6-1895

# Forestry

J.M. Trueman
*South Dakota Agricultural College*

# SOUTH DAKOTA

# AGRICULTURAL COLLEGE

AND

# Experiment Station,

BROOKINGS, S. D.

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DEPARTMENT OF HORTICULTURE AND FORESTRY.

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# FORESTRY.

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# FORESTRY.

L. C. CORBETT.

Since publishing Forestry Bulletin No. 32 a very severe test of the hardiness of the several species in the forest plat at this station has been passed through. 1893 was perhaps an average season with something less than the usual amount of rainfall, but the season of 1894 was almost unprecedented for the extreme duration of the dry period. It began early and continued until after the plants had completed their season's growth. For some species under such trying conditions the provisions for winter appear to have been insufficient, as is evidenced by the great falling off in number in some of the plats noted further on in this bulletin. Severe drouth, however, was not the only cause of the loss of vitality. On May 19, 1894 and again on May 10, 1895, this section was visited by severe frosts which destroyed tender plants and nearly all the fruit. Some of the forest trees are susceptible to injury from late frosts, the tender varieties were set back both seasons and as a result made a low average growth. Certain varieties had made more growth previous to the frost of May 19th than was made during the remainder of the season. It, therefore, stands us in hand to select both for grove and street planting those varieties which show the greatest immunity to late spring frosts.

After a careful study of the trees represented in the plantations upon the College grounds the following list of species, arranged in the order of their power to withstand spring frosts, seems to be justified:—1, white birch; 2, wild black cherry; 3, cottonwood; 4, quaking aspen; 5, Scotch pine; 6, red cedar; 7, laural-leaved willow; 8; red willow; 9, Russian olive (*Elæagnus hortensis*); 10, choke cherry; 11, buffalo berry; 12, white elm; 13, box elder; 14, *Populus (certinensis) laurifolia*, 15, silver maple; 16, white spruce (native); 17, green ash; 18, burr oak; 19, black walnut; 20, European larch.

There was more actual loss in the larch than in any other species in the forest plats. The other trees sustained temporary injury, only a small percentage being actually killed; while the loss in the larch was heavy as is shown in the falling off in the number recorded for 1891 and 1894 in Plat 3. Heavy loss of box elder in Plat 4; also of *Populus laurifolia* in Plats 7, 8, 9, 10, will be noted in the record for 1894 and '95, but this is believed to be due to other causes than late frosts.

The time at which the buds start in the spring is not an index of the hardiness of the tree, although in sections subject to spring frost, species that start late are to be preferred. The family to which a tree belongs is not an infallible guide although it is perhaps the best index we have, e. g. the mere fact of its being an ash does not determine the hardiness as it may be a green ash, or a white ash; this together with the surroundings or conditions under which the tree is growing, its age and the length of time it has been standing in a given position are all potent factors to be taken into consideration in determining its immunity to frost.*

*The influence of cold upon plants—*a resume*. C. Abbe.—Experiment Station Record, Vol. VI, pps. 777-781.

## HARDINESS OR ADAPTABILITY.

The hardiness of a species is the measure of its ability to withstand adverse conditions of soil and climate. In this particular, trees exhibit quite as varied characteristics as do herbaceous plants, and since propagation by selection is a much longer and more laborious operation with these plants than with the herbaceous annuals and perennials; man's intluence iu this direction is less felt. But in our native forest trees we have the results of generations of natural selection and we, as planters, have only to interpret and make use of the work that has there been done for us.

The species made use of in nature are not always those best suited to the *economic* wants of man, hence species foreign to the locality but possessing useful qualities, must be imported and their adaptability determined.

This work should not be confined solely to the introduced species, for experiment has determined that even the natives, when transplanted from soil of one character to that of another change their habit of growth materially or their longevity may be very considerably reduced as is the case with the cottouwood when transferred from the river-bottoms to high prairie.

When the country was settling rapidly under the stimulus of the "wheat craze" this fact, if known, was entirely ignored and as a result cottonwood groves that today should be an incentive to tree planting are discouraging because of the number of dead or dying trees.*

The loss in the cottonwood is due to its inability to withstand close planting upon high prairie. In this case as with the box elder, the drawback does not manifest itself until the trees have reached considerable size. It

*See note in Garden and Forest, May, 1895, page 173.

most frequently happens that trees planted closely, 4x4 ft., show indications of failure soon after the crowns have become sufficiently developed to cause the suppression of the lower branches, In very uniform and apparently thrifty groves when the trees reach the first stages of true forest condition; i. e. when one begins to interfere with those about it, it is not unusual for the whole grove to die or be killed back so that all new growth starts from near the ground. This stage is sooner reached by many of the poplars than by the box elder. It is believed that wider planting or pruning followed by early thinning will overcome this evil with the box elder and perhaps to a lesser extent, with the cottonwood. So far no other species have manifested like peculiarities, but there are upon our plantations none of the more desirable species such as elm, ash, cherry, walnut, etc., which are old enough to demand more room; and in other groves throughout the country no such bad effects have been noted. But in any case it is believed to be best for the trees, to remove branches as soon as their ability to elaborate plant food is lost. In other words, it is better to prune than to leave the work to nature. From those who have good success and long experience in growing trees upon the prairie we hear "box elders cannot be successfully grown here unless they are pruned."

The average rate of growth of various species during seasons of unusual drouth is of value in showing the ability of the species to withstand drouth and to adapt itself to a naturally dry country.

# TABLE I.

## METEOROLOGICAL RECORD.

| MONTH. | Rainfall. | | | Temperature. Degrees | | | Wind | |
|---|---|---|---|---|---|---|---|---|
| | No. Days | Greatest in one day | Total | Highest | Lowest | Mean | Northerly | Southerly |
| **1889.** | | | | | | | | |
| January | ..... | ..... | .3 | 41. | -24. | 15. | ..... | ..... |
| February | ..... | ..... | .5 | 43. | 30. | 19 6 | 11 | ..... |
| March | ..... | ..... | .16 | 55. | 4. | 32. | 17 | 6 |
| April | 11 | .27 | 1.025 | 83. | 12. | 51.30 | 10 | 15 |
| May | 9 | .62 | 1.93 | 91. | 20. | 56.7 | 15 | 8 |
| June | 11 | .54 | 1 486 | 83.6 | 36.1 | 64.2 | 15 | 14 |
| July | 9 | .89 | 2.918 | 98. | 40. | 68.8 | 11 | 16 |
| August | 3 | .53 | .72 | 97. | 41.8 | 69.5 | 6 | 15 |
| September | 4 | 2.22 | 2.70 | 89. | 30. | 55.1 | 9 | 10 |
| October | 1 | .005 | .005 | 76.4 | 23.8 | 43.7 | 18 | 10 |
| November | ..... | ..... | ..... | 28. | -6. | 22.87 | 15 | 11 |
| December | 5 | .475 | .975 | 52. | -11. | 26.78 | 13 | 18 |
| **1890.** | | | | | | | | |
| January | 5 | *2. | *6.5 | 43.9 | -28 | 7.56 | 15 | 16 |
| February | 1 | *2. | *2. | 47. | -35 | 14.32 | 15 | 13 |
| March | 3 | .31 | .56 | 32.25 | -4. | 19.69 | 13 | 14 |
| April | 4 | .51 | .787 | 84. | 10. | 46.71 | 10 | 12 |
| May | 17 | .80 | 3.33 | 90. | 23. | 32.197 | 20 | 9 |
| June | 14 | 2. | 7.91 | 90.5 | 39. | 67.75 | 6 | 22 |
| July | 5 | .54 | 1.535 | 94.5 | 41. | 71.06 | 10 | 19 |
| August | 5 | .88 | 2.07 | 99. | 35. | 63.8 | 14 | 16 |
| September | 5 | .19 | .45 | 91. | 25. | 57.5 | 11 | 14 |
| October | 7 | .12 | .32 | 74.5 | 21. | 38.8 | 6 | 11 |
| November | 1 | ..... | .03 | 68. | 0. | 29.41 | 22 | 12 |
| December | ..... | ..... | ..... | 58. | -18. | 21.2 | 8 | 19 |
| **1891.** | | | | | | | | |
| January | ..... | ..... | ..... | 52. | -10. | † | 14 | 16 |
| February | *3 | *4. | *10. | 48. | -28. | 6.95 | 11 | 17 |
| March | *2 | *4. | 6. | 50. | -24. | 17.94 | 13 | 15 |
| April | 9 | .98 | 2.23 | 88. | 11. | 43.9 | 18 | 9 |
| May | 5 | .38 | .84 | 92.5 | 30. | 55.54 | 17 | 12 |
| June | 11 | 1.34 | 4.09 | 89. | 40. | 62.5 | 15 | 14 |
| July | 7 | .7 | 2.01 | 80. | 60. | 69.5 | 13 | 16 |
| August—Frost on 23d | 7 | .44 | 1.38 | 90.5 | 30.5 | 66.3 | 15 | 14 |
| September | 5 | .27 | .48 | 88. | 28.5 | 65.1 | 24 | 6 |
| October | 2 | .62 | 1.07 | 80. | 19.5 | 45.4 | 15 | 11 |
| November | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| December | ..... | ..... | ..... | ..... | ..... | ..... | 1 | 2 |
| **1892.** | | | | | | | | |
| January | 6 | .20 | .35 | 49. | -34. | 8.33 | 11 | 7 |
| February | 5 | .20 | .36 | 48. | -19. | 18.78 | 14 | 9 |
| March | 3 | .26 | .84 | 65. | -7. | 27.10 | 15 | 14 |
| April | 10 | 1.12 | 3 15 | 65. | 15. | 39. | 19 | 10 |
| May | 14 | 3.63 | 7.32 | 75. | 28. | 47. | 24 | 7 |
| June | 9 | 1.09 | 3.82 | 85. | 38.5 | 62.8 | 16 | 14 |
| July | 7 | 1.43 | 3.69 | 97. | 45. | 69.2 | 12 | 19 |
| August | 11 | 1 19 | 3.03 | 94.5 | 36. | 67.2 | 11 | 20 |
| September | 3 | .89 | 1.49 | 97. | 30. | 60.7 | 15 | 15 |
| October | 8 | .26 | .53 | 92. | .09 | 49.2 | 15 | 13 |
| November | 4 | *.16 | 0.22 | 67. | -11. | 49.9 | 18 | 7 |
| December | 4 | *.15 | 0.32 | 48. | -19. | 33.0 | 15 | 8 |

TABLE I.—*Continued.*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1893. | | | | | | | | |
| January | † | † | *0.45 | 40 | -19 | 12.47 | † | † |
| February | 6 | .63 | *0.80 | 50 | -29 | 16.22 | † | † |
| March | 4 | .60 | *0.90 | 60 | -8 | 27.61 | ..... | ..... |
| April | † | † | † | † | † | † | † | † |
| May | 10 | 1.25 | 2.85 | 81.5 | 17 | 58. | ..... | ..... |
| June | 7 | .43 | 1.54 | 93 | 41 | 69.17 | ..... | ..... |
| July | 4 | .47 | 0.68 | 98 | 57.5 | 72.74 | ..... | ..... |
| August | 7 | .49 | 1.70 | 96 | 40.5 | 68.75 | ..... | ..... |
| September | 3 | .34 | 0.56 | 95.5 | 18.5 | 61.48 | ..... | ..... |
| October | 6 | .22 | 0.44 | 59.7 | 22 | 44.2 | ..... | ..... |
| November | 6 | .043 | 0.043 | 73 | 15 | 29.8 | ..... | ..... |
| December | 7 | .20 | 0.269 | 47 | -21 | 12.97 | ..... | ..... |
| 1894. | | | | | | | | |
| January | 4 | .056 | *.111 | 49 | +33 | 6.75 | ..... | ..... |
| February | 1 | .05 | .05 | 47 | -18 | 13.7 | ..... | ..... |
| March | 6 | .56 | 1.23 | 75 | -4. | 32.19 | ..... | ..... |
| April | 6 | 1.60 | 3.03 | 82 | 21 | 46.27 | ..... | ..... |
| May | 2 | .25 | 0.31 | 83 | 42 | 69.7 | ..... | ..... |
| June | 6 | .68 | 1.30 | 97 | 49 | 70.47 | ..... | ..... |
| July | 1 | .09 | 0.09 | 104 | 39 | 76.45 | ..... | ..... |
| August | 2 | .72 | 0.73 | 97 | 30 | 72.11 | ..... | ..... |
| September | 4 | 1.31 | 1.68 | 94 | 18 | 61.4 | ..... | ..... |
| October | 7 | .91 | 2.37 | 86 | 16 | 45.57 | ..... | ..... |
| November | 3 | .15 | 0.19 | 57 | -5 | 26 8 | ..... | ..... |
| December | 3 | .09 | *0.14 | 53 | -18 | 24.64 | ..... | ..... |

*Snow. †Observations not completed.

The total rainfall during the growing season:

April to November inclusive, 1889, 10.78 inches

" " " " 1890, 16.40 "

" " " " 1891, 12.10 "

" " " " 1892, 25.12 "

" " " " 1893. 7.87* "

" " " " 1894, 9.69 "

Table I gives the monthly rainfall during the period since the forest plats were first established. In a few instances the table is incomplete but a sufficiently definite idea can be had for comparison with Table II, which gives the maximum, minimum and average growth of the several species during the time they have been growing upon the station grounds.

*Record for April lacking.

# TABLE II.

## GROWTH OF THE SEVERAL SPECIES COMPARED.

| | VARIETIES. | TOTAL GROWTH IN INCHES. | | | | | | | | | | | | | | | | | | Avg. for Period |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1889 | | | 1890 | | | 1891 | | | 1892 | | | 1893 | | | 1894 | | | |
| | | Max. | Min. | Avg. | Max. | Min. | Avg. | Max. | Min. | Avg. | Max. | Min. | Avg. | Max. | Min. | Avg. | Max. | Min. | Avg. | |
| 1. | *Populus pyramidalis* | 23 | 10 | 16 | 40 | 18 | 36 | 43 | 16 | 35 | .... | .... | .... | .... | .... | .... | .... | .... | .... | 29 |
| 2. | *Populus nolester* | 80 | 5 | 18½ | 38 | 18 | 35 | 46 | 20 | 37½ | .... | .... | .... | .... | .... | .... | .... | .... | .... | 24⅝ |
| 3. | *Cottonwood (*Populus moniliferae*) | 25 | 4½ | 15½ | 66 | 16 | 40¼ | 40 | 19 | 29½ | 49 | 33 | 40 | 20 | 6 | 14 | 30 | 11 | 17½ | 26⅛ |
| 4. | *Populus (certinensis) Laurifolia* | 39 | 9 | 25½ | 40 | 14 | 37 | 31 | 10 | 24¼ | 46 | 23 | 35 | .... | .... | .... | 17 | 5 | 11¼ | 26½ |
| 5. | White Elm (*Ulmus Americana*) | 24 | 3 | 9½ | 42 | 10 | 22⅜ | 46 | 15 | 32 | 62 | 19 | 30 | 40 | 26 | 31½ | 24½ | 13 | 19½ | 24⅛ |
| 6. | Soft Maple (*acer dasycarpum*) | 12½ | 4 | 8⅜ | 35 | 16 | 22⅛ | 45 | 20 | 34¼ | 40 | 20 | 33 | 29 | 7½ | 21½ | 20 | 8 | 13 | 22⅛ |
| 7. | *Box Elder (*Negundo aceroides*) | 32 | 3½ | 10¾ | 38 | 10 | 28⅜ | 39 | 22 | 32 | 31 | 13 | 21 | 35 | 16 | 23 | 24 | 14 | 18¾ | 23 |
| 8. | †" " " " | 34 | 5½ | 18 | 45 | 20 | 37½ | 51 | 24 | 38½ | 62 | 45 | 30 | 28 | 16 | 22 | 25 | 10 | 16⅛ | 27 |
| 9. | Green Ash (*Fraxinus viridis*) | 14 | 3 | 9¼ | 34 | 8 | 22¾ | 31 | 6 | 19 | 48 | 16 | 26 | 17 | 4 | 9 | 16 | 7 | 12 | 16⅛ |
| 10. | Burr Oak (*Quercus macrocarpa*) | 5 | 1 | 1⅞ | 9 | 2 | 5½ | 13 | 7 | 10 | 22 | 4 | 8 | 18 | 6½ | 12 | 23½ | 5 | 12 | 8⅛ |
| 11. | White Birch (*Betula alba*) | 7¾ | 2½ | 5¼ | 20 | 12 | 16 | 40 | 10 | 23 | 48 | 17 | 30 | 28 | 2 | 8 | 13 | 4 | 8½ | 15⅝ |
| 12. | Yellow Birch (*Betula lutea*) | 10 | 3 | 6 | 30 | 7 | 20¾ | 36 | 9 | 21 | 60 | 22 | 39 | .... | .... | .... | .... | .... | .... | 14½ |
| 13. | Black Walnut (*Juglans nigra*) | 7½ | 1½ | 1¼ | 9 | 3 | 6 | 20 | 6 | 18 | 40 | 3 | 11 | 39 | 9 | 29 | 33 | 10½ | 14 | 13⅜ |
| 14. | Butternut (*Juglans cinerea*) | 9¾ | 1¼ | 6¼ | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 6¼ |
| 15. | Black Wild Cherry (*Prunus serotina*) | 12 | 4 | 8 | 26 | 6 | 16 | 32 | 20 | 28⅜ | 40 | 23 | 30 | 32 | 10 | 22¼ | 18 | 4 | 11 | 19⅜ |
| 16. | Scotch Pine (*Pinus sylvestris*) | 7¾ | 2¼ | 4¾ | 9 | 2 | 5 | 16 | 2 | 4 | 25 | 6 | 14 | 27½ | 8 | 19 | 24 | 9 | 16½ | 10¾ |
| 17. | White Pine (*Pinus strobus*) | 7½ | ½ | 4½ | 8 | 1 | 4½ | .... | .... | .... | .... | .... | .... | 11 | 8 | 8½ | 2½ | 1 | 1¼ | 4½ |
| 18. | Black Hills Spruce (*Picea alba*) | .... | .... | .... | .... | .... | .... | .... | .... | .... | 6 | 1 | 3¼ | 10¼ | 4 | 8½ | 10 | 4 | 7 | 6¼ |
| 19. | European Larch (*Larix europaea*) | 7½ | 2⅜ | 5 | 14 | 8 | 11⅜ | 16 | 5 | 11½ | 37 | 15 | 25 | 32 | 12½ | 22½ | 10⅝ | 2 | 4 | 13⅜ |
| 20. | Fragile Willow (*Salix fragilis*) | 15¼ | 8 | 8½ | 30 | 18 | 24 | 40 | 22 | 29¼ | 54 | 22 | 32 | 18 | 4 | 12 | 17 | 6 | 9 | 19¼ |

*One year old when transplanted. †Two years old when transplanted.

Plate I, taken from these two tables graphically represents the amount of growth of each species and at the same time presents to the eye the relation between the annual growth of each species and the annual precipitation. In each case the average growth for the season of 1889 is taken as zero, and the deviation from this line represents the actual difference in growth between that year and each succeeding year. The scale used is one-sixteenth natural size, i. e. each inch in growth is represented by one-sixteenth of one inch upon the chart.

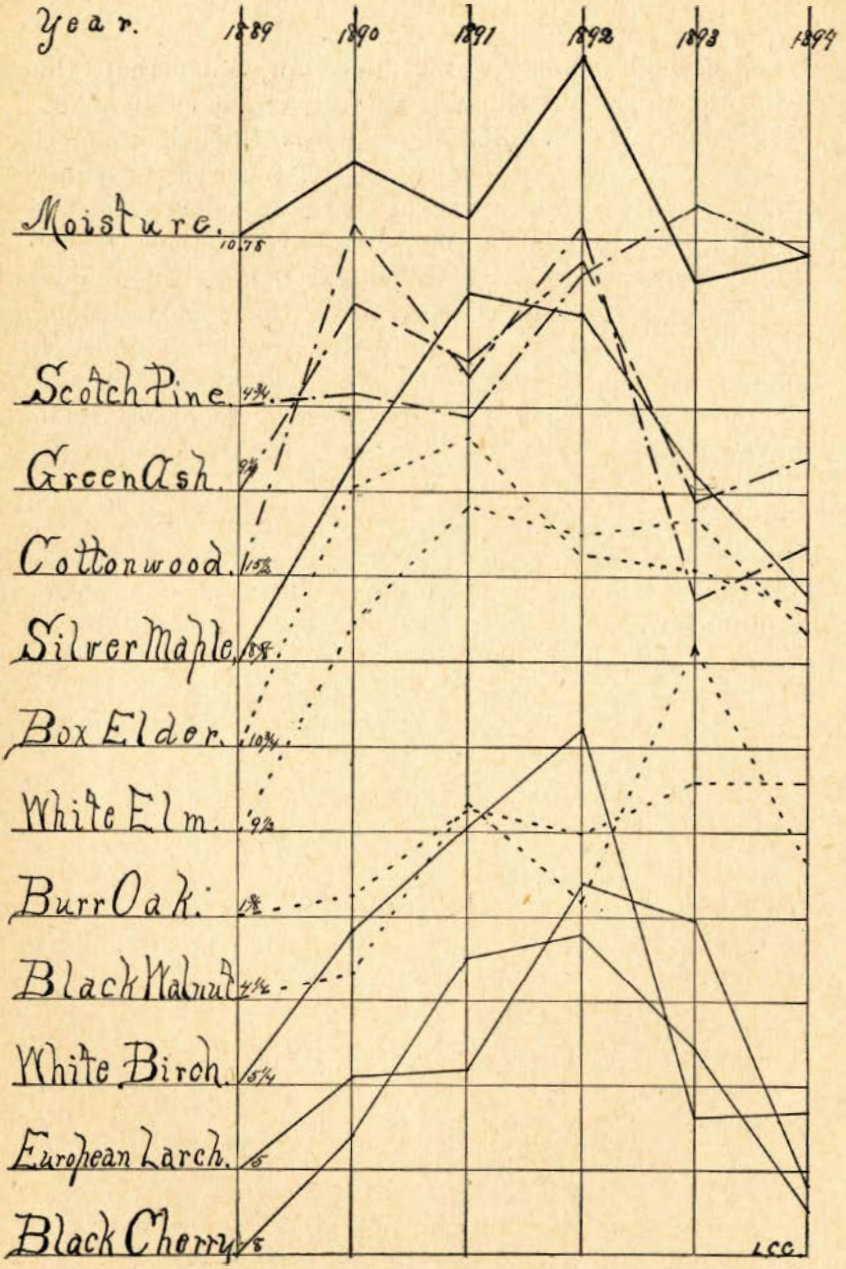
From a study of the lines of growth of the several trees it is notable that certain kinds follow very closely the deviation in the *moisture curve*, while others are quite independent of it, and in some instances seem to be absolutely the reverse. It is evident therefore that certain species are quite dependent upon the supply of moisture and that the average annual growth of these species under normal conditions is a direct index of the amount of precipitation. The line of growth of such species is marked thus —— – —— – ——– – —— upon the chart. The Scotch pine is placed with this group although its line of growth during 1893 is opposed to the general law governing this class. No cause can be assigned for this exception unless it be that this species did not suffer any check from the late frost and was better able to utilize the rain that fell during the early part of the season.

Those species which have a line of growth running contrary to the line of direction for the annual precipitation are marked thus – – – – – – – upon the chart. The evidence here produced would lead one to the conclusion that these varieties are well suited to meet the requirements of a country of scanty rainfall, this together with the number of each which have remained standing in the several plats still further commends them.

Although the oak, walnut and elm, with perhaps the exception of the latter, have not been very generally planted throughout the state, they are nevertheless our most valuable timber producing trees. The ash ranks higher than the elm for timber, but the cherry does not exceed the black walnut in value, and in rate of growth they are not to be compared, as the walnut increases rapidly in volume.

There is still another class of trees that seem to belong to neither of the groups above described, but approach more closely, in general, to the first. These from a lack of characteristics sufficient to give them a definite position have been marked thus ———— for the sake of distinction.

From the eleven species here enumerated we may, then, select a wet weather group, a dry weather group and yet others which seem to thrive independent of any perceptible law.




GRAPHIC COMPARISON OF TREE GROWTH AND PRECIPITATION.

## CONDITION OF THE TEN ORIGINAL PLATS.

PLAT I.

| VARIETY. | No. of Trees Standing. | | | Height of tallest tree. | | Circumference of tallest tree in inches. | Average growth in inches. |
|---|---|---|---|---|---|---|---|
| | 1891 | 1894 | 1895 | ft. | in. | | |
| Black Hills White Spruce | 79 | 63 | 56 | 3 | 5 | 3¼ | 7.0 |
| Scotch Pine | 17 | 17 | 17 | 7 | 9 | 7 | 15.4 |
| Green Ash | 102 | 224 | 224 | 10 | 7 | 7¾ | 6.6 |
| Poplars | 335 | 250 | 156 | 18 | 8 | 17 | 17.4 |
| Box Elder | 502 | 478 | 478 | 12 | 1 | 11½ | 13.3 |
| Total | 1035 | 1032 | 931 | ..... | ..... | ..... | ..... |

As will be noted from the catalogue of species represented in this plat, all the permanent trees are what are termed slow growing, and a large per cent. of the nurse trees are of an upright habit, thus forming a thin leaf canopy. The box elders used form about one-third of the entire plantation, but they have produced a small growth as compared with others of the same age planted more densely or used exclusively as the nurse tree of a plat. The result is that this is an open one which has allowed the growth of more weeds than any other plat of the ten originally planted at the same time. The above table shows adaptability of these trees to our soil and climatic conditions.

The Scotch pine, an exotic, has not lost a single specimen during the three years, while twenty per cent. of the white spruce, a native, have died. The injury to the spruce by late frost is only temporary, the tree soon recovers but the growth is shortened by the time lost in the recovery. It is symmetrical in form and one of our most attractive

evergreens. The one drawback is slow growth during its early life. Being a native its success among ornamentals is assured, but as a timber tree it can never take a high rank because of its small size and slow growth.

The Scotch pine is of more rapid growth and because of its hardiness and value as a timber tree it is by far the best evergreen yet tested at the Station.

PLAT II.

| VARIETY. | No. of Trees Standing. | | | Height of tallest tree. | | Circumference of tallest tree in inches. | Average growth in inches. |
|---|---|---|---|---|---|---|---|
| | 1891 | 1894 | 1895 | ft. | in. | | |
| Cottonwood | 330 | 192 | 126 | 17 | 10 | 16 | 15.3 |
| Box Elder | 243 | 235 | 198 | 15 | 11 | 12 | 23.8 |
| White Elm | 111 | 94 | 94 | 16 | 0 | 10¼ | 16.3 |
| Green Ash | ..... | 104 | 104 | 10 | 6 | 5¼ | 10.4 |
| Black Cherry | ..... | 5 | 5 | ..... | ..... | ..... | ..... |
| White Birch | ..... | 1 | 1 | ..... | ..... | ..... | ..... |
| Total | 684 | 638 | 528 | .... | ..... | ..... | ..... |

In this plat most of the trees of a permanent nature have made a satisfactory growth. Up to 1892 it was rapidly approaching true forest conditions, the leaf canopy being dense enough to discourage the growth of weedy plants and at the same time to give the ash and elm an upward tendency. The cottonwoods, however, show their characteristic upland habits; during the three years over fifty-eight per cent. of the trees of this variety standing in 1891 have died.

The ash suffers severely from late frosts yet its injury is shown only in blackened early shoots and in the decreased annual growth. Large trees of this species growing in open situations suffer little from frost as compared

with young trees in close plantations. In spite of the frost and of its being a slow grower the ash is one of the most valuable native trees for ornamental or general planting, still, it should not be planted in large plantations without being combined with other trees. The nurse tree used must not be of too rapid growth, as the ash cannot endure dense shade, but slight crowding gives it a more upward tendency. The ability with which it can be transplanted and its facility to withstand drouth, although it responds quickly to abundant rainfall, give it a high rating among trees for permanent planting.

The plat as a whole has a better combination than Plat I. The elm and ash are the most satisfactory species, although the box elder has made a somewhat greater growth.

PLAT III.

| VARIETY. | No. of Trees Standing. | | | Height of tallest tree. | | Circumference of tallest tree in inches. | Average growth in inches. |
|---|---|---|---|---|---|---|---|
| | 1891 | 1894 | 1895 | ft. | in. | | |
| European Larch | 208 | 40 | 34 | 9 | 1 | 7¼ | 4.1 |
| Box Elder | 529 | 506 | 506 | 13 | 9 | 13 | 16.3 |
| Green Ash | ..... | 444 | 256 | 3 | 11 | 2½ | 5.6 |
| Total | 737 | 990 | 796 | ..... | ..... | ..... | ..... |

Prior to the spring of 1893 the larch had made only a dwarfed, spreading growth, but at that time the outlook was promising for this plat, nearly all the trees made a strong upright growth which in some cases exceeded three feet in length, and all gave promise of forming valuable trees. In 1894, however, all but forty of the two hundred trees of this species were killed by the frost of June 19th. Those that survived and sustained slight injury only, made

a fair growth but not as good as the year previous, as is shown by tracing its course upon the chart. The line shows not only the peculiar behavior of this tree during the first three seasons, but its susceptibility to injury from spring frosts. In general little injury has been experienced from winter-killing, but it cannot endure frost after growth has commenced in the spring; and as it starts comparatively early, if planted, it should be given the mostfavored place in the plantation, that is, a place where it will be least subject to spring frosts and where growth will start latest in the season. A northeasterly slope would be best.

As a nurse tree the box elder seems to serve well for this species, but as only about forty per cent. of the plat was occupied by box elders we cannot judge of the results of a more dense leaf-canopy and closer planting with the nurse trees. The larch is classed among the light demanding species and as a result would probably not thrive where there was a predominance of quick growing, broad leaved trees.

It is to be regretted that this valuable tree does not give greater promise.

The ash in this plat gave a low average growth, but this may be partially accounted for by the late frost and by the fact that they were set with older and larger trees and as a result have been somewhat overtopped. The ash is also a light demanding species standing second only to the oak in this respect, and the disadvantage under which it is in this plat growing is clearly brought out by a comparison of the average growth here and in the other plats.

PLAT IV.

| VARIETY. | No. of Trees Standing. | | | Height of tallest tree | | Circumference of tallest tree in inches. | Average growth in inches. |
|---|---|---|---|---|---|---|---|
| | 1891 | 1894 | 1895 | ft. | in. | | |
| Box Elder (2 yrs)..... | 877 | 754 | 516 | 16 | 5 | 11½ | 16.6 |
| " " (1 yr)..... | ..... | 97 | 97 | 14 | 4 | 13¾ | 18.8 |
| White Birch..... | 105 | 63 | 51 | 16 | 0 | 21 | 10.4 |
| White Pine..... | 49 | 6 | 5 | ..... | 18 | 2 | 1.5 |
| Colorado Blue Spruce..... | 8 | 4 | 4 | ..... | 17 | 2½ | 2.3 |
| Total..... | 1039 | 924 | 673 | ..... | ..... | ..... | ..... |

This plat presents a most interesting history. It was originally planted with box elder, white birch and white pine, a few blue spruce were added later. The box elders were greatly in excess of all others, constituting about sixty-six per cent. of the total. As is noted in the table both yearling and two-year-old trees were set, and up to 1893 the two-year-old's had made decidedly the best growth and presented the best condition in the plat. But as might be expected from close planting of rapid growing, shade, producing species, such as this, none but rapid growing, light demanding kinds or the most shade enduring could be grown with them. The birch being a moderately rapid growing tree, needing much light, it could not thrive when overtopped by dense shading species, hence the heavy losses noted, in this variety. The few representatives still remaining are confined either to the boundaries of the plat or where other varieties were interspersed most frequently, namely, near the south side of the plat, where the majority of the pines were set and where the plat is more open; and again at the north edge where the yearling box elders were planted together with the blue spruce. Not a speci-

men of the birch remains alive in the interior of the plat where the two-year-old trees were set thickest and where they grew best until the winter of '94 and '95 when all the tops winter-killed so that the only life shown is in a few weak shoots starting from near the root.

A few of the white pines have managed to keep alive but no growth was made. This is, however, one of the most promising conifers grown throughout the southern part of the state. Although it is classed among the trees that are not decided in their likes or dislikes for shade it has certainly, in this plat, had most adverse circumstances to contend with.

The blue spruce show nearly the same state of affairs that the larch in Plat III presented the first three years of their existence. At present the prospects for this tree are brighter.

It seems useless to attempt growing box elders in closely planted groves or of planting a less rapid growing, light demanding species where it is liable to be overtopped by a broad leaved tree. But, again, had the closely planted box elders succeeded of what economic value would the product have been? The box elder never grows large and is, in general, exceedingly gnarly and crooked, and consequently returns a product of low value.

PLAT V.

| VARIETY. | No. of Trees Standing. | | | Height of tallest tree. | | Circumference of tallest tree in inches. | Average growth in inches. |
|---|---|---|---|---|---|---|---|
| | 1891 | 1894 | 1895 | ft. | in. | | |
| Box Elder | 872 | 891 | 842 | 16 | 6 | 13 | 10.1 |
| White Elm | 164 | 167 | 165 | 14 | ..... | 7¾ | 8.2 |
| Burr Oak | 46 | 39 | 39 | 7 | 11 | 4¾ | 11.9 |
| Ash | ..... | 91 | 91 | ..... | ..... | ..... | ..... |
| Black Walnut | ..... | 2 | 2 | ..... | ..... | ..... | ..... |
| Maple | ..... | 1 | 1 | ..... | ..... | ..... | ..... |
| Total | 1082 | 1191 | 1140 | ..... | ..... | ..... | ..... |

In this plat white elm, burr oak and black walnut were planted as permanent trees with box elder as a nurse. The walnuts have nearly all disappeared, only two remaining, but the elm and oak are promising. The west side is well stocked with box elders, elm and oak, while the east half is not so densely shaded. We have, therefore, an opportunity to study the effect of both light and shade upon the oak in the plat as a whole. In the east portion few trees overtop the oaks themselves, while in the western part of the plat the conditions are exactly the reverse and both box elder and elm are taller than the oaks. At present the oaks are thriving in both conditions and those in the shade are making a more rapid upright growth than those in the more open portion, but what the outcome would be were the companion trees to keep in advance of the oaks is hard to foretell.

The oak, as has been said, is considered a light demanding species and it is reasonable to suppose that a heavy leaf-canopy close upon the crowns would soon cause their destruction.

In comparison with the elm and box elder the oak grows slowly, it also has another drawback in being severely injured by late frosts. In other respects it is one of our most desirable hard wood trees. The timber is valuable in the arts and the tree itself is among the most picturesque in age. It has the further advantage of being indigenous to the region, and therefore perfectly adapted to our conditions.

PLAT VI.

| VARIETY. | No. of Trees Standing. | | | Height of tallest tree. | | Circumference of tallest tree in inches. | Average growth in inches. |
|---|---|---|---|---|---|---|---|
| | 1891 | 1894 | 1895 | ft. | in. | | |
| Poplar | 688 | 508 | 92 | 5 | 10 | 1½ | 53.2* |
| White Elm | 344 | 337 | 337 | 14 | 2 | 11½ | 19.3 |
| Green Ash | 277 | 319 | 246 | 9 | 10 | 7 | 8.1 |
| Total | 1309 | 1164 | 675 | ..... | ..... | ..... | ..... |

*All were root sprouts of the season.

Here one of the poplars was used as a nurse tree and it has proven its utter unfitness for such use. As a nurse tree *Populus (certinensis) laurifolia*, is much inferior to the cottonwood both in its habit of growth and shading power. The effects of the cottonwood leaf beetle (*Lina scripta*) are much more destructive to this species than to the native. It has been removed from some of the plats as worthless and in this one it has almost entirely disappeared because of its inability to stand when left to its own resources. In another plat an attempt is being made to rejuvenate it under a system of clean culture and coppice management. It will be given every possible opportunity to prove any good features that it may have.

The elms in this plat are among the largest upon the grounds and have had abundant room to develop themselves in all directions as during the last three seasons the poplars have neither given shade nor offered resistance to lateral development. It appears that at first the poplar made a more rapid growth than the elm and ash, the permanent trees, of the plat. The worst feature resulting from this use of the poplar was the inducing of a heavy

growth of lateral branches near the ground. This is undesirable in any species and when at best there is a tendency among individual trees to throw out small branches along the bole, producing the feathered appearance often seen in elms, such nurse trees are to be avoided. Such an appearance might be attractive in plants used for decorative purposes, but in timber trees it is quite the reverse and tends to make the resulting product gnarly and knotty. Aside from this (which is not a fault of the species) and the tendency of sending out two strong leading branches, the elm is the best tree we have for general planting.

It is growing here both in pure and mixed plantations and while the trees are too young to judge of the bad results, if auy, to come from growing it pure; it attains to large size more quickly when planted with rapid growing species that by retaining their branches close to the ground produces a dense shade which has the effect of discouraging the growth of the undesirable side branches of the elm, and at the same time produce an upward tendency of growth. This tree is little injured by spring frost, but sometimes kills back considerably during the winter, particularly if the growth was strong during the season and continued late in the fall. It is a tree of few enemies and is unusually clean for lawn planting. True it is, elm is not used in the arts to the extent many other timbers are and it cannot take the place of the oak, walnut or cherry for many uses upon the farm, but where beauty, longevity and hardiness are desirable, rather than a tree of high economic value, the elm easily stands above all other hard wood trees for South Dakota plantations.

PLAT VII.

| VARIETY. | No. of Trees Standing. | | | Height of tallest tree. | | Circumference of tallest tree in inches. | Average growth in inches. |
|---|---|---|---|---|---|---|---|
| | 1891 | 1894 | 1895 | ft. | in. | | |
| White Elm | 75 | 68 | 65 | 15 | 9 | 12 | 8.0 |
| Black Wild Cherry | 55 | 48 | 32 | 12 | 4 | 11¼ | 10.9 |
| Green Ash | 83 | 164 | 143 | 11 | 3 | 9 | 6.8 |
| Black Walnut | 14 | 15 | 11 | 9 | 10 | 6⅛ | 13.7 |
| Box Elder | 573 | 599 | 570 | 15 | 0 | 14 | 11.6 |
| Poplars (2 var) | 313 | 112 | 39 | 9 | 4 | 10½ | 23.2 |
| Total | 1113 | 1006 | 860 | ..... | ..... | ..... | ..... |

The poplars here, as elsewhere, have proven a failure; which must be considered a fault of the species rather than of the combinations.

The walnuts have held their own better here than in any other plat of the plantation, and while the number of trees is not great the prospects are, at this time, encouraging. While the annual growth is only average, it is quite equal to that of other hard wood species the partial success at the station taken in connection with the more gratifying results of planters in the immediate vicinity and particularly throughout the southern counties of the state leads me to believe that as soon as home grown seed can be had for purposes of reproduction the success of this species is assured. As it is one of the most valuable trees it should be with pride that we name it among the hardy species for our state.

PLAT VIII.

| VARIETY. | No. of Trees Standing. | | | Height of tallest tree. | | Circumference of tallest tree in inches. | Average growth in inches. |
|---|---|---|---|---|---|---|---|
| | 1891 | 1894 | 1895 | ft. | in. | | |
| White Birch | 110 | 102 | 100 | 16 | 8 | 15¼ | 9.6 |
| Scotch Pine | 84 | 68 | 63 | 9 | 2 | 10½ | 15.2 |
| Soft Maple | 165 | 164 | 147 | 13 | 9 | 12¾ | 11.9 |
| Poplars | 560 | 99 | 85 | 14 | 0 | 13 | 10.1 |
| Green Ash | 99 | 97 | 94 | 10 | 8 | 7 | 11.3 |
| Total | 1018 | 530 | 489 | ..... | ..... | ..... | ..... |

In 1891 there were in this plat 560 poplars, in 1894 99 and in 1895 only 85.

The Scotch pines here are the best of any in the plantation. The loss during the three years has been light and although they do not grow as rapidly as some of the deciduous trees, their value where winter protection is desired is not questioned when compared with that of deciduous species. It is a popular notion which is sustained by actual observation that during winter evergreen woods are warmer than deciduous.

The other species in this plat deserving special note is the maple (*Acer dasycarpum*). While this tree has made a height growth comparing favorably with that of the other deciduous trees of the plantation, it shows characteristics under the treatment it has received here which are undesirable in a tree for permanent planting.

In this plat the nurse trees did not fulfill the purpose for which they were intended; i. e. that of preventing, in the permanent trees, lateral growth and at the same time inducing upward growth. The failure of the poplars al-

lowed the branches of the maples to develop close to the ground. The boles of the trees are, therefore, short and of little value. The same species planted pure is no better when standing 4x4 ft., but in several instances where the trees were grown thickly in nursery rows, eight feet apart, for the first few years and gradually thinned, much bette, results have been attained than from the transplanted trees. In the neighborhood of Gary, Deuel county, some fifty miles north of the station I find the maple giving the most satisfactory results under this treatment. In the southern part of the state where trees have had the most time in which to make a history, the maple has outgrown all other species except the cottonwood and has a high rank among deciduous trees.

PLAT IX.

| VARIETY. | No. of Trees Standing. | | | Height of tallest tree. | | Circumference of tallest tree in inches. | Average growth in inches. |
|---|---|---|---|---|---|---|---|
| | 1893 | 1894 | 1895 | ft. | in. | | |
| White Elm | 50 | 45 | 45 | 14 | 1 | 10½ | 7.3 |
| Green Ash | 67 | 150 | 84 | 10 | 7 | 7½ | 11.0 |
| Black Wild Cherry | 35 | 27 | 24 | 8 | 10 | 5¾ | 5 4 |
| White Birch | 24 | 24 | 24 | 13 | 2 | 16 | 9.6 |
| Walnut | 3 | 3 | 3 | 4 | 1 | 2½ | 12.7 |
| Red Willow | 235 | 200 | 200 | 11 | 3 | 17 | 9.0 |
| Poplars | 289 | 110 | 110 | 9 | 10 | 15 | 16.7 |
| Box Elder | 256 | 259 | 259 | 13 | 0 | 13½ | 11.2 |
| White Pine | 0 | 1 | ..... | ..... | ..... | ..... | ..... |
| Total | 1959 | 819 | 749 | ..... | ..... | ..... | ..... |

Plat nine contains the greatest variety of species of any upon the grounds, yet since willows and poplars far outnumbered any of the other species, the combination is not satisfactory as the poplars have died and the willows have made a bushy growth suited only to a hedge plant.

The better kinds are sufficient in number to leave the plat quite well stocked as the trees grow older, so its condition will probably improve. The willows used are not adapted to forest planting. In a hedge where they would never be overtopped by other species, and where they could be conveniently and properly sprayed, they would undoubtedly prove themselves worthy of cultivation. Under the conditions existing in this plat they have shown themselves altogether wanting in those qualities which would commend them for use in forest plantations. Since 1891 there has been considerable falling off in numbers probably due both to drouth and defoliation by insects.

PLAT X.

| VARIETY. | No. of Trees Standing. | | | Height of tallest tree. | | Circumference of tallest tree in inches. | Average growth in inches. |
|---|---|---|---|---|---|---|---|
| | 1891 | 1894 | 1895 | ft. | in. | | |
| Black Cherry | 252 | 252 | 250 | 12 | 4 | 11¼ | 10.9 |
| White Birch | 171 | 165 | 152 | 16 | 4 | 14¾ | 8.5 |
| White Elm | 329 | 322 | 322 | 13 | 9 | 11 | 9.3 |
| Green Ash | 301 | 305 | 229 | 12 | 6 | 7½ | 16.0 |
| *Populus, laurifolia* | 147 | 8 | 8 | 2 | 8 | 1 | 23.3* |
| Evergreens | 47 | 5 | 5 | ..... | 16 | 2 | 3.4 |
| Total | 1247 | 1057 | 966 | ..... | ..... | ..... | ..... |

*Root sprouts.

This plat presents today the most promising combination species of any in the original plantation. The nearest approach to true forest conditions is here presented, and the trees appear to take kindly to one another. The four predominating species have grown uniformly in height, the birch alone overtopping the others, but as this is emphatically a light demanding species such a result was to be anticipated. The habit of this tree, however, prevents

any injury to adjacent trees providing they are not much inferior in height. The greatest value of the birch is found in its comparatively quick growth, hardiness and ornamental features. We have no tree growing in our collection which equals the white birch and its varieties in grace of form or leaf. While its color forbids its extensive use upon home or public grounds yet its hardiness, grace and dignity go a long way toward removing any prejudice to its color.

The wild cherry (*Prunus serotina,*) which is growing in plats two, nine and ten is one of the most promising species on the grounds. Our trees have at some time received a severe check to their growth as the boles are short and the crowns too low for the ideal forest tree, however, the perfect adaptability together with an average rate of growth for deciduous trees are points greatly to the credit of the tree. The fruit, while of no commercial value in itself, tends to attract birds of various species, a feature sufficient to warrant the growing of the tree, but the timber of the cherry is among the most valuable of any produced by the native trees of our country. It is a tree infested by but few insects all of which, save a borer, are easily treated by arsenical sprays. So far, however, none of our trees have needed such treatment. In appearance the cherry is inferior to the birch but its foliage is as clean and glossy and its long pendulous racimes of flowers, in their season, add to its attractive appearance.

## SUMMARY.

1. Among valuable timber and ornamental trees which are not injured by late spring frosts, we have: wild black cherry, white birch, white elm, Scotch pine, red cedar and cottonwood.

2. Species which are most injured by frost are: European larch, walnut, oak and ash.

3. The age and conditions under which a tree is growing influences the injury from late frosts quite as much as the family or species to which it belongs.

4. In rate of growth all forest trees are not alike affected by precipitation, some follow closely the line of direction of the rainfall while others are quite independent of it.

5. When planted in groves a critical period in the growth of the cottonwood and box elder is reached at a time when natural pruning begins, and heavy losses are, at that time, liable to occur.

6. None of the combination of species as they exist in the plats upon the Station grounds are satisfactory in all particulars, therefore, none of them are recommended for use by the general planter.

7. Pure plantations of any one species are not advocated unless in the case of the maple when grown from seed as noted on page 148.

8. The following trees are discarded as being of uncertain value for planting in groves upon high prairie: *Populus* (*certinensis*) *laurifolia*, cottonwood, European larch, willow (*Salix fragilis*).

9. The following species for general planting are recommended in the order named: Deciduous—white elm, green ash, wild black cherry, burr oak, black walnut, white birch, box elder, laural-leaved willow. Cottonwood for street or lowland groves, balm gilead as specimen tree. Evergreens—Scotch pine, red cedar, white spruce.

10. The future timber supply of this country is a feature to be kept constantly in view in selecting trees for permanent plantations, yet the greatest value resulting from extended tree planting arises from the protective influence which they exert.