ART. XLVII.—*On Growth-periods of New Zealand Trees, especially* Nothofagus fusca *and the Totara* (Podocarpus totara).

By H. B. KIRK, M.A., F.N.Z.Inst., Professor of Biology, Victoria University College.

[*Read before the New Zealand Science Congress, Palmerston North, 29th January, 1921; received by Editor, 14th February, 1921; issued separately, 12th August, 1921.*]

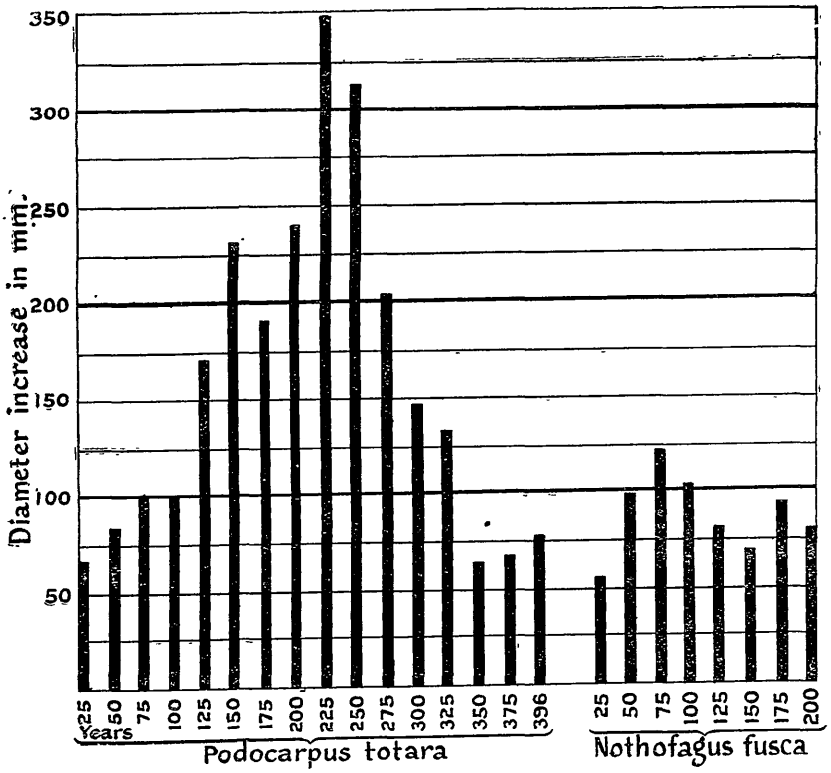
MOST of the information available as to the diameter-increase in New Zealand trees is expressed in terms of the diameter achieved by a tree during its whole life, little regard being paid to its growth at different periods of its life. Examination of several of our trees, however, shows that there is a well-marked period of youth, during which growth is slow; a prime, during which growth is, relatively at all events (and often absolutely), rapid; and a period of senescence, during which growth is slower than in youth. I was much impressed by this when marking the section of a big totara (*Podocarpus totara*) in the Biology Museum of Victoria University College. The Forestry Commission of 1913 published a photograph of this section in its report, together with a diagram showing the relative position of the twenty-five-year points marked on the radius, but did not otherwise call attention to the widely varying rate of growth at different periods. This varying rate is shown by the figures in Table A of this article, and by the graphic representation which shows the increase in diameter for each period of twenty-five years. It will be seen that in the first 100 years—the youth of the tree—a diameter of only 350 mm. (13·8 in.) was achieved. At 200 years the diameter had reached 1,180 mm. (46·49 in.). The period of most rapid growth (of the arbitrary periods marked) was that from 200 years to 225 years, bringing the diameter up to 1,528 mm. (5 ft.). From this time growth became slower until it was less than during the youth of the tree. At the age of 396 years, when the tree was felled, its diameter was 2,528 mm. (8·3 ft.). It has been assumed that only one growth-ring was formed in each year, and I believe the assumption is justified.

I have not examined other totara-trunks with the same attention, but have found that the slow early growth, the rapid growth of the prime, and the slower growth of age are constant features. The bearing of this upon the conservation of totara that have passed their first hundred years is obvious.

In February, 1920, I was for a few days at Paradise, at the head of Lake Wakatipu, where milling was being carried on in the beech forest, and trees were being felled to supply material for the bridge over the Reece. A number of trees of *Nothofagus fusca* had been felled, and examination of these showed a well-marked youth and prime, and that later growth had been at a slower rate, though the rate did not decline uniformly. The oldest of these trees showed 213 rings, but it is probable that none had reached full age. Standing trees of much greater diameter were probably older, but they were generally hollow. I counted carefully the rings on four of the sound trees, and measured the diameter-growth for each period of five years. In Table A these results are shown for periods of twenty-five years, to correspond with those chosen for the totara. These figures, with the graphic representation, show the slowest growth during the first twenty-five years, relatively rapid growth during the next seventy-five, followed by a growth-rate slower than the maximum, but never coming to be so slow as that of the youth period. I do not suppose that the period of old age had been entered upon by any of these trees. The

average for these four shows the greatest growth in the third of the twenty-five-year periods. The tree C made its greatest growth in the second period. Although I was able to count with sufficient exactness for tabulation the rings on only four trees, I was able to count those on seven other trees with sufficient approximation to exactness to show that the averages of the different periods as ascertained for the four could not be far wrong, if wrong at all, for the whole number.

In order to see whether the growth of younger trees was proceeding at the same rate I examined a number of saplings that had been felled. The figures obtained are given in Table B, II. They are given for ten-year periods, as the life of none of these saplings covered two full periods of twenty-five years. Also, the figures are given for the longest radius only,



not for the diameter. The reason for this is that growth in nearly every young tree of *N. fusca* is eccentric, and sometimes the amount of eccentricity is great. The total length of the opposite radius, usually the shortest, is noted. After from fifty to seventy-five years the eccentricity becomes corrected by the unequal later growth.

In Table B, I, the radial growth of the four big trees A, B, C, and D is given for the first four periods of ten years. A comparison of the Tables B, I, and B, II, shows that the growth of the forest saplings is very much slower than was that of the big trees. It seems likely that these old trees were among the original members of the forest, and had a much more abundant supply of light than they permitted their descendants to have.

The view expressed at the conclusion of the preceding paragraph gains support from examination of saplings grown without the competition of older trees. Beside the road, and on the original road-clearing near the

head of Diamond Lake, are closely-crowded young trees, often with only a few square inches of soil-surface for each tree. In many cases they are drawn up to a height of from 20 ft. to 30 ft. Table B, III, shows the radial increase for six of these plants. For the first of the ten-year periods these made nearly three times the radial growth made by the forest saplings, and a greater growth than that made by the four big trees in their first ten years. Those that had completed a second period showed greater growth than the forest saplings in the corresponding period, but less than the big trees had made. On the whole, they tend to show that competition with trees of their own age has been less retarding of diameter-increase than competition with older trees would have been.

No record was made in the case of any tree of which the foliage was not available to make certain identification possible.

So far as I could learn, the road was made about twenty-two years ago. As beech-seedlings lose little time in starting, it is probable that some of those that I examined were among the first competitors on the newly cleared site. If so, there is no reason to suppose that two growth-rings have been formed in any one year.

The data here given are recognized as inadequate for the foundation of a theory, but are, I think, adequate to show that in measurements of our trees we should have regard to growth-periods, and should not be content with a statement that a tree of a given age has a stated diameter.

TABLE A.

Nothofagus fusca, Paradise, 17th February, 1920.

—	Example.	Age, in Years. 25.	50.	75.	100.	125.	150.	175.	200.	Over 200.
		Mm	Mm.	Mm	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.
Diameter	A	54	142	246	336	402	438	610	700	742 (213 yrs.)
	B	32	102	218	368	462	562	628	696	710 (206 yrs.)
	C	68	190	280	340	390	468	486 (158 yrs.)		
	D	64	176	356	486	576	636	694 (174 yrs.)		
Average diameter ..		54·5	152·5	275·0	377·5	457·5	526·0	619·0	698·0	
Average increase in diameter		54·5	98·0	122·5	102·0	80·0	68·5	93·0	79·0	

Totara (*Podocarpus totara*) in Biology Museum of Victoria University College.

—	Age, in Years. 25.	50.	75.	100.	125.	150.	175.	200.
Diameter ..	Mm. 68	Mm. 150	Mm. 250	Mm. 350	Mm. 520	Mm. 750	Mm. 940	Mm. 1,180
Increase in diameter	68	82	100	100	170	230	190	240
—	Age, in Years. 225.	250.	275.	300.	325.	350.	375.	396.
Diameter ..	Mm. 1,528	Mm. 1,838	Mm. 2,042	Mm 2,188	Mm. 2,320	Mm. 2,384	Mm. 2,452	Mm. 2,528
Increase in diameter	348	310	204	146	132	64	68	76

TABLE B.

Nothofagus fusca: *Increase in Radius shown for Periods of Ten Years.*

I. Trees A, B, C, D, First Forty Years.

—	Example.	Age, in Years. 10.	20.	30.	40.
		Mm.	Mm.	Mm.	Mm.
Radius	A	11	21	33	53
	B	8	13	19	34
	C	9	23	44	75
	D	6	23	41	67
Average radius		8·5	20	34·2	57·3
Average increase in radius		8·5	11·5	14·3	23·0

II. Saplings in the Forest.

—	Example.	Age, in Years. 10.	20.	30.	40	—	Opposite Radius.
		Mm.	Mm.	Mm.	Mm.	Mm	Mm
Radius	E	5	11	18	31	41 (47 yrs.)	30
	F	4	14	22	35 (39 yrs.)	..	30
	G	4	9	15	34 (40 yrs.)	..	27
	H	4	9	22	27 (35 yrs.)	..	27
	J	4	10	23	27 (37 yrs.)	..	25
Average radius		4·2	10·6	20·0			
Increase in radius ..		4·2	6·4	9·4			

III. Saplings grown in Road-clearing.

—	Example.	Age, in Years. 10.	20.	30.	Opposite Radius.
		Mm.	Mm.	Mm.	Mm.
Radius ..	K	10	18	19 (21 yrs.)	11
	L	13	19 (12 yrs.)	..	12
	M	16	18 (11 yrs.)	..	5
	N	14	19 (16 yrs.)	..	9
	O	9	16	17 (21 yrs.)	10
	P	5	7 (14 yrs.)	..	5
Average radius		11·2			