

they are useful only for firewood and packing-case timber. Now an observant person will notice that quick-growing trees in a plantation do not shed their side branches before reaching maturity, and the natural conclusion is that these offending branches must be removed by artificial means. The man who succeeds in pruning such trees economically will have achieved the greatest success that has been the lot of any forester the world over. The question of pruning away a portion of the live branches has come under discussion very much of late, but observations made throughout the South Island are not convincing. The macrocarpa strongly resents such treatment even to the extent of dying out. The insignis pine and Douglas fir show a great decrease in growth and a strong tendency to throw out bunches of growth which must prove almost as detrimental to the production of clean timber as the branches themselves. This important branch of silviculture then resolves itself into the question of accurate spacing to produce the desired crown cover and the removal of suppressed branches to a height of, say, from twenty-four feet. If such a butt log were produced throughout our plantations, we could then afford to consign the tops to the firewood-merchant and the box-maker.

I commend these three problems to those men of the community who have "tree sense." The requirements are urgent, the work most worthy.

Wood Technological Notes.

(C. S. Barker.)

EDITOR'S NOTE.—Owing to Mr. Barker's sudden departure for England, the following paragraphs were arranged by Mr. Hutchinson from laboratory records as outlined by Mr. Barker. The descriptions are therefore not as detailed in form as would other have been the case.

1. Anomalous Tissue in the Wood of N.Z. Podocarps:

In a brief item in the 1927 issue of *Te Kura Ngahere* a description was given of an anomalous tissue encountered in the stem of rimu. This tissue takes the form of abnormal masses of thick walled irregularly shaped, indefinitely arranged cells, filled with a brownish content. These masses were encountered on both butt and top sections of rimu trunks, were of unknown but seemingly considerable height, or transverse length, and on transverse sections were easily dis-

cernable to the unaided eye as a small dark mass or core of tissue at the centre, or pith, with several fine dark lines radiating outward from the centre for an indefinite but considerable distance. The description was illustrated by three microphotographs which, unfortunately, were very poorly reproduced.

Since writing the above, further observations of anomalous tissue have been made in the course of examination of other indigenous podocarp timbers.

(a) Miro.

Macroscopic examination of this timber frequently reveals a number of small black specks or fleckings sometimes appearing on the transverse section as tangential groups of two or three, occurring scatteringly throughout the heartwood. Micro-sections through such flecks reveal anomalous tissue, similar in general nature to that described in rimu, but not localised in the pith and radiating outward therefrom, as was the case described for the latter species.

In transverse section the phenomenon shows as a group of from one to three or four tangentially adjacent areas of large, irregularly shaped and indefinitely arranged cells mostly filled with a brownish or darker content. The area thus affected is roughly circular, though ending on one radial side rather flatly against a row of radially appressed tracheids such as form the ill-defined growth zones in this species. In the opposite radial direction, the tendency is for the affected area to taper off in a long narrow point, finally losing itself in normal tissue. (Mr. Barker's notes do not state which radial direction is toward the pith and which toward the bark. From the slides it is not possible to say definitely, though apparently the tapering point is towards the bark. F.E.H.) Around these areas of affected tissue the medullary rays bend somewhat in most cases, though some rays seem to lose their identity in these areas, or to commence from them.

The tangential section reveals the most characteristic view of these areas of abnormal tissue. Each area is revealed as a fusiform mass of indefinite height, bearing a most striking superficial appearance to the large rays of oak for instance. They are frequently vertically aggregate, with thin sinuous strands of normal tracheid between the sections of anomalous tissue. The individual cells in the affected area are loosely grouped, indefinitely arranged and mainly circular in outline. At the upper and lower extremities of the fusiform groupings a spiralling inward of the outer cells and of the more or less normal though misshapen adjacent tracheids is sometimes evidenced,

the grouping, under low power, bearing a resemblance to the concentric spirals so common in Maori art—a centre or core of abnormal tissue, surrounded by incurling tracheids. This aspect is not so pronounced in the tangential sections of miro examined, as in totara, for instance.

In radial section, however, the spiralling, or incurling of the cells of the surrounding tissue is distinctly marked, the longitudinal tracheids especially being greatly distorted and bent out of alignment, while ray tissue is also involved to greater or less extent, the rays in some cases having a slanting course for a short distance, continuing again on a higher or lower horizontal plane when past the disturbing area.

(b) Totara.

In totara, two forms of occurrence of anomalous tissue have been noted. In one case, the occurrence is as described last year for rimu—namely, a circular mass of undifferentiated cells filling the centre or pith of the stem, from which fine lines of this tissue radiate outward as spokes from a hub. The description of the tissue given for rimu applies also to totara. Six to seven radiating lines have been noted, of which two or three are macroscopic, the remainder being sub-macroscopic. The larger radiations are one to four cells wide, on transverse section, not always fully continuous, but radially aggregate, extending outward as much as four to seven growth zones, or 5 mm. in length.

The second occurrence noted is similar to that recorded for miro—namely the observation of isolated masses of anomalous tissue, not localised at the pith but occurring sporadically in the secondary tissue of the stem, the case described being found in a section from the top of the milling bole. This formation appeared macroscopically on the transverse surface as a dark mass of tissue of 10 mm. in tangential length by about half this dimension in radial width. Sectioned, it proved to be a large area of tissue similar in character to that already described for rimu and miro. It was more clearly defined in transverse outline than was the case of the flecks encountered in miro, however. Commencing very definitely with a clear cut separation against the outer terminating row of thicker walled cells delimiting a growth zone, with a tangential length of 10 mm., the mass of anomalous tissue proceeded outward radially as a mass of rounded indefinitely arranged cells, for an average width of 2 mm. when it broke up into several points which continued outward, tapering to blunt points with an extreme total width of 5 mm., and affecting four growth zones. On this outer side the definition between the anomalous

and the normal tissue was not clear cut, but gradual, the adjacent tracheids being affected in size, shape and arrangement to greater or less extent, with scattered outlying groups of abnormal cells intermingling with the more or less distorted longitudinal tissue. The growth zones were affected also, swinging outward as they approached one of the radiating points, to swing inward again to the old alignment after passing. The rounded, undifferentiated cells, filled with a brown deposit, are similar to those already described. This may be regarded as the anomalous tissue proper. The adjacent tissue, which has been referred to as distorted normal tissue, is of interest, however. The normally longitudinal, radially arranged secondary tissue of tracheids and diffuse parenchyma seems to be undergoing a change into an undifferentiated form. The order and arrangement becomes progressively upset as the anomalous tissue proper is approached. In front of one of the points referred to the tissue shows in transverse section tracheids lying at all angles and in all directions—that is, the order is upset both transversely and longitudinally. Longitudinal sections reveal, however, that this disorder takes the form of a spiral incurling toward the centre of disturbance—the mass of undifferentiated tissue, round which distorted tracheids weave in strange concentric spiralling fashion. This characteristic was mentioned previously in regard to miro, but in the case of totara was very strongly marked, every possible angle and direction being taken by tracheid ends, and every possible stage between normal secondary tissue and completely undifferentiated cells being observable.

2. Growth Ring Formation.

The 1926 number of *Te Kura Ngahere* contains an article entitled "The Value of Growth Rings in New Zealand Mensuration Studies," wherein the writer, Hutchinson, raised a doubt as to the annual nature of the growth zones or rings formed by the native taxed (podocarp) trees of New Zealand. The main points raised in regard to these trees were, first, the intermittent character of leaf formation, and second, the occurrence of fused or "split" rings, to quote Hutchinson's phrase, "where one of the narrow limiting bands of thicker walled cells divides into two bands of equal size and general character with a band of thin walled cells intervening." He records the chance discovery of such a splitting or division in a micro-section of kahikatea, and goes on to state that he suspects this to be a common occurrence in New Zealand podocarps, in support of a theory that growth occurs as a series of loosely de-

fined and over-lapping periods of cambial activity not definitely related to calendar periods.

In regard to the occurrence of these split rings in the various podocarps, examination of micro-sections prepared during the past year from specimens of the chief commercial podocarps of New Zealand has shown that this phenomenon may be encountered not infrequently in kahikatea, rimu, miro, silver pine and totara. In all cases, the observation was accidental, being noted on sections cut for general structure study. It is impossible therefore to state the complete nature of the double ring formed—whether it joined up again with the same ring further round the circumference, united with the other adjacent ring, or lost its identity by becoming merged into thin walled tissue. Observation of the slides showed only the point of division of the thick-walled band, with a short distance on either side. In one instance in kahikatea, on the one section, a thick-walled band split into two, with thin walled material between. About 2 mm. further on one of these bands again split into two, making three rings or bands in all, in place of one.

In addition to these softwoods it may be mentioned that the wood of rewarewa is typically formed by alternate concentric layers of fibres and of parenchyma embracing the pores—a “ring porous” wood. One micro-section of this wood revealed a splitting into two of a parenchymatous band, to form two bands with fibre tissue intervening. This is more or less analogous to the formations in the softwoods mentioned, but whether the parenchyma represents “early” wood and the fibre “late” wood has yet to be established.

How common such a feature may be in the species mentioned is not known, but from its accidental observance in a number of slides cut for general study, it is probably rather frequent. It is suggested that the full investigation of the nature and occurrence of these split rings would be an interesting and valuable subject for study, as it might help to establish more particularly the nature of cambial action in the New Zealand trees.

In this regard attention may be drawn to the recent work of Coster published in the annals of the Botanical Gardens at Buitenzorg, in the investigation of the whole field of cambium activity in the tropics, both on trees indigenous to tropic latitudes, and on trees from temperate climates being grown at Buitenzorg and elsewhere in Java. A translation of parts of Coster's work is now available in the School of Forestry Library, though the most recent article from Coster's pen is still unavailable here except in the

original German. The whole of the work so far translated is well worth study in this connection, though the following quotations seem particularly apt. They are from “On the Anatomy and Physiology of Growth Zones and Annual Ring Formation in the Tropics.” Vol. XXXVII. *Annales du Jardin Botanique de Buitenzorg*.

Speaking of teak, after detailing and tabulating measurements made on growing shoots, Coster says (P. 126, p.2): “He (Geiger) found that in East Java the annual rings are formed normally; at times the rings here are lacking for the first 1—2 years. In West Java the ring formation is irregular, often obscure, or distinct only in places; the rings may here be lacking for 12 years in succession. Older trees, however, mostly form distinct rings. My own observations thoroughly agree with this account. A nine-year-old tree from Djasinga, near Buitenzorg, showed only one well developed ring at the periphery. The second-last (ring) was interrupted in places, and further in still less continuous short strips of a growth zone were to be found. A similar appearance was presented by two young trees of unknown age from Buitenzorg, and by a slab of a tree of perhaps about 15 years from Oelele (Atjeh, Sumatra; here likewise, there is almost no dry season). On the other hand a branch of a big old teak (?) tree in the Buitenzorg botanical garden has distinct growth zones, for the most part joined up all round, but running together in places and vanishing; in one case it also seemed that a ring became lost in the tissues. A bored-sample, which was extracted from the main trunk of this tree with a Pressler's Increment borer, showed not only distinct normal rings, but also others formed only of a narrow strip of parenchyma, and others which at irregular distances apart showed irregular structure; it may therefore be supposed (or suspected) that the main trunk can also exhibit an analogous and somewhat irregular ring-formation. But these rings are not annual rings at all, but only growth rings, as demonstrated in the following observation: At the beginning of March, 1925, the same old tree,* which has been described by Volkens and Simon, was in full green leaf, but almost completely at rest; it bore old flowerstalks with fruit. Soon after, the whole upper part of the crown burst forth into a mass of young foliage, and produced a great quantity of flowerstalks. It was on April 15, when the young foliage had already become well developed, that a boring of the main trunk and

*In July, 1925, the tree fell; it was hollow and rotten inside.

of a large branch from the upper half of the crown was secured. Both showed a very active cambium, which in the upper part of the branch had already formed two rows of vessels of the new ring; in the lower part of the branch (about two metres below the top) there was about one row, and in the main stem scarcely the first vessels of the new growth ring. Other branches, which formed a new covering of leaves or flowers, had also formed already one or two rows of vessels of the new ring. The branches, however, in which the terminal bud was still dormant but which were otherwise fully in leaf, showed a resting or a very weakly active cambium, which was forming the last (or final) elements of a growth ring. In this tree, therefore, the cambium activity exactly coincided with the production of leaves; it is clearly proved, through the observations of Volkens and Simon as well as through my own, that this tree shows a very irregular delay (suppression) of leaf development, and that consequently the growth zones are not true annual rings at all.

"The annual rings of the Djati (teak) have been so frequently described that I can be brief concerning them.

The boundaries (limits) are marked out by a narrow or broader strip of parenchyma, in which the numerous very large vessels of the young wood are arranged regularly along the boundary. The old wood reveals fewer and smaller vessels scattered ad libitum (?). But when the cessation of growth is not so sharply defined, in the moister localities or in the case of smaller striplings, the normal ring may be absent and the growth zone marked out only by a narrow distinct line of parenchyma. In the young wood the vessels are then often quite absent. At times a ring forming arrangement of the vessels without bands of parenchyma is to be seen. One of the branches examined on April 15, 1925, from the big teaks of the Foreign laboratory (equal exotics laboratory?) in the Buitenzorg gardens, showed in different places another type of ring formation; towards the upper end of the branch the second-last ring was formed of a circular arrangement of larger vessels which joined on abruptly to the numerous small vessels of the old wood, so that for a broad strip of the vessels the boundary was marked only by the larger vessels. Lower down the boundary had vanished, because the transition from the smaller vessels of the old wood to the larger ones of the young wood took place gradually; still further down the ring was normal and sharply defined. And in the same cross-section similar differences are found at times in the structure of the same ring."

On page 63, speaking of *Pinus Merkusii*, Coster says:—

"Pinus Merkusii, Jungh. and de Vr.

This species is the only example of the genus *Pinus* which comes from south of the Equator; the natural distribution is North and Middle Sumatra, but it is transplanted here and there in Java, as for example some young trees in the mountain-garden at Tjibodas. Like all species of pines, it is evergreen; a section of the branches of a young tree at Tjibodas always shows an active cambium, both in the wet and dry seasons, although in the latter case the increase in thickness is less vigorous. The branches show no sharply limited growth zones, only in places an indistinct indication of a ring, so styled because of some rows of tracheids with somewhat thicker and darker walls, which, however, for the most part do not form a complete ring.

"A slab of a young tree from Gajoe Land (Sumatra) also showed a similar vague and often incomplete (ly circular) sign of a ring. The limits of growth were here formed of some rows, sometimes many rows, of radially shorter tracheids, which, however, are not sharply marked off from the wider elements either on the inner or the outer side, but gradually merging into them (Plate VI, Fig. 1). (This seems to refer to the next issue.—E.W.B.). However, the older trees from this region form the typical sharply defined growth zones, as shown also in figs. 10 and 14 of the article upon it by J.W. Gonggryp (no reference given).

"The section of a thick branch of a large tree in the Buitenzorg Botanical Gardens showed, together with numerous sharply defined complete rings, certain other rings which were not sharply defined, or lost in the tissue. The sharp growth agreed with (or corresponded to) the usual coniferous type, yet there were others in which the radially shorter tracheids of the late wood passed gradually into the wide tracheids of the early wood; I also found zones which were apparently doubled, because close up against the edge of a zone a second one occurred which farther along vanished again. There were also similar "doubled" rings which joined up (or fused) with one another. No doubt zones must therefore appear in the older trees also in Buitenzorg, which are not true annual rings at all."

Turning next to *Podocarpus cupressina* R. Br.:—

"Material—W. Java, 2 sections, 20-24 c.m.

"This giant of the forest is an evergreen mountain-tree spread over the whole island. I made sections from the branches and took borings during the wet and dry seasons of the years 1924 and 1925 at Tjibodas, and

found the cambium always active. This interrupted* activity of the cambium corresponds well with the formation of growth zones. In the section from W. Java I found only a few completely circular rings, situated at irregular intervals from one another. Between them appeared indistinct rings which could be followed only for a short distance, when they became lost in the tissue.

"Between two consecutive complete (ly circular) rings of the large section I found for example, a distance of 56 mm., then again one of 2½ mm., then 25 mm. and 40 mm. These thus do not represent annual rings, but probably irregular cessations of growth in consequence of unfavourable surrounding circumstances. These complete rings were formed by the sudden transition, typical of the conifers, from the radially narrow tracheids of the late wood to the radially enlarged tracheids of the early wood. The indistinct rings show a more gradual transition in the radial diameter of the tracheids of the late and the early wood; sometimes, indeed, they show only slight difference in the thickness of the walls.

"Beekman calls the growth zone of this species "mostly distinct"; he refers also (or however) to *Podocarpus amara* Bl. (whose growth zones have been described as irregular and often fading out) with the remark that perhaps the differences between these two species are not constant."

In dealing with species from the temperate zone being grown in the tropics, the following is worthy of quotation:—

"*Pinus halepensis* Mill (Pinaceæ). In section on "species from the temperate zone"). Material: 1 section, Tjibodas, 5 c.m. Of this species, which hails from the Mediterranean region, about 15 specimens were transplanted at Tjibodas in 1916; and in that place they exhibit a vigorous growth. I found the cambium active on each of the three occasions on which I examined it, viz., Jan. and Aug., 1924, and July, 1925. I secured a section from the bole of one of the smaller trees, which was about 4 m. high (13 feet) and showed a diameter of 5 cm.** at the base of the stem. This section, which was thus nine years old, showed only some very indistinct, vanishing and incomplete (ly circular) rings. They were formed from a zone of tracheids of the late wood, whose radial diameter was a little less than that of the tracheids of the

open wood (litt. "wide" wood),* the transition both inwards and outwards, however, frequently occurred fairly regularly, and the zone of tracheids of the late wood often became lost further along in the tissue. The growth zones of the thinner branches were also of the same indefinite and discontinuous type.

"*Pinus palustris* Mill. (Pinaceæ). Material: 1 14 cm. block from Tjibodas.

In this species, which comes from the southern states of North America, I have examined the activity of the cambium only once; but from the behaviour of the other species of *Pinus* which have been investigated, as well as from the nature of the growth zones, it appears very probably to be the case that this species likewise shows an almost uninterrupted growth in thickness.

"There are certain rather large trees in the mountain garden, which reveal a moderately good growth; they are all divided right at the ground level into three or four trunks or large branches, which all grow practically straight upwards. The thinner lateral branches are long and thin, curved like snakes, and bear at the end a tuft of needles. In July I investigated various branches of the same tree. The cambium was very active, but was not forming the same elements in all parts; on the one branch, radially small tracheids of late-wood were being formed, on another wide tracheids as a commencement of a growth-zone. Indeed, within the one cross-section the same elements were not always being formed in all parts.

"The large section of a vertical main branch showed many growth zones, some sharp, others indistinct, fusing together at times, at very different distances from one another. (Plate 11, fig. 2). (Plates not yet published.—E.W.B.) The growth zones were of different types; the tracheids of the late wood were at times only radially shortened, but at times they were also thick-walled; the one zone was sharply bounded on the outer side by an abrupt transition between early and late wood, the other passed gradually on either side into open (equals large celled?) wood. Here there would be a broad zone of early wood and only a few rows of late wood tracheids, and there the early wood would be restricted to only one row of wide-lumened (equals with wide lumina) tracheids. It gave the impression that the tendency for periodical formation of the differ-

*Evidently a misprint for "uninterrupted," as shown by previous remark, and the general meaning.—E.W.B.

**The dimensions in this case suggest that the figures quoted in the opening statement of the material refer to the diameter.

*He does not talk of autumn wood and spring wood, but of early and late. I have translated literally. Does it mean early and late in the year, or in the wet season? I suspect it is an idiom, not necessarily meaning late at all.—E.W.B.

ent elements was quite in evidence, but that under uniform conditions of growth it could be quite irregularly expressed. An authentic sample of this species from America showed very distinct and sharply limited zones of growth with broad late wood, in which the thick-walled and radially shortened tracheids contrasted sharply with the wide-lumened tracheids of the early wood.

"Taxodium distichum. Rich. (Pinaceæ).
Material: 1 section from Tjibodas, 7.5 cm.

This tree, which comes from the eastern and western (southern—F.E.H.) states of N. America, is represented in the mountain gardens of Tjibodas by two trees, which remain green throughout the whole year and continually produce a greater or less quantity of young foliage. In its own home and in Europe, this species is leafless in winter. As far as I was able to examine it, I found the cambium always more or less active; nevertheless distinct and complete (ly circular) growth rings of the normal conifer type were formed. In the different branches, periodicity of cambium activity was quite independent. Thus in August, 1924, I found, on one of the two trees, branches which had arrived about at the end of a growth zone, together with others which were apparently about half way, and still others which had merely formed some rows of wide-lumened tracheids of early wood. Even the cambium cells of one and the same cross section did not all work in unison (synchronise); for on one occasion, in April, 1925, I found a cross section of a little branch about 8 mm. thick, where in places the cambium had formed only about four rows of wide-lumened tracheids of the early wood, but nearer the periphery was forming three, two and one rows, and still nearer was forming the last elements of the late wood of the previous ring. This periodicity of the cambium is quite in agreement with the periodicity of the foliage, in the sense that some time after the sprouting of young short branches (equals dwarf shoots?), the cambium forms wide-lumened tracheids lower down, and with the ageing of the leaves commences to produce narrow tracheids. When a branch bears two lateral branches, of which one bears new foliage and the other still has the old, the main branch will produce tracheids of the young (or spring) wood on the one side and old (autumn) wood on the other. The unfolding of the leaves, however, does not often occur strictly branch by branch, so that one then has confused data, difficult to analyse.

"The growth zones occur at rather irregular distances from one another in the thinner branches; at times there will be two of them crowded close together, and separated only by a single row of radially shorter tracheids, and at other times will be far apart with

numerous rows of radially shorter late-wood tracheids. At times two growth zones will run together, but in by far the majority of cases they are concentric. The section of a 7.5 cm.-thick branch, however, showed a much more regular indication of rings; in this there were 13 complete, distinct, and sharply defined growth zones at approximately equal distances from one another, of which only two were doubled in places round about (or approximately) one-third of the circumference. The three inner rings were more irregular and were lost here and there in the tissue. At the circumference the cambium had formed in places about 1 to 1½ mm. of young wood, consisting of about 20 rows of wide-lumened tracheids; but a few cm.'s further along, the young wood consisted of only one row of thin tracheids, and further towards the circumference they constituted once more a broader island of young wood. Some yards higher up than this spot the cambium was still engaged in producing the last tracheids of the late wood, while the more slender lateral branches presented a changing appearance. Some had already produced several rows of tracheids of young wood, others on the other hand were still occupied in the formation of the last elements of the previous ring. Another branch lower down on the stem showed equal differences in the activity of its cambium, viz., the formation of the last part of a growth zone, together with the production of open-wood tracheids. A definite though nevertheless very small relationship between the cambium activity in the different parts of the tree was to be noticed here. At the time when I investigated this branch, at the beginning of July, 1925, it had scarcely rained for two months, so that for Tjibodas it was an unheard of drought. The tree, however, had not suspended its growth in thickness, and the cambium had in spite of the desiccation observed its own periodicity.

"An authentic specimen of this species from New York State College of Forestry showed very fine (equals good) sharp growth zones with a broad layer of late wood. The late wood tracheids were very thick walled and radially much shortened, the tracheids of the early wood on the other hand were thin walled and had very wide lumina. The most distinct difference from the wood from Tjibodas, nevertheless, consisted of the much strong formation of late wood."

It is evident from the above quotations that in favourable climates periodicity of growth, and zone or ring formation are governed by other factors than the calendar year. Coster has in train a series of investigations on the factors stimulating the cambium to activity. His results will make most interesting reading.