and encouraging it, the authorities should take into account every future possibility. When deer were liberated, few people thought that they would become the pest that they are now. When it is realized that the regeneration of our native bush must play an important part in providing for our future timber requirements, everything will be done that will favour such regeneration. A healthy stocking of native birds for pollination, seed dissemination and insect control purposes will be required. It is impossible that the opossum, for its fur-bearing qualities, would be encouraged under such conditions, where it is a factor (perhaps small) against the regeneration and permanence of our timber and protection forests.

It appears that the opossum has an exceedingly wide range of vegetable foods at least, but what would be the result if the crop of forest tree berries failed, as it did in 1877, when it drove rats and birds (mainly paroquets) out of the bush in search of food in the settled areas? If such a season of poverty should occur again, what would the opossum do under such circumstances? Would they be able to find sufficient food in the bush under such conditions, or would they be forced to migrate to any adjacent orchards and plantations? In many districts their favourite plant foods are being destroyed by their own depredations and those of deer and goats—thus Nothopanax, Melicytus, Fuchsia, etc., are vanishing—so leaving them more dependent on tree fruits, which have cycles of good and bad seed years. In the United States the squirrel is giving trouble to the foresters, on acount of the depletion of its natural food resources, with the result that migrations are sometimes made, in times of want, to adjacent plantations. By nipping off the terminal and lateral buds of such species as Pinus sylvestris, larch and spruce, it may cause considerable damage. It is the unusual season, when supplies are scarce and the depth of snow has rendered ground supplies unavailable, that damage is severe. (See "Red Squirrel Damage to Coniferous Plantations and its Relation to Changing Food Habits" by N. W. Hosley, "Ecology," Jan., 1928.)

The supporters of the opossum assume that the price obtainable for the skins will always be sufficient remuneration for the labour expended in trapping them, and thus they will always be able to be kept under control by trapping. But is this assumption correct? Will there always be a demand for opossum skins, and if so, might it not be supplied by farming the animals under control, with the production of skins at a price that would render the trapping of the wild animal unprofitable? Silver foxes are farmed commercially in Canada, and the production of rabbit skins in England from rabbit farms is greater in number per annum than that exported from New Zealand—perhaps the opossum will be added to the list of commercially farmed animals.

It is considered that the reports so far submitted do not definitely establish the innocuousness of the opossum. To completely satisfy all critics more detailed investigation seems called for. The stomach contents of a large number of animals trapped mainly in the nesting season, should be examined. They should be trapped in many districts, and the class and condition of flora, the numbers and conditions of animals and birds noted, and if possible, the effect of a bad seed year on their diet, should be examined. The forest policy of the future should be taken into account, the silvicultural welfare of native and exotic alike being examined. An investigation with these objects in view would definitely and finally show the true relation of the opossum to the forest.

Some Growth Measurements in Canterbury Exotics.

(D. Kennedy.)

With a view to obtaining accurate data regarding growth and yield of the exotic plantations in Canterbury, the School of Forestry in 1925 established the first of a series of permanent sample plots in the various plantations throughout the province, upon which growth could be periodically measured, and comparative data regarding species, sites and methods of treatment obtained which would be invaluable in planning future forestry operations. The data derived from such a project include the study of growth and the elaboration of yield tables on a basis of comparative development in three forms, namely: The comparative rate of growth and comparative form of different species under the same conditions. The effect on form and on volume growth of varying site qualities, and the effect on growth and development of silvicultural practice in the way of preparation of the soil, thinning, etc.

To carry out the first part of this programme demands a choice of stands of various species growing under uniform conditions of site and receiving uniform treatment. These requirements are well filled by

the younger plantations of the Selwyn Plantation Board on the Plains, where pure stands of several species of conifers are found close together, enjoying practically identical climatic ands oil conditions. The second part of the project plan calls for the establishment of plots in plantations of the chief species all over Canterbury whereby differences in yield due to soil quality, altitude, rainfall and such factors, may be analysed.

The effect of different methods of silvicultural treatment does not occupy a very important place in the project, owing to the fact that silviculture, as practised at present in Canterbury, is rather elementary, but the effect of different methods of planting, as for example, ploughing the land prior to planting or grubber pitting, may be gauged. Until the present, all measurements taken on sample plots have been confined to height only, while plots on which the trees are very young and small have not been measured for height, the trees on such plots being counted to ascertain mortality, and average heights taken. In another year or so, it will be possible to record diameters on some of the older plots, so that yield per acre may be computed.

At present, the School of Forestry has control over twenty-three sample plots, fourteen of which are in the Selwyn Plantation Board's areas on the Canterbury Plains, five at Burke's Pass, and two at Ma Waro, these being in plantations owned by the Mackenzie County Council, and two at Mr. Johnstone's estate, "Springbank," Otaio. Of these, eight plots were established in the Selwyn Plantation Board's reserves and four at Burke's Pass in 1925. Three of the Selwyn and all the Burke's Pass plots were large enough to record individual heights and at the present time the heights of the trees are known for the years 1925-26-27 and 1928, for the three Selwyn plots, and for 1925-27 and 1928 for those at Burke's Pass. No new plots were established in 1926, but in 1927 four more plots were put in on Selwyn Plantation Board's blocks, and one at "Springbank." The heights of the trees on all these plots were recorded and two years' measurements have now been obtained. During 1928, two more plots were established in Selwyn Plantation Board's area, these completing the series for the Canterbury Plains, three in Mackenzie County Council's Plantations, one of these being at Burke's Pass, and the other two at Ma Waro or the Fairlie Branch line. The trees on the Selwyn plots were measured for height growth, but a mortality count and the determination of average heights was considered sufficient for the others. It will now be seen that, with the data in hand, it is not altogether too soon to begin to draw conclusions as to the rate of growth of different species on sites of equal soil quality. Although a complete set of measurements—four years' growth—is available for only seven plots, it is possible to ascertain the average rate of growth for most of the others, as a complete record has been kept of the date of planting the blocks in which the various plots are located. At the same time, it must be remembered that the data set down here is, at the most, the result of only four years' observation, so it is scarcely safe to assume too much from such information, but it is to be hoped that such data will give some indication of growth and development for young stands at least.

It is altogether beyond the limits of this article to give a detailed description of each plot, but the following description should indicate just how much growth is being made by the chief species which are being planted on a commercial scale in this province.

Eight of the fourteen plots situated in the Selwyn Plantation Board's reserves are in blocks of P. radiata and, for seven of these, height growth has been recorded. Thus it is possible to give definite information on height growth on an age basis. In giving these results, the age of the trees has been taken as the time since the trees have been planted out, as it is the usual custom to disregard the time the trees were in the nursery as seedlings. Although this may give rather a high result on young trees, such an approximation would make no noticeable difference on trees of, say, twenty-five or thirty years of age. The average height growth for the seven Selwyn plots of P. radiata since planting is 2.0 ft. per year, the minimum being 1.5 feet and the maximum 2.8 feet per year. The six-year-old plots—four in all, show an average annual height growth of 2.1 feet, although both the maximum and minimum height growth has been made by plots of this age. It is interesting to note that the trees are making much greater annual growth at the present time. For the year ending July, 1928, the average growth of all plots on which two or more years' measurements have been recorded, was 3.2 feet, the minimum being 2.4 feet, and the maximum 4.4 feet. This goes to prove that P. radiata increases considerably in height growth once it is properly established. A remarkable feature is the early age at which some of the trees begin to bear cones, trees only six years old having fully formed cones on them this year. This means that these trees really began to produce cones at five years of age, which is indeed uncommon. Whether or not this point has any biological significance, it is impossible to say, but the trees themselves

appear to be quite healthy and are doing particularly well. The individuals bearing cones are the leading members of the stand, their present height being 20 to 22 feet, while the plot averages are only 12 to 13 feet.

The average annual growth of other species can also be furnished from data in hand, and such growth, when compared with that of P. radiata, should give a good basis for arriving at the merits of the various species from the point of view of rate of growth, as this is often the deciding factor in the choice of species. An excellent comparison is afforded by a block of young trees belonging to the Selwyn Plantation Board. The block is planted with three different species, P. radiata, P. ponderosa and Douglas fir, growing on adjacent areas and enjoying identical conditions of site. The trees were all planted in 1923, and they are, to a certain extent, sheltered by a belt of P. radiata some seventy feet high, growing on all four sides of the area. Sample plots have been established in all three species and from the measurements taken, the results are as follows: P. radiata has made an average annual height growth of 2.0 feet; P. ponderosa 0.5 feet, and Douglas fir 0.88 feet, since time of planting. It would appear that the P. ponderosa has made rather a poor showing, but its slow height growth is in no small measure due to the fact that the trees received a severe setback soon after planting through having many of their leading shoots nipped by hares, these animals exhibiting a strange partiality for the young shoots of this species. Many of the trees survived, however, and at the present time appear to be in very good condition. Indeed individual trees may be seen up to six feet in height, but the average is greatly lowered by the incidence of trees only one or two feet high, most of which are still suffering from the effects of the attack by hares. It is safe to assume that the P. ponderosa would have made height growth at least equal to, if not actually greater than that registered by the Douglas fir had it not been for this untoward occurrence.

Pinus laricio, a species which has figured to some extent in New Zealand planting programmes, is making fairly good growth, although, of course, it is altogether eclipsed by the phenomenal P. radiata. Records of two sample plots, one on the Canterbury Plains, and one at Burke's Pass, show the former has grown in height 1.15 feet per year since planting, the increase for last year being 1.45 feet, while the trees on the plot at Burke's Pass have made an average annual growth of 1.10 feet, registering an increase of 2.5 feet for last year. The above two plots are growing on very different sites and the effects of this difference will be discussed later.

The growth of P. ponderosa has also been recorded for different parts of the Province, plots being located on the plains and at Burke's Pass. The average annual growth of the Selwyn plot of P. ponderosa has already been given—0.5 feet—while the Burke's Pass plots have increased in height 0.87 feet per year since planting, leaving a balance in favour of those at Burke's Pass of about ¼-foot per year.

Two plots of Douglas fir growing on the Plains have made an average height growth of 0.88 and 0.98 feet per year respectively, while the trees on the plot at "Springbank" have made an average growth of 1.16 feet per year. Larch, which is not being planted on the Canterbury Plains, is considered a suitable tree for high country planting, the trees on a plot at Burke's Pass making an average height growth of 1.1 feet per year. In view of the exacting conditions which are encountered in this locality, this growth must be considered very satisfactory. The trees themselves have not a very good form, being rather bushy, while the leaders are somewhat wind-whipped; but it is probable that the trees will attain a sturdier form in the course of a few years.

It would not be out of place to consider here the effect of different sites upon tree growth; site quality, of course, having an all important bearing on height growth besides exerting a considerable influence on the mortality among young trees during the years immediately following their establishment in a plantation, although the value of such data may be greatly discounted by such factors as faulty planting or as often happens on the Canterbury Plains, an extremely dry season immediately after planting. All the sample plots on the Canterbury Plains are situated in the Selwyn, Hororata or Hawkins Survey Districts, and while the soil is, in the main, of similar quality, it differs within fairly narrow limits. Taking first of all the Selwyn plots of P. radiata, the average mortality is 8.9 per cent., the minimum being 0.6 per cent. and the maximum 19.9 per cent. Taking for granted the fact that the height growth is solely governed by site quality, the supposition that mortality is largely dependent on this factor also, is strengthened by the fact that the plot on which the lowest mortality has taken place, has also made the greatest height growth, 2.8 feet per year since time of planting. On the other hand, although the plot with the heaviest mortality has not registered the slowest height growth it has grown only 1.6 feet per year, which is 0.1 feet greater than the minimum. However, there is reason to believe that this mortality has been influenced to a certain extent by other factors which will be discussed later.

In the McKenzie County Council's plantations there are two sample plots located in blocks of P. radiata, one at Burke's Pass and one at Ma Waro on the Fairlie branch line. Here again, site quality appears to play an important part in the mortality incurred in establishing plantations. The land on which the Burke's Pass plot is located is 2,200 feet above sea level and experiences a somewhat rigorous climate with a fairly heavy rainfall, while snow lies for some time every winter. The soil, which is about one foot in depth, overlies decaying rock and shingle and is really very poor. The locality generally is very unfavourable for tree growth; so data collected on tree growth here should provide an excellent indication of the success which may be expected in forest planting in back country districts. The trees on this plot of P. radiata were only one year old so that heights were not recorded when the plot was established. The mortality was 15.3 per cent. The Ma Waro plantation is on considerably better soil—a fair depth of loam over clay—and if flat would be quite suitable for growing field crops. This is also a young block, trees being too small to record individual heights. The mortality, however, was only 4.3 per cent. for the year, showing that on good sites, trees may be expected to establish themselves with much fewer deaths than on poorer areas. Pinus laricio, observed on two different sites, gives a rather unexpected result from the point of view of percentage of mortality. The plot in the Selwyn Plantation Board's block shows an average annual growth of 0.95 feet and a mortality of 8 per cent. The soil on which these trees are growing is approximately of average quality for the Canterbury Plains—a few inches of loam overlying deep beds of shingle. At Burke's Pass on a very poor site, however, P. laricio has made an average annual height growth of 1.1 feet and at the same time, not a single death has occurred on the plot since the time of planting eight years ago. The trees were planted on a four foot by four foot spacing, and it is a fine tribute to the skill of the planters, particularly so when one remembers the severe climate with which the trees have to contend.

This locality receives a fairly heavy summer rainfall in the form of numerous light showers and fogs, and Pinus laricio is evidently more suited to these conditions than it is to the drier lower country. The Burke's Pass trees have a healthier appearance than those on the Selwyn block, and there is little doubt that the value of P. laricio for high country planting will be more widely recognised in the future.

It will be remembered that the Selwyn plot of Pinus ponderosa was badly set back by hares and as a result some 22 per cent. of the original stocking succumbed, so that it is impossible to compare this plot with the plots of the same species growing at Burke's Pass, at least on a basis of site quality. The latter plots have had a mortality of 3.8 per cent. and all these deaths occurred during the first three years after planting out. It is probably exaggeration to say that, even had the trees on the Selwyn plot not been killed by hares they would scarcely have become established with such a low death rate as this. Judging by the success attained in establishing ponderosa at Burke's Pass, this appears to be another species which is eminently suited for planting in localities which would be impossible for many species less hardy as to temperature. The sample plots of Douglas fir show great variation in growth and mortality. On the plains Douglas fir does not appear to be doing very well, as evidently the lower country is too dry for this species, the result being that the trees have little vitality and are often cut back by frost, a feature which makes the future planting of this tree rather problematical—at least for the lower altitudes. Nearer the foothills, however, Douglas fir seems to be doing well, this probably being due in some measure to increased rainfall. On a plot near Coalgate the mortality has been 12.4 per cent. since planting, but the trees are now thriving. The soil here is no better than the average for the Plains, while it would be expected that frosts would be more severe as the block is some 800 feet above sea level.

Douglas fir was planted at Burke's Pass in 1921, but it failed completely and the block was replanted to Pinus ponderosa in 1922, the latter tree being more suited to the locality.

At "Springbank," Otaio, Mr. Johnstone has a plantation of five-year-old Douglas fir growing on a steep south-west face. The land is a heavy clay loam and is evidently suited to this species, as only 0.7 per cent. of the original stocking has been lost.

Those engaged in forestry have sometimes to determine exactly how much shade a certain species will endure and still make satisfactory growth. With this end in view two plots have been established at Kirwee in a block of P. radiata which was underplanted in 1922 in a stand of diseased Eucalypts, mainly E. globulus, E. obliqua and E. amygdalina, these trees being about 40 years old and ranging in size up to 32 inches D.B.H., the stand itself being somewhat scattered with a fair number of blanks and open spaces which admit a good deal of light. The soil is of rather better quality than that usually met with on the Canterbury Plains, being rather more moisture-retentive owing to the presence of a clay loam some ten inches in depth overlying the alluvial shingle which is the foundation of the whole of the Plains. Thus the trees are quite favourably situated

Photo School of Forestry.

INSIGNIS PINE UNDERPLANTED IN DISEASED EUCALYPT STAND,
Showing weedy growth under moderate shade. Photo Sept., 1926.

Photo School of Forestry.

OPEN PORTION IN SAME STAND.
Showing Sturdier Growth in Full Light. Photo Sept., 1926.

as regards soil and it will be interesting to observe whether P. radiata is tolerant enough to withstand the moderate shading afforded by the Eucalypt overstand and produce trees of good growth and form.

One sample plot was established in a part of the block where average shading was encountered, while advantage was taken of a considerable area in the centre of the plantation which is free of Eucalypts, by establishing a second sample plot to act as a control and thus furnish an excellent gauge on the effects of overshading. This second plot naturally enjoys all the benefits of the overstand such as shelter, etc., without being actually shaded. Photos of these two plots taken in September, 1926, accompany this article, and reveal the differences in characteristic development.

The trees on the shaded plot have made an average annual height growth of 1.5 feet, and the original stocking has been reduced through deaths by 4.5 per cent., while those on the plot in the open space have grown in height 2.8 feet per year since planting; the mortality in this case being only 0.6 per cent. The trees on this plot are looking much better than those under the Eucalypts, the latter exhibiting a tendency towards a thin spindly manner of growth, while many of the trees are sending out adventitious shoots. Even moderate shading thus has a considerable influence on the growth of P. radiata, but whether this retarding effect will mean a better quality in the final product of saw timber, it is as yet too early to say. However, this underplanting experiment is a departure not often encountered, and the final result will be both interesting and illuminating.

To what extent does the method of planting influence the early growth and the mortality among young trees? This is a question which is often asked, but little information has been forthcoming on this point. From the records in hand it is possible to give some results which have been obtained by the Selwyn Plantation Board for two different methods, namely, ploughing the soil as a preparation for planting as opposed to grubber pitting the trees into the original sod. A block of P. radiata was planted by these two methods, one portion being grubber pitted with one-one stock, that is, trees which have been one year in seed-beds and one year in nursery rows as transplants. Another part of the block was ploughed and planted with 1-0 stock, and the third portion which was also ploughed was planted with 1-1 stock. The part of the block which was ploughed with 1-0 stock has made the best growth to date, the average annual height growth being 2.3 feet, as against 1.7 feet per year for the 1-1 grubber pitted area and 1.9 feet per year for the 1-1 portion which was ploughed. These figures show that ploughing the land preparatory to planting enables the trees to make greater height growth in early life, this probably being due to the fact that ploughing suppresses the growth of grass and other weeds which which would otherwise compete with the trees for plant-food and light. It is rather hard to account for the fact that 1-0 stock has eclipsed 1-1 stock in ploughed land, but probably where the trees have no competition from grass and weeds, the smaller trees would suffer less of a set-back through planting out and would thus get a better start than larger trees. The mortality for this block was almost the same for both methods of planting. It seems that the depth of ploughing can be too great, as another block of P. radiata on a very similar site suffered a loss of 19.9 per cent. of the original stocking. The soil, being very deeply ploughed before planting, was studded with underground pockets, as anyone walking over the surface was continually breaking through. It is thought that the very high mortality was the result of putting the roots of the young trees into these air-pockets in planting, in which case they could not be expected to grow. The same feature was in evidence in a recently established block of Cupressus macrocarpa at Ma Waro. The land, a very good loam and quite suitable for tree growth, was ploughed to a depth of one foot prior to planting, and these underground "potholes" were much in evidence. The mortality on a plot situated in the block was 28.4 per cent. and although C. macrocarpa is undoubtedly a difficult species to establish this extremely high percentage of deaths cannot be altogether due to this factor as the past season in the Fairlie district was quite favourable for tree growth. Although ploughing prior to planting is doubtless an excellent preparation for the soil, it is perhaps as well not to plough to too great a depth unless the soil is to be thoroughly cultivated afterwards.

It is to be hoped that the above will give some idea of the value of sample plots and that the results set down give a true indication of the relative merits of the various species in different localities, but at the same time it must be borne in mind that it is really too early to draw any very definite conclusions from such tentative data. However, when another ten or fifteen years' records are available it will be possible to predict with a greater degree of certainty exactly how much may be expected from any species on a known site for any stipulated time, while to attempt to do this at present would be merely guesswork and perhaps productive of disastrous results.