

and Walnut. From Asia, Japanese Oak and Ash.

The field available for investigation into the various timbers is, therefore, not quite as small as we at first thought. Casual specimens may also be obtained in unexpected places. When cutting up a crate which the grocer had sent along for kindling wood, a banana crate from Fiji, I obtained four species of wood from one crate, and among the specimens a very interesting one of *Alstonia* showing radial canals which look more like borer holes than parts of the anatomy of the wood.

A proper knowledge of the various timbers and woods which various climes produce, is a necessity to the working forester, for how can he operate when he does not know his own wares, how they behave under the saw, how they behave under the plane, and how they behave after they have been put into use of some kind or other.

Some woods work "sweetly"—take a good surface and stay put. These are ideal woods, and when, in addition to these qualities, the wood does not readily split for nails, we have a wood with the characteristics of Mahogany, and these qualities have more than the actual appearance of the wood made it a most excellent all-round wood.

Some woods may have many good qualities, but fail severely in one direction, causing the wood to be of little value. Brittleness and lack of durability are undesirable features in a wood, while irritating substances in the wood are not appreciated before one is actually working with the wood. Our own common *Ratas* (*Metrosideros* spp.) while of excellent structure for turnery purposes, contain some substance which irritates the nasal membranes and causes quite severe bleeding. Some of the *Dipterocarps* are irritating in the same manner, while *Cocobola* is notoriously poisonous and injurious to the men who work the wood up. It is therefore not sufficient to judge a timber on its appearance alone and neglect those peculiarities or qualities which will be apparent when the wood is actually put to some definite use, peculiarities which can only be appreciated by the working of the wood.

The subject of the timbers of the World is a tremendous one if seriously tackled, and a complete knowledge of the subject cannot be hoped for in the general run of forest technicians. It must, however, be expected that the average technician possess a wide general knowledge of the subject, so that he may at least deal with care when attempting to identify timbers of commerce.

## *Studies in Rimu.*

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### A Popular Exposition.

There have been a number of references in recent numbers of "Te Kura Ngahere" to the work being done by the School of Forestry for the State Forest Service, in the native forests of Westland. This is the major research project of the School, engaging the attention of the staff, assisted by students, for the greater part of the long vacation each year. It has been suggested that it would be of interest to a great number of those of our subscribers who are not technical foresters if the broad general aims of the investigation were set out in a way that would permit of a ready grasp of the situation as a whole, thus making for a fuller understanding of the detailed accounts of sections of the work which appear from time to time in the journal.

The investigation centres about two main points in regard to the rimu forests of the terrace land of Westland. The first point is the rate of growth of the forests, and the second is the conditions under which the forest will reproduce itself, and develop to maturity.

The investigation of the rate of growth of the forests is one easily grasped by the layman. Its underlying principle may be summed up thus:—How long does it take, under average conditions on a large scale, to produce trees of good usable size, and how many such trees, or what quantity of super feet of timber may be expected per acre at the end of that time. In other words, what will our forests yield us? Increment, or growth is expressed as an average increase in volume per acre per year. Knowing this average rate of increase for a number of species, in regard to the same quality of soil and climate, direct comparison may be made, and, provided the relative quality of the final product is duly considered, the most profitable species to grow under the given soil and climatic conditions would be the one showing the highest increment, or growth per acre per year. The State Forest Service is experimenting with a number of exotics, while the School of Forestry is studying the rimu stands adjacent. When the respective studies are completed, we will know which type of forest will give us the greatest volume of timber in a given length of time.

To determine yield, three points must be known—area, age, and volume, for yield is defined as volume per acre at known age.

The simplest method of determining the yield would be to measure the volume per acre on a number of stands of known ages, over a whole series of ages from young to mature stands. The results could then be put together in the form of a table showing the yield or volume per acre by regular periods, such as ten-year intervals. The difference in volume between any period and the next succeeding would represent the growth or increment put on in the ten years, while the volume at any age, divided by that age gives the mean annual increment, or average annual rate at which the volume of wood has been laid down. Such a table is known as a yield table, and is used for predicting the returns that may be expected from any area by assuming that the results recorded in the table will be secured again with that species, if grown under the same soil and climatic conditions, and treated in the same way during its life. The yield table, therefore, is one of the most useful things to the forester, and is, in fact, quite indispensable for orderly management.

In attempting to compile a yield table for the rimu forests, the chief obstacle encountered was that the ages of the various stands that might be measured were quite unknown. It is a simple matter to mark off an acre in a good uniform, evenly distributed stand of forest, and to measure its volume, but unless its age can be determined, no headway can be made. With plantations, the age can usually be found definitely, as the date of planting is a matter of record. With a virgin forest no record exists. Where the trees are of such a nature as to show rings of growth known definitely to be annual in character, the age may be determined very closely by felling a tree or two in each of the stands to be studied, and making a count of the rings. With the rimu, however, it seems from the little study that has been made of the subject that the rings formed in the bole are not by any means annual in character, but may be formed two or three in a year, and furnish no reliable index of the age of the tree. This characteristic is by no means unique, of course, but seems to be frequently the case with tropical and sub-tropical trees.

The difficulty is being surmounted in this way. A series of plots have been established in stands covering a whole range of sizes from seedlings to mature trees. These plots are all of measured area, and are permanently marked. The volume of timber on them was measured at the time the plot was installed. It will be measured again at the end of five years, and then probably again after ten years have elapsed. At the end of this time we will have, say, a ten-

year section out of the life of each plot. If we assume that the same average size indicates the same age, we shall then be able to piece together a complete life history of the forest, by adding the successive time intervals to the series of plots observed. Thus, if seedlings grew to be 2 in. in diameter in ten years, and 2 in. saplings grew to 4 in., and 4 in. to 8 in., and so on, the age of the oldest stand could be arrived at very closely, without having to wait the whole period of time needed to grow to maturity a stand whose year of origin was definitely known.

The first big project set on foot was, therefore, the picking out, marking, and measuring of a series of plots, covering as full a range of sizes as possible. We now have seventeen such plots established on the Experimental Area, four or five each in seedlings, saplings, poles, and mature timber. Most of them were put in during 1928, with a few more in 1929. The first remeasurement will take place in 1933, therefore, when the new volume measurements will show for each plot the increase in volume, or increment, made in the five years period. To secure a fuller knowledge of seedling growth, these stands are being counted and measured annually, but the five year period is being adhered to in the case of all plots whose average size is above 4 in. at breast height.

The next section of the work deals with the second point set out in the opening paragraph, namely, the conditions under which the forest will reproduce itself. This is a problem somewhat more complex in nature, perhaps. At least, it is one not in the least grasped by current popular opinion in New Zealand. The general conception in New Zealand is that forestry consists in planting trees—"reafforestation" to use the barbarous and uncouth word of which the Press is so fond. In New Zealand planting has in the recent past occupied an unusually prominent place, because we have been engaged on a big programme of afforestation of waste lands hitherto bare, meanwhile destroying our own virgin forests without any thought of perpetuating them. Yet in the world at large, planting occupies a relatively small part in forestry activity, being considered only as a last resort in unfavourable conditions. The general aim is to attempt to have the forest reproduce itself from seed, so that it will carry on indefinitely, the mature trees as removed being replaced, and their space occupied by younger growth. The reasons for so doing, rather than replanting the area, are obvious and sound. Firstly, and mainly, the natural seeding-in, if successfully achieved,

costs little or nothing, while the cost of clearing up after logging, of raising seedlings in nurseries, and of planting them out in rough cutover land may be very considerable. Secondly the natural seedlings, suffering no check in nursery, lining out, or planting, are somewhat more resistant, in their youth at least, to insect and fungoid attack. Thirdly, it is possible in many cases to provide more favourable conditions of shelter, moisture, and shading, for early development by a series of partial cuttings within a stand, than would be possible on open cutover land. This third aspect will be developed in subsequent paragraphs.

Should it be decided that the rimu stands, occupying as they do, distinctly non-agricultural land that may be permanently dedicated to forest, are growing at such a rate, and are of high enough value to be perpetuated in favour of other species that might also be considered for the same soil and climatic conditions, it will be the aim of management to so handle them that as the mature trees are cut out, fresh seedlings will naturally and continually take their place. The forest will then go on indefinitely, so long as care is taken to remove each year or decade only a quantity equal to the fresh growth laid on over all the younger portions of the forest in the same time. This is known as the principle of "sustained yield," and is the ultimate aim of all forest management, for income is then regular and continuous, meeting all current expenses as they arise, and avoiding heavy carrying charges over times when no ripe timber may be secured from a forest. Regular planting to replace cutting will, of course, give the same result, but as previously stated, if a stand will, by its own natural forces, reproduce itself to the desired species, it is usually much preferable to permit it to do so than to neglect or waste this potential asset, and to sink a heavy investment in doing the same thing artificially.

The securing of natural reproduction following logging is therefore a matter to which much thought has been devoted, resulting in the evolution of a number of "silvicultural systems"—methods of so handling the forest in logging that reproduction, satisfactory in amount, species, and distribution is secured, and favourable growing conditions for the early life of the new crop provided. The various silvicultural systems have been developed along different lines because the various forest species of the world have differing "silvical characteristics"—that is, they differ in their demands for light, moisture, shelter, quality and nature of soil, etc., and if satisfactory

reproduction is desired these silvical demands must be satisfied. If they are not fulfilled, then the desired species will not reproduce. The seed may not germinate, or the seedlings may not thrive, and instead of a forest of a certain desired species, we will find the area being taken up by some other species within seeding reach, which may be of no value to us commercially, but which happens to be suited to the combination of silvical factors we have left behind us. Exactly that change has taken place on much of our cutover lands, merely because we were not interested in securing regeneration of rimu, and did not trouble to find out, and leave behind after logging, the conditions which would best suit its needs. Now that it is at last being realized that our rimu stands may prove of great future value, the investigation of the silvical characteristics of the rimu has been commenced, so that when we finally decide that we wish to manage these forests on a perpetual basis, we will know how to go about it. And that investigation into the factors governing reproduction is the second phase of the work being done by the School of Forestry. A number of experiments have been set on foot to test the response of the forest to different silvicultural methods.

There are three main silvicultural systems in general use, each having various modifications. First might be put the "clear-cutting" system. This system rests upon the removal of the whole of the old stand at one clean sweep, establishing in its place a uniform crop of seedlings all at the one time. It is thus intended for forests in which the trees of different ages are all kept separate in distinct blocks or compartments, each of which contains trees all of the same age, one compartment being logged at a time, and each immediately reproduced to a new crop, also even aged, and so on right round the forest, taking each compartment in turn. The various modifications of this method deal with the way in which the reproduction of the cutover area is secured. Thus we have clear cutting and planting; clear cutting, and leaving seed trees, either scattered, or in groups (depending on the danger from wind-throw); clear cutting with seeding from the sides, where the cutting is done in long narrow belts, so that it is all within reach of seed cast by younger trees in the adjacent compartments; and so on. This system is in the main simple in application. It has the great advantage of cheap logging in that all the trees to be removed at any time are concentrated in one compact unit, and are removed in one operation. For this reason the method is a favourite in countries where

logging costs are high due to poorly developed transport facilities. It has, however, some grave disadvantages. It can be used only for species which can germinate and develop in the full light. The cut-over area is exceedingly likely to be dried out following the logging, and only hardy species will be able to develop. Further, the removal of all cover from the soil over extensive areas may permit soil deterioration, with serious erosion on steep slopes; while the area may be seized upon by weeds and grasses, which would choke out the tree seedlings or transplants. Segregation of the stand into separate extensive blocks is bad practice, also, for it greatly increases the hazard from insect and disease epidemics. The system therefore tends to be modified or discarded in countries of good markets, close utilization, and well-developed transport facilities, but in a country such as New Zealand the factor of logging costs is so important that it is the first system whose possibilities deserve exploration. We have made a start, therefore, on this clear cutting system, and have in the past two years commenced the attack from the following angles. One experiment is concerned with how far from a parent tree may seed be carried, on an average, in quantity sufficient to give a reasonable stocking of young growth. This would determine the distance apart of our seed trees, if relying upon that method of securing the seed, or the maximum width of our cutting strips if depending on seeding from the side. Rimu seed, though fairly light, has no wing that would make it likely to be carried long distances by the wind, and we shall probably find that the radius of effective distribution is comparatively short. This experiment is not yet complete, but good results have been secured up to five chains. Supposing this should prove to be the limit, it would entail, for the clear-cut-with-scattered-seed-trees modification, leaving at least one seed bearing tree to every eight acres. Actually, more would be required, firstly because the trees would tend to spread seed on one side only, that away from the prevailing wind, secondly, because many might be windthrown before having a chance to spread their seed, and thirdly, because, with rimu, the male and female flowers are on separate trees, so that enough female trees must be left to cover the area, together with sufficient male trees to pollinate the females. If to secure good healthy seeds it is necessary to leave trees that might otherwise be logged, the cost of the method is the investment of foregone royalty unless it pays to come back later to salvage the seed trees after their work is

done. As the trees are scattered singly, this is rarely a remunerative operation, and they are usually left to finally blow over. In the case of the rimu forests the very serious danger of windfall to scattered trees, together with the need for ensuring pollination of the female trees seems to indicate that this method is not the ideal. However, we are trying it in one instance where a number of scattered smaller trees were passed over by the loggers. These are being watched to see how effectively they are seeding up the adjacent land, and how resistant to the wind they prove to be.

A modification of greater promise is that in which, in place of isolated scattered seed-trees, small compact clumps or blocks are left. This makes for much greater safety from windfall, and also ensures the pollination of the female trees. The clumps must be spaced within the radius of effective seed distribution, obviously, just as were the single trees in the first place, so that the quantity of timber left behind is much greater than for the scattered seed-tree method. This is really an advantage, for the quantity left behind is usually sufficient to justify coming back after seeding in has been secured, and cutting out the seed blocks. Nevertheless, it means double working over the area, which raises the logging cost above that of clear-cut-and-plant, for instance.

The next modification being studied is clear cutting in hope of securing reproduction from seed in the duff. It rests on the assumption that the mature trees have been shedding seed for many years prior to logging, so that the duff, or forest floor, must be fairly thickly strewn with seed. Under favourable conditions much of this seed may retain its vitality for a number of years, but in the cool shade of the older trees, may not germinate. With the removal of the mature stand, the light and warmth may then cause this seed to develop, thus giving a new crop of seedlings without any investment in seed trees. This method is on the face of it extremely simple, and at the same time the cheapest of all suggested. No timber is foregone in seed trees, the area is worked but once, to the fullest extent of its utilizable content, and no cost of establishment is incurred in any way. The conditions to be fulfilled, however, are rather exacting. The seed must retain its viability over at least two or three seasons (as one year's crop is seldom sufficient in itself to fully restock an area) it must not be easily destroyed by fungoid, insect, or animal life, it must germinate well when given warmth and light, and must become established quickly enough to compete successfully with

the weeds, grasses, herbs, etc., that always come in on areas that are clear-cut.

Experiments have been arranged in three forms along the lines of this method to test its possibilities. The three forms used differ in regard to their treatment of the logging slash, secondary species, ground cover, etc., left after removal of the usable portions of the milling trees. This slash and secondary growth is very considerable under present logging conditions, and presents a considerable problem as regards occupation of the ground, casting of shade, etc. The three methods under trial are:—the burning off of the slash immediately following the logging; the clearing up and piling of the slash without the use of fire, and third the leaving of an area just as the loggers left it. The first and third methods have been put into operation already, and are now being watched. The second has not yet been finished, but will be put into effect this summer. In each case the cost per acre of treatment is ascertained, and then the three areas will be watched for results in the form of comparative number of seedlings established per acre at the end of one, two, or five years' time. In the first case, a wonderful response has been secured. On an area logged in September, 1927, and burnt the following December, counts of young rimu seedlings of from 6,000 to 10,000 per acre have been recorded. In this case the fire burnt most of the area very clean, leaving only a blackened waste behind. On this, the following summer, young rimu were found to be springing up in places as thick as gorse that has been burnt. A year later, in the spring of 1929, there were even more, while growth has been good in the main. Very little weed or grass growth had appeared, strangely enough, while the rimu seedlings were standing erect and sturdy in the full light, with their roots well down into the true soil. As at maturity there is room on an acre for only one to two hundred trees at most, there is here abundant margin for losses by windfall, insects, and disease during the life of the stand. The adjacent area to this, the one on which the slash was not disposed of in any way, presents a much less optimistic aspect. Comparatively few seedlings are present on the area, while of these many are badly shaded by kamahi and other secondary trees, and may not develop, while others are rooted on moss, decaying logs, etc., and seem in grave danger of being dried out in the summer. On the face of it, it would seem apparent that the burning off was obviously the successful method. It may yet prove to be, but the story is not yet told. The obtaining of germination is but the first step. The next is the youthful

development. It is very possible that the seedlings on much of the burnt area may be parched out in midsummer, as they are very unprotected, and the Westland summer, while short, is hot. The fact that they have in great measure survived the first summer is a good omen, but then, the summer of 1928-29 was very broken with many showers and cool days. It is possible also that the seedlings now so well established may be altogether choked in a few years by a rank growth of herbs, etc. The fact that two years after the fire the area is still almost bare, except for mosses and the rimu seedlings is another good omen, but rimu is not a rapid grower in its youth, and it is yet possible for the next year or two to see the numbers greatly reduced through this cause. On the unburnt areas, it seems that the heavy carpet of needles, leaves, twigs, etc., prevents the access of light and warmth to the soil, and thus prevents germination, while seedlings germinating in the top layer of duff, unable to get their roots down into the true soil, largely dry out and are lost. On the other hand, on the area where the slash and secondary growth has been left, the shade cast will perhaps prevent the serious drying out of the seedlings present, while the same cause will prevent the rush of rank growth that may be expected on the burn, so that though far fewer seedlings are in evidence now, the death rate may be much lower, and so the ultimate result the same. When the intermediate experiment, that of removing the slash without burning off the duff, has been put into effect, we shall be in a position to judge the relative effect on germination of the partial shade, and of the thick layer of duff. For the effect of the shading on the youthful development and mortality, periodical counts and measurements on the small typical areas that have been set out in different parts of the respective areas will in a few years furnish the answer. The full history of the development of this project forms one of the most interesting stories in the development of forestry in New Zealand, and it is hoped to have it completely written up for publication after the close of the coming season.

It was stated earlier in this article that there are three main silvicultural systems, each with its modifications. A description has been given of the work being done in regard to one of the systems—the clear-cutting. Work has also been commenced upon each of the other two systems (known as the shelterwood and selection systems), but as this article has already overrun the editorial limitation of space, a description of the other projects must be held over until the following issue of this journal.