.5	-0.3	-1.3
t-tests of correlations of frequency of use with ordination scores along Axis 2 (n=34)							
Winter 1983	-0.4	-0.5	-0.2	1.6	1.6	0.7	1.8
Spring 1983	1.2	1.3	0.4	1.7	1.2	0.3	1.7
Summer 1983-84	1.2	0.7	*2.1	1.9	0.7	-0.2	0.3
Autumn 1984	**2.9	*2.4	1.5	*2.3	*2.2	*2.3	1.6
Winter 1984	0.9	0.2	0.7	1.2	1.4	00	1.3
Spring 1984	2.0	2.0	0.3	1.4	*2.4	1.4	1.6
H-values from Kruskall Wallis tests of use of vegetation groups (n=6)							
Winter 1983	7.61	8.92	2.70	8.74	6.58	6.66	10.32
Spring 1983	3.90	2.55	9.42	*11.61	3.32	1.37	3.92
Summer 1983-84	8.32	8.03	*11.76	9.04	5.91	9.41	3.70
Autumn 1984	8.91	7.01	*14.75	8.75	6.01	6.88	8.38
Winter 1984	9.31	7.74	6.16	9.56	5.61	3.49	*12.05
Spring 1984	7.72	7.81	2.24	6.58	6.74	4.41	4.39

Table 5.10: Intraseasonal comparisons of use of vegetation groups in Summit home range. Seven aspects of behaviour were examined with respect to kokako use of vegetation groups, i.e. (1) all activities, (2) feeding, (3) singing, (4) use of canopy, (5) use of subcanopy, (6) use of ground tiers, and (7) use of epiphytes.

Analysis was by parametric two-way ANOVAs of ranked variables. Sratisrical F-values were for overall seasonal differences, overall differences in use of groups, and for season by group interactions. Degrees of freedom with each test have been listed also. The levels of significance associated with each test were derermined from the F-values and degrees of freedom.

Significance levels: * = P<0.05, ** = P<0.01, *** = P<0.001

	Season	Group	Season x group
Degrees of freedom	5:25	5:25	25:168
All activities	***6.02	**4.46	1.06
Feeding	**5.50	*3.20	1.06
Singing	1.99	***6.78	1.05
Degrees of Freedom	5:21	5:21	21:78
Use of canopy	0.97	1.00	1.48
Use of subcanopy	0.65	0.69	0.56
Use of ground tiers	0.22	1.06	0.83
Use of epiphytes	1.59	0.58	*1.72

APPENDIX 5.4

CORRELATIONS BETWEEN FREQUENCY OF USE OF PLANT SPECIES BY KOKAKO FOR VARIOUS ACTIVITIES AND PLANT SPECIES ABUNDANCE.

In each of six seasons (Winter 1983 - Spring 1984) use of plant species by kokako for all activities, for feeding and for singing were plotted against the mean cover abundance values of plant species in three forest tiers where kokako spent most of their time (tier 1 = greater than canopy height, tier 2 = 12m-canopy height and tier 3 = 5m-12m). A non-parametric Spearman correlation coefficient between the frequency of species use and species density was derived - these have been tabulated below. A t-test statistic accompanied each coefficient and the level of significance has been denoted.

	All Activities		Feeding		Singing		Sample Size
	Spearman Coefficient	t-value	Spearman Coefficient	t-value	Spearman Coefficient	t-value	
Tier 1							
Winter 1983	0.479	1.5	#	#	0.491	1.6	10
Spring 1983	0.634	**3.1	0.309	1.2	0.438	*1.8	16
Summer 1983-84	0.706	***3.7	0.082	0.3	0.706	***3.7	16
Autumn 1984	0.615	**2.7	0.200	0.7	0.380	1.4	14
Winter 1984	0.784	***5.0	0.350	1.5	0.638	**3.3	18
Spring 1984	0.649	**3.4	0.158	0.6	0.616	**3.1	18
Tier 2							
Winter 1983	0.393	**2.7	0.080	0.5	0.113	0.7	41
Spring 1983	0.550	***4.9	0.262	*2.0	0.319	**2.5	57
Summer 1983-84	0.623	***5.9	0.206	1.6	0.301	*2.3	57
Autumn 1984	0.615	***5.6	0.239	*1.8	0.303	*2.3	53
Winter 1984	0.704	***7.5	0.445	***3.8	0.350	**2.8	60
Spring 1984	0.632	***6.2	0.366	**3.0	0.281	*2.2	60
Tier 3							
Winter 1983	0.443	***3.8	0.241	*1.9	#	#	62
Spring 1983	0.469	***5.0	0.312	**2.9	#	#	80
Summer 1983-84	0.483	***4.9	0.180	1.6	0.048	0.4	80
Autumn 1984	0.628	***7.0	0.373	***3.5	0.097	0.8	77
Winter 1984	0.647	***7.6	0.414	***4.1	0.093	0.8	82
Spring 1984	0.531	***5.6	0.356	***3.4	0.026	0.2	82

none of this activity occured in this tier in this season.

* = P<0.05 ** = P<0.01 *** = P<0.001

APPENDIX 5.5

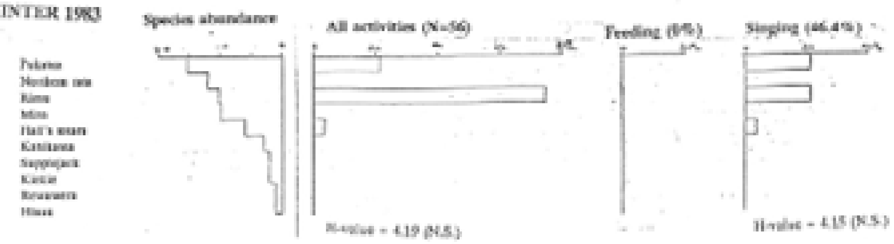
USE OF PLANT SPECIES BY KOKAKO IN FOUR FOREST TIERS.

(Next page)
5.4: Comparison of the abundance and use of plant species in tier 1 by kokako

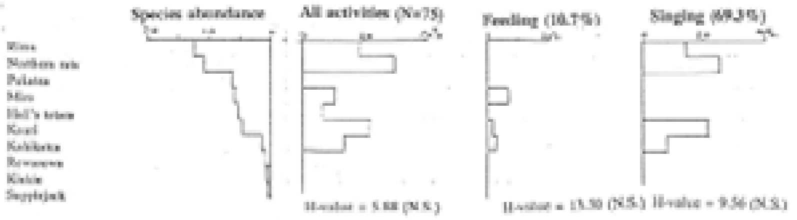
Plant species have been depicted in descending order of cover abundance frequency of use for all activities, for feeding and for singing. A statistical H-value (and its level of significance) was calculated from Kruskal-Wallis 1-way ANOVAs of the frequency of use of species. Significant H-values denoted significant selection of those species used must frequently by kokako.

No use of this tier for this activity. N.S. = Not significant.

WINTER 1983

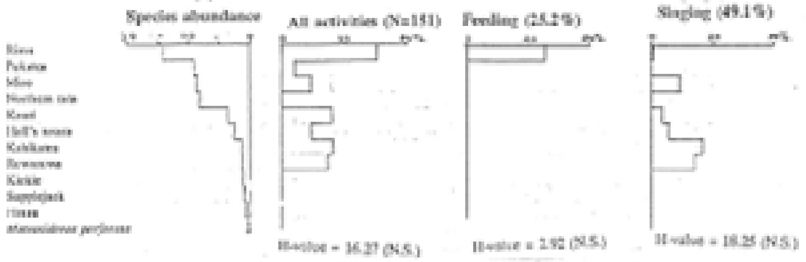


SPRING 1983

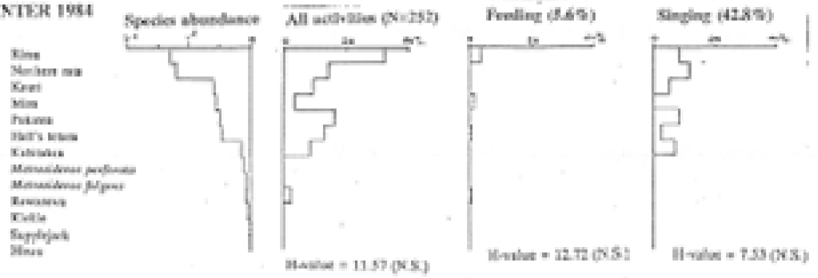


SUMMER 1983/4

AUTUMN 1984



WINTER 1984



SPRING 1984

Tier 2

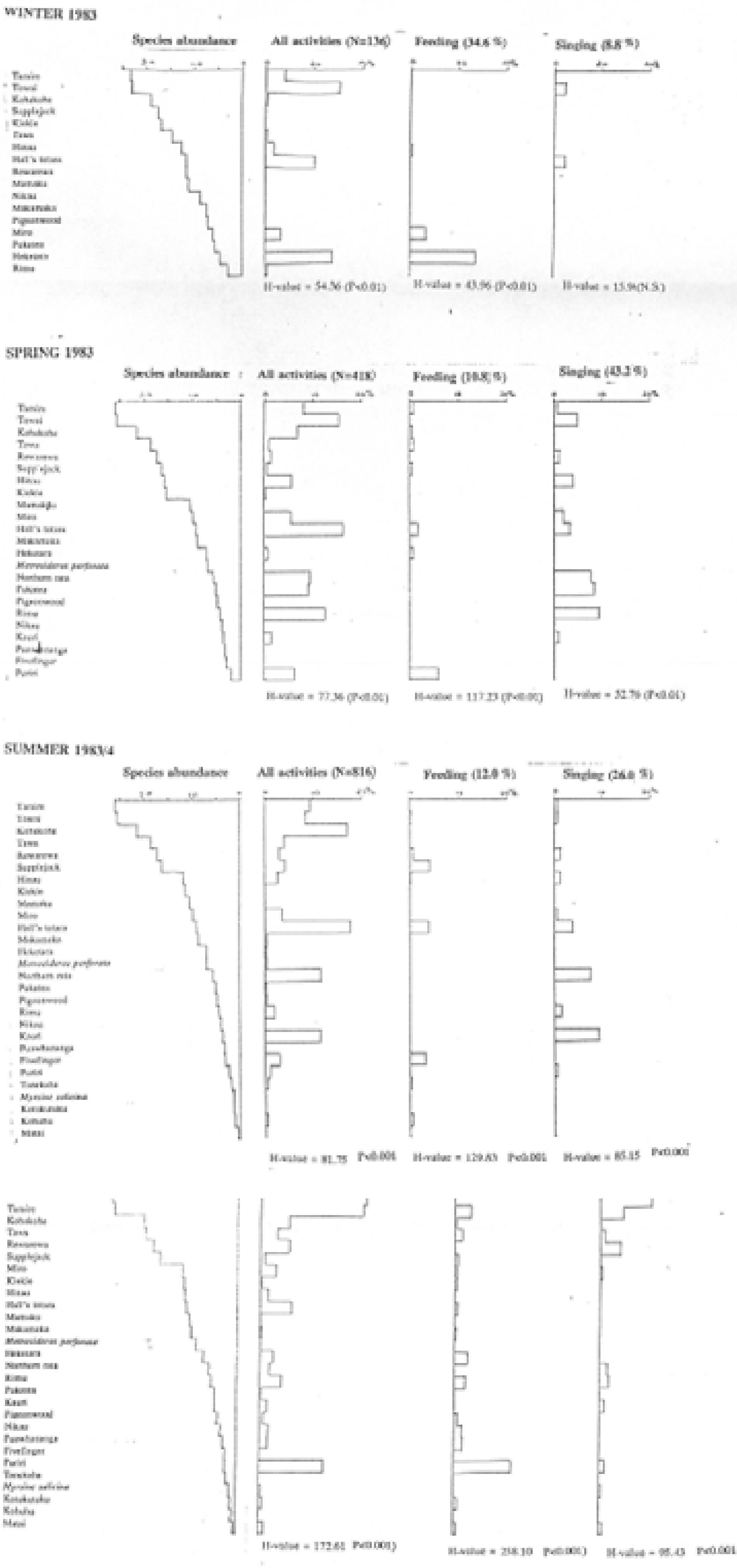


Figure 5.5: Composition of the abundance and use of plant species in tier 2 by kokako

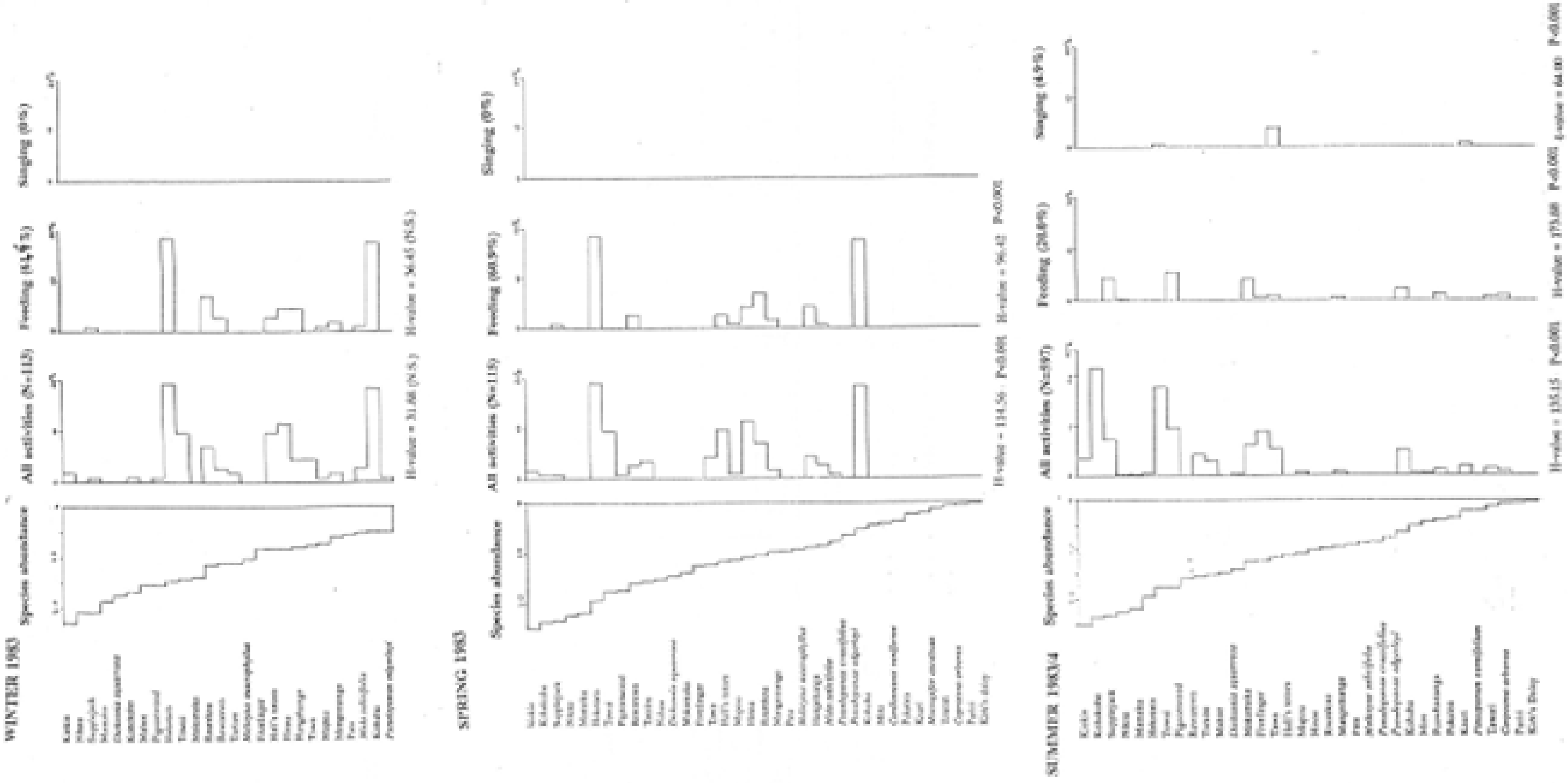
Plant species have been depicted in descending order of cover abundance and frequency of use for all activities, for feeding and for singing. A statistical H-value [and its level of significance] was calculated from Kruskal-Wallis 1-way ANOVAs of the frequency of use of species. Significant H-values denoted significant selection of those species used more frequently by kokako.

= No use of this tier for this activity. N.S. = Not significant.

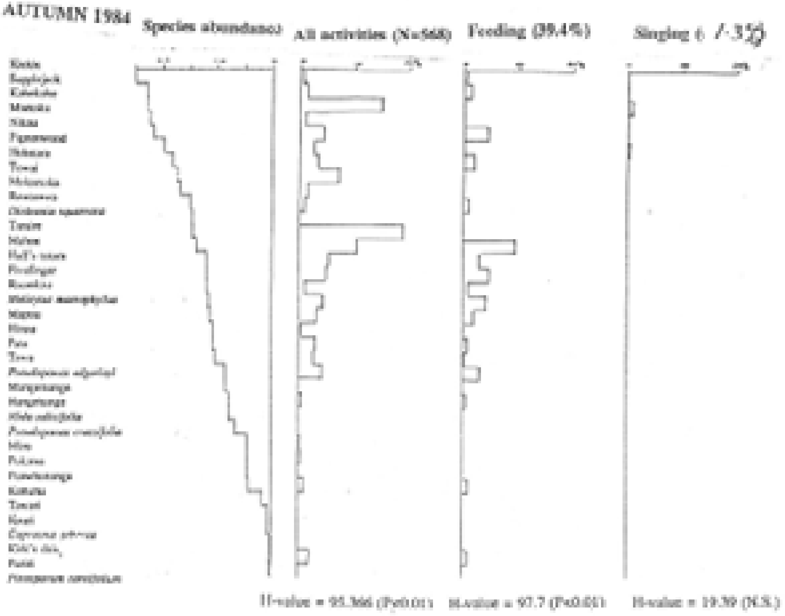
Figure 2.6: Comparison of the abundance and use of plant species in tier 3 by kokako

Plant species have been depicted in ranked descending order of cover abundance and frequency of use for all activities, for feeding and for singing. A statistical H-value (and its level of significance) was calculated from Kruskal-Wallis 1-way ANOVAs of the frequency of use of species. Significant H-values denoted significant selection of those species used most frequently by kokako.

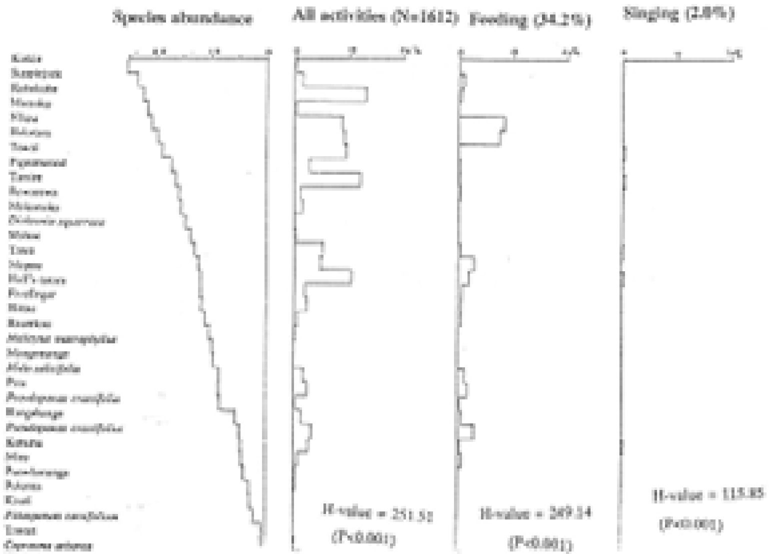
= No use of this tier for this activity. N.S. = Not significant.



AUTUMN 1984



WINTER 1984



SPRING 1984

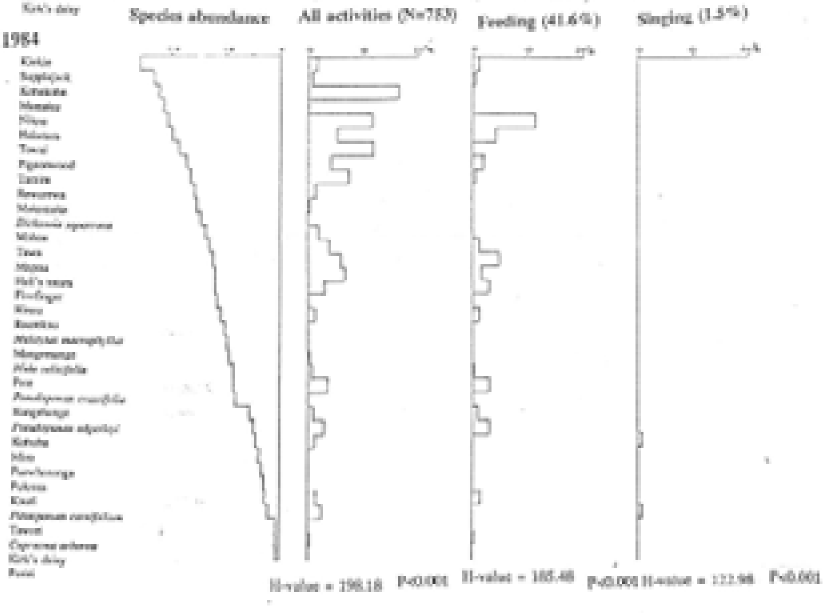


Table 5.11: The frequency of occurence of epiphytic plant species (=tier 7) in kokako home ranges compared with their use by kokako.

Plant species have been listed in ranked descending order of frequency of occurence and frequency of use by kokako for "all activities", for feeding and for singing. The ten most frequently recorded species and the ten most frequently used species have been listed for each of the three activity classes. A statistical H-value (and its level of significance) was calculated from Kruskal-Wallis 1-way ANOVAs of frequency of use of species. Significant H-values denoted significant selection of those species used most frequently by kokako.

= No use was made of this tier for this activity.

Season	Species listed by frequency of occurence	All activities	Feeding	Singing
Winter 1983	*Asplenium flaccidum* ssp.*flaccidum*	*Asplenium flaccidum*	*Asplenium flaccidum*	#
	Hymenophyllum revolutum	*Earina autumnalis*	*Earina autumnalis*	
	Filmy fern	Filmy fern	Filmy fern	
	Phymatosorus diversifolius	*Dendrobium cunninghamii*	*Dendrobium cunninghamii*	
	Earina autumnalis	*Phymatosorus diversifolius*	*Phymatosorus diversifolius*	
	Puka	Puka	Puka	
	Collospermum hastatum	*Anarthropteris lanceolata*	*Anarthropteris lanceolata*	
	Hymenophyllum flabellatum			
	Kidney fern			
	Dendrobium cunninghamii			
		30.91 (P<0.05)	30.91 (P<0.05)	#
Spring 1983	*Asplenium flaccidum*	Filmy fern	Filmy fern	#
	Hymenophyllum revolutum	*Asplenium flaccidum*	*Asplenium flaccidum*	
	Filmy fern	*Phymatosorus diversifolius*	*Phymatosorus diversifolius*	
	Phymatosorus diversifolius	Puka	Puka	
	Earina autumnalis	*Earina autumnalis*	*Earina autumnalis*	
	Puka	*Asplenium polyodon*	*Asplenium polyodon*	
	Collospermum hastatum	*Earina mucronata*	*Earina mucronata*	
	Hymenophyllum flabellatum	*Anarthropteris lanceolata*	*Anarthropteris lanceolata*	
	Kidney fern	*Collospermum hastatum*	*Collospermum hastatum*	
	Dendrobium cunninghamii	*Blechnum filiforme*	*Blechnum filiforme*	
		92.07 (P<0.001)	96.59 (P<0.001)	#
Summer 1983-84	*Asplenium flaccidum*	Puka	Puka	Fivefinger
	Hymenophyllum revolutum	Filmy fern	Filmy fern	
	Filmy fern	*Collospermum hastatum*	Fivefinger	
	Phymatosorus diversifolius	Fivefinger	*Earina mucronata*	
	Earina autumnalis	*Earina mucronata*	*Astelia solandri*	
	Puka	*Astelia solandri*	*Asplenium flaccidum*	
	Collospermum hastatum	*Asplenium flaccidum*		
	Hymenophyllum flabellatum			
	Kidney fern			
	Dendrobium cunninghamii			
		89.12 (P<0.001)	98.69 (P<0.001)	27.05 (N.S.)

Season	Species listed by frequency of occurence	All activities	Feeding	Singing
Autumn 1984	*Asplenium flaccidum*	*Collospermum hastatum*	*Asplenium flaccidum*	Puka
	Hymenophyllum revolutum	*Asplenium flaccidum*	*Earina mucronata*	
	Filmy fern	*Earina mucronata*	Puka	
	Phymatosorus diversifolius	Puka	Filmy fern	
	Earina autumnalis	Filmy fern	*Collospermum hastatum*	
	Puka	*Dendrobium cunninghamii*	*Dendrobium cunninghamii*	
	Collospermum hastatum	*Earina autumnalis*	*Earina autumnalis*	
	Hymenophyllum flabellatum	*Anarthropteris lanceolata*	*Anarthropteris lanceolata*	
	Kidney fern			
	Dendrobium cunninghamii			
		58.77 (P<0.001)	41.68 (P<0.01)	15.87 (N.S.)
Winter 1984	*Asplenium flaccidum*	*Asplenium flaccidum*	*Asplenium flaccidum*	Puka
	Hymenophyllum revolutum	*Phymatosorus diversifolius*	*Phymatosorus diversifolius*	
	Filmy fern	Puka	Puka	
	Phymatosorus diversifolius	*Earina autumnalis*	*Earina autumnalis*	
	Earina autumnalis	*Collospermum hastatum*	*Earina mucronata*	
	Puka	*Earina mucronata*	*Drymoanthus adversus*	
	Collospermum hastatum	*Drymoanthus adversus*	Filmy fern	
	Hymenophyllum flabellatum	Filmy fern	*Pittosporum cornifolium*	
	Kidney fern	*Pittosporum cornifolium*	*Asplenium polyodon*	
	Dendrobium cunninghamii	*Asplenium polyodon*	*Dendrobium cunninghamii*	
		147.15 (P<0.001)	167.95 (P<0.001)	16.09 (N.S.)
Spring 1984	*Asplenium flaccidum*	*Asplenium flaccidum*	*Asplenium flaccidum*	#
	Hymenophyllum revolutum	*Phymatosorus diversifolius*	*Phymatosorus diversifolius*	
	Filmy fern	Puka	Puka	
	Phymatosorus diversifolius	Filmy fern	Filmy fern	
	Earina autumnalis	*Earina mucronata*	*Earin mucronata*	
	Puka	*Pittosporum cornifolium*	*Pittosporum cornifolium*	
	Collospermum hastatum	*Collospermum hastatum*	*Asplenium polyodon*	
	Hymenophyllum flabellatum	*Asplenium polyodon*	*Dendrobium cunninghamii*	
	Kidney fern	*Dendrobium cunninghamii*	*Collospermum hastatum*	
	Dendrobium cunninghamii	*Earina autumnalis*	*Earina autumnalis*	
		158.09 (P<0.001)	163.70 (P<0.001)	#

N.S.: Not statistically significant

Filmy fern includes common species on branches of trees, i.e. *Hymenophyllum demissum*, *H. dilatatum*, *H. multifidum* and *H. sanguinolentum*

SECTION SIX : CONCLUSIONS

6.1 INTRODUCTION

Puketi Forest contains one of the largest populations of kokako in existence (Rasch pers. comm.). Most birds have been found in the central portion of the Forest (Fig 1.2), an area characterised by sharply dissected ridges and gullies. Kokako occur mainly in the heads of side catchments of the Waipapa River, where there is maximum diversity of forest vegetation coincident with abrubt changes in topography. The ridges of this sharply dissected terrain are often crowned with kauri-dominated vegetation. Areas with little topographic variation, e.g. the south-western upland and the alluvial terraces of the Waipapa River support very few kokako.

6.2 LIKELY CONSEQUENCES OF LOGGING ON THE KOKAKO POPULATION IN PUKETI FOREST

6.2.The likely effect of selection logging of kauri on kokako habitat

Selection logging of kauri began in Puketi Forest in 1973. From 1975 to 1979, of 870cu.m of saw logs were extracted annually, the technique being to select the larger diameter trees and leave residual trees (Halkett 1980). Selection logging of kauri has occurred mainly in mature forest on ridges and spurs as this is where most kauri are found. Ridges and spurs are also the most suitable landforms for the placement of access roads.

6.2.B. Impact of logging on forest structure and composition

Felling of trees created sizeable openings in the forest mantle. Neighbouring trees may have been knocked over, or have limbs tom off. Vegetation in the path of the falling tree was smashed. Typically, a sizeable proportion of the larger trees were removed from an area, resulting in widespread damage to all vegetation tiers. This altered the by exposing the subcanopy plants to increased sun and wind, affecting species that favoured shaded and sheltered conditions. Further damage to understorey and ground vegetation was inflicted in the process of manoevering and hauling logs to sites where were loaded onto trucks. Thus logging at Puketi Forest has resulted in gross simplification of the forest structure and a substantial reduction in the overall abundance of species, some of which are prominent in the diet of kokako.

Kauri in Puketi Forest grew mainly on leached podsolised soils. The main supporting root systems of kauri trees were quite shallow, often extending no more than 3m into the soil. Kauri feeding roots were concentrated in the humic soil horizons (the uppermost, surface veneer), especially in pukahukahu (the large mounds of leaf litter and shed bark that accumulated at the base of each tree; Halkett and Sale 1985). Logging machinery disrupted the humic layers of soil, and damaged pukahukahu mounds, thereby destroying kauri feeding roots. Kauri trees became more suseptible to windthrow when their root plates had been damaged, or when large gaps had been opened in the canopy. Several mature kauri trees near logging tracks were toppled during storms in the course of our study.

Regeneration appeared to be slow in areas logged selectively for kauri. Typically, dense masses of *Gahnia xanthocarpa* sedge have established where the soil has been disturbed, though some areas remained bare for many years after logging. Eventually, shrub hardwood species (e.g. kanuka, towai, kohuhu, fivefinger, and heketara) have colonised these areas, usually as isolated plants above dense *G. xanthocarpa*. Saplings of mature forest species (kauri, podocarps) which formerly covered the area were very rare. A typical vegetation profile of these logged areas has been described in Appendix 2.4, vegetation group (iv).

Kokako seldom ventured into logged areas and usually then only along the fringes for short periods. The majority of kokako activities (singing, calling, moving, roosting-preening and some feeding) occurred above (see Section 4.2.3). Very little vegetation remained above this height after logging. Many tree species and epiphytes that provided important foods, were removed or damaged during logging, and were slow to reestablish afterwards.

The use of regenerating vegetation by kokako appeared to depend on three factors in combination.

1. Size. Small pockets in a mature forest matrix (such as those that developed on solo sites) were more likely to be used than larger areas.

2. The stage of regeneration. The diversity and maturity of species was likely to increase with time, thereby enhancing the suitability of the site.

3. The species present. Some seral species such as *Gahnia xanthocarpa*, wineberry or treeferns were not used by kokako to any significant extent, whereas others such as fivefinger, heketara and kohuhu were.

Removal of podocarps and tree hardwoods prior to 1973 resulted in a great reduction in the food supply available to kokako. Podocarps and tree hardwoods were important to kokako not only for the food they produced themselves, but also as they carried the greatest loadings of epiphytes and lianes, each of which contributed substantially to the diet of kokako.

6.2.C. Impact of past logging on kokako distribution

Logging has had a major influence on kokako distribution in Puketi Forest. Very few kokako reside in forest that was logged heavily prior to 1973, which are now supporting regenerating forest or (see Anderson 1979; 1984). Most kokako home ranges in such areas are now centred on isolated enclaves of mature forest.

Disruption of the forest structure by selection logging since 1973 has rendered affected areas unsuitable for kokako. Examples of the probable impact of selection logging on the Puketi kokako population can be found on Bramley's and Totara Ridges, which enclose Canadian's Creek. These ridges lie in the centre of the densest concentration of kokako in Puketi Forest. Both have been selectively logged, and logging roads extend along most of their lengths. Although no kokako are known to inhabit logged sections of these ridges, we surmise they were present beforehand. Historic information (Sexton 1939) indicated that the vegetation prior to logging was similar to that now frequented by kokako in the unlogged side spurs and ends of Bramley's and Totara Ridges. About 20 kokako (a fifth of the Puketi population) are present in the unlogged parts of these two ridges, with some home ranges lying immediately alongside (but not including) logged areas.

6.3 THE IMPORTANCE OF KAURI TO KOKAKO

The relationship between kauri and kokako in Puketi Forest appeared to be thus:

1. Kokako were most plentiful:
- where the terrain was most variable, and thus the habitat was most diverse
- along prominent ridges
- where there has been least disturbance to the mature indigenous forest cover.

2. Kauri were most plentiful:
- along prominent ridges
- where there has been least disturbance to the mature indigenous forest cover.

3. Kauri was a highly favoured song past species owing to its large, towering habit and because it grew on ridges and other elevated landforms. Other trees of similar stature were used when kauri was not present. Removal of kauri on the scale seen to date has resulted in major disturbance which has been highly prejudicial to the survival of kokako in the area being logged.

6.4. THE LIKELY EFFECTS OF MAMMALIAN BROWSING ON KOKAKO HABITAT

The diet of kokako changed with season, depending on the availability of food on the plant species concerned. Some plant food species favoured by kokako have also been found to be highly palatable to browsing mammals, particularly possums (see below). Although no quantitative data were collected on possum numbers in the course of this study, sign of their presence increased appreciably in the period. Possums appeared to have penetrated the mature forest from surrounding farmland and shrubland, using logging roads along ridges as their main access routes. Browse was noted initially at the forest margins along logging roads. Plants tagged alongside these roads for phenology studies bore no evidence of browse early in 1983. The first signs of browse were apparent in Winter 1983, heavy browse on some individuals was noted by Summer 1983-84, and a few appeared to have been browsed to death by Winter 1984. Possum sign in mature forest was seen rarely at the start of the study (late 1982). However, browse was noted commonly in all of the main kokako study home ranges by Spring 1984, particularly on fivefinger.

The plant species eaten most commonly by kokako are listed in Table 4.2, and Appendix 4.3. These include fivefinger, hangehange, kohekohe, kotukutuku, mahoe, pigeonwood, raukawa, raurekau, rewarewa and supplejack. These species are also favoured foods of possums (Fitzgerald 1976; Fitzgerald and Wardle 1979; Leathwick *et al.* 1983). Possum browse was evident on most of these species in Puketi Forest as well as on *Melicytus macrophyllus, Mida salicifolia* and northern rata. Some of the fivefinger and kotukutuku plants in the phenology study were killed by browsing possums. The overlap in diet between kokako and possums in the Forest is of concern. Left unchecked, possum browse is likely to significantly reduce the availability of many of the foods preferred by kokako in the Forest. [Subsequent to the kokako study, it has been estimated that more than fifty percent of the rata in Puketi Forest have died from overbrowsing by possums (Yarwood 1989)].

Low numbers of cattle and goats in Puketi Forest also have an adverse influence on quality of habitat for the kokako population. If allowed to remain, their browsing on the understorey will inhibit regeneration, resulting in simplification of the complex forest structure. This may lead to depletion of important food plant species in the kokako diet. Leathwick *et al.* (1983) have implicated impoverishment of habitat by browsing in the collapse of kokako populations elsewhere in the North Island.

6.5 THE VALUE OF PUKETI FOREST

A. To Kokako

Puketi Forest:

(i) comprises the largest known kokako population centre in Northland and is isolated from all other kokako populations.

(ii) contains one of the largest and densest kokako populations known to exist. The population is within a contiguous forest tract, unlike some other North Island populations.

(iii) has a breeding population of kokako. Two juveniles were seen and a nest was found during the study.

Less than half of the kokako population of Puketi Forest lies within protected areas (reserves in the forest tract include the 92ha Manginangina Scenic Reserve and the Onekura Ecological Area). Forest forms, along with the adjacent forested areas of Omahuta Forest, Otangaroa State Forest and Scenic Reserves, a contiguous forest tract of c.14,600ha. Even though much of the forest in Omahuta has been logged, given time its value as kokako habitat will gradually increase allowing room for considerable expansion of the existing kokako population in Puketi Forest.

B. As a habitat for other wildlife.

Ogle (1982) drew attention to the value of Puketi Forest along with the adjacent forested areas mentioned above as wildlife habitat of outstanding value, not only for kokako but for the North Island kaka, red-crowned parakeet, North Island brown kiwi and the snail *Paryphanta busbyi busbyi.* He also stressed its values as an indigenous forest remnant and drew attention to its botanic values. A full list of the vascular flora appears in Appendix 6.1.

Puketi Forest contains populations of nationally rare and endangered plant species, amongst which the most outstanding are *Davallia* sp. nov., *Grammatis rawlingsii, Hebe acutiflora, Pittosporum* *virgatum* and *Bulbophyllum tuberculatum.* There are also northern distribution records for numerous other species.

The creation of the Onekura Ecological Area recognises the uniqueness of the dissected landforms and vegetation of Puketi Forest, and, in particular that of its mature kauri forest (Nicholls 1979).

There are, however, important vegetation types and other features which are not represented within the existing reserves (see Willetts 1985).

Its diversity of habitat, its range of altitude, and its inclusion with Omahuta Forest of a nearly completely intact major river catchment makes Puketi Forest an area of outstanding value. As a remnant of indigenous forest in Northland and an outstanding wildlife habitat, coupled with it being habitat for a major population of North Island kokako, it has no parallel.

APPENDIX 6.1

VASCULAR FLORA OF PUKETI FOREST

by P.J. Bellingham

A species list of vascular flora found within the boundaries of Puketi Forest follows, with notes on each species' distribution and habitat in the Forest.

Nomenclature follows Allan (1961), Moore and Edgar (1970), Healy and Edgar (1980), Healy (1984), Connor and Edgar (1987), Webb, Sykes and Garnock-Jones (1988), and Brownsey and Smith-Dodsworth (1989) except where other authorities are cited.

The indigenous flora has been vouchered comprehensively - voucher specimens have been lodged in the Herbarium of the Auckland Institute and Museum (AK), with a few also lodged in the Herbarium of the Botany Department of the University of Auckland (AKU). Voucher numbers are included in the list of the flora.

The list of adventive flora, while quite full, is unlikely to be as exhaustive as that of the indigenous flora, as search effort centred primarily on the undisturbed mature forest tract rather than forest margins. Many adventive species are also vouchered. Some of the flora found within the forest's boundaries have been omitted deliberately. These include garden escapes at Forest Road, and plants in cultivation at Forest Headquarters. At the latter site some indigenous species not known to be growing naturally in the forest are planted as ornamentals. To avoid confusion, these have been omitted from the floral list.

Additional records of three other authors are also included in the flora. These are unpublished lists by:

- A.N. Sexton (1939) in an appendix to his report on Puketi Forest. Localities were provided for many of the species. Some parts of Puketi Forest have been modified extensively since this report was prepared, and destruction of habitat may account for some species not being found in this survey.

- The late G.B. Rawlings (c.1972). I am grateful to Mr A.E. Esler for making this list available to me. There are also some published accounts of G.B. Rawlings which refer to the Puketi Forest flora.

- C.C. Ogle (1979), based on three visits to the forest. I am grateful to the author for making this list available to me.

Some additional records are based on herbarium material in AKU and AK.

A total of 516 species of vascular plants have been recorded from Puketi Forest, a breakdown of which follows:

	Indigenous species	Adventive species	Plantation species	TOTALS
Fern allies	9	1		10 (2%)
Ferns	90			90 (17%)
Gymnosperms	12	1	5	18 (4%)
Dicotyledons	160	91	1	252 (49%)
Monocotyledons	94	52		146 (28%)
TOTALS	**365** (71%)	**145** (28%)	**6** (1%)	**516 (100%)**

Some nationally rare plants are found in Puketi Forest, the most notable are:

1) *Davallia* sp. unnamed. Discovered in 1984, this new species is apparently endemic to the Forest.

2) *Grammitis rawlingsii* Parris. Rare in the Forest, this is only the second locality of this species known in Northland, other than at its type locality in Waipoua Forest Sanctuary.

3) *Hebe acutiflora*. The Waipapa and Mangapapa Rivers which are the main catchments of Puketi And Omahuta Forests contain the largest known population of this vulnerable species.

4) *Pittosporum virgatum*. Puketi Forest contains the largest Northland population of this nationally rare species.

5) *Bulbophyllum tuberculatum.* Rare in the Forest; this is one of the few recent Northland localities for this vulnerable species.

6) *Utricularia lateriflora*. Rare in the Forest, this plant is nationally rare and local, and few of its known localities are reserves.

Puketi Forest is also a Northland stronghold for several regionally rare species. *Loxsoma cunninghamii* was regarded as a nationally rare species (Williams and Given, 1981) and while it is not as rare as was thought, Puketi Forest nonetheless contains one of the largest populations of this fern in Northland. Manoao is found in some other Northland forests, but some of the largest remaining stands and the largest trees of the species in Northland are in Puketi Forest. Similarly, while silver pine is found in other Northland forests, Puketi is a major regional stronghold of the species. *Pratia physaloides* is becoming increasingly rare on the New Zealand mainland, and while some other northern forests still contain large populations of this species, Puketi contains many major populations.

Puketi Forest also provides several important distribution records of species. The main northern locality records are those of:

Grammitis rawlingsii Parris. Its discovery in Puketi Forest at 35°11' is north of its type locality in Waipoua Forest Sanctuary at 35°40'.

Hypolepis lacteal Brownsey et Chinnock. Brownsey and Chinnock (1984) state that the distribution of this species in Northland is based on one early collection. The Puketi locality reconfirms its presence in Northland.

Brachyglottis myrianthos (Cheesm.) Drury. The discovery of this species in the Forest represents a major northward extension of range from c. 36°30' to 35°11', and its first known occurrence in Northland.

Viola filicaulis The occurrence of this species in Puketi Forest at 35°11' is probably its northern limit. Its other occurrences in Northland are on the Tutamoe Range and in Waipoua Forest (c.35°35').

FERN ALLIES:
* = adventive species

		Voucher specimen (AK unless stated otherwise)
Lycopodium cernuum	locally abundant on dry, well-lit clay banks, road cuttings and in manuka communities.	168061
L. ducterodensum	locally wmmon on dry ridges especially under manuka or pole kauri, and rarely under mature kauri canopy.	168958
L. laterale	very restricted in range, but locally common on poorly drained acid soils under *Gleichenia dicarpa, Baumea rubiginosa* and *Schoenus brevifolius* in the gumland community south of Forest Headquarters.	166091
L. varium (incl. *L. billardieri*)	common epiphyte in both mature and regenerating forest throughout. Usually hanging from the bases of epiphytic lilies.	166124
L. volubile	abundant in regenerating communities, particularly under manuka. Occasional on dry ridges under mature forest.	166613
*Selaginella kraussiana**	locally common on poorly drained disturbed sites, especially on old road formation on alluvial terraces of the Waipapa River, and it is adjacent areas aggressively.	
Tmesipteris elongata	common epiphyte, particularly on ponga trunks, in shaded gullies throughout. The form "subsp. *robusta* Chinnock" is occasional as an epiphyte from the bases of epiphytic lilies in mature forest throughout	166528, 168929, 166612
T. lanceolata Dang	common epiphyte, especially on the trunks of mamaku and wheki, in moist gully bottoms.	168015
T. sigmatifolia Chinnock	common epiphyte on ponga, and to a lesser extent on *Dicksonia* sp. (aff. *D. lanata*), usually on ridge flanks. Less common in upland parts of the forest (>450m asl).	166138, 168016, 168370
T. tannensis	common epiphyte, particularly on ponga trunks, thoughout and most common in upland parts of the forest. Also common terrestrially and on mounds of kauri litter in mature kauri stands. There appear to be two distinctly different morphological forms between these two sites.	168017

FERNS:

Adiantum cunninghamii	common on steep banks near streams, particularly along the major river systems (Waipapa and Mangapapa Rivers) but also frequent in lower reaches of most side catchments.	166604

A. diaphanum	occasional on well drained loam banks above alluvial terraces of the Waipapa River in its lower reaches, and on flanks north of the lower Waihoanga Stream.	170023, 170486
A. fulvum	locally common especially on steep rubbly well-drained slopes, especially around waterfall sites.	168365, 170010
A. hispidulum	local on steep well-drained sites usually rock banks, usually near stream or river systems.	170485
A. viridescens Col.	moderately common in low altitude forest in gully heads on fairly steep, well-drained banks.	168750, 170142
Anarthropteris lanceolata	abundant epiphyte on a wide range of trees and tree ferns, particularly at lower altitude. Rarely terrestrial.	166631
Arthropteris tenella	locally common only on alluvial terraces of the Waipapa River between the confluence of the Pukatea Stream and its junction with the Mangapapa River. Also on loose rock slopes in Pukatea Stream and Te Rereatuoro Stream and north of the lower Waihoanga Stream. Mostly terrestrial and rarely scandent.	165040, 169726, 170159, AKU21890
Aplenuim bulbiforum	Hen and chickens fern. Abundant throughout the mature forest in gullies and moist sites.	166652, 166653, 170157
A. flaccidum subsp. *flaccidum*	abundant epiphyte throughout the forest. Rarely terrestrial on dry ridges.	166606
A. gracillimum Col.	local, occasional on well drained loam banks under low altitude forest (>200m asl) in the lower reaches of the Waipapa River. Also on loose rock slopes in Te Rereatuoro Stream.	169736, 170017, 170158
A. lamprophyllum	local. Common on steep rocky banks under mature forest north of the lower Waihoanga Stream. Other smaller populations occur on Mokau Ridge and near the middle reaches of Pukatea Stream.	166609, 167891, AKU 21888
A. oblongifolium Col.	common epiphyte and ground cover throughout, predominantly at lower altitude.	166463
A. polydon Forst. f.	abundant epiphyte and uncommon ground cover throughout in all but early successional communities.	166578
Blechnum chambersii Tindale	common ground cover on shaded stream banks and on alluvial terraces of the main rivers.	166565, 168370, 168371
B. discolour	common ground cover species, particularly on ridge flanks and on ridges under podocarp/hardwood canopy	166614
B. filiforme	common in mature forest throughout as ground cover and scandent form, particularly in midslope and shaded sites.	166615

B. fluviatile	occasional in moist shaded sites, especially near stream banks and stream headwaters. Most common at higher altitude (>300m asl).	166528
B. fraseri	abundant ground cover under mature and regenerating forest throughout.	166529, 168354
B. membranaceum	common in mature forest near stream headwaters in damp shaded gullies.	166126, 166137, 170141
B. nigrum	locally common in damp shaded sites in mature forest above 350m asl and rare below this. Most common on the upland southern massif.	166125, 170145
B. procerum (Forst.f) Swartz	occasional small populations above 200-400m asl, mostly on damp points on ridges. Common above 400m on the upland southern massif plateau.	166452, 168364, 168568, 168569
B. sp. (*B. capense* sensu Allan (1961))	kiokio - common throughout, but flourishes in disturbed sites e.g. slips, road cuttings and in regenerating forest.	168964, 168965
B. minus (R.Br.) Ettingsh	swamp kiokio - rare and local - only one population population known near a seepage in clay in manuka shrubland in the logged area in the headwaters of the Waipapa River.	170020
B. procerum (Forst.f.) Swartz X B. sp. (*Blechnum* sp. *capense* sensu Allan (1961))	rare and local - only one small colony found with *B.* sp. (*Lomaria latifolia* Col.) on the upland southern massif near the head of Ravell's Creek.	170061, 170062
Cardiomanes reniforme (Forst.f.) Presl.	kidney fern - abundant epiphyte throughout mature and regenerating forest. Common terrestrially on mature kauri-dominated ridges.	167651
Ctenopteris heterophylla (Labill.) Tindale	very common epiphyte throughout mature and regenerating forest. Occasional on rock faces near waterfalls.	166567
Cyathea cunnibghamii	locally common tree, mostly on alluvial terraces of the major river systems, and less common in the side catchments. Seldom in disturbed sites.	16856
C. dealbata	ponga - abundant subcanopy tree fern, in all sites except the driest ridges and dampest gullies in mature and regenerating forest throughout.	168374, 170045
C. medullaris	mamaku - very common canopy tree fern in gully sites and alluvial terraces throughout. A vigorous of damp disturbed sites (e.g. logging tracks and slips).	168375, 168376, 168571, 170060

C. smithii	common tree fern in mature podocarp hardwood forest above 300m asl - much less common below this. Primarily in gullies and flanks, but common on the upland southern massif plateau.	166075, 166076, 166077, 166536, 166537, 166537, 166538, 166539, 166540
Davallia sp. unnamed	very rare and local - on dry east-facing greywacke bluffs (Onekura Bluff) west of Onekura Stream. On exposed sites and under light Hall's totara canopy. Mostly terrestrial, rarely epiphytic.	168571
Deparia petersenii (Kunze) Kato subsp. *congrua* (Brackenr.) Kato	moderately common in damp sites and stream throughout. Flourishes in more disturbed sites.	168051, 168361
Dicksonia sp. (aff. *D. lanata*)	locally abundant in some kauri communities above c. 250m asl (mostly in those with an apparently high water fable), and common in the upland forest of the southern massif. Forms upright trunks up to 2m in some sites.	168002, 168038, 168039, 168040, 168041
D. squarrosa	wheki- abundant in damp sites (gullies, alluvial terraces) in both mature and regenerating forest.	167905-6, 168378
Diplazium australe (R. Br.) Wakef.	uncommon - predominantly on broad alluvial terraces of the Waipapa River, and lower reaches of some side catchment (e.g. Te Rereatuoro Stream).	168163
Doodia media R. Br. subsp. *australis* Parris	uncommon on dry banks under mature forest, e.g. near Merumeru Falls, Te Rereatuoro Falls, rock bluffs near the southern pan of the Waipapa River, and above lower Te Harua Stream. Occasionally in regenerating forest communities.	166465, 166587
D. mollis Parris	rare and local - known only from dry rubbly banks on either side of the Merumeru Falls with *D. media* subsp. *australis, Libertia grandiflora* and *Peperomia urvilleana* under karaka/titoki canopy.	166588, 167625
Gleichenia dicarpa	locally abundant, particularly in the poorly drained community near Forest Headquarters, but also under poorly drained manuka shrub-land along the Forest's eastern boundary, with *Baumea rubiginosa.*	166121
G. microphylla	locally abundant. In early seral forest communities in the east of the forest it forms dense tangles under kanuka/towai. Occasional under pole kauri on dry ridges.	166144
Grammitis ciliata	locally common on banks in stream courses and canyons (e.g. in Merumeru, Waikape, Pukatea, and Mangakino Streams, usually near waterfalls). Rare on shaded rock banks or clay banks in the forest.	166645, 170011, 170018

G. pseudociliata Parris	common epiphyte on a range of host species, usually in damper areas. Rare below 300m, and common above 400m asl especially on the southern massif.	164794
G. rawlinsii Parris	very rare and local - only one small colony known. Occurs as low epiphytes under a mature kauri canopy on a side ridge north of the Waikape Stream.	168545
Histiopteris incisa	water fern - common in damp, disturbed sites in both mature and regenerating forest.	168052, 168053, 168359
Hymenophyllum armstrongii	fairly common epiphyte in mature forest, especially in the crowns of podocarps and rare on tree trunks in regenerating communities. Rare below 250m asl.	166142, 166163
H. atrovirens	local. Common on rock banks in the gorges of the Waikape Stream, and in the upper Pukatea Stream. Rare in the lower Merumeru Stream and in the gorge near the head of the Waipapa River.	164912, 165048, 168031, 168032
H. cuppressiforme Labill.	rare and local -found only on rocks in and near the stream course in the lower reaches of the Waikape Stream.	169731
H. demissum	abundant epiphyte throughout the forest, and common ground cover in damp gullies under mature forest.	166630
H. dilatatum	abundant epiphyte in moist sites (gullies, upland sites) in mature forest. Rarely terrestrial.	166514
H. ferrugineum	common epiphyte on tree fern trunks in the dampest sites in mature forest, particularly the bottoms of gullies and on the southern massif.	166513, 170146
H. flabellatum	abundant epiphyte on tree fern trunks, particularly ponga, in both mature and regenerating forest.	166516
H. flexuosum	rare epiphyte and terrestrial fern in moist shaded sites in mature forest above 250m asl.	165187, 166127
H. lyalli	locally common epiphyte on tree fern trunks, particularly ponga, under podocarp/hardwood canopy, mostly on ridge flanks. Occurs mostly above 300m asl.	165063, 166109
H. multifidum	common epiphyte in both mature and regenerating forest. Rarely terrestrial in mature kauri stands. Most common in damp areas and at high altitude.	166129
H. rarum	common epiphyte in mature forest throughout on both trees and tree ferns.	166134, 168360
H. revolutum	abundant epiphyte on tree ferns and tree trunks, and rarely terrestrial. In mature and regenerating forest communities throughout.	166096
H. sanguinolentum	abundant epiphyte mostly in the crowns of trees in mature and regenerating forest communities throughout.	166128

H. scabrum	common epiphyte in moist sites (gully bottoms and high altitude) in mature forest throughout.	166068, 166655-6, 168373
Hypolepis distans	very rare and local - two localities known - terrestrial under manuka scrub near the head of the Waipapa River, and on rotting wood in a forest light well on the banks of the middle section of the Waipapa River.	170024
H. lacteal Brownsey et Chinook	very rare and local - one small population only known under towai/taraire forest on Mokau Ridge, north of Camp Creek.	165170
H. rufobarbata (Col.) Wakefield	very rare and local -only one small population known from the southern massif from banks of the headwaters of Flavell's Creek	170054
H. sp. (indeterminate)	late G.B. Rawlings recorded *H. tenuifolia* in an unpublished list (c. 1972), which may equate with *H. ambigua* Brownsey et Chinook which occurs in Northland, although it was not recorded in the present survey in Puketi Forest.	
lastreopsis glabella (A. Cunn.) Tindale	common in welldrained gully sites more commonly at lower altitude, especially along flanks of alluvial terraces lower Waipapa River.	166611, 170139, 170474
L. hispida (Swartz) Tindale	abundant in moist sites (gullies and high altitude) in mature forest throughout.	168651, 170143
L. microsora (Endl.) Tindale subsp. *pentangularis* (Col.) Tindale	rare and local small populations on alluvial terraces and steep banks above them on the Waipapa River near the Forests' southern boundary, and on steep flanks north of the lower Waihoanga Stream.	170046, 170472, AKU 21891
Leptolepia novaezelandiae	local and uncommon on banks in the headwaters of streams (e.g. Pukatea Stream, Flavell's Creek, Canadian's Creek) under mature forest canopy.	
Leptopteris hymenophylloides (A. Rich.) Presl.	heruheru - common in moist gullies and damp sites under mature forest canopy throughout.	168044
Lindsaea trichomanoides	common on dry ridges and well drained ridge flanks under mature kauri and podocarp/hardwood communities throughout.	
Lozsoma cunninghamii R. Br. ex. A. Cunn.	local and uncommon. Occurs most frequently where dominated ridges approach stream courses; inhabiting the soils near stream banks. Occasional populations line the Waipapa and Mangapapa Rivers, but also occur in side catchments Waikape, Pukatea, Waihoanga and Streams).	166617, 167996
Lygodium articulatum	mangemange - abundant on ridge sites and flanks in mature and regenerating forest throughout, often forming dense tangles.	166589, 168363

Paesia scaberula	abundant in disturbed sites throughout, on clay banks, road cuttings, slip sites and under manuka shrubland.	168967
Pellaea rotundifolia s.s.	local -frequent on steep exposed bluffs west of lower Te Harua Stream and another small population found on shaded rock banks near major falls on Te Rereatuoro Stream.	170169, AKU 21899
Phymatosorus diversifolius (Willd.) Pic. Ser.	abundant epiphyte on trees and occasionally terrestrial in mature and regenerating forest throughout.	168943
P. scandens (Forst.f) Pic. Ser.	common epiphyte in gullies, shaded sites and alluvial terraces in mature forest throughout.	166654
Pneumatopteris pennigera (Forst.f.) Holttum	abundant in gullies and moist sites in mature and regenerating forest throughout, often forming trunks more than 1.5m tall.	168045
Polystichum richardii	local and uncommon. Mostly on dry, very well drained banks under mature forest, above streams or off razor-back ridges, e.g. lower Waipapa River, lower Waihoanga Stream, upper Mangakino gorge, Pukatea Ridge, near the falls on Merumeru and Te Rereatuoro Streams.	166586
Pteridium esculentum (Forst.f.) Cockayne	rahurahu, bracken -abundant in early seral communities in the head of the Waipapa River and around disturbed sites e.g. logging roads. Occasional on slips in mature forest and on steep, well-lit bluffs, e.g. west of Te Hurua Stream.	168934
Pteris macilenta A.rich	locally common on steep, well-drained banks under mature hardwood forest in broad-draining valleys especially the lower reaches of Pukatea Stream, Fklavell's Creek, Te Rereatuoro Stream and Waipapa River, below 300m asl.	169728, 170140
P. saxatilis Carse	locally moderately common on steep well-drained banks above the alluvial terraces of the Waipapa River, below 100m asl. Found also near the falls in Te Rereatuoro Stream (c. 250m asl).	170019, 170047, 170199
P. tremula	uncommon, although scattered throughout the forest, usually on well-drained banks at lower altitude where there has been some disturbance, or on banks above alluvial terraces in the lower part of the Waipapa River.	168182
Pyrrosia eleagnifolia (Bory) Hovenkamp	common epiphyte in tree crowns throughout. Grows terrestrially on exposed rock outcrops.	166123
Rumohra adiantiformis	epiphytic particularly in tree ferns. Found in mature forest throughout, but abundant on the damp plateau of the southern massif.	166108
Schizaea bifida	very rare and local - a small population growing under a low sparse manuka cover on skeletal fractured rock substrate with uncommon S. fistulosa in logged forest on Bramley's Ridge north of the Waikape Stream.	166074

S. dichotoma	locally common, but almost restricted to sites under kauri canopy (both pole and mature) usually in the deepest kauri litter.	166568, 168367
S. fistulosa	locally common but found only in seral communities in the gumland community and under manuka shrublands in the eastern part of the forest.	166141, 170063
Sticherus cunninghamii	waewae kotuku - locally common but apparently restricted to skeletal soils, especially on dry ridges (e.g. under kauri) in mature and regenerating forest throughout.	166616
S. flabellatus (R. Br.) H. St. John	rare on skeletal soils in open sites on Onekura Bluff and near the Waipapa River. Also on logging road cuttings.	164795, 168-011, 168012, AKU 21906
Trichomanes elongatum	locally common, usually on shaded banks of lower ridge flanks and stream banks in mature forest throughout.	165033
T. endlicherianum	common on dark shaded rock faces, usually near streams and also a common epiphyte on nikau in the bottoms of gullies of mature forest throughout.	164785, 166130
T. strictum	rare and local - few populations are known, all above 300m asl in damp sites usually on rotting wood. Chiefly in the Takapau Kauri Stand on Pukatea Ridge.	165032
T. venosum	common epiphyte on tree ferns, particularly on wheki, in moist gully bottoms in mature and regenerating forest.	166515, 168377
GYMNOSPERMS:	*** = adventive species**	
Agathis australis	kauri - abundant to form the predominant canopy. Mature stands occur mainly on the crests of the axial ridge systems above side streams of the Waipapa River, particularly on either side of its central reaches between Canadian's Creek and Pukatea Stream. In the headwaters of both the Waipapa and Mangapapa Rivers some substantial stands have survived logging. Some poorly drained plateaux e.g. Onekura Bluff and Takapau area support large mature stands. The Takapau Stand contains three of the largest kauri known. With the notable exceptions of stands north of the Opaopao Stream, east of Te Harua Stream, and north of Waihoanga Stream, kauri stands are rare in the southern portion of the forest. On the high altitude southern massif there are few kauri - mostly scattered stands or individuals. Pole stands are scattered throught the forest on similar sites - some are regenerating after historic clearance, others after natural disasters. Some kauri has been planted in the north and east of the forest in regenerating forest communities, where locally natural regeneration is common.	167890
*Cryptomeria japonica**	Japanese cypress - planted around Headquarters and locally in regenerating forest along Mokau Ridge.	

Dacrycarpus dacrydioides	kahikatea -scattered trees sometimes very large, occur throughout, in damp sites and gullies but it seldom forms a major canopy component except on alluvial terraces in the central reaches of the Waipapa River near Camp Creek, where it is codominant with matai.	170050
Dacrydium cupressinum	rimu -common throughout the forest in both mature and regenerating forest. Most commonly on gully sites and gully heads, but also on ridges and sometimes in kauri stands. Some individuals are very large, and in a few sites e.g. north of Pukatea Stream there arepodocarp- dominant sites where rimu is predominant.	166590
Halocarpus kirkii (Parl) Quinn	manoao - virtually restricted to kauri and stands on ridges, both mature and regenerating stands. Mature trees are fairly rare. Saplings are most common and are found mainly in pole stands and in regenerating communities where manoao appears to be an early species. In open sites, juvenile foliage gives way readily to adult foliage on saplings. Major areas of manoao are in the upper Waikape basin, upper Merumeru basin, Onekura Stand. Takapau Stand and north of Waihoanga Stream. It is rare below 300m asl.	168137
Lagarostrobos colensoi (Hook.) Quinn	silver pine - rare and local. The distribution of silver pine is similar to that of manoao in mature forest - mostly in kauri-dominated stands above 300m asl. It is rare in seral vegetation. It is most common in stands with apparently high water tables e.g. Onekura and Takapau Stands. Low stature trees to 8m are very rare; more frequently seedlings or striplings are found.	166608, 167633
Libocedrus plumosa	kawaka -uncommon throughout the forest in both mature and regenerating forest. It usually occurs on ridge top sites and usually as single trees or small groves of trees. Saplings are more common than adults.	167859
Phyllocladus glaucus	toatoa - local and uncommon in the forest. Apparently confined to skeletal soils of low fertility on either poorly drained sites (e.g. adjoining near the headwaters of Puruwharawhara Stream, and in the Takapau Stand) or in extremely well-drained sites (e.g. the top of Onekura Bluff, ridges above the major falls on the Waikape Stream).	167896
P. trichomanoides	tanekaha - common throughout the forest except on wet sites (especially the southern massif) in both mature and regenerating forest. Similar in distribution to kauri, it is abundant in early succession communities back onto kauri forest associations. It persists into mature forest, occasionally as large trees, but it is seldom common on ridge sites and is rare in kauri stands with high watertables.	167874

*Pinus eliiottii**	slash pine - rare and local planted south of Forest Headquarters with *P. taeda*, formerly more extensive but now only a few trees.	
P. nigra var *laricio**	Corsican pine -a stand of these trees was planted south of Forest Headquarters in 1948. They have been badly affected by the needle blight *Dothistroma pini*	
*P. patula**	a small stand of these trees at Forest Headquarters is what remains of a formerly more extensive plantation of this species.	
*P. radiata**	radiata pine. This is the most extensively grown *Pinus* species in the forest. Two plantations exist - one is east of headquarters, which is replanted on a site previously in *P. patula, P. elliottii* and *P. taeda*, and, prior to that, in dry gumland vegetation. The other is south of Headquarters in a headwater catchment of Puketotara Stream on a site formerly in early seral community and regenerating forest. Some young trees occur in manuka south of Forest Headquarters. Control and monitoring of the spread of this weed species into seral communities is desirable.	
*P. taeda**	loblolly pine - a few trees south of Forest Headquarters planted with slashpine. Formerly more extensive.	
Podocarpus hallii	Hall's totara - locally abundant throughout the forest in both mature and regenerating communities, except in the highest parts of the forest. It is mainly on well-drained ridges and ridge flanks, where it often forms the dominant canopy species, or is subdominant to kauri.	167986, 168176
P. totara s.s.	totara - local and uncommon - confined principally to fertile sites e.g. alluvial terraces and river fans, mostly at low altitude. Very few large trees are known.	170056
Prumnopitys ferrunginea (D. Don) de Laubenfels	miro - common throughout the forest at all altitudes in both mature and regenerating communities. It occurs on a wide range of sites from alluvial terraces to high altitude podocarp/hardwood forest of the southern massif to dry ridge systems with kauri.	170039
P. taxifolia	matai - local and uncommon. It occurs primarily as saplings and occasionally trees on the lower part of ridge systems. It is most common on the alluvial terraces of the Waipapa River, and on one broad terrace near Camp Creek it forms a canopy co-dominant with kahikatea.	166607, 168008
DICOTYLEDONS	*** = adevtive species**	
Acaena anserinifolia	piripiri -common in disturbed and drained well-lit sites in the forest, particularly road cuttings where it is locally abundant.	133733, 167885

Ackama rosifolia A. Cunn	makamaka - most common in gullies and alluvial at lower altitude (below 350m asl) as a subcanopy tree. At higher altitudes (especially on the southern massif) it forms a canopy with towai. It occurs mostly in mature communities, although it is common alongside roads in mature forest.	168056
*Ageratina adenophora**	Mexican devil - locally common, though not as common as mist flower. Mostly as scattered individuals on well-lit moderately drained sites, seldom forming dense colonies. Often associated with mist-flower on margin of roads, e.g. Forest Road and Mokau Ridge Road.	133056
*A. riparia**	mist flower. Locally abundant. Most abundant along the hanks of the Waipapa River south of the confluence with the Mangapapa River and along the Waihoanga Stream . Common along logging roads, especially the Mokau Ridge. This is the most aggressive weed species in Puketi Forest; it to have greatly increased in range since Sexton's 1939 report. What is most alarming is its ability to colonise unmodified forest aggressively, especially well-lit areas e.g. river banks and faces around waterfalls e.g. Merumeru Falls, Flavell's Creek Falls, and bluffs in the Te Harua Stream catchment, where it rapidly becomes the dominant species out native ground cover species, including rare plants e.g. *Pratia physaloides.* It also extends far up many side creeks, in some instances colonising under mature forest canopy, and displaces the native vegetation of these unmodified sites. Some remedial work may be necessary to attempt to remove this weed from some areas.	133541, 133550
Alectryon excelsus	titoki - locally moderately mostly below 250m asl. It is common on well-drained, well-lit sites e.g. around waterfalls (Merumeru Falls and Te Rereatuoro Falls) and also on alluvial terraces of the Waipapa River.	168924
Alseuosmia banksii (incl. *A. banksii* A. Cunn var. *banksii* and *A. banksii* A. Cunn var *linariifolia* (A. Cunn.) Gardner	locally common layered shrub, mostly in well-drained gully heads under mature podocarp/hardwood canopy. Most common below 350m asl - rare at the highest altitude moist sites. This species exhibits a very wide range of leaf morphology, and the distinction between this species and the hybrid *A. x. quercifolia* was often quite arbitrary.	168968
A. macrophylla	toropapa - very common shrub on ridges and ridge flanks under mature podocarp/hardwood and kauri canopies, but also on the high altitude southern massif. Widespread in the Forest, although less common in regenerating forest communities.	133472, 168172, 168353
A. banksii X.A. Macrophylla (A.X. quercifolia)	locally common layered shrub, mostly in well-drained gully heads under podocarp/hardwood canopy, but also common (especially linear-leaved forms) under kauri canopy. Rare at high altitude and in regenerating forest. The hybrid exhibits an extremely wide range of leaf morphology from small-leaved forms similar to *A. banksii* to others similar in appearance to *Mida salicifolia* and some even to *Lophomyrtus bullata*.	164796, 166132, 168351

_Alternathera sessilis_*	nahui - rare and local. A few plants growing amidst rank weed growth on a poorly drained road margin on river terraces of the Waipapa River near the southern boundary of the forest.	170111
_Anagallis arvensis_*	scarlet pimpernel - occasional weed in pasture at Forest Headquarters and at Forest Road, and along banks of the lower reaches of the Waipapa River, and on bluffs west of lower Te Harua Stream.	
Anaphalis keriense (Cunn.) C. Webb	locally common. On steep rock banks of main river systems and some side creeks (e.g. Pukatea Stream, Waihoanga Stream, Waikape Stream, Mangakino Stream) which are periodically swept by floodwaters.	169744
Aristotelia serrata	makomako, wineberry - common in gully bottoms and moist sites throughout. It is usually indicative of disturbance, e.g. windthrow, slips and it thrives at the margins of logging roads.	167870, 169758
Ascarina lucida	hutu – Rawlings (1974) recorded this shrub in Puketi Forest and observed it flowering. None were found in the course of the present study.	
_Aster subulatus_*	sea aster - very rare and local. A few plants next to the old road formation above the Waipapa River at Forest Road.	170490
Australina pusilla	rare and local - small populations known from steep rocky banks under dense mature canopy north of lower Waihoanga Stream and another small population known from a small, shaded rock face near a small stream south of Pukatea Stream.	169738, AKU 21889
Beilshmiedia tarairi	taraire - abundant throughout mature forest, principally on ridge flanks and in gullies. It is rare on dry ridge systems and it is rare under kauri canopy. It is less common at the highest altitudes of the forest, hut at low altitudes, particularly along the river of the Waipapa and Mangapapa Rivers, it is the predominant canopy tree.	168035
B. tawa	tawa - common throughout mature forest, though only rarely the dominant canopy tree. It is relatively less common on the southern massif. It mostly on ridge flanks and is rare in gullies. It is common under some kauri canopies, sometimes as the predominant sub-canopy tree.	168037
_Bellis perennis_*	daisy. Recorded by E.B. Bangerter 1973 as common along the margin of the now overgrown track from Puketi Road to Pirau Ridge, growing with sweet vernal, turf speed well and _Ranunculus_ spp. Not located in the present survey.	170421

*Bidens pilosa**	cobblers' pegs - rare amongst mist flower on terraces of the Waipapa River near the southern boundary of the forest.	
Brachyglottis myrianthos (Cheesm.) Drury	rare and local. On a side ridge west of Camp Creek south of Mokau Ridge. Covering only a small area (c. 0.5 ha) on the ridge top under northern rata/tawa/mangaeo canopy.	165028
B. repanda	rangiora - common shrub pre-dominantly below 400m, mostly on ridge flanks. Common in both seral communities and mature forest, and in recently logged areas.	168942
B. sp. *(Senecio kirkii* Hook. f. var. *anguistor* Allan)	Kirk's daisy - locally abundant in mature forest, primarily on dry ridges and ridge flanks in the dissected country in the middle of the forest, under podocarp and kauri canopies. Common along the margins of logging roads in mature forest. Uncommon in regenerating forest and in hardwood-dominated forest at low and high altitude.	168368, 170482
Callitriche muelleri	common throughout in poorly drained sites where surface water often accumulates, especially tracks and old clay road surfaces.	165052
*C. stagnalis**	locally common, especially on the poorly drained old road formation extending from Forest Road along the alluvial terrace of the Waipapa River. Elsewhere floating in small ponds.	130977, 133505
Calystegia tuguriorum	rare and local - scrambling over mist flower on alluvial terraces above the Waipapa River at Forest Road.	170208
Cardamine sp. (*C. deblis* agg.)	rare on margin of Forest Road on the bank of the Waipapa River.	176148
Carmichaelia aligera	common on river margins, especially on the banks of the Waipapa and Mangapapa Rivers, but also in the broader reaches of the major side creeks. Rare on dry ridges at low altitude in mature forest.	168005
Carpodetus serratus	putaputaweta - common only on alluvial terraces and river margins, mainly in the main river systems but also in the lower reaches of major side creeks. Rare elsewhere in the forest, mostly in poorly drained sites e.g. near the headwaters of the Puruwharawhara Stream.	168135
Cassnia leptophylla	recorded by Sexton (1939) from “manuka heathland on outskirts - not common." It is possible that this habitat has disappeared since 1939 with conversion to pine plantation. Not recorded in this survey.	
*Centaurium erythraea**	centaury- locally common along dry clay logging road margins and under manuka communities in well-lit, well-drained sites.	170134

Centella uniflora	common herb in well-lit sites in early seral communities and disturbed sites, e.g. slips and logging roads.	170136
Cerastium fontanum subsp. *vulgare**	mouse-ear chickweed. Recorded by E.B. Bangerter in 1973 as occasional along the margins of the Mokau Ridge track, which has since been made a road. Not located in the present survey.	133544
*C. glomeratum**	annual mouse-ear chickweed - occasional in pasture at Forest Headquarters and at Forest Road above Waipapa River.	
*Chenopodium ambrosioides**	Mexican tea - rare. On gravel banks of the Mangapapa River near its confluence with the Waipapa River.	170203
*Ciclospermum leptophyllum**	rare and local - rowing in a poorly drained road margin on the terraces of the Waipapa River near Forest Road.	170114
*Cirsium vulgare**	Scotch thistle – scattered throughout the forest on disturbed sites, e.g. slips, roadside cuttings.	133542
Clematis cunninghammii Tercz	common on well-drained steep banks, e.g. gorges of streams and in gully heads, mostly below 300m. Seldom of large size.	165182
C. paniculata	puawhananga -common in mature forest and regenerating communities throughout. Most common in well-lit areas and forest margins, especially near logging roads.	168927
*Conyza albida**	broad-leaved fleabane - common throughout the forest in well-drained sites, e.g. slips and roadsides.	
Coprosma arborea	mamangi - locally common subcanopy tree or shrub, mostly near ridge systems, especially under Hall's totara. Also frequent in regenerating communities.	167643
C. areolata	rare - mostly in well-lit moist sites near forest margins, e.g. on alluvial terraces and it is common in regenerating forest at the head of Puketotara Stream.	166113
C. crassifolia	very rare and local. Only two small shrubs found on the lower part of the ridge north of Opaopao Stream under karaka-taraire-puriri-nikau canopy.	168025
C. grandifolia Hook. f.	raurekau, kanono - abundant subcanopy shrub in mature and regenerating communities throughout, mostly in gullies and ridge sites, and seldom on dry ridge sites.	168960
C. lucida	karamu - common low shrub in mature and regenerating communities throughout, mainly on ridge systems, including on dry ridges under kauri. Rare at high altitude sites.	166618
C. parvifolia s.s.	occasional shrub in a variety of sites in mature forest through out, mostly under podocarp/hardwood canopy.	165787

C. rhamnoides	common subcanopy shrub in most communities in both seral and mature forest throughout.	165801, 167588, 170069
C. rigida	recorded by Sexton (1939) as "local, Onekura", presumably near the stream. The species was not located in the present survey.	
C. robusta	karamu - characteristic of seral communities in which it is common and also of disturbed sites, e.g. logging road margins and slips, where it is locally common.	169746
C. rotundifolia	rare and local. A few subcanopy shrubs under taraire, karaka and puriri on alluvial terraces of the Waipapa River in its lower reaches near Forest Road.	175910
C. spathulata subsp. *spathulata*	common low subcanopy shrub mostly on ridge tops and drained sites in mature forest, mostly below 350m asl.	168029
C. tenuicaulis	local. Restricted to very poorly drained sites, in which it is locally common, both in mature and regenerating forest, e.g. at seepage sites in stream headwaters, near river banks and beside a pond near the headwaters of Waipapaiti Stream.	166619, 1666511, 169748, 170026
C. propinqua subsp. *propinqua X C. robusta (C. X cunninghamii)*	locally common only on flood-washed banks of the main rivers and broad reaches of side creeks. Elsewhere rare, mainly in seral forest communities at low altitude.	168007, 168157
Coriaria arborea	tutu - common only in disturbed sites throughout the forest, both in mature forest and seral communities, e.g. slips, logging road margins and the banks of rivers and side creeks.	168945
Coriaria buddleioides	kiokio - local. Common only on extremely dry ridge sites (especially along the top of the Onekura Bluff, west of Onekura Stream) and on podsolised soils under mature kauri forest.	166131, 168057
Corynocarpus laevigatus	karaka - locally common canopy tree, mostly below 100m asl, where, particularly near the Waipapa River in its lower reaches, it is a major canopy component. Above this altitude it is rare, although scattered individuals, especially seedlings, are found in mature forest through-out.	168033
*Crepis capillaris**	hawksbeard - moderately common in rank pasture alongside old logging roads on reasonably well-drained sites.	
Cyathodes juniperina	mingimingi - rare and local - restricted to extremely dry ridges, usually under either mature or regenerating kauri stands (e.g. north of Opaopao Stream, Pukatea Ridge), and mostly below 200 m asl.	166572, 168019
*Daucus carota**	wild carrot -locally common in rank pasture on river terraces above the Waipapa River at the end of Forest Road.	170121

*Digitalis pupurea**	foxglove -locally common on well-lit margins of drained logging roads (e.g. east and west of Onekura Stream).	
Dodonaea viscosa	akeake common on bluffs west of Te Harua Stream, and very rare on well-lit dry clay banks above the Te Rereatuoro Falls and on Pukatea Ridge.	169745 AKU 21901
Dracophyllum latifolium	neinei – common in mature forest throughout, primarily on ridge systems, particularly under kauri and/or Hall's totara but also at higher altitudes.	168036
D. lessonianum	locally common in seral communities in the east of the forest with manuka, kanuka and towai, where it can a canopy up to 5m. It usually occurs on podsolised soils, on sites probably previously occupied by kauri. It is common on thefringes of the gumland association near Forest Headquarters.	169733
D. sp.	very restricted in range. Two populations are known, both on kauri soils. The smaller population is in the Takapau Stand on Pukatea Ridge, and the major population is in the Onekura Stand west of Onekura Stream, especially along the top of the Onekura Bluff where it is common.	165041, 167-629, 168572, 170052
Drosera binata	rare on well-lit bare clay seepage points on acid podsol soils e.g. on road cuttings and in the gumland association near Forest Headquarters.	169751
D. peltata Thunb. subsp. *auriculata* (Backh. Et Planch.) Conn	on bare clay sites or under very light manuka canopy in early communities, mostly in the eastern part of the forest.	168557
*Duchesnea indica**	Indian strawberry -rare in damp shaded seepage sites in disturbed areas,e.g. around the headwaters of the Waipapa River.	
Dysoxylum spectablie	kohekohe - abundant canopy tree in mature forest, mostly in gullies and on ridge flanks. It is less common on high altitude massif and is rare on dry ridge sites under kauri. It is relatively uncommon in early seral communities.	170117
Eleaocarpus dentatus	hinau - common tree throughout the forest in both mature and regenerating communities at all altitudes. It occurs primarily on ridge systems; including under kauri canopy.	167899
E. hookerianus	pokaka -recorded by C.C. Ogle (unpublished list, 1979) from the upper Waipapa catchment (C.C. Ogle pers. comm.). Not found in the present survey.	
Elatostema rugosum	parataniwha - locally abundant in damp sites near stream courses throughout the forest, usually in side creeks and less common on banks of rivers. It is locally abundant, clothing valley floors and faces around canyons and waterfalls. In some sites it can reach a height of 2.5m.	168014

Entelea arborescens	whau - local and uncommon. Only below 100m asl along alluvial terraces of the lower reaches of the Waipapa and Mangapapa River, and extending into the lower reaches of some side creeks (e.g. Opaopao, Te Rereaturoro, Pukatea). Rare tree in forest at the south-ern lowest end of Puketi.	168963
Epacris pauciflora	rare and local. Restricted to the gumland near Forest Headquarters on poorly-drained acid podsol soils amongst *Gleichenia dicarpa, Baumea rubiginosa* and *Shoenus brevifolius.*	166116
*Epilobium ciliatum**	rare and local - a few plants growing on seepage sites on river banks in the lower reaches of the Waipapa River.	
E. nerteroides	locally common over rocks and rock banks in the beds of the main river systems, and, to a lesser extent in the side streams. (e.g. Mangakino, Onekura, Waikape, Pukatea Streams).	169722
E. rotundifolium	local and quite rare, on seepage sites, clay banks and gravel margins of some streams, e.g. Canadian's Creek, Te Rereatuoro Stream.	170112, 170201
*Erechtites valerianifolia**	Brazilian fireweed - rare and local. Only a few plants known on well-lit, well-drained logging road margins on Bramley's and Totara ridges above Canadian's Creek.	
*Erica lusitanica**	Spanish heath - locally common in early seral communities in the east of the forest, especially under manuka on dry clay podsolised ridges.	133779, 170037
Fuchsia excorticata	kotukutuku fairly common throughout mature forest, particularly in poorly drained sites, stream sides and gully bottoms. It is common alongside logging roads, especially Mokau Ridge at the forest margin. Possum browse was noted on many individuals and a few had killed.	168940
Galium divericatum	Te Harua Stream	AKU 21902
G. propinqua	scattered and uncommon in poorly drained fertile sites throughout the forest e.g. next to stream and river courses and on logging roads.	166139, 170195
Gaultheria antipoda	rare and local -mostly in exposed dry sunny sites e.g. on Onekura Bluff and in early manuka communities in the east of the forest.	166143, 168030
Geniostoma rupestre J.R. et G. Forst var. *ligustrifolium* (Cunn.) Conn	hangehange -abundant low in mature and regenerating forest, and common alongside old logging roads. Most common under podocarp/hardwood canopy from alluvial to ridge tops. Less common on the high altitude southern massif and rare under kauri canopy.	168156

*Geranium homeanum**	rare and local -trailing from dry rock banks above alluvial terraces of the Waipapa River near Forest Road.	170174
*G. retrorsum**	rare and local - struggling through rank weed growth at the margin of Forest Road on alluvial terraces of the Waipapa River.	
*G. robertianum**	recorded by E.B. Bangerter in 1973 in one locality on the Mokau Ridge track, which has since been made a formed road. Recorded from "around the base of *Rubus* and *Pteridium* in grassland by track". Not recorded in this present survey.	133476
*Gnaphalium calviceps**	rare - on gravel banks of the lower reaches of the Waipapa River.	170204
*G. coarctum**	purple cudweed - common along clay road margins and well-lit disturbed sites throughout the forest.	
G. gymnocephalum	locally common - around well-lit disturbed sites throughout the forest, especially in rank weed growth about the sides of logging roads. Occasional on slip sites and rare on stream banks.	167873, 170128
G. involucratum	rare and local - amongst rank weed growth on the well-drained sunny road margin of Pirau Ridge logging road.	164926
*G. simplicicaule**	recorded by E.B. Bangerter in 1973 as occasional on the Pirau Ridge logging road "in mud along the track with *Juncus* spp.". Not recorded in the present survey.	133501
*G. sphaericum**	Japanese cudweed- rare and local- colonising gravel surfaces in a quarry on Mokau Ridge.	170058
Gonocarpus incanus (A Cunn.) Orchard	fairly common on very well-drained clay soils of well-lit sites, particularly in the logged eastern part of the forest, and sometimes under light manuka canopy.	166146
G. micranthus Thunb. subsp. *micranthus*	common on poorly drained well-lit soils, especially on old logging roads, with *Juncus* spp.	167857
Gratiola sexdentata	rare and local - in poorly drained well-lit areas on Mokau Ridge in light wells on the Mangahorehore Track, and on overgrown logging roads to Onekura and to Mangahorehore.	166107, 168347
Griselinia lucida	puka - very common liane and epiphyte throughout mature forest, in gullies and on ridges and at all altitudes. Occasionally terrestrial on clay banks, and especially on bluffs e.g. Onekura and Mangahorehore Bluffs.	168933
Gunnera monoica	fairly common on rock banks, particularly those near seepage points, which are periodically swept by flods, only in Mangakino Stream and the Mangapapa and Waipapa Rivers.	167653, 170031

*Hakea salicifolia**	locally fairly common on dry clay soils in early seral communities with manuka in the eastern logged part of the forest. Does not appear to be a very aggressive weed species.	
H. sericea	locally fairly common in similar sites to *H. salicifolia* and of similar distribution. It sdoes seem to spread in mature forest to some extent, e.g. small colonies were found on a ridge north of the main Waikape Falls and on ridges west of Te Harua Stream. Eradication of these populations is desirable.	
Haloragis erecta var. *erecta*	local and uncommon. Around disturbed sites, mostly in or near mature forest, e.g. bordering slips and logging roads, usually in damp parts of the forest.	
Hebe acutiflora	Locally common. On steep rock banks lining the Waipapa and Mangapapa Rivers, which are swept periodically by floodwaters. In no cases does it occur in any side catchments of these rivers, even by a matter of metres. The Puketi population, along with a much smaller one around the Kerikeri Falls some 15km away, is the entire population known. The population on the banks of the Kerikeri River is now extremely small and is severly threatened by the encroachment of invasive weeds. The large degree of modification of the Kerikeri River catchment and the lack of a large forest buffer, such as occurs in the Waipapa River catchment, around the population threatens the long-term viability of the population there. It is classed as a 'vulnerable' species. Although first recorded in the Forest by Sexton (1939), the first widely reported records of the species were in the late 1970's. Its distribution in the forest suggests periodic flooding may be essential to its survival. The Puketi population numbers several thousand from about Canadian's Creek downstream in the Waipapa River, and format least Mangakino River to the southern boundary of the forest at Forest Road. The major threat to the species is the apparent spread of mist flower up the banks of these rivers which may smother it.	164797, 170028, 170049
H. macrocarpa var. local	a substantial population exists on steep bluffs of Te Harua Stream in well-lit sites. A smaller population exists on steep, well-drained parts of Pukatea Ridge.	AKU 21897
H. stricta var. *stricta*	koromiko – moderately common in well-lit sites e.g. stream margins, exposed ridge-top sites and on steep sunny banks throughout.	168003

Hedycarya arborea	porokaiwhiri, pigeonwood - common subcanopy tree in both mature and regenerating forest, primarily in gullies and on ridge flanks throughout the forest.	168138
Helichrysum aggregatum var. *aggregatum* Yeo	local - common over steep bluffs around lower Te Harua Stream and on sunny exposed steep slopes around the Merumeru Falls about which it is common.	166597
H. lanceolatum	near Te Harua Stream.	AKU 21905
Hoheria populnea var. *populnea*	houhere, lacebark - common in mature forest, in gullies and alluvial terraces of streams and rivers. Uncommon in regenerating forest.	167886
Hydrangea macrophylla	rare and local - a few plants wild in shrubland near forest Headquarters.	
Hydrocotyle dissecta	common in disturbed areas mostly seepage sites, especially on damp, overgrowing logging roads.	166566, 169724
H. elongata	under mature forest, mainly on poorly drained sites on alluvial terraces. Also uncommon in disturbed sites and regenerating forest at seepage points.	166567, 167596
H. heteromeria Col.	recorded in an unpublished list by Rawlings (c.1972) with no locality mentioned. Not recorded in the present survey.	
H. moschata	uncommon in disturbed poorly-drained sites in regenerating areas (e.g. on clay road surfaces). Rare in disturbed sites in mature forest, and at river margins.	169719, 170033, 170053
H. sp. (*H. novae-zeelandiae* DC agg).	rare and local - one small population known from a rock bank on the lower Waipapa River.	170022
*Hypericum androsaemum**	tutsan - rare and local -a few plants scattered among mist flower on steep bluffs west of Te Harua Stream	AKU 21900
*H. japonicum**	occasional in well-lit damp disturbed areas, e.g. overgrowing logging roads, primarily in regenerating forest.	164913
*H. mutilum**	rare and local - known only from a damp overgrowing logging road south of Pirau Ridge east of Pukatea Stream.	167607
*Hypochaeris radicata**	catsear - common throughout on disturbed sites in full-light which are well-drained e.g. slips, clay roads, manuka communities and also on rock surfaces e.g. rock banks in streams and around waterfalls.	
Ileostylus micranthus (Hook f.) Tiegh.	mistletoe - rare throughout mature forest, parasitic in the crowns of Hall's totara	AKU 14939
Ixerba brexioides	tawari -locally common in kauri stands above 250m asl both on dry ridges e.g. around Merumeru Falls and the upper Waikape Basin but also in stands with high water tables, e.g. Takapau and Onekura Stands. It is very rare away from kauri-dominated sites in mature forest, and is rare in regenerating forest.	165183

Knightia excelsa	rewarewa - common throughout the forest in both mature and regenerating communities from gully bottoms to ridge tops, although it is uncommon on kauri-dominated sites.	170006
Kunzea ericoides (A Rich.) J. Thompson var. *ericoides*	kanuka-common in seral communities throughout, especially in previously logged areas in the east of the forest, where, with towai it forms a dominant canopy, replacing a manuka community. It occurs mostly on dry ridge sites, e.g. those previously occupied by kauri. In selectively logged areas and in sites of hurricane damage in mature forest, it appears to be the first tree to these sites. Large individuals persist as mature forest develops around them.	169749
Lagenifera pumila	locally common on rock banks, especially around in Pukatea Stream and in Flavell's Creek. Uncommon on similar sites in the Waipapa River.	167896, 168354
Laurelia novaezelandiae	pukatea - common throughout mature forest on poorly drained sites, especially stream headwaters, broad gully bottoms and alluvial terraces. Some individuals are extremely large.	167896, 168354
*Leontodon taraxacoides**	hawkbit - rare on rocks in the bed of the Waipapa River.	
Leptospermum scoparium	manuka - locally abundant, but only in the most disturbed sites, where it is the main component of early seral communities, especially in the east of the forest and on the plateau east of Collin's Creek. It is common on dry clay ridges, but it is also common in poorly drained areas e.g. near Waiare Road and in the gumland association near Forest Headquarters. It very rarely persists in mature forest, mainly near slip sites and stream beds.	167901
*Leucanthemum vulgare**	oxeye daisy - occasional in rank growth over old logging roads e.g. south of Pirau Ridge east of Pukatea Stream.	
*Leycesteria formosa**	Himalayan honeysuckle - rare and local - a few plants on the margin of the logging road on Bramley's Ridge, and on an old slip above the lower Waihoanga River.	
Litsea calicaris	mangeao - uncommon throughout mature forest, mainly on ridge sites, where it is occasionally a major canopy constituent of podocarp/hardwood communities. It is also frequent as stunted trees in kauri associations.	168932
Lobelia anceps	occasional in disturbed sites e.g. trailing through rank weed growth at the margins of logging roads and tracks.	167868, 170137
*Lonicera japonica**	Japanese honeysuckle - rare and local -trailing over clay banks at the start of the nature trail at Forest Headquarters.	

Lophomyrtus bullata	ramarama - fairly common throughout mature forest under podocarp/hardwood canopies, particularly in gully heads and on alluvial terraces.	168175
*Lotus pedunculatus**	locally common in rank weed growth at the margins of logging roads and tracks.	
*L. suaveolens**	rare in rank weed growth at the margin of the Pirau Ridge road near Bramley's Ridge.	
*Ludwigia palustris**	locally common on poorly drained overgrowing logging roads and on seepage points on gravel banks near some streams, e.g. the outlet of Te Rereatuoro Stream.	
L. peploides subsp. *montevidensis*	occasional on poorly drained, over-growing logging roads, e.g. Bramley's Ridge.	
*Lythrum hyssopifolia**	loosestrife - occasional at the margins of pasture around Forest Headquarters and at Forest Road.	
Macropiper excelsum f. *excelsum*	kawakawa -mainly in gullies under podocarp/hardwood canopy in mature forest throughout, but common only below 100m asl and rare above this altitude. Particularly common in forest near the southern boundary at Forest Road and on alluvial terraces of the lower reaches of the river systems.	168022
Melicope simplex	poataniwha - occasional in mature forest throughout, usually on ridge flanks and gully heads as small groves of low stature trees.	168043
M. ternata	wharangi -local. Frequent on bluffs west of lower Te Harua Stream and very rare on alluvial terraces of the Waipapa River south of the confluence of Pukatea Stream.	168021 AKU 21896
Melicytus macrophyllus	common throughout mature and regenerating forest usually on ridge flanks and ridge tops other than those dominated by kauri. Uncommon on the southern massif.	166629
M. micranthus	local and uncommon, usually in small groves in mature podocarp/hardwood forest away from kauri- dominated areas, particularly at the northernmost and southernmost parts of the forest.	170147
M. ramiflorus subsp. *ramiflorus*	mahoe - common throughout mature and regenerating forest usually in gully bottoms, on alluvial terraces, and in moist areas (e.g. the southern massif).	167903
Mentha X piperita var.*	peppermint. Rare and local. A few plants growing in a ditch at the margins of the old road formation on the banks of the Waipapa River north of Forest Road.	170478
*Mentha pulegium**	pennyroyal - rare and local - on damp overgrowing logging roads on Mokau ridge.	

Metrosideros albiflora	locally abundant liane almost restricted to mature kauri stands where it commonly forms dense low thickets. Very rare elsewhere in mature forest, although it occurs occasionally on the high altitude southern massif. Very rare in regenerating forest.	168009, 168371
M. carminea	locally common in mature forest, most commonly below 400m asl. Usually on shaded rock faces near stream courses, where it maintains juvenile form to coat these sites. It very rarely becomes scandent to reach tree crowns, adopts adult foliage and flowers.	166605, 168018, 168941
M. diffusa	common liane throughout mature forest, mostly on gully and ridge flank sites and seldom on ridge tops. It occurs at all altitudes of the forest and is common on the southern massif.	166469
M. fulgens	common liane throughout mature and regenerating forest, mostly on ridge flanks and ridge tops. It flourishes in well-lit sites, especially forest margins.	166470
M. perforata	very common liane throughout mature forest, and less common regenerating forest. Occupies a wide range of sites and altitudes, but is most abundant in well-lit ridge top sites.	167644
M. robusta	northern rata - common liane and tall forest tree in mature forest throughout though it is uncommon on the southern massif. Occurs most commonly on ridges and ridge flanks, but also in gullies -usually commencing life as an epiphyte in the crowns of tall podocarps or pukatea. Some trees of the species are very large. Occasionally grows as trees from arid sites, e.g. dry ridge crests and rock bluffs. Some possum browse was noted on some trees, particularly on solitary trees remaining after logging.	168346, 168356, 170122
Mida salicifolia	maire - common subcanopy tree in mature forest throughout, except on the southern massif and at the lowest altitude sites. Common under kauri canopy and near rimu in gully sites - it appears to be a root parasite of kauri, tanekaha and rimu. It is frequently browsed by possums - some trees were defoliated and some apparently killed as a result of browse.	166577, 168167, 168941
Muehlenbeckia australis	uncommon liane in mature forest, usually in moist gully sites at higher altitudes in the forest.	168066
Myosotis laxa subsp. *caespitosa**	water forget-me-not. Rare at seepage pints in gravel banks on the main river systems and the lower reaches of some side catchments.	AKU 21881
Myrsine australis	mapou - common subcanopy tree in mature and regenerating forest, primarily on ridge systems and ridge flanks, including under kauri canopy, but also in a wide variety of other sites.	
M. salicina	toro - moderately common subcanopy tree in mature	168962

	forest, mostly on ridge systems and ridge flanks, but also in a wide variety of other sides. Uncommon in regenerating forest.	
Neomyrtus pedunculata	rare subcanopy shrub on skeletal soils, usually under kauri canopy e.g. on the lower part of the ridge west of Camp Creek and in the Takapau Stand.	169727
Netera depressa	common in disturbed sites throughout the forest, e.g. on clay banks and road cuttings, and also common on rock banks on major rivers and side creeks.	168139
N. dichondrifolia s.s.	common ground cover species in mature forest throughout, in a wide variety of sites, usually in fairly moist conditions.	167352
N. setulosa	occasional ground cover in disturbed sites, e.g. under manuka and in rank weed growth covering old logging roads.	166531
Nestegis cunninghamii (Hook f.) L. Johnson	black maire - recorded by Rawlings (unpublished list, c. 1972) and by Sexton (1939) from "on ridges, not plentiful". Not located during the present survey.	
N. lanceolata (Hook f.) L. Johnson	white maire - moderately common in podocarp/hardwood forest, primarily on ridges and ridge flanks in mature forest throughout. Seldom of great size.	167640
N. montana (Hook f.) L. Johnson	local and uncommon. Occurs primarily in ridge top kauri-dominated associations, but sporadically in most other sites in mature forest as well.	167893
*Oenanthe pimpeinelloides**	parsley dropwort - rare and local in rank pasture on alluvial terraces of the Waipapa River at Forest Road.	170115
Olearia furfuracea	local. Confined to extremely well-drained ridge sites throughout the forest, e.g. north of the Waikape Falls, and on side ridges above Te Rereatuoro Stream, and on bluffs and ridges west of lower Te Harua Stream.	167897
O. rani var. *rani*	heketara - abundant in both mature and regenerating forest throughout at all altitudes, and in a wide variety of sites, although it is least common in podsolised, kauri-dominated sites.	168961
Oxalis magellanica Forst.f.	locally common on rock banks in the main rivers and also in some side catchments, e.g. Waikape Stream and Pukatea Stream.	167894
*Parentucellia viscosa**	tar weed. Uncommon in rank weed growth alongside old logging roads, e.g. Bramley's Ridge.	176377
Parsonsia capsularis var. *capsularis*	kaihua - uncommon in podocarp/hardwood forest throughout, particularly near forest margins, in both mature and regenerating communities.	164782, 164783
P. heterophylla	kaihua - recorded by Sexton (1939) as "rare on	

	outskirts". Not recorded in the present survey.	
*Passiflora caerulea**	rare and local - one liane only known from banks of the Waipapa River at Forest Road.	170032
Pennantia corymbosa	kaikomako -recorded by Sexton (1939) as "rare and local". The present survey failed to locate any.	
Peperomia urvilleana	locally common on dry shaded rock banks, especially around gorges of streams and rivers, and on the steep slopes around major waterfalls (e.g. Merumeru Falls, falls in the upper Mangakino Stream).	166598, 170048
Phebalium nudum	mairehau - locally common but almost restricted to kauri dominated sites, predominantly in mature forest, both in extremely well-drained sites and those with high water tables (e.g. Takapau Stand). It has flourished in some sites following selective logging of kauri.	165186
*Physalis peruviana**	cape gooseberry - recorded by Sexton (1939) from "slips and clearings". Not found in the present survey.	
*Phytolacca octandra**	inkweed - local and uncommon on podsolised bare clay in the head-waters of the Waipapa River north of Forest Headquarters.	
Pimelea prostrate var. *prostrata*	Strathmore weed. Recorded by Sexton (1939) from "manuka heathlands". This habitat may have disappeared since 1939; it was not located in the present survey.	
Pittosporum cornifolium	common epiphyte in mature forest throughout, particularly in tall trees, e.g. podocarps and kauri. Rarely terrestrial on extremely well-drained ridge tops.	168132
P. kirkii	rare epiphyte in mature forest in the crowns of tall trees, seldom found below 300m asl. Very rarely a terrestrial shrub.	166133
P. tenuifolium	kohuhu - moderately common in both mature and regenerating forest, mostly on ridge tops and flanks but in a wide variety of other sites. Common in regrowth after logging or storm damage.	168178
P. virgatum	-local and uncommon. Almost restricted to between 250m and 400m asl in both mature and regenerating communities. Occurs primarily on ridge sites under kauri canopy and a range of other communities. It usually as single shrubs or small groves; seedlings are more common than adults. It is often found on margins of old logging roads and in regrowth after logging or damage. Puketi Forest contains the main Northland population of this nationally rare species.	165181, 166471, 168355
*Plantago australis**	local and uncommon. In swampy road margins e.g. the overgrowing logging road to Onekura Bluff.	

*P. lanceolata**	narrow-leaved plantain. Moderately common alongside logging roads and in pasture (e.g. at Forest Headquarters and at Forest Road).	133548
P. major subsp. *major**	broad-leaved plantain. Uncommon alongside logging roads and in pasture.	
P. raoulii	rare on rocks at the margin of the Waipapa River.	
*Polygonum hydropiper**	local and uncommon. Mostly on gravel banks in the lower reaches of the Waipapa River and in adjacent side streams. Also around the margins of the pond at the headwaters of Waipapaiti Stream.	170015, 170043
P. salicifolium Willd.	rare and local. One small population known from the margins of a pond at the headwaters of the Waipapaiti Stream.	169735
Pomaderris kumeraho	kumarahou - locally common on dry clay ridges in early communities, frequently colonising bare clay surfaces in these sites. Mainly in the headwaters of the Waipapa River and east of Forest Headquarters.	168133
P. phylicaefolia var. *ericifolia*	local and uncommon in early seral communities, mostly on dry clay ridges in the headwaters of the Waipapa River, east of Forest Headquarters and alongside logging roads.	166145
Pratia sp. *(P. angulata* spp.)	local and uncommon on rocks and banks alongside the Waipapa River, Mangapapa River and Mangakino Stream.	167895
P. (=Colensoa) physaloides	koru, colensoa. Local and uncommon in mature forest, usually on steep banks or rock faces near streams and occasionally in poorly drained seepage points. Also on shaded rock banks around major waterfalls. It is usually found in places inaccessible to browsing mammals, particularly possums and goats. There are seldom more than five plants in a locality, but it is scattered in suitable habitat along the major rivers and in most side catchments. It is quite a rare plant on mainland Northland. The threats to its continued survival in Puketi Forest are browsing mammals and the spread of mist flower which forms dense thickets in similar habitat to that of koru.	16518, 168032, 170016, 170205
*Prunella vulgaris**	selfheal - common in disturbed sites throughout the forest, especially poorly-drained margins of logging roads and tracks.	133422
*Prunus persica**	peach -scattered and uncommon along the banks of the lower reaches of the Waipapa River.	
Pseudognaphalium sp. (*O. luteo-album* (L.) Hilliard et Burtt agg.)	Jersey cudweed. Rare and local. A few plants on rock banks next to the lower major falls in Flavell's Creek.	170014

Pseudopanax anomalus (Hook) Philipson	very rare and local. Two shrubs only located near the highest points of the southern massif on the ridge separating the Opaopao and Te Rereatuoro catchments.	170175
P. arboreus (Murr) Philipson var *arboreus*	fivefinger, whauwhaupaku. Common throughout mature and regenerating forest in most sites at all altitudes. It is common on or near ridge systems and under kauri canopy. It is frequently epiphytic. Possum browse and defoliation of this species was observed frequently, and, particularly in seral communities and near logging roads, some individuals apparently had been killed as a result of debilitating browse.	168938
P. crassifolius (A. Cunn.) C. Koch	lancewood, horoeka. Common throughout mature and regenerating forest in most sites and at all altitudes. It is most common on or near ridge systems and is common under kauri canopy.	168971
P. edgerleyi (Hook.f.) C. Koch	raukawa. Locally common in mature forest, but rarely found below 300m asl. Mostly in forest, it is particularly common in the south of the forest south of Pukatea Ridge and especially on the southern massif. It frequently commences life as an epiphyte. Some possum browse was noted on this species.	164910
Pseudowintera axillaris	horopito - uncommon but scattered throughout a range of sites in mature forest, although seldom found below 250m asl. It usually occurs as single shrubs or small groves, usually at or near gully heads, under a variety of canopies.	166468
Quintinia serrata	tawheowheo - local and uncommon. Seldom found below 250m asl. Trees are usually found in kauri stands with high water tables e.g. Takapau and Onekura stands, but small shrubs and small epiphytes on tree ferns are found on the southern massif.	169732
*Racosperma melanoxylon**	Tasmanian blackwood. A small plantation of this species is south of Forest Headquarters planted under some mature Corsican pine	
Ranunculus reflexus Garnock-Jones s.s.	fairly common in moist disturbed sites throughout both mature and regenerating forest e.g. slips and margins of old logging roads.	133433, 166610
R. repens	common along damp margins of overgrowing logging roads, and along the banks of the lower Waihoanga Stream.	133543
R. sardous-*	recorded by E.B. Bangerter in 1973 from a swampy paddock near Pukatea Ridge, growing with *R. repens*. Not located in the present survey.	133546
Rhabdothamnus solandri	waiuatua - locally common in mature forest on steep, well-drained banks in gully heads, in gorges of streams and surrounding under forest canopy.	168034, 168372

*Rorippa nasturtium aquaticum**	water cress -at seepage points on gravel banks of the main river systems.	
Rosa sp.	rare and local - growing next to rank pasture on alluvial terraces of the Waipapa River.	
Rubus australis	bush lawyer, tataramoa. Common throughout mature forest, particularly in disturbed sites e.g. after storm or logging damage, and common at mature forest margins. Moderately common in undisturbed canopy both as large lianes and ground cover.	168134
R. cissoides	bush lawyer, tataramoa. Less common than *R. australis* in mature forest and seldom found away from ridge sites. Common at forest margins of mature forest and also common in regenerating forest.	168010
R. sp. (*R. fruticosus* agg.)	blackberry - locally common around forest margins mostly around pasture, seral communities and regenerating forest throughout, but seldom near mature forest.	
R. australis X R. cissoides	recorded by Ogle (unpublished list, 1979) with no location given. Not recorded in the present survey.	
*Rumex acetosella**	sheep's sorrel - occasional in pasture at Forest Headquarters and on alluvial terraces of the Waipapa River at Forest Road.	133539 AKU 21909
*R. conglomeratus**	clustered dock. Locally moderately common on gravel banks in the lower reaches of the main river systems.	
*R. crispus**	curled dock. Locally moderately common on gravel banks of the lower reaches of the main river systems and in rank pasture on alluvial terraces of the Waipapa River at Forest Road.	
*Sagina procumbens**	pearlwort - Occasional on seepage points on rocks and around waterfalls on the main rivers and sidecreeks.	
*Salix babylonica**	weeping willow. Recorded by Sexton (1939) from "river banks on the forest boundary." Not recorded within the forest in the present survey.	
Schefflera digitata	pate. Common throughout mature and regenerating forest, particularly in damp sites gullies, alluvial terraces and on the southern massif. Also common in areas damaged by storms or logging.	166512, 170131
*Scrophularia auriculata**	water betony. Locally common on gravel banks of the lower reaches of the main river systems.	AKU 15795
*Senecio bipinnatisectus**	-Australian fireweed. Moderately common on dry clay banks and disturbed sites throughout,e.g. slips, clay logging road margins.	
*S. diaschides**	moderately common in disturbed sites induced by logging, especially along the margins of clay logging roads.	168566 AKU 15475

S. hispidulus	rare and local. Small populations known from open rock faces next to falls in the upper reaches of Flavell's Creek, and from bluffs west of lower Te Harua Stream.	170055
*S. jacobeae**	ragwort - local and uncommon on gravel hanks of the lower reaches of the main river systems, and in rank pasture on alluvial terraces of the Waipapa River at Forest Road.	
S. minimus	moderately common on clay banks and disturbed sites throughout, e.g. slips, clay logging, road margins.	168947
S. diachides X S. minimus*	occasional plants on dry clay banks alongside logging roads, e.g. Bramley's and Totara Ridges.	170489
*Siegesbeckia orientalis**	recorded by Sexton (1939) from the Waipapa River. Not located in the present survey; it is possible that it has since been replaced by mist flower at the site.	
*Sison amomum**	stone parsley. Local and uncommon in poorly drained margins of the road formation on alluvial terraces of the Waipapa River north of Forest Road.	
Solanum americanum	occasional in both mature and re-generating forest in damp sites, e.g. on river banks and on gravel banks in side creeks and occasional at the margins of logging roads.	170202
S. aviculare var. aviculare	poroporo - Occasional at forest margins and in light wells in mature forest, primarily at low altitude (100m asl).	168024
*S. mauritianum**	woolly nightshade. Occasional small trees on alluvial terraces of the Waipapa River near Forest Road. Severe browse was evident on most plants.	
S. nigrum	black nightshade. Rare at the margins of pasture at Forest Headquarters.	
*Sonchus asper**	prickly sow thistle. Rare under mature forest canopy on alluvial terraces of the main river systems.	
*S. oleraceus**	sow thistle - occasional on exposed rock hanks in mature forest in gorges, around waterfalls and in stream beds, and occasional pasture at Forest Headquarters and at Forest Road.	
Sophora microphylla	kowhai -local and uncommon. On steep rock banks above the Waipapa River at the forest's southern boundary and a few trees on alluvial terraces beneath, and along banks of the lower Waihoanga Stream.	169759
*Stellaria media**	chickweed - rare and local. At the margins of the lower reaches of the Waipapa River at seepage points on gravel hanks and at road margins.	133545

S. parvifolia	local and uncommon. On damp shaded rock banks in mature forest, usually in gorges or near waterfalls in side streams (e.g. Waikape Stream and Flavell's Creek and above lower Waihoanga Stream).	165051, 170170
Streblus heterophyllus (Blume) Corner	turepo, milk tree. Uncommon on alluvial terraces of the main rivers, and extending into gully heads of some side catchments below 300m asl.	168062, 168136
Styphelia fasciculata (Forst.f) Sleumer [*Leucopogon fasciculatus* A. Rich]	mingimingi - common throughout the forest on dry sites, especially ridge tops in both mature and regenerating forest. It is a common shrub under mature kauri canopies.	168004
S. nesophila (DC.) Sleumer *Leucopogon fraseri* [A.Cunn]	patotara - recorded by Rawlings (unpublished list 1972) and by Sexton (1939) from "manuka heathlands". Not recorded in the present survey.	
Syzygium maire (A.Cunn.) Sykes et Garnock-Jones	maire tawake - rare and local. Single trees are growing in very poorly drained stream headwaters of Purawharawhara Stream and Waikape Stream. It is moderately common adjacent to kauri stands in a very poorly drained site at the head of Waipapaiti Stream in Manginangina Scenic Reserve.	168931
*Taraxacum officinale**	dandelion -recorded by E.B. Bangerter in 1973 from grassland at the margin of the Mokau Ridge track, which has since been made a formed road. Not located in the present survey.	133477
Toronia toru (A.Cunn) Johnsn et Briggs	toru - locally common in regenerating forest in the eastern part of Puketi Forest, where it is a major component of communities on dry ridge top sites previously occupied by kauri. It is rare in mature forest in dry ridge top communities under kauri canopy.	167634
*Trifolium dubium**	suckling clover - occasional in pasture at Forest Headquarters and on alluvial terraces of the Waipapa River at Forest Road.	
*T. pratense**	red clover - rare and local in rank pasture on alluvial terraces of the Waipapa River at Forest Road.	
*T. repens**	white clover - locally common in pasture at Forest Headquarters and at Forest Road on the terrace above the Waipapa River.	
*Ulex europaeus**	gorse – locally common in regenerating forest, particularly in early seral communities with manuka on bare clay in the headwater catchments of the Waipapa River, in a wide range of sites. Elsewhere moderately common along the margins of old logging roads and invading those which are over-growing. Very rare in mature forest on disturbed sites e.g. slips and in selectively logged areas.	

Utricularia laterifolia R.Br. (incl *U. deliculatus* Cheesm.)	rare in damp ground in acid gumland community near Forest Headquarters. Evident in summer.	175716
*Verbena bonariensis**	purple top - locally common along the margin of the road formation on the alluvial terraces of the Waipapa River north of Forest Road.	
*V. litoralis**	blue vervain -locally common along the road formation on the alluvial terraces of the Waipapa River north of Forest Road and on gravel banks in the lower reaches of the main rivers.	170021
*Veronica arvensis**	field speedwell. Rare and local in pasture at Forest Headquaters.	
*V. plebeia**	Australian speedwell. Local and uncommon near margins of regenerating forest, especially manuka communities e.g. on Pirau Ridge west of Puketotara Stream.	166090
*V. serpyllifolia**	turf speedwell. Rare and local at poorly drained sites on the margin of pasture at Forest Headquarters and at Forest Road.	133433, 130809
Viola filicaulis	rare and local. On moist shaded rocks in the stream beds in the lower reaches of the Waikape Stream and the Merumeru tream.	166646
Vitex lucens	puriri - moderately common in mature forest throughout from alluvial terraced to upper altitude sites, although it is rare on the top of the southern massif. It is rare on dry ridges in the most dissected terrain between Canadian's Creek and Pukatea Stream where it occurs mostly in gully heads. Seedlings are rare and appear in lightwells following windthrow. It is rare in regenerating forest.	167902
Wahlenbergia gracilis	rare on dry well-lit ridge tops (e.g. Pukatea Ridge) in mature forest, and on banks next to rivers.	169739
W. marginata (Thunb.)* A. DC.	moderately common in rank weed growth alongside overgrown logging roads in disturbed forest throughout.	170030
Weinmannia silvicola var. *silvicola*	towai -abundant canopy tree throughout most of the forest both in mature and regenerating forest, although it is much less common below 150m asl, and it is comparatively rare on alluvial terraces and in low altitude forest. Although most common on ridge flanks, it is also common in gullies and on ridge tops, including under kauri. At higher altitudes it is by far the commonest tree, and is codominant with makamaka at the highest points of the forest on the southern massif. It is an abundant component of regenerating communities in the east of the forest and is often the major tree species to develop from manuka communities. It is also a major coloniser following disturbance in mature forest (e.g. storm or logging damage).	166620

MONOCOTYLEDONS: * = adventive species

Acianthus fornicatus var. *sinclairii*	common ground orchid from autumn until late spring at all altitudes in both mature and regenerating forest in most sites except soils and acid kauri litter where it is rare. Most under podocarp or podocarp/hardwood canopy	166567
A. reniformis	-locally common. Apparent in early spring on dry ridge top sites on soils and in acid kauri litter. It is uncommon under mature kauri, but is locally com-mon under pole kauri canopy (e.g. lower Pukatea ridge).	169729
*Agrostis capillaris**	browntop. Locally abundant grass at the margins of logging roads and in disturbed sites in the east of the forest.	
*A. stolonifera**	creeping bent. Rare and local - next to a small rivulet on the old road formation on the banks of the Waipapa River near Forest Road, and on the bank of the lower Waihoanga River.	AKU 21887
*Aira caryophyllea**	silvery hair grass. Local and uncommon on dry bare sites mostly near forest margins e.g. Waihoanga Falls and above Te Rereatuoro Falls, and on bluffs west of lower Te Harua Stream.	AKU 21894
*Alocasia macrorrhiza**	elephant's ear. Rare and local - growing in a roadside drain on alluvial terraces of the Waipapa River at Forest Road.	
*Anthoxanthum odoratum**	sweet vernal. Common in disturbed sites throughout, particularly in the logged eastern part of the forest and alongside logging roads, but also in disturbed or open dry sites in mature forest.	33540,164911
*Aristea ecklonii**	rare and local - a few plants on clay banks in open sites amongst low manuka near of the Waipapa River, and on clay logging mads near Pukatea Ridge.	
Arthropodium cirratum	rengrenga -Locally common on usually dry, well-lit rock faces near streams in gorges and surrounding major waterfalls in most side catchments, and also on dry rocky banks near ridge tops.	167898, 168944
*Arundo donax**	giant reed. Rare and local. A few plants growing in a roadside drain at the forest's eastern boundary north of Forest Headquarters.	
*Asparagus scandens**	climbing asparagus. Rare and local at a forest margin on Pirau Ridge north of Pukatea Stream.	
Astelia fragrans	local and uncommon. Usually single large lilies on ridge flanks under mature podocarp/hardwood canopies on well-drained sites.	

A. grandis	rare and local. A few large lilies under light canopy on poorly drained soil east of the gumland association near Forest Headquarters.	166097
A. solandri	common epiphyte in mature forest throughout in most associations and at all altitudes. Very rarely terrestrial.	166464
A. sp. (*Astelia* 'kauri')	rare and local in the Takapau kauri stand on Pukatea Ridge.	
A. trinervia	locally abundant, usually under undisturbed mature kauri on dry ridge tops, but also common under podocarps on ridge tops and to a lesser extent on ridge flanks. Relatively rare in most other sites, including under pole kauri stands and regenerating forest.	167875
*Avena barbata**	slender oat. Rare and local. On banks above alluvial terraces of the Waipapa River at Forest Road.	
*Axonopus affinis**	narrow-leaved carpet grass. Locally common on well- lit disturbed sites, particularly damp areas, e.g. overgrowing logging roads and road margins.	120504, 133479, 170130
Baumea rubiginosa	locally abundant sedge in early seral communities, particularly in poorly drained sites e.g. gumlands near Forest Headquarters where it is abundant with *Gleichenia dicarpa*, and also on the forest's eastern boundary under manuka with *G. dicarpa.*	166111, 170009
B. teretifolia	locally common sedge at drainage points on podsolised acid soils e.g. in drainage channels from regenerating communities and the gumland near Forest Headquarters, and also in the pond at the head of the Waipaiti Stream.	168555, 168573, 170008
*Briza minor**	very grass - rare on dry exposed banks, mostly near the forest margin, e.g. falls on the Waihoanga Stream.	175721
Bulbophyllum pygmaeum	common orchid in exposed well-lit sites throughout the forest - usually high in tree crowns, but occasionally on trunks at forest margins and in regenerating forest. Uncommon in damp sites and on the southern massif.	130816, 164784
B. tuberculatum	very rare and local. One very small colony found in the crown of a puka in a fallen taraire with *B. pygmaeum* and *Drymoanthus adversus* mature forest on alluvial terraces of the Waipapa River near Forest Road. Collected from the same locality by A.E. Orchard in 1972.	170487
Caladenia catenata (Sm.) Druce f. *carnea* (R.Br.) Halle.	rare and local. One small colony found under kanuka canopy in an area recovering from storm damage north of Waihoanga Stream.	165188
Carex breviculmis	collected by J.E. Braggins the margins of the Forest in 1973. Not located in the present survey.	AKU 2574

_C. demissa_*	rare and local - a small colony on the tramping track into the Takapau kauri stand from the Pirau Ridge logging road.	AKU 15786
C. dissita	common in moist areas and poorly drained sites in mature forest throughout, especially in gully heads and occasionally near poorly drained logging roads.	164791, 165-168, 165785, 170004, AKU 21833
_C._ sp. (_C. germinata_ agg.)	rare and local - a small colony on a poorly drained margin of the Waipapaiti Stream in manuka shrubland.	170001, 170013
C. lambertiana	rare and local -plants growing in low altitude forest on the lower parts of ridges at the south of the forest (e.g. on the ridge separating Opaopao and Te Rereatuoro catchments).	170193
C. lessoniana	uncommon - growing on open poorly drained sites, usually at forest margins (e.g. on Bramley's Ridge) in disturbed sites or beside rivers and streams at seepage points.	AKU 15477 AKU 15794 AKU 21832
C. ochrosaccus	local and uncommon on banks and poorly drained sites in low altitude forest above the Waipapa River near the forest's southern boundary.	170197, AKU 15796
C. spinirostris	rare and local. On dry rock banks under mature forest e.g. Pukatea Ridge with waiuatua and _Libertia grandiflora._	169723
C. virgata	very restricted but common at the sites at which it occurs, e.g. around the margins of ponds in mature forest on Pukatea Ridge and north of Waihoanga Stream. A few plants at the margin of Waihoanga Stream.	168574, 170176, AKU 21836
_C. vulpinoidea_*	very rare and local - growing with _C. virgata_ on the banks of Waihoanga Stream at the forest's south-east boundary.	170210
Chionocloa conspicua	rare on rocky banks at the margin of Waipapa River.	
Collospermum hastatum	abundant epiphyte in mature forest throughout except of the driest ridge top sites. Less common in regenerating forest.	170025
C. microspermum	locally epiphyte, seldom found below 300m asl, in mature forest only. Mostly in podocarp/hardwood or hardwood forest and rare in kauri-dominated sites.	164786
Colocasia esculenta (L.) Schott*	taro. Reported by Sexton (1939) as "rare in abandoned cultivations". The present survey failed to locate any; it may have become locally extinct.	
Cordyline australis	ti, cabbage tree. Local and uncommon, mostly in regenerating forest or forest margins near Forest Headquarters, and surrounding the pond at the head of Waipapaiti Stream.	169747
C. banksii	ti ngahere. Moderately common in both mature and regenerating forest throughout, mostly on ridge-flanks and gullies and often near streams. Common in disturbed sites, and it flourishes at forest margins along side logging roads.	168948

C. pumilio	ti kouka. Common on welldrained sites in mature forest, mostly on ridges or ridge flanks under podocarp or podocarp/hardwood canopy.	170152
Cortaderia sp. (aff. *C. fulvida* (Buchan.) Zotov	locally common on gravel margins and rock banks of the major rivers and in well-lit parts of most major side streams. Uncommon alongside logging mads and other damp disturbed sites.	167887, 167888
*C. jubata**	purple pampas grass -rare and local on clay banks on the margins of logging roads, especially Pirau Ridge.	
*C. selloana**	pampas grass - local and uncommon on clay banks on the margins of old logging roads, especially Pirau, Bramley's and Totara Ridges.	
Corybas aciminatus M. Clements et Hatch	rare and local. Two populations known from damp shaded stream margins of Canadian's Creek and Pukatea Stream.	
C. oblongus	local and uncommon. This spring-flowering orchid occurs on clay banks under a wide variety of mature forest and in a wide range of usually well-drained sites.	167855
C. orbculatus	locally very common, on moss covered rock banks on the margins of major side catchments and rivers.	165779, 167864
C. invularis	rare and local. Two populations known from damp shaded stream margins of Canadian's Creek and Pukatea Stream.	
Crocosmia X crocosmiiflora	montbretia. Local and common at the site at which it occurs lining the margin of the Pirau Ridge logging road west of Puketotara Stream.	
*Cyperus brevifolius**	rare and local in a drain at the side of the road on alluvial terraces of the Waipapa River north of Forest Road.	
*C. eragrostis**	moderately common on damp sites, particularly gravel margins of the main rivers and major side catchments.	
*C. tenellus**	rare and local at seepage sites on gravel hanks in the lower reaches of the Waipapa River and on clay road margins.	133504
C. ustulatus	local and uncommon at the margins of the major river systems in their lower reaches.	170207
Dendrobium cunninghammii	-abundant epiphyte in mature forest in well-lit sites throughout. Common also in regenerating forest.	164892

Deyeuxia avenoides	locally common on very dry ridges and exposed sites in both mature and regenerating forest throughout.	170150, 170196
D. sp. (*D. quadriseta* agg.)	rare and local at the margins of logging roads (e.g. Pirau and Bramley's Ridges).	170110, AKU 15797
Dianella nigra	turutu. Common throughout the forest in both mature and regenerating forest in well-lit areas and around disturbed sites from ridge tops to gully bottoms. It flourishes on the margins of logging roads.	167872, 168369
Dichelachne crinita	long-hair plume grass. Rare on dry exposed banks, e.g. above Te Rereatuoro Falls and on the banks of the main rivers.	
D. inaequiglumis (Cheesm.) Edgar et Connor	very rare and local. One small population known from a dry rock bank above the Waihoanga Falls at the south-east boundary of the forest.	170211, AKU 21904
D. rara	Te Harua Stream	AKU 21892
*Digitaria violascens**	rare and local. A small population known from the old road formation on alluvial terraces of the Waipapa River north of Forest Road.	170479
Drymoanthus adversus	moderately common epiphyte in tree crowns and well-lit sites in both mature and regenerating sites through out, except on the southern massif. Particularly common on tree trunks in some regenerating stands.	166082
Earina autumnalis	very common epiphyte in mature forest, usually in sheltered sites. Less common in regenerating communities.	166085
E. mucronata	very common epiphyte in both mature and regenerating forest throughout in well-lit sites in crowns of trees and on tree trunks.	168013
*Echinochloa crus-galli**	barnyard grass. Rare and local on the margin of the old road formation on the alluvial terraces of the Waipapa River north of Forest Road.	
Echinopogon ovatus	hedgehog grass. Rare on river banks and on rocks in the beds of the main river systems.	170473
Eleocharis acuta	rare and local. A small population growing amidst rank weed growth on a poorly drained road margin on river terraces of the Waipapa River north of Forest Road.	168023
E. gracilis	rare and local. A small population on a poorly drained site under manuka in the headwater catchment of the Waipapa River.	170042
Elymus rectisetus (Nees. in Lehm.) Love et Connor	rare, alongside well-drained margins of old logging roads e.g. Bramley's and Totara Ridges.	AKU 15771

*Entolasia marginata**	bordered panic grass. Locally common on the well-drained margins of old logging roads in the east of the forest, especially Bramley's, Totara and Pirau Ridges.	168358
*Eragrostis brownie**	bay grass. Locally moderately common in bare well-lit sites, e.g. overgrowing old logging roads.	
*Festuca arundinacea**	tall fescue. Local and uncommon on gravel banks in the lower reaches of the main river systems.	AKU 21884
Freycinetia baueriana Endl. subsp. *banksi* (A. Cunn.) Stone	kiekie. Abundant in mature forest throughout at all altitudes and in almost all habitats. It is particularly common on ridges and ridge flanks. Locally it forms large extremely dense thickets, especially on ridge tops and in drained areas. It is common at forest margins but is much less common in regenerating communities.	170198
Gahnia lacera	locally common on very dry banks, mostly at lower altitude (<300m asl), particularly around gorges in streams or on steep banks around waterfalls.	168020
G. pauciflora	locally common on ridge systems, rarely under kauri, but common under podocarp/hardwood or hardwood canopy, mostly under mature forest.	166579, 168357
G. setifolia	common on open sites in both mature and regenerating communities throughout; locally very common around slips and alongside margins of old logging roads.	170044
G. xanthocarpa	toikiwi, “cutty grass". Locally abundant ground cover in mature forest on ridge tops, mostly under kauri, although on ridge sites under most other canopy types. It is more common than *Astelia trinervia* in higher altitude kauri stands, especially those with high water tables (e.g. Takapau and Onekura stands). In disturbed kauri stands (e.g. logging or storm damage) it forms extremely dense thickets in light wells and readily colonises bare ground. It is also locally abundant in regenerating forest and in early seral communities on sites previously occupied by kauri.	168355
Gastridium ventricosum	nit grass. Rare and local on the old formation on alluvial terraces of the Waipapa River north of Forest Road.	170119
*Glyceria fluitans**	floating sweet grass. Very restricted in range, but common floating in the pond at the headwaters of Waipapaiti Stream at the forest's eastern boundary.	170477
*Holcus lanatus**	Yorkshire fog. Common in disturbed sites, especially alongside logging road margins and in rank pasture, but also in disturbed fertile sites in mature forest, e.g. slips near stream sides.	
Isolepsis prolifer	rare and local on gravel banks at the margin of the Waipapa River.	

I. reticularis	common throughout the forest in both mature and regenerating forest and in disturbed sites at seepage points and alongside stream banks.	165788, 170003, 170187, 170188, 170189
*I. sepulcralis**	rare and local on the old road formation on alluvial terraces of the Waipapa River north of Forest Road under canopy on very poorly drained sites.	AKU 15773
*Juncus acuminatus**	occasional on poorly drained clay logging road margins and on the road formation on the banks of the Waipapa River north of Forest Road.	170190 AKU 15785
*J. articulatus**	locally common on poorly drained clay logging roads and in the pond at the headwaters of Waipapaiti Stream.	
*J. bufonius**	toad rush. Occasionally on poorly drained clay logging roads and foot tracks in the east of the forest.	170138
*J. dichotomus**	rare and local. One small population growing next to the gumland near Forest Headquarters at the margin of a road.	170005
J. sp. (*J. effuses* agg.)*	locally common on poorly drained sites, e.g. margins of clay logging roads, overgrowing tracks and roads, and rarely by seepages near streams.	170194
J. gregiflorus	locally common on poorly drained sites, e.g. next to margins of clay logging roads, overgrowing roads and tracks and rarely by seepages near streams.	166110, 170192
J. holoshoenus	rare on the margins of poorly drained clay logging roads e.g. Bramley's and Pirau Ridges.	168650
*J. microcephalus**	rare on the margins of poorly drained clay logging roads e.g. Bramley's and Pirau Ridges.	AKU 15777
J. pallidus	occasional on the margins of poorly drained clay logging roads e.g. Bramley's and Pirau Ridges.	167892, 170124
J. planifolius	common on the margins of clay logging roads and occasional on over-growing poorly drained roads and tracks.	167856 AKU 21907
J. prismatocarpus	moderately common on the margins of poorly drained clay logging roads.	167900
J. sarophorus	rare and local, at the margin of Pirau Ridge road adjacent to farmland at the forest's eastern boundary.	167600
*J. tenuis**	moderately common in well-lit disturbed sites, especially on tracks and overgrowing logging roads.	
Lachnagrostris filiformis (Forst. f.) Trin. var. *filiformis*	wind grass. Occasional on rock bluffs (e.g. Onekura Bluff) and rock banks in streams and rivers throughout the forest.	170029, 170123
Lepidosperma australe	occasional on well-lit poorly drained clay surfaces	167871

	e.g. at the margins of logging and in manuka shrubland at the headwaters of the Waipapa River.	
L. laterale	rare and local in low manuka shrubland on dry gumland soils east of Forest Headquarters and among young radiata pine in the adjacent plantation.	170000, 170038
Liberti grandiflora	locally common in mature forest on dry ridgetops underpodocarp/hardwood or hardwood communities, and also common on steep rock banks, especially near waterfalls (e.g. Merumeru Falls).	168939
L. pulchella	local and uncommon in damp sites under mature forest canopy. Small populations are at the bottom of the ridge west of Camp Creek, on Mokau Ridge and in the Onekura Stand. It is only common under mature kauri canopy in the Takapau Stand.	165184
*Lolium perenne**	perennial ryegrass. Common in pasture at Forest Headquarters and on alluvial terraces of the Waipapa River at Forest Road. Elsewhere rare alongside logging road margins.	
Luzula campestris	Te Harua Stream.	AKU 21903
*L. congesta**	recorded by E.B. Bangerter in 1973 from grassy margins of the Pirau Ridge logging road. Not located in the present survey.	143788
*L. multiflora**	recorded E.B. Bangerter in 1973 as occasional on the margins of the now overgrown logging road from Puketi Road to Pirau Ridge. Also recorded by A.E. Orchard in 1973 from pasture near Forest Headquarters. Not located in the present survey.	133704
L. picta var. *picta*	occasional on well-lit banks of the main river systems and occasionally in side catchments, e.g. Mangakino Stream.	168546
Microlaena avenacea (=Ehrharta diplax)	bush rice grass. Very common under mature forest throughout at all altitudes under podocarp/hardwood or hardwood canopy. It is absent under kauri canopy. It is much less common under regenerating forest canopy.	168972
M. stipoides (=Ehrharta stipoides)	meadow rice grass. Locally common at well-drained well-lit forest margins and at the sides of roads. It is in mature forest at open sites, e.g. banks and slips.	164798
Microtis parviflora	rare and local on dry clay banks in summer, e.g. at road cuttings on the Bramley's ridge logging road.	170135
M. unifolia	locally common on dry clay banks in summer, especially alongside road cuttings, but also on exposed banks near waterfalls and on dry rocks in stream beds.	165798
Morelotia affinis	rare and local in low manuka shrubland on dry gumland soils east of Forest Headquarters.	170036

Oplismenus hirtellis (L.) P. Beauv.	locally moderately common under podocarp/hardwood or hardwood canopy in mature forest, especially on alluvial moderately in regenerating forest.	168559
Orthoceras strictum	occasional on dry clay banks on roadside cuttings and in early seral communities at the head of the Waipapa River in summer.	170125
*Paspalum dilatatum**	paspalum. Locally common at the margins of pasture at Forest Headquarters and at Forest Road, and along the margins of logging roads and well-lit tracks through-out the forest.	
*P. distichum**	mercer grass. Rare and local at the margins of the Waipapa River on gravel banks.	AKU 15792
*P. urvillei**	vasey grass. Occasional at damp margins of logging mads and on the old road formation on alluvial terraces of the Waipapa River north of Forest Road.	170129
*Pennisetum clandestinum**	kikuyu grass. Fairly common in pasture at Forest Headquarters	
Phormium cookianum subsp. *cookianum*	harakeke, mountain flax. Local and uncommon on extremely well drained ridge top sites under a variety of canopies in mature forest throughout, including under kauri canopy.	168559
P. tenax	harakeke, New Zealand flax. Rare and local at the margins of the Waihoanga Stream at the forest's south eastern boundary.	170206
Poa anceps subsp. *anceps*	rare and local at the margin of the Waipapa River and on rock faces above alluvial terraces of the river at the forest's southern boundary, and on bluffs west of lower Te Harua Stream.	170118 AKU 21898
Pooid grass sp.* (indet)	rare and local - one plant seen on the bank of the Waihoanga Stream at the forest's south-east boundary.	170493
*P. annua**	rare and local at the margins of the old road formation north of Forest Road on alluvial terraces of the Waipapa River.	170488
Prasophyllum colensoi	rare and local. A few plants in the gumland community near Forest Headquarters under low manuka, *Schoenus brevifolius* and *Baumea teretifolia.* Evident in summer.	
Pterostylis banksii	tutukiwi. Common in spring under both mature and regenerating forest under podocarp/hardwood and hardwood canopies.	168959, 168966

P. brumalis	local and uncommon in autumn, under regenerating forest and manuka shrubland on sites previously occupied by kauri forest.	167660
P. graminea var. *rubricaulis*	locally common in winter, but almost restricted to kauri-dominated sites, both pole and mature stands.	165190
P. trullifolia	locally common in autumn under regenerating forest and manuka shrubland in sites previously occupied by kauri fores, where it is more common than *P. brumalis*. Also common under pole kauri canopy, and rare under mature kauri canopy.	166140
Rhopalostylis sapida	nikau. Common in gullies and on alluvial terraces throughout mature forest, sometimes forming large groves. Rare in regenerating forest.	170148, 170200
Ripogonum scandens	supplejack, kareao. Very common throughout mature forest in most sites at all altitudes, but abundant in gully bottoms at stream headwaters where it forms extremely dense tangles. Much less common in regenerating forest.	167804
Rytidosperma biannulare (Zotov) Connor et Edgar	locally common on well-lit dry banks throughout, e.g. around waterfalls, on road cuttings.	133777, 170149, 170151
R. gracile (Hook.f.)	locally common on dry banks either in full light around waterfalls, road cuttings) or under light canopy (e.g. manuka shrubland).	165169, 165784, 170133, 176376
R. penicillatum (Lab.) Connor et Edgar*	local. On dry clay soils in full light along the margins of logging roads (e.g. near Forest Headquarters).	170034
R. tenuius (Steud.) Hans. Et Sund.*	rare and local on dry gumland soils in full light east of Forest Headquarters.	170035
Schoenus apogon	locally common on poorly drained clay surfaces, e.g. on logging roads and in early seral communities in the headwaters of the Waipapa River.	133696, 133735, 165189, 168372
S. brevifolius	very restricted in range, although locally common with *Gleichenia dicarpa* on poorly drained acid soils in the community south of Forest Headquarters.	166112
S. maschalinus	moderately common on damp seepage sites throughout both mature and regenerating forest and in disturbed sites.	164799
S. tendo	locally common in early seral communities, especially manuka shrubland, on dry clay soils where it sometimes forms large tussocks.	165778
*Setari glauca**	yellow bristle grass. Local and uncommon in rank weed growth at the margins of the old road formation on alluvial terraces of the Waipapa River north of Forest Road.	170484

*Sisyrinchium iridifolium**	rare and local. A small population growing on a poorly drained overgrowing section of Bramley's Ridge logging road.	AKU 15476, AKU 15776
S. sp.* (*S.* "blue")	rare alongside road to Bramley's Ridge.	175715
*Sporobolus africanus**	ratstail. Locally common on dry well-lit banks throughout, e.g. on clay road cuttings, on banks around waterfalls.	
Tetraria capillaris	rare and local. Small populations are known from two poorly drained localities, one adjacent in the gumland association south of Forest Headquarters, and the other in the pond at the head of Waipapaiti Stream with *Baumea rubiginosa* and *B. teretifolia.*	170007, 170027
Thelymitra ?carnea	near Puruwharawhara Stream.	AKU 21908
Thelymitra longifolia	locally common indry, well-lit sites previously occupied by kauri, on clay banks and under manuka canopy. Very rare under pole and mature kauri canopy.	170127
T. pulchella	rare and local on poorly drained clay sites previously occupied by kauri, e.g. on overgrowing logging roads and in the headquarters of the Waipapa River in full light in early seral communities, and in the gumland community south of Forest Headquarters.	168929
*Tradescantia fluminensis**	wandering Jew - rare and local – small population at the Forest's southern boundary at the lower Waihoanga Stream. This aggressive weed should be eliminated to prevent its spread into the forest.	AKU 21885
Typha orientalis	raupo. Rare and local. A small population growing at the outlet of a small unnamed stream south of Te Rereatuoro Stream on an alluvial terrace of the Waipapa River next to the old road formation.	168077
Uncinia banksii	locally common on steep very well drained banks under mature and regenerating forest, often near gorges or waterfalls of streams.	169743
U. uncinata	abundant under podocarp/hardwood and hardwood canopy in mature forest throughout in most sites at all altitudes. Less common in regenerating forest.	169730
U. zotovii	uncommon in mature forest throughout in a range of sites under a range of conopies, including under kauri and on the southern massif.	170012

DUBIOUS AND EXCLUDED RECORDS

FERNS:

Cheilanthes sp.	recorded in an unpublished list of C.C. Ogle 91979). C. Ogle (pers. comm.) states that the locality is at Takapuwahia in Otangaroa State Forest, north of Puketi Forest.

GYMNOSPERMS:		
Lepidothamnus intermedius (Kirk) Quinn	yellow-silver pine. Both this species and silver pine are recorded by Sexton (1939). I believe that the record of yellow-silver pine is based on misidentified silver pine. The northernmost known locality of this species is on Hirikimata (Mount Hobson) on Great Barrier Island. I know of no authenticated of vouchered records from Northland despite it being reported widely.	
DICOTYLEDONS:		
*Fragaria vesca**	- wild strawberry. Recorded by Sexton (1939) from the lower reaches of the Waipapa River. This is probably a misidentification of Indian strawberry.	
Nestegis apetala (Vahl.) L. Johnson	recorded by Sexton (1939) from 'on ridges, not plentful': I believe this is based on misidentification of white maire, the leaves of which are extremely variable in dimension in the forest. *N. apetala* may be present as it occurs sporadically in coastal sites in the Bay of islands some 20km distant, but in the absence of a vouchered specimen I have not accepted this record.	
Pseudopanax ferox	recorded by Sexton 91939) as 'local'. I believe this record is based on misidentification of *P. crassifolius* which is deeply toothed on occasions. The northern New Zealand records are from dune forest remnants (Ninety Mile Beach, Te Huka, Ahipara and Woodhill State Forest) in forests and on substrates entirely different from those found in Puketi Forest.	
Ranunculus rivularis	recorded in 1973 by E.B. Bangerter from the Forest. The voucher specimen was collected from headwaters of Waihoanga Stream near the now overgrown road from Puketi to Pirau Ridge, but the specimen collected was from private land considerably outside the Forest Boundary.	133784
Rubus schmidelioides	recorded by Sexton (1939) as 'common throughout'. I believe this record is based on misidentification of *R. cissoids* which is not recorded by Sexton.	
MONOCOTYLEDONS:		
Libertia ixioides	recorded by Sexton (1939) from 'well-lighted ridges'. This is almost certainly based on misidentification of *L. grandiflora,* which is not recorded by Sexton.	
Potamogeton c.f. *chessmanii*	recorded by E.B. Bangerter in 1973 growing submerged in a stream headwaters of Waihoanga Stream with *Ranunculus rivularis.* The voucher specimen was collected well east of the Forest's south-east boundary.	133502

SECTION SEVEN :SUMMARY

North Island kokako are birds of the larger remnant tracts of tall, mature lowland forest in New Zealand, of which Puketi Forest, Northland is an example. The birds are primarily fruit and leaf eaters. Adult kokako are sedentary, and live as solitary or paired birds in discrete home ranges. Our study concentrated on quantifying aspects of kokako behaviour in the Forest, in relation to the vegetation in their habitat.

7.1. VEGETATION OF KOKAKO HOME RANGES

The kokako study home ranges were located in headwaters of side streams of the Waipapa River and ranged from 100m to 450m in altitude. Each was centred on an axial ridge. The vegetation structure and composition was influenced primarily by topography. The more sharply dissected ridges were exposed sites with well-drained, podsolised soils and were usually crowned with kauri-dominated or podocarp-dominated vegetation. Ridge flanks and gently-rolling ridge tops were clad mainly in a canopy of tree hardwoods (particularly towai, taraire, kohekohe and tawa) with scattered emergent trees. Vegetation in gullies grew on more fertile sites that were shaded, damp and sheltered, and the canopy was dominated by supplejack and kohekohe, with emergent pukatea. Typically, kokako home ranges included a range of topography which resulted in a great diversity of vegetation types and species.

Additionally, the vegetation in most of the study home ranges was influenced to some extent by disturbance, either natural (cyclone damage, slips) or man-induced (logging, roading).

Observations of phenology of about 50 common forest plant species showed that all produced flushes of new leaves in spring and (with some notable exceptions) flowered in spring or early summer. However, the ripening period for fruit was quite variable. The fruit of some species ripened within a week, while that of other species took more than a year to ripen. Consequently, ripe fruit were present on a range of species at different times of the year.

7.2. KOKAKO BEHAVIOUR

Kokako in Puketi Forest fed on a wide variety of material mostly plant but invertebrates were taken also, especially the bag moth. Features of the diet that were examined in detail included:

(i) the types of food eaten, e.g. leaves, fruit, flowers, invertebrates;
(ii) the frequency with which food was obtained from certain vegetation classes (kauri, podocarp, tree hardwood, etc), and
(iii) the species composition.

For each of these categories, there were marked differences in diet from season to season, and between home ranges within a season.

The activity patterns of kokako changed seasonally. Kokako sang most during late-spring and summer (during breeding) and least in winter. Feeding activity per hour was greatest in winter and early spring (when air temperatures were low, hours of daylight restricted, and the range of available foods was limited) and least in summer. Roosting and preening activities were greatest in summer-early autumn (during moult).

Activity patterns also changed during the day. Singing was most common in the first and last two or three hours of daylight, whereas feeding took place mainly in the middle half to three-quarters of the day. However, the time spent on each activity per hour varied greatly from one day to another.

Nearly all kokako activities took place in canopy trees except for singing which occurred mainly from emergent trees. Most activities were centred on branches and twigs. Feeding, calling, moving, roosting, preening, and incidental activities were concentrated within 2-4m of the canopy. Singing birds though generally perched well above the canopy in the tallest trees present, sometimes even favouring specific individual trees. Birds which were calling, moving, and roosting-preening used the most common canopy tree species available - usually tree hardwoods and podocarps.

Not all parts of the study home ranges were used equally. In some home ranges, most activities were concentrated centrally, but in others they were not. Different parts of each of the home ranges were used from season to season. In some seasons (summer-autumn), birds occupied relatively compact areas, but at other times (late winter-early spring), they ranged more widely over their home ranges.

Within each study home range, feeding was wherever food was most plentiful at the time. Other activities (except for singing) tended to be concentrated in the same areas too. Singing was often centred in slightly different parts of the home range, and depended on the distribution of suitable song posts (e.g. emergent trees on prominent sites).

7.3. USE OF HABITAT

Although the kokako study home ranges contained a diverse array of vegetation and habitat types the resident birds used some habitats much more than others. Overall, kokako activities were focused mainly on vegetation of upper ridge crests and flanks. Gully bottom vegetation was also important for feeding. Changes in use of habitat types occurred seasonally. For example, in summer kauri-dominated sites were favoured (in home ranges that had such vegetation) primarily for singing, and during autumn birds lived in fruits of these species were most plentiful then.

Kokako used plant species generally in proportion to their relative abundance. However, feeding buds could be quite selective and at times comparatively rare plants featured prominently in their diet. The composition of the diet changed with season according to the availability of edible material on individual species. Some of the principle plant food species eaten by kokako were also highly palatable to browsing mammals, particularly possums.

There were also preferences in the use of plant species for singing, and (as for feeding) these changed with season. Singing was the only means by which holders of home ranges could advertise their presence and status (single or paired) to others. Differences in the songs of neighbouring birds probably served to identify individuals. Nearly all singing took place from the emergent parts of the tallest trees, especially those on elevated landforms. Singing was a prominent kokako activity in summer, and kauri was used particularly (when present) owing to its tall stature and its long spindly branches that reached out far over the canopy. Kokako avoided areas of kauri-dominated vegetation that had been damaged by logging and and used undisturbed stands instead. Logging of kauri stands removed an important song canopy and understorey, leaving vegetation that was not favoured by kokako.

SECTION EIGHT: RESEARCH REQUIREMENTS FOR KOKAKO IN PUKETI FOREST AND NORTHLAND

Research required in the near future falls into the following categories:

1 VIABILITY OF THE KOKAKO POPULATION IN PUKETI FOREST

There is very little information on the status of the kokako population in Puketi Forest, apart from the number of birds present, their distribution pattern and that breeding occurs. There is nothing known of the degree of breeding success, or whether productivity balances mortality. During 1982-84, a fledged chick was seen in Ben home range (April 1982) and Pukatea home range (November-December 1983), and a juvenile was observed beside the track to Mangahorehore trig, 200m eastwards of Summit home range (March 1984).

Surveys have indicated that a sizeable portion of the kokako counted in Puketi Forest were not paired; 52 singles and 24 pairs were recorded in November 1983 (Anderson 1984). Some counts of single kokako could have represented pairs, of which only one member was singing at the time. However, when singing in a home range with paired kokako, both birds usually participated. Of the kokako home ranges visited in our study (five intensively studied home ranges, plus thirteen additional home ranges), ten had only single birds whenever visited and eight contained pairs. (Pairs were present originally in two study home ranges, Ben and Pukatea. In Ben home range, the pair were displaced to an adjacent ridge by a single bird after January 1984, and in Pukatea home range only a lone bird was present from March 1984 until the end of the study). The presence of paired birds in less than half of all home ranges limits the breeding potential of the kokako population in Puketi Forest. It is not known whether this is typical of a healthy kokako population or is indicative of one under pressure from some environmental factor (e.g. predation at nests).

Studies in the central North Island by Hay (1981) and J.G. Innes (FRI, Rotorua) indicate that kokako have a low annual production. Furthermore, there is evidence that not all pairs attempt to nest each year (Hay *et al.*, 1985a), a feature that may be related to food supply. During the 1980 and 1981 seasons in the central North Island, 46 study pairs produced only eight fledged young (i.e. approximately one fledging/10 pairs each year). Predators were implicated in the failure of most of the nests found.

To ensure the continued survival of kokako in Puketi Forest, it is essential that adequate information be obtained on their productivity to determine

(i) whether the population is maintaining itself;
(ii) the factors' that influence breeding success; and
(iii) the most suitable methods for enhancing breeding success and survival of birds.

As food availability may well be crucial to breeding success, dietary and vegetation condition studies should he carried out at the same time.

2 DISTRIBUTION OF KOKAKO IN NORTHLAND

At present, none of the larger remnant tracts of mature indigenous forest in Northland have been surveyed adequately for kokako, except for Puketi Forest. Although wildlife surveys of Northland between January 1977 and January 1979 (Ogle 1982) sampled all of the forests likely to contain kokako, only five birds were found (two each in Mataraua Forest and in the Maungataniwha Range, and one in Puketi Forest). The techniques used in the 1977-79 survey were most suited to assessing the distribution, and relative abundance of the more common species of wildlife. They were not adequate for recording the rarer and more secretive species such as kokako, for which specific techniques are required.

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[1] Some of these include the effects of mammals on food availability, and the influence of mammalian predators on nesting success.

Detailed surveys are needed for kokako in all of the larger forest tracts in Northland having suitable habitat, the prime candidates being the Waipoua-Waimea-Matarau Forests continuum, Warawara Forest and the Maungataniwha Range.

SECTION NINE: RECOMMENDATIONS FOR THE CONSERVATION OF KOKAKO IN PUKETI FOREST, NORTHLAND

1 THAT NO FURTHER LOGGING TAKES PLACE

This recommendation is made because of the likely adverse impact that logging of mature kauri would have on the kokako population. Protection from logging should include not only the mature forest, but also regenerating forest and shrubland which may provide future habitat into which the kokako population could expand.

2 THAT CONTROL OF BROWSING MAMMALS BE CARRIED OUT

The present control of pigs should be maintained, and attempts should be made to eradicate goats and cattle. Fencing to exclude goats and other livestock should be carried out promptly. There is an immediate need for determining the level of the possum population in Puketi Forest and to reduce it to its lowest possible level. This should be undertaken in such a way that has the least possible effect on the native bird populations. Appropriate methods of possum control in forest inhibited by kokako have been assessed recently by the Forest Research Institute. Methods of possum control in puketi Forest should be formulated on the basis of that study's recommendations and only after consultation with the appropriate experts in FRI, DOC (Science and Research) and DOC Conservancies. Control of browsing animals is a priority not only because of the likely adverse affect on kokako of browsing of their habitat, but also to protect the floristic values of the forest. Emphasis on control of browsing mammals should recognise that Puketi Forest and adjacent Omahuta Forest are a single entity, and therefore management plans for mammal control should be intergrated.

3 THAT FURTHER RESEARCH ON KOKAKO BE UNDERTAKEN

There are needs to:

a) Determine whether the population in Puketi Forest is stable. Surveys should be carried out at five year intervals to monitor the population level.

b) Determine the bredding success kokako and the factors influencing the breeding success (e.g. food supply, predation, habitat quality and social behaviour). This work is necessary to ascertain whether birds produce adequate young per year to offset mortality. It may be necessary to devise methods by which breeding success may be enhanced (e.g. predator control in the vicinity of nests).

c) Determine the numbers and distribution of kokako in other large Northland forest remnants (including Raetea, Waipoua, Mataraua, Waima, Marlborough, Warawara and Omahuta Forests).

4 THAT ECOLOGICAL AERA STATUS BE EXTENDED TO PROTECT ALL OF THE INDIGENOUS VEGETATION IN PUKETI FOREST.

This would preserve all forest occupied by kokako and protect a wildlife habitat of international importance. This extension wouls also afford protection to important vegetation types and other features which are not safeguarded currently. The presence of kokako in adjacent Omahuta Forest underlines the need for protection of the entire forest tract, and their status in the adjacent forest tract needs to be established urgently.

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