# THE KAHIKATEA (*Dacrycarpus Dacrydioides*) FOREST OF SOUTH WESTLAND

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SUMMARY: *Dacrycarpus dacrydioides* forests in South Westland between the Waitangitaona and Saltwater rivers occur on low terraces of alluvial silt. Their relationship to other river flat and swamp communities on post-glacial surfaces is described. Recently abandoned river beds are colonised by pioneer species, which give way to vegetation dominated by grasses, sedges and rushes, which in turn are invaded by woody plants, especially *Coprosma propinqua* and *Podocarpus totara* var. *waihoensis*. Seedlings of several tree species grow up under the shrub thickets, leading to young forests dominated by *Pennantia corymbosa* and various other species on the heavier silts and by *Podocarpus totara* on stony ground. These forests form a nursery for *Dacrycarpus* and other podocarps.

Mature stands occur on surfaces less than 1,000 years old. They range from those with closely spaced *Dacrycarpus* trees and correspondingly sparse lower storeys, which are most extensive at the seaward ends of the main valleys, to those with scattered large trees of *Dacrycarpus* and other podocarps and a dense canopy of small hardwoods, which occur mainly between the meanders of the Waitangiroto and Saltwater rivers. Partial destruction and rejuvenation of *Dacrycarpus* forest during changes in river courses are discussed.

Stands of *Dacrycarpus* bordering swamps are wetter and include dense colonies of *Astelia grandis*, *Blechnum capense* and, near the coast, *Freycinetia banksii* and *Gahnia xanthocarpa*. There are transitions to "fertile" swamps dominated by species such as *Phormium tenax*, to "infertile" swamps on the older post-glacial surfaces with *Baumea* spp., *Calorophus minor*, *Leptospermum scoparium*, small species of *Dacrydium*, etc. and to coastal swamps bordering tidal lagoons. In some places, *Dacrydium cupressinum* forest is interpolated between *Dacrycarpus* forest and "infertile" swamp.

The extent of mature *Dacrycarpus* forest seems disproportionately large in relation either to the frequency of young trees within the mature stands or to the extent of seral forest containing young *Dacrycarpus*. The apparent imbalance resembles that which has been previously described for hill stands of podocarps, although the condition of the stands near the coast may be related to tectonic uplift of the coast line.

*Dacrycarpus* forms a highly distinctive forest, meriting effective conservation, but the best existing reserves are in areas threatened by changing river courses. Reserves should therefore include the seral stages leading towards mature stands.

## INTRODUCTION

At the time of first European settlement forest dominated by kahikatea was one of the most distinctive natural features of New Zealand. Nearly pure stands of this tree, characterised by tall, straight trunks bearing small crowns of foliage and reaching heights of over 60 m, were extensive on wet alluvial lowlands of the two main islands. Even in areas widely deforested by Maori fires, such as the Canterbury Plains, clumps of kahikatea forest surviving on wet ground formed notable land marks. Such forest has now virtually disappeared through the greater part of the country since the land it occupied is valuable for dairying and its timber provided the cases for exporting the products of that industry. It is only in South Westland that large stands remain, although there are scattered reserves of doubtful viability in other districts. The South Westland stands had a respite because of their remoteness and because the timber became obsolete as containers for butter. Recently, new uses have appeared, especially in the export timber trade, and the stands are again being rapidly cut out. Some have been set aside as reserves, the largest covering 220 ha in the Waitangiroto Flora and Fauna Reserve. Reservation does not ensure survival, however, because kahikatea forest in South Westland mostly occurs on the flood plains of destructive rivers and is liable to be damaged or destroyed whenever these rivers erode their banks or change their courses. The two stands reserved within Westland National Park have both suffered in this manner during the past seven years. It is therefore evident that any scheme to reserve examples of kahikatea forest should be backed by knowledge of the ecology of the species. The only statements available are those by Cockayne (1928, p. 178) and Poole (1946) to the effect that the kahikatea community occurred on ground too wet for normal podocarp-hardwood forest, and that it succeeded *Typha-Phormium* swamp as conditions became drier. To obtain a more complete

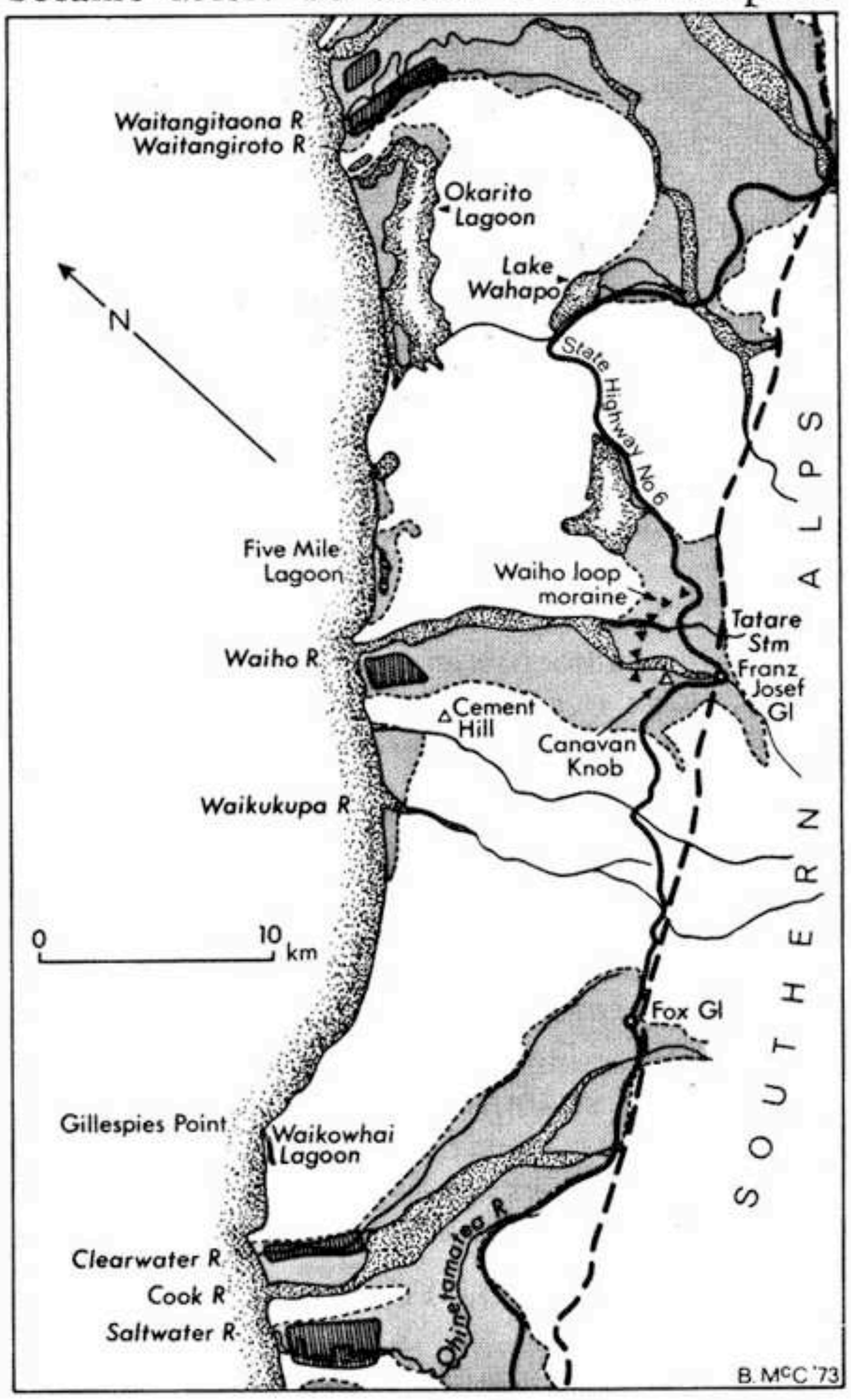


FIGURE 1. *Locality map, based on Warren (1967).*

*Broken line: Alpine Fault, which separates the Southern Alps from mainly Quaternary rocks.*
*Fine stippling: Postglacial surfaces (other surfaces north west of the Alpine Fault are mostly moraine).*
*Hatching: Larger blocks of dense podocarp forest on postglacial alluvium.*

picture, kahikatea forest and related communities in the area between the Waitangitaona and Saltwater rivers (Fig. 1) were described from visual estimates of cover and abundance. Further north the forests have been extensively logged and cleared, while to the south, beyond Paringa, they often contain silver beech *(Nothofagus menziesii)* and therefore present a rather different aspect.

## THE PHYSICAL SETTING

Kahikatea forest in South Westland is confined to post-glacial alluvial flats and plains which mainly lie in troughs carved by late Pleistocene glaciers through the older moraines and basement rocks of the coastal strip. The major rivers follow the troughs. Their sources are in the existing glaciers of the Southern Alps, and they have developed braided courses through aggradation. These courses are likely to change, and two or three major river captures have taken place during the last century in the study area. Existing and recent channels are formed in gravel, but elsewhere the surface is usually formed by a layer of silt, often three metres or more thick, which is deposited when the rivers overflow their banks. The surfaces are generally less than 1,000 years old, but there are portions which have not been disturbed by rivers for a long time. These have developed very wet, deep organic soils.

The smaller rivers mostly flow directly into the lagoons which border the coast. Some arise in the outer ranges of the Southern Alps, but those with dark, peat-discoloured water arise in the swamps or drain from the morainic hills. The Waitangiroto and Saltwater Rivers, which drain the two largest swamps, have incised meandering channels and are tidal for several kilometers above their lagoons.

## SUCCESSIONS

Successions from flood-plain to forest begin where abandoned river bed becomes available for colonisation. On gravel the first stage is characterised by *Raoulia tenuicaulis, R. hookeri* and *Epilobium microphyllum,* but there are several variants, such as *Cortaderia richardii* colonising banks of deep silt, *Festuca arundinacea* colonising wet depressions and *Coriaria arborea* growing among large stones. Other common species include *Hypochaeris radicata, Holcus lanatus, Lachnagrostis lyallii* and *Muehlenbeckia axillaris.*

The second stage is the establishment of a closed herbaceous sward. This stage no longer exists in its primitive form, as it is invariably grazed and largely dominated by introduced plants. Typically, grasses such as *Holcus lanatus* and *Anthoxanthum odoratum* dominate, but there are tussocks of *Poa caespitosa, Uncinia affinis* and *Carex testacea,* and low-growing native plants including *Gunnera dentata, Muehlenbeckia axillaris* and *Cotula squalida* which become more apparent when the introduced grasses die down in winter. Wet Hollows support *Eleocharis acuta, Juncus gregiflorus, J. effusus, J. articulatus, Schoenus nitens, Hydrocotyle tripartita, Galium palustre, Carex flaviformis, Festuca rubra* var. *commutata, Holcus lanatus* and *Myosotis caespitosa.* Invasion by shrubs also begins at this stage, although it is discouraged by cutting to retain pasture. The main species are *Coprosma propinqua,* and on dry stony ground, totara *(Podocarpus totara* var. *waihoensis). Polystichum vestitum* is often abundant on steep banks and where driftwood logs have provided sheltered places for establishment. Gorse *(Ulex europeus)* is not yet widespread on these river beds.

Thickets of *Coprosma propinqua* and totara provide shelter for seedlings of many forest species, including those of kahikatea. On the heavier silts *Pennantia corymbosa* usually dominates the first forest stage, with *Coprosma rotundifolia* forming a shrub storey, and *Microlaena avenacea, Blechnum lanceolatum* and *B. fluviatile* abundant on the floor. There are many variants. Kamahi *(Weinmannia racemosa)* can dominate, probably where driftwood logs have provided establishment sites for its normally epiphytic seedlings; kowhai *(Sophora microphylla)* is abundant near the coastal lagoons and tidal reaches of the rivers; and there are various mixtures in which *Carpodetus serratus, Melicytus ramiflorus* and *Plagianthus betulinus* can be among the main canopy species. Seedlings and young trees of kahikatea occur in most of these communities and can be locally abundant. The young forest on the stonier, better drained soils is often dominated by totara, which is dense enough to largely suppress the lower storeys (Fig. 2). In this community young kahikatea can be especially numerous; there are also seedlings of other lowland podocarps i.e. rimu *(Dacrydium cupressinum),* miro *(Podocarpus ferrugineus),* totara and matai *(P. spicatus).* The seedlings of the last are scarce and local by comparison with the general occurrence and, in places, dominance of the adult trees on better drained alluvial sites.

FIGURE 2. *Young forest dominated by* Podocarpus totara *var* waihoensis *on well-drained alluvium. The arrow shows a dead trunk from a previous forest overwhelmed during aggradation. Ohinetamatea River.*

The succession is apt to be delayed in places, especially in swamps and hollows and on drier ground where grassy glades can persist many years. Such glades are frosty in winter, and the forest encroaches on them only slowly.

## MATURE FOREST ON YOUNG ALLUVIAL SOILS

In keeping with the variable density of kahikatea and other podocarps in seral communities, stocking in mature stands varies widely. In the lower reaches of the Cook, Waiho and Waitangi valleys there are extensive stands of very dense kahikatea growing on low silt terraces (Fig. 3). The example has about 220 trees to the hectare, giving a basal area in the order of one percent, but because of the small crowns, canopy cover is only about 30 percent.

Six cut stumps revealed about 240, 350, 370, 380, 440 and 460 growth rings.

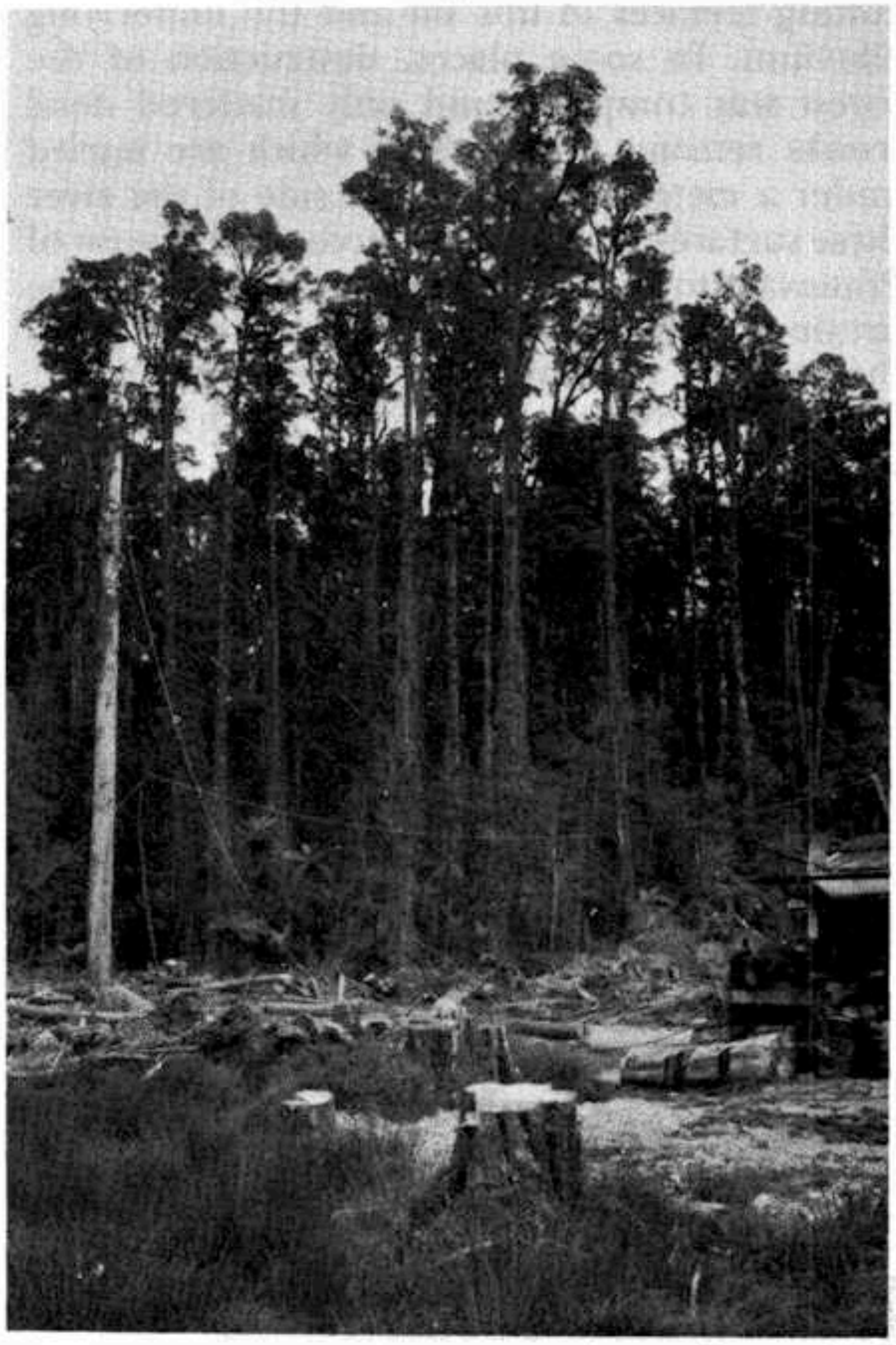

FIGURE 3. *Dense stand of kahikatea near the mouth of the Waiho River being logged.*

A few trees of rimu, matai and totara also occur in these stands, but they are generally small and malformed, probably because of competition with kahikatea, which reaches estimated heights of 45 m. Lower tree and shrub storeys are sparse and include slender trees of kamahi, *Dicksonia squarrosa*, and, in some places, thickets of *Ripogonum scandens*. The floor usually supports a continuous cover of mosses, *Microlaena avenacea* and uncinias, with clumps of *Astelia grandis* in damp hollows. Young plants of kahikatea are absent. The soil shows only slight weathering and gleying.

In forest between the meanders of the Waitangiroto and Saltwater rivers, scattered, massive-crowned kahikatea and occasional matai and rimu stand over a canopy, about six metres high, of small hardwoods, among which *Carpodetus serratus, Pennantia corymbosa, Melicytus ramiflorus* and *Schefflera digitata* are prominent. Locally, the tree ferns *Dicksonia squarrosa* and *Cyathea smithii* form most of the canopy. Kamahi can also be important, but apparently on somewhat older sites. The ground cover is largely *Microlaena avenacea* and *Asplenium bulbiferum*. Soils are deep silts, which are well-drained and above normal flood level, but occasional floods rejuvenate the surface both by erosion and deposition. Wet hollows, where present, tend to be occupied by *Astelia grandis* and *Phormium tenax*.

Closer to the mountains, where stonier and better drained soils prevail, kahikatea is equalled or exceeded in abundance by matai and other podocarps. An especially mixed stand, between Canavan's Knob and the Alpine Fault, contains kahikatea, matai, miro, *Podocarpus hallii*, totara, rimu and the cypress *Libocedrus bidwillii*. Within the mountain valleys, and even for a short distance out on to the lowland plains, severe frosts restrict species such as kahikatea to the warmer sites, and the cold flats develop forest dominated by kamahi and rata *(Metrosideros umbellata)*. Usually conifers are few and belong to the hardier species, particularly *Podocarpus hallii*, miro and *Libocedrus bidwillii*.

Supporting evidence for the youth of podocarp/hardwood stands comes from the Waiho Valley below its gorge, where gravels brought down by the Tatare and Waiho Rivers have been impounded by the Waiho Loop moraine and subsequently cut into terraces. The oldest terrace supports hardwood forest (mainly kamahi) with scattered large kahikatea, matai and rimu. The probability that these podocarps are first-generation trees is confirmed by two radio-carbon dates, one dating a stage of the aggradation at 2,430±35 years B.P. (NZ 724) and the other, the completion of it, at 989±42 years B.P. (NZ 1,155).

In addition to the ecologically important species already mentioned the following species occur mainly or exclusively in mature and seral forest on young soils: *Dicksonia fibrosa* (local), *Pseudowintera colorata, Thelypteris pennigera, Clematis indivisa, Urtica incisa, Muehlenbeckia australis, Aristotelia serrata, Paratrophis microphylla* (Waitangi only), *Cardamine debilis, Rubus australis, R. schmidelioides, Parsonia hyterophylla, Fuchsia excorticata, F. perscandens Pittosporum colensoi, Pseudopanax anomalum, Coprosma propinqua, C. wallii, Cordyline australis* and *Polystichum vestitum* and *Hoheria glabrata.* However these last two have their main development on immature soils at higher altitudes.

## REJUVENATION OF STANDS

Changes in river courses are important for maintaining kahikatea forests. The first stage can be seen at the head of Lake Wahapo. The Waitangitaona River flowed north-westwards to the sea until 1967 when it changed its course into the lake following aggradation in its middle reaches. By 1970 its new course was still not well-defined, and water was flowing and silt being deposited through most of the kahikatea forest at the head of the lake. The trees have died where deposition of silt was deepest, but where there was only up to 60 cm of new silt, only a few of the trees have died, although the crowns of most became sparse and unhealthy. This will probably be a temporary set-back, as the trees have produced adventitious roots enabling them to adjust to the saturated silt. Other species which have also survived through producing adventitious roots are totara (as described by Foweraker (1929)), miro, *Pseudowintera colorata, Coprosma rotundifolia* and *Schefflera digitata.* Only the herbs, mosses and smaller shrubs have been completely destroyed, but these could redevelop quickly if the increment of silt ceases. The lake itself has an average level about one metre higher than before because of the greater quantity of water entering, and the lake shore trees are surviving the inundation.

A later phase can be seen at the Ohinetamatea River which changed its course, probably during the last century, and joined the Saltwater* River instead of the Cook River. The river is transporting a blanket of silt which has now reached four kilometres downstream, and it is cutting terraces in this silt and the underlying alluvium. In some places, destruction of the forest was complete, and only scattered dead trunks remain, the roots of which are buried under a metre of silt. On one side of the river these surfaces now support successional forest of *Pennantia,* totara and kamahi as described in the previous section, but on the other side some of the original kahikatea trees survived (Fig. 4). These stand over a lower canopy, which has three components:

1. Flat, wet areas have a ground vegetation of *Microlaena avenacea, Blechnum fluviatile* and young plants of *Myrsine divaricata, Pennantia* and *Coprosma rotundifolia.*
2. Silt-covered mounds built over logs, stumps, or roots support most of the young kahikatea, which are up to 40 cm in diameter and 15 m tall.
3. On fallen logs without a silt cover, kamahi trees have become established.

The young kahikatea trees seem numerous enough to ensure that a dense stand will become re-established.

FIGURE 4. *Stand of kahikatea, showing mature trees which have survived an episode of silting, and young trees which have grown subsequently. Ohinetamatea River.*

*Ohinetamatea and Saltwater are alternative names for the same river, but for present purposes it is convenient to restrict them to the upper and lower portions respectively of the river.

## TRANSITIONS TO SWAMP

Kahikatea forests bordering swamps, lakes and lagoons tend to be wetter than those just discussed, with permanent pools and dense colonies of *Astelia grandis* and *Blechnum capense* which, near the coast, are accompanied by *Freycinetia banksii* and *Gahnia xanthocarpa*. With increasing wetness the trees become smaller and further apart, and the forest grades into true swamp which can be classified tentatively as either "fertile" or "infertile".

The fertile sequence is most common where swamp forms a zone between forest and the open water of a lake or slow-flowing river (Fig. 5). Drainage tends to be into or through such swamps and the water is only mildly acidic (pH 5.7-6.0). *Phormium tenax* is usually dominant. Sometimes a succession towards forest can be discerned, as organic or mineral soil builds up or as water levels fall, but often any trends are obscured by burning, since swamp vegetation is flammable. In very wet situations with sluggish drainage *Carex coriacea* and *C. secta* co-dominate with *Phormium*.

FIGURE 5. *Kahikatea bordering on swamp dominated by* Phormium tenax. *Near head of Waitangiroto River.*

In the infertile sequence swamp conditions have developed over large areas because vertical drainage is impeded by hardpans in the alluvium, and lateral drainage is impeded by build-up of vegetation and peat. These infertile swamps occur only on the older surfaces. Apparently they are nourished by the rain falling on them, so that water tends to drain outwards and is more acidic (pH 3.8-5.0). The height and complexity of the vegetation decreases away from drainage channels, probably reflecting poorer aeration of the soil. Typically, densely-stocked gallery forests of kahikatea follow the larger streams. Where the kahikatea trees become smaller and sparser they are joined by silver pine *(Dacrydium colensoi)*, tall manuka *(Leptospermum scoparium)* and *Phyllocladus alpinus*. There is dense *Astelia grandis, Carex coriacea, Blechnum capense* and, in some places, *Gahnia rigida* beneath. Further from the streams kahikatea drops out altogether, and shrubby manuka becomes dominant. In central areas this can pass in turn into openings dominated by *Calorophus minor*, with *Baumea* spp, stunted plants of manuka, silver pine and bog pine *(Dacrydium bidwillii), Coprosma parviflora* and in some swamps *Typha orientalis, Leptocarpus similis* or *Gleichenia circinata*. These, however, are rather extreme situations, for only the most infertile swamps support *Calorophus*. More usually *Carex gaudichaudiana* and *Baumea rubiginosa* are dominant, and the shrub *Olearia virgata* var. *laxifolia* is characteristic, although scarce. Many swamps have been burnt, so that *Dacrydium* species are eliminated, and *Leptospermum* and *Coprosma* are represented only by plants which have recovered or become established since the last fire.

The transitional vegetation between forest and infertile swamps, where it has not been destroyed by fire, usually appears to be stable with kahikatea of all ages present. Successional situations occur, however, where the drainage of the swamp is being locally improved, as by the headward erosion of a stream or the lateral erosion of a river.

Transitions to swamp also occur around the inland shores of the coastal lagoons. Swampy forest away from brackish influence is dominated by kahikatea alone or by a mixture of kahikatea and rimu. Bordering the lagoons, either *Baumea teretifolia* and *Lepidosperma australe* or *Leptocarpus similis* dominate, and there are bushes of *Coprosma propinqa, C. parviflora* and *Plagianthus divaricatus* together with stunted plants of *Phormium tenax*. Manuka forms the transition and is usually accompanied by small or young trees of kahikatea, rimu and silver pine and an abundance of *Gahnia xanthocarpa*.

### RIMU FOREST ON FLATS AND TERRACES

In some places there is a belt of forest dominated by rimu between kahikatea forest and infertile swamp. This resembles the rimu forest which is widespread on Pleistocene terraces, except that some kahikatea is present in the canopy, indicating that the soil is not as infertile. The ground surface is drier than under some kahikatea stands but up to three metres or more of semi-liquid, silty peat underlie the top horizon of roots and peaty humus. Where the ground slopes gently towards a river the proportion of kahikatea increases as the depth of wet peat decreases. Such kahikatea-rimu mixtures can extend over considerable areas: for instance inland from the Five-Mile Lagoon, where there is a close mosaic with kahikatea dominating over its typical understorey plants such as *Astelia grandis* in the hollows and rimu dominating over *Blechnum discolor* on the rises.

Rimu forest is the main vegetation for two kilometres inland from the lagoon of the Saltwater River. It meets infertile swamp *via* a 50 metre-wide transition containing silver pine and manuka, which is evidently successional. The rimu nearest the swamp are saplings up to six centimetres in diameter, and about 80 growth rings were counted in one of the largest. The silver pines in the swamp are slender, and 60 rings were counted in one five centimetres in diameter, whereas those furthest into the forest include dead trees and living trees 20 cm in diameter. Although the ground surface is much drier in the rimu forest than in the swamp, the depth of semi-liquid peat increases from 1.5 m in the swamp to over three metres beneath the forest, indicating that the organic layer thickens as the succession proceeds. This succession is also described by Holloway (1954 p. 381) and Chavasse (1964).

Forest with rimu as the main podocarp also eventually develops on better drained sites where the earliest mature stands would have been mixed podocarp forest. Examples occur on post-glacial terraces at 200 m and 275 m in the Waikukupa valley, where the present river flat, supporting a mixture of conifers, is about 150 m above sea level.

### SUCCESSION AFTER FIRE AND FELLING

These successions have received only passing attention. The denser stands of kahikatea and mixed podocarps and the successional stages leading towards them have, when cleared, provided the most intensively farmed land in the district, but where the opportunity arises there is a vigorous secondary succession to species of *Coprosma* and small trees such as *Pennantia, Carpodetus, Fuchsia excorticata* and *Aristotelia serrata*. Seedlings of podocarps, especially kahikatea, enter freely into these communities. Where ecotones between swamp and forest have been burnt there is also adequate regeneration of kahikatea.

### FOREST REGENERATION

The regeneration of the larger podocarps is a recurrent theme in New Zealand forest ecology. Potentially there are two kinds of regeneration pattern. Where the mature podocarp stands are part of a succession, preceding and subsequent stages should be identifiable and of appropriate areal extent. Alternatively, where mature stands are a climax community, they should contain adequate numbers of younger plants either intermixed or as a mosaic of different age classes.

River-flat successions which lead to young forest containing various densities of pole-sized kahikatea and other podocarps are clearly recognisable in the district. These must lead to the mature stands on somewhat higher terraces which consist of either scattered large podocarps over a canopy of hardwoods or, where initial stocking is denser, dense stands of mature kahikatea. A difficulty is that the very extensive stands of dense kahikatea near the mouths of the river valleys are not accompanied by appropriate areas of seral forest with young kahikatea. Possibly they have arisen by progressive recruitment involving the kind of rejuvenation described on page 66. There is evidence for this in the spread of ages shown in cut stumps (page 65). Near the junction of the Cook and Clearwater rivers, and elsewhere, mature kahikatea forests grow on deep silt beds containing layers of tree stumps, showing that destruction of preceding forests by changing river courses, giving rise to rejuvenation and succession, has been important in maintaining this forest type. Even where there is no destruction flood waters enter the vegetation, depositing silt and creating soil conditions which favour kahikatea.

However, even granted these processes of forest development, it remains doubtful whether the present extent of younger stages in the lower reaches of the main valleys is enough to account for the extent of mature stands. In the stands with scattered large podocarps young plants are rare, and the indications are that they will revert to hardwood dominance (Table 1). In dense kahikatea stands the lack of young plants, other than very small, ephemeral seedlings, is understandable in view of the density of adult trees; but in the only stand seen where the adult trees are beginning to thin out through wind fall and death, the gaps are being filled by small hardwoods and tree ferns.

Notwithstanding the indications that there may be widespread failure of podocarps to maintain their position at the end of the first generation (which is up to 1,000 years) it seems that, in the long term, rimu gradually replaces kahikatea and matai as podsolisation and gleying lead to decreasing soil fertility (see also Franklin 1968, p. 505). Among the hardwoods, kamahi replaces *Pennantia,* and in the understorey *Blechnum discolor* replaces *Asplenium bulbiferum.* The stands of rimu described on page 68 can be interpreted in this way, as they occupy higher terraces or older soils than neighbouring kahikatea or mixed hardwood communities. In these rimu stands, and the transitional mixtures of rimu and kahikatea, there is also an apparent preponderance of mature trees. Although young plants are present in some places there is not the

TABLE 1. *Distribution of Kahikatea and Rimu in Size Classes.*

| Community | Species | 1.2 m* | −10** | −20 | −30 | −41 | −51 | −61 | −71 | −81 | −91 | −102 | −112 | −122 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dense stand near mouth of Waiho River | Kahikatea | | | | 1 | 3 | 6 | 4 | 7 | 5 | 1 | 3 | 1 | |
| Open upper podocarp canopy over main canopy of hardwoods, Saltwater River | Kahikatea | | 1 | 2 | 1 | 5 | 2 | 3 | 3 | 6 | 5 | 2 | 4 | 1 |
| Local area of dense podocarp regenera- | Kahikatea | | 3 | 5 | 1 | 1 | 1 | | | | | | | |
| tion, Saltwater River | Rimu | | 2 | 12 | 4 | 5 | 2 | 1 | | 1 | | | | |
| Mature stands of rimu, Saltwater | Rimu | 7 | 4 | 3 | 2 | 3 | 5 | 4 | 4 | 3 | 3 | | | |
| River | Rimu | | | 7 | 8 | 13 | 10 | 4 | | 1 | | | | |

*Seedlings up to 1.2 m tall. Only those more than 15 cm tall are included.

**This and subsequent classes are 4 in. diameter classes, expressed to the nearest cm, diameter being measured approximately 1.2 m above the ground.

conspicuously mixed-age structure evident in rimu growing on Pleistocene terraces. An area of dense pole-sized rimu and kahikatea, with only scattered mature trees near the Saltwater River appears to be a local anomaly rather than an element of a regeneration mosaic.

The only stands of kahikatea other than obviously seral ones which include an expected proportion of younger trees are those forming ecotones to swamp. Kahikatea in the ecotones is comparatively stunted and bears out what has already been described for other podocarp species; i.e. they regenerate best on sites which are suboptimal for growth, because the seedlings have more chance of becoming established where there is less competition from other plants.

The extent of mature stands of kahikatea and rimu, contrasted with the paucity of younger stages, recalls the similar situation described for hill stands of rimu and other podocarps (e.g. Holloway 1954, Wardle 1963), which has been attributed to an unfavourable climatic fluctuation. An additional or alternative explanation applicable in the lower reaches of the valleys may be uplift of the coastal strip, representing continuation of the movements which have raised an interglacial beach line at Cement Hill to 220 m (Wellman & Willett 1942). This would steepen the gradients near the river mouths and explain the rather restricted channels of the Cook and Waiho Rivers near their mouths compared with their wide, braided beds further inland. The mature forests are on terraces two metres or so above the present river beds, and if they are first generation, as seems probable, the uplift took place some 600-1,000 years ago. Although the steepened river gradients could have resulted from the general retrogradation of the coastline shown in the erosion of morainic bluffs, the coastlines themselves carry good evidence that retrogradation was interrupted by a period of progradation, which could only have resulted from a relative fall of sea level:

1. Between the Waitangiroto Lagoon and the northern end of the Okarito Lagoon a series of fixed dunes lie behind the beach. The youngest of these are being eroded by the sea and reactivated, and the erosion is exposing sand cemented by iron pans, indicating that the shore line is retreating after a period of progradation.
2. Between Gillespies Point and the Waikukupa River the coast consists mainly of cliffs cut in moraine. These are being actively eroded by the sea at most points, but in places they lie behind the shore and are separated from the shingle beaches by lagoons, alluvium and vegetated former beach ridges. These surfaces are evidently young, and the forest is mainly hardwoods with scattered mature kahikatea and rimu which are probably of the first generation. Generally, the coast line is again being eroded and the forest being killed by salt spray, although progradation is continuing immediately south of the Waikukupa River.
3. At the Five Mile, Okarito and Waikowhai lagoons, uplift is suggested by well-vegetated flat islands and promontories, formed of lacustrine fill, which are now one to two metres above high water mark.

## A PLEA FOR CONSERVATION

I have described forest succession and river regimes in some detail to emphasise the shifting pattern of vegetation on the alluvial plains. The last chances to retain good examples of kahikatea forest, which is no less magnificent and unique than the kauri *(Agathis australis)* forests in the north, lie in South Westland. The main practical difficulty is that the best stands are liable to be destroyed by the same forces which originated them. Any new surfaces which are exposed as rivers change their courses are soon occupied for farming, and are therefore no longer available for development of kahikatea forest. The areas available are further restricted by the priorities of river control, for understandably greater efforts are made to prevent destruction of farm land than forest or swamp. If examples of kahikatea forest are to be retained, their reserves should include areas where new stands can develop in the event of the mature ones being destroyed. To do this could entail setting aside farmable land. Nevertheless, areas of kahikatea, swamp and river bed which are reasonably removed from existing pressures to mill, farm or graze should be selected for nature reserves. By the time pressures to "develop" are brought to bear these would have amply justified their reservation.

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