akiraho, *Olearia solandri*, tauhinu, *Melicytus crassifolius* and *Coprosma propinqua* are met. Among the smaller plants are the salthorn, *Samolus repens*, *Selliera radicans*, *Einadia triandra*, *Tetragonia trigyna*, *Linum monogynum*, *Lobelia anceps*, *Disphyma australe*, the common spaniard, *Pimelea prostrata* and mountain flax. Of the smaller exotics the most common would be *Carpobrotus edulis*, sweet alyssum and the horned poppy.

APOLOGIA

It is obvious that some plants have been omitted from mention which ought not to have been. Equally, opinions will differ as to the relative frequency and importance. My tendency has been to specify the more noticeable species. Cockayne, somewhere, talks about the physiognomy of the landscape. He was talking of growth forms but I feel that many of the plants mentioned here do affect the physiognomy of the Wellington landscape.

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Otari Vegetation

Stan Reid[1]

INTRODUCTION

A large, smooth boulder rests some 80 m from the Banks Entrance just beyond the central lawn, flanked on its left by the rock garden. It marks the grave of Dr Leonard Cockayne and his wife Maud and a viewpoint from which to obtain one's first intimate impression of the reserve for which he was botanist-architect (Fig. 1). The foreground may well have achieved his vision of a comprehensive assembly from all New Zealand of shrubby species belonging to genera that are peculiarly characteristic of our country, and species brought together for the first time from widely separate habitats are sufficiently at home to have produced new hybrids. Beyond, in the middle distance, the conserved native forest fills the Bledisloe Gorge clothing steep slopes on either side. Along with the shrub border to the right massed with native cultivars of horticultural merit, these elements reflect three facets of his broad scheme for the Otari Native Botanic Garden. If one focuses attention on the spur to the right of Bledisloe Gorge, numerous

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conical treetops emerge from the forest canopy where the spur flattens and broadens; some are rewarewa and others kauri, the latter representing the fourth element of Cockayne's scheme that called for establishment of certain primitive forest associations that do not occur naturally in the Wellington area. Beyond the kauri forest the spur steepens and narrows close to the reserve boundary at 200 m altitude where an eminence is aptly named "Cockayne Heights" (Fig. 1); it is a good spot from which to look eastward over the reserve, and removal of a little of the intrusive gorse would reveal the view without seriously disturbing forest regeneration beneath its canopy. To have this additional facet of native forest returning after having been cleared by Europeans for pastoral farming, further adds to the value of the reserve.

Fig. 1. Boulder and plaque marking Cockayne's grave. To the north, beyond the toetoe, is Cockayne Heights. (Photo: Wellington City Council)

To return to Cockayne's grave viewpoint, if one looks up to the left of Bledisloe Gorge the view embraces the unmistakable shapes of mature rimu trees, some of a dispersed group containing a few whose size and general grandeur is such as to warrant "national monument" status with an age of about 800 years!

A more comprehensive view of the extensive south-western natural bush is gained from Northland heights. The long swathe of green reaches up from the deeply entrenched Kaiwharawhara Stream almost to the crest of the ridge, beyond which one may see Cook Strait and the South Island. On the descent from Northland towards the reserve when the east facing slopes are brightly illuminated by morning sunshine, the forest becomes a closely fitting cloak moulded to the contours with pleats emphasising the several side streams. The smooth cloak may be seen as a mosaic of greens reflecting the several species of trees and lianes in the forest canopy, among which the brilliant green of

kohekohe is very prominent. Ruffles mark where the taller karaka, rewarewa, pukatea, podocarp and tawa trees emerge through the canopy. Towards the upper forest margin at about 260 m altitude, forest stream heads are green tongues between spur crests where gold touches, at certain seasons, betray the continuing presence of gorse where the pasture was some sixty years ago.

A map of the reserve shows that the part lying east of the Kaiwharawhara Stream containing the gardens is a small proportion of the whole area, but there is room in it for one of the best preserved pieces of natural podocarp-hardwood forest as well as the developed gardens.

Access paths always pose a problem in New Zealand forest associations with their tiered structure and floor with easily damaged ferns, mosses and general undergrowth: damage to the moisture retaining floor is, of course, detrimental to the whole biological complex. Steep slopes, pressure of public use and liability for slips to occur along the sides of entrenched streams, or for paths to become water courses, are other practical problems, but path systems must be extensive enough to avoid the awkward alternative of "adventive" tracks. The latter term has the connotation of being less elaborate than "path"; neither term seems to come in for the criticism which "trail" evokes and botanists may regret also that the public path names do not retain the whimsical Cockayne touch (Fig. 2). Thus, the "Circular Walk" commencing at the Solander Entrance (from the Wilton Bush Road) would be the Hooker Path, following up the main stream past the Darwin Rock which is a solid mass compressing the stream into a narrow tortuous channel. Close to the bridge a little distance upstream Haast Path turns off sharply to the right. Further upstream where a side creek comes in from the right (MacKenzie Burn after J.G. MacKenzie who, as Director of Reserves for Wellington City Council, co-operated closely with Cockayne at the development stage of Otari), Hooker Path divides into Cheeseman Path, continuing along the stream to the Troup picnic ground and Kirk Path, going up the spur to the right to Flax Clearing. Petrie Path turns off to the right up Bledisloe Gorge just before crossing the bridge to the picnic ground where Cheeseman Path ends. A bridge from the picnic area now connects with the main bush area to the south-west, in which is the Blue Trail and the Lady Alice Fern Walk linking up stream with the Petrie Path and now shown as part of the Yellow Trail. Vice-regal interest is commemorated in "Bledisloe" and "Lady Alice" (Ferguson) whilst "Troup" relates to the then mayor. From the picnic ground the Circular Walk heads to the left uphill, traversing Aston Bank and the gardens featuring collections of indigenous shrub genera. Close to the southern boundary fence the most defined route to Banks Entrance is Forster Path. Another early botanist is commemorated in the Cunningham Path from Banks Entrance northward, paralleling Wilton Road past the Information Centre, to the northern entrance whence the "Walk", now entitled Richard d'Urville Path returns downhill to Solander Entrance. It may be remarked that scope exists in the extensive south-western part of

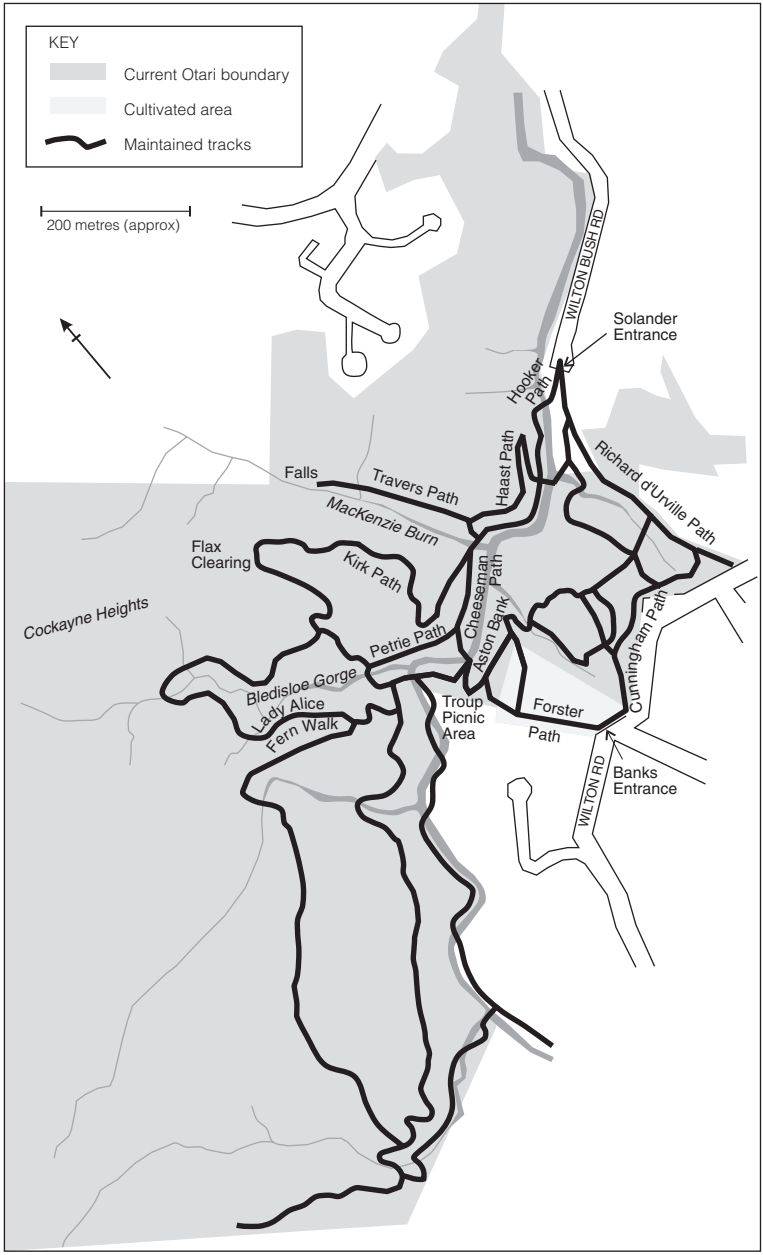

Fig. 2. The current network of tracks showing the names given to them by Cockayne. (Reproduced from the Otari Native Botanic Garden Management Plan, with permission of Wellington City Council.)

Otari for the path system there to incorporate the names of other botanists who contributed substantially to the finding and naming of New Zealand plants: Colenso is one major omission from the scheme noted above. In more recent time the thread of continuity from Cheeseman Path should certainly extend to Allan, and other names which suggest themselves are Cranwell, Moore, Scott-Thomson and Simpson.

GEOLOGICAL AND CLIMATIC FACTORS

Cotton, whose name is associated with the study of geomorphology used the area in which Otari is located to illustrate certain land form changes including entrenchment of streams as a consequence of land uplift. It is now considered that uplift is a more or less continuous slow process but is interrupted by occasional rapid displacements by earthquakes. In this brief essay it is impracticable to discuss in detail the geological processes that have shaped and are shaping the land occupied by Otari, or to relate the geological time scales to those relating to botanical changes. What is very significant is the substantial part of the total area contained in the trench-sides, their steepness and instability due to shattering by earthquakes of the underlying and often emergent rock, and the continuing reduction of gently sloping land by stream gullying or by erosion along upper margins of trench sides. Specifically the main (Kaiwharawhara) stream and its principal tributary within Otari, that is the stream coming in at the main picnic ground and called Bledisloe Gorge by Cockayne, are deeply entrenched. The next tributary downstream coming in from the west (MacKenzie Burn) is moderately entrenched, two small side streams from the east also downstream from the picnic ground and two upstream, from the west side, have a steep descent and slight entrenchment. The last mentioned streams in their upper course have had to cope with excessive run off during a December 1976 concentrated rain-storm; the courses have become gullies even where they are traversing well forested slopes. Severe loss of surface soil from the forest areas was another legacy from that cataclysm. It is the relatively gentle slopes above the entrenched streams, especially remnants of an ancient valley floor, that carry the best forest including a mature podocarp-hardwood association in which rimu, tawa and hinau are dominant. In comparison with the nearby Karori and Ngaio areas where similar forest grew and which early in European settlement days saw milling developed to meet the timber needs, the small extent of Otari stands probably saved them from that fate. The point west of the stream was Native Reserve from 1850s to 1906. During this time parts were leased and grazed. It was probably ownership as well as steepness that saved it from being cleared.

Pertinent features of Wellington's present climate that warrant mention in relation to Otari vegetation are the small variations in temperature, the large number of days when wind is recorded and the few days when frosts occur. Within the reserve are sheltered valley bottoms, for example in the narrow

Kaiwharawhara Stream gorge above Troup picnic ground where records made in 1934 revealed air frosts to be frequent in winter and severe enough to exclude certain common woody plants. The siting of Gresley Lukin alpine rock garden by Solander Gate no doubt reflected appreciation of the virtues of winter frosts in maintaining healthy alpines. By contrast in some of the higher western spurs wind has been a considerable constraint on plant growth. As well as the direct mechanical effect of high winds, they increase evapo-transpiration, this perhaps exacerbating ground water depletion in periods without much rain. The drying effect of salt laden winds may also be significant. Sites most subject to water deficiency in Otari appear to be the steep trench sides where soil and humus are minimal on unstable shattered rock.

In general terms the mild climate with well dispersed rainfall is favourable to forest growth, especially to semi-coastal forest with kohekohe and mahoe already dominant in western parts, and invading podocarp-hardwood stands elsewhere. Wind damage to mature podocarp-hardwood stands and especially to rimu whose age is considered to be more than 800 years raises the question as to why these apparently healthy trees should stand undamaged for 750 years and then sustain severe mechanical damage within the last 60 years. While accepting that the "Wahine" storm (April 1968) was more intensive than other recorded storms, expert opinion looks for associated factors that could have contributed to the degree of damage sustained at Otari.

Before European settlement 150 years ago the Otari rimu would have been subject to strong southerly winds because of the proximity of Cook Strait and the north-south orientation of the parallel ridge-valley system. Indeed southerlies equal in intensity to the wind-storms in February 1936 and May 1985 are likely to have recurred at average intervals of 10 to 15 years, according again to expert opinion. One factor that would have been operative since European settlement is the loss of forest cover and the impedance it affords to the passage of southerly gales, but another factor that is peculiarly pertinent to Otari is the land fill between Wilton and Karori lying in the path of those gales. Its overall effect has been to replace a narrow winding "V"-shaped valley with a relatively smooth elevated plateau. It seems reasonably certain that southerly winds approaching Otari will be concentrated at higher levels than previously, leading to lower intensity strong winds at low levels (in the valley) and stronger winds at higher levels, unhappily at the level at which the old rimu stands are located. This hypothesis also helps to explain the impetus given to development, since the 1934 observations, of a forest association on the shaded western side of the entrenched Kaiwharawhara Stream a short distance above the main picnic ground where in 1934 a combination of funnelling winds and of winter frosts led to sparse forest.

The term "cataclysm" has been applied to the December 1976 rain storm and is appropriate also for the "Wahine" storm. In each instance the assumption is made

that they rank with climate and geological events as matters beyond the control of people whose activities, as they relate to the vegetation of Otari, receive attention under the next sub-heading. A sobering thought is that removal of the forest to provide pastoral farming was responsible for much of the damage sustained in Otari and elsewhere during the rain storm and that European reshaping of the terrain gave the extra edge to the Wahine storm which brought disaster to the 800 year old rimu.

HUMAN ACTIVITIES THAT HAVE HELPED TO SHAPE VEGETATIVE COVER

Pastoral Farming

European settlement led to rapid extensive removal of forest vegetation, generally by fire, followed by establishment of a grass sward suitable for pastoral farming: it is not implied that Maori in earlier times had not used the forest but rather that they did not indulge in wholesale clearing. In Otari the extent of clearing for pastoral farming has been indicated as the upper slopes of the western sector adjacent to the skyline ridge which continues to be used for pastoral farming. Grass spur tops between tongues of bush occupying heads of streams were recorded 60 years ago as supporting a form of vegetation which is now almost eliminated from the reserve. The western boundary fence and its continuation down the southern boundary adjoining farmland were effective at that time in excluding stock, following demarcation and development of Otari. Where a tongue of bush is intersected near the south-west corner by the fence a plot examined in 1934 showed an immediate recovery in the enclosed bush whose further development during the 50 intervening years has been examined. It is, however, the spur-top vegetation which has shown the most dramatic changes from rank grassland, grown to 0.25 m height, in 1934 to a sparse-canopied gorse stand with woody native invaders in 1984. The herbaceous species and many of the native shrubs that had come in since erection of the fence, have apparently vanished now, the grassed area is described under "Developmental Phases of Forest Regrowth". Of the farming phase, occasional bricks in the vicinity of Flax Clearing are presumed to relate to the Heighton Farm.

The extent to which fencing material and other wood was removed from the reserve by farmers or Maori owners can only be guessed at, although the paucity of totara trees is not easily explained. It is totara and hinau that would be of principal value for fencing and house piles. The excellent preservation of the rimu-tawa-hinau forest trees in the eastern sector of Otari reflects the interest expressed by the private owners in this asset. There may have been some access by stock affecting the forest floor and other vegetation beneath the canopy and emergents, as the second storey in 1934 was remarkably even in height at a little more than 4.5 m, suggesting a recovery following a check to growth.

Release of Mammals and Birds of Overseas Origin

It is a matter for congratulation that feral animals that are of major concern in relation to damage to New Zealand plants (i.e., deer, goats, chamois, thar, hares, rabbits and pigs) are absent, but possums are still an awkward problem in Otari. The damage done to northern rata trees alone required extensive counter measures (tree banding) and in addition mortality has been high with species such as fivefinger, tree fuchsia and broadleaf. A possum control programme has been in place since 1993 and possum numbers are currently very low.

In public reserves the usual measures adopted for control of such pests always seem to bring complaints that cannot be ignored. The two groups of beech trees established above Flax Clearing under Cockayne's direction were reported by him to have been "eaten to the ground by hares" with the recommendation that future plantings should have wire netting protection. At an age of about 60 years the beech trees are poor specimens which do scant justice to the genus.

Among the imported birds, magpies have adapted to the bush and may be met flying beneath the canopy in corridors that used to be sacred to the native birds which have become fugitives to a disturbing degree.

Plant Invaders

One notorious invader of reserves near Wellington is old man's beard (*Clematis vitalba*) which mercifully has not been seen to any significant extent in Otari, but another plant, Darwin's barberry (*Berberis darwinii*), requires similar strong action, immediately, to kill mature fruiting plants and to maintain a constant watch for seedlings. The most probable source for Darwin's barberry is an area on Johnston Hill where it has been for some 60 years and is within easy flying distance of Otari for the birds that find the fruit attractive. Recently a review of the 1934 quadrats in Otari has revealed the serious nature of the invasion which has been brought to the attention of the City Parks Manager. Factors that have favoured the rapid spread are fast growth to fruiting age, bird dispersal of seeds throughout Otari and private gardens at least as far away as Wadestown, ready germination of seeds in moderate light (bush paths, canopy breaks, forest margins), ability to persist where shading inhibits gorse, and vegetative spread. With gorse, outside bush margins, it often forms an umbrella canopy about 2.5 m tall.

Gorse areas within the reserve have escaped being burnt and hence are treated here as a pioneer species on grassed land that is a desirable nursery for woody natives and ferns. Few adventive herbs pose a serious threat to native vegetation apart from *Tradescantia fluminensis* which displaces *Australina pusilla* and several ferns alongside Hooker Path, and where it grows densely it prevents seedling regeneration.

Engineering works, such as the sewer by Kaiwharawhara Stream and the steel power pylons traversing the reserve, pose problems when repairs and maintenance are required. Stream side vegetation by MacKenzie Burn was notably rich and varied especially in bryophytes and delicate ferns until the

December 1976 rain storm brought down spillover from road-making near the head of the stream.

OTARI VEGETATION

The Broad Perspective

Apart from the "developed" areas east of the Kaiwharawhara Stream, two picnic areas at stream level and one designated "Flax Clearing" on a spur, the vegetation of Otari is basically forest. As forest its most surprising feature is the large proportion of total area occupied by forest margins and developmental phases. Remote and recent geological events have lead to steepness and instability of the terrain. Earthquakes shattered the basic rock and caused multi-stage uplift which was followed by deep entrenchment of streams. Reclothing of the steep, unstable slopes whose vertical height sometimes exceeds 60 m, is slow. Where a forest canopy is relatively continuous, the main damage suffered is to emergent trees and species such as hinau in the canopy that carry heavy epiphyte loads; such damage occurring during occasional severe southerly wind storms results in canopy breaks inviting the entry of light-demanding species – again the forest margin situation.

Associations designated "semi-coastal forest" usually dominated by kohekohe and "podocarp-hardwood forest" dominated by rimu, tawa and hinau exhibit various degrees of gradation some of which are described briefly as "sub-types". Verbal descriptions however fail to indicate an almost universal occurrence of mahoe in vegetation taller than "scrub", of rangiora in scrub vegetation (other than gorse and bracken) as well as in forest on steep slopes, of supplejack in all single storey, tight canopied forest and of tree ferns as occupying a time slot in many phases of forest development.

It is difficult also to give enough attention to woody species that are dominant on forest margins some being light-demanding and likely to become eliminated in advancing forest (makomako, *Leucopogon*, fivefinger, tree fuchsia, large-leaved coprosma spp., kohuhu, tarata, *Myrtus* spp.). More facultative forest margin species are mahoe, pigeonwood, kaikomako, mapou, *Coprosma areolata*, and kanuka. In Otari instances of moderate diameter trees in all the latter group are not infrequent.

Matai and kahikatea are the podocarps of greatest frequency in forest margins both as seedlings and small trees. Miro occurs frequently as seedlings in forest but uncommonly as small trees on bush margins.

Totara seedlings are appearing on stable shelves on the steep trench side west of Kaiwharawhara Stream but advanced-growth examples are rare. Regeneration of rimu in Otari is very rare: one spur-top forest-margin tree with a short bole and rounded form is thought to have grown since European settlement. Of the introduced native conifers, both kauri and tanekaha produce seedlings.

Small plants like terrestrial orchids and other herbs, small epiphytic ferns and orchids, rock face and stream-side ferns and bryophytes, lichens and fungi in their several habitats, are most easily handled in a species list with habitat indicated, i.e., where comprehensive studies have been completed. Public use of Otari must be one factor in the apparent disappearance since 1934 of several fern species.

In describing vegetation one relies on observation with a large measure of deduction: the measure being dependent frequently upon records of the activity of people. With Otari, much is dependant on living memory as records kept by those unconcerned with the preservation of the native vegetation are not very helpful, whilst those most solicitous about its preservation have tended to neglect the keeping of diary records or their safe housing. Thus, one is left with Cockayne's scheme without records of those activities by which his ideas were put into effect; the plea is made that henceforth diaries be kept of operations within natural bush areas as well as in the actively-managed "Museum" section.

Cataclysms such as the "Wahine" storm and 1976 rain storm need to be fully documented as to the damage caused. Within much-used parts of Otari east of Kaiwharawhara Stream one's living memory of changes apart from those occurring in quadrats, covers such items as:

- the healthy, if small, alpine garden by the Solander Entrance where conditions seem to suit montane *Ranunculus* and *Celmisia* species, *Jovellana repens*, etc.;
- Mrs M. Martin's introduction, north of the stream flowing west from Chapman's Garden of an extensive fern collection in which *Asplenium* spp. were prominent (*Asplenium lyallii* is still present);
- before the Wahine storm devastation along the forest margin near Wilton Road one point of interest some 60 years ago was northern rata in the process of enveloping its rimu tree host; deduction in this instance has to contend with inadequate knowledge of the "establishment" phase as compared with the terrestrial trunk development stage in this surviving landmark;
- the fulfilment of one of Cockayne's proposals for sub-alpine forest association by the alpine gardens at Solander Entrance: few of the small tree components have been able to compete with invading lowland natives.
- the Aston Bank south-east of Troup picnic ground has a tree, shrub, herb cover in which totara, *Halocarpus bidwillii*, and *Pomaderris apetala* plantings had figured; above the bank by the path as it approaches the generic shrub collections abundant regeneration of totara and of *Pseudopanax* hybrids is occurring within a manuka stand. It would have been valuable to know the intended use of this site.

Kohekohe Semi-coastal Forest

In the western sector where slopes are generally towards the east a low canopy forest dominated by kohekohe and considered to be an immature climax association, occupies much of the higher ground towards the western boundary. With its tight canopy only 8–12 m above ground, the heavy shade favours the growth of sparse understorey, in which tree species, other than kohekohe are few in number and species. It is presumed that wind storms of cataclysmic status have but light effect on the stability of this forest over which both easterly and southerly winds flow smoothly: the poet Ruskin spoke of forests that "yield(s) to the form and sway of the ground clothe(s) it with soft compliance". From a vantage spot gained by climbing through the supplejack entwined canopy one is aware of occasional emergents breaking the smoothness of the "roof". Very dark green, rounded humps are karaka trees and stiffly upright (almost spire like) ones are mostly rewarewa, with occasional mapou and young kahikatea – they are usually located on spurs between the shallow valley heads of water course. Shade loving ferns, especially *Asplenium bulbiferum* are abundant on the floor.

Some puzzling features of this forest are the absence of trees of mature diameters from whose seed the small diameter kohekohe, pigeonwood, rewarewa and mapou trees forming the canopy have come. It is not known whether the large diameter, spaced mahoe and karaka trees are the only survivors of the forest that preceded this one. On the forest floor occasional hinau log shells and durable stumps of tree ferns suggest they were elements of the earlier forest; indeed one tall mamaku in a study plot was alive 60 years ago but has been shaded out by neighbouring kohekohe which in that spot have attained a height of 13 m. It has to be assumed that the earlier forest, destroyed presumably by Europeans soon after their arrival would have been a rimu-tawa-hinau association with dispersed emergent podocarps and a canopy containing some kohekohe together with tawa and hinau.

In pre-settlement days the hills southward to the coast had forest cover whose continuity was, of itself good protection from the ravaging southerlies that now sweep in, so the forest canopy height was probably substantially greater than the 12 m average for kohekohe association.

Rimu-Tawa-Hinau Forest

It has been noted that mature rimu trees 20–30 m tall, are the principal emergents through a canopy 10–15 m above ground in forest remnants occupying the remains of an ancient valley floor. Among the dispersed rimu are occasional emergent kahikatea, northern rata, miro and pukatea trees with rewarewa on spurs where the rock remains solid. Rimu crowns, except those in Westland terrace forests, appear designed to foster a great variety of epiphytes: in Otari one may readily distinguish the heavy *Collospermum* clumps, northern rata juveniles

with descending stem roots scarcely distinguishable from ascending rata vine stems, broadleaf trees whose descending roots are distinctively vertical-ribbed and the shrubby *Pittosporum cornifolium*. Clumps which may become detached by wind reveal associated epiphytic *Asplenium* ferns and occasionally the minute *Bulbophyllum* orchid; all too frequently the epiphytic masses become an overload for the host tree's limbs – a feature found also in kahikatea veterans, in pukatea and especially in hinau. The last mentioned species is a canopy component along with tawa, mahoe, karaka, maire, pigeonwood and several other small tree species. Hinau has a crown whose main branches are more or less horizontal and otherwise favoured sites for epiphytes. Another feature of hinau trees in Otari is for them to develop heartrot in trunks 40 cm and over in diameter; the outermost heartwood remains unaffected by the rot and remains as a sound shell in trees that have been prostrate on the forest floors for many decades. The central rot however extends into the main branches and its weakening effect contributes to the breakages of these epiphyte-laden branch bases under heavy wind loads.

Variation in the completeness of the canopy, its composition and nature and composition of the understorey and floor vegetation are almost infinite. It is a matter for conjecture whether human activities are the principal reasons for such variation, but topography aspects, geological processes and cataclysms are all important factors.

Subtype with kohekohe as important canopy component

Detailed observations of vegetation quadrats in Otari relate to a 50 year period during which there has been substantial progress in the proportion of the canopy occupied by kohekohe at the expense of hinau, tawa and mahoe. Kohekohe has also become a much more important species in the understorey and forest floor. The advance of kohekohe towards dominance in the canopy is a feature applying generally to Otari, but more apparent in the western sector.

Subtype with kohekohe at early stage of invasion

As recently as sixty years ago the only kohekohe recorded in a survey of the eastern sector were two in the 1–3 m height class tally of a belt transect from the Kaiwharawhara Stream through to the eastern boundary. Across the Kaiwharawhara Stream in the northernmost part of the western sector that has recently been added to (with the piece of forest traversed by the Red Trail near its exit to Chartwell Drive), again the only records of kohekohe 60 years ago were two seedlings included in a belt transect tally. Three of the identified quadrats in 1984 revealed that rimu-tawa-hinau stands in these neighbouring parts of Otari now contain kohekohe as a minor component in the 1–3 m height class with a lesser number in the 3–7 m height class in two of the quadrats. They grew where the canopy was complete but one quadrat of the forest margin contained no kohekohe: it is the subject of comment in the next paragraph.

Sub-type free from kohekohe but characterised by significant podocarp regeneration and an assortment of light-demanding small trees

Rimu-tawa-hinau forest in Otari may be said to have more margins than it has continuity. A sample area on the western border (downhill towards the Kaiwharawhara Stream) of the forest in the eastern sector has one large rimu and one totara tree within its boundaries, with other big rimu and an even bigger northern rata just outside the boundaries, but all of them occupying a substantial part of the air space above. The light demanding group is less tall than the tawa and hinau trees, so the canopy is uneven as well as incomplete: species present are mapou, matai, heketara, fivefinger, lancewood (several), kanuka, mingimingi (*Leucopogon fasciculatus*), kohuhu, tarata, two large leaning *Coprosma linariifolia*, and several smaller *C. crassifolia*. The pigeonwood, maire and one 22 cm diameter miro and a tall rimu similar in girth are considered to be normal components of the forest association. Two observed changes during the past fifty years include high mortality among the mingimingi that have failed to keep pace with associated small trees, and the development in one corner of the quadrat of a ponga colony whose individual crowns overlap to make a dense low canopy about 1.5 m above ground. Similar colonies of ponga accompanied by mamaku, are frequent in Otari where the canopy and lower storeys of rimu-tawa-hinau stands have been interfered with by human activities. From the early stage, when the tree ferns are trunkless, through the short-trunked stage, the heavy shading retards development of the multi-storeyed forest. When the fern trunks become taller, improved light on the forest floor allows re-entry of woody plants which in turn may overtake and suppress the tree ferns. Early phases of forest development in the spur-top gorse growth near the western boundary contain young tree ferns whose life-cycle in relation to woody associates could well be studied by a succession of botanical observers; observations at Otari suggest a cycle of 100 years-plus in favourable sites, in which heights in excess of 10 m may be attained.

Shrubs bordering Flax Clearing feature native species such as pohutukawa, golden akeake, flax and toetoe. On the uphill side of the clearing further plantings include beeches whose form in the exposed site does little credit to the *Nothofagus* genus, and an extensive area of kauri with several of its natural associates that is an extension to the North Auckland conifer association.

The exposed site and aggressive competitors, especially manuka, rewarewa, mahoe and mamaku, has distorted and suppressed what was patently a valuable feature of Otari, an observation supported by the excellent kauri trees and associates at the south-western end of the area where good shelter from the southerlies is provided by tall kahikatea, rewarewa, karaka and one veteran ngaio whose presence suggests it was on a bush margin during the mid-1920s. The presence of this artificial association is not only in accord with Cockayne's wishes but adds interest to an area already modified by humans. Of particular botanical

interest is that tanekaha and *Ackama rosifolia* have become acclimatised to the degree that they are regenerating successfully.

Sub-type bordering streams

Mention has been made about funnelling southerly winds upstream from the Troup picnic area in Kaiwharawhara Stream. In that shaded gorge records made in 1934 showed frosts there to be relatively frequent and severe, which was not so for readings within the bush. The combined effect of strong cold winds and frequent frosts seems to be reflected in the vegetation of the gorge locality. In the Gresley Lukin alpine garden too the incidence of frosts noted at that time was considered advantageous in the retention of healthy alpine herbs. Along the Hooker Path features of particular interest have been the generous growth of the herb *Australina pusilla* on banks until invasion by *Tradescantia fluminensis*, and the continuous presence of healthy trees of *Fuchsia excorticata*, due no doubt to the shyness of possums in a place much used by people. In the same general locality at the foot of a waterfall in a small side stream an extensive healthy growth of parataniwha (*Elatostema rugosum*) has persisted for more than five decades but is assumed to have been introduced.

Observations of 1934 plots in certain side streams provide detailed data on woody plants and large ferns but it is the more extensive observations alongside paths and stream beds that round off the following records:

- a cataclysm like the December 1976 concentrated rain storm can be catastrophic to vegetation along the sides of streams in eroding rock shattered by earthquakes. Two quadrats near stream beds became unrecognisable.
- pukatea trees are seen to particular advantage in the partially filled, flat stream-bed of the upper Bledisloe Gorge, although the largest tree suffered severe crown damage in the 1968 Wahine wind storm, leading to one side of the trunk becoming decayed.
- in the same area tree ferns have become very tall especially mamaku, ponga and the gully fern. Further down the same rock gorge grow the two *Dicksonia* tree ferns.
- high above the stream in the Bledisloe Gorge are colonies of kidney ferns and *Hymenophyllum flexuosum* as well as common ferns found elsewhere.
- it is the smallest side streams in the relatively inaccessible parts that have the greatest wealth of filmy ferns along with mosses and liverworts. The small *Trichomanes endlicherianum* is found still on shaded rock faces but a single clump of *Leptolepia novae-zelandiae* seen in 1934 appears to have vanished. MacKenzie Burn was a rich site until a wash down from excavations in the stream head in the 1976 rain storm destroyed the vegetation.

Developmental Phases of Forest Regrowth

Arbitrary lines have to be drawn between forest associations, scrub and largely herbaceous vegetation that precedes scrub under some circumstances. In Otari four developmental phases described are:

Grassed Spur Tops

While the extent to which such sites now occur in Otari is very limited they receive attention because of occurrence elsewhere in the same general area although factors such as stock exclusion, exposure to wind, proximity of bush, aspect and altitude are likely to vary.

Following burning and grass establishment and then stock exclusion, the grass (species not recorded) became rank (c. 0.25 m tall) with native herb invaders belonging to *Acaena*, *Wahlenbergia*, *Gnaphalium*, *Helichrysum* and *Vittadinia*, and adventive ragwort, tutsan (*Hypericum androsaemum*) and spotted clover recorded. Away from the most exposed spur-tops taller vegetation ranged in height from about 2 m close to the bush margin to under 1 m higher up the slope. Small leaved composites – *Cassinia leptophylla* and *Olearia solandri*, manuka, *Coprosma propinqua*, *Melicytus crassifolius*, *Muehlenbeckia complexa* and the spiny perennial *Aciphylla squarrosa* reflect coastal affinities. Elsewhere are humps consisting of the three common lianoid *Metrosideros* spp. clustered around the stumps of tree ferns killed during the initial clearing, lianes or other aggregations of woody items mentioned above plus rangiora, C*oprosma rhamnoides*, hangehange, mahoe, ramarama, kawakawa, bush lawyer and the ferns *Polystichum richardii*, *Asplenium flaccidum*, *A polyodon*, *A. oblongifolium*, *Rumohra adiantiformis*, and *Phymatosorus pustulatus*.

Close to the bush edge were juvenile *Pennantia* and *Coprosma areolata* (both 2 m tall) with shorter *Coprosma robusta* and hybrids with *C. propinqua*, *Myrtus* hybrids, poroporo, bracken, *Fuchsia excorticata*, occasional gorse, fivefinger, hinau, mapou, matai, miro, *Coprosma grandifolia*, karaka, *Hebe parviflora*, *Griselinia lucida* (terrestrial), *Coprosma foetidissima* and *Melicope ternata* (the last two are now very uncommon).

Bracken Reversion

Bracken still persists in patches as an element in an early phase of forest development on the heavily shaded side of the deeply entrenched Kaiwharawhara Stream, growing on unstable rock. Reversion to bracken following clearing is now relatively uncommon in Otari but a dense stand along the crest of a spur close to the north-western boundary at an altitude of 180 m was sampled in 1934.

Its period of occupation was presumed to have been several decades as the only evidence of the forest cleared for farming was only an occasional hinau log shell that is very durable, and a log remnant presumed from bark fragments to have been miro. Into the dense bracken had come a few clumps of gorse and an

assortment of native vegetation which high up on the spur were about 1 m tall increasing to 3 m where the land sloped on the leeward flank. Where the spur crest fell away sharply to the entrenched Bledisloe Gorge rewarewa was about 4 m tall and closely spaced, excluding bracken.

In 1984, the aggressive native woody vegetation and tree fern colonies and singles had virtually eliminated the bracken and such light demanders as hebe, *Cassinia leptophylla*, adventive tutsan and makomako. Emergents over 4 m tall are mapou, pigeonwood and rewarewa which attain 5 m up on the spur and 8–10 m lower down. A canopy ranging in height from 2 m in exposed areas where gorse clumps persist along with rangiora, mapou, mahoe, *Coprosma grandifolia*, kawakawa and hangehange is being invaded by kohekohe whose numbers exceed those of any other species. It should, however, be noted that most species in the 1–3 m class are of very bushy habit and generally multi-stemmed contrasting markedly with the slender kohekohe and the occasional hinau. Clumps and creeping ferns belonging to eight species, apart from tree ferns and bracken provide another element of the developing forest association. A solitary *Berberis darwinii* is evidence of a serious threat in an inaccessible location.

Rangiora Scrub

This is so widespread and distinctive that it justifies being given the status of "association". Its importance has been especially as a dominant shrub on both steep unstable sides of the entrenched Kaiwharawhara Stream at the eastern end of Otari, and on the northern side of the stream where it is the reserve boundary on the long south-western part, upstream from the Troup picnic ground; the latter part is less well known because the path by the stream cannot be maintained. A new track on the east side of the Kaiwharawhara Stream was formed in 1994 when the sewer pipe was renewed. In the 1932–34 botanical survey two belt transects at 90 degrees to the stream sampled the trench side vegetation up to the contour path (now the Blue Trail) in the south-western part. One transect on each side of the stream provided data for the most eastern part. Quadrats plotted at the same time provide a graphical supplement to transect data and a measure of the vegetation changes during 50 years. The rangiora belt bordering the Kaiwharawhara Stream on its sunny side used to be easily seen from the Hooker-Cheeseman path especially when wind revealed the dramatic whiteness of the rangiora leaf backs; forest on each side of the stream is close enough to make this a relatively sheltered area where now the rangiora has become submerged during the lapsed 50 years.

In the south-western area, where southerly winds have been funnelled, rangiora scrub was the scant covering for the precipitous slope made up more of shattered rubble than of solid rock. In its extreme form rangiora scrub forms an almost impenetrable growth with supplejack or bracken, but wind which brought the rangiora seeds also brought heketara, another daisy, which in the south-west

transect was the commonest associate of rangiora as a sort of upper storey 3 m and up containing also small trees from bird-carried seed of mahoe, titoki, tawa, pate, tree fuchsia, fivefinger, pigeonwood and mapou. Shade and shelter in turn bring kawakawa and hangehange.

A slightly different association sampled in a 1934 quadrat had fivefinger as the main emergent – rounded trees 4–6 m tall – with shorter multi-stemmed rangiora, mahoe and large leaved coprosma dispersed in scrambling bracken. Stable rock down the western boundary carried rewarewa and hinau up to 4 m tall which in 50 years have grown to between 8 and 11 m. *Hebe stricta* which in 1934 was frequent on open sites has disappeared and kohekohe up to 4 m tall have come in to join the characteristic kawakawa and hangehange. Rangiora, mahoe, fivefinger and mapou have persisted. Tree ferns form new, small, exclusive colonies. Two seedlings represent the incoming podocarps.

Gorse as a Nursery

More often than not the local reaction to gorse-clad hills is distinctly hostile despite their undoubted beauty when deep gold hill slopes merge into the brilliant blue sky. One of numerous overseas visitors expressing envy of our good fortune in being able to grow gorse so easily was a forestry man from South Korea who asked hesitantly, whether gorse seed could be obtained to try to clothe the steep, depleted hill slopes of his country. So much hill country in New Zealand has now been accepted as marginal for pastoral farming that hopes of outlawing burning are beginning to take root. Allowing the native forest to return is seen as a reasonable option and practicability is being demonstrated as close to Wellington as the Otari Native Botanic Garden. More than 50 years ago the upper north-western slopes towards the skyline but within the reserve boundary, remained grass-clad on several of the spurs. No exact dates are available for the incoming gorse but the Second World War period is considered to be the time when it took possession to the virtual exclusion of grass, low bracken and dispersed, wind-shaped clumps of native shrubs and lianes, including *Cassinia leptophylla*. Now, the gorse is senescent with no greenness between the ground and the spreading flattened green top at about 2.5 m. The tops of the dispersed bushes form a broken canopy with natives such as mahoe, rangiora, pigeonwood and tree ferns; in some parts near the south-western boundary the adventive barberry is a very aggressive competitor for canopy space. Mapou, currently is the native seen in greatest numbers: with its upright habit it is a distinctive emergent in certain areas. Elsewhere the gorse scrub close to kohekohe forest has this species as a principal item under the shelter of the canopy with kawakawa and hangehange. The cumulative effect of developing forest associations where low scrub or bracken, in their turn, have replaced grass or something approaching barrenness are important on the credit side of the overall balance of Otari.

Discontinuities in forest cover as a result partly of human activities and partly

through natural cataclysms are slowly but positively being smoothed over so that the effects of strong winds are ameliorated. Raising the canopy height by 2–3 m on exposed spurs may confidently be expected to have favourable effects on adjacent forest especially on the leeward side, for example, allowing a small increase in canopy height.

ARTIFICIAL FOREST ASSOCIATIONS

Of the several associations proposed by Cockayne in his future plans for Otari, two were developed in part during his lifetime – the Arthur's Pass type sub-alpine forest which, along with the Gresley Lukin alpine garden alongside, has been smothered by invading, lowland, woody species belonging to the vicinity, and the North Auckland conifer forest established in the spur on the opposite side of the main valley from the generic collections. The past history of the vegetation on the spur which runs up to Cockayne Heights and beyond the reserve boundary to the skyline, has included pastoral farming, the formation of an open grassland area called Flax Clearing, the planting above and below that clearing of North Auckland conifers and further down extensive totara planting.

The North Auckland plantings below Flax Clearing have suffered especially from invasion by aggressive indigenous trees resulting in death of several of the northern species, but it is interesting to note that *Phyllocladus trichomanoides* and *Ackama rosifolia* are regenerating freely. In the more extensive upper area mainly planted with kauri, this species has been badly damaged by wind and invasion by kanuka, rewarewa and tree ferns but shows notable persistence. At the sheltered southern end are many well grown kauri, mature *Toronia toru* and *Ackama*, and several healthy *Halocarpus kirkii* still bearing juvenile foliage at an estimated age of 70 years.

OPEN AIR NATIVE PLANT MUSEUM

A letter sent by Dr Leonard Cockayne to Wellington City Council in June 1926 in his role of Honorary Botanist to the New Zealand Institute of Horticulture proposed that an open air collection, or living museum, be established within the Otari Reserve consisting of as many species as possible of the wild plants of New Zealand. In drawing attention to our unique flora, he said that an open-air museum as envisaged in his proposal had never been attempted before in this country or elsewhere. A booklet printed subsequently with Dr Cockayne and Mr J G MacKenzie, Director of Parks and Reserves, as co-authors, detailed the overall scheme for the Reserve. Of the four main objectives, two have been introduced already, namely restoration of the natural forest to its original state, and representation of important plant associations as they existed elsewhere in primeval New Zealand. The other two objectives, building up a collection of living New Zealand wild plants from throughout New Zealand and outlying

Fig. 3. Looking east from the lookout over cultivated gardens in the foreground and a section of the original forest preserved by Job Wilton in the right background with the suburb of Ngaio in the middle distance. (Photo: Wellington City Council)

Fig. 4. Looking west from the main garden is the rock garden built by W. B. Brockie. A section of kohekohe forest is on the hillside in the distance on the right. (Photo: Wellington City Council)

islands and demonstrating the horticultural use of New Zealand plants have been pursued vigorously; results of work done are more demonstrable with smaller, short lived plants than with the trees which are an essential component of both natural and artificial forest associations. Hence to many visitors the formal gardens with their wealth of native shrubs and other non-tree life forms are the immediate and rewarding focus of interest – the obvious manifestation of the "Open-air Museum" (Fig. 3)

The most distinctive feature of primitive New Zealand, whether seen through Maori, European or Asian eyes would have been the primeval forest on steepish hills, dark green against a background of blue sky, or snow clad mountain tops or merging into enveloping cloud. To establish a living museum, a microcosm of New Zealand flora, without the continuing natural forest background would detract in so many ways from its purpose.

Entry by the Banks Gate leads to a rock garden in which a variety of plant forms, mainly from alpine and sub-alpine sites, are cleverly blended (Fig. 4). Beyond the central lawn are shrubs and small trees with special horticultural merit, again with contrasting life forms as provided for instance, by the flaxes. At the north end of the rock garden is the Cockayne grave and garden of native grasses and sedges clothing the "lip" where the land falls away towards the main stream. The immediate foreground contains the mainly shrubby generic grouping – *Hebe*, *Olearia*, *Pittosporum*, *Pomaderris* etc. with numerous species drawn from widely separate habitats. If a return is made to the Banks Entrance and thence northwards along Cunningham Path more gardens may be found.

Of particular botanical interest east of the Information Centre is the collection of native conifers; those unrepresented here are found in the rock garden or the nearby natural bush. A long border garden mainly of *Carmichaelia* leads on to the scree gardens of alpine herbs and there is an extensive fern collection in the fringing bush mainly of tawa and hinau. Then the space where mature native bush was unmercifully savaged by the Wahine Storm in 1968 is used very effectively for garden beds shared by *Dracophyllum* and luxuriant *Myosotidium* and especially the Wild Garden with its amazing collection of tender species from the warm north and outlying islands with enough native trees to give shelter. Horticultural interest is maintained throughout the walk towards the north-east exit to Wilton Road or the Richard d'Urville Path downhill to the Solander Entrance.