On the Exact Measurement of Trees (Part 5). 1. The Growth of Wood in 1880. 2. The Limit of the Growing Months

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working members at the age of fifty-two. Lindsay's life was really that of a scientific recluse, his lichens and minerals giving needful recreation in his toilsome and depressing official position. We first remember Lindsay as a High School dux, ardent even when a boy in foreign travel, with an omnivorous appetite for all knowledge. A near relative of that distinguished bibliophile, the "Scottish book-hunter," it could not have been otherwise. But he himself latterly held that the too close application of his boyish and student years did permanent injury to his health, necessitating afterwards frequent long professional vacations of colonial and continental travel. He thought there was wisdom in even the too great rebound to cricket and football, so characteristic of middle-class education now a-days. Mineralogy was Lindsay's first scientific love. It was only when he came under the influence of Professor Balfour's teaching that he entered with equal zest on his botanical career. He was a skilful draughtsman, and characteristically neat handed. The beautiful preparations of the grasses, now in the museum at the Royal Botanic Garden, gained the prize offered by the Messrs Lawson to the University Botanical Class. And his elaborate and exquisitely illustrated monograph on the "Spermogones and Pycnides of the Higher Lichens," gained the first Neill Prize, in 1859, from the Royal Society of Edinburgh. His extensive lichen collection is to be deposited in the University Herbarium.

On the Exact Measurement of Trees (Part 5). 1. *The Growth of Wood in 1880.* 2. *The Limit of the Growing Months.* By Sir ROBERT CHRISTISON, Bart.

(Read 13th January 1881).

In the last observations submitted to this Society on the exact measurement of trees, I endeavoured to show that in the unfavourable season of 1879 the growth of wood, both of leaf-shedding and evergreen trees, was materially less than in the comparatively favourable season of 1878; that the depressing influence of that of 1879 affected various species in very different degrees; that most leaf-shedding

trees appeared to suffer severely, and more so than ever-green trees, but the oak tribe, so far as observed, least of all. For this failure three climatic causes were assigned:— a great reduction of the mean temperature of every growing month under the average, a similar reduction of sunshine, and the loss of the greater part of one of our usual growing months in consequence of both climatic deficiencies having prevailed so seriously as to delay the development of the new leaves till near the beginning of July.

In continuation of these inquiries, I have now to state the result of measurements of the same trees for the recent favourable season of 1880.

The previous autumn of 1879 was unfavourable for the ripening of young wood. September, indeed, was not far amiss; but the month of October was ungenial. This circumstance, together with the loss of June as a growing month, was a sorry omen for the solidification of young wood, as well as for the formation of buds, and consequently for their ability to resist uninjured the customary frosts of winter. But it so fell out that in this unprepared condition they were exposed during great part of December to an asperity of climate unprecedented in this latitude, and such as it may be earnestly hoped will not be soon again paralleled. For nearly three weeks, in the country around Edinburgh, the minimum was often a little above zero F, and sometimes below it; and in other parts of the Lowlands, especially in Berwickshire and Roxburghshire, much lower temperatures were noted. A descent to -18° , and in one instance to -20° was authenticated.

I have given this general account of the weather since autumn 1879 chiefly from a diary of observations kept by myself. But since drawing it up, I have been favoured with the following confirmatory statement of the differences from the average of the previous twenty-four years in the mean temperature of each month after August 1879, kindly furnished by Mr Buchan:—

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1879 .	...	...	...	...	...	...	...	...	-1.0	-0.7	-0.1	-3.1
1880 .	-1.0	+3.8	+1.3	+0.6	-0.2	-0.4	-1.0	+2.9	+2.4	...	...	...

The baneful influence of cold so unusually intense as in December 1879, must have been apparent to most ordinary observers after vegetation had made some progress in the ensuing summer. Any one might notice in this neighbourhood that on the birch, robinia, and some introduced continental oaks, many two-year old twigs were leafless because dead; in Roxburghshire six-year old branches of the common oak were similarly destroyed; in one district several oaks of large size put out no leaves at all except on spray from their trunks; and a fine holly, 150 years old, was killed outright.

These unhappy facts, which could easily be multiplied from the observation of many, might have led one to foresee something less than the usual year's growth of wood during the subsequent favourable season. But I confess I was not prepared for the great defalcation shown by the annexed measurements to have been sustained during so fine a summer and autumn as those of 1880.

The remainder of the winter of 1879-80 was by no means so severe as was threatened by its formidable opening in December. There were considerable tracts of open weather; the temperature was often above the freezing point; and the thermometer was never much or long under it. Such particularly was the character of the weather in February. There was little frost, none severe, a day temperature rising frequently to 45°, 47°, and once to 50°, with an unusual frequency of bright sunshine. Consequently early-budding trees and shrubs began to push out their green points before the close of that month. In March and April, though cool, frost was rare, and only in the morning; and there was a fair proportion of bright sun. Consequently the buds opened gradually without injury; and when the month of May set in, with temperate, though never warm, weather, and a generally unclouded sun, tree-foliage in general was matured, or nearly so, at the beginning of June. June, July, August, and September were fine months throughout Scotland generally, and August especially, when the heat was greatest. The only other meteorological circumstance requiring mention is a decided deficiency of rain from early in March till near the close of the first week of September.

I have recalled in this summary the weather in 1880 in order to show that the season was favourable for tree foliage, and consequently for the formation of wood. In point of

	1878.	Increase in		
	May 1.	1878.	1879.	1880.
	inches.	inches.	inches.	inches.
1. Birch	55.35	0.25	0.05	0.05
7. Beech	71.40	1.20	0.95	0.65
8. Beech	60.50	1.20	0.80	0.90
14. Beech, <i>Arboretum</i>	75.80	0.60	0.60	0.25
38. Beech, <i>Arboretum</i>	60.30	0.60	0.45	0.15
2. Lime	76.10	0.50	0.15	0.00
18. Lime	42.70	0.70	0.40	0.15
4. Sweet-Chestnut,	70.80	1.10	0.90	0.85
6. Tulip-Tree	75.70	1.00	0.40	0.30
9. Horse-Chestnut	48.75	0.75	0.50	0.35
16. Hawthorn	38.00	0.80	0.10	0.75
23. Flowering Ash	75.30	0.60	0.40	0.30
28. Sycamore	58.60	0.50	0.20	0.15
13. Sycamore, <i>Arboretum</i>	131.80	0.60	0.45	0.35
12. Walnut, <i>Arboretum</i>	61.00	0.50	0.40	0.00
40. Hungary Oak	23.60	1.80	1.70	1.40
43. Turkey Oak	41.90	0.60	0.65	0.35
44. American Oak, <i>Q. rubra</i>	30.80	0.50	0.40	0.30
33. Hornbeam	44.50	0.40	0.35	0.10
5. Douglas Pine	56.10	0.60	0.45	0.45
10. Douglas Pine	64.30	0.80	0.30	0.35
17. Corsican Pine	64.30	0.40	0.10	0.50
19. Scotch Fir	49.20	0.00	0.00	0.00
11. Scotch Fir, <i>Arboretum</i>	94.30	0.30	0.00	0.00
37. Scotch Fir, <i>Arboretum</i>	52.55	0.25	0.30	0.00
36. Scotch Fir, <i>Arboretum</i>	52.95	0.25	0.00	0.00
24. Pinus excelsa	30.90	0.35	0.20	0.05
26. Pinus excelsa	32.70	0.40	0.20	0.35
25. Sequoia gigantea	23.95	1.15	0.80	1.00
27. Sequoia gigantea	23.95	1.75	1.65	1.80
1. Sequoia gigantea	18.95	1.85	1.50	1.50
2. Sequoia gigantea	23.85	1.25	1.70	1.55
29. Deodar	26.10	1.10	0.70	0.45
30. Deodar	64.00	1.20	0.60	0.40
31. Picea Lowei	15.00	1.40	1.25	1.40
32. Picea Lowei	16.10	0.50	0.20	0.15
34. Araucaria imbricata	18.10	0.60	0.50	0.55
35. Araucaria imbricata	20.20	0.50	0.90	0.75
39. Atlas Cedar	27.55	1.65	1.40	1.75
45. Evergreen Oak	41.50	in 1879	0.30	0.80
46. Evergreen Oak	29.05		0.40	0.10
41. Yew	67.60	0.60	0.60	0.35
42. Yew	34.10	0.50	0.15	0.20
47. Yew	33.20	in 1879	0.15	0.05
48. Yew	37.50		0.60	0.40
49. Yew	23.50		0.30	0.35
50. Yew	33.30		0.45	0.40
53. Yew	32.35		...	0.15

fact the foliage of most trees was rich. There were exceptions, for in some places that of the beech and oak was

defective. But this appeared to arise rather from the ravages of superabundant insects than from atmospheric inclemency; and certainly in most places, and in respect to trees generally, foliage was healthy and abundant.

In the adjoining table are re-stated from my last paper on this subject the girth of the trees in the beginning of May 1878, and the successive increments in that favourable year, and in the unfavourable year of 1879; and there is now added the increments for 1880. On comparing the columns of increments with one another, it will be seen at a glance that, with very few exceptions, the growth of wood last year was even more below the average of equally favourable years than in the bad year of 1879. Of fifteen leaf-shedding trees of various species, exclusive of the oak tribe, the average growth of trunk-girth in the three successive years was 0·80 of an inch for each, 0·45, and 0·35. For four specimens of the oak tribe it was 0·82, 0·77, and 0·54. For twenty trees belonging to the evergreen *Pinaceæ* the increments were 0·81, 0·68, 0·65. For six of the common yew the growth for 1879 and 1880 was 0·37 and 0·29 on an average; and of the only two of these measured also in 1878, the average growth in the three years was 0·55, 0·37, 0·28. The observations made on two specimens of evergreen oak (*Q. ilex*) are remarkable. One of them made 0·4 in 1879 and only 0·1 in 1880; but the other, a much finer plant, made only 0·3 in the former year and 0·8 last year. It will be seen presently how easily this apparent discrepancy may be explained.

It appears then that with few exceptions trees of all kinds failed to make the growth of wood which in ordinary circumstances so fine a season as that of 1880 might have been expected to produce; and that the defalcation was even greater than in the very unfavourable season of 1879; that leaf-shedding trees suffered most, exclusive of the oak tribe; that the evergreen *Pinaceæ* suffered least; and that the oaks, though intermediate in that respect between the two foregoing denominations, suffered decidedly more in 1880 than in 1879.

Some more special facts deserve a little notice:—

1. The beech (7) suffered less in 1879, but more in 1880,

than its neighbour. This was traced in the end of July last to its foliage having sustained serious damage from insects.

2. The hawthorn (16) alone greatly surpassed in 1880 the growth of 1879, and indeed may be said to have come up even to that of 1878, the increments being, in the order of the three years, 0·8, 0·1, and 0·75. The tree is a very fine pendulous Mary-Thorn, which last year, as usual, put out its buds and expanded its leaves very early, and was covered with dense vigorous foliage. But, though I never before observed it otherwise than richly covered in due season from top to bottom with flower, last year its blossom was confined entirely to a few twigs near the top, facing south-west, and constituting scarcely a twentieth part of the tree. Everywhere hawthorn flower was extremely poor.

3. Of the oak tribe the Hungary oak shows the best product of wood in 1880. It increased its girth by nearly an inch and a half. I may add that two younger plants of 13½ and 16½ inches in girth of trunk, measured for the first time last year, were richly leaved, and added each 1·10 inch to their girth. This beautiful species having been thus proved to defy the most ungenial of our summers, and a winter of unexampled harshness, it well deserves more attention than it has yet received as a quick-growing ornamental tree.

4. Two Douglas pines, a Corsican pine, two Araucarias, a *Pinus excelsa*, a Cedar of the Atlas, four Sequoias, and a *Picea Lowei*, notwithstanding that its top shoot had been broken off, have shown little or no backwardness in 1880. But four specimens of our indigenous Scotch fir seem to have made no progress whatever. It has been stated in the public news that this species has suffered severely in some parts of the north of Scotland. As for the four now referred to, the first, the only Scotch fir in the Botanic Garden, has not advanced for three years past at least; the last two in the table, in the east clump of the Arboretum, are also shabby trees, ill-branched, limited in spread, and thin in foliage; but the other in the Arboretum (11) was in 1878 a rather handsome tree, which in that year measured 7 feet 10 inches in girth at 5 feet from the

roots, and carried a fine leafy head. But it has evidently been severely damaged since, for the trunk made no advance last year, and in October its head was miserably defective in foliage.

5. The two evergreen oaks were not measured in 1878. In 1879 both made a little progress, but probably less in that unpropitious summer than in average years. In 1880, however, in spite of the fineness of the season, one of them made an increase of only 0·10, while the other grew actually 0·80, or fully twice as much as in the previous year. This difference supports the view that the cause of the general defalcation in the growth of wood in 1880 was not merely the want of thorough ripening of the young wood of 1879, but also the intense frosts in December of that year. For the former grew unprotected in the middle of the garden, and, in common with its species generally, lost its evergreen leaves long before the approach of spring; while the other grew about 30 feet to the south of the Palm House, being thus defended by a lofty heated house from N.E., N., and in some degree N.W.; and in consequence this tree, alone of all its species in the garden, retained its leaves green and vigorous till they withered and dropped, according to the usual rule, with the development of new foliage in summer.

6. Of two specimens of *Pinus excelsa*, apparently of the same age, growing on the terrace in front of the long line of glass-houses, near one another, and circumstanced in all respects exactly alike, both added rather over a third of an inch to their girth in 1878, and both only a fifth of an inch in 1879. But in 1880, while one was fully clothed with foliage, old and young, and again increased its trunk-girth by a third of an inch, the other showed very thin old foliage, scanty new twigs, and two years' growth of its top-shoot completely dead, and its trunk had scarcely increased in girth at all. I do not see what else will account for this difference, except a difference in individual constitution, rendering the latter more sensitive than the former to the influence of the intensely cold weather of December 1879.

Experience having given me confidence in the minute

measurement of trees, it occurred to me as desirable to ascertain, by means of a few trees of vigorous growth, what is the rate of increase of wood at different periods of the growing season. That season has been already found to exclude the six winter months, from October to April, equally for evergreen and leaf-shedding trees. It now turns out, however, that, in our climate at least, the period of growth of wood in an ordinarily good season is much more limited.

For this investigation I selected the Beech and Hungary Oak among leaf-shedding trees, and the Sequoia, Araucaria, and Atlas Cedar among evergreens, as in previous years their trunks made an annual increment in girth of 1 inch to nearly 2 inches. The leading result may at first create some surprise, viz., that the growth of wood in leaf-shedding trees is confined in general to the three months of June, July, and August. This will appear from the following table, showing the girths on April 30, 1880, and

	Apr. 30.	May 31.	June 30.	July 31.	Aug. 31.	Oct. 9.
	inches.	inches.	inches.	inches.	inches.	inches.
Beech	73.50	0.00	0.25	0.50	0.10*	0.00
Beech	62.40	0.10	0.30	0.20	0.35	0.05
Hungary Oak	27.10	0.30	0.40	0.40	0.30	0.00
Hungary Oak	16.45	0.05	0.40	0.30	0.30	0.05
Hungary Oak	13.50	0.20	0.30	0.30	0.25	0.05
Sequoia	25.9	0.40	0.25	0.40	0.05	0.00
Sequoia	27.35	0.55	0.50	0.70	0.15	0.00
Sequoia	22.40	0.70	0.40	0.30	0.00	0.00
Sequoia	27.45	0.55	0.40	0.45	0.00	0.00
Araucaria	21.60	0.40	0.15	0.15	0.05	0.00
Atlas Cedar	30.65	0.45	0.30	0.40	0.30	0.05

the increments at the end of each successive month. The Hungary oak is in some measure an exception, as in two specimens there was an undoubted increase during the month of May. The explanation is, that in 1880 this early species was far advanced in foliage in the middle of that month. The explanation of the generally narrow limit of growth to three months, in spite of the favourable weather last May and the still finer weather of September last,

* In the end of July the foliage of this beech was observed to be very thin, owing to the extensive ravages of an insect. The observations for August 31st were made for me in my absence by Mr Sadler.

seems to be that in May the trees are only developing their leaves, without which wood cannot be formed; and that in September they are busy forming their buds for next spring, and also ripening their new wood. More extensive observations are necessary for settling the relative rate of growth in the several months. Already, however, the table gives an indication that June and July are the most favourable.

The only other general conclusion to be drawn from the table is that evergreen trees begin to increase in girth a month earlier than leaf-shedding trees—a fact which is intelligible enough, as they have leaves ready to make use of the sap at its first rise. It is not so easy to understand why most of these made the subject of observation added little, or even nothing, during the month of August, when the weather was invariably fine.

On the Morphology of the Pitcher of Cephalotus follicularis.

By ALEXANDER DICKSON, M.D., Professor of Botany in the University of Edinburgh. (PLATES V. and VI.).

In a paper on the Structure of the Pitcher of *Cephalotus follicularis*, read at the Plymouth meeting of the British Association, and published in the "Journal of Botany" in January 1878, I pointed out the remarkable difference as to the position of the lid of the pitcher between *Cephalotus*, on the one hand, and *Sarracenia* and *Nepenthes*, on the other. In *Cephalotus* the lid is placed on that side of the orifice of the pitcher nearest to the main axis, while in *Sarracenia* and *Nepenthes* it is on the side farthest from the main axis. At that time I was inclined to assume that the pitcher-lid in *Cephalotus* represented the extremity of the leaf, and this led me to suggest—although under reserve—that, while the pitcher in *Sarracenia* and *Nepenthes* appears as a pouching of the leaf from the upper surface, in *Cephalotus*, on the other hand, the pouching would, on the assumption indicated, be from the lower leaf-surface. Developmental evidence is at present scarcely attainable, requiring, as it would do, the sacrifice of many specimens of a plant not very easy of cultivation, and never