Bracken Fern and Scrub Communities in Otari Reserve, Re-observed after Fifty Years

J S Reid, Wellington

ABSTRACT

Quadrats and transects were used in a botanical survey in 1932-34 of natural or induced indigenous vegetation at Otari Open-Air Native Plant Museum, Wellington. Two study areas, in which woody indigenous plants were invading bracken fern stands, were selected as quadrat locations, one of them also having a small content of introduced species. Re-examination of areas in 1982-84 reveals, in one site, substantial development of a storeyed forest structure on an exposed but gently sloping spur crest. On the other site, forest development has been retarded by more severe environmental conditions. Height growth data are presented for some species.

INTRODUCTION

Indigenous forest occupies most of the Otari Open-Air Native Plant Museum (called "Otari Reserve" in this paper) in Wellington. During the one and a half centuries since European settlement commenced, most inroads into the forest cover in the Otari vicinity were associated with pastoral farming. There was negligible commercial sawmilling, as stands of the sought-after podocarps were of small extent. A botanical study (Reid 1934, 1985) commenced in 1932 and, extending through the following two years, was centered initially on reasons for the widespread occurrence in Otari of rangiora *(Brachyglottis repanda)* as a component of damaged or developing forest. The rangiora study led to consideration of rangiora's associates and a broad botanical survey.

Transects were used in the reconnaissance but quadrats became the preferred method for vegetation analysis; their employment as permanent plots for periodic review was not a primary objective in 1932-34. Two quadrats located in bracken fern *(Pteridium esculentum)* combined with other forms of scrub, were mapped in 1932-34, analysed and discussed as to the probable succession. The plots were re-located and reviewed in 1982-84 to the extent admitted by their initial definition. Site differences and human interference before 1932 have contributed materially to the succession.

A map (p 49, Reid 1989) shows the main physical features of Otari with an indication also of the 1930 bush edge near the western boundary where the crests of spurs mostly carried a sward of grass linking to pastoral farming which continues today beyond the fence. Several spur crests have reverted to bracken and Quadrat 14 (Fig. 1) is located on one of them.

A prominent physical feature of Otari is the deeply entrenched Kaiwharawhara Stream that separates the easily accessible eastern part with its "developed" botanical and horticultural sectors, as well as natural forest (Area A in the survey), from the extensive western part rising c. 230m to the western boundary. Two of the four side-streams flowing in from the west are deeply entrenched for most of their lengths. Their drainage areas, defined by main spurs leading to the ridge-top, provided suitable sub-divisions (Areas B, C, D) for the survey. Steep gully sides have provided additional sites for bracken scrub

vegetation and one of them, close to the main stream with a southerly aspect, is sampled in Quadrat 15 (fig. 3).

STUDY AREAS

1. Where the leading spur separating Botanical Survey Area B (northwards) from Botanical Survey Area C (southwards) crosses the western boundary of the reserve at Cockayne Heights, a side spur to the south was approachable through low gorse *(Ulex europaeus)* in 1934. About 100m from the spur's origin, vegetation on its crest changed from low gorse to dense bracken fern 1m tall, in the process of being invaded by woody natives: this was selected for Quadrat 14. At that time it was assumed that the side spur must have been inadequately grassed after burning of the forest cover or, alternatively, after pasture had become inaccessible to stock grazing on the adjacent broad main spur. The burning premise is supported by the presence of apparently charred logs, including hinau *(Elaeocarpus dentatus)* whose durable outer heart-wood remains when other forest tree remnants have disappeared. Along the spur crest, surface humus also points to the earlier presence of forest.

To establish a quadrat at the selected site proved difficult without destroying much of the vegetation. Instead of mapping the vegetation at ground level, an 8m × 6m sample was taken at the bracken canopy level with plants other than bracken being shown in terms of space occupied at that level. Further down the spur the fern and scrub height increased and entry could be forced only by cutting groups of bracken stipes close to the ground. Additional small plots were mapped at bracken canopy level except where small canopy openings had allowed koromiko *(Hebe stricta* var. *atkinsonii),* tauhinu *(Cassinia leptophylla),* and tutsan *(Hypericum androsaemum)* to become established. The several plots were aggregated in Quadrat 14 (Fig. 2).

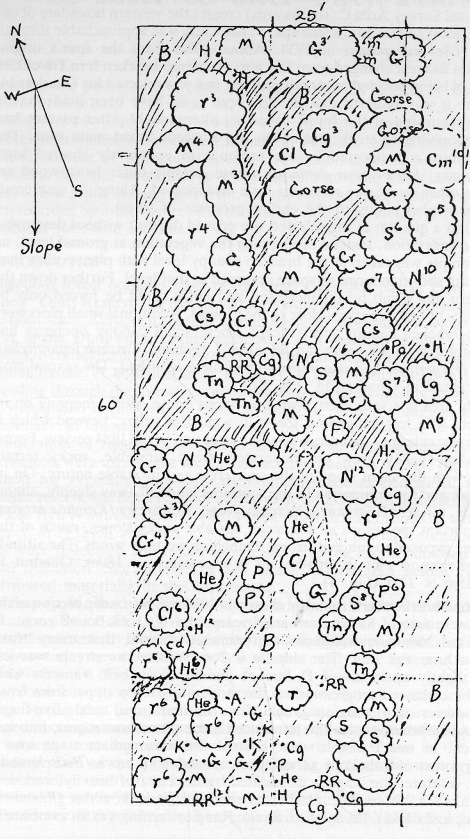
The study area is a spur crest averaging about 8m in width, merging on its eastern flank with low indigenous forest in a shallow valley, beyond which is another narrow side spur that received some attention in the 1984 review. Forest in the shallow valley grew on moderately steep, unstable, rocky terrain contrasting with the slight slope of the spur crest and its stable nature. On its western flank and its termination to the south the land fell away steeply, almost precipitously, towards B Stream in its rocky gorge. Rewarewa *(Knightia excelsa)* was an important species on all the steep unstable rocky slopes, much of the terrain being exposed to sun and strong, funnelling westerly winds. The altitude in the northernmost plot in Quadrat 14 is approximately 180m. Quadrat 14 (1984) is 15m × 12m (Fig. 3).

2. The second bracken/scrub quadrat chosen in 1934 was on a steep section of the shaded western face of Kaiwharawhara Stream, above a rock-bound gorge. In 1934, a fixed maximum-minimum thermometer showed that many frosts occurred in June and July. The altitude is 70m. Where the stream was less enclosed, slightly upstream of D Stream junction, two belt transects were studied. These showed progression up the moderately steep slope, from frost-resistant species like rangiora, heketara *(Olearia rani)* and five-finger *(Pseudopanax arboreus),* plus the introduced elder *(Sambucus nigra),* into low forest which, in one transect, went beyond the intermediate stage into a developing forest of kohekohe *(Dysoxylum spectabile)* – tawa *(Beilschmiedia tawa).* The intermediate stage is dominated by heketara of heavily-branched, thickly-trunked habit, mahoe *(Melicytus ramiflorus),* kaikomako *(Pennantia corymbosa),* and titoki *(Alectryon excelsus).* Rangiora remains as an associate in

FIGURE 2

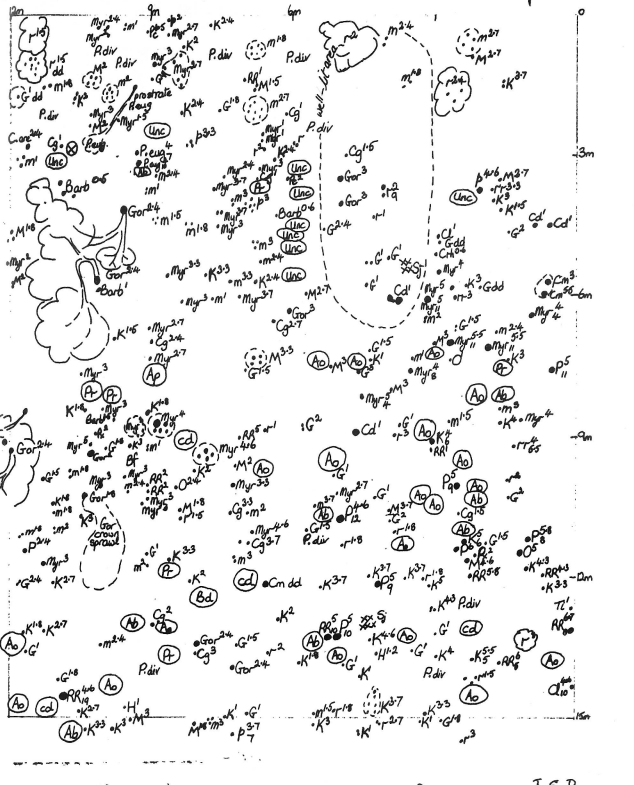
QUADRAT 14 - AREA C 1934

VEGETATION 1 M AND TALLER:



QUADRAT 14: OCT 1984

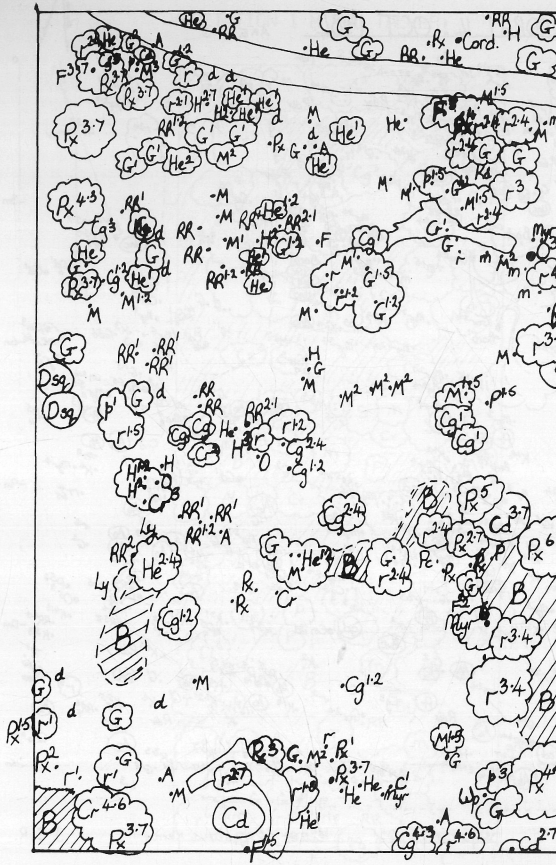
AREA C.

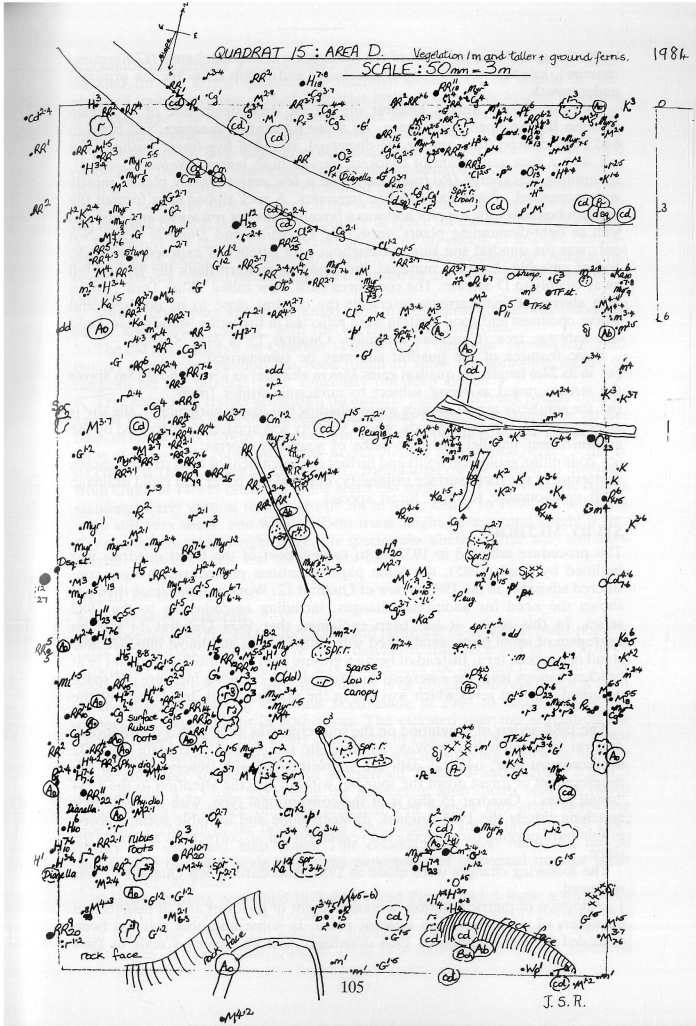


Vegetation 1m. and taller + ground ferns

J.S.R.

QUADRAT 15: AREA D. 1932-34




QUADRAT 15 : AREA D. Vegetation 1m and taller + ground ferns. 1984
SCALE : 50mm = 3m
Sparse low r.3 canopy
Surface Rubus roots
Rubus roots
rock face
rock face
J. S. R.

both storeys in the upper parts of the transects, where hangehange *(Geniostoma rupestre)*, kawakawa *(Macropiper excelsum)* and clump ferns are the principal undergrowth.

By contrast, the nearby quadrat site on the downsteam side of D Stream junction had an open appearance. As a fire prevention measure, tall bracken had been cleared from among the dispersed, rounded five-finger bushes 4-5m tall with a new generation of bracken, lianoid bush lawyer *(Rubus cissoides)*, scrambling blackberry *(R. fruticosus)*, and a few native woody plants, mostly with enmeshed, scrambling bracken remnants. A rock-ribbed spur formed the western boundary for the plot and was a favoured site for rewarewa and hinau as well as light-demanding plants, especially koromiko and *Dianella nigra*. Not only was the quadrat site steep throughout with patches of exposed firm rock, and of unstable shattered material, but along its western flank the ground fell away steeply to D Stream. The contoured path, now called "Blue Trail", about 30m above the main stream intersects the quadrat close to its northern end where openness and good lighting were reflected in the herbs, woody plants and one cabbage tree *(Cordyline australis)*. Quadrat 15 is 24m × 15m.

Basic features of the quadrat site may be summarised:

(a) in its 24m length the quadrat gains 15m in altitude; its lower end is 15m above the stream noted as being subject to numerous winter frosts;

(b) the southerly aspect implies winter shading but, more particularly, the site is subject to cold, salt-laden winds, whose velocity was apparently increased by the entrenchment parallel with the paths of southerly storms;

(c) continuing geological uplift and further entrenchment of both streams causes shattering of the rock, surface instability, minimal soil cover and rapid drainage – all unfavourable to most forest species.

STUDY METHODS

The procedure adopted in 1932-34 to survey most of the Otari quadrats was outlined by Reid (1985); the same paper mentions procedural changes considered advisable in the 1982 review of Quadrat 12. Work at Otari since then has shown the need for additional changes, including amendments to the 1982 series. In this paper, it has been explained that 1934 Quadrat 14 was an aggregate of small plots, established with difficulty, in an almost impenetrable stand of bracken fern. Instead of being a ground plan, the drawing sketches in at bracken canopy level the emergent woody plants to convey a measure of "space occupied" at that level which was 1m in the northernmost and largest of the plots.

The 1984 review of vegetation on the spur crest was done with a conventional quadrat large enough to provide an adequate sample and to contain the 1932 northernmost plot; quadrat data are supplemented with observations on the development of forest down the spur but without specific attention to the 1934 "small plots". Quadrat 15 also is of the conventional type, with the 1984 plot matching closely the 1934 original; its steep slope and unstable surface posed problems in pegging for mapping the vegetation but no corrections are made for slope.

The following changes were made to 1982 procedure, when Quadrat 12 was reviewed.

1. Adoption of metric notation in measurement of quadrats and of heights and diameters of trees shown on quadrat plans. In some instances this has been extended to re-draughting of 1934 drawings. A more generous scale in 1984

accommodates growth and diversification of species since 1934, within limits dictated for the larger quadrats by intended publication. It should be emphasized that size entries alongside species symbols now have heights in metres at upper right and diameters in centimetres at lower right. The use of "cm" rather than "mm" for diameters to save space on the drawings.

2. Coping with the large number of botanical name changes since 1934 has posed problems in the review where species symbols are derived from them rather than from the more stable (and brief) common names. Where species symbols are based on botanical names, a single letter is adequate for single species genera in the national or local sense; again economy of space on quadrat plans is sought.

3. Diameters are measured at "breast height" (dbh) except in unusual circumstances, eg in prostrate rewarewa and mapou *(Myrsine australis)* in Quadrat 15, vertical shoots (stems) developing after blowdown are measured at position of origin.

4. Shrubs developing a multi-stemmed habit at groundline are recorded as single plants and shown, usually, with the several stems encircled.

5. The old gorse bushes on Quadrat 14 have their "umbrella" crowns indicated but no satisfactory method has been found to show the sprawling nature of rangiora on the quadrat plan, especially on steep slopes.

6. Tree ferns with trunks are shown on quadrat plans with trunk height entered against the species symbol but classification into height class should be on the basis of trunk plus crown. A convention applied to ponga *(Cyathea dealbata)* in most of Otari is for ferns with trunk height 2.7m to have a total height 3.7m, ie its crown is 1m. A group of mamaku *(C. medullaris)* on the spur crest downhill from Quadrat 14 was observed at the trunkless stage in 1982 with central fronds standing nearly vertical to a height of 3m in some cases. In 1984, when trunks were still very short, one with an 0.4m trunk might have a total height 3.7m. Even at the 2m trunk height stage, the species elsewhere in Otari may still have vertical central fronds and total height 5m.

RESULTS OF STUDIES

1. Analysis of Quadrats

(I) Procedure developed for recording and portrayal of details of plant populations in a botanical survey have been described and discussed in the light of experience gained since the study was initiated. In the bracken fern/scrub study under comment it is plant succession which is of primary interest. Enlargement of the quadrat mapping scale has been made in 1984 to accommodate the remarkable development in both areas. The elevated spur top vegetation has changed from a single, low storey dominated by bracken to a three storey forest community. Within the upper storeys new species arriving match in number those volunteer species that have succumbed. Table 1 and Figures 2 and 3 demonstrate a 2.5-fold increase in the number of individuals, plus the varied ground plants of which only the principal fern species and other herbs are mapped. Inclusion of the floor species, and diameter and height data for trees justify the increased map scale. This consideration over-ruled the use of quadrats at the same scale to portray persistence of individual trees or other plants over 50 years.

Quadrat 15 data contained in Table 1 and Figs 3 and 4 show a three-fold increase in the number of individuals in the Woody Plant category between 1934 and 1984. The changes are generally similar to those in Quadrat 14, with the differences, however, that Quadrat 15 in 1934 had reached a more advanced

stage in succession and that development in the elapsed 50 years has been slower in the less favourable site. The 1984 plot was mapped at the same increased scale used for Quadrat 14.

(II) Table 1 lists species alphabetically (species symbols) within groupings given descriptive names in Table 2. These groupings are devised to emphasise dynamic changes in the plant population sampled in Quadrat 14. It will be observed that column 3 values in Table 2 are percentages based on "occupancy" for reasons already explained, while values in the other columns are percentages based on plant numbers; Quadrat 15/1934 omits the undefinable bracken element.

(III) Despite the marked differences in sites represented by the two quadrats, there is a substantial degree of similarity in the performance of species, enough to justify applying the Quadrat 14 dynamic groupings to Quadrat 15 in Table 2. Species rated as "Persistent" and "Aggressive" in 1984 together account for 90% and 89% respectively in Quadrats 14 and 15; in the latter – the less favourable site – "Persistent" species made up 32% and "Aggressive" 57% compared with 18% and 72% in Quadrat 14. Site differences are reflected in the species included in "Volunteers" and "New arrivals" of which some, including the ferns listed in Table 1, will be components of the developing forest. Bracken, the principal "Volunteer" species estimated as occupying 58% (Quadrat 14) and 50% (Quadrat 15) in 1934, has virtually disappeared from the former but persists close to the latter quadrat. In Quadrat 14 the disappearance of bracken has not been matched by gorse, where the green "umbrellas" of gorse 2.4m tall persist at the exposed western margin in 1984. These have provided conditions favourable to the adventive *Berberis darwinii* and to *Pterostylis banksii* and *P. graminea*. In Quadrat 15 in 1934, koromiko and the herb *Dianella nigra* were abundant, especially on steep slopes with exposed rock, but five-finger was dominant, with 11 bushes ranging from 3.7m to 6m in height, with the characteristic rounded form of open-grown plants.

(IV) Table 1 has a footnote relating to lianes occurring in the quadrats but not readily shown in the plan; a similar difficulty is encountered with epiphytes. In quadrat 15/1984 development of a forest community with several storeys and a diversity of species is slower than in Quadrat 14/1984, but two filmy ferns, *Trichomanes venosum* and *Hymenophyllum flabellatum,* epiphytic on tree fern trunks, are indicators of a humid forest atmosphere in one part of the quadrat. Indicators of humid conditions in Quadrat 14/1984 include *Microlaena avenacea, Uncinia uncinata* and several of the tabulated clump ferns.

(V) Reference has been made to the path traversing the upper end of Quadrat 15 providing well-lit conditions favourable to the growth of young tree ferns. The path sides in 1984 are favourable also to a wide variety of woody plants, partly on account of good light and partly because the path provides a corridor for birds.

2. Pointers to Plant Succession

(I) Forest Canopy and Emergents.

After a period of rapid growth and forest development, dynamic groups, within the context of 1984 observations, may be expected to change substantially. Thus of the "Persistent" group, only hinau is expected to contribute to the forest canopy, together with mahoe, kohekohe, rewarewa, mapou and pigeonwood from the "Aggressive" group. The last two species are intermediate rather than long-term canopy components. Eight species are grouped under "New Arrivals"

TABLE 1(a) SPECIES TALLIES IN HEIGHT CLASSES 1934 and 1984
WOODY PLANTS AND TREE FERNS

	QUADRAT 14				QUADRAT 15						
	HC3	HC2	HC3	HC4	HC1	HC2		HC3		HC4	
Species* Symbols	1934		1984		1984	1934	1984	1934	1984	1934	1984
	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
A	1									5	2
B										7	patches
C	1									1	8
Cass	2										
C rob	5					1		3		present	2
F	1					1		2	2	1	1
He	6							17		9	2
Tn	4										
C g	7	1	10	present		1	7	12	15	1	8
C luc	3	1	1						7		3
C m	1	1							4		
Cord								1	1dd		
D sq								2	2		
Gor	3		9								
H	6		2		9		12	5	8	1	
Px	4		2		2	11	7	4	5	6	10
r	10		18	present		2	8	16	59	5	12
C d	1		4			2	2	3	20		
G	8		29				2	12	39	26	57
K	3	12	28	present			2		11		2
M	13	2	12	present	1		26	14	29	14	34
Myr	6	14	26	present		1	13		18	3	30
m	2	1	33	present			2		22	4	31
P	4	7	1	present			6	1	11	1	6
RR	4	7	3	present	17		16	14	27	7	25
Barb			4								
C are			1								
Ka							2		4	2	12
Mi									1		
Myr s							1				
O		1	2	present	2	1	2		7	2	19
P c	1		2	present					1	1	18
P eug		2					1		1	present	4
P t							1			present	3
p		1	3					4	5		
rr		1	2						4		
T									1		3
Ti			1						1		1
Wp									1	1	
L											4
Totals	96	51	193		31	20	110	110	304	97	297

* Species symbols are defined in Table 2.

Table 1(b)

FOREST FLOOR FERNS AND PRINCIPAL HERBS

Species Symbols	Botanical Name	QUADRAT 14	QUADRAT 15	
		1984	1934	1984
		No.	No.	No.
* A b	Asplenium bulbiferum	8		4
* A h	A. hookerianum	1		
A o	A. oblongifolium	18		14
* A p	A. polyodon	1		
* B ch	Blechnum chambersii			1
* B d	B. discolor	1		
B f	B. filiforme	1 patch		
* L g	Lastreopsis glabella			1
P div	Phymatosorus diversifolius	9 patches		
* P r	Polystichum richardii	6		3
Dia n	Dianella nigra		12	3
Unc	Uncinia uncinata	9		
		54	12	26

Notes

1. "Height Classes": 1 = 7.6m and up
   2 = 3.7 to 7.5m
   3 = 1 to 3.6m
   4 = ground
2. Lianes present in Quadrat 14 in 1934 are still present in 1984: main genera are *Metrosideros, Rubus, Parsonsia* and *Muehlenbeckia.* In Quadrat 15, *Rubus* and *Ripogonum* have persisted over the same period.
3. Woody plants are in alphabetical sequence in the four groups – volunteers, presistent spp., aggressive supp. and new arrivals.

* Indicates "clump" ferns; on quadrat maps the encircling of the species symbols is the method used to distinguish them and certain herbs.

in Quadrat 14, compared with 14 species in Quadrat 15; potential canopy species in significant numbers are heketara and kaikomako in both quadrats with karaka in addition in Quadrat 15. (Rewarewa in Quadrat 15 is the only emergent prospect at present.)

(II) Under-storeys

Hangehange and kawakawa are important understorey species in both quadrats now and should remain so in the developling forest. Except for *Polystichum richardii,* ferns growing on the forest floor are expected to be present in fully-canopied forest communities developing on both quadrats.

(III) Key Species and Groups

(a) Kohekohe, which is tending to dominate low canopy forest in Otari, has to contend with exposure to strong north-west winds at the Quadrat 14 site, but effective protection along the western flank is provided by multi-stemmed mapou and rewarewa. Entry of kohekohe to the Quadrat 15 site suggests alleviation in climate in regard to southerly wind exposure and gully bottom frosts, as will be discussed later. Obviously the overhead cover has increased substantially during recent years. Possum browse observations (Purchas 1975) showed kohekohe to be one of the species eaten at Otari but botanical observations over a period of years have indicated heavy browse to be infrequent.

TABLE 2: DYNAMIC CHANGES IN STUDY AREAS REPRESENTED BY QUADRATS 14 and 15 BETWEEN 1932-34 and 1982-84 SAMPLINGS

Species Symbols	Species	QUADRAT 14		DYNAMIC GROUPS	QUADRAT 15	
		1934	1984		1934	1984
		*		**		
		Occupancy by all Species at bracken canopy level, 1m	Species in Upper Height Classes 1m and taller		Species in Upper Height Classes 1m and taller	Species in Upper Height Classes 1m and taller
		percent	percent		percent	percent
A	Aristotelia serrata	0.1		VOLUN-		
B	Pteridium esculentum	58		TEERS		
C	Carpodetus serratus	0.1				
Cass	Cassinia leptophylla	0.3				
C rob	Coprosma robusta	2.0			3.1	
F	Fuchsia excorticata	0.3			2.3	0.44
He	Hebe stricta	1.7			13.1	
Tn	Hypericum androsaemum	0.3				
Cord	Cordyline australis				0.8	
C g	Coprosma grandifolia	2.0	4.5	PER-	10	4.88
C luc	C. lucida	1.0	0.8	SIS-		1.5
C m	Cyathea medullaris	0.6	0.4	TENT		0.9
D sq	Dicksonia squarrosa			SPP.	1.5	0.44
Gor	Ulex europaeus	4.0	3.6			
H	Elaeocarpus dentatus	0.8	0.8		3.8	6.44
Px	Pseudopanax arboreus	2.0	0.8		11.5	3.22
r	Brachyglottis repanda	7.7	7.2		13.9	14.9
C d	Cyathea dealbata	0.3	1.6	AG-	3.8	4.88
G	Geniostoma rupestre var. ligustr.	0.5	11.5	GRES-	9.2	9.11
K	Dysoxylum spectabile	0.3	16.4	SIVE		2.88
M	Melicytus ramiflorus	8.0	5.7	SSP.	10.8	12.44
Myr	Myrsine australis	3.3	16.4		0.8	6.88
m	Macropiper excelsum	0.16	13.5			5.33
P	Hedycarya arborea	1.5	3.2		0.8	3.77
RR	Knightia excelsa	0.3	4.1		10.8	13.33
Barb	Berberis darwinii		1.6	NEW		
C are	Coprosma areolata		0.4	ARRI-		
Ka	Corynocarpus laevigatus			VALS		1.33
Mi	Prumnopitys ferruginea					0.22
Myr s	Myrsine asalicina					0.22
O	Olearia rani		1.2		0.8	2.44
P c	Pennantia corymbosa		0.8			0.22
P eug	Pittosporum eugenioides		0.8			0.44
P t	P. tenuifolium					0.22
p	Schefflera digitata		1.6		3.1	1.11
rr	Lophomyrtus bullata		1.2			0.88
T	Beilschmiedia tawa					0.22
Ti	Alectryon excelsus		0.4			0.22
Wp	Dacrycarpus dacrydioides					0.22

* "Occupancy" (col. 3) is an estimate of space occupied in Quadrat 14 (1934) by the several species forming a canopy with bracken fern at c 1m.
** DYNAMIC GROUPS (col. 5) have been given descriptive names based on species performance in Quadrat 14 and are not strictly applicable to *Olearia rani* and *Schefflera* in Quadrat 15. Floor ferns are "NEW ARRIVALS".

(b) Rewarewa and mapou are associates on the exposed study area sampled in Quadrat 14, both exhibiting the multi-stemmed habit usually attributed to wind exposure. Trees with this habit may be short-lived in comparison with single-stemmed trees that commence life with some overhead cover. In Otari, single-stemmed rewarewa trees become the characteristic emergents on many forested spurs. Mapou, again in the single stem type, is a common bush margin species likely to persist as an intermediate phase canopy component in low canopy forest.

(c) Podocarps have been the principal emergent on old valley floor sites in Otari. Seedlings have persisted during the elapsed 50 years and one miro *(Prumnopitys ferruginea)* has arrived and grown to 1.5m in Quadrat 15. On the slopes adjacent to the quadrat, totara *(Podocarpus totara)* seedlings are not uncommon. In Otari, the term "persistent" applies to podocarp seedlings other than rimu *(Dacrydium cupressinum)*. Tanekaha *(Phyllocladus trichomanoides)*, introduced to Otari, has acclimatised to the extent that seedlings are appearing in adjacent bush regeneration.

(d) Tree ferns
Close to Quadrat 14 on the spur crest a 1982 reconnaissance revealed a tight group of eight mamaku without trunks, preventing plant competition by heavy shade and cast-off fronds. Wheki *(Dicksonia squarrosa)* and ponga had been suppressed, as shown by dead trunks but ponga is shown by the quadrat tallies to be a significant component in the new community, and one that may suppress persistent items in the succession for a period, the likely duration of which cannot be answered from available Otari data. By 1984 the mamaku group had developed 0.4m trunks, and retained a central cluster of vertical fronds over 3m long to produce an effective height approaching 4m, at which stage the shading had changed very little. In kohekohe – mahoe forest flanking the spur on the east side, both *Cyathea* spp. are present but mature dead trunks of mamuku suggest it is the volunteer species.

Of particular interest in Quadrat 15/1984 is the large number of young ponga in height class 3 posing the threat of delayed development of the forest understorey in the south-east corner. Two ponga recorded in 1934 as being 3.7m tall were identified on the 1984 plot, having gained 1m in trunk height in 50 years. Another feature of the 1984 plot is the presence of many young ponga by the path and two young wheki in the same well-lit location; a group of mature wheki on or close to the steep, rocky, western quadrat boundary in 1934 have mostly succumbed.

(e) Five-finger deserves mention, as both a terrestrial volunteer species on the unfavourable Quadrat 15 site and an effective nurse for forest-forming trees and shrubs. Mention of the terrestrial habit is prompted by the observation that the species commonly starts life as an epiphyte on ponga in forest adjacent to the quadrat site which gives it an advantage in competing for space in the relatively low canopy.

3. Height Growth Observations

Table 3 presents data obtained from analysis of entries made on Quadrat 15 maps drawn in 1934 and 1984 using matched sub-plots 15m × 6m located along the western side of the quadrat. The sub-plot representing one quarter of the quadrat area contains 26 rewarewa and 11 hinau trees out of quadrat totals of 33 rewarewa and 21 hinau.

TABLE 3: HEIGHT GROWTH DATA
(from sub-plot in Quadrat 15 in 1934 and 1984)

Species Symbols	1934			1984			Estimated 50 yr Height growth m	
	No.	Height Class	Mean Height m	No.	Height Class	Mean Height m		Mean Max
RR	6 11	3 4	1.5) 0.61)	12	1	9.14	6 HC3 grew 6 HC4 grew 12	7.64 8.53
H	6	3	2.1	5	1	9.34	5 HC3 grew	7.24
M	2 4	3 4	1.5) 0.61)	7	2	4.0	2 HC3 grew 4 HC4 grew 1 post-1934 grew	2.5 3.39 4.0
Myr	1	4	0.3	5	2	4.57	1 HC4 grew 4 post-1934 grew	4.27 4.57
0	2	4	0.45	1	2	3.7	1 HC4 grew	3.25
r	1	3	1.5	5	2	4.0	1 HC3 grew 4 post-1934 grew	2.5 4.0
G	10	4	0.61	1	2	5.5	1 HC4 grew	4.9
Ka	Absent			2	2	3.7	2 post-1934 grew	3.7
* K	Absent			2	2	3.8	2 post-1934 grew	3.8

* Kohekohe trees are from outside the sub-plot.
Note 1: For 5 species the height growth figures relate to trees less than 50 years of age (post-1934).

(I) Rewarewa (RR) and hinau (H) classified in height classes 3 and 4 in 1934 are identified in height class 1 population in 1984. Mean maxima for height growth in 50 years are tabulated but some individuals grew 9m. It is presumed that both species have been in a phase when height growth occurs at the expense of diameter growth. A high mortality is predicted among these trees in the near future. It has already been pointed out that rewarewa in Quadrat 15 is characteristically single-stem type.
(II) Compared with rewarewa and hinau, other woody species have provided few useful height growth results from analysis of the sub-plot in Quadrat 15, because very few individuals of each species listed have bridged the 50 year gap. It will be noted that many of the values are for growth periods less than 50 years.

DISCUSSION

1. Fifty years free from obvious interference by man through fire, grazing by domestic stock, or physical clearance, favoured the growth of indigenous forest at the expense of bracken fern in both study areas. In 1934 the elevated spur-top study area and one on the steep, south-facing, unstable side of the deeply-entrenched Kaiwharawhara Stream had one obvious feature in common – a dense entanglement of bracken fern had occupied at least 50% of each quadrat. Five-finger in Quadrat 15/1934, already dominant in height classes 2 and 3 above the bracken, and koromiko growing on emergent rock, gave that vegetation an appearance quite different from the earlier phase Quadrat 14/1934; both species, and 14 other species of indigenous trees and shrubs, were shared by the quadrats despite the marked site differences. The passage of 50 years has seen four of the 16 shared species eliminated from Quadrat 14/1934, with four others, including bracken, barely persisting in the rapidly-developing forest. Table 1 data for kohekohe and mahoe emphasise their important future role, but those relating to rewarewa and mapou have to be interpreted with caution on account of their multi-stemmed habit in Quadrat 14. By contrast, the 1984 figures for rewarewa and mapou in Quadrat 15 assure their future importance, along with hinau and mahoe on that steep site as forest canopy and emergent trees.

2. Modification of site conditions in and near Quadrat 15 since the plot was established has to be inferred to explain the entry of kohekohe, tawa, titoki and several fern species, as well as the increase in kawakawa and pigeonwood. As the sparseness of vegetative cover in 1934 was attributed variously to steep slope with much emergent rock or to unstable shattered rock with minimal soil cover, to proximity to a frost-affected gorge bottom, and especially to blasting salt-laden, southerly winds gusting to high velocities along the entrenched stream, it is appropriate to seek reasons for apparent change. I am aware that elsewhere in Otari, one recent southerly storm devastated mature but healthy rimu forest growing on old valley floor remnant at a higher altitude than Quadrat 15. Forest trees which had withstood southerly storms for seven centuries or more lost all or part of their heavily-limbed crowns. One explanation is that land-fill operations in the path of the southerlies, upstream of Otari, had raised the level of wind gusts, to favour the lower slopes at the expense of the higher (pers. comm., S J Reid, NZ Meteorological Office, Wellington).

3. Future stages in forest development have been predicted for the spur-top site from quadrat population analyses. These showed that kohekohe and mahoe are dominant species in low canopy bush like that growing on the lee-side. It is, however, more difficult to envisage how effective shelter along the exposed western flank will be maintained if, indeed, the multi-stemmed rewarewa and mapou are short-lived. No emergents are envisaged. Podocarps present on adjacent exposed spur-tops are short-boled and bushy.

In Quadrat 15, away from the concentrated rewarewa, mapou and hinau along the western rock rib, the elements of a forest community are recognisable now, with intermediate phase species like mapou, kaikomako and heketara associated with the long-term dominant canopy species such as kohekohe, mahoe and hinau. The main problem area is where steep rubbly slopes are sparsely clad with multi-stemmed rangiora whose 4-5m long flexible stems sprawl downslope, forming a partial canopy about 2.5m above ground. Wind causes those stems to sweep the rubble clear of competing vegetation. A developing forest community may gradually enclose those slopes sufficiently to minimise wind movement and allow invasion by tree seedlings.

4. Islands created by pongas, both live and dead, on steep, rubbly slopes promote successional changes. During life, the trunk bases provide firm rooting for other species, and soil movement is restricted by fallen fronds. Dead stumps and prostrate trunks continue to provide stability for many decades. Hence, the Quadrat 15/1984 ponga tallies, mainly at the trunkless stage, may be expected to have a bearing on slope stabilisation which could outweight the suppression of growth by competitors.

5. Man's activities outside the reserve may, unwittingly, be responsible for severe wind damage during southerly storms. During the 50 years, 1934-1984, the "Wahine" wind-storm of April 1968 and the rain-storm of December 1976 caused damage at Otari of cataclysmic proportions. Another factor affecting native plant succession adversely is the introduction of adventive plants and animals among which gorse and possums are too well-known to need further comment. In 1934 Quadrat 15 was pegged-out and mapped following removal of most of the bracken as a fire protection measure. Following that substantial tampering with the botanical succession, there has been virtually no human interference except for the felling of one cabbage tree in Quadrat 15.

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A P Druce