Additional Observations, since 1897, on the Girth-increase of Deciduous Trees in the Royal Botanic Garden, Edinburgh, and their connection with the Twenty Years' Observations (1878–97) previously published.

BY

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Introduction.

The results of the observations begun by my father in 1878, and continued by me after his death in 1882, have been published from time to time down to the year 1897.* They principally deal with, and determine with sufficient accuracy, the average annual and monthly rates of girth-increase in a large number of deciduous trees. In accordance with the tapes then in use, the records were kept in twentieths of an inch. But the introduction of the fine steel tape of Chesterman, graduated to millimetres, insured an accuracy previously unattainable, and all my measurements since 1897 have been taken with this tape, the records being kept in millimetres, and even in half-millimetres. As my confidence increased, I initiated new inquiries and reduced the intervals of the observations to five days in general, besides recording occasionally, for short terms, at intervals of two days or daily, and finally three times a day.

For purposes of comparison, and to link on the new with the old records, it was necessary to reduce the parts of an inch in

*1. *On the Exact Measurement of Trees*. By Sir R. Christison, Baronet. Trans. and Proc. Bot. Soc., Edin., 1879-80-81.

2. *Observations on the Annual and Monthly Growth of Wood.* Sir R. Christison and Dr. D. Christison. Trans. R.S.E., XXXII., Part I., p. 46.

3. *The Weekly Rate of Girth-increase in Trees, and its Relation to the Growth of the Leaves and Twigs.* Trans. and Proc. Bot. Soc., Ed., 1891. Dr. Christison.

4. *The Girth-increase of Trees in the Royal Botanic Garden, Edinburgh, for Twenty Years* (1878–97). Notes, R.B.G., Edin., No. III, 1900; No. IV., 1901.

[Notes, R.B.G., Edin., No. XVII., April 1907.]

the latter to millimetres, a laborious task accomplished by help of Dowling's invaluable Metric Tables.

My method of measuring, and the precautions taken in selecting suitable trees are fully explained in the "Notes" (4), Royal Botanic Garden, Edinburgh, and need not be repeated here.

DIVISION OF THE SUBJECT.

From the beginning of the observations certain objects were kept specially in view, and subsequently others suggested themselves and were duly followed up. Thus, ultimately, a considerable number of lines of inquiry were established, so distinct from each other that they can be treated in separate and more or less independent chapters. In considering them, the most convenient plan will be to take the later results first and work gradually back to the earlier ones, republishing the latter only when necessary. Finally, the history of the trees individually throughout their whole career will be given.

The divisions of the subject will be taken in the following order :—

I. Effects of transplantation on girth-increase.
II. „ „ pruning „ „
III. Fluctuations in girth-increase (*a*) in frost, (*b*) in open weather.
IV. Annual and monthly girth-increase.
V. The beginning and end of girth-increase in the growing season.
VI. Progress of girth-increase in the growing season.
VII. History of the trees individually.

As it seems undesirable to delay publishing the results until the whole of them have been digested, the first instalment is now offered, containing the first two divisions.

PRELIMINARY REMARKS ON THE EFFECTS OF TRANSPLANTATION AND PRUNING.

When the square park surrounding Inverleith House was joined to the Botanic Garden in 1876 to form an Arboretum, a considerable amount of timber, from about 50 to 100 years old,

or thereby, stood upon it. But besides this, before the ground was handed over to the officials of the Garden, shelter belts of young trees were planted on the north, west, south, and part of the east sides.

When it became desirable to thin the belts, the selected trees were removed to new sites, the formation of the main avenue at the foot of the bank on the south side of the house, and of groups of the different species, being chiefly kept in view. Re-arrangements necessitated a second transplantation in not a few instances, and the removal of several much older trees from the Botanic Garden to the Arboretum was also undertaken.

The general method of transplantation followed has been to remove infant trees without any previous preparation, but with trees from about 6 or 8 to 18 or 20 inches in girth the outer roots were severed by cutting a circle in the ground round the tree, which was left standing for a year, or even for two years, to encourage the growth of new roots in the enclosed "ball" of earth. When transplanted the twigs were slightly pruned. In the case of unusually large trees—from 3 to 4 feet or nearly 5 feet in girth—the circular cut became a trench 4 feet deep.

Another practice seriously affecting the girth-increase, and introduced about the same time, was the pruning of trees into a conical sharp-pointed form to promote upward growth.

As most of the trees selected by me for observation soon after the establishment of the Arboretum were in the shelter belts, it was unavoidable that many of them should be transplanted, and of those that remained some were prepared for removal, and others were closely pruned for upward growth; thus my records were dislocated, at a varying number of years after their commencement, from these three distinct causes. The period before interference lasted in nearly every case long enough to determine what may be called the natural annual rate of girth-increase, and, as in most cases eleven years have elapsed since interference, not only have the immediate effects on the rate been well established, but the rates for several years after recovery from the operations have also been generally determined.

I.—EFFECTS OF TRANSPLANTATION.

(*a*) Trees of a Considerable Size.

1. Five trees of unusual size for transplantation were removed in the spring of 1896 from the Botanic Garden to the Arboretum. They varied between $3\frac{1}{4}$ and nearly 5 feet in girth, and along with them came a sixth of the more ordinary girth of 1 foot 8 inches. One of the larger size, *Pyrus Aria*, failed to recover and was cut down in 1901, so that it may be left out of account. The rate of increase after transplantation of the other five is given in Table I.

Although, on the whole, the aggregate rate is progressive, it has not been regularly so. Thus, it was rather less in the second year than in the first, and it was considerably less in the sixth than in the fifth year. It was equal in the seventh and eighth, but decidedly less again in the tenth than the ninth.

TABLE I.

No.		Girth, March, 1896.	Increase in Millimetres.						
			1896	1897	1898	1899	1900	T.	Av.
1.	*Pyrus rotundifolia*,..	Met. 1·027	1·3	1·3	3·8	7·6	6·3	20·3	4·06
2.	,, *communis*, ..	1·223	2·5	2·5	..	1·3	5·1	11·4	2·28
3.	*Cratægus oxyacantha*,	1·123	2·5	1·3	2·5	5·1	5·8	15·2	3·04
4.	,, ,,	0·527	..	−1·3	1·3	2·5	7·7	10·2	2·03
5.	*Juglans regia*, ..	1·443	..	1·3	1·3	..	3·8	6·4	1·28
			6·3	6·3 −1·3 5·0	8·9	16·5	26·7	63·5	12·7

No.	1901	1902	1903	1904	1905	T.	Av.	Girth, Oct. 1906.	Increase, Millimetres.
1.	3·8	11·4	10·2	10·2	7·6	43·2	8·65	1·100	11
2.	−3·8	3·8	..	12·7	3·8	16·5	3·30	1·241	5
3.	8·9	8·9	10·2	14·0	19·0	61·0	12·20	1·217	18
4.	7·6	10·2	12·7	15·2	10·2	55·8	11·16	0·613	19
5.	..	1·3	2·5	2·5	..	6·3	1·26	1·457	2
	20·3 −3·8 16·5	35·6	35·6	54·6	40·6	182·8	36·6		55

In the quinquennia the rate of the second was nearly three times that of the first, the aggregate results being 63.5 and 182.8 mil., and the averages 12.7 and 36.6.

THE TREES SEPARATELY.

1. PYRUS ROTUNDIFOLIA.

The recovery in the general appearance of the foliage was slow, and did not seem to be complete till 1905. There was no loss of branches, and the head of foliage is now large and dense. The stem is about 3 feet 7 inches in girth and 14 feet in height, and the total height of the tree is 39 feet.

The rate of girth-increase was progressive on the whole, that of the second quinquennium being double that of the first, but it was irregular from year to year. The average for the last five years, 8·6 mil., or about a third of an inch, and the last year's rate of 11 mil. must be low, if we may judge from another of the same species in the Rosarium of the Botanic Garden, which has a stem 14 feet in height, girthing 6 feet 3½ inches (2·015 mil.), and is perfectly symmetrical, and crowded with foliage, which has a circumference of 165 feet.

2. PYRUS COMMUNIS.

This tree has not done so well as the last, and although the foliage is now healthy and fairly abundant, it shows awkward gaps from the death of branches. The girth is now barely 4 feet 1 inch and is only about ¾ inch more than eleven years ago. The stem is 12 feet high and the tree 44 feet.

The average annual rates for the two quinquennia were 2·28 and 3.3 mil., but there was great annual variation—from a loss of 3·8 in 1901 to a gain of 12·7 in 1904. The increase in 1906 was only 5 mil.

3. CRATÆGUS OXYACANTHA, var. PLENO FLORE RUBRO.

The progress of the foliage to a healthy condition was not much quicker in the two hawthorns than in the pears, but the girth-increase began to improve earlier and went further.

In No. 3 the average annual rates in the two quinquennia were about 3 and 12 mil., and the increases of 19 and 18 in the years 1905 and 1906 augur well for the future of a tree of the species already 4 feet in girth, 34 feet high, with a bole of 9 feet.

4. CRATÆGUS OXYACANTHA, var. FLORE PLENO.

This considerably smaller hawthorn followed much the same course as No. 3, but the quinquennial averages of about 2 and 11 mil. were rather less than in it, and the increases of 10 and 19 in 1905 and 1906 compare unfavourably, considering the smaller girth, barely 2 feet, of No. 4.

5. JUGLANS REGIA.

This remarkably handsome walnut is the largest "transplant" in the Garden. When operated on it measured within 3 inches of 5 feet in girth, and had a stem of 17 feet and a total height of 50 feet. With its ball of earth it must have weighed about 7 tons.

After transplantation its progress, if progress it can be called, was exceedingly slow, and it was no better in the second than in the first quinquennium, the amounts being 6·4 and 6·3 mil., or 12·7 in ten years.

The annual increase was *nil* in 1896, '99, 1901, '05; and the greatest amount in any one year was 3·8 in 1900. This is a disheartening record; nevertheless, the tree retains its fine appearance, and, if the foliage continues to be very poor, it is not unhealthy and there are few dead twigs. It is to be hoped, therefore, that recovery will eventually be complete, and that an interesting proof may be furnished that a tree, after "marking time" for at least ten years, may enter on a fresh career of progress.

The results in *Cratægus Oxyacantha*, No. 16, another large hawthorn, may appropriately be given here. The effects of transplantation in this tree were complicated by the effects of frost. So far back as 1878 this was by far the finest hawthorn in the Garden, symmetrically clothed with dense foliage to the ground. It girthed 3 feet 2 inches and the increase of that year was 20½ mil., but the disastrous frost of that winter brought it down to 2½ in 1879: in 1880 it rallied to 19, but the hard frost of that winter

reduced it to 9 in 1881. For the next ten years the rate was $14\frac{1}{2}$.

It was prepared for transplantation by pruning and cutting round the roots in autumn, 1894, when 3 feet 8 inches in girth, and quite retaining its handsome look; but it was allowed to stand for five years more, the girth-increase rate falling to 4 mil. In 1899 it was removed to the south walk of the Arboretum, when it was noted that a great mass of roots had formed in the ball of earth. But the increase since the operation has fallen almost to zero. and the tree is a complete wreck, though still allowed to stand. This result was doubtless mainly caused by the tree having been twice blown down after transplantation. On the second occasion the holding stays were broken, and the tree torn out of the ground, the roots being broken across, and the soil shaken from them.

(*b*) Trees of Smaller Girth.

In the Tables under this head the results before and after transplantation are separated by a double line, and are expressed in millimetres.

ACER PSEUDOPLATANUS. No. 67.

Girth, March, 1887=0·175 mil.

Trd.

	1887-1889	1890	1890-94	1895-99	1900-04	1905	1906
Amount,.. ..	$2\frac{1}{2}$ 5 $7\frac{1}{2}$	$12\frac{3}{4}$	$82\frac{1}{2}$	$105\frac{1}{2}$	112	$21\frac{1}{2}$	23
Rate, ...	5	..	$16\frac{1}{2}$	21	$22\frac{1}{2}$	$22\frac{1}{4}$	

Transplanted in spring, 1887, to an open grassy space, where it still stands, quite free, but well sheltered. When transplanted it was an infant, girthing only $6\frac{3}{4}$ inches. Since then it has only been interfered with by pruning to promote upward growth.

The rate of increase before transplantation is unknown, but ought to have been, and no doubt was, much above the 5 mil. of the following three years. In the next year the amount sprang

up to 12¾ mil., indicating that the effects of transplantation were over, particularly as the quinquennium, then beginning, yielded an average of 16½, and the next one 21. This was, apparently, in accord with the upward march of adult life, but hardly any further development has occurred in the final seven years, such as might be expected in a sycamore 20 inches in girth.

The annual records show that in the last ten years the most flourishing period was in 1899, 1900, and 1901, when the increases were 25½, 28, and 26½ mil., and that there was a sudden drop to 14 in 1903.

1897				1901					1906
21½	21½	25½	28	26½	21½	14	21½	21½	23

The foliage, although always healthy, has not the density usual in sycamores. Its rate of increase also compares unfavourably with that of the following two trees of the same species.

ACER PSEUDOPLATANUS. No. 71.

Girth, March, 1887=0·214 mil.

	1887–1890	1891–96	1897–1898	1898
Amount, ..	108	182½	0	Died
Rate, ...	27	30½	0	..

This young tree, barely 8½ inches in girth in 1887, throve well for the eight years when it stood in the south shelter belt of the Arboretum, its annual rate being nearly 30 mil., but it did not survive removal.

ACER PSEUDOPLATANUS. No. 74.

Girth, March, 1887=0·233 mil.

	1887–1890	1891–1895	1895	1896–1899	1900	1900–1905	1906
Amount, ..	106¾	186¾	39¼	3¾ 7½ 6½ 10	22¾	184¾	28
Rate, ..	26¾	37½	..	7	..	30·7	..

A companion of the last, and not $\frac{3}{4}$ inch larger in girth, No. 74 was transplanted at the same time, but with a better fate. It grew at the same rate as No. 71 in the first four years, but in the next five got ahead of it, the respective rates being $30\frac{1}{2}$ and $37\frac{1}{2}$. After removal to its present open grassy situation near the old walnut in the Arboretum, its rate for four years was only about 7 mil., the decline in the first year being extreme—from $39\frac{1}{4}$ to $3\frac{3}{4}$. In 1890 the rate jumped to $22\frac{3}{4}$, and in the six years 1900–1905 averaged 30, but was slightly less—28—in 1906. That this rate did not equal the rate before transplantation may be due to the clearing of the dense plantation in which the tree was growing at first, and to its exposure in its present position.

ÆSCULUS HIPPOCASTANUM. No. 73.

Girth, March, 1887=0·173 mil.

Trd.

	1887–1895	1895	1896	1897–1901	1902–1906
Total,.. ..	$185\frac{1}{2}$	$15\frac{1}{4}$	$6\frac{1}{4}$	$129\frac{1}{2}$	165
Average, ..	$20\frac{1}{2}$	..	..	26	33

Girthing about 7 inches when first measured, No. 73 increased at the rate of $20\frac{1}{2}$ for nine years. In the last of these years the increase was only $15\frac{1}{4}$, due, probably, to pruning of branches and roots to prepare for transplantation. This was in 1895, and in 1896 the increase fell to $6\frac{1}{4}$; but next year it rose again to $15\frac{1}{4}$, and the career of the tree ever since, in its new situation near the ruins of the old walnut, has been prosperous, the rate from 1897 to 1901 having been 26, and from 1902 to 1906, 33.

ÆSCULUS HIPPOCASTANUM. No. 80.

Girth, March, 1887=0·187 mil.

Trd. Trd.

	1887–1891		1895–1896	1897–1902	1902–1904		1906–1906	
Total, ..	150	$2\frac{1}{4}$ 10 $12\frac{3}{4}$	$63\frac{1}{2}$	$102\frac{1}{4}$	$3\frac{3}{4}$	$3\frac{3}{4}$ $6\frac{1}{2}$	$17\frac{1}{2}$	22
Average,	30	$8\frac{1}{2}$	$31\frac{3}{4}$	$20\frac{1}{2}$	$4\frac{1}{2}$		20	

Girthing 7½ inches when first measured in 1887, this companion of the last had the apparently high rate, for so young a tree, of 30 mil. for five years. Transplanted in 1892, it took three years to recover instead of one, as in No. 73. The recovery was complete, the rate rising for two years to 31·5 ; but, as the result of pruning and retransplantation in 1902, followed by a fungoid disease of the bark, the rate fell for the three years 1902–04 to 4½, and the tree had a very shabby appearance. The diseased bark was extirpated, and a cure apparently effected, as the appearance of the tree is much improved in the last two years, and the rate of girth increase has risen to 20.

ALNUS GLUTINOSA. No. 88.

Girth, March, 1887=0.242 mil.

Trd.

	1887–1889	1890–95	1896
Total, ...	73¾	92¾	Languished and died in 1900
Average, ..	24½	15½	

The rate of this alder, 9½ inches in girth in 1887, was 24½, for three years, which seems good. It then fell off for the next six years to 15½, and after transplantation in 1896 the tree did no good for four years and was cut down.

BETULA ALBA. No. 78.

Girth, March=0.237 mil.

Trd.

	1887–1894	1894	1895	1898
Total, ...	232	31¾	2½ 11½ 5	Cut down
Average, ..	29	..	6¼	..

This birch, 9⅓ inches in girth, promised to be a fine tree, having had a rate of 29 mil. for eight years before transplantation in 1895. In the previous year the increase was 31¾, but it fell to 2½ in 1895, and after lingering on for two years more, with increases of 2½, 11½ and 5, the tree died in 1898.

CARPINUS BETULUS. No. 81.

Girth, March, 1887=0.186 mil.

	1887–1891	1892	Trd. 1893–1894	1895–1904	Trd. 1905–1906
Increase, ..	89	11½	0 9	199	..
Average, ..	18	..	4½	20	2

This hornbeam, 7½ inches in girth in 1887, had a rate of 18 for five years. Next year the increase dropped to 11½, probably from the pruning before transplantation. After that operation in 1893 there was no increase in the first year, and it amounted to only 9 in the second, but for ten years thereafter the rate was 20. The tree was then—1895—again transplanted, and the average of 1895–96 was only 2.

CARPINUS BETULUS. No. 86.

Girth, March, 1887=0·150 mil.

	1887–1890	1891–1896	Trd. 1896	1897–1906
Increase, ..	53¼	120	21½	57¾
Average, ..	13¼	20½	..	5½

A companion of No. 81, originally in the south shelter belt, and even less in size, only 6 inches in girth, its rate was only 13¼ as an infant, but after four years it increased for six years to 20, or the same as in No. 81. Transplanted in 1897, the increase fell from the high 21½ of the previous year to 3¾, and the rate for ten years down to 1906, was only 5½, the minimum being 0· and the maximum 11½. The foliage in this period has been scanty, but not unhealthy, and, as it is gradually filling up, the tree may yet do well.

CRATÆGUS OXYACANTHA. No. 8 (formerly 19).

Girth, March, 1887=0.245 mil.

	1887–1892	Trd. 1893–1895	1896–1898	1899–1904	Trd. 1905–1 06
Total, ...	163½	11½ 12¾ 21½	2½ 1¼ 2½	122½	3½
Average, ...	27¾	15¼	2	20	1¾

9½ inches in girth in 1887, this tree had a rate of 27¾ for six years, when it fell for three years to 15¼, probably from pruning. In the last of these years, however, the rate had improved to 21½ and the tree looked well. It was then transplanted, when the rate for three years fell to the excessively low amount of 2. Recovering a rate of 20½ in the period 1899–1904, it was again transplanted in spring, 1905. The increase for 1905–06 was only 3½, but the tree is well clothed with healthy foliage in 1906, and should now do well.

CYTISUS LABURNUM No. 21.

Girth, March, 1887=0·153 mil.

	1887–894 Trd.	1895–1896 Trd.	1897–1904 Trd.	1905–1906 Trd.
Total, ...	168	3¾ 9	201	13
Average, ..	21	5½	25	6½

Six inches in girth in 1887, this laburnum had the probably good rate, for so young a tree, of 21 for eight years. Transplanted then, the increase in 1895 was only 3¾; in 1896 it was 9; but recovered to 21½ in 1897, and a rate of 25 was kept up for eight years till 1904, when the tree was again transplanted. The rate for 1905–06 was 6½, and the tree seems in good condition.

FAGUS SYLVATICA. No. 97.

Girth, March, 1888=0·262 mil.

1888 Trd.	1893 Trd.
29 33 38 22¾	1¼
122	Died
30½	

This fine young beech, 10¼ inches in girth in 1888, increased at the rate of 30½ mil. for four years. It was then transplanted, but died from the operation.

FAGUS SYLVATICA. No. 98.

Girth, March, 1888=0.205 mil.

1888	Trd.
25½ 28 37 34½ 39½ 164 32¾	Died

This companion of the last, although only 8 inches in girth in 1888, had a similar rate for five years, but underwent the same fate from transplantation.

FRAXINUS EXCELSIOR. No. 75.

Girth, March, 1887=0.124.86 mil.

	1887–1894	Trd. 1895–1898	1899	1899–1904	Trd. 1905–1906
Total, ...	116	1¼ 6¼ 12¾ 14	25½	128½	8½
Average, ..	14½	8·5	..	21½	4¼

This young ash, measuring under 5 inches in girth at first, increased at the rate of 14½ for eight years, when it was transplanted, with the result of a fall to 1¼ in 1895, an amount which was gradually improved upon for the next three years; but it was not till 1899 that real recovery took place, as shown both by the aspect of the tree and the sudden jump of the increase to 25½, a rate which was somewhat diminished in the next six years, chiefly from a fall to 15½ in 1904. It was then re-transplanted, and the rate for the final two years was 4¼. The general rate, which is apparently low, was no doubt kept down by pruning for upward growth.

FRAXINUS EXCELSIOR. No. 23.

Girth, March, 1887=0.146·05 mil.

	1887–1891	Trd. 1892	1894	1894–1896	Trd. 1897	1901
Total, ...	115½	7½ 6½	26¾	93	5 3¾ 5 7½	Died
Average, ..	23	7	..	31	5½	

A little larger than the last in 1887, this ash had a much better rate for five years. Transplanted in 1892, the rate fell to 7 for two years. A sudden rise to 26¾ proclaimed a complete recovery in the following year, and a rate of 31 gave good promise for the future. But, unfortunately, it was retransplanted, and after struggling feebly with a rate of 5½ for four years it was cut down.

POPULUS FASTIGIATA. No. 9.

Girth, March, 1892=0.217 mil.

	Pruned.				Trd.				
	1892–1895	1895	1896–1899	1900–1901	1902–1906				
Increase, ..	125¾	33	71	25½ 26¾	1½	1¼	5·00	6·00	11½
Average, ..	31½	—	17½	26	5				

Only 8 inches in girth in 1892, this young poplar started with a rate of 31½ for four years. Pruning reduced it to 17½ for the next four years, but in the following two it improved to 26. The tree was then transplanted, and, although always looking well, the rate for the last five years has been only 5· ; for the first two of them it was almost nil, but in 1906 it had improved to 11½·

POPULUS FASTIGIATA. No. 76.

Girth, March, 1887=0.209 mil.

	Trd.	
	1887–1892	
Increase, ...	186	Died
Average, ...	31	

About the same size as No. 9, this poplar had the same good rate for six years, when it was transplanted and died.

POPULUS FASTIGIATA. No. 7 (formerly 23).

Girth, March, 1899=0.620 mil.

	Trd.			
	1899–1901	1902	1902–1905	1906
Increase, ..	93	9	55	16
Average, ..	31	..	13¾	..

Girthing 2 feet in 1899, and with a rate of 31 for the next three years, transplantation reduced the increase in 1902 to 9; and, although the tree looked perfectly healthy and vigorous for the four years to 1905, the rate was only 13¾. In 1906 it rose to 16, but even this seems quite low, as it would be difficult to find a better clothed or healthier-looking tree of the kind, and it is not yet old.

PRUNUS AVIUM. No. 18.

Girth, March, 1887=0.116 mil.

			Trd.			Trd.
	1887-1894	1894	1895	1896-1899	1900-1904	1905
Total, ...	158½	15¼	0	86½	159½	—
Average, ...	20	..	..	21½	32	—

Only 4½ inches in girth when first measured in 1887, this cherry stood in the south border of the Arboretum till 1894, with a rate of 20 mil. After transplantation in 1895 there was no increase for that year, but next year it at once regained the old rate and has improved since, so that in the period 1900–04 it had risen to 32 mil.—a remarkable record of rapid recovery. In 1905 the tree was again transplanted, but failed and was cut down.

PRUNUS AVIUM. No. 22.

Girth, March, 1887=0.165.97 mil.

			Trd.			
	1887-1891	1891	1892	1893	1893-1901	1902-1906
Total,.. ..	162½	34¼	3¾	20¼	270	56
Average, ..	32½	..	..	..	30	11¼

A companion of the last and slightly larger—6½ inches in girth —its rate before transplantation—32½—was considerably higher than that of No. 18. Like it, the recovery took place after a single year of great depression. The rate, however, for the next 9 years was rather lower—30· —than before transplantation, although the tree seemed healthy. In 1902 it looked sickly and continues to do so, the rate from then till 1906, or for five years, being also

reduced to $11\frac{1}{4}$. The removal of shrubs growing under and close to it, and the substitution of grass sods for the earth on which it stood, are the only ostensible causes, but seem insufficient to account for such serious results.

PYRUS AUCUPARIA. No. 79.

Girth, March, 1887=0.274 mil.

	Trd.						Trd.
	1887–1891	1891	1892–1893	1894	1894–1897	1898–1901	
Total, ..	$119\frac{1}{2}$	23	$3\frac{3}{4}$ $11\frac{1}{2}$	$20\frac{1}{4}$	85	54	Died
Average, ..	24	..	$7\frac{1}{2}$	..	$1\frac{1}{2}$	$13\frac{1}{2}$	

The rate—24 for the first five years—seems good for a tree $10\frac{3}{4}$ inches in girth. It fell to $7\frac{1}{2}$ for two years after transplantation, rose to $21\frac{1}{2}$ for the next four years, but fell off for some unknown reason to $13\frac{1}{2}$ from 1898 to 1901, when the tree was again transplanted ; but it never recovered, and died in 1894.

PYRUS AUCUPARIA. No. 77.

Girth, March, 1888=0.176 mil.

	Trd.						
	1888–1894	1895–1896	1897	1897–1903	1904	1905	1906
Total, ...	112	$1\frac{1}{4}$ 9	19	$110\frac{1}{2}$	$13\frac{1}{2}$	$5\frac{1}{2}$	6
Average, ..	16	5	..	$15\frac{1}{2}$		$8\frac{1}{4}$	

Only 7 inches in girth when first measured in 1888, this rowan had the low rate—compared with No. 79, a rather older tree—of 16 for seven years. Transplantion reduced it to almost nil in 1895, but in 1897 it reached its maximum—19—and for the period 1897–1903 the tree resumed almost exactly its rate, before removal, of $15\frac{1}{2}$. In 1904, however, it fell to $13\frac{1}{2}$, and in 1905–1906 to $5\frac{1}{2}$ and 6. The cause is not evident, unless it was disturbance of the ground, due to removal of trees and shrubs near it. The tree looks healthy, but has a rather small head of foliage.

QUERCUS PEDUNCULATA. No. 1.

Girth, March, 1888=0.140 mil.

	Trd.							Trd.
	1888–1889	1890	1890–1894	1895–1896	1897	1897–1901	1902–1904	1905–1906
Increase,	10¼ 10¼	16½	77½	2½ 3¾	15¼	100	50	8 7
Rate, ..	10¼	..	15½	3	..	20	16½	7½

The low rate of 10¼ for the first two years may have been due to transplantation, as next year it rose to 16½, continuing nearly at the same for five years. Transplantation then reduced it for two years to 3. Next year—1897—it jumped to 15¼, and an enhanced rate of 20 was maintained till 1901, when it fell to 16½ for three years, possibly due to the removal of neighbouring trees and shrubs, which may have interfered with its roots. It was then retransplanted, and the increase in 1905 and 1906 fell to 8 and 7; but the tree looks well.

QUERCUS PEDUNCULATA. No. 2.

Girth, March, 1888=0.203 mil.

	Trd.							
	188?–1889	1890	1890–1895	1896–1898	1899–1901	1903–1904	1905	1906
Increase, ..	5 7½	16½	106¾	1½ 2½ 3¾	42	12	13	15½
Rate, ...	6¼	..	18	2½	14	6	14¼	

This companion of the last, and a little larger at first, had a rather lower rate for the first two years, which probably succeeded transplantation, and a rather better rate than that of No. 1 for the next six years. It was transplanted a year later than the other, and took a year longer than it to recover. Even then the rate was low, and a depression to 6 for the two years 1903 and 1904 followed, which it is difficult to explain; a recovery to 13 in 1905 and 15½ in 1906 gives hope that the tree may yet do well.

QUERCUS RUBRA. No. 61.

Girth, March, 1887=0.131.76 mil.

Trd.					Trd.		
1886	1887–1889	1890	1890–1894	1895–1896	1897–1898	1899	1900–1906
—	2¼ 2¼ 7¼	22¾	150	30½	9 6¼	12¾	90
Rate,	4¼	..	30	15¼	7½	..	13

Only 5½ inches in girth when transplanted in the spring of 1887, this handsome young oak nearly perished from the operation. In 1887 the foliage was very scanty, and in 1888 it entirely disappeared in consequence of the death of the young twigs of the previous year. It is therefore remarkable that an increase in girth took place in both these years, though only of 2¼. In 1889 there was an unexpected, though but slight, improvement in the aspect of the tree, and in 1890 the recovery was suddenly completed. The girth-increase rose to 22¾, and the excellent rate of 30 was maintained for five years. Consequent on preparation for a second removal, the rate dropped for two years to 15¼. After transplantation it fell for two years to an average of 7½, and in 1899 recovered to 12¾, a rate which it has not improved upon since.

Well placed in prepared ground on the north side of the Arboretum, the tree, nevertheless, has not yet recovered the well-clothed aspect and rapid rate of girth-increase that characterised the period from 1890 to 1894.

QUERCUS ILEX. No. 16.

Girth, March, 1887=0.107.08 mil.

	Trd.					
	1887–1893	1894	1894–1898	1899	1899–1905	1906
Total, ...	113	3¾	35	11½	79	11½
Average, ...	16	..	7	..	11¼	..

This infant evergreen oak grew at the rate of 16 for seven years. Transplanted in 1894, the increase fell to 3¾ in that year and averaged 7 till 1898. A rise to 11½ in 1899 seemed to show

recovery from removal, but the rate till 1906 failed to improve upon these figures. Youth could not account for this low rate in the period 1899 to 1906, because the rate from 1887 to 1893 was considerably better, although in the infancy of the tree. Nevertheless, it is a healthy, vigorous looking, bushy tree and occupies a fine open situation in the Quercetum.

The largest evergreen oak in the Garden, much damaged by the great frost of 1878, was noted as being upwards of 6 feet in girth at that time, and perhaps has somewhat increased since, as in autumn 1906 it was 6 feet 7½ inches at 3 feet; 6 feet 11 inches at 3 feet 9 inches; and 6 feet 9 inches at 5 feet.

TILIA EUROPŒA. No. 69.

Girth, March, 1887=0.237 mil.

	1887–1891	1892–1896	1897–1898 Trd.	1899	1900–1901 Trd.	1902	1903–1906
Increase, ..	86½	105½	0 0	14	20¼ 22¾	0	3¾ 12 5½ 12
Average, ..	17½	21	0	14	21½	—	8¼

9½ inches in girth in 1887, this young lime increased at the rate of 17½ for the first five years and of 21 for the second. Transplanted in 1896, it had absolutely no increase for the next two years, and grew only 14 in the third year. In 1900 and 1901 it resumed the rate of the second quinquennium. Retransplanted in 1902, it had no increase for one year, and has had the low rate of 8¼ since. Yet it looks healthy and as if it would do well eventually.

TILIA EUROPŒA. No. 85.

Girth, March, 1887=0.233 mil.

	1887–1891	1892–1896	1897	1898 Trd.		1901 Trd.		1906
Increase, ..	66	87½	1¼	16½	0 9	17¾	0	2¼ 1 6 11
Average, ..	13¼	16½	..	..	4·5	..	..	7½

A companion of No. 69, and of the same size in 1887, this tree had the lower rates of $13\frac{1}{4}$ and $16\frac{1}{2}$ in the first and second quinquennia, as compared with $17\frac{1}{2}$ and 21. For some unrecorded or unknown reason the increase in 1897 fell to $1\frac{1}{4}$; but in 1898 it sprung up to $16\frac{1}{2}$, and the tree must have been considered to be in good condition, as it was transplanted. Two years followed, the first with no increase, the second with only 9; but next year it amounted to $17\frac{3}{4}$, when the tree was again transplanted, once more with the result of no increase in the first year, and the rate for the succeeding four years down to 1906 was only $7\frac{1}{2}$. The tree looks healthy enough.

ULMUS MONTANA. No. 94.

Girth, March, 1888=9.270.51 mil.

Trd.

	1888–1891	1892	1895	1895–1898	1899–1902	1903–1906
Total, ...	$144\frac{3}{4}$	$2\frac{1}{4}$ $7\frac{1}{2}$ $20\frac{1}{4}$	$39\frac{1}{2}$	$143\frac{1}{2}$	146	141
Average, ..	$36\frac{1}{4}$	10	..	36	$36\frac{1}{2}$	35

The wych elm is the most thriving and quickest growing tree in the town gardens of Edinburgh, and No. 94, with its former neighbour No. 93, are among the best of all the trees under my observation. They stood together in the original east belt of the Arboretum, which was done away with, No. 93 being almost the only tree that was not removed.

No. 94 is now a handsome spreading specimen in its new site in the main avenue of the Arboretum. Transplanted in 1892, its rate fell from an average of $36\frac{1}{4}$ to $2\frac{1}{2}$ in that year, and, improving in the next two years, had wholly recovered with an increase of $39\frac{1}{2}$ in 1895. Its rate for four periods between 1888 and 1905, excluding the three years when it was affected by removal, has been remarkably uniform, varying only from 35 to $36\frac{1}{2}$.

REMARKS.

Large Trees.—As far as can be judged from the small number of trees between 3 and nearly 5 feet in girth that were transplanted in 1896, the risk of death from the operation in trees of

that size is not excessive, as only one tree of the five perished. But if we take the hawthorn, No. 16, transplanted in 1899 and now standing without hope of recovery, the proportion of deaths is more serious.

In every instance recovery, both in appearance and in the rate of girth-increase, was slow. None of these trees could be regarded as healthy looking and handsome till from eight to ten years had elapsed; and one, although by no means in a desperate condition, has still very scanty and ill-developed foliage, while another has scarcely any at all. As regards girth-increase, none of the trees have regained the rate that might be expected from their size. In three it is still very deficient, and in two of these girth-increase has either scarcely or not at all begun.

Probably the risk of failure increases with the size of the tree; but, of course, the number experimented on is too small to warrant a conclusion on this point.

The final results, both in regard to appearance and girth-increase, in this group have still to be ascertained, and it will be very interesting to watch future developments.

Small Trees.—In all, 29 trees were transplanted, thirteen of them twice, making 42 actual cases.

In no less than 9, or 20 per cent., death resulted. Moreover, in ten others, eight of which were second transplantations, the recovery is not yet certain, although to all appearance the trees are healthy.

The period of depression after transplantation varied considerably.

It lasted one year in Nos. 7, 18, 22, 67, 69 (2nd time), 73 (2nd time), 74;
two years in Nos. 1, 9, 21, 23, 61 (2nd time), 69 (twice), 77, 79, 81 (2nd time), 85;
three years in Nos. 2, 8, 61, 80 (twice), 94;
four years in Nos. 16, 75.

The deficit in the girth-increase of trees that recovered fell to zero in 18, 69 (twice), 81, 85.

Average of 2 to 3 mil. in 1, 2, 8;
$3\frac{3}{4}$ to $4\frac{1}{2}$ mil. in 22, 80, 81, 85;
5 to $6\frac{1}{4}$ „ „ 21, 73, 75, 77;
7 to 10 „ „ 7, 16, 23, 61, 74, 79, 94.

A general view of the results is given in Table A. The first column shows the average increase before transplantation, based

on the results of from 4 to 11 years; the second column gives the number of years of depression following transplantation; the third shows the annual average amount of the depression; and the fourth the average rate of increase after recovery.

TABLE A.—GENERAL VIEW OF THE RESULTS OF TRANSPLANTATION ON GIRTH-INCREASE.

No.		Original Average.	Depression. Years.	Depression. Millimetres.	Final Average.	No.		Original Average.	Depression. Years.	Depression. Millimetres.	Final Average.
73	Æsculus Hippocastanum,	20½	1	6½	29½	80	Æsculus Hippocastanum,	30½	3	4½	20
75	Fraxinus excelsior ..	14½	4	8½	21½	61	Quercus rubra, ..	22½	2	7½	12¾
18	Prunus Padus, ..	20	1	0	27	9	Populus fastigiata, ..	26	5	5	?
21	Cytisus Laburnum,..	21½	2	5½	25	86	Carpinus Betulus, ..	17	10	5½	?
81	Carpinus Betulus, ..	18	2	4½	20	54	Quercus conferta., ..	13	1	1¼	?
85	Tilia europœa, ..	16½	2	4½	17¾	98	Fagus sylvatica, ..	32¾	?	?	Died.
94	Ulmus montana, ..	36½	3	10	36	97	,, ,, ..	30½	?	?	,,
77	Pyrus Aucuparia, ..	16	2	5	15½	71	Acer Pseudoplatanus,	30½	1	0	,,
22	Prunus avium, ..	32½	1	3¾	30	76	Populus fastigiata, ..	31	1	0	,,
69	Tilia europœa, ..	21	2	0	19	78	Betula alba, ...	29	3	6½	,,
69	,, ,, 2nd time,	21	1	0	?	23	Fraxinus excelsior,..	31	4	5½	,,
78	Pyrus Aucuparia, ..	24	2	7½	21½	87	Populus fastigiata, ..	22½	1	0	,,
74	Acer Pseudoplatanus,	37½	4	7	30	88	Alnus glutinosa, ..	19	3	2½	,,
85	Tilia europœa, 2nd time,	17¾	4	5	11	6	Ulmus campestris, ..	10½	2	?	,,

It will be seen that the original average was exceeded by the final average in 6 cases; that these two averages were nearly equal in 5; and that the final fell decidedly below the original in 4.

In general, the appearance of a tree is an index to the degree of its recovery of girth-increase, but not invariably. The American oak, No. 61, is a remarkable exception. The year after transplantation the foliage was very scanty, and next year, in consequence of the death of the young twigs, there was no foliage, but in the following year there was a slight improvement, and in the next the recovery both of foliage and girth-increase was complete.

II.—EFFECTS OF PRUNING.

Nearly all the observations on the effects of pruning were made upon trees in the shelter borders of the Arboretum. As explained in the Introduction, these trees had been on my lists for some years before being pruned, so that their previous rate of increase had been ascertained. In the autumn of 1895 all the trees in these borders were pruned, root and branch, in preparation for transplantation ; but, as it happened, only a few of the twenty on my list were transplanted, and thus an opportunity was afforded of studying the results of pruning in a considerable number of trees not afterwards disturbed, as well as in a few complicated by transplantation. By some mistake two or three of the trees were much over-pruned,* so that the prospects of recovery under such circumstances could also be ascertained.

ACER PSEUDOPLATANUS. No. 16.

In the north border of the Arboretum from the beginning till now. In 1892 it girthed 11½ inches, and in that and the two following years increased at the rate of 31 mil., but in 1895 the increase unaccountably fell to 11½. The amounts fell still further, after pruning, to 3¾ and 1¼, and the average for six years—1896–1901—was only 3¾ ; but in 1902 there was a revival to 16½, and the rate from 1903 to 1906 was 22, which is low for a tree of its species and age. In appearance the tree was always healthy.

ACER CAMPESTRE. No. 12.

Also in the north border from the first. Its girth in 1892 was 13½ inches, and from 1892 to 1894 the average rate of increase was 32½ mil. ; but in spring 1895 it was noticed that the top branches were dead, and the increase in that year fell to 8¼. After pruning next year the increase unexpectedly rose to 25½, and the rate till

*This over-pruning, which I regret to say affected more trees than the two or three mentioned by Dr. Christison, amounted in some cases to mutilation from which recovery was hopeless. The pruning which was necessary in order to obtain shapely trees was entrusted to a forester on the staff whose zeal far outran the discretion which his training had taught him, with most unfortunate consequences to many of the trees with which he dealt at the outset of his operations and until the over-pruning was observed.—Is.B.B.

1899 was 22½. The subsequent very low rate for seven years to 1906 of 8½ is unaccountable, as the tree seems well-clothed and healthy.

ÆSCULUS HIPPOCASTANUM. No. 4.

Always in the west border. Girthed 12¾ inches in 1892 and for four years had a rate of 31 mil. In 1896, after pruning, the increase fell to 19½; and the average, by a steady decline for three years, to 13; and for the next four, to 10. The results for the remaining four years to 1906 were even worse, the figures being 5, 3, 3½, 0. There is nothing in the appearance of the tree to account for this remarkable history, and the removal of surround-trees and bushes seems too slight a reason for so great a decline in the increase.

ALNUS GLUTINOSA. No. 7.

On its original site in the west border. Girthed 8½ inches in 1892 and increased for four years at the rate of 19½ mil. In 1896, after pruning, the increase fell to 7¾ and the average for four years to 4½. In the next five it improved to 9, but in 1905 the increase was only 3½, and in 1906 2½; yet the tree does not seem unhealthy.

BETULA ALBA. No. 17.

Always near the north-east corner of the Arboretum shelter belt. Girthed 13½ inches in 1892 and had the high rate of 41 mil. for four years. After pruning in 1896 the increase was only 12¾, and the rate for four years to 1899 was only 10½. In 1900 it jumped up to 28, but the rate fell again for six years till 1896 to 22, not much above half of that before the pruning.

CRATÆGUS OXYACANTHA. No 11.

In its original site at the north-west corner of the Arboretum shelter belt. Girthed 10 inches in 1892. Dividing the years of observation into three periods of four years each and one of three years, the first gives a rate of 25½ before pruning; the second, 6½ after it; the third, a recovery to 17½; and the last to 24, or nearly the rate before the tree was pruned.

CYTISUS LABURNUM. No. 1.

On its original site in the west border. Girthed 8½ inches in 1892 and increased at the rate of 16½ till pruned in 1896, in which year the increase fell to 7½, and for the eleven years till 1896 the rate has been no more than 8¾, varying between 6½ and 17¾, and showing no sign of improvement latterly.

FAGUS SYLVATICA. No. 20.

Always in the north border till transplanted in 1905 to form part of a new row of beeches near the west border. Girthed 13½ inches in 1892 and increased for three years at the rate of 36½ mil. Pruned in 1896, the increase for that year was 15, and the average for three years 14. In 1899 it revived to 20½, and that rather low rate for a beech of its age was not improved on for five years, when the tree was transplanted.

FRAXINUS EXCELSIOR. No. 2.

In its original position in the west border. Girthed 12 inches in 1892, and the rate for four years to 1896 was 30¾ mil. Pruned in that year, the increase fell to 16½, and the rate till 1896 was only 13½. Neither has there been much improvement since, as for the seven years 1899–1905 the rate was 17, and the increase for 1906 was no more than 14.

POPULUS FASTIGIATA. No. 9.

Stood in the west shelter belt and girthed 8½ inches in 1892, and for four years increased at the rate of 31½ mil. Pruned in the spring of 1896, the rate fell in the following four years to 17¾, but recovered in the next two to 26, when the tree was transplanted to the poplar group.

PRUNUS PADUS. No. 5.

Always close to the Lodge, Arboretum Gate. Girthed 12½ inches in 1892, and in that year had the extraordinary increase of 2 inches—said to be, perhaps, due to its site being on a former midden. The rate continued as high as 45½ mil. till 1896, when, after pruning, the increase fell to 27½ in that year and the rate to 25 for six years. There has been a further decline to 19 in

the last four years, although the tree retains its very healthy, vigorous, spreading appearance.

PYRUS COMMUNIS. No. 8.

Still stands in its original position in the west shelter belt. Girthing 11 inches in 1892, its average rate of increase was $20\frac{1}{4}$ for four years. It was then, by some mistake, pruned to such excess that a perpendicular section of the foliage would have resembled a sharp-pointed spear.

The result on the girth-increase was, of course, disastrous, as shown in the Table, although it is remarkable that there should have been any increase at all at first, with the foliage reduced almost to nil. The decline, however, was steady till zero was recorded in 1899 and $1\frac{1}{4}$ in 1900. Thinking that the tree was dead or dying, I gave up measuring it; but in 1903 it was beginning to form a head of foliage, and a remeasurement in autumn showed an average increase of $3\frac{3}{4}$ for the three years 1901–3, and this has been slightly improved upon since.

Average of Four Years.	1896-1900	Average of Three Years, 1901–1903.	1904–1906
21	$6\frac{1}{4}$ $2\frac{1}{2}$ $1\frac{1}{2}$ 0 $-1\frac{1}{4}$	$3\frac{3}{4}$	4 4·5 5

The tree has now assumed a columnar form, the foliage being nearly equally wide below and above. The stem is 9 feet long and the height of the tree 22 feet, the foliage-spread, or diameter, being only 6 feet. The young branches all tend to grow upwards, resembling a Lombardy poplar. As the foliage is dense and healthy, it will be interesting to see if it will now spread out, and if a tree, which had been so near dying, can eventually thrive. It is well placed, with room to spread, and in autumn 1906 was surface-manured with withered leaves and grass.

QUERCUS CERRIS. No. 15.

Situated always in the north border. Girthed almost 6 inches in 1892, and for four years had the rate of 17 mil. After pruning, it dropped for three years to $14\frac{1}{2}$, but rose for the next five to $19\frac{1}{2}$, and for the final three years to 1906 it has been 18.

QUERCUS CONFERTA. No. 40.

Situated to the east of the Rockery in the Botanic Garden. Girthed 23½ inches in 1878, and for six years increased at the rate of 44 mil. In two quinquennial periods—from 1884 to 1893—it was 39 and 37. After pruning in 1894 the increase in that year fell to 22, and the quinquennial rate to 1898 was 17, and to 1903, 14; while it fell off still further—to 11½—for the period 1904–1906. This progressive falling off through the whole period of 29 years was, probably, mainly the natural result of increasing age, but accelerated by the pruning in 1894.

QUERCUS CONFERTA. No. 54.

Girthed 16½ inches in 1880. Unlike No. 40, the progress in this younger oak was upwards at first in three periods of from four to six years, the rates being 41, 43, and 47 mil. Pruning in 1894 reduced the amount in that year to 27, and the rate for eight years was only 18. An alarming and unaccountable progressive decline to 7½, 6½, and 4 followed in 1903–4–5, when the tree was transplanted.

QUERCUS CONFERTA. No. 55.

Girthed 13½ inches in 1880, and the rates for the three periods corresponding to those of No. 54 were 40, 38, and 43 mil. After pruning in 1894 the increase fell to 19, and the rate for five years to 16½. In one of these—1897—the increase was only 1¼; in the next three years—1899–1901—the rate revived to 24; but relapsed again to 14 for four years to 1905. The increase of 27 in 1906, however, is encouraging. Like Nos. 40 and 54, this tree has always looked well, but in none of them has the pruning produced a vigorous upward growth as yet.

QUERCUS PEDUNCULATA. No. 2.

Situated near the ruined walnut, Arboretum entrance. Girthed 8 inches in 1888, and for three years its rate of increases was 9 mil. Infancy seemed then to be passed, as the rate for the next three years was 22, but it fell back to 12 in 1894–95. The tree was then pruned and the increases for the next three years were only 1¼, 2½, and 3¾. A revival to 12¾ took place in the following

year—1899—and this rate was maintained for three years ; but a depression followed in 1902 and 1903 to 5 and 2½, which I can only account for by disturbance from the removal of neighbouring trees and shrubs. Since then—from 1904 to 1906—there has been a progressive improvement to 9½, 13, and 15½.

QUERCUS PEDUNCULATA. No. 10.

Always in the west border. Girthed 11½ inches in 1893. For two years the rate was 17¾ mil., but in the next—1895—the increase was only 9. After pruning in 1896 it fell to 5, and the rate for eight years was only 6½. Finally, in the three years 1904–5–6, it has only improved to 10.

QUERCUS ILEX. No. 16.

In the Quercetum. Girthed 4 inches in 1887 and increased at the rate of 16 mil. for seven years. Pruning in 1894 brought down the increase of that year to 4, and the rate for five years to 1898 was 7½ ; in the next five it revived to 11, and in the final three—to 1906—to 18.

ROBINIA PSEUDACACIA. No. 14.

Always in the north border. Girthed 6½ inches in 1892 and increased at the rate of 22¾ mil. for four years. It was only slightly pruned in 1896, and the general rate, which at that age would naturally be upwards, seemed but little affected, as for the next five years it was 26¼ ; as, however, the amount of increase in 1895—the year before pruning—was 35¼, and in 1896—after the pruning—only 26¼, the difference, 9 mil., may represent the effect of the operation.

TILIA EUROPŒA. No. 3.

Always in the west border, near the Arboretum Lodge. Girthed 14 inches in 1892 and had the satisfactory rate of 31½ mil. for five years. After pruning, the rate fell for three years to 12 ; rallied for 2 to 18 ; fell for 2 to 11½ ; and for the final three—to 1906—the increases were very irregular—23, 6½, and 12.

TILIA EUROPŒA. No. 85.

In the south border. Girthed 9 inches in 1887, and for the two quinquennia before pruning the rate of increase was only $13\frac{1}{4}$ and $16\frac{1}{2}$. In 1897, the second year after the pruning, the increase was only $1\frac{1}{4}$; but next year it recovered to $16\frac{1}{2}$. The tree was then transplanted in March, 1899, and, after recovery, was retransplanted in spring, 1902. The rate continues very low, but the tree is healthy and well clothed.

ULMUS CAMPESTRIS. No. 6.

In the west border. Girthed $9\frac{1}{2}$ inches in 1892 and had a rate of $15\frac{1}{4}$ increase for four years. After pruning, the rate for three years was only 7. Transplanted in 1899, the tree died and was cut down in 1900.

ULMUS MONTANA. No. 21.

In the north border. Was a fine, handsome tree, 24 inches in girth, when far too severely pruned in 1896. The increases for the four years—1896–99—were only 6, $2\frac{1}{2}$, 4, $1\frac{1}{4}$, and the average for the next five years was 4. The severe pruning left the tree at first almost without a head of foliage, but it gradually began to form, and the increases for the two years 1905–06 have improved to 8 and $14\frac{1}{2}$.

In appearance the tree suffers from the loss of its top-shoot branch, which had to be cut away low down. Thus the foliage at the top is flat, and its general form is cylindrical, equally wide below and above, the diameter of the foliage being 15 feet. The tree is about 20 feet high and the cylindrical mass of foliage begins at 5 feet, where the first branch is given off.

REMARKS.

The chief events in the history of the twenty-three trees subjected to pruning are put together in Table B. The results are historical in regard to the trees individually, rather than comparative between one tree and another, because the degree of pruning to which they were subjected varied much, and cannot be systematised.

The facts are given in the Table in the following order :—

1. The average rate of increase before pruning.
2. The average rate for the whole period after it.
3. The highest record in any one year.
4. The lowest record in any one year.
5. The average rate for the last two or three years.
6. The lapse of years between the pruning and the final results.

TABLE B.—EFFECTS OF PRUNING ON THE RATE OF GIRTH-INCREASE, IN THE ORDER OF THE LEAST EFFECT.

No.		Rates.		Highest in any year.	Lowest in any year.	Average of 2 or 3 last years.	Lapse of years.
		Before Pruning.	Whole period after it.				
14	Robinia Pseudacacia, ..	22¾	23¾	29¼	20½	23½	11
16	Quercus Ilex, ...	16	12¼	21½	9	20	13
15	,, Cerris, ...	17	17¾	21½	12¾	18	11
85	Tilia europœa, ...	16½	11¾	16½	1¼	16½*	3
11	Cratœgus Oxyacantha, ..	25½	15½	26	5	25¾	11
9	Populus fastigiata, ..	31	20½	26½	15¼	26¾	7
55	Quercus conferta, ..	43	17	28	1½	27	11
16	Acer Pseudoplatanus, ..	31	10½	27½	1¼	19	11
20	Fagus sylvatica, ...	36	19	25½	12¾	19¾	10
17	Betula alba, ...	41	17¾	29½	6¼	19¼	11
10	Quercus pedunculata, ..	17¾	7	10½	5	9	11
1	Cytisus Laburnum, ..	16½	10½	27	6½	7¼	11
6	Ulmus campestris, ..	15½	7	10	5	6	3
2	Fraxinus excelsior, ..	30¾	16¾	20½	11½	11	11
8	Pyrus communis, ...	20½	3½	10	0	7½	11
5	Prunus Padus, ...	50¾	22½	28	15	16	11
21	Ulmus montana, ...	35	5	14½	1½	11½	11
3	Tilia europœa, ...	31	14	23	6½	9	11
40	Quercus conferta, ...	39	12	20¼	2¾	11	11
12	Acer campestre, ...	32½	15½	25½	1¼	11½	11
54	Quercus conferta, ..	47	12½	20½	0	7	9
7	Alnus glutinosa, ...	19½	6	10	2½	3	11
4	Æsculus Hippocastanum,	31	8	19	0	2	11

* Last year only.

Taking the rate for the last two or three years as the criterion of recovery, the most obvious fact is that only five of the trees have recovered their original rate before pruning, and only one of them, the evergreen oak, has exceeded it by an appreciable amount. Six have recovered about half their original rate; four rather above a third of it; four rather under a third; while in two the recovery is only to about a sixth, and in one to a sixteenth.

The question what practical lessons, if any, can be deduced from the tabulated results is not easy to determine. Do they show that the trees generally were over-pruned? At first sight it would seem so, from the great diminution in the girth-increase of the stems; but if the object desired—the promotion of growth upwards—was obtained, this sacrifice of girth increase may have been natural and proper. To me, however, it seems that this object was not fully obtained, because, in most instances, the stems above the bole appear to taper too suddenly upwards. But I have no experience to guide me in forming a definite opinion.

One conclusion is clear, that the pruning carried out in 1896 has been followed, in the majority of instances, by a serious falling-off in the girth-increase in the stems for at least eleven years. It has also been proved that a tree so over-pruned as to have its head of foliage reduced to a "spear-point," and its girth-increase reduced for several years almost to nil, may gradually recover and give promise of becoming eventually a handsome specimen.