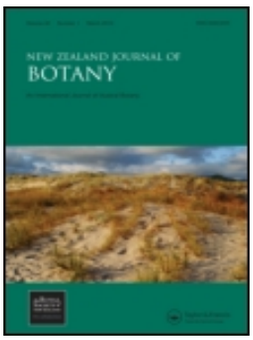

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Plant communities of Westland National Park (New Zealand) and neighbouring lowland and coastal areas

P. WARDLE

Botany Division, DSIR, Private Bag, Christchurch, New Zealand

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SYNOPSIS

A. Dense conifer forest on flats and terraces below 400 m.
1. Forest on recent alluvial soils.
* (a) Kahikatea forest on silt.
(b) Mixed conifer forest on well drained soils.
2. Forest on gley podzol and peat.
* (a) Rimu forest.
(b) Rimu–kahikatea forest on more-fertile sites than (a).
(c) Rimu–silver pine forest on very wet ground.

B. Forest with a main canopy of hardwoods and an open overstorey of conifers.
1. Open kahikatea forest transitional to swamps.
2. Forest on recent soils.
* (a) Forest of small hardwoods with an overstorey of large kahikatea.
(b) Kamahi forest with first generation of podocarps (mainly Waiho and Fox valleys).
3. Forest with kamahi dominant on yellow-brown earths below 400 m.
* (a) Rimu and miro overstorey, kamahi main canopy, and *Blechnum discolor* abundant beneath.
(b) Variant of (a) with open tree canopy and abundant lianes occurring near the coast.
(c) [Variant of (a) on more-fertile soil with very large podocarps.]
(d) Forest similar to (a), but on younger soils in cold valleys with *Todea superba* important beneath.
(e) Rimu and miro overstorey, kamahi and quintinia main canopy, with *Blechnum discolor* and *Gleichenia cunninghamii* beneath on podzolised yellow-brown earth.
(f) [Variant of (e) dominated by miro, with *Astelia solandri* abundant beneath.]
4. Forest with *Libocedrus bidwillii* prominent, in frosty localities below 600 m.
(a) *Libocedrus* forest on recent terraces.
(b) [*Libocedrus* and/or Hall's totara dominant on podzolised yellow-brown earth].
(c) [*Dacrydium bidwillii*, Hall's totara, and *Libocedrus* on gley podzol.]
5. Upland forest dominated by rata and kamahi with Hall's totara usually important. On yellow-brown earths to 650 m.
* (a) Forest with *Blechnum discolor* dominant beneath. On the main ranges.
* (b) Similar to (a), but on podzolised yellow-brown earth and with *Gahnia procera* also important beneath. On the piedmont hills.
6. High-altitude forest dominated by rata, with an overstorey of *Libocedrus bidwillii* usually accompanied by Hall's totara.
* (a) Forest at 550–900 m on the main ranges.
(b) Variant of (a), with *Phyllocladus* and *Gahnia procera*. Omoeroa Range only.
* (c) Transitions from B5 and 6 to low forest in gullies. Discontinuous overstorey of large trees over a low main canopy with *Pseudopanax simplex*, *Griselinia littoralis*, and *Hoheria glabrata*.

C. Forest with canopy of tall hardwoods (no overstorey of conifers).
*1. Successional forest of rata and kamahi on recent moraine, fluvio-glacial terraces and slips. 100–700 m.

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* Community widespread.
[ ] Community occurring as small stands at only one or two places.
† Adventive species (*see* text).

*2. Tall silver beech forest in Karangarua valley.

D. Low hardwood forest, i.e., with main canopy less than 10 m, and taller trees scattered or absent.

1. Seral low forest on alluvial and fluvio-glacial flats.
* (a) Forest with *Pennantia corymbosa, Plagianthus betulinus,* Westland totara, etc., on lowland river flats.
(b) Variant of (a) in mountain valleys up to 650 m, containing upland species such as *Olearia ilicifolia* and *Polystichum vestitum.*
(c) Transition between *Olearia avicenniaefolia* scrub (E2) and rata-kamahi forest (C1) on fluvio-glacial surfaces below the Fox and Franz Josef Glaciers.
2. Low forest on steep slopes subject to soil creep, below 750 m.
* (a) Forest dominated by kamahi (usually as coppicing growth), *Schefflera digitata, Melicytus ramiflorus,* and *Hedycarya arborea,* with *Asplenium bulbiferum* abundant beneath. Below 450 m.
(b) Resembling (a) but seral, with *Schefflera* dominant. Pioneering species such as *Aristotelia serrata* can co-dominate in early stages.
(c) Transition between (a) and *Hoheria glabrata* forest (D3a).
* (d) Complex forest communities on very steep slopes include mosaics of (a), early seral stages, and climax forest (B3, 5).
3. Subalpine low forest.
* (a) *Hoheria glabrata* forest with understorey of *Polystichum vestitum.* Talus slopes at 750–1 050 m.
(b) Forest dominated by *Dracophyllum* and *Olearia* at 850–1 000 m.
(c) [*Griselinia littoralis* dominant on ridges of talus and moraine, 800 m].

E. Tall scrub, 2–5 m.

1. *Coprosma* scrub on recent alluvium and moraine.
(a) *Coprosma* scrub on river terraces below 430 m.
(b) Dense *Coprosma rugosa* scrub at 780–1 050 m.
2. *Olearia avicenniaefolia* scrub on recent fluvio-glacial surfaces. 200–800 m, mainly below Franz Josef and Fox Glaciers.
3. Tall scrub on slips and talus.
* (a) Tall scrub of varied composition, though *Carmichaelia grandiflora* always present. Lowland to 1 150 m.
(b) *Coriaria arborea* scrub on coarse fans, rock falls, etc., with water percolating through substratum. Below 700 m.
4. Subalpine scrub composed mainly of *Dracophyllum* and *Olearia* species.
(a) Tall climax scrub at 750–1 050 m. *Dracophyllum longifolium, D. traversii, Olearia lacunosa,* and *O. colensoi* the main dominants.
(b) *Dracophyllum longifolium* scrub on moraines at 750–1 000 m. This has developed from E1 and E2 and contains seral species such as *Olearia nummularifolia.*
(c) Attenuation of (a) at 1 050–1 200 m, reduced to as low as 2 m, and lacking species such as *Libocedrus bidwillii, Pseudopanax simplex, P. lineare,* and *Myrsine divaricata.*

F. Low or discontinuous scrub.

1. Open seral shrubland on flat or rolling ground (mainly fluvio-glacial deposits) with pioneer herbs dominating between the shrubs.
* (a) Communities below 750 m with *Carmichaelia grandiflora* as the main shrub.
(b) Communities at 750–1 050 m, with *C. grandiflora* co-dominant with upland species such as *Dracophyllum longifolium* and *Olearia moschata.*
(c) *Coprosma rugosa* dominant on moraine and talus at 900–1 100 m.
*2. Open seral shrubland of varied composition on slips and talus, lowland to subalpine. Sites moister than 1.
*3. Low scrub at 950–1 200 m on recent soils. Important species are *Olearia moschata, Hebe subalpina,* and (near the Main Divide) *Podocarpus nivalis.*
4. Mosaic of shrubs, grasses, and herbs on gley podzols at 750–1 200 m. Frequent species are *Dracophyllum longifolium, D. uniflorum,* and *Chionochloa* cf. *rigida.*
*5. *Dracophyllum uniflorum* scrub on steep slopes at 1 200–1 600 m.

G. Tall grassland and herbfield.

1. Seral communities with tall herbs or semi-woody plants other than snow-tussock prominent.
* (a) On alpine talus at 1 050–1 300 m. *Poa cockayniana, Hypolepis millefolium,* and *Chionochloa pallens* characteristic, but the last often eliminated by browsing.
(b) Fans dominated by summergreen *Coriaria* spp. Copland Valley at 800 m.
2. *Chionochloa pallens* grassland.
(a) On moraine and alluvium at 750–1 250 m, with *Muehlenbeckia axillaris* and other seral species important beneath.
* (b) Dense climax *C. pallens* grassland. Mainly on south-facing talus slopes. 950–1 350 m with patches to 1 550 m.
* (c) *C. pallens* tussocks forming less than 50% cover, over turf largely of *Poa colensoi.* Higher altitudes (1 100–1 600 m) than (b), on spurs and ridges, shallow

soils, or in gullies where snow lies late.
(d) [Similar to (c), but including small shrubs such as *Hebe ciliolata*. 1 983 m on Mt Moltke–the highest stand of continuous vegetation seen in the Park.]
3. *Celmisia walkeri* community, on steep stony slopes at 1 100–1 350 m.
4. *Chionochloa* cf. *flavescens* grassland.
(a) Seral communities on moraine and talus at 1 000–1 250 m.
(b) Communities on precipitous north-facing slopes at 1 250–1 850 m.
5. *Chionochloa* cf. *rigida* grassland. Results where fire has destroyed the shrubs in F4.
*6. *Chionochloa crassiuscula* grassland on wet, leached soils at 900–1 700 m.

H. Short grassland and herbfield.
1. Seral grasslands on valley flats and terraces.
* (a) Lowland grassland with introduced species prominent.
(b) Mid-altitude (450–950 m) grasslands still dominated by native grasses, such as *Poa cockayniana, Festuca mathewsii*, and *Notodanthonia gracilis*.
2. High-alpine short grassland and herbfield.
* (a) Grassland dominated by *Poa colensoi* and *Chionochloa oreophila*. 1 300–1 850 m, and patches to 1 914 m.
* (b) Herbfield dominated by species such as *Celmisia sessiliflora, Poa colensoi*, and *Raoulia grandiflora*. 1 500–1 750 m, stonier sites than (a).
*3. *Poa colensoi* grassland at 1 050–1 300 m, induced through destruction by browsing of *Chionochloa* pallens in G2b.
4. Turf induced by browsing of shrubby vegetation.
* (a) Browsed seral vegetation at 250–1 000 m dominated by *Cotula squalida, Muehlenbeckia axillaris, Galium perpusillum*, etc.
(b) Turf resulting from destruction of F5.

I. Short, open herbaceous vegetation.
1. Pioneer vegetation on lowland, montane, and subalpine slips.
2. Pioneer *Raoulia* communities on fine alluvial and fluvio-glacial gravel.
(a) Up to 200 m. Shrub seedlings mainly lowland species.
(b) 200–900 m. Shrub seedlings include upland species such as *Dracophyllum longifolium*.
(c) At 900–1 250 m. *Notodanthonia setifolia* replacing *Raoulia* in all but the youngest stages.
(d) Lowland and montane silt banks with, e.g., Yorkshire fog (*Holcus lanatus*) and catsear (*Hypochoeris radicata*) tending to be more important than *Raoulia*.
3. Seral alpine vegetation on slips, schist slabs, moraine, etc.
* (a) Open grassland at 1 150–1 550 m, usually with *Notodanthonia setifolia* dominant.
(b) [Slip sole at 1 200 m on Copland Range with turf of *Gunnera monoica*, etc.]
4. High-alpine areas (fellfield) with bare rock predominant.
(a) Cushion plant communities on stable soil; *Colobanthus monticola, Hectorella*, etc.
* (b) Talus; *Poa novae-zelandiae* and *Ranunculus sericophyllus* the most frequent species.
(c) Snow hollows, dominated by *Raoulia subulata, Carex pyrenaica*, etc.

J. Heath; vegetation characterised by stunted woody plants with small, hard leaves, growing on shallow or podzolised leached soils.
1. Heath-forest, generally less than 10 m tall.
* (a) Silver pine, *Dacrydium biforme, Phyllocladus*, and manuka dominant on wet, acid soils on piedmont moraines.
(b) *Dacrydium intermedium* dominant on very poor soils on ridges on piedmont moraines.
* (c) Heath-forest at 500–900 m on shallow (10–30 cm) soils in Karangarua catchment. Species largely as (a), but silver beech often also important.
2. Heath-scrub, with openings supporting pakihi species.
(a) Manuka, silver pine, and *Dacrydium biforme* dominant on extreme gley podzols on broad crests of piedmont moraines.
(b) Montane heath-scrub, stunted equivalent of (1c) on soils 2–5 cm deep.
(c) Subalpine (850–1 250 m) heath-scrub, with *Dacrydium biforme, Phyllocladus*, and manuka sharing dominance with *Dracophyllum longifolium* and *Olearia colensoi*.

K. Mires
*1. Lowland fertile swamps; dominants include *Carex coriacea* and *Phormium tenax*.
*2. Lowland infertile swamps; dominants include *Carex gaudichaudiana, Baumea* spp., and in poorest areas, *Gleichenia circinata* and *Empodisma minus*.
3. Pakihi; vegetation characterised by *Empodisma minus* and *Gleichenia circinata* on gley podzols, usually with little peat.
* (a) Natural, unburnt pakihi. Manuka and other shrubs very stunted.
* (b) Pakihi derived by burning forest or heath-scrub. Tendency for manuka to invade and develop into tall thickets.
4. Upland *Carex* swamps.

(a) Dominated by *C. coriacea* (to 600 m), *C. gaudichaudiana* (widespread), or *C. sinclairii* (up to 1 000 m). Very limited in extent.
(b) *Carex gaudichaudiana* co-dominant with *Sphagnum*. Moraine hollows and tarn margins, 800–1 300 m.

5. Cushion bog.
(a) *Oreobolus pectinatus* dominant. Tarn margins and central parts of swamps, 800–1 300 m.
(b) *Donatia novae-zelandiae* dominant. Very small areas within natural pakihi on piedmont moraines, and at 850–1 300 m on shallow, wet soil overlying glacially-scoured rock.
6. *Schoenus pauciflorus* flush on alpine slopes. Described at 1 250 and 1 300 m.
7. High-alpine wet ground. Tarn margins and flushes at 1 550–1 700 m dominated by mosses, but vascular species such as *Claytonia australasica* and *Scirpus aucklandicus* also present.

L. Aquatic vegetation.
1. Lowland aquatic vegetation.
2. Upland aquatic vegetation.
3. [High-alpine tarns.]

M. Bluffs and cliffs
1. Bluffs and cliffs below 1 200 m.
* (a) Rock bluffs supporting a mosaic of trees, tall shrubs, and herbs.
(b) Rock behind intermittent waterfalls; *Schoenus pauciflorus* the main species.
(c) Glacially scoured schist supporting successions leading to rata forest; most extensive below the Franz Josef Glacier.
* (d) Cliffs in alluvium and moraine; prominent species include *Polytrichadelphus magellanicus*, *Blechnum capense "procerum"*, and *Gunnera monoica*.
2. Alpine bluffs.
* (a) Low-alpine bluffs supporting a mosaic of herbs and small shrubs.
* (b) High-alpine bluffs supporting a much sparser vegetation of fellfield species.

N. Coastal vegetation.
1. Forest.
(a) Forest on cliffs; *Melicytus ramiflorus* usually dominant.
(b) Forest on dunes.
(c) Coastal fringe of climax forest, with abundant lianes.
2. Scrub on cliffs; species include *Olearia avicenniaefolia* and *Hebe elliptica*.
3. *Phormium tenax* and gorse scrub on dunes and headlands.
4. Herbaceous vegetation on cliffs. Typical species are *Gunnera monoica* and *Poa* cf. *anceps*.
5. Dune grassland.
6. Active dunes and beach ridges.
7. Fertile coastal swamp and related seral vegetation. Similar to K1.
8. Infertile coastal swamp and transitions to swampy forest. Similar to K2, but *Leptocarpus similis* always important.
9. Aquatic vegetation in tidal water.

INTRODUCTION

Westland National Park extends over 88 608 ha, from sea level to the summit of Mt Tasman (3 498 m). This paper is an inventory of the natural plant communities of the district lying between the Karangarua River in the south and Okarito Lagoon in the north, and so includes some lowland and coastal plant communities that do not occur within the present boundaries of the National Park. A list of vascular species has been published for the same area (Wardle 1975), establishing the nomenclature and terms for altitudinal zonation, soils, and other ecological features. Fig. 1 shows the main localities. The following maps published by the Department of Lands and Survey give more detailed information: L & S 50/3 (Westland National Park); NZMS 1, Sheets S63 (Okarito), S70 (Gillespies), S71 (Waiho), S78 (Bruce Bay), S79 (Mt Cook), S88 (Landsborough).

The plant communities are based on field descriptions which include lists of species and estimates of cover, and their delineation and classification is essentially non-quantitative and subjective. I have aimed to define units that are easily recognisable, that relate predictably to the physical environment, and that provide a suitable basis for detailed vegetation maps (in preparation). The classification follows a sequence from tall dense forest to low discontinuous vegetation. Superimposed on this, there are subdivisions based on floristic content, habitat, and successional status. Vegetation of cliffs, coastline, lakes, swamps, and acidic wet-lands does not readily fit into the main sequence, and is described in separate classes. Estimates of ages of seral communities depend largely on dated sequences of moraines (Wardle 1973; Fig. 2).

Most of the plant communities have changed little since European settlement, the vegetation of the

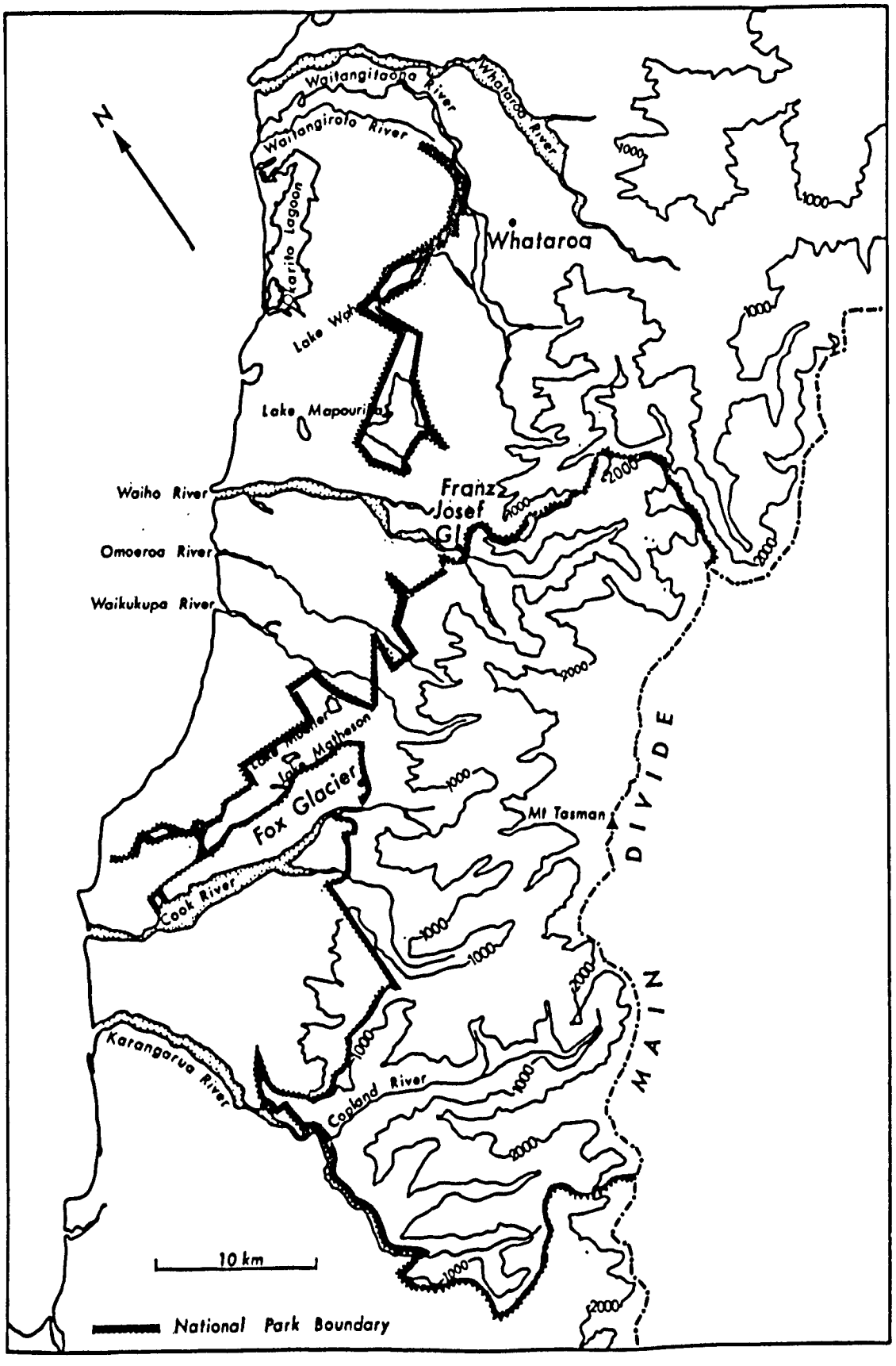

Fig. 1 Locality map.

Fig. 2 Franz Josef Glacier and the Waiho River valley. Bare floodplain and recently deglaciated rock walls are shown; an intermediate shrub-dominated zone grades into the forest of the mid slopes. The roches moutonnées at the lower left also support various successional stages.

piedmont hills especially being in almost virgin condition. However, red deer (*Cervus elaphas*), chamois (*Rupicapra rupicapra*), and thar (*Hemitraga jemlahicus*) inhabit the mountainous part of the Park, and in the headwaters of the Karangarua River multiplied greatly, drastically modifying the low-alpine grassland, and to a lesser degree, subalpine scrub and low forest communities of the montane belt. Successions on slips, that normally lead to forest, are often arrested at a herbaceous or open shrubland phase. Domestic cattle and sheep have damaged forest, grassland, and swamp in the lowland valleys and coastal dunes.

Brush-tailed opossums (*Trichosurus vulpecula*) were first liberated in the National Park in 1924 (L. T. Pracy, *in litt.*) and are still spreading. These highly selective canopy browsers are associated, directly or indirectly, with the death of kamahi, rata, Hall's totara, *Pseudopanax colensoi*, and *Fuchsia excorticata*, all of which are important trees. Fire has been unimportant, except in some lowland heath and swamp communities. Introduced plants are insignificant in the natural vegetation, except in some lowland grassland and shrubland.

The plant communities are described as they ap-

peared during the survey, between 1964 and 1975. However, changes caused by introduced animals are identified as far as possible, and derived communities related to their primitive equivalents. Only purely anthropogenic vegetation is excluded from consideration, even though it may contain many native species. Managed pastures, in particular, not only retain remnant podocarp trees, but also include abundant small native herbs such as *Hydrocotyle "novae-zelandiae"*, *Pratia angulata*, and *Cotula squalida*.

Although time, manpower, and the aims of the survey did not allow or justify a detailed, quantitative, and objective approach to the description of the vegetation or its subsequent classification, the composition of some of the more important communities was checked by point analysis (Appendix 1). Estimates of species diversity within communities (Appendix 2) and a glossary of common names and Latin equivalents (Appendix 3) are also given.

PREVIOUS CLASSIFICATION OF WESTLAND VEGETATION

Early information on the botany of Westland is either floristic (*see* references in Wardle 1975) or consists of observations of botanical interest interspersed among general comments on the nature of the landscape. Cockayne's "Vegetation of New Zealand" first published in 1921 contains the first classification of vegetation that is applicable to Westland, and although the community types are defined in general terms relating to the whole country, some are based on fairly detailed descriptions of stands in Westland. Examples from Cockayne's 1928 edition (with catalogue numbers of approximately equivalent communities in this treatment following in parentheses) include: southern rata forest at the Franz Josef Glacier (C1), river terrace scrub of "subalpine character" (D1b), western South Island *Raoulia* association (H1, 12a), western river bed forest (D1a, and at higher altitudes B4a). Cockayne & Teichelmann (1930) also published a brief account of the vegetation of what is now Westland National Park.

The National Forest Survey between 1945 and 1956 sampled the forest vegetation of the south Westland piedmont and produced forest-type maps, but only a brief summary of the survey has been officially released (Masters *et al.* 1957). About 45 forest types are recognised for the area within and adjacent to the National Park. The classification is based on dominant trees and emphasises content of timber, so that in forest with a large volume of rimu or kahikatea, types are defined more narrowly than in this account. On the other hand, variations among subordinate species that reflect soil differences are not necessarily recognised, and the classification of steepland protection forest is very broad.

Protection forests and subalpine scrub in Westland have recently been classified by J. Wardle & Hayward (1970) and J. Wardle *et al.* (1973), using indices of similarity, importance values, and multi-linkage cluster analyses. For the Taramakau catchment in north Westland, their categories and approximate equivalents in this account are subalpine scrub (E4a), bushline forest (B6a), rata–totara forest (B5a), kamahi forest (B3a), and short scrub–hardwood forest (D3a). Most of the vegetation they describe from far-southern Westland is dominated by silver beech and does not occur in the National Park, but some of their communities can be recognised in the probably drier beech forests of the Landsborough Valley (*see* C2). Non-beech communities are *Dracophyllum* (D3b), tall lacebark–*Olearia*–*Polystichum* (D3a), *Fuchsia*–wineberry–pate forest (D2b), and kamahi–pate–mahoe forest (D2a).

Classifications of non-forest vegetation in the catchment of the Hokitika River resulted from surveys by the Forest Service. For woody vegetation P. Wardle (1960) recognised *Hoheria glabrata* forest (D3a), *Olearia* forest (D3b), *Olearia* scrub (E4a), *Dracophyllum uniflorum* scrub (F5), and *Dacrydium biforme* scrub (J1c, J2b). In alpine grassland, Wraight (1960) recognised 10 associations, each characterised by a dominant species. These and their equivalents in this account are *Poa colensoi* (H3), *Rostkovia* (=*Marsippospermum*) *gracilis* (apparently arising from H2a through depletion by browsing), *Danthonia* (=*Notodanthonia*) *setifolia* (I3a), *Carpha alpina*–*Oreobolus pectinatus* (K5a), *Danthonia flavescens* broad-leaved form (=*Chionochloa* cf. *flavescens*–G4a), *D. flavescens* narrow-leaved form (=*C. pallens*–G2), *D.* (=*C.*) *crassiuscula* (G6), *D.* (=*C.*) *oreophila* (H2a), and *Poa cockayniana* (G1a). Only Wraight's *Danthonia rigida* (=*Chionochloa rubra*) association is absent from the alpine grasslands of Westland National Park, but the habitat is occupied by *C.* cf. *rigida* (in F4 & G6); forms of *C. rubra* dominate on alluvial terraces in the Landsborough catchment and occur in natural pakihi (K3a) on the piedmont hills.

Rigg (1962) described in detail the floristic composition, vegetation development, and soils of burnt pakihi (K3b) near Westport. Burrows & Dobson (1972) describe mires near Lakes Manapouri and Te Anau which floristically resemble heath and pakihi communities on the Westland piedmont, although they are more consistently associated with bog peats.

THE COMMUNITIES

A. Dense conifer forest

Podocarps form the main canopy at over 30 m, with individual trees having relatively slender boles and narrow crowns. There is a suppressed lower storey of hardwoods. This forest occupies flat terrain.

1. Conifer forest on recent alluvial soils

(a) *Kahikatea forest* (Figs 3, 4)

Forests clearly dominated by kahikatea grow on recent river silts in the main valleys, and to a more limited extent on silty flats on the inland shores of the coastal lagoons. Kahikatea trees, reaching a height of 50 m, are physiognomically dominant though the canopy cover is usually less than 50%. On well-drained fertile sites the proportion of matai increases, on more-acid sites there are scattered rimu which are usually small and crooked.

Kahikatea forest is a seral community and its successional relationships are described by Wardle (1974). Floristically, it is closely related to other forest communities on recent river silt, especially B2 (scattered kahikatea/hardwoods). Kamahi is commonly the main subcanopy species, occurring as slender trees, and as saplings epiphytic on tree fern trunks. The floor of the forest is usually a mosaic of flat, wet areas occupied by colonies of *Astelia grandis*, and drier rises (which are often mounds of humus built over roots and logs) supporting the tree fern *Dicksonia squarrosa* and creeping stems of the liane *Metrosideros diffusa*. Other species which can be abundant are *Blechnum capense* (in the "procerum" and "subalpine" forms), *Ripogonum scandens*, *Freycinetia banksii* (near the coast), and *Microlaena avenacea*. There is usually an extensive ground cover of bryophytes.

Other species recorded from at least half of the described stands are *Trichomanes reniforme*, *Asplenium bulbiferum*, *A. flaccidum* (epiphyte), *Phymatosorus diversifolius*, *Pseudowintera colorata*, *Ascarina lucida*, *Rubus australis*, *Pseudopanax crassifolius*, *P. colensoi* (epiphyte), *Schefflera digitata*, *Griselinia littoralis*, *Coprosma lucida*, *C. foetidissima*, *C. rotundifolia*, and *C. wallii*. *Cyathea smithii*, *Hedycarya arborea*, *Carpodetus serratus*, and *Pennantia corymbosa* occur mainly as seedlings or saplings.

To this list can be added the following less frequent species: *Todea superba*, *Hymenophyllum ferrugineum*, *H. demissum*, *H. scabrum*, *Polystichum vestitum* (as small plants), *Lastreopsis hispida*, *Asplenium falcatum*, *A. flaccidum*, *Podocarpus ferrugineus*, *P. totara*, *Metrosideros umbellata* (usually of epiphytic origin), *Neomyrtus pedunculata*, *Pittosporum colensoi*, *Aristotelia serrata*, *Clematis paniculata*, *Cardamine debilis*, *Melicytus ramiflorus*, *Pseudopanax anomalus*, *Myrsine australis*, *M. divaricata*,

Fig. 3 Dense kahikatea forest (A1a) at the head of Lake Wahapo. The trees are beginning to show the adverse effects of silt and higher water levels.

Fig. 4 A kahikatea stand where deposition of silt has destroyed part of an old stand and allowed groups of younger trees to become established. Ohinetamatea River.

Coprosma propinqua (persisting from earlier stages), *C. rhamnoides*, *C. wallii*, and *Hebe salicifolia* var. *paludosum* (only from Lake Wahapo northwards). Other epiphytes are *Griselinia lucida*, *Astelia solandri*, *Earina autumnalis*, and *E. mucronata*.

(b) *Mixed conifer forest on well drained soils*

Better drained soils than those with dense kahikatea forest support a mixture of conifers, but most stands have now been modified by logging. Matai is the main species on silty soils, and rimu on stonier soils. Probably, mature forest of Westland totara grew on many stony soils, but today in the lowland valleys stands of this species are now either pioneer or secondary. A virgin stand remains on a stony fan at Cassel Flat at 200 m. In places there is a remarkable admixture of conifers; for instance, on an alluvial flat near Canavan Knob there is rimu, totara, Hall's totara, matai, miro, kahikatea, and *Libocedrus bidwillii*.

There is usually a lower canopy of kamahi. *Pseudowintera colorata*, *Cyathea smithii*, *Dicksonia squarrosa* (in the lowlands), *Coprosma rhamnoides*, and *C. rotundifolia* form most of the shrub layer. Shrubs tend to be sparse, but the herbs *Nertera* cf. *dichondraefolia* and *Uncinia egmontiana* can be abundant. The floor is covered by moss and thin litter.

Other species are those typical of forest on recent alluvial soils.

2. TALL CONIFER FOREST ON GLEY PODZOLS AND PEATS

(a) *Rimu forest* (Fig. 5)

This very distinct community forms the main reserve of millable forest in South Westland. It occurs below 400 m, on alluvial and fluvio-glacial terraces of Otiran and early post-glacial age, where vertical drainage is completely prevented by cemented iron-humus pans in the gravel. The A horizon overlying the gravel varies; at one extreme there can be *c.* 75 cm of leached silt loam grading upwards into an organic layer only *c.* 10 cm deep; at the other extreme there are A horizons with over 1 m of soft, wet silty peat and peaty silt loam. The more organic soils are on the younger surfaces (e.g., along the Cook–Gillespies Road), the less organic on the older (e.g., bordering the new highway south of Lake Wahapo). On the oldest surfaces rimu forest is confined to galleries following streams.

Fig. 5 Dense rimu forest (A2a) on Cook–Gillespie Road.

Rimu forms the canopy at 30 m or more. Miro is much less abundant and not as tall, and there are occasional trees of Hall's totara. Kamahi is always abundant, though mostly as slender, suckering growth, few trees reaching their potential girth and height of 15–20 m. *Quintinia acutifolia* is usually common, and also mainly suckering. Otherwise, the shrub storey consists mainly of *Neomyrtus pedunculata*, although *Dicksonia squarrosa*, *Phyllocladus alpinus*, *Myrsine divaricata*, *Pseudopanax colensoi*, *Coprosma foetidissima*, and *C. lucida* occur in most stands.

Herbs usually give only a sparse cover. *Blechnum capense "minus"* is the main species, *Astelia nervosa* is present in most stands, and *Gahnia xanthocarpa* occurs near the sea. Epiphytes and lianes are minor features of the type, but *Trichomanes reniforme* is always present, growing on logs and the bases of trees, and *Luzuriaga parviflora* is usually present. Bryophytes usually form a complete carpet, except where there are pools.

Further species: *Lycopodium volubile*, *Todea superba*, *Gleichenia cunninghami*, *Lastreopsis hispida*, *Rumohra adiantiformis*, *Hypolepis rufobarbata*, *Lindsaea trichomanoides*, *Grammitis billardieri*, *G. heterophylla*, *Asplenium flaccidum*, *A. falcatum*, *Ascarina lucida*, *Pseudowintera colorata*, *Metrosideros umbellata*, *M. fulgens*, *Elaeocarpus hookerianus*, *Pseudopanax crassifolium*, *P. simplex*, *Griselinia littoralis*, *Myrsine australis*, *Coprosma rhamnoides*, *C. colensoi*, *Nertera depressa*, *N.* cf. *dichondraefolia*, *Dianella nigra*, *Astelia solandri*, *Libertia pulchella*, *Dendrobium cunninghamii*, *Ripogonum scandens*, and *Uncinia rupestris*. *Metrosideros perforata* and *Freycinetia banksii* occur mainly near the coast.

(b) *Rimu–kahikatea forest on more-fertile sites than (a)*

On the post-glacial terrace behind Ohinetamatea Lagoon the depth of wet, predominantly organic mud was found to be over 2.8 m at one point. The forest here and at similar sites (e.g., near the Waitangiroto River and behind Five Mile Lagoon) represents points on the transition between kahikatea forest and rimu forest, and contains the following species which indicate higher fertility — *Cyathea smithii*, *Blechnum discolor*, *Dacrycarpus dacrydioides*, *Hedycarya arborea*, and *Microlaena avenacea*.

(c) *Rimu-silver pine forest*

On very wet ground, where pools lie on the surface for much of the year, the rimu trees are mostly or all of small diameter, and mixed with silver pine. Some of these communities belong to the transition between rimu forest and heath-forest (J1), and in places succession towards the former can be discerned. The status of other examples is not clear, but they may be areas where wind-throw prevents rimu from attaining maturity, and produces hollows which favour silver pine.

B. Conifer/hardwood forest

The main canopy is formed by hardwoods, but conifers are present, usually as a discontinuous overstorey of wide-crowned trees with large boles. Characteristically, conifer saplings, poles, or young trees are absent or scarce. Most of the forest on the montane hill slopes is of this category.

1. Open kahikatea forest transitional to swamps (Fig. 6)

Swamps often have a fringe of kahikatea forest, in which the trees are more-or-less widely spaced because there are relatively few sites for their seedlings to establish. Trees are large where they border fertile swamp dominated by *Phormium tenax*, which itself is often marginal to the open water of rivers and lakes, but they are short and spindly bordering infertile swamp (K2) dominated by manuka, *Empodisma minus*, *Baumea* spp., etc.

There is a lower storey, usually open, in which *Griselinia littoralis*, *Coprosma* cf. *parviflora*, *C. propinqua*, *C. lucida*, *C. wallii*, *Myrsine divaricata*, and *Pseudopanax crassifolius* are the main species. Kamahi is locally abundant and there is usually also manuka. In forest transitional to infertile swamp, the latter can be subdominant, and silver pine and *Phyllocladus alpinus* are common. The herb layer is dense, consisting of *Blechnum capense "procerum"*, *Astelia grandis*, and *Carex coriacea*. Near the coast, *Gahnia xanthocarpa* and *Freycinetia* are abundant.

Other widespread species: *Dacrydium cupressinum*, *Elaeocarpus hookerianus*, *Pittosporum colensoi*, *Carmichaelia arborea*, *Neomyrtus pedunculata*, *Clematis paniculata*, *Astelia nervosa*, and the epiphytes *Asplenium flaccidum* and *Hymenophyllum multifidum*.

Restricted to transitions to fertile swamp: *Rubus australis*, *Carpodetus serratus*, *Coprosma rhamnoides*, *C. foetidissima*, *Nertera depressa*, *Hebe salicifolia* (var. *paludosum* north of Lake Wahapo), *Cordyline australis*, *Juncus gregiflorus*, *Ripogonum scandens*.

Restricted to transitions to infertile swamp: *Podocarpus totara* (in depressed form).

2. Conifer/hardwood forest on recent soils

(a) *Kahikatea/hardwood forest*

On some lowland recent silt loams, podocarps are widely scattered, large, and spreading. Kahikatea is the main species but there are often also matai, and occasionally rimu and miro. The canopy consists chiefly of small hardwoods, being a variable mixture of kamahi, *Pennantia corymbosa*, *Schefflera digitata*, *Pseudowintera colorata*, *Carpodetus serratus*, *Melicytus ramiflorus*, and *Dicksonia squarrosa*. *Metrosideros diffusa* and *Ripogonum scandens* are always present and often abundant, and there is *Freycinetia banksii* near the coast. The herbaceous understorey is better developed than in dense kahikatea forest, main species including *Astelia grandis*, *Microlaena avenacea*, *Asplenium bulbiferum*, *Uncinia* spp. and *Nertera* cf. *dichondraefolia*.

Accompanying species are the same as in dense kahikatea forest, but *Asplenium falcatum* and *Astelia solandri* (epiphytes), *Polystichum vestitum*, *Coprosma propinqua*, and *Pittosporum colensoi* were listed more consistently than in that community. *Sophora microphylla* is common in kahikatea/hardwood forest along the tidal reach of the Waitangiroto River; here also are the only local records of *Paratrophis microphylla* and *Phymatosorus scandens*. A mountain valley variant with trees of kahikatea scattered in a shrubbery of *Myrsine divaricata*, *Pseudopanax anomalus*, and *Hoheria glabrata* grows on a swampy fan at Cassel Flat.

Some, and perhaps all, of these stands have their first generation of podocarps, which seem to owe their scattered occurrence to a low initial density of seedlings, perhaps the result of too-vigorous competition on very fertile sites.

(b) *Kamahi forest with first generation podocarps*

This community has developed from rata-kamahi successional forest (C1) on terraces in the Fox and Waiho valleys, from the seventeenth century moraines to just below the highway bridges. Podocarps—miro, Hall's totara, and rimu—are widely scattered, with diameters ranging from 60 to 150 cm according to the age of the surface (on warmer terraces they would dominate to form mixed conifer forests, A1b). Kamahi forms an open overstorey of trees with massive trunks (e.g., 2 m diameter), composed largely of coalesced aerial roots. Some of

Fig. 6 Kahikatea forest transitional to swamp (B1) showing coprosmas, manuka, *Astelia grandis*, *Blechnum capense*, and a rhizomatous *Carex*. Ohinetamatea River.

these trees begin as epiphytes on dead podocarps. Rata, if present at all, occurs as young epiphytic plants. *Griselinia littoralis* is also epiphytic. The main canopy is of small trees, especially *Schefflera digitata*, *Melicytus ramiflorus*, *Cyathea smithii*, and *Dicksonia squarrosa*. *Asplenium bulbiferum* is usually abundant, and the lianes *Metrosideros diffusa*, *Ripogonum scandens*, and *Rubus cissoides* are more important than in earlier stages.

3. Forest with kamahi dominant on yellow-brown earths below 400 m

(a) *Rimu/kamahi/Blechnum forest* (Fig. 7)

This forest type grows on yellow-brown earths, on slopes steep enough to prevent podzolisation without slipping occurring, and also on post-glacial moraines over 5 000 years old. It extends up to 350–400 m.

Fig. 7 Interior of rimu/kamahi/*Blechnum* forest (B3a) with *Blechnum discolor* and *B. capense "procerum"* in the undergrowth. Near Lake Wombat, Waiho Gorge.

Three tree storeys are conveniently recognised. The upper has rimu and miro as large scattered trees. The middle layer is mainly kamahi of epiphytic origin. Hall's totara* and rata are present in under half of the stands examined. The lowerstorey is a mixture of small trees, the most frequent being *Hedycarya arborea*, *Pseudopanax simplex*, and *Myrsine australis*.

Coprosma foetidissima is the only consistently occurring shrub. *Dicksonia squarrosa* is usually present, giving a cover of up to 50%. *Blechnum discolor* is very characteristic and abundant, its cover often exceeding 50%. *Nertera* cf. *dichondraefolia* is present on most sites, but as a minor species. The community is characterised also by copious lianes, especially *Metrosideros fulgens*, the juvenile foliage of which covers up to 20% of the ground. *M. diffusa*, *Ripogonum scandens*, and *Phymatosorus diversifolius* can also be abundant. Epiphytic filmy ferns are always present, and can include *Trichomanes reniforme*. The vascular epiphyte *Astelia solandri* is also in most stands. *Blechnum capense "procerum"* locally dominates the understorey on steep ground with a tendency to slip and on surfaces intersected by small channels. *Schefflera digitata*, *Asplenium bulbiferum*, *Todea superba*, and *Microlaena avenacea* grow along water courses and in damp hollows.

Further species: *Tmesipteris tannensis*, *Lycopodium varium*, *Cyathea smithii*, *Grammitis billardieri*, *G. heterophylla*, *Rumohra hispida*, *R. adiantiformis*, *Asplenium falcatum*, *Blechnum capense* "subalpine" and *"minus"*, *Ascarina lucida*, *Pseudowintera colorata*, *Metrosideros perforata*, *Neomyrtus pedunculata*, *Quintinia acutifolia*, *Rubus cissoides*, *Elaeocarpus hookerianus*, *Griselinia littoralis*, *G. lucida*, *Pseudopanax colensoi*, *P. edgerleyi*, *P. crassifolius*, *Myrsine divaricata*, *Alseuosmia pusilla*, *Coprosma lucida*, *C. rhamnoides*, *C. colensoi*, *C. wallii*, *Nertera depressa*, *Astelia fragrans*, *Luzuriaga parviflora*, *Libertia pulchella*, *Dendrobium cunninghamii*, *Earina mucronata*, *E. autumnalis*.

(b) *Liane-dominated variant of* (*a*)

Near the coast on north-facing slopes of piedmont valleys there are areas where the overstorey of large trees (predominantly kamahi) is very open, and the bulk of the vegetation is a jungle of lianes, chiefly

*Trees of Hall's totara are dying throughout the hill-slope forests, and will become much less important unless replenished by juveniles.

Ripogonum scandens and *Freycinetia banksii*. Small trees, especially *Hedycarya arborea* and the tree fern *Dicksonia squarrosa*, are abundant in these stands.

(c) *Fertile-slope variant of (a)*

On the terrace face behind the Franz Josef Motor Camp the forest has large rimu trees up to 175 cm diameter over lowerstoreys dominated by kamahi and *Blechnum discolor*, but the soil is fertile enough for species characteristic of the kahikatea/hardwood community (B2a) to be prominent, including *Cyathea smithii*, *Todea hymenophylloides*, *Polystichum vestitum*, *Blechnum fluviatile*, *Asplenium bulbiferum*, *Melicytus ramiflorus*, *Aristotelia serrata*, *Schefflera digitata*, *Pseudopanax edgerleyi*, and *Coprosma rotundifolia*. There is also one large kahikatea tree.

(d) *Rimu/kamahi/Todea forest*

Some sites that would otherwise support rimu/kamahi/*Blechnum* forest have soils that are too immature, and are somewhat shaded, moist, and subject to temperature inversion. Such conditions are frequent on sloping fans in the lower reaches of the Karangarua and Copland valleys, and occur over small areas in the piedmont region. Trees of rimu are usually large and scattered, leaving kamahi as the main dominant. On young terraces, matai, kahikatea, Hall's totara, and *Libocedrus* are present, providing a transition to the mixed podocarp forest of recent soils (A1b).

Dicksonia squarrosa can form extensive thickets. *Blechnum discolor* is accompanied or replaced by *Todea superba*, together with *Microlaena avenacea* on the youngest soils. *Metrosideros diffusa* is the only abundant liane. Lowland forest species which tend to be absent include *Hedycarya arborea*, *Metrosideros fulgens*, *Pseudopanax edgerleyi*, *Myrsine australis*, *Ripogonum scandens*, and *Freycinetia banksii*.

(e) *Rimu/kamahi–quintinia forest*

This lowland forest type grows on gleyed podzolised yellow-brown earths with a cemented B horizon. Its canopy is three-storied, the upper being dominated by rimu trees, which tend to be more numerous and smaller than in the rimu/kamahi/*Blechnum* type. Hall's totara is always present, miro usually so, and both can be abundant. The second storey is dominated by kamahi and quintinia; rata is also usually present, and can be co-dominant. Among a mixture of small trees, *Phyllocladus alpinus* is consistently common and *Myrsine australis* only slightly less so.

The main shrub is *Neomyrtus pedunculata*. *Gleichenia cunninghamii* and *Blechnum discolor* form the tall herb layer and *Blechnum capense* ("subalpine" and "*minus*" forms) is also important on some sites. Very locally there are colonies of *Dicksonia lanata*. Characteristic small ferns are *Lindsaea trichomanoides* and *Trichomanes reniforme*. Other filmy ferns are also common on the forest floor and tree trunks except near the coast. The liane *Metrosideros fulgens* is abundant, together with *Freycinetia banksii* and *Gahnia xanthocarpa* near the coast.

Other species which are either frequent or locally abundant include *Dicksonia squarrosa*, *Griselina littoralis*, *Pseudopanax crassifolius*, *P. colensoi*, *Coprosma lucida*, *C. foetidissima*, *Astelia nervosa*, and *Gahnia procera*.

Further species: *Lycopodium volubile*, *Cyathea colensoi*, *Grammitis heterophylla*, *G. billardieri*, *Phymatosorus diversifolius*, *Ascarina lucida*, *Pseudowintera colorata*, *Metrosideros fulgens*, *M. perforata*, *Pseudopanax simplex*, *Myrsine divaricata*, *Coprosma rhamnoides*, *C. colensoi*, *Nertera* cf. *dichondraefolia*, *N. depressa*, *Dianella nigra*, *Luzuriaga parviflora*, *Astelia solandri*, *Ripogonum scandens*, *Libertia pulchella*, *Uncinia angustifolia*, *Dendrobium cunninghamii*, and *Earina mucronata*.

Elaeocarpus dentatus and *Myrsine salicina* are very rare, having been found only near Lake Mapourika. Occasionally *Dacrydium intermedium* is present, indicating a relationship to *D. intermedium* low forest (J1b).

(f) *Miro-dominated variant*

On the summit of Canavan Knob, at 250 m, miro dominates a closed upper canopy; another unusual feature is that the normally epiphytic *Astelia solandri* is the main tall plant of the understorey.

4. FOREST WITH LIBOCEDRUS PROMINENT IN FROSTY LOCALITIES BELOW 600 M

Several of the forest communities described above are represented by related communities on sites subject to temperature inversion; in these the usual lowland species are accompanied or replaced by species more typical of higher altitudes. The communities are mostly fragmentary, but can be arranged in three groups, the first being the most distinctive.

(a) *Libocedrus forest on recent terraces* (Fig. 8)

Libocedrus bidwillii is dominant on shaded valley floors and backs of terraces at altitudes between 100 and 350 m. The sites are relatively young and on one the soil was described as recent humic gley. *Libocedrus* forms an upperstorey, generally with trees in discrete groups. The main canopy is of small trees or tall shrubs, mostly of divaricating habit; *Phyllocladus alpinus*, *Coprosma wallii*, *Myrsine divaricata*, and less consistently, *Neomyrtus pedunculata*, *Pseudopanax anomalus*, and *Pseudowintera colorata*.

Fig. 8 *Libocedrus* forest on a terrace (B4a) at Welcome Flat.

In some stands *Todea superba* forms a dense understorey; in others, the main species are *Microlaena avenacea* and *Astelia nervosa*. Usually there are cushions of *Sphagnum*.

Other species: *Dendroligotrichum dendroides, Cyathea colensoi, Dicksonia squarrosa, Polystichum vestitum, Blechnum fluviatile, Podocarpus totara, P. acutifolius, Viola filicaule, Griselinia littoralis, Nertera* cf. *dichondraefolia, Coprosma foetidissima, Uncinia egmontiana, Luzula picta,* and *Luzuriaga parviflora. Hebe canterburiensis* and *Coprosma depressa* were found at one site at 350 m.

(b) *Forest subject to temperature inversion on podzolised yellow-brown earth*

On the plateau between the Waikukupa and Omoeroa Rivers at 400 m, ridge crest rimu/kamahi–quintinia forest passes down into a south-facing stand dominated by *Libocedrus* and Hall's totara, still on podzolised yellow-brown earth. Its links with lowland climax forest are shown by the presence of *Phyllocladus alpinus, Coprosma colensoi,* and *Gleichenia cunninghamii,* with upland forest by *Pittosporum crassicaule, Coprosma pseudocuneata, Archeria traversii,* and *Phormium cookianum*. Other important species are *Pseudopanax simplex, P. colensoi, Coprosma foetidissima, Microlaena avenacea,* and *Astelia nervosa*. A similar community occupies the inland slope of a moraine at 100 m between Okarito Lagoon and Lake Wahapo.

On a frosty site near Lake Matheson, Hall's totara dominates over a shrubby storey of *Neomyrtus pedunculata* and *Phyllocladus alpinus,* with *Todea superba* as the main large fern. *Cyathea colensoi* is also present.

(c) *Forest subject to temperature inversion on gley podzols*

On three sites between 300 m and 600 m, where drainage is impeded by underlying iron-humus pan or solid rock, there is co-dominance of *Dacrydium biforme,* Hall's totara, and *Libocedrus,* together with silver pine on the Omoeroa Saddle (300 m). At Lame Duck Flat (600 m), silver beech is also present, apparently as a recent invader. On these soils *Pseudopanax simplex, Dracophyllum longifolium, D. traversii,* and *Olearia colensoi* provide further links with upland vegetation.

5. UPLAND RATA–KAMAHI FOREST ON YELLOW-BROWN EARTH

(a) *Rata–kamahi/Blechnum forest*

This upland equivalent of rimu/kamahi/*Blechnum* forest (B3a) occurs on the main ranges to an altitude of 650 m. It is chiefly on the outer slopes but grows also on the slopes of the lower reaches of the mountain valleys. Because many of the sites are somewhat exposed spurs, the canopy is often tight and wind-smoothed. Rata and kamahi are dominant,

the former generally being the more important. Hall's totara is usually also important with *Pseudopanax simplex* and *Griselinia littoralis* as the main small trees. *Cyathea smithii* reaches its limits in this type at *c.* 600 m. *Coprosma foetidissima* is the main shrub except where browsing confines it to an epiphytic existence. *Blechnum discolor* dominates the undergrowth, but is not usually as extensive as at lower altitudes. It is usually accompanied by *Astelia nervosa*, except where the latter has been reduced by browsing.

Further widespread species: *Blechnum capense*, *Asplenium flaccidum*, *Phymatosorus diversifolius*, *Podocarpus ferrugineus*, *Metrosideros diffusa*, *M. fulgens* (to 540 m), *Myrsine australis*, *Pseudopanax colensoi*, *P. crassifolius*, *Coprosma lucida*, *Luzuriaga parviflora*.

The following species, mostly characteristic of more-fertile soils, enter on faces and fans: *Todea superba*, *Cyathea colensoi*, and *Pseudowintera colorata* (all abundant); also *Tmesipteris tannensis*, *Polystichum vestitum*, *Blechnum fluviatile*, *Dicksonia squarrosa*, *Asplenium bulbiferum*, *Rubus cissoides*, *Carpodetus serratus*, *Schefflera digitata*, *Nertera* cf. *dichondraefolia*, *Coprosma astonii* (above 600 m), and *Microlaena avenacea*.

(b) *Rata–kamahi/Gahnia forest*

This is the upland, less species-rich equivalent of rimu/kamahi–quintinia forest (B3a). It occupies weakly podzolised yellow-brown earths on crests and upper slopes in the piedmont area, usually on moraine but also on greywacke. The community ascends to 600 m. Rata is always a dominant species. Kamahi and Hall's totara are abundant to co-dominant, but rimu decreases in importance with increasing altitude. Miro is usually present. Silver beech dominates an essentially similar community at 650 m in the upper Karangarua Valley. *Pseudopanax simplex* and *Phyllocladus alpinus* are the main small trees, and are usually accompanied by *Myrsine australis* and *Pseudopanax colensoi*. Suckering young growth of quintinia is present in some stands, the most abundant shrub is *Coprosma foetidissima*, and *C. lucida* and *C. colensoi* can be common. The characteristic tall herbs are *Blechnum discolor*, *B. capense "minus"*, *Gahnia procera*, and *Astelia nervosa*, but the cover is sparser and patchier than at lower altitudes. Instead, bryophytes are more extensive, or even continuous, on the forest floor. Locally, however, there are dense colonies of *Dicksonia lanata*. Lianes and vascular epiphytes are not an important feature in ridge-crest stands, but *Metrosideros fulgens* is abundant on steep spurs near Lake Mapourika.

Further species: *Asplenium flaccidum*, *Gleichenia cunninghamii*, *Trichomanes reniforme*, *T. strictum*, *Grammitis billardieri*, *Lindsaea trichomanoides*, *Neomyrtus pedunculata*, *Elaeocarpus hookerianus*, *Griselinia littoralis*, *Luzuriaga parviflora*, *Libertia pulchella*, and *Uncinia angustifolia*. *Blechnum capense "procerum"* and *B. vulcanicum* were listed from precipitous slopes. In one stand, presence of *Pseudowintera colorata*, *Microlaena avenacea*, and *Uncinia uncinata* indicates pockets of moister, less-stable soil.

6. HIGH-ALTITUDE RATA FOREST

(a) *Rata–Libocedrus forest on the main ranges*

This occupies ridges and the more-stable faces of the main ranges, on yellow-brown earths. It begins above 650 m on the outer slopes, but descends to 550 m on the sides of inland valleys. Around 900 m it merges into *Dracophyllum–Olearia* scrub with emergent *Libocedrus* (E4a–Fig. 9).

On ridges rata is overwhelmingly dominant. The trees have spreading trunks that are often prostrate in their lower portion, and dense, smooth canopies. On faces the canopy is less even, and the rata trees are taller, most having commenced as epiphytes in *Libocedrus* crowns. *Libocedrus* is much less abundant, and in most stands most, and in some places all, of the trees are dead. Hall's totara is usually present, and is co-dominant in places. Kamahi is important only on the outer slopes of the Alps, to 840 m. *Pseudopanax simplex* is always abundant, and *Griselinia littoralis* only a little less so. Together they form a lower tree storey, or reach the canopy in the shorter, ridge-crest stands.

Coprosma foetidissima is the main shrub, except where it has been destroyed by deer. *C. astonii*, *C. wallii*, and *Myrsine divaricata* are usually present; *Pseudowintera colorata* is common on the faces. The tall herb layer has nearly everywhere been modified by browsing. The main species are *Astelia nervosa*, *Cyathea colensoi*, *Blechnum capense* "subalpine" and, on the faces, *Todea superba* and *Polystichum vestitum*. Colonies of the large moss *Dendroligotrichum dendroides* are also characteristic. Through most of the community deeply incised tracks cover much of the ground, the grass *Microlaena avenacea* has spread to cover much of the floor, and clumps of *Histiopteris incisa* have become established.

Further species: *Hymenophyllum ferrugineum*, *Grammitis billardieri*, *Asplenium flaccidum*, *Phymatosorus diversifolius*, *Pseudopanax linearis*, *P. colensoi*, *Dracophyllum traversii*, *Archeria traversii*, *Coprosma pseudocuneata*, *Nertera* cf. *dichondraefolia*, *Senecio bennettii*, *Luzuriaga parviflora*, and *Uncinia angustifolia*; also *Cyathea smithii* (up to 640 m);

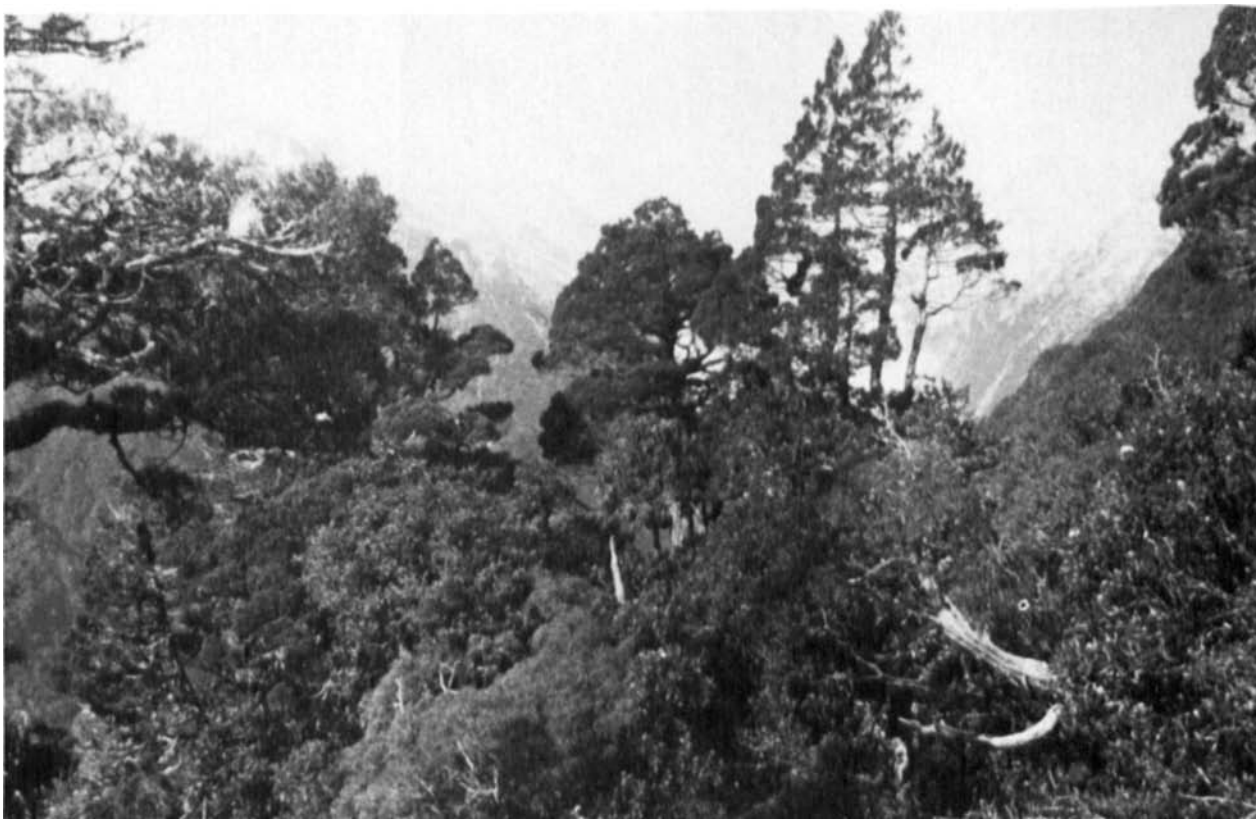

Fig. 9 Transition from rata–*Libocedrus* forest (B6a) to *Dracophyllum–Olearia* scrub (E4a). Alex Knob.

Blechnum discolor and *Rubus cissoides* (up to 700 m); *Coprosma pseudocuneata* (above 900 m); *Uncinia filiformis, Phormium cookianum,* and *Gahnia procera* (mainly on ridges); *Blechnum fluviatile, Hypolepis millefolium,* and *H. rufobarbata* (on faces, especially where the forest has been damaged by deer).

(b) *Variant of (a) on piedmont hills*

The summits of the Omoeroa Range rise above 650 m and support forest with *Libocedrus.* Because the soils are more mature than on the main ranges, *Phyllocladus alpinus* and *Gahnia procera* are abundant in the lowerstories, so that this community can also be regarded as the high-altitude equivalent of rata–kamahi/*Gahnia* forest (B5b). On a windthrow area near the summit of Omoeroa Hill (683 m) a shrubbery of *Phyllocladus, Pseudopanax simplex,* and *Myrsine australis* has developed, and young *Libocedrus* is present.

(c) *Transitions between tall and low forest*

In the transitions from rata–kamahi/*Blechnum* and rata–*Libocedrus* forest towards gully communities on immature soil, the tall canopy trees become a discontinuous emergent layer, *Pseudopanax simplex* and *Griselinia littoralis* are joined by *Hoheria lyallii* to form a main canopy of small trees, and *Polystichum vestitum* becomes dominant in the undergrowth. Other canopy species include *Olearia lacunosa, O. ilicifolia,* and below 600 m, *Fuchsia excorticata, Schefflera digitata,* and *Aristotelia serrata.* At the lower altitudes, *Pseudowintera colorata* is abundant and *Asplenium bulbiferum* can accompany *Polystichum vestitum.* The liane *Muehlenbeckia australis* is also characteristic.

Throughout the Karangarua catchment, between the altitudes of 430 m and 750 m, collapse of glacially oversteepened valley sides has produced talus slopes littered with large angular blocks. The talus supports the small trees and understorey described in the preceding paragraph, together with *Libocedrus* trees. The blocks support trees of rata, Hall's totara, *Libocedrus, Griselinia littoralis,* and *Pseudopanax simplex.*

C. Tall hardwood forest

In this category the tall hardwood species form a more-or-less closed canopy, and conifers are either scarce or absent, or present as young plants in successional communities.

Fig. 10 Successional rata–kamahi forest (C1) on a slip above Hare Mare Creek.

1. SUCCESSIONAL RATA–KAMAHI FOREST

Rata and kamahi succeed scrub dominated by *Olearia avicenniaefolia* on moraines and coarse outwash in the Franz Josef and Fox valleys. On surfaces formed before *c.* 1 800 AD these two species form a dense canopy at 12–18 m. Ridge crests tend to carry almost pure rata; hollows and moist terraces tend to carry pure kamahi. There is a well developed storey of tall shrubs, small trees, and saplings, the main species being *Griselinia littoralis*, kamahi (but not rata), *Pseudopanax colensoi*, *P. simplex*, *Coprosma foetidissima*, *C. lucida*, *Schefflera digitata*, and *Cyathea smithii*. Scattered young podocarps are present from 130 years, reaching pole size by 300 years. These are mainly miro, with some Hall's totara and rare rimu.

Asplenium bulbiferum forms most of the understorey on moister sites where kamahi is dominant, whereas *Nertera* cf. *dichondraefolia* does so on drier, rata-dominated sites. On a solid-rock spur, the understorey is chiefly *Phymatosorus diversifolius* and lichens, but generally these plants have become epiphytic by this stage. Other important herbs are *Astelia fragrans* and *Blechnum capense "procerum"*, the latter forming dense colonies in hollows. In the soils, 3–8 cm of humus overlie the beginning of an A horizon, and there is visible weathering.

Almost identical communities grow on very steep slips with slopes approaching 50° and altitudes up to 700 m, mainly along the Alpine Fault (Fig. 10). These sites are harsh and over-drained, so that rata is usually more important than kamahi, and mesic understorey species such as *Asplenium bulbiferum* are of restricted occurrence. Although *Blechnum capense "procerum"* locally dominates the understorey, *Astelia nervosa* replaces *A. fragrans*, and young plants of rimu are more abundant than other podocarps. On these sites rata–kamahi forest succeeds open shrubberies (F2).

Kamahi-dominated successional forest occupies some river terraces in the lower reaches of the mountain valleys and in the piedmont valleys close to the mountains. These appear to be too stony for seral low forest (D1). Young podocarps are extremely abundant on some sites, and absent from others which are probably too frosty.

Felled conifer/hardwood forest usually passes through a phase of dominance by kamahi and other hardwoods, which provide a nursery for seedlings of rimu and other conifers.

Fig. 11 Silver beech forest (C2) on Lame Duck Flat.

Other species recorded from at least two stands: *Dicksonia squarrosa, Blechnum discolor, B. vulcanicum, Polystichum vestitum, Pseudowintera colorata, Hedycarya arborea, Melicytus ramiflorus, Carpodetus serratus, Pseudopanax crassifolius, Myrsine australis, M. divaricata, Coprosma wallii, C. rhamnoides, C. astonii, Ripogonum scandens;* and the following epiphytes, *Tmesipteris tannensis, Lycopodium varium, Asplenium flaccidum, Grammitis billardieri,* and species of Hymenophyllaceae.

2. Tall beech forest

In the National Park silver beech is restricted to the Karangarua catchment between Cassel Flat and Christmas Flat and probably arrived quite recently. Within this area it is well distributed on shallow, gley soils, where it is a constant component of heath (J). Otherwise, beech gives the impression of having invaded other community types, including rata–kamahi/*Gahnia* forest (B5b), rata–*Libocedrus* forest (B6a), and pioneer communities.

Nevertheless, dense stands of tall beech trees growing on recent and immature soils on terraces and slopes form a well defined community, occurring between 180 m and 850 m (Fig. 11). Beech forms a complete canopy except for gaps left by the death of trees, and the floor is covered by moss, litter, and patches of *Hymenophyllum multifidum.* Other species are sparse and rather varied, but the following are fairly constant, *Polystichum vestitum, Pseudowintera colorata, Pseudopanax simplex, Griselinia littoralis, Myrsine divaricata, Coprosma colensoi, C. astonii, C. pseudocuneata* "erect", *C. wallii, Nertera* cf. *dichondraefolia, Microlaena avenacea, Uncinia* spp. Gaps support seral species such as *Histiopteris incisa, Paesia scaberula,* and *Fuchsia excorticata.*

Beech forest occupies the whole of the Landsborough Valley downstream from Fettes Glacier. Stands were not described in detail but a broad division can be made into:

(a) Stands of the valley floor and upper and lower slopes; these are similar to stands described above for the Karangarua catchment, though generally drier. They correspond with silver beech–pepperwood–water fern forest and silver beech – *Myrsine* – *Polystichum* forest of Wardle *et al.* (1973), described from further south in Westland.

(b) Mid-slope stands form a belt of variable width between 400 m and 600 m. They have a lower tree storey, mainly of kamahi and *Pseudopanax simplex,* with *Blechnum discolor* locally forming

a tall herb layer. Other species include *Podocarpus hallii, Elaeocarpus hookerianus, Carpodetus serratus, Rubus cissoides,* and *Pseudopanax crassifolius.* [Cf. silver beech–kamahi–*Blechnum* forest of Wardle *et al.* 1973.]

(c) Towards the upper forest limit, undergrowth of shrubs is prominent on spurs and other places with shallow soils and stunted beech trees. *Coprosma pseudocuneata* is the main understorey species; others include *Phyllocladus alpinus* and *Dracophyllum traversii.* This can merge into a narrow belt of scrub at timber line. [Cf. silver beech–*Archeria* forest of Wardle *et al.* 1973.]

(d) Shady talus slopes (some prone to avalanches) at 550–1 050 m support forest with an upper canopy of beech with a closure of only c. 10%, a lowerstorey of *Hoheria glabrata* which has been decimated by deer, and a herb layer of *Polystichum vestitum.* This is equivalent to *Hoheria forest* (D3a) except for the presence of beech.

(e) Beech is a component of vegetation colonising moraine and alluvium, in communities which would otherwise be classified as *Coprosma rugosa* scrub (E1b), low *Coprosma ciliata* scrub (F1c), and herbaceous vegetation dominated by *Rhacomitrium lanuginosum.*

D. Low hardwood forest

Large areas of Westland National Park and adjoining lowlands are covered by small hardwood trees, with canopies not exceeding 10 m, except where the taller *Plagianthus betulinus* is dominant or where there are scattered mature trees of kamahi. The stands occur on immature soil, and are therefore generally seral, although some form effectively stable communities because the sites where they occur are subject to continuous soil movement.

1. Seral low forest on alluvial and fluvioglacial flats

(a) *Low forest on lowland river flats*

This community succeeds the pioneering grass and scrub. The flats are usually stony in the early stages, but silt is gradually built up by floods. The canopy is mostly dominated by *Pennantia corymbosa,* and *Carpodetus serratus* and *Plagianthus betulinus* can also be important. Small trees of Westland totara dominate where soil remains stony. The main understorey shrub is *Coprosma rotundifolia.* Seedlings and saplings of kahikatea are always present, and locally there are young plants of other podocarps–matai, miro, rimu, and Hall's totara–thus the community develops towards podocarp forest, usually the kind dominated by kahikatea (A1).

The herbaceous layer, which is often damaged by trampling, consists mainly of moss, with locally dense areas of *Blechnum penna-marina, B. fluviatile, B. chambersii, Nertera* cf. *dichondraefolia,* and *Microlaena avenacea,* and small plants of *Polystichum vestitum.*

Other species recorded from at least three stands are *Grammitis heterophylla, Phymatosorus diversifolius, Asplenium bulbiferum, Pseudowintera colorata, Rubus schmidelioides, Muehlenbeckia australis, Griselinia littoralis, Pseudopanax crassifolius, Scheffflera digitata* (usually as seedlings), and *Parsonsia heterophylla. Cordyline australis* and *Dicksonia fibrosa* were listed for this community at a few localities, but were not seen in any other forest communities. The total species list is characteristic of forest growing on lowland alluvium (*see* A1a), with the addition of some species more characteristic of earlier successional stages, e.g., *Rubus schmidelioides, Olearia avicenniaefolia,* and *Coprosma propinqua.*

(b) *Seral low forest in mountain valleys*

At Cassel Flat and Welcome Flat *Coprosma* scrub on silty terraces becomes supplanted by *Plagianthus betulinus. Coprosma rotundifolia* is again the main shrub, but the community shows affinities with vegetation of higher altitudes in the dominance of *Polystichum vestitum* in the herb layer, and in the importance of species such as *Aristotelia fruticosa* and *Olearia ilicifolia.* At Cassel Flat there are seedlings, saplings, and occasional trees of Westland totara.

In the Waiho Valley near Peter's Pool at 200 m, frost-influenced seral low forest has distinctly subalpine affinities. The community apparently develops from *Coprosma rugosa* scrub (E1b). At 100 years, *Aristotelia serrata* and *Olearia ilicifolia* are emergent over a lower canopy of pioneer shrubs, mainly *C. rugosa.* Similar scrub on a surface c. 120 years old has scattered saplings of Hall's totara and *Libocedrus;* the cold-tolerant *Myrsine divaricata* and *Coprosma* cf. *parviflora* are abundant, and there are also *Senecio bennettii, Olearia colensoi, Pseudopanax simplex,* and *Phormium cookianum. Astelia fragrans* and *A. nervosa* form the undergrowth. Similar scrub-by vegetation with cold-tolerant species persists around damp hollows on seventeenth century moraines.

Flats in the Regina valley at 450 m and at the confluence of the Troyte and Karangarua Rivers at 650 m show co-dominance of *Olearia ilicifolia, Hoheria glabrata,* and *Myrsine divaricata,* with dense *Polystichum vestitum* beneath except where deer have destroyed it (Fig. 12). This community is

Fig. 14 Low forest (D2c) on a fan at Lame Duck Flat, with the original understorey destroyed by browsing and replaced by turf.

Many of these stands have been very severely modified by deer, the original undergrowth becoming replaced by patches of the ferns *Hypolepis millefolium* and *H. rufobarbata*, clumps of *Juncus gregiflorus*, and turf with *Ranunculus hirtus*, *Hydrocotyle "novae-zelandiae"*, *Schizeilema nitens*, *Pratia angulata*, and *Scirpus habrus* (Fig. 14).

(d) *Complex forest communities on steep unstable faces*

On very steep slopes, especially along the Alpine Fault and in the river gorges, fragments of kamahi/*Schefflera* forest, truly seral stages, and climax rata–kamahi/*Blechnum* forest form close mosaics and gradations. The rough terrain provides niches for some species of restricted occurrence, such as *Blechnum patersonii* and *B. vulcanicum*. *Fuchsia excorticata* tends to dominate along narrow watercourses, or did so before it was killed by opossums. Small slips can be colonised predominantly by *Carpodetus serratus* which may then persist as discrete colonies.

3. SUBALPINE LOW FOREST

(a) *Hoheria forest*

Low forest of *Hoheria glabrata* occupies talus slopes between 750 m and 1 050 m, in places where soil creep keeps the stony soil immature. The tree canopy is usually less than 50%. *Hoheria glabrata* may share dominance with *Griselinia littoralis* or *Olearia ilicifolia* and sometimes *Pseudopanax colensoi*, where deer have not reduced this species. The understorey is dominated by *Polystichum vestitum*, except where it is locally replaced by the procumbent shrub *Coprosma depressa*. *Hypolepis millefolium*, *Ranunculus hirtus*, *Hydrocotyle "novae-zelandiae"*, *Scirpus habrus*, and *Poa breviglumis* become important where the vegetation has been damaged by browsing.

Further species: *Fuchsia excorticata* (below 800 m), *Schizeilema trifoliolatum*, *Cardamine debilis*, *Myrsine divaricata*, *Coprosma wallii*, *C. astonii*, *Olearia ilicifolia*, *O. colensoi*, *Senecio bennettii*, *Senecio wairauensis*, *Phormium cookianum*, *Astelia nervosa*, *Uncinia gracilenta*, and *Chionochloa conspicua*.

(b) *Dracophyllum–Olearia forest*

Trees of *Dracophyllum traversii*, *D. longifolium*, and *Olearia lacunosa* form low forest on moist, stable talus and moraine between 850 and 1 000 m in the

heads of valleys. Soils supporting the community are not as mature as under rata–*Libocedrus* forest or *Dracophyllum–Olearia* scrub, nor as immature and unstable as under *Hoheria* forest. Associated species reflect the intermediate status. *Hoheria glabrata* is present and the main shrubs are *Myrsine australis*, *Pseudopanax colensoi*, *Senecio bennettii*, and *Coprosma pseudocuneata* "erect". *Blechnum capense*, *Polystichum vestitum*, and *Astelia nervosa* form most of the undergrowth.

Further species: *Griselinia littoralis*, *Coprosma depressa*, *C. serrulata*, *Olearia ilicifolia*, and *Phormium cookianum*.

(c) *Griselinia forest*

This community is of very limited extent around 800 m. Stands occur on ridges of talus north of Lame Duck Flat and above Roberts Point, and on seventeenth century moraine crests of the Balfour Glacier. *Griselinia littoralis* is dominant, and *Dracophyllum traversii* (usually) and rata (sometimes) are also in the canopy. A subcanopy tier contains *Myrsine divaricata*, *Pseudopanax simplex*, *P. colensoi*, and *Coprosma wallii;* and *C. astonii* is usually present in the shrub tier. The herb layer consists mainly of *Blechnum capense* "subalpine", *Polystichum vestitum*, and *Astelia nervosa*.

E. Tall scrub

At low and middle altitudes scrub 2–5 m tall represents stages in succession. There is also climax tall scrub above the forest limits.

1. Coprosma scrub on recent alluvium and moraine

(a) *Coprosma scrub on river terraces below 430 m*

On river terraces up to the altitude of Welcome Flat, with silty or fine gravelly soils, a phase dominated by small-leaved, divaricating shrubs intervenes between the pioneer grassland and young forest (D1). Usually, *Coprosma propinqua* is the main species, but other species dominate where cold air ponding has delayed the succession – especially *Coprosma parviflora*, *C. wallii*, and *C. rigida*. On an old bed of the Waiho River north of Peter's Pool, subject to very severe frosts, scrub dominated by *Coprosma rugosa* has gradually invaded grassy vegetation. Other characteristic shrubs are *Aristotelia fruticosa*, *Hymenanthera angustifolia* (seen only near the Tatare River), *Carmichaelia arborea*, *C.* cf. *grandiflora*, *Pseudopanax anomalus*, *Myrsine divaricata*, *Olearia avicenniaefolia*, and *O. lineata*. *Rubus schmidelioides*, *Muehlenbeckia australis*, and *M. complexa* are the common lianes.

Polystichum vestitum may dominate beneath the shrubs, but where there is grazing then species such as *Acaena anserinifolia*, *Cardamine debilis*, *Hydrocotyle "novae-zelandiae"*, *Uncinia egmontiana*, and *Microlaena avenacea* are more common. The community also includes seedlings of the succeeding forest, especially Westland totara, *Plagianthus betulinus*, *Pennantia corymbosa*, *Sophora microphylla* (bordering coastal lagoons), and *Hoheria glabrata* and *Olearia ilicifolia* (in mountain valleys).

(b) *Dense subalpine Coprosma rugosa scrub*

Dense *Coprosma rugosa* scrub up to 3 m tall grows on rolling, relatively fine-textured moraine and river terraces, between 780 and 1 050 m. It succeeds herb-dominated pioneer communities, which can persist in a mosaic for over 200 years. The commonest accompanying shrubs are *Olearia moschata*, *Carmichaelia* cf. *grandiflora*, *Hebe subalpina*, and young plants of *Dracophyllum longifolium*. The tall herbs *Polystichum vestitum*, *Chionochloa conspicua*, and *Phormium cookianum* and the undershrub *Coprosma depressa* are usually present as scattered plants, and there is always a ground cover of *Blechnum penna-marina* and *Muehlenbeckia axillaris*.

Other species frequently encountered are *Lycopodium fastigiatum*, *Hoheria glabrata*, *Aristotelia fruticosa*, *Griselinia littoralis*, *Pseudopanax colensoi* (seedlings), *Gaultheria rupestris*, *Dracophyllum uniflorum*, *Olearia ilicifolia*, *O. avicenniaefolia*, *O. nummularifolia*, *Celmisia coriacea*, *Helichrysum bellidioides*, and *Chionochloa* cf. *flavescens*.

2. Olearia avicenniaefolia scrub (Fig. 15)

This community is well developed below the Franz Josef and Fox Glaciers at 200–250 m on fluvio-glacial surfaces, including patches of moraine overlying bedrock. *O. avicenniaefolia* enters early in the succession, and is fully dominant between 40 and 80 years, forming scrub 3.5–5 m tall. In the older stages the floor becomes thickly carpeted with litter and raw humus to depths of 15 cm. *Carmichaelia* cf. *grandiflora* and *Coprosma rugosa* are usually present, and often also *Coriaria arborea*, all persisting from earlier stages. Beneath the dense canopy there is a sparse-to-dense layer of saplings of *Schefflera digitata*, *Griselinia littoralis*, and, less consistently, *Melicytus ramiflorus*, *Olearia arborescens*, *Coprosma lucida*, and *Myrsine divaricata*. Saplings of rata and kamahi occur on terrace edges, and on spurs and ridges of moraine. The herbaceous understorey is usually sparse, but can be dense locally, the main species being *Polystichum vestitum*, *Asplenium bulbiferum*, *Phymatosorus diversifolius*, and in places *Acaena anserinifolia*.

Fig. 15 Floor of *Olearia avicenniaefolia* scrub (E2), with forest tree and shrub seedlings appearing. Waiho Valley, on a fluvio-glacial surface *c.* 50 years old.

Patches of the community ascend above 600 m, but by this altitude *O. avicenniaefolia* has usually yielded to other species, especially *Coprosma rugosa*. Communities on moraines of the Balfour Glacier at 800 m, dating from the nineteenth century, have *O. avicenniaefolia* sharing dominance with *Dracophyllum longifolium*, with *Coprosma rugosa* also in the canopy. Saplings of rata and broadleaf are abundant beneath, and those of *Dracophyllum traversii* and *Pseudopanax colensoi* are also present. *Phymatosorus diversifolius* here is near its altitudinal limits.

Other species: *Lycopodium varium, Hymenophyllum multifidum, Grammitis hetetrophylla, Asplenium flaccidum, Blechnum capense "procerum", Cardamine heterophylla, Lagenifera petiolata, Senecio wairauensis, Mazus radicans, Astelia fragrans, A. nervosa, Uncinia uncinata, Chionochloa conspicua, Pterostylis australis, P. banksii*, and *Corybas macranthus; Pyrrosia serpens, Earina autumnalis*, and *E. mucronata* as epiphytes; and young plants of *Cyathea smithii, Hoheria glabrata, Aristotelia serrata, Pennantia corymbosa, Pittosporum colensoi, Fuchsia excorticata, Pseudopanax colensoi, Coprosma wallii*, and *Olearia ilicifolia*.

3. TALL SCRUB ON SLIPS AND TALUS (Fig. 16)

(a) *Communities of varied composition* (Fig. 16)

Slips and talus provide moister sites than those dominated by *Olearia avicenniaefolia*, but the substratum is very variable and the vegetation develops as a mosaic that does not permit convenient separation of distinct communities other than the *Coriaria arborea* community described as 3b below. *Carmichaelia* cf. *grandiflora* is always present, and was noted as dominant or co-dominant from 200 to 1 150 m. *Coprosma rugosa* is also widely dominant, on sites which appear to be drier and no clear separation can be made from the steeper communities of Elb. On some sites around 900 m, *Olearia arborescens* is dominant. Other shrubs which can share dominance are *Hoheria glabrata* (above 850 m), *Aristotelia serrata* (below 300 m), and *Hebe salicifolia*.

Below 500 m, understoreys tend to be weakly developed and consist mainly of *Asplenium bulbiferum* and *Astelia fragrans*. Above 800 m, understoreys are dense in the moister communities, with abundant *Polystichum vestitum, Blechnum capense, Coprosma depressa*, and *Chionochloa conspicua* were also recorded as sub-dominants. In openings, many of which

Fig. 16 Steep fan of Coleridge Creek, with seral scrub dominated by *Coprosma rugosa*. Abundance of *Olearia ilicifolia* and presence of turfy glades reflect heavy browsing.

result from browsing. *Gunnera monoica*, *Coriaria plumosa*, *Acaena anserinifolia*, *Nertera depressa*, *Helichrysum bellidioides*, *Cotula squalida*, *Pratia angulata*, *Luzula picta*, *Uncinia divaricata*, *Poa cockayniana*, and *Lachnagrostis lyallii* can be abundant (*see* H4a). Seedlings and saplings predictive of later stages include *Schefflera digitata*, *Melicytus ramiflorus*, *Carpodetus serratus*, rata, and kamahi (all below 700 m), *Griselinia littoralis* and *Olearia ilicifolia*.

There are many associated species, mostly characteristic of immature soils, but only *Hypolepis millefolium*, *Blechnum penna-marina*, *Viola* sp., *Pseudopanax colensoi*, *Dracophyllum longifolium*, *Senecio wairauensis*, *Olearia avicenniaefolia*, *O. nummulariifolia*, *Gnaphalium audax*, *Hebe subalpina*, *Parahebe lyallii*, *Phormium cookianum*, *Notodanthonia setifolia*, and *Agrostis canina* were listed from more than 1 of the 10 described stands.

(b) *Coriaria arborea scrub* (Fig. 17)

Coriaria arborea dominates the shrub phase below 700 m where there is plenty of water percolating through the substratum of coarse fans, rock falls, and narrow moraine terraces. Banks of river silt can also support a *Coriaria* phase. *Coriaria* enters early, and by 14 years can form dense scrub 5.5 m tall. There are other pioneer shrubs, especially *Hebe salicifolia*, as well as *Coprosma rugosa*, *Carmichaelia* cf. *grandiflora*, and *Olearia avicenniaefolia*. Taller scrub has a well-developed layer of saplings of *Aristotelia serrata*, *Griselinia littoralis*, and less abundantly, *Schefflera digitata*, *Olearia arborescens*, and *Coprosma lucida*. Scattered saplings of kamahi and rata occur where the understorey is not too dense. A stand 44 years old transitional to *Schlefflera* forest (D2a) has *Aristotelia serrata* in the 7.5 m canopy, with *Coriaria arborea* and *Schefflera digitata* beneath to 4.5 m.

The herb layer is usually sparse, consisting mainly of *Blechnum capense "procerum"*, *Chionochloa conspicua*, and, more locally, *Polystichum vestitum*, *Blechnum fluviatile*, and *Asplenium bulbiferum*. *Phymatosorus diversifolius* and *Uncinia* sp. are also constant.

4. Dracophyllum–Olearia scrub

(a) *Tall climax subalpine scrub* (Fig. 18)

This low-canopied, dense vegetation is mainly in the heads of the mountain valleys where it occurs

Fig. 17 *Coriaria arborea* scrub (E3b) on the fan of Thirsty Creek.

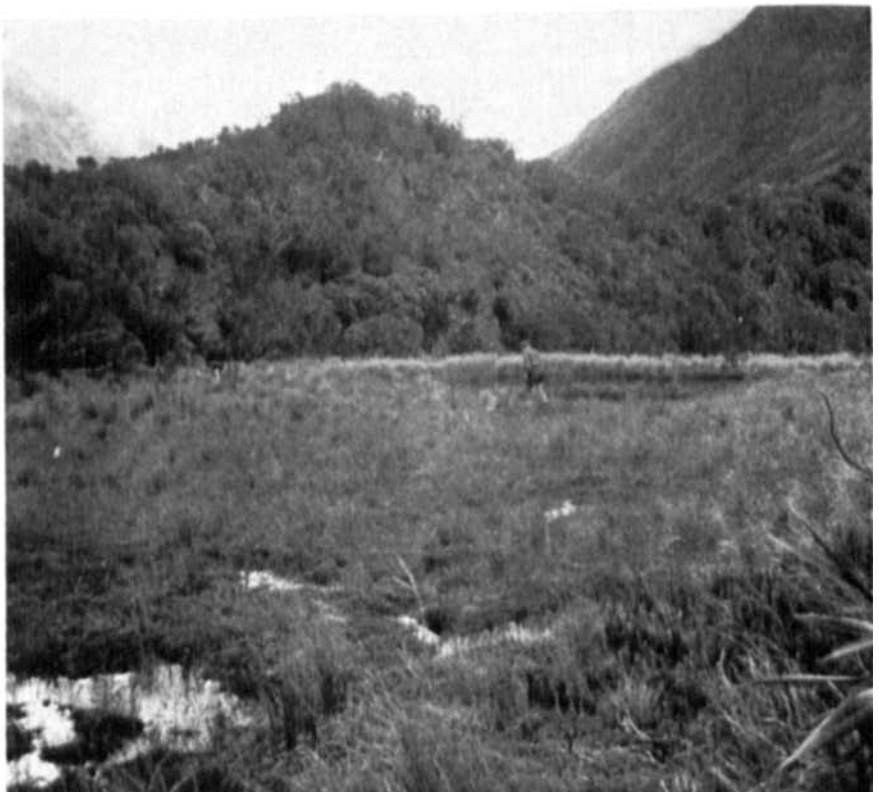

Fig. 18 Climax *Dracophyllum–Olearia* scrub (E4a) on an old moraine of the La Perouse Glacier, with *Carex gaudichaudiana–Sphagnum* bog (K4b) in the foreground.

Fig. 19 Interior of *Dracophyllum–Olearia* scrub dominated by *O. colensoi* (E4a) on Alex Knob. *Astelia nervosa* is conspicuous in the understorey.

with its low forest equivalent (D3b) on the lower slopes and old moraines between 750 m and 1 050 m, intervening between the valley-flat grasslands, and the grass and low shrub vegetation of the higher slopes. It also forms a belt above rata–*Libocedrus* forest on spurs in the lower valley reaches. Its stature is usually only 3.5–4.5 m, but the larger woody plants have thick gnarled trunks. Soils are mostly moderately deep and weathered, with up to 8 cm of peaty humus overlying a well developed A_1 horizon.

The canopy is largely *Dracophyllum traversii, D. longifolium,* and *Olearia lacunosa. Myrsine divaricata, Coprosma pseudocuneata,* and (except in severely browse-damaged stands) *Pseudopanax colensoi* form a sub-canopy and fill gaps. Other species usually present in these tiers, and sometimes rising to co-dominance, are *Griselinia littoralis, Pseudopanax simplex, Senecio bennettii,* and *Olearia colensoi.* The proportions of the dominant species vary according to site, as follows:

(i) On very well drained sites with shallow soils, *Dracophyllum longifolium* is strongly dominant, and *Olearia lacunosa* scarce or absent.

(ii) On deep, moist soils on sheltered sites on talus fans, *Olearia lacunosa* tends to dominate, and *Dracophyllum longifolium* tends to disappear.

(iii) On the outer ranges (Mt Fox, Alex Knob, Copland Range), *Olearia colensoi* becomes the most abundant shrub, forming either an understorey to the taller species, or the main canopy from which species such as *Dracophyllum traversii* project (Fig. 19). In Architects Creek there is a stand dominated by *Olearia colensoi* on a bench at only 670 m.

Libocedrus bidwillii occurs sparsely and locally, but because of its height is conspicuous where present. It occurs mainly at the lower altitudes, but ascends to 1 050 m on steep north-facing spurs. At the heads of the Karangarua and Douglas Rivers, *Phyllocladus alpinus* is locally abundant. *Dacrydium biforme* is abundant in two stands at 900 m, which are otherwise transitional to B6; one is on a gley podzol overlain by 35 cm of peat, and the other is on shallow soil over solid rock.

The ground vegetation is sparse, except in gaps, and consists of *Blechnum capense* "subalpine", *Astelia nervosa,* and *Phormium cookianum. Polystichum vestitum* and *Coprosma depressa* are also often present.

Other species: *Hymenophyllum multifidum, Grammitis billardieri, Podocarpus nivalis, P. nivalis* × *hallii, Pittosporum crassicaule, Coprosma wallii, C. serru-*

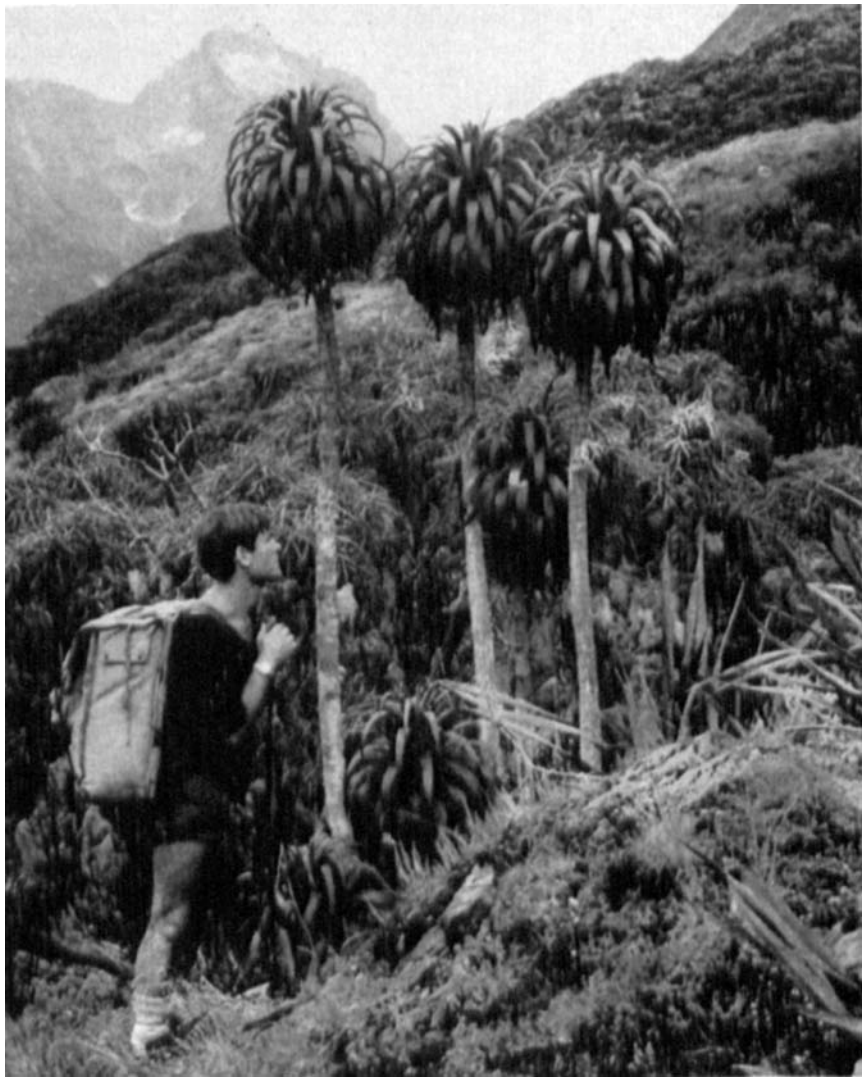

Fig. 20 High-altitude *Dracophyllum–Olearia* scrub (E4c), showing *D. fiordense* and *O. lacunosa*. Between Christmas Flat and Twain Col.

lata, C. astonii, Uncinia angustifolia, Chionochloa conspicua, and *Pterostylis venosa*. The following low-growing species enter into stands modified by browsing; *Blechnum penna-marina, Cotula squalida, Pratia angulata, Luzula picta, Scirpus habrus, Poa breviglumis,* and *Deyeuxia aucklandica*.

(b) *Seral Dracophyllum longifolium scrub*

On upland moraines formed during the seventeenth and eighteenth centuries scrub dominated by *Coprosma rugosa, Dracophyllum longifolium,* and *Olearia avicenniaefolia* has developed into near-climax scrub dominated by *D. longifolium*. This is similar to community 4ai, but because of the porous immature soils *Dracophyllum traversii* is confined to sheltered hollows and *Olearia lacunosa* is absent. Other species reflecting the successional nature of this community are *Aristotelia fruticosa, Epilobium chlorifolium, Olearia nummularifolia, Coprosma rugosa,* and *Hebe subalpina*. Young rata trees are beginning to overtop the scrub on seventeenth century moraines of the Balfour Glacier at 800 m.

(c) *High-altitude Dracophyllum–Olearia scrub*

Between 1 050 m and 1 200 m there is a high altitude attenuation of the *Dracophyllum–Olearia* community, reduced to as low as 2 m in height, and lacking *Libocedrus bidwillii, Pseudopanax simplex, P. linearis,* and *Myrsine divaricata*. In the Callery River headwaters, *Dracophyllum traversii* is absent, whereas from the Franz Josef Glacier southwards, it is replaced at the upper limit of the community by *D. fiordense* (Fig. 20). This scrub extends as fingers and patches on favoured sites into areas otherwise occupied by low-alpine scrub and *Chionochloa* grassland, and accordingly contains many species more typical of those communities, such as *Anisotome haastii, Aciphylla horrida, Dracophyllum uniflorum, Gentiana*

Fig. 21 Open shrubland of young *Carmichaelia* cf. *grandiflora* (F1a) below the Franz Josef Glacier. The surface was bare outwash in 1951, and the photograph was taken in 1967.

patula, Chionochloa cf. *flavescens, C. pallens, Microlaena colensoi,* and *Deyeuxia aucklandica.*

F. Low or discontinuous scrub

Diverse communities are included in this group. At lower altitudes they consist of open successional communities in which the shrubs are not yet tall or dense enough to constitute tall scrub. It also includes patches of low scrub in the subalpine and low-alpine zones.

1. Open seral shrubland on flat or rolling sites

These communities are mainly on fluvio-glacial deposits and tend to be drier than (2) below. Pioneer herbs dominate between the shrubs.

(a) *Open montane Carmichaelia shrubland* (Fig. 21)

Open shrubland is well developed on fluvio-glacial surfaces in the Fox and Waiho valleys at *c.* 20 years, after which it gradually attains the tall, dense scrub stage. Smaller areas occur on bouldery fans and landslide debris, up to 750 m. Precise composition varies according to exposure, distance from seed sources, and age. *Carmichaelia* cf. *grandiflora* up to 2 m tall is usually the most abundant shrub, varying in density from scattered bushes to nearly continuous cover, but *Olearia avicenniaefolia* is always present, and can be the dominant shrub. Other characteristic woody plants are *Olearia arborescens, Hebe salicifolia, Coprosma rugosa,* and *Coriaria arborea* (mainly on moist ground). Seedlings of kamahi and rata are usually present on bouldery areas. The commonest large herb is *Chionochloa conspicua.*

On dry exposed surfaces the ground cover consists mainly of *Rhacomitrium* spp., but *Raoulia tenuicaulis* and *Epilobium brunnescens* form extensive mats on sand and fine gravel. *Helichrysum bellidioides, Parahebe lyallii,* and, in sheltered areas, *Nertera ciliata* can be abundant.

Other frequent species: *Blechnum penna-marina, B. capense, B. fluviatile, Polystichum vestitum* (small plants), *Gunnera monoica, G. dentata, Coriaria plumosa, Epilobium glabellum, Griselinia littoralis* (seedlings), *Gaultheria rupestris, Olearia ilicifolia, Gnaphalium trinerve, Hypochoeris radicata*†, *Hebe subalpina, Luzula* sp., *Festuca matthewsii, Poa laevis, P. novae-zelandiae, Notodanthonia setifolia, N. gracilis,* and *Lachnagrostis lyallii.*

(b) *Open seral shrubland on recent subalpine moraines*

Succession is slower between 750 m and 1 050 m than at lower altitudes, with generally less than a tenth of the surface becoming covered by plants by 20 years. Above 950 m, tall tussock grassland or low subalpine scrub tend to become dominant eventually. The commonest young shrubs are *Carmichaelia* cf. *grandiflora*, *Dracophyllum longifolium*, *Coprosma rugosa*, and *Olearia moschata*. The main herbs are *Muehlenbeckia axillaris*, *Raoulia tenuicaulis*, *Parahebe lyallii*, and *Notodanthonia setifolia*.

Other frequent species: *Polystichum vestitum* (among boulders), *Blechnum penna-marina*, *Epilobium brunnescens*, *E. melanocaulon*, *Gaultheria rupestris* var. *parvifolia*, *Olearia ilicifolia*, *Celmisia coriacea*, *Helichrysum bellidioides*, *Hebe subalpina*, *Luzula* sp., *Uncinia divaricata*, *Chionochloa* cf. *flavescens*, *Festuca matthewsii*, and *Lachnagrostis lyallii*.

(c) *Open subalpine Coprosma shrubland*

At altitudes between 900 m and 1 100 m, *Coprosma rugosa* and associated tall shrubs on older moraine and talus tend to grow as a mosaic with low shrubs and tall herbs, especially *Polystichum vestitum*, *Hypolepis millefolium*, *Coprosma depressa*, *Celmisia coriacea*, *Poa cockayniana*, and *Chionochloa* cf. *flavescens*. Most of these species can form extensive colonies. *Coprosma rugosa* itself tends to be supplanted by *C. ciliata* as surfaces age further. Scattered trees and groves of *Hoheria glabrata* are usually present, marking a transition to *Hoheria* forest (D3a).

In many areas browse-tolerant turf has expanded at the expense of taller plants. Open shrubland dominated by *Coprosma rugosa* on the north side of the Douglas River between the Horace Walker and Douglas Glaciers has replaced more-mixed communities destroyed by fire in 1895.

2. Open shrubland on steep slips and talus

This develops on sites which are moister than moraine, because of more ground water, and because they are often narrow guts eroded from surrounding forest. The species vary greatly according to exposure, moisture, and altitude. *Hebe salicifolia* seedlings and *Blechnum capense* (especially the "*procerum*" form) are frequent at all altitudes. *Nertera ciliata* and sporelings or seedlings of *Cyathea smithii*, *Aristotelia serrata*, *Carpodetus serratus*, *Melicytus ramiflorus*, *Coprosma lucida*, and *C. foetidissima* are frequent below 600 m.

Towards the coast *Ascarina lucida* is common. Where sites are severe enough to reduce competition from fast-growing species, seedlings of kamahi and rata establish as pioneers, and lead to rata-kamahi forest. Other species locally prominent on low altitude slips include *Lycopodium scariosum*, *Blechnum fluviatile*, *Gaultheria rupestris*, and *Nertera* cf. *dichondraefolia*. Characteristic species above 450 m are *Hypolepis millefolium* (often dominant above 900 m), *Polystichum vestitum*, *Acaena anserinifolia*, *Coprosma rugosa*, *Phormium cookianum*, and *Poa cockayniana*.

These communities normally constitute a brief stage leading from early pioneer vegetation (H1) to tall scrub (E3) and thence to forest. Often, however, open slips are heavily used by browsing animals which destroy the more palatable shrubs and maintain dominance of browse-tolerant herbs (H4).

Other frequent species: *Griselinia littoralis* and *Pseudopanax colensoi* (widespread); *Coriaria arborea*, *Gunnera monoica*, *Metrosideros diffusa*, and *Hypochoeris radicata*† (mainly at low altitudes); *Epilobium brunnescens*, *Olearia arborescens*, *O. avicenniaefolia*, *O. ilicifolia*, *Cassinia vauvilliersii*, *Gnaphalium* spp., and *Pratia angulata* (mainly at higher altitudes).

3. Low subalpine scrub on recent soils

These communities grow at 950–1 200 m on coarse talus and rocky banks and terraces, as patches in a mosaic with bare areas, and grass- and herb-dominated vegetation on finer-textured soil. The main shrubs are 0.5–1 m tall. *Olearia moschata* is always present, and tends to dominate on the younger sites. *Hebe subalpina* can be dominant on moister soils, again on younger sites. *Podocarpus nivalis* dominates in later stages near the Main Divide and locally can retain its position on relatively mature soils, where the accompanying species are characteristic of climax scrub (E4) and scrub/grass mosaics (F4). Other common shrubs are *Aristotelia fruticosa*, *Hymenanthera alpina*, *Carmichaelia* cf. *grandiflora*, *Coprosma depressa*, *C. ciliata*, *Olearia ilicifolia*, and *O. nummulariifolia*. *Polystichum vestitum*, *Hypolepis millefolium*, and *Chionochloa pallens* are the main large herbs. Most of the low cover is provided by *Blechnum penna-marina*, *Helichrysum bellidioides*, *Poa laevis*, *P. colensoi*, and *Festuca matthewsii*.

Other species (the list could be extended by including plants of adjacent grassy margins and enclaves): *Muehlenbeckia axillaris*, *Viola cunninghamii*, *Epilobium chlorifolium*, *Geranium microphyllum*, *Stellaria parviflora*, *Oxalis lactea*, *Cardamine debilis*, *Acaena anserinifolia*, *Hoheria glabrata* (scattered stunted plants, or trees on moister sites), *Hydrocotyle "novae-zelandiae"*, *Coprosma rugosa*, *Celmisia walkeri*, *C. coriacea*, *Pratia angulata*, *Phormium cookianum*, *Uncinia divaricata*, *Chionochloa* cf. *flavescens*, *Trisetum antarcticum*, *T. youngii*, *Agrostis dyeri*, and *Notodanthonia setifolia*.

4. DRACOPHYLLUM–CHIONOCHLOA SCRUB/GRASS MOSAIC

This is described from eight stands growing on gley podzol soils. It is usually on flat or rolling surfaces, but occurs on slopes up to 40° that fall from gentler slopes above. It extends down to 750 m on valley-floor moraines, and up to 1 200 m. The mosaic has:

(i) tall shrubs (1–2 m), usually clumped in depressions and best developed at the lower altitudes; *Dracophyllum longifolium* is the most frequent.
(ii) low shrubs, chiefly *Dracophyllum uniflorum* 0.6–1.2 m tall and providing 3–40% cover.
(iii) tall tussocks; chiefly *Chionochloa* cf. *rigida*, providing cover from 10% to nearly 50%. *Phormium cookianum* is also important. Other large herbs listed from at least four stands are *Anisotome haastii*, *Celmisia coriacea*, *C. armstrongii*, and *Astelia nervosa*.
(iv) sub-shrubs; *Coprosma cheesemanii*, *C. serrulata*, and *Myrsine nummularia* are each in over half the stands.
(v) More-or-less continuous turf between the larger plants. *Schoenus pauciflorus* occurs in five stands, *Lycopodium fastigiatum*, *Oreobolus impar*, and *Aporostylis bifolia* in four, and the following in two or three: *Blechnum penna-marina*, *Gaultheria depressa*, *Pentachondra pumila*, *Coprosma pumila*, *Abrotanella linearis*, *Forstera sedifolia*, *Pratia angulata*, *Euphrasia zelandica*, *Carpha alpina*, and *Agrostis dyeri*. Most of these reflect the leached, poorly drained nature of the soils. Mosses, especially *Dicranoloma*, can also provide up to 20% cover.

Other species recorded at least twice are *Hymenophyllum multifidum*, *Blechnum capense* "subalpine", *Podocarpus nivalis*, *Phyllocladus alpinus*, *Ranunculus lyallii*, *Pittosporum crassicaule*, *Gentiana patula*, *Coprosma pseudocuneata* "erect", *Celmisia walkeri*, *Olearia colensoi*, *Hebe macrantha*, *H. odora*, and *Chionochloa pallens*.

5. ALPINE DRACOPHYLLUM SCRUB

This community is described from eight stands between 1 200 and 1 600 m. It is on steeper slopes than F4 (15–60°), and grows on all aspects below 1 300 m but only on north to west aspects above. Most of the sites are spurs with shallow soil which nevertheless shows much weathering.

The *Dracophyllum uniflorum* shrubs are 0.3–1.2 m tall, and usually provide between 30% and 100% cover, although they can be scattered in communities approaching grassland. Spaces between shrubs are filled by tussocks and large herbs. Compared with the *Dracophyllum–Chionochloa* mosaic, the florula lacks the species typical of poorly drained, leached soil, and to some extent reflects the generally higher altitudes. *Chionochloa* cf. *flavescens* occurs in seven stands, but is replaced in one by *C. pallens*. The following species were listed from at least four stands: *Ranunculus lyallii*, *Anisotome haastii*, *Coprosma serrulata*, *Celmisia coriacea*, *C. armstrongii*, *Pratia angulata*, *Astelia petriei*, *A. nervosa*, *Phormium cookianum*, *Microlaena colensoi*, and *Chionochloa pallens*.

The following occurred at least twice: *Hymenophyllum multifidum*, *Blechnum penna-marina*, *Polystichum vestitum*, *Oxalis lactea*, *Aciphylla horrida*, *Pseudopanax colensoi*, *Gaultheria rupestris* var. *parvifolia*, *Myrsine nummularia*, *Coprosma cheesemanii*, *Gentiana patula*, *G. bellidifolia*, *Olearia lacunosa*, *Celmisia vespertina*, *Hebe macrantha*, *Luzula picta*, *Uncinia divaricata*, *Schoenus pauciflorus*, *Poa colensoi*, *Agrostis dyeri*, *Hierochloe* sp., and *Chionochloa* cf. *rigida*.

G. Tall grassland and herbfield

Tall-tussock grassland dominated by species of *Chionochloa* forms one of the major vegetation units of Westland National Park. It is mostly subalpine or alpine, forming late-seral or climax stages, but small areas are found at montane altitudes, mainly in successional situations where there is severe temperature inversion. For convenience, communities of medium-sized grasses, ferns, and sub-shrubs are also included here. The only lowland tall grasslands are transient communities of *Cortaderia richardii* on riverine silt banks (*see* I2d), that are in the process of yielding dominance to shrubs, especially *Coriaria arborea* (G3b).

1. SERAL COMMUNITIES WITH TALL HERBS OR SEMI-WOODY PLANTS OTHER THAN SNOW-TUSSOCK PROMINENT

(a) *Tall herbaceous vegetation on alpine talus*

Subalpine seral communities on talus (F2), which have *Poa cockayniana* and *Hypolepis millefolium* as major species and are developing towards scrub or low forest, have an alpine equivalent between 1 050 and 1 300 m, which is developing towards *Chionochloa pallens* grasslands. The succession tends to be delayed by avalanche, erosion, and encroachment by rock debris, or to be deflected by grazing. *Poa cockayniana* is at first much more abundant than *Hypolepis*, providing up to 70% of the cover and there are young plants of *Chionochloa pallens* where grazing is not severe. Later, *C. pallens* and *Hypolepis* co-dominate and *Poa* becomes minor and eventually *C. pallens* excludes both other species (no time scale is available for this succession). Shrubs such as

Fig. 22 Extensive grassland of *Chionochloa pallens* (G2a-b) on old moraines of the Strauchan Glacier.

Coprosma rugosa and *Aristotelia fruticosa* grow among boulders.

In the Douglas Valley *Chionochloa* has been eliminated from these communities by grazing. Stony gullies tend to support dense communities of *Hypolepis millefolium*, and there are swards of *Poa cockayniana* on less sheltered slopes. Dead sticks show that these communities (especially the *Poa*) have partly replaced open shrubland containing *Dracophyllum uniflorum* and *Coprosma ciliata*. Browse-resistant species such as *Pratia angulata* and *Viola cunninghamii* persist and *Taraxacum magellanicum* is also present in the three described browsed stands.

Six stands substantially unaffected by browsing were described. The following species are present in at least two of them: *Polystichum vestitum*, *Blechnum penna-marina*, *Ranunculus lyallii*, *Acaena anserinifolia*, *Viola cunninghamii*, *Epilobium chlorifolium*, *Oxalis lactea*, *Hydrocotyle novae-zelandiae* var. *montana*, *Coprosma depressa*, *Galium perpusillum*, *Celmisia coriacea*, *Pratia angulata*, *Uncinia divaricata*, *Chionochloa* cf. *flavescens*, and *Poa colensoi*.

(b) *Subalpine Coriaria community*

At Flashing Creek in the Copland Valley, avalanches prevent scrub and low forest from developing on fans, and at 800 m there are quite extensive areas dominated mainly by *Coriaria plumosa*, *C. sarmentosa*, and their hybrid. Other important species are *Polystichum vestitum* (locally dominant on steep banks), *Acaena anserinifolia*, *Holcus lanatus*†, *Chionochloa conspicua*, and *Poa cockayniana* (locally dominant on the youngest sites). Shrubs such as *Hoheria glabrata* are mainly in the lee of large rocks, and their growth form is modified by the avalanches.

2. CHIONOCHLOA PALLENS GRASSLAND (Fig. 22)

(a) *Seral Chionochloa pallens grassland on moraine and alluvium*

This occurs between 750 and 1 250 m on surfaces deduced to have formed in the seventeenth and eighteenth centuries. It develops in hollows and flat areas with finer soil, forming a mosaic with other vegetation developing on rougher rises, usually scrub below 1 100 m and *Chionochloa* cf. *flavescens* grassland above. *Chionochloa pallens* provides 30–80% cover, and the main inter-tussock species is usually *Muehlenbeckia axillaris*. Other species which can be abundant are *Acaena anserinifolia*, *Celmisia walkeri*, *C. coriacea*, *Helichrysum bellidioides*, *Raoulia glabra*, *Notodanthonia setifolia*, *Poa cockayniana*, and *Festuca matthewsii*.

Fig. 23 *Chionochloa pallens* tussocks forming an open community over turfy species (G2c). Pioneer Peak.

Fig. 24 Solifluction terrace with open *Chionochloa pallens* grassland (G2c) on the slope and stony herbfield (H2b, approaching cushion fellfield I4a) on the tread. Pioneer Peak.

Other species in at least two stands are: *Lycopodium fastigiatum, Blechnum penna-marina, Ranunculus lyallii, Gaultheria rupestris* var. *parvifolia, Galium perpusillum, Coprosma depressa,* and *Lachnagrostis lyallii.*

(b) *Dense climax Chionochloa pallens grassland*

Extensive stands of climax *C. pallens* grassland occur between 950 and 1350 m, on generally southerly aspects with 10–35° slopes. Smaller stands extend to 1 550 m, among grassland that would otherwise be classed as (c) below. The soils are weakly weathered and usually developed on talus, but some stands are on moraines which are probably less than 370 years old.

The leaf cover of *C. pallens* is from 70 to 100%, with tussock bases covering 30–50%. Other plants are usually in minor quantities, but *Aciphylla crenulata* and *Pratia angulata* were recorded as 5% cover in one stand each and *Coprosma cheesemanii* as 30% in another. Further species, recorded in at least two stands, are *Ranunculus lyallii* (in nearly every stand), *Muehlenbeckia axillaris, Cardamine debilis, Anisotome aromatica, Coprosma depressa, Celmisia petiolata, Uncinia divaricata, Poa colensoi, Microlaena colensoi, Hierochloe* sp., and *Agrostis dyeri.*

(c) *Open Chionochloa pallens/turf* (Figs 23, 24)

This is a widespread community, which like (b) grows on freely drained sites with weakly-differen-

Fig. 25 *Celmisia walkeri* community (G3) with *Microlaena colensoi* important, between Christmas Flat and Twain Col.

tiated soil profiles. The altitudinal range (1 150–1 500 m) is generally higher than for dense *C. pallens* grassland, and the sites (spurs, ridges, stony shallow soils, and gullies where snow lies late) are more severe. The community tends to occupy south aspects below 1 300 m, and north to west aspects above. Leaf cover of *C. pallens* was estimated at 10–50%, and the tussocks are smaller than in (b). The ground between is covered by a close turf. Usually *Poa colensoi* is a major species, but *Schoenus pauciflorus* or *Coprosma pumila* can also be important throughout the altitudinal range. Mosses and lichens can also be abundant. Below 1 350 m *Celmisia petiolata*, *C. armstrongii*, or *Microlaena colensoi* are often prominent, and above 1 300 m *Celmisia sessiliflora*, *C. vespertina*, *Raoulia grandiflora*, or *Astelia nivicola* likewise. On a ridge crest with podzolised soil at 1 325 m *Lycopodium fastigiatum*, *Cyathodes pumila*, and *Pentachondra pumila* form most of the turf, representing an approach to G6.

Other species (recorded in at least three stands): Widespread—*Ranunculus lyallii* (as reduced plants), *Caltha novae-zelandiae*, *Muehlenbeckia axillaris*, *Anisotome aromatica* and *A. flexuosa* (the latter at higher altitudes), *Aciphylla crenulata*, *Gentiana bellidifolia*, *Senecio scorzoneroides*, *Helichrysum bellidioides*, and *Uncinia* (*divaricata* and related spp.). Up to 1 350 m—*Gaultheria depressa*, *Dracophyllum uniflorum*, *Celmisia petiolata*, *C. walkeri*, and *C. coriacea*. Above 1 350 m—*Celmisia haastii*.

(d) *High-alpine variant of* (c)

The highest stand of continuous vegetation seen in the Park is at 1 983 m, on the 60–70° north slope of Mt Moltke. *Chionochloa* cf. *flavescens*, which dominates similar sites at lower altitudes, grows only as scattered tussocks among *Poa colensoi* on less-stable areas in small gullies. Otherwise, there is a mosaic of *Chionochloa pallens* (mainly in the gullies), with *Celmisia vespertina*, *Hebe ciliolata*, *H. treadwellii*, *Coprosma pumila*, and *Poa colensoi* (mainly on small ridges). Nineteen vascular species were listed from the mosaic.

3. CELMISIA WALKERI COMMUNITY (Fig. 25)

This was described between 1 100 and 1 350 m. It replaces *Chionochloa pallens* grassland on stable talus where angular stones predominate at the surface, and in places covers extensive areas of steep slopes. At the lower altitudes it grades into low scrub (F3) on rockier sites. Two of the stands are fairly unmodified, and in these *Chionochloa pallens* provides 10–20% of the total cover. In the other two the snow-tussocks have been eaten out (though seedlings or tillers are present in one), and replaced by browse turf species, especially *Poa colensoi*, *Helichrysum bellidioides*, and on the tops of rocks, *Notodanthonia setifolia*.

Species listed from at least half of the stands are *Lycopodium fastigiatum*, *Ranunculus lyallii*, *Muehlenbeckia axillaris*, *Gaultheria depressa*, *Myrsine nummularia*, *Coprosma depressa*, *C. pumila*, *Gentiana bellidifolia*, *Helichrysum bellidioides*, *Celmisia vespertina*, *C. petiolata*, *Wahlenbergia pygmaea*, *Luzula crinita*, *Uncinia divaricata*, *Poa colensoi*, *Chionochloa pallens*, *Notodanthonia setifolia*, *Agrostis dyeri*, and *Microlaena colensoi*. *Dracophyllum menziesii*, which in the Park is almost restricted to the Karangarua catchment, also belongs mainly in this community.

Fig. 26 *Chionochloa* cf. *flavescens* growing with large herbs including *Celmisia coriacea*, *Aciphylla horrida*, and *Ranunculus lyallii* on talus in the Copland Valley (G4a).

4. CHIONOCHLOA CF. FLAVESCENS GRASSLAND

Broad-leaved snow-tussock dominates where soils are immature, either because of the stage of succession or because the slope is so steep that the soil does not attain maturity.

(a) *Seral C. cf. flavescens communities* (Fig. 26)

These occur on moraine and talus at 1 000–1 250 m. The lowest stand, described in the upper reaches of the Copland Valley, occupies a fan where it has replaced burnt scrub, via a phase during which *Hebe subalpina* was abundant. At 1 100 m in McKenna Creek broad-leaved snow-tussock dominates ridges of talus in an area otherwise occupied by *Hypolepis millefolium*, *Polystichum vestitum*, and *Poa cockayniana* (G1a). The community is well established on a moraine of the Callery Glacier formed before 1875 at 1 100 m, of the Burton Glacier formed before 1891 at 1 150–1 200 m, and of the Fritz Glacier at 1 250 m, following a low open herbfield stage on rather unstable ground (I2c). In this role this tussock stands in for the successional scrub of lower altitudes, as *Chionochloa pallens* does in hollows with fine soil (*see* G2a).

In these successional communities *Chionochloa* cf. *flavescens* provides a cover of up to 50%, and *Celmisia coriacea* is usually also abundant. The only other species noted as providing substantial cover are *Coprosma rugosa*, *C. depressa*, *Olearia moschata*, *Chionochloa pallens*, *Poa colensoi*, and in a very young stand, *Coriaria plumosa*, *Notodanthonia setifolia*, and *Uncinia divaricata*. Also, *Ranunculus lyallii*, *Muehlenbeckia axillaris*, *Dracophyllum uniflorum*, *Helichrysum bellidioides*, and *Festuca matthewsii* were listed from at least two stands.

(b) *C. cf. flavescens communities on steep slopes*

The very steep slopes which support this facies of *C.* cf. *flavescens* grassland range from 40 to 80°, all face north, and are at higher altitudes than the seral stands. On Mt Spencer at 1 280 m, the community is confined to the depressions between steep spurs carrying *Dracophyllum uniflorum* scrub, and contains the same dominant species as the latter, differing mainly in that *D. uniflorum* is less abundant than *C.* cf. *flavescens*, *Celmisia coriacea*, and *Astelia nervosa*. In the three stands between 1 500 and 1 850 m the cover of *C.* cf. *flavescens* was recorded as only up to 20%,

most of the cover being provided by *Dracophyllum kirkii, Coprosma pumila,* and/or *Poa colensoi.* Additional species recorded in at least two stands are *Gingidium montanum, Gentiana divisa, Celmisia petiolata, C. vespertina, Hebe treadwellii, H. ciliolata, Astelia petriei,* and *Festuca matthewsii.*

5. Chionochloa cf. rigida grassland

Rolling areas with mature soils and presumably with grass-scrub mosaics were burnt in the 1890s near Christmas Flat and the Horace Walker confluence and probably at about the same time at the northern end of the Copland Range, all at altitudes between 900 and 1 200 m. The total species list is very similar to F4, but *Chionochloa* cf. *rigida* is generally clearly dominant, and the shrubs, which are mainly *Dracophyllum longifolium,* have grown up after the fires. In some areas heavy browsing has resulted in dead shrubs of *Dracophyllum uniflorum,* incised tracks in the erodable soil, and development of turf with, e.g., *Poa colensoi, Microlaena colensoi,* or *Pratia angulata.*

6. Chionochloa crassiuscula grassland

Chionochloa crassiuscula, the smallest of the snow-tussocks, was recorded as an important species of wet, leached soils between 950 and 1 700 m. Below 1 200 m it tends to replace *C.* cf. *rigida* and other dominants of the *Dracophyllum–Chionochloa* mosaic (F4) in deep, wet hollows and gullies, and in places where water is forced to the surface by solid rock 5–15 cm below the surface. At higher altitudes it forms a major vegetation type, occupying similar sites and also alpine gley podzol soils on gentle and moderate slopes which at lower altitudes would support *C.* cf. *rigida.*

Fifteen stands were described. *C. crassiuscula* clearly dominates nine of these with cover between 20 and 60%. The rest are transitional to other communities, namely the *Dracophyllum–Chionochloa* mosaic (F4), *Chionochloa pallens*/turf (G2c), bog with *Schoenus pauciflorus* and *Celmisia glandulosa* as important species, and bog dominated by *Astelia linearis.* All stands, however, are floristically related, and consist of an open cover of small tussocks with dense turf between.

Chionochloa crassiuscula is less palatable to browsing mammals than *C. pallens,* and the extent of its dominance has been less reduced, or perhaps even increased. One badly damaged area was nevertheless described on a slope on the north side of Twain Col at 1 500 m, where *C. crassiuscula* had recently been eaten right down, leaving the way open to dominance by *Poa colensoi* and species such as *Celmisia glandulosa* and *Gaultheria depressa.*

Dracophyllum uniflorum was recorded in eight stands and occurs up to 1 400 m; in this community it is stunted, often to less than 15 cm tall. Other species in at least eight stands are *Celmisia armstrongii* (up to 1 400 m), *Lycopodium fastigiatum, Gentiana bellidifolia, Coprosma pumila, Astelia linearis* var. *novae-zelandiae, Schoenus pauciflorus, Oreobolus impar, Chionochloa pallens,* and *Poa colensoi.* The following were listed from at least four stands: *Pentachondra pumila* and *Celmisia glandulosa* (up to 1 400 m), *Anisotome aromatica* and *A. flexuosa* (the latter at the higher altitudes), *Caltha novae-zelandiae, Gaultheria depressa, Celmisia vespertina, C. sessiliflora, Euphrasia zelandica, Astelia nivicola,* and *Microlaena colensoi.* The community is also a main habitat for *Phyllachne colensoi* and *Cyathodes pumila.*

H. Short grassland and herbfield

Continuous vegetation of sward- and turf-forming grasses and herbs is found from near sea level to the high-alpine belt. On valley flats such vegetation occurs where soil conditions and temperature inversion have delayed the succession to forest. On slopes to as high as the low-alpine belt, turfy vegetation results from destruction by browsing of taller vegetation, usually scrub or *Chionochloa* grassland. Only in the high-alpine zone do short grasslands and herbfields have a climax status.

1. Seral grasslands on valley flats and terraces

(a) *Lowland valley grassland* (Fig. 27)

Pioneer communities on alluvium are mostly succeeded by forest and scrub, but on many places, especially the wider flats, closed grassland develops at an early stage and resists invasion by woody plants for a long time, in some places for no less than 100 years. There is marginal invasion by forest, usually via an ecotone of small-leaved coprosmas (*C. rugosa, C. propinqua, C. rigida,* and *C.* cf. *parviflora*); *Olearia lineata* and *Carmichaelia arborea* are also characteristic plants of this ecotone.

In the valleys of the Waiho and Cook Rivers, and in the Karangarua valley up to Cassel Flat, adventive species dominate the grassland, the main ones being *Holcus lanatus*† and *Anthoxanthum odoratum*†. *Hypochoeris radicata*† and *Lotus pedunculatus*† are also abundant. Native species are in three categories:

(i) Shrubs and young trees; *Coprosma propinqua* is the most abundant, followed by *Podocarpus totara.*

(ii) Tussocks can provide over half the cover; e.g., *Juncus gregiflorus, Carex testacea, Uncinia egmontiana,* and *Poa laevis.*

(iii) Small native herbs provide an extensive turf,

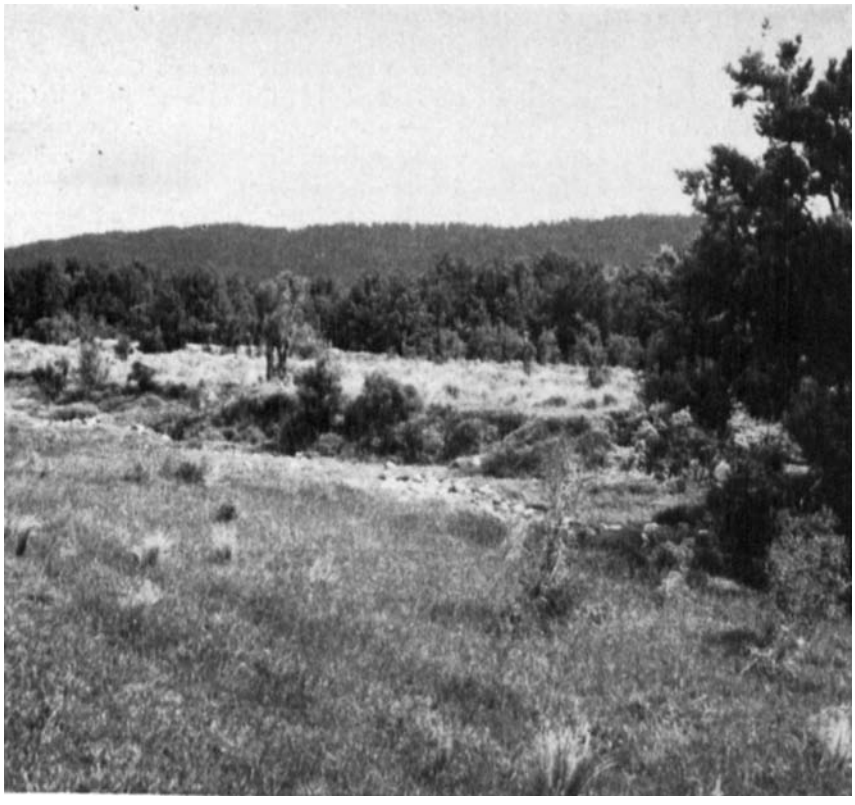

Fig. 27 Lowland grassland of native tussocks and adventive sward species (H1a) in the Cook Valley. Seral forest (D1a) with Westland totara prominent in middle distance.

which becomes more conspicuous when the summer-green adventives die down. Common species include *Blechnum penna-marina*, *Galium perpusillum*, *Hydrocotyle novae-zelandiae* var. *montana*, *Cotula squalida*, *Lagenifera petiolata*, and *Pratia angulata*. In the younger stands, species characteristic of pioneer vegetation (I2) are also important, e.g., *Muehlenbeckia axillaris*, *Gunnera dentata*, and *Coprosma brunnea*.

Because the grassy flats are derived from braided river beds there are damp channels containing other species, major ones being *Schoenus nitens* and *Hydrocotyle tripartita*, together with *Eleocharis acuta* and *Juncus articulatus*† in semi-permanent pools. On damp, silty areas grasses share dominance with summergreen rhizomatous sedges (especially *Carex coriacea*), and tall rushes such as *Juncus gregiflorus* and *J. effusus*† can be common (cf. K1).

Altogether about 80 species were recorded from stands of the mosaic, the more common additional ones being *Haloragis depressa*, *Cerastium holosteoides*†, *Trifolium dubium*†, *Pimelea prostrata*, *Pernettya macrostigma*, *Cyathodes fraseri*, *Plantago lanceolata*†, *Leontodon taraxacoides*†, *Helichrysum filicaule*, *Mazus radicans*, *Prunella vulgaris*†, *Luzula congesta*†, *Festuca matthewsii*, and *F. rubra*†. More mesophytic or semi-aquatic species include *Ranunculus repens*†, *Potentilla anserinoides*, *Galium palustre*†, *Stellaria graminea*†, *Centella uniflora*, *Plantago triandra*, *Myosotis caespitosa*†, *Veronica serpyllifolia*†, *Sisyrhyncium "chilense"*†, *Carex flaviformis*, and *Glyceria fluitans*†.

Below the Franz Josef Glacier the stony outwash flats have generally developed scrub, but there are grassy enclaves, some known to have persisted for 60 years. The stoniness leads to a greater proportion of woody plants, including *Olearia avicenniaefolia* and the sub-shrubs *Coprosma brunnea*, and in earlier stages, *Parahebe lyallii*. For the altitude (200 m) there is a well-developed upland component including *Geum parviflorum*, *Coriaria plumosa*, *Gingidium montanum*, *Dracophyllum longifolium*, *Celmisia coriacea*, *Parahebe linifolia*, *Hebe subalpina*, *Chionochloa conspicua*, and *C.* cf. *flavescens*, while the dominant tussock grass is *Poa cockayniana* instead of *P. laevis*. These species reflect both more severe frosts and nearby seed sources.

(b) *Mid-altitude grassy flats* (Fig. 28)

There are several extensive grass flats in the Karangarua River system, ranging in altitude from Welcome Flat (450 m) to Christmas Flat (750 m). On these, introduced grasses are less abundant, probably because there has been little or no grazing by stock. However, *Cerastium holosteoides*†, *Hypochoeris radicata*†, *Holcus lanatus*†, and *Agrostis tenuis*† and about four other exotics were recorded. The native grasses

Fig. 28 Grassy flat at 550 m (H1b). Architects Creek.

Poa cockayniana, P. colensoi, Festuca matthewsii, Notodanthonia gracilis, Lachnagrostis lyallii and, locally, *Agropyron scabrum* or *Cockaynea gracilis*, dominate in various proportions. There is considerable development of turfy species, partly a result of grazing by feral animals. The main ones are *Muehlenbeckia axillaris, Viola cunninghamii, Hydrocotyle novae-zelandiae* var. *montana, Schizeilema nitens* (especially in old channels), *Cotula squalida*, and *Pratia angulata*.

In scrub clumps *Coprosma rugosa* is the usual species, but *Olearia avicenniaefolia* and *Coprosma propinqua* are abundant at Welcome Flat, whereas *Aristotelia fruticosa* and *Hoheria glabrata* occur on higher flats. Tussocky uncinias (*U. affinis* and *U. egmontiana*) tend to be only near and within scrub clumps. Because of sharper topography (i.e., the terraces are higher than on the lower river flats) channel communities are not so distinct, although on stream banks subject to flooding and erosion there can be mesic communities with, e.g., *Gunnera dentata, Plantago raoulii, Poa cockayniana*, and *Lachnagrostis richardii*, as well as *Coprosma rugosa*.

Other species include *Ranunculus lappaceus, Epilobium alsinoides, Acaena anserinoides, Oreomyrrhis ramosa, Helichrysum filicaule*, and *Wahlenbergia pygmaea*, and to as high as Welcome Flat, *Pimelea prostrata, Cyathodes fraseri, Coprosma brunnea*, and *Carex testacea*.

2. HIGH-ALPINE SHORT GRASSLAND AND HERBFIELD

(a) *Chionochloa oreophila–Poa colensoi grassland*

This ranges from 1 300 m to 1 850 m with isolated patches to as high as 1 914 m (Craig Peak), generally on slopes of 15° or less. The lower occurrences are on south aspects, on flattish ground or in hollows where snow lies late, whereas the highest occurrences are on north and west aspects. The proportions of the two dominants, *Chionochloa oreophila* and *Poa colensoi*, vary with either rising to 80 or 90% cover. Though the basis for this is not clear, it seems that *C. oreophila* tolerates neither as much nor as little snow as *P. colensoi*, and is mainly on deeper, more weathered soils.

Marsippospermum gracile was recorded from half the stands, generally those dominated by *C. oreophila*, and itself tending to rise to co-dominance on the steepest parts of rolling surfaces. The ground occupied by the community tends to be hummocky and in several places well-defined solifluction steps were described. On these, low herbfield tends to grow on the flat treads, *C. oreophila* and *Marsippospermum* co-dominate on the steep risers, and turf grassland occupies gently sloping ground below the risers.

Only two other species, *Anisotome flexuosa* and *Celmisia haastii*, are in at least half of the stands. Species recorded from at least three stands are *Lycopodium fastigiatum* (below 1500 m), *Drapetes lyallii, Celmisia sessiliflora, C. vespertina, Raoulia grandiflora, Euphrasia* (probably both *zelandica* and *revoluta*), *Microlaena colensoi*, and *Carex pyrenaica* (rising to co-dominance with *Poa colensoi* in the deeper hollows). In places where there is erosion or deposition, species from unstable fellfield enter, e.g., *Luzula crinita* and *Agrostis magellanica*. Occasionally there are stunted plants of *Chionochloa pallens*, marking a gradation to taller grassland dominated by this species (G2).

Fig. 29 Extensive area of induced *Poa colensoi* grassland (H3) between Christmas Flat and Twain Col.

(b) *Short alpine herbfield*

This vegetation was described from 14 stands (plus several partial descriptions) between 1 500 and 1 750 m. It grows on all aspects, mainly on slopes of 15° or less, but also on short steep banks on rolling country influenced by solifluction. The communities are fragmentary, usually replacing turfy grassland on knolls and ridges where soils are shallow and stony, but patches also occur in fellfield where the soil is finer or more stable. Vascular plant cover varies from 40 to 100%, the remainder consisting of loose or anchored stones, or soil covered with mosses (normally *Rhacomitrium lanuginosum*) or soil-encrusting lichens.

The following species were recorded as dominant in different stands: *Celmisia sessiliflora* (in four stands), *Marsippospermum gracile* and *Poa colensoi* (each in two stands), *Pernettya alpina*, *Coprosma pumila*, and *Raoulia grandiflora* (each one stand). Also, *Anisotome flexuosa*, *A. imbricata*, *Cotula pectinata* subsp. *willcoxii*, *Carex pyrenaica*, and *Chionochloa oreophila* were recorded as sharing dominance. This variation in dominance is more likely to be related to the small areas of the communities and the dense, mat-forming habit of most of the main species, rather than to habitat variations.

The following additional species were listed from at least three stands: *Lycopodium fastigiatum*, *Hectorella caespitosa*, *Caltha novae-zelandiae*, *Drapetes lyallii*, *Gentiana patula*, *G. bellidifolia*, *Celmisia vespertina*, *C. du-rietzii*, *C. haastii*, *Raoulia grandiflora*, *Phyllachne colensoi*, *Forstera* cf. *sedifolia* "A", *Euphrasia* (probably usually *revoluta*), and *Luzula* (including *pumila* and *colensoi*).

The list is similar to 2a above, but contains species from stable fellfield.

3. INDUCED POA COLENSOI GRASSLAND (Fig. 29)

Large areas of *Poa colensoi*-dominated grassland in the Douglas Valley and upper reaches of the Karangarua Valley, occurring between 1 050 and 1 300 m on south aspects on stabilised talus slopes, have been derived from *Chionochloa pallens* grassland (G2b-c) through browsing by deer, chamois, and thar. Most stands contain small plants of *C. pallens*. In 1968 these plants were scarcely visible, but by 1973 a remarkable recovery was underway, with tussocks often redeveloping from a single surviving tiller.

On stony ground *Celmisia walkeri* is abundant, and on progressively stonier sites there is a gradation towards communities dominated by this species (G3). *Lycopodium fastigiatum*, *Helichrysum bellidioides*, and *Microlaena colensoi* are also important. Other species found in most stands are *Hydrocotyle novae-zelandiae* var. *montana*, *Luzula crinita*, and *Uncinia divaricata*. On a spur north of Christmas Flat the turf grassland at 1 050 m has replaced *Chionochloa pallens* which itself may have replaced the upper fringes of the subalpine scrub since the area was burnt by A. P. Harper in 1894. At present there are young plants of *Olearia ilicifolia* and *O. lacunosa* in the grassland. Where induced turf grassland has developed from seral *Chionochloa pallens* communities (e.g., on high lateral moraines of the Douglas Glacier), *Notodanthonia setifolia* is also important, and in places co-dominant. *Poa colensoi* grassland also occurs on flats

at 900 m at the confluence of the Horace Walker and Douglas Rivers, and at present (1975) *Chionochloa pallens* is increasing rapidly.

The following were recorded in at least two stands: *Senecio scorzoneroides* and *Ranunculus lyallii* (scattered, small plants, but probably now increasing), *Lycopodium fastigiatum, Polystichum vestitum, Geranium microphyllum, Epilobium brunnescens, Anisotome aromatica, A. flexuosa, Oreomyrrhis colensoi, Coprosma pumila, C. cheesemanii, C. depressa, Celmisia haastii, C. petiolata, C. armstrongii, C. vespertina, Cotula squalida, Pratia angulata, Wahlenbergia pygmaea, Euphrasia zelandica, Marsippospermum gracile, Poa cockayniana, P. breviglumis, Festuca matthewsii, Agrostis canina, A. dyeri,* and *Lachnagrostis lyallii.*

4. Browse turf derived from shrubby vegetation

(a) *Derived from seral vegetation*

Browsing pressure is often intense on young vegetation on immature soils at 250–1 000 m. On fans, slips, and narrow terraces which would normally succeed quickly from herbaceous vegetation to dense scrub or young forest, a turf of browse-resistant and browse-tolerant species characteristic of valley grassland persists indefinitely, between clumps of scrub which predate the animals or which have grown up despite them.

The most abundant species is usually *Cotula squalida,* and others which can co-dominate are *Muehlenbeckia axillaris, Galium perpusillum, Nertera depressa, Helichrysum bellidioides, Pratia angulata,* and *Notodanthonia gracilis.* At one site, *Gunnera monoica, Epilobium brunnescens, Raoulia glabra,* and *R. tenuicaulis* were also listed as abundant.

Coprosma rugosa is usually the commonest shrub, but below 450 m young plants of the more browse-resistant species of lowland seral forest are also present, especially *Carpodetus serratus.* At higher altitudes seedlings of *Olearia ilicifolia* tend to increase with browsing and develop into thickets. Colonies of *Histiopteris incisa* and *Paesia scaberula* also develop on browsed slips. On steep slips below 450 m there are tussocks of *Uncinia uncinata, Carex cockayniana, Cortaderia richardii,* and *Chionochloa conspicua* as well as browse turf.

(b) *Browse turf resulting from degradation of alpine scrub* (Fig. 30)

Two stands were described at 1 050 and 1 150 m on Pioneer Peak, where *Dracophyllum uniflorum* has been killed by thar, and *Chionochloa* cf. *rigida* is recovering from chewed-down bases. Other *Chionochloa* species and large herbs are absent, possibly as a result of grazing. Scattered tall plants of *Dracophyllum longifolium* and *Olearia lacunosa* may indicate that the low scrub itself results from Harper's fire of 1894. The ground surface is eroding, and dominated by mat-forming species, the following being important at one or both sites: *Hymenophyllum multifidum, Acaena anserinifolia, Hydrocotyle novaezelandiae* var. *montana, Pratia angulata, Poa cockayniana,* and *Agrostis canina.* Similar degraded sites occur widely in the Douglas valley and adjacent part of the Karangarua valley.

I. Short, open herbaceous vegetation

Primary successions begin with scattered small herbaceous plants, together with seedlings of shrubs at the lower altitudes. In the high-alpine belt there are also low, open plant communities which are climax in nature.

1. Pioneer vegetation on lowland and subalpine slips

Landslides frequently expose underlying weathering parent material on steep slopes. These sites appear more mesic and fertile than other new surfaces, and succession is very rapid, so that the pioneer phase is transient and shrubland soon develops. Even within a few weeks of the landslide, seedlings of woody plants appear, especially those of *Aristotelia serrata* at low altitudes. A steep (45°) slip at 350 m in the Waikukupa valley provides a more severe site. When the plant cover comprised *c.* 50% mosses and lichens and 5% vascular species, the main vascular plant was *Luzula picta.* Seedlings of fast-growing woody plants were patchily distributed, allowing seedlings of rata and kamahi to enter.

On landslide talus at Douglas Rock (750 m) the cover after 2 years was *c.* 10%, but there were at least 48 vascular species, including herbaceous pioneers such as *Cardamine debilis, Gnaphalium luteoalbum, Epilobium brunnescens,* and *Luzula picta,* species which had been in the destroyed montane forest such as *Hoheria glabrata, Phormium cookianum,* and *Muehlenbeckia australis,* as well as species characteristic of other communities. By 7 years the predominant vegetation was open shrubland dominated by *Carmichaelia* cf. *grandiflora* (Fla), with denser, more mixed scrub (E3a) already developed in hollows (Fig. 31).

2. Pioneer Raoulia communities

(a) *Lowland Raoulia community*

This is described from sites below 200 m, on fluvial or fluvio-glacial gravels. The plant cover is incom-

Fig. 30 *Dracophyllum uniflorum* scrub (F5) being degraded to turf (H4b) by browsing. Between Twain Col and the Douglas Glacier terminal.

plete (10–80%), and liable to flooding and, often, complete destruction. *Raoulia tenuicaulis* is the main species, and *Epilobium brunnescens* is always present. *Epilobium glabellum, Raoulia hookeri, Uncinia divaricata, Lachnagrostis lyallii,* and *Poa laevis* or *P. cockayniana* are present at most sites. Lichens and the moss *Rhacomitrium crispulum* are also important.

Seedlings of shrubs are always present, especially *Carmichaelia* cf. *grandiflora* (the commonest and most vigorous), *Olearia avicenniaefolia, O. arborescens, Coriaria arborea, Hebe salicifolia,* and *Aristotelia serrata.* In the valleys of the Fox and Franz Josef Glaciers these can be abundant enough to lead towards communities E2 and F1, although on many sites the *Carmichaelia* dies out after a few years (presumably because porosity of the gravel causes drought) and succession deflects towards grassland. On more-open river valleys the pioneers tend to be succeeded by herbaceous species, and grassland develops more directly.

Some 82 species were listed from 5 stands, most of them only once. Most occur also in valley grassland (H1), but others are characteristic of other communities; e.g., there can be seedlings of forest species including kamahi, and sporelings of *Dicksonia squarrosa* which presumably would not persist. The following species were *not* recorded from neighbouring related communities at later successional stages: *Oxalis lactea, Gentiana* sp., *Ourisia caespitosa,* and *Poa novae-zelandiae,* which are normally found at higher altitudes; *Carmichaelia nigrans, Epilobium microphyllum, Nertera ciliata, Gnaphalium luteo-album, Vulpia myuros*†, and *Aira caryophyllea*† (all pioneers); *Gnaphalium trinerve* (a plant of cliffs); and *Cuscuta epiphthymum*† and *Parentucella viscosa*†, which are parasites.

(b) *Upland Raoulia communities*

Raoulia communities similar to (a) occur on alluvium and fine moraine between 200 and 900 m, although on moraine the shrub component soon becomes conspicuous, so that the community fits F1 better. Also, only half as many species (48) were listed as in the valley flat communities, and the main ones are present in somewhat different proportions.

Fig. 31 Shrubland on a landslide (F2 rapidly developing into E3a) at Douglas Rock. *Hebe salicifolia* and *Olearia ilicifolia* are the most obvious species. The landslide occurred in 1968 and the photograph was taken in 1975.

Common herbs accompanying *R. tenuicaulis* include *R. glabra, Blechnum penna-marina, Muehlenbeckia axillaris, Epilobium brunnescens, Parahebe lyallii, Uncinia divaricata, Notodanthonia setifolia, Festuca matthewsii,* and *Lachnagrostis lyallii. Poa cockayniana* is important at only one of five sites. The usual shrub seedlings are those of *Coprosma rugosa* and *Dracophyllum longifolium. Carmichaelia grandiflora* is less abundant than at lower altitudes, possibly because of browsing.

The occurrence of scattered seedlings on surface moraine over ice of the Balfour (750 m) and La Perouse (900 m) Glaciers provides an unusual variant. The following species were listed: *Blechnum penna-marina, Epilobium glabellum, E. melanocaulon, E. brunnescens, Carmichaelia* cf. *grandiflora, Gaultheria rupestris, Olearia moschata, Raoulia tenuicaulis, Helichrysum bellidioides, Parahebe lyallii, Uncinia divaricata, Lachnagrostis lyallii, Notodanthonia setifolia, Agrostis canina,* and *Poa novae-zelandiae.*

(c) *Raoulia–Notodanthonia setifolia community*

This community is an upland continuation of (b) and connects it with seral alpine grassland (13a). It was described between 900 and 1 250 m. *Raoulia tenuicaulis* and/or *R. glabra* are present in all stands, but dominate only in the younger stages on the finer material. Elsewhere *Notodanthonia setifolia* is the most abundant species. As an indication of rate of colonisation, a moraine of the Horace Walker Glacier, probably *c.* 60 years old, had a plant cover of 80% (60% *N. setifolia*). Other species attaining co-dominance in places are *Festuca matthewsii, Poa colensoi, Hydrocotyle novae-zelandiae* var. *montana,* and *Wahlenbergia pygmaea. Rhacomitrium lanuginosum* and *R. ptychophyllum* are often important and on the flat below Fitzgerald Glacier provide most of the cover. There can be scattered shrubs at lower altitudes, especially of *Coprosma rugosa* and *Carmichaelia* cf. *grandiflora.* On moraine rises, succession is towards scrub, but this can be delayed by browsing.

In heavily browsed areas, such as the moraines of the Horace Walker Glacier, *Notodanthonia setifolia* can still be dominant in closed grass-scrub mosaics, on surfaces possibly 100 years old (cf. H3).

The following additional species were listed from at least two stands: *Cerastium holosteoides, Viola cunninghamii, Ranunculus lappaceus, Geum parviflorum, Epilobium brunnescens, Muehlenbeckia axillaris, Gingidium montanum, Galium perpusillum, Helichrysum bellidioides, Parahebe linifolia, Luzula crinita, Uncinia divaricata, Poa cockayniana, Chionochloa pallens, Lachnagrostis lyallii,* and *Agropyron scabrum* (Douglas Valley).

(d) *Lowland and montane silt banks*

These are a very minor habitat. Plant cover is more complete than at a corresponding stage on stony ground, and *Holcus lanatus*† and *Hypochoeris radicata*† tend to be more important than *Raoulia tenuicaulis*. Locally, there are areas dominated by *Cirsium arvense*† or *Cortaderia richardii*.

3. Alpine successional short grassland and herbfield

(a) *Alpine successional short grassland*

Successional grassland was described from 13 stands between 1 150 and 1 550 m on schist slabs, moraines, slips in *Chionochloa pallens* grassland, torrent beds, and active slips. Vascular plant cover varies from very sparse to 70% and on the more stable areas mosses and lichens also form up to 70% cover. *Notodanthonia setifolia* is dominant or co-dominant on 11 sites; *Poa colensoi, Coprosma pumila,* and *Anisotome flexuosa* each on 1 site. Only *Helichrysum bellidioides* (9 sites) and *N. setifolia* are on more than half the sites. The following occur on 3–5 sites: *Epilobium glabellum, Gaultheria depressa, Agrostis magellanica, Anisotome pilifera, A. flexuosa, Coprosma pumila, Leucogenes grandiceps, Cotula pectinata* subsp. *willcoxii, Wahlenbergia pygmaea, Forstera* cf. *sedifolia, Ourisia caespitosa, Luzula crinita, Marsippospermum gracile, Poa novae-zelandiae, P. colensoi, Microlaena colensoi.* On shallow slips in *Chionochloa pallens* grassland, young plants of *C. pallens* can be well established, indicating a return to climax grassland. A total of 74 vascular species was recorded from the community, however, and, as in other seral communities, includes chance species from a wide range of vegetation, especially fellfield (with which it merges at higher altitudes) and alpine grassland. There is also a scattering of shrubs such as *Dracophyllum menziesii, Olearia moschata,* and seedlings of *O. ilicifolia.* Typical pioneers include *Muehlenbeckia axillaris, Luzula banksiana,* and *Festuca matthewsii.*

On unstable moraine faces at the Callery and Fritz Glaciers, between 1 100 and 1 200 m, similar seral vegetation is developing towards *Chionochloa* cf. *flavescens* dominance. This community also occurs on an area of moraine or snow-avalanche debris at 1 000 m, and supports the following species at the lowest altitude recorded for them in the Park: *Hectorella caespitosa, Anisotome pilifera, Schizeilema haastii, Senecio scorzoneroides,* and *Ourisia caespitosa.*

This vegetation differs from fellfield in its potential for succession, but transitions were recorded on talus slopes at *c.* 1 300 m.

(b) *Alpine succession on slip sole*

This was described from one community at 1 200 m on a 30° slope at the southern end of the Copland Range. The topsoil had slipped off, leaving rocky subsoil supporting turf of *Gunnera monoica, Nertera depressa, Epilobium ?alsinoides,* and *Poa colensoi,* and young plants from neighbouring scrub and grassland, chiefly *Celmisia coriacea* (providing 20% of cover), *Hebe odora, Chionochloa* cf. *flavescens,* and *C.* cf. *rigida.*

4. Fellfield

At the highest altitudes supporting vascular plants the vegetation is kept open through climatic severity, and bare ground predominates. There are three distinct habitats which share many of the same species, but each is dominated by plants of different life-form: (a) cushion plants, (b) tufted plants, and (c) creeping plants forming loose mats respectively. In addition to the species given below for each community, the following were occasionally recorded in fellfield: *Polystichum cystostegia* (among boulders), *Ranunculus buchananii, Cardamine* "alpine", *Anisotome imbricata, Leucogenes grandiceps, Celmisia haastii, C. sessiliflora, C. du-rietzii, C. hectori, Cotula pectinata* subsp. *willcoxii, Forstera* cf. *sedifolia* "A", *Phyllachne colensoi, Pratia macrodon, Hebe ciliolata, Euphrasia revoluta, E. petriei, Notodanthonia setifolia, Chionochloa oreophila, Luzula colensoi,* and *Uncinia divaricata.*

(a) *Cushion plant community*

This occurs on stable gravelly or rubbly soil on crests of spurs and ridges, where there is less snow and water and therefore less solifluction. It was described between 1 600 and 2 050 m. At the lower altitudes it occurs on south aspects, but from 1 750 m it is only on north and west aspects, and occupies increasingly restricted areas. Plant cover is usually 1–5%, but can be up to 50%. The main species form dense cushions. *Colobanthus monticola* is in all eight stands described, but *Hectorella caespitosa* (five stands), *Pygmea ciliolata* and *Poa colensoi* (each six stands) provide most of the cover. Other species occurring in at least two stands are *Ranunculus sericophyllus, Drapetes lyallii, Anisotome flexuosa, Gentiana divisa, Raoulia grandiflora, R. subulata, Luzula petriei, Marsippospermum gracile, Carex pyrenaica, Poa novae-zelandiae,* and *Agrostis magellanica.*

Fig. 32 Mound of talus (I4b) below a persistent snow slope. Pioneer Peak.

(b) *Sparsely vegetated talus* (Figs 32, 33)

This is the most extensive high-alpine habitat, and consists of angular rock fragments subject to solifluction. Nine stands were described between 1 500 and 2 050 m but it can occur at lower altitudes, one nearly typical stand being described at 1 200 m in the head of the Callery River, in a deeply shaded valley only recently deglaciated. Species typical of the habitat also descend to 1 200 m on dry, rocky watercourses, together with species more characteristic of these lower altitudes. Plant cover is usually 1–5% but occasionally up to 40%, being greater where the talus is more stable, e.g., as a result of being anchored by large rocks. Slopes are between 10° and 35°, and occupy all aspects except at the highest altitudes, where plants are confined to north and west aspects.

The most frequent species are *Poa novae-zelandiae* and *Ranunculus sericophyllus*. The following are on at least three of the sites: *Claytonia australasica*, *Epilobium glabellum*, *Schizeilema haastii*, *Anisotome pilifera*, *Gentiana divisa*, *Senecio scorzoneroides*, *Luzula crinita*, *Marsippospermum gracile*, *Poa colensoi*, *Microlaena colensoi*, and *Agrostis magellanica*. *Colobanthus* (*monticola* and/or *canaliculatus*) and *Myosotis* (*suavis*, cf. *lyallii*, *pygmaea*) are also frequent. This is also the main habitat of *Ranunculus godleyanus*.

(c) *Snow hollows*

Flat to gently sloping (15°) hollows, where snow lies till January or later, provided six stand descriptions between 1 300 and 1 800 m. Plant cover is greater than in other fellfield communities; 30–50% vascular plants, and often a considerable cover of mosses and lichens as well. Cover is formed mainly of *Raoulia subulata* and *Carex pyrenaica*, and also *Ranunculus sericophyllus* which tends to dominate on less stable soils than the other two species. This community grades into communities of alpine flushes (K9). The following species were listed from at least two stands; *Colobanthus canaliculatus*, *Drapetes lyallii*, *Ourisia sessiliflora*, *Agrostis magellanica*.

J. Heath

Over large areas between the sea and the Alpine Fault, podzolisation and gleying have proceeded beyond the point where soils are fertile enough to support climax vegetation. The woody vegetation is stunted to various degrees, and consists mainly of slow-growing, microphyllous or cupressoid plants, mixed with wiry sedges and ferns in the shorter, more open shrublands. In the mountains similar vegetation grows on shallow, leached soils overlying glacially scoured bedrock.

1. Heath-forest

(a) *Piedmont heath-forest on wet ground* (Fig. 34).

Forest of small and stunted species, generally less than 10 m tall, but up to 12 m on the better sites, occupies flat, poorly drained ground on the piedmont moraines. The soils vary from deep, wet basin peats, to gley podzols with less than 25 cm of peat. The canopy is generally uneven, and dominance is shared among *Dacrydium colensoi*, *D. biforme*, *Phyllocladus alpinus*, and manuka. The first two tend to be emergents, with *D. colensoi* more abundant below *c.* 300 m and *D. biforme* more so at higher altitudes. Manuka, *Phyllocladus*, and saplings of the dacrydiums form a dense main canopy. There is usually a dense carpet of mosses, including *Sphagnum*, but otherwise the understorey is usually sparse, although *Empodisma minus* and *Gleichenia microphylla* can be abundant in stands marginal to bogs and mires.

This community grades towards A2b (rimu with silver pine) and, at least on Moana and post-glacial surfaces (Warren 1967), tends to be successional towards the latter, because it contains rimu saplings and poles.

Fig. 33 *Ranunculus sericophyllus* on a talus slope (I4b). Copland Pass.

Other species: *Dacrydium intermedium* (on sloping ground), stunted plants or saplings of *Podocarpus hallii, Weinmannia racemosa, Quintinia acutifolia, Metrosideros umbellata,* and *Elaeocarpus hookerianius; Lycopodium ramulosum, Gleichenia cunninghamii, Hymenophyllum multifidum, Blechnum capense "minus", Grammitis billardieri, Neomyrtus pedunculata, Pseudopanax simplex, P. colensoi, Cyathodes juniperina, Dracophyllum palustre, Coprosma colensoi, C. foetidissima, Libertia pulchella, Luzuriaga parviflora, Astelia nervosa, Gahnia procera,* and *Uncinia rupestris.*

(b) *Dacrydium intermedium forest*

Low ridges on Okarito surfaces with extremely impoverished podzolised soils are dominated by almost pure stands of *Dacrydium intermedium.* Manuka is abundant, mainly as layering shoots on the forest floor. *Gahnia procera* forms a well developed understorey of up to 30% cover, and there is a complete, hummocky layer of moss. The community grades into J1a on passing down-slope, and there are transitions to the rimu/kamahi–quintinia community (B3e) on better soils. Associated species include *Dacrydium colensoi, D. biforme, Cyathodes juniperina,* and *Empodisma minus.* There are also occasionally very stunted rimu trees. Most of the other species listed for (a) also occur in (b).

(c) *Montane heath-forest*

In the upper reaches of the Karangarua valley there is a large expanse of country where shallow soil stunts or precludes woody vegetation. Instead, there is a mosaic of low forest, scrub, and moor. Smaller areas occur also in the Regina and Douglas catchments. The low forest is supported by a soil mantle 10–30 cm deep, on slopes of 0–40° and altitudes between 500 and 900 m, although at the higher altitudes forest is confined to favourable pockets. *Dacrydium biforme, Phyllocladus alpinus,* rata, and

Fig. 34 Heath-forest on piedmont moraine with manuka in the foreground and *Dacrydium biforme* behind (J1a). *Chionochloa rubra* dominant on mire (K3a) in the near-foreground.

Hall's totara are the dominant trees. In the Karangarua Valley, silver beech is also important on the slopes between Lame Duck Flat and White Rose Falls, and in pockets of deeper or better-drained soil is locally dominant and taller (i.e., over 10 m). Manuka is always present, and can attain co-dominance.

Gahnia procera is the main understorey herb with cover up to 70%, and there is usually a dense moss layer. Other species present in most of the six described stands are *Lycopodium scariosum, Blechnum capense "minus", Libocedrus bidwillii, Weinmannia racemosa, Pseudopanax linearis, Dracophyllum longifolium, Archeria traversii, Coprosma colensoi, C. foetidissima, Olearia colensoi*, and *Phormium cookianum*.

The following were found in at least two stands: *Lycopodium varium, Elaeocarpus hookerianus, Griselinia littoralis, Pseudopanax colensoi, P. simplex, Cyathodes juniperina, Myrsine divaricata, Coprosma pseudocuneata, Astelia nervosa, Libertia pulchella*, and *Luzuriaga parviflora*. Scattered plants of *Dacrydium colensoi* were also noted.

Two stands were described from *c.* 900 m, which would be regarded as transitional between rata–*Libocedrus* forest (B6a) and *Dracophyllum–Olearia* scrub (E4a) were it not for the abundance of *Dacrydium biforme;* they represent a poorly drained facies, in one case on a gley podzol overlain by 35 cm of peat, in the other case on shallow soil over solid rock.

2. Heath-scrub

(a) *Dacrydium scrub of piedmont moraine crests*

Where the extreme gley podzol soils extend over broad moraine crests they support *Dacrydium intermedium forest* (J1b) if there is a substantial depth of humus. Where this is missing, and only 12–20 cm of leached silt loam overlies the hard pan, there is open scrub of manuka, *Dacrydium colensoi*, and some *D. biforme*. The canopy is very uneven, the manuka varying from only a few cm up to 2.5 m. The dacrydiums also are mainly small, but there are scattered gnarled bushes to 3.5 m tall, with trunks 30 cm in diameter. *Gleichenia circinata, Empodisma minus*, and the semi-scandent *Dacrydium intermedium* × *laxifolium* scramble between the shrubs. Small turfy openings have *Cyathodes empetrifolia, Pentachondra pumila*, and *Oreobolus strictus*. This scrub grades downslope into heath-forest. The associated

Fig. 35 Low manuka, *Lycopodium ramulosum*, *Empodisma minus*, etc., forming turf in an opening on montane heath-scrub (J2b), Karangarua Valley.

species, which include *Lycopodium ramulosum*, *Phyllocladus alpinus*, *Dracophyllum palustre*, *Gentiana* cf. *spenceri*, *Gahnia procera*, and *Thelymitra venosa*, reflect the intermediate nature of this community with respect to taller heath vegetation and natural pakihi (K3a).

(b) *Montane heath-scrub* (Fig. 35)

In the upper reaches of the Karangarua River and on the northern slope of Conical Hill, areas with only 2–5 cm of soil over bedrock provide conditions of infertility and poor drainage akin to those of the piedmont moraines, but there are differences related to altitude. Because soil depth varies considerably over small distances, the shrub-dominated communities form a close mosaic with heath-forest (J1c). Manuka ranging from creeping plants to small trees forms up to 50% cover. *Dacrydium biforme*, and, in the Karangarua catchment, silver beech are also common, the latter growing into stunted gnarled trees. *Gahnia procera* tussocks grow among the shrubs, and openings support turf of *Lycopodium ramulosum* and *Empodisma minus*.

Other species: *Phyllocladus alpinus*, *Dacrydium colensoi*, *Drosera spathulata*, *Dracophyllum longifolium*, *Cyathodes juniperina*, *Cyathodes empetrifolia*, *Pentachondra pumila*, *Oreobolus strictus*, and *Thelymitra venosa*. The only record of *Oreostylidium subulatum* is from this community.

(c) *Subalpine heath-scrub*

In the same localities as (b) similar vegetation above 850 m takes the character of a *Dracophyllum–Olearia* community (E4) stunted to 0.3–1.5 m tall, in which *Dacrydium biforme*, *Phyllocladus*, and manuka share dominance with *Dracophyllum longifolium* and *Olearia colensoi*. The community includes rock outcrops and ledges which support rupestral species such as *Lycopodium scariosum*, *Gaultheria rupestris* var. *parvifolia*, and *Schoenus pauciflorus*. Above 1 000 m there is intermingling of species characteristic of poorly drained alpine grassland, including *Chionochloa crassiuscula*, *Oreobolus impar*, and *Carpha alpina*. Manuka disappears by 1 050 m and the other dominant shrubs by 1 250 m. Other frequent species are *Pentachondra pumila*, *Phormium cookianum*, *Gahnia procera*, and *Aporostylis bifolia*.

K. Mires

Water-logged soils occupy much of the lowland and piedmont area. True swamps, with an acidity just below neutral (pH 5.7–6.0), occur on the more recent sites; these are referred to below as "fertile swamps" (Wardle 1974). As surfaces age, swampiness tends to be the result of impedence of drainage by iron-humus pans. The pH is lower (down to 3.8), and the habitat is designated as "infertile swamp". Finally, on the oldest surfaces (early Otiran or older) vegetation which is floristically very similar to that of infertile swamp is supported by extreme gley podzols. For want of a better term, this is referred to as "natural pakihi"; the same assemblage of species constitutes induced pakihi where it has been extended by fire.

In the mountains mires are limited to small areas on gentle slopes, river terraces, and inter-morainal hollows. Pakihi is not recognisable as such, although some of the typical species contribute to montane heath-scrub (J2a).

1. Lowland fertile swamp

Fertile swamps develop where there is movement of water, where fertility is improved by influx of silt, or on recently impounded areas. The most characteristic dominant is *Carex coriacea*, but on less fertile sites it is joined or replaced by *C. gaudichaudiana* (communities dominated by the latter are transitional to infertile swamp (K2)). Two other rhizomatous carices, *C. sinclairii* and *C. geminata*, also occur, but are not easily distinguished from the more abundant species. *Phormium tenax* is present throughout, and although generally stunted, it is robust and dominant where drainage is good, and in these conditions *Astelia grandis* can also be important. *Carex secta* co-dominates with *C. coriacea* in deeper water, and in more than *c.* 0.6 m of water it can form pure colonies. Either *Coprosma* cf. *parviflora* or *C. propinqua* are present, giving cover up to 20%; the former in the less fertile sedge-dominated communities, the latter in fertile communities where *Phormium* is dominant. Other frequent species are *Cordyline australis*, *Myrsine divaricata*, *Blechnum capense* (in "*procerum*" and other forms – often abundant), *Sphagnum* (sometimes abundant), *Lotus pedunculatus*†, *Juncus gregiflorus*, and *Viola lyallii*. *Juncus articulatus*† can fill pools, and *Eleocharis acuta* forms colonies at borders with open water.

Fertile swamp often borders kahikatea forest, and can show evidence of succession towards that community by the presence of young plants of kamahi, kahikatea, *Pseudopanax crassifolius*, and, in frost hollows, *Libocedrus bidwillii*. *Carex gaudichaudiana* especially also invades open ponds, such as Peter's Pool, a kettlehole left by the Franz Josef Glacier.

In the open grassy valleys rhizomatous carices, especially *C. coriacea*, dominate large areas, often as a major component of rough pastures. Although such communities can occupy wet hollows and flushes in natural valley grassland, their wide extent today results from the tolerance of these sedges to burning, grazing, and siltation, factors which tend to eliminate associates such as *Phormium tenax*, as well as the woody plants which tend to succeed them. These sedges are summer-green, and their dead leaves have carried fire into considerable areas of ecotonal kahikatea forest (B1); this has extended the sedge-dominated areas, which show a tendency to revert to forest (Fig. 36).

Other species found mainly in lowland fertile swamp include *Ranunculus flammula*†, *Hydrocotyle "novae-zelandiae"* (pilose form), *Hebe salicifolia* var. *paludosa*, *Elatine gratioloides*, *Glossostigma elatinoides*, *Gratiola sexdentata*, and *Carex virgata*.

2. Lowland infertile swamp

Infertile swamp has developed on post-glacial fill in the large alluvial valleys, in a kettlehole on the most recent full-glacial surface (Fig. 37), and in an embayment of Lake Mapourika. The substratum varies from soft, peaty silt to as much as 8 m of wet, structureless peat becoming silty at the base.

Variations in drainage and acidity make the composition likewise variable. *Gleichenia circinata* and *Empodisma minus* are usually present on central areas furthest from drainage channels, and often dominate there. Otherwise, dominants include *Carex gaudichaudiana*, *Baumea rubiginosa*, and, on slightly drier ground, *B. teretifolia*. *Leptocarpus similis* and *Lepidosperma australe* are usually present, and can dominate by the coastal lagoons. *Sphagnum* cover varies from isolated hummocks to continuous. Shrubs can occupy much of the surface. Manuka is the commonest, and is up to 3 m tall. *Dacrydium colensoi* is also common, whereas *D. bidwillii* and *D. biforme* are more local.

Other frequent or locally important species are *Blechnum capense* (apparently "subalpine" form), *Drosera binata*, *Centella uniflora*, *Dracophyllum palustre*, *Coprosma* cf. *brunnea*, *C. parviflora*, *Olearia virgata* (usually scattered, but dominating a transition to scrub at Lake Mapourika), *Utricularia novae-zelandiae*, *Typha orientalis*, *Centrolepis ciliata*, *Baumea tenax*, and *Gahnia rigida*.

Transitions to fertile swamp are marked by stunted plants of *Phormium tenax*. On drier ground, as more-fertile conditions are approached, height and density of shrubs increase, *Astelia grandis* enters, and seed-

Fig. 36 Fertile swamp (K1) derived by burning kahi'katea forest (B1), and showing strong invasion by woody plants. Ohinetamatea River.

lings of forest trees appear, representing both an ecotone and a succession towards kahikatea (A1a) or rimu–kahikatea forest (A2b). Around a small lake inside the Waiho Loop moraine, *Sphagnum* with *Gleichenia circinata*, *Blechnum capense*, and *Phormium tenax* forms a quaking bog which is extending over open water. Tree seedlings, especially those of *Libocedrus bidwillii*, are colonising the moss.

Many of the infertile swamps have been burnt. The main effect is to kill the shrubs. Manuka, coprosmas, and *Olearia virgata* soon re-establish, but the dacrydiums can be completely eliminated, and probably their return depends on the development of a nurse stand of manuka.

3. Pakihi

(a) *Natural pakihi* (Fig. 38)

The poorest soils on the morainic rolling country between sea level and 450 m support a mosaic of herbaceous vegetation and scrub. On unburnt herb-dominated areas, the main species is *Empodisma minus*, and *Gleichenia circinata* is also abundant. Woody plants are important but exceedingly stunted, the main species, manuka, being semi-rhizomatous and often less than 30 cm tall. *Dracophyllum palustre* is always present and *Dacrydium laxifolium* and *D. bidwillii* are locally common.

Soils are extremely well differentiated, shallow gley podzols, usually with little surface peat, and a pan at 20–80 cm. Locally, however, there is up to 1.5 m of slightly silty peat, in effect a highly organic A_1 horizon. Within the community type there are variations depending on drainage. In a few places very poorly drained central areas pass into *Donatia* bog (K5b). Where there is much surface water the *Empodisma* forms hummocks; the pools between have *Centrolepis ciliata* and sometimes *Utricularia novae-zelandiae* and *Liparophyllum gunnii*. *Sphagnum* is also common in these wet areas. In still wetter areas with water moving in channels, *Carex gaudichaudiana* rises to dominance and *C. echinata* can be present. The woody plants are taller and denser where there is better drainage or even more movement of water. Manuka is usually dominant in the ecotones with heath-forest but it is accompanied, and sometimes replaced, by silver pine. Dense communities of *Gahnia rigida* also occur in these transitions.

Other species: *Lycopodium ramulosum*, *Dacrydium biforme*, *Cyathodes empetrifolia*, *Gentiana spenceri*, *Celmisia graminifolia*, *Carpha alpina*, and *Chiono-*

Fig. 37 Infertile swamp dominated by *Empodisma minus* (K2) occupies a kettlehole near Cook-Gillespies Road. Beyond, an ecotone dominated by manuka and *Dacrydium colensoi* (J1a) merges into rimu forest (A2a).

Fig. 38 Natural pakihi (K3a) with *Chionochloa rubra*, *Dacrydium bidwillii*, *Empodisma minus*, and *Gleichenia circinata*. Plateau between Omoeroa and Waikukupa Rivers.

Fig. 39 Frequently-burnt pakihi (K3b) dominated by *Baumea* spp. and *Gleichenia circinata*. Near Okarito.

chloa rubra. Two rather rare plants recorded only from pakihi or related communities are *Hemiphues suffocata* and *Astelia linearis* var. *linearis*.

(b) *Induced pakihi* (Fig. 39)

Fire has modified pakihi in many places and extended it over areas previously occupied by heath-scrub (J2), heath-forest (J1), rimu forest (A2a), and rimu/kamahi–quintinia forest (B3e). After a single fire the woody dominants may regenerate fairly quickly, but pakihi becomes entrenched after repeated fires. Differences from natural pakihi are that *Baumea teretifolia* shares dominance with *Gleichenia circinata* and *Empodisma minus*, and that manuka invades persistently, developing into tall thickets. Other common species are *Lycopodium ramulosum*, *Pteridium aquilinum*, *Drosera binata*, *D. spathulata*, *Haloragis micrantha*, *Nertera scapanioides*, *Celmisia graminifolia*, *Dianella nigra*, *Lepidosperma australe*, *Baumea tenax*, *Gahnia rigida* (mainly in drier or better-drained places), *Notodanthonia gracilis*, *Pterostylis venosa* and, in or around pools, *Schizaea fistulosa*, *Utricularia novae-zelandiae*, and *Centrolepis ciliata*. Locally, *Bulbinella modesta* is common.

When left unburnt, manuka increases until it forms dense thickets 3–6 m tall. These suppress the tall pakihi herbs and act as nurse to tree seedlings; especially Hall's totara, *Phyllocladus alpinus*, rimu, silver pine, kamahi, and *Pseudopanax crassifolius* (Fig. 40).

4. Upland Carex swamps

(a) *Carices dominant without Sphagnum*

South-east of the Alpine Fault mid-altitude fertile swamps are scarcely developed, because open valley flats and terraces are well drained and of limited extent. At Welcome Flat, *Phormium tenax* and *Carex secta* grow anomalously at 450 m beside the hot pools. On the flats of Architects Creek there is a *Carex coriacea–C. gaudichaudiana* swamp at 600 m. At one point near here the lower valley slopes are also swampy, and, although the same two carices are dominant, the community includes *Ranunculus lyallii*, *Aristotelia fruticosa*, *Coprosma pseudocuneata*, *Gentiana patula*, *Celmisia glandulosa*, *C. armstrongii*, *C. petiolata*, *Euphrasia zelandica*, *Phormium cookianum*, *Juncus novae-zelandiae*, *Oreobolus strictus*, *Schoenus pauciflorus*, and *Chionochloa conspicua*. These are species typical of higher altitudes and their presence indicates severe temperature inversion. Rhizomatous carices dominate small flushes up to 1 000 m; some, if not all, of those at the higher altitudes are *Carex sinclairii*.

Fig. 40 Forest recolonising a burnt pakihi (K3b) near Okarito.

Meadow communities grow on wet silt bordering swamps. Two stands, both modified by browsing, were described at 1 000 and 1 150 m. The main species include *Carex gaudichaudiana, Galium perpusillum,* and at one locality each *Nertera balfouriana, Gnaphalium* cf. *paludosum, Scirpus aucklandicus,* and *Chionochloa pallens. Ranunculus lappaceus* "alpine swamp", *Epilobium brunnescens,* and *Viola ?cunninghamii* also occur at both sites. Where the higher swamp is intersected by running water, *Schoenus pauciflorus* provides nearly 20% cover, and a link with K6 below.

(b) *Carex gaudichaudiana–Sphagnum swamp*

This is described from three inter-morainal swamps, two at 800 m at the La Perouse Glacier, and one at 1 000 m at the Horace Walker Glacier. They form a dated sequence, at c. 1 000, 2 500, and 5 000 years B.P. On the youngest the peat is very wet and soft. Vigorous *Carex gaudichaudiana* forms 40% cover above a loose turf of *Sphagnum* (2 spp.) and *?Hypnum*. The 2 500-year swamp is firmer, and *C. gaudichaudiana* and *Carpha alpina* each give about 10% cover, the rest being *Sphagnum*. The oldest swamp has about the same amount of *C. gaudichaudiana*, and, again, there seem to be at least two species of *Sphagnum*, one of them cushion-forming. *Forstera tenella* and *Coprosma pumila* are on the three swamps. On the two younger there are tussocks of *Chionochloa pallens*, whereas on the oldest there is *C.* cf. *rigida* instead, together with *Drosera arcturi* and *Oreobolus pectinatus*.

Related communities grow on the peaty fringes of tarns, up to 1 300 m. Here, the most vigorous *C. gaudichaudiana* grows as a semi-floating fringe around the open water; behind, it is shorter and mixed with *Sphagnum*. At the highest altitude sites the dominant sedge may prove to be *C. lachenalii. Scirpus aucklandicus* is usually also present, and around small alpine tarns and pools can be dominant to the exclusion of *Carex. Juncus novae-zelandiae* can also be important, and can dominate shallow rivulets.

5. CUSHION BOG

(a) *Oreobolus pectinatus bog*

This widespread but patchy community occurs between 800 and 1 300 m around the peaty margins of tarns, on acid, outward-draining central parts of swamps above the level of standing water, and alternating with *Carex*-dominated communities in small pool-mire complexes on gentle flat and concave

slopes. *O. pectinatus* is usually associated with peat building, but also grows to a limited extent on flushed slopes on leached mineral soil. It is always accompanied by, and can share dominance with, *Celmisia glandulosa*. *Sphagnum* is present, occasionally forming large cushions as a major part of the mosaic.

Other species: *Drosera arcturi*, *Forstera tenella*, *Celmisia graminifolia*, *Carpha alpina*, *Carex gaudichaudiana* (stunted tillers adjacent to communities of this species), *Poa colensoi*, and *Chionochloa pallens*.

(b) *Donatia cushion bog*

Donatia novae-zelandiae occurs very locally on extreme sites in natural pakihi, from as low as 250 m between the Omoeroa and Cook Rivers. An example at 450 m near Lake Mueller has *Donatia* and *Oreobolus pectinatus* co-dominant. The other species are very stunted manuka (1 cm tall), *Empodisma minus* (5 cm tall), *Dracophyllum palustre*, *Drosera arcturi*, and *Carpha alpina*.

In the mountains this community is also of extremely limited extent. It occurs between 850 and 1 250 m on the slopes south of Lame Duck Flat as patches of only a few square metres, and also on glacially rounded country at 1 250–1 300 m in the head of the Waikukūpa River. Slopes are 0–10° and include both north and south aspects. The soil is usually 12–20 cm of saturated, gritty, leached silt overlying solid rock. *Donatia* provides 30–80% of the cover. Other important mat plants are *Oreobolus pectinatus* (co-dominant in one site at the margin of a tarn), *Celmisia glandulosa* and *Pentachondra pumila*, and less constantly, *Lycopodium ramulosum* and *Oreobolus strictus* (up to 1 100 m) and *O. impar*. *Empodisma* is important up to 1 000 m. Stunted shrubs include *Dacrydium biforme*, *Dracophyllum longifolium*, and manuka (up to 1 000 m), *Dracophyllum uniflorum*, and *Hebe odora* (at the Waikukupa site). *Chionochloa crassiuscula* is on all sites above 1 000 m. Other species include *Drosera arcturi* and *Schizaea fistulosa*.

6. Schoenus pauciflorus flush

This was described from two stands at 1 250 and 1 300 m, where 5–20 cm of silt overlie solid rock on slopes of 15° and 25° respectively. *Schoenus* provides up to 50% cover, and in the stand with the shallower soil *Notodanthonia setifolia* is also abundant. Other species in both stands are *Epilobium brunnescens*, *Viola cunninghamii*, *Gnaphalium* cf. *paludosum*, and *Scirpus aucklandicus*. The only record of *Carex petriei* was from the 1 300-m stand on Pioneer Peak.

7. High-alpine wet ground

Tarns at 1 550–1 600 m on the Twain and Karangarua saddles have periodically inundated margins which support mostly moss, with, e.g., 10% cover of vascular plants; species listed were *Claytonia australasica*, *Raoulia subulata*, *Gnaphalium* cf. *paludosum*, *Carex pyrenaica*, *Scirpus aucklandicus*, and *Chionochloa oreophila*. There is no peat.

Flushes at 1 600–1 700 m on the mountains on either side of the Horace Walker Glacier are also dominated by mosses, together with *Claytonia australasica*, *Marsippospermum gracile*, and other fellfield species. Both habitats show an affinity to snow hollows (I4c).

L. Aquatic vegetation

1. Lowland aquatic vegetation

The three large, deep lakes in Westland National Park, Wahapo, Mapourika, and Matheson, occupy unfilled lobes of former glacial troughs. There are several shallower lakes on the piedmont moraines, as well as various ponds, tarns, and deep swamps. Many of the smaller lowland streams also have sufficiently permanent channels to support an aquatic vegetation, but beds of the large rivers are too unstable to support any plants other than the temporary growth of algae.

The waters in the Park are oligotrophic, and vegetation is comparatively sparse. The commonest submerged plants are *Potamogeton cheesemanii*, *Myriophyllum propinquum*, and *Myosotis caespitosa*.† *Ranunculus rivularis*, *Lilaeopsis*, and *Lepilaena bilocularis* grow on the bottom. *Ranunculus rivularis*, *Hydrocotyle "novae-zelandiae"* (pilose form), and *Galium palustre*† also grow out into deep water from marginal vegetation. In water of moderate depth (c. 0.6 m) there are reed beds of *Eleocharis acuta* or *E. sphacelata*. *Callitriche stagnalis*† is often abundant in small pools, especially on farmland. In Lake Mapourika *Elodea canadensis*† was well established by 1974.

2. Upland aquatic vegetation

The torrential mountain streams scarcely support vascular aquatic plants, and they are absent also from most of the peaty mountain tarns. The main habitats for vascular aquatics are tarns and sluggish streams on the more recent surfaces, such as moraines and alluvial flats. *Potamogeton cheesemanii* and *Myriophyllum propinquum* are the main species, being recorded up to 1 000 m and 1 200 m respectively. Also recorded were *M. elatinoides* in a stream at 1 150 m, and *Isoetes alpinus* in a tarn at 1 200 m. The commonest aquatic in tarns is the long slender moss *Drepanocladus fluitans*.

3. High-alpine tarns

The few small permanent tarns above 1 200 m lack macroscopic plants, although vegetation grows on the flooded margins (K7).

M. Bluffs and cliffs

Much of Westland National Park south-east of the Alpine Fault is too steep to support a continuous cover of vegetation. Most of this steep terrain consists of schist bluffs, grading into greywacke towards the Main Divide. There are also areas where avalanches or recent scouring by glaciers have prevented a continuous cover of vegetation from developing. Along the river valleys and on the coast, cliffs cut in alluvium and moraine provide another set of partly vegetated habitats.

1. Bluffs and cliffs below 1 200 m

(a) *Rock bluffs*

These bluffs present a great variety of habitats, and the total species list is accordingly long. Lower altitude (below *c.* 600 m) and higher altitude variants are recognisable, and the latter grade into alpine bluff communities, but the altitudinal overlap of species is much greater than in other vegetation. The following are the main species of predominantly low altitudes: *Coriaria arborea* (damp bluffs below 300 m), *Metrosideros umbellata, Griselinia littoralis, Olearia avicenniaefolia, O. arborescens,* and *Chionochloa conspicua* (to 1 050 m), and *Leptospermum scoparium* (a major species on a few bluffs below 600 m in the Karangarua watershed).

The following are characteristic of higher altitudes: *Olearia colensoi* (dominant on many bluffs above 700 m), *Chionochloa* cf. *flavescens,* and *Notodanthonia setifolia* (on dry rocks). *Blechnum capense* ("*procerum*" form at lower altitudes), *Dracophyllum longifolium, Phormium cookianum,* and *Schoenus pauciflorus* are common at all altitudes.

Other frequent species: *Hymenophyllum multifidum, Carmichaelia grandiflora, Gingidium montanum, Pseudopanax colensoi, Gaultheria rupestris* (mainly var. *parvifolia*), *Coprosma rugosa, Forstera tenella, Parahebe lyallii,* and *Astelia nervosa* (all widespread); *Myrsine divaricata* and *Gnaphalium trinerve* (lower altitudes); *Ranunculus lyallii, Coriaria plumosa, Geum parviflorum, Dracophyllum traversii, Coprosma serrulata, Celmisia coriacea, C. petiolata, Ourisia macrocarpa, Lachnagrostis richardii, Poa novae-zelandiae* var. *desiliens,* and *P. colensoi* (mainly higher altitudes); *Dracophyllum fiordense* (above 900 m).

(b) *Waterfalls*

The rocks behind temporary waterfalls and steep cataracts are often occupied by mesic successions, in which *Schoenus pauciflorus* is the main species. The trailing form of *Poa novae-zelandiae* (var. *desiliens*) can dominate where water drips continuously. *Gunnera monoica* and *Chionochloa conspicua* are also common in these habitats.

(c) *Seral vegetation on glacially scoured schist*

In the Waiho Valley the advances and retreats of the Franz Josef Glacier during the last 400 years bared extensive areas of solid rock, which are now exhibiting various stages of succession. The only other comparable habitats of any extent are Cone Rock below Fox Glacier, and an area at the former terminal of Spencer Glacier. Coarse sluice tailings on the terrace behind Franz Josef village, worked for gold about 1900 A.D., now support an open shrubbery of young rata and kamahi, similar to that developed on roches moutonnées.

Mosses appear in crevices after 3–4 years. After 9 years mosses and fruticose lichens cover the whole of south-facing rock surfaces, and the following vascular plants were listed from the larger crevices: *Epilobium brunnescens, E. glabellum, Olearia arborescens* (0.5 cm tall), *Ourisia* sp., and *Poa novae-zelandiae.* On the north aspect, crustose lichens *c.* 15 cm in diameter cover *c.* 70% of the rock, and mosses 10%.

Vascular plant cover increases very slowly as soil builds up in crevices and hollows. Seedlings of rata, which eventually becomes very conspicuous, were first noted on rock bared for 32 years. There tends to be a phase of dominance by *Olearia avicenniaefolia* on surfaces bare of ice for 60–80 years. Succession is faster on moist pockets of gravel stranded on the rock. In the early stages, *Poa novae-zelandiae* and *Epilobium glabellum* are common; later, dense clumps of *Coriaria arborea* usually develop, to provide nuclei for forest succession. Seral in this habitat are *Celmisia bellidioides* and *Schoenus pauciflorus.*

On the extensive surfaces bared 100–120 years ago there is very uneven development of scrub dominated by rata, with intervening areas covered in *Blechnum capense, Hymenophyllum multifidum, Lycopodium scariosum,* and *Rhacomitrium crispulum.*

A small area on the east wall of the Waiho Valley at 350 m appears to have been bared during the seventeenth century glacial advance. It is relatively sheltered, and notable for the abundance of young rimu and miro trees.

(d) *Lowland cliffs in alluvium and moraine* (Fig. 41)

Vertical cliffs cut in alluvium and moraine (including river banks and road cuttings) are barren where

Fig. 41 Cliff in fluvio-glacial deposit at Deep Creek, Okarito, supporting *Blechnum capense "procerum"* (Mld).

being actively eroded, but where stable they first develop a cover of *Polytrichadelphus magellanicus* followed by vascular species with fast-growing stolons or rhizomes. These include *Lycopodium volubile*, *Blechnum capense "procerum"*, *Gunnera monoica*, and *Gnaphalium trinerve*. Locally, *Blechnum vulcanicum* is dominant. Seedlings of kamahi, quintinia, *Coprosma foetidissima*, etc., usually become established but fall out by their own weight before they become large. As a variant on this, there are shaded banks (e.g., in narrow gorges) where filmy ferns such as *Hymenophyllum flabellatum* or *Trichomanes strictum* dominate.

2. ALPINE BLUFFS

(a) *Low-alpine bluffs* (Fig. 42)

Alpine bluffs provide another complex habitat, the main elements being ledges and slopes where pockets of soil accumulate, fissures in rocks, and rock surfaces, but the last are occupied almost exclusively by cryptogams. Each of these elements has damp, sheltered facies, and dry, exposed facies. Species were listed from seven stands between 1 250 and 1 600 m and two of these were analysed into microhabitats in some detail. The species are mostly characteristic of other communities, but several are most abundant in bluff habitats. Those recorded from at least two stands are listed according to their most characteristic microhabitat, the most abundant species being marked with an asterisk:

Soil pockets: *Geum parviflorum**, *Dracophyllum kirkii**, *D. uniflorum*, *C. petiolata**, *C. coriacea*, *Schoenus pauciflorus**, *Poa colensoi**, *Microlaena colensoi**, *Festuca matthewsii*, and *Chionochloa pallens**.

Sheltered rock crevices: *Polystichum vestitum*, *P. cystostegia*, and *Ourisia caespitosa*.

Dry or exposed crevices: *Gaultheria rupestris* var. *parvifolia*, *Coprosma serrulata*, *Leucogenes grandiceps*, *Parahebe linifolia*, and *Notodanthonia setifolia*. *Poa novae-zelandiae** grows in both exposed and sheltered crevices but probably as different varieties. Listed only: *Grammitis pumila*, *Ranunculus lyallii*, *Epilobium glabellum*, *Schizeilema haastii*, *Anisotome pilifera*, *Gaultheria depressa*, *Gentiana* cf. *divisa*, *Wahlenbergia pygmaea*, *Celmisia vespertina*, *Senecio scorzoneroides*, *Craspedia* cf. *major*, *Ourisia macrocarpa*, *Hebe ciliolata*.

(b) *High-alpine bluffs*

High-alpine bluffs support fragmentary communities which, like those on bluffs at lower altitudes, contain elements typical of other vegetation. *Poa novae-zelandiae* was present on four out of five sites between 1 600 and 2 050 m, and *Ourisia caespitosa* was on three, although 24 further species were listed once or twice; these are otherwise characteristic of fellfield. *Parahebe birleyi* was found only below Fitzgerald Pass, on north- to west-facing rock crevices between 2 050 and 2 150 m.

N. Coastal vegetation

The coastal vegetation zone in the vicinity of the National Park is very narrow, at least as far as terrestrial vegetation is concerned. This reflects high rainfall, infrequency of strong on-shore winds, and perhaps also the absence of solid rock substrata. Most of the coastline consists of cliffs cut in moraine and fluvio-glacial outwash, rising to as high as 170 m, and fronted for much of their length by narrow lagoons

Fig. 42 Low-alpine bluff at Castle Rocks above Franz Josef Glacier (M2a). Species include *Blechnum capense* "subalpine", *Ranunculus lyallii*, *Ourisia macrocarpa*, and *Poa novae-zelandiae*.

Fig. 43 Waikowhai Bluff, with low forest (N1a) and scrub (N2).

impounded by gravel beach ridges (Fig. 43). Lagoons and beach ridges also close off the seaward ends of the main river valleys. Where the piedmont moraines become low as they approach the sea, there are large brackish lagoons, and the impounding beach ridges consist partly of sand dunes. Both cliffs and beach ridges support various stages of succession leading to low forest, but the vegetation in many places has been greatly influenced by over a century of grazing and burning.

1. FOREST

(a) *Forest on coastal cliffs*

The most developed vegetation on the moraine cliffs is patches of forest on talus; because this talus is being added to by material falling from cliffs above, and eroded by the sea from below, the community remains as low forest typical of immature soils, but with a distinctive coastal aspect. The canopy is only 3–6 m tall, and is often closely wind-shorn. *Melicytus ramiflorus* is usually dominant, but can also share dominance with *Hedycarya arborea* and *Coprosma lucida*, the latter being characteristic of younger forest. The typical understorey species are *Carex solandri*, *Uncinia uncinata*, and where not heavily browsed by goats, *Asplenium bulbiferum* and *Astelia fragrans*. On the few places where the soil has developed towards yellow-brown earth, *Blechnum discolor* is present.

The community is the usual habitat for *Cyathea medullaris* and for several species at or near their southern limits, e.g., *Pteris macilenta*, *Lastreopsis glabella*, and *Macropiper excelsum*.

(b) *Low forest on dunes*

Although the less exposed gravel and sand dune habitats would succeed towards forest in the absence of disturbance, successions have been widely deflected by burning and by burning and grazing by Maoris and Europeans respectively. On Okarito Spit small groves in the lee of dunes are variously dominated by stunted Westland totara, *Fuchsia excorticata* and its hybrids with *F. perscandens*, *Aristotelia serrata*, and *Melicytus ramiflorus*. Associated species include *Dicksonia squarrosa*, bracken, *Rubus fruticosus*†, *Myrsine australis*, *Coprosma propinqua*, *Calystegia tuguriorum*, *Cordyline australis*, and *Uncinia uncinata*.

Other kinds of immature forest were described from other localities; at Gillespies Beach there is a dense community of kamahi and *Dicksonia squarrosa* on the lee side of a dune, and north of Waitapi Creek, one mainly consisting of *Hedycarya* and young rimu on the beach ridge.

(c) *Coastal fringe of climax forest*

In most places the usual lowland forest on the piedmont hills comes to the tops of the cliffs, but close to the edge the tree crowns are malformed by wind, and extensive gaps in the canopy are filled by

small trees and, especially, by *Freycinetia* and *Metrosideros* vines. Along the very brows there is usually a zone a few metres wide where *Freycinetia banksii* and *Metrosideros perforata* are dominant.

2. Scrub on coastal cliffs

Shrubs form patchy communities in various situations; on cliff faces which have remained stable long enough, on ledges and patches of talus too small or exposed to support low forest, around the margins and in openings in low forest, and on recent slips and talus. Dominance varies among *Olearia avicenniaefolia*, *Phormium tenax*, *Metrosideros perforata*, *Hebe salicifolia* (on moist sites), gorse†, *Hebe elliptica* (mainly close to the beach), and *Carmichaelia* cf. *grandiflora* (very local, on talus).

3. Coastal Phormium tenax and gorse scrub

The earliest mention of the vegetation of Okarito Spit, by Haast (1879) in 1865, is of "high grass" (at the northern end), and "high flax and small groves, consisting of Coprosma, Veronica, and dwarf totara bushes, intersected with grass flats". Because there were numerous signs of Maori occupation, it can be assumed that this vegetation had already been modified by fire. With increased frequency of burning, coupled with grazing, *Phormium tenax* and low forest is destroyed, and gorse† becomes dominant after temporary establishment of grassland.

Phormium and gorse† communities attain their best development on moister areas, such as in dune hollows and along the margins of inter-dune swamps. Species associated with *Phormium* on a dune at Waitangiroto (since destroyed by the sea) include *Blechnum penna-marina*, *Polystichum vestitum*, bracken, *Rubus schmidelioides*, *Acaena anserinifolia*, *Muehlenbeckia australis*, *Lotus pedunculatus*†, *Dactylis glomerata*†, *Carex coriacea*, and *Cordyline australis*. On an old dune with a thick gley podzol at Gillespies Beach, bracken has become dominant with repeated fire, with *Phormium tenax* and gorse† as main accompanying species.

The old coastal route crossed over moraine ridges which project as headlands. For this reason, the windswept forest and scrub on these headlands has been burnt, and replaced by *Phormium tenax*, or by mixtures of *Phormium* and gorse†. *Blechnum capense* "*procerum*" is usually dense in the understorey. Succession back to the original vegetation is indicated by shrubs of *Olearia avicenniaefolia* and *Coprosma lucida*, and by young plants of various forest species.

4. Herbaceous vegetation on coastal cliffs

Shrubby vegetation grades into herb- or grass-dominated communities on less-stable younger sites. On cliff faces *Blechnum capense* "*procerum*", *Gunnera monoica*, *Gnaphalium trinerve*, and *Poa* cf. *anceps* (in trailing form) form large colonies. On talus young shrubs occur among an open community with *Poa* cf. *anceps* (in caespitose form), *Scirpus nodosus*, and other typical pioneer species, such as *Paesia scaberula*, *Notodanthonia gracilis*, *Cortaderia richardii*, and *Dichelachne crinita*. *Histiopteris incisa* occupies openings in low forest.

5. Coastal dune grassland

On Okarito Spit, grassland forms a mosaic with gorse†, *Phormium tenax* and the active dune communities described as N6. In one example, tussocks of *Carex flagellifera* and *C. testacea* provide up to 60% of the cover; the turf between includes bracken, *Cerastium holosteoides*†, *Rumex acetosella*†, *Lotus pedunculatus*†, *Trifolium repens*†, *Pernettya macrostigma*, *Cyathodes fraseri*, *Dichondra brevifolia*, *Hypochoeris radicata*†, *Helichrysum filicaule*, *Dactylis glomerata*†, *Notodanthonia gracilis*, *Anthoxanthum odoratum*†, *Holcus lanatus*†, and *Agrostis tenuis*†. Taller plants include *Lepidosperma australe* and *Scirpus nodosus*. *Cyperus ustulatus* is a common tussock in some stands. The total species list is very similar to that for lowland valley grassland.

6. Active dunes and beach ridges (Fig. 44)

The intertidal beaches vary from purely cobble to sand with many stones. Ridges of somewhat less stony material have been thrown up behind these beaches, along with great quantities of driftwood. True sand dunes are extensive only along Okarito Spit, although there are limited areas along the spits separating smaller lagoons from the sea. The beach ridges and fore dunes, where least stable, support a patchy vegetation of *Desmoschoenus spiralis*, which is always accompanied by *Calystegia soldanella*. Other species enter and rise to local dominance on more-stable ground, including marram (*Ammophila arenaria*†), *Zoysia minima*, gorse†, *Carex pumila*, *Scirpus nodosus*, and *Phormium tenax*.

There is usually no orderly succession from active dunes or ridges to stable features with mature soils and closed vegetation because these areas are grazed and frequently burnt, and also because the shore line is generally retreating, so that active dunes and ridges are invading much older, completely stabilised surfaces.

Fig. 44 Beach ridge (N6) at the mouth of Ohinetama tea River. *Desmoschoenus spiralis* in the foreground.

7. Fertile coastal swamp and related seral vegetation

Swamps form at the seaward margins of the large coastal lagoons, in dune hollows, and behind gravel beach ridges. Representative examples on Okarito Spit have no particularly coastal species, and have been modified by grazing. Typical dominants include *Carex coriacea, C. gaudichaudiana, Juncus gregiflorus* and very locally, *Typha orientalis, Carex virgata,* and *C. secta.* Various small plants characteristic of fertile swamp also occur, e.g., *Viola lyallii, Elatine gratioloides, Glossostigma elatinoides,* and *Gratiola sexdentata.*

Where large rivers reach the sea, the lagoons are narrow and bordered on the inland side by alluvial terraces; some smaller creeks have similar mouths. The terraces bear stages of succession similar to those described for lowland valleys further inland, ranging from fertile swamp with carices and *Phormium* on low-lying ground, and on higher ground, from low forest through to kahikatea or rimu forest. Differences are that kowhai (*Sophora microphylla*) is prevalent in hardwood-dominated phases, because its pods are carried along the coast into the lagoons and up the tidal reaches of the smaller rivers. Rimu is sometimes as abundant as kahikatea in successions on terraces, peat-filled dune hollows, and old beach ridges and dunes, which suggests that it is relatively favoured by slightly saline conditions. The mature podocarps have broad, wind-damaged crowns and are more widely spaced than in equivalent inland forests, but there is a greater density of small hardwood trees and lianes.

8. Infertile coastal swamp and transitions to swampy forest (Fig. 45)

Okarito, Three Mile, Five Mile, and Gillespies Lagoons are much larger and more permanent expanses of water than those discussed under N7. Extensive flats within a metre of high-tide level border them or form islands, and possibly are uplifted remnants of old lagoon floors. The substratum is gravel (probably representing beach deposits), overlain by up to 0.6 m of sand, silt, or peat. Low-lying margins adjacent to the open water of lagoons are dominated by *Leptocarpus similis* which in places shares dominance with *Juncus maritimus. Coprosma propinqua* and, more locally, *Plagianthus divaricatus* are abundant. On slightly higher ground this usually grades into extensive infertile swamp dominated by *Baumea teretifolia, Lepidosperma australe, Leptocarpus similis,* and *Gleichenia circinata* in various proportions. In central areas this passes into short vegetation dominated by *Baumea huttonii* and *Centrolepis ciliata.* On the inland side the swamps meet swampy forest dominated by kahikatea and rimu, via an ecotone dominated by manuka with small trees of kahikatea, rimu, and silver pine. *Freycinetia banksii* and *Gahnia xanthocarpa* are particularly abundant in the forest, and the podocarps are again more widely spaced than is usual further inland.

Fig. 45 Transition from coastal swamp, through ecotones dominated by stunted *Phormium tenax* and manuka (N8), to open forest of rimu and kahikatea. Five Mile Lagoon.

9. Aquatic vegetation in tidal water

Aquatic vegetation in the coastal lagoons consists mainly of *Ruppia megacarpa* and Characeae (including *Nitella hyalina* and *Chara globularis*); *Lilaeopsis* cf. *novae-zelandiae* grows on the bottom. At the north end of Okarito Lagoon there are large colonies of the emergent species *Scirpus lacustris; Eleocharis sphacelata* grows in deep inter-dune ponds. *Zostera muelleri* beds grow in the southern, presumably more saline, parts of Okarito Lagoon.

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APPENDIX 1—POINT ANALYSIS OF PLANT COMMUNITIES

An adaptation of the point analysis system was used to sample representative stands of a range of plant communities. Fifty equidistant points were taken along a tape, the spacing varying from 5 in. (12.7 cm) for low herbaceous vegetation to 2 links (40.2 cm) for tall vegetation. A perpendicular line was projected from each point, and leaves, stems, and canopies intersecting this perpendicular were listed by species for the following height intervals: 0–10 cm, 10–60 cm, 60 cm–2 m, 2 m–7.5 m, >7.5 m.

A1b. Mixed conifer forest on well drained soil. McDonald's Creek, on silty alluvium. Flat, altitude 100 m. Length 100 links (20.1 m).

Species	%
0–10 cm	
Grammitis heterophylla	2
Metrosideros diffusa	2
Nertera cf. *dichondraefolia*	2
Bryophyte	18
Exposed root	6
Litter	70
Bare soil	2
Total plant cover	*28*
10–60 cm	
Dicksonia squarrosa	6
Metrosideros diffusa	6
Hymenophyllum ferrugineum	2
Pseudowintera colorata	2
Ripogonum scandens	2
Bryophyte	2
Total plant cover	*16*
60 cm–2 m	
Dicksonia squarrosa	12
Metrosideros diffusa	2
Total plant cover	*14*
2–7.5 m	
Dicksonia squarrosa	46
Metrosideros diffusa	30
Weinmannia racemosa	30
Carpodetus serratus	10
Pseudopanax edgerleyi	8
Asplenium falcatum	6
Fuchsia perscandens	2
Aristotelia serrata	2
Total plant cover	*80*
>7.5 m	
Podocarpus spicatus	82
Metrosideros diffusa	54
Podocarpus dacrydioides	28
Hymenophyllum sp.	14
Griselinia littoralis	6
Pseudopanax edgerleyi	6
Weinmannia racemosa	6
Asplenium falcatum	4
Epiphytes, unidentified	14
Total plant cover	*100*
Other species near transect	
Trichomanes reniforme	
Asplenium bulbiferum	
Asplenium flaccidum	
Pseudowintera colorata	
Hedycarya arborea	
Griselinia lucida	
Melicytus ramiflorus	
Schefflera digitata	
Coprosma rotundifolia	
Coprosma rhamnoides	
Ripogonum scandens	

A2a. Rimu forest. West side of new road between Lake Wahapo and the Forks. Flat, altitude 100 m. Length 100 links (20.1 m).

Species	%
0–10 cm	
Bryophyte	52
Litter	48
Total plant cover	*52*
10–60 cm	
Myrtus pedunculata	26
Weinmannia racemosa	18
Phyllocladus alpinus	6
Hymenophyllum revolutum (epiphyte)	2
Myrsine divaricata	2
Podocarpus ferrugineus	2
Quintinia acutifolia	2
Weinmannia racemosa	2
Total plant cover	*56*
60 cm–2 m	
Weinmannia racemosa	28
Griselinia littoralis	10
Quintinia acutifolia	6
Neomyrtus pedunculata	6
Phyllocladus alpinus	4
Trichomanes reniforme	2
Coprosma foetidissima	2
Weinmannia racemosa	2
Total plant cover	*52*
2–7.5 m	
Weinmannia racemosa	64
Quintinia acutifolia	34
Podocarpus ferrugineus	18
Coprosma foetidissima	4
Dacrydium cupressinum	2
Total plant cover	*82*
>7.5 m	
Quintinia acutifolia	38
Dacrydium cupressinum	20
Podocarpus ferrugineus	20
Weinmannia racemosa	20
Total plant cover	*90*
Other species near transect	
Lindsaea trichomanoides	
Blechnum capense "minus"	
Hymenophyllum incl. *armstrongii*	
Dicksonia squarrosa	
Gleichenia cunninghamii	
Metrosideros umbellata	
Podocarpus hallii	
Pseudopanax colensoi	
Pseudopanax crassifolius	
Coprosma lucida	
Uncinia rupestris	
Luzuriaga parviflora	
Libertia pulchella	
Astelia nervosa	

B3a. Rimu/kamahi/Blechnum forest. East of Lake Mapourika. Aspect W, slope 10°, altitude 100 m. Length 100 links (20.1 m).

Species	%
0–10 cm	
Nertera cf. *dichondraefolia*	6
Metrosideros diffusa	4
Nertera depressa	4
Blechnum capense "procerum"	2
Metrosideros fulgens	2
Bryophyte	48
Exposed root	2
Litter	34
Total plant cover	*68*
10–60 cm	
Blechnum capense "procerum"	32
Blechnum discolor	8
Dicksonia squarrosa	4
Hedycarya arborea	4
Lastreopsis hispida	4
Coprosma lucida	2
Dacrydium cupressinum	2
Hymenophyllum sp. (epiphyte)	2
Metrosideros diffusa	2
Metrosideros fulgens	2
Weinmannia racemosa	2
Total plant cover	*52*
60 cm–2 m	
Blechnum capense "procerum"	14
Weinmannia racemosa	14
Blechnum discolor	10
Dicksonia squarrosa	6
Coprosma lucida	4
Neomyrtus pedunculata	4
Griselinia littoralis	2
Hedycarya arborea	2
Ripogonum scandens	2
Total plant cover	*56*
2–7.5 m	
Dicksonia squarrosa	14
Metrosideros diffusa	14
Myrsine australis	8
Pseudopanax crassifolius	8
Weinmannia racemosa	8
Coprosma lucida	6
Metrosideros fulgens	2
Ripogonum scandens	2
Rumohra adiantiformis	2
Total plant cover	*70*
>7.5 m	
Dacrydium cupressinum	58
Podocarpus ferrugineus	20
Weinmannia racemosa	18
Astelia solandri	2
Dendrobium cunninghamii	2
Hymenophyllum sp. (epiphyte)	2
Total plant cover	*88*
Other species near transect	
Asplenium flaccidum	
Pseudowintera colorata	
Quintinia acutifolia	
Schefflera digitata	
Griselinia lucida	
Pseudopanax colensoi	
Pseudopanax edgerleyi	
Pseudopanax simplex	
Luzuriaga parviflora	

B3a. Rimu/kamahi/Blechnum approaching rimu/kamahi–quintinia forest. Moraine terrace near Lake Wombat, Waiho Valley. Aspect SE, slope 18°, altitude 250 m. Length 100 links (20.1 m).

Species	%
0–10 cm	
Metrosideros fulgens	6
Blechnum discolor	2
Bryophyte and lichen	24
Exposed root	2
Litter and humus	70
Total plant cover	*30*
10–60 cm	
Blechnum discolor	46
Astelia solandri	6
Podocarpus hallii	6
Gleichenia cunninghamii	6
Rumohra adiantiformis	6
Metrosideros fulgens	4
Pseudopanax simplex	4
Neomyrtus pedunculata	4
Phymatosorus diversifolius	2
Pseudopanax colensoi	2
Total plant cover	*72*
60 cm–2 m	
Weinmannia racemosa	8
Metrosideros fulgens	8
Astelia solandri	6
Blechnum discolor	6
Podocarpus hallii	6
Pseudopanax simplex	4
Neomyrtus pedunculata	4
Coprosma colensoi	2
Coprosma foetidissima	2
Total plant cover	*38*
2–7.5 m	
Podocarpus hallii	32
Weinmannia racemosa	28
Coprosma foetidissima	26
Metrosideros fulgens	14
Podocarpus ferrugineus	14
Pseudopanax simplex	14
Neomyrtus pedunculata	4
Total plant cover	*28*
>7.5 m	
Podocarpus ferrugineus	62
Podocarpus hallii	54
Weinmannia racemosa	28
Metrosideros umbellata	9
Metrosideros fulgens	1
Total plant cover	*94*
Other species near transect	
Lycopodium varium	
Trichomanes reniforme	
Hymenophyllum sanguinolentum	
Lindsaea trichomanoides	
Asplenium flaccidum	
Dacrydium cupressinum	
Myrsine australis	
Luzuriaga parviflora	

B3d. Rimu/kamahi/Todea forest. Moraine terrace near Lake Wombat, Waiho Valley. Flat, altitude 250 m. Length 100 links (20.1 m).

Species	%
0–10 cm	
Nertera cf. *dichondraefolia*	8
Metrosideros diffusa	2
Pseudopanax simplex	2
Luzuriaga parviflora	2
Bryophyte	72
Litter	14
Total plant cover	*78*
10–60 cm	
Todea superba	16
Metrosideros diffusa	6
Dicksonia squarrosa	6
Blechnum discolor	6
Microlaena avenacea	6
Nertera cf. *dichondraefolia*	2
Astelia nervosa	2
Total plant cover	*44*
60 cm–2 m	
Blechnum discolor	30
Dicksonia squarrosa	4
Blechnum capense "*procerum*"	2
Pseudopanax colensoi	2
Total plant cover	*20*
2–7.5 m	
Weinmannia racemosa	28
Griselinia littoralis	8
Dicksonia squarrosa	6
Pseudopanax crassifolius	4
Hymenophyllum sp. (epiphyte)	2
Total plant cover	*38*
>7.5 m	
Dacrydium cupressinum	44
Weinmannia racemosa	36
Podocarpus ferrugineus	22
Podocarpus hallii	18
Metrosideros umbellata	8
Griselinia littoralis (epiphyte)	4
Hymenophyllum (epiphyte)	2
Total plant cover	*96*
Other species near transect	
Trichomanes reniforme	
Blechnum capense "subalpine"	
Cyathea smithii	
Pseudowintera colorata	
Myrsine divaricata	
Coprosma lucida	
Coprosma foetidissima	
Coprosma wallii	
Astelia solandri	
Ripogonum scandens	
Uncinia sp.	

B3e. Rimu/kamahi–quintinia forest. Ancient moraine north of Forks–Okarito Road. Aspect W, altitude 50 m. Length 100 links (20.1 m).

Species	%
0–10 cm	
Nertera depressa	4
Quintinia acutifolia	2
Uncinia angustifolia	2
Weinmannia racemosa	2
Bryophyte	30
Exposed root	2
Total plant cover	*54*
10–60 cm	
Neomyrtus pedunculata	40
Weinmannia racemosa	14
Metrosideros diffusa	10
Quintinia acutifolia	10
Blechnum capense	8
Phyllocladus alpinus	2
Ripogonum scandens	2
Quintinia acutifolia	2
Astelia nervosa	2
Total plant cover	*64*
60 cm–2 m	
Neomyrtus pedunculata	28
Weinmannia racemosa	20
Quintinia acutifolia	6
Gahnia xanthocarpa	4
Myrsine australis	2
Myrsine divaricata	2
Total plant cover	*54*
2–7.5 m	
Quintinia acutifolia	48
Weinmannia racemosa	34
Pseudopanax crassifolius	6
Podocarpus hallii	6
Metrosideros fulgens	2
Myrsine australis	2
Pseudopanax colensoi	2
Total plant cover	*80*
>7.5 m	
Weinmannia racemosa	28
Podocarpus hallii	20
Dacrydium cupressinum	14
Quintinia acutifolia	6
Total plant cover	66
Other species near transect	
Hymenophyllum spp.	
Lindsaea trichomanoides	
Dicksonia squarrosa	
Cyathea colensoi	
Grammitis heterophylla	
Blechnum discolor	
Podocarpus ferrugineus	
Ascarina lucida	
Metrosideros umbellata	
Griselinia littoralis	
Nertera cf. *dichondraefolia*	

B5a. Rata–kamahi/Blechnum forest. Track to Alex Knob. Aspect NW, slope 25°, altitude 550 m. Length 100 links (20.1 m).

Species	%
0–10 cm	
Nertera cf. *dichondraefolia*	4
Blechnum nigrum	2
Hedycarya arborea	2
Luzuriaga parviflora	2
Metrosideros diffusa	2
Todea superba	2
Bryophyte	36
Litter and log	52

Bare soil	6
Total plant cover	*46*
10–60 cm	
Blechnum discolor	14
Cyathea smithii	2
Luzuriaga parviflora	2
Phymatosorus diversifolius	2
Pseudopanax colensoi	2
Bryophyte and lichen	6
Logs	6
Total plant cover	*84*
60 cm–2 m	
Cyathea smithii	12
Hymenophyllum sp.	4
Metrosideros diffusa	4
Blechnum discolor	2
Astelia nervosa	2
Dicksonia squarrosa	2
Metrosideros fulgens	2
Pseudopanax simplex	2
Tmesipteris tannenis	2
Pseudowintera colorata	2
Bryophyte	2
Exposed root	6
Total plant cover	*40*
2–7.5 m	
Cyathea smithii	40
Pseudowintera colorata	34
Podocarpus ferrugineus	12
Weinmannia racemosa	10
Coprosma foetidissima	4
Dicksonia squarrosa	4
Metrosideros diffusa	4
Phymatosorus diversifolius	2
Total plant cover	*84*
>7.5 m	
Weinmannia racemosa	82
Metrosideros umbellata	22
Coprosma foetidissima	2
Total plant cover	*90*

Other species near transect

Podocarpus hallii
(list incomplete)

B6a. Rata-Libocedrus forest. Track to Alex Knob on side of broad spur. Aspect NE, slope 26°, altitude 700 m. Length 100 links (20.1 m).

Species	%
0–10 cm	
Dendroligotrichum dendroides	14
Blechnum fluviatile	4
Pseudowintera colorata	2
Bryophyte	36
Exposed root	6
Litter and log	66
Total plant cover	*42*
10–60 cm	
Dendroligotrichum dendroides	16
Cyathea colensoi	8
Weinmannia racemosa	4
Blechnum discolor	2
Blechnum fluviatile	2
Coprosma foetidissima	2
Log	6
Total plant cover	*36*
60 cm–2 m	
Pseudowintera colorata	10
Coprosma foetidissima	4
Pseudopanax simplex	2
Weinmannia racemosa	2
Total plant cover	*20*
2–7.5 m	
Podocarpus hallii	22
Pseudopanax simplex	20
Coprosma wallii	16
Pseudowintera colorata	16
Weinmannia racemosa	16
Rubus cissoides	14
Metrosideros umbellata	10
Pseudopanax linearis	8
Coprosma foetidissima	2
Myrsine divaricata	2
Total plant cover	*80*
>7.5 m	
Metrosideros umbellata	66
Weinmannia racemosa	26
Libocedrus bidwillii	22
Podocarpus hallii	20
Griselinia littoralis	10
Pseudopanax simplex	2
Rubus cissoides	2
Total plant cover	*90*

Other species near transect

Todea superba
Grammitis billardieri
Polystichum vestitum
Astelia nervosa
Microlaena avenacea (dominant in patches)

C1. Successional rata-kamahi forest. Moraine formed during seventeenth century, Waiho Valley. Rolling, altitude 200 m. Length 100 links (20.1 m).

Species	%
TRANSECT 1	
0–10 cm	
Nertera cf. *dichondraefolia*	8
Weinmannia racemosa (seedling)	2
Bryophyte and lichen	44
Litter and humus	46
Total plant cover	*56*
10–60 cm	
Astelia fragrans	10
Astelia nervosa	6
Blechnum capense "procerum"	2
Coprosma colensoi	2
Dicksonia squarrosa	2
Grammitis billardieri (epiphyte)	2
Myrsine divaricata	2
Lichen	2
Total plant cover	*30*
60 cm–2 m	
Cyathea smithii	22
Griselinia littoralis	8
Podocarpus ferrugineus	6
Coprosma foetidissima	2

Pseudopanax simplex	2
Pseudopanax colensoi	2
Total plant cover	*40*
2–7.5 m	
Coprosma foetidissima	42
Griselinia littoralis	24
Podocarpus ferrugineus	20
Cyathea smithii	14
Myrsine divaricata	14
Weinmannia racemosa	10
Coprosma rhamnoides	8
Pseudopanax simplex	8
Coprosma wallii	4
Pseudopanax crassifolius	4
Pseudowintera colorata	4
Phymatosorus diversifolius	2
Total plant cover	*96*
>7.5 m	
Metrosideros umbellata	100
Griselinia littoralis (epiphyte)	6
Hymenophyllum sp. (epiphyte)	2
Total plant cover	*100*

TRANSECT 2

>7.5 m	
Weinmannia racemosa	58
Metrosideros umbellata	56
Hymenophyllum sp. (epiphyte)	2
Total plant cover	*100*

Other species near transects
Hymenophyllum incl. *flabellatum*
Tmesipteris tannensis
Asplenium flaccidum
Polystichum vestitum
Podocarpus hallii
Myrsine australis
Schefflera digitata
Carpodetus serratus
Farina autumnalis
Dendrobium cunninghamii

Note:
Weinmannia racemosa—single stems to 43 cm diameter, height 18–24 m.
Metrosideros umbellata—single stems to 53 cm diameter; height 18–24 m.

C1. Successional rata–kamahi forest. Old slip on rolling glacial terrace, near Lake Wombat, Waiho Valley. Aspect SE, slope 25°, altitude 250 m. Length 100 links (20.1 m).

Species	%
0–10 cm	
Litter	100
Total plant cover	—
10–60 cm	
Blechnum discolor	4
Total plant cover	*4*
60 cm–2 m	
Blechnum capense "procerum"	100
Blechnum discolor	4
Weinmannia racemosa	4
Total plant cover	*100*
2–7.5 m	
Weinmannia racemosa	58
Pseudopanax colensoi	32
Pseudopanax simplex	18
Coprosma lucida	8
Coriaria arborea	6
Dracophyllum longifolium	4
Griselinia littoralis	4
Metrosideros umbellata	4
Coprosma foetidissima	2
Rubus cissoides	2
Total plant cover	96
>7.5 m	
Metrosideros umbellata	30
Weinmannia racemosa	10
Total plant cover	*30*

Other species near transects
Lycopodium volubile
Podocarpus hallii
Hedycarya arborea
Schefflera digitata
Coprosma wallii
Olearia arborescens

Note: Large trees are overhanging transect from above.

D1c. Low forest developing into successional rata–kamahi forest. Moraine formed shortly before 1840, Waiho Valley. Rolling, altitude 250 m. Length 100 links (20.1 m).

Species	%
0–10 cm	
Nertera cf. *dichondraefolia*	8
Bryophyte	6
Exposed root	2
Litter and humus	82
Total plant cover	*16*
10–60 cm	
Astelia fragrans	10
Blechnum capense "procerum"	6
Asplenium bulbiferum	6
Polystichum vestitum	4
Asplenium flaccidum	2
Rubus schmidelioides	2
Hedycarya arborea	2
Total plant cover	*28*
60 cm–2 m	
Blechnum capense "procerum"	32
Astelia fragrans	24
Asplenium bulbiferum	6
Phymatosorus diversifolius (epiphyte)	4
Melicytus ramiflorus	2
Griselinia littoralis	2
Rubus schmidelioides	2
Schefflera digitata	2
Total plant cover	*54*
2–7.5 m	
Melicytus ramiflorus	46
Fuchsia excorticata	28
Phymatosorus diversifolius	16
Coriaria arborea	10
Griselinia littoralis	10
Olearia avicenniaefolia	8
Metrosideros umbellata	8
Coprosma lucida	6
Hedycarya arborea	6

Asplenium flaccidum	4
Rubus schmidelioides	4
Coprosma wallii	4
Ripogonum scandens	4
Schefflera digitata	2
Carpodetus serratus	2
Total plant cover	*90*
>7.5 m	
Metrosideros umbellata	48
Weinmannia racemosa	14
Total plant cover	*62*

Other species near transect
Cyathea smithii
Hymenophyllaceae
Blechnum chambersii
Grammitis heterophylla
Podocarpus ferrugineus
Dacrydium cupressinum
Weinmannia racemosa
Myrsine australis
Pseudopanax colensoi
Earina mucronata

D2a. Kamahi/Schefflera forest. Track to Alex Knob and Lake Wombat. Aspect E, average slope 18°, altitude 250 m. Length 100 links (20.1 m).

Species	%
0–10 cm	
Asplenium bulbiferum	4
Blechnum chambersii	2
Nertera cf. *dichondraefolia*	2
Bryophyte	18
Exposed root	4
Litter and humus	72
Rock	2
Total plant cover	*36*
10–60 cm	
Asplenium bulbiferum	22
Schefflera digitata	8
Blechnum chambersii	2
Dicksonia squarrosa	2
Metrosideros diffusa	2
Polystichum vestitum	2
Bryophyte	8
Dead shrub	2
Total plant cover	*40*
60 cm–2 m	
Asplenium bulbiferum	36
Schefflera digitata	18
Dicksonia squarrosa	10
Cyathea smithii	8
Phymatosorus diversifolius	8
Metrosideros diffusa	4
Melicytus ramiflorus	2
Bryophyte and lichen	8
Log	6
Total plant cover	*64*
2–7.5 m	
Schefflera digitata	80
Cyathea smithii	34
Phymatosorus diversifolius	12
Griselinia littoralis	6
Melicytus ramiflorus	4
Rubus cissoides	4
Asplenium bulbiferum	2
Hymenophyllum spp.	2
Ripogonum scandens	2
Trichomanes reniforme	2
Bryophyte	16
Total plant cover	*96*
>7.5 m	
Melicytus ramiflorus	13
Griselinia littoralis	1
Total plant cover	*13*

Other species near transect
Hymenophyllum flexuosum
Hymenophyllum sanguinolentum
Rumohra adiantiforme
Dacrydium cupressinum
Hedycarya arborea seedling
Weinmannia racemosa
Metrosideros umbellata
Aristotelia serrata epiphytic seedlings
Fuchsia excorticata epiphytic seedlings
Pennantia corymbosa seedling

D2a. Kamahi/Schefflera forest. Track to Alex Knob. Aspect NW, slope 40°, altitude 350 m. Length 100 links (20.1 m).

Species	%
0–10 cm	
Blechnum nigrum	6
Metrosideros diffusa	6
Nertera cf. *dichondraefolia*	6
Asplenium bulbiferum	4
Cyathea smithii	4
Blechnum chambersii	2
Coprosma foetidissima	2
Grammitis billardieri	2
Hedycarya arborea (root)	2
Dicksonia squarrosa	2
Phymatosorus diversifolius	2
Ripogonum scandens	2
Lastreopsis hispida	2
Bryophyte and lichen	8
Exposed root	2
Litter	58
Rock	12
Bare soil	4
Log	2
Total plant cover	*42*
10–60 cm	
Asplenium bulbiferum	30
Metrosideros diffusa	24
Blechnum nigrum	4
Cyathea smithii	2
Hedycarya arborea	2
Hymenophyllum ferrugineum	2
Phymatosorus diversifolius	2
Ripogonum scandens	2
Todea hymenophylloides	2
Total plant cover	*58*
60 cm–2 m	
Cyathea smithii	24
Metrosideros diffusa	16
Asplenium bulbiferum	12
Ripogonum scandens	12
Weinmannia racemosa (trunk)	6
Coprosma foetidissima	2

Dicksonia squarrosa	2
Hedycarya arborea	2
Schefflera digitata	2
Total plant cover	*64*
2–7.5 m	
Cyathea smithii	30
Melicytus ramiflorus	30
Metrosideros diffusa	20
Hedycarya arborea	14
Weinmannia racemosa	10
Ripogonum scandens	8
Phymatosorus diversifolius	4
Pseudowintera colorata	4
Schefflera digitata	4
Total plant cover	*76*
>7.5 m	
Weinmannia racemosa	74
Ripogonum scandens	6
Total plant cover	*74*

Other species near transect
Asplenium flaccidum
Asplenium falcatum
Dacrydium cupressinum (epiphytic seedling)
Myrsine australis (epiphyte)
Astelia solandri

E2. Olearia avicenniaefolia scrub. Gravel surface formed *c.* 1930, upper Waiho Valley. Measured 1972. Flat, altitude 250 m. Length 100 links (20.1 m).

Species	%
0–10 cm	
Bryophyte	2
Litter	45
Rock	2
Stem base	2
Total plant cover	*4*
10–60 cm	
Polystichum vestitum	30
Chionochloa conspicua	10
Asplenium bulbiferum	2
Asplenium flaccidum (epiphyte)	2
Griselinia littoralis	2
Hymenophyllum sanguinolentum	2
Schefflera digitata	2
Bryophyte (epiphyte)	6
Total plant cover	*50*
60 cm–2 m	
Blechnum procerum	16
Aristotelia serrata	4
Schefflera digitata	4
Hymenophyllum sanguinolentum (epiphyte)	2
Total plant cover	*26*
2–7.5 m	
Olearia avicenniaefolia	82
Carmichaelia cf. *grandiflora*	26
Coprosma rugosa	14
Coriaria arborea	6
Hebe salicifolia	4
Aristotelia serrata	2
Phymatosorus diversifolius (epiphyte)	2
Total plant cover	*96*

Other species near transect
Histiopteris incisa
Cyathea colensoi
Grammitis heterophylla
Blechnum fluviatile
Melicytus lanceolatus
Melicytus ramiflorus
Hoheria glabrata
Myrsine divaricata
Gingidium montanum
Acaena anserinifolia
Gaultheria rupestris
Olearia arborescens
Olearia ilicifolia
Senecio bennettii
Senecio wairauensis
Uncinia uncinata
Pterostylis graminea
Corybas triloba
Corybas sp.

E4a. Tall climax subalpine scrub. Track to Alex Knob. Aspect N, altitude 1 150 m. Length 10 m.

Species	%
0–10 cm	
Blechnum capense	2
Bryophyte	12
Litter	86
Total plant cover	*14*
10–60 cm	
Astelia nervosa	20
Olearia colensoi	12
Blechnum capense	8
Coprosma serrulata	2
Phormium cookianum	2
Total plant cover	*40*
60 cm–2 m	
Coprosma pseudocuneata	44
Olearia colensoi	34
Pseudopanax colensoi	14
Dracophyllum traversii (trunk)	6
Coprosma depressa	2
Coprosma serrulata	2
Pittosporum crassicaule	2
Hymenophyllum villosum	2
Dracophyllum longifolium	2
Total plant cover	*82*
2–7.5 m	
Dracophyllum longifolium	38
Coprosma pseudocuneata	32
Olearia colensoi	24
Pseudopanax colensoi	14
Dracophyllum traversii	2
Total plant cover	*82*

Other species near transect
Archeria traversii
Senecio bennettii (seedlings)
Olearia lacunosa
Uncinia angustifolia

F1a. Open montane Carmichaelia shrubland. Waiho Valley, on gravel outwash formed *c.* 1950. Measured in 1972. Flat, altitude 230 m. Length 100 links (20.1 m).

Species	%
0–10 cm	
Nertera ciliata	36
Hypochoeris radicata†	28
Notodanthonia gracilis	24
Gunnera monoica	18
Holcus lanatus†	16
Luzula picta	12
Cerastium holosteoides†	10
Raoulia hookeri	6
Uncinia divaricata	6
Anthoxanthum odoratum†	4
Carmichaelia cf. *grandiflora*	2
Gnaphalium sp.	2
Craspedia lanata	2
Erechtites wairauensis	2
Parahebe lyallii	2
Aira caryophyllea†	2
Bryophyte and lichen	68
Total plant cover	*100*
10–60 cm	
Carmichaelia cf. *grandiflora*	32
Holcus lanatus†	32
Anthoxanthum odoratum†	16
Luzula picta	6
Olearia avicenniaefolia	6
Notodanthonia gracilis	4
Cerastium holosteoides†	2
Cortaderia richardii	2
Hebe salicifolia	2
Mentha cunninghamii	2
Gaultheria rupestris	2
Lotus pedunculatus†	2
Total plant cover	*34*
60 cm–2 m	
Chionochloa conspicua	6
Hebe salicifolia	4
Olearia avicenniaefolia	4
Total plant cover	*86*
2–7.5 m	
Coriaria arborea	2
Total plant cover	*2*
Other species near transect	
Gingidium montanum	
Dracophyllum longifolium	
Coprosma rugosa	
Celmisia coriacea	
Olearia arborescens	
Helichrysum bellidioides	
Hebe subalpina	
Parahebe lyallii	
Festuca arundinacea†	

G1a trans. to F3. Tall herbaceous vegetation on alpine talus transitional to low subalpine scrub on recent soils. Alf Creek, at low end of Chancellor Shelf. Aspect SW, slope 22°, altitude 1 050 m. Length 500 in. (17.5 m).

Species	%
0–10 cm	
Poa cockayniana	20
Blechnum penna-marina	18
Uncinia divaricata	6
Olearia moschata	6
Acaena anserinifolia	4
Polystichum vestitum	4
Chionochloa pallens	2
Hypolepis millefolium	2
Pratia angulata	2
Ranunculus hirtus	2
Taraxacum magellanicum	2
Bryophyte	6
Exposed soil	2
Total plant cover	*58*
10–60 cm	
Hypolepis millefolium	76
Poa cockayniana	44
Chionochloa pallens	14
Olearia moschata	14
Uncinia divaricata	10
Blechnum penna-marina	8
Polystichum vestitum	8
Senecio scorzoneroides	2
Trisetum youngii	2
Taraxacum magellanicum	2
Total plant cover	*98*
60 cm–2 m	
Olearia moschata	*18*
Other species near transect	
Oxalis lactea	
Coprosma depressa	

G2b. Dense climax Chionochloa pallens grassland. Talus slope above Chancellor Shelf. Aspect SW, slope 28°, altitude 1 250 m. Length 500 in. (12.7 m).

Species	%
0–10 cm	
Chionochloa pallens	26
Hydrocotyle novae-zelandiae var. *montana*	16
Poa colensoi	14
Uncinia divaricata	8
Hebe treadwellii	6
Coprosma cheesemanii	4
Deyeuxia aucklandica	4
Muehlenbeckia axillaris	4
Senecio scorzoneroides	2
Viola cunninghamii	2
Bryophyte	2
Litter	46
Total plant cover	*66*
10–60 cm	
Chionochloa pallens	100
Hebe treadwellii	12
Uncinia divaricata	6
Coprosma cheesemanii	4
Poa colensoi	4
Deyeuxia aucklandica	2
Total plant cover	*100*
Other plants near transect	
Ranunculus lyallii	
Geranium microphyllum	
Helichrysum bellidioides	
Celmisia petiolata	
Hebe macrantha	
?Trisetum youngii	

G2b. Dense climax Chionochloa pallens grassland. Moraine on Chancellor Shelf. Rolling, altitude 1 300 m. Length 500 in. (12.7 m).

Species	%
0–10 cm	
Poa colensoi	28
Schoenus pauciflorus	22
Cotula squalida	16
Gaultheria depressa	16
Oreomyrrhis colensoi	14
Chionochloa pallens	8
Muehlenbeckia axillaris	8
Microlaena colensoi	8
Uncinia divaricata	8
Caltha novae-zelandiae	6
Pratia angulata	4
Astelia nivicola	4
Lycopodium fastigiatum	4
Dicranoloma sp.	4
Chionochloa conspicua	2
Dicot. seedling	2
Epilobium gracilipes	2
Anisotome aromatica	2
Celmisia vespertina	2
Pernettya alpina	2
Litter	20
Total plant cover	94
10–60 cm	
Chionochloa pallens	88
Schoenus pauciflorus	34
Dracophyllum kirkii	10
Poa colensoi	8
Microlaena colensoi	8
?Trisetum youngii	6
Aciphylla lyallii	4
Celmisia vespertina	2
Grass, sp. not identified	2
Poa kirkii	2
Total plant cover	96
Other species near transect	
Geranium microphyllum	
Myrsine nummularia	
Anisotome haastii	
Cyathodes fraseri	
Plantago uniflora	
Gentiana bellidifolia	
Celmisia petiolata	
Euphrasia cf. *zelandica*	
Hebe treadwellii	
Hebe macrantha	
Oreobolus impar	
Astelia petriei	

G2b. Dense climax Chionochloa pallens grassland. Talus slope above Chancellor Shelf. Aspect SW, slope 33°, altitude 1 350 m. Length 250 in. (6.4 m).

Species	%
0–10 cm	
Poa colensoi	56
Chionochloa pallens	24
Coprosma pumila	16
Uncinia divaricata	4
Pernettya alpina	2
Litter	36
Total plant cover	82
10–60 cm	
Chionochloa pallens	88
Celmisia petiolata	10
Ranunculus lyallii	2
Senecio scorzoneroides	2
Total plant cover	88
Other species near transect	
Aciphylla crenulata	
Senecio scorzonerioides	
Celmisia petiolata	
Hebe treadwellii	
?Trisetum youngii	

G2c. Open Chionochloa pallens/turf. Moraine, Chancellor Shelf. Aspect SW, slope 18°, altitude 1 350 m. Length 250 in. (6.4 m).

Species	%
0–10 cm	
Poa colensoi	46
Coprosma pumila	24
Celmisia sessiliflora	24
Lycopodium fastigiatum	18
Anisotome aromatica	10
Caltha novae-zelandiae	8
Celmisia vespertina	8
Chionochloa pallens	6
Forstera cf. *sedifolia* species A	6
Pernettya alpina	4
Plantago lanigera	2
Bryophyte	8
Litter	22
Rubble	2
Total plant cover	96
10–60 cm	
Chionochloa pallens	34
Celmisia vespertina	4
Marsipposperma gracile	2
Total plant cover	38
Other species near transect	
Rhacomitrium lanuginosum	
Ranunculus lyallii	
Aciphylla crenulata	
Celmisia du-rietzii	
Raoulia grandiflora	
Senecio scorzoneroides	
Gentiana bellidifolia	
Euphrasia cf. *zelandica*	
Hebe treadwellii	
Trisetum youngii	

G4a. Seral Chionochloa cf. flavescens grassland. Bordering stream, lower end of Chancellor Shelf. Aspect W, slope 5°, altitude 1 050 m. Length 500 in. (12.7 m).

Species	%
0–10 cm	
Chionochloa cf. *flavescens*	18
Poa colensoi	4
Celmisia coriacea	2
Carmichaelia cf. *grandiflora*	2
Poa kirkii	2
Pratia angulata	2
Total plant cover	32
10–60 cm	
Celmisia coriacea	14
Astelia petriei	4

Coprosma serrulata	4
Ranunculus lyallii	2
Total plant cover	*24**
>60 cm	
Chionochloa cf. *flavescens*	*96*

* Intercepts of *Chionochloa* cf. *flavescens* were not recorded in the 10–60 cm range.

G6. Chionochloa crassiuscula grassland. Thin peaty silt loam on solid rock, lower end of Chancellor Shelf. Aspect W, slope 20°, altitude 1 050 m. Length 250 in. (6.4 m).

Species	%
0–10 cm	
Coprosma pumila	18
Carpha alpina	10
Poa colensoi	10
Chionochloa crassiuscula	10
Celmisia petiolata	4
Schoenus pauciflorus	4
Caltha novae-zelandiae	2
Celmisia du-rietzii	2
Celmisia vespertina	2
Dicranoloma sp.	2
Astelia petriei	2
Chionochloa oreophila	2
Myrsine nummularia	2
Plantago cf. *novae-zelandiae*	2
Bryophyte	24
Litter	20
Exposed soil	4
Total plant cover	*74*
10–60 cm	
Chionochloa crassiuscula	38
Schoenus pauciflorus	14
Dracophyllum uniflorum	6
Astelia petriei	4
Celmisia petiolata	2
Celmisia vespertina	2
Myrsine nummularia	2
Total plant cover	*8*

Other species near transect
Lycopodium fastigiatum
Ranunculus lyallii
Coprosma cheesemanii
Euphrasia zelandica
Ourisia macrocarpa
Hebe macrantha
Forstera species A
Phormium cookianum
Aporostylis bifolia

H2a. trans. to G2c. Chionochloa oreophila–Poa colensoi grassland transitional to open Chionochloa pallens/turf. Moraines at high end of Chancellor Shelf. Aspect N, slope 22°, altitude 1 400 m. Length 250 in. (6.4 m).

Species	%
0–10 cm	
Chionochloa oreophila	20
Coprosma pumila	12
Poa colensoi	10
Pernettya alpina	4
Celmisia sessiliflora	4
Agrostis magellanica	2
Anisotome aromatica	2
Gentiana bellidifolia	2
Bryophyte	6
Litter	8
Rubble and rock	56
Total plant cover	52
10–60 cm	
Chionochloa pallens	4
Marsippospermum gracile	2
Total plant cover	*16*

Other species near transect
Colobanthus ?monticola
Anisotome aromatica
Schizeilema haastii
Gentiana divisa
Raoulia grandiflora
Celmisia ?haastii
Senecio scorzoneroides
Oreobolus impar

H2a. Chionochloa oreophila–Poa colensoi grassland. Moraine at high end of Chancellor Shelf. Apect S, slope 34°, altitude 1 400 m. Length 250 in. (6.4 m).

Species	%
0–10 cm	
Poa colensoi	36
Microlaena colensoi	30
Chionochloa oreophila	12
Polytrichaceae	10
Anisotome flexuosa	6
Marsippospermum gracile	6
Ourisia sessilifolia	6
Uncinia clavata	6
Forstera sedifolia species A	4
Coprosma pumila	2
Carex pyrenaica	2
Bryophyte	26
Litter	18
Rubble	2
Total plant cover	*92*
10–60 cm	
Marsippospermum gracile	32
Chionochloa oreophila	2
Chionochloa pallens	2
Total plant cover	*34*

Other species near transect
Lycopodium australianum
Schizeilema haastii
Celmisia sessiliflora
Senecio scorzoneroides
Raoulia grandiflora
Pygmea ciliolata

H2a. Chionochloa oreophila–Poa colensoi grassland. Moraine at high end of Chancellor Shelf. Aspect S, slope 28°, altitude 1 400 m. Length 250 in. (6.4 m).

Species	%
0–10 cm	
Poa colensoi	22
Chionochloa oreophila	16
Marsippospermum gracile	10
Celmisia sessiliflora	2

Coprosma pumila	2
Pernettya alpina	2
Bryophyte and lichen	20
Litter	16
Rock and rubble	34
Total plant cover	*68*

Other species near transect
Lycopodium australianum
Polystichum vestitum
Schizeilema haastii
Anisotome flexuosa
Forstera sedifolia species A
Raoulia subulata
Raoulia grandiflora
Celmisia haastii
Senecio scorzoneroides
Chionochloa pallens

112a. Chionochloa oreophila–Poa colensoi grassland. Crest of moraine at high end of Chancellor Shelf. Aspect SW, slope 17°, altitude 1 400 m. Length 250 in. (6.4 m).

Species	%
0–10 cm	
Poa colensoi	28
Raoulia grandiflora	12
Chionochloa oreophila	10
Pernettya alpina	10
Anisotome aromatica	6
Celmisia sessiliflora	4
Drapetes lyallii	2
Lichen	10
Litter	10
Rock and rubble	50
Exposed soil	12
Total plant cover	*56*
10–60 cm	
Chionochloa pallens	*2*

Other species near transect
Senecio scorzoneroides
Celmisia ?haastii
Marsippospermum gracile

112a. Chionochloa oreophila–Poa colensoi grassland. Depression in moraine, high end of Chancellor Shelf. Aspect N, slope 28°, altitude 1 500 m. Length 250 in. (6.4 m).

Species	%
0–10 cm	
Poa colensoi	62
Microlaena colensoi	16
Carex pyrenaica	8
Marsippospermum gracile	8
Chionochloa oreophila	4
Bryophyte	30
Litter	4
Rubble and rock	8
Total plant cover	*90*
10–60 cm	
Marsippospermum gracile (browsed)	*58*

Other species near transect
Senecio scorzoneroides

112b. Short alpine herbfield. Moraine at high end of Chancellor Shelf. Aspect N, slope 28°, altitude 1 500 m. Length 250 in. (6.4 m).

Species	%
0–10 cm	
Poa colensoi	30
Anisotome flexuosa	8
Microlaena colensoi	8
Raoulia grandiflora	6
Colobanthus monticola	4
Luzula colensoi	2
Rubble and rock	66
Bare soil	2
Total plant cover	*38*

Other species near transect
Claytonia australasica
Drapetes lyallii
Anisotome pilifera
Celmisia du-rietzii
Luzula crinita
Carex pyrenaica
Marsippospermum gracile

112b. Short alpine herbfield. Moraine at high end of Chancellor Shelf. Aspect W, slope 18°, altitude 1 500 m. Length 250 in. (6.4 m).

Species	%
0–10 cm	
Poa colensoi	16
Marsippospermum gracile (browsed)	10
Luzula colensoi	6
Pygmea ciliolata	2
Raoulia grandiflora	2
Lichen	2
Litter	10
Rubble and rock	62
Total plant cover	*38*
10–60 cm	
Marsippospermum gracile (browsed)	*38*

Other species near transect
Lycopodium australianum
Colobanthus ?monticola
Anisotome flexuosa
Anisotome pilifera
Schizeilema haastii
Gentiana divisa
Raoulia grandiflora
Senecio scorzoneroides
Celmisia du-rietzii
Myosotis suavis
Luzula pumila
Microlaena colensoi

12a. Lowland Raoulia community. Gravel area formed during flood in 1965, upper Waiho Valley. Measured 1972. Flat, altitude 250 m. Length 100 links (20.1 m).

Species	%
TRANSECT 1	
0–10 cm	
Carmichaelia nigrans	30
Raoulia tenuicaulis	30
Raoulia hookeri	12

Epilobium brunnescens	2
Bryophyte and lichen	50
Rock	18
Total plant cover	*84*
10–60 cm	
Carmichaelia cf. *grandiflora*	6
Lachnagrostis lyallii	2
Total plant cover	*8*
TRANSECT 2	
0–10 cm	
Raoulia tenuicaulis	40
Raoulia hookeri	10
Epilobium brunnescens	2
Epilobium microphyllum	2
Bryophyte and lichen	34
Rock	20
Total plant cover	72

Other species near transect
Cerastium holosteoides†
Epilobium glabellum
Coriaria arborea
Hypochoeris radicata†
Hebe salicifolia
Cortaderia richardii
Holcus lanatus†
Poa novae-zelandiae
Notodanthonia setifolia
Aira caryophyllea†
Microtis unifolia

Plant dimensions
Carmichaelia cf. *grandiflora* and *Olearia avicenniaefolia* to 20 cm tall.
Raoulia tenuicaulis to 2.75 m diameter.
Raoulia hookeri to 45 cm diameter.

13a. Alpine successional short grassland. Talus with large boulders, recently disturbed by stream, Chancellor Shelf. Aspect SW, slope 28°, altitude 1 250 m. Length 250 in. (6.4 m).

Species	%
0–10 cm	
Poa colensoi	22
Muehlenbeckia axillaris	14
Uncinia divaricata	10
Chionochloa pallens	8
Geranium microphyllum	6
Hydrocotyle novae-zelandiae var. *montana*	4
Viola cunninghamii	4
Hebe treadwellii	2
Taraxacum magellanicum	2
Bryophyte	12
Litter	16
Rock	52
Total plant cover	*50*

Other species near transect
Epilobium glabellum
Celmisia petiolata
Senecio scorzoneroides
Hebe ciliolata
?*Trisetum youngii*

13a. Alpine successional short grassland. Talus slope recently disturbed by stream, above Chancellor Shelf. Aspect SW, slope 28°, altitude 1 250 m. Length 250 in. (6.4 m).

Species	%
0–10 cm	
Muehlenbeckia axillaris	48
Poa colensoi	22
Hydrocotyle novae-zelandiae var. *montana*	18
Helichrysum bellidioides	6
Agrostis dyeri	4
Chionochloa pallens	2
Grass seedling	2
Uncinia divaricata	2
Viola cunninghamii	2
Litter	10
Rubble and rock	64
Total plant cover	*68*
10–60 cm	
Chionochloa pallens	16
Poa colensoi	4
Total plant cover	*18*

Other species near transect
Polystichum vestitum
Epilobium brunnescens
Schizeilema haastii
Leucogenes grandiceps
Taraxacum magellanicum

14a. Cushion plant community. Across moraine higher than Chancellor Shelf. Aspect N–S, slopes 28°, altitude 1 700 m. Length of each transect 25 ft (7.6 m).

Species	%
TRANSECT 1 (Across crest)	
0–10 cm	
Raoulia grandiflora	14
Celmisia sessiliflora	6
Poa colensoi	4
Carex pyrenaica	4
Anisotome flexuosa	2
Luzula colensoi	2
Marsippospermum gracile	2
Pygmea ciliolata	2
Bryophyte	2
Litter	4
Rock and rubble	56
Bare soil	10
Total plant cover	*30*
TRANSECT 2 (N slope)	
0–10 cm	
Raoulia grandiflora	10
Poa colensoi	10
Chionochloa oreophila	6
Celmisia sessiliflora	4
Anisotome flexuosa	2
Litter	2
Rubble and rock	72
Total plant cover	*24*
TRANSECT 3 (S slope)	
0–10 cm	
Hectorella caespitosa	4
Agrostis cf. *magellanica*	2
Anisotome flexuosa	2
Luzula colensoi	2
Poa colensoi	2
Rubble and rock	82
Bare soil	6

Total plant cover	*12*

Other species near transect
Lycopodium australianum
Colobanthus monticola
Drapetes lyallii
Gentiana divisa

J1b. Dacrydium intermedium forest. West of bridge on Okarito River, on Forks–Okarito Road. Flat, altitude 90 m. Length 100 links (20.1 m).

Species	%
0–10 cm	
Gahnia procera	4
Blechnum capense "minus"	2
Nertera scapanioides	2
Podocarpus hallii (trunk)	2
Bryophyte	66
Litter	26
Exposed root	2
Total plant cover	*74*
10–60 cm	
Gahnia procera	54
Blechnum capense "minus"	12
Neomyrtus pedunculata	8
Quintinia acutifolia	4
Astelia nervosa	2
Coprosma foetidissima	2
Dacrydium intermedium	2
Podocarpus hallii	2
Phyllocladus alpinus	2
Bryophyte (epiphytic)	2
Total plant cover	*80*
60 cm–2 m	
Podocarpus hallii	8
Dacrydium intermedium (trunk)	4
Phyllocladus alpinus	4
Dacrydium cupressinum (trunk)	2
Quintinia acutifolia	2
Total plant cover	*56*
2–7.5 m	
Podocarpus hallii	32
Dacrydium intermedium	22
Weinmannia racemosa	18
Pseudopanax crassifolius	14
Phyllocladus alpinus	8
Dacrydium cupressinum	2
Pseudopanax colensoi	2
Total plant cover	*62*
>7.5 m	
Dacrydium intermedium	50
Dacrydium cupressinum	12
Phyllocladus alpinus	6
Pseudopanax colensoi	2
Total plant cover	*56*

Other species near transect
Hymenophyllum spp.
Trichomanes reniforme
Dacrydium colensoi
Leptospermum scoparium
Griselinia littoralis
Luzuriaga parviflora
Libertia pulchella
Ripogonum scandens

K3b. Induced pakihi. Between the Forks and Okarito. Burnt in 1967, measured in 1973. Flat, altitude 100 m. Length in each transect 25 ft (7.6 m).

Species	%
TRANSECT 1	
0–10 cm	
Baumea teretifolia	20
Haloragis micrantha	4
Drosera spathulata	2
Notodanthonia gracilis	2
Bryophyte	32
Bare soil	36
Water	6
Total plant cover	*58*
10–60 cm	
Gleichenia circinata	70
Baumea teretifolia	46
Baumea tenax	20
Total plant cover	*50*
TRANSECT 2	
0–10 cm	
Baumea teretifolia	10
Empodisma minus	4
Bryophyte	4
Bare soil	12
Mud	62
Total plant cover	*18*
10–60 cm	
Baumea teretifolia	62
Empodisma minus	40
Total plant cover	*78*
TRANSECT 3	
0–10 cm	
Lycopodium ramulosum	46
Empodisma minus	8
Baumea teretifolia	6
Notodanthonia gracilis	6
Liparophyllum gunnii (pools)	4
Celmisia graminifolia	2
Bryophyte	24
Bare soil	10
Water	14
Total plant cover	*76*
10–60 cm	
Baumea teretifolia	30
Gleichenia circinata	22
Empodisma minus	20
Total plant cover	*58*
TRANSECT 4	
0–10 cm	
Empodisma minus	6
Lycopodium ramulosum	2
Baumea teretifolia	2
Bryophyte	78
Litter	2
Bare soil	10
Total plant cover	*88*
10–60 cm	
Gleichenia circinata	92
Empodisma minus	34
Baumea teretifolia	18
Bulbinella modesta	4
Total plant cover	*100*

Other species near transects
Drosera binata
Leptospermum scoparium (burnt)
Euphrasia disperma
Utricularia novae-zelandiae
Centrolepis ciliata
Gahnia rigida
Thelymitra venosa

M1c. Seral vegetation on glacially scoured schist. Sentinel Rock, Waiho Valley. Freed from ice *c.* 110 years. Aspect NW, slopes averaging 25°, but up to 37°, altitude 280 m. Length 100 links (20.1 m).

Species	%
0–10 cm	
Lycopodium scariosum	8
Schoenus pauciflorus	2
Coprosma lucida	2
Bryophyte	92
Litter	12
Total plant cover	*84*
10–60 cm	
Lycopodium fastigiatum	20
Coprosma lucida	4
Phormium colensoi	4
Schoenus pauciflorus	2
Dracophyllum longifolium	2
Olearia arborescens	2
Total plant cover	*74*
60 cm–2 m	
Dracophyllum longifolium	10
Phormium colensoi	6
Carmichaelia grandiflora	4
Olearia arborescens	4
Gaultheria rupestris	2
Total plant cover	*30*

Other species near transect
Trichomanes reniforme
Blechnum capense "subalpine"
Cyathea smithii
Pseudopanax colensoi
Myrsine divaricata
Coprosma foetidissima
Coprosma wallii
Astelia solandri
Ripogonum scandens

APPENDIX 2 – SPECIES DIVERSITY

The numbers of vascular species listed from full field descriptions of the more extensive communities are tabulated in Appendix Table 1. No detailed interpretation is possible, because stands varied in number, area, and homogeneity, but some broad conclusions can be drawn. The three richest communities, containing between 82 and 98 species, represent stages of primary successions (i.e., tall scrub on slips and talus, lowland seral grassland, and pioneer *Raoulia*-dominated community). The richest forest communities (68–79 species) grow on recent alluvial soils in the lowland valleys (dense kahikatea forest, kahikatea/hardwood forest, and seral low forest on river flats). Short grassland and herbfield communities all contain over 54 species, irrespective of altitude or successional status.

At the other end of the scale, fellfield communities yield relatively few species (24–29). Mire and heath communities are also poor, none exceeding 46 species, but in most of these community types species were listed from only a few stands. Otherwise no consistent differences emerge between or within physiognomic classes.

Appendix Table 1 Rankings of communities according to diversity of species.

No. of species in community	2–5	6–10	11–15
100		E3a H1a	
90			
80	I2a		
70	B2a	A1a H4	G2c G6 I3a
60	D1a	A2a F1a F2 F3 H3	E4a
50	B3e A4a H1b	B3a B6a E1b E2 F4 F5 I2c	C1 H2a H2b
40	F4c G3 I2b J2c K2	G2b J1a	
30	B5a E1a E3b E4b F1b F1c G2a G5 J1c K3a K5a K6	B5b D2a	
20	B4a D3a D3b G4b J2b J2b K1 K3b K5b	G1a I4a I4b I4c	

No. of stands listed

APPENDIX 3 - GLOSSARY OF COMMON NAMES

bracken	*Pteridium aquilinum* var. *esculentum*
gorse	*Ulex europaeus*†
Hall's totara	*Podocarpus hallii*
kahikatea	*Dacrycarpus dacrydioides*
kamahi	*Weinmannia racemosa*
manuka	*Leptospermum scoparium*
matai	*Podocarpus spicatus*
miro	*Podocarpus ferrugineus*
quintinia	*Quintinia acutifolia*
rata	*Metrosideros umbellata*
rimu	*Dacrydium cupressinum*
silver beech	*Nothofagus menziesii*
silver pine	*Dacrydium colensoi*
snow-tussock	*Chionochloa* spp.
Westland totara	*Podocarpus totara* var. *waihoensis*

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