Secondary Totara-Titoki-Matai Forest on the Otaki Plain

A. P. Druce

BETWEEN Te Horo and Otaki, 40 miles north of Wellington, the main highway crosses a stony plain—an old, gently sloping alluvial fan laid down by the Otaki R. The most notable feature of the landscape here is the number of patches of secondary forest scattered through the pasture. Many of these patches are linked together by single trees. One's first impression on passing is of a sizeable stretch of forest, yellowish green in colour, uniform in height and consisting largely of totara.

During the last five years I have visited this area on a number of occasions. The vegetation has proved most interesting to study, not only because of its unusual origin but also because of its unsuspected floristic diversity. I wish to thank all those people who have helped make the observations on which the present account is based. The record of visits and helpers is as follows:

21 Nov. 1960—Mr. G. C. Kelly.
2 May 1961—Mr. D. R. McQueen.
20 July 1962
8 June 1963—Wellingon Botanical Society study group (Mrs. G. R. Bennie, Mr. F. Bodley, Mr. and Mrs. J. D. Coulter, Dr. J. W. Dawson, Mrs. F. Duguid, Mrs. F. Elphick, Dr. M. B. Forde, Miss A. Hutson, Miss E. Jones, Mrs. M. P. Lonska, Miss M. Ladvenski, Dr. I. M. Morice, Mr. P. Rider, Mr. F. B. Sampson, Miss M. A. Ward).
April 1964—Mr. G. C. Kelly.
17 Aug. 1965

The forest studied consists of some twenty more or less separate stands close to the main road; the majority can be seen in the air photo reproduced in Fig. 1. The land is closely subdivided and in most of the paddocks the pasture has been improved by top-dressing. Although stock (mostly cattle) have access to all stands examined, bar one very small one near a homestead, those stands associated with unimproved pasture are somewhat less modified through browsing and trampling than are those associated with improved pasture. Young totara coming up in the pasture have been cleared from most paddocks at one time or another but very little cutting has been done within the closed stands of forest.

In many of the paddocks stones and boulders have been gathered up and carefully stacked in hundreds of rectangular piles (Fig. 2). The largest pile measured was 18 ft. long, 15 ft. wide and 3 ft. high. None have been seen in the forest. A local farmer, questioned, said that the stones had been piled up in the course of

Fig. 1—Aerial photograph of portion of Otaki plain north of Te Horo, showing stands of secondary forest. The main road and railway run from bottom left to top right. The letters (A-G) indicate stands referred to in the text. Photo: 307/5, taken 28 Apr. 1948 (north at top). Scale: 20 ch. to 1 in.

clearing the more or less open parts of the plain during the depression. Mr. N. L. Elder, in a letter, confirms this. He says: "Most of these piles were made by gangs of unemployed during the slump. I have seen these men at work, presumably when I was coming down from Hawke's Bay on the last of our Tararua field trips, say 1933-1935 at a guess. I think this must have come under Scheme IV B ('over the fence') aimed at long-term improvements to farm land, and much criticised at the time. Clearing stones must have been quite a regular practice on a smaller scale in pioneering times. I can remember big dumps off a terrace up the Waikanae on our place and my father telling me that he'd tried unsuccessfully to clear Stony Flat for ploughing by taking drayloads off the surface."

In other articles Mr. J. D. Coulter describes the climate of the Otaki plain (as part of the Horowhenua lowlands) and Mr. I. A. E.

Atkinson describes the soil. The altitude of the plain in the area studied varies from 70 ft. near the southern margin of the fan to 120 ft. at the crest. The distance from the sea is 2 to 3 miles, and old sand dunes, overlying the alluvium, extend to within half a mile of the main road. The stony soil of the plain allows rapid drainage. In order to provide water for stock several races have been constructed.

The Forest

The following description applies only to the main body of closed forest; the forest margin and adjacent areas of scattered totara are described in the next section. The forest was analysed by the point intercept method, in which a plant is recorded at a point if it is intercepted by a vertical line of sight from the observer. More attention was paid to the canopy of the forest than to the understorey. The trees of the canopy not only give the community its characteristic appearance but also largely determine the dynamics of the community (energy flow and cycling of organic matter, nutrients and

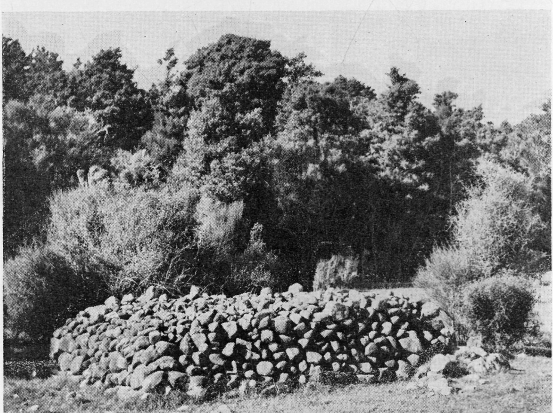

Photo: A. P. Druce, April, 1961.

Fig. 2—Stone pile in the pasture near stand A. The small-leaved shrubs nearby are *Melicope simplex*, *Coprosma crassifolia* and rohutu (*Lophomyrtus obcordata*).

water). This is not to deny, of course, the vital importance of the understorey in the regeneration or otherwise of the canopy species.

The canopy was analysed by recording at regular intervals—usually every five paces—the species whose *crown* was intercepted by the vertical line of sight. If the crowns of two plants were intermingled in the canopy, as often happens when a liane scrambles over a tree, then each was scored half a point. On the first occasion at Otaki (June 1963), when records were made at 50 points, the vertical line of sight was obtained by looking up a plumb-line suspended from an inclined eight-foot pole. Subsequently a trial by Mr. G. C. Kelly and myself on the slopes of Mt. Egmont showed that for short forest, less than 30ft high, as at Otaki, the results would not be affected to any extent by dispensing with the plumb-line and obtaining an approximate vertical by eye. Accordingly the plumb-line was not used on the next occasion at Otaki (April 1964), when records were made at a further 213 points. The two traverses (263 points) covered ¾ mile of forest, in six separate stands. The estimated crown cover percentages for the canopy of the forest as a whole are given below. The total cover was 99 ± 0.5 per cent, i.e. there were very few canopy gaps (gaps in the canopy above 7ft.). (The sampling errors cannot be calculated precisely; the figures given are probable maxima.)

Crown Cover Percentages for the Canopy

Totara	27 ± 3
Titoki	26 ± 3
Matai	14.5 ± 2.5
Melicope simplex	6 ± 1.5
Akeake	5 ± 1.5
Rohutu	4 ± 1.5
Mapou	3.5 ± 1.5
Other plants	13 (none > 2 ± 1)
Trees (as a group)	94.5 ± 1.5
Lianes (as a group)	4.5 ± 1.5

The category "other plants" comprises 19 different trees and lianes; only four of these scored more than two points each, out of the total of 263. It is not surprising, therefore, that a further 15 trees and lianes were seen in the canopy in passing without their crowns being intercepted. (Point analysis is a method of estimating cover; it is clearly inefficient for determining the species present, unless all the species happen to make significant contributions to the cover. Scanning the vegetation by eye is the best method for determining the species present.) The above two groups of plants —the "minor plants" of the canopy—are listed together below. An asterisk indicates that the plant was one of those intercepted.

Clematis foetida
C. paniculata
**Coprosma areolata*
C. crassifolia
**Heketara*
**Hinau*
**Kaikomako*
Karaka
**Kohekohe*
Kohuhu
**Lancewood*
**Lophomyrtus bullata X obcordata*
**Mahoe*
**Maire, black*
Maire, narrow-leaved
**Maire, white*
**Melicope simplex X ternata*
**Muehlenbeckia australis*
Milk tree
Milk tree, small-leaved
**Ngaio*
**Parsonsia heterophylla*
Pigeonwood
**Puka*
**Rewarewa*
Rubus australis
**R. cissoides*
R. schmidelioides
R. cissoides X australis
R. cissoides X schmidelioides
Tarata
Tawa
**Tetrapathaea tetrandra*
**Wharangi*

The forest, though it appears from the outside to be composed of totara and little else, is thus seen to be floristically rich, containing in its canopy no fewer than 37 species and 4 hybrids. However, the three most important species account for over two-thirds of the cover; and it is from these species that the forest is named *totara-titoki-matai forest*.

In the above analysis the forest has been treated as a single unit but the composition of the canopy varies a good deal, not only from one stand to another but also within a single stand. The following table shows the estimated cover percentages of totara, titoki and matai in each of the six stands analysed. The positions of the stands are shown in Fig. 1.

Crown Cover Percentages for the Canopy in Individual Stands (A-F)

	A	B	C	D	E	F
	(94 points)	(50 pts.)	(31 pts.)	(45 pts.)	(27 pts.)	(16 pts.)
Totara	19 ± 4	31 ± 6.5	34 ± 8.5	26 ± 6.5	33 ± 9	44 ± 12
Titoki	26 ± 4.5	40 ± 7	16 ± 6.5	24 ± 6.5	19 ± 7.5	19 ± 10
Matai	20 ± 4	2 ± 2	18 ± 7	6 ± 3.5	22 ± 8	22 ± 10

The samples are mostly rather small but it can at least be seen that matai is less important in stands B and D than in stand A.

The six stands are separated from one another by fences, so past differences in land use could be responsible for present differences in vegetation. In some of the other stands, not analysed by the point intercept method, both titoki and matai are unnimportant. Totara is the one canopy species that is important in every stand; but even so this species appears to be clumped in its distribution, one part of a stand having many trees while

another part has none. Akeake is an important species in one part of stand A but not in another part, as can be seen by comparing the cover percentages obtained from the first 50 points of the sample with those obtained from the next 44.

Totara	18 ± 5.5 :	20 ± 6
Titoki	18 ± 5.5 :	34 ± 7.5
Matai	20 ± 5.5 :	20 ± 6
Akeake	20 ± 5.5 :	2 ± 2

The canopy of the forest, though by no means smooth, is fairly even in height, with few trees emerging far above the general level of tree crowns. The crowns of the taller trees tend to be asymmetrical, their western sides being windshorn as a result of "burning" by salt. In a stand the height of the canopy usually increases gradually from the exposed western margin as successive trees partially shelter one another. The height of 27 canopy trees growing in the central part of stand A are given below. The height of a tree was estimated (June 1963) by holding a 12-foot pole against the tree so that the lower end of the pole was 6 ft. from the ground and then assessing the remaining distance to the top. The trees ranged in height from 22 to 45 ft., with an average of 27 ft. Only two trees exceeded 30 ft. in height—both totara.

Heights of Canopy Trees (feet)

Totara	26, 27, 27, 30, 30, 38, 45	Mapou	24
Titoki	24, 25, 26, 28, 28	Hinau	30
Matai	22, 26, 28, 28	Lancewood	23
Melicope simplex	23	Mahoe	22, 28
Akeake	28, 28	Rewarewa	25
Rohutu	23, 24		

The diameters of 164 canopy trees growing in the central parts of stands A and C were measured at breast height. The results are summarised below. Only two trees greater than 24 in. diam. were seen in any of the other stands; both were totara, each with a diameter of about 40 in.

Distribution of Canopy Trees in Diameter Classes

	Under 5 in.	5-8 in.	9-12 in.	13-16 in.	17-20 in.	21-24 in.
Totara	7	4	10	5	3	1
Titoki	4	18	11	2	—	—
Matai	11	10	6	1	—	—
Melicope simplex	21	5	—	—	—	—
Akeake	4	5	8	—	—	—
Rohutu	5	1	—	—	—	—
Mapou	4	4	—	—	—	—
Hinau	2	3	2	1	—	—
Mahoe	2	1	—	2	—	—

The diameters of tree crowns in the canopy were not measured, but in general it can be said that the crowns of *Melicope simplex*

and rohutu are small compared with those of totara, matai, titoki, akeake and other trees. The cover of leaves in a crown varies from species to species, being high for totara, matai and titoki, but rather low for akeake.

Typically the understorey of the forest consists almost entirely of small-leaved shrubs, the most abundant and widespread of which are *Melicope simplex* and *Coprosma crassifolia*. Saplings of matai are abundant in some stands but not in others. Of the remaining small-leaved shrubs *Coprosma areolata*, rohutu and saplings of totara are fairly common while *Coprosma rhamnoides*, small-leaved milk tree and saplings of kaikomako are rather rare. Larger-leaved saplings are either uncommon (mapou, titoki) or rare (mahoe, hangehange, kawakawa). Poroporo, Jerusalem cherry and Cape gooseberry have only been seen in one or two stands each, but the two nightshades, *Solanum nigrum* and *S. nodiflorum*, are present in most stands. When the forest was visited in April 1964 the tips of the branches of a number of *Coprosma crassifolia* shrubs in the understorey were heavily infested with a mealy aphid; the tips were drooping and beginning to wither.

There is a big difference between the upper and lower parts of the understorey. The understorey was analysed in stand A (June 1963) by the point intercept method, using the pole and plumb-line as set up for analysis of the canopy. At each of 50 points 10 ft. apart a record was made of those species whose crowns were intercepted (a) between 7 ft. and the canopy, and (b) between 7 ft. and 8in. Intercepts between 7 ft and the canopy were made by vertical line of sight; those between 7 ft and 8 in. were made by lowering the plumb-line from the top of the pole. The results are shown in the table below. (The original figures have been doubled so as to provide an index figure based on 100 points.) In the upper understorey there were only five points at which no crowns were intercepted (cover 90 ± 4 per cent), whereas in the lower understorey there were 38 such points (cover 24 ± 6 per cent).

Crown Contributions in the Understorey
(no. of intercepts per 100 points)

	Upper Understorey (above 7 ft.)	Lower Understorey (8 in - 7 ft.)
Melicope simplex	56	2
Matai	24	2
Coprosma crassifolia	8	18
Titoki	6	—
Mapou	6	—
Rohutu	6	—
Totara	4	2
Other plants	8	8
All plants	118	32

Pyrrosia serpens is a conspicuous epiphyte in the upper understorey, growing copiously on the rough bark of totara. Bryophytes

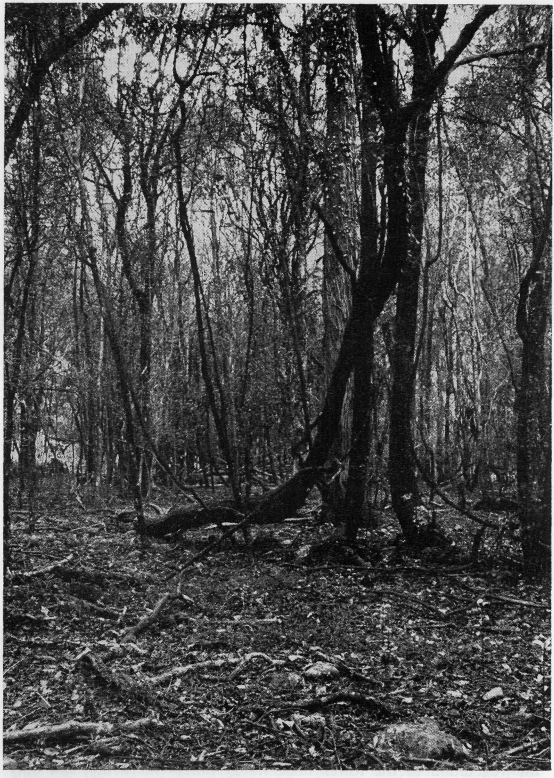

Photo: G. C. Kelly, April, 1964.

Fig. 3—View inside stand A, looking towards south-west margin and showing sparseness of vegetation in the lower understorey.

and lichens, though abundant, are unconspicuous, forming only a thin discontinuous cover on trunks and branches. Other epiphytes, all rare, are as follows: *Asplenium flaccidum, Mecodium sanguinolentum, Collospermum hastatum, Dendrobium cunninghamii, Earina mucronata* and *Sarchochilus adversus.* The lianes, *Metrosideros diffusa* and *M. perforata* are present on the trunks of a few trees.

The ground-storey (0-8 in.), like the lower understorey, is largely devoid of plants (Fig. 3). An analysis of *leaf* cover in stand A, using a crosswire sighting instrument, gave the results below. The sample consisted of 50 points, spaced 10 ft. apart

Cover Percentages for the Ground-storey

Bryophytes (on stones)	10 ± 4
Oplismenus undulatifolius	4 ± 3
Other plants	8
Litter	78 ± 6

At the time this analysis was made (June 1963) all stones lying on the surface of the ground were completely covered with bryophytes. It is unlikely that they would be covered like this in summer.

For the forest as a whole the most important higher plants in the ground-storey are the grasses, *Oplismenus undulatifolius* and *Microlaena stipoides,* and the fern, *Pellaea rotundifolia.* However, *Microlaena stipoides* is more characteristically found under an open canopy or near the forest margin than in the main body of a closed stand. Small seedlings appear to be abundant in most stands. The following species has been noticed in large numbers at one time or another: *Melicope simplex, Coprosma crassifolia, C. areolata,* rohutu, akeake, mahoe, titoki, mapou, hangehange and totara. The herb, *Parietaria debilis,* is important in a few stands, but in general herbaceous plants other than the grasses and fern mentioned above are unimportant. In addition to about a dozen adventive species, the following indigenous species have been recorded: *Asplenium bulbiferum, A. falcatum, A. flaccidum, A. flabellifolium, A. lucidum, Microsorium diversifolium, Pteris tremula, Pyrrosia serpens, Galium propinquum, Cardamine* sp., *Echinopogon ovatus, Oxalis corniculata, Stellaria parviflora, Uncinia* sp., *Pterostylis banksii, P. trullifolia* and *Caladenia carnea* var. *minor.*

One small stand of forest (G, Fig. 1), dominated by totara, has had cattle excluded from it for a number of years. Although the vegetation of the upper understorey is similar to that found elsewhere the vegetation of the lower understorey differs markedly; not only is it very much more dense, but saplings of several larger-leaved species are conspicuous among the usual small-leaved shrubs. In rough order, the four most important species in this storey are *Coprosma crassifolia, C. areolata,* mohe and kawakawa. Others less

important are *Melicope simplex*, milk tree and titoki. In the ground-storey *Oplismenus undulatifolius, Pellaea rotundifolia, Microlaena stipoides* (near the margin), and bryophytes (on stones) are important, as are also seedlings of mahoe, titoki and *Coprosma crassifolia.* No matai were seen in the company, nor were any seen in the lower storeys.

When stands A and C were last visited, in April 1964, the nearby unimproved pasture had not been grazed for some time —perhaps not for a whole growing season. In the forest, seedlings were particularly abundant and coppice shoots at the base of mahoe trees had reached a height of 2 ft.

In order to find out the approximate age of the forest at Otaki, cores were extracted from a small number of totara and matai trees with an increment borer. In addition one matai was felled and one was found already cut. It was apparent that a number of the rings in these trees were false (intra-annual), i.e., they had been formed as a result of growth cessation during periods of summer drought. The totara could not be used since many of their rings were unclassifiable. However, in three of the matai the false and annual rings were reasonably distinct. The approximate ages and diameters of these trees were determined as follows (winter 1963): 70 years (12 in. d.b.h.), 70 years (6 in. d.b.h.) and 65 years (8 in. d.b.h.). As matai on the Otaki plain undoubtedly requires the shelter of other plants for establishment (see below) the bulk of the forest could be 80 to 100 years old. A few totara (40 in. d.b.h.) are probably much older than this; they could be the last remaining trees of an earlier, pre-European generation.

The Forest Margin and Adjacent Areas of Scattered Trees

The composition of the margin differs significantly from that of the main body of forest. Totara is the dominant tree, matai being of minor importance and titoki of little or no importance. Trees, in addition to totara, that appear to be present at or near the margin in greater numbers than within the forest are akeake (Fig. 4), kohuhu and ngaio, but the last two are of little importance in either situation.

Beneath the trees at the margin there is often a dense belt of small-leaved shrubs (Fig. 4 and 5). *Melicope simplex* is the most important species here; less important are rohutu, *Coprosma crassifolia, Melicope simplex* X *ternata, Lophomytus bullata* X *obcordata* and saplings of matai, mapou and totara. *Coprosma crassifolia* becomes very much more important immediately inside this marginal belt, i.e. in the understorey. The mistletoes, *Korthalsella lindsayi* and *Loranthus micranthus,* are occasionally seen on shrubs along the margin. Lianes present include *Muehlenbeckia australis,*

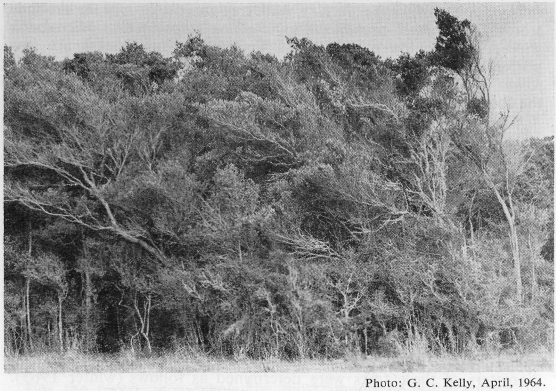

Photo: G. C. Kelly, April, 1964.

Fig. 4—Forest margin, north-west side of stand C, composed of windswept akeake and various small-leaved shrubs.

M. complexa, Rubus cissoides, R. schmidelioides, Tetrapathaea tetranda and *Calystegia tuguriorum.*

At the margin the crowns of the totara trees not uncommonly extend down to ground level, the small-leaved shrubs then being interspersed between the totara crowns. A portion of such a margin, on the south-west side of stand A, was analysed at a height of 4 ft. above ground level, using the point intercept method. The first crown intercepted by a pole, moved *horizontally* into the margin, was recorded at five-pace intervals along the margin. The sample consisted of 40 points and the following results were obtained for lateral cover: *Melicope simplex* 46 ± 8 per cent, totara 41 ± 8 per cent, other plants 13 per cent.

There is not always a dense belt of vegetation in the lower part of the margin; there may be many gaps not filled by either shrubs or totara. As woody plants decrease in importance so grasses and herbs, mostly adventive, increase. Apart from *Microlaena stipoides* these species are mostly those found in the adjacent pasture. They are indicated in the list of herbaceous plants at the end of this article. Where the margin is open there may be patches of inkweed, and scattered plants of sweet briar, barberry and hawthorn.

Beyond the forest margin proper there are numerous solitary trees and small groups of trees, surrounded by pasture (Fig. 6).

With the exception of about 30 kanuka in a group and a few ngaio and hawthorn, nearly all of the trees are totara. These are up to 20 ft. in height and occur in two forms. In one form a short bare trunk is visible beneath the crown; in the other the crown extends to the ground (Fig. 6). Trees with bare trunks nearly all show a smoothed portion between 1 and 4 ft. above ground level, produced by cattle rubbing themselves against the bark.

In between the trees young totara and various shrubs may be present. These occur mainly where the totara are fairly closely spaced and are growing on unimproved land. The commonest shrub is *Melicope simplex* the next most common rohutu. Others that may be present are sweet briar, barberry, gorse, *Coprosma crassifolia* and saplings of kohuhu. No manuka or tauhinu has been seen, and very little bracken. The unimproved pasture between the trees and shrubs has as its main components browntop, sweet vernal, crested dogstail, cocksfoot, white clover, suckling clover, ribgrass, catsear and moss. Numerous other species are present, including *Thelymitra longifolia, T. pauciflora, Microtus unifolia, Carex breviculmis, Acaena novae-zelandiae, A. ovina, Graphalium* sp.,

Photo: G. C. Kelly, April, 1964.

Fig. 5—Forest margin, south-west side of stand A, showing belt of small-leaved shrubs, mainly *Melicope simplex*, under a canopy of totara.

Luzula sp., *Dichondra* sp., *Nertera setulosa, Notodanthonia clavata* and *N. penicillata.*

Though the individual stones of the stone piles scattered through the pasture are covered with lichens, the piles themselves have not been covered to any extent (Fig. 2). *Muehlenbeckia complexa, M. complexa* X *australis* and *Microsorium diversifolium* are the only plants of any significance.

Seedlings and saplings of a number of plants are found in abundance under the totara in the pasture wherever the crowns reach the ground. An examination of three trees showed *Coprosma crassifolia* to be the most abundant species, followed by *Melicope simplex* and rohutu. Others present were sweet briar, totara, matai, mapou, white maire, kaikomako, lancewood, *Coprosma areolata, Melicope* hybrids and *Lophomyrtus* hybrids. Lianes present were *Muehlenbeckia australis* and *Rubus schmidelioides.* The seed of every one of these plants appears to be dispersed by birds.

All trees and shrubs exposed to the west, both in the pasture and in the forest margin, have asymmetrical windshown crowns. Browning of foliage, presumably due to the deposition of salt, was noted on two

Photo: A. P. Druce, April, 1961.

Fig. 6—Totara in pasture at margin of stand A, showing crown extending to ground level.

occasions. The exposed crowns of matai saplings in the margin appear to be particularly susceptible to damage.

From their wide range of size it is clear that the totara growing in pasture cover a correspondingly wide range of age. But older plants outnumber younger plants in most places; periodically a farmer will have partially cleared his land, and in doing so the younger plants will probably have been selectively cut. In one paddock where clearing was in progress (May 1961) trees were being cut as well as younger plants; the low-crowned totara were sawn off at ground level and then burnt. The opportunity was taken to count the rings in a couple of trees 10 to 15 ft. high. One tree was estimated to be 22 years old, the other 30 years old, but the presence of what were assumed to be false rings makes these figures open to considerable error. Nevertheless it is probably safe to say that these trees had grown up since the land was cleared during the depression of the mid 1930s. Taller trees could have been there much longer.

Development of the Forest

The problem is: How did forest develop on the Otaki plain without protection from farm animals? In the absence of a sequence of precise historical records all one can do is to suggest a *possible* way, keeping in mind all relevant observations.

The original vegetation of the plain would probably have been tall forest with matai and totara emergent above hinau, maire, tarata, titoki, rewarewa, mahoe and other trees. Whether this vegetation was destroyed before or after European settlement is not known; it is possible that a search of early historical records would provide the answer. Although no large stumps or logs have been seen in the present forest, there are a few large standing totara (d.b.h. 40 in.). These indicate that there was at least some primary or secondary forest in existence when the latest cycle of development began perhaps 80 to 100 years ago. The vegetation over much of the plain prior to settlement could conceivably have been kanuka scrub. The few kanuka present in pasture today might then be viewed as the descendants of a former and much larger population. However, the complete absence of kanuka from the forest almost certainly indicates that this species was not involved in the early stages of succession. It is unlikely, therefore, that kanuka was important in the preceding vegetation. *Microlaena stipoides* grassland, with or without young totara scattered through it, may well have covered much of the plain; this kind of vegetation was widespread on similar land in Hawke's Bay at the time of settlement. Periodic burning would have maintained the community at the grassland stage.

Whatever the previous history of the plain, there can be little

doubt that during the initial stage of development of the present vegetation totara became established in some sort of open pasture, either sown or "natural". It appears that totara can survive in such a community because (a) it is not browsed much, (b) it is moderately drought resistant, (c) the seedlings can withstand full exposure to sunlight, and (d) the cover of competing plants is insufficient to suppress the seedlings. Stones on the surface may well be important in modifying the environment of the seedling, through keeping the community open for instance. Shrubs that can survive in pasture in a similar way to totara, but to a lesser extent, are *Melicope simplex, Coprosma crassifolia* and rohutu (Fig. 2), though it seems that some shelter and some protection from livestock are necessary during the early stages of growth. The establishment of other species in the open—for instance kohuhu and ngaio—probably depends on complete protection from browsing.

Once established the totara would have been visited by birds carrying seed from forest remnants on the plain and on the adjacent hills. Seedlings growing within the confines of the trees would have been protected from livestock by the low crowns reaching to the ground. In time the crowns of separate trees would have coalesced, giving rise to small enclaves of forest. Gaps within the enclaves would have been filled by *Melicope simplex, Coprosma crassifolia* and rohutu, and perhaps a few kohuhu and ngaio; other species, such as matai, mapou and akeake would have followed as soon as the first cover had been formed. Later still would have come titoki, mahoe, white maire, and many others. From some of these young plants, growing *among* the totara rather than *under* them, would have developed the present day canopy trees. As the young plants increased in height and the enclaves of forest became further aggregated a continuous canopy would have formed. With the death of the shaded portions of the low totara crowns the understorey would have become more accessible to stock, but by this time many of the plants in the understorey would have grown high enough to be out of reach. Those that established first and in large numbers—*Melicope simplex, Coprosma crassifolia* and rohutu—would have been at an advantage; they are the species, along with totara, that are found in abundance in all stands today. (Although the cover of *Melicope simplex* and rohutu amounts to only 10 per cent, the small size of the crowns in these species means that a very large number of individuals are present. In fact *M. simplex* and rohutu are probably the most abundant woody plants in the forest—with the possible exception of *Coprosma crassifolia* which is practically confined to the understorey now.) The species that established later—matai, mapou, akeake, titoki, etc—would have grown more slowly in the reduced light of the understorey and would have been more susceptible to browsing. The rings in the matai that was cut down to age the forest showed that the tree had taken

30 years to reach a diameter of 1 in. The fact that matai and titoki are important in some stands today but not in others points to there having been significant differences in animal stocking during the early stages of forest development. During later stages there do not seem to have been such differences for the understorey is more or less depleted on all stands today.

It is possible that some of the variation in the composition of the present forest is due to variation in the texture of the original alluvial deposits. A difference in the percentage of fine alluvium amongst the gravel and stones could easily lead to a difference in the vegetation. Certainly where a thick layer of fine material overlies stony alluvium in the Otaki district the composition of the canopy in secondary forest is profoundly different from what has been described above; the main canopy species are then kohekohe, tawa and mahoe.

The Need for a Scientific Reserve

The kind of ecological system or community described above, in which totara is characteristically associated with pasture, livestock and a well drained stony soil on an alluvial plain, is found extensively along the eastern flanks of the central portions of the Tararua and Ruahine ranges. In most places the totara are scattered and few forest species have been able to enter the community. So far as is known there are no stands in other districts that are as well developed as are those at Otaki, and with more intensive farming it seems unlikely that any will develop in the future. Furthermore, the stands at Otaki could easily be lost if a few farms changed hands or if the land was subdivided for housing. Already on the main road where it crosses the plain we can see the beginnings of ribbon development and the erection of roadside stalls.

As there is no reserve of this type of forest I think one should be created while it is still possible. (It should be noted here that the forest at Totara Reserve in the Pohangina V. differs in many ways from that on the Otaki plain. A description of Totara Reserve is given by R. M. Greenwood in *Bull. Well. Bot. Soc. 21.*) Stand A (Fig. 1), which has an area of 3 acres, would meet the requirements of a reserve—a scientific one rather than a scenic one—where the future development of the forest could be studied wtihout interference from livestock. Once stock were excluded there is no doubt that significant changes would take place in the understorey, with plants like mahoe and kawakawa becoming prominent. The biggest problem in creating such a reserve is how to deal with the margins. If the boundary fence is put inside the forest then the distinctive margin is open to destruction by stock; if it is put outside then grass and bracken grow up between the fence and the margin, and become a fire hazard. The ideal solution is for the fence to follow closely the present margin of the forest.

List of Ferns, Gymnosperms and Flowering Plants Seen in the Forest, and along the Grassy Margins of the Forest

*Adventive species.

(M) Species found mainly or solely along the margins and in the adjacent pasture; if present within the forest, then usually in a canopy gap.

Trees and Shrubs

Akeake—*Dodonaea viscosa*
*Barberry—*Berberis vulgaris* (M)
Coprosma areolata
C. crassifolia
C. rhamnoides
*Elder—*Sambucus nigra* (M)
*Gorse—*Ulex europaeus* (M)
Hangehange—*Geniostoma ligustrifolium*
*Hawthorn—*Crataegus monogyna* (M)
Heketara—*Olearia rani*
Hinau—*Elaeocarpus dentatus*
*Jerusalem cherry—*Solanum pseudocapsicum*
Kaikomako—*Pennantia corymbosa*
Kanuka—*Leptospermum ericoides* (M)
Karaka—*Corynocarpus laevigatus*
Kawakawa—*Macropiper excelsum*
Kohekohe—*Dsoxylum spectabile*
Kohuhu—*Pittosporum tenuifolium*
Lancewood—*Pseudopanax crassifolium*
Mahoe—*Melicytus ramiflorus*
Maire, black—*Nestegis* (*Olea*) *cunninghamii*
Maire, narrow-leaved—*N. montana*
Maire, white—*N. lanceolata*
Mapou—*Myrsine australis*
Matai—*Podocarpus spicatus*
Melicope simplex
Milk tree—*Paratrophis banksii*
Milk tree, small-leaved—*P. microphylla*
Ngaio—*Myoporum laetum*
Pigeonwood—*Hedycarya arborea*
Puka—*Griselinia lucida*
Porporo—*Solanum aviculare*
Ramarama—*Lophomyrtus bullata*
Rangiora—*Brachyglottis repanda*
Rewarewa—*Knightia excelsa*
Rohutu—*Lophomyrtus obcordata*
*Sweet briar—*Rosa rubiginosa* (M)
Tarata—*Pittosporum eugenioides*
Tawa—*Beilschmiedia tawa*
Titoki—*Alectryon excelsus*
Totara—*Podocarpus totara*
*Tree lucerne—*Cytisus proliferus* (M)
Wharangi—*Melicope ternata*

Lianes

Calystegia tuguriorum (M)
Clematis foetida
C. paniculata
Metrosideros diffusa
M. perforata
Meuhlenbeckia australis
M. complexa (M)
Parsonsia heterophylla
**Passiflora mollissima*
Rubus australis
R. cissoides
R. schmidelioides
Tetrapathaea tetrandra

Mistletoes

Korthalsella lindsayi (on *Melicope simplex* and *M. simplex X ternata* (M)
Loranthus micranthus (on *Melicope simplex, Coprosma crassifolia* and mahoe) (M)

Ferns

Asplenium bulbiferum
A. falcatum
A. flabellifolium
A. flaccidum
A. lucidum
Mecodium sanguinolentum
Microsorium diversifolium
Pellaea rotundifolia
Pteridium aquilinum var. *esculentum* (M)
Pteris tremula
Pyrrosia serpens

HERBACEOUS PLANTS (OTHER THAN FERNS)

Allium triquetrum (M)
*Australian flax—*Linum marginale* (M)
Bidibidi—*Acaena novae-zelandiae* (M)
Bidibidi, Australian—*A. ovina* (M)
*Browntop—*Argostis tenuis* (M)
*Buttercup, small-flowered—*Ranunculus parviflorus* (M)
Caladenia carnea var. *minor*
*Canadian fleabane—*Conyza canadensis* (M)
*Cape gooseberry—*Physalis peruviana*
Cardamine sp.
Carex breviculmis (M)
*Catsear—*Hypochoeris radicata* (M)
*Chickweed—*Stellaria media* (M)
*Chickweed, mouse-eared—*Cerastium holosteoides* (M)
*Clover, suckling—*Trifolium dubium* (M)
*Clover, white—*T. repens* (M)
*Cocksfoot—*Dactylis glomerata* (M)
Collospermum hastatum
*Crested dogstail—*Cynosurus cristatus* (M)
*Daisy—*Bellis perennis* (M)
*Dandelion—*Taraxacum officinale* (M)
Dendrobium cunninghamii
Dichondra sp. (M)
*Dovesfoot—*Geranium molle* (M)
Earina mucronata
Echinopogon ovatus
Fumaria sp. (M)
Galium parisiense (M)
G. propinquum
Gnaphalium sp. (*G. collinum* aggr.) (M)
Gnaphalium sp. (*G. collinum* aggr.) (M)
*Hawkbit—*Leontodon taraxacoides* (M)
*Hawksbeard—*Crepis capillaris* (M)
*Herb Robert—*Geranium robertianum*
Hydrocotyle moschata (M)
*Inkweed—*Phytolacca octandra* (M)
*Ivy-leaved lettuce—*Mycelis muralis*
Luzula sp. (M)
Microlaena stipoides
Microtis unifolia (M)
*Milkweed—*Euphorbia peplus* (M)
Nertera setulosa (M)
*Nightshade—*Solanum nodiflorum*
*Nightshade, black—*S. nigrum*
Notodanthonia clavata (M)
N. penicillata (M)
Oplismenus undulatifolius
Oxalis corniculata
Parietaria debilis
Pterostylis banksii
P. trullifolia var. *alobula*
*Ratstail—*Sporobolus capensis* (M)
*Ribgrass—*Plantago lanceolata* (M)
Sarchochilus adversus
*Scarlet pimpernel—*Anagallis arvensis* (M)
*Scotch thistle—*Cirisium vulgare* (M)
*Selfheal—*Prunella vulgaris* (M)
Senecio hispidulus (M)
S. minimus (M)
*Sow thistle—*Sonchus oleraceus* (M)
*Sow thistle, prickly—*S. asper* (M)
Stellaria parviflora
*Sweet vernal—*Anthoxanthum odoratum* (M)
Thelymitra longifolia (M)
T. pauciflora (M)
*Tutsan—*Hypericum androsaemum* (M)
Uncinia sp.
Vicia sp. (M)
*Yorkshire fog—*Holcus lanatus* (M)

HYBRIDS DETERMINED

Asplenium bulbiferum X *flaccidum*
Lophomyrtus bullata X *obcordata*
Melicope simplex X *ternata*
†*Muehlenbeckia australis* X *complexa*
Rubus australis X *cissoides*
R. cissoides X *schmidelioides*

†In addition to plants intermediate in form between *M. australis* and *M. complexa* there are plants of another kind, in which the leaves are like those of *M. australis* and the inflorescences like those of *M. complexa*. Very few fruits develop on these plants and they are presumed to be second generation hybrids. Specimens have been deposited in the herbarium of Botany Division, D.S.I.R., Lincoln, as follows:

M. australis—158520.
M. australis X *complexa* (first generation)—158519.
M. australis X *complexa* (second generation)—158521, 158522.