MATAI / TOTARA FLOOD PLAIN FORESTS IN SOUTH WESTLAND

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SUMMARY: A survey of matai *(Podocarpus spicatus)* / *totara (Podocarpus totara var. waihoensis)* forest in South Westland recorded that c. 600 ha of these forests remain from a possible former 43,000 ha. Basal discs cut from logged or windthrown matai and totara showed a strong linear relationship between diameter and age (annual growth rings). Detailed surveys of stands showed grouping of size class distributions, reflecting the seral nature of these forests. A pattern of continuous regeneration of matai/totara forests in the region for at least the last 400 years is apparent and there is no evidence of any climatically-induced regeneration gap. Widespread grazing has destroyed much recent regeneration, particularly of matai. The reservation of the remaining stands of matai/totara forest is advocated as a matter of urgency since 25% of the remaining forests in South Westland have been logged or cleared in the last two years.

INTRODUCTION

Both matai *(Podocarpus spicatus)* and totara *(P. totara)* have importance in Maori mythology and, until European settlement, were generally conserved in accordance with this mythology which restricted these timbers to specialised end uses (e.g. carving, canoes) and also allowed only a proportion of the available trees to be used (Gordon, 1958).

Forests containing matai and totara were widespread before European settlement on well-drained flood plains throughout New Zealand, as well as on the deeper pumice deposits in the central North Island. The former extent of flood plain forests dominated by these two species is not well known, but existing stands throughout the country are mostly confined to very freely-drained soils and are obviously just remnants of a forest type that was once much more widespread (Hinds and Reid, 1957). With European settlement, most of these flood plain forests were cleared. They grew on the best farming soils and both species yielded excellent timber. Matai was used for truck-decking, framing, flooring and weatherboards, and totara for fencing, framing, weatherboards and a multitude of other purposes. As these forests disappeared, so did the rich bird life associated with them.

South Westland still contains significant areas of unlogged matai/totara forest as isolated trees, as clumps of trees across farmland, and as virgin stands on inaccessible sites. Some accessible virgin stand have been reserved by farmers. In all, there are still about 600 ha of totara, matai/totara and matai/totara/kahikatea *(Dacrycarpus dacrydiodes)* forest between the Hokitika River catchment and Paringa River. Within this area, approximately 43,000 ha of soils can be identified which may have supported these communities in earlier times. It is likely, therefore, that present day stands represent less than 2 % of the matai/totara forest that existed prior to European settlement in this part of Westland.

Over half the matai/totara stands occur on Crown-owned land and there should be little difficulty in either adding these areas to existing National Parks and reserves, or creating new reserves. Opportunities also exist to retain the stands on freehold land under farmer-orientated reserve schemes, such as the Queen Elizabeth II National Trust Open Space Covenants and the Conservation Covenant provisions of the Reserve Act 1977.

ECOLOGY OF MATAI/TOTARA FORESTS

Successful conservation of an exploited population demands an understanding of its population dynamics. In the case of flood plain matai/totara forests, there are no published, comprehensive studies of the ecology of these communities. One of the best studies is that of Druce (1966) which gives detailed stand descriptions of remnants of secondary totara/titoki *(Alectryon excelsum)/matai* forest on the Otaki Plain. Information about other alluvial matai/totara communities appears to be of a generally descriptive nature, e.g. Greenwood (1949), Esler (1962), Duguid and Druce (1966).

Primary succession to totara-dominated forest on better drained alluvial sites in South Westland has been briefly described by Wardle (1974, 1980). Wardle (1972) considers that this totara is P. *totara* var. *waihoensis,* a stable hybrid between P. *totara* and P. *acutifolius*. This is described as a small tree

rarely exceeding 12 m in height, but during this survey, totara up to 30 m were frequently found.

Foweraker (1929), in briefly describing some characteristics of matai/totara communities in South Westland, highlighted the interesting ability of totara to produce a new root system after inundation with river silt. He did not, however, appear to consider any conservation of these forests likely.

> "Totara sites. . . make excellent pasture land. Thus it is recognised that these river flats forests must pass, they are rapidly passing now and it is deemed necessary to put on record" while .still possible some data concerning their life histories."

Holloway (1954a) suggested that the matai/totara communities in South Westland were relict stands surviving from times past. He considered that, under present-day climatic conditions, matai and totara do not behave as pioneer species, as they did in the past when they developed into dense mature podocarp stands of the present day. This opinion is reiterated in his major paper on forests and climate (Holloway, 1954b) where South Westland totara and matai are lumped with other podocarp communities as showing regeneration failure over a sustained period.

Wardle (1963) gave further support to this theory of a podocarp regeneration gap with evidence for regeneration failure in matai, rimu *(Dacrydium cupressinum)* and kaikawaka *(Librocedrus bidwillii)* between 1600-1800 AD. He suggested that regeneration ability contracted during this period into the "coolest, moistest and leas! drought prone parts of the country". His only matai site was in the Kaituna Valley, Banks Peninsula and comprised only 26 mature trees and some seedlings.

Wardle (1974, 1979) suggests that young plants of matai are scarce and local almost everywhere in South. Westland by comparison with the general occurrence, and in places dominance, of the adult trees on better drained sites. While Wardle. and Holloway (loc. sit.) both imply that the matai forests of South Westland show anomalous stand, structure and regeneration failure even to the present day, neither produced detailed survey data to support this contention.

Other work on totara includes that of Beveridge (1964) who conducted detailed studies of totara seed production, germination and "destruction by native and introduced animals in the Central North Island. Bond (1967) showed that an endophytic fungus was necessary for growth of totara in a soil deficient in available phosphorus and calcium, although evidence that the extensive nodules on totara root systems fix nitrogen is inconclusive.

In summary, limited information is available on the matai/totara alluvial communities of South Westland. Few attempts have been made to under stand the ecological status of these communities and no proposals have been published seeking protection for representative examples of this association in South Westland. This is despite opportunities such as the recent botanical review of the scenic reserves of South Westland (Wardle, 1980) which showed that less than 2 ha of this association was protected within the 17,532 ha of Scenic Reserves in the region.

One priority of this study of an exploited population was to provide detailed information on matai / totara stand dynamics so as to determine whether reserves of this association could be established and maintained in the long term.

METHODS

Present and former extent of matai j *totara stands*

Forest remnants on the flood plains of all rivers between Hokitika and Paringa were identified from aerial photographs and 1:63,360 scale topographical maps. Gley recent and Recent (Hari Hari, Karangarua, Hokitika) soil type distribution was marked on these topographical maps using 1: 253,440 scale soil maps for reference.

A light plane was used to survey all stands from the air. It was possible to identify the podocarp composition, area and condition of each stand from the air; totara appears yellow green, rnatai a deep green, and kahikatea a distinct blue green. Rimu and miro *(Podocarpus ferrugineus)* are uncommon on flood plains.

Isolated tree species across farmland were also identified and their location plotted on soil maps to gain an appreciation of the former extent of different forest types. The aerial survey showed the extent of forest clearance in the two years since the aerial photographs had been taken.

Each major stand was later visited on foot to confirm aerial survey work. Ground surveys and consultation with local farmers were also undertaken to build up a picture of the former extent of forest stands.

Growth rates

Increment corings were not used to determine the age of standing trees because of the difficulties of this technique with flared and compressed ring sequences, as well as the possible risk of damage to live trees. Instead, basal discs were cut from windthrown or logged trees wherever these could be located. Fortunately both species survive on the

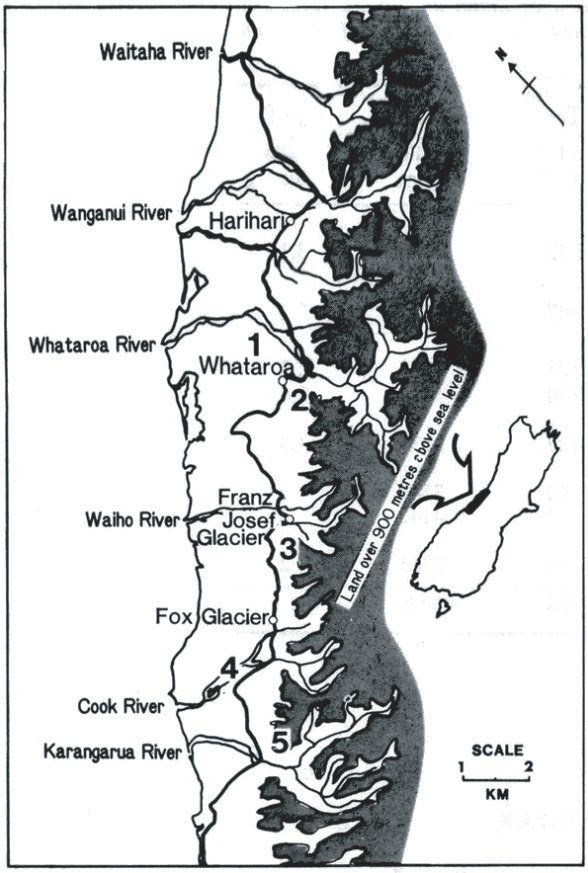

FIGURE 1. *South Westland showing the locations of the major matai / totara remnants. 1—Ballyhooly bush, Lower Whataroa; 2—Upper Whataroa;* 3—*Waiho Valley; 4—Cook River; 5— Cassel Flat.*

ground for some time before rotting.

In total, 54 totara and 15 matai were counted. These came from two localities; near Franz Josef, where, after a major land development project many totara and some matai with shallow roots had been blown over, and from Ballyhooly bush (Fig. 1, site 1), where discs were cut from windthrows throughout different aged forest stands.

After drying and sanding the discs, both species were found to exhibit very distinct growth rings with no evidence of the discontinuous or false rings described by Franklin (1969) for rimu.

Stand characteristics

Five major stands were examined in detail. These were located at Ballyhooly bush on the flats of the lower Whataroa River, on flats of the upper Whataroa River, alongside the Waiho River between Lake Wombat Terrace and Canavans Knob, alongside the Cook River, and at Cassel Flat adjacent to the Karangarua River. These sites are labelled 1-5 respectively in Figure 1.

Plots were located at 400 m intervals along a pre-selected compass bearing through each forest stand. The number of plots recorded at each stand was determined by the stand's size and ranged from seven at Waiho River to three at Cook River. The breast height diameter and species of all trees greater than 2 cm diameter were recorded. A soil description, plant species list and a general assessment of smaller shrubs and ground cover were completed for each plot. In addition ten 1 m2 randomly selected quadrats were laid out in each plot and all podocarp seedlings therein counted.

RESULTS

Present and former extent of matai / totara stands

Results of the survey of the major river valleys between Paringa and Hokitika are presented in Table 1.

Four major stands greater than 40 ha were identified. These were at Cassel Flat, on the true left bank of the Cook River, the stand near Canavans Knob in the Waiho River, and Ballyhooly bush in the Whataroa River Valley. The first three are on Crown-owned land. While it is recognised that these larger areas stand the most chance of retaining a diversity of both plants and animals in the long term (Fleming, 1975), the smaller areas show a diversity of pattern and process, and undoubtedly have significant scientific value.

Growth rates

In Figure 2, diameters of matai and totara trees from the Whataroa and Waiho valley sites are graphed against age. The sample of matai trees is small, but the larger number of totara trees shows a strong linear relationship between diameter and age. Both sites contained a mixture of diameter classes.

Stand characteristics

(1)Size class distributions-

The size classes of trees within each surveyed stand are presented in Figure 3. One of the upper Whataroa stands was of young trees, the other of old, and these have been presented separately. The proportion of matai to totara varied considerably, being greatest on the lower Whataroa Flat and least at Cassels Flat where kaikawaka is very prominent, but in most cases totara greatly outnumber matai. The most obvious feature of these stands is that they can be classified as young, sub-mature, mature

TABLE 1. *Present and possible former extent of matai and totara forests in South Westland. Original forest is assumed from the extent of Hokitika Hari Hari and some Ikamatua soils.*

Location	No. of stands	Largest stand (ha)	Total area (ha)	Possible original area	% of original remaining
Mahitahi/ Jacobs River	4	14	32	1036	3.1
Karangarua River	5	50	107	2075	512
Fox/Cook River	6	47	105	3861	2.7
Waiho River	8	65	150	5695	2.6
Whataroa River	16	67	127	9838	1.3
Wanganui/ Poerua	15	12	60	8544	.7
Waitaha	2	2	7	4142	.2
Hokitika/ Kokatahi	4	3	20	8285	.2
TOTAL	60		608	43476	1.4

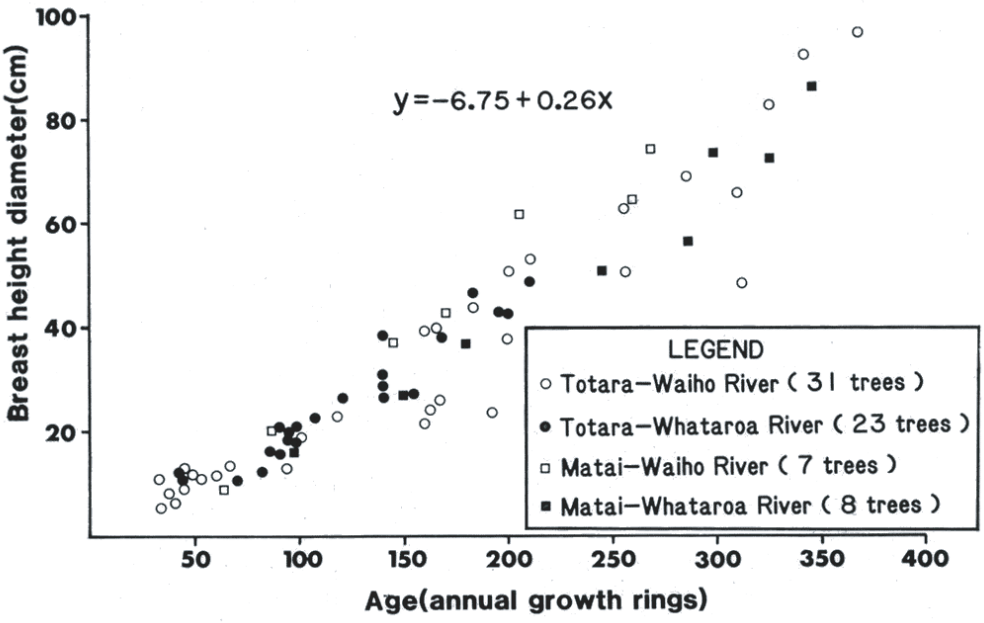

FIGURE 2. *Diameter-age relationship of 54 totara and 15 matai trees from Waiho and Whataroa River valleys. South Westland.*

TABLE 2. *Podocarp seedlings/m² (mean of 30 plots) in grazed and ungrazed sites within a uniform stand of matai/totara forest, Whataroa Valley.*

	0-10 cm height		11-50 cm height	
	Grazed	Ungrazed	Grazed	Ungrazed
Matai	1.1	10.2	.05	3.1
Totara	0	0.5	0	0.1
Kahikatea	2.3	13.9	1.8	1.9

or old, which is a reflection of their seral nature. (ii) Seedling counts–

The only site where significant numbers of matai and totara seedlings were located was at Ballyhooly bush where stock had been excluded for seven years. All the other areas were subject to cattle grazing which had eliminated most of the seedlings.

Differences in seedling density between grazed and ungrazed sites are shown in Table 2.

Matai is clearly heavily browsed whereas kahikatea is browsed less severely. Totara does not appear to regenerate under grazing and its regeneration even in the absence of grazing is sparse beneath a forest canopy. However, it regenerates readily on the forest margin and in adjoining scrubland, and is more a true forest pioneer than matai, although this latter species must establish within the flood plain forest community at an early stage to account for the significant proportion of matai within these forests.

DISCUSSION

Long term survival of flood plain matai/totara forests

Fresh alluvium deposited by floods obviously plays a major part in the dynamics of matai/totara forests in South Westland. These are catastrophe-dominated communities, although unlike kahikatea forests, matai and totara both show some ability to withstand windthrow and siltation. Field observations during the survey and observations by local farmers, who have attempted to dig up stumps with multilayered root systems, reveal that both matai and totara can produce new root systems from their trunks after silt is deposited around them. Totara trees were also seen to produce root systems high up horizontally lying trunks uprooted by windthrow. Some totara trees were seen to develop new root systems and grow after being carried long distances down the Waiho and Cook Rivers. This survival ability may help, to explain the presence in some stands of old trees amidst predominantly younger age classes such as presently occurs in the Waiho River valley below Canavans Knob.

There is strong evidence that totara is unable to regenerate beneath a closed canopy or even in small gaps within the canopy. Its regeneration is most vigorous in large wind throw gaps, forest margins or in open scrub and grassland. Matai, by contrast can regenerate beneath a continuous forest canopy. This agrees with Druce's (1966) findings.

The long-term survival of matai/totara forests clearly depends on the periodic deposition of fresh alluvium and the availability of these sites for seedling establishment. However, such sites are in high demand for pastoral farming. They are invaded quickly by introduced grasses and legumes and are favoured by grazing animals, which quickly eliminate most podocarp seedlings.

In 24 of the 26 stands surveyed, totara and matai seedlings were rare. The two fenced stands where stock had been excluded for seven years contained prolific matai seedlings throughout both stands and numerous totara seedlings at the forest margins.

Fencing and stock exclusion from both forested and non-forested successional sites are the only ways of ensuring the survival of matai/totara forests. This will become even more important as pastoralism is intensified on the South Westland flood plains.

Climate change or cultural interference

Holloway (1954a) commented that "the appearance of many old stands (of matai / totara forest in South Westland) suggests that the podocarp species were once vigorous colonisers of bared alluviums but they do not behave as pioneer species under present day climatic conditions",

The 26 stands described here show a pattern of continuous regeneration throughout the region over the last 350 to 400 years and there is no evidence to support Holloway's theory. P. Wardle (pers. comm.) suggests Holloway never intended the climate-change podocarp regeneration-gap theory to be applied to seral sites, but this is not apparent from Holloway's statement quoted above. Certainly there is a deficiency of podocarp seedlings at 24 of the 26 study sites, but this is almost certainly due to grazing and the seral nature of the stands rather than from any change in climate. Once grazing is eliminated, regeneration can be vigorous.

Matai / totara forest-an endangered community

Flood plain matai/totara forests are a distinct ecological association. They can provide insights into New Zealand forest ecology and forest dynamics. They are of importance also as research areas for base-line studies of the most important agricultural soils in Westland, and in much of the country. A later paper will show that in South Westland this

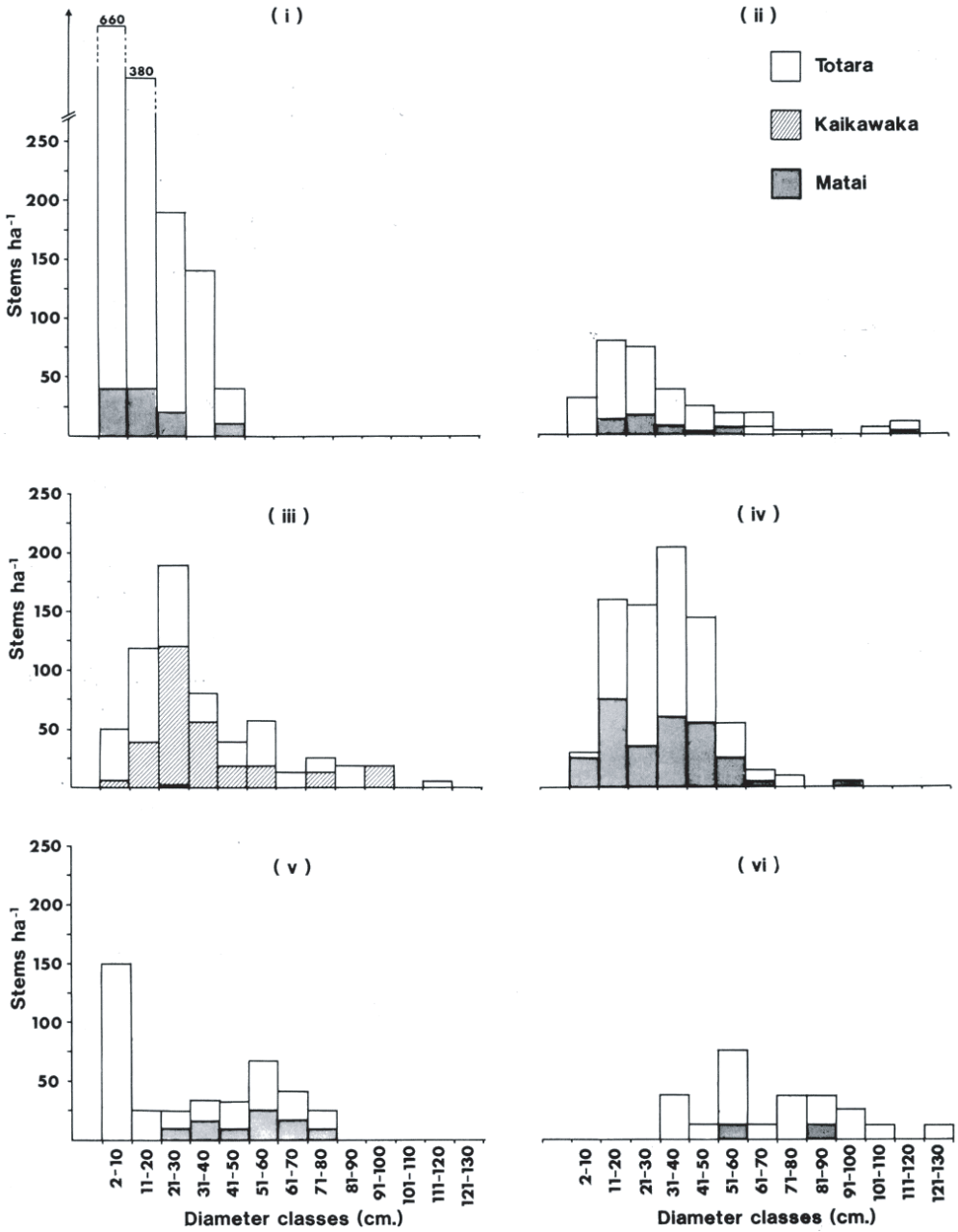

FIGURE 3. *The sizes of matai (stippled) and totara (open) trees in six remnant stands of matai / totara forest in South Westland. Stand age and location (and number of 400 m^2 plots measured within the stand) are (i) young stand, upper Whataroa River (5); (ii) sub-mature stand, Waiho River (7); (iii) mature stand, Cassel Flat (4). This stand includes kaikawaka (stripes); (iv) mature stand, lower Whataroa River (5); (v) old stand. Cook River (3); (VI) old stand. upper Whataroa River.*

FIGURE 4. *Matai / totara beside Docherty Creek, Waiho River flats. South Westland showing the stony soil on which this forest grows.*

FIGURE 5. *A tiny totara forest remnant near Hari Hari showing heavy browsing by cattle.*

forest association assumes an importance as forest bird habitat which far exceeds that anticipated for such small areas.

These forests have now disappeared from much of New Zealand. Two years ago approximately 800 ha was left in South Westland. Since then one quarter of the remaining forest has been destroyed, largely through state-assisted land development encouragement loans.

Estimates indicate that over half the remaining stands are on Crown-owned land administered by the Lands and Survey Department. This department has the major responsibility in determining the future of this exploited and now rare association. Recently this department argued strongly for protection for two key sites at Cassel Flat (50 ha) and the Waiho River (65 ha). Such protection urgently needs to be extended to the other matai/totara forests, and the successional stages towards these, elsewhere in South Westland.

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REFERENCES

BEVERDIGE, A. E. 1964. Dispersal and destruction of seed in central North Island podocarp forest. *Proceedings of the New Zealand Ecological Society* 11: 48-55.

BOND, G. 1967. Fixation of nitrogen by higher plants other than legumes. *Annual Review of Plant Physiology* 18: 107-26.

DRUCE, A. P. 1966. Secondary totara-titoki-matai forest on the Otaki Plain. *Bulletin of the Wellington Botanical Society*. 33: 22-39.

DUGUE. F. C.; DRUCE. A. P. *1966*. Totara forest at Ohau. *Bulletin of the Wellington Botanical Society*. 33: 20-21.

ESLER, A. E. *1962*. The Banks Lecture: Forest remnants of the Manawatu lowlands. *New Zealand Plants and Gardens*. 4: 255-268.

FLEMING, C. A. *1975*. Scientific principles for the selection and design of reserves. *Forest and Bird 196:* 15-18.

FOWERAKER. C. E. *1929*. The podocarp rain forests of Westland, New Zealand, No.2: Kahikatea and totara forests and their relationships to silting. *Te kuru Ngahere* 2: 4: 6-12.

FRANKLIN, D. A. *1969*. Growth rings in rimu from South Westland terrace forest. *New Zealand Journal of Botany* 7: *177-88.*

GORDON, M. 1958. *The Garden of Tane*. A. H. and A. W. Reed, Wellington, 132 pp.

GREENWOOD, R. M. *1949*. Totara reserve. *Bulletin of the Wellington Botanical Society 21:* 2-7.

HINDS, H. V.; REID, J. S. 1957. *Forest trees and timbers of New Zealand*. New Zealand Forest Service Bulletin No. 12.

HOLLWAY, J. T. 1954a. An ecological classification of the forest types of the Westland podocarp region. *New Zealand Journal of Forestry* 7(1): 24-33.

HOLLOWAY, J. T. 1954b. Forest and climate in the South Island of New Zealand. *Transactions of the Royal Society of New Zealand* 82: 329-410.

WARDLE, P. 1963. The regeneration gap of New Zealand gymnosperms. *New Zealand Journal of Botany* 1: 301-15.

WARDLE, P. 1972. *Podocarps totara* var. *waihoensis* var. *nov*: the result of introgressive hybridization between *P. totara* and *P. acutifolius*. *New Zealand Journal of Botany* 10: 195-201.

WARDLE, P. 1974. The kahikatea forest of South Westland. *Proceedings of the New Zealand Ecological Society* 21: 62-71.

WARDLE, P. 1979. *Plants and landscape in Westland National Park*. National Parks Scientific Series No. 3. Dept. Lands and Survey, Wellington.

WARDLE, P. 1980. *Scenic reserve of South Westland*. Biol. Survey of Reserves Series No. 5. Dept. of Lands and Survey, Wellington.