IV.—*Observations on the Annual and Monthly Growth of Wood in Deciduous and Evergreen Trees.* By the late Sir ROBERT CHRISTISON, Bart., and Dr CHRISTISON.

(Read 19th March 1883.)

Having undertaken to continue the observations on the growth of trees commenced by my father in 1878, and carried on by him with unflagging zeal until a few months before his death in 1882, I give in the present paper the measurements made by him in 1881, which he did not live to publish, and those made in 1882 by myself. I shall also endeavour to point out the conclusions which may be drawn from the whole series of observations, beginning in 1878, arranging them under the heads of—

I. ANNUAL OBSERVATIONS.
II. MONTHLY OBSERVATIONS.
III. INFLUENCE OF WEATHER ON THE GROWTH OF WOOD.

Thus the deductions already arrived at by my father in this branch of his investigations on the growth and measurement of trees will be again reviewed and tested by the experience of two additional years. The other branches of his subject, including his inquiry as to the proper mode of measuring the girth of trees, the kind of information to be derived from such measurements, his discussion of DECANDOLLE'S rule for estimating the age of trees by the annual rings, the modes of doing so recommended by himself, and his description of the Fortingall Yew, have been so fully treated in his earlier papers, published in the *Transactions of the Botanical Society of Edinburgh,* as to require little further elucidation. Very different is it however with the yearly and monthly measurements. These can only become truly reliable after a prolonged series of observations; and even the present review of five years' experience must be considered as to a considerable extent provisional and subject to correction.

Before proceeding with the proper subject of this paper, it is advisable to state that the observations and deductions in it rest entirely on the possibility of making accurate measurements of the girth of trees. Previous to Sir ROBERT'S observations measurements of the kind were made in the vaguest and most unreliable manner. It was reserved for him, in extreme but vigorous old age, to make the simple discovery that such measurements could be depended upon to within a tenth or even a twentieth of an inch, and that consequently not only the annual but even the monthly increase could be accurately recorded. I thought it was desirable however on taking up the subject as it dropped from his hands to retest this question, and to ascertain whether my measure-

ments might not, from some difference of manipulation, disagree with his. Accordingly, with the aid of my brother, I remeasured early in 1882 the forty-one trees in the Botanic Garden measured by Sir ROBERT at the end of the growing season in 1881. The result was satisfactory. In nineteen instances there was no appreciable difference between the two measurements; in seventeen the difference did not exceed a twentieth of an inch; in three it amounted to a tenth, and in two to a seventh of an inch. Thus in only five cases were the discrepancies so great as to be of material consequence; and, on investigation, these discrepancies were found to be evidently due either to extreme roughness or a tendency to scale in the bark. So great a degree of accuracy as this however cannot be obtained with ordinary tapes. I have found some of the inches marked on these a tenth of an inch too large, others a tenth too small. Another source of error with them is the terminal ring with the fastenings by which it is attached to the tape. If the measurement be taken over the ring, and it happens to be sunk in a depression of the tree, no error results; but if the ring be on a projection of the bark, its bulk may cause an error in excess amounting to a twentieth or even a tenth of an inch. A different result from either of these will probably be got if the measurement is kept clear of the ring altogether. In the early part of his experiments Sir ROBERT used a tape, painted so as to avoid stretching, and graduated by himself; an extra inch graduated to tenths served for taking the fractions of an inch, so that it was unnecessary to graduate the tape throughout into tenths. But mistakes were apt to arise from the necessity of reckoning the tenths in a direction contrary to the numbering of the inches, and ultimately he used a steel tape, graduated throughout to tenths, made specially for him by Messrs CHESTERMAN. This is certainly the kind most to be recommended.

I. ANNUAL OBSERVATIONS.

Following Sir ROBERT'S example, I give the increments for 1881 and 1882 in a tabular form, along with those already published for previous years. As in the course of time however several of the trees originally selected have ceased to be eligible, I have found it necessary to remodel the table to a considerable extent. Thus the Scots fir, No. 19 in his list, and the *Picea Lowei*, 32, having ceased to grow, have been cut down; the Scots firs, 11, 36, 37, have also ceased to grow for three years; and the yew, 47, is almost in the same predicament. As it was obviously useless to retain these, they have been struck out; and the *Pinus Laricio*, 17, the aged sycamore, 13, and walnut, 14, having bark either so scaly or so rugged as to be unsuitable for minute measurements, have shared the same fate. In compensation for these losses in the Botanic Garden, a larger number of trees growing at Craigiehall, five miles from Edinburgh, have been selected for observation and added to the list. No confusion need be feared from these changes in making comparisons with former years, as the

increments are computed on the average increase per tree in the different classes. For the sake of clearness it has also been judged advisable to divide the table into two parts, the first comprising the twenty-eight deciduous and the second the twenty-three evergreen trees under observation.

I have ascertained that the results obtained from this new list do not differ materially from those derived from the former list by Sir ROBERT. But as it would be useless to cumber these pages with more than one set of observations, I have resolved to give the results of the new list alone, as being both more reliable when corrected so as to apply to the past, and forming a more accurate basis for the future.

TABLE I.—ANNUAL INCREASE IN GIRTH OF DECIDUOUS TREES,

All in the Botanic Garden or Arboretum, except those marked "Craigiehall."

Trees.	Date and Girth when first measured.		Increase.				
			1878.	1879.	1880.	1881.	1882.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Birch, ...	1878	55·35	0·25	0·05	0·05	0·10	0·10
„ (Craigiehall), .	1880	56·30	...	...	0·40	0·55	0·45
Beech, ...	1878	71·40	1·20	0·95	0·65	0·85	1·15
„	„	60·50	1·20	0·80	0·90	0·90	1·10
„	„	75·80	0·60	0·60	0·25	0·50	0·60
„	„	60·30	0·60	0·45	0·15	0·50	0·50
„ (Craigiehall), .	1880	135·00	...	...	0·50	0·65	0·60
„ „ . .	1878	116·35	0·80	0·60	0·40	0·35	0·65
„ „ . .	„	61·75	0·60	0·30	0·50	0·50	0·70
„ „ . .	„	71·85	0·70	0·50	0·55	0·65	0·85
Lime, ...	1878	76·10	0·50	0·15	0·00	0·65	0·55
„	„	42·70	0·70	0·40	0·15	0·25	0.40
„ (Craigiehall), .	„	99·65	0·20	0·15	0·10	0·25	0·35
Sweet chestnut, . .	„	70·80	1·10	0·90	0·85	1·10	0·90
Tulip tree, . . .	„	75·70	1·00	0·40	0·30	0·55	0·50
Horse chestnut, . .	„	48·75	0·75	0·50	0·35	0·70	0·10
Hawthorn, . . .	„	38·00	0·80	0·10	0·75	0·35	0·65
Flowering ash, . .	„	75·30	0·60	0·40	0·30	0·75	0·50
Sycamore, . . .	„	58·60	0·50	0·20	0·15	0·30	0·40
English oak (Craigiehall),	„	69·45	0·65	0·50	0·20	0·35	0·35
Turkey oak, „ .	1880	73·00	...	...	0·70	1·25	0·90
„ „ . .	1878	41·90	0·60	0·65	0·35	0·60	0·65
American oak, . .	„	30·80	0·50	0·40	0·30	0·30	0·40
Hungary oak, . .	„	23·60	1·80	1·70	1·40	1·85	1·85
„ „ . .	1880	16·45	...	...	1·10	1·60	1·90
„ „ . .	„	13·50	...	...	1·10	1·70	1·50
Hornbeam, . . .	1878	44·50	0·40	0·35	0·10	0·55	0·50
Total increase of 22 trees first marked in 1878,	...	...	15·05	11·05	8·75	12·90	13·75
Average per tree,	...	...	0·68	0·50	0·40	0·58	0·62
The same, with 5 added in 1880, . . .	...	...	...	...	12·55	18·65	19·10
Average per tree,	...	...	...	...	0·46	0·69	0·71

TABLE II.—ANNUAL INCREASE IN GIRTH OF EVERGREEN TREES,

All in the Botanic Garden or Arboretum, except those marked "Craigiehall."

Trees.	Date and Girth when first measured.		Increase.				
			1878.	1879.	1880.	1881.	1882.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Douglas pine, . .	1878	56·10	0·60	0·45	0·45	0·60	0·50
„ „ . .	„	64·30	0·80	0·30	0·35	0·35	0·40
Pinus excelsa, . .	„	30·90	0·35	0·20	0·05	0·30	0·15
„ „ . .	„	32·70	0·40	0·20	0·35	0·35	0·40
Sequoia gigantea, . .	„	23·95	1·15	0·80	1·00	0·35	0·70
„ „ . .	„	23·95	1·75	1·65	1·80	1·50	1·40
„ „ . .	„	18·95	1·85	1·50	1·50	1·30	1·75
„ „ . .	„	23·85	1·25	1·70	1·55	1·35	1·65
Deodar, . . .	„	26·10	1·10	0·70	0·45	0·35	0·95
„ . . .	„	64·00	1·20	0·60	0·40	0·25	0·70
Picea Lowei, . .	„	15·00	1·40	1·25	1·40	0·90	1·05
Araucaria, . . .	„	18·10	0·60	0·50	0·55	0·50	0·45
„ . . .	„	20·20	0·50	0·90	0·75	0·60	0·85
„ (Craigiehall),	1879	17·90	...	0·85	0·65	0·45	0·70
Atlas cedar, . . .	1878	27·55	1·65	1·40	1·75	1·40	1·60
Evergreen oak, . .	1879	29·05	...	0·40	0·10	0·10	0·25
Yew, ...	1878	67·60	0·60	0·60	0·35	0·50	0·50
„	„	34·10	0·50	0·15	0·20	0·30	0·45
„	1879	37·50	...	0·60	0·40	0·40	0·55
„	„	23·50	...	0·30	0·35	0·45	0·55
„	„	33·30	...	0·45	0·40	0·35	0·45
„	1880	32·35	...	...	0·15	0·15	0·40
Cypress (Craigiehall), .	1879	14·20	...	0·80	1·15	0·85	0·85
Total increase of 16 trees first measured in 1878, . . .	...	...	15·70	12·90	12·90	10·90	13·50
Average per tree,	...	...	0·98	0·80	0·80	0·68	0·84
The same, with 7 added in 1880, . . .	...	...	...	...	16·10	13·65	17·23
Average per tree,	...	...	...	...	0·70	0·59	0·75

The most remarkable result from the whole series of observations is the want of correspondence between the deciduous and evergreen classes in the increase and decrease of the growth of wood in the different years under review. Thus, as the tables show, a remarkable decline took place in both classes in 1879 as compared with 1878, the average growth of each tree for these years in the deciduous class being 0·68 in. and 0·50 in., and in the evergreen class 0·98 in. and 0·80 in. But in 1880, while the deciduous average declined still further,—to 0·40, the evergreens remained quite stationary;* and in 1881, when

* Sir ROBERT CHRISTISON believed that they also had declined, although to a less extent, but he was misled by an error in the figures of his MS.

the deciduous average rose decidedly,—from 0·40 to 0·58, the evergreens suffered a decided fall,—from 0·80 to 0·68. In 1882 the difference was not so remarkable, as the average of both rose, but in the case of the evergreens to much the greater extent of the two.

I shall endeavour to explain the causes of these differences at the conclusion of this paper, under the head of the connection of weather with the growth of wood.

Sir ROBERT CHRISTISON was inclined to attribute to the oak tribe a greater power of resisting inclement winters than other leaf-shedding trees possessed. At page 84, part iv. of his paper, he states that while leaf-shedding trees in general suffered a reduction of 41 per cent. in their increment in 1879 as compared with 1878, seven oaks measured by him lost only 10 per cent. Unfortunately, for various reasons, all these oaks are not available for comparison in subsequent years, but at page 168, part v., he showed that the average increments of fifteen leaf-shedding trees in three successive years down to 1880 were 0·80 in., 0·45 in., and 0·35 in., and that the corresponding numbers for four of the oak tribe were 0·82 in., 0·77 in., 0·54 in., a result still favourable to the oaks, although not so much so as in the previous instance. But if the facts be examined in detail, it is evident that this apparent superiority of the four members of the oak tribe is really due to one of their number—the hardy and quick-growing Hungary oak —and that the other three, although they suffered little loss in 1879, fell off greatly in 1880. It must be considered also that all these trees, with the exception of the hornbeam, which Sir ROBERT classed with the oaks, are of foreign origin. If we reckon the growth of the hornbeam with that of the only two British oaks whose measurements are at all reliable, the result is most disastrous for our native oaks; for while their united growth in 1878 was 2·05 in. and in 1879 1·65 in., it was only 0·70 in. in 1880. In these experiments the number of trees may be too small to give thoroughly reliable results, but it certainly seems probable that the foreigners—the Hungary, American, and Turkish oaks—stand severe winters, in our neighbourhood at least, better than our native oaks, the Hungary oak being much the hardiest of all, while the British oak comes out worse than any other species of tree under observation.

The yew seems to form an exception to the rule that the increment of wood in evergreen trees continued to decline in 1881, notwithstanding the remarkable rally made in the leaf-shedding class in that year. We have seen that the average growth of all the evergreen trees declined from 0·80 in. in 1880 to 0·68 in 1881; but if we take the yews alone, five in number, we find that their average growth rose from 0·35 in. in 1880 to 0·40 in 1881. Thus in the wave of decline and rise during the three severe winters they followed the deciduous group, and not their relations the evergreen Pinaceæ.

II. Monthly Observations.

Encouraged by the results of his annual measurements, Sir Robert Christison selected in 1880 five deciduous and six evergreen trees, already ascertained to be quick growers, as suitable for monthly observations. These trees comprised two beeches, three Hungary oaks, four Sequoias, one Araucaria, and an African cedar. They were measured at the end of May, June, July, August, and September. The operation was repeated by himself in the same months, with the exception of May, in 1881; and again by me in 1882, with the exception of August. Thus a tolerably complete record of the monthly increments of these trees was obtained for three seasons. As the number experimented upon, however, was both too limited and comprised too few species to give altogether reliable results, I commenced in 1882 to make monthly measurements of a considerably larger number, and henceforth twenty-eight deciduous and eighteen evergreen trees, including twenty-two species, will be under observation.

I shall now proceed to consider the conclusions to be derived from these measurements in the solution of the following questions:—1. *What are the months to which the growth of wood is confined* (a) *in deciduous trees as a class and* (b) *in evergreens as a class?* 2. *In which month is the growth of wood most active in these two classes* (a *and* b) *respectively?* 3. *What are the peculiarities in these respects of different species of trees?*

In the Tables III., IV., and V. the facts will be found in detail on which the subsequent conclusions are founded. Table III. gives the three years' measurements and average growths of the smaller number of trees originally selected by Sir Robert; Tables IV. and V. the results of a single year's observations on the larger number, measured for the first time in 1882. The trees in this list only partially correspond with those used for annual observations, as a considerable number of the latter, from growing too slowly or from other causes, are not reliable for minute measurements.

1, a. *The Months to which the Growth of Wood is confined in Deciduous Trees.*

From the measurements made in 1880 on his five selected trees, Sir Robert came to the conclusion that the growth of wood in leaf-shedding trees is confined in general to the months of June, July, and August. I think however that he underrrated the importance of the May growth. It amounted to 12 per cent. of the annual total, which it must be admitted is a substantial sum. It was due however almost entirely to the three Hungary oaks, the increase in the two beeches having been scarcely appreciable. Unfortunately the measurements for 1881 were not taken till the end of June, so they are not available for this inquiry. But after the unusually mild winter of 1882 the May growth

was nearly twice as great as in 1880, amounting to 21 per cent. of the annual increase. Again no doubt it was mainly due to the Hungary oaks, their proportionate growth for May having been 24 per cent. of their annual increase; still the beeches were not idle, their corresponding growth amounting to 10 per cent. And although the Hungary oak—exceptional among deciduous

TABLE III.—MONTHLY INCREASE IN GIRTH, IN HUNDREDTHS OF AN INCH, OF FIVE DECIDUOUS AND SIX EVERGREEN TREES IN THE BOTANIC GARDEN.

	1880.					1881.				1882.			
	May.	June.	May and June.	July.	Aug.	Sept.	May and June.	July.	Aug.	Sept.	May.	June	May and June.	July.	Aug. and Sept.
Deciduous Trees—															
Beech, . .	·00	+ ·25	= ·25	·50	·10	·00	·20	·25	·35	·05	·10	+ ·35	= ·45	·40	·30
„ . .	·10	+ ·30	= ·40	·20	·35	·05	·35	·35	·15	·05	·15	+ ·30	= ·45	·30	·35
Hungary oak,	·30	+ ·40	= ·70	·40	·30	·00	·60	·50	·65	·05	·30	+ ·45	= ·75	·60	·50
„ „	·05	+ ·40	= ·45	·30	·30	·05	·65	·45	·50	·00	·35	+ ·50	= ·85	·55	·50
„ „	·20	+ ·30	= ·50	·30	·25	·05	·60	·55	·50	·00	·65	+ ·15	= ·80	·50	·20
Total, .	0·65	+ 1·65	= 2·30	1·70	1·30	0·15	2·40	2·10	2·15	0·15	1·55	+ 1·753	= ·30	2·35	1·85
Average per tree, . .	0·13	+ 0·33	= 0·46	0·34	0·26	0·03	0·48	0·42	0·43	0·03	0·31	+ 0·35	= 0·66	0·47	0·37
Monthly percentage, .	12	+ 30	= 42	31	24	3	35	31	32	2	21	+ 23	= 44	31	25
Evergreen Trees—															
Sequoia, .	·40	+ ·25	= ·65	·40	·05	·00	·40	·00	·15	·00	·25	+ ·30	= ·55	·10	·05
„ .	·55	+ ·50	= 1·05	·70	·15	·00	1·00	·05	·45	·00	·45	+ ·65	= 1·10	·20	·10
„ .	·70	+ ·40	= 1·10	·30	·00	·00	·85	·25	·20	·00	·75	+ ·65	= 1·40	·25	·10
„ .	·55	+ ·40	= ·95	·45	·00	·00	·75	·30	·30	·00	·55	+ ·55	= 1·10	·40	·15
Araucaria, .	·40	+ ·15	= ·55	·15	·05	·00	·35	·10	·15	·00	·45	+ ·10	= ·55	·15	·15
Atlas cedar, .	·45	+ ·30	= ·75	·40	·50	·05	·55	·35	·50	·00	·35	+ ·40	= ·75	·40	·45
Total, .	3·05	+ 2·00	= 5·05	2·40	0·75	0·05	3·90	1·05	1·75	0·00	2·80	+ 2·65	= 5·45	1·50	1·00
Average per tree, . .	0·51	+ 0·33	= 0·64	0·40	0·12	0·01	0·48	0·17	0·29	0·00	0·46	+ 0·44	= 0·90	0·25	0·17
Monthly percentage, .	37	+ 24	= 61	30	9	0	51	18	31	0	35	+ 33	= 68	19	13

trees for its early vigour—unduly raises the average in so small a number of trees, a substantial increase in May nevertheless did take place among deciduous trees in general. For if we include the whole of them, twenty-five in number, other than Hungary oaks, which were measured for the purposes of this inquiry for the first time in this same year, their average growth in May proves to be 12 per cent. of the annual increase. Including the three Hungary oaks the proportion amounted to 16 per cent.

At the conclusion of the growing season the limit is probably more fixed. Neither in 1880 nor in 1881 was a greater increase than a twentieth of an inch recorded in any tree in September. So small an amount as this comes within

TABLE IV.—MONTHLY INCREASE IN GIRTH OF TWENTY-EIGHT LEAF-SHEDDING TREES IN THE BOTANIC GARDEN, ARBORETUM, AND AT CRAIGIEHALL IN 1882.

No.	Trees.	Girth 31st March.	Increments in hundredths of an inch.			
			May.	June.	July.	August.
7	Beech,	75·05	·10	·35	·40	·30
8	„	64·30	·15	·30	·30	·35
14	„	77·85	·05	·20	·20	·15
38	„	62·00	·00	·15	·30	·05
8	„ Craigiehall,	136·15	·00	...	·25	·15
9	„ „	118·45	·10	·15	·25	·15
14	„ „	63·70	·15	·10	·25	·20
15	„ „	74·30	·15	·20	·30	·20
22	„ „	98·35	·10	·10	·20	·05
40	Hungary oak,	30·35	·30	·45	·60	·50
54	„ „	19·15	·35	·50	·55	·50
55	„ „	16·30	·65	·12	·50	·20
44	American oak,	32·55	·15	·10	·15	·00
43	Turkish oak,	44·20	·10	·15	·30	·15
10	„ „ Craigiehall,	74·95	·20	·20	·30	·20
12	English oak,	71·15	·05	·05	·10	·15
33	Hornbeam,	45·90	·15	·15	·15	·05
28	Sycamore,	59·75	·00	·25	·15	·05
58	„	63·50	·00	·05	·05	·00
7	„ Craigiehall,	127·75	·00	·25	·15	·05
18	Lime,	44·20	·05	·15	·20	·00
21	„ Craigiehall,	100·35	·00	·05	·15	·25
3	Ash,	77·35	·20	·15	·15	·00
6	„ Craigiehall,	141·40	·10	15	·05	·05
4	Spanish chestnut,	74·75	·05	·20	·30	·35
9	Horse chestnut,	51·05	·00	·05	·05	·00
6	Tulip tree,	78·15	·00	·05	·20	·25
5	Birch, Craigiehall,	57·15	·00	·15	·20	·10
Average of the 28 trees,		...	·11	·18	·24	·16
„ 3 Hungary oaks,		...	·43	·37	·53	·40
„ 25 others,		...	·07	·15	·20	·13
„ 9 Beeches,		...	·09	·19	·27	·18
Monthly percentage of 28 trees,		...	16	26	35	23
„ „ 3 Hungary oaks,		...	25	20	31	24
„ „ 25 others,		...	13	27	36	24
„ „ 9 Beeches,		...	12	26	37	25

the limit of probable error ; it may be doubted, therefore, whether any increase really took place in that month ; but as the differences between the records of

August and September, trifling though they were, all indicated an increase, it is probable that a slight and altogether immaterial growth did occur. Measurements kindly made for me by Mr SADLER in 1882 to test this question further

TABLE V.—MONTHLY INCREASE IN GIRTH OF EIGHTEEN EVERGREEN TREES IN THE BOTANIC GARDEN, ARBORETUM, AND AT CRAIGIEHALL IN 1882.

No.	Trees.	Girth 31st March.	Increments in hundredths of an inch.			
			May.	June.	July.	August.
		Inches.				
25	Sequoia,	27·55	·25	·30	·10	·05
27	„	30·65	·45	·65	·20	·10
1	„	25·10	·75	·65	·25	·10
2	„	29·70	·55	·55	·40	·15
29	Deodar,	28·70	·10	·20	·30	·35
30	„	66·45	·00	·20	·30	·20
34	Araucaria,	20·25	·25	·10	·05	·05
35	„	22·95	·45	·10	·15	·15
4	„ Craigiehall,	19·85	·25	·25	·10	·10
31	Picea Lowei,	19·95	·45	·20	·20	·20
5	Douglas pine,	58·20	·15	·25	·10	05
2	Austrian pine, Craigiehall,	21·55	·65	·40	·20	·30
39	African cedar	33·75	·35	·40	·40	·45
1	Cypress, Craigiehall,	17·00	·35	·25	·20	·05
41	Yew,	69·65	·10	·15	·10	·15
48	„	38·90	·15	·15	·20	·05
49	„	24·60	·20	·10	·15	·10
53	„	32·50	·20	·00	·05	·15
	Average of 18 trees,	...	·31	·27	·19	·15
	4 Sequoias,	...	·50	·53	·24	·10
	3 Araucarias,	...	·31	·15	·10	·10
	4 Yews,	...	·16	·10	·12	·11
	2 Deodars,	...	·05	·20	·30	·27
	Monthly percentage of 18 trees,	...	34	29	21	16
	4 Sequoias,	...	36	39	28	7
	3 Araucarias,	...	47	23	15	15
	4 Yews,	...	33	20	25	22
	2 Deodars,	...	6	24	37	35

proved unfortunately unavailable, owing to inaccuracies in the tape used. But as the increment for August and September combined was less than in the two previous years, it is fair to conclude that there could have been no material growth in the latter month.

1, b. *The Months to which Growth of Wood is confined in Evergreen Trees.*

From the monthly measurements in 1880 of the six originally selected trees, Sir ROBERT concluded that the evergreen class begins to increase materially in girth

in May, a month earlier than leaf-shedding trees. This conclusion is amply confirmed by the measurements of the two succeeding years. In 1881, indeed, the proof is not positive, as the first measurements did not take place till the end of June; but as 51 per cent. of the whole annual growth was accomplished by that date, it is fair to conclude that a considerable proportion of the increase must have taken place in May. In 1882 there is no room for doubt. The increment till the end of that month actually exceeded the increment of any other month, and the only question is whether a portion of that remarkable growth was not due to April. Unfortunately, as no measurements were taken at the end of that month, this point must remain doubtful.

But the reliability of results obtained from so limited a number of trees and species may justly be questioned. At all events, it may be held that, although true of these species, they may not be true of evergreens in general. Fortunately, however, these results are amply corroborated by observations on the larger number of evergreen trees, first measured for monthly comparison in 1882. The proportion of annual increment in these eighteen trees due to May was 34 per cent., almost identical with that of the selected six, which was 35 per cent.

The limit of the growing season in evergreen trees is better ascertained at the end than at the beginning. Of the six selected trees only one—the African cedar—showed the slightest trace of increase in September, and that only in one of the two years in which observations are available. The increment recorded, moreover, was so slight as to come within the limit of probable error.

In August the proportionate growth seems to be much less in evergreen than in deciduous trees. In August 1880 the increment of the six selected evergreen trees was only 9 per cent. of the annual increase, while in the deciduous group it was 27 per cent. In 1881 there was a greater equality, the respective percentages being 31 and 34. But in 1882 that of the evergreens again fell to 13, while the deciduous percentage reached 25. The results for the latter year were confirmed by the observations on the larger number of eighteen evergreen trees, whose proportionate growth for August was only 15 per cent. of the annual increase.

On the whole, the conclusions to be drawn from all these observations are—*First*, that in ordinary seasons the growth of wood in deciduous trees is mainly confined to June, July, and August. In September it is scarcely appreciable. In May however a small growth does take place, which in favourable seasons may become of no insignificant amount. The Hungary oak not only grows with exceptional vigour in May, but probably in favourable seasons makes a start in April. *Secondly*, that evergreen trees as a class begin to grow probably a month earlier than the deciduous group. They make substantial progress in May, and some of them perhaps make a start in April. On the other

hand, the measurements indicate that they stop growing somewhat earlier than the deciduous class.

Thus Sir ROBERT CHRISTISON'S conclusions are substantially confirmed, although the growth of deciduous wood in May is probably of somewhat greater importance than he supposed. It must be remembered, however, that these rules apply only to the neighbourhood of Edinburgh. In the milder climate, aided by a richer soil, of the south-western districts of Britain, where the leaves expand two or three weeks earlier than here, it is to be expected that the growth of wood will also be correspondingly earlier. Other leaf-shedding species besides the Hungary oak may also be found to be exceptional in the early vigour of their growth, as Sir ROBERT'S observations and my own include but a small proportion of the numerous native and foreign trees which thrive in our islands.

A greater irregularity in the distribution of the monthly growth of the evergreens as compared with the deciduous trees occurred in all the three years during which monthly measurements were made. Thus, while the July percentages of growth in deciduous trees as shown in Table III., were 31, 31, and 31 in these three years, in the evergreen group they were 30, 18, and 19. In August the differences were still more striking, the respective figures being 24, 32, 25 for the deciduous group, and 9, 31, 13 for the evergreen.

It is remarkable that in 1881 the growth of the six evergreens, which in July amounted to only 18 per cent. of the annual increment, became vigorous again in August, when it reached 31 per cent. The deciduous group seemed to partake in this exceptionally vigorous growth in August 1881, but to a much less degree, the proportions being 31 per cent. for July and 34 per cent. for August. In treating of the influence of weather on the growth of wood I shall endeavour to explain these apparent anomalies.

2, a. *The Months in which the Growth of Wood is most active in Deciduous Trees.*

TABLE VI.—MONTHLY PERCENTAGES OF INCREASE IN GIRTH OF DECIDUOUS TREES.

	May.	June.	May and June.	July.	August	Sept.
5 Selected deciduous trees, 1880, .	12	+ 30	= 42	31	24	3
„ „ 1881, .	...	...	35	31	32	2
„ „ 1882, .	21	+ 23	= 44	31	25	...
28 Deciduous trees, 1882, . .	16	+ 26	= 42	35	23	...

To elucidate this subject I give in Table VI. the percentage of growth due to each month of the years 1880, 1881, and 1882, in the five originally selected

deciduous trees, and the corresponding results for the growing months of 1882 in the larger number of trees then under observation.

The Table shows that in 1880 June and July were the best growing months for the five selected trees. The amount in these two months was nearly equal. The united growth of August and September, of which September's share was very trifling, was not much less than that of June or July, while that of May was only half that of August.

The year 1881 is not fully available for this inquiry, no measurements having been taken for May; but as the united growth of May and June but little exceeded that of July or August, it is fair to conclude that the increase in June alone was less than in either of the subsequent months.

In 1882 the growth of the five trees in question was apparently distributed over a longer period. May takes a more prominent place with 21 per cent. The growth for June and combined August and September is not much greater, while July takes a decided lead with 31. The preponderance of the early-growing Hungary oak in the small number of selected trees, however, gives a false impression of the increased deciduous growth in May of this year. If we consider the whole number of deciduons trees, twenty-eight in all, under observation in 1882, the percentage for May is reduced to 16, which is still, no doubt, a substantial and probably an unusual amount.

2, b. *The Months in which the Growth of Wood is most active in Evergreen Trees.*

TABLE VII.—MONTHLY PERCENTAGE OF INCREASE IN GIRTH OF EVERGREEN TREES.

	May.	June.	May and June.	July.	August.
6 Selected evergreen trees, 1880,	37 +	24 =	61	30	9
" " 1881,	...	...	51	18	31
" " 1882,	35 +	33 =	68	19	13
18 Evergreen trees, 1882, . .	34 +	29 =	63	21	16

It is more difficult to determine from the available data the month of greatest growth in evergreen than in deciduous trees. Not only are the variations in this respect in different years greater in the former than the latter, but it is doubtful whether a part of the increment attributed to May ought not to be credited to April in the case of evergreen trees. This doubt arises from Sir ROBERT having concluded, probably too hastily, that no growth takes place in April. I can find no evidence in his papers of his having ascertained this by measurement, and I do not know how he came to form and act upon that conclusion. Further observations are evidently necessary to settle this doubt, and

these I hope to undertake in future years.* At present all that we can safely say is that the increase of wood in evergreen trees from the beginning of spring till the end of May probably exceeds on an average that of every subsequent month. Table VII. shows that it did so in the case of the six selected trees in 1880 and 1882, also in the eighteen trees measured in the latter year. In 1881 the observations are incomplete, as separate measurements were not made for May and June, but August—with 31 per cent.—has a strong claim to the highest place, due I believe to exceptional circumstances.

One of the most remarkable conclusions that may be drawn from the three years' monthly observations on evergreen trees, as a class, is that they apparently accomplish the greater part, and sometimes much the greater part, of their growth by the end of June. Thus in 1880, 64 per cent., in 1881, 51 per cent., and in 1882, 68 per cent. of the annual increment of the six selected trees was finished by that date, and the increment of the eighteen trees measured in 1882 was almost identical with that of the six in the same period, amounting to 63 per cent. Apparently then it is not heat alone which regulates the growth of wood in many evergreen trees. By some inherent vital power they complete the greater part of their growth before the commencement of the two warmest months in the four which constitute the growing period, or else their vital power is so exhausted in the early part of the season that growth cannot be carried on with vigour when the real heat of summer comes on.

In conclusion, it must be allowed that further observations, both on deciduous and evergreen trees, are required to determine which is the best growing month in each class. At present the indications are in favour of July for the former and May for the latter, if the whole, or nearly the whole, of the growth hitherto ascribed to that month really belongs to it.*

3. *Monthly Increase in certain Species of Trees.*

There is considerable variety in the vigour of growth in different species both of deciduous and evergreen trees in the different months of the growing season. My observations on this point indeed, on any considerable number of trees, extend only to a single year, but the results are sufficiently striking to deserve attention. In Table VIII. are given the percentages of monthly growth in seven species, which, either from the number of specimens under observation, or from the certainty of their measurement, yield the most reliable results.

The Hungary oak begins to grow earlier than any other of the deciduous trees under observation. In the backward spring of 1880 the three specimens marked in the Botanic Garden were well clothed with foliage on the 15th May,

* Since this paper was read, the spring measurements for 1883 show a growth in April amounting to two-fifths of that in May in twenty evergreens under observation. It appears probable therefore that June is the month of greatest growth for evergreens.

and after the wonderfully mild winter of 1882 one of them was beginning to expand its leaves on the 27th of March. Their growth was more evenly distributed over the four growing months than that of any others of the deciduous group, and among the evergreens the yews alone rivalled it in that respect. The Turkish and American oaks seem also to be early growers. The proportion of their May growth was not much less than that of the Hungary oaks, still in both the first and last months of the growing season they were less active than the latter. The British oak grows poorly in this district, and besides, from the roughness of its bark, it is not suitable for minute measurements. The only one experimented upon showed no appreciable increment in May.

The beeches made only 12 per cent. of their annual increment in May, about half the proportion of the foreign oaks, and as this was in an unusually early season it is probable that in ordinary years their May growth must be very trifling.

TABLE VIII.—MONTHLY PERCENTAGE OF INCREASE IN GIRTH OF SEVEN SPECIES OF TREES IN 1882.

	Till 31st May.	June.	July.	August.
3 Hungary oaks,	25	21	31	23
2 Turkish and 1 American oak,	22	22	38	18
9 Beeches,	12	26	37	25
4 Sequoias,	36	39	18	7
3 Araucarias,	48	22	15	15
2 Deodars,	6	24	37	33
4 Yews,	33	20	25	22

Among other deciduous species, which being less reliable do not find a place in this Table, the ash and the hornbeam alone showed an appreciable growth in May. It is fair to state however, that in the Edinburgh district the horse chestnut leaves were almost universally destroyed in 1882 by early frost and the ravages of insects. It is no wonder therefore that the specimen measured in the Botanic Garden grew only a tenth of an inch in the year.

The Sequoias were remarkable, even among evergreens, for the early vigour of their growth. No less than 75 per cent. of their annual growth was finished by the end of June. But they ceased to increase earlier than any of the other species, their growth in August being only 7 per cent.

The Araucarias also grew rapidly in the early part of the season, accomplishing very nearly one half of their annual increment by the end of May, and 70 per cent. by the end of June.

With the Deodars it was exactly the reverse, 70 per cent. of their increment taking place after June. If the observations for a single year on two trees may be trusted, the Deodar is an exception to the general rule of early growth in evergreens

The increase of the yews was nearly equally divided between the first and second periods of the season. The former had indeed a slight advantage, but the spring of 1882 was unusually early, and a longer experience may show that yews do not follow the rule of early growth which appears to hold good in most of the Pinaceæ.

As it may be of some interest to show the comparative rate of growth of wood in certain species of trees under observation, I give the following Table:—

TABLE IX.—AVERAGE INCREASE IN GIRTH OF EIGHT SPECIES OF TREES FOR THREE YEARS.

	1880.	1881.	1882.	Average.
Average of—	Inch.	Inch.	Inch.	Inch.
3 Hungary oaks,	1·20	1·72	1·75	1·55
1 American and 2 Turkish oaks,	0·45	0·75	0·65	0·62
9 Beeches,	0·53	0·64	0·79	0·65
4 Sequoias,	1·46	1·17	1·40	1·01
3 Araucarias,	0·65	0·51	0·66	0·61
2 Deodars,	0·42	0·30	0·82	0·51
4 Yews,	0·31	0·37	0·50	0·39
1 African cedar,	1·75	1·40	1·60	1·58

III. INFLUENCE OF WEATHER ON THE GROWTH OF WOOD.

This is a complicated inquiry, so many and various are the influences which may come into play. Extreme frost, prolonged frost, the amount of heat and sunshine, drought or excessive rain, strong winds, all no doubt affect the growth of wood, their influence varying with the seasons, and not necessarily showing their effects immediately.

Of all these agents cold is probably the most energetic; I have therefore looked to it mainly for explanation of the differences in annual growth, adopting Mr SADLER'S record of temperature in the Botanic Garden as my guide, because the greater number of the measured trees are situated either there or in the adjoining Arboretum. The thermometers used by him are four feet from the ground, and being unprotected the readings are not strictly accurate, but for purposes of comparison with each other the observations are sufficient.

Sir ROBERT CHRISTISON showed that the remarkable cold and absence of sunshine in the spring and summer of 1879 caused a great deficiency in the growth of wood, both in deciduous and evergreen trees, in that year as compared with the previous one; that the deficiency was greatest in the deciduous class; and least of all, so far as his observations went, in oaks.

In 1880 the spring was favourable to the opening buds, the temperature

being considerably above average in February and March, while although April was cool it was free from severe frosts. The summer was also of an average character. The foliage was therefore, in general, rich and abundant. Nevertheless there was again a great falling off in the growth of deciduous wood. This Sir ROBERT attributed to the extraordinary low temperatures of the previous December, succeeding an autumn unfavourable to the ripening of wood and formation of buds. He believed that evergreen trees had also suffered, although not to the same extent; but I find that he had been deceived by an error in copying his figures, and that their growth in 1880 was almost identical with that of 1879.

It is not easy to explain why both classes should have suffered a diminution in the growth of wood in 1879, and only the deciduous class a further decline in 1880. In the first of these years the cause of deficiency was no doubt, as Sir ROBERT believed, the inclement spring and summer, as the cold of the previous winter although prolonged was not remarkably intense; under these circumstances both classes of trees were unfavourably influenced. In 1880 on the other hand the cold of the previous winter was both prolonged and intense, and in all parts of the country its effects were visible in the killing of tender young wood or even of whole trees. It is no wonder then that the deciduous trees showed a marked decline in addition to the serious loss they had suffered in the previous year. But why did the evergreen class escape this further loss? Possibly the explanation of this difference may be found in the earlier activity of growth in evergreens in spring. In their exposure to the intense frost of winter their circumstances must have been much the same as those of the deciduous class, but their comparatively early buds would probably come under the influence of the genial March and April to a greater degree than the later buds of the leaf-shedding trees, which, on the other hand, would encounter a rather inclement May. Another cause that may be suggested is that the previous autumn, which was highly unfavourable to the ripening of wood, may have in some way prejudiced the evergreens less than the deciduous trees. That the evergreen trees under observation were not really hardier than the deciduous ones was proved by their fate in the following year.

The winter of 1880–81 was even more protracted and severe than that of 1879–80. Both the lowness of the average temperature and the number of extremely low readings at the Botanic Garden in January, the coldest month of 1880–81, were more remarkable than in December, the coldest month of the previous winter. Thus the lowest temperatures recorded in the latter month were 1°, 4°, 15°, 17°, 19°, but those of January 1881 were 0°, 4°, 7°, 10°, 11°, 12°, 12°, 12°, 13°, 14°. And this greater cold was prolonged far into the spring. On the last day of February and first few days of March 15°, 15°, 18°, and 19° were recorded,

and another wave of cold brought the thermometer below the freezing point on twelve nights in the first fortnight of April, the lowest readings being 21°, 22°, and 23°. On the other hand, the lowest readings in the same months of 1880 were only 23° in February, 22° in March, and 27° in April. Moreover, the total number of nights of frost in these three months in 1880 was only thirty-four, while in the corresponding period of 1881 it was fifty-three.

After so severe a winter and spring it might have been expected that even more disastrous effects on the growth of wood would have resulted than after the less extreme cold of the previous year. But, on the contrary, the deciduous trees, at least, made a remarkable rally, the average growth of twenty-seven of them having risen from 0·46 in. in 1880 to 0·69 in. in 1881, an increase of nearly one-third. Very different however was the fate of the evergreen trees. Unlike the deciduous class they had successfully resisted the efforts of the previous hard winter, but now they suffered seriously, thus differing once more from the leaf-shedding trees, but in the opposite way, for their average growth, which in 1880 had been 0·70 in., was now only 0·59 in.

The wonderful rally made by the leaf-shedding trees in 1881, notwithstanding the almost unprecedentedly low temperatures of the previous winter, can only be accounted for, I believe, by the favourable character of the preceding autumn, which allowed the growth of wood of 1880 to be perfectly matured, and so enabled it to withstand the rigour of the winter in 1881. But why was a similar effect not produced upon the evergreens? Is it because the maturing of wood is not so effectual with them as it appears to be with the deciduous trees in enabling them to resist a severe winter? Or shall we find the reason in the comparatively early growth of evergreens which might expose their tender buds to the frequent low temperatures of March and April, a danger from which the buds of the deciduous class, coming out later, would be free, while they would benefit by the geniality of May? The latter seems the most probable cause, but further observations are required to settle the question.

The winter of 1881–82 was one of the mildest on record. It was well suited therefore to test Sir ROBERT'S suggestion that evergreens might in an unusually mild winter show some trace of growth; but none could be detected in any of the twenty-eight measured trees. Vegetation however was very early. A sycamore and a Hungary oak among the marked trees in the Botanic Garden began to expand their leaves on the 27th of March. The sycamore paid dearly for its temerity. Caught by an early frost and afterwards attacked by insects, its leaves were irretrievably injured, and its increase in girth for the year only amounted to a twentieth of an inch. A similar fate befell nearly all the horse chestnuts near Edinburgh, including a fine specimen, one of my measured trees, which grew only a tenth of an inch in the year. The Hungary oak, on the other hand, did not suffer at all. The deciduous class as a whole,

however, were not injured in this way; but notwithstanding the mild winter they only maintained their improvement of the previous year, without attaining the standard of growth of 1878. The reason of this failure, no doubt, was the unfavourable nature of the previous autumn for the ripening of wood, combined with the ungenial nature of the growing season, both of which were well-marked evils at the Botanic Garden, as I was informed by the late lamented Mr SADLER shortly before his death.

The evergreens, on the other hand, recovered their loss of the previous year. Apparently the frost of April had not injured them, and they had been stimulated by the mildness of May, as their growth till the end of that month bore a high proportion to the whole annual increase.

This attempt to connect the annual variations in the increase of wood with temperature, and to explain the curious contrasts between deciduous and evergreen trees in their annual growth by the effects of temperature alone, cannot be considered as altogether satisfactory. Neither are the difficulties cleared up by considering other causes which must manifestly affect the growth of wood. Violent winds, for example, must be prejudicial not only by tearing down important branches, but by damaging the leaves. Every one must have observed the injury done to foliage by storms, particularly in spring and the beginning of summer. Multitudes of leaves are blown away, and those which remain hang limp and shrivelled from the branches, their petioles twisted by the wind, and the circulation through them thus hindered by bruising of the vessels. In the records of the Scottish Meteorological Society many gales are reported as having occurred at Edinburgh in the years with which we have to do, but I cannot clearly trace a connection between them and any diminution in the growth of wood. I should have expected the greatest damage to have been done in 1881. In the previous year, indeed, there were three gales in May, but it was a backward spring, and the leaves may thus have escaped. At all events we know that Sir ROBERT remarked the richness and abundance of foliage in June, and there were no gales in that or the subsequent growing months. In 1881, on the other hand, one gale in May, three in June, two in July, and four in August were recorded; yet this was the year in which, with all the disadvantage of a previous winter of almost unprecedented severity, the growth of deciduous wood made a remarkable rally. But the fact is that the effects of each gale must be watched in order to know whether any general damage has been done to the leaves or not, so much depends on the strength of the wind, its direction, and the shelter which may protect the trees concerned. I should expect that differences between the annual increase of deciduous and evergreen trees might sometimes be due to this cause, as the leaves of the latter, from their shape, cannot be exposed to

the same injury as those of the former; but in the years now under consideration I cannot trace any such effect.

In a climate such as ours, with frequent variations from the average in the monthly rainfall, considerable effects on the growth of wood may be expected from excess or deficiency of rain at the growing season. To trace these effects may be difficult, from the possible simultaneous action of other causes immediate or remote; nevertheless I think something may be made of an examination of the principal abnormalities in the rainfall during the three years in which monthly observations of growth were taken. I owe to the kindness of Mr BUCHAN the following Table, showing the excess or deficiency of rain during the months of the period in question. The means from which these are calculated are derived from twenty-eight years' observations at Charlotte Square, whereas the monthly rainfall is taken from observations at Cumin Place, Grange; but the general results are not likely to be seriously affected by this difference.

TABLE X.—MONTHLY EXCESS OR DEFECT OF RAIN AT EDINBURGH IN 1880, 1881, AND 1882.

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1880, .	-1·69	+0·03	-0·09	+0·11	-1·05	-0·46	+1·91	-2·46	+0·17	+1·66	+1·54	+1·01
1881, .	-0·70	+2·81	+0·13	-0·32	-0·04	-0·61	+0·52	+3·06	+0·97	-0·50	+0·60	-0·83
1882, .	-0·55	+0·01	+1·04	+1·00	+0·29	+0·28	-0·51	-0·85	...	...	...	...

In comparing the rainfall with the tree-growth, I shall make use of the proportion which the monthly percentage of the latter bears to the whole annual growth. These will be found in Table VI. and VII.

1880.—The rainfall of May was less than half the average, and that of June was deficient by about a third; but the increase of wood in both classes of trees was quite up to the average of the same period for three years. In July the rainfall was much in excess: the deciduous growth was an average one; but the evergreen growth was much above the average. In August there was a great deficiency of rain, — 2·46, and an excess of heat, + 3°·3; the deciduous growth was about an average, the evergreen greatly below average.

1881.—In April, May, and June there was a deficiency of rain, but it only amounted to an inch in all, and as vegetation was completely checked by severe weather till the middle of April, the small proportionate growth of both classes of trees in May and June may fairly be attributed to the latter cause. In July the rainfall was slightly in excess: the deciduous growth was again an average, but the evergreen under average. In August, the memorable month of the Volunteer Review at Holyrood Park, no less than 6 inches of rain, double the

average, fell at Edinburgh: then the evergreens made a surprising rush, no less than 31 per cent. of their annual growth taking place, whereas in August 1880 the portion was only 9 per cent., and in 1882, 13 per cent. This result was the more remarkable, as the temperature of the month was 2°·3 below the average. The deciduous trees were also apparently benefited by this excessive rain, although accompanied by deficient temperature, their proportion being 34 per cent. in August and September of 1881, while it was only 27 per cent. in 1880, and 25 per cent. in 1882.

1882.—The rainfall of March, April, May and June was abundant, exceeding the average by an inch in each of the first two months, and being rather above the average in the third and fourth. In the same period the growth of evergreen wood was large, but this may easily be accounted for by the mild winter and early spring, without calling in the aid of the rainfall.

Taking a general view of this investigation, it appears as if an abundant rainfall were favourable to the growth of wood, but much more favourable to the evergreen than the deciduous class. It must be admitted however that a longer series of observations, taken on a larger scale, are necessary to determine this point. The most striking fact shown is the extraordinary increased growth of the evergreens in August 1882, along with a very heavy rainfall and low temperature, whereas in the previous August, when the conditions were reversed, the rainfall being 2·46 inches in default and the temperature 3°·3 in excess, the evergreen growth was very deficient.

Summary.

To give a better idea of the general scope of this paper, the details of which are necessarily of a somewhat dry and tedious character, I now give a summary of the chief conclusions which are scattered throughout the text. It must be remembered however that these conclusions are strictly applicable only in the Edinburgh district, and that some of them are only indications of the probable truth, and require to be confirmed by a larger series of observations.

1. The effects upon the growth of wood of the severe winters preceding the growing seasons of 1879, 1880, 1881 were not the same in deciduous and evergreen trees. In 1879 both suffered: the former more than the latter. In 1880 a further decline took place in the deciduous class, but not in the other. In 1881 the deciduous class recovered their loss of the previous year, but it was now the evergreen's turn to fall off. After the unprecedentedly mild winter of 1882 they again differed. For while the deciduous trees made no further recovery, the evergreens regained the loss sustained in 1881; neither class however attaining to the standard of growth in the favourable season of 1878.

2. Evergreen trees probably do not increase their wood at all in winter,

however mild it may be, as not the slightest trace of growth could be detected in the measured trees after the wonderfully mild winter of 1882.

3. The British oak probably suffered a greater decline in its growth of wood from the severe winters than any other tree under observation. The Hungary oak, on the other hand, was less affected than any other tree; and the Turkish and American oaks less than our native oak.

4. In the wave of increase and decrease in wood growth through these years the yews followed the deciduous class, and not their congeners the evergreen pines.

5. The appreciable growth of wood in deciduous trees is mainly confined to June, July, and August in ordinary seasons; but a material increase does take place in May, particularly when the spring is unusually mild.

6. The growing season in evergreen trees includes May, and probably an appreciable start is made even in April, when the spring is favourable.

7. The proportionate monthly growth seems to vary more in evergreens than in deciduous trees.

8. The growth of wood is probably greatest in July in deciduous trees, and in June* in evergreens; but further observations are required to settle these points.

9. On an average of three years the evergreen trees as a class accomplished 60 per cent. of their annual increase of wood before the end of June, the deciduous 60 per cent. of theirs after that date. Deodars appear to be exceptional, as they agreed with the latter instead of the former group. In yews the growth is probably pretty equally divided between the two periods.

10. Of all the species measured, the Hungary oak and African cedar proved much the quickest growers. Then followed the *Sequoia gigantea.*

11. Thorough ripening of wood in autumn seems to be of immense consequence in enabling deciduous trees to stand extremely low temperature in winter. Evergreens however do not seem to be so dependent on it.

12. An excessive rainfall seems to be favourable to the increase of wood, particularly in evergreen trees. A great excess of rain in August 1881 apparently stimulated the growth of wood in these to a remarkable degree, although the temperature of the month was decidedly low.

In conclusion, I cannot help expressing a wish that others who have better opportunities than I can command would take up a line of inquiry which Sir ROBERT CHRISTISON has made easy by the practical rules he has laid down for its prosecution. The necessary observations are not difficult to make, merely requiring precision; and they take up little time when the trees experimented upon are near at hand. The work is interesting, and the results may prove to

* See foot note, page 57.

be of importance in unexpected ways. I must also repeat the surprise which Sir ROBERT often expressed, that little or nothing seems to have been done to ascertain the effects of manuring on tree growth. "Mulches" have indeed been applied to favourite trees when in a sickly state, and often with the best results, but the farther step of trying the effect of manures in stimulating the growth of healthy trees has not, so far as I am aware, been taken. Perhaps the want of any reliable method of ascertaining the rate of growth of wood has hitherto stood in the way of such experiments ; but surely there is the greatest encouragement to undertake them, now that Sir ROBERT has shown the ease and accuracy with which minute measurements of the girth of trees can be made, and their rate of growth thus ascertained in comparatively short periods of time. If such application of manures proved useful, but at the same time too expensive to be employed on the great scale, it should at least be welcomed by the landed proprietor to secure a more rapid growth of young ornamental wood.

Note.—In Table III. the average growth of the Evergreen trees for May and June 1881 should be 0·65 instead of 0·48, and the monthly percentages 59, 15, 26, instead of 51, 18, 31. The latter errors occur also in Table VII. The conclusions in the text are not materially affected by these errors, except that the claim of August to the highest average monthly growth in 1881, mentioned on page 57, becomes very doubtful.