

THE GROWTH AND YIELD OF EXOTIC CONIFERS IN CANTERBURY.

(F. E. Hutchinson.)

III. Early Development of a Typical Stand.

The impending departure of the writer overseas has prevented this article, which must now conclude the series, from taking the shape originally intended. As has been set out in previous issues of this journal, the School of Forestry commenced in 1925 the installation of a series of permanent sample plots in various plantations throughout Canterbury. Practically all the plots were installed in young stands within a short time after planting, and were intended to follow through the whole life cycle of the plantations in which they were installed. Annual measurements were made during the early years to enable a close watch to be kept on seedling development and survival, and it had been planned for this article to discuss early mortality in some detail. This has not been possible for the cause mentioned above, and instead will be presented a study of the development of one plot only, located in a stand of insignis pine planted in 1921. This plot is chosen because it typifies in large measure the present forestry practice of the Canterbury Plains. The stand is located on the mid-plains, with the typical thin loam over loess clay, over deep beds of impacted shingle, the loam being but an inch or two, and the loess varying from three to six inches in depth. The site falls half-way between Sites II. and III., as given in the yield table by J. W. Syme, published in the 1933 issue of this journal. The stand is of 1-1 stock at a spacing of 8 x 8 feet grubber pitted in a cover of fairly rank old grass.

These are the species, site, planting method and spacing of the majority of recent afforestation projects carried out in this province. The date of planting was August, 1921, and the sample plot was installed in August, 1925, or four years later. The plot is square, $\frac{1}{4}$ acre in area, and was located in what seemed average conditions so far as the stand had developed. Measurements were made annually from 1925 to 1930 inclusive, when a 5-year period was to be followed. A special measurement was made, however, in August of this year.

From 1925 to 1928 inclusive the annual measurements consisted of a mortality count, and a measurement of the height of all living trees to the nearest foot, taken with a long folding rod. By 1929 the leading trees were beyond

reach of the rod, and Abney and chain were used. Many trees were inaccessible through poor visibility, and heights were taken only on a portion of the total number. Measurements of D.B.H. on all trees 2.0in and over were commenced in this year. In 1930 the same procedure was followed, and in 1934 it was amplified slightly to include the crown class of every tree. From these measurements the following story of development is taken.

At time of establishment of the plot, the stand was four years old. In these four years, development was found to have been surprisingly irregular, both in height growth and in mortality. The plantation was traversed fairly thoroughly in picking a location for the plot, and over the whole was observed a frequent occurrence of groups of small sickly trees or of blanks left by deaths, intermingled with the main body of tall, healthy and well growing trees. These small areas were usually long and narrow, and ran parallel with the planting rows; and so regular was their occurrence that it was first thought that faulty planting by some individual planter was the cause. It was established, however, that the primary cause of each of these unsuccessful areas was a ridge or bar of shingle very close beneath the surface, the axis of these bars just happening to coincide with the direction of the planting rows.

One such area was included in the plot, in fact, a square quarter-acre plot could not be laid out without including one, so the plot figures typify the average for the stand as a whole as well as may be expected.

At this initial measurement in 1925, mortality had been but five trees out of the original stocking of 203, all concentrated on the shingle bar along the south-western side of the plot. The trees ranged from $\frac{1}{2}$ foot to 10 feet in height, averaging 4.0 feet, but were divided rather sharply into successful trees of 3 feet and upward, and unsuccessful trees of $\frac{1}{2}$ to 2 feet in height, the majority of these being recorded as $\frac{1}{2}$ foot. These unsuccessful trees were mainly concentrated on the south-western side, on the shingle bar already mentioned, but were also scattered throughout. These trees never improved, and the history of the plot from 1925 to 1930 is largely a record of growth on the successful class, together with the steady elimination by death of these unsuccessful trees. In this elimination, suppression took no part, as all expired under conditions of full light and abundant space.

Crown widths varied from a few inches on the unsuc-

cessful trees to three feet across in the larger individuals. With a spacing of 8 x 8 feet, there was naturally no crown contact, and the cover of coarse grass was in no way affected yet.

The area had been rabbited and netted at time of planting, and no damage was noted.

Sixteen trees were noted as being infested with the "white blight" *Pineus pini* Born, these being rather surprisingly not so much the definitely unsuccessful trees as individuals from three to five feet in height.

In 1926 when the second measurement was made, the records show a death of 9 more trees, all of the unsuccessful class, and all located on the shingle bar on the south-west side of the plot. This concentration of mortality was already causing a fair sized gap to occur, as is shown in the plot diagram. Heights ranged from $\frac{1}{2}$ foot to 12 feet, the average being 5.8 feet, representing an increase of 1.8 feet for the year, due not alone to growth, but partly to the elimination of nine unsuccessful trees which had died. The occurrence of "white blight" was about the same as before, but it was noted that while some trees were newly infested, a few that were marked as infected in 1925 were now free from infestation.

The 1927 measurements record one death, increasing further the gap forming on the shingle bar on the south-west side. Heights ranged from 1 foot to 15 feet, the average being 8.6 feet, an increase of 2.8 feet, due almost wholly to growth. The plot record describes the stand as follows: "The plantation, now 6 years old, has not yet assumed the character of a forest stand. The crowns are still far from touching throughout the greater part of the area, only occasional clumps of large trees being seen where the crowns are intermingling. Between the rows vision is not curtailed for some chains. A dense mat of grass still possesses the whole floor of the stand except immediately about the root collar of the largest trees. There is absolutely no suppression yet in evidence, the larger trees being tall but spindly with narrow crowns, and the small unsuccessful trees are in no way shaded."

By 1928 a further four trees of the unsuccessful class had succumbed, again concentrated on the southwest side. Heights ranged from 1 to 20 feet, averaging 12.2 feet, an increase of 3.4 feet, due partly to growth and partly to elimination. Lower branches were beginning to interlock at 3 to 5 feet from the ground, though the grass cover was

not yet suppressed. A few two-year-old ripe cones were noted on the tallest trees, together with a large number of one-year-old cones. White blight receives no mention in the record from now on.

The next measurement, that of 1929, records numerous cones. The successful trees were looking very well, and it is noted that the larger individuals were developing rather heavily limbed crowns. Crowns were meeting in most cases from 3 to 8 feet above the ground, and the limbs of the lowermost collar were beginning to die back. Grass growth was still rank, however. Mortality in the year had been but one tree, again an unsuccessful tree on the southwest side, where a considerable gap had now developed.

Height measurements were in 1929 not quite comparable with those of previous years, in that but 128 trees were measured, with rod and Abney, out of 183 live trees. Those measured included all the small and sickly trees, while those excluded were larger trees which could not be taken with Abney due to poor visibility. D.B.H. was recorded on all trees above 2 inches, and a curve of height on D.B.H. was constructed from the measured trees. The range of recorded height was from 3 to 27 feet. The arithmetic average of the 128 measured trees was 15.7 feet, though this, as explained, is biased downward. Of the 183 living trees, 144 had a D.B.H. of 2.0 inches and more, and were tallied to the nearest 1/10th inch with steel diameter tape. Of these, 81 came into the measurable 4 inch class (that is, 3.6 inches and over), and were studied for volume. The D.B.H. of the mean sample tree, i.e., the tree of average basal area, was 4.3 inches, and its height, from the curve, was 21.0 feet. Its volume by interpolation on Wickett and Moorhouse's volume table was 0.775 cu. ft. giving a volume per acre of 251 cubic feet. (Total volume I.B.) The largest D.B.H. recorded was 5.5 inches.

The 1930 measurements were carried out on similar lines to those of 1929. Mortality for the year was nil. The total stocking of live trees was 183, of which 29 were below 2.0 inches D.B.H. and were not measured. Of the 154 measured trees, 116 were of 3.6 inches D.B.H. or over, and were computed for volume. The mean sample tree proved to be one of 5.0 inches D.B.H., with a height, from the curve, of $21\frac{1}{2}$ feet. Its volume by interpolation in the volume table was 1.074 cu. ft., giving an indicated volume of 498 cu. ft. per acre. The largest D.B.H. recorded was 7.2 inches

The measurement of August, 1934, revealed striking changes in the stand since the 1930 record. The most important was the fact that true forest condition had been achieved. The grass cover was gone from all except the gap on the southwest side, its place having been taken by a carpet of needles already disintegrating in the bottom layers. Lower limbs had been suppressed to a height of four to seven feet, the dead stubs, tough and springy, protruding, and adhering tightly as is characteristic of the insignis pine. Crown class differentiation had been almost achieved. The suppressed and intermediate classes were quite distinct, though the classification of the dominant and codominant classes was somewhat vague and arbitrary. Most significant was the fact that the mortality of 17 trees in the four years had been accomplished by suppression, the dead trees being found in the densely stocked portion of the plot, and comprising individuals from the earlier intermediate and lower codominant classes—individuals which had previously been among the shorter members of the successful class. In addition to the 17 deaths, a further nine trees are recorded as dying back, presaging an early elimination. The deaths had mainly occurred recently, evidently the cumulative result of three exceptionally and increasingly dry years. There still existed a few of the unsuccessful class, mainly green and healthy, but having made little growth since establishment. Most of these should soon be eliminated by suppression. The gap on the southwest side had by 1934 attained a width of twenty feet and a length of thirty feet, but had almost ceased to expand, and was now being slowly reduced by crown expansion of the bordering trees.

The boles of the dead and dying trees showed plentiful exit holes of the horntail *Sirex juvencus*.

Of the 166 living trees, 150 were of 2 inches D.B.H. and over, while 136 were of pole size, 3.6 inches and upward. Of these 136 trees, the mean sample tree had a D.B.H. of 6.6 inches, a height from the curve of $34\frac{1}{2}$ feet, and a total volume by interpolation in the volume table of 3.579 cu. ft.; giving an indicated volume of 1,699 cu. ft. per acre.

By using the volume table direct on all trees above 3.6 inches, the figure of 1,764 cu. ft. per acre total volume is obtained.

The greatest height recorded was 47 feet, and the greatest D.B.H. 9.7 inches.

The crown class distribution was:—

Dominant	53 trees, of which 15 measured averaged 38½ feet.
Codominant	61 trees, of which 17 measured averaged 33 feet.
Intermediate	27 trees, of which 2 measured averaged 24 feet.
Suppressed	25 trees, of which 8 measured averaged 11 feet.

The stand table was:—

D.B.H.	....	....	4	5	6	7	8	9	10
Average Height	....	....	26	29	33	36	39	42	45
No. Trees	....	....	9	28	33	31	27	7	1

The yield table by J.W. Syme in the 1933 issue of this journal would indicate that for 13 years of age, and a height of dominant trees of 38 feet the fully stocked or normal yield should be 2,064 cu. ft. per acre. On this basis the plot is at present .8 stocked, the deficiency being due to the gap on the shingle bar already mentioned. As has been stated, the gap is now being encroached upon by surrounding trees, so that the density factor will tend to increase in future, and there is reason to anticipate that full stocking should be achieved well before maturity.

The following table summarizes the statistical data presented.

Year	Age	Stocking per acre	Mortality %	Av. Ht.	Ht. Dom. Trees	Mean D.B.H.	Sample Tree Ht.	Tree Vol.	Volume per acre
1925	4	792	2.5	4.0					
1926	5	756	7.4	5.8					
1927	6	752	7.4	8.6					
1928	7	736	9.3	12.2					
1929	8	732	9.8	15.7		4.3	21	0.775	251
1930	9	732	9.8	—		5.0	21½	1.074	498
1934	13	664	18.2	—	38½	6.6	34½	3.579	1,699

Notes:—The average height for 1929 is too low in that a number of large trees were omitted.

The volumes given are total cubic feet, inside bark.

The "mean sample tree" is the tree of average basal area of the measured trees, i.e., trees 3.6 inches and more in D.B.H.