A Hypothesis in Regard to the Westland Rimu Bush.

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It is now seven years since, with the passing of the State Forests Act of 1921-22, the people of this Dominion set about the conserving of the natural forest wealth of the country, and the taking of reasonable steps to insure to future generations the same freedom from timber shortage now enjoyed by the present occupiers of the land. In that short time much has been accomplished in certain lines. In the planting of previously waste lands to exotic trees, mainly conifers, a world's record, it is understood, has been set in scope of enterprise, improvement of technique, and lowering of establishment costs, so that over half a million acres of land are now being turned to profitable account, where previously nothing was produced. Side by side with that achievement can be set the investigations, only now commencing to bear fruit, into the use of forest produce, resulting in the new system of timber grading, for instance, and the exploration of new avenues for use of previously wasted timber species, and so on.

Nothing has yet been done, however, in regard to the management of the native bush, even though it is this same native bush which provides the lion's share of the revenues which make possible the extensive afforestation work now in hand. Cruising and other mensuration methods have been vastly improved, and the old royalty on output system with its incentive to inefficient cutting, has been displaced by the system of lump sum payment on estimated volume, so that utilization has advanced somewhat. Not one step has yet been taken toward the securing of natural regeneration on the cutover areas, however. The lands as relinquished by the logger are either turned back for settlement, if considered worthy of such purpose, or merely held as cutover land, pending an ultimate solution of the problem of this cutover land. The beginnings of fire protection are in evidence, but no silvicultural measures leading to the securing of natural regeneration have yet been definitely adoptd as standard policy or practice.

There is still, indeed, much questioning as to the possibility or the advisability of perpetuating the native bush at all. It is coming to be freely admitted that most of the land now occupied by native bush is useless for agriculture, but in regard to securing a second crop of timberland, public opinion has yet to be convinced that efforts toward securing a perpetual series of crops of timber from the stands of native bush hold out any prospect of economic success. In fact the opinion of the man in the street on the whole subject may be summarised as either:—

That the native (Podocarp) bush will not reproduce to timber trees after logging, but invariably progresses into a "second-growth" or new type association, usually broad-leafed and of no commercial value.

Or that the native bush under certain conditions will reproduce to timber species but that it grows so slowly that it is not worth while to attempt it.

Sometimes both these ideas are advanced together. Either way, the case for the native bush is dismissed as hopeless. From the scientific aspect, the first objection raises the question of plant succession,—the second, that of rate of growth, both matters of vital import to the forester considering the natural perpetuation on a commercial basis of a virgin forest area.

It is intended in this paper to discuss certain aspects of the two objections given above, on the basis of recent investigations in the rimu stands on the Westland terrace areas. The arguments put forth are intended to apply only to those stands, and not to the rimu forests of either the North Island or Southland, where tawa in the first case and beech in the second introduce complicating factors not present in Westland.

In the first place let it be said immediately that the theory that the rimu type is a temporary or transition type in a plant progression, or succession, is not accepted in this paper. This theory has found its chief scientific expression in Cockayne, who in his latest work, Part II. of his monograph on the beech forests, makes the following statement: "All this (the self-perpetuating nature of the beech type) is very different from the broad leaf tree-podocarp rain forest, where the desired podocarp stand is a temporary succession, not a climax. . . . . ."

It is held that this statement is not proven. No conclusive evidence is given by Cockayne either here or elsewhere in his published works, to prove this statement, which seemingly is based upon relative proportions of rimu and broad-leafed seedlings under mature forest as judged by observation. The factors of comparative tolerance, comparative rate of height growth, and comparative total height growth seem not to have

been thoroughly weighed and considered. Until concrete evidence, quantitatively expressed, and applying to a definite area, shows beyond doubt that a change in type is actually in progress in the virgin stands, it seems rash at least to say flatly that the rimu type, so universal in New Zealand over such a wide range of latitudes and soils as the dominant rain forest type, is but a transitory stage.

A more plausible theory is that tentatively advanced by Foweraker in 1923 in a Government report, extracts of which appeared in Te Karere o Tane, the newsletter of the State Forest Service. The substance of this was that the rimu type was a climax one, arrived at through a transition stage of broad-leafed species,—that the rimu was unable to regenerate direct, but reproduction came up under a "nurse" association formed by a broad-leafed growth which furnished shade, shelter, high humidity, etc., needed by the young rimu. Considerable tolerance enabled the rimu to withstand the dense shade in its youth, the greater total height growth ultimately lifted the rimu above the tops of the broad-leafed trees to form a pure rimu top canopy or upper tier once more.

These two authorities constitute the whole of recent published work on this matter, though as Foweraker has been concentrating on this subject from the quantitative standpoint since the time of the report quoted, it is understood that some definite evidence is being assembled. Publication of his findings will therefore be awaited with great interest.

Turning, now, to the second objection— that the native bush is of such slow growth that it is not worth while wasting a thought on its perpetuation, the forester in New Zealand hears again the old familiar objection conquered by foresters first in Germany about the sixteenth century, in France a century later, in America in the last twenty years, and in Britain only since the War. In New Zealand we have had as yet little of a conclusive nature presented quantitatively. Opinions range from the optimistic estimate of Sir David Hutchins, to the utmost pessimism of the man in the street, but in no case yet have figures of an unassailable nature been brought forward, to apply the touchstone of fact to the various opinions expressed.

With matters in this happy stage of thorough uncertainty, as regards growth, at least, it has seemed pardonable therefore to set out a conception of the Westland rimu forest, admittedly still very theoretical but seemingly in accordance with the facts as so far known. The basic idea can be stated briefly, after which the evidence can be submitted. The idea is this:—That the Westland rimu bush represents a forest type which, little matter its present condition in virgin stands, is one capable of being managed, on a perpetual basis as a pure evenaged type yielding returns of milling timber greatly in excess of that now secured from the virgin stands, within a very reasonable time as that is viewed by foresters, and indeed on a basis which compares very favourably with European yields of timber of considerably inferior intrinsic value.

To support this statement, silvical evidence must be called in regard to the statement that rimu grows "pure" and "evenaged," and in regard to the possibility of securing fully stocked regeneration after logging, while the evidence of mensuration must support the statements made in regard to growth and yield.

The evidence is as follows:—

For the propriety of calling the rimu bush a pure one, from the forestry standpoint, the following may be said:

In regard to composition of the rimu bush, the Westland ecological investigations of Foweraker, summarized in a brief descriptive article published in the 1925 issue of Te Kura Ngahere, reveal the wealth of plant species included in the rimu forest type. Including all arborescent forms over thirty distinct species are mentioned. No wonder visiting foresters from temperate climates were amazed, and baffled, in their earlier attempts to analyze this forest and grasp the essential components of its composition. To the botanist, the forest is an almost overwhelming association of plants, each meaning as much or as little as the next. To the bushman, the problem is exceedingly simple. The forest contains one primary and one very secondary milling soft wood with one hardwood sometimes disposable but usually not. To him, it is a rimu forest, either pure, or with varying admixtures of rata, and with always a fairly constant sprinkling of miro. To the forester, seeking not only to secure a forest of high commercial value, but also to perpetuate it, which of these two conceptions is the vital one? Foweraker has pointed the way in his classification of the members of the forest association into a series of height tiers or storeys, though in his article previously referred to he considerably understates the height of the rimu, or top tier, which is from 80 to 110 feet in height. In the virgin bush of Westland there are but two occupants of the top tier from 80 feet upward, namely rimu, always predominating, and rata from almost absent up to perhaps close on 50 per cent. at an elevation of 1,000 feet and over. Likewise, in the second tier, from 60 to 80 feet, are but two species—miro

and hinau. Below that level the number of constituent species increases in multiple proportions. The forester is therefore fully justified in regarding his stand as a pure rimu, or a rimu-rata type, once the main height growth of the key species has been attained. With its heads once above the 80 foot level the development of a rimu generation goes on almost unmindful of the lower members of the stand. It is quite immune from further competition except through the expansion of its own crowns, and lives out its cycle almost as though no other species were present, save for the non-competitive effect in maintaining a high humidity, building up the forest soil, etc. Far from being a jungle, without order or explanation, the mature rimu forest becomes a forest type far simpler in composition than many of our artificial exotic stands once the nature of the height relationship is graphed. The lower tiers become of interest only when a rimu stand is developing from the seedling stage to the time when height growth has taken it beyond the reach of the third, or kamahi—kamarahou tier, the densest of all the height levels, which reaches up to about 60 feet. The factors of density of shading and condition of the forest floor will largely determine the density of stocking of rimu seedlings, and the factors of comparative tolerance and comparative rate of growth between the rimu and the inhabitants of the lower tiers will determine, not the ultimate occupiers of the realms of upper light but the completeness of the ultimate stocking of the upper tier by the rimu which survive the struggle upward through the broad-leafed canopy of the third tier as typified by kamahi and kamarahou. The advantage of greatest ultimate height lies always with the rimu, and if a full stocking of seedlings can take place, and then through tolerance or rapid growth can endure, and still keep on increasing in height, however slowly, ultimate victory is certain, and a fully stocked rimu stand will result,—that is, a stand whose crowns occupy the whole of the top tier space. What then may happen in the lower tiers is of no further moment. And though most of the present mature rimu stands are seriously understocked, fully stocked areas of various sizes can be found everywhere, proving that under favourable conditions sufficient rimu can and do survive this ordeal to fully stock the upper tier upon their ultimate arrival.

The rimu stands, therefore, may quite accurately be conceived as pure stands of a single species of forestry concern, except that the problem of perpetuation of the stands is complicated by the presence of a host of broad-leafed third tier associated species through which, in many cases, the young rimu must struggle upward to the light and freedom of the top tier. This aspect of the case is now being thoroughly explored by Foweraker, as previously referred to.

Turning now to the second point, the age-form of the stands, it seems evident that new ground must be broken. It seems to have been generally accepted without any great investigation, that the rimu stands occur naturally in a typically all-aged or selection form,—that any unit of area contains, within itself, rimu of all ages and in all stages of development from seedlings to veteran.* Such a conception naturally entails a fairly to very tolerant species. It also means that though a normal stocking and a normal distribution of age classes may be present on an area, the mature trees are scattered over an entire forest, rather than segregated in distinct areas each given over to one age class only. In other words, it is the most expensive type of forest to log, as opposed to the clear cutting in evenaged stands, which is the cheapest type. The prospect of the higher logging costs that might be incurred were silvicultural restrictions applied to logging operations has frightened not only sawmillers but also forest executive officers, and the matter has been hastily shelved.

Yet there is distinct evidence that, in Westland at least, the rimu stands are by no means selection, or all-aged in nature, but have a distinct tendency toward an evenaged grouping. There is reason to believe that the natural habit of this species is to develop in evenaged stands, and very scanty material so far studied would indicate that the present virgin stands now being milled are composed of groups, clumps, patches and areas of considerable size, all of which are evenaged within themselves.

The possibilities opened up by this theory of origin are immense. If it can be shown that it is the natural tendency of rimu to develop in evenaged stands, there is a challenge to the forester to see whether such stands can be induced under management. A few studies of density of stocking on the basis of crown space occupation in mature stands would point to a fully stocked yield of about 75,000 feet per acre or somewhat more. If a managed forest of rimu can be made to produce fully stocked stands at maturity of the above yield, grown in evenaged stands of some considerable extent, then a vastly better utilization prospect is offered

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*Hutchins at least seems to work on this assumption, and little other reference to the matter can be found.

than is now the case. The sawmiller's bogey of silvicultural practices which would decrease his yield per acre, with consequent increased logging costs, is gone; and in its place is the prospect of securing treble to quadruple the present yield per acre from every acre worked over, with consequent lowered costs of logging.

The prospect is an alluring one. Can it be given effect to? That question is unanswerable as yet, but let us examine the evidence in regard to the evenness of age of the rimu stands.

The first impression gained by the writer that the rimu bush was by no means typically selection was in 1924 in the couse of rimu stem analysis work in Butler's Bush, south of Hokitika. Following the felling crew over five consecutive rope roads it was noticeable that the trees worked upon were mainly, or almost wholly of two size groups only. Most of the trees were roughly either from 14 to 18 inches D.B.H., or from 26 inches to 30 inches. It was not possible to secure a full range of D.B.H.'s from which it was hoped to work up a correlation of age with diameter, and the scene of operations had to be shifted to other parts to get a full run of sizes. The possible significance of this was not realized at the time, and no records were kept as to the occurrence of the trees as to size groups, etc., so that this data is of inferential value only.

In 1927-28, however, in the course of establishing a series of permanent sample plots for the observation of the development of rimu stands on the Westland Forest Experimental Area, unmistakable evidence was encountered that a number of the stands being dealt with were evenaged. Once this characteristic was recognised it was sought for, and it was found possible to establish quite a connected series of plots of different average sizes, all of which were evenaged in character. Proof of evenness of age is found in the stand table showing D.B.H., height, and crown class. The following case is typical:—

1. Total number of podocarps above 3 in. D.B.H., on ¼-acre plot—64.
2. Total number of rimu only above 3 in. D.B.H., on ¼-acre plot—54.
3. Average D.B.H., all classes, all species— 9.5.
4. Average D.B.H., all classes, rimu only— 9.7.
5. Dom. Cr. Cl.:—No. 21, Av. D.B.H. 14.0, Dispersal 9.0—19.9.
6. Codom. Cr. Cl:—No. 21, Av. D.B.H. 10.1, Dispersal 7.1—15.2.
7. Interm. Cr. Cl.:—No. 14, Av. D.B.H. 6.8, Dispersal 3.1—8.4.

8. Suppr. Cr. Cl:—No. 8, Av. D.B.H. 4.3, Dispersal 3.1—5.9.

Such a range of average D.B.H., and a fall, or range of dispersal, of upper and lower limits is what may be secured from any overcrowded Canterbury plantation, where every tree was planted on the same day from the same class of stock, and the stand then let go unthinned. There is no questioning this evidence of evenness of age for the plot in question. This case is not isolated nor hand picked. Several other such tables could be given showing the same relations between average D.B.H.'s and the dispersal of D.B.H.'s in the four crown classes, but the case given, Plot C 2, Westland Experimental Area, is typical. Altogether, out of a series of eleven plots established, seven were in stands of pole to small standard size in various stages of development, and showed unmistakably their evenaged character.

The areas thus investigated were all small in themselves. In some cases difficulty was experienced in fitting in a rectangular quarter-acre plot without getting into old workings. The stands as typified by the plots were all the remnants of small areas of young growth that had been passed by in logging due to smallness in size, and had been fortunate enough to escape subsequent injury by fire. Snig tracks and tramlines ran through many, leaving a broad path of destruction later widened by fires, so that little could be definitely said as to their original area at the time of logging. One and all were characterized, however, by a uniformity of heights, of D.B.H.'s and of crown class dispersal, and in every case, also, by an overstocking which in one case was as much as 50 per cent. in excess. There was no lack of natural regrowth here. Evidently some conditions had operated favourably to induce on these areas, which were probably at least an acre in size, and probably more, a full stocking of rimu regeneration all at one time. The trees had all come up together, had successfully run the gauntlet of any third tier competition that might have been in existence at that time, and had emerged above the kamahi-kamarahou level of 60 feet in numbers so great as to be overstocked almost immediately.

The series of plots investigated went as far upward as a stand whose average D.B.H. for all classes was 11.5 in., and for the dominant-codominant crown classes only was 14.3 in., with a dispersion of from 9.8 to 21.1 in. The evenness of age and the overcrowded stocking mentioned were unmistakably present here in this stand of almost milling size, so that undoubtedly it appears that certain conditions will give rise to evenaged

PLOT C2. AN EVENAGED POLE RIMU STAND.

stands of some extent, which maintain a full canopy, and full possession of the upper tier right up to the commencement of maturity.

With this much definitely established in regard to younger stands, an examination of mature stands was begun, to see whether any tendency toward evenaged composition could be discovered. The Westland Experiment Station furnished two plots in mature and distinctly overmature bush passed over by the loggers, due probably to factors of accessibility. The stand table here was not so definite in its indication. As is the case with most mature stands, the areas were greatly understocked, one quarter to one third of the available space being occupied by crowns of mature rimu. Advance growth of several stages of development occupied some of the gaps in the top tier of crowns. At the same time, the main body of mature trees fell into rather more or less well defined D.B.H. groups. In Plot C 4, for instance, the stand table showed the following mature trees:—

D.B.H.	No. Trees.	
35	2	Age Group I.
33	1	
28	4	
27	4	
26	3	
25	2	Age Group II.
24	1	
23	4	
21	1	
19	1	Age Group III.
18	2	

In regard to this stand-table, it seems quite feasible that the origin of the present stand is roughly as follows:—

The three large trees, Age Group 1 represent the advance regeneration which got a start in the gaps of a previous approximately evenaged stand, whose stocking like almost all present stands, was subnormal. This group was originally somewhat larger than now, and has lately begun to lose numbers through decadence. The main body, Age Group II., then followed on more or less together upon the overthrow within a comparatively short time of the previous stand. Age Group III. probably represents the stragglers, those which originated upon the overthrow of the last of the previous stand. Still another age group, from 9 to 14 inches D.B.H., is now formed, advance growth come in comparatively recently, due to the understocked nature of the present stand of mature trees. With a full occupation of top canopy by the mature trees, this fourth age group could not have come into existence.

This explanation seems feasible but of

course is by no means definite. The stand is well on in its development, and so many things may have happened in the past to affect the stand that crown class, D.B.H. and age correlations based on the present appearance of the stand may be hopelessly awry.

The close of the field season prevented the serious study of millable green bush on a large scale, but ocular inspection of several miles of cruise line seemed to support the theory of the evenaged origin. Over any given few chains, in most cases, a uniformity of D.B.H. was apparent, which might indicate an evenness of age. No data was gathered as to the area over which these stands of seemingly evenaged trees extend. Some size-type mapping is planned for a future field season to further investigate this matter.

In regard to the present milling stands, then, the most that can be said from present knowledge is that it is quite possible that an evenaged tendency is present. The stands are by no means regular in nature, as is to be expected. In the virgin stands the ranks of the veterans are always thinned unevenly, as the period of over-maturity drags out long past the age for most economical milling, and it is only natural that advance growth will be starting at different times in different places on a small scale as overthrow of the previous generation proceeds. From the standpoint of forest management, indeed, it is really of little matter whether the present stands are evenaged or selection in nature, so long as a full distribution of age classes is to be found somewhere. The important fact is the positive evidence that under certain conditions the species will develop in evenaged form in a fully stocked stand right up to the verge of milling size. The important thing now is to discover, and if possible duplicate on a large scale, the conditions under which these evenaged stands took their origin.

This matter will be touched upon in dealing with the next topic, the possibility of securing regeneration after logging.

Turning therefore to this third heading, —the regenerative powers of the stands, definite knowledge, based on systematic counts and measurements is again far from complete, and it is as yet impossible to make any definite statements covering any aspect of the question. Foweraker is now at work on this problem, and his sample plot figures should clinch the case definitely. In the meantime, theorizing seems necessary. Enough has been revealed, however, to show clearly that under certain conditions, rimu not only regenerates but comes up so thickly that it forms almost pure evenaged stands so dense that overstocking is chronic right from the

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beginning of the pole stage. The cases of the series of plots mentioned in discussing the second point, the form of the stands, form illustrations in this regard, and these are not isolated cases by any means. Every bushman, in fact, can point out numerous areas, usually a chain or so across, though occasionally many times this size, where sapling and pole rimu may be seen almost literally "as thick as young wheat." The weak point is that none of these areas are usually of any great extent in themselves, nor do they occur very frequently as a rule. Under mature bush, of course, seedlings and saplings are conspicuously rare. On cutover lands, conditions are variable, but as a usual thing, little reproduction is seen. It is quite understandable, therefore, that the general impression is that the rimu stands will not easily reproduce. Yet the case is by no means as hopeless as would seem. The fact that good areas of regeneration can be found at all, tends to upset the theory of changed silvical conditions making impossible the further perpetuation of the rimu type. A reasonable explanation is at hand to account for the almost complete lack of regrowth under mature stands, and for the sickly and stagnant condition of those that are present. This is the conception of rimu as an intolerant tree, unable to develop in the heavy shade of the mature forest, with its very complete utilization of light by upper, second, third, and fourth tiers of vegetation, each getting less and less of the available sunlight. Rimu, the tree of the top tier, in the full upper sunlight throughout its mature life, might feasibly demand a very considerable proportion of full light throughout its early life as well. This characteristic is by no means new to foresters, but is a feature of many of the best known timber trees of the world. It does not harmonize with the selection theory of form-origin, but does harmonize with the theory of evenaged origin brought forward in this paper. If this conception is correct, then the complete lack of regeneration under nature stands is the natural sequence of things, and would be quite expected.

The hypothesis is advanced that the rimu is a moderately intolerant tree not only during its mature stage, but throughout its whole life, and will reproduce only when a rather large proportion of direct light has access to the ground. When such is the case, under certain conditions reproduction is abundant, though just what conditions are necessary has not yet been satisfactorily explained. In the virgin state, it is postulated, the reproduction gets a start on "blowdowns"—areas where from one to many mature trees are uprooted and sent crashing to the ground together through the force of the wind. These blow-downs are of frequent occurrence in Westland. Often but a single tree is involved, but more frequently an initial tree, in falling, will strike others and uproot them, they in turn felling others in their fall, so that a considerable area may be laid flat at one time. An authentic recent blowdown near Hokitika involved about two hundred acres in a comparatively long narrow belt, over which destruction was more or less complete. It is advanced that it is in such areas that the stands of evenaged densely stocked pole stands that have been previously cited, took their origin. In such "blowdowns" the destruction is usually fairly complete. The larger trees carry with them practically all of the smaller second, third, and fourth tier trees, and a goodly share of the mineral soil is exposed to the light in the upturning of the root systems. It is very possible that it is this exposure of mineral soil and/or the removal of the broadleafed third tier which provides the necessary conditions for successful germination of rimu, and its subsequent uninterrupted development. Mention has been made of Foweraker's tentative succession theory, which advances the hypothesis that rimu will not regenerate to rimu direct in full light and exposure, but after the area has gone through a scrub stage, as myrtle, and a kamahi—kamarahou stage, then rimu regeneration, favoured by shade, shelter, high humidity, etc., will come in, to rise beneath the kamahi, push through it, and again form a pure rimu top canopy. In many cases this is undoubtedly true, and this process may be seen in progress on many Westland areas, but it is held that it is not by this process that the present virgin stands have arisen, nor is it necessary in attempting to reproduce the rimu stands to go through this time-consuming progression. It is advanced that the broad-leafed associations are not "nurses" to foster and protect the desired rimu, but rather distinctly deleterious, tending to smother out any rimu that may germinate beneath. This view gets a certain amount of confirmation from various aspects. First, where rimu does come in under kamahi-kamarahou, it is only after the latter have attained full height, and their crowns are thinning out, letting more light through to the floor beneath, that any rimu will germinate on the area. This means a delay of 16 years after logging before regeneration begins according to Foweraker's investigations at Bold Head, on an unburnt area. Recently logged unburnt areas examined, where a low dense cover of myrtle, hupiro, sucker kamarahou, etc., is in full possession, are almost devoid of rimu. Adjacent areas so hotly burned that all the broadleafed trees were

killed, however, but where live rimu seed trees were not far away, show, on the other hand, comparatively plentiful rimu regeneration.

Seedling stockings up to 15,000 per acre, in fact, have been counted on areas logged, burnt, cleared, grassed, and gone back, after Forest Service control had put a stop to recurrent scrub fires, and the presence of stock, while the same areas showed a very fair stocking—250 per acre for a measured quarter acre—which had germinated and attained heights of three to twenty feet in spite of the fires and the stock. So there seems good ground for the theory that exposed mineral soil or freedom from broadleaf suppression, but probably both these conditions, must be secured in order to get a satisfactory natural regrowth.

If such is the case, the question arises, why is not the cutover land well covered with regeneration, since it would seem that such areas offer an approach to the conditions just postulated as being necessary for successful establishment of regeneration? Recurrent fires, together with the presence of stock, probably are the cause for the present barrenness of the cutover lands, coupled with the fact that as logging advances, destruction is fairly complete as regards all rimu of seed bearing age, so that very few seed trees are left to restock the area. A first good hot burn soon after logging sems to be of high value in killing the broadleafed trees, and baring the mineral soil. On such areas fairly abundant regeneration can be expected, from seed lying dormant in the duff, mainly, perhaps, and from surrounding uncut trees. Later burns kill this regrowth, and then all chance of securing regeneration in any quantity seems lost, as the rimu seed is comparatively heavy and is not well adapted to wind dissemination, while it is also seemingly, as it occurs usually in Westland, unpalatable to birds.

Shortness of effective radius of seed distribution coupled with the dioecious nature of the species may, indeed, prove to be stumbling blocks of some magnitude in attempting to secure reproduction by means of reserved seed trees, to say nothing of the windthrow liability, but the very little evidence so far at hand gives rise to the hope that it may be found that the reproduction from seed lying dormant in the duff at time of logging may be great enough to give a reasonable stocking without the assistance of reserved seed trees.

It is a matter upon which little is known definitely as yet, and it will be a few years before results are to hand from Foweraker's series of investigations now under way. In the meantime, there seems good ground on which to base the theory that regeneration of rimu takes place in satisfactory quantity on areas where the mineral soil is exposed to greater or less extent, and where full light has access to the ground level. It should therefore prove feasible under forest management, to secure a reasonable stocking of young growth following clear cut logging and slash burning, provided that the areas are protected against further fires, or damage from stock. This would mean that the period of 15 to 20 years of lost time in succession stages could be deleted, and a better stocked regeneration got under way almost immediately, while presumably the rate of growth would be accelerated in youth due to freedom from suppression.

This concludes the silvical evidence in regard to the three points set out for discussion. The remaining point is that dealing with growth and yield, a factor which is the crux of the whole question of management. To support the initial statement, namely that the rimu bush was a type "capable of yielding returns of milling timber greatly in excess of that now secured from virgin stands within a reasonable time on a basis which compared favourably with European forest yields," tentative evidence has been assembled on three points, the factor of density of stocking as applying to present virgin stands, the current increment now being made in young stands, and a provisional yield table for pole sizes.

As a start to a study of density in present virgin stands, an investigation was made of crown space utilization in two stands, one of mature, and the other of rather overmature rimu bush. The present milling volumes of rimu only are 24,000 and 19,000 super. feet gross respectively. Like all present virgin stands the areas are greatly understocked, so far as mature trees go. Great gaps in the canopy occur on all sides of the groups, clumps, or individuals of rimu. By means of mapping in the crown space actually utilized, an attempt was made to determine the approximate yield that would be obtained were the areas fully stocked as to crown space utilization. The results were that in the first case the area was 31.5 per cent. and in the second case 27.8 per cent. utilized. Increasing the present volumes to a basis of complete utilization, the indicated volumes would be 77,800 and 76,000 sup. ft., per acre respectively. The inference drawn therefore, is that fully stocked rimu stands at maturity, if such can be obtained, could be expected to yield about 75,000ft. per acre. In this calculation no account was taken of D.B.H., except that only those trees which entered the top canopy were mapped, and tallied for volume. This excluded all young rimu up to

about 14in. D.B.H. The two areas are Plots C 4 and C 6, the stand table for the former being quoted elsewhere in this paper. No data on the rotation needed to produce this yield can be given, but the final yield gives a tentative basis for comparison with other species. The 75,000 feet quoted are based on the present rather wasteful conversion methods.

The next point is that dealing with current increment. A start has ben made on a fairly extensive series of sample plots in virgin stands to measure the increment actually in progress, but no data is as yet to hand giving the result of periodic remeasurement except in two cases. One case is the remeasurement in Sept., 1927, of the Perry's Bush plot established in 1921, the details of which are given in the 1927 issue of Te Kura Ngahere, and the other is the re-measurement in 1928 of a plot established in 1925 on the Experimental Station,—Plot H 3 as it is now known. The results of these two remeasurements may be briefly stated as follows:—

In Perry's Bush the stocking is given as 245 trees per acre, though this seems abnormally low in comparison with all the young plots on the Experimental Station. The average D.B.H. in 1921 was 8.17in., and the volume 2,818 cu. ft. per acre. This stand increased in $6\frac{1}{2}$ years at the rate of $83\frac{1}{2}$ cu. ft. per acre per year to a volume of 3,360 cu. ft. per acre, representing an increment per cent. of 3.19 per cent. per acre per year, while the average D.B.H. increased to 8.71, a gain of over $\frac{1}{2}$ inch.

The results obtained on Plot H 3 were considerably better, a slightly greater D.B.H. increase and a greater increment per cent. gain being recorded, while the total volume, due to a much greater stocking, is also greater. The average D.B.H. of 8.3in. in 1925, increased to 8.6in. in 1928, individual increases of .2 to .6 inch being the rule, with one increase of .9in. in a kahikatea. The stocking of 384 trees per acre was reduced to 369 trees per acre during the three years.

In basal area, the 1925 area of 159.7 sq. ft. lost 2.626 sq. ft. in deaths and gained 10.848 sq. ft in growth to give a new total in 1928 of 168.0 sq. ft. or a net increase of 8.3 sq. ft or 2.8 sq. ft. per acre per year.

Similarly in volume the 1925 figure of 5,439 cu. ft. per acre lost 74.4 cu. ft. in deaths and gained 880.5 cu. ft. in growth to give a 1928 total of 6,245.1 cu. ft. being a net gain of 806.1 cu. ft. per acre in three years, or 268.7 cu. ft. per acre per year, which is equivalent to an increment per cent. of 4.6 per cent. per acre per year.

By themselves, these two isolated cases mean little, for we have nothing with which to compare them. The increment per acre per year is three times in one case, what it is in the other. Is the difference due to age, stocking, site, abnormal conditions or error in mathematics? On a comparison of the stocking per acre for the two plots, both of almost the same average D.B.H., it seems possible that an error in measurement of area has occurred at Perry's Bush. Perry's Bush has a much lower stocking than H 3, yet it is stated to be overcrowded also. It is possible that its area has been wrongly computed. The figures for H 3, if a true picture of average growth conditions, are really most encouraging, as the increase of 268.7 cu. ft. per acre per year, if being laid on upon boles of merchantable size would mean a growth of roughly 1,500 sup. ft. per acre per year. It is quite possible, of course, that the increment recorded here is abnormally high, though considering the overstocked nature of the stand, this is not likely.

So far as increment by known time periods goes, this is the extent of our present knowledge. It is little enough, and of only indicative value, but it gives ground for considerable optimism, and shows clearly that under some conditions at one period of its life, rimu makes a comparatively large increment, as such is judged in European or North American practice at least.

The final point to be submitted deals with the construction of a tentative table of yields for young stands based on plots in evenaged pure rimu of small to large pole size. Four areas were selected for the purpose. They were of uniform site, so far as could be judged by observation, and presented a good field for comparative results. Lacking any authentic data as to age, the age factor could not be introduced, so that in the strict meaning of the term the table evolved is not a "yield table," but D.B.H. was used as the time function, and periodic remeasurements of increase in D.B.H. from one average size to the next will in time permit the time element to be substituted for D.B.H. The plan followed was this:—The present volume, average height, D.B.H., stocking, crown space utilization, and proportions of crown classes present were studied as carefully as possible. Crown space utilization was obtained by combined crown mapping and ocular estimate. From these results a conception was formulated of the normal stand which might be expected to occupy the area under favourable conditions. This conception was based on the trees of the dominant and codominant crown classes. From the crown-space studies the number of dominant-codominant trees which would stock the area at normal density of these two classes only was determined. From

actual present volume of these two classes now on the area, increased or decreased to the required normal stocking, the normal volume for the fully stocked area was derived. The average present D.B.H. of the two classes was taken as being the average for the normal stand, while average height was treated similarly.

The present condition of the four plots studied may be tabulated on a per acre basis as follows:—

Plot.	C 1	H 3	C 2	C 7
Av. D.B.H.	5.4	8.3	9.7	11.5
Av. Vol. per Tree	4.2	15.3	22.3	33.5
Stocking—				
Dom.	160	123	84	64
Codom.	210	102	84	76
Inter.	150	72	52	44
Suppr.	130	72	36	52
Total	650	369	256	236
Basal Area	140	168	149	182
Volume	3,338	6,245	5,690	7,227

The yield table which was evolved for normally stocked stands of the same ages as those of the above plots is as set out below:—

Basis D.B.H.	No. Plot	Ht. ft. Av.	Av. Vol. Cu. ft.	Stocking per acre	Basal area.	Volume per acre. cu. ft.	Appar. In-crement cu. ft.
6.6	C 1	52	6.21	920	124	3,224	
10.2	H 3	80	24.74	246	139	6,086	2,862
11.9	C 2	74	28.56	224	173	6,398	312
14.3	C 7	83	46.26	168	187	7,773	1,375

In these tables evidently H 3 is abnormal compared with the others, with its greater height for given D.B.H. The high proportion of dominant trees is explained, however, by the fact that one end of the plot was lightly culled within recent years, so that a number of trees previously suppressed are now dominant. The difference in total volume between the present and the conceived normal condition of each of the stands is slight, but a comparison of the stocking and D.B.H. figures brings out well the point of the discussion,—namely that under management, whereby the density was maintained at the normal or optimum for best diameter growth, the rotation would be appreciably lessened. That is, that at the same age as that now possessed by the present stands, whatever it may be, the trees under optimum density conditions, would average considerably larger, thus shortening the time taken to produce a crop of boles of economical milling size, even though the total cubic volume per acre at the given age might not be greatly affected.

To obtain an indicative check on the table, the stand table of yet another plot, C 5, was examined to see whether the average dimension and volume figures tended to harmonize with the table. This plot has a stocking of 490 trees per acre, a basal area of 210 sq. ft., and a volume of 7,535 cu. ft. per acre. The average present D.B.H. is 8.5 and average volume per tree 16.0 cu. ft. Dominant and co-dominant trees total 250 per acre of the total of 490. Considering these two crown classes only, the average D.B.H. is 10.5. Interpolating in the normal table for this D.B.H. a stocking of 240 is indicated. The plot is seemingly slightly overstocked. The heavy ratio of 160 co-dominant to 90 dominant trees bears this out. Evidently slight stagnation is present. The volume for these two crown classes, 5,953 cu. ft., also bears this out, the normal from the table being about 6,100 by interpolation. In other words the evidence of Plot C 5 goes to show that the tentative yield table drawn up on the average D.B.H. of the upper two crown classes holds approximately true in its proportionate relations of volume and stocking in pole stands.

The table as formulated shows an interesting parallel to Schlich's yield table for Scots Pine, Site 1. On the basis of identical D.B.H., stocking, basal area, and volume run very similarly. Scots Pine, according to Schlich, takes 100 years to reach an average D.B.H. of 14 inches, at which time the stocking is 170 stems, the basal area 181, the height 95, and the volume 8,460 feet. At what age rimu reaches the same size and yield, as quoted for Plot C7, is, of course, yet to be discovered, but whatever the absolute age, it is still in its physical youth, and making rapid height growth with the characteristic pyramidal crown. The flattening of the crown and cessation of rapid height growth do not occur in any of the pole stands so far studied, so that there is abundant time, relatively, for development from the C7 stage with its 8,000 cu. ft. per acre to the 16,000 cu. ft. needed to produce the 75,000 sup. ft. per acre of final yield previously referred to.

In conclusion it is freely admitted that the method used in thus formulating a yield table lacking any knowledge of the element of time, and based upon a conception of normality checked only by observation, for a species whose silvical characteristics are by no means fully worked out, and based upon only a few plots not by any means optimum for the purpose, can be criticised from several angles. It is thought, however, that the inferences drawn in regard to the silvical nature of rimu, and its development and rate of growth together with the admittedly scanty, but still indicative evidence upon which they are based, should be made public. None of the points made can be called proven by any means, but in view of the absence of any other data based on quantitative work, they may serve to awaken interest in the native bush, and to initiate a discussion which may bring forth a great deal of knowledge now not available in published form.

Opossums in our Forests.

(M. R. Skipworth.)

It is doubtful whether any other country possesses such a history of mismanagement and lack of foresight in the introduction of fauna, as that of New Zealand. We are certainly without the English fox, which was successfully established in Australia, with the result that it is now the greatest animal pest in certain parts there. Fortunately, the attempts at acclimatization of this pest in New Zealand were unsuccessful. Where man introduces mammals and birds to a new country, without exercising efficient control over them after their successful establishment, the result is usually detrimental.

With forests in New Zealand that have been evolved almost entirely without the presence of mammals, the effect of release of the latter in recent years has been great. The silvicultural welfare of our native forests, however, has always been entirely neglected. The providing for New Zealand's future timber requirements has been entrusted to the planting of exotics, an unusual and daring policy, being on entirely new forestry principles. The Eucalypts and spruce have already been devastated by insect attack, certainly perhaps, aided by the choice of the wrong situation in many cases, and there is no reason to assume that our pine plantations, the majority of which are in an unnatural habitat, will remain immune from such attacks. Sir William Schlich referred to the fact that our indigenous forests "have practically been thrown overboard" as "certainly a very bold measure," and asked: "Whether it is safe to introduce exotic species on this large scale without risking the development of disease which may lead, in the end, to disastrous results?"

Apart from considerations of timber, our protection forests require correct silvicultural treatment for regeneration in order that they may be permanent. This correct silvicultural treatment consists in the maintenance of their natural conditions, with the exclusion of all things that tend to upset those conditions. For some years they have been subjected to the depredations caused by deer, pigs, goats and wild cattle, but the damage is largely recognized, some steps having been taken towards their extermination. It is peculiar that the acclimatisation societies, who are largely responsible for the presence of deer in such numbers, should share none of the expense involved in their extermination in districts where they are causing damage, but they are allowed to continue exercising protection over them in some districts, and introducing and protecting such pests as moose and wapiti. The chamois and thar, liberated in the Mt. Cook region, are already causing great damage to the mountain flora, and if allowed to multiply and spread along the Alps, they will be an extremely efficient force to wipe out the vegetation in those regions. In commenting on such acclimatisation mistakes the Hon. Geo. M. Thomson in his book "Naturalisation of Animals and Plants in New Zealand" states: "The whole history of acclimatisation efforts in New Zealand abounds in similar bungles and blunders, and while a certain measure of good has been achieved—notably in stocking our nearly empty rivers and lakes with fine food—and sport—fishes, yet the record of harm done is enormously greater. So called acclimatisation societies to-day are only angling and sporting clubs, and it is a question whether the whole control should not be taken up by the Government."

In the 'eighties and 'nineties various acclimatisation bodies and private persons introduced the Tasmanian and Australian opossums, and they were liberated in several different parts of the Dominion. They adapted themselves to the new conditions, which were ideal, and multiplied rapidly, spreading over many parts of the country. They were free from their natural enemies, trapping being the only thing which limited their numbers, whereas in Australia they are preyed on by the eagle and the great monitor lizard, or goanna, which is able to climb the trees and attack the opossum in its retreat. The effect of the opossum on our forests, however, has caused considerable argument. Past reports of the Director of the State Forest Service state that its economic value as a fur-bearing animal much outweighs the very slight damage that it causes, and recommend the extension of the opossum trapping industry by closed seasons in over-trapped areas, and the release of animals in unstocked regions. On the other side a number of observers throughout the Dominion report on damage done by the opossum both to native and exotic forests and also as to their effect on native bird life. Those who are opposed to the opossums certainly have all biological and silvicultural principles with which to support their argument. Two reports have been prepared for the Government, in order to decide on what policy should be pursued in the future with regard to the opossum. Both reports, one by Professor Kirk in 1920, and the other in 1924 by Mr. A. W. Perham of the State Forest Service, stated that the damage it caused was slight in comparison to its economic value.

The damage which they cause in the bush