Vegetation of the Redwood Bush Area, Tawa

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INTRODUCTION

The municipality of Tawa, in spite of its name, now has within its boundaries very few stands of tawa* or, indeed, native forest of any sort. Largely in consequence of this scarcity, the most extensive remaining stand of mature forest — that known locally as Redwood Bush — has been recently the subject of considerable activity directed towards its conservation. Precipitating this activity has been the development of some previously forested land into urban residential lots, and proposals for similar development of much of that remaining.

As part of an attempt by the Tawa Borough Council to satisfy the conflicting demands of interested parties, a comprehensive survey of Redwood Bush and the adjacent vegetation was undertaken, in late 1975, by the author. This paper is a report of the descriptive material from that study. A subsequent paper will cover research into the impact of urban development and recreational activity on the forest remnant.

THE LOCALITY

The study area is approximately centre on grid co-ordinate 370350 (New Zealand topographical map, 1:25000, sheet N.160/8, Tawa, 1943), and is situated on the east-facing side of the Porirua-Tawa-Ngauranga depression (Stevens 1974). Except towards the ridge crests, its general aspect provides reasonable shelter from the prevailing N-NW winds, but not from those in the S-SE quarters which blow down the depression and across the area. New Zealand Meteorological Service wind records from Wellington Airport (Bagnall 1975), 16 km to the SE, show a 30 percent frequency of S-SE winds with strong gusts being common. However, the intervening land mass between the south coast and Tawa — much of it at a higher altitude than the study area — may have a moderating effect on the wind velocity, although Coulter (1975) observes that dissected terrain results in gusty turbulent winds, an effect which is particularly marked at Wellington.

The area is approximately midway between Kelburn (Wellington) and Plimmerton, from both of which there are rainfall data (New Zealand Meteorological Service 1973). However, the altitude of the study area (76-183 m) accords more closely with that of the Kelburn meteorological station (126 m) than it does with the

* Binomials for common names are given in Appendix 3.

Plimmerton station (3 m). Mean annual rainfall at Kelburn is 1231±196* mm (n = 42 years) and at Plimmerton 1037±193 mm (n = 33 years). Monthly rainfall figures show lower precipitation in the summer months than in winter; for example, at Kelburn the monthly mean for January is 80±51, for February, 88±52, and March, 80±50, but for June is 122±60, July, 135±56, and August, 125±59. The high standard deviations for these figures, expecially those of the critical summer months (as high as 64 percent of the mean) reflect a very variable precipitation from year to year with a high frequency of very dry spells.

Although Coulter (1975) notes that frosts are very rare at Kelburn, the geological depression in which the study area lies would promote a higher frequency in that region. Tawa is mapped by Coulter as being in a zone with screen temperatures of less than 0°C on 5-20 days/year.

Soils over most of the study area are classified as Korokoro Hill Soils (Heine 1975). These are well drained and occur on moderately steep to steep slopes, being developed *in situ* from weathered greywacke parent material under broadleaf or podocarp-broadleaf forest. The lowermost country — on the eastern margin of the area — has a gently undulating topography and carries deeper soil formed from wind-deposited loess. This soil, a pocket of Judgeford Silt Loam, is deeper and more fertile than the Korokoro Hill Soils, and its fine, uniform texture offers minimal impedance to root development.

HISTORY

Carman (1956) has collated reports and pictorial records of vegetative cover in the Tawa area from the time of European settlement, 1841. It was then that the Porirua road was first surveyed and the adjacent land divided into 100 acre (25 ha) blocks by the New Zealand Company. Those blocks covered by the present vegetation survey — numbers 34, 36 and 38 (ref. NZMS 189A Tawa, Wellington Series, Sheet 26, 1966) — were all apparently forest covered. This forest, which extended throughout the Porirua-Tawa-Ngauranga depression, was a very dense, tall podocarp-broadleaf forest, dominated by rimu and northern rata on the hill slopes, and on the valley floor and lower hill slopes by kahikatea, totara, and pukatea. Tawa, mamaku and nikau were recorded as being especially abundant in the understorey. The profusion of epiphytes and lianes was most notable.

Forest clearing on all land holdings in the area was undertaken shortly after the initial survey. By the 1850s Tawa would seem to have lost practically all of its forest cover, the area being converted to a rather close settlement of pastoral blocks. However, the forest cover on section number 38 appears to have been less effectively cleared than that on other blocks. This was probably aided by the

* All errors are to one standard deviation.

Fig. 1 — Remnants of protruding roots (arrowed), parts of an old northern rata tree base. The humus mound associated with this tree has been almost entirely removed by gardening enthusiasts.

transfer, in 1852, of its title to the Roman Catholic Bishop of Wellington, as land on which to build a school (Carman 1956). The school was not built, the land being leased for grazing until its recent sale and partial sub-division into residential lots.

Some records from the late 1840s onward which are noted by Carman include reports of the dominant trees — northern rata and rimu in the area of the present survey — being dead prior to felling. Whether this was from burning, the effect of exposure after clearing adjacent stands, or some other cause is not clear. However, it does suggest that Redwood Bush — the small stand of surviving forest on block number 38 and marginally on the adjacent block 36 — may have lost its upper canopy trees at an early stage. In fragments of protruding roots and mounds of humus (Fig. 1) there are still evident the decayed remains of massive tree bases scattered throughout the forest. On its northern margin these are associated with charcoal, but this is not general throughout the stand, suggesting that the firing was marginal rather than a dominant influence in destruction of the canopy. There also is little evidence of old fallen tree trunks, which suggests either that the largest trees were milled or that decomposition has been complete, possibly aided by stock scattering the decomposition fragments.

Light browsing by stock probably has been an influential factor in forest development since European settlement. It continues today with cattle sporadically entering the stand. However, browsing has not been of sufficient intensity, over any prolonged period of time, to prevent forest regeneration, although it may have had a selective influence on species composition.

A 1924 map reproduced by Carman (p. 191) shows the area of Redwood Bush at about that time. It is evident that the boundaries of the mature forest were not altered appreciably between then and late 1969. Examination of Lands and Survey Department aerial photographs from 1941 (survey No. 163, run No. 181/8, 17-2-1941), 1961 (survey No. 1407, run No. 3293/34, 6-12-1961) and 1969 (survey No. 3185, run No. 4228/8, 28-9-1969) reveal the continuing stability of the forest area with a progressive development of shrublands from previously cleared ground, both adjacent to the forest and in some isolated pockets. The 1969 aerial photograph was taken immediately prior to the first urban inroads into Redwood Bush. The effect of this development (Fig. 2) was to reduce the stand area to 9.3 ha (as calculated using a fine square grid pattern over an enlargement of aerial photograph No. 4735/23, survey No. 3672, 21-1-1974). Following the vegetation survey reported here, further urban subdivision within the stand has occurred (Fig. 2), although this has not involved complete destruction of the forest affected.

METHODS

Recording

Redwood Bush and adjacent vegetation within the Tawa Borough boundaries was mapped by the author using aerial photographs and ground surveys as described by Bagnall (1975), although soil features were not recorded. Particular note was made of the condition of the vegetation, any damage to it, and the presence of any important or potentially important weed species.

During visits to the area for reconnaissance, mapping and quantitative sampling, a list was compiled of all vascular plant species encountered in Redwood Bush proper (i.e., vegetation types 6k — kohekohe-dominated mature forest, and 6t — tawa-dominated mature forest; ref. Fig. 3). Separate lists were made of the species on each of the soil types and of species occurring in recent canopy gaps.

To obtain data on species frequency, canopy cover, and the size distributions of tree species, further recording was undertaken in the Redwood Bush proper. Circular, horizontal plots of 2 m radius were used for quantitative work. The centre of each plot was marked by a point-sampling pole used to record the uppermost canopy cover over 2 m above ground. The plot boundary was determined with a 2 m rule. Fifty such plots were evenly spaced along seven parallel sampling lines. Each line was run on a magnetic bearing of 220° from one side of the stand to the other. No plots were laid within 8 m of the vegetation margin.

From each plot were recorded: (a) each vascular plant species growing (rooted) within the plot or epiphytic on a plant growing within the plot; (b) the presence of any tree seedlings (<10 cm ht); (c) the height of each young tree between 10 cm and 200 cm ht; and (d) the circumference or diameter of each tree (>2 m ht) at breast height (1.4 m). A plant was included within the plot if 50 percent or more of its base area was within the plot. On sloping ground the ground level was taken at the lateral midpoint of the tree.

Specimens of gorse and tawa recently killed by development activity were taken for ageing by ring counting. The trees were from vegetation type 3a (gorse samples) at the head of Balliol Drive and 6t (tawa samples).

Treatment of the data

The base used in drafting the vegetation map was an uncorrected partial enlargement of the 1969 aerial photograph noted above.

To supplement the species list, frequency percent occurrences of species recorded in the sample plots were calculated from the presence/absence data.

Fig. 2 — A 1961 aerial photograph (New Zealand Department of Lands and Survey, survey No. 1407, run No. 3293/34) of Redwood Bush and the adjacent area surveyed. Boundary changes are as follows: ooo = lower boundary prior to 1970 (from before 1941 at least); --- = boundary after urban development of 1969-70 (x = mature forest destroyed); . . . = approximate boundary of urban development, 1977 (c = area of mature forest affected).

To plot the size distributions of tree species, diameters were used; circular trunk cross sections were assumed when converting circumferences. Density was calculated as plant density, that is, as separate stems at ground level. Diameter and density statistics were calculated on a per hectare basis as vertically projected on to a plane surface. Standard errors of cover values obtained from the point sampling data were calculated using the formula given by Atkinson (1962).

RESULTS

Vegetation

The vegetation types identified are given the following descriptive titles: pasture on steep slopes (1a), pasture on moderate slopes (1b), recently burned shrublands (1c), tauhinu/pasture (2a), gorse shrubland (2b), gorse shrubland with mahoe (3a), mixed shrubland/pasture (3b), mahoe forestland in gullies (4a), mahoe forestland on faces (4b), old mahoe forestland (4x), immature forest (5), kohekohe-dominated mature forest (6k), tawa-dominated mature forest (6t), and planted macrocarpa (p). The distribution of these types is shown in Fig. 3. Vegetation descriptions are given in Appendix 1.

Apart from the progressive inroads which urban development is making on the forested areas, the vegetation is affected both indirectly and directly by human activity. Overgrowth by climbers, especially bush lawyer and bush pohuehue, is causing die-back in the canopy of the narrow strips of regenerating mahoe forestland in gullies (Fig. 4). Damage to the mature forest, especially through uncontrolled recreational use by children, is considerable. An example of localised clear-felling is shown in Fig. 5, which also gives an impression of the general structure of tawa- and kohekohe-dominated mature forests.

Examination of the component species and their size distributions (estimates only were used) suggests that the vegetation types are linked through time into the convergent successional sequence outlined in Fig. 6. The only pertinent ageing of successional species in the area has been that of gorse in type 3a (gorse shrubland with mahoe). The specimens examined were aged at 21, 23, 23, 28, and 29 years. Therefore, most of the time spans given for successional changes are very approximate and are extrapolated

Fig. 3 — Vegetation map of the Redwood Bush area. Grid lines, approximate only, are transferred from the New Zealand topographical map, 1:25 000, sheet N.160/8, Tawa, 1943. Sharp vegetation boundaries are shown as solid lines, unclear boundaries as broken lines. *1a* = pasture on steep slopes; *1b* = pasture on moderate slopes; *1c* = recently burned shrublands; *2a* = tauhinu/pasture; *2b* = gorse shrubland; *3a* = gorse shrubland with mahoe; *3b* = mixed shrubland/pasture; *4a* = mahoe forestland in gullies; *4b* = mahoe forestland on faces; *4x* = old mahoe forestland; *5* = immature forest; *6k* = kohekohe-dominated mature forest; *6t* = tawa-dominated mature forest; *p* = planted macrocarpa.

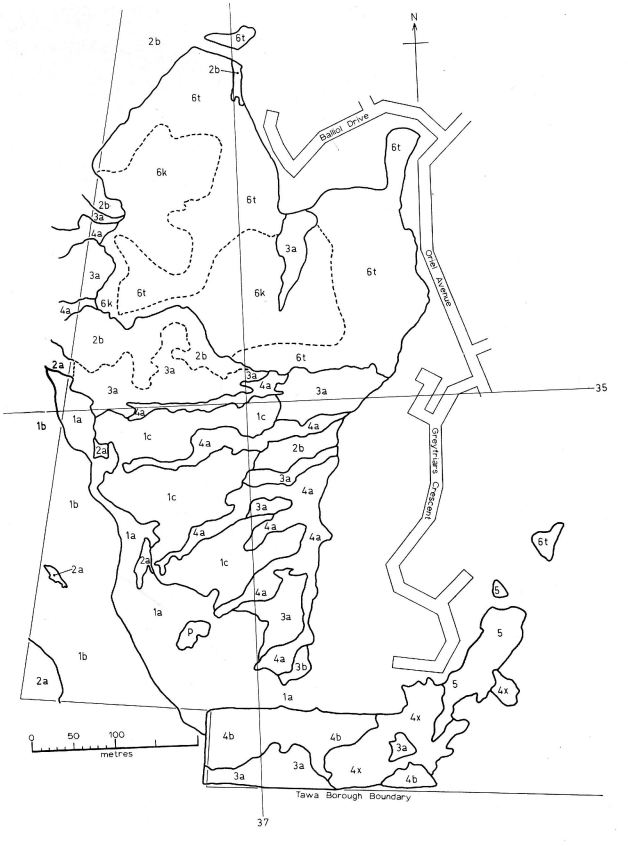
N
Ballot Drive
Orlel Avenue
Orlel Forest Crescent
35
37
0 50 100
metres
Tawa Borough Boundary

Fig. 4 — Mahoe forestland in gullies (across centre) showing overgrowth by bush lawyer (to the left) and bush pohuehue. Margin of mixed shrubland/pasture in the foreground; gorse shrubland with mahoe behind.

Fig. 5 — Area in kohekohe-dominated mature forest which has been clear-felled by children. Tawa-dominated mature forest is evident to the rear of the clearing, kohekohe to the right.

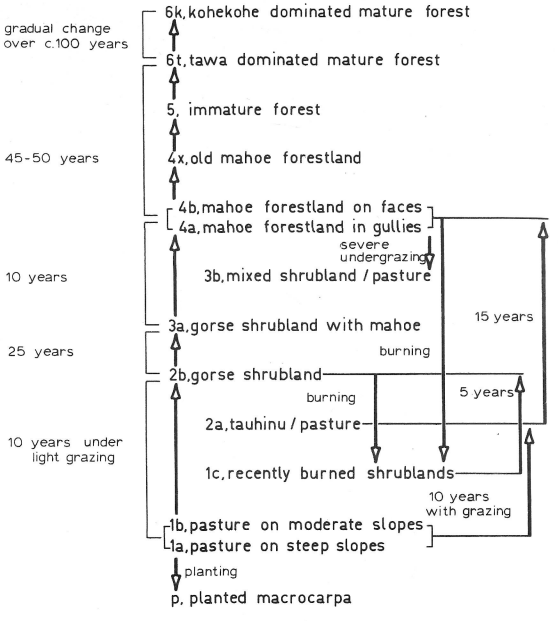

Fig. 6 — Suggested successional relationships among the vegetation types, with approximate times involved in each change. The times relate only to the temporally dependent changes marked by the ascending arrows.

from data given by Crocker (1953) for the Belmont Hills, Druce (1957 for the Soil Bureau catchment at Taita, and Esler (1967) for Kapiti.

From the diagram of succesional relationships it can be seen that the suggested time required for vegetation to develop from burned shrubland to mature forest is approximately 90-100 years; from lightly grazed pasture to mature forest, 80-105 years; from gorse shrubland to mature forest, 80-85 years; and from mahoe forestland to mature forest, 45-50 years.

Species	% Cover and Error
Dysoxylum spectabile (kohekohe)	48±7
Beilschmiedia tawa (tawa)	30±6
Melicytus ramiflorus (mahoe)	6±3
canopy gap	6±3
Myrsine australis (mapou)	4±3
Elaeocarpus dentatus (hinau)	2±2
Geniostoma ligustrifolium (hangehange)	2±2
Olearia rani (heketara)	2±2
	100

Table 1 — Canopy composition of mature forest including both tawa-dominated and kohekohe-dominated. Only the uppermost foliage over 2 m above the ground surface was recorded on 50 sample points. Errors are to one standard deviation.

The uppermost canopy cover of the mature forest — types 6k and 6t combined — is shown in Table 1. This reveals a slight predominance of kohekohe (48 percent cover) over tawa (30 percent), with a very low cover of mahoe (6 percent cover). This order of relative dominance is reflected also in the distribution of tree stem sizes (Table 2). Judging from the size distribution of tawa it is evident that this species, under existing conditions, is dying out as the major canopy species and is being replaced by kohekohe. Mahoe, pigeonwood, titoki, karaka, and kaikomako appear likely to retain their positions as associated species, there being no evidence to suggest major changes in canopy composition involving these species.

The ages of the youngest tawa trees collected, corrected for time since death, were as follows (dbh in parentheses): 39 (14.5 cm), 39 (12.5 cm), and 58 years (15.5 cm). These tawa were as small as any measured within the forest, and indicate that regeneration of tawa effectively ceased in the late 1930s. Also, no evidence could be found of tawa establishing in recent times in the sub-climax forest or older forestlands where young plants could be expected normally. Kohekohe regeneration and establishment is, however, not affected (Fig. 7). Most trees of mamaku in the mature forest have died and fallen, the few remaining trees having been felled and removed. Mamaku, also, is regenerating only very sparsely.

The causes of these changes in forest composition are not known, but are most likely to be climatic or browsing by introduced animals. Summer drought is perhaps the climatic factor most likely to affect tawa regeneration. However, while drought periods are known to be common and occasionally severe, the local importance of this factor is not clear.

Frost is observed to have a selective damaging effect on the

Fig. 7 — Light gap in tawa-dominated mature forest, showing the lack of young tawa, and the dense growth of seedling and sapling kohekohe.

Table 2 — Size distribution of tree species. Only the largest trunk on a multiple-trunked tree is included.

Species	Plots in which Present	Size Classes in cm Number per hectare				
	0-10 ht	11-50 ht	51-200 ht	201 ht -10 dbh	10.1-20 dbh	> 20 dbh
Beilschmiedia tawa (tawa)	6%	32	—	—	96	175
Dysoxylum spectabile (kohekohe)	80%	3374	875	733	366	270
Alectryon excelsus (titoki)	12%	207	255	—	—	—
Corynocarpus laevigatus (karaka)	—	1703	16	—	—	—
Dacrycarpus dacrydioides (kahikatea)	—	—	—	16	—	—
Elaeocarpus dentatus (hinau)	3%	64	—	—	—	—
Hedycarya arborea (pigeon wood)	6%	64	48	—	32	—
Knightia excelsa (rewarewa)	4%	32	16	—	—	—
Laurelia novae-zelandiae (pukatea)	—	—	—	—	16	—
Melicytus ramiflorus (mahoe)	28%	1544	525	16	32	32
Olearia rani (heketara)	—	48	80	64	—	—
Pennantia corymbosa (kaikomako)	14%	430	127	111	—	—
Podocarpus ferrugineus (miro)	2%	—	—	16	—	—
Pseudopanax arboreus (five finger)	4%	—	32	—	—	—
Pseudopanax crassifolius (lancewood)	—	16	—	—	—	—
		7514	1974	956	542	477

mature forest canopy. The fairly severe frosts which occurred in the winter of 1976 killed all exposed terminal shoots and leaves of kohekohe, but left the tawa almost undamaged. Wind does not appear to be critical except in conjunction with human interference, as will be discussed in a later paper.

Flora

The annotated species list is presented in Appendix 2. From a total of 92 indigenous species recorded in the survey, 17 (19%) were noted as occurring only on the lower soil type (Judgeford silt loam). Unfortunately, since the time of the survey, most of this lower area has been subdivided into residential lots, although to date, development has been achieved with little damage to the vegetation, excepting that cleared for a central access road. The six indigenous species recorded by Atkinson (1972) but not by the present author may either have been overlooked or else have become locally extinct between these surveys.

Northern rata, which once was a co-dominant species, is now only present as two small trees, one (which is nearly dead) in the bush remnant between Oriel Avenue and Fitzwilliam Terrace, and the other in the immature forest area under threat of urban development. Two fern species *(Arthropteris tenella* and *Grammitis billardieri)* also were recorded in the immature forest but not elsewhere in the survey area.

The apparent absence of epiphytic orchids in the mature and immature forests, where they were expected to be common, is unexplained.

Although there is apparently a large number of exotic species in the mature forest (35 species), almost none of these poses a threat to the forest, most being species of temporary light gaps or else small plants of little ecological consequence. The exotic species such as gorse, scotch broom and grasses, now abundant elsewhere in the survey area, will be replaced in time by indigenous plants of later successional stages. The following are the main exotic weeds which are seriously affecting forest elsewhere in the Wellington region, but which are absent still from the survey area: wandering Jew, traveller's joy, Cape ivy, German ivy, and cobaea.

The one recorded exotic plant which is a potential problem is the ivy. This species, although scattered in the forest, is still scarce enough to be eradicated.

The indigenous climbers bush pohuehue, native passion flower and bush lawyer can seriously damage disturbed bush such as that in the survey area. They grow over the forest canopy from the exposed margins, and can progressively kill the forest cover. Already these species are affecting the mahoe forestland in gullies (type 4a).

Fauna

The only indigenous birds noted in the area were fantail,

silvereye and grey warbler. Kingfisher would be expected also. These all are species which have adapted to urban or semi-urban situations and are unlikely to disappear from the area. The apparent absence of other native species is a reflection of the small total extent of the mature forest.

The silvereye and the introduced blackbird are the only resident birds which would be important in the dispersal of forest tree seeds.

Opossums are present in the area, inflicting moderate damage on the forest and forestlands. The recent death of most mature fuchsia may be attributable to their browsing. Other trees (e.g., pate, five finger and kohekohe) were noted to be heavily browsed only locally.

Cattle are present in low numbers in the mature forest. The immature forest, while not presently containing stock, was heavily grazed in the understorey by sheep until 1-2 years prior to the survey. The forestlands and shrublands generally are accessible to sheep and cattle from adjacent pasture. In all stands these stock are undesirably modifying the vegetation to varying degrees.

CONCLUSIONS

The tawa- and kohekohe-dominated Redwood Bush is one of the few remaining stands of mature forest in Tawa Borough. Its present composition is quite unlike that of the pre-European hill country forest, in which the uppermost stratum was a tall, close growth of rimu and northern rata. The present canopy approximately represents a development of the subcanopy of that period.

Interesting structural and floristic changes are occurring still in the stand. Those noted here are consequent particularly upon the failure of tawa to regenerate in recent decades. The forest area is critically small with local extinctions of species resulting even from small inroads into its boundaries.

The forest straddles two soil and topographic types. The lowermost area, on more gentle topography, includes a larger number of both indigenous and exotic species which are not present on the steeper slopes. Unfortunately, the greater part of this lower area has been subdivided for housing since the survey was undertaken.

The vegetation in close proximity to Redwood Bush includes a diversity of successional stages which, if spared from further urbanisation, would be educationally very valuable. In time, these stands also would supplement the mature forest area, increasing its recreational carrying capacity and providing additional habitat for avifauna which at present exhibit a low species diversity.

The paucity of serious and potentially serious weed species should facilitate management of the area as a recreational and educational reserve. However, the small extent of the forested area and its proximity to recent urban settlement add considerably to the need for its careful management and the control of recreational use.

ACKNOWLEDGEMENTS

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REFERENCES

ALLAN, H. H. 1961: *Flora of New Zealand.* Vol. 1, Government Printer, Wellington. 1085 pp.

ATKINSON, I. A. E. 1962: Semi-quantitative measurements of canopy composition as a basis for mapping vegetation. *Proc. N.Z. Ecol. Soc. 9:* 1-8.

——1972: Bush remnants at Tawa. Unpublished report. 6 + 4 pp.

BAGNALL, R. G. 1975: Vegetation of the raised beaches at Cape Turakirae, Wellington, New Zealand. *N.Z. Jl Bot. 13:* 367-424.

CARMAN, A. H. 1956: *Tawa Flat and the Old Porirua Road, 1840-1955.* A. H. Carman, Wellington. 251 pp.

COULTER, J. D. 1975: The climate. *In* Kuschel, G. (Ed.) *Biogeography and Ecology in New Zealand.* Dr W. Junk; The Hague: 87-138.

CROCKER, BARBARA H. 1953: Forest regeneration of the western Hutt hills, Wellington. *Trans. R. Soc. N.Z. 81:* 11-21.

DRUCE, A. P. 1967: Botanical survey of an experimental catchment, Taita, New Zealand. *N.Z. Dep. Sci. Industr. Res. Bull. 124:* 1-81.

EDGAR, ELIZABETH 1971: Nomina nova plantarum Novae-Zelandiae 1960-1969 Gymnospermae, Angiospermae. *N.Z. Jl Bot. 9:* 322-330.

ESLER, A. E. 1967: The vegetation of Kapiti Island. *N.Z. Jl Bot. 5:* 394-399.

HEINE, J. C. 1975: Interim report on soils of Wellington Region, New Zealand. *N.Z. Dep. Sci. Industr. Res. Soil Bureau Record 39:* 1-39 + map.

MOORE, LUCY B.; EDGAR, ELIZABETH 1970: *Flora of New Zealand.* Vol. II. Government Printer, Wellington. 354 pp.

NEW ZEALAND METEOROLOGICAL SERVICE 1973: Rainfall percentiles: tables of percentiles, means, standard deviations, and extremes, of monthly, seasonal, and annual rainfall for New Zealand and Pacific Island stations. *N.Z. Meteorol. Serv. Misc. Publ. 141:* 1-98.

NEW ZEALAND WEED AND PEST CONTROL SOCIETY 1969: *Standard Common Names for Weeds in New Zealand.* Editorial Services, Wellington. 141 pp.

ORNITHOLOGICAL SOCIETY OF NEW ZEALAND 1970: *Annotated Checklist of the Birds of New Zealand. Including the Birds of the Ross Dependency.* Reed, Wellington. 96 + 2 pp.

STEVENS, G. R. 1974: *Rugged Landscape: the Geology of Central New Zealand, including Wellington, Wairarapa, Manawatu and the Marlborough Sounds.* Reed, Wellington. 286 pp.

WODZICKI, K. A. 1950: Introduced mammals of New Zealand: an ecological and economic survey. *N.Z. Dep. Sci. Industr. Res. Bull. 98:* 1-255.

APPENDIX 1 — DESCRIPTION OF VEGETATION TYPES

Each vegetation type is described by strata, numbered from the uppermost downward, with the data arranged in the following order: normal canopy height range (with extreme figures in parentheses), total cover percent, and the main component species in decreasing order of importance (where appropriate, with cover values of these in parentheses). Any notable features of the vegetation, such as an abundance of epiphytes, are also recorded. Binomials for common names are given in Appendix 3.

1a, pasture on steep slopes

Grazed pasture on slopes of approximately 10-40°.

1. 0.5-1.5 m; up to 50% cover on margins; scattered tauhinu, gorse and occasionally *Olearia solandri.*
2. <0.2 m; grazed pasture; 100% cover away from shrubs; perennial ryegrass and browntop (90% cover); with cocksfoot, sheep's sorrel, sweet vernal, *Poa pratensis,* barley grass, fiddle dock, dove's foot, dandelion and Yorkshire fog (together c. 10% cover).

1b, pasture on moderate slopes
Grazed pasture on slopes of < c. 10°.
1. < 0.2 m; 100% cover; grazed pasture of browntop and perennial ryegrass.

1c, recently burned shrublands
Areas of vegetation type 2b with some marginal areas of type 3a burned in the summer of 1974-75.
1. 2-3 m; < 10% cover; dead, charred stems of gorse with marginal areas of mahoe.
2. < 0.5 m; 60-100% cover; resprouting gorse, gorse seedlings, herbaceous species and local areas of bracken.

2a, tauhinu/pasture
1. 1-1.5 m; 5-80% cover; tauhinu with scattered gorse.
2. grazed pasture (refer type 1a).

2b, gorse shrubland
1. 1-2.5 m; 80-100% cover; gorse.
2. up to 0.5 m; litter; with, scattered in older stands, seedling and young sapling mahoe and karamu.

3a, gorse shrubland with mahoe
1. 2-3 m; 80-90% cover; gorse (69-80%) and mahoe (20-30%).
2. up to 2 m; up to 60% cover; bracken, local but more abundant on steep faces where upper canopy is not or poorly developed.
3. up to 2 m; 5% cover; scattered seedling and sapling mahoe, karamu and kaikomako.

3b, mixed shrubland/pasture
1. up to 4 m; 20% cover; scattered mahoe overgrown by bush lawyer and bush pohuehue.
2. 0.5-2 m; up to 50% cover; bracken (30%) and *Coprosma rhamnoides* (30%) overgrown by coastal pohuehue.
3. pasture in canopy gaps (refer type 1a).

4a, mahoe forestland in gullies
1. 4-6 m; up to 30% cover; emergent mamaku in lower gullies.
2. 3-4 m; 80-90% cover; main canopy of mahoe (70%); with kaikomako, karamu, fuchsia and rangiora (together about 30% cover); abundant bush lawyer and bush pohuehue is overgrowing the canopy.
3. < 3 m; < 10% cover; subcanopy; undergrazed, but ferns and some seedlings, particularly of mahoe, kaikomako and putaputaweta.

4b, mahoe forestland on faces
1. 2-4 m; 80-90% cover; canopy of mahoe (80%) with gorse (10% dominant on margins), karamu (10%) and scattered scotch broom.
2. subcanopy of ferns and seedlings, especially of mahoe, kaikomako and pigeon wood.

4x, old mahoe forestland
1. 2.5-4 m; 100% cover; mahoe (95%), karamu (5%), with scattered gorse, mamaku and kaikomako.
2. undergrowth of ferns and kawakawa with seedlings and young saplings, particularly of mahoe, kaikomako, pigeon wood, titoki and hinau.

5, immature forest
1. up to 10 m; < 5% cover; occasional emergent northern rata and rewarewa.
2. 4-6 m; 80-90% cover; mahoe (80%) and kaikomako (10%) with scattered lancewood, tawa, titoki and pigeon wood.
3. 1-2.5 m; 5-15% cover; kawakawa (10%) and mapou (5%), with scattered *Coprosma areolata* and *Coprosma rhamnoides*.
4. < 0.5 m; < 5% cover; ground cover, undergrazed until recently; scattered ferns, young kawakawa, and scattered seedling mahoe, kohekohe, pigeon wood and titoki; seedling mahoe, kohekohe, pigeon wood and titoki; no tawa seedlings. Severe trampling from children. Much rubbish and spoil marginally from building and subdivision work.

6k, kohekohe-dominated mature forest

1. 10-12 (-14) m; 0-30% cover; tawa, with scattered hinau and rewarewa.
2. 6-8 (-10 m); 50-100% cover; kohekohe with scattered pigeon wood, rewarewa, titoki and mahoe; also on ridges and forest margins are mapou and *Coprosma areolata*.
3. 1-3 m; up to 80% cover; kawakawa, with hangehange and raurekau; sapling kohekohe, mahoe and titoki.
4. < 0.5 m; up to 70% cover; ground cover of ferns, especially *Asplenium bulbiferum, Blechnum filiforme* and *Phymatodes scandens;* on drier sites *Lastreopsis hispida, Phymatodes diversifolium* and *Uncinia uncinata* are common; seedling kohekohe, mahoe, kaikomako and *Coprosma areolata*.

Climbers are abundant in strata 1 and 2, particularly supplejack and ratas (largely red climbing rata). Also in these strata are abundant epiphytic ferns and occasional astelias, but no epiphytic orchids.

6t, tawa-dominated mature forest

1. 10-12 (-18) m; 40-95% cover; tawa, with scattered rewarewa, hinau and kahikatea; pukatea in gullies.
2. 6-8 (-10) m; 5-60% cover; kohekohe, with scattered titoki and mahoe.

On the upper ridges strata 1 and 2 are not distinguishable and are at c. 6 m ht.
3 & 4 Refer type 6k.
Climbers and epiphytes as for type 6k.

p, planted macrocarpa

1. 8-10 m; 100% cover; macrocarpa.
2. sparse ground cover of small herbs and grasses.

APPENDIX 2 — LIST OF VASCULAR PLANT SPECIES RECORDED FROM MATURE FOREST OF REDWOOD BUSH

Species growing only on the forest margins are not included. Common names are shown in parentheses; * = exotic species; g = present only in canopy gaps; d = recorded only from the Judgeford Silt Loam; t = recorded by Atkinson (1972) but not seen in the present study; the figure is the frequency percent in 50 circular plots of 2 m radius. Except where authorities are cited, nomenclature follows Allan (1961), Moore and Edgar (1970), New Zealand Weed and Pest Control Society (1969), and Edgar (1971), the last taking priority.

1. TREES AND SHRUBS

Alectryon excelsus (titoki) 30%
Aristotelia serrata (wineberry) d 0%
Beilschmiedia tawa (tawa) 30%
Brachyglottis repanda (rangiora) 24%
Carpodetus serratus (putaputaweta) 2%
Coprosma areolata 56%
Coprosma australis (raurekau) 28%
Coprosma rhamnoides 36%
Coprosma robusta (karamu) g 12%
Coprosma propinqua x *C. robusta* g 2%
Corynocarpus laevigatus (karaka) 4%
Cotoneaster sp. *
Dacrycarpus dacrydioides:*rydioides* (kahikatea) 2%
Dysoxylum spectabile (kohekohe) 94%
Elaeocarpus dentatus (hinau) 14%
Eugenia maire (swamp maire) t
Fuchsia excorticata (fuchsia) 3% most trees have died in recent years
Geniostoma ligustrifolium strifolium (hangehange) 88%
Griselinia lucida (puka) 0%
Hedycarya arborea (pigeon wood) 22%
Knightia excelsa (rewarewa) 8%
Laurelia novae-zelandiae (pukatea) 2%
Leycesteria formosa (Himalayan honeysuckle) * g
Lophomyrtus bullata (ramarama) 2%
Macropiper excelsum (kawakawa) 92%
Melicytus ramiflorus (mahoe) 66%
Myrsine australis (mapou) 84%
Olearia rani (heketara) 12%
Paratrophis microphylla (turepo) 0%
Pennantia corymbosa (kaikomako) 46%
Podocarpus ferrugineus (miro) 4%

Podocarpus totara (totara) t
Pseudopanax arboreus (five finger) 8%
Pseudopanax crassifolius (lancewood) 2%
Sambucus nigra (elder)* d 2%
Schefflera digitata (pate) 0%
Solanum aviculare (poroporo) g 2%
Solanum laciniatum (poroporo) t
Ulex europaeus (gorse)* g 0%

2. LIANES

Clematis paniculata (clematis) 4%
Freycinetia banksii (kiekie) t
Hedera helix (ivy) * 0%
Metrosideros diffusa (climbing rata) 34%
Metrosideros fulgens (red climbing rata) 40%
Metrosideros perforata (climbing rata) 22%
Muehlenbeckia australis (bush pohuehue) 20%
Muehlenbeckia complexa (coastal pohuehue) 2%
Parsonsia heterophylla (parsonsia) 88%
Ripogonum scandens (supplejack) 60%
Rubus cissoides (bush lawyer) 2%
Tetrapathaea tetrandra (native passion flower) 26%

3. FERNS

Asplenium bulbiferum 70%
Asplenium bulbiferum x *A. hookerianum* 10%
Asplenium falcatum 16%
Asplenium flaccidum 26%
Asplenium hookerianum 14%
Asplenium lucidum 52%
Botrychium australe var. *millefolium* d 2%
Blechnum chambersii Tindale 16%
Blechnum filiforme 94%
Blechnum membranaceum 4%
Cyathea dealbata (ponga) *34%*
Cyathea medullaris (mamaku) 0% most plants are dead
Dicksonia squarrosa (wheki) t
Histiopteris incisa g d 0%
Humenophyllum demissum 22%
Hymenophyllum sanguinolentum t
Hypolepis tenuifolia 2%
Lastreopsis decomposita d 2%
Lastreopsis glabella 26%
Lastreopsis hispida 32%
Lastreopsis velutina d 2%
Pellaea rotundifolia 12%
Phymatodes diversifolium 30%
Phymatodes scandens 72%
Polystichum richardii 4%
Pteridium aquilinum var. *esculentum* (bracken) g 4%
Pteris macilenta (8%)
Pteris tremula d 0%
Pyrrosia serpens 28%
Rumohra adiantiformis 2%
Thelypteris pennigera d 4%
Todea hymenophylloides 10%

4. GRASSES AND SEDGES

Anthoxanthum odoratum (sweet vernal) * g d 0%
Carex dissita d 0%
Carex forsteri g d 0%
Dactylis glomerata (cocksfoot) * g 8%
Holcus lanatus (Yorkshire fog) * g d 0%
Juncus pallidus d 0%
Juncus sarophorus d 0%
Lolium perenne (perennial ryegrass) * g d 2%
Microlaena stipoides (meadow rice grass) 16%
Poa annua * g d 2%
Schoenus maschalinus d 2%
Scirpus prolifer d 0%
Uncinia banksii (hook grass) 6%
Uncinia uncinata (hook grass) 62%

5. IRISES, LILIES, ORCHIDS

Astelia solandri 2%
Collospermum hastatum 0%
Iris sp. * d 2%
Microtis unifolia d 0%
Pterostylis banksii 24%
Pterostylis graminea d 2%
Thelymitra longifolia d 0%

6. OTHER HERBS AND SUB-SHRUBS

Cardamine debilis 4%
Carduus tenuiflorus (winged thistle) * g d 2%
Cerastium glomeratum (annual mouse-ear chick weed) * g d 2%
Cirsium vulgare (scotch thistle) * g 8%
Digitalis purpurea (foxglove) * g 4%
Erigeron sp. (fleabane) * g 12%
Galium aparine (cleavers) * g 24%
Geranium robertianum (herb robert) * g 2%
Hydrocotyle americana 23%
Hydrocotyle novae-zelandiae 0% strongly hispid form with leaves 8-25 mm diam.
Hypericum androsaemum (tutsan) * g 4%
Hypochaeris radicata (catsear) * g 8%
Mycelis muralis (wall lettuce) * d 2%
Myosotis sylvatica (wood forget-me-not) * d 0%
Oxalis corniculata (oxalis) * g 2%
Plantago lanceolata (plantain) * g d 2%
Prunella vulgaris (self heal) * g 4%
Ranunculus hirtus 2%

Ranunculus repens (creeping buttercup) * g 0%
Senecio jacobaea (ragwort) * g 6%
Senecio sylvaticus (wood groundsel) * g 0%
Solanum nigrum (black nightshade) * g 12%
Sonchus oleraceus (sow thistle) * g 6%
Stellaria media (chickweed) * g d 4%
Stellaria parviflora (native chickweed) 4%
Taraxacum officinale (dandelion) * g d 4%
Trifolium repens (white clover) * g d 2%
Urtica incisa (stinging nettle) d 2%
Vicia hirsuta (hairy vetch) * g d 2%
Vicia sativa (including *V. angustifolia*) (vetch) * g d 2%

APPENDIX 3 — BINOMIALS FOR COMMON NAMES USED IN THE TEXT AND APPENDIX 1

Botanical nomenclature follows that in Appendix 2. For mammals, Wodzicki (1950) is followed, and for birds, the Ornithological Society of New Zealand (1970).

PLANTS

astelias	*Astelia solandri* and *Collospermum hastatum*
barley grass	*Hordeum murinum*
bracken	*Pteridium aquilinum*
browntop	*Agrostis tenuis*
bush lawyer	*Rubus cissoides*
bush pohuehue	*Muehlenbeckia australis*
Cape ivy	*Senecio angulatus*
coastal pohuehue	*Muehlenbeckia complexa*
cobaea	*Cobaea scandens*
cocksfoot	*Dactylis glomerata*
dandelion	*Taraxacum officinale*
dove's foot	*Geranium molle*
fiddle dock	*Rumex pulcher*
five finger	*Pseudopanax arboreus*
fuchsia	*Fuchsia excorticata*
German ivy	*Senecio mikanioides*
gorse	*Ulex europaeus*
hangehange	*Geniostoma ligustrifolium*
hinau	*Elaeocarpus dentatus*
honeysuckle	*Lonicera japonica*
ivy	*Hedera helix*
kahikatea	*Dacrycarpus dacrydioides*
kaikomako	*Pennantia corymbosa*
karaka	*Corynocarpus laevigatus*
karamu	*Coprosma robusta*
kawakawa	*Macropiper excelsum*
kohekohe	*Dysoxylum spectabile*
lancewood	*Pseudopanax crassifolius*
macrocarpa	*Cupressus macrocarpa*
mahoe	*Melicytus ramiflorus*
mamaku	*Cyathea medullaris*
mapou	*Myrsine australis*
native passion flower	*Tetrapathaea tetrandra*
nikau	*Rhopalostylis sapida*
northern rata	*Metrosideros robusta*
pate	*Schefflera digitata*
perennial ryegrass	*Lolium perenne*
pigeon wood	*Hedycarya arborea*
pukatea	*Laurelia novae-zelandiae*
putaputaweta	*Carpodetus serratus*
rangiora	*Brachyglottis repanda*
ratas	*Metrosideros diffusa, M. fulgens, M. perforata*
raurekau	*Coprosma australis*
red climbing rata	*Metrosideros fulgens*

rewarewa	*Knightia excelsa*
rimu	*Dacrydium cupressinum*
scotch broom	*Cytisus scoparius*
sheep's sorrel	*Rumex acetosella*
supplejack	*Ripogonum scandens*
sweet vernal	*Anthoxanthum odoratum*
tauhinu	*Cassinia leptophylla*
tawa	*Beilschmiedia tawa*
titoki	*Alectryon excelsus*
totara	*Podocarpus totara*
traveller's joy	*Clematis vitalba*
wandering Jew	*Tradescantia fluminensis*
Yorkshire fog	*Holcus lanatus*
BIRDS	
Blackbird	*Turdus merula*
fantail	*Rhipidura fuliginosa placabilis*
grey warbler	*Gerygone igata*
kingfisher	*Halcyon sancta*
silvereye	*Zosterops lateralis*
MAMMALS	
cattle	*Bos taurus*
opossum	*Trichosurus vulpecula*
sheep	*Ovis aries*

Leaves from volunteer seedlings of a putative *Pseudopanax* hybrid in a Palmerston North garden. A leaf from the parent tree is shown centre bottom. Seedlings appear frequently, despite the apparent isolation of the parent, and show the range of leaf form seen in these selected examples.