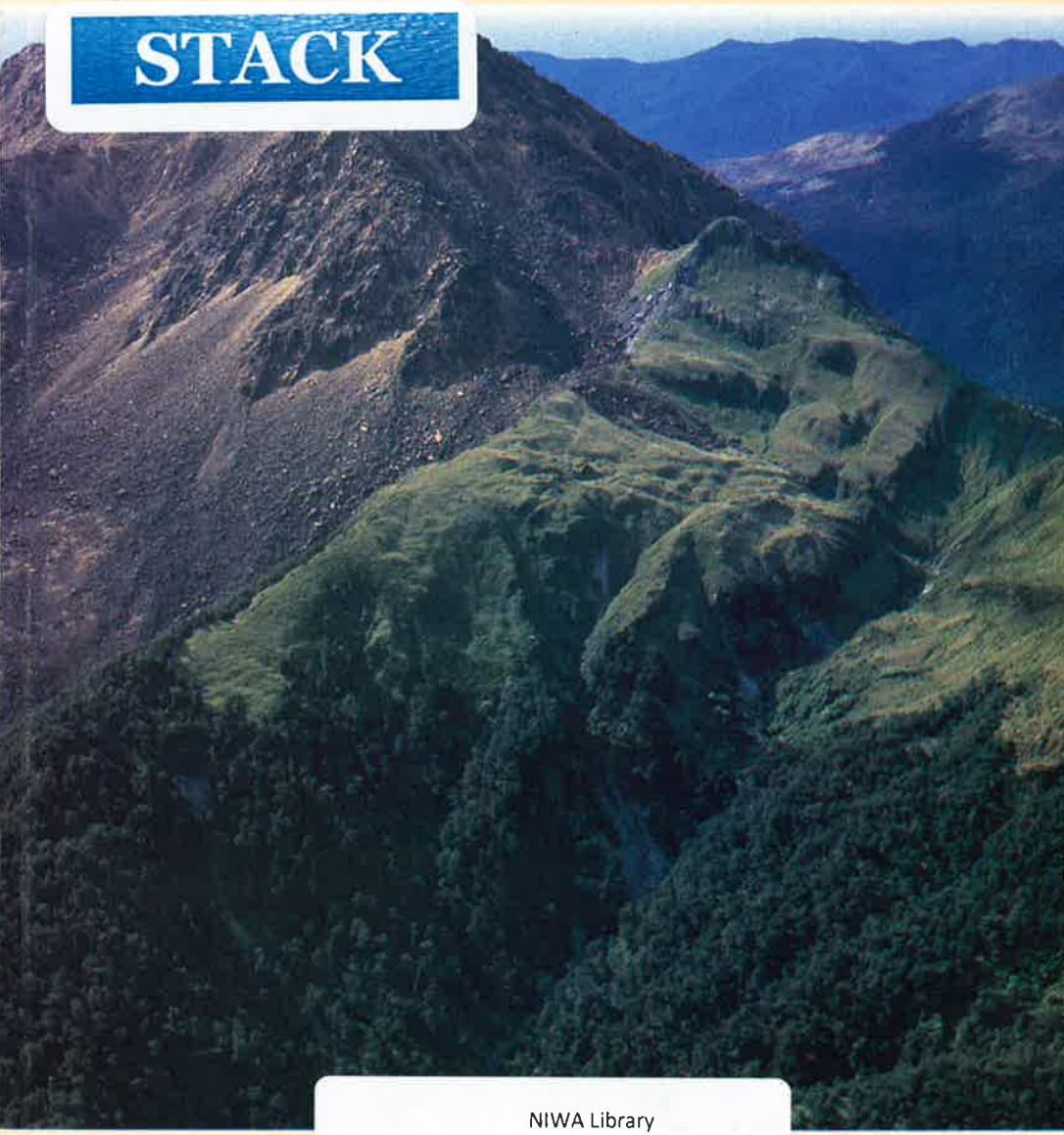
The Vegetative Cover of New Zealand

P F J Newsome



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THE VEGETATIVE COVER OF NEW ZEALAND

P F J NEWSOME
1987

The Vegetative Cover of New Zealand

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The 1:1,000,000 scale Vegetative Cover Map of New Zealand is the first vegetation survey which can be applied nationally for planning, research, and education. It optimises the cartographic potential of the vegetation information available in the early 1980s, and provides an historical record which will aid in future analyses of vegetative cover and land utilisation.

The map classification recognises 47 Vegetative Cover Classes identified by alphanumeric code, and 17 Vegetative Cover Elements identified by symbols and patterns. A spectrum of 16 colours and tones highlight broad physiognomic groupings while urban areas, roads, and areas of bare rock and ice are identified by shades of grey. The map comprises two sheets 730 mm × 880 mm, covering the three principal islands of New Zealand and all offshore islands within 100 km of the coast.

The 153 page book which contains 51 colour illustrations; considers the origins of New Zealand's vegetation and how it has been influenced by natural and anthropic factors, describes the compilation of the Vegetative Cover Map, and discusses the 47 classes. Each of the Vegetative Cover Classes are considered in the context of their composition, appearance, area and distribution, ecological influences, and their likely future under present environmental conditions and management.

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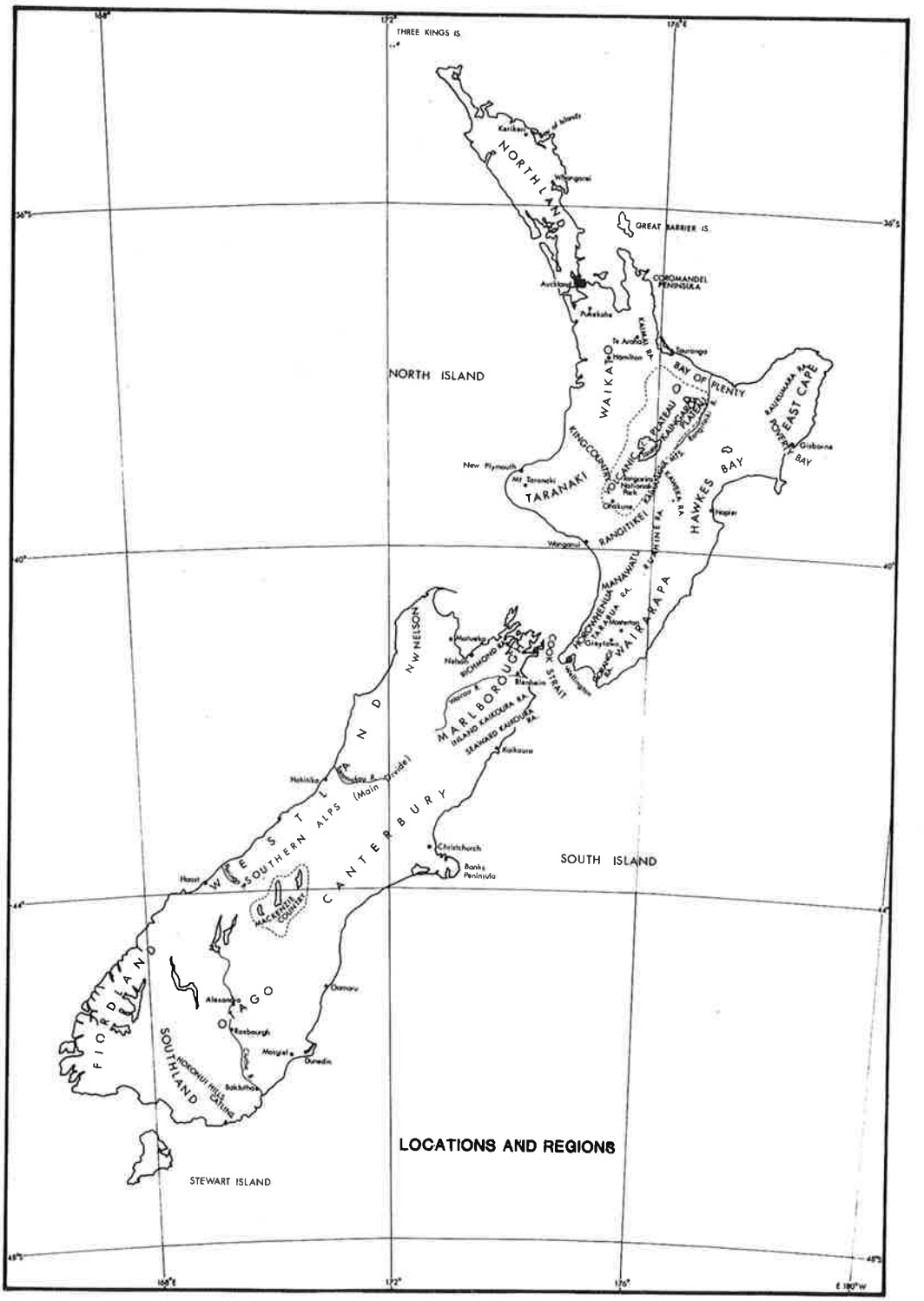
THREE KINGS IS.
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BAY OF PLENTY
EAST CAPE
RAUKUMARA RANGE
POVERTY BAY
Gisborne
New Plymouth
Mt Taranaki
TARANAKI
KINGCOUNTRY
VOLCANIC PLATEAU
Tongariro National Park
RUAPEHU
HAWKES BAY
Napier
RANGITIKEI
Wanganui
TARARUA RA.
PUKETOI RA.
WAIRARAPA
Wellington
Nelson
NW NELSON
RICHMOND RA.
Blenheim
COOK STRAIT
MARLBOROUGH
INLAND KAIKOURA RA.
SEAWARD KAIKOURAS RA.
Kaikoura
Hokitika
Haast
SOUTHERN ALPS (Main Divide)
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SOUTH ISLAND
MACKENZIE COUNTRY
FIORDLAND
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LOCATIONS AND REGIONS

INTRODUCTION

Most countries have developed strategies founded upon a sound base of physical resource information (rock, soil, and vegetation maps etc). New Zealand by contrast, while having vegetation maps which date from just prior to the Second World War (e.g. Hilgendorf 1935; Madden 1940), has never had a comprehensive, national vegetation map comparable to those available for geology and soils. Recently, however, the National Water and Soil Conservation Organisation completed the New Zealand Land Resource Inventory (NWASCO 1975-79) which includes vegetation as one factor in an inventory of five physical factors. While this did not in itself constitute a vegetation map it was obvious that it could provide a framework upon which existing information (e.g. Atkinson 1981; New Zealand Forest Service 1974) and field assessments could be placed, and so yield the first Vegetative Cover Map of New Zealand. The project began in 1981 and draws upon the work and the accumulated experience of many field mappers, resource scientists and ecologists. The product of this work, being the two map sheets and this accompanying book, aims to serve three broad functions (Kuchler 1967):

1. It is an inventory of vegetation communities occurring in a given time and place.

2. It is a tool for analysing the natural and cultural environment and the relation between it and the various vegetation types. As vegetation distribution is influenced by physical and cultural factors of the land, so may these factors be deduced from the vegetation.

3. It is a tool which will assist in the future planning for optimal land use.

Kuchler observes that *"Vegetation maps permit man to work in harmony with nature rather than against it or in ignorance of it"*. New Zealand's need of such maps is perhaps more acute than that of other developed countries, in view of its singularly short but ecologically significant cultural history and its natural history characterised by a very long period of independent evolution. New Zealand, its landscape, flora, and fauna have evolved during a period of 80 million years of virtual isolation from any other land mass.

The land which has emerged during this time extends over 13 degrees of latitude, a distance of 1600 km, from warm temperate climatic zones in the north to cold temperate in the south. It encompasses altitudinal zones from lowland to the high alpine. In its 27 million hectares it presents a host of landforms offering countless habitats for plants and animals.

The arrival of humans in the last thousand years, geologically speaking the last syllable of recorded time, has introduced a new armoury of landscaping tools. Nature's forces of volcanics, tectonics, wind and water were augmented by the axe, the firestick, exotic animals and the bulldozer. Only locally, following severe storms, volcanic events or earthquakes can the landscape changes of prehistoric times compare with the rate of change during the human era.

The impact of these forces is most clearly evident in the vegetation, and few media are better suited to depict the general state of the vegetation than is a map. It is the aim of the Vegetative Cover Map to present an accurate, though generalised, picture of the present form and extent of New Zealand's most important vegetation communities. In doing so, it conveys an image of New Zealand's landscape, its vegetation, and by implication, the modifications which have occurred in recent times.

At the present time New Zealand has a small but diverse flora of approximately 2000 indigenous vascular plants, augmented with over 1000 naturalised exotic species. These combine to form a comprehensive array of communities representing the major formations of forest, shrubland, grassland, wetland and alpine herbfield.

The native forests are all evergreen, although locally they may contain noticeable elements of deciduous species. They are dominated by various combinations of gymnosperms and angiosperms, termed "podocarps" and "broadleaves" respectively in this book. These are found in every conceivable combination from young vigorous stands dominated exclusively by podocarps, through an array of situations where podocarps are emergent over a broadleaved canopy, to forests in which solely broadleaved trees dominate. In addition to the native forests, there are over 1.2 million hectares of exotic forest in the North and South Islands, based principally upon pines but including a minor component of specialist hardwood timber trees.

The scrub and shrublands include indigenous colonising species in which manuka and kanuka (*Leptospermum* spp) and mixtures of broadleaved shrubs are nationally conspicuous, some relatively stable dryland communities, and subalpine shrublands. Exotic species such as gorse (*Ulex europaeus*) and sweet brier (*Rosa rubiginosa*) have assumed a position of some importance in many lowland and montane situations.

Indigenous grasslands, in which tussock grasses are the most prominent element, are naturally a feature of areas too dry, too wet or too cold to sustain

forest. These grasslands have, however, been greatly modified during the human era and have been augmented by extensive agricultural development based on exotic sward grasses. Exotic pasturelands currently occupy in excess of 7 million hectares of lowland and montane plains, and hill country.

Wetlands encompass a range of communities from the northern estuarine mangroves, almost unknown elsewhere outside the tropics, to inland mires dominated by rushes, sedges, flax and sphagnum.

In the high alpine environment among and above the limit of the snow tussocks, a unique flora of herbs and sub-shrubs has developed. These include mountain daisies and other composites, alpine buttercups and gentians, and *Hebe*, a woody genus which attains its fullest expression in New Zealand.

Among the indigenous vascular flora there is a high proportion (over 80%) of species found nowhere else in the world. Many of the remainder also occur in Australia 2000 kilometres to the west and it is with Australia that New Zealand's vegetation has most affinity. However there are notable relationships with plant taxa elsewhere in south-east Asian and Pacific lands extending north-east to Hawaii and as far east as South America (Godley 1975). To appreciate the reasons for these linkages one must begin many millions of years ago at the dawn of the creation of the land we now call New Zealand and then move forward and see how climatic change and the arrival of man has influenced these patterns.

The brief account of the geologic and biotic history of New Zealand, presented in the succeeding chapter, follows more rigorous descriptions in Fleming (1979), Stevens (1974, 1980), Gage (1980) and Cumberland (1981). The botanical nomenclature follows the "Flora of New Zealand" (Allan 1961, Moore and Edgar 1976, Healy and Edgar 1980) and "Standard Common Names for Weeds in New Zealand" (Healy 1984). The names of the indigenous snow tussocks follow Zotov (1963, 1970). Subsequent taxonomic revision and nomenclatural changes as summarised from time to time in the New Zealand Journal of Botany, particularly Edgar and Connor (1978, 1983) and Brownsey *et al* (1985), have generally been adopted. Botanical names are given in association with their respective common names, only at their first mention and thereafter the common names alone are used. A glossary of botanical and common plant names used in the text is provided at the end of the book. Words unfamiliar in common English usage, particularly those relating to botanical or geological concepts and identities, are defined in a glossary of technical terms also at the end of the book.

CHAPTER 1

NEW ZEALAND'S VEGETATION HISTORY

IN THE BEGINNING

Some 300 million years ago, the section of the earth's crust which was later to support New Zealand comprised a large, rapidly subsiding, undersea depression. This depression, known as the New Zealand Geosyncline, was located in antarctic latitudes off the eastern coasts of what were to become Australia and Antarctica, but which at that time were part of a much larger super-continent which researchers have named Gondwanaland.

For about 200 million years erosion debris from the nearby landmass of Gondwanaland was deposited in the New Zealand Geosyncline forming immensely thick accumulations of material. An arc of volcanic islands and undersea volcanic cones contributed volcanic debris to the basin. As the basin continued to subside the erosion debris were buried deeper and deeper and geological processes began to change these sediments into rocks such as sandstones and mudstones. With further increases in pressure and temperature, some were metamorphosed into schist and gneiss, and perhaps ultimately re-melted and solidified to form granitic rocks.

About 150 million years ago the the Rangitata Orogeny commenced, and continued for approximately 50 million years. This was characterised by a reversal in the behaviour of the earth's crust from subsidence of the basin floor to reflexion. The earth's crust began to buckle and evert and there emerged a new landmass, an ancestral New Zealand. The new land extended as far north as what we now call New Caledonia, as far south as Campbell Island, and as far east as the Chatham Islands. The climate was similar to that prevailing today. This primaeval, greater-New Zealand was colonised by plants and animals already present on neighbouring Gondwanaland and the volcanic islands of the former New Zealand Geosyncline. Among the animal migrants were the ancestors of some of New Zealand's more distinctive elements; the Leiopelmid frogs (notable for having no free-living tadpole stage), the tuatara, and the ratite birds (notably the moa and kiwi). The plant life was no less distinctive and comprised ancestors of the modern conifers, including the podocarps and kauri (*Agathis australis*), the

forerunners of our modern ground ferns and tree ferns, and remnants of an even more ancient and now extinct group of spore-bearing herbs and trees.

The next 20 million years (from 100-80 million years ago) were characterised by a cessation of the geologic uplift coupled with a gradual lowering of relief as erosion began to wear down the land. Concurrently, there was continuing colonisation by plants from the ancient lands which then comprised Gondwanaland. This period was notable for the rapid worldwide evolution, speciation, and expansion of a new lineage of plants, the flowering plants or Angiosperms. The ancestors of the southern beeches first appeared in the New Zealand flora at this time.

During this period and in the following 20 million years (up to 60 million years ago), the primaeval super-continent of Gondwanaland began to disintegrate. This colossal geologic rifting between the earth's crustal plates was followed by a gradual drifting away of sections of this greater landmass. The break-up of the Gondwanan super-continent occurred later in the Australasian sector than elsewhere and there was little impediment to plant distribution in this region until 70-80 million years ago. By this time the growing ocean gap between Australia/Antarctica and New Zealand was about half that of the present day. But, before these links were severed, there arrived recognisable ancestors of tawa (*Beilschmiedia tawa*) and rewarewa (*Knightia excelsa*), and quite probably a host of other flowering plants. In the ensuing competition for habitats, and in the face of continually fluctuating climates, many of the ancient lower plants and gymnosperms, and some of the angiosperms, became extinct.

Erosion continued to be a feature of the next 45 million years. During this time much of the land was gradually submerged beneath the sea, and the relief of the remainder became reduced to a low peneplain. The climate underwent a series of oscillations between warm temperate and cold temperate, with two pronounced warmings to subtropical conditions around 55 and 20 million years ago. The first evidence of an ice cap in the now polar continent of Antarctica dates from about 45 million years ago (Kemp 1978).

In ancestral New Zealand, now geographically isolated, the flora continued to adapt and evolve independently from its congenitors in what were to become South America, Australia, New Guinea and Antarctica. The great podocarps continued to dominate much of the forests but in association with a growing proportion of broadleaved species. Among the latter were recognisable ancestors of fuchsia (*Fuchsia excorticata*), hinau (*Elaeocarpus dentatus*), kamahi (*Weinmannia racemosa*), kohekohe (*Dysoxylum spectabile*), pukatea (*Laurelia novae-zelandiae*), rewarewa, rata (*Metrosideros* spp), tawa, species of *Coprosma, Leptospermum, Pittosporum*, and many ferns, epiphytes, lianes and grasses.

Fleming (1979) recognises three geographic affinities in this flora: an Australian (typified by *Leptospermum*), a Paleoaustral (for example the beeches, the podocarps and rewarewa) and a Malayo-Pacific (including many ferns, nikau (*Rhopalostylis sapida*), kohekohe, tawa and mangrove (*Avicennia marina* var *resinifera*). Many of these species recognisably present in the fossil record from around this time would have been present in New Zealand prior to the ultimate separation from other Gondwanan lands. Others would have established by chance dispersal across the ocean, or by "island-hopping" along an archipelago which may once have extended northward along the Lord Howe Rise and southward along the Campbell Plateau. All would have undergone adaptation or speciation to compete in the array of niches in their new environment. Less competitive plants would have diminished in numbers and many would have faced extinction. It is noteworthy that during this time of speciation and adaptation in the New Zealand flora, other lands were witnessing the evolution of mammals, most of which were to become specialist herbivores. New Zealand, by contrast, remained populated with a relatively modest array of birds and insects. These, while exploiting a variety of habitats, were never to exert as great a level of environmental pressure on the vegetation as the mammals.

Approximately 13 million years ago there began another phase of mountain building the Kaikoura Orogeny. This was characterised by extensive faulting, folding and uplift, both of the existing land and also of the coastal sediments produced by the previous 100 million years of erosion. These geologic events coincided with a gradual climatic cooling which culminated two million years ago at the beginning of the Pleistocene glaciations.

The Pleistocene period lasted until almost 10,000 years ago, during which time the New Zealand flora was subject to the rigours of an increasingly severe climate. For the more tender elements of the flora, stranded on a land similar in size and shape to the New Zealand of today, there was no escape northward to more temperate latitudes. Forest species retreated to lower altitudes and northward, and into local refugia of favourable climate. Shrublands and grasslands expanded to take their place as far as their own limits of tolerance would allow. There was strong selection pressure for the evolution of a flora to fully exploit the increasing area of land between the depressed treeline and the zone of perennial ice and snow. This pressure for an alpine flora was satisfied in part by speciation and hybridisation among 'genetically plastic' lowland and montane genera, for example *Celmisia, Coprosma, Dracophyllum, Hebe, Myrsine* and *Podocarpus*. Others may have arrived by migration of elements of Antarctic and tropical mountain affinity, for example *Epilobium, Gentiana* and *Ranunculus*. But the plants which were adapted to the lowland habitat were in a more difficult predicament. With their retreat to warmer latitudes cut off, extinction for many species was inevitable. So this period saw the disappearance from New Zealand of a

number of elements which had been prominent in the preceding 40 million years. Among those to disappear were a group of large-leaved beeches previously common in an arc from New Guinea, New Caledonia, Australia, New Zealand through Antarctica to South America but now only present in New Guinea and New Caledonia.

For the most part however, there was a more or less complete recovery of the vegetation during the interglacials and in the present post-glacial period. Forest occupied all but the most arid lowlands and extended up-slope to meet the now well developed highland shrublands, grasslands, and alpine herbfields.

THE POST-GLACIAL PERIOD

The post-glacial period was characterised by a gradual warming which culminated about 8000 years ago. Since this time, the climatic regime has oscillated around an average similar to, but slightly warmer and wetter than, the present day (Denton and Karlen 1973, McGlone and Topping 1977). These comparatively minor fluctuations in climate would have had an unsettling effect upon the vegetation resulting in constant small adjustments in plant distribution. But the great longevity of many forest trees and even the larger tussock grasses would have served to smooth out the effects of the more extreme climatic fluctuations.

More spectacular changes, although quite local in extent, are those initiated by sporadic volcanic events, or fire caused by lightning. Fire is known to have been widespread during this period (Molloy *et al* 1963) and is likely to have been most extensive in the drier eastern districts. Volcanism has been a feature of New Zealand for millions of years and has conferred upon the landscape such features as Banks Peninsula, the Taranaki volcanoes and those of the Volcanic Plateau, parts of the Coromandel Range, and many hills and domes in Auckland and Northland.

The New Zealand flora was well able to adjust to these and other types of disturbance, having as it does, a range of successional mechanisms to recover from natural disasters. But these natural events have usually been in the form of either gradual and extensive change or local and sudden catastrophe. Then, overnight in evolutionary terms, the character of disturbance changed to a form of repeated extensive and sudden catastrophes. This change was consequent upon the arrival of humans.

THE POLYNESIAN ERA

It is not known exactly when the first human set foot in New Zealand, but the earliest conceivable arrival of the Polynesians is thought to be about 750 AD (Cumberland 1981). Their manner of coming and their numbers are also a matter for conjecture. Current opinion reported by Cumberland (1981) inclines towards a theory of repeated accidental colonisation from large

canoes carried off course on inter-island voyages, and under the influence of wind and current, making a landfall on the coast of New Zealand.

It is presumed that among the canoes' cargoes were the tropical foods of the Polynesians: kumara, taro, yam and gourds, all of which require a mild climate and care in cultivation. In this new-found land, which was colder and wetter than they were used to, and largely covered with forbidding forest, the Polynesians found rich compensation in a prolific bird fauna, fertile soils and a range of edible plants.

Whilst the bulk of the Maori population remained concentrated in the north where the warmer climate allowed growth of their tropical crops, other parties began to explore the southern regions. These southern Maori, foraging for fern-root, fruits and shellfish and hunting the flightless moa and other native birds, evolved a parallel but separate culture to their northern kinsfolk. This gave rise to the myth of an earlier, more primitive, moa-hunter people.

In addition to their tools of bone, wood and stone, both the farming and the moa-hunting sub-cultures brought with them fire and used it in hunting, in communications, and in agriculture. Walsh (1896) relates

> *". . . the firestick formed an important part in their travelling outfit and was constantly in requisition to clear away the dense growth of fern or tea-tree which impeded their movements . . . . Such fires were noticed by Tasman as he sailed along the western coast 250 years ago . . . ".*

In northern regions, even with their higher populations, the area affected by fire was comparatively modest when compared with that of the central and southern regions. The northern Maori used fire principally as a tool to clear land for food crops. In these regions of heavy forest and a moist climate, it is probable that containment of burns was usually successful and repeated uncontrolled fire unusual.

In central, eastern and southern regions the effect of fire was more marked and more remarkable in view of the comparatively low density of Maori population. Fire was employed as a tool in hunting moa, to favour the growth of edible bracken fern (*Pteridium esculentum*), and to open up routes of travel southward and into the interior. For these purposes containment of burns was less critical but there were also climatic factors which made fire a much more devastating weapon here, than in the northern and western forests. Most of New Zealand's weather derives from a succession of high and low pressure systems originating over the Tasman Sea and Australia. To a large degree the rain that they bring is intercepted by the western ranges giving a "rain shadow" effect to the eastern regions. Coupled with this naturally drier climate is a hypothesised climatic change to slightly cooler, drier conditions than was present 2000 years ago (Holloway 1954, McGlone and Topping 1977), although the evidence for this is by no means unequivocal (Burrows and Greenland 1979). For whatever reason the less dense, eastern

podocarp-broadleaved and beech forests have a much more tenuous hold on the drought-prone hills and plains. Therefore, they were less able to recover from the repeated fires which raged through their domain. As a consequence, in the millennium before the arrival of the Europeans, forest was eliminated from much of the eastern lowlands from northern Hawke's Bay to Southland. Figure 1 shows the reduction in forest cover over the country as a whole from approximately 75% of the total land area in about 700 AD to approximately 55% in 1800 AD (Cumberland 1981; Wards 1973).

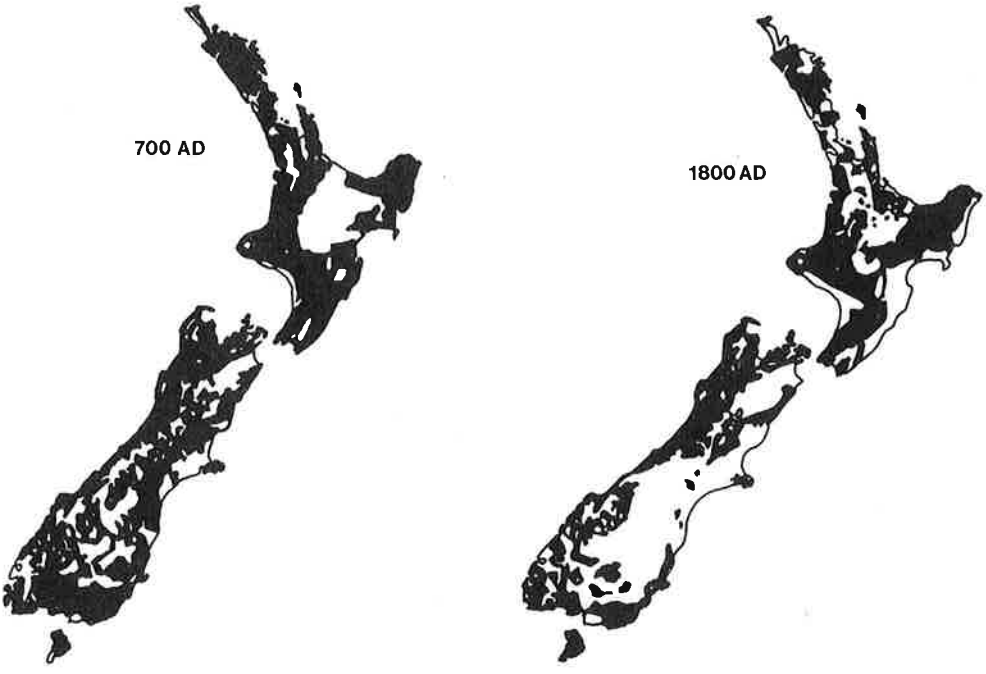


Figure 1: From 700 AD to 1800 AD there was a reduction in forest cover from approximately 75% of the total land area to approximately 55% (adapted from Cumberland 1981; Wards 1973).

The forest clearance was not synchronous throughout. As Maori populations increased and spread into less inhabited areas, there was an increase in the number and size of clearings made for village sites, gardens, and along routes of travel. Studies of the age of buried woods and charcoals in the eastern South Island (Molloy *et al.* 1963) show that there was a progression from earlier fires on the coastal plains, to later fires in the interior.

As time passed, the once plentiful moa became rarer on the coastal plains where the larger species had lived, and so they were pursued further and further into the inland valleys and basins. As the hunting became more difficult even the use of fire to drive the flocks from their retreats yielded fewer prey. Ultimately, not long before 1800, even the small bush moa had been hunted to extinction.

Consequent upon the decline in moa populations there was a decline in the prosperity and cultural strength of the southern moa-hunting Maori. This opened the way for tribes from the north to extend their influence in the south. And so it was, that the moa-hunter culture was eventually subjugated by the "classic Polynesian culture" from the north, to the extent that this was the Maori civilisation which prevailed when Tasman and Cook visited New Zealand in the 17th and 18th century (Cumberland 1981).

European contact was sporadic and local until almost the middle of the 19th century. However, even those early encounters were later to have enormous effect on the ecology of the land. For with them the early Europeans brought the first truly exotic plants and animals since the Maori introduced their own food crops and the Polynesian rat and Polynesian dog. These early explorers, whalers and sealers released pigs and goats and even established cultivated gardens.

Among these garden crops, and thought to have been introduced around 1770, was the potato. This immediately caused an agricultural revolution among the Maori (Cameron 1964). Here was a crop whose cultivation technique they readily understood and whose climatic range, soil tolerance, and productivity were far in excess of the kumara. Furthermore, potatoes and other foods had an increasing trade value to the rising numbers of whalers, sealers, and flax and timber merchants visiting the coast of New Zealand. This saw a resurgence in demand for arable land and a renewed assault on the forests and shrublands, particularly in the north. Many of the early writers described the shifting agricultural technique, and the land clearances effected. This account by Dieffenbach in 1843, reproduced by Cameron (1964), is typical of the period leading up to large-scale European settlement:

> *"It is evident that the forest has at some former period covered a greater extent of land in the neighbourhood of Taupo than it now does: it does not appear to have been destroyed by volcanic eruptions but by the fires kindled by the natives in order to clear the ground for purposes of cultivation . . ."*

As the 19th century advanced the early whalers, sealers, missionaries, explorers and traders were followed by increasing numbers of settlers, and so were heralded the most far-reaching and rapid changes in New Zealand's long history.

THE EUROPEAN ERA

Conventionally 1840 is taken to mark the beginning of the European era, although local settlement on a small scale had been known from the beginning of the century. The centres of population in the early days were in the north—around the Bay of Islands, Auckland and Tauranga—and later

in the areas of Wellington, Nelson, New Plymouth, Wanganui, Canterbury and Otago. Other settlements were subsequently established as new immigrants arrived and as populations began to move from the coastal settlements into the interior.

In many areas, particularly in the North Island, and despite the forest clearances made by the Maori, a necessary prerequisite to making a living was to first build a dwelling, clear the forest and scrub, and sow the land with pasture grasses. To this task the settlers applied themselves with a dogged zeal. They would cut the standing trees and leave them to dry over the hot summer months and then return in the autumn to burn the felled forest. Timber mills were often established alongside the best stands of forest to serve the growing demand for sawn timber. Hundreds of small sawmills were established throughout the country and began a thriving trade principally milling kauri (in the north), totara, rimu and matai for both the domestic and export markets. But, in the face of a more immediate need for pastoral land, vast areas of prime forest, beyond the reach of the millers, were simply destroyed by burning.

Early writings of this period observe, often with sadness how, for days and even weeks at a time, the autumn sky would be darkened with smoke and the night lit with the glow of the forest burns (e.g., Reed 1948). The Rev. P. Walsh in 1896 expressed concern at the destruction of the northern forests in an address to the Auckland Institute:

> *". . . since the axe and the saw have come into operation the living bush has been attacked throughout the length and breadth of the land, and not only is an increasing area annually deforested for farming purposes but the bush is gutted in all directions by timber-workings and roads and telegraph lines."*

In the drier eastern areas, particuarly those of the South Island, the pattern of development was somewhat different. Much of this country had been cleared of forest during the Polynesian era and now supported vast areas of short tussock and snow tussock grasslands. This was a landscape which the settlers of the old world felt they understood and to which they applied farming practices from their homelands, sometimes modified by experience gained in the Australian colony. Large pastoral runs (or "stations") were taken up and stocked with sheep, often the fine-wool Merino breed. Unconfined by fences the flocks grazed widely from the plains and river flats to the alpine tussocklands of the mountains. To promote the growth of palatable young shoots and to assist in mustering the runholders would periodically burn the tussocks.

At first the results were encouraging and, as the settlers had experienced in their home country, fire promoted a flush of soft young palatable shoots. However, after a succession of fires a different effect began to show. After

each burn the vigour of the tussocks decreased and fewer and shorter new shoots appeared. With the resulting decrease in ground cover, frost action began to severely inhibit seedling establishment and to loosen soil particles so that erosion became a serious problem. John Buchanan, then of the Geological Survey of New Zealand, wrote in 1868:

> *"Nothing can show greater ignorance of grass conservation than the repeated burning of the pasture in arid districts, which is so frequently practised. . . . Much of the grass land around Otago has been thus deteriorated, since its occupation, by fire, and it is no wonder that many of the runs require eight acres to feed one sheep . . ."*

During the wheat boom of the 1870s much of the lowlands of the eastern South Island were converted from tussock to cropland. Today arable cropping in rotation with fat lamb farming on sown pastures, continues to be a prominent land use in this region. The expansion in the 1890's of a frozen meat export trade saw a growing emphasis throughout the country on fat lambs and cattle farming and a lessening reliance on wool.

By the beginning of the First World War the pace of forest clearance in the northern and western districts was slowing down. Much of the cleared land had been sown to some form of permanent exotic grassland. In the years following the war there was more emphasis on 'infilling' in the rural sector, with larger station blocks being broken up into smaller farm units and more intensive development on hitherto poor pasture and scrubland. In some localities, soldier resettlement schemes saw a renewed development drive in marginal hill country. Some such schemes, particuarly those in the steep hill country of inland Wanganui-Taranaki-King Country, provided only years of heartbreak and ultimate failure because of high rates of soil erosion and scrub reversion, coupled with low stocking densities and very expensive roading. In the central North Island on soils derived from volcanic ash, the mysterious "bush sickness" plagued the early sheep and cattle farmers. Here and elsewhere as the depression years of the late 1920s loomed, many farmers were forced to abandon their hard-won gains of the previous decades.

From the mid-1920s an embryonic Forest Service began large-scale planting of exotic pine forests on the rapidly reverting lands of the Kaingaroa Plateau. These projects provided work for some of the thousands of unemployed during the Great Depression and later made available an alternative source of timber to the fast-dwindling areas of native forest. The momentum of these early efforts was to continue, and when joined by those of private companies, these plantations were to form the nucleus of today's large exotic forest estate.

By the middle of the 20th century virtually all the plains and downlands, and much of the low hill country had been cleared of forest or scrub and

converted to agricultural use. High-producing exotic grasses and clovers occupied a significant and increasing area of the country. More intensive farming and cropping on relatively small holdings became the norm, especially in the lowlands.

However, darkening the horizon of both the developed and the undeveloped land was a growing problem which had its roots in the very early days of the colonial period. The early settlers had brought with them, either by accident or design, an array of plants, fish, land animals and birds from their respective homelands or from countries in which they had travelled. Many of these introductions were absorbed into the New Zealand biota with little environmental impact, but others began to run rampant across the land.

The first 'naturalised exotic' to reach pest proportions was the rabbit. From the 1870s, through to shortly after the Second World War, these prolifically-breeding, voracious animals were responsible for the degradation of millions of hectares of extensively-farmed pasture and tussockland. In their effort to control the problem, farmers and the authorities tried shooting, poison, cats, dogs and ferrets and erected many kilometres of rabbit-proof fencing, but these measures served only to retard the rabbit's advance. It was only after the Second World War and the technique of aerial dropping of poisoned bait that success appeared possible.

Among animal pests of similar magnitude are the possum and deer, and locally goats, pigs, thar, and wapiti. Because these animals established themselves largely in undeveloped or 'wild' habitats, and because they browsed at different levels in a forest structure, they have had an insidious and drastic effect on forest health and regeneration. These effects are manifest in the loss of vigour and death of palatable trees, increased susceptibility to disease, reduction or loss of understorey shrubs and seedlings, and, with the depletion of vegetative cover, a higher incidence of erosion and wind damage.

Of New Zealand's naturalised exotic flora of over 1000 species, only about a score are gazetted as Noxious Plants (Upritchard 1985). The threat of some of the more aggressive adventive plants is familiar to most people, and concern has been expressed since the early days of botanical writing. Armstrong in 1879 remarked:

> *"The rapidity with which these introduced plants have spread over the province of Canterbury is indeed an extraordinary circumstance . . ."*

and Townson in 1906 observes:

> *". . . I was sorry to see that the country round the Junction* (Inangahua Junction, North Westland) *was overrun with blackberry, and I noticed that it had taken complete possession of several paddocks near the bridge . . ."*

For the most part the degree of notoriety with which these 'weeds' are held is dependent on how much they interfere with human agricultural practices. Therefore, held in lowest esteem are plants like gorse (*Ulex europaeus*), sweet brier (*Rosa rubiginosa*), broom (*Cytisus scoparius*), *Hieracium* spp and blackberry (*Rubus fruticosus*) as well as thistles, ragwort (*Senecio jacobaea*) and a number of other agriculturally valueless or detrimental herbs or shrubs. Other plants are viewed with disdain and alarm by ecologists because of their potential to do irreparable harm to indigenous ecosystems and here must be included *Pinus contorta*, old mans beard (*Clematis vitalba*), *Hakea* spp and heather (*Calluna vulgaris*).

With all these plant and animal pests it was eventually realised that early policies of 'extermination' were impractical, and so the emphasis changed to a policy of 'control'. The experience of recent years suggests that even with the more advanced methods available it will demand constant application to contain the menace which some of these plants and animals present.

The years following the Second World War saw further advances in land use technology and a maturing of New Zealander's attitudes with regard to land use issues. Aerial topdressing provided an economic method for applying fertiliser and improved pasture seed to hill country, and offered an avenue for the control of crop diseases, noxious weeds and noxious animals via aerial spraying and poison drops. A more appropriate, and financially rewarding, use of high producing land was afforded with the cultivation of horticultural and orchard crops such as berryfruit, citrus, pip and stone fruit, grapes, kiwifruit and subtropical fruits. Meanwhile, on the less productive land, after a century of unrestricted and often ill-advised development, there was increasing concern that the cost in terms of soil erosion, deposition and flooding had long passed that which was acceptable. As a consequence, a soil conservation organisation was established with the responsibility for soil erosion control and repair, and to apply the principles of wise land use to help minimise future hazards. Recently the whole issue of environmental conservation has received wider public attention with a sharpened focus on land planning, district and regional schemes, moves toward a representative system of parks and reserves and most recently, with the establishment of government departments with a statutory responsibility for environmental and conservation issues. The natural end point of this trend, a land and people co-existing in harmony, is still far in the future. Meanwhile the Vegetative Cover Map provides a representation of New Zealand's ever-changing landscape giving a hint of the turbulent past and offering to the perceptive some suggestion of where the future might lie.

CHAPTER 2

AN ANALYSIS OF TODAY'S VEGETATION

For over a century now researchers have been studying New Zealand's flora, compiling species lists, observing plant form and anatomy, classifying into taxonomic units and noting community structures and their adaptation to their environment. Much has been written on individual plants or selected plant groups, on selected vegetation zones throughout the country or selected localities throughout all vegetation zones. Occasionally an ecologist attempts a synthesis as Cockayne did in his "Vegetation of New Zealand" (1928) and "New Zealand Plants and Their Story" (1967). Other accounts include Godley's (1975) "Flora and Vegetation', those published in the New Zealand Atlas (Wards 1973) and in "The Natural History of New Zealand" (Williams 1973). More recently Blaschke *et al.* (1981) published an analysis of New Zealand's vegetative cover using data from the New Zealand Land Resource Inventory Survey (NWASCO 1975-79), the first study to be based upon surveyed areas. The Vegetative Cover Map of New Zealand provides an opportunity to both update and expand upon Blaschke's analysis.

A bulletin describing the New Zealand Land Resource Inventory Vegetation Cover Classification which superficially resembles some classes in the Vegetative Cover Map legend was produced by Hunter and Blaschke (1986). This publication differs from Hunter and Blaschke as follows:

- Hunter and Blaschke discuss the development of the classification and the methods of mapping and recording vegetation cover at the scale of 1:63,360, whereas this publication reinterprets and updates that information at the scale of 1:1,000,000. See Chapter 3 for details.

- Hunter and Blaschke describe 44 vegetation cover classes within 5 vegetation groups and which were recorded in about 6000 combinations nationally. This publication distinguishes, within 8 physiognomic groups, 47 vegetative cover classes which are either pure communities or associations of two communities.

In reading the following account of the vegetation and in interpreting the maps, the reader may find it helpful to consider two ecological concepts:

The first is that change or adaptation to environmental forces is presently occurring and will continue to occur. This is particularly so in New Zealand with its geologically youthful landscape and its short cultural history. The present condition is summarised in the following extract:

> *". . . Presently there are six million hectares of remaining indigenous forest. Approximately the same area of occupied land is unimproved tussock grassland and related associations. For only about a quarter of these 12 million hectares can be found convincing evidence of ecologic or cultural stability in their present conditions. There are nearly three million hectares of land cleared from forest on which pastoral farming has hitherto failed. There are about 10 million hectares on which farming is succeeding. A half million hectares are devoted to exotic forestry. In short, half the land area of New Zealand is occupied by life systems which have either ecological or cultural stability, half by systems which lack both."* (O'Connor 1973).

The second concept is that of a series of natural continua. The vegetation communities, their structure and composition, change continuously in both time and space in response to changes in other environmental conditions. In reality there are few boundaries in nature, but the very act of describing natural features requires that the subject be ordered and classified. The reader must be aware that the classification and the map unit boundaries are an artifact, one devised after painstaking and exhaustive thought, but still an artifact. Nevertheless, a map, while it can only approximate the continuous natural systems, remains one of the most expressive forms of ecological account.

This chapter begins a narrative of New Zealand's present vegetation as portrayed by the Vegetative Cover Map. It focusses on the major vegetation complexes, the Vegetative Cover Groups (figure 3, page 26; table 1, page 28).

The underlying logic to the Vegetative Cover Groups is based on the assumption that at 1:1,000,000 scale there are three dominant plant formations in New Zealand; **Grassland, Scrub** and **Forest**. Conceptually, these may be regarded as the "pure" communities, being dominated by just one plant form—grasses, shrubs or trees respectively. In the majority of instances, the communities in the **Grassland** and **Forest** Groups, are relatively close to a "steady-state" condition i.e. they effectively have either cultural or ecological stability. Except in the sub-alpine zone those in the **Scrubland** Group are less stable and are usually undergoing succession towards forest. In addition to these primary groups there are, by association, three binary groups; **Grassland-Scrub, Grassland-Forest**, and **Forest-Scrub**. These may be regarded as the "mixed" communities, being dominated by two plant forms. A greater proportion of communities in the binary groups than in the primary groups, are successional or at least are potentially so under present environmental conditions. In many instances the communities described have

no strong ecological basis and may merely be a common geographical coincidence of two unrelated plant communities. The remaining two groups, **Cropland** and **Miscellaneous**, are assemblages of economically or ecologically important communities which are not affiliated uniquely with the preceeding groups but are nationally significant and are resolvable at 1:1,000,000 scale.

The following account is amplified in Chapter 4 by more detailed descriptions of the individual plant communities, the Vegetative Cover Classes (figure 7, page 39). A diagrammatic representation of the altitudinal zones referred to in the following passages and in Chapter 4 is provided in figure 2 (below). A guide to map interpretation is presented in Chapter 3.

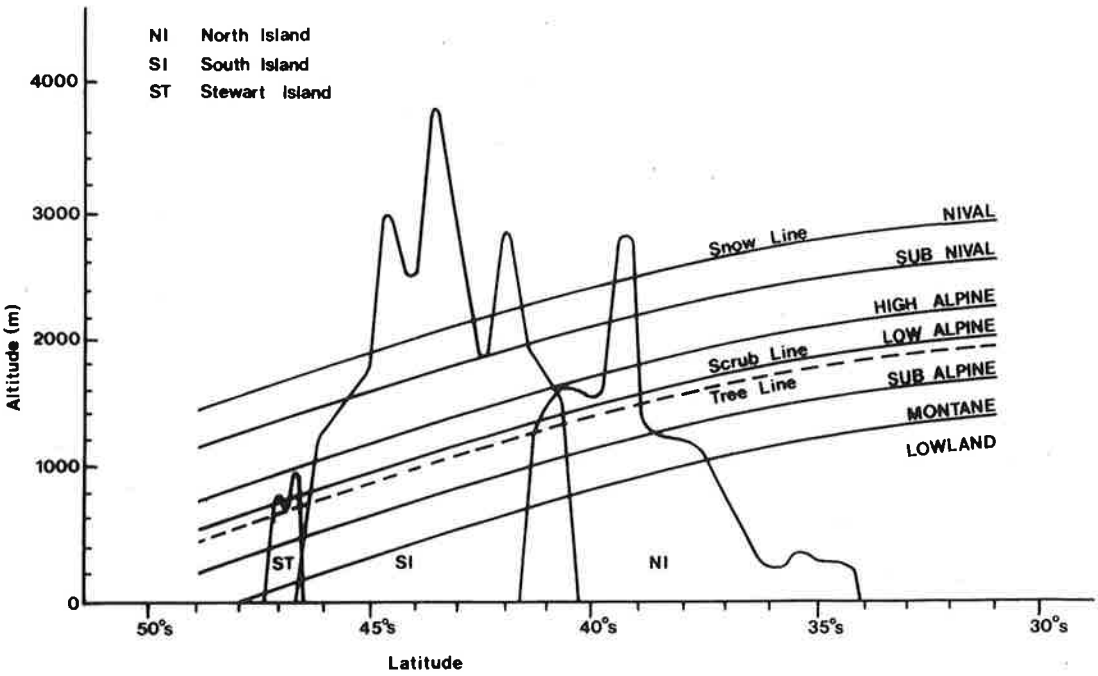


Figure 2: Altitudinal zones in New Zealand in relation to Latitude and Altitude. Derived from Fleming 1979, Burrows 1967, Wardle 1964.

THE MAJOR PLANT FORMATIONS

The vegetation today represents the sum of the interactions of the factors of biota, climate and soil during the whole of New Zealand's history. Overshadowing the effects of a great many other factors is the influence of the human race, who in the space of a thousand years have effected changes as significant as those which took place over millions of years in former times. Discussions on New Zealand's vegetation have conventionally identified an adventive or introduced flora (post-dating the arrival of humans), and an indigenous flora (pre-dating the arrival of humans). These two florae are now inextricably linked components of the modern New Zealand vegetation, albeit with identifiable entities whose origin may be either indigenous or exotic. From place to place about the country one or other

of these components may attain a greater representation in the vegetation than the other, as the following account and the Vegetative Cover Map will show. Some communities have a cultural stability maintained by the continued activities of humans, while others have achieved a degree of ecological stability independent of human influence. The remaining, still large, proportion is contained in a range of dynamic communities variously drawn toward one or other of these stable conditions.

Very little remains today of the vegetation which greeted Captain Cook when he stepped ashore in 1769 and proportionately even less than that which confronted the first Polynesian a millenium ago.

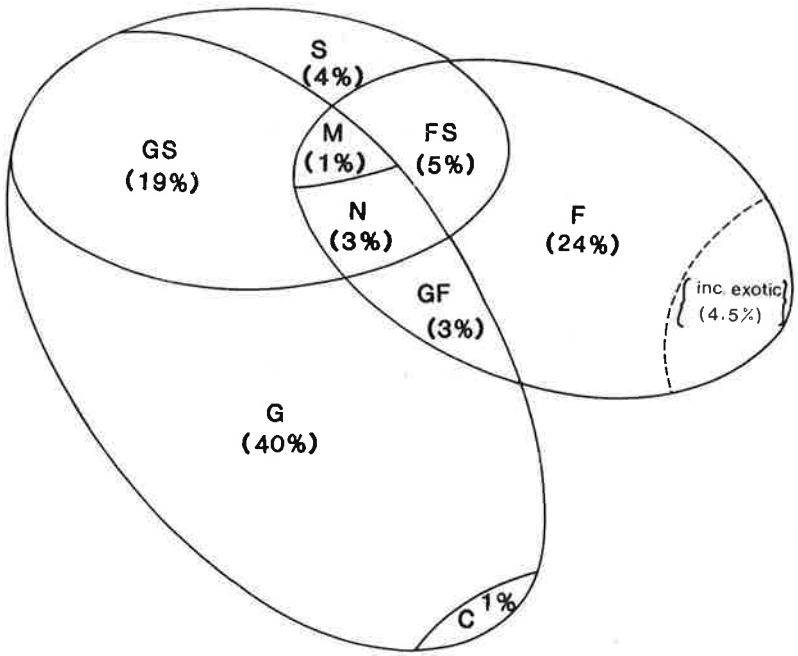
The floodplains, low terraces and dunelands

On the floodplains, low terraces and dunelands up to an altitude of about 200 metres, only a vestige of the former vegetation remains and even this is sporadically represented. The vast majority of the vegetation communities in this zone are dominated by exotic species and are intensively managed for agricultural production. Most are classified as **improved pasture** on the map and are devoted primarily to dairy, fat lamb, and beef farming. Virtually all of New Zealand's orchards and vineyards, vegetable and horticultural cropping and a large proportion of the field cropping is practised in these lowland areas.

Most of the coastal dunelands are now dominated by the introduced marram grass (*Ammophila arenaria*), while extensive areas, particularly in Northland, the western North Island and the eastern South Island, have been converted to sown pasture or planted as exotic production forest. Likewise, most of the wetlands which once occupied extensive areas, particularly in Waikato, Manawatu and Southland, have disappeared, leaving only scattered remnants in places where there has hitherto been little economic incentive to develop for farming.

Similarly undeveloped sites, with some notable exceptions, often support remnants of the formerly ubiquitous lowland kauri, podocarp, podocarp-broadleaved and broadleaved forests. These remnant forest stands are usually recognised as **Grassland-Forest** communities on the map, and frequently comprise young (80-150 year old) regrowth stands rather than mature forest. Locally in regions such as Northland and Southland and more extensively in Westland and Stewart Island, larger forest remnants are resolvable as **Forest** or **Forest-Scrub** communities, but these, where not protected in reserves, diminish yearly as a result of continued logging and land clearance.

Grassland-Scrub communities, often indicative of low intensity pastoral management, are not well represented on the plains and low terraces. They are most frequently encountered in Northland and Westland, areas which



C	**Cropland**	**FS**	**Forest-Scrub**
G	**Grassland**	**F**	**Forest**
GS	**Grassland-Scrub**	**M**	**Miscellaneous**
S	**Scrub**	**N**	**Unvegetated**
GF	**Grassland-Forest**		

Figure 3: Venn diagram representing Vegetative Cover Groups in New Zealand. The areas of the ovals and their intersecting segments are proportional to the areas of the respective Vegetative Cover Groups in New Zealand.

are in their first few decades of pastoral development, and in the drier (though not semi-arid) eastern areas of the North and South Islands.

The hill country, downlands and high terraces

On the hill country, downlands and high terraces, betweeen about 200 metres and 500 metres altitude, most of the land is still under pastoral management but the greater proportion of this remains in a strongly dynamic state. **Grassland-Scrub** and **Scrub** communities compete for dominance with exotic pasture grasses. The scrub communities are many, but in the North Island and moister areas of the South Island they are dominated by mixed broadleaved shrubs, *Leptospermum* and bracken communities, while in the drier inland South Island matagouri and sweet brier dominate. **Gorse scrub**,

as shown by the map, is of local significance in the vicinity of Wellington and in Marlborough and Southland.

Forest remnants, often occurring in gullies, scarps and steeper hillslopes, are more frequently encountered here in the hills, downlands and high terrace country, than on the plains and low terraces. These remnants, commonly of mature forest, are identified on the map as **Grassland-Forest** communities, and small **Forest-Scrub** and **Forest** units. More extensive areas of mature and modified forests are encountered in the steeper hill country such as in the King Country-inland Taranaki-Wanganui region and in the foothills of the main ranges. The greater proportion of New Zealand's 1.2 million hectare exotic forest estate occurs here with particular concentrations on the Volcanic Plateau and in the regions of East Cape, Hawke's Bay, Nelson, North Canterbury, Westland and Southland.

The remainder of the field and vegetable cropping is practised on these high terraces and downlands, particularly in the Rangitikei and Canterbury regions.

Remnants of the formerly extensive tussock grasslands are identified on the map as **short tussock grassland** units or as the **short tussock grassland** pattern superimposed upon exotic pasture units. The once widespread red tussock grasslands of Southland have disappeared, leaving a few small remnants in the Hokonui Hills and the Catlins.

The upland hill country and mountainlands

The upland hill country and mountainlands above about 500 metres are the realm of the extensively managed tussocklands, and of the vast forests of the axial ranges. Here indigenous communities, while heavily modified in many places, still dominate the landscape. Farming based upon exotic pastures continues to be practised in the southern King Country-northern Rangitikei region, the Volcanic Plateau, inland East Cape and some inland basins and foothills of the South Island but the predominant management practice is extensive grazing on natural or oversown tussock grasslands. Virtually all of New Zealand's 3.2 million hectares of short tussock and snow tussock grasslands have been influenced by or are threatened by rangeland management. These practices variously include grazing and burning with consequent depletion and invasion by exotic weeds, aerial oversowing with improved pasture species, or cultivation and conversion to pure exotic pasture. Tussockland depletion is manifest in a reduced vigour of individual tussocks, increased inter-tussock bare ground, and the spread of cushion plants such as *Raoulia* spp and weeds such as *Hieracium* spp, the major areas of which are denoted on the map by the **semi-arid herbfield** symbol. The red tussock grasslands of the central North Island are to some extent secure from disturbance where they occur within Tongariro National Park, but these and the extensive areas to the east are threatened with invasion by *Pinus contorta* and heather. Very often these tussock communities are associated

with other shrubs, in particular *Dracophyllum* spp, which extend over considerable areas of the tephra-mantled Volcanic Plateau. Shrublands of the drier inland South Island are indicated on the map as **Grassland-Scrub** communities dominated by matagouri or sweet brier, while those in moister regions more prone to scrub reversion are usually dominated by *Leptospermum* or mixed indigenous scrub.

Remnants of the former forest occur sporadically throughout, as **Grassland-Forest** communities occuring particularly in valley heads and near to more extensive forest tracts. The beeches (*Nothofagus* spp) are often a prominent component of these upland forest remnants especially in the South Island. Relatively stable communities of subalpine scrub are often present in a zone associated with the actual or theoretical treeline. This is particularly prominent in forested areas where beech is naturally absent or of reduced extent, but occurs elsewhere as a frequently *Dracophyllum* dominated shrubland mapped as **Tussock grassland and subalpine scrub**.

Above the altitudinal limit of the snow tussocks and below the limit of permanent snow there may be a zone of low-growing herbs forming a usually open community structure among the rock and boulders of the mountain slopes. These are recognised as **Sub-alpine and alpine herbfield** on the map and are particularly prominent in the mountains of inland Canterbury and Otago.

The greatest proportion of New Zealand's 5.1 million hectares of indigenous forests are congregated in these upland ranges and mountains. Here, relatively secure in the fastness of its mountain retreats, nature reigns supreme, with the most serious threats from humans acting indirectly via the agency of introduced animals.

Of New Zealand's total indigenous forest estate about two thirds lies in the South Island and Stewart Island and of this about half is beech forest. The

Table 1: An analysis of New Zealand's present vegetative cover.

Vegetative	*North Island*		*South Is/Stewart Is*		*New Zealand*	
Group	*area (ha)*	*%*	*area (ha)*	*%*	*area (ha)*	*%*
C	109,000	1	55,000	<1	164,000	1
G	4,210,000	37	6,394,000	42	10,604,000	40
GS	2,143,000	19	3,027,000	20	5,170,000	19
S	716,000	6	388,000	3	1,104,000	4
GF	533,000	5	199,000	1	732,000	3
FS	624,000	5	653,000	4	1,277,000	5
F	2,758,000	25	3,572,000	23	6,330,000	24
M	93,000	1	280,000	2	373,000	1
unvegetated	173,000	1	728,000	5	901,000	3

bulk of the remainder of the southern upland forests are various forms of podocarp-broadleaved or podocarp-broadleaved-beech forest. In the North Island the greater proportion of the forest, about three quarters, is podocarp-broadleaved and podocarp-broadleaved-beech with the remaining quarter being dominantly beech or broadleaved forest.

Collectively, in both these upland regions and in the lowlands, very little now remains of the once extensive podocarp forests of both the North and South Islands or of the kauri forests of the northern North Island. Where they occur, these forests and remnants of them, are identified on the map as classes **F1, GF3** (without the beech pattern superimposed) or as **F2** (with the kauri pattern superimposed) respectively. A proportion of the forested communities are very evidently still recovering from extensive disturbance, often in the form of logging or fire but also from natural or induced erosion. These are identifiable as **Forest-Scrub** units on the map.

It is sobering to reflect upon the changes in New Zealand's vegetation during a millennium of human occupation and more particularly in the 150 years of European exploitation. It is easy to react with scorn at the apparent folly of our forebears but little acknowledgement is made of analogous practices in use today. Today's New Zealanders condemn the introduction of rabbits and yet propose to introduce and farm llamas and fitches. Today's New Zealanders decry the wastage in which the kauri forests were logged and burned almost to extinction and yet propose to continue logging Westland podocarp forests. It is instructive to compare New Zealand's present forest cover with that of Japan, a country similar in size and geography, a far longer cultural history and population density 27 times greater than that of New Zealand, but which still retains a forest cover of 67 percent compared to New Zealand's 26% (Kelly 1980).

CHAPTER 3

THE VEGETATIVE COVER MAP

SCALE

Initially two alternative scales were proposed for the Vegetative Cover Map, 1:250,000 and 1:1,000,000. The former was perceived to have advantages in its greater resolution for planning and research purposes but disadvantages in its greater bulk, time requirements and costs. Additionally this larger scale is more appropriately applied to a primarily species-based vegetation map, than to a primarily physiognomic/community-based vegetative cover map which existing data would most easily facilitate. The 1,000,000 scale proposal was favoured for reasons of it still being applicable to national and regional planning, its greater suitability for educational purposes, its more appropriate resolution for existing information and, with its lower requirements in time and money, it could be compiled and printed with a minimum of delay. An intermediate scale of 1:500,000 was considered to be an unhappy compromise between the two ideals, and one which could potentially lead to dissatisfaction among all users.

COMPILATION

The Vegetative Cover Map of New Zealand has one feature in common with all small-scale vegetation maps; it has been compiled in the first instance, from existing source maps, surveys, and reports, and is not based primarily upon field work. This feature is a function of scale. At 1:1,000,000 scale 1 millimetre represents 1 kilometre, so the minimum sized map unit into which can be placed an identifying code would be about 2 kilometres long and 4 kilometres wide (8 square kilometres or 800 hectares). To mentally assimilate and classify vegetation in the field over such large areas would be a tedious and inefficient operation.

The technique for the Vegetative Cover Map involved both compilation from source maps and surveys, and subsequent field checking. The primary source of information is a major national survey called the New Zealand Land Resource Inventory (NWASCO 1975-79). This large-scale (1:63,360 or 1 inch to 1 mile) survey of the North and South Islands of New Zealand is intended primarily for soil conservation and land use planning purposes.

However it contains vegetation as one of five physical factors recorded, (Hunter and Blaschke 1986) the others being rock, soil, slope and erosion.

The New Zealand Land Resource Inventory is particularly suitable as the database for a small-scale map such as the Vegetative Cover Map since it has virtually national coverage at a large scale and is based upon recent field work. Additionally, the entire survey, both boundary and inventory information, is stored on, and is accessible from, computer. The New Zealand Land Resource Inventory is the 'parent document' for the Vegetative Cover Map, but many other sources were also used in all stages of compilation.

In the compilation of the Vegetative Cover Map it is convenient to recognise the following 4 steps (summarised in Figure 4).

Step 1: Computer Classification

In the 90,000 map units in the New Zealand Land Resource Inventory there are as many as 6000 vegetation entities. A computer retrieval program (van Berkel and Eyles 1981; van Berkel and Williams 1985) allowed each of these to be indexed to one of approximately 90 provisional Vegetative Cover Classes. The information thus classified was then computer plotted at an intermediate scale of 1:250,000.

Utilising this automated procedure saved countless days of manual editing during map compilation. It also produced a simplified, intermediate scale base upon which to work without compromising to any extent the quality of information.

Step 2: Manual Editing

The 1:250,000 scale computer classified plot, still contained more detail than could be accommodated at the final scale of 1:1,000,000. Furthermore, other sources of potentially valuable information had not yet been considered.

For large parts of the country the New Zealand Land Resource Inventory was the only suitable source of vegetation information. In these areas the computer classified data were accepted alone, subject to later field checking, or supporting evidence was sought in the form of written accounts. For Stewart Island, (which is not covered by the Land Resource Inventory) compilation was based primarily upon ''Plant Communities of Stewart Island' (Wilson, in press). Frequently however, it was possible to obtain corroborative information from other sources. Reference was made to vegetation maps of indigenous forests, National Parks and other localities where they were available, as well as enquiries to the New Zealand Forest Service for information on the extent of exotic forests. Other government departments and regional authorities, private companies and individuals were also consulted. The most recent topographic maps were used to assist in identifying the location of wetlands, forest and scrub, to assign boundaries to woodland margins and to relate vegetation more clearly to landform.

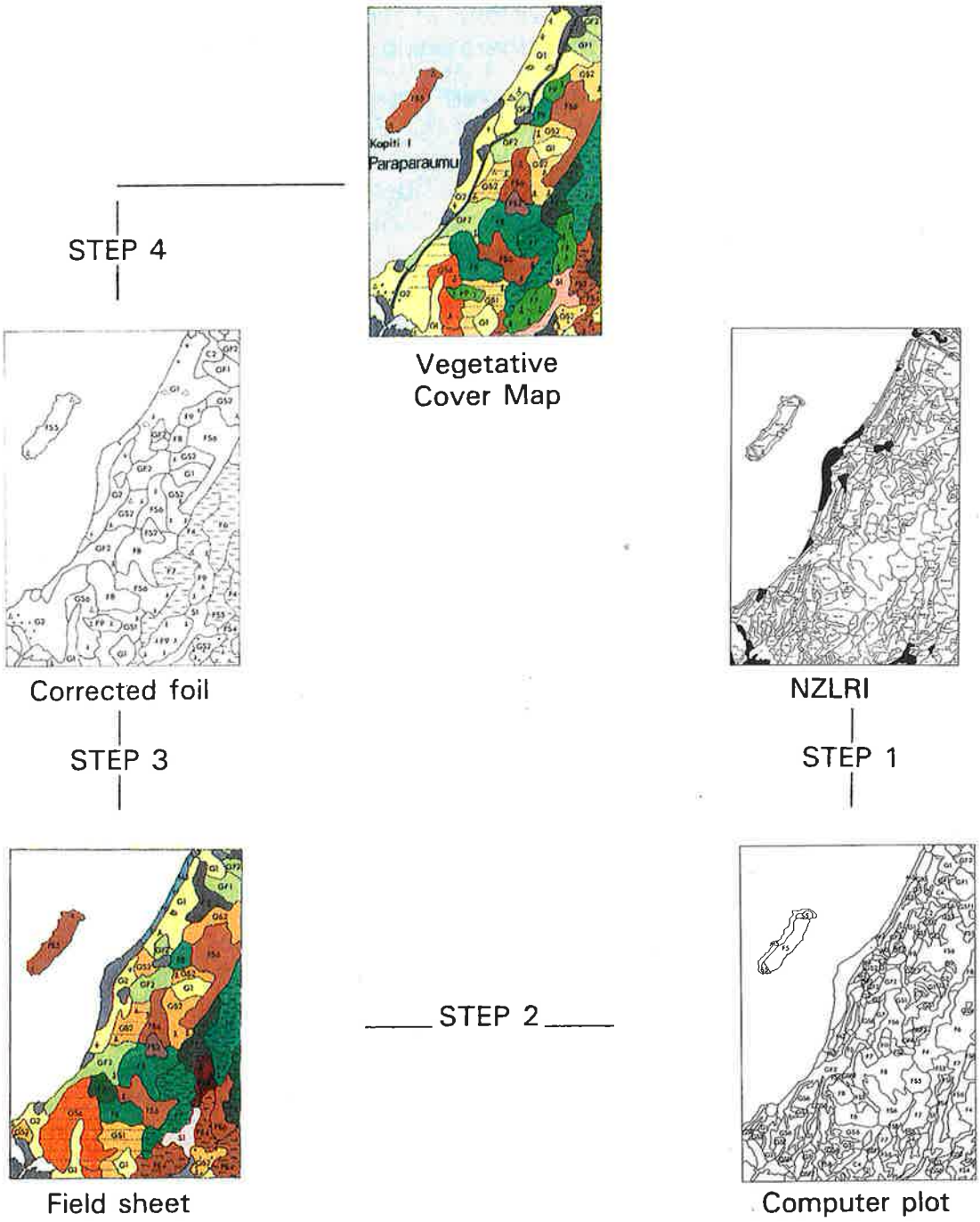


Figure 4: A summary of the compilation process for the Vegetative Cover Map of New Zealand. Each stage is shown at the final map scale of 1:1,000,000 to illustrate the successive reduction in detail in steps 1 and 2. In reality the scale of the Land Resource Inventory is 1:63,360 (64 times larger by area than the section shown) and the scales of the computer plot, the field sheet and the corrected foil are 1:250,000 (16 times larger by area).

The resulting edited copy was then redrafted, printed onto a topographic base map and coloured in accordance with the Vegetative Cover Map legend. For the first time this 1:250,000 scale 'field sheet' (see Figure 4) began to resemble a map.

Step 3: Field Checking

The 1:250,000 scale field sheet now approximated the level of detail of the final 1:1,000,000 scale map. What was not certain was how well the data, reclassified from diverse sources, agreed with the current state of the vegetation in the field.

During the course of field work as many map units as possible were checked. Particular care was taken in localities which had been subject to recent changes in vegetative cover or were presenting difficulties in classification or boundary definition. Authorities on the vegetation of specific areas often contributed valuable information.

Field investigations ultimately traversed over 40,000 km of mainly sealed and gravelled roads supplemented by over 130 hours or 20,000 linear km of aerial survey.

Step 4: Scale Check

This final step comprised two operations: a photo-reduction of the corrected foil to the final scale of 1:1,000,000, and a critical appraisal by other ecologists.

In the first operation a check was made for legibility and meaning at the final scale. In the second operation the map sheets were critically reviewed for accuracy and legibility both by scientists experienced in land resource mapping and botanists conversant with the ecology of New Zealand's vegetation.

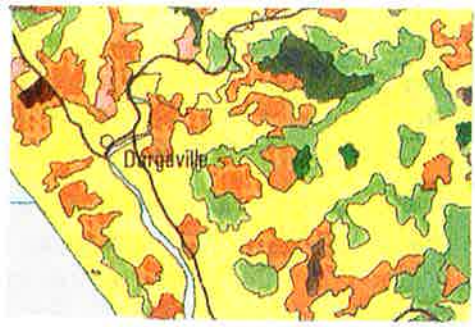
INTERPRETATION

The true test of any map lies in how a reader can relate the two-dimensional information on the map to their own field experience.

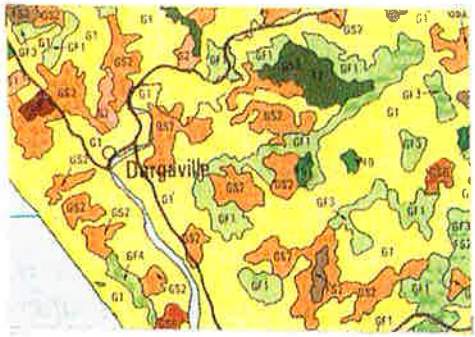
The key to reading the Vegetative Cover Map lies in the three levels of the classification; the **Vegetative Cover Group**, the **Vegetative Cover Class**, and the **Vegetative Cover Element**. These categories were selected to allow three successively more detailed levels of scrutiny (Figure 5).

The first level is as if viewing from 2 metres distance where all that can readily be discerned is colour. Colour identifies the highest order of the classification, the **Vegetative Cover Group**. The colours are arranged with yellow for grassland, red for scrub, and green for forest. Groups intermediate in structure between these three primary groups are identified by the respective intermediate colour. There are commonly different tones of the

Level 1; likened to viewing from 2 metres away. Only colour is discernible. This identifies the **Vegetative Cover Groups** which indicate community appearance or structure.



Level 2; likened to viewing from half a metre away. As well as colour the descriptive code is discernible. This identifies the **Vegetative Cover Classes** which indicate community type.



Level 3; likened to viewing from a quarter of a metre away. As well as colour and code the overlay patterns are discernible. This identifies the **Vegetative Cover Elements** which highlight selected components of the vegetation.

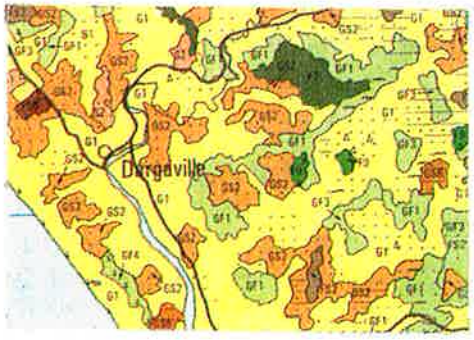
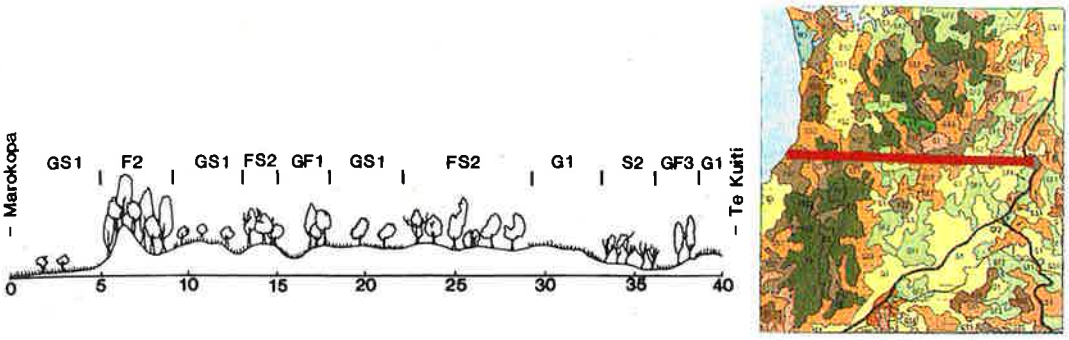
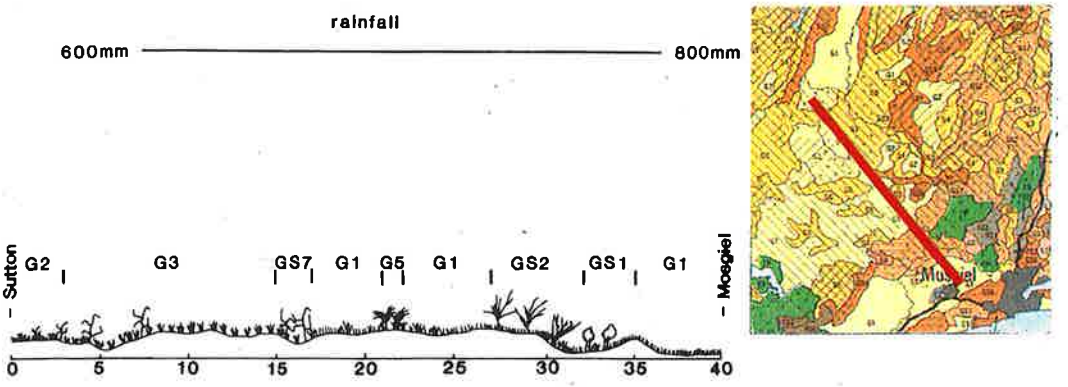


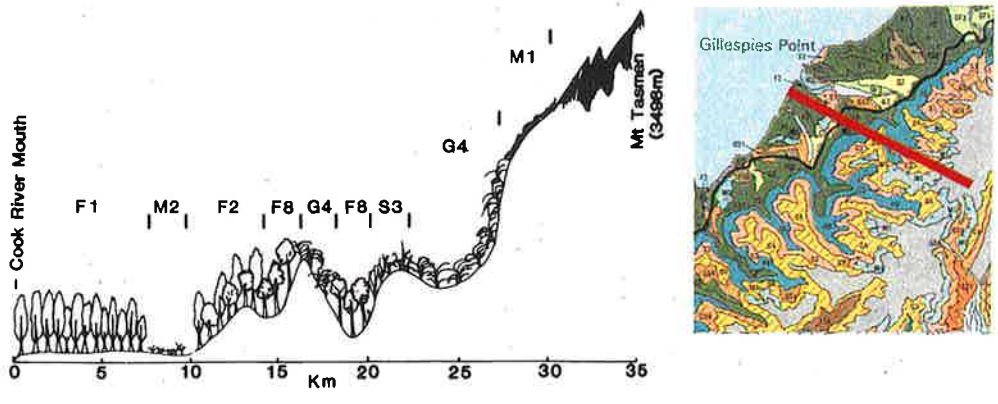
Figure 5: The hierarchy of levels in the classification of the Vegetative Cover Map.



A spectrum of Vegetative Cover Classes responding to varying cultural history or management, from the least developed (F2) to the most intensively developed land (G1) and a range of intermediate forms.



A spectrum of Vegetative Cover Classes responding to a rainfall gradient from high producing improved pasture at Mosgiel through a range of lower producing pastureland, tussocklands and shrublands to low producing unimproved pasture at Sutton.



A spectrum of Vegetative Cover Classes responding to an altitudinal sequence from podocarp forest on the coast to perennial ice and snow and bare rock on the summit of Mt Tasman.

Figure 6: Three examples of how Vegetative Cover Classes are indicative of the environment, where they are influenced by both cultural history and natural gradients. (refer to map legend, Figure 7 for code description)

theme colour within a group, often to contrast between indigenous and exotic communities or, in forested areas, to denote presence or absence of podocarps. Colour, then, is indicative of community structure and its affinity to the three major plant formations of forest, scrub and grassland.

The second level can be likened to a scrutiny at about half a metre distance where, as well as colour, the identifying code for each unit can be discerned. This code, the **Vegetative Cover Class**, is indexed to one of 47 community descriptions on the map legend. These descriptions are amplified in Chapter 4. The class code identifies the most important vegetation assemblages which can be accommodated on a map of this scale.

The third and most detailed level, likened to examining the map from a distance of about a quarter of a metre, are the superimposed symbols and patterns, the **Vegetative Cover Elements**. The 17 elements highlight selected components of the vegetation. These components have a tendency to occur in **Vegetative Cover Classes** in which their presence is not necessarily implied. For example 'Wetland communities' are frequently encountered as small swamps and mires in a wide range of landscape situations and symbols superimposed upon the map are the most practical method of recognising them.

Inferences about landscape or environmental sequences can be derived from careful interpretation of the map information. Some examples of how environmental and historical influences are reflected in the vegetation are given in Figure 6.

The fullest measure of value from the map can, however, only come when a reader's own experience or intuition is prompted while reading the map so that they may actually visualise the landscape being studied. As well as conferring insight, this will aid in derived interpretations, such as a unit's successional status, relation to soil and geologic features, and climatic influences.

CHAPTER 4

THE VEGETATIVE COVER CLASSES

The 47 **Vegetative Cover Classes** are subdivisions of the eight **Vegetative Cover Groups**, described in chapter 2 (Figure 3). Classes which are structurally similar appear on the map with similar colour tones.

The classes are identified by a two-part alpha-numeric code both on the map face and on the legend. The first part is one or two alphabetical characters which identify with the **Vegetative Cover Group**; for example **'GF'** equates with **'Grassland-Forest'**. The second part is a single numeric character which identifies the class uniquely within that group; for example **'GF4'** equates with **'Grassland and exotic forest'**. There is no implied hierarchical ranking in the numeric values in the class code.

The **Vegetative Cover Classes** (Figure 7) represent New Zealand's most important communities, or aggregates of communities, which are able to be resolved at this scale. The selection criterion for the classes was made initially on the basis of the national significance of vegetation associations from an analysis of the New Zealand Land Resource Inventory (NWASCO 1975-79). Subsequent modification recognised ecological importance and the practicalities of cartographically depicting these communities.

The descriptions which follow, outline for each class, its area, its distribution and landform, and some factors which are characteristic of the class as a whole. These latter include notes on appearance, environmental factors, and successional status or how the community interacts with natural processes or human activities. These accounts are not comprehensive, and nor do they necessarily apply in every instance, but they are generally representative of the majority of conditions.

CROPLAND

C1 Orchards or vineyards and pasture

C2 Horticultural crops and pasture

GRASSLAND

G1 Improved pasture

G2 Unimproved pasture

G3 Short tussock grassland

G4 Snow tussock grassland

G5 Short tussock—snow tussock grassland

G6 Red tussock grassland

GRASSLAND-SCRUB

GS1 Grassland and mixed indigenous scrub

GS2 Grassland and *Leptospermum* scrub or fern

GS3 Grassland and *Cassinia* scrub

GS4 Tussock grassland and sub-alpine scrub

GS5 Grassland and *Dracophyllum* scrub

GS6 Grassland and gorse scrub

GS7 Grassland and matagouri

GS8 Grassland with sweet brier or sweet brier and matagouri

SCRUB

S1 Mixed indigenous scrub

S2 *Leptospermum* scrub or fern

S3 Sub-alpine scrub

S4 Gorse scrub

GRASSLAND-FOREST

GF1 Pasture and podocarp-broadleaved forest

GF2 Pasture and broadleaved forest

GF3 Pasture and beech or podocarp forest

GF4 Pasture and exotic forest

GRASSLAND-FOREST (cntd)

GF5 Tussock grassland and beech forest

GF6 Tussock grassland and podocarp-broadleaved-beech forest

FOREST-SCRUB

FS1 Kauri and *Leptospermum* or mixed indigenous scrub

FS2 Podocarp-broadleaved forest and scrub

FS3 Podocarp-broadleaved-beech forest and scrub

FS4 Beech forest and scrub

FS5 Beech-broadleaved forest and scrub

FS6 Broadleaved forest and scrub

FS7 Sub-alpine scrub and indigenous forest

FS8 Exotic forest and scrub

FOREST

F1 Podocarp forest

F2 Lowland podocarp-broadleaved forest

F3 Highland podocarp-broadleaved forest

F4 Lowland podocarp-broadleaved-beech forest

F5 Highland podocarp-broadleaved-beech forest

F6 Beech forest

F7 Beech-broadleaved forest

F8 Broadleaved forest

F9 Exotic forest

MISCELLANEOUS

M1 Sub-alpine or alpine herbfield

M2 Wetland communities

M3 Sand-dune communities

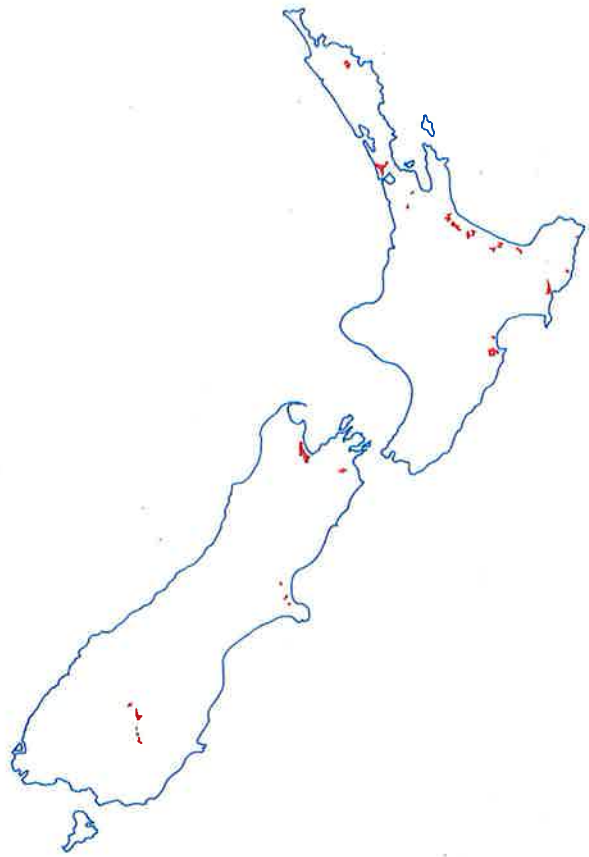
M4 Pakihi heathland communities

Figure 7: Legend of Vegetative Cover Classes.

C1 ORCHARDS OR VINEYARDS AND PASTURE

97,000 ha

Admixtures of pasturelands with tree fruit orchards, and perennial vine fruit crops



Distribution and Landform

Orchards or vineyards and pasture occupies a comparatively small area of New Zealand and is concentrated into those distinct regions with an equable climate, and suitable soils. The class is conspicuous in the North Island in the vicinities of Kerikeri and Auckland, in the Bay of Plenty, Poverty Bay and Hawke's Bay. In the South Island it is mapped between Nelson and Motueka, in the vicinities of Blenheim and Christchurch and in the Clutha Valley from Alexandra to Roxburgh. It usually occupies flat land on plains and terraces but also occurs on areas of low rolling hills and gentle footslopes where the crops benefit from a lower incidence of frosts.

Characteristic Features

This class encompasses a variety of tree and vine crops, often in such close association with pastoral farming that to separate one from the other is impractical. It is easily recognised by the close, regular grid of shelterbelts enclosing block-planted orchards or long lines of espaliered trees, or vines trained along wires. Houses, roadside stalls, implement and packing sheds are much in evidence. Irrigation systems and chemical sprays are important components in crop management. The cropping operations may be broadly divided into 5 groups: pip fruit, stone fruit, citrus fruit, subtropical fruit and grapes.

Pip fruit orcharding, of apples and pears, is concentrated in the Nelson and Hawke's Bay regions. Management has traditionally been as block-planted orchards but more recent plantings have been as trees espaliered along wires.

Stone fruits are also usually grown as block-planted orchards. Apricots,

cherries and nectarines are a feature of the Clutha Valley with further areas of cherries in Marlborough and of nectarines in Hawke's Bay. Peaches and plums are mainly grown in the Hawke's Bay and Auckland districts.

Citrus orchards are usually the preserve of the northern districts. Grapefruit, lemons, mandarins and tangelos are mainly grown in the Bay of Plenty with Northland contributing to the mandarin and tangelo harvest and Poverty Bay to the tangelo crop. Oranges are mainly grown in Northland and Poverty Bay.

Subtropical fruits encompass a variety of crops among which kiwifruit is the most important, but including tamarillos, avocados, feijoas and passionfruit. Tamarillos, avocados and feijoas are grown as block-planted orchards, while passionfruit and kiwifruit are trained along wires, the latter between T-bar posts or overhead pergolas. The principal growing districts are the Bay of Plenty and Northland with some avocado orchards in Poverty Bay. Kiwifruit has also been shown to be viable further south in the North Island, and in the Nelson-Marlborough regions.

Grapes grown primarily for wine production, were until recently the preserve of the Auckland, Poverty Bay and Hawke's Bay regions but now have significant areas in the Marlborough district. Vines are usually grown trained along post and wire 'fences'.

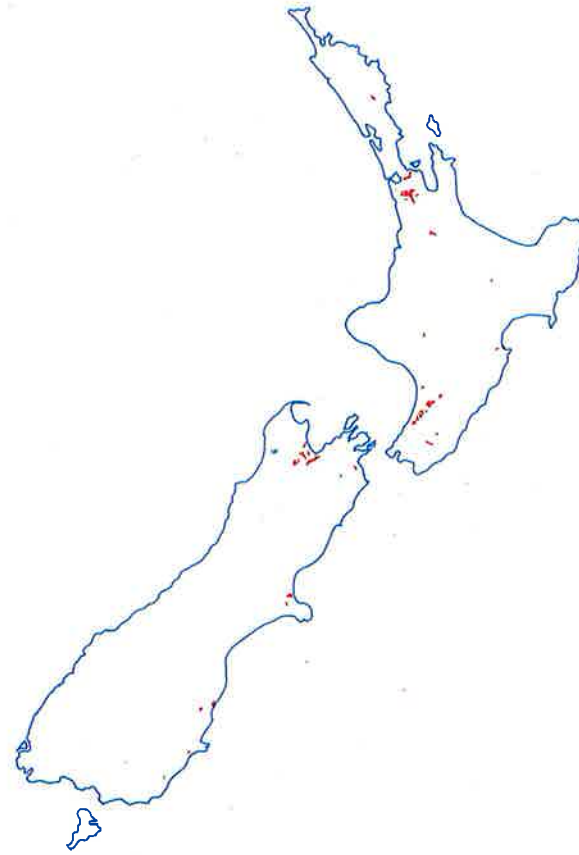
The only other vine crop worthy of mention is the very local area of hop gardens in the Nelson area, which supply all New Zealand requirements, primarily for brewing. Further increases in the area of orchards and vineyards seems likely as export markets continue to expand.

Figure 8: C1. Orcharding, north of Motueka, Tasman Bay.
NZMS 260 N26/111.146 →SW

C2 HORTICULTURAL CROPS AND PASTURE

67,000 ha

Admixtures of pasturelands with berry fruits, or field crops or garden vegetable crops



Distribution and Landform

Horticultural crops and pasture, while quite limited in extent, is concentrated on prime arable land characterised by fertile soils, equable climate and proximity to the major markets in the cities, and export ports. Virtually all occurrences are on alluvial plains and terraces or gentle tephra-covered slopes. In the North Island the class is mapped in the vicinities of Whangarei, Auckland, Pukekohe, Hamilton, Ohakune, Napier, Masterton and Greytown and in the Manawatu and Horowhenua regions. In the South Island it is mapped in the vicinities of Nelson, Blenheim, Christchurch, Oamaru, Mosgiel and Balclutha.

Characteristic Features

Horticultural cropping takes a variety of forms, from small market gardens, growing a wide range of fresh vegetables, to capital-intensive field cropping of a single vegetable, for processing.

Horticultural cropland is less intensively subdivided by shelterbelts than orchards and vineyards but shows a similar grid-patterned field system, associated with a network of tracks, implement sheds and roadside stalls. Fields may support a succession of different crops during the year, and tillage, weed and pest control and harvesting may be either highly mechanised or labour intensive.

Most districts mentioned have a proportion of their area devoted to market gardening of fresh vegetables. These supply a comprehensive range of

vegetables including cabbages, lettuces, cauliflowers, kumara and potatoes, pumpkins, onions and leeks, carrots and tomatoes, for the domestic market.

Some districts, notably those in Hawke's Bay, Manawatu, Gisborne and in the vicinity of Christchurch devote considerable areas to field cropping for the canning, freezing and dehydrating industries. These crops are primarily peas, beans and sweet corn.

A few areas are notable for one or a few vegetable crops, cultivated on a large scale. Among these are Pukekohe for onions and potatoes, Ohakune for carrots (with some cabbages and broccoli) and Manawatu for potatoes. Another geographically restricted crop is tobacco which is grown in and around Motueka.

Berry fruit, mainly blackcurrants, blueberries, boysenberries, raspberries, strawberries and gooseberries are concentrated in the vicinities of Auckland and Nelson and in the Canterbury and Southland regions. They are grown to provide both fresh and processed fruit and are sold on both the local and export markets.

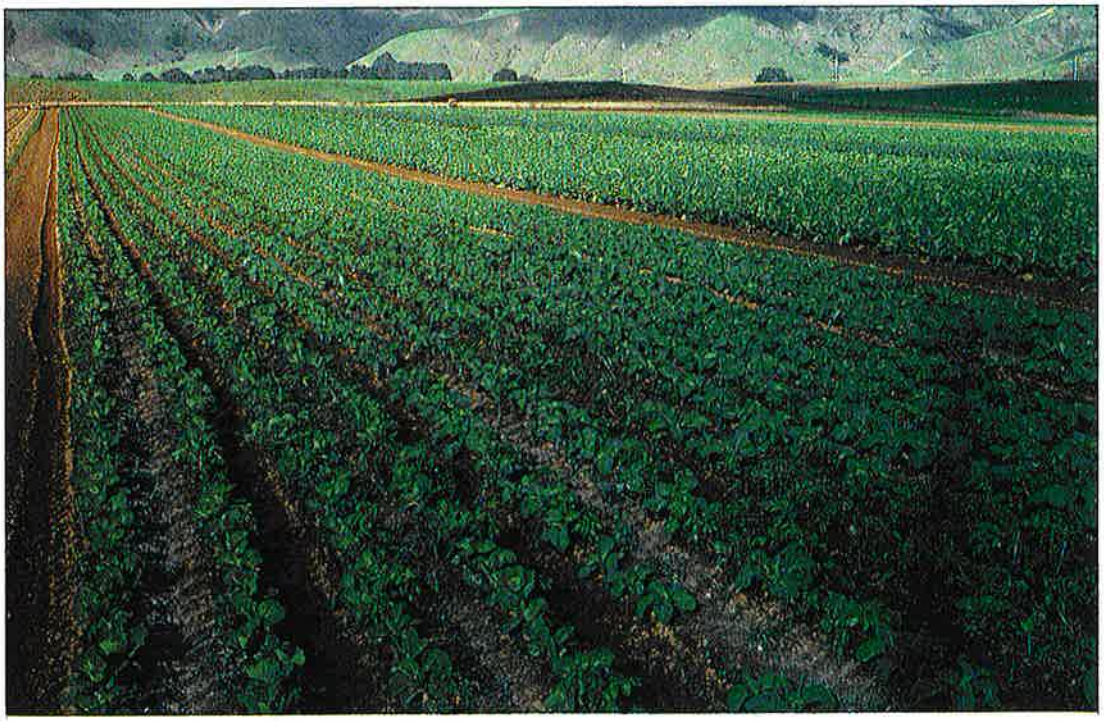
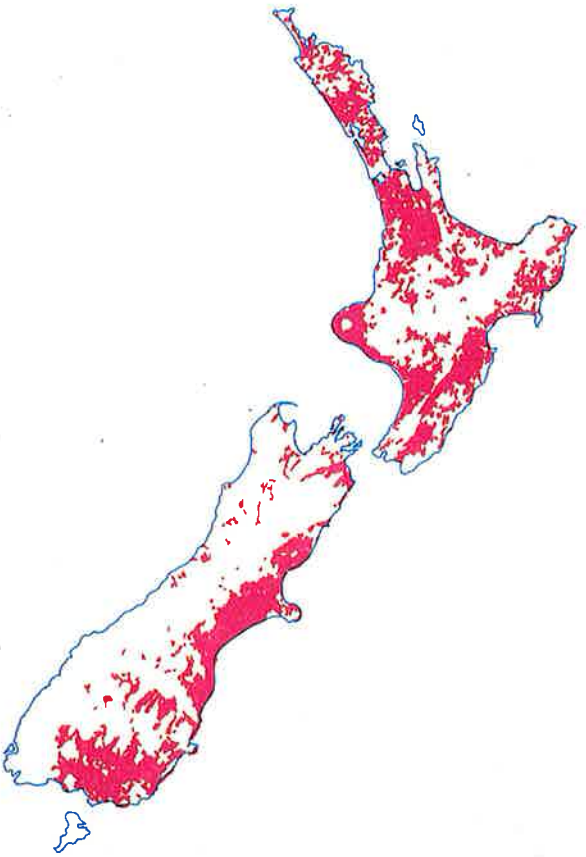


Figure 9: C2. Market gardening, south-west of Shannon, Horowhenua.
NZMS 260 S25/095.665 →SE

G1 IMPROVED PASTURE

6,447,000 ha



Exotic sward grassland of good pastoral quality reflecting relatively high levels of soil fertility and grazing management.

Distribution and Landform

Improved pasture is the usual grassland community on intensively managed plains, terraces, downlands and low hill country throughout New Zealand. On steeper terrain, and in drier localities it is of reduced extent and of lower productivity but improved pasture occurs on virtually all agricultural land to some degree.

Characteristic Features

Improved pasture usually exhibits a healthy appearance with vigorous green growth for most of the year, resulting from a selected blend of pasture species. Trees planted for farm shelter or erosion control, occasional hedges and streamside willows (*Salix* spp) may form a conspicuous though areally insignificant feature of the landscape. Pasture weeds such as thistles may also be present to a limited extent. Grazing management is intensive with medium to high stock densities, relatively smaller paddock sizes by comparison with **unimproved pasture** and a tendency toward rotational grazing. The farming systems cover the range from wool, fat lambs and beef to dairying and deer farming. **Improved pasture** is variously comprised of perennial and short rotation ryegrasses (*Lolium* spp), white clover (*Trifolium repens*), red clover (*T. pratense*), cocksfoot (*Dactylis glomerata*), timothy (*Phleum pratense*) and yorkshire fog (*Holcus lanatus*). In the northern North Island the summer vigour of paspalum (*Paspalum dilatatum*) can be used to advantage and in semi-arid areas of the South Island lucerne (*Medicago sativa*) plays an important role.

Permanent pastures are important in environments of relatively high soil

fertility and a mild climate with adequate rainfall yielding a long growing season. These pastures may vary from the truly permanent, sustained by fertiliser application and oversowing, to pastures renewed after 10-12 years. Yields are comparatively high and so these pastures support intensive stock management devoted mainly to dairying, lamb and beef production. Growth of supplementary feed such as hay and silage occupies only a minor part of farm management (Levy 1970).

Rotational pastures apply to situations where an alternation of grassland and forage or cereal crops is a significant part of the farming system. Generally speaking, the harder the agronomic conditions the more management relies on annual crops, especially cereals and temporary pastures. In much of the South Island a long rotation system of 9-10 years is favoured. Here the exhausted pasture is sown to cereal, rape, turnip, chou moellier or mangolds which then provide supplementary feed prior to reseeding with grasses. In the North Island there is less need for supplementary crops and so much pasture is resown to grasses directly. Short rotation pastures are a feature only of New Zealand's driest country, virtually all of which is in the South Island. Here, rapidly establishing, bulky grasses and legumes (Italian and 'Manawa' ryegrass, red clover, lucerne) after 2-4 years are sown to cereals, rape, root or green fodder crops for up to 2 years. Re-establishment of pasture in the following year may be through a cover crop of cereals, turnip, rape, millet or lupin (Levy 1970).

Figure 10: G1. Improved pasture, east of Pukekohe.
NZMS 260 R12/860.418 →NW *Photo: M R Jessen*

G2 UNIMPROVED PASTURE

891,000 ha

Exotic sward grassland of poor pastoral quality reflecting relatively low levels of soil fertility and grazing management.

Distribution and Landform

Unimproved pasture is present throughout New Zealand wherever combinations of low rainfall, poor soils, lax or extensive pastoral management, low stocking densities or insufficient fertiliser produce an environment unsuited to high producing pasture species. **Unimproved pasture** is often a feature of ineffective pastoral development from forest and scrub in areas of moderate to high rainfall. In the North Island it is common on steep hill country in both low and high rainfall districts while in the South Island it is concentrated on foothills, inland basins and hill country in regions of low rainfall, and where the colder climate results in a short growing season.

Characteristic Features

Unimproved pasture often has the appearance of lower vigour and a higher proportion of dead material and weeds than is the case with **improved pasture**. On free-draining soils such as those derived from sand and pumice, and in the dry eastern hill country, there are more pronounced seasonal fluctuations in growth rates with a noticeable drying off to a straw colour during dry weather. Conversely, in regions of ample rainfall there is often the threat of reversion to scrub and forest. This is exemplified by small remnant pockets of scrub, scattered scrub and tree seedlings or patches of bracken or ring fern. Erosion too may be a problem in these latter areas and hillslope and gully plantings of poplars (*Populus* spp) or other trees may be a prominent though areally insignificant feature of the landscape.

Composition is typified by browntop (*Agrostis capillaris*), danthonia

(*Rytidosperma* spp), sweet vernal (*Anthoxanthum odoratum*), Chewings fescue (*Festuca nigricans*) and Yorkshire fog. Clovers are of very reduced extent but may comprise very sparse white clover or annual clovers. Associated with these may be ratstail (*Sporobolus africanus*) and baygrass (*Eragrostis brownii*) annuals such as hairgrass (*Vulpia* spp), brome grasses (*Bromus* spp), annual poa (*Poa annua*) and numerous weeds.

Grazing management is usually extensive rather than intensive and tends toward set stocking with generally low stocking densities. Paddock sizes are usually larger than those of **improved pasture**.

The farming systems are primarily concerned with wool, sheep meat and beef production with some fat lambs carried on the better country. In moderate to high rainfall districts, cattle have a role in weed control thus suppressing a tendency toward reversion to scrub and forest. Goats too are used in this way, as well as in developing new pastureland from scrub.

On some **unimproved pasture**, especially in the North Island, aerial oversowing and topdressing and more intensive management have substantially improved agricultural production. The dividing line between these semi-improved pastures and **improved pasture** tends to be diffuse as more intensive management yields higher producing pastures.

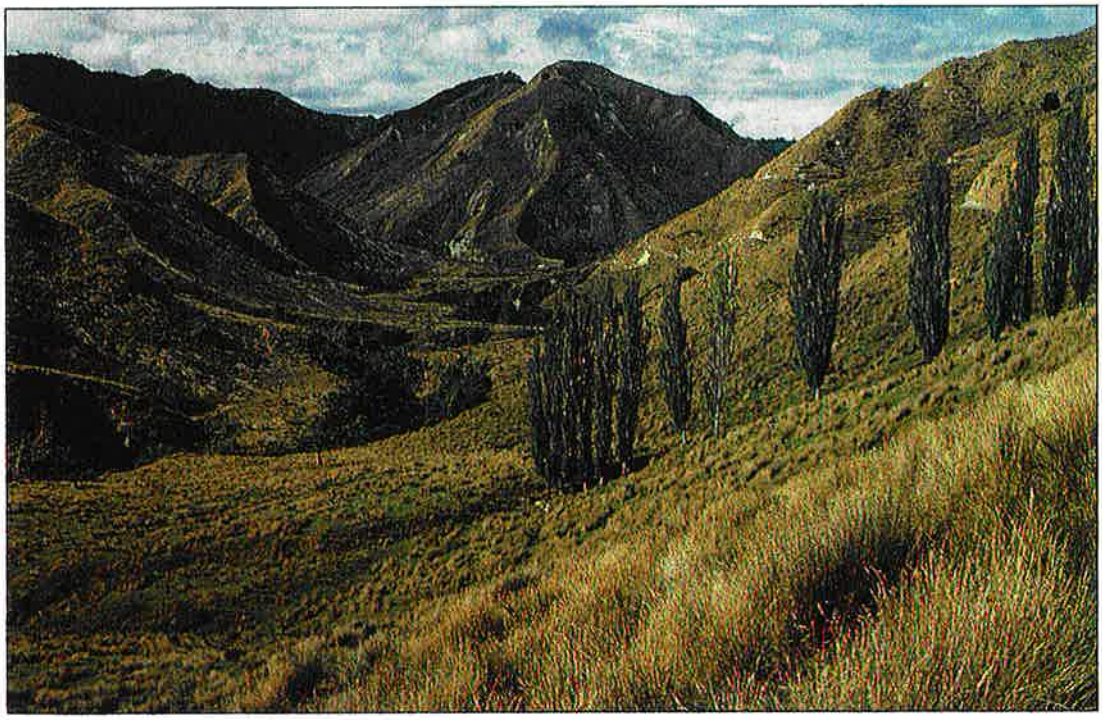
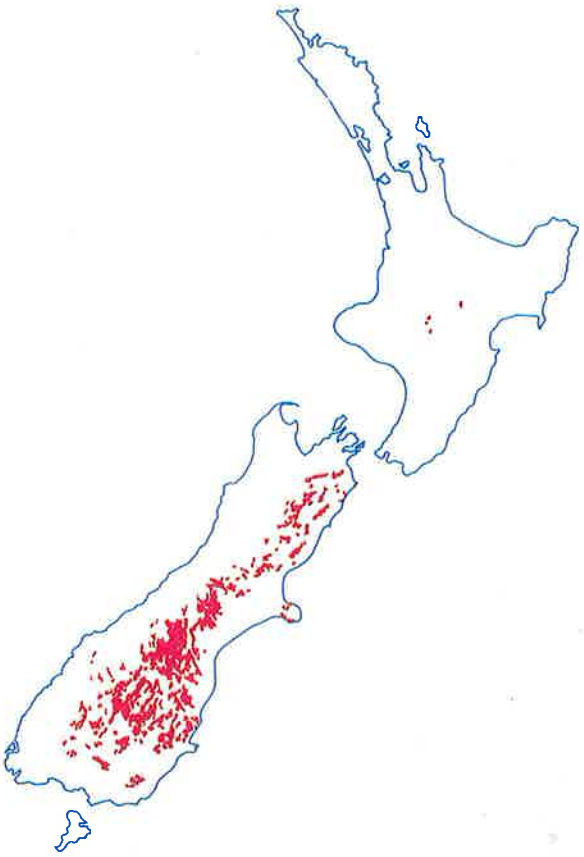


Figure 11: G2. Unimproved pasture, Wanganui Valley 33 km south-west of Taumarunui. NZMS 260 S19/292.315 →NE *Photo: P M Blaschke*

G3 SHORT TUSSOCK GRASSLAND

1,114,000 ha

Lowland to alpine short tussock grassland usually dominated by indigenous species of *Festuca*, *Poa* or *Rhytidosperma*



Distribution and Landform

Short tussock grassland is mapped in the North Island locally on the Volcanic Plateau and in the northern Kaimanawa mountains. In the South Island it is extensive in areas of low rainfall east of the Main Divide, where it occurs at elevations up to 1450 metres. It is a conspicuous feature of dry inland valleys, montane basins and hill slopes from Marlborough to Southland. In these areas forest is either naturally absent or of reduced extent, or has been eliminated by fire or other land clearance practices.

Characteristic Features

Short tussock grassland is usually dominated by species of *Festuca* or *Poa* whose foliage imparts a golden brown colour to the landscape. The canopy may be up to half a metre in height and in the relatively undisturbed state (a condition rarely found today) forms a dense ground cover. Most short tussock grassland is managed as part of large run-holdings or 'stations' and is extensively grazed for wool or beef production. In many instances oversowing of the tussocklands with exotic pasture seed has been undertaken to improve their pastoral value.

Hard tussock (*Festuca novae-zelandiae*) is by far the most important constituent and is frequently the sole dominant on steep, sunny, exposed slopes (Barker 1953). Silver tussock (*Poa laevis*) becomes more common at lower elevations and gentler slopes, and may assume dominance on mild shady slopes and on moist soils of higher fertility (Hunter and Blaschke 1986). The smaller, blue tussock (*Poa colensoi*), is a frequent associate over a wide altitudinal range and on slopes of shady and intermediate aspect. It may

assume local dominance on shallow soils such as ridge crests and rocky outcrops (Barker 1953) up to elevations of 1450 metres. These three species are outwardly similar in appearance except later in the growing season, when blue tussock as the name suggests begins to exhibit a bluish tinge.

Locally important are two other species; alpine fescue tussock (*Festuca matthewsii*) and bristle tussock (*Rytidosperma setifolium*). Alpine fescue is a component of tussocklands usually above the altitudinal limit of hard tussock where it may sometimes dominate (Connor 1961). Bristle tussock occurs throughout the ranges of the North and South Islands, and has been suggested as indicative of fire-induced grasslands in such places as the central North Island and the Wairau Valley (Wraight 1963). Both alpine fescue and bristle tussock and also blue tussock may dominate the vegetation at elevations up to 1450 metres and often above a zone of snow tussock grassland.

The effects of fire and grazing are acutely felt in these tussock grasslands. The botanist, Leonard Cockayne wrote in 1928: "*. . . At the present time as far as I know there are no examples of the primitive formation . . .*". From Polynesian times depletion of the tussock cover has occurred which later, during the European era, allowed the ingress of exotic weeds and grasses. In semi-arid regions such as in the Waitaki basin and central Otago the introduced *Hieracium* spp, thyme, the native *Raoulia* spp and occasionally rabbits and hares pose a threat to the economic viability of farming. Virtually nowhere is there not a component of catsear (*Hypochaeris radicata*), sweet vernal, browntop, Yorkshire fog, or other exotic species.

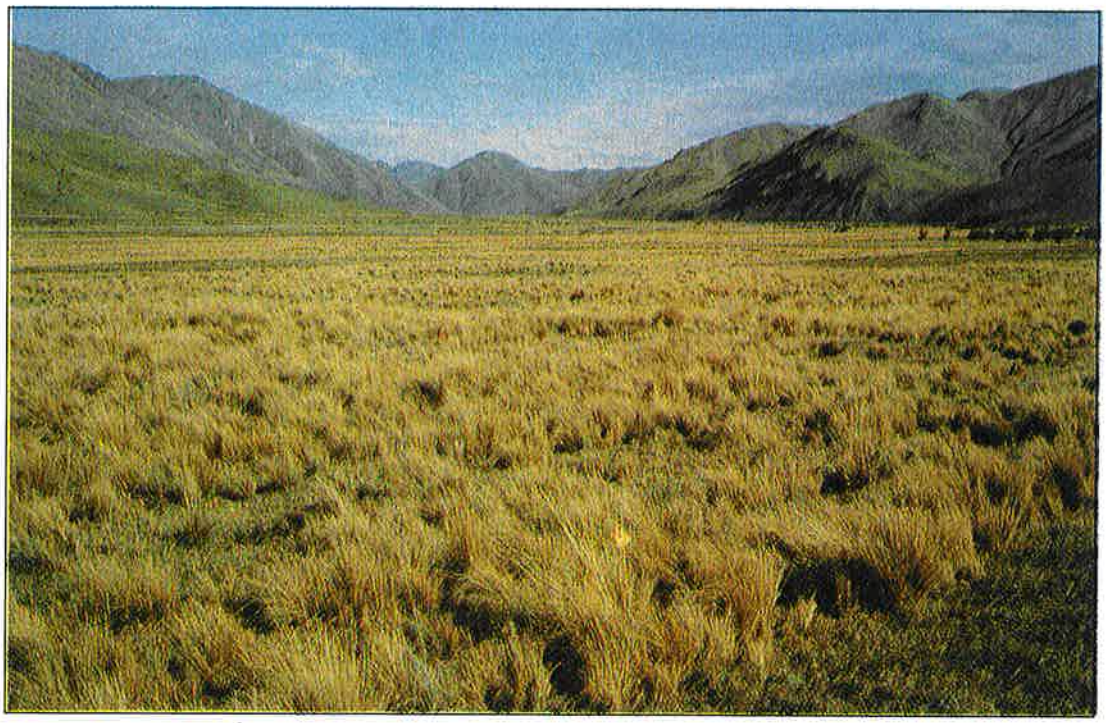
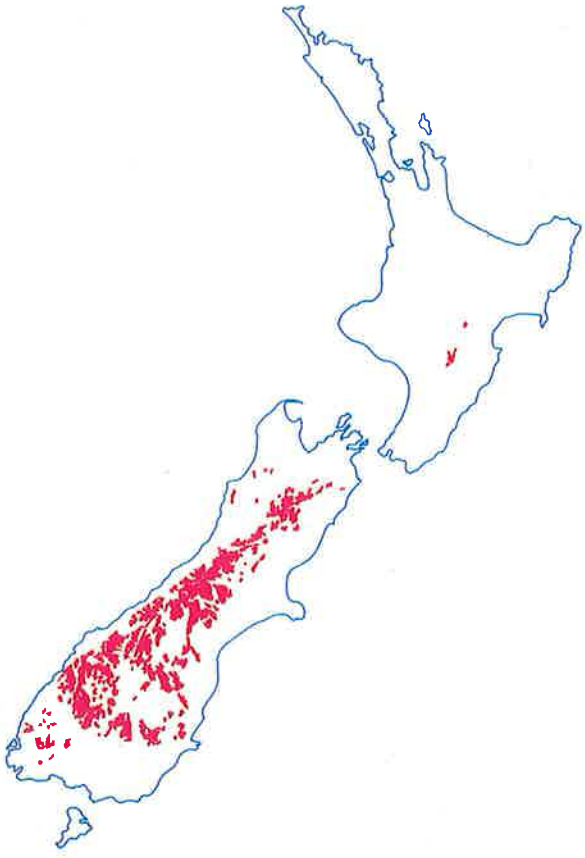


Figure 12: G3. Slightly modified short tussock grassland, dominated by hard tussock. Molesworth Station, Marlborough.
NZMS 260 N30/190.990 →SW

G4 SNOW TUSSOCK GRASSLAND

1,361,000 ha

Montane and alpine tall tussock grassland dominated by the indigenous genus *Chionochloa* but excluding *C. rubra*



Distribution and Landform

Snow tussock grassland occurs throughout New Zealand, in the mountain ranges above the actual or theoretical timberline and below the high alpine herbfields and barrens. However, in the North Island it is mapped only on the summits of the Ruahine and Kaweka ranges. This contrasts with the South Island where it is mapped on virtually all high mountains. On the western side of the Main Divide and on the northern and southern ranges snow tussock occurs above a usually abrupt treeline at about 950-1250 metres. On the drier mountains east of the Main Divide, snow tussock occurs above a zone of short tussock grassland, often following a transition zone in which components of both communites are prominent.

Characteristic Features

Snow tussocks usually attain heights of over half a metre and frequently up to 1.5 metres and they may grow so closely together that in a breeze the whole hillslope appears to move in soft ripples. Viewed from a distance the grasslands have a yellowish green colouration.

In the higher rainfall mountains, mainly those of the North Island and the northern, western and southern South Island, four species predominate. *C. flavescens* and *C. pallens* dominate a zone from the treeline to about 200 metres above the treeline. In the South Island these merge gradually at higher altitude into communities where the smaller *C. crassiscula* or *C. oreophila* are the principal components (Mark 1969). These western and northern

tussocklands include a proportion of herbs and shrubs such as species of *Celmisia, Ranunculus, Gentiana, Hebe* and *Dracophyllum*.

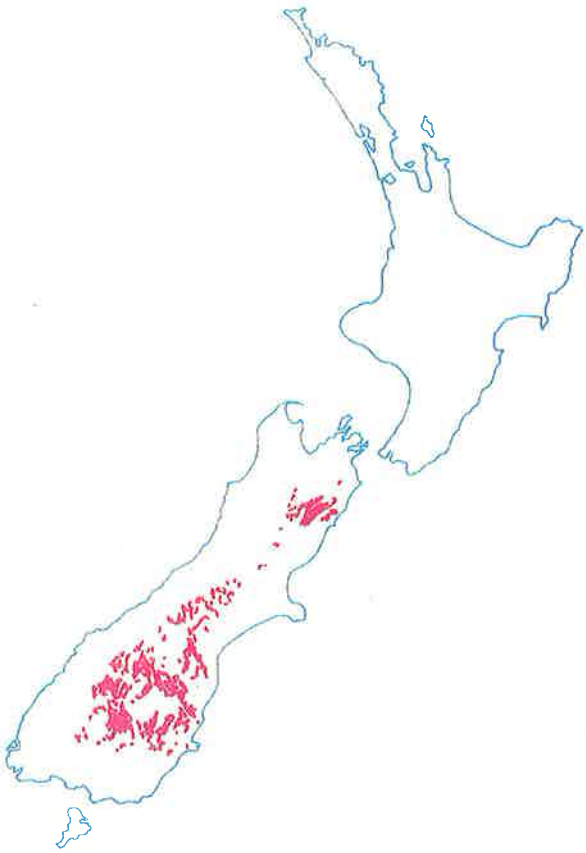
In the drier South Island mountains east of the Main Divide two other species of paramount importance are; *C. rigida* and *C. macra*. The former occupies large areas of rangelands at lower elevations south of the Rakaia River, while the latter is distributed over a wide altitudinal range north of the Rakaia River but is common only at higher altitudes south of the Rakaia (Godley 1975). These tussocklands usually have fewer associated herbs and shrubs than those of the higher rainfall western and northern districts.

Current trends in high country management will see the retirement of much of the snow tussock grasslands currently used for summer grazing (NWASCA and LSB 1985). The effects of fire and the grazing of farm stock have served to reduce tussock vigour which has led to depletion of grass cover in many localities. As with the short tussock grasslands, these effects are exacerbated by introduced feral animals such as hares, deer and chamois. Invasion by exotic plant species is less apparent in the alpine environment, but in these often steep and exposed mountainlands, any increase in bare ground has its attendant threat of subsequent erosion and further deterioration.

Figure 13: G4. Snow tussock grassland dominated by *Chionochloa rigida*. Lindis Pass, Otago. NZMS 260 G40/430.190 →S

G5 SHORT TUSSOCK—SNOW TUSSOCK GRASSLAND

715,000 ha



Subalpine and low alpine tussock grassland where both the indigenous short tussocks and snow tussocks are prominent canopy components.

Distribution and Landform

Short tussock-snow tussock grassland is mapped throughout the South Island sub-alpine and low alpine tussocklands. It is generally a feature of long, gentle mountain slopes between 700 and 1500 metres altitude east of the Main Divide and particularly those which formerly supported forest or woodlands.

Characteristic Features

Short tussock-snow tussock grassland, as the title suggests, is a transition-zone community which occupies the ecotone between snow tussock grasslands and short tussock grassland. Hence it is variously characterised by species of *Festuca, Rytidosperma*, or *Poa* and *Chionochloa,* such that each are significantly prominent and contribute more or less equally to the physiognomy of the community.

In species composition this class differs in no major respect from those mentioned for short tussock grassland and snow tussock grassland. Among the short tussocks, alpine fescue, blue tussock and bristle tussock are important components at all elevations with hard tussock confined more to lower elevations. Of the snow tussocks, *C. rigida* and *C.macra* are the most important with *C. pallens* and *C. flavescens* assuming some prominence in the higher rainfall areas close to the Main Divide.

The extent of **short tussock-snow tussock grassland** has probably increased substantially in the last millenium, since it is now especially prominent in

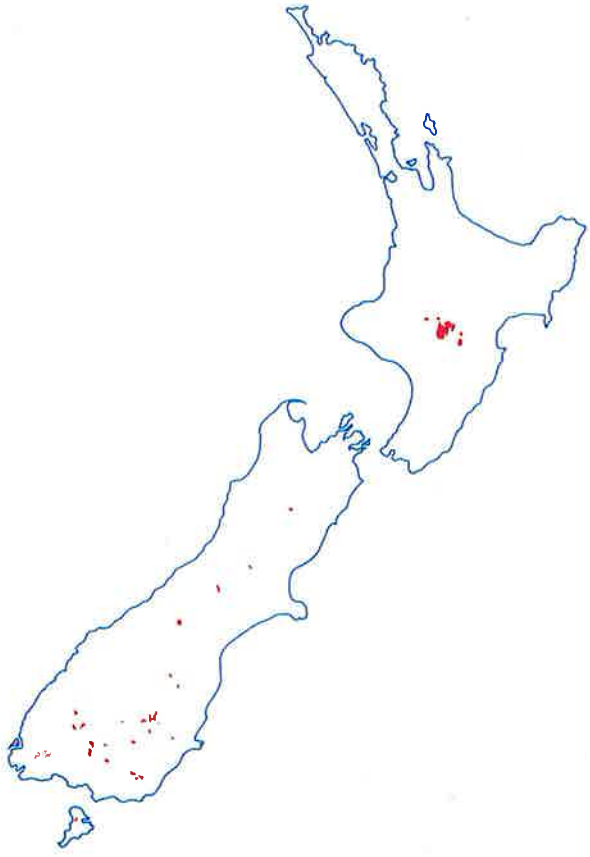
areas deforested by European and Polynesian fire. In these areas the short tussocks and the snow tussocks have migrated to fill this vacuum in habitat and so created this wide zone of transition. This is a classic illustration of how the original flora of New Zealand responded to ecosystem disturbance before the arrival of specialist, aggressive, colonising plants such as catsear, browntop and sweet vernal.

Figure 14: G5. Short tussock-snow tussock grassland, Orari Catchment, South Canterbury. approx NZMS 260 I37/400.700 →E *Photo: G G Hunter*

G6 RED TUSSOCK GRASSLAND

76,000 ha

Lowland and montane tussock grassland dominated by the indigenous red tussock, *Chionochloa rubra*



Distribution and Landform

Red tussock grassland is locally represented on poorly drained rolling uplands and plains. It usually occurs at altitudes below about 1200 metres, although Connor (1964) notes its occurrence in the alpine zone on poorly drained micro-sites. It is mapped in the North Island on the deep tephra deposits of the Volcanic Plateau extending eastward to the Kaimanawa Mountains. It is mapped in the South Island on moraines, low-level terraces and upland basins from Marlborough to Southland, and on Stewart Island.

Characteristic Features

Red tussocks may attain a height of about 1 metre and grow quite closely together, presenting a soft texture similar to **snow tussock grassland**. However in colour red tussocks differ in that their finely tapered leaves, while fundamentally yellow-green in colour, are tinged with red or orange, which may confer a distinctly reddish-gold hue to the landscape.

Red tussock grassland was formerly more widespread on the Southland and South Otago plains and downlands but has been much reduced in extent through conversion to pasture. On the Volcanic Plateau during the early colonial days there were several attempts to establish pastoral farming on the red tussocklands (Debreceny 1981) and quite probably similar efforts were made in the South Island. However, all were to no avail in consequence of the very low palatability of red tussock as forage.

The chief ecological factor controlling its distribution is red tussock's adaptation to wet, sour, peaty soil. Such soils result from cold temperatures, an abundance of rain and poor soil drainage. Cockayne (1928, 1967) observed that red tussock associations are related to bog formations, and notes that in Southland the red tussock communities are the next stage in succession from sphagnum bog.

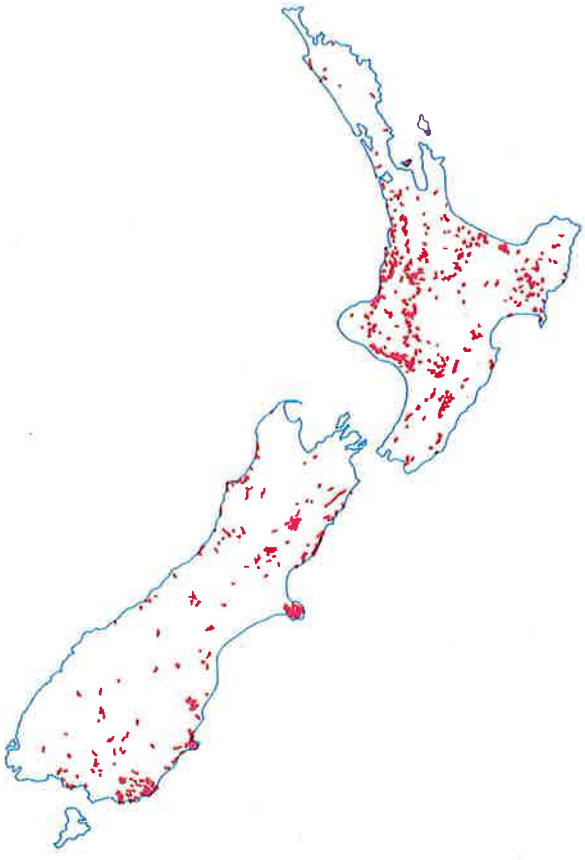
It has been suggested (Levy 1970; Debreceny 1981) that red tussock grassland is a successional phase in the development to forest. Unquestionably much of the land which now supports red tussock has been forested in the last 2000 years and is still environmentally suited to forest. In Southland it was probably Polynesian fire which removed much of the forest cover, and a resulting rise in the water table predisposed this flat and gently rolling, high rainfall country, to red tussock as the first step toward natural reafforestation. On the Volcanic Plateau a probable combination of volcanic eruption and Polynesian fire destroyed the original forest but here too there are observations (Debreceny 1981; Atkinson 1981) which suggest that forests are now reinvading their former domain.

Figure 15: G6. Red tussock grassland, Three Kings Range, Kaimanawa Mountains.
NZMS 260 T20/602.956 →WNW *Photo: T F Crippen*

GS1 GRASSLAND AND MIXED INDIGENOUS SCRUB

856,000 ha

Formations of lowland or montane, mixed broadleaved indigenous shrubs, with exotic or indigenous grassland.



Distribution and Landform

Grassland and mixed indigenous scrub is mapped throughout New Zealand although it is of limited extent in well developed pastureland, remote forested areas and low fertility or low rainfall regions. It is a prominent feature of hill country peripheral to the forested ranges, and of low producing pastureland, where it is often present as wooded gullies and scrub patches on steep, less productive hillslopes.

Characteristic Features

Grassland and mixed indigenous scrub includes a diverse array of communities in a variety of situations. Some are more or less stable communities, while others are dynamic associations reverting to forest. In areas of higher rainfall there is a greater diversity of species and a more developed stand structure.

A stable condition is approached in the dry foothills and valleys of the eastern South Island. This is usually a sparse, open shrubland of small-leaved, divaricating shrubs associated with low-producing pasture or short tussock grassland. Species represented include small-leaved coprosmas (e.g., *Coprosma propinqua*), *Corokia cotoneaster*, *Muehlenbeckia complexa*, *Hymenanthera alpina*, native brooms (*Carmichaelia* spp), spaniards (*Aciphylla* spp), and tutu (*Coriaria sarmentosa*). Matagouri (*Discaria toumatou*) is often present. The appearance of these communities is variable but is generally of a low discontinuous texure with a dull, dark green and brown colouration superimposed upon the straw-coloured tussocks or the greener exotic grasses.

In areas of higher rainfall there is a perceptible successional trend toward

forest. Often this reversion is contained only by more intensive land management ranging from stock control and herbicides to crushing and burning of the successional scrub. These communities comprise many large-leaved shrubs typically present in the understorey of mature forests. Component shrub species vary according to climate, soils and available seed source but may include: mahoe (*Melicytus ramiflorus*), mapou (*Myrsine australis*), pigeonwood (*Hedycarya arborea*), species of *Coprosma, Hebe, Olearia, Pseudopanax*, and *Pittosporum*, tutu, wineberry (*Aristotelia serrata*) and tree ferns. These communities exhibit a vigorous, sometimes glossy, lush appearance, of mid-green to dark greens and an obviously leafy texture.

Some less usual communities include: bog pine (*Halocarpus bidwillii*) shrublands in Southland, kowhai (*Sophora microphylla*) shrublands in the mudstone hill country near Taihape, shrublands of tree fuchsia such as on Banks Peninsula, and some quite stable associations on exposed coastal cliffs and hills.

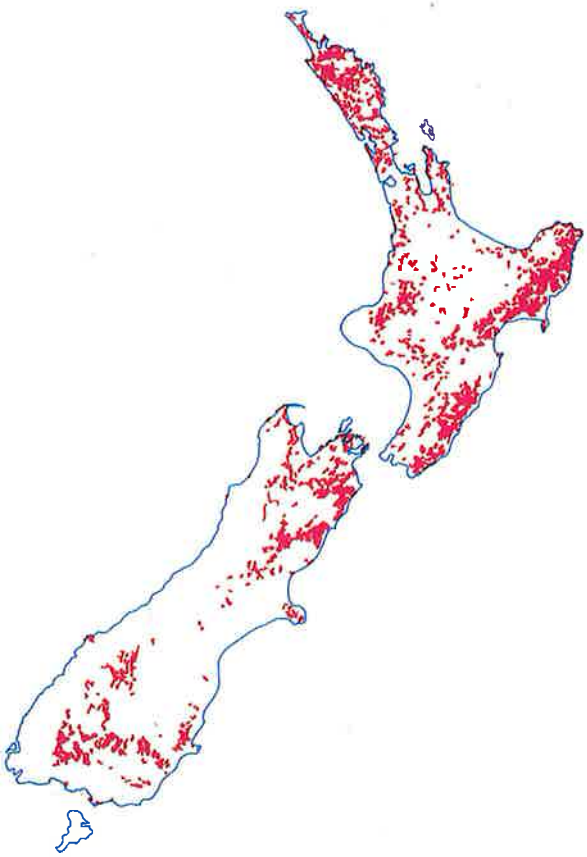
As an indicator of land capability the class is generally a key to areas in which pastoral farming is only marginally viable under current economic conditions and management. Alternatively, but less often, **grassland and mixed indigenous scrub** may reflect quite enlightened land management where gullies and steep hillslopes of doubtful agricultural value have been allowed to regenerate while farming has concentrated on the more productive hillslopes, valley bottoms and terraces.

Figure 16: GS1. Mixed indigenous scrub occupying gullies on the slopes of Mt Karioi, Waikato. NZMS 260 R14/730.720 →SE

GS2 GRASSLAND AND *LEPTOSPERMUM* SCRUB OR FERN

2,284,000 ha

Formations of manuka or kanuka (*Leptospermum* spp) or bracken or bracken-like fern with exotic or indigenous grassland



Distribution and Landform

Grassland and *Leptospermum* scrub or fern is extensively distributed throughout New Zealand being of limited extent only in areas of low temperature or low rainfall or in forested or intensively farmed districts. It attains greatest prominence in extensively managed, low-producing or recently 'broken-in' pastureland, particularly in the moist hill country of both main islands. However, the class is significantly represented in the drier foothills and inland valleys of the central and eastern South Island.

Characteristic Features

Leptospermum scoparium (manuka) and *L. ericoides* (kanuka) comprise the principal woody species and may be found either alone or in combination. Manuka has the wider ecological tolerance of the two and is encountered in both wetter and drier conditions and at higher elevations. By contrast kanuka has a preference for well-drained, relatively fertile soils and so dominates in the volcanic region of the central North Island and in a number of alluvial sites. Kanuka is the longer lived and may attain a greater height, occasionally up to 10 metres. Both are well adapted to cope with fire and much of todays extensive area will have been maintained by repeated burning and volcanic activity. Manuka and kanuka are similar in appearance, both presenting dark green or greyish-green brush-like foliage, but with that of

kanuka tinged slightly red-brown. During flowering from September to February the contrast is more marked, with the flowers conferring upon kanuka a brownish cream and upon manuka a snow white colour.

The most common fern species are bracken (*Pteridium esculentum*) and ring fern (*Paesia scaberula*), although occasionally others such as prickly shield fern (*Polystichum vestitum*) and kiokio (*Blechnum procerum*) may be locally prominent. Viewed from a distance bracken appears an overall dark olive green with mottles of brown and darker green, in a low, more or less even but scruffy canopy. Ring fern is a light green and usually occurs in patches (often circular) on low producing pasture.

All species mentioned are important colonisers in areas which are climatically suited to forest. Manuka and kanuka in particular are noted for their function as a 'nurse' community, protecting the soil surface and allowing other trees and shrubs to establish beneath their canopy. In time the *Leptospermum* canopy becomes less dense, admitting more light, and forest species are able to emerge and finally overtop the original scrub.

Throughout the range of the class, the grasland component usually comprises exotic pasture grasses, and usually those of low agricultural value. However in the eastern South Island short tussocks are well represented, and in the central North Island the grassland component is sometimes red tussock.

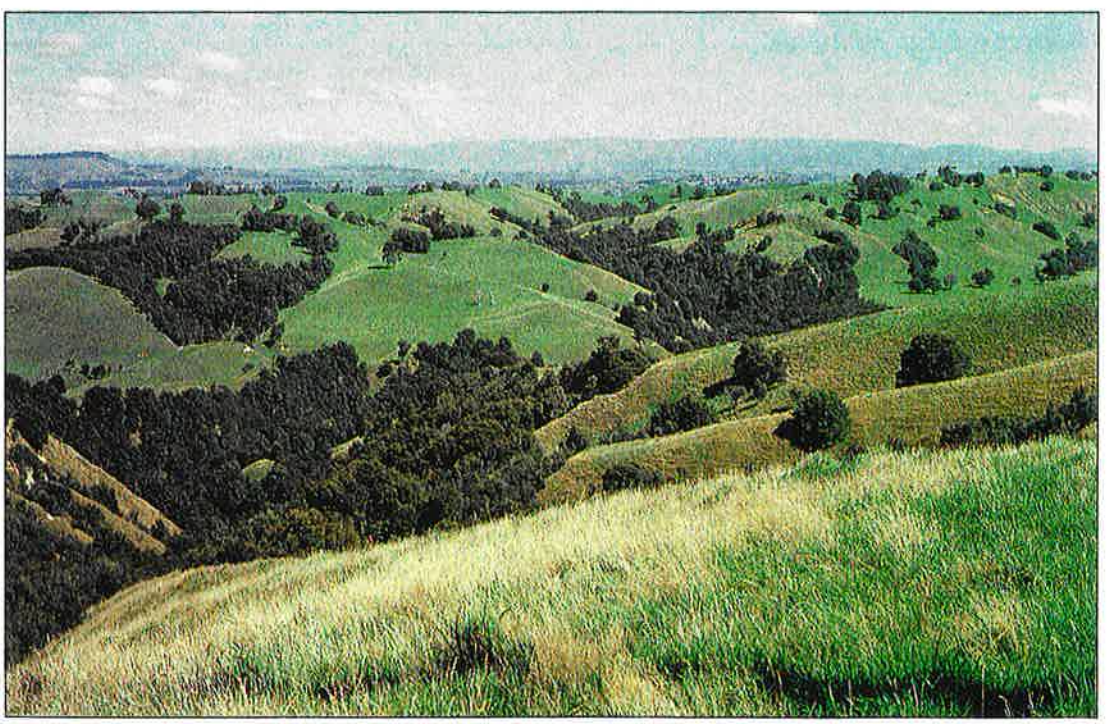
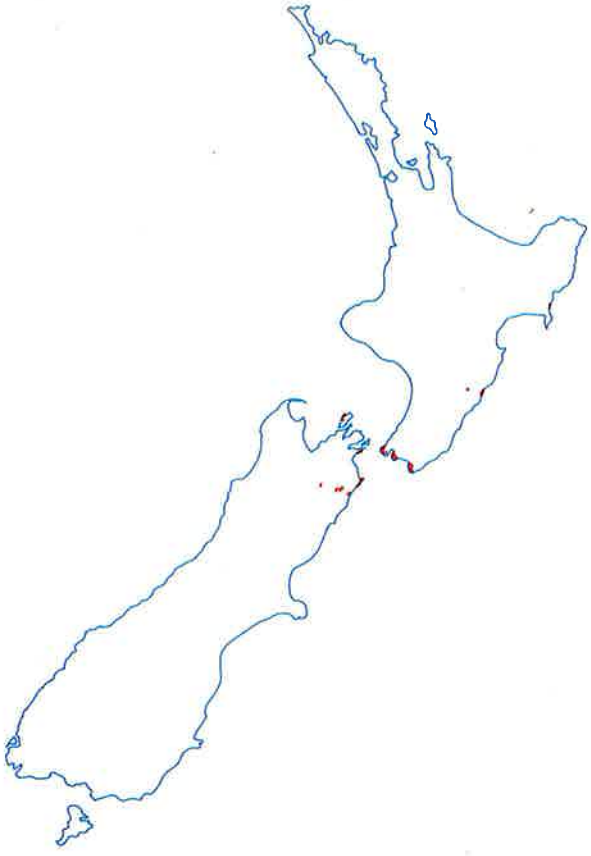


Figure 17: GS2. Grassland and *Leptospermum*, north-west of Rissington, northern Hawke's Bay.
NZMS 260 V20/263.953 →W *Photo: M J Page*

GS3 GRASSLAND AND *CASSINIA* SCRUB

39,000 ha

Formations of coastal scrub dominated by species of *Cassinia* with exotic or indigenous grassland



Distribution and Landform

Grassland and *Cassinia* scrub is sufficiently extensive to be mapped only between Gisborne and Kaikoura. Here it occurs on coastal hills and cliffs in the Hawke's Bay, Wairarapa, Wellington and eastern Marlborough regions. It is occasionally recorded in exposed situations some kilometres inland from the coast.

Characteristic Features

Throughout its range **Grassland and *Cassinia* scrub** is typified by tauhinu (*Cassinia leptophylla*) which often forms an almost pure shrubland in assocation with generally low- producing pasture. Toward the northern limit of its range in the region of Gisborne, *C. retorta* begins to assume prominence and may be a component of some **'GS3'** units. In the South Island in the vicinity of Cape Campbell, inclusions of *Olearia solandri* are a conspicuous component of the class. The limited occurrences of this class in the vicinity of the Inland Kaikoura Range are composed dominantly of *C. vauvilliersii*. In appearance the *Cassinia* species are quite similar, being a light grey-green colour and growing to a height of about 1-2 metres. Communities may appear either as an open, low shrubland or as an almost closed scrub whose canopy has a smooth though dimpled texture. *Olearia solandri,* where it is present, confers a darker, khaki colouration to the canopy though it is otherwise similar in its ecology and appearance.

In most situations *Cassinia* occurs in areas which were previously covered by coastal forest or tall scrub and which are still ecologically suited to such closed, woody vegetation. Therefore, despite the stressful exposed environment, there is a perceptible successional trend through species of

Coprosma and *Olearia*, pepper tree (*Pseudowintera colorata*), tutu and other shrubs to a coastal broadleaved forest. Such forest would probably be eventually dominated by kohekohe, titoki (*Alectryon excelsus*), nikau and perhaps karaka (*Corynocarpus laevigatus*) and ngaio (*Myoporum laetum*).

Undoubtedly the controlling influence in these localities is exposure to salt-laden winds but possibly poor, shallow soils are also a contributing factor. In these situations tauhinu has a distinct competitive advantage over the poorly adapted exotic grasses. This suitability to coastal conditions and its unpalatability to grazing animals has meant that tauhinu has assumed the status of a weed in these areas.

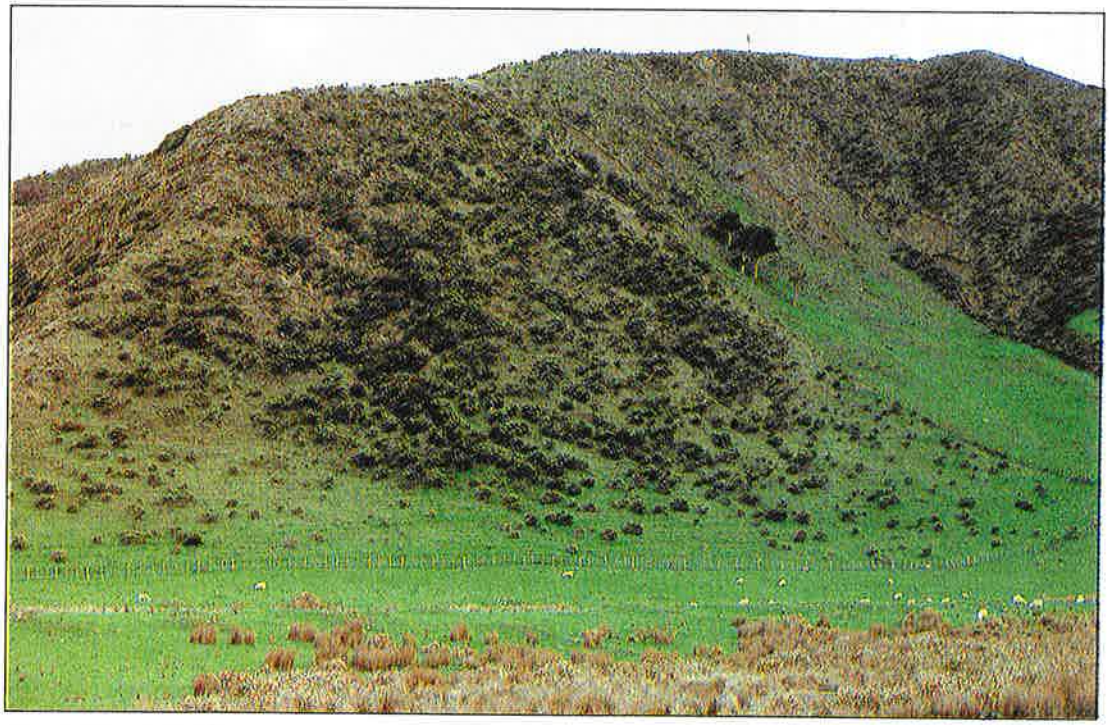
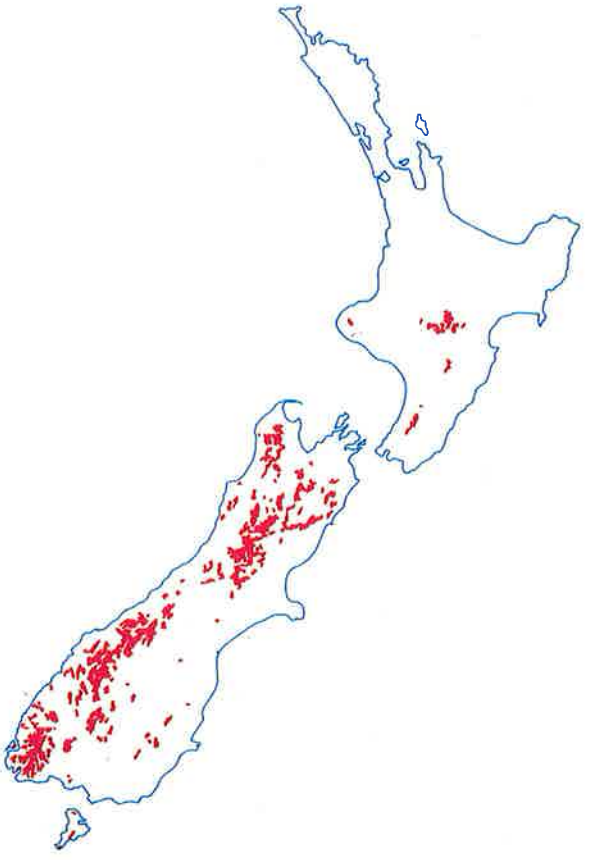


Figure 18: GS3. *Cassinia leptophylla* on coastal hills, north-east of Cape Palliser, Wairarapa. NZMS 260 s28/168.604 →N

GS4 TUSSOCK GRASSLAND AND SUB-ALPINE SCRUB

966,000 ha

Formations of indigenous scrub and tussock grassland occurring above actual or theoretical timberline.



Distribution and Landform

Tussock grassland and subalpine scrub is mapped extensively throughout the high mountains of New Zealand. In the North Island it is confined to the crests of the axial ranges and the highest volcanic mountains. In the South Island it is conspicuous on virtually all high mountains from Nelson and Marlborough to Fiordland and Stewart Island, but is of reduced extent in the drier high country of Canterbury and Otago.

Characteristic Features

In the axial ranges of the North Island leatherwood (*Olearia colensoi*) is often a conspicuous element and may form a dense low canopy in a belt just above the treeline. At higher or more exposed sites, and possibly on poorer soils and where there is less available moisture, there is an increasing proportion of snow tussocks and greater expression other of shrubs including species of *Brachyglottis, Coprosma, Dracophyllum, Dacrydium, Hebe, Podocarpus* and other *Olearia* spp.

The South Island with its wider range of habitats supports a correspondingly more diverse array of communities. In the mountains of inland Marlborough and Otago, east of the Main Divide, communities tend toward a shrubland of *Dracophyllum* and *Hebe* species, *Podocarpus nivalis* and *Phyllocladus alpinus* in association with snow tussock grassland. In areas of higher rainfall, west of the Main Divide, there is generally a discrete belt of sub-alpine scrub just above the treeline and a transition upwards into grassland-scrub mixtures

and ultimately alpine tussockland. Throughout the mountains there is a marked preference shown by the scrub components for warmer sunny slopes, with the cooler, shady slopes supporting greater concentrations of snow tussocks. This differentiation was not always able to be expressed on the map.

With such variety in form and composition, identification of these communities relies on recognising such features as the position of the treeline as well as the component blue- green of leatherwood, the rust-brown of *Dracophyllum* and the yellow-green of the snow tussocks.

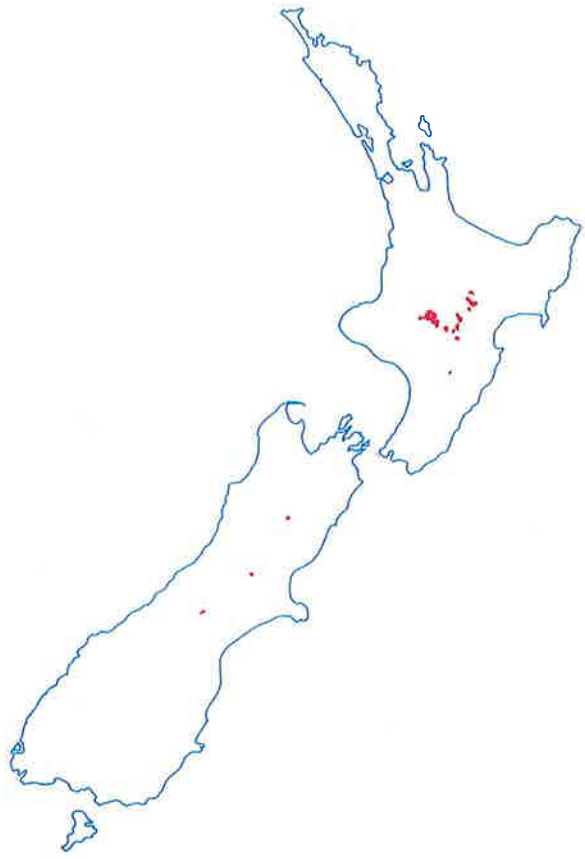
Sub-alpine scrub either alone or in association with grassland is an element of most New Zealand treelines. Since the time of human occupation it has expanded significantly into areas such as Porters Pass where fire has destroyed the original forest. Subsequent fire and introduced animals have since modified vast tracts of **grassland and subalpine scrub**. In this fragile environment where the growing season is measured in weeks, and recovery from fire for example, is in the order of a hundred years (Calder and Wardle 1969), such repeated events have the potential to cause catastrophic damage.

Figure 19: GS4. Sub-alpine shrubland with conspicuous *Dracophyllum* species. Compare with sub-alpine scrub dominated by leatherwood (figure 26). Clarence Valley, 25 km north-north-east of Hanmer Springs, Marlborough.
NZMS 260 N31/910.760 →W

GS5 GRASSLAND AND *DRACOPHYLLUM* SCRUB

49,000 ha

Formations of montane scrub dominated by *Dracophyllum* species with indigenous or exotic grassland.



Distribution and Landform

Grassland and *Dracophyllum* scrub is localised and is concentrated in the regions of Tongariro National Park, the Kaimanawa mountains, and the upper Rangitaiki plains. It occurs at altitudes between 750 and 1050 metres.

In the South Island the class, **Grassland and *Dracophyllum* scrub**, is infrequent and is mapped only in the hills of inland north Canterbury. However, *Dracophyllum* species, are common components, at higher altitudes, of sub-alpine scrub, in class **'GS4'**.

Characteristic Features

Grassland and *Dracophyllum* scrub is generally characteristic of the so-called 'frost-flats' of the Volcanic Plateau, but it also occupies appreciable areas on flow tephra deposits and some rolling hill country. Component species include combinations of *D. recurvum, D. subulatum* and *D. longifolium*, frequently associated with umbrella fern (*Gleichenia microphylla*), *Hebe* species, heather, sometimes manuka, red tussock, short tussock (especially *Rytidosperma setifolium*) and exotic grasses such as browntop and sweet vernal.

Described as a heathland by Burrows *et al.* (1979), it appears as a low (usually less than 1 metre in height), often windswept, tawny brown canopy hugging the contour of the land. Individual components usually show up clearly as a contrast between the soft textured, reddish yellow foliage of

red tussock, or the bristly textured, straw colour of short tussock, and the wiry, red-brown of the *Dracophyllum* shrubs. Other shrubs, for example species of *Hebe*, are usually more green in colour.

Extensive disturbance in the form of volcanism, and fire both natural and that induced by humans, have played a role in forming this habitat (Burrows *et al.* 1979, Nicholls 1983) and appear to be instrumental in maintaining the vegetation. Other factors which favour **grassland and *Dracophyllum*** communities are a propensity for summer frosts, relatively drought-prone soils and an acid litter produced by the *Dracophyllum* shrubs (Druce 1952). Nevertheless, where undisturbed there is often a perceptible invasion of these communities by forest species (Atkinson 1981) and so an eventual re-occupation of many areas by forest is likely.

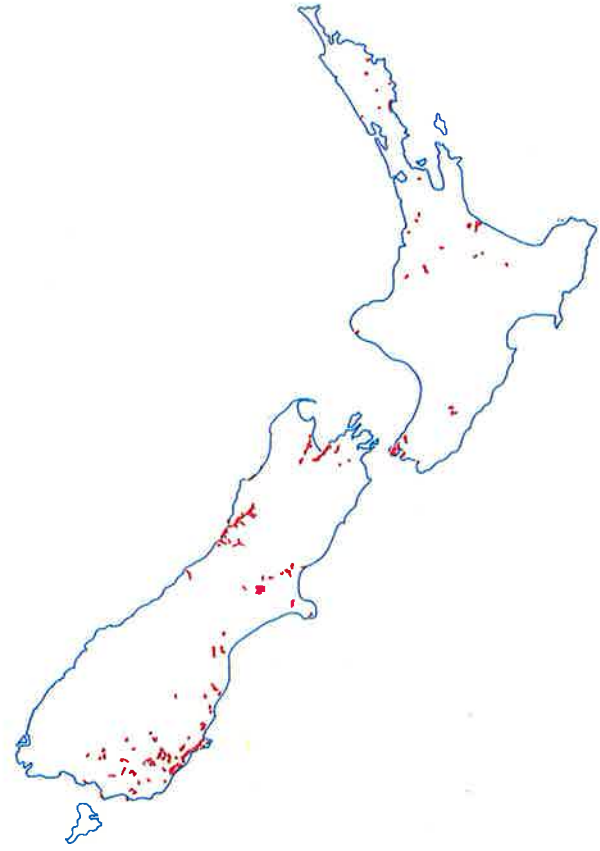
In the area of Tongariro National Park some areas of **grassland and *Dracophyllum*** contain considerable components of heather (*Calluna vulgaris*). This introduced plant was sown widely in the north-western sector of the park from about 1913 to 1926 in an attempt to establish a "*grouse moor*" (Bagnall 1982). Now, 60 years later, heather is prominent in the northern and western sectors of the park and shows a disturbing ability to spread even under a developed native shrub and grassland cover. Its present extent shows up clearly during summer, when its purple flowers contrast with the indigenous shrubs and tussocks.

Figure 20: GS5. *Dracophyllum* heathland, looking toward Mt Ngauruhoe from a point 5 km north-west of Whakapapa Village, Tongariro National Park.
NZMS 260 S19/262.228 →W *Photo: I A E Atkinson*

GS6 GRASSLAND AND GORSE SCRUB

234,000 ha

Formations of scrub dominated by gorse *(Ulex europaeus)* with exotic or indigenous grassland.



Distribution and Landform

Grassland and gorse scrub is widespread on extensively managed, low fertility hill country farmland particularly in the regions of Southland, Coastal Otago, Canterbury, Westland, Nelson and Wellington, with local occurrences in northern districts. Usually it appears as pockets of gorse on hillslopes, in gullies and narrow valley bottoms.

Characteristic Features

In outward appearance a young gorse stand is dark green with a soft texture. With age this soft texture disappears and the canopy, commonly up to 2 metres in height, assumes a more irregular profile, with dead stems and old wood contributing toward a mottled green and brown colouration. Prolific flowering occurs in spring to early summer and again in autumn. The flowers confer a yellow-green mottled colour to the canopy, which from a distance appears as a dull yellow. The grassland component usually comprises species typical of **improved pasture** or **unimproved pasture**.

The environmental factors which most influence gorse growth are soil fertility, moisture, temperature and grazing pressure. The nutrient requirements of gorse are low and, because it has nitrogen-fixing bacteria in its roots, it is largely independent of soil nitrogen. This accounts for its competitiveness on skeletal soils on eroded and burned hillslopes. Gorse is, however, intolerant of low temperatures and requires ample moisture but good soil drainage for optimum growth.

Gorse was introduced to New Zealand in the early European era as a

decorative hedge plant, whereupon it rapidly spread and established in a host of environments provided by the under-utilised or mismanaged land. Gorse is a plant ideally adapted to repeated burning through its ability to coppice from burnt stems, and through fire's effect in reducing soil nutrients and promoting gorse seed germination. In less direct ways many practices which promote erosion or land degradation also encourage the spread of gorse (and other weeds) by providing new, impoverished, habitats such as erosion scars and aggraded riverbeds.

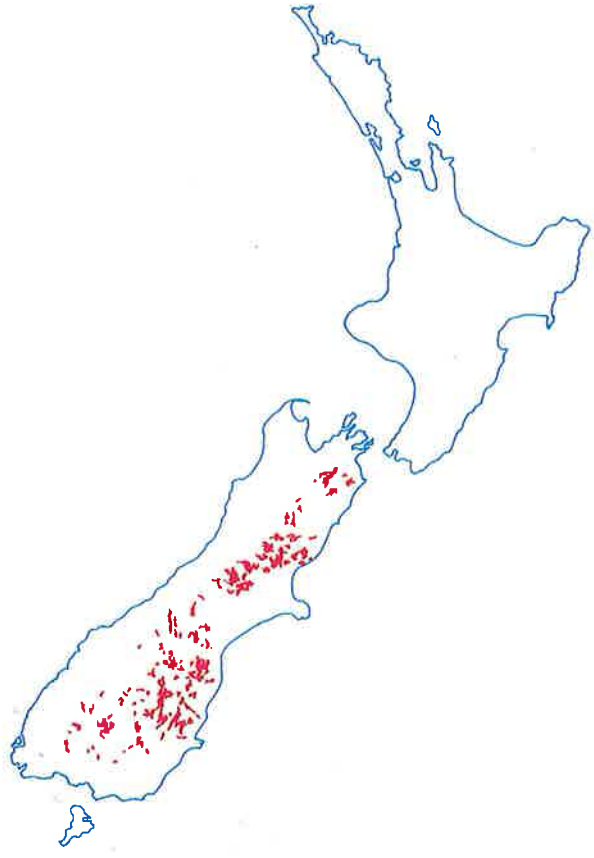
But despite its aggressiveness, resulting in it being classed as a noxious weed throughout the country, gorse has qualities which can benefit many sites. Its nitrogen-fixing capability and rate of organic matter accumulation is several times higher than that of an equivalent native seral vegetation such as manuka, kanuka and kamahi (Egunjobi 1969). Thus it has been suggested that where undisturbed, many sites supporting gorse will follow a succession toward indigenous forest more rapidly than they could without gorse (Hackwell 1980). The time taken for gorse to be succeeded by indigenous shrubs and trees varies according to habitat and from north to south. Druce (1957) reports that near Wellington gorse is completely suppressed in 30-40 years, while Lee *et al.* (1986) relate that near Dunedin this may take up to 60 years and they even identify some quite stable communities on exposed coastal cliffs.

Figure 21: GS6. Grassland and gorse scrub, east of Palmerston North, Manawatu. A locally more prominent inclusion in an area recorded on the map as grassland and *Leptospermum* (GS2) with minor inclusions of gorse.
NZMS 260 T24/349.888 →SE

GS7 GRASSLAND AND MATAGOURI

510,000 ha

Semi-arid shrublands dominated by matagouri (*Discaria toumatou*) with indigenous or exotic grassland.



Distribution and Landform

Grassland and matagouri is widespread in the South Island, in semi-arid and moderate rainfall regions east of the Main Divide. It is common on moist but freely-drained, recent soils, frequently associated with colluvial slope deposits. These deposits may occur on a range of landforms including terraces, floodplains and steepland sites. The class occurs almost entirely in the montane zone below 1000 metres altitude and in districts with annual rainfalls below 1600 mm (Hunter 1986).

Characteristic Features

Matagouri is a shrub of short to medium stature which can attain heights up to 5 metres, but is usually encountered in open shrublands or small thickets with heights ranging between 0.5 and 2 metres. It is a divaricating thorny shrub often with reduced leaves, and so it often has the appearance of a grey-brown, spiky bush, which from a distance might be imagined to be dead. The flowers, which are a creamy colour, appear in early summer, but do not confer a greatly different appearance on the bush.

The grassland component is usually dominated by short tussocks of the genera *Festuca* or *Poa* or by introduced grasses, among which browntop and sweet vernal are conspicuous. Matagouri will often be associated with other small-leaved divaricating shrubs such as *Corokia cotoneaster, Coprosma propinqua*, prostrate kowhai (*Sophora prostrata*), and species of *Hymenanthera* and *Muehlenbeckia*.

Matagouri is most competitive on moist, well drained, recent soils relatively rich in available phosphate (Daly 1967). Matagouri is unusual in that, like the legumes, it has root nodules containing a symbiotic bacterium which can fix atmospheric nitrogen. It is therefore independent of soil nitrogen. As soil development increases and in areas of imperfect drainage, matagouri loses its competitive edge and may eventually be eliminated from the scrub. However, land management practices such as application of phosphate fertiliser usually also result in a flush of growth of matagouri. Likewise, burning for land clearance or pasture renewal has the effect of favouring colonisation by matagouri by depleting soil nitrogen. Such incompatability with some aspects of agricultural management has meant that matagouri is viewed as a minor to serious weed through much of the extensively-managed rangeland of the South Island (Bascand and Jowett 1982).

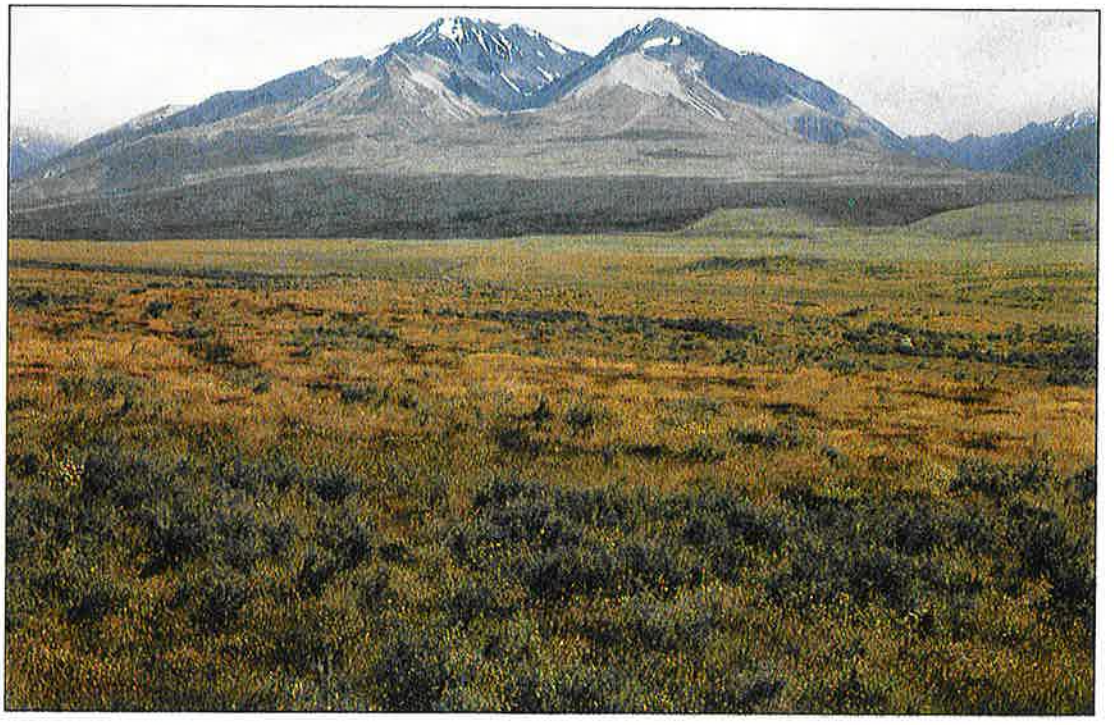
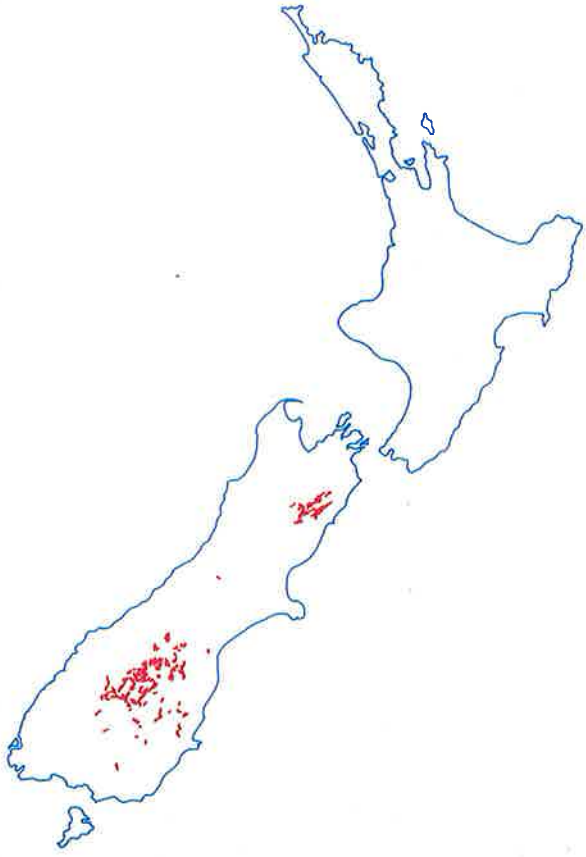


Figure 22: GS7. Matagouri shrubland, near Lake Clearwater, Canterbury. NZMS 260 I36/490.330 →NNW

GS8 GRASSLAND WITH SWEET BRIER OR SWEET BRIER AND MATAGOURI

232,000 ha

Semi-arid shrublands dominated by sweet brier (*Rosa rubiginosa*) or dog rose (*R. canina*) either alone or in association with matagouri (*Disaria toumatou*), with indigenous or exotic grassland.



Distribution and Landform

Grassland with sweet brier, or sweet brier and matagouri, is common in the South Island in semi-arid and moderate rainfall country east of the Main Divide. It is usually encountered on tussocklands and low-producing pasture in the inland areas of Marlborough, South Canterbury and Otago, where annual rainfalls are below 1400 mm (Hunter 1983). Here it occupies moist sites on freely drained recent soils, frequently associated with colluvial slope deposits, alluvial terraces, plains and riverbeds.

Characteristic Features

As their names suggest both sweet brier and dog rose are wild roses but, in appearance are an untidy caricature of their horticulturally-bred cousins. They generally lack a distinct trunk and develop along numerous thorny erect (sweet brier) or straggling (dog rose) canes which, in sweet brier, may attain heights in excess of 2 metres. In appearance the shrubs are mid-green to olive green, tending more reddish brown as the leaves yellow and fall. Flowering is in summer and contributes a pink (sweet brier) or white (dog rose) colour to the canopy. Community structure varies from a shrubland of scattered bushes to impenetrable thickets, among a grassland of short tussocks, or low- producing exotic grasses such as browntop and sweet vernal.

Ecologically, sweet brier has similar adaptations to matagouri, hence the considerable overlap in their habitats. Both show a preference for recent, fertile soils with good drainage. Both require adequate moisture levels, and hence sweet brier's tendency to concentrate in seepage zones and along watercourses. But unlike matagouri, sweet brier does not possess nitrogen-fixing root nodules and this may restrict its range in some sites.

Sweet brier was introduced to New Zealand in the early 1800's and cultivated as an ornamental rose *". . . to improve the appearance of the lonely station homesteads . . ."* (Anon 1962). Being resistant to fire and strongly competitive on the depleted tussocklands, it spread rapidly and by the end of the century was declared a noxious weed throughout the country. Its spread was contained to some extent by browsing by stock and rabbits until the second half of this century. Since then rabbit control, a reduced incidence of overstocking, and aerial topdressing of fertiliser has led to a resurgence of sweet brier to an even greater extent than it has with matagouri. The management implications of this trend are serious, as sweet brier spreads on under-utilised tussocklands and consolidates its present hold on such sites as road berms and stream margins.

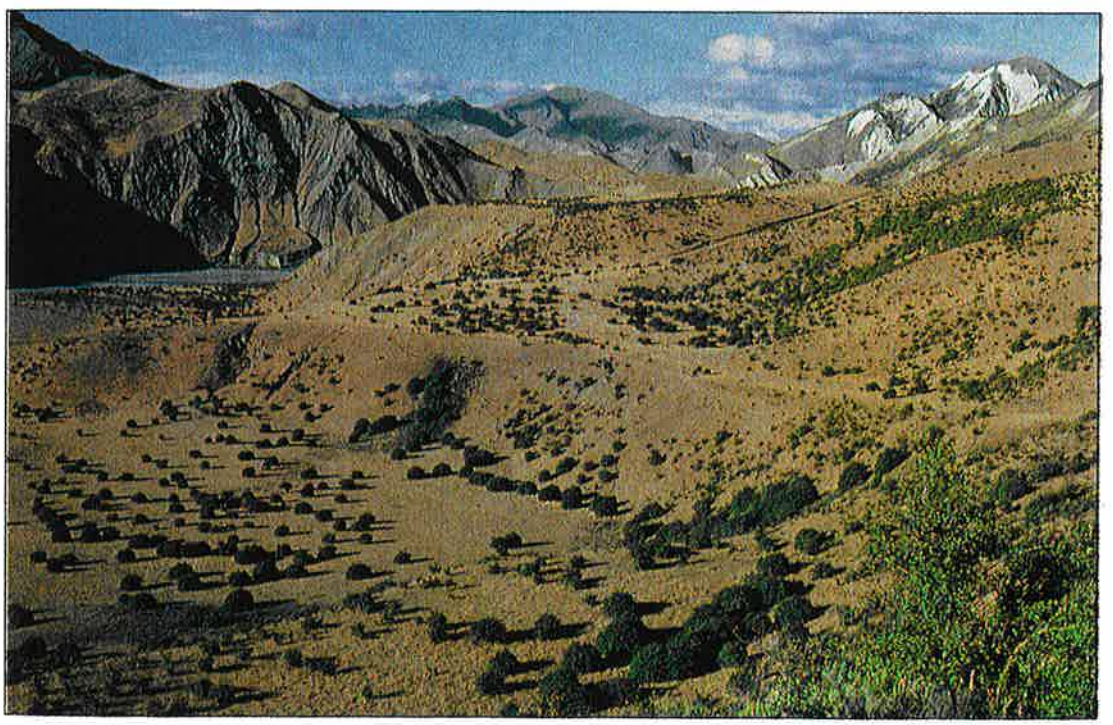
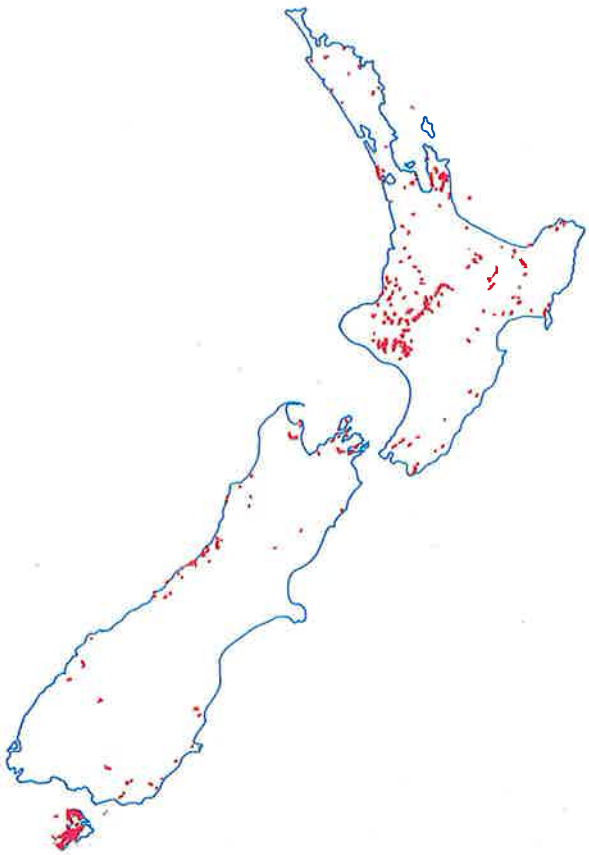


Figure 23: GS8. Sweet brier shrubland, Clarence Valley, Marlborough.
NZMS 260 031/690.050 →NE *Photo: P A Williams*

S1 MIXED INDIGENOUS SCRUB

362,000 ha

Lowland scrub communities dominated by indigenous, mixed broadleaved shrubs generally forming a dense, more or less continuous canopy.



Distribution and Landform

Mixed indigenous scrub is widespread in medium to high rainfall areas throughout New Zealand. It achieves greatest expression in formerly forested hill country, often of low productive value, which was cleared for pasture earlier this century. Elsewhere, it is mapped on exposed and often inhospitable sites such as on outlying islands and cliffs, and on infertile or skeletal soils such as the granitic ridges and domes of Stewart Island.

Characteristic Features

Mixed indigenous scrub usually has the appearance of a young, vigorous stand dominated by broadleaved shrubs and forming a closed canopy between 2 metres and 5 metres in height. Colouration varies with composition but is usually a mosaic of mid-greens. Canopy texture is usually unevenly dimpled, tending toward smoothness with exposure to wind, and roughness with increasing components of young forest trees. Tree ferns are often prominent.

In most localities the canopy is dominated by the broadleaved shrubs and small trees commonly found in the understories and margins of mature forest. These may include species of *Coprosma, Hebe, Olearia* and *Pittosporum*, as well as mahoe, five finger (*Pseudopanax arboreus*), tree ferns, fuchsia, pigeonwood, mapou, wineberry and a host of others. In less favourable habitats there is a greater proportion of the more tolerant species, such as flax (*Phormium* spp), ngaio, rata and species of *Olearia*. On poor soils tutu

is favoured, and in areas of lower rainfall small-leaved divaricating plants become prominent. In many localities of moderate rainfall, and particularly areas with a history of fire, manuka or kanuka may precede mixed indigenous scrub and persist in the canopy for a considerable time before being suppressed. A particular example of this type of occurrence may see manuka persisting on drier spurs and ridges while mixed indigenous scrub expands only slowly from the moister valley floors.

With the exception of the more stable communities in exposed or otherwise stressful habitats, **mixed indigenous scrub** represents an advanced successional stage in forest regeneration. In higher rainfall or high fertility hill country such as in the King Country and inland Taranaki, such reversion poses serious management problems to farmers. In these and many other areas **mixed indigenous scrub** is often indicative of land of questionable agricultural value, better suited to watershed protection and landscape enhancement.

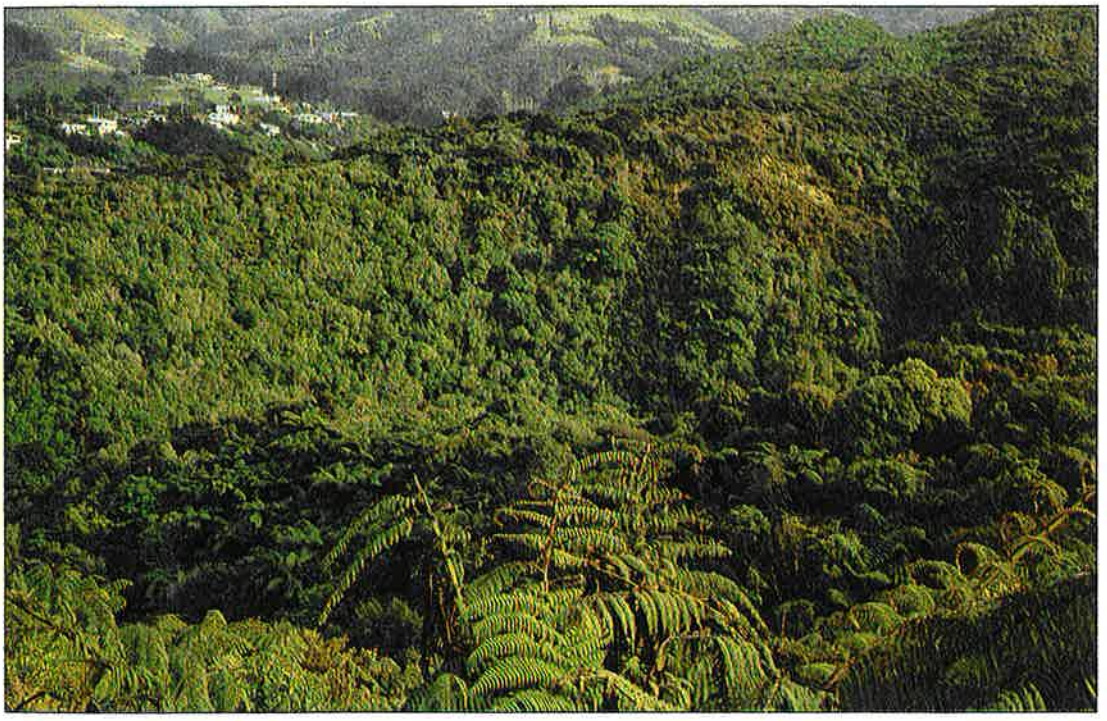
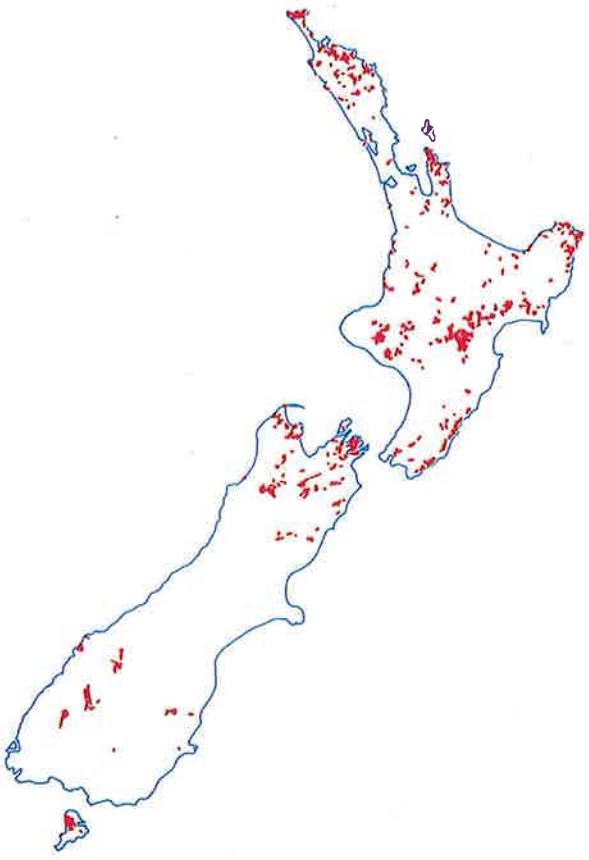


Figure 24: S1. Mixed indigenous scrub, Speedy's Valley, Kelson, Wellington. Advanced succession after fire destroyed the original vegetation. This community has probably followed an earlier stage dominated by gorse.
NZMS 260 T27/718.007 →W

S2 *LEPTOSPERMUM* SCRUB OR FERN

626,000 ha

Lowland scrub communities dominated by manuka (*Leptospermum scoparium*) or kanuka (*L. ericoides*) or by bracken (*Pteridium esculentum*) or bracken-like ferns



Distribution and Landform

***Leptospermum* scrub or fern** is mapped throughout New Zealand. It is particularly conspicuous in moist hill country, formerly cleared of indigenous forest, but not able to economically sustain agriculture. The class is a feature of land bordering the main ranges, and of steep hill country in the North Island, and northern, and southern South Island. *Leptospermum* (manuka or kanuka) is consistently more prominent than fern, but the fern element is important in the King Country, inland Taranaki and in the vicinity of Murchison.

Characteristic Features

A young, vigorous stand of *Leptospermum* will appear dark green sometimes with a slightly reddish tinge. Its canopy exhibits a smooth, soft, brush-like texture standing between 1 and 3 metres high. With age the canopy grows to a height of between 3 and 5 metres, and becomes more open. During summer flowering the contrast between manuka and kanuka is pronounced, with kanuka- dominated stands assuming a brownish cream colour and the canopy of manuka dusted a snow white.

Bracken is the usual fern component although locally ring fern may be prominent. Bracken presents a ruffled, uneven, canopy which may be up to 2 metres high and very dense. Colouration ranges between olive and light-green, with brown mottles where dead fronds are present. Ring fern is substantially smaller and forms a light green carpet rarely more than ½ metre high. Bracken may occur with *Leptospermum*, often in a mosaic pattern of fern-dominated and *Leptospermum*-dominated patches. This situation is usually transitional to tall *Leptospermum* or mixed indigenous scrub.

Leptospermum is most competitive in areas of moderate rainfall and on soils of lower natural fertility and good internal drainage. Manuka is tolerant of both wetter and drier conditions than kanuka and has a higher altitudinal limit. Kanuka is more prominent on the well-drained volcanic soils of the central North Island. It is longer lived, will attain a greater height and is more resistant to manuka blight. Bracken occurs on well-drained but moist soils, and is often concentrated in seepage zones in the drier, eastern South Island. Communities of *Leptospermum* and of bracken are well adapted to recover from fire (though kanuka less so than manuka) and regenerate aggressively after burning.

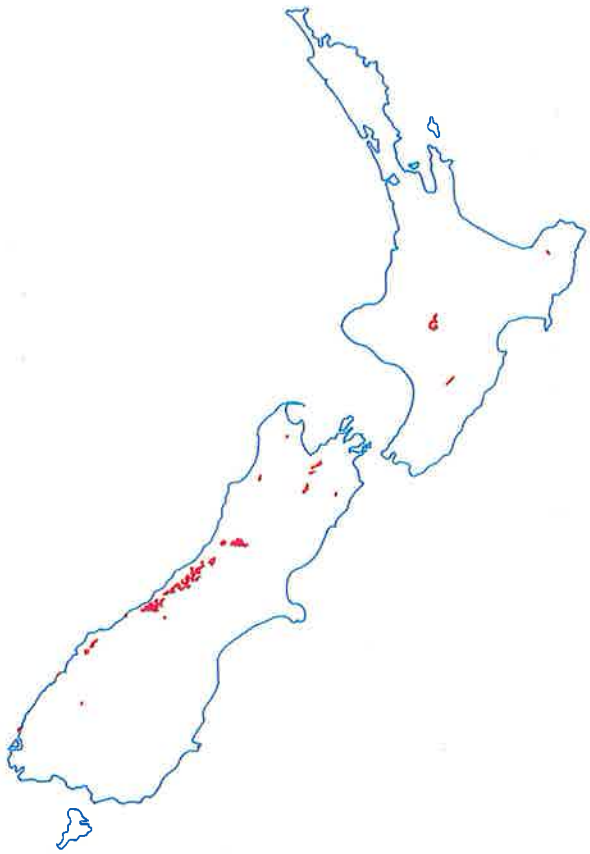
All species of this class are colonisers of bare and under-utilised land and so perform an important role in natural succession. Hence, ***Leptospermum* scrub or fern** may include other shrubs and ferns common to mixed indigenous scrub and forest understories. As the age of the scrub stand increases, these subdominant components will gain ascendance and ultimately suppress the *Leptospermum*. Usually the succession through *Leptospermum* is achieved within one generation, but this is not always the case. Some *Leptospermum* stands in Central Otago and Marlborough are self perpetuating and because of a climate less favourable to forest, and the distance from suitable seed sources, it may be a few hundred years before beech forests re-establish.

Figure 25: S2.*Leptospermum* scrub, southern Great Barrier Island. A locally less advanced successional stage in an area recorded on the map as kauri and *Leptospermum* scrub.
NZMS 260 T09/351.380 →SW *Photo: N A Trustrum*

S3 SUB-ALPINE SCRUB

96,000 ha

Highland scrub dominated by indigenous shrubs and occurring above the actual or theoretical timberline



Distribution and Landform

Sub-alpine scrub, while common as a shrubland in association with tussock grassland in most high mountains (class **GS4**), is mappable as a more dense scrub only in a restricted range of localities. In the North Island it is mapped on the slopes of the volcanic cones of Tongariro National Park, and on the crest of the Raukumara and Ruahine Ranges. In the South Island it is a feature of a region of generally lower treelines in Westland between the Taramakau and Paringa rivers. Elsewhere it is recorded locally in the mountains of north-west Nelson, the Richmond Range and on the ultramafic rock ranges of Marlborough and Fiordland.

Characteristic Features

The South Island mountains, with their wide range of habitats, are the stronghold of sub-alpine scrub in New Zealand. In the drier mountains east of the Main Divide communities tend to be of lower stature, fairly open in structure and dominated by *Podocarpus nivalis, Phyllocladus alpinus* and species of *Brachyglottis, Dracophyllum* and *Hebe*. In appearance these tend to form a discontinuous canopy up to 2 metres high, with a mottled colouration of rust browns and various shades of green. With increasing rainfall, such as occurs west of the Main Divide, communities increase in stature and density, and contain more broadleaved shrubs and trees. Conspicuous in the canopy may be leatherwood, and mountain ribbonwood (*Hoheria glabrata*), *Olearia lacunosa* and species of *Brachyglottis* and *Dracophyllum*. Such communities are a feature of central Westland where beech is naturally absent and there is a consequently depressed treeline.

These communities on such wetter mountain slopes appear a more luxuriant green than their dryland counterparts, and with a more even textured but hummocky canopy. A somewhat singular situation is the strongly rock-type-controlled communities of the ultramafic ranges of Marlborough and Fiordland. These very sparse associations of species of *Cassinia, Hebe, Olearia* and *Leptospermum* are classified as **sub-alpine scrub** as a 'best-fit', even though altitudinally they are not strictly sub-alpine.

Similarly open communities of mountain inaka (*Dracophyllum recurvum*) and mountain gaultheria (*Gaultheria colensoi*) are mapped as **sub-alpine scrub** on the slopes of the volcanic mountains of Tongariro National Park. These contrast with the other North Island situation in the Ruahine range where a dense, 1 metre to 3 metre high canopy of leatherwood provides a blue-green blanket over the upper slopes and ridges.

Being somewhat remote, and often protected by a buffer-zone of forest, **sub-alpine scrub** tends to be affected only indirectly by human activities, via the browsing of introduced feral animals. The extent of **sub-alpine scrub** and its altitudinal position has probably oscillated in both recent and prehistoric times in response to catastrophes in the forest below, such as storm damage or erosion, and to climatic change (Elder 1963). Its own upper limit where it grades into the alpine tussocks above is determined both by the prevailing average climate and also by unseasonal frosts, desiccating winds, and snow. Periodic mortality in North Island leatherwood scrub has been correlated with deer browsing, insect attack and possible fungal infection (Holloway *et al.* 1963).

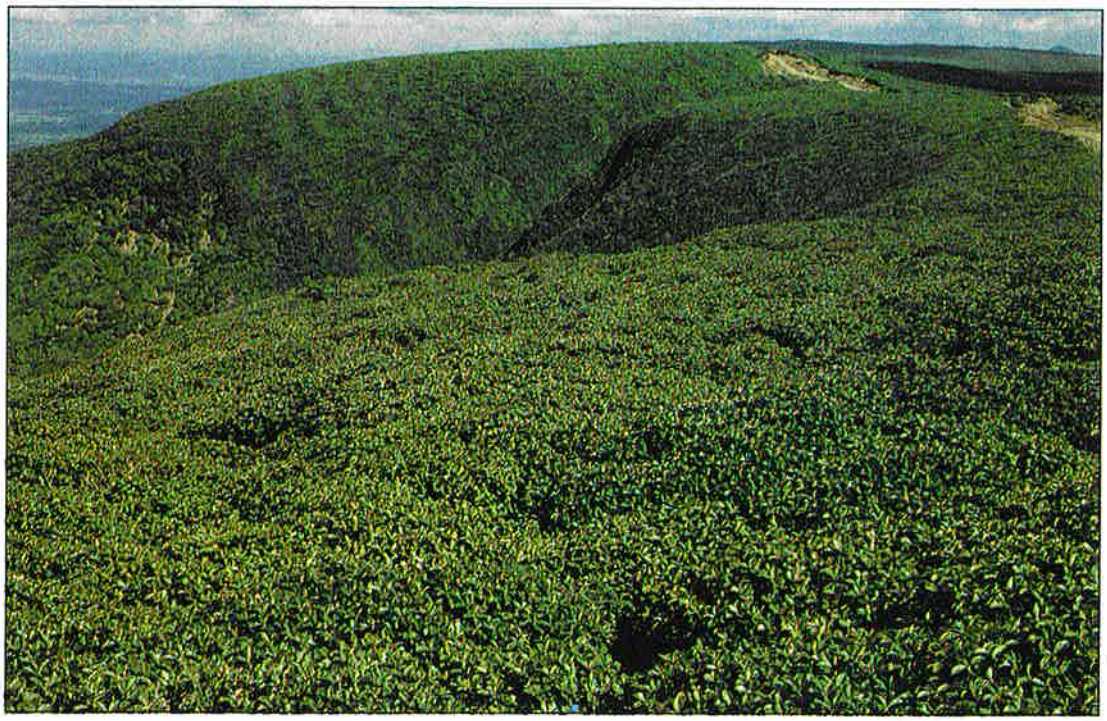
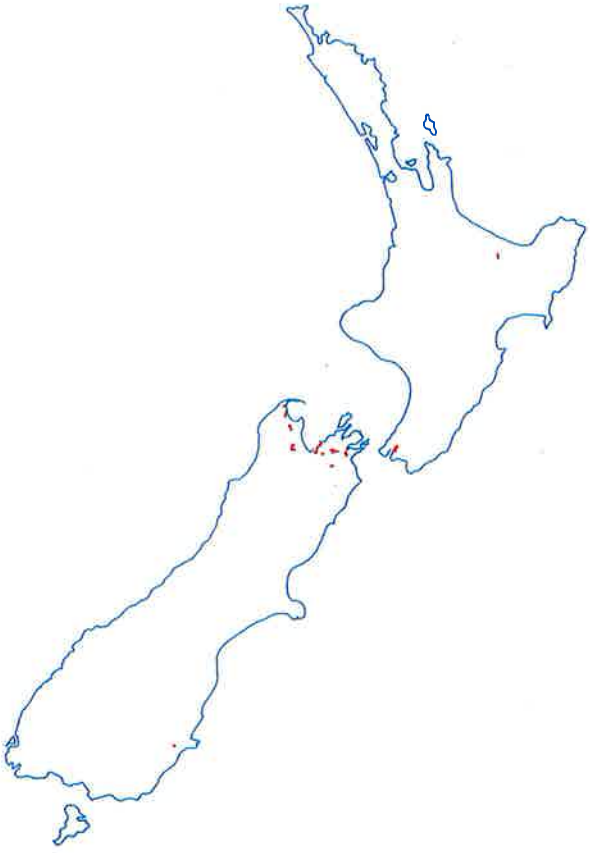


Figure 26: S3. Leatherwood scrub, Ruahine Range.
NZMS 260 T23/678.193 →S

S4 GORSE SCRUB

20,000 ha

Lowland scrub communities dominated by gorse (*Ulex europaeus*)



Distribution and Landform

While gorse as a species is widely distributed, as a closed scrub it achieves expression mainly in the Wellington and Nelson regions with isolated occurrences in the Bay of Plenty and coastal Otago. **Gorse scrub** typically occupies steep, low fertility, greywacke hill country and is often maintained in a vigorous, healthy state by periodic fire.

Characteristic Features

Gorse scrub in its youth appears as a hummocky, soft-textured canopy up to 1 metre in height and dark green in colour. With age, the canopy exhibits a more irregular, open form up to 3 metres in height, with branches and dead foliage contributing brown mottles to the colour. Flowering is between late spring to early summer and again in autumn when the canopy assumes a mottled yellow and green colouration, which from a distance appears as a dull yellow.

The success of gorse as a coloniser can be attributed to its adaptation to a number of environmental factors. The first is low soil fertility; gorse is relatively undemanding of soil nutrients and, as a very efficient nitrogen-fixing plant, is independent of soil nitrogen. But it does require adequate soil moisture with good soil drainage for optimal growth. Under these conditions it has a very high level of nitrogen and organic matter accumulation, in fact substantially in excess of an equivalent native seral vegetation such as manuka, kanuka and kamahi (Egunjobi 1969). Gorse distribution and spread is limited in cooler areas, where low temperatures inhibit seed germination. However, where conditions are suitable gorse seed may remain viable in the soil for over 30 years (Zabkiewicz 1976) and may be further dispersed in the wheels of agricultural machinery. Effective control relies on chemical

sprays which are both expensive and indiscriminate in their effect if wind should carry them onto surrounding productive land. Gorse has a strong adaptive advantage in its recovery from fire, manifest in a high regrowth rate, competitiveness on fire-impoverished soils and stimulation of seed germination by heat. All these factors are present in the Wellington and Nelson localities. Repeated fires in particular, contributes greatly to maintaining the high vigour of the gorse communities.

Appearing with middle-aged and old-aged gorse stands may be an understorey of indigenous broadleaved shrubs. These, while sparse at first, gradually become more conspicuous as the gorse canopy opens out, until eventually they may suppress the gorse altogether. Druce (1957) reported that in the Wellington region gorse is completely suppressed by indigenous shrubs and trees in 30-40 years while Lee *et al.* (1986) relate that in the hills near Dunedin this may take up to 60 years.

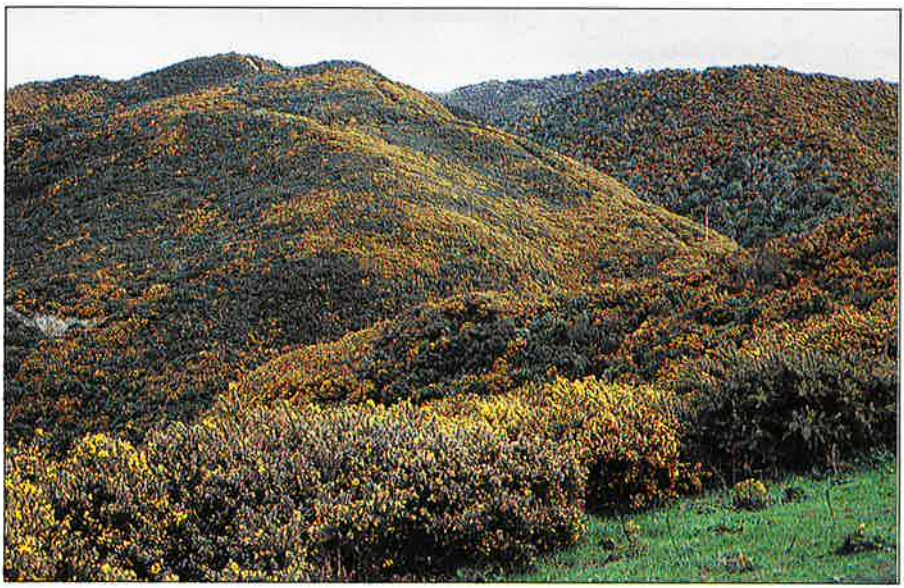
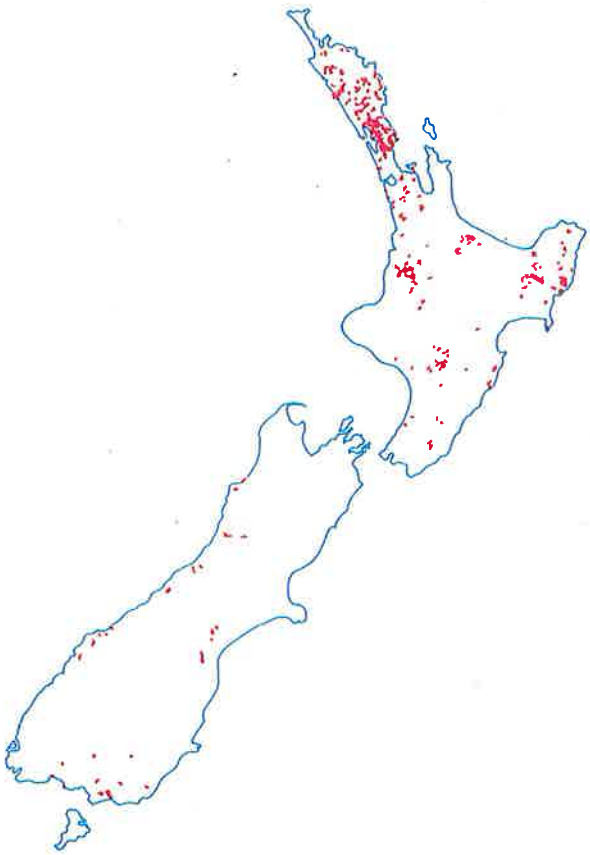


Figure 27: S4. Gorse scrub, Brooklyn, Wellington. A locally extensive scrub community in an area recorded on the map as grassland and gorse scrub.
NZMS 260 R27/570.877 →SW

GF1 PASTURE AND PODOCARP-BROADLEAVED FOREST

340,000 ha

Woodlands of trees typical of indigenous podocarp-broadleaved forest with exotic pasture grasses



Distribution and Landform

Pasture and podocarp-broadleaved forest is locally distributed throughout the North Island but in the South Island is mapped only in the regions of Westland, South Canterbury and Southland. It occurs on landforms ranging from steep hill country to rolling downlands, plains and terraces. In all instances it is recorded on land which has formerly supported extensive forest. It includes both well-developed, high-producing land now supporting more or less stable woodlands; and land more recently cleared, but retaining isolated stands of mature forest in gully heads and on hillslopes.

Characteristic Features

Pasture and podocarp-broadleaved forest arising from recent land clearance appears as mature forest stands isolated in a pastoral setting, often with numerous fallen and burnt trunks and stumps on the cleared land. It presents a forlorn appearance, as tall canopy and emergent trees suffer dieback along its now unprotected stand margin. Woodlands of longer standing may appear either as remnants of the original forest in various stages of decline, or as healthy stands, often of younger trees which have established subsequent to the original land clearance and which are in a more or less stable condition. The latter have probably established a stable stand margin, are protected from domestic stock and are often of a size sufficient to allow natural regeneration to continue.

Species composition usually reflects the composition of the former forest

and of nearby seed sources. Totara (*Podocarpus totara*), matai (*Prumnopitys taxifolia*) and miro (*Prumnopitys ferruginea*) are the principal podocarps, with rimu (*Dacrydium cupressinum*) less prominent except among stands arising from recent land clearance. The broadleaved component is often dominated by tawa, kamahi and rewarewa, with titoki and kohekohe conspicuous on coastal plains, and taraire (*Beilschmiedia tarairi*) and puriri (*Vitex lucens*) prominent in the north. Understorey and subcanopy trees comprise a host of broadleaved shrubs and small trees including hinau, lacebark, mahoe, pigeonwood, wineberry, species of *Coprosma* and *Pseudopanax*, and young canopy trees, as well as a greater or lesser proportion of exotic weeds. Pasture grasses are usually those typical of **improved pasture** or **unimproved pasture** (classes **G1** and **G2**) and can usually be inferred from any adjacent pasture units on the map.

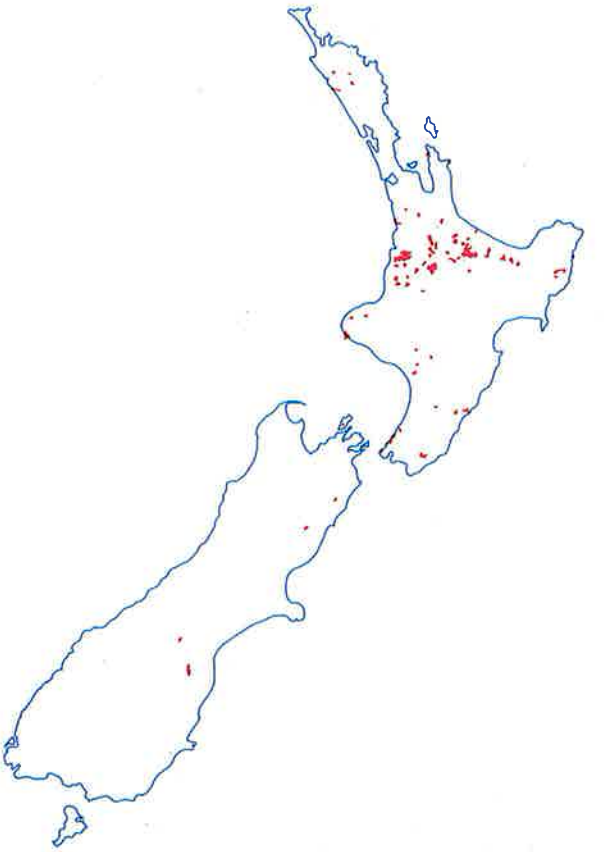
Browsing by stock represents the greatest threat to the viability of these remnant stands. Continued stock pressure will eliminate understorey shrubs entirely and suppress regeneration, while leaving a stand margin unprotected from wind and allowing the ingress of weeds. Conspicuous among adventive weeds are *Tradescantia fluminensis* and old man's beard (*Clematis vitalba*). However, given an awareness of the value of these forest remnants, management including fencing, weed and animal control and occasional understorey planting may ensure their continued viability.

Figure 28: GF1. Pasture and podocarp-broadleaved forest. Podocarps are young and relatively few in this scene, a condition typical of stands which have regenerated following land clearance 60-100 years ago. In Northland, kauri is a sometimes prominent element in such stands. East of Warkworth, Northland.
NZMS 260 R09/674.340 →SW *Photo: K E Noble*

GF2 PASTURE AND BROADLEAVED FOREST

133,000 ha

Woodlands of trees typical of indigenous broadleaved forest with exotic pasture grasses



Distribution and Landform

Pasture and broadleaved forest is well represented in the Waikato and Bay of Plenty Regions and locally elsewhere in the North Island but in the South Island is confined to only a few map units on the downlands of South Canterbury and the foothills of the Seaward Kaikoura Range. In most instances it occurs on rolling land and hill country but also has a minority of sites on plains and terraces.

Characteristic Features

In stand structure and appearance these units exhibit the slightly better adaptive ability of broadleaved trees to grow in isolation from continuous forest and in situations exposed to wind, than can their podocarp counterparts. Nevertheless these units can exhibit a similar degree of variability, ranging from the ill-conditioned canopy arising from the recent clearance of the surrounding forest through a spectrum of declining or adaptive conditions, to the mature phase of comparatively stable woodlands.

Component species feature tawa and kamahi prominently in the canopy, in association with maire (*Nestegis* spp), hinau, rewarewa, titoki and many others. In coastal situations kohekohe, nikau and titoki are particularly important and in northern districts taraire, puriri and towai (*Weinmania silvicola*) assume prominence. Podocarps are either naturally absent or few in number or have been removed from the parent forest by logging. Canopy appearance is usually undulating and even, with an obviously leafy texture. Colour is influenced by the yellow-green of tawa, the brown-grey of kamahi and its northern relative towai, the dark greens of maire, rewarewa and hinau,

the lime green of titoki, and the deep glossy greens of kohekohe and puriri. Associated with these canopy trees may be a well developed understorey of mahoe, pigeonwood, kawakawa (*Macropiper excelsum*), species of *Coprosma, Olearia* and *Pittosporum*, ground ferns and tree ferns, and many others including seedlings and saplings of canopy trees. In unfenced stands accessible to farm stock, the understorey may be completely denuded, and adventive plants such as black nightshade (*Solanum nigrum*), poroporo (*S. aviculare, S. laciniatum*), Jerusalem cherry (*S. pseudocapsicum*), *Tradescantia fluminensis* and old man's beard may be conspicuous. The pasture grasses are usually those typical of **improved pasture** or **unimproved pasture** (classes **G1** and **G2**) and can usually be inferred from any adjacent pasture units on the map.

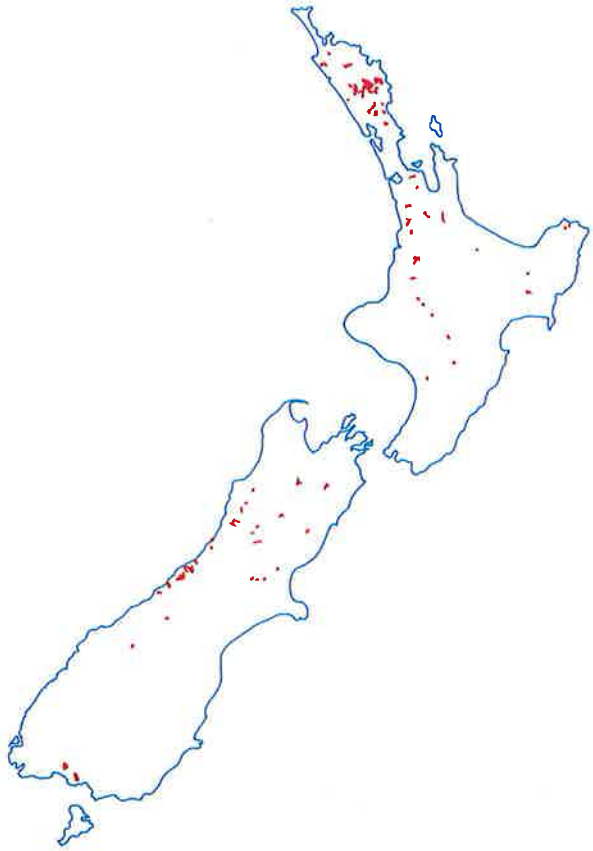
Browsing by domestic stock poses the greatest threat to the future of these remnant stands. Stock ingress has the effect of disrupting stand margins, reducing the understorey and suppressing regeneration, causing soil compaction, increasing erosion hazard and allowing the establishment of adventive weeds. Were protection afforded to these forest remnants, a great many would remain viable in perpetuity, enhancing the appeal of a landscape which may still be managed for agricultural production.

Figure 29: GF2. Pasture and Kohekohe forest, north-east of Paraparaumu, Horowhenua. NZMS 260 R26/812.333 →SE

GF3 PASTURE AND BEECH OR PODOCARP FOREST

129,000 ha

Woodlands of trees typical of indigenous southern beech (*Nothofagus*) or podocarp forest with exotic pasture grasses



Distribution and Landform

Pasture and beech or podocarp forest is mapped mainly in the regions of Northland, Waikato, the King Country, North Canterbury and Westland. Landforms range from alluvial plains with impeded drainage where kahikatea (*Dacrycarpus dacrydioides*) dominates, to coarse-textured soils on rolling hills, terraces and plains where totara is the prevailing canopy tree. Beech-dominated stands are fewer and occur at higher elevations in hill country of the eastern North Island and eastern and southern South Island.

Characteristic Features

Kahikatea-dominated woodlands are found on fertile, poorly-drained alluvial plains and terraces and sand plains. Most are relatively young secondary forest stands exhibiting vigorous healthy growth, with tall conical crowns, dark green in colour. Some have suffered from land drainage, cattle trampling and understorey grazing. In the main, however, kahikatea has shown itself able to survive well in isolated stands.

Totara-dominated woodlands are found on stony or coarse- textured soils on alluvial plains and terraces, or on hillslopes and rolling lands, often with well-drained soils. These remnants are also relatively young forest, often with marginal trees having developed a shrubby multi-stemmed habit which provides the stand with some protection against wind. In colour the trees appear dark olive green with a rough, spiky texture, and from a distance may be confused with tall dense manuka or kanuka.

Woodlands dominated by beech are quite restricted in pasturelands, and are recorded on drier, cooler, less fertile hill country. The beech component may comprise black beech (*Nothofagus solandri* var *solandri*), hard beech (*N. truncata*), red beech (*N. fusa*) or silver beech (*N. menziesii*). In appearance these remnant stands have an undulating canopy soft in texture, with the branches and the mid-green to dark green leaves arranged in the overlapping lamina typical of the beeches.

In all these formations the grassland component comprises species typical of **improved pasture** or **unimproved pasture** (classes **G1** and **G2**) and may be inferred from any adjacent pasture units on the map.

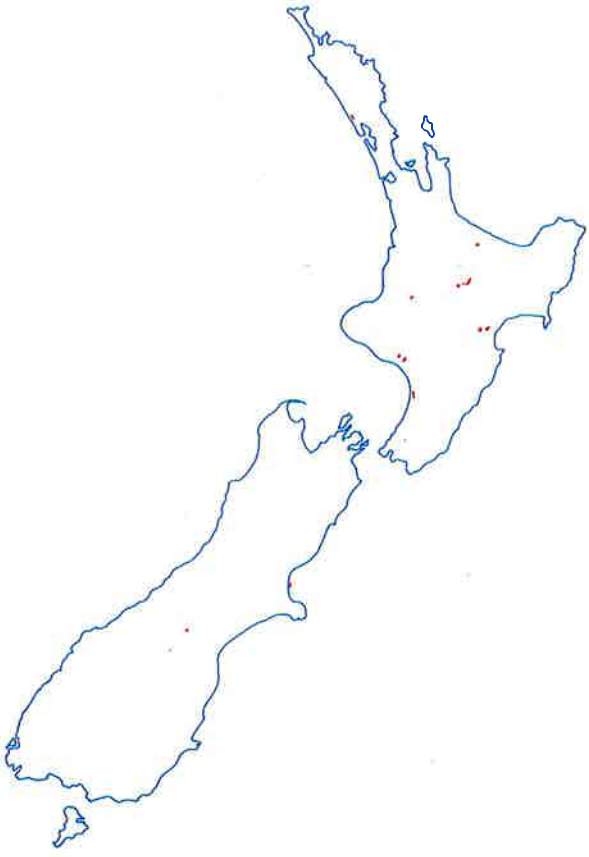
Many of these remnants, particularly the podocarp stands, are young forests which have not yet developed the complex stature and structure of the primary forest. It is likely that they evolved during the closing decades of the 19th century when stocking densities were insufficient to control all regrowth from cleared and burned forest tracts. Hence, they would have evolved and adapted in a pastoral setting and thus have a high potential to remain viable if given consideration in management. Protective measures may include fencing and stock exclusion, control of adventive weeds, cessation of adjacent land drainage, protection from wind, and even planting seedlings into a depleted understorey.

Figure 30: GF3. Pasture and podocarp forest dominated by young kahikatea. North-east of Te Kuiti, Waikato.
NZMS 260 S16/990.240 →E

GF4 PASTURE AND EXOTIC FOREST

19,000 ha

Woodlands of trees typical of exotic production forest with exotic pasture grasses.



Distribution and Landform

Pasture and exotic forest is nowhere extensive and is almost entirely a North Island phenomenon apart from isolated occurrences in coastal Canterbury and in the Mackenzie County. The class may occur on any lowland landform from dunes to hill country and is represented in the North Island in the Northland, Volcanic Plateau, King Country, Manawatu and Hawke's Bay regions, and in the vicinity of Wanganui.

Characteristic Features

This class identifies exotic production forest or erosion-control plantings, established in small woodlots which, individually, were too small to be recognised as 'pure' exotic forest. In most instances these units represent medium-sized (100-200 ha) plantings in the form of sand-dune stabilisation woodlots, local-supply forestry plantations, and the larger of the farm forestry and agro- forestry situations. In the latter two instances, grazing between the block planted or widely spaced trees is important in the management regime prior to canopy closure. This practice has been shown to have economic advantages over either forestry or agriculture alone (Arthur-Worsop 1985, Stewart 1985). In erosion control woodlots such as those on sand dunes and unstable hill country the productive component of the forestry operation may be secondary to the soil conservation function, and not all of the trees will necessarily be milled. Many such stands and some of the older production stands have not received the pruning and thinning necessary to produce good quality saw logs and so may have a high proportion of deformed, broken, thin and heavily branched stems.

Component species include *Pinus radiata*, macrocarpa (particularly in areas exposed to salt spray) and occasionally douglas fir or exotic hardwoods such as *Eucalyptus* species. In all these associations the grassland component comprises species typical of **improved pasture** or **unimproved pasture** (classes **G1** and **G2**) and may be inferred from any adjacent pasture units on the map.

Being monocultures in virtually every instance, the appearance of the stands are essentially expressive of the species planted. Thus, pines and macrocarpa confer a dark green colouration, soft in texture, with foliage held erect in pines and more irregular in profile with a laminar arrangement in macrocarpa. Douglas fir is light green with a soft but spiky texture, and eucalypts present a mottled red-brown/light green colouration with obviously leafy foliage.

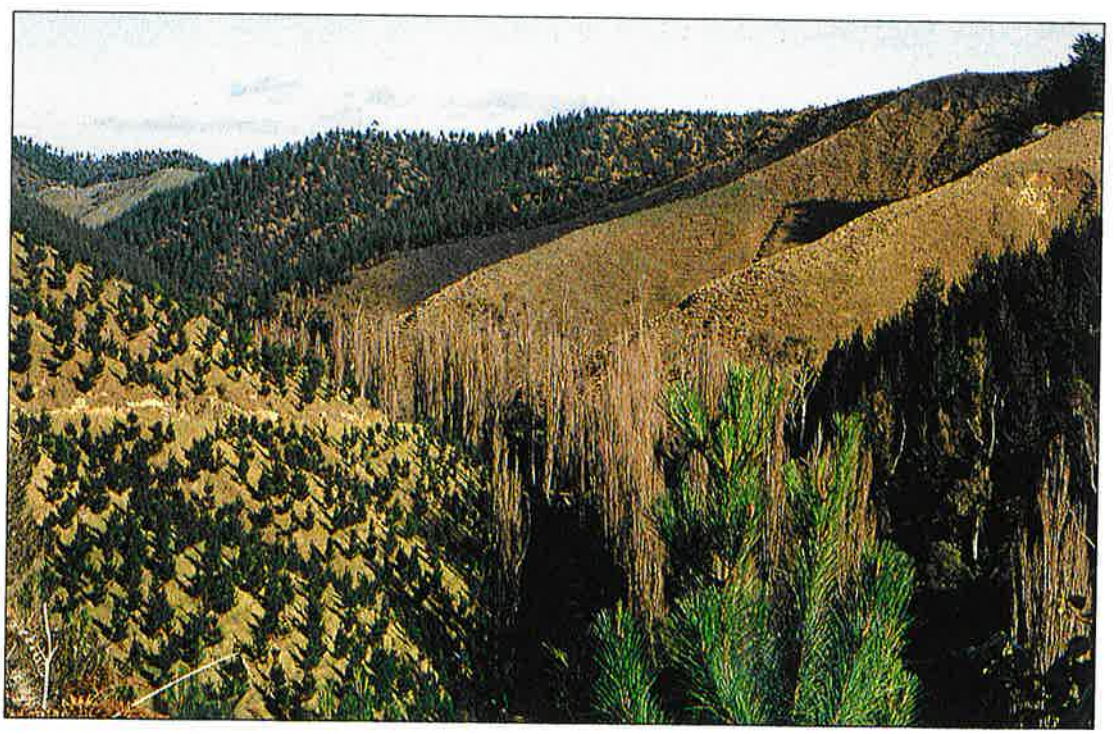
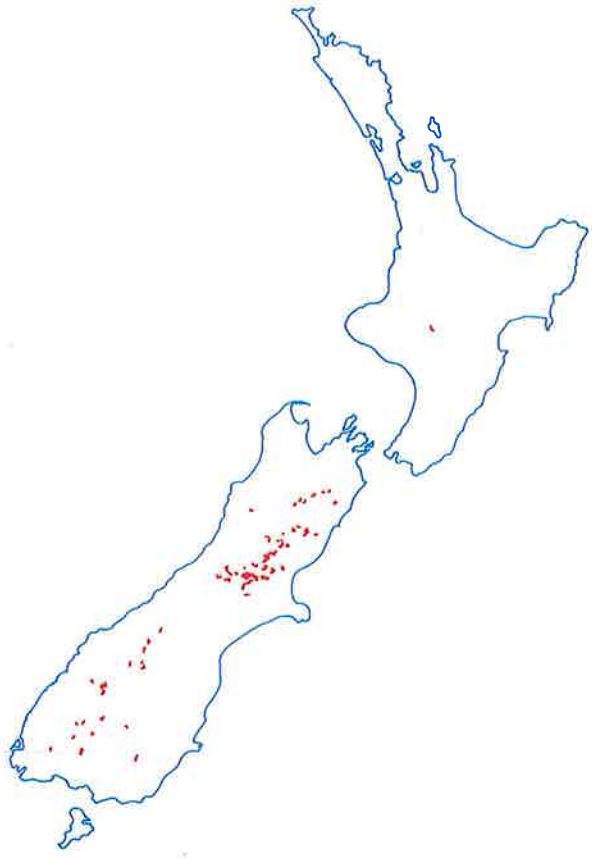


Figure 31: GF4. Small-scale commercial forestry and farm forestry plantings north of Wanganui. NZMS 260 R22/870.540 →SSW

GF5 TUSSOCK GRASSLAND AND BEECH FOREST

101,000 ha

Woodlands of trees typical of indigenous southern beech (*Nothofagus*) forest with indigenous tussock grasses.



Distribution and Landform

Tussock grassland and beech forest is extensively distributed throughout the formerly forested inland areas of the South Island, but in the North Island is mapped only in Tongariro National Park. It usually occurs in moderately steep hill country, on terraces and valley bottoms, particularly in the head-waters of the major rivers of Canterbury and Otago and in areas peripheral to the forested ranges.

Characteristic Features

These forest remnants, despite their usually isolated location, often exhibit most of the developed structural characteristics of mature forest. In many cases, these stands of beech are actual remnants of the formerly more widespread primary forests in areas deforested by Polynesian or European fire or by natural catastrophe. They usually comprise trees with a range of sizes and ages, and good marginal canopy protection against wind. Small shrubs and ferns may feature in the understorey. Beech seedlings and saplings are a prominent feature of the understorey and are particularly prolific below canopy gaps and along stand margins. In appearance these stands are of a dark green colouration, with the soft-textured undulating canopy, and the laminar arrangement of branches characteristic of the beeches.

With the exception of hard beech whose range in the moister areas west of the Main Divide is outside the distribution of this class, all other species of beech (red beech, silver beech, black beech, mountain beech) may be present. The grassland communities are usually those typical of **short tussock grassland** (class **G3**), with species of *Festuca* and *Poa* dominant.

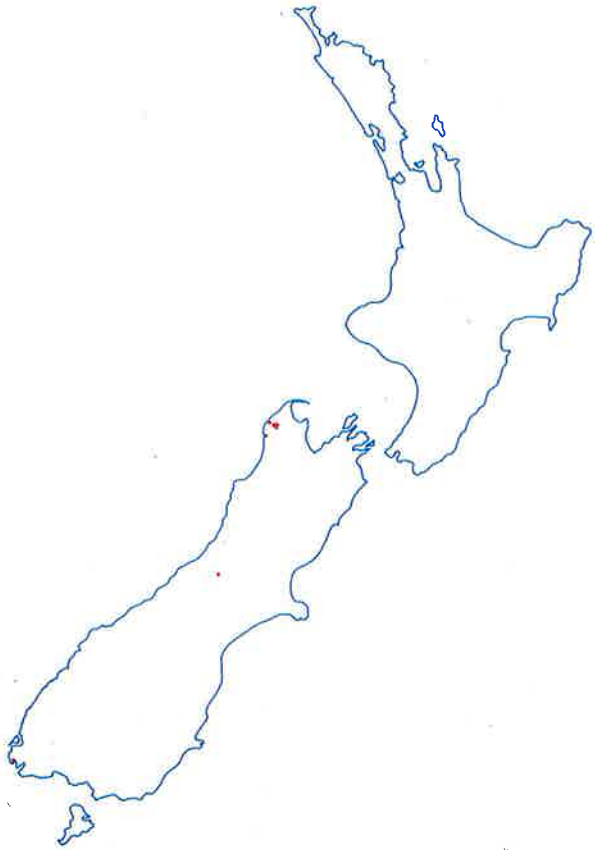
Because of the lower pressure for land development in these areas, these remnant stands are under less threat than their lowland counterparts. Possible dangers take the form of indiscriminate burning of the surrounding tussocklands, browsing by deer and other feral animals and to a lesser extent, by farm stock. Where grazing pressure from domestic and feral animals is low there is a perceptible expansion outward from the margin of these stands but at a rate that would take many hundreds of years for beech to reoccupy the large areas still environmentally suited to it.

Figure 32: GF5. Red tussock grassland and mountain beech forest, south-west of Mt Ruapehu, Tongariro National Park.
NZMS 260 S20/272.095 →W *Photo: I A E Atkinson*

GF6 TUSSOCK GRASSLAND AND PODOCARP-BROADLEAVED-BEECH FOREST

10,000 ha

Woodlands of trees typical of indigenous podocarp-broadleaved-southern beech forest with indigenous tussock grassland.



Distribution and Landform

Tussock grassland and podocarp-broadleaved-beech forest is mapped only in the South Island where it occurs on imperfectly-drained, undulating upland plateaux in the regions of north-west Nelson and Fiordland. The few occurences east of the Main Divide are less typical of the class and occur in valley heads and hillslopes in inland Canterbury.

Characteristic Features

In most instances **tussock grassland and podocarp- broadleaved-beech forest** communities have not been modified by human activity except perhaps those few occurences east of the Main Divide. On the upland plateaux of north-west Nelson and Fiordland climate and soil constraints are responsible for the woodland condition. A combination of low temperature, high rainfall, poor soil drainage, podzolisation and peat formation contribute to a distinctly marginal environment for tall forest. In these situations the tree component occupies the areas of slightly higher relief, on low mounds and ridges, while grasses and low shrubs dominate the hollows and flats.

The tree species include hard beech and silver beech, rimu, pink pine (*Halocarpus biformis*), silver pine (*Lagarostrobos colensoi*), kamahi, yellow-silver pine (*Lepidothamnus intermedius*), quintinia, mountain beech (*Nothofagus solandri* var *cliffortioides*), *Pseudopanax* spp, southern rata and mountain toatoa (*Phyllocladus alpinus*) (McKelvey 1984). The grasslands may variously include the snow tussock *Chionochloa acicularis, Gahnia procera,*

the restiad *Empodisma minus* and umbrella fern (Wardle *et al* 1973). Red tussock and a sometimes conspicuous element of small shrubs including manuka, yellow-silver pine and *Dracophyllum* spp may also be present.

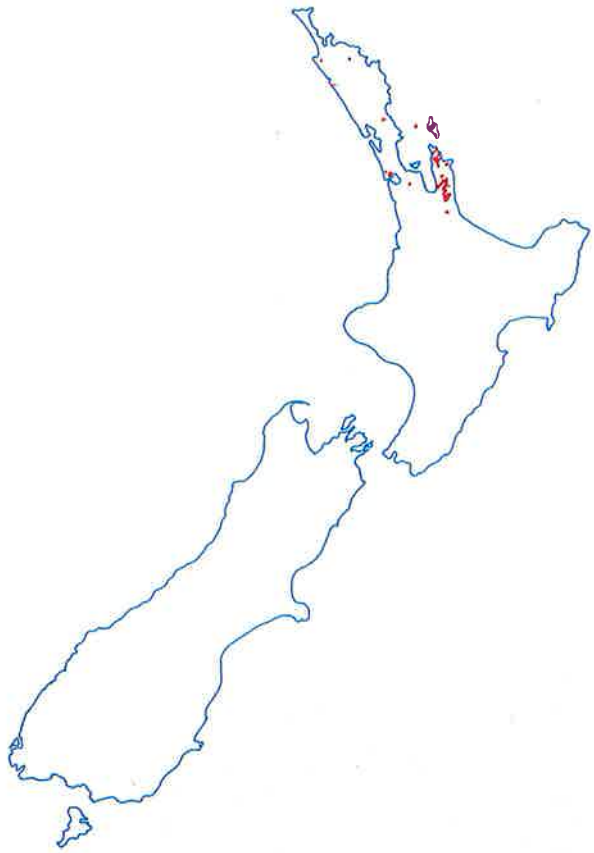
Wardle *et al* (1973) relate that peat accumulation is very slow or inactive in the West Cape district of Fiordland and does not mention any sign of tree communities advancing from their enclaves onto fresh accumulation surfaces. Salt spray was observed to be an important factor in peat formation and in community composition, form and growth rate. Deer were considered to be causing considerable erosion, from which recovery is particularly slow in this cold, wet environment exposed to the prevailing westerly winds.

Figure 33: GF6. Tussock grassland and podocarp-broadleaved-beech forest, Mackay Downs, North-West Nelson.
NZMS 260 L26/460.370 →N

FS1 KAURI AND *LEPTOSPERMUM* OR MIXED INDIGENOUS SCRUB

47,000 ha

Formations of trees or stands of trees typical of indigenous kauri (*Agathis australis*) forest with *Leptospermum* or mixed indigenous scrub



Distribution and Landform

Kauri and *Leptospermum* or mixed indigenous scrub is extensively mapped in the Northland, Auckland and Coromandel Peninsula regions north of latitude 37°30′S. It almost always occurs on moderate to steep slopes in hill country and rangeland, usually with a history of logging and/or failed pastoral development.

Characteristic Features

Virtually all of these map units comprise stands in an advanced state of regrowth toward forest, but may also include some remnant stands of mature kauri forest now occurring in a **Scrub** or **Forest-Scrub** situation. In appearance the canopy presents a broken and discontinuous outline of young conical and columnar forest trees (conspicuously kauri) appearing over a tall scrub canopy.

Associated with the emergent kauri may be toatoa (*Phyllocladus glaucus*), tanekaha and rewarewa. Older stands may contain rimu, Hall's totara (*Podocarpus hallii*) and miro. These trees are emergent over a mature scrub canopy in which *Leptospermum* is frequently present with many broadleaved shrubs and ferns. Among this scrub storey may be sapling kauri and rimu, species of *Coprosma, Corokia, Olearia*, and *Pittosporum*, tawari (*Ixerba brexioides*), and tree ferns together with sapling towai and tawa which may later contribute to the canopy beneath kauri.

The environmental tolerances of kauri are reflected in its preference for warm humid lowlands with moderate rainfall and low frost frequency (Ecroyd

1982). It grows on a range of soils but has a tendency toward less fertile sites, where podzolisation resulting from its acid litter is inclined to make them even less fertile (Beveridge 1975). A deep layer of resinous, acid litter, coupled with the low light conditions under a pristine forest canopy, further inhibits the growth of kauri seedlings (Bieleski 1959).

Virtually all units recorded on the map are sites where the primary kauri forest has been destroyed by logging or by fire. Probably as a result of the very low productive potential of this land, it has since been allowed to regenerate. Thode (1983) commenting on the devastation of New Zealand's kauri resource remarked: *"The policy which would have justified this wastage, the creation of a prosperous agriculture on the land, foundered on the poverty of the soil"*. In most instances the succession is through an initial stage of *Leptospermum* (dominantly manuka) which provides an ideal 'nursery' cover for kauri establishment. Thereafter succession progresses through an increasing proportion of broadleaved shrubs and trees, through this **Forest-Scrub** condition and ultimately to forest.

Of the major timber trees in New Zealand kauri is one of the few species found to be amenable to silvicultural management although on cycles of between 80 and 170 years (Halkett 1986).

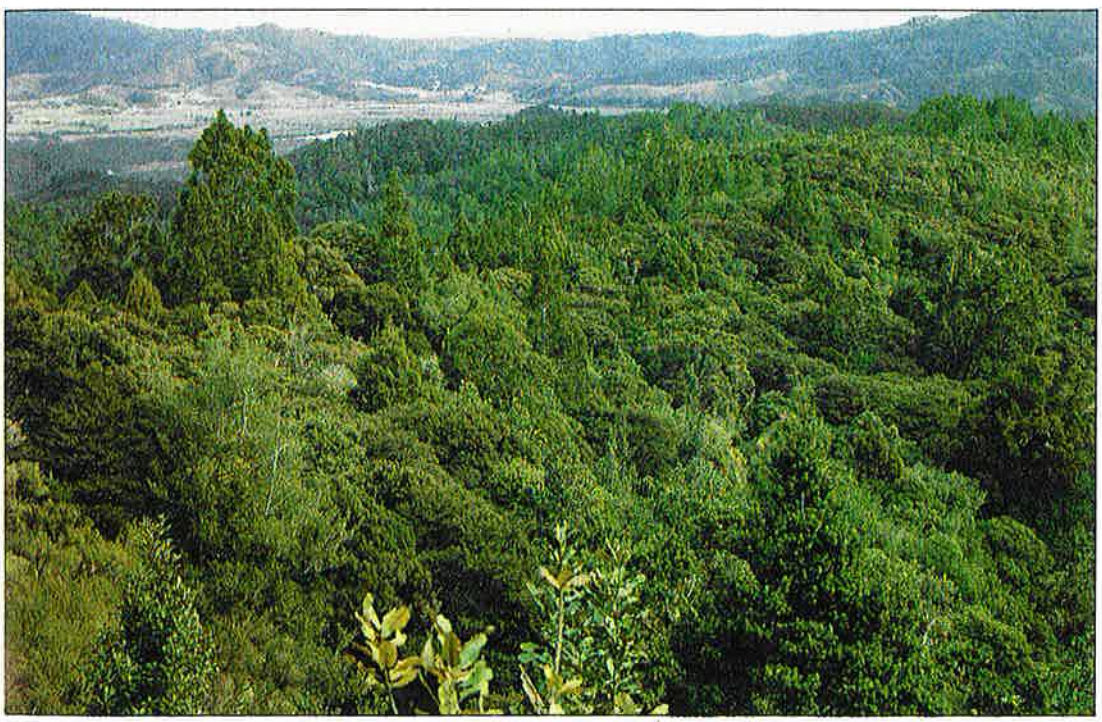
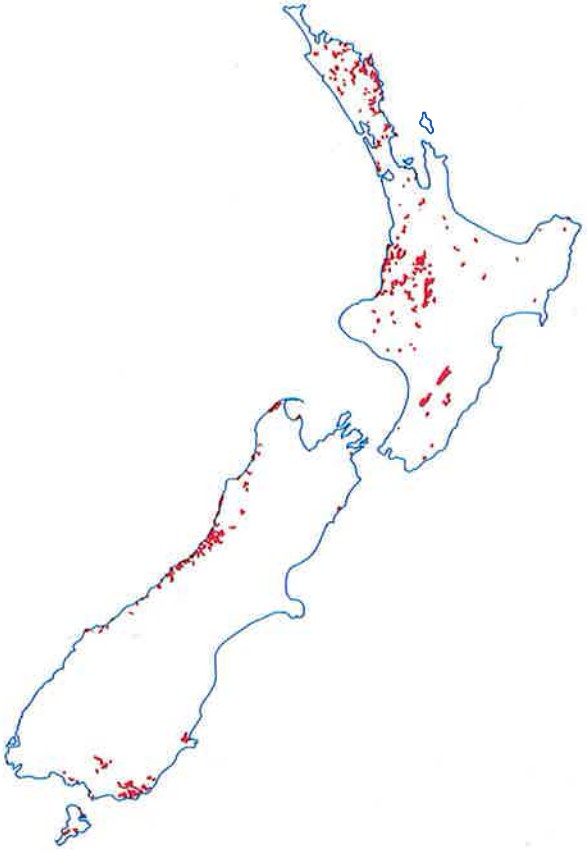


Figure 34: FS1. Regenerating kauri forest, with the conical crowns of young kauri emerging from a canopy dominated by mixed indigenous shrubs, small trees and very old *Leptospermum*. Russell State Forest, Bay of Islands, Northland.
NZMS 260 Q05/250.540 →N

FS2 PODOCARP-BROADLEAVED FOREST AND SCRUB

446,000 ha



Formations of trees or stands of trees typical of indigenous podocarp-broadleaved forest with *Leptospermum* or mixed indigenous scrub.

Distribution and Landform

Podocarp-broadleaved forest and scrub occurs extensively throughout the ranges and hill country of New Zealand. It is a feature of moderate to high rainfall hill country, often of lower pastoral value, and is usually proximal to other forested or scrub covered areas.

Characteristic Features

Podocarp-broadleaved forest and scrub is usually a condition induced by human activity, arising from clearfelling for timber or from clearing for pastoral farming or from heavy selective logging. Stand structure variously appears as a dense array of young vigorous forest trees emergent over a canopy of shrubs and small trees, or as senescent or deformed canopy and emergent trees standing over a highly disrupted canopy and understorey. Alternatively, this **Forest-Scrub** condition may result from a combination of environmental pressures such as climate, erosion or animal browsing.

Common canopy and emergent trees are hinau, kamahi, maire, matai, miro, rewarewa, rimu, tawa, and totara. Subcanopy and understorey shrubs and trees include species of *Coprosma, Pittosporum*, and *Pseudopanax*, mahoe, tree ferns, ground ferns and many others. In northern areas there may be inclusions of kauri and in southern regions a component of beech, while on poorer soils *Leptospermum* may be present. The species present are mostly those typical of the mature forest, though their proportional representation may be vastly different. Community structure is also different, manifest either

as incomplete successional development of subcanopy, canopy and emergent tiers, or as the breakdown of the mature forest condition.

Most of these units are under comparatively little threat of further exploitation, especially in view of the fairly marginal returns that would accrue from land clearance for pastoral development. However the land upon which many **podocarp-broadleaved forest and scrub** units lie may still be attractive for exotic forestry and some former areas would have been converted to exotic forest during the recent planting boom of the late 1970s and early 1980s. Where these communities are allowed to remain there is a reasonable expectation that succession will lead to mature **podocarp-broadleaved forest** which, as well as having aesthetic appeal, will contribute further to indigenous wildlife habitats and opportunities for recreation.

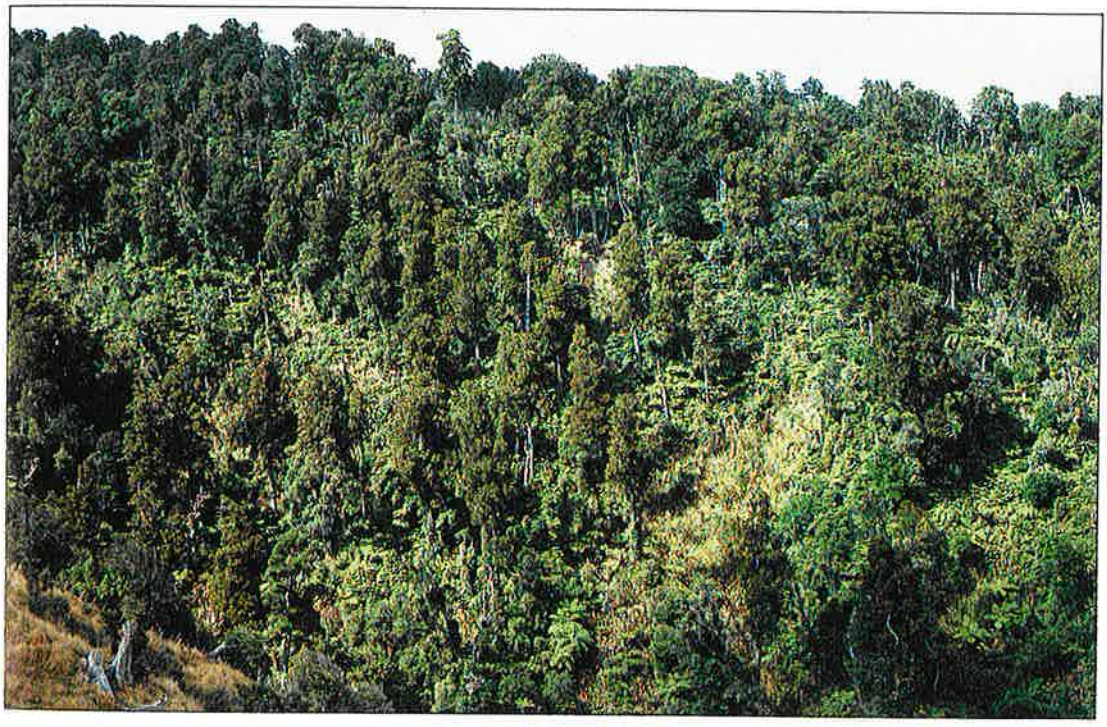
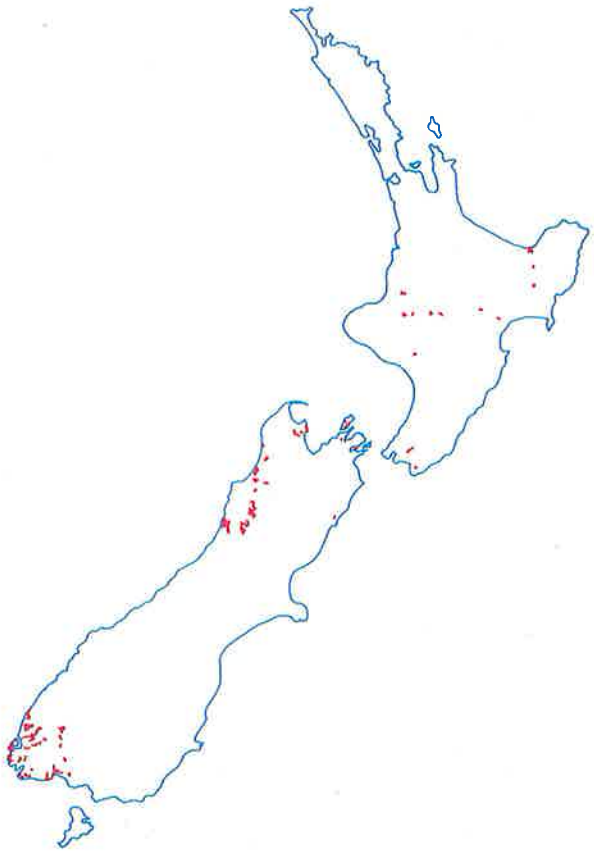


Figure 35: FS2. Regenerating podocarp-broadleaved forest with prominent rimu standing over a shrub tier dominated by tree ferns. Western Ruahine Range.
NZMS 260 T23/627.228 →SE

FS3 PODOCARP-BROADLEAVED-BEECH FOREST AND SCRUB

139,000 ha

Formations of trees or stands of trees typical of indigenous podocarp-broadleaved-southern beech forest with *Leptospermum* or mixed indigenous scrub.



Distribution and Landform

Podocarp-broadleaved-beech forest and scrub attains its greatest expression in steep, high rainfall hill country in Fiordland, north Westland and inland Taranaki. Here, as elsewhere in the country, it may either occupy sites with a history of logging or land clearance, or sites which have been subject to short-term or long-term natural catastrophies such as erosion, storms and climatic oscillation.

Characteristic Features

Podocarp-broadleaved-beech forest and scrub possesses most of the component species of a mature forest, though in proportions markedly different. In appearance these stands may be of three forms. The first, the 'regenerative' form, appears as young, emergent forest trees overtopping a well developed shrub and tree canopy. The second, the 'degenerative' form, occurs where massive disturbance has left dead and dying emergent and canopy trees over a disrupted canopy and understorey. And the third, a mosaic form, results where erosion, or less frequently, selective logging, has left a patchwork of mature forest and scrub.

Present among the canopy and emergent trees may be rimu, silver beech or mountain beech, kamahi, miro, northern rata or southern rata, and Hall's totara, with rewarewa, tawa, hinau, black beech and hard beech also being of importance in the North Island. These may appear above a more or less profuse subcanopy and understorey of quintinia (*Quintinia acutifolia*), kamahi,

species of *Coprosma* and *Psuedopanax*, ground ferns and tree ferns, and many other shrubs and small trees.

These communities are often a penultimate stage in a succession toward closed forest and in the absence of future disruption may generally be expected to reach this end. However, on the steeplands where environmental factors are the dominant influence limiting forest structure, the **Forest-Scrub** condition may be a natural state which has perhaps been recently exacerbated by deer, possum and other feral animals. Elsewhere, an appreciation of the marginal value for productive use of this land in comparison with its value in protecting catchment headwaters from erosion, its aesthetic qualities and recreational potential, makes any large-scale disturbance of these communities unlikely.

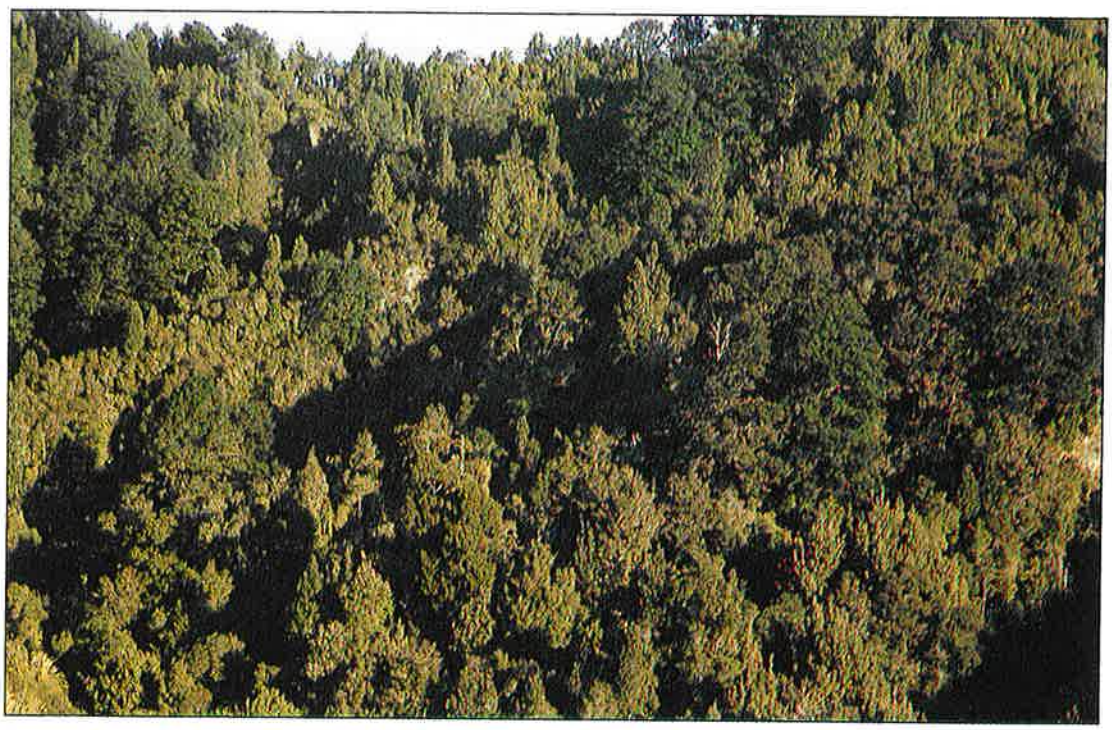
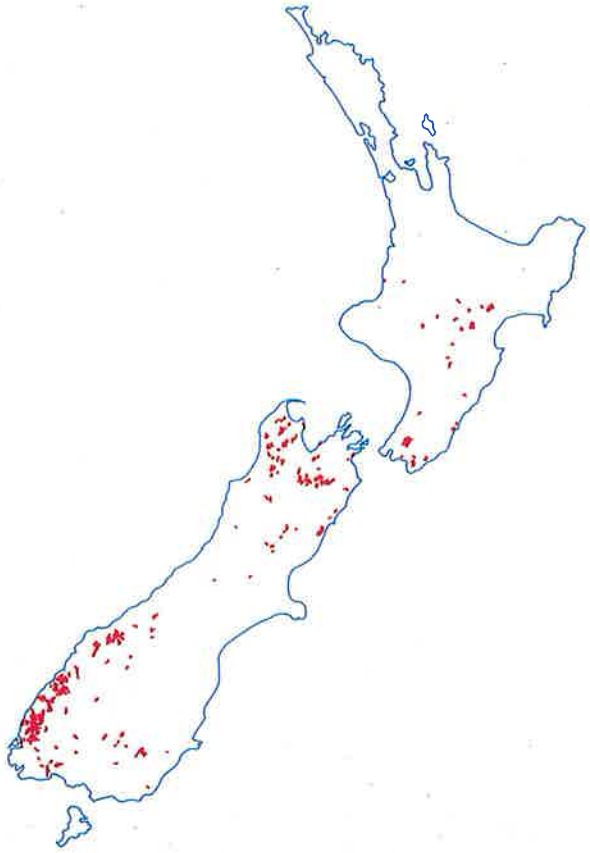


Figure 36: FS3. Podocarp-broadleaved-beech forest and mixed indigenous scrub. Note how the dark green crowns of the beech trees contrast with the lighter green of the broadleaved trees and the olive green of rimu (centre foreground). A locally disrupted section of an area which was recorded on the map as podocarp-broadleaved-beech forest (class F4). North of Waverley, Taranaki.
NZMS 260 R21/500.700 →SE

FS4 BEECH FOREST AND SCRUB

314,000 ha

Formations of trees or stands of trees typical of indigenous southern beech (*Nothofagus*) forest with *Leptospermum* or mixed indigenous scrub.



Distribution and Landform

Beech forest and scrub is well represented in the hill country and ranges of the central and southern North Island, but achieves its greatest expression in the South Island. Here it is most commonly encountered close to, and within, the forested ranges west of the Main Divide, but it also occurs locally in the east in the hills and ranges of Marlborough, north Canterbury and Southland.

Characteristic Features

Beech forest and scrub generally occurs in one of two situations: those where humans have been directly instrumental in forest breakdown; and those where physical and biotic factors inhibit development of a forest structure. In the North Island humans have been the primary disruptive influence, usually via the agency of fire. Bush clearance by fire has left pockets of forest, often in gullies, around which scrub, frequently dominated by *Leptospermum,* has grown. This scrub is now being reinvaded by beech. Secondary disruptive influences have been exposure to wind and animal browsing, which have served to suppress regeneration, impede recovery and, occasionally, promote degradation. In the South Island the same is often true, with logging still widely practised in the areas of north Westland and Nelson. However, in the mountainlands from north-west Nelson to Fiordland, natural calamities are the principal disruptive agency. On these shallow steepland soils factors such as storm damage and erosion, either spontaneous or that induced by animal browsing or by earthquake (for example the Matiri Valley, north Westland), have resulted in a mosaic of forest and scrub.

The species composition of the forest stands differs in no significant way from the mature forest although there may be a slight swing in prominence toward mountain beech in sites regenerating after recent disturbance. Virtually any of the five species of beech may be present, with silver beech, mountain beech, and red beech of particular importance in southern regions, and including black beech and hard beech in northern regions. Associated with the beeches may be a number of shrubs and small trees such as manuka, kanuka, quintinia, broadleaf (*Griselinia littoralis*), kamahi, species of *Coprosma* and *Pseudopanax* and ground ferns.

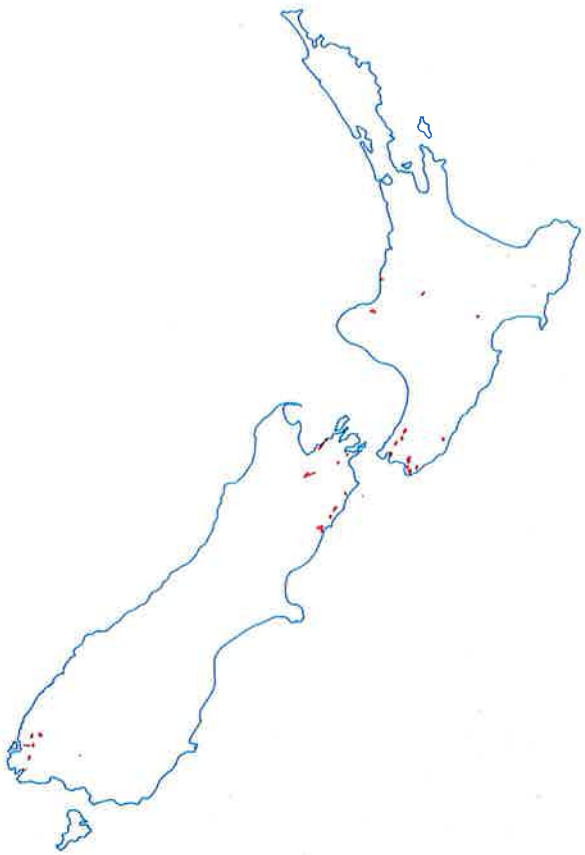
These communities are a penultimate stage in a succession which tends strongly toward a closed forest. Inhibiting this trend are the activities of browsing animals, humans, and natural catastrophe. Nevertheless the benefits which accrue from these communities' role in catchment protection provide a generous return on the investment in management and noxious animal control.

Figure 37: FS4. Regenerating beech forest on hill country in Taranaki substantially cleared of forest perhaps 50-100 years ago. Note how the concentration of beech trees on the spurs and ridges contrasts with the more diffuse admixture shown in Figure 45. This figure is a scene characterised by beech regeneration in an area which was recorded on the map as podocarp-broadleaved-beech forest and scrub (class FS3). 35 km west-north-west of National Park.
NZMS 260 S19/900.255 →E *Photo: P M Blaschke*

FS5 BEECH-BROADLEAVED FOREST AND SCRUB

48,000 ha

Formations of trees or stands of trees typical of indigenous southern beech-broadleaved forest with *Leptospermum* or mixed indigenous scrub.



Distribution and Landform

Beech-broadleaved forest and scrub is scattered to locally frequent, in hill country and mountainlands from north Taranaki to Fiordland. However only in the vicinities of the southern Tararua Range, the Aorangi Range, the Seaward Kaikoura range, Nelson, and in Fiordland does it cover large areas.

Characteristic Features

Virtually all of the North Island occurrences and those of the northern South Island have arisen as a result of former land clearance or logging. Climatic stress (particularly wind in the Aorangi Range) and animal browsing have been contributing factors in some areas. These communities appear as pockets of forest in various states of health, isolated amongst scrub, and often occurring in gullies and valley heads. Frequently the beech is reinvading the scrub stands and the mosaic pattern becomes more diffuse. In southern Fiordland the **Forest-Scrub** condition is a result of, and is maintained by, erosion and snow avalanche on the steep slopes and shallow soils of the formerly glaciated valleys. This gives a mosaic effect of alternating forest and broadleaved scrub communities across the slope.

The canopy species composition differs in no major respect from the local mature forest condition, though the proportional representation of the species varies considerably. In north Taranaki hard beech and black beech are associated with *hinau, kamahi, rata, rewarewa* and *tawa*; near Wellington tawa is of reduced importance among the broadleaved trees and black beech and hard beech are more prominent than silver beech and red beech; in the

Aorangi Range kamahi is associated with black beech, hard beech, red beech and silver beech. In the South Island, black beech, mountain beech and red beech are prominent in the drier country near Kaikoura; with silver beech, red beech, hard beech and mountain beech prominent in the Richmond Range near Nelson. Further south, in Fiordland, silver beech and mountain beech are associated with kamahi, quintinia, pokaka (*Elaeocarpus hookerianus*) and occasional podocarps. All these dominants may be associated with a number of understorey shrubs and small trees such as putaputaweta (*Carpodetus serratus*), broadleaf, lancewood (*Pseudopanax crassifolius*), species of *Coprosma* and *Leptospermum,* and other components of local indigenous scrub communities.

The successional trend of these units is strongly toward a closed forest. However, in some areas such as those in Fiordland and south Westland which are subject to repeated erosion, and those in the Aorangi Range which are exposed to wind stress, they may be formations which pre-date humans and their activities. The presence of feral animals may serve to exacerbate the disclimax condition and prolong recovery.

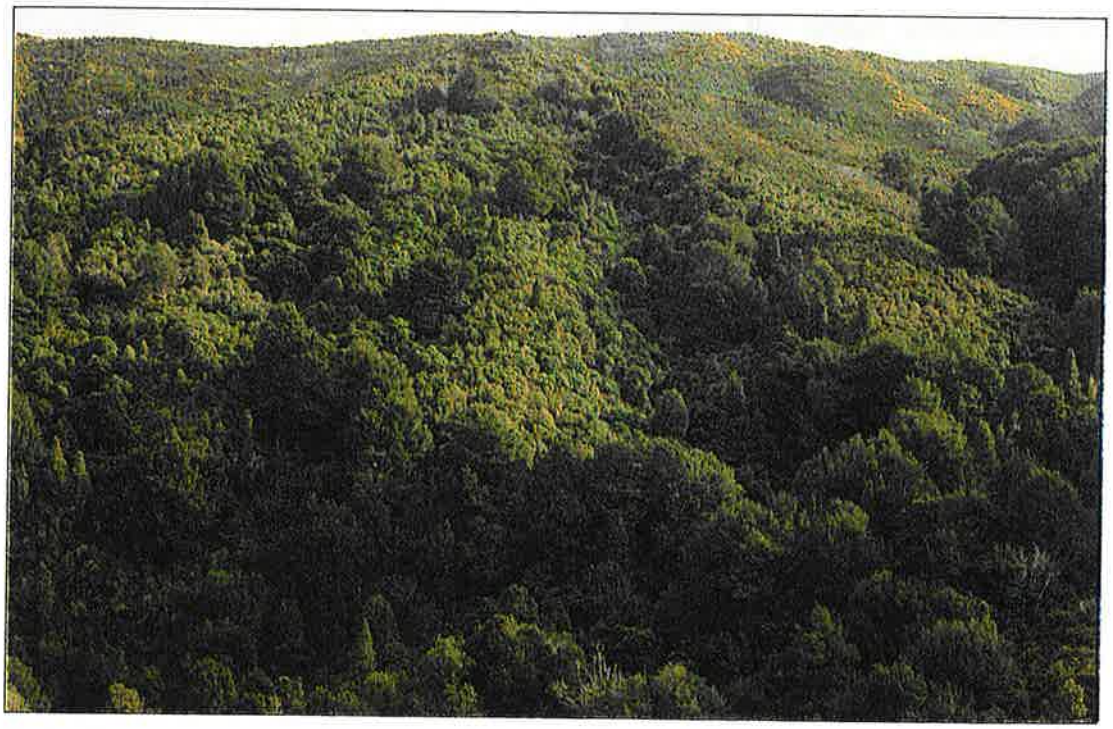
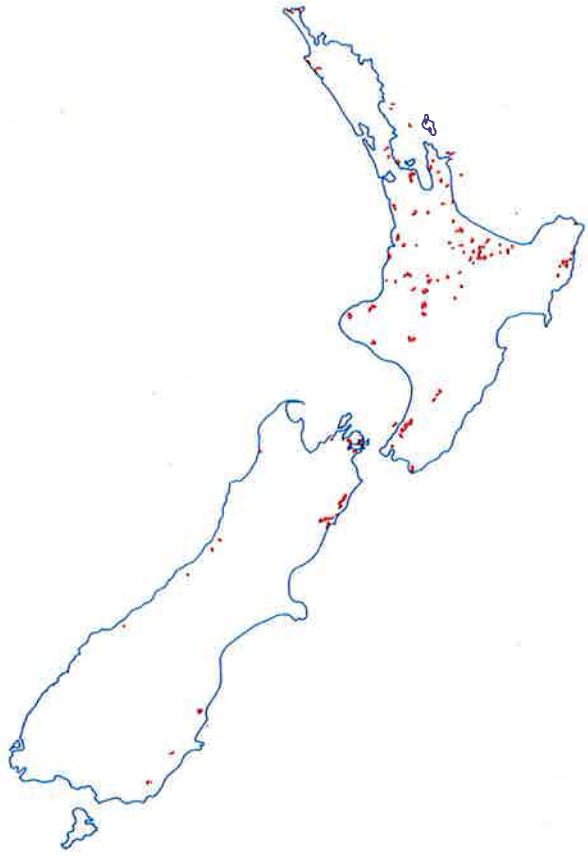


Figure 38: FS5. Beech-broadleaved forest and scrub. An area cleared of forest by logging and fire 60-100 years ago and repeatedly burnt since. The large beech trees however must have survived the more recent fires and they and the broadleaved trees are now colonising the mixed indigenous scrub, which is itself supplanting the gorse communities on the upper slopes. Akatarawa Valley, Wellington.
NZMS 260 R26/869.120 →NW

FS6 BROADLEAVED FOREST AND SCRUB

177,000 ha



Formations of trees or stands of trees typical of indigenous broadleaved forest with *Leptospermum* or mixed indigenous scrub.

Distribution and Landform

Broadleaved forest and scrub is extensively distributed in the North Island and locally in the South Island in coastal areas of Westland, Kaikoura and Otago. It generally occurs in areas of moderate to high rainfall on rolling to moderately steep hill country which has been cleared of forest during historical time.

Characteristic Features

Conceptually, **broadleaved forest and scrub** may be viewed as occurring in two conditions. The first condition, the 'regenerative' form, appears as discontinuous but vigorous stands of broadleaved forest trees emergent over a lower tier of generally broadleaved indigenous shrub. This condition is typical of the many areas which have suffered from logging or land clearance earlier this century. The irregular canopy is made up of a variety of species, each lending their own character to the stand's appearance; the soft leafy yellow-green of tawa, the dark brown-green of kamahi, the glossy mid-green of kohekohe, or the lime green of titoki. The subcanopy and scrub communities are dominated by the leafy mid-greens from a range of mixed broadleaved shrub species, with the occasional dark green brush-like foliage of manuka or kanuka.

The second condition, the 'degenerative' form, typifies sites which have suffered recent disturbance, either from logging for merchantable timber or from land development. They exhibit an ill-conditioned canopy over a poorly developed and broken understorey. In time the community will recover, and given favourable conditions, begin to exhibit characters resembling the regenerative phase.

In some circumstances natural forces, particularly erosion and windthrow, have served to promote the **Forest-Scrub** condition, usually as a mosaic pattern of mature forest and regenerating scrub. Such a situation can be encountered on steep hillslopes in Westland.

The successional trend of these **broadleaved forest and scrub** units is usually toward a closed forest either dominated solely by broadleaved trees, or dominated by these in combination with podocarps, or kauri in the north, or beech in southern districts. In sites of equable climate, succession to forest is generally quite rapid, except where it is inhibited by the activities of humans or browsing animals.

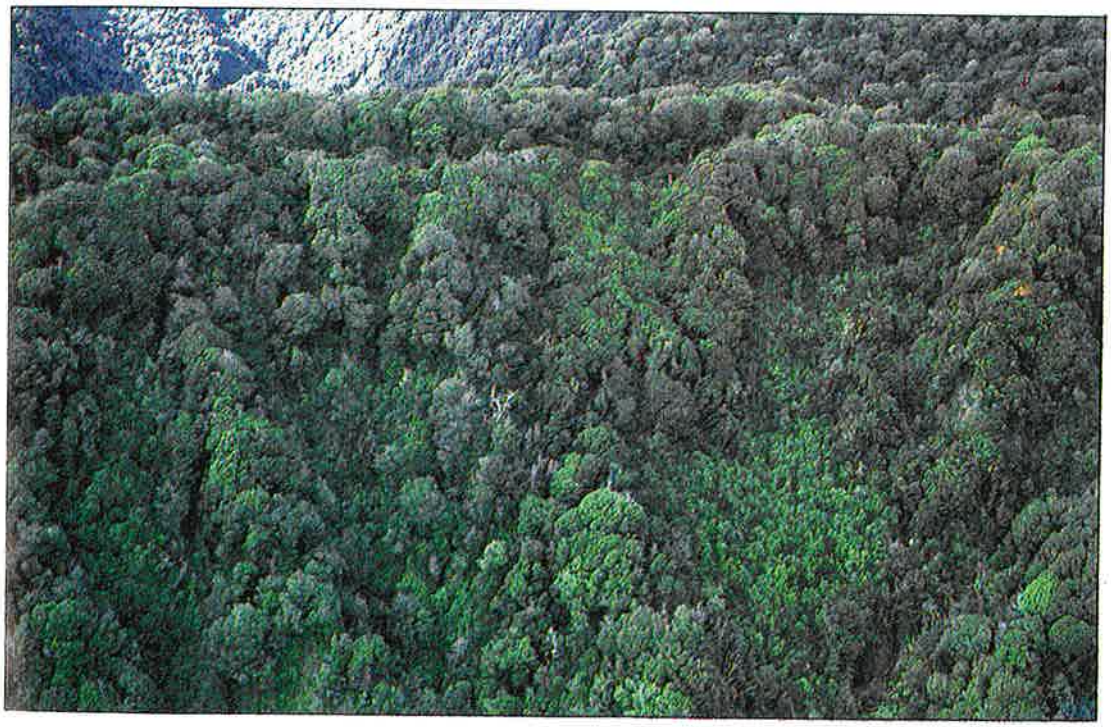
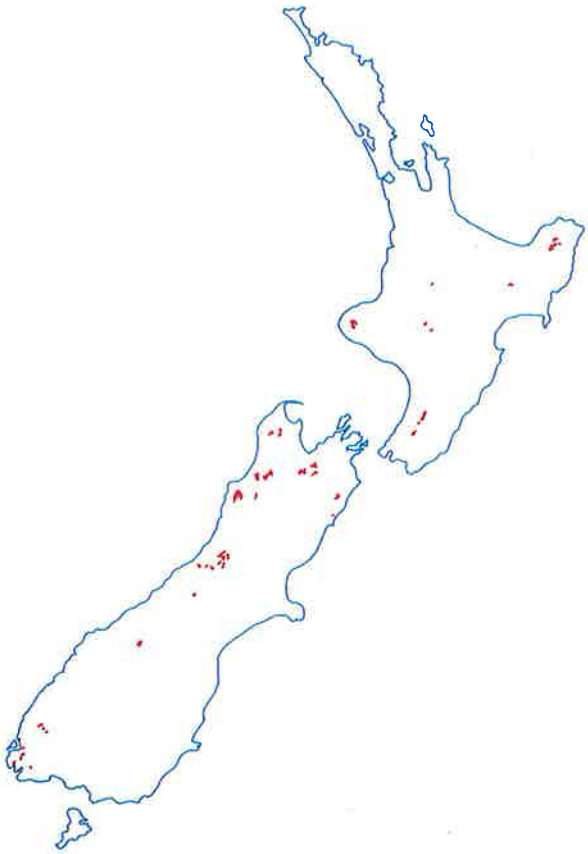


Figure 39: FS6. Broadleaved forest and scrub resulting from recurrent erosion on steep slopes. Price Range, near Whataroa, Westland.
NZMS 260 I35/920.610 →E

FS7 SUB-ALPINE SCRUB AND INDIGENOUS FOREST

88,000 ha

Formations of trees or stands of trees typical of highland indigenous forest in association with indigenous subalpine shrub communities.



Distribution and Landform

Subalpine scrub and indigenous forest is recorded throughout New Zealand on the upper slopes or ridges of many high mountains and axial ranges.

Characteristic Features

Subalpine scrub and indigenous forest occurs in the transition zone between tall, closed forest and sub-alpine scrub. This merging of highland forest with sub-alpine scrub is present in most mountains in a more or less diffuse altitudinal band of variable width. In this zone the forest trees rarely attain the stature which they do at lower elevations, and there is often both a species and structural gradation from forest to scrub. The vigour of the stands also varies from a healthy canopy and good understorey development, well adapted to the harsh conditions, to a more broken, open structure, perhaps as a consequence of exceptional climatic stress, animal browsing or disease.

Among the forest trees may be silver beech or mountain beech, kaikawaka (*Libocedrus bidwillii*), Hall's totara, broadleaf, mountain toatoa and pink pine. These may grade into communities variously dominated by leatherwood, and species of *Brachyglottis, Dracophyllum*, and *Hebe,* mountain ribbonwood and *Podocarpus nivalis*.

The **sub-alpine scrub and indigneous forest** condition is typical if the forest below treeline has a mixed broadleaved tree component. Elsewhere, if the forest is largely pure beech there is usually a sharp treeline where forest gives way over a very short distance to snow tussock grassland. The altitudes of New Zealand treelines about which this class occurs, decrease from about

1500 metres in the north to about 900 metres in the south. They occur at much lower elevations (about a third of the altitude) than continental European and North American treelines at comparable latitudes (Wardle 1974). However climatically the New Zealand and Northern Hemisphere treelines are virtually the same, all establishing at elevations where the average summer temperature is about 10°C and being scarcely influenced by winter cold. Experimental confirmation is provided by Wardle (1973, 1985b) who found that Northern Hemisphere treeline species establish their upper limits in New Zealand at similar altitudes to New Zealand species. One exception to this rule is *Pinus contorta* which is in the singular position of being tolerant of conditions at as much as 200 metres altitude above the treeline established by indigenous species (Wardle 1985a), and hence its demonstrative potential as a weed in New Zealand's sub-alpine tussocklands.

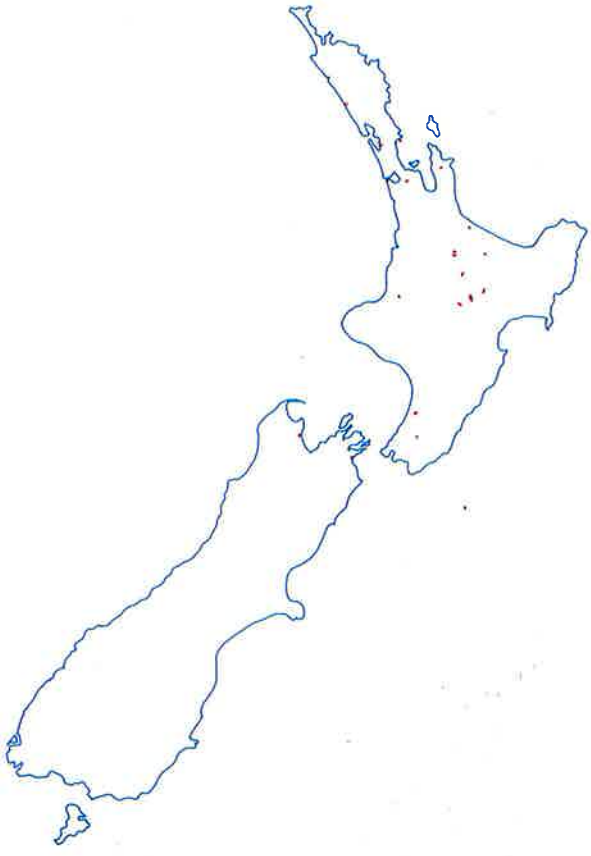
By virtue of their remote position these sites are relatively unaffected by humans and their activities, although the influence of introduced browsing animals is keenly felt. In this ecosystem, subject to climatic stress and the attendant threat of erosion, such additional biotic pressure presents a danger to the continued well-being of these communities.

Figure 40: FS7. Sub-alpine scrub and indigenous forest, with conspicuous pink pine emergent over a matrix of leatherwood, *Brachyglottis* and other sub-alpine shrubs. West of Honokawa trig. Raukumara Range.
NZMS 260 Y15/470.610 *Photo: P A Williams*

FS8 EXOTIC FOREST AND SCRUB

18,000 ha

Formations of trees or stands of trees typical of exotic production forest with *Leptospermum* or mixed indigenous scrub.



Distribution and Landform

Exotic forest and scrub is sporadically represented in the North Island and northern South Island, generally in areas of relatively recent exotic forest plantings. It occurs on landforms which vary from flat and undulating sand plains, to moderately steep hill country.

Characteristic Features

Exotic forest and scrub is essentially a patchwork of planted exotic trees in an otherwise scrub-dominated situation and does not have any ecological basis or pattern to its distribution. The individual components of forest and scrub differ in no way from their more extensive 'pure' communities of **mixed indigenous scrub (S1)**, ***Leptospermum* scrub or fern (S2)** and **exotic forest (F9)**.

Most of these situations are ones where exotic trees have been planted into the most favourable sites of a scrubland, commonly on the upper slopes and ridges, leaving the lower slopes and stream-beds in scrub. Hence the appearance is one of an irregular mosaic of exotic trees interspersed with the lush leafy mid-greens of mixed indigenous scrub or the dark green brush-like foliage of *Leptospermum*. Being monocultures in virtually every instance the appearance of the forest stands relate to the component species. Pines, conspicuously *Pinus radiata,* present a soft textured erect foliage of dark-green needles. These contrast with the lighter green, spiky needles of douglas fir (*Pseudotsuga menziesii*) and the mottled red-brown/light green colour and leafy appearance of many eucalypts.

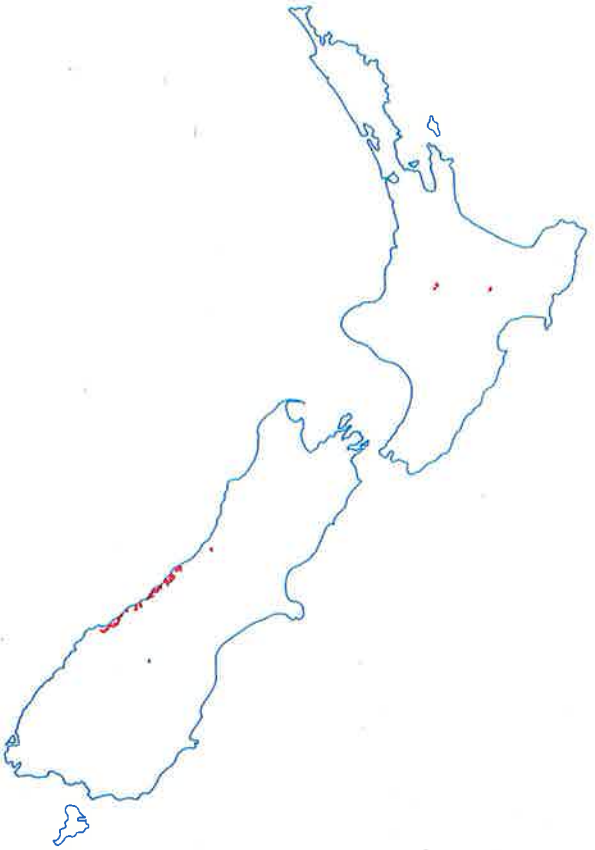
The **Forest-Scrub** configuration in exotic forestry is viewed with favour by many land managers and may become more widely accepted in the future. This will mean that exotic production forests are planted where they will yield the greatest returns and where the land is best suited to sustain that land use without inviting later management problems from erosion. It also has the effect of controlling sediment generation during logging operations and inhibiting nutrient transfer into watercourses, both of which can cause considerable downstream problems in rivers and lakes.

Figure 41: FS8. Exotic forest and scrub, showing the mosaic effect from pine planting on the most favourable sites while leaving mixed indigenous scrub in the less favourable gullies. Kaiteriteri, Tasman Bay.
NZMS 260 N26/100.190 →W

F1 PODOCARP FOREST

43,000 ha

Evergreen forest with a canopy dominated by indigenous podocarp trees.



Distribution and Landform

Podocarp forest occurs in both North and South Islands but is of restricted distribution in all but a few localities. In the North Island it is mapped on undulating and rolling hills on the eastern and western margins of the Volcanic Plateau. In the South Island the class is recorded on flat and undulating glacial outwash terraces between Hokitika and Haast.

Characteristic Features

Podocarp forest appears as dense, tall stands, with the crowns of the emergent trees often towering 35 metres above the forest floor upon a majestic array of smooth columnar trunks. The olive green foliage of rimu dominates in most situations, forming an undulating, soft-textured canopy. Associated with rimu, may be miro, matai, totara, silver pine and kahikatea. Subdominant tawa and kamahi form a diffuse lower tier. In swampy flats kahikatea dominates the canopy and can be seen towering up to 50 metres above the ground. Subcanopy and understorey tiers are made up of a variety of broadleaved trees and shrubs such as broadleaf, hinau, quintinia, species of *Coprosma* and *Pseudopanax* and a variety of epiphytes, lianes, ferns and mosses.

The North Island sites occur on deep volcanic tephra deposited in a series of volcanic events, such as the Taupo Pumice Eruption (1800 years ago). There is some speculation as to whether podocarp forests are themselves successional to forests with a more prominent broadleaved component (class **F2**) as McKelvey (1963) suggests. The reality probably invokes several mechanisms among which McKelvey's (1963) linear succession is a single phase interrupted by reversely acting cycles, whereby the podocarp forests are ultimately rejuvenated by fire (Cameron 1960, Whirinaki Forest Promotion Trust 1984)

or by thinning and toppling of aged trees. (Cameron 1954; Beveridge 1973, 1983; Herbert 1978, 1986.) Such events may yield podocarp regeneration either directly or more frequently through an intermediate phase dominated by tree fern, kamahi or hinau and therefrom to dense podocarp stands.

The South Island sites occur on deep, stony, glacial outwash terraces in central and southern Westland. These sites are characterised by high rainfall and poorly drained soils of low fertility. The podzolising action of the dominant podocarps has further impeded drainage and leached nutrients from the upper soil horizons. Where drainage is severely impeded, swamp and pakihi vegetation may locally dominate, bordered by kahikatea or silver pine (Chavasse 1971). There is evidence to suggest (Six Dijkstra *et al.* 1985) that these forests regenerate successfully from windthrow or senescence of mature trees, again following a temporary stage of dominance by mixed broadleaved trees.

The extent of **podocarp forest** has been much reduced by logging, and formerly included a substantial element of kahikatea forest on the floodplains of both islands. Selective logging has been under trial in New Zealand since the 1960s but earlier trials gave discouragingly high rates of windthrow and deterioration of residual trees (Beveridge and Herbert 1978, Environmental Council 1979). Even so the remaining areas of podocarp forest continue to receive preferential attention from sawmillers, despite the opposition of conservation and tourism organisations.

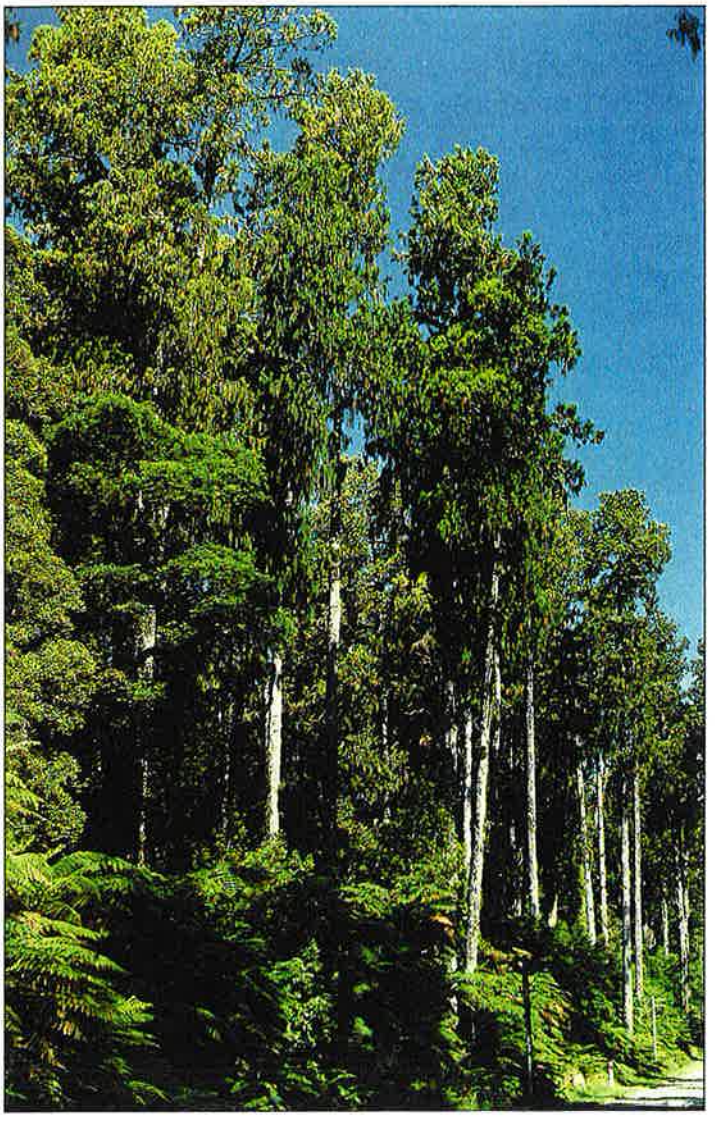


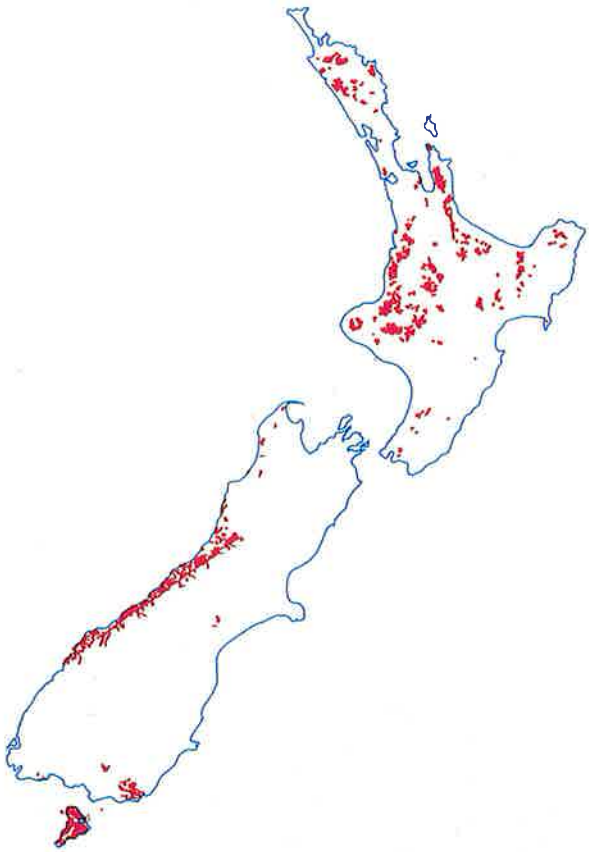
Figure 42: F1. Dense rimu forest viewed from the forest margin. The heights of these trees are well in excess of 35 metres (compare with the height of the telegraph pole in the foreground). Near Harihari, Westland.

Photo: G G Hunter

F2 LOWLAND PODOCARP-BROADLEAVED FOREST

1,091,000 ha

Evergreen forest, occurring below the altitudinal limit of rimu, with a canopy dominated by indigenous mixed broad-leaved and podocarp trees and an emergent storey dominated by podocarp trees.



Distribution and Landform

Lowland-podocarp broadleaved forest occurs throughout the forested lowlands from Northland to Stewart Island and from sea level to altitudes of about 900 metres in the North Island and 300 metres on Stewart Island. Formerly distributed throughout the higher rainfall plains and hill country it is now largerly restricted to the axial ranges and remote hill country.

Characteristic Features

The mature **lowland podocarp-broadleaved forests** of New Zealand achieve such a high degree of structural complexity that they have been compared to tropical rain-forests (e.g., Dawson and Sneddon 1969). These observations are supported by the tall, multi-storied structure, including an emergent tier overtopping a closed canopy and a profusion of lianes and epiphytes, ferns and mosses, features so characteristic of the tropical rain-forest.

Viewed from above, the forest presents an irregular, ruffled appearance, with the crowns of emergent podocarps spreading over a generally closed, mixed broadleaved canopy. It appears as a mottle of colours from mid-greens through olive greens to dark green. The emergent trees, at heights of 35 metres or more, are indigenous conifers of the family Podocarpaceae and include rimu which is the most consistently present, matai, miro, totara and kahikatea. Northern rata (*Metrosideros robusta*) or southern rata (*M. umbellata*) are often present among the emergent podocarps. In northern districts kauri is locally prominent. The canopy is made up of broadleaved

trees and smaller podocarps and forms the next tier at heights between 15 and 30 metres. Prominent constituents include tawa, kamahi, hinau, Hall's totara, rewarewa, pukatea, maire and quintinia. North of latitude 39°S other species become prominent such as towai, mangeao (*Litsea calicaris*) and taraire. South of latitude 42°S many of the above are less frequent or absent and kamahi and quintinia assume greater importance. A host of smaller trees and shrubs including species of *Coprosma, Pittosporum and Pseudopanax*, kohekohe, titoki, mahoe, tree ferns, and others constitute the subcanopy and understorey. Ground layers comprise a profusion of ferns and herbs, mosses and lianes, many of which ascend to, or descend from, the canopy and subcanopy trees.

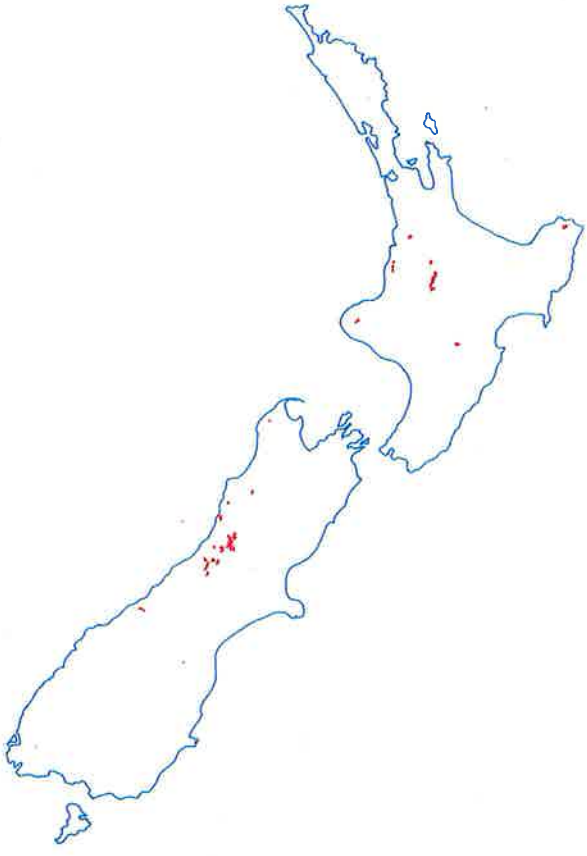
This ubiquitous class occurs in a wide variety of soils and landforms throughout the generally mild, moist climatic zones. It has been much reduced in extent during the period of human occupation, and continues to be the subject of logging and land clearance operations, though at a very much slower rate than earlier this century. Feral animals have altered the species composition of some forests and have the potential to impair their ability to regenerate.

Figure 43: F2. Lowland podocarp-broadleaved forest showing the olive green crowns of rimu emergent over the broadleaved trees. North-north-east of Karamea, North-West Nelson. NZMS 260 L27/385.060 →SE

F3 HIGHLAND PODOCARP-BROADLEAVED FOREST

51,000 ha

Evergreen forest, occurring above the altitudinal limit of rimu, with a canopy dominated by indigenous mixed broad-leaved and conifer trees and an emergent storey dominated by conifers.



Distribution and Landform

Highland podocarp-broadleaved forest is encountered in moderate to high rainfall forested ranges, from Coromandel to south Westland. It is often continuous with the lower altitude class '**F2**', and particularly where beeches are of reduced extent, may form a tree-line at elevations ranging from 1400 metres in the north to 900 metres in the south.

Characteristic Features

Highland podocarp-broadleaved forest is of generally medium to low stature, forming a canopy between 5 and 15 metres in height and sometimes of an open or discontinuous nature. Viewed from above, the forest appears irregular in profile, with the crowns of the emergent conifers standing above a generally closed mixed broadleaved canopy. The forests reduce in stature with increasing altitude and sometimes appear quite stunted and open at the treeline. The varying composition of the canopy confers a mottled colouration of light to dark greens and rust browns.

The emergent trees, whose heights range between 10 and 20 metres, are indigenous conifers among which kaikawaka is prominent along with the podocarps miro, Hall's totara and mountain toatoa. The canopy comprises a mixture of broadleaved trees and conifers. Among these may be: broadleaf, kamahi, mountain ribbonwood, southern rata and quintinia; and additionally, in the North Island, tawari. These may be associated with the conifers pink pine, silver pine and yellow-silver pine, and any of the emergent species. There is usually a moderately well developed subcanopy and understorey,

often comprising species common to lower altitude forests or higher altitude scrublands. These may include species of *Brachyglottis, Coprosma, Fuchsia* and *Olearia* along with mountain flax (*Phormium cookianum*) mountain cabbage tree (*Cordyline indivisa*) and some ground ferns.

Direct disturbance by humans has probably not been great in these highland forests. However introduced browsing animals have been accused of causing severe damage in some regions (Elder 1965, Chavasse 1971, O'Loughlin 1986). A source of particular concern is that rata and kamahi, two of the most prominent trees in this class, are selectively browsed particularly by possum, while understorey damage by deer for example, has the potential to severely inhibit forest regeneration, or change forest composition.

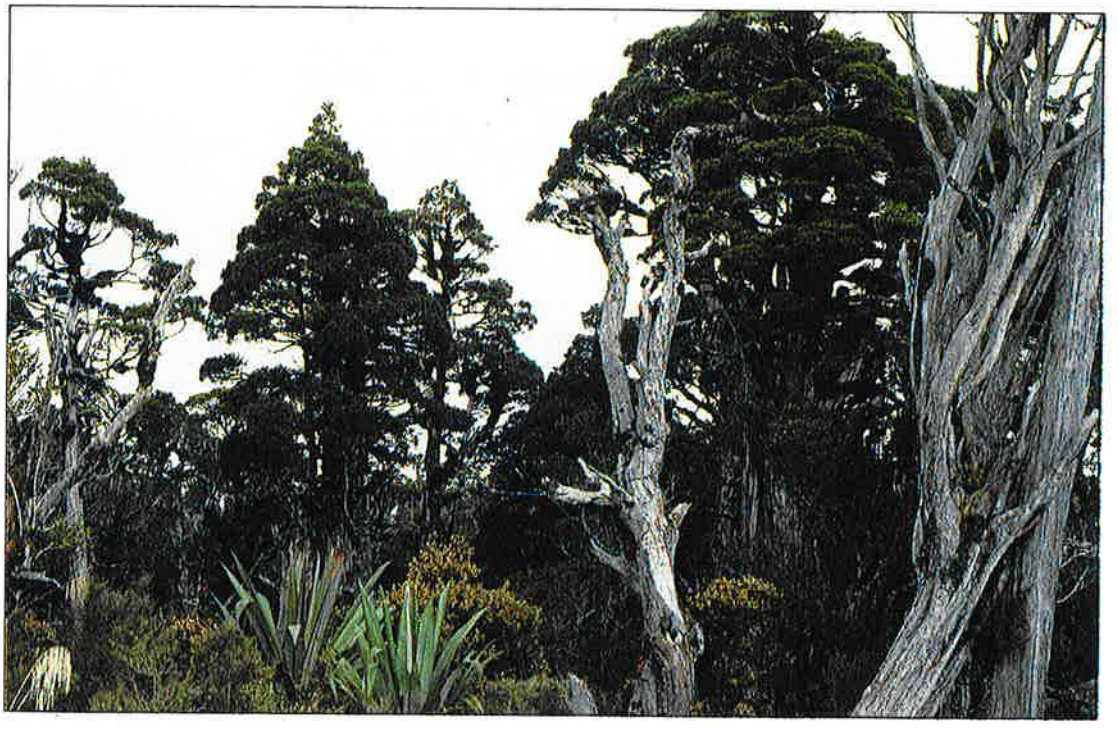
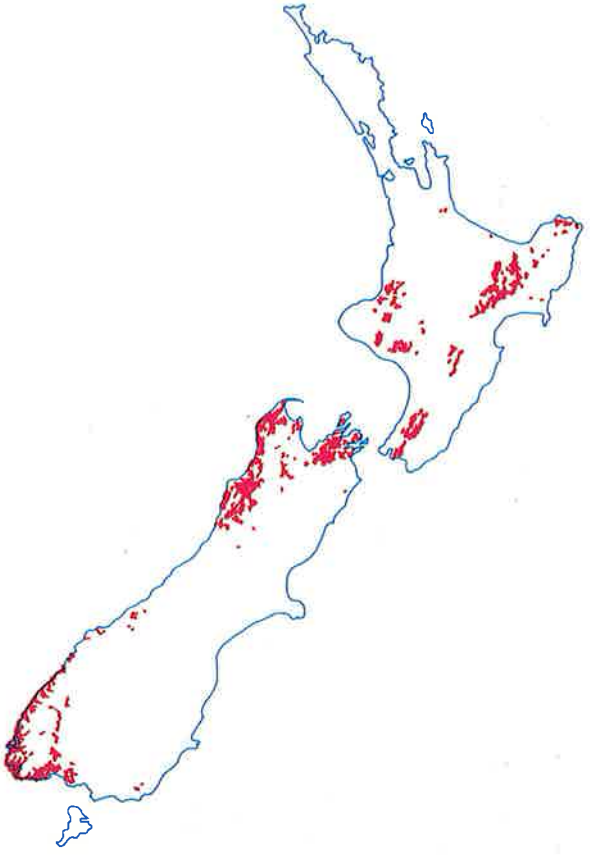


Figure 44: F3. Highland podocarp-broadleaved forest viewed from a clearing within the forest. Kaikawaka dominates in this scene where the broadleaved canopy trees are not particularly evident, but which illustrates the often conspicuous element of dead wood. This forest is locally dominant at the upper limit of an area recorded on the map as podocarp-broadleaved forest and scrub (class FS2). Western Ruahine Range.
NZMS 260 T23/653.212 →S

F4 LOWLAND PODOCARP-BROADLEAVED-BEECH FOREST

1,399,000 ha

Evergreen forest, occurring below the altitudinal limit of rimu, with a canopy dominated by indigenous mixed broadleaved, southern beech and podocarp trees and an emergent storey dominated by podocarp trees.



Distribution and Landform

Lowland podocarp-broadleaved-beech forest is a prominent element of the forested ranges and hill country from the Kaimai Range in the North Island (at approximately the southern limit of kauri) to Fiordland in the South Island. It occurs in regions of medium to high rainfall at altitudes up to 900 metres in the north and 350 metres in the south.

Characteristic Features

These forests are generally tall statured and dense with a well developed storied structure. In appearance the forest has a ruffled irregular form, in which the emergent crowns of the podocarps stand noticeably above a usually smooth, closed canopy of mixed broadleaved trees and beeches. Colouration is a mottle from the light green of tawa through the olive green of rimu to the darker greens of kamahi and the beeches.

The distribution of the beech component within the forest matrix may generally be of two forms. The first is particularly noticeable in the forests of the inland Taranaki hill country where the beech component is confined to the dry sandstone ridges and spurs while the hillslopes and valley floors are clothed in podocarp-broadleaved forest. The second form is typified by the forests of north-west Nelson where the beech component is distributed in varying proportions throughout the forest.

The emergent trees, with heights ranging between 25 and 35 metres, are

dominated by indigenous conifers, among which rimu is almost always present in association with matai, miro, totara, kahikatea on alluvial sites, and northern rata or southern rata. The canopy, at heights of between 15 and 25 metres is dominated by mixed broadleaved trees, beeches and smaller podocarps. Important are: tawa, kamahi, hinau, Hall's totara, rewarewa, pukatea, maire and rata, along with red beech, silver beech, black beech and hard beech. Below the canopy a large number of smaller trees and shrubs make up the understorey such as species of *Coprosma, Pittosporum* and *Myrsine*, quintinia, tree ferns, ground ferns, lianes and many others.

Along with other lowland forests the human influence is evident, though not quite as severely felt as in forests with a higher podocarp component (classes **F1** and **F2**). Both Polynesian and European land clearance have greatly reduced the extent of these forests in the flat lands and gentle hill country. Browsing by introduced animals has from place to place served to modify the forest, particularly in the understorey, and now demands continual control measures.

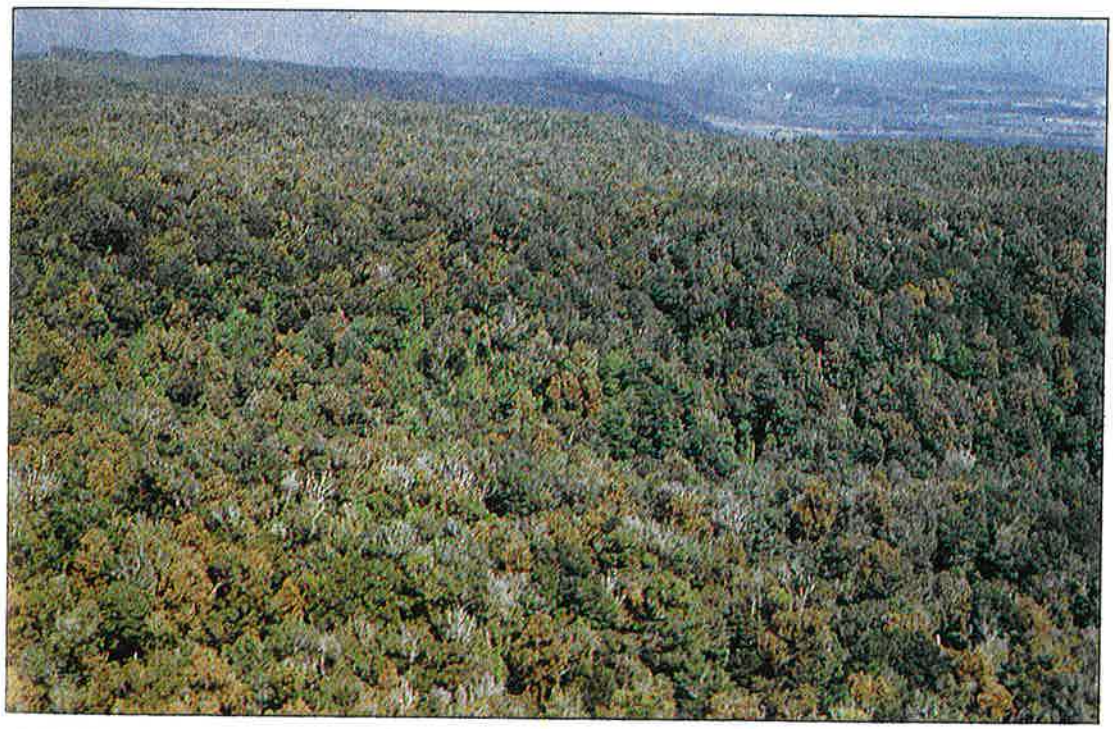
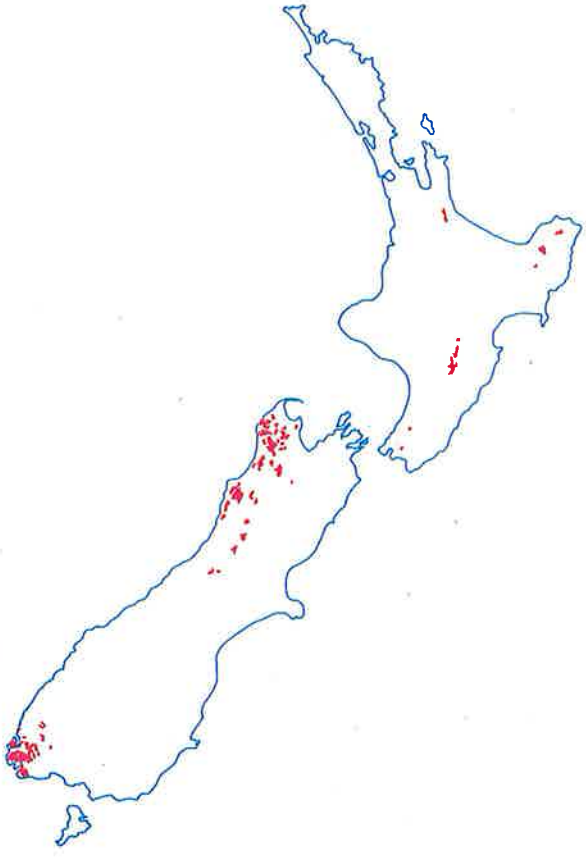


Figure 45: F4. Lowland podocarp-broadleaved-beech forest showing the almost homogenous mixing of the darker crowns of the beech trees with the lighter greens of the broadleaved trees and the olive green of rimu. North of Karamea, North-West Nelson.
NZMS 260 L27/375.090 →S

F5 HIGHLAND PODOCARP-BROADLEAVED-BEECH FOREST

205,000 ha

Evergreen forest, occurring above the altitudinal limit of rimu, with a canopy dominated by indigenous mixed broadleaved, southern beech and conifer trees and an emergent storey dominated by conifers.



Distribution and Landform

Highland podocarp-broadleaved-beech forest is occasionally encountered in moderate to high rainfall forested ranges from the Kaimai Range to Fiordland. It is usually continuous with the lower altitude class '**F4**', and may form a treeline at elevations ranging from about 1400 metres in the north to 900 metres in the south.

Characteristic Features

Highland podocarp-broadleaved-beech forest is generally of medium stature, and forms a fairly closed canopy between 6 and 8 metres high. Viewed externally the forest has an irregular profile in which emergent crowns of the conifers stand above an otherwise smooth canopy of broadleaved trees and beeches. The variety of the component trees confers a mottled colouration ranging from mid greens to browns to dark green.

The emergent trees, which may be up to 20 metres in height, are indigenous conifers among which kaikawaka is prominent, along with the podocarps miro, Hall's totara, and mountain toatoa. In the canopy silver beech , mountain beech and to a lesser extent, red beech are present in varying abundance, and generally assume greater importance at higher altitudes. These are associated with a variety of other broadleaved trees and smaller podocarps, notably kamahi, mountain ribbonwood, Hall's totara, broadleaf, southern rata and quintinia. In the North Island they may be joined by tawari, and in the South Island, silver pine and yellow-silver pine. These will usually

be ranged above a moderately developed understorey comprising species of *Brachyglottis*, *Coprosma*, *Dracophyllum* and *Olearia*, fuchsia, mountain cabbage tree, and some ground ferns such as kiokio (*Blechnum procerum*).

For the most part **highland podocarp-broadleaved-beech forest**, being remote from the developed lowlands, has escaped the direct attentions of humans except in the eastern South Island where Polynesian fire was responsible for destroying large tracts of forest. Of greater present concern is the effect of introduced animals which, by browsing the understorey and canopy, have the potential to reduce forest vigour and regeneration and hence increase the risk of erosion.

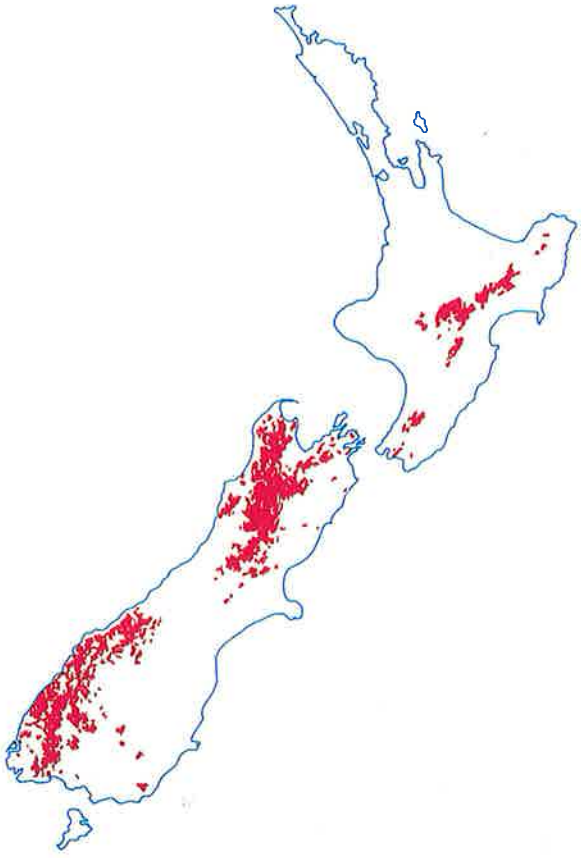
Figure 46: F5. Highland podocarp-broadleaved-beech forest with the lamina arrangement of branchlets showing clearly in the mountain beech trees in the foreground. The distinctive, broadly conical but broken, crowns of kaikawaka are recognisable near the skyline. Eastern Ruahine Range.
NZMS 260 U22/810.440

Photo: M J Page

F6 BEECH FOREST

1,992,000 ha

Evergreen forest with a canopy dominated by indigenous southern beech (*Nothofagus*) trees.



Distribution and Landform

Beech forest presently accounts for almost half of the total area of indigenous forest in New Zealand. It commonly forms a distinct tree-line at elevations ranging from 1400 metres in the north to 900 metres in the south. **Beech forest** is concentrated in the foothills, hill country and mountainlands from the Raukumara Range in the North Island to Fiordland. It is curiously absent from the vicinity of Mt Taranaki and from both central Westland and Stewart Island, facts which have been attributed respectively to volcanic activity and to an as yet incomplete recovery from the last glaciations (Wardle 1964).

Characteristic Features

Beech forest forms a relatively uniform, undulating canopy, up to 35 metres high in favourable sites, reducing to 10-15 metres as it approaches the treeline. Foliage has a soft, feathery texture, and is typically arranged in overlapping lamina. Colouration is in tones of dark-green, with red beech, particularly its young spring leaves, a perceptably lighter tone than silver beech, which is in turn slightly lighter than mountain beech.

All five indigenous species are canopy trees, and each contributes to significant areas of beech forest either regionally or nationally. Beech forests comprising just a single species or mixtures of all five species can be found (Wardle 1984), with black beech, hard beech and red beech generally showing a preference for lower elevations and giving way to silver beech and mountain beech with increasing altitude.

Generally speaking, beech forests lack the complex structural development of the podocarp and broadleaved forests, and bear a greater resemblance to northern hemisphere beech and oak forests with their relatively sparse understories, than to a dense rainforest. As a consequence associated species are correspondingly fewer. Common understorey plants are species of *Coprosma, Olearia, Pseudopanax*, and *Myrsine*, quintina, broadleaf, mountain ribbonwood, mosses, and ground ferns such as prickly shield fern and filmy ferns.

Formerly beech forest, particularly mountain beech forest, occupied much of the drier lands east of the axial ranges of both islands. But of these once extensive tracts only a vestige remains, the bulk having been destroyed by Polynesian fire. The upland forests of the main ranges have by contrast escaped interference, chiefly by virtue of their remote location, difficult terrain, and the less attractive qualities of beech timber when compared to that of the podocarps. In recent times however, there has been a revival in beech forest logging both for timber and wood chips. Substantial areas in north Westland, Nelson and Southland are being either clearfelled or managed on a rotational or sustained yield system. Of concern in all the beech forests are the effects of introduced animals, especially deer and goats, which browse the understorey and inhibit regeneration, but also the canopy damage from possum browsing.

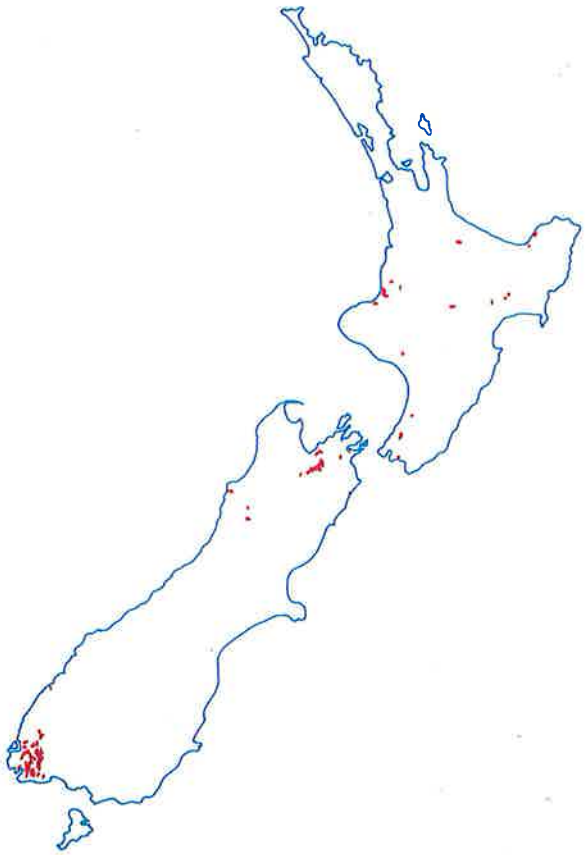
Figure 47: F6. Red beech—silver beech forest, north-east of Lake Waikaremoana, northern Hawke's Bay. Note the more uniform colouration and canopy texture of this forest in comparison with podocarp-broadleaved-beech forest (figure 45) and podocarp-broadleaved forest (figure 43).
NZMS 260 W18/730.690 →SE

Photo: M J Page

F7 BEECH-BROADLEAVED FOREST

114,000 ha

Evergreen forest with a canopy dominated by indigenous southern beech and mixed broadleaved trees.



Distribution and Landform

Beech-broadleaved forest occurs in forested lowland and montane foothills and ranges, from the Kaimai Range in the north to Fiordland in the south; but only in a few localities does it attain any prominence.

Characteristic Features

Beech-broadleaved forest usually exhibits a medium to tall-statured canopy ranging in height from 20 to 30 metres. It has a soft slightly feathery textured foliage, arranged in lamina typical of beech trees but interspersed with the more erect lighter green and russet coloured foliage of the mixed broadleaved trees.

In the North Island, black beech, hard beech, silver beech and red beech are variously represented in association with rewarewa, kamahi, hinau, and southern rata. Tawa is frequently present with occasional maire. The South Island **beech-broadleaved forests** again have red beech and silver beech, but include a large component of mountain beech and, locally in Marlborough, black beech. The broadleaved canopy trees almost always include kamahi, with varying proportions of southern rata, pokaka, quintinia and tree fuchsia. Understorey trees comprise a variety of small trees and shrubs including; broadleaf, quintinia, species of *Coprosma, Cyathodes*, *Olearia* and *Pseudopanax*, pepper tree, tree ferns and ground ferns.

A proportion of North Island and northern South Island occurrences of this class are former **podocarp-broadleaved- beech forest** (class **F4** or **F5**), from which the podocarps, usually rimu, have been felled or which have not fully recovered after fire swept through the primary forest. In common with other

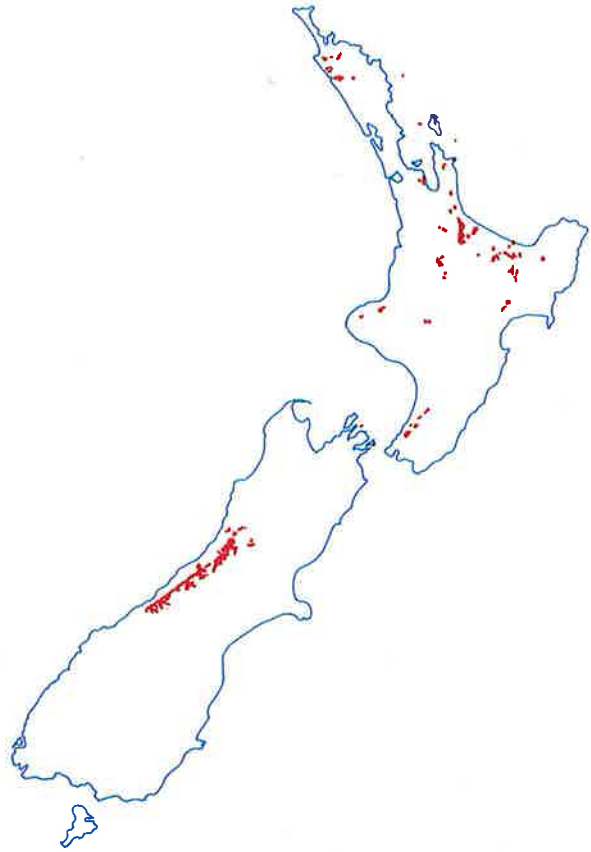
lowland indigenous forests, forests of this class are often under threat from development. However, with a distribution now concentrated in the more remote ranges they are afforded some protection from indiscriminate disturbance. Browsing by introduced animals is of some concern, particularly as kamahi, a conspicuous element in these forests, is also especially favoured by possum.

Figure 48: **F7.** Red beech-kamahi-mixed broadleaved forest. Akatarawa Valley, Wellington. NZMS 260 R26/880.247 →SE

F8 BROADLEAVED FOREST

223,000 ha

Evergreen forest dominated by indigenous mixed broadleaved trees other than southern beech.



Distribution and Landform

Broadleaved forest is present in high rainfall forested districts of the North and South Islands. In the North Island it is important on the foothills of the ranges, and in other situations transitional between agricultural and forested land. In the South Island it is one of the most important forest classes on the mid-slopes of the ranges in central Westland where beech is naturally absent.

Characteristic Features

These forests usually have a quite dense canopy which varies in height from 20 metres to 30 metres. The dominant trees each confer their own qualities on the appearance of the canopy, ranging from the yellow-green of tawa through the glossy mid-green of kohekohe to the dark green and russet colours of kamahi. The environment may impose its own features, by reducing the stature of the forest at higher elevations, and near the coast by shaping a low, dense, windshorn canopy, strongly controlled by wind and salt spray.

In the northern North Island tawa, taraire, puriri and rewarewa are often prominent along with kamahi, hinau, towai and mangeao while in coastal situations kohekohe and pohutukawa may be conspicuous. Further south the forests are dominated more often by tawa and kamahi, in association with hinau, rewarewa, maire and pigeonwood. In areas with a coastal influence, kohekohe, titoki and nikau are important, and locally, especially near centres of early Maori occupation karaka is found. **Broadleaved forest** in central Westland is predominently kamahi, southern rata and quintinia, in association with occasional Hall's totara and kaikawaka. In this region the class occupies a niche above the **podocarp-broadleaved forests** of the

lower slopes, and forms a treeline at about 900 metres altitude. The canopy trees are associated with understories of smaller trees and shrubs including species of *Coprosma, Cyathodes, Geniostoma, Hoheria, Lophomyrtus, Olearia, Pittosporum* and *Pseudopanax* and tree ferns and ground ferns.

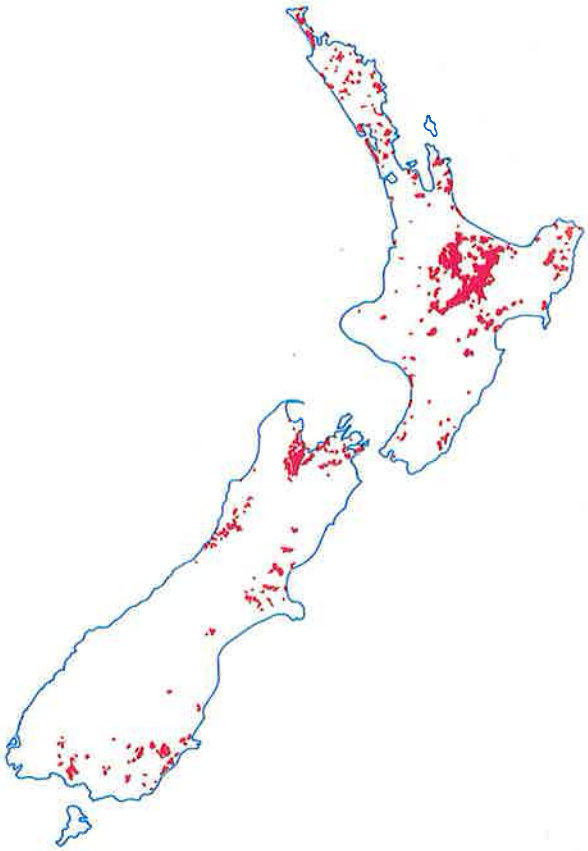
In the North Island, many such forests have originated from logging or fire, or less frequently windthrow, of former **podocarp-broadleaved forest** (class **F2** or **F3**), to the extent that the podocarp element has been reduced to insignificance. Elsewhere, **broadleaved forest** may be a condition which has evolved naturally on sites where the mixed broadleaved trees have a competitive advantage over the podocarps such as at higher elevations in the montane forests of Westland and in exposed coastal situations. Modifying influences in the form of land clearance or logging, and introduced animals, are common also to these forests. Being very often in close proximity to human activities has its attendant danger of further land clearance. Browsing animals are of particular concern in these forests, composed as they are largely of palatable species, especially where they protect mountain slopes such as in central Westland (O'Loughlin 1986).

Figure 49: F8. Rata-kamahi-quintinia forest. Otira Gorge, Westland.
NZMS 260 K33/920.160 →S *Photo: R T Salter*

F9 EXOTIC FOREST

1,212,000 ha

Forest plantations dominated by exotic conifers or broadleaved trees.



Distribution and Landform

Exotic forest has been planted extensively in lowland and mid-altitude areas with particular concentrations in Northland, Volcanic Plateau, Hawke's Bay, East Cape, Nelson, north Westland, north Canterbury and Southland. It occurs on a variety of landforms from dunelands and alluvial plains, to volcanic plateaux and steep hill country, but usually not on fertile plains and downlands where other forms of land use predominate.

Characteristic Features

These forests are commonly monocultures, among which pines, Douglas fir and eucalypts are nationally significant.

Pines form the bulk of the exotic forest estate, and of these, *Pinus radiata* is by far the most important. Other species include limited areas of Corsican pine (*P. nigra*) and ponderosa pine (*P. ponderosa*) and locally the cypress, macrocarpa (*Cupressus macrocarpa*). In appearance pine forests have a dark green foliage, a soft brush-like texture, a canopy remarkably even in profile, and mature heights ranging between 25 and 40 metres. A typical management regime for a high density *P. radiata* production forest on a 25-30 year rotation is an initial planting of about 1500 seedlings per hectare followed by two or three thinnings to give a final density of 200-400 trees per hectare. Pruning to remove lower lateral branches is often done at the time of thinning, and perhaps once subsequently, to give clear, straight trunks. At harvest the trees will be about 30-35 metres high and with trunk diameters of up to 60 centimetres.

Douglas fir is the second-most important species and is managed in a similar

regime to *P. radiata* although on a rotation of about 40-45 years. Its short, light green needles confer a soft, though spiky, texture to the canopy, and an appearance less dense than that of a pine plantation.

Eucalyptus species and Australian blackwood (*Acacia melanoxylon)* have been planted in limited quantities to provide decorative and joinery timbers. Their management varies and is often more intensive, but generally follows a similar pattern to that described for *P. radiata* with plantations thinned to approximately 100 trees per hectare, on a rotation of 35-40 years or more. Their very much leafier foliage and variety of colours gives the canopy a mottled light green or mid-green and brown colouration quite different in appearance from the exotic conifers.

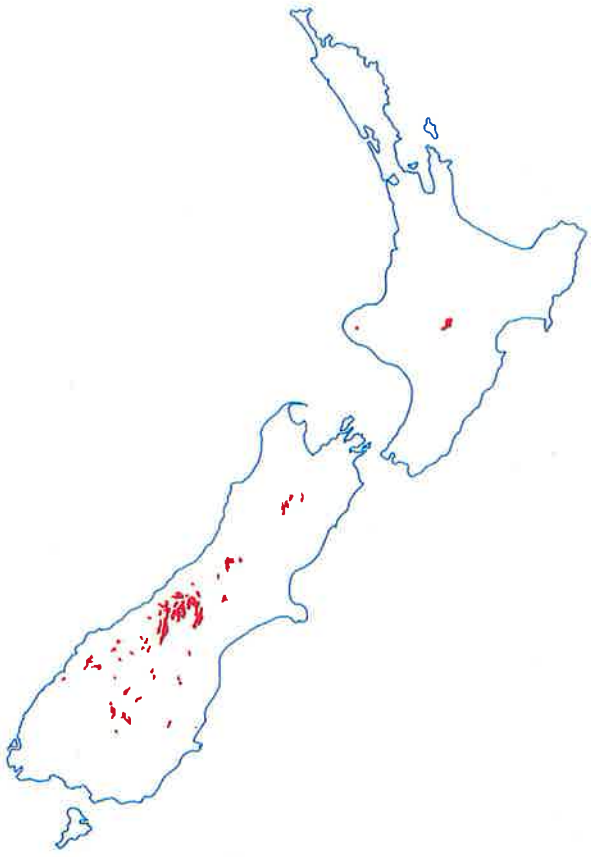
Quite significant areas of **exotic forest**, mainly in state ownership, play an important role in erosion control on dunelands and on steep unstable hillslopes.

Figure 50: F9. *Pinus radiata* production forest, showing recently planted, recently logged, and maturing compartments. Golden Downs Forest, south-west of Nelson.
NZMS 260 N29/996.494 →N

M1 SUB-ALPINE OR ALPINE HERBFIELD

187,000 ha

Communities dominated by herbaceous species, other than grasses, occuring above the actual or theoretical timberline.



Distribution and Landform

Sub-alpine or alpine herbfield is present on most high mountains, on ridges in the alpine zone below the lower limit of permanent snow and ice, and occasionally descending into the upper sub-alpine zone. In the North Island it is mapped only on the summits of Mt Taranaki and the Kaimanawa Range, but in the South Island it is frequently recorded both on the Main Divide and on outlier ranges in Canterbury and Otago.

Characteristic Features

Sub-alpine or alpine herbfield appears as a low growing, usually open, low density community, with stones, boulders and bare rock a conspicuous feature of the landscape. It commonly occurs above a zone of low snow tussock, alpine fescue tussock, blue tussock or bristle tussock and below the level of perennial ice and snow. These herbfields are inhabited by a variety of plant forms, including cushion plants, mat plants, turf plants, rosette herbs and lichens. All exhibit adaptive features to contend with an environment characterised by extreme cold, extreme daily temperature fluctuations, high winds and low available moisture. Common adaptive features are: a general hairiness, woolly thick leathery or fleshy leaves, prostrate or low stature, and the retention of old leaves to form a water-retentive and insulative mat round the plant. Flowering in most species occurs during the months of December and January when the generally white, cream and yellow blooms provide a display of delicate beauty across the mountain landscape.

Snow tussock, alpine fescue tussock, blue tussock and bristle tussock may be locally conspicuous but communities are largely dominated by alpine daisies, buttercups, gentians (*Gentiana* spp), spaniards (*Aciphylla* spp) and other alpine

plants. Prominent genera are *Celmisia, Gentiana, Oreobolus, Ranunculus, Euphrasia, Epilobium, Raoulia, Haastia, Aciphylla* and *Anisotome*. Inclusions of bog communities of rush and sedge species (*Carex, Carpha, Schoenus* and *Juncus*) with umbrella fern, *Empodisma minus*, and species of *Donatia, Phyllachne* and *Drosera* may locally dominate in areas of poor drainage.

Environmentally, **sub-alpine and alpine herbfield** exists in one of the most stressful sites imaginable. The climate is typified by high diurnal temperature fluctuations, high annual precipitation usually in the form of snow, mean annual temperatures close to freezing and high winds. Cloud and fog may also blanket the mountains for extended periods. Snow may fall at any time of the year and, on less steep slopes and those with a southerly aspect, may lie for prolonged periods. Where snow lies well into the growing season such as in depressions and shaded banks, the plants may be arranged in concentric zones according to the time they require for growth and reproduction when they are finally released by the summer thaw.

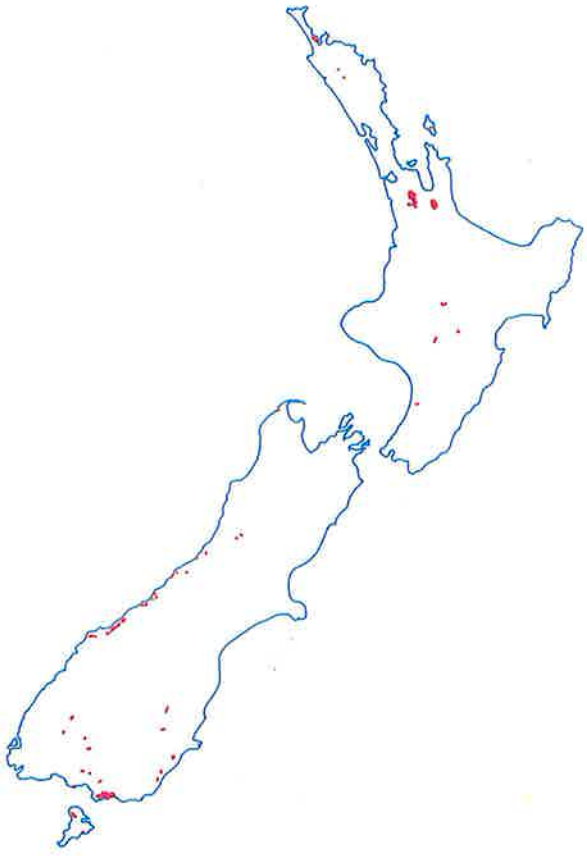
As these communities are remote from human activities, anthropic disturbance is minimal and is largely felt indirectly, via the agency of introduced animals such as chamois, thar and hares. The natural forces of erosion manifest in a high weathering rate, dislodgement by frost and transport by wind, sheet flow and scree have historically exerted the main inhibiting influence on community vigour and extent.

Figure 51: **M1.** Alpine herbfield at 1400 metres altitude on the crest of the Dunstan Mountains, Otago. Bare rock, with an even greater extent than appears in this scene, is usual in these communities.
NZMS 260 G41/380.850 →SW

M2 WETLAND COMMUNITIES

89,000 ha

Communities dominated by herbaceous species occuring in freshwater habitats where the water table is above, at, or just below the substrate surface for most of the year.



Distribution and Landform

Wetlands are present throughout New Zealand, though often in small isolated patches which are often remnants of the much greater areas present in former times. Only in northern Waikato, south Westland, Southland and Stewart Island does the class still attain regional importance. It occurs on alluvial plains often in association with former river courses and ponding areas, lake margins and dune hollows.

Characteristic Features

Dobson (1979) described the principal wetland communities in New Zealand and of these, three types are of national importance.

The first is the eutrophic (high fertility) mire, in which the reed, raupo (*Typha orientalis*) dominates. These commonly occur in lowland lake margins, old lake basins and cut-off river meanders, subject to a continual input of nutrients by way of streams. Surface water up to a metre in depth is usually present.

The second type is the mesotrophic (medium fertility) mire, variously dominated by flax (*Phormium tenax*), rushes and sedges including *Carex* spp, *Schoenus pauciflorus*, and species of *Juncus*, *Baumea* and *Lepidosperma*. Standing water is usual, though usually less than 1 metre deep. These wetlands are best developed in high rainfall areas on alluvial plains and valley bottoms subject to impeded overland drainage. They have a lower internal nutrient circulation than the eutrophic mire.

The third type is the oligotrophic (low fertility) Sphagnum-restiad mire. In appearance it has a flat or gently domed, sometimes hummocky form,

comprised of a blanket of moss and rush-like plants and little obvious surface water. Manuka and umbrella fern may be associated with the *Sphagnum* species, the restiads *Empodisma minus* and locally *Sporodanthus traversii* and *Leptocarpus similis*. The proportion of sphagnum in the vegetation increases and the proportion of the restiads decreases, from north to south and with increasing altitude (Dobson 1979). Hence the mires of the northern Waikato are restiad-dominated and those of the Awarua Plain in southern Southland are sphagnum-dominated.

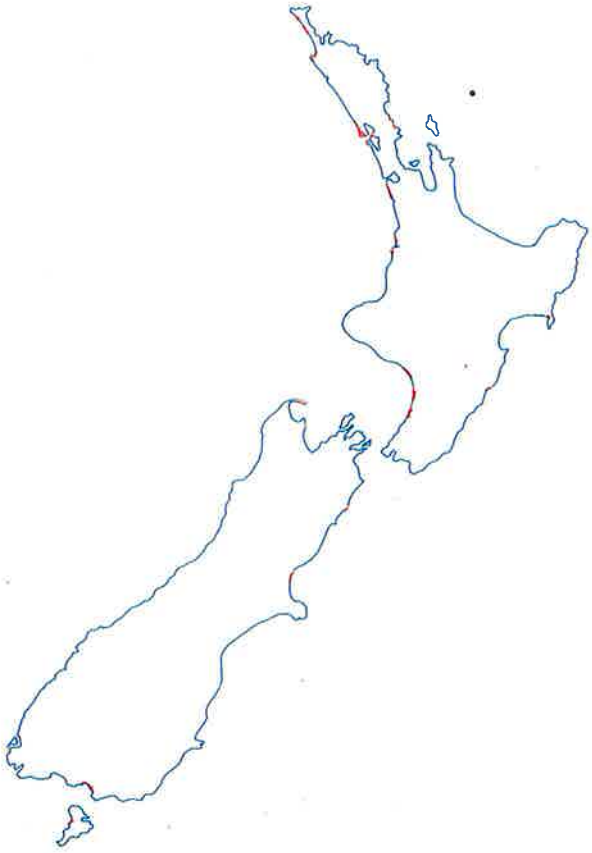
Individual mires across their full extent may comprise species typical of more than one mire type because of varying nutrient status, acidity, substrate or water depth. Woody vegetation such as manuka, willows and species of *Dracophyllum* and *Dacrydium* may occupy substantial areas round the margins of the mire (Burrows and Dobson 1972, Davoren 1978).

There can be few other vegetation classes which have suffered so severely during human times than have the wetlands. The reasons for this are manifold, but can be attributed largely to their position on flat land, ideally suited to agriculture, and to the generally low esteem in which such vegetation is held in the eyes of the layperson. These changes have occurred despite the manifest value of wetlands as wildlife habitats, as regulators of flood waters, for recreation, and for scientific research. Nevertheless a far larger area than remains today has been lost through drainage, fire, topdressing and flooding.

Figure 52: M2. Mesotrophic mire dominated by flax, toetoe, rushes and sedges. Waiotaka River, Lake Taupo.
NZMS 260 T19/563.465 →SW

M3 SAND DUNE COMMUNITIES

52,000 ha



Communities dominated by herbaceous plants and low shrubs occurring on recent, unstable dune sands.

Distribution and Landform

Sand dune communities have been recorded locally throughout New Zealand, but are of particular importance in the western, coastal dunes and sand plains of Northland and Manawatu.

Characteristic Features

Sand dune communities take a variety of forms depending on their position in the dune complex. The unstable fore-dune is typified by windblown sand and extreme exposure to salt-laden winds. It is the exclusive domain of a very few, specialist sand-binding plants. In New Zealand only three species are of national importance the indigenous grass spinifex (*Spinifex sericeus*), the introduced grass marram (*Ammophila arenaria*) and the indigenous sedge pingao (*Desmoschoenus spiralis*). The latter, while distributed throughout the country, is the least common of the three, and its golden, grass-like foliage is conspicuous only in the southern South Island, Stewart Island, and locally in northern districts. Spinifex, by contrast, is prominent in the northern South Island and North Island, where its silvery foliage and large spiney, star-shaped seedheads are a feature of steeper, higher dune systems. Of greatest importance nationally and the dominant component of most dunes is marram, a grass introduced for sand stabilisation and now naturalised throughout the country. It builds an irregular, steep sand dune, higher than either pingao or spinifex (Esler 1970).

Where the dunes are more stable other associations make their appearance, among which are a number of small shrubs as well as grasses and herbs. These may include the low growing and prostrate shrubs *Coprosma acerosa* and *Pimelia arenaria,* or in southern districts *Pimelia lyallii* and taller shrubs

such as tauhinu, *Olearia solandri* and boxthorn (*Lycium ferocissimum*). Among these will be a range of native and introduced grasses, rosette herbs, locally the succulent ice plants (*Disphyma australe* and *Carpobrotus edulis*), and where the dunes have a longer history of stability, tall shrubs and small trees such as manuka and cabbage tree or toetoe (*Cortaderia toetoe)* and pampas (*C. selloana*). In areas where erosion-control planting has been done, tree lupin (*Lupinus arboreus*) may be present, and is often established prior to planting **exotic forest** (class **F9**). In dune hollows and sand plains behind the foredune the water table can be quite close to the surface and here may occur communities which include *Carex pumila, Selliera radicans, Leptocarpus similis, Scirpus nodosus* and a number of other indigenous and introduced herbs and grasses.

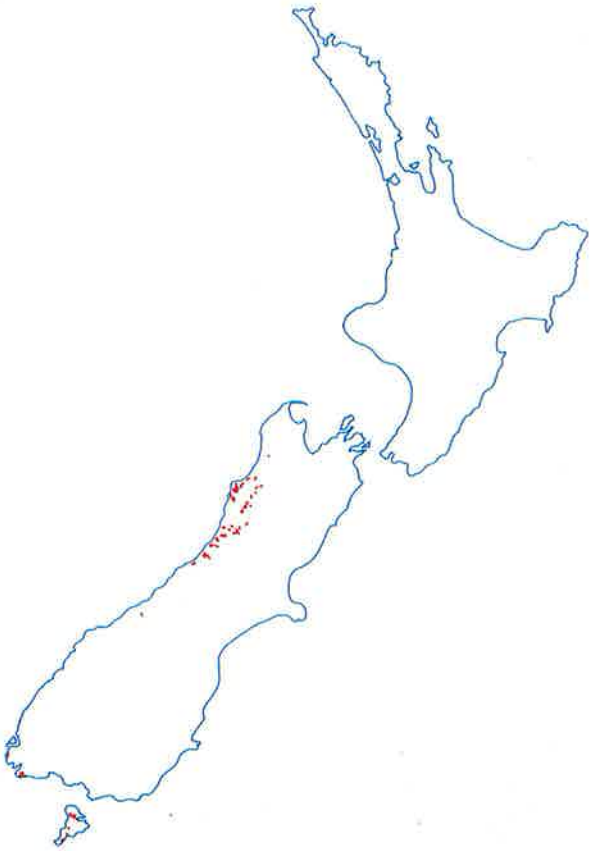
In this, one of the most stressful lowland habitats, few dune systems bear much resemblance to the pristine state, as a consequence of stock grazing, invasion by adventive plants, sand mining and erosion-control planting.

Figure 53: M3. Sand dune communities dominated by spinifex and marram. Waiterere Beach, Horowhenua.
NZMS 260 S25/955.695 →SSW

M4 PAKIHI HEATHLAND COMMUNITIES

45,000 ha

Communities dominated by low fern, shrub, rush and moss plants occurring on gley-podzols and podzols in the western South Island and Stewart Island.



Distribution and Landform

Pakihi heathlands occur intermittently in Westland, Fiordland and Stewart Island in areas of high rainfall (in excess of 2200 mm per annum), and on land which is generally level or of low relief, poor soil drainage and very low fertility (Mew 1983). These qualities are present on intermediate and high terraces, poorly drained alluvial flats and elevated plateaux.

Characteristic Features

Pakihi is a term of uncertain origin variously interpreted to mean "open country", "barren land", "place where fern root has been dug" and "at lowest ebb". It is generally descriptive of the landscape, particularly as it contrasts with the surrounding forest (Mew 1983). These communities typically possess an irregular, low (less than 1 metre) canopy whose colour is a mottle of olive, mid-green, dark green and charcoal grey. The vegetation will typically comprise umbrella fern, wirerush (*Empodisma minus*), rushes and sedges (usually species of *Baumea* and *Juncus*), manuka, and sphagnum, associated with a number of minor herbs and shrubs. These interact in a mosaic sensitive to the undulating and ridged heathland, whereby the more bog-tolerant plants assume greater importance in depressions, and manuka and sometimes gorse and bracken dominate the elevated areas (Rigg 1962). These communities may grade at one extreme into forest through a transition of manuka or silver pine, and at the other extreme into oligotrophic mires (class **M2**).

Most pakihi heathlands were formerly tall podocarp or podocarp-broadleaved

forest, but have degenerated to the pakihi condition as a result of soil deterioration, Polynesian fire or possibly climatic change. What is not clear is whether this succession is irrevocable or, as some authorities suggest, is cyclical in nature (Chavasse 1971, Mark and Smith 1975). However, since the arrival of humans, any obvious trends have been obscured by their use of fire, and by stock grazing and land drainage. Pakihi heathland as a community is relatively tolerant of fire, and fire was regularly used in some areas to promote new growth palatable to stock, and during attempts at conversion to pasture. Many pakihi heathlands have thus been sustained in a similar state for the last 100 years or more. In addition, induced pakihi heathlands were inadvertently formed through felling of the primary forest on land with a high water table and poor soils.

Some success has been achieved in recent times in conversion of pakihis to pasture through drainage, deep cultivation and massive applications of lime and superphosphate.

Figure 54: M4. Pakihi heathland dominated by umbrella fern, wire-rush and occasional flax. Dublin Terrace, Buller Valley, Westland.
NZMS 260 L29/330.335 →E *Photo: P A Williams*

CHAPTER 5

THE VEGETATIVE COVER ELEMENTS

The seventeen **Vegetative Cover Elements** are the most detailed level of the map classification but, unlike the **Vegetative Cover Classes**, they are not representative of all vegetation components in New Zealand. To bring this about would require far more symbols and patterns than the map could accommodate. Instead, the map symbols highlight those components of the vegetation which need to be emphasised as occurring as part of the map unit. These **elements** also have a tendency to occur as inclusions in **Vegetative Cover Classes** in which their presence is not necessarily implied. For example, **wetland communities** are frequently encountered as small mires or swamps within grassland, scrub or forest; and symbols superimposed upon the map are the most practical method of recording them. Similarly, where a vegetative component, particularly scrub types like gorse, *Leptospermum* and matagouri, occur too diffusely or at too low a frequency to justify their own map unit, then superimposed patterns are a convenient way to denote their presence in vegetation classes dominated by other species.

For consistency of presentation, where the elements are explicitly mentioned in the class name they are also shown. Here they perform a valuable function in providing a 'ready-reference' to the identity of cover classes. For example, the 'beech' pattern is present in units belonging to classes **F4** and **F5** (among others), as would be expected since they are both '**podocarp-broadleaved-beech forests**'. But the advantage to the map reader, is that without having to refer to an identifying code, these units obviously contrast with other units of the same colour, classes **F1, F2** and **F3.**

In other instances the patterns provide the only means of correctly reading some map units, and were thus designed as an integral part of the classification. For example, mature kauri forest is now of such restricted extent that to erect a **Vegetative Cover Class** in its name could not be justified in a national survey of this scale. Where such forests do exist, even in the few areas where kauri dominates, they usually contain prominent components of podocarp and mixed broadleaved trees typical of class '**F2**'. The solution to the problem of denoting a *de facto* kauri forest class lay in

a kauri overlay pattern, which when applied to the **podocarp-broadleaved forest** units, distinguishes these sites as being **kauri-podocarp-broadleaved forest.**

The following brief descriptions of the seventeen **Vegetative Cover Elements** are intended to be read in conjunction with the descriptions of the **Vegetative Cover Classes** in which they occur. Consequently, information contained in the class descriptions has not been unnecessarily duplicated.

SHORT TUSSOCK: Lowland to alpine short tussocks occurring as extensive stands or as localised or diffuse inclusions. Usually dominated by indigenous species of *Festuca, Poa* or *Rytidosperma*. Distribution is mainly on the eastern ranges and the Main Divide of the South Island and the axial ranges of the North Island. Invariably present in classes **G3** and **G5**; usually present in classes **GS7, GS8** and **GF5**; and occasionally present in other mid-altitude situations.

SNOW TUSSOCK: Montane and alpine tall tussocks, dominated by indigenous species of *Chionochloa*, and occurring as extensive stands or as localised or diffuse inclusions. Distribution is mainly on the eastern ranges and the Main Divide of the South Island, and on the axial ranges of the North Island. Invariably present in classes **G4** and **G5**; frequently present in classes **GS4** and **GF6**; and occasionally present in other highland situations.

CASSINIA: Coastal shrubs dominated by species of *Cassinia* notably tauhinu (*C. leptophylla)*, and occurring as extensive stands or as localised or diffuse inclusions. Distribution is mainly on eastern and southern coasts between Gisborne and Kaikoura and locally in the vicinity of the Inland Kaikoura Range. Invariably present in class **GS3**; and occasionally present in other situations, particularly those exposed to coastal influences.

MATAGOURI: Shrub communities dominated by matagouri (*Discaria toumatou*) occurring in semi-arid districts as extensive stands or as localised or diffuse inclusions. Distribution is mainly in inland, lowland and montane eastern areas of the South Island. The presence or absence of the matagouri pattern in class **GS8** is solely indicative of whether sweet brier occurs in association with matagouri or alone. Invariably present in class **GS7**; frequently present in classes **GS8** and **G3**; and occasionally present in other semi-arid situations.

LEPTOSPERMUM: Shrub communities dominated by manuka or kanuka (*Leptospermum* spp) occurring in lowland or montane districts as extensive stands or as localised or diffuse inclusions. Distribution is throughout moderate rainfall hill country and downlands. The presence or absence

of this pattern in classes **GS2, S2** and **FS1** is solely indicative of whether *Leptospermum* is or is not a prominent component of these scrub communities. Usually present in classes **GS2** and **S2**; frequently present in classes **FS1, FS4** and **FS5** and occasionally present in classes **G2, GS1** and **S1** and other lowland or montane situations.

GORSE: Shrub communities dominated by gorse (*Ulex europaeus*) occurring in lowland districts as extensive stands or as localised or diffuse inclusions. Distributed sporadically throughout moderate to high rainfall hill country and downlands. Invariably present in classes **GS6** and **S4**; and occasionally present in other lowland and particularly low fertility situations.

KAURI: Stands of trees dominated by kauri (*Agathis australis*) occurring in lowland situations as extensive stands or as localised or diffuse inclusions. Distributed in forested districts approximately north of Te Aroha (latitude 37°30′s). The presence of this pattern in class **F2** is solely indicative of the mature kauri forest condition and should be interpreted as **kauri-podocarp-broadleaved forest**. Invariably present in class **FS1**; frequently present in class **F2** in Northland, the Coromandel Peninsula and Great Barrier Island; and occasionally present in other northern lowland situations.

BEECH FOREST: Stands of trees dominated by southern beech (*Nothofagus* spp) occurring in lowland to sub-alpine situations as extensive stands or as localised inclusions. Distribution is mainly in axial ranges and hill country south of the Kaimai Range (latitude 37°) but excluding Stewart Island and central Westland. The presence or absence of this pattern in class **GF3** is solely indicative of whether the forest communities are beech forest or podocarp forest. Invariably present in classes **GF5, GF6, FS3, FS4, FS5, F4, F5, F6**, and **F7**; frequently present in class **FS7**; and occasionally present in other lowland to subalpine situations.

EXOTIC FOREST: Stands of trees dominated by species typical of exotic production forest, and occurring in lowland to sub-alpine situations as extensive stands or as localised inclusions. Distributed throughout the North and South Islands, usually on land of moderate to low agricultural value, and concentrated in Northland, Volcanic Plateau, East Cape, Poverty Bay, Hawke's Bay, Nelson, Canterbury, Westland and Southland. Usually identifies woodlots and forests planted solely for production, but includes some forests with erosion control as a primary or secondary function, as well as shelter/production plantings in Canterbury, and infrequently some extensive naturalised exotic trees which have spread from managed forests. Invariably present in classes **GF4, FS8** and **F9**; and occasionally present in other lowland to montane situations.

SUB-ALPINE OR ALPINE HERBFIELD: Herbaceous species, not predominantly grasses, occurring above actual or theoretical timberline as extensive

communities or as localised or diffuse inclusions. Distributed mainly in the eastern ranges and Main Divide of the South Island, the Kaimanawa Range and Mt Taranaki in the North Island. Invariably present in class **M1**; and occasionally present in classes **G4** and **GS4**.

WETLAND COMMUNITIES: Mire vegetation of mostly herbaceous species occurring as extensive communities or as localised inclusions. Distributed mainly on lowland alluvial plains, valley floors and sand plains throughout New Zealand, but recorded locally elsewhere on sites with severely impeded drainage. Invariably present in class **M2**; and occasionally present in other situations.

SAND DUNE COMMUNITIES: Herbaceous plants and low shrubs occurring on recent, unstable dune sands as extensive communities or localised inclusions. Distributed mainly on northern and western North Island and northern, eastern and southern South Island coasts, but recorded elsewhere in coastal dune systems. Invariably present in class **M3**; and occasionally present in other coastal sand dune situations.

SEMI-ARID HERBFIELD: Herbaceous rosette and mat plants occurring as extensive communities or as localised or diffuse inclusions in lowland or montane areas, in districts with annual rainfalls below approximately 600 mm. Usually composed of indigenous mat plants of the genus *Raoulia* and species of introduced weeds including *Hieracium* spp, catsear, *Rumex acetosella* and locally, in the region of Alexandra, the low shrub, thyme (*Thymus vulgaris*). Distributed mainly in severely modified and depleted short tussock grasslands in the Mackenzie country and central Otago regions.

MANGROVES: Estuarine wetland vegetation dominated by the indigenous mangrove (*Avicennia marina* var *resinifera*). Distributed in northern North Island tidal mudflats north of approximately Tauranga (latitude 37°40′s). It appears as a low-growing tree between half a metre and 3 metres in height, with broad robust leaves and a dull mid-green to dark green colour. At low tide numerous short, erect, breathing-roots are revealed on the mudflats among the stems. Through these pneumatophores the plant roots obtain oxygen to sustain their metabolic activity. Mangroves inhabit inter-tidal mudflats and river estuaries subject to tidal flow but protected from strong wave action. The New Zealand mangrove is noteworthy in that mangroves elsewhere are almost unknown outside the tropics (Cockayne 1967). The mangrove symbol is recorded on the map wholly outside the coastline.

BROOM: Shrub communities dominated by broom (*Cytisus scoparius*) occurring in lowland and montane districts as extensive stands or as localised or diffuse inclusions. Distributed sporadically on hill country and downlands of the central North Island and eastern and southern South

Island. Broom often occurs on extensively managed agricultural land and is particularly common on moderately dry, free-draining soils, such as occur in river beds and rocky hill slopes and in the North Island on volcanic material (Hunter and Blaschke 1986). It usually appears as a dark green, apparently soft-textured, erect, brush-like foliage up to 2 metres high, which during spring and early summer, is almost obscured by the brilliant yellow of the flowers. Occasionally recorded in classes **G1, G2, GS2** and **GS6** and in other lowland situations.

BLACKBERRY: Thickets dominated by blackberry (*Rubus fruticosus*) occurring in lowland districts as localised or diffuse inclusions. Distributed sporadically on moist sites in hill country and downlands, or along the margins of water courses, mainly in Northland, Waikato and Taranaki and Westland. Blackberry is a fairly common feature of seepage zones and damp ground throughout much of the country, but is rarely of sufficient extent to be mappable at small scales. It appears as irregular, hummocky shaped thickets of canes up to 3 metres in height, and coloured in dull shades of greens and russet. Occasionally recorded in classes **G1** and **G2** and in other lowland situations.

ARABLE CROPPING: Farming systems where extensive field cropping is a prominent and consistent feature of the landscape. Principal crops are wheat, oats, barley, maize and peas. Distribution is always on flat to gently undulating land, mainly on the plains of Waikato, Gisborne, Hawke's Bay and Manawatu in the North Island, and Marlborough, Canterbury and Southland in the South Island. In these localities cropping of cereals, or less frequently peas, is carried out more or less continuously, or in a short rotation with pasture grasses whereby fields are regularly sown to a crop for two to three years out of every five. The produce is usually processed for domestic consumption, or for export, or as stock feed, but typically in New Zealand is not used as on-farm green-fodder. Usually present in class **G1** but occasionally overlapping with cropland situations.

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REFERENCES

Allan, H H. 1961: "Flora of New Zealand, Vol I". Government Printer, Wellington.

Anon. 1962: Sweet brier. *Tussock Grasslands and Mountain Lands Institute Review 3*: 1-15.

Armstrong, J B. 1879: A short Sketch of the Flora of the Province of Canterbury, with Catalogue of Species. *Transactions and Proceedings of the New Zealand Institute (Botany) XII*: 325-353.

Arthur-Worsop, M J. 1985: An economic evaluation of agro-forestry. *New Zealand Agricultural Science 19*: 99-106.

Atkinson, I A E. 1981: Vegetation Map of Tongariro National Park, North Island, New Zealand. Scale 1:50,000. New Zealand Department of Scientific and Industrial Research, Wellington.

Bagnall, A G. 1982: Heather at Tongariro - A study of a weed introduction. *Tussock Grasslands and Mountain Lands Institute Review 41*: 17-21.

Barker, A P. 1953: An ecological study of tussock grassland, Hunters Hills, South Canterbury. *New Zealand Department of Scientific and Industrial Research Bulletin 107*.

Bascand, L D; Jowett, G H. 1982: Scrubweed cover of South Island agricultural and pastoral land. 2. Plant distribution and managerial problem status. *New Zealand Journal of Experimental Agriculture 10*: 455-492.

Beveridge, A E. 1973: Regeneration of podocarps in a central North Island forest. *New Zealand Journal of Forestry 18*: 23-35.

Beveridge, A E. 1975: Kauri forests in the New Hebrides. *Philosophical Transactions Royal Society London B 272*: 369-383.

Beveridge, A E. 1983: Regeneration of podocarp forests and maintenance of productivity. *In*: "Lowland Forests in New Zealand. Proceedings of a symposium held at the University of Waikato, Hamilton. 1980". (Edited by K Thompson; A P H Hodder; A S Edmunds.) University of Waikato, Hamilton. Pp 93-112.

Beveridge, A E; Herbert, J. 1978: Selective logging trials and their implication for management of the West Taupo forests. *Forest Research Institute Indigenous Silviculture Report No 20*: New Zealand Forest Service.

Bieleski, R L. 1959: Factors affecting the growth and distribution of Kauri (*Agathis australis*). *Australian Journal of Botany 7*: 252-294.

Blaschke, P M; Hunter, G G; Eyles, G O; van Berkel, P R. 1981: Analysis of New Zealand's vegetation cover using land resource inventory data. *New Zealand Journal of Ecology 4*: 1-19.

Brownsey, P J; Given, D P; Lovis, J D. 1985: A revised classification of New Zealand pteridophytes with a synonymic checklist of species. *New Zealand Journal of Botany 23*: 431-489.

Buchanan, J. 1868: Sketch of the Botany of Otago. *Transactions and Proceedings of the New Zealand Institute 1*: 181-212.

Burrows, C J. 1967: Progress in the study of South Island alpine vegetation. *Proceedings of the New Zealand Ecological Society 14*: 8-13.

Burrows, C J; Dobson, A T. 1972: Mires of the Manapouri-Te Anau lowlands. *Proceedings of the New Zealand Ecological Society 19*: 75-99.

Burrows, C J; Greenland, D E. 1979: An Analysis of the Evidence for Climatic Change in New Zealand in the Last Thousand Years—Evidence from Diverse Natural Phenomena and from Instrumental Records. *Journal of the Royal Society of New Zealand 9*: 321-373.

Burrows, C J; McQueen, D R; Esler, A E; Wardle, P. 1979: New Zealand Heathlands. *In* "Heathlands and Related Shrublands. Ecosystems of the World Vol 9A." (Edited by R L Specht.) Elsevier, The Hague. Pp 339-364.

Calder, J W; Wardle, P. 1969: Succession in subalpine vegetation at Arthur's Pass, New Zealand. *Proceedings of the New Zealand Ecological Society 16*: 36-47.

Cameron, R J. 1954: Mosaic or Cyclic Regeneration in North Island Podocarp Forests. *New Zealand Journal of Forestry 7(1)*: 55-67.

Cameron, R J. 1960: Natural Regeneration of Podocarps in the Forests of the Whirinaki River Valley. *New Zealand Journal of Forestry 8(2)*: 337-354.

Cameron, R J. 1964: Destruction of the indigenous forests for Maori agriculture during the nineteenth century. *New Zealand Journal of Forestry 9(1)*: 98-109.

Chavasse, C G R. 1971: Forests, Soils and Landforms of Westland. *New Zealand Forest Service Information Series No 43*.

Cockayne, L. 1928: "The vegetation of New Zealand (2nd ed)." Englemann, Leipzig.

Cockayne, L. 1967: "New Zealand plants and their story." (4th ed). E J Godley (ed). Government Printer, Wellington.

Connor, H E. 1961: A tall tussock grassland community in New Zealand. *New Zealand Journal of Science 4*: 825-835.

Connor, H E. 1964: Tussock grassland communities in the Mackenzie County, South Canterbury, New Zealand. *New Zealand Journal of Botany 2*: 325-351.

Cumberland, K B. 1981: "Landmarks." Reader's Digest Services Pty Ltd. Sydney.

Daly, G T. 1967: Matagouri (*Discaria toumatou*). *Tussock Grasslands and Mountain Lands Institute Review 12*: 18-21.

Davoren, A. 1978: A survey of New Zealand peat resources. *Water and Soil Technical Publication No 14*. National Water and Soil Conservation Organisation, Wellington.

Dawson, J W; Sneddon, B V. 1969: The New Zealand rain forest—A Comparison with tropical rain forest. *Pacific Science 23*: 131-147.

Debreceny, P. (ed) 1981: "The restless land—The Story of Tongariro National Park." Department of Lands and Survey, Wellington.

Denton, G H; Karlen, W. 1973: Holocene climatic variations—their pattern and possible cause. *Quaternary Research 3*: 155-205.

Dobson, A T. 1979: Mire types of New Zealand. Proceedings of the International Symposium on Classification of Peat and Peatlands. Hyytiala, Finland. International Peat Society.

Druce, A P. 1952: The vegetation of western Taupo. *New Zealand Science Review 10*: 89-91.

Druce, A P. 1957: Botanical survey of an experimental catchment, Taita, New Zealand. *Department of Scientific and Industrial Research Bulletin 124*: 1-81.

Ecroyd, C E. 1982: Biological flora of New Zealand. 8. *Agathis australis* (D Don) Lindl (Araucariaceae) Kauri. *New Zealand Journal of Botany 20*: 17-36.

Edgar, E; Connor, H E. 1978: Nomina Nova II, 1970-76. *New Zealand Journal of Botany 16*: 103-118.

Edgar, E; Connor, H E. 1983: Nomina Nova III, 1977-1982. *New Zealand Journal of Botany 21*: 421-441.

Egunjobi, J K. 1969: Dry matter and nitrogen accumulations in secondary succession involving gorse (*Ulex europaeus* L.) and associated shrubs and trees. *New Zealand Journal of Science 12*: 175-193.

Elder, N L. 1963: Evidence of climatic change from the vegetation of the North Island. *Proceedings of the New Zealand Ecological Society 10*: 45-48.

Elder, N L. 1965: Vegetation of the Ruahine Range: An Introduction. *Transactions of the Royal Society of New Zealand (Botany) 3(3)*: 13-66.

Environmental Council, 1979: A Review of the Indigenous Forest Policy and Its Implementation. The Environmental Council, Wellington.

Esler, A E. 1970: Manawatu sand dune vegetation. *Proceedings of the New Zealand Ecological Society 17*: 41-46.

Fleming, C A. 1979: "The Geological History of New Zealand and its Life." Auckland University Press.

Gage, M. 1980: "Legends in the Rocks. An outline of New Zealand geology." Whitcoulls Publishers, Christchurch.

Godley, E J. 1975: Flora and Vegetation. *In*: "Biogeography and Ecology in New Zealand." (Edited by G Kuschel.) Dr W Junk b.v. Publishers, The Hague. pp 177-229.

Hackwell, K. 1980: Gorse—A helpful plant for regenerating native forest. *Forest and Bird 215*: 25-28.

Halkett, J C. 1986: Management of Kauri. *In*: "1986 Forestry Handbook." (Edited by H Levack.) New Zealand Institute of Foresters (inc): pp 68-70.

Healy, A J. 1984: Standard Common Names for Weeds in New Zealand. New Zealand Weed and Pest Control Society Inc., Hastings.

Healy, A J.; Edgar, E. 1980: "Flora of New Zealand, Vol III." Government Printer, Wellington.

Herbert, J. 1978: Forest pattern and regeneration ecology of the Rangitoto-Hauhungaroa forests. Proceedings of the New Zealaland Forest Service Seminar on mangement proposals for State Forests of the Rangitoto and Hauhungaroa Ranges, central North Island. New Zealand Forest Service, Wellington.

Herbert, J. 1986: Cyclic Regeneration of Podocarps at Tihoi. *In*: "Ecological Research in the central North Island Volcanic Plateau Region. Proceedings of a workshop held at Pureora. 1985." (Edited by B Veale; J Innes.) New Zealand Forest Service, Rotorua. 44 pp.

Hilgendorf, F W. 1935: The grasslands of the South Island of New Zealand. *New Zealand Department of Scientific and Industrial Research Bulletin No 47.*

Holloway, J T. 1954: Forests and Climates in the South Island of New Zealand. *Transactions of the Royal Society of New Zealand 82*: 329-410.

Holloway, J T; Wendelken, W J; Morris, J Y; Wraight, M J; Wardle, P; Franklin, D A. 1963: Report on the condition of the Forest, Subalpine-Scrub Lands and Alpine Grasslands of the Tararua Range. *Forest Resarch Institute Technical Paper No 41*: New Zealand Forest Service.

Hunter, G G. 1983: An assessment of the distribution of sweet brier (*Rosa rubiginosa*) in New Zealand. *New Zealand Journal of Experimental Agriculture 11*: 181-188.

Hunter, G G. 1986: The distribution of matagouri (*Discaria toumatou*) in New Zealand. *Tussock Grasslands and Mountain Lands Institute Review 43*: 114-121.

Hunter, G G; Blaschke, P M. 1986: The New Zealand Land Resource Inventory vegetation cover classification. *Water and Soil Miscellaneous Publication No 101.* National Water and Soil Conservation Authority, Wellington.

Kelly, G C. 1980: Landscape and nature conservation. *In*: 'Land Alone Endures—Land Use and the Role of Research.' (Edited by L F Molloy.) *New Zealand Department of Scientific and Industrial Research Discussion Paper No 3.* pp 63-88

Kemp, E M. 1978: Tertiary Climatic Evolution and Vegetation History in the southeast Indian Ocean Region. *Palaeogeography, Palaeoclimatology, Palaeoecology, 24*: 169-208.

Kuchler, A W. 1967: "Vegetation Mapping." The Ronald Press Company, New York.

Lee, W G; Allen, R B; Johnson, P N. 1986: Succession and dynamics of gorse (*Ulex europaeus* L.) communities in the Dunedin Ecological District, South Island, New Zealand. *New Zealand Journal of Botany 24*: 279-292.

Levy, E B. 1970: "Grasslands of New Zealand." Government Printer, Wellington.

McGlone, M S. 1983: Polynesian deforestation of New Zealand: a preliminary synthesis. *Archaeology in Oceania 18*: 11-25.

McGlone, M S. 1985: Plant biogeoraphy and the late Cenozoic history of New Zealand. *New Zealand Journal of Botany 23*: 723-749.

McGlone, M S: Topping, W W. 1977: Aranuian (post-glacial) pollen diagrams from the Tongariro region, North Island, New Zealand. *New Zealand Journal of Botany 15*: 749-760.

McKelvey, P J. 1963: The Synecology of the West Taupo Indigenous Forest. *New Zealand Forest Service Bulletin 14*.

McKelvey, P J. 1984: Provisional classification of South Island virgin indigenous forests. *New Zealand Journal of Forestry Science 14*: 151-178.

Madden, E A. 1940: The grasslands of the North Island of New Zealand. *New Zealand Department of Scientific and Industrial Research Bulletin No 79*.

Mark, A F. 1969: Ecology of snow tussocks in the mountain grasslands of New Zealand. *Vegetatio 18*: 289-306.

Mark, A F; Smith, P M F. 1975: A lowland vegetation sequence in South Westland—pakihi bog to mixed beech-podocarp forest. Part 1: The principal strata. *Proceedings of New Zealand Ecological Society 22*: 76-92.

Mew, G. 1983: Application of the term "pakihi" in New Zealand—A Review. *Journal of the Royal Society of New Zealand 13*: 175-198.

Molloy, B P J; Burrows, C J; Cox, J E; Johnston, J A; Wardle, P. 1963: Distribution of Subfossil Forest Remains, Eastern South Island, New Zealand. *New Zealand Journal of Botany 1*: 68-77.

Moore, L B; Edgar, E. 1976: "Flora of New Zealand, Vol II." Government Printer, Wellington.

National Water and Soil Conservation Organisation (NWASCO), 1975-79: New Zealand Land Resource Inventory Worksheets 1:63,360. National Water and Soil Conservation Organisation, Wellington.

National Water and Soil Conservation Authority (NWASCA); Land Settlement Board (LSB), 1985: Review of Policies for Destocking and Land Surrender—South Island high country. National Water and Soil Conservation Authority and Land Settlement Board, Wellington, New Zealand.

New Zealand Forest Service (NZFS), 1974: New Zealand Indigenous Forests, Scale 1:1,000,000. *Forest Service Mapping Series No 15*.

New Zealand Forest Service (NZFS), 1977: Management Policy for New Zealand's Indigenous State Forests. Government Printer, Wellington.

Nicholls, J L. 1983: The extent and variability of native lowland forest. *In*: "Lowland Forests in New Zealand. Proceedings of a symposium held at the University of Waikato, Hamilton, 1980." (Edited by K Thompson; A P H Hodder; A S Edmonds.) University of Waikato, Hamilton. Pp 79-92.

O'Connor, K F. 1973: A summary of the vegetation of New Zealand and the influence of land use. *Proceedings of the Fourth Asian Pacific Weed Science Society Conference*: 8-16.

O'Loughlin, C. 1986: Serious mortality in New Zealand's rata- kamahi mountain forests. *Asia Pacific Forest Watershed Newsletter 9*: 7-8. Environment and Policy Institute, East-West Center, Hawaii.

Reed, A H. 1948: "The Gumdigger." A H and A W Reed, Wellington.

Rigg, H H. 1962: The Pakihi bogs of Westport, New Zealand. *Transactions of the Royal Society of New Zealand (Botany) 1(7)*: 91-108.

Six Dijkstra, J G; Mead, D J; James, I L. 1985: Forest architecture in terrace rimu forest of Saltwater Forest, south Westland, and its implications for management. *New Zealand Journal of Forestry Science 15(1)*: 3-22.

Stevens, G R. 1974: "Rugged Landscape: The Geology of Central New Zealand." A H and A W Reed, Wellington.

Stevens, G R. 1980: "New Zealand Adrift." A H and A W Reed, Wellington.

Stewart, K M. 1985: Agroforestry Economics. Proceedings of the Agro-forestry/Forest Grazing Seminar, Wanganui: 137-144. Rangitikei-Wanganui Catchment Board, Marton.

Thode, P J. 1983: Northland's forest history and present resources. *New Zealand Journal of Forestry 28*: 203-224.

Townson, W. 1906: On the Vegetaton of the Westport District. *Transactions of the New Zealand Institute 39*: 380-433.

Upritchard, E A. 1985: A guide to the identification of New Zealand common weeds in colour. New Zealand Weed and Pest Control Society (Inc), Palmerston North.

van Berkel, P R; Eyles, G O. 1981: The New Zealand resource inventory data base of the National Water and Soil Conservation Organisation. *In*: "Information Systems for soil and related data." (Edited by A W Moore; B G Cook; L G Lynch.) *Proceedings of the Second Australian Meeting of the ISSS Working Group on Soil Information Systems, Canberra, Australia, 1980*. Centre for Agricultural Publishing and Documentation, Wageningen, the Netherlands. pp 104-121.

van Berkel, P R; Williams, R D. 1985: Introduction to LADEDA--a geographic information system. *New Zealand Geographer 41*: 84-90.

Walsh, P. 1896: On the Disappearance of the New Zealand Bush. *Transactions of the New Zealand Institute 24*: 490-496.

Wardle, J. 1984: "The New Zealand Beeches—ecology, utilisation and management." New Zealand Forest Service, Wellington.

Wardle, P. 1964: Facets of the distribution of forest vegetation in New Zealand. *New Zealand Journal of Botany 2*: 352-366.

Wardle, P. 1973: New Zealand Timberlines. *Arctic and Alpine Research 5(3)* pt 2: A127-A135.

Wardle, P. 1974: Alpine Timberlines. *In*: "Arctic and Alpine Environments." (Edited by J D Ives; R G Barry.) Methuen.

Wardle, P. 1985a: New Zealand Timberlines. 1. Growth and survival of native and introduced tree species in the Craigieburn Range, Canterbury. *New Zealand Journal of Botany 23*: 219-234.

Wardle, P. 1985b: New Zealand Timberlines. 3. A synthesis. *New Zealand Journal of Botany 23*: 263-271.

Wardle, P; Mark, A F; Baylis, G T S. 1973: Vegetation and Landscape of the West Cape District, Fiordland, New Zealand. *New Zealand Journal of Botany 11*: 599-626.

Wards, I (ed) 1973: "New Zealand Atlas." Government Printer, Wellington.

Whirinaki Forest Promotion Trust, 1984: "To Save a Forest—Whirinaki." David Bateman Ltd, Auckland.

Williams, G R. (ed) 1973: "The Natural History of New Zealand." A H and A W Reed, Wellington.

Wilson, H D. (in press): Plant Communities of Stewart Island, New Zealand. *New Zealand Journal of Botany 25*.

Wraight, M J. 1963: The alpine and upper montane grasslands of the Wairau River Catchment, Marlborough. *New Zealand Journal of Botany 1*; 351-376.

Zabkiewicz, J A. 1976: The ecology of gorse and its relevance to New Zealand forestry. *In*: "The Use of Herbicides in Forestry in New Zealand." *Forest Research Institute Symposium 18.* New Zealand Forest Service. Pp 63-68.

Zotov, V D. 1963: Synopsis of the grass subfamily Arundinoideae in New Zealand. *New Zealand Journal of Botany 1*: 78-136.

Zotov, V D. 1970: *Chionochloa macra* (Gramineae): A new species. *New Zealand Journal of Botany 8*: 91-93.

GLOSSARY OF PLANT NAMES

Throughout the text, plant common names, where they are in colloquial usage have been adopted either alone or supported by their corresponding botanical name. The following alphabetical listing provides a reference of these common names with their respective botanical name.

Nomenclature follows the "Flora of New Zealand" (Allan, 1961; Moore and Edgar, 1976; Healy and Edgar, 1980) and "Standard Common Names for Weeds in New Zealand" (Healy, 1984). Subsequent taxonomic revision and nomenclatural changes as published in the New Zealand Journal of Botany, in particular Edgar and Connor (1978, 1983) and Brownsey *et al* (1985) have generally been adopted.

Alpine fescue tussock	*Festuca mathewsii*
Annual poa	*Poa annua*
Australian blackwood	*Acacia melanoxylon*
Baygrass	*Eragrostis brownii*
Beech—black	*Nothofagus solandri* var *solandri*
—hard	*N. truncata*
—mountain	*N. solandri* var *cliffortioides*
—red	*N. fusca*
—silver	*N. menziesii*
Blackberry	*Rubus fruticosus*
Black nightshade	*Solanum nigrum*
Blue tussock	*Poa colensoi*
Bog pine	*Halocarpus bidwillii* (syn *Dacrydium bidwillii*)
Boxthorn	*Lycium ferocissimum*
Bracken	*Pteridium esculentum*
Bristle tussock	*Rytidosperma setifolium*
Broadleaf	*Griselinia littoralis*
Brome grass	*Bromus* spp
Broom—common	*Cytisus scoparius*
—native	*Carmichaelia* spp

Browntop	*Agrostis capillaris*
Cabbage tree (mountain cabbage tree)	*Cordyline indivisa*
Catsear	*Hypochaeris radicata*
Chewings fescue	*Festuca nigricans*
Clover—white	*Trifolium repens*
—red	*T. pratense*
Cocksfoot	*Dactylis glomerata*
Corsican pine	*Pinus nigra*
Danthonia	*Rytidosperma* spp
Dog rose	*Rosa canina*
Douglas fir	*Pseudotsuga menziesii*
Five-finger	*Pseudopanax arboreus*
Flax	*Phormium tenax*
—mountain	*P. cookianum*
Fuchsia (tree fuchsia)	*Fuchsia excorticata*
Gaultheria (mountain gaultheria)	*Gaultheria colensoi*
Gentian	*Gentiana* spp
Gorse	*Ulex europaeus*
Hairgrass	*Vulpia* spp
Hall's totara	*Podocarpus hallii*
Hard tussock	*Festuca novae-zelandiae*
Heather	*Calluna vulgaris*
Hinau	*Elaeocarpus dentatus*
Iceplant	*Disphyma australe*
	Carpobrotus edulis
Inaka (mountain inaka)	*Dracophyllum recurvum*
Jerusalem cherry	*Solanum pseudocapsicum*
Kahikatea	*Dacrycarpus dacrydioides*
Kaikawaka	*Libocedrus bidwillii*
Kamahi	*Weinmannia racemosa*
Kanuka	*Leptospermum ericoides*
Karaka	*Corynocarpus laevigatus*
Kauri	*Agathis australis*
Kawakawa	*Macropiper excelsum*
Kiokio	*Blechnum procerum* (syn *B. capense*)
Kohekohe	*Dysoxylum spectabile*
Kowhai	*Sophora microphylla*
—prostrate	*S. prostrata*
Kumara (sweet potato)	*Ipomoea batatas*
Lacebark	*Hoheria populnea*
Lancewood	*Pseudopanax crassifolius*
Leatherwood	*Olearia colensoi*
Lucerne	*Medicago sativa*

Lupin (tree lupin)	*Lupinus arboreus*
Macrocarpa	*Cupressus macrocarpa*
Mahoe	*Melicytus ramiflorus*
Maire	*Nestegis* spp
Mangeao	*Litsea calicaris*
Mangrove	*Avicennia marina* var *resinifera*
Manuka	*Leptospermum scoparium*
Mapou	*Myrsine australis*
Marram	*Ammophila arenaria*
Matagouri	*Discaria toumatou*
Matai	*Prumnopitys taxifolia* (syn *Podocarpus spicatus*)
Miro	*Prumnopitys ferruginea* (syn *Podocarpus ferrugineus*)
Ngaio	*Myoporum laetum*
Nikau	*Rhopalostylis sapida*
Old-man's-beard	*Clematis vitalba*
Pampas	*Cortaderia selloana*
Paspalum	*Paspalum dilatatum*
Pepper tree	*Pseudowintera colorata*
Pigeonwood	*Hedycarya arborea*
Pingao	*Desmoschoenus spiralis*
Pink pine	*Halocarpus biformis* (syn *Dacrydium biforme*)
Pohutukawa	*Metrosideros excelsa*
Pokaka	*Elaeocarpus hookerianus*
Ponderosa pine	*Pinus ponderosa*
Poplar	*Populus* spp
Poroporo	*Solanum aviculare, S. laciniatum*
Prickly shield fern	*Polystichum vestitum*
Pukatea	*Laurelia novae-zelandiae*
Puriri	*Vitex lucens*
Putaputaweta	*Carpodetus serratus*
Quintinia	*Quintinia acutifolia*
Ragwort	*Senecio jacobaea*
Rata—northern	*Metrosideros robusta*
—southern	*M. umbellata*
Ratstail	*Sporobolus africanus*
Raupo	*Typha orientalis*
Restiad	Family Restionaceae
Rewarewa	*Knightia excelsa*
Ribbonwood (mountain ribbonwood)	*Hoheria glabrata*
Rimu	*Dacrydium cupressinum*
Ring fern	*Paesia scaberula*

Rushes	Family Juncaceae
Ryegrass	*Lolium* spp
—perennial	*L. perenne*
Sedges	Family Cyperaceae
Silver pine	*Lagarostrobos colensoi* (syn *Dacrydium colensoi*)
Silver tussock	*Poa laevis*
Spaniard	*Aciphylla* spp
Spinifex	*Spinifex sericeus*
Sphagnum	*Sphagnum* spp
Sweet brier	*Rosa rubiginosa*
Sweet vernal	*Anthoxanthum odoratum*
Tanekaha	*Phyllocladus trichomanoides*
Taraire	*Beilschmiedia tarairi*
Tauhinu	*Cassinia leptophylla*
Tawa	*Beilschmiedia tawa*
Tawari	*Ixerba brexioides*
Tea tree (see manuka)	
Thyme	*Thymus vulgaris*
Timothy	*Phleum pratense*
Titoki	*Alectryon excelsus*
Toatoa	*Phyllocladus glaucus*
—mountain	*Phyllocladus alpinus*
Toetoe	*Cortaderia* spp (usually *C. toetoe*)
Totara	*Podocarpus totara*
Towai	*Weinmannia silvicola*
Tutu	*Coriaria arborea*
	C. sarmentosa
Umbrella fern	*Gleichenia microphylla*
Willow	*Salix* spp
Wineberry	*Aristotelia serrata*
Wirerush	*Empodisma minus*
Yellow-silver pine	*Lepidothamnus intermedius* (syn *Dacrydium intermedium*)
Yorkshire fog	*Holcus lanatus*

GLOSSARY OF TECHNICAL TERMS

angiosperm
Flowering plants. In New Zealand forest description there is a conventional sub-division into a southern beech (*Nothofagus* spp) element and a mixed broadleaved element.

broadleaved
As applied to woody plants, describes angiospermous shrubs and trees except the southern beeches (*Nothofagus* spp) which it is convenient to refer to separately. Synonymous with the term "hardwood".

climax
As applied to vegetation dynamics is essentially an abstract concept suggestive of the final or stable community in a successional series. In reality since climatic, edaphic and biotic factors are also in a state of continual change the climax condition must also be changing, so it is more realistic to consider climax as a state of extremely slow change, barely distinguishable from a self-perpetuating stable 'ideal'.

disclimax
The vegetation replacing or modifying the theoretical climax following a disturbance of the environment.

ecotone
A transition zone spatially and environmentally intermediate between two previously defined communities and characterised by a community which is also compositionally, and physiognomically intermediate.

eutrophic
Rich in nutrients.

evolution
The process by which genetic changes have taken place in plants (and animals) over millions of years in reponse to environmental pressures.

geosyncline
A mobile elongate or basin-like downwarping of the crust of the Earth,

measured in hundreds of kilometres, and into which sedimentary and volcanic materials accumulate to thickness of thousands of metres.

gymnosperm
Cone bearing plants or conifers, also synonymous with the term "softwoods". New Zealand representatives belong to the family Podocarpaceae (the "podocarps"), the family Araucariaceae (kauri—*Agathis australis*) and the family Cupressaceae (*Libocedrus* spp).

interglacial
The time interval between glacial stages, characterised by warmer climates and the retreat of ice sheets.

mesotrophic
A moderate supply of nutrients.

oligotrophic
Poor in nutrients.

orogeny
The processes of folding and faulting of the Earth's crust, which is traditionally associated with mountain building.

paleoaustral
Ancient elements of the vegetation (or fauna etc) common to, or having relations with, other lands of high southern latitudes.

peneplain
A low, nearly featureless, gently undulating land surface of considerable area, which is considered to be the end result of an extended period of erosion.

physiognomy
The external appearance of the vegetation, including aspects of struture, composition and function.

Pleistocene
An epoch of geological time from two million years ago to about 10,000 years ago. Climatically it is characterised by generally cool temperatures with four glacial periods during which there was an increase in the number and extent of ice sheets and a correspondingly reduced sea level.

podocarp
As used in the preceeding text, describes gymnospermous trees of the Family Podocarpaceae.

restiad
Of the Restionaceae, a family of rush-like plants.

scrubline
The upper altitudinal limit of closed shrub communities.

speciation
The formation of new species, a component of the evolutionary process.

timberline (actual)
The upper altitudinal limit of closed forest of normal stature.

timberline (theoretical)
The presumed upper altitudinal limit of closed forest of normal stature, if such forest were actually occurring at the site in question.

treeline
The upper altitudinal limit of trees.

ultramafic
Coarse grained, silica deficient, igneous rocks consisting of essentially ferromagnesian minerals, which form soils of very low fertility and locally toxic levels of nickel and chromium.

woodland
Admixtures of grassland with formations of individual trees or closed stands of trees such that each contribute significantly to the appearance of the landscape.