POTENTIALITIES FOR INDIGENOUS AND EXOTIC FORESTRY IN WESTLAND*

By C. G. R. CHAVASSE

Introduction

There is a tendency in humankind to construct detailed hypotheses on the basis of somewhat flimsy evidence. We are, I believe, all prone to this. The important thing to remember is, after constructing the hypothesis on the basis of the evidence already brought together, we do not then close our eyes to other evidence which may be forthcoming, which does not fit in with the hypothesis.

During 18 months' study of rimu forests in Westland, the number of hypotheses constructed is so far equalled by the number discarded, and thus, in the following discussion, an attempt will be made to present the few facts which have come to light by observation and experiment, concerning the silviculture of rimu and the exotic species to be found in Westland and their relations to the soils.

The main condition to be borne in mind is that there has never been any attempt to manage podocarp forests in practice. Many schemes have been put forward, but the forests have remained out and out exploitation areas. The only attempt to do anything about this state of affairs was the establishment of Mahinapua Forest, termed in the early days an experimental area, with certain exotic species.

It is not difficult to see why this was so. The possibilities of rimu management appeared (and still appear) so unattractive financially and the exotic species so far tried showed so little promise, that from the national standpoint it was better to concentrate on other areas. The general policy must be accounted wise, since it has led to the establishment of a very considerable and valuable supply of timber, on a scale which could not possibly have been achieved in Westland with a much greater expenditure of money. Moreover, there has always been plenty of indigenous timber in Westland, and there could have been no sense of urgency either in supplementing this with exotic crops or in attempting to grow rimu and other podocarps on rotations which might be as long as 500 years. An even more important consideration was the nature of the forest soils of Westland, soils so poor that it is surprising that the indigenous forest is so well stocked with valuable timber. And last, but also important, the timber grown in Westland could not find a home market, and would have to be exported, at some cost, via the difficult Midland line.

Forest liquidation and devastation have thus continued, unabated, up to the present time. The position is at present that, in State Forest,

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some 100,000 acres of rimu and silver pine forest has reverted to
waste land after logging and burning, and this acreage is continuing
to grow at the rate of over 2,000 acres per annum. Without con-
sidering the areas of beech forest, which have to some extent regenerated
in spite of what was done or not done during logging, the paucity of podocarp regeneration is astonishing unless one enquires
the reason. Stands of sapling and pole silver pine and rimu form
only an infinitesimal part of the general "badland" vegetation of cutover
forest land.

The reasons are not far to seek. Rimu forest consists almost
tirely of merchantable stems. The unmerchantable trees are mostly
small and suppressed and do not bear much seed. Most of them
are overturned or broken during logging, and exposure leads to
dieback in the tops, and windthrow, even though rimu is relatively
windfirm. Clear felling on a continuous front has been the rule, and
steam equipment has led to certain destruction of all remaining trees,
advance growth and regeneration within a few years of logging. Fires
have been the universal concomitant of logging. Originally, it is
supposed that the fires were used to clear land for farming, as was
the case at Mahinapua Forest. But no-one manged to farm the rimu
forest lands, and retired defeated by high water content, high acidity
and the general poverty of the soils, or by the unmanageable growth
of gorse and tree ferns on the better drained land. Latterly the fires
have been haphazard and considered completely normal. Many areas
have been burnt two or three times, and the consequent degradation
of soils already poverty stricken, has rendered them unfit for any
purpose.

Anyone contemplating this dismal picture would be inclined to
give up hope, and certainly no forest land owner in Westland has
made any attempt to improve things of recent years.

In the very early days of the Forest Service, the problems were
attacked with some vigour. The rimu story, if the experiments had
been continued, would no doubt be clearly understood by now. And
the same might be said for the exotic story. But, unfortunately for
Westland, the depression led to a shut-down on any further work,
and it is only during the last two or three years that an attempt has
been made to start again with some hope for the future. For there
is hope. And in the intervening years the whole conception of land
use and values has been changing rapidly. What were, until a few
years ago, considered valueless soils for farming, are now blossoming
into first-class pastures in many parts of the North Island, in South-
land and elsewhere. There is a limit to such expansion, but it is
clear, for one thing, that a large part of the exotic forest estate has
been planted on lands equally suited to farming. This has altered to
a great extent the ultimate value of the Westland soils which have
been considered unfit for anything. There are even some who think,
and make their thought vocal, that all land below 1,000 feet in West-
land is farmable. The experience in the past points the other way,
but it is not completely outside the realms of possibility—within the next millennium.

As well as this revaluation of land—not of course in terms of cash, but in terms of potential—there is the realization that the indigenous forests provide high quality clean timber, the like of which will not be available in any quantity from exotic forests for many years to come, and this realization leads naturally to attempts at conservation of these valuable resources.

Moreover, the value of permanent forest production to the relatively isolated population of the area can not be ignored, especially since the farming potential, though not by any means fully realized, is definitely limited.

This preamble has led to a point where the details of the position can be discussed more fully.

Soils and Forest Types

The Forest Service controls only small areas, often isolated enclaves, of recent soils. These bear kahikatea forest, sometimes with matai and totara. These soils are sometimes swampy, but could with difficulty be drained, and are mainly suited to farming.

Apart from these limited areas and other areas of peats and natural pakihis, the three major soils are first skeletal, derived from various parent materials; secondly the Arahura sandy loam soils, and Runanga clay loam; and thirdly the Okarito fine sandy loam soils, together with limited areas of Kumara loam and Waiuta loam.

The skeletal soils (though they form the largest part of the forest estate, and are clothed in valuable protection forest) will not be further discussed.

The Arahura soil type occurs on hilly lands. This is described as immature to semi mature podsolic soil, "developed on moderately steep slopes from stony sediments under beech or rimu/kamahi forest." The Nothofagus forests will not be discussed further. The podocarp forest consists of large, mature, often branchy, rimu, at a low density, and stands of 6,000 to 15,000 bd. ft. per acre. Associates are miro, often small though of good form, large rata, and a dense understorey of broadleaved species, including kamahi, quintinia, hinau and toro. Regeneration of indigenous timber species is sparse, except in areas worked for gold, and poles of these species are virtually lacking. This is a somewhat variable soil type. Being on moderate to steep slopes, the soil is determined to some extent by the parent material. The best soils are derived from limestone, and approach the Runanga clay type. Intermediate fertility is found in soils derived from morainic material and gravel wash, while soils derived from "blue bottom" tend to be wet and shallow. On the whole, however, the soils are reasonably good for forest purposes, iron pan is not highly developed, and the structure of the soils is suitable to ensure drainage.

Some 250,000 acres of this type exists in Westland. About half of this is, or was, clothed in beech forest. Of the remainder,
some has already been logged and abandoned, and about half the area logged each year is within the Arahura soil type.

The Okarito group of soils are typically found on the numerous terrace lands of Westland. Kumara loam is similar to the Okarito type, though of more recent origin, and has not the fully developed iron pan of the true Okarito soil. Only limited areas of this type are to be found in State Forest. The Waiuta soil type is also similar, being found on morainic mounds. The principal difference is that drainage is better in the Waiuta than in the Okarito type, but this is a difference of some consequence.

This group is described as mature podsolic soil. The soils are, however, highly variable, as are also the forest types. The major area was or is covered with dense rimu forest, with miro, kamahi and quintinia as associates, but certain shallow basins, often with peat soils, carry silver pine forest, and this species is a frequent associate of the rimu on certain variants of the soil type. In every respect these soils are poor. Downward drainage is completely impeded by fully developed iron pan, and gley horizon, the main one at some 9 to 24 inches below the surface, but secondary ones being found at various depths down to 10 feet or more. Lateral drainage also is severely imperfect or impeded on account of the compact silty soils, without any detectable structure. Analysis on the best of this type shows only a trace of phosphorus, highly limited supplies of calcium, and potassium, a high carbon nitrogen ratio, and a pH of about 5.0. This is the analysis, I must stress, of one of the best types of soil in this group. pHs of 3.5 have been recorded for this soil type in Mahinapua forest, though even here the soils are better than the worst encountered. It is quite clear, therefore, that except in conditions of severe food shortage, this soil type will not, and can not, make any contribution to the national larder, either practically or economically. But it grows, or once grew, adequate crops of podocarps.

Effect of Felling and Burning

Enough, and more than enough, has been done in the past to show fully and conclusively what ought not to be done. An examination of past exploitation and devastation makes it abundantly clear that the forests and the lands have not been treated in such a way as to make any future contribution to the well-being of the district or of the country as a whole.

After felling, the Arahura soils revert to a dense growth of shrubs and broad-leaved species, of no commercial value at present, and these species are of slow growth and poor form, but present in a few years a dense jungle, impossible to cope with from the point of view of forest management. If after felling these areas are burnt, the result is a dense growth of tree ferns (one of the few indigenous species which survives fire) and gorse. Repeated burning only perpetuates the association. Not only is the land unusable, but it
remains a high fire hazard, increased by the usual practice of burning off whenever a dry spell allows for this. There are, of course, ways of dealing with this association, but the land is usually too steep to allow any form of cultivation, and fire plus stock has also proved useless time and time again. Large areas of such land have become and remain derelict.

A similar story can be told of the Okarito soils, for they have had the same history. Felling was concentrated on these lands because of the high volume per acre (up to 40,000 bd. ft.), the ease of access, and the proximity of these forests to lines of export. Almost all these cut-over lands have been burnt, and it has consequently been assumed that the podocarps were "one-croppers."

However, the diversified forest types on these soils were such that areas of small material (up to large pole size) were often bypassed in the early days, and though most of these groups have since been destroyed by fire (to which rimu especially succumbs easily) there are small areas where regeneration of the podocarps has shown much promise. Almost invariably, where an adequate seed source has remained, rimu regeneration of sorts has appeared. Because of its painfully slow growth, little notice has heretofore been taken of this, but it is there and available for study.

Burning on these soils causes intense degradation. Removal of the forest cover alone leads to such water conditions at the surface that there can be little hope of quick re-establishment of forest. And clear felling on a broad front, the universal practice, means that such regeneration that does appear is subject to severe exposure, and does not thrive. There is, moreover a complete destruction of the centuries-old deep humus layer, on which so much depends, and consequent severe loss of nitrogen. These factors are all inimical to rimu regeneration, and lead to a complete change in the vegetative cover from forest to non-forest species. Any area where Gleichenia dicarpa and rushes have become the dominant species has passed out of use for some time to come. Without a good deal of study the extent of this devastation, both on Forest Service and private land, cannot be gained, but it is estimated that at least 45,000 acres of State Forest, and possibly an equal area of private land, has reached this condition.

It is clear, however, that this need not be so. Certain areas, logged in the very early days for the cream of the crop, have regenerated well to rimu. The forest conditions have been maintained, seed trees have remained, fire has not entered, the soils have not become waterlogged, and there has been no change in the species composition of the cover. There is here an important lesson, which it is hoped will be taken advantage of in the future. This will be further discussed below.

Climate

No discussion of Westland forest conditions is complete without some mention of climate. Particularly so, since the climate has a
profound bearing on soils in Westland. The most important parent material is morainic or fluvi-glacial. I suspect that a good deal of the older terrace country formed under tundra conditions, and if this is so, it is to be expected that before forest vegetation ever colonized these areas a great deal of leaching and washing had already taken place. But this warm humid climate tends to form soils very quickly. The fertile river valleys, over which the rivers have roamed fairly rapidly, show the ease with which gravels and sands are formed into soils. The dredge tailings are a more recent and striking example. Some of these tailings, ten years ago a barren bouldery wilderness, now carry flourishing gorse and native vegetation. But this very faculty of quick soil formation is inimical to the maintenance of fertile soils. Leaching is very severe with 120 inches of rain, or more, and the natural direction is towards intense podsolization. This factor, combined with the infertile older soils, poses a problem which agricultural techniques may possibly be able to overcome, but not without enormous and most probably recurring expense.

Forest Research

In the early 20s the Forest Service and the Canterbury School of Forestry began to tackle the problems with commendable zeal. The Sample Plots and experimental areas they laid down are still largely awaiting evaluation, but it will be some time before the threads are all gathered up. In spite of these research projects being abandoned for so long, the very fact that they were laid down gives something to start working upon. The fact they have remained untouched for so long puts forest management on a firm basis just that number of years behind, locust years that seem now to be all-important. The plots cover a comprehensive range of conditions and stands, and luckily most of these have escaped destruction in the intervening period.

The other side of research also awaits evaluation. I speak of exotic trials. It is unfortunate that detailed direction on the spot was not forthcoming in these early years. A large number of species was tried at Mahinapua Forest, but many of these were in small lots, and no record is extant of the whereabouts of these lots. Fairly soon, too, the forest lost all pretence of being an experimental area, and became a re-afforestation project. It is interesting to record that in the first two years, ponderosa pine appeared to be the most likely species. But later Western red cedar showed most promise, and this was the major species planted in the forest. It is not known how much consideration was given to the natural sites and ecology of the species tried, but evaluation today leads to the conclusion that little, if any, was given. This is hardly surprising, but it does mean that a number of likely species have not been tried, and that a large number of unlikely species were tried and have failed.

Various appraisals of the growth of exotics planted at Mahinapua Forest have been made from time to time. Most of them illustrate the
unwisdom of counting chickens before they are hatched, for today there are some species which show reasonable promise, but only on certain sites. The Okarito soils remain obdurate.

The main criticism of these early trials does not concern the species tried, but the fact that the whole of the planting area is either Okarito or Waiuta soil—that is, the poorest soils in the forest area. The lost opportunity is to be regretted now, but without the necessary technical direction it is interesting to observe how valuable, in fact, these early plantings are, for the evaluation of present potentialities. Admittedly a good deal of the evidence is negative, but even that has its value. And there is enough evidence to show at least the species which can now be planted on selected sites with every hope of success.

Silvicultural Characteristic of Rimu

No very detailed work has been carried out concerning the silvicultural characteristics of rimu, but observations are available aplenty. The species is dioecious, a factor which alone renders it unsuited to certain silvicultural systems, and as far as I am aware, no attempt has ever been made to manage dioecious forest species.

Not only this, but rimu is notoriously a shy seeder, by repute. It is possible that some seed is produced from rimu stands each year—and the evidence points in this direction. Fertile seed was certainly produced in each year from 1951 to 1954. But it appears that in most years the percentage of filled seed is low, and even filled seeds often lack embryos. Seed years in the accepted sense are rare. Present evidence also points to the short period of viability.

But rimu bears seed for a long period. Isolated female trees, known to be forty years old, have been found bearing fertile seed. In young stands, the age at which fertile seed is first borne is greater, and it seems that in dense stands the quantity of seed produced is not large. But mature trees produce a phenomenal quantity at least in some years—this year's seed crop illustrating this well.

Distribution of seed from parent trees is, however, poor. Recent research has revealed that, this year, a relatively good seed year, virtually no seed has been distributed for more than one chain from parent trees, in spite of some days of fairly high wind, both from the west and the east. Indeed, the physical form of the seed renders it unsuitable for wind dispersal. It is possible, of course, that wind is not the major form of distribution, and the large number of pigeons and other birds feeding on the red arils this year may indicate that a significant distribution is effected by birds. But observations throughout the Conservancy do not support this view. Occasional seedlings are found round the few broad-leaved trees left standing after logging. Sometimes there is heavy stocking round these trees. Otherwise only infrequent seedlings are found in cut-over areas isolated by only a few chains from seed-bearing individuals or residual stands. No area has been found where these sparsely scattered seedlings would ever form a tree crop. Generally regeneration can only be found in narrow
strips along standing forest edges, up to a distance of about three chains. Towards this limit, density drops off sharply; moreover the ages of seedlings decrease rapidly as the distance from the seed tree increases. It must be concluded that the major agent for seed distribution is wind, with birds making a significant contribution only in those years when there is extensive development of red arils.

These factors are not encouraging, but the amount of rimu advance growth that is found over much of the Okarito soil type terraces must show that they are not prohibitive. And the occasionally dense stocking of young rimu, in certain conditions, gives reasonable grounds for management prescriptions. It yet remains to find out all about these conditions, but it is quite clear that the main reason for the lack of rimu regeneration in the past has been simply lack of seed.

With this in view, it is necessary to examine the possibilities for natural regeneration of the species. It has already been stated that the hill forests have low volumes per acre and low stocking. In this often difficult country, if seed trees were to be left at a sufficient density, the stands could not repay logging. Moreover, the removal of much of the understorey would be necessary. A characteristic of these hill forests is the abundant and vigorous coppice and sucker growth of kamahi and quintinia that grows up after logging. This shows much faster growth than can be expected of rimu even in the best circumstances, and silvicultural treatment would be laborious and costly. Moreover, the soils are suited to certain exotics, the production from which would be far superior to that of any of the podocarps. The true economic use can not in any circumstances be the perpetuation of the indigenous species. Indications are that even on the best sites, and in the best conditions, re-colonization of rimu is slow. In one area, cleared by burning and thus offering no competition from coppice and sucker growth, the stocking of rimu seedlings (in spite of relatively good seed supply from intact forest edge) was from 260 to 356 per acre at 30 years; 356 to 440 at 40 years; 440 to 548 at 50 years; and 560 to 744 at 80 years.

Recolonization by other species is faster, but growth is not significantly greater. This will be referred to again below.

On Okarito soils the factors are more favourable. Certain forest types (often referred to in the past as "pole-type" rimu) show marked variation in size, and, though this is not proven, considerable disparity in ages. Sample trees felled in a so-called even-aged pole stand in Mahinapua Forest exhibit ages nearly 100 years apart, and young saplings and seedlings are still growing up through the understorey vegetation. The older trees in this stand are certainly more than 300 years old, while a suppressed sample tree was only 156 years old. Moreover, much rimu regeneration occurs in small patches and groups, and it is only after many decades have passed that the gaps are stocked with timber trees. The general tendency, on present
information, is towards uneven-aged forest, either mixed by small
groups or intimately by single stems.

It will be observed here, and in much of the discussion following,
that a good deal of reliance is placed on growth rings for obtaining
basic data. The method has been called in question, but it is the
only method by which long term information can be gained in a
short period. The value of growth rings is, however, becoming more
clearly understood, as a result of remeasurement of sample plots
coupled with stem analysis of trees felled in the surrounds of those
plots. As a result of this, it was found that the growth in diameter
of the sample trees was slightly greater than the mean diameter growth
of the various crown classes in the plots. The sample trees were, as
nearly as possible, the same dimensions as the means for the crown
classes in the plots.

This is, of course, only a limited example, but shows that in this
particular instance the rings must indeed be annual. The figures are
as follows:

<table>
<thead>
<tr>
<th>Crown Class</th>
<th>Sample trees</th>
<th>Plot Wd. 43</th>
<th>Wd. 44</th>
<th>Mean*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominant</td>
<td>3.38</td>
<td>3.2</td>
<td>1.8</td>
<td>2.1</td>
</tr>
<tr>
<td>Co-dominant</td>
<td>1.75</td>
<td>1.9</td>
<td>1.4</td>
<td>1.5</td>
</tr>
<tr>
<td>Intermediate</td>
<td>1.37</td>
<td>2.3</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Suppressed</td>
<td>0.65</td>
<td>1.8</td>
<td>0.3</td>
<td>0.4</td>
</tr>
</tbody>
</table>

* Mean of all trees on Plots Wd. 43 and 44.

Rings have, in all recent research, been determined by dissection
microscope. Normally, at breast height, they are easily discernible.
At stump height, however, as observed also in the past, they tend to
show variable growth, but careful observation should lead to reason-
ably accurate age counts, if each ring is followed round its circum-
ference.

The theory that rimu forms even aged stands in the true sense
of the term is not supported by the available evidence. The most
striking example is that of stump analysis in Ianthe Forest carried
out in 1936. 32 trees were examined, with diameters from 14 to
28 inches. In the 14-inch class were three trees, 240, 340 and 560
years old. The two trees in the 28 inch class were 440 and 600
years old. And it is most interesting to observe that the youngest
tree, 190 years old, and the oldest, 720 years old, were both in the
20-inch diameter class! This stand would look like an even-aged
forest, maybe, but the facts tell a different story. A similar story is
told by recent areas of regeneration. Can a stand be even-aged with
a regeneration period, a steady restocking of the area, spread over
80 years and more? I would suggest that it would be stretching the
conception of even-agedness too far if stands of 200 years old with
differences in age of more than 100 years, could be considered even-
aged.

Throughout the forest types on the Okarito and Waiuta soils.
there is a limited stocking of rimu seedlings, saplings and poles. It is true that much of the seedling crop is ephemeral, but that is only to be expected in these dense stands. It is true that saplings may be only 15 ft. high and one inch in diameter, and yet be over 100 years old. The main point is, that in natural forest conditions on these sites, rimu does regenerate consistently.

But the right conditions have to be created for successful re-establishment of rimu crops. It is clear that the species will stand considerable shade for a long time. Some of the young growth is completely overgrown with secondary species, but appears to be healthy and thrifty. Moreover it eventually outgrows the other species. In dense forest, though mortality is high, a good deal of advance growth survives for long periods, and where there is a minor break in the canopy, some of this eventually grows to timber size. If we consider that these forests have existed much longer than the time taken for the growth and decay of one generation of trees, it is clear that there must have been a continuous replacement throughout this long period, notwithstanding climatic changes, and it is also clear that this process is still continuing. However, rimu does not thrive when fully exposed, particularly in clear felled areas. The degradation of soils and waterlogging is no doubt responsible for this, to some extent, but it seems likely, from observations, that young rimu actually requires the cover afforded by the secondary species for healthy growth in the seedling, thicket and sapling stages, even though this leads to severe competition and retardation of growth.

This is illustrated in various ways. Three examples will suffice. The first concerns plots laid down by the Canterbury School of Forestry, in patches of good rimu regeneration in the seedling stage. Today, the mortality of these seedlings where fully exposed is extremely heavy, and little of this regeneration survives, unthrifty and of a poor colour. The second illustration is from partially felled rimu stands logged during the early years of the century. Here regeneration has often been good, and growth and survival appear to be excellent. It is probable, however, that the critical factor is not the lack or otherwise of vegetative cover, but the maintenance or otherwise of forest conditions; in these conditions the soil and moisture are thought to be of great importance. The third instance concerns silver pine areas exploited in the early days. These areas are normally surrounded with rimu forest. Today, rimu regeneration in the fringes of these is often dense and thriving, even though the overhead cover is heavy, and root competition likely to be severe.

But there is also a good deal of information on the ground which indicates that a certain amount of soil disturbance, though not apparently vital to regeneration, yet promotes better coverage and higher stocking. Some of the best sapling stands have been found on Arahura soils subject to burning after felling. And on certain recent soils, and on limited areas of Okarito soils, intense cattle usage has led to abundant regeneration and vigorous growth. In
another instance, a horse tram route, covered with sawdust, has led to a dense coverage of seedlings. And in the partially felled areas alluded to above, the densest regeneration is to be found on the old haul tracks—indeed this is common in cut-over but unburnt forest. On the other hand, burning on Okarito soils appears to lead to poor conditions for regeneration, and since these soils are the vital ones in rimu forest management, the use of fire for ground disturbance can not be recommended.

The conclusion is that the necessities for successful regeneration of rimu include a full forest stand or edge for sufficient seed supply, and sufficient opening of the canopy coupled with some climatic protection in the first 100 years or so, and soil conditions not rendered unsuitable by clear felling and burning. The right conditions can be met by treating rimu forest either on a selection system or by group or strip felling. The selection system would no doubt be the best in the long run, but is so revolutionary in the present circumstances that little hope of its successful inauguration can be entertained. The strip method, in fact, offers the best compromise, though width of strips and other silvicultural details have yet to be worked out.

It has always been supposed that the secondary species grew so much faster than rimu, that there was little chance of growing the principal timber species. Recent studies have refuted this argument, though it is more important to differentiate between seedling growth and coppice and sucker growth. Moreover it is important to the extent that the secondary species appear to recolonise areas rather faster than rimu.

The following mean figures can be given for height growth of certain competing species:

<table>
<thead>
<tr>
<th>Species</th>
<th>Minimum Age</th>
<th>Maximum Age</th>
<th>Height Growth (ins. annum)</th>
<th>Max Height Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manuka</td>
<td>23 - 46</td>
<td></td>
<td>9.00</td>
<td>11.35</td>
</tr>
<tr>
<td>Kamahi</td>
<td>35 - 79</td>
<td></td>
<td>4.13</td>
<td>6.80</td>
</tr>
<tr>
<td>Quintinia</td>
<td>38 - 79</td>
<td></td>
<td>4.07</td>
<td>5.58</td>
</tr>
<tr>
<td>Toatoa</td>
<td>51 - 99</td>
<td></td>
<td>3.75</td>
<td>4.83</td>
</tr>
</tbody>
</table>

The corresponding figures for rimu are:

<table>
<thead>
<tr>
<th>Minimum Age</th>
<th>Maximum Age</th>
<th>Height Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>34 - 77</td>
<td></td>
<td>4.06</td>
</tr>
</tbody>
</table>

There is thus the proposition that, if rimu can be induced to recolonize felled areas at the same time as competing species, it will be able to compete successfully. This may sound difficult, but on the Okarito soils, the density of secondary vegetation, and the amount of coppicing and suckering is not excessive, as it is prone to be on the Arahura soils. Nor is recolonization so fast. Indeed, the amount of secondary regrowth is expected to be sufficient only to form the side cover so necessary for rimu in the early years, without giving undue competition.

Increment of Rimu

There is no doubt that, in spite of the high stocking of stems often found on the Okarito soils, the increments attained appear inadequate if measured against Douglas fir and radiata pine. An
exotic forester must make an effort to re-focus his mind on the figures which are presented here. They refer to a stand of comparatively young rimu in Mahinapua Forest, in which plots were laid down in 1925. This is a reasonably long period of study and the figures are thought to be reliable and indicative of the potentialities of the average Okarito site.

One dominant tree felled and analysed gave the following figures:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>24½</td>
<td>3.00</td>
<td>0.551</td>
<td>0.018</td>
<td>0.006</td>
</tr>
<tr>
<td>150</td>
<td>38½</td>
<td>5.58</td>
<td>3.308</td>
<td>0.070</td>
<td>0.022</td>
</tr>
<tr>
<td>200</td>
<td>56</td>
<td>8.28</td>
<td>10.448</td>
<td>0.272</td>
<td>0.051</td>
</tr>
<tr>
<td>230</td>
<td>69½</td>
<td>12.20</td>
<td>25.186</td>
<td>0.498</td>
<td>0.120</td>
</tr>
</tbody>
</table>

It is interesting to observe that neither the current nor the mean annual increment have reached their peak at the advanced age of 230 years, though the indications are that the current increment should reach a maximum during the next decade or two.

Before dismissing these figures as preposterous, it must be borne in mind that this tree grew through a dense stand of silver pine and rimu and has been subjected to a long period of partial suppression. Another tree, which apparently had little competition from the time of germination, yielded the following figures:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>18½</td>
<td>1.84</td>
<td>0.186</td>
<td>0.0151</td>
<td>0.0062</td>
</tr>
<tr>
<td>40</td>
<td>24½</td>
<td>2.54</td>
<td>0.460</td>
<td>0.0274</td>
<td>0.0115</td>
</tr>
<tr>
<td>50</td>
<td>32½</td>
<td>3.52</td>
<td>1.042</td>
<td>0.0582</td>
<td>0.0208</td>
</tr>
<tr>
<td>60</td>
<td>37</td>
<td>4.76</td>
<td>2.161</td>
<td>0.1119</td>
<td>0.0432</td>
</tr>
</tbody>
</table>

It will be observed that the mean and current annual increments are faster for this tree at 60 years than for the previous tree at 150 years. It will also be observed that the dimensions at 40 years are similar to those of the first tree at 100 years. This must surely indicate great plasticity in the species.

It is not uncommon to find trees with certain periods of growth with about 10 to 15 rings to the inch, though the normal growth from ages over 100 is nearer 30 rings to the inch. Indeed, free-growing trees have been found with 6 - 7 rings to the inch, though open grown trees would produce only short log lengths of timber. These figures indicate, however, that silvicultural treatment designed to hasten diameter growth would prove successful, for the periods of faster growth may take place at any stage in the life of an individual tree, and do so according to the amount of suppression or otherwise. Response to more open conditions, even in old trees, is good.

However, foresters are not so much concerned with individual trees as with stands. The sample plots at Mahinapua Forest have yielded in conjunction with stem analysis a good deal of information
on this score. The following figures are given in total stem volume, any merchantable consideration being out of the question in stands with such a variation in size. The volume of all stems in 1925 is calculated as 2,998 cubic feet (the plot being just over half an acre). In 1953 the standing volume was 3,985 cubic feet. The increment is thus 987 cubic feet for the period of 28 years. This contains three components, however—the increment of all trees which have remained alive during the period, plus the recruitment into the 4 inch d.b.h. class, and less the volume loss in mortality. Recruitment accounts for 47 cubic feet, and mortality for 235 cubic feet. The figure given (987 cubic feet is thus the net increment for the period. This corresponds to a mean annual increment per acre of 32.35 cubic feet, and a current nett annual increment of 63.8 cubic feet.

This may be compared with previous measurements of the Perry's Bush plots, now destroyed. The first measurement there in 1921 revealed a total volume of 4,870 cubic feet per acre. And the re-measurement in 1927 showed 5,806 cubic feet. This gives a current annual increment per acre of 144 cubic feet. The site is above average.

Though these figures appear low by New Zealand exotic standards, they are not so low as to make any attempt at rimu management impracticable. But these figures do not, of course, refer to merchantable increment on present standards. They are also net figures. There is yet a long way to go before the full story can be told.

**Exotic possibilities**

It is now necessary to examine the other major aspect of forestry in Westland—the possibilities for successful exotic establishment and growth. A full appraisal of the information available at Mahinapua Forest and elsewhere yet remains to be made. But it is clear that of the large number of species tried only a few show any signs of success. However, it may yet be too early to draw final conclusions. The area is a mosaic of Okarito and Waiuta soils, and on the latter, many species show some promise. The best of these, taking only volume growth into account, is undoubtedly radiata pine. But an examination of soils under pine stands shows that no long term reliance can be placed on these species, on account of intense compaction, leaching and degradation. Lawsons cypress, Western red cedar and Japanese cedar, though showing much less growth, do not have this deleterious effect on the soils, and they appear promising. However, there are indications that they fare better in mixture with pines.

There is now no doubt that the Waiuta soils, if they can be recognized in the field (and this is not always easy, especially after burning) will grow exotic crops. But so far, there have been no plantings on the Arahura soils. And, moreover, there are numerous species which, by reference to the available information, appear to be suited to the conditions, which have not so far been tried.
It can also be said that so far no species show any promise on Okarito soils. Indeed, in parts of Mahinapua Forest, the indigenous species are growing faster than the exotic on the same sites. This is a serious matter when considered in the light of the large area of devastated country.

So far, study has been confined to specimen trees and shelter belts growing on farm lands. These studies show that certain species grow vigorously, and appear to be thoroughly healthy and thrifty. Admittedly the forest soils are poorer than the farm lands, but a few figures will here be quoted:

<table>
<thead>
<tr>
<th>Species</th>
<th>Age yrs.</th>
<th>d.b.h. ins.</th>
<th>Height feet</th>
<th>*Increment radial - ins.</th>
<th>Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. radiata</td>
<td>20</td>
<td>13.7</td>
<td>69</td>
<td>3.9</td>
<td>Runanga</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>20.0</td>
<td>101</td>
<td>3.5</td>
<td>Runanga</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>63.0</td>
<td>144</td>
<td>1.2</td>
<td>Ahaura</td>
</tr>
<tr>
<td>Picea excelsa</td>
<td>80</td>
<td>35.0</td>
<td>91</td>
<td>0.6</td>
<td>Ahaura</td>
</tr>
<tr>
<td>Picea sitchensis</td>
<td>36</td>
<td>31.8</td>
<td>69</td>
<td>4.0</td>
<td>Harihari</td>
</tr>
<tr>
<td></td>
<td>47</td>
<td>25.4</td>
<td>93</td>
<td>3.8</td>
<td>Ahaura</td>
</tr>
<tr>
<td>Araucaria imbricata</td>
<td>35</td>
<td>23.6</td>
<td>48</td>
<td>1.9</td>
<td>Ahaura</td>
</tr>
<tr>
<td>Crypt japonica</td>
<td>80</td>
<td>48.0</td>
<td>82</td>
<td>0.9</td>
<td>Ahaura</td>
</tr>
<tr>
<td>Ch. lawsonia</td>
<td>30</td>
<td>20.7</td>
<td>48</td>
<td>1.5</td>
<td>Ahaura</td>
</tr>
</tbody>
</table>

* 1953.

These are admittedly not growing in forest stands, and the figures are only indicative of possibilities. Moreover they are not always suited to the actual conditions to be met with in areas scheduled for planting. It would be as well, therefore, to examine the conditions. In the first place, no attempt can be made, on present knowledge, to afforest Okarito soils. It may be some time before suitable species can be found—there will no doubt be few only that can tolerate the wretched conditions. And it is the soil that is the critical factor. The climate, though it may be too wet for some species, is yet one favouring growth. Plentiful moisture, warm or mild temperatures throughout the year, plenty of sunshine, and a long growing season, with absence of gales and snow, light frosts only, and infrequent droughts — surely these are almost ideal forest conditions.

But where the soils are favourable there are a number of difficult silvicultural and protection problems which need to be solved before full scale operations are possible. As explained earlier in this paper, it is the Arahura soils, some 150,000 acres, to which we turn for the establishment of exotic stands. And the natural forest on these soils has a large, dense, unmerchantable component. It might be supposed that the heavy slash remaining after logging could be cleared by fire, and this is undoubtedly the most promising agent, were it not so dangerous. Without some form of land clearing after logging, only about one third of the gross area will be sufficiently open to plant. And the residual canopy is so dense that little hope can be entertained for underplanting. There is more to underplanting
than merely lack of light — for nowhere in New Zealand has underplanting been successful; exotics appear not to be able to tolerate indigenous forest conditions. Apart from this, the more important exotic species will have no difficulty in overcoming the regrowth of indigenous species.

But this is only the start of the problem. The indigenous forest harbours the honey fungus, no doubt rendered more vigorous by infesting stumps and debris left after logging. This fungus attacks most of the conifers planted in Mahinapua Forest, where, because of the clearing and burning, it is likely to be less vigorous and widespread than in freshly felled hill forest.

The major problem is one of protection. The deer population of the hill forests, and even of the terrace forests, appears to be increasing; in certain areas goats are plentiful and range far and wide; and, even more important, perhaps crucial, the opossum population of these hill forests is dense. This last fact is a definite limiting factor in all possibilities for exotic forestry. We have, for the time being, to concentrate on species which are more or less immune to opossums, or at least not heavily attacked. For this reason alone, the use of certain Eucalyptus species is considered justified.

This is the problem. It concerns land use. The potential is there. Assume that we can reach an annual increment of 200 cubic feet per acre on this 150,000 acres of relatively good land. The total annual increment from this area would be 30,000,000 cubic feet — a figure which makes the present annual harvest from Westland look puny. There is, of course, little hope of reaching this figure within the next hundred years or so, but that may be the potential.

Conclusion

The whole of this discussion has revolved round the question of proper and economic land use. Without being able to foresee the future it is easy to make mistakes, but present knowledge shows quite definitely that the major soils discussed in this paper have no potential for farming, either practically or economically. The proper land use is forestry. The practical problems which have to be overcome are numerous and difficult, and it can easily be shown that afforestation with exotics in other parts of the Dominion would yield greater profits besides being practically simpler. This is surely not the point. The growing demand for food in the world is such that eventually the amount of land devoted to forestry must dwindle, and then it is up to the forester to increase the yield from the available acreage in the same way as the farmer increases his yields — by improved plants and techniques. Here in Westland there is a large area of land definitely suited to forestry, and as far as we can see at present, this condition will obtain for some time to come. Whereas, in much of the rest of New Zealand, land now devoted to forests is found highly suited to farming. The future of forestry in New Zealand must lie to an important extent in Westland.
This is true economics: the proper use of natural resources. Though financial considerations cannot be ignored, they must not be allowed to overshadow these considerations. There is no doubt that the growing of perpetual rimu crops is a poor financial venture, and it may yet be shown that there are certain exotics which will do better. But at present the indications are otherwise—the true economic use of the Okarito soils is to grow podocarp forest, even with scanty returns and long rotations.

This is the problem. For 50 years and more, about two thousand acres of forest have been logged and laid waste every year in Westland. The waste lands continue to grow at that rate. No use has so far been found for these desert areas, and they present an ever-growing problem. Their rehabilitation will be costly and difficult, far more so than in any form of forest management devised to keep them in continuous production. The potential is to hand; our knowledge is increasing: our duty is to make use of this knowledge and this potential.

REFERENCES


(3) Foweraker and Hutchinson. Sample plot records—Canterbury School of Forestry Annual Reports, 1928 to 1932, and final report.
