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Forestry

C.A. Keffer
South Dakota Agricultural College

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In this Bulletin an effort will be made to give an accurate history of the work in forest tree culture for the past year, together with observations on plantations visited, and suggestions based upon them.

The tables included show the growth of the different species during the several months of 1889 and 1890, and they should be studied in connection with the weather record for the two years.

It is hoped that, while the observations of but two years cannot be more than suggestive, yet when compared with the experience of the reader, or when applied where conditions of soil and climate are similar, and especially when considered in connection with the cultivation given, they may prove useful to intending planters. The value of observations on the growth of trees, whether forest or fruit bearing, is cumulative, and the record of ten successive years is of far greater value, proportionately, than the record of two years. Hence we may hope that as time passes and our plantations are extended, each year will add greatly to their usefulness, both in themselves and as object lessons for workers throughout the state.

A brief study of the weather tables given herewith, will show that the season of 1890 was more favorable for tree growth than that of 1889. About twenty-five and one-half inches of rain fell during the year, of which amount over sixteen inches fell during the growing season. The month of April was unfavorable for planting, having only about three-fourths of an inch of

rain, one-half inch of which fell April 3rd. Planting began April 22d, so that the ground was quite dry. In the first week of May growth received a severe check by frost and snow, but the week following brought a soaking rain, and the months of June and July were very favorable for growth. The early part of August was dry and the growth was much less than in July. Only .8 of an inch of rain fell during the months of September, October and November. What effect this extremely dry autumn will have on the trees remains to be seen. It insured perfect maturing of the wood, and thus far was a benefit.

Compared with the preceding season, the past spring was not as favorable for planting, but the summer was far better for growth.

A tabulated statement of items from the Meteorological Record of the year at this Station follows:

MONTH.	RAINFALL.			TEMPERATURE.			WIND.	
	No. Days.	Greatest in 1 Day	Total.	Highest.	Lowest.	Mean.	Northerly.	Southerly.
1888.		Inch.	Inch.					
September	5	.287	.56	93.2	28.	37.3	....	....
October	5	.14	.62	82.	21.	42.9	....	....
November	0	.....	.....	67.	2.	31.49	...	...
December	4	.....	.....	58.	-5.	25.96	16	13
1889.								
January	.....	.....	.3	41.	-24.	15.	....	....
February	.....	.....	.5	45.	-30.	19.6	14	....
March	.....	.....	.16	55.	4.	32.	17	6
April	11	.27	1.025	83.	12.	51.29	10	15
May	9	.62	1.93	91.	20.	56.7	15	8
June	11	.54	1.485	93.6	36.1	64.2	15	14
July	9	.89	2.918	98.	40.	68.8	11	16
August	3	.53	.72	97.	41.8	69.6	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	.455	.975	52.	-11.	24.78	13	18
1890.								
January	3	2.	6.5	43.96	-28.	7.56	15	16
February	1	2.	2.	47.	-35.	14.92	15	13
March	3	.31	.56	32.25	-4.	19.69	13	14
April	4	.51	.787	84.	10.	46.71	10	12
May	11	.80	3.33	90.	23.	32.197	20	9
June	14	2.	7.91	90.5	30.	67.75	6	22
July	5	.54	1.535	94.5	41.	71.06	10	19
August	5	.88	2.07	90.	35.	63.8	14	16
September	5	.19	.45	91.	25.	57.5	11	16
October	7	.12	.32	74.5	21.	38.8	6	11
November	1	.....	.03	68.	0	29.41	22	12
December	.....	.....	.....	53.	-18.	21.2	8	19

THE PLANTATION OF 1890.

Beginning the middle of April a plat of about six acres, lying adjacent to the plantation of 1889, described in our Bulletin No. 15, was planted with the following varieties of forest trees and cuttings: White elm, green ash, box elder, silver maple (*Acer dasycarpum,*) *Populus certinensis*, shell-bark hickory and bitter hickory. The land had been plowed to a depth of eleven inches, a part in the spring, immediately before planting, and a part the previous November.

It was divided into one-half acre plats, of eight by ten rods. The trees were planted four by four feet, the rows being a continuation of the previous year's planting. The arrangement of the entire forestry plantation, showing the plantings of 1889 and 1890, the number of living trees at this date, January, 1891, and the varieties of trees in each plat, is shown in the diagram on next page. Plats one to ten were set in April, 1889. Plats eleven to twenty-six were made in April, 1890.

SOUTH.

ROAD—1 rod wide. 8 rods.

17A	16	14	12	10	8	6	4	2	10 rods.
Populus Certinensis.	Silver Maple.	Green Ash.	Box Elder.	Bl'ck Ch'rry Yellow Birch White Birch White Ash White Elm	Soft Maple. Cottonwood Scotch Pine. White Ash. White Birch	Populus Certinensis. White Elm. White Ash.	Box Elder. Yellow Birch. White Pine.	Pop. (4 var.) Bl'ck W'l'n't White " " Birch. " Elm. " Ash. Box Elder.	
840*	1260	1212	1131	1251	1093	1313	1136	948	

ROAD.

17B	15	13	11	9	7	5	3	1
Populus Certinensis.	White Elm.	Green Ash Seed.	Box Elder Seed.	Bl'ck W'l'n't Cherry. Box Elder. Wh'te w'l'n't P'c'r't'n'sis White Elm. S'lix b'r'gilis White Birch White Ash. White Pine.	Box Elder. White Ash. Black Walnut. Black Wild Ch'rry White Elm. Populus 2 varities.	White Elm. Box Elder. White Oak. Black Walnut.	European Larch. Box Elder.	Black Hills Spruce. Box Elder. Cott'nwood. Populus Certinensis. Scotch Pine.
968	658	†	1107	1152	1122	821	1086	

ROAD.

				26	24	22	20	18
				Populus Certinensis.	Green Ash.	White Elm.	Populus Certinensis. S. Maple.	Silver Maple. Hickory.
				1079	1252	1223	1173	1248‡

*840 trees in plats 17A and B. †Nearly all failed. ‡No. of living trees, January 1st, 1891.

For purposes of comparison, plats side by side were planted with seeds and yearling trees of ash and box elder.

About half of the box elder seed germinated, but before the spring rains began there were several days of strong wind, which whipped the little seedlings to death.

Of 756 hills of box elder seed planted, only eighteen trees, a little over two per cent., were living at the end of the season, while of the trees seven to fifteen inches high when set, 1134 trees, about 83 per ceut. were living at the end of the season, a difference in favor of the trees of 81 per cent.

The green ash seed germinated much better that did box elder. They were slower in sprouting and thus measurably escaped the severe winds that killed the box elder plants. At the end of the season, of 1386 hills planted, 558 were alive. Just opposite this plat the same number of young trees were set, of which 1212 were alive in the fall, a difference in favor of the trees of 47½ per cent.

The same culture was given both seed and tree plats, save that the seed plats required hand weeding in the hills once in addition to the hoeings.

The plats were cultivated both ways in May, in June and in July, and were hoed, so as to loosen the soil about the trees, after each cultivation. About the middle of August all weeds were cut out with hoes, and the ground was sowed lightly with oats, which were cultivated in. A harrow tooth cultivator was used, which stirred the soil about two inches deep.

From the trial of seeds and trees above noted, the advantage of setting the trees is apparent; first in the better stand, and second, in the saving in labor, the seedlings requiring an additional weeding. In the case of seeds the planting was a failure. and hence an entire year is lost, as the work will have to be done over again next season.

All the trees set in 1890, except the hickories, were bought of a South Dakota nursery, and were received about two weeks before planting began. The roots were puddled and the trees heeled in near the plat to be planted. In setting, the land was first marked both ways with a four-foot marker. The trees were carried about fifty at a time in a pail, the roots covered with a little earth to prevent drying, and they were planted with a

spade, care being taken to plant the trees as firm as possible.

The cuttings were calloused before being set; in one plat of a little less than a half acre, (1212 cuttings,) 372 failed to grow. In another plat of just half an acre, (1386 cuttings,) 287 failed. This plat was planted about ten days later than the other, and the cuttings received a good rain sooner, and hence suffered less from dry weather. This shows the value of setting cuttings in moist soil, or just before a rain.

All the trees in this plantation were set during the latter part of April; but little rain had fallen during the month and the ground was too dry for best results, so that great care was taken in planting to get the soil firm around the trees. The plats that were set earliest show the least percentage of growth, and those that were set latest grew the best. Shortly after the last plat was set copious rains came, and this explains the better stand secured.

The condition of the soil at the time of planting has very much to do with the growth. If the tree is put in damp soil its roots will go to work at once, and the loss of moisture by evaporation is made good by root absorbtion. But if the soil is very dry, and especially if the tree is set loosely in the dry soil, the loss of moisture by evaporation is either not supplied at all, in which case the tree dies, or else the supply does not equal the loss, when the growth is very feeble. Nature usually provides an abundance of moisture for the beginning of growth in the spring. When trees are transplanted, however, most of their fine absorbent roots are destroyed, and hence they are in need of especial care and favorable conditions, and even then there is usually a severe check to growth. If the planter could have everything in readiness, and then set his trees just before a good rain, it would doubtless be the best plan. But oftentimes the rain does not come until the trees begin to leave out, or other work becomes pressing; so that probably the safest way is to set the young trees very early, before the snow water has been lost from the soil, or as soon as the frost is out of the ground. Each year presents peculiar conditions, however, which make any set rule of little value. The planter will have to depend upon good judgment, based upon the condition of the soil and weather, to

determine just when to begin planting.

The work of setting trees was done entirely by students, and the errors they made may be taken as common ones. In setting cuttings the young men were very apt to firm the earth very carefully around the crown, where the cutting leaves the ground, and leave the root end untramped. Cuttings are set at a slight incline so that the base end, from which the roots start, may be tramped upon and thus made firm in the moist undersoil. If the cutting is set perpendicularly, it is much more difficult to make it firm—it can be easily pulled ont after the soil is tramped about it.

Firm setting, both of trees and cuttings, is of especial importance in this State, because soil thus firmed, if a little loose earth be brushed over it, retains moisture better than loose soil, and hence the tree is often kept alive, if the rains happen to be delayed.

Another common mistake in planting was to permit the tip of the root to turn upwards, instead of making it take a downward trend throughout. This was apt to be the case especially if the little tree had an extra long root. The spade is put into the ground at a slight incline from the planter, the handle is then pushed forward, thus making a wedge-shaped hole into which the root is thrust. If care be taken the root can be made to descend its full length, but hasty or careless workmen are apt to allow the end of the root to come upward, in which case it is either apt to be imbedded in dry surface soil, or the young roots are given a lateral trend and do not so readily seek the moist soil below. An examination of the root system of several species of transplanted trees, seemed to indicate that the direction of the new roots is somewhat influenced by the position of the old root at the time of setting. If further investigation should prove rhis to be true, it becomes an added reason for controling the position of the roots of young trees in transplanting them. In any event, the fact that the lower soil is constantly moist when cultivation is thorough, is sufficient reason for setting young trees carefully, so that the root shall rest in the moist soil.

In setting trees, much of the labor of after-cultivation can be

avoided if the plants are all set in the same direction. When a row is finished, the planter usnally turns into the next row and sets back to the starting line. In this way the alternate rows are not quite even with one another, and if the trees lean at all from the perpendicular, as is most likely, they lean in opposite directions in alternate rows. So in cross plowing the cultivator cannot be brought close up to each tree. If the planter, when he finishes a row, goes back to the starting point to begin the next, all the trees will lean in the same direction, and the cross rows will be exactly straight. A little more time is required in planting by this method, but the time saved in cultivating and the more thorough cultivation made possible, will more than compensate for the extra expense in planting.

The best stand of any variety was secured with soft maple, (*Acer dasycarpum.*) Less than eight per cent. failed. The growth, while healthy, is not so strong as I have secured with this variety in Iowa; and from observations made during the summer in other plantations, the species does not seem so well adapted to Dakota as ash, box elder or cottonwood.

In the plantation of Mr. Perry Lewis, in the western part of this County, the soft maple trees are from twelve to eighteen feet high. Nearly all of the trees of the species, which occupies about two acres, grow in bush or coppice form, the trunk dividing into several branches of equal size within a foot from the ground. Mr. Lewis says that while young the trees killed back, and thus assumed their present form. They seem perfectly hardy now and are robust and growing well. Mr. Lewis' trees occupy the crest of a ridge. Mr. Geo. H. Whiting of Esmond, Kingsbury County, a much dryer locality than Brookings, regards the soft maple as a better drouth-withstanding tree than either box elder or cottonwood. Mr. Whiting is a close observer and a planter of large experience, and his opinion is deserving of consideration.

The elm trees were very small when set—mere whips. They were slow in starting and made but little growth during the season. In November, in one plat, 968 were alive, and in another, planted a little later, only 163 died, or about 12 per cent. The elm grows much more rapidly after the first season, as will be

seen by comparing the growth in this plantation with the trees set in 1889.

Three hundred hickories in two varieties (*Carya alba* and *C. amara*,) were set twelve feet apart among maples in one plat. The hickories had been started in nursery and were very small—from two to four inches high. Most of them failed and the remainder showed only a few leaves during the season.

The following table will show the growth of the trees set during the past year:

VARIETY.	JUNE. Growth in inches.			JULY. Growth in inches.			AUGUST. Growth in inches.			SEPTEMBER Growth in inches.			TOTAL. Growth in inches.		
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Max.
Box Elder (S).	5	2	3	6	2	4 1/4	4	1	3	....	....	....	15	5	10 1/4
Box Elder (T).....	12	4	7 3/4	15	3	8 1/2	3	1	2 1/2	2 2	....	1 1/2	33	3	19 1/2
Green Ash (S).....	3	2	2 1/2	4	2	3 3/8	3	1	1 1/2	2 2	....	1/2	10	4	7 3/4
Green Ash (T).....	6	2	4 1/2	7	4	4 3/4	3	1	2 1/4	....	....	....	16	3	10 3/4
Elm (T).....	2	1/4	7/8	4	2 1/2	3 1/16	1	....	1/2	1	....	1/4	8	2	4 3/4
Maple (T)	6	3	4 1/4	6	2	5	8	3	4	2	....	1/2	19	5	13 3/4
Pop Certinensis (C)	7	3	5 1/4	15	3	7 3/4	8	4	7 1/2	....	....	....	30	10	20 1/2
Pop. Nolester (C).	14	6	10 1/2	16	4	10	2	1	1 3/4	2	....	1 1/4	30	11	23 1/2
Carga Alba* (T)...	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Carga Amara* (T)	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

S—Seedlings: T—Transplanted: C—Cuttings: *—Less than one inch.

THE PLANTATION OF 1890.

The diagram on page 6 will show the plan and varieties of trees used in this planting, which includes plats one to ten, made in April, 1889. The method of planting was described in detail in Bulletin No. 15.

The plantation had been left free from weeds in the fall of '89 and the ground under the trees was bare, with only a slight ridge on either side the tree rows. The heavy winds of the following March and April exposed the surface roots of many of the trees, especially the European Larch, which had made but little growth the previous season. Early in May all exposed roots were covered. During the first week in May, when the leaves of the Larch were about half grown, a snow storm and

heavy frost ruined the foliage and quite a number of the trees were killed.

The box elder also received quite a severe check by the exposure of the roots and the subsequent freezing weather which came just as the box elder trees began to push forth their leaves. The cottonwood and Russian poplars did not seem in the least harmed by the exposure of their roots. These four varieties were the only ones affected, the other species in the plantation seeming to have fewer surface roots.

The cultivation was the same as that given the plantation of '90. The couch grass was removed from both plantations twice during the season.

In August, after cultivation, had ceased, weeds were kept down with a hoe. The land was left bare under the trees, as it was thought that the added growth of the past season would enable them to protect the soil from winds.

The leaves on the young trees cast quite a thick shade in August, giving to the plantation an appearance of density that was rather misleading. In November, when the leaves were gone, the soil seems almost as much exposed to wind action as it was the year before. The young trees of the past year's planting, however, lie to the north of the older plantation, and as the ground under them is quite well covered with oats, they may protect the larger trees from the north winds. In any event, the soil cover under the young trees will be sufficient to demonstrate the value of the protection it affords.

The record of growth which follows is made up of averages. A number of the strongest growing branches were measured, and the average of these makes the "maximum" of the table. In the same way the "minimum" and "average" of the table were secured. In preparing the column of totals, the entire growth of the season was measured in number of trees showing the greatest, the average, and the least new wood. Hence the figures may not agree with the sum of averages for each month.

CONTINUED ON PAGE 42.

VARIETY.	Froze back during the winter of 1889-1890.			MAY. Growth in inches.						JUNE. Growth in inches.						JULY. Growth in inches.					
				1889.			1890.			1889.			1890.			1889.			1890.		
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
Populus Pyramidalis	....	....	....	3	2	2 3/8	5	3	4 1/4	6	1	2 1/2	30	9	17 3/4	19	5	8	13	6	12
Populus Nolester	....	....	....	2 1/2	1/8	1 3/8	5	2 1/2	4	9 1/2	1 3/4	6	14	9	11	17	2 1/2	9 1/2	18	4	15
Black Walnut	4	1	2	1	....	1/8	3	1	1 3/4	4	1/2	2	3	1	2 3/4	2	1	1 1/2	2	1/2	1
White Walnut	18	....	4	3/4	....	1/4	3	1/4	1	4 1/4	1/4	2 1/8	8	....	....	2 1/8	1	1 2/4	....	....	....
Yellow Birch	6	....	1 3/8	2	....	1/2	3	3/4	1 1/2	3	1 1/4	2 1/4	11	1	8 1/4	3	1 1/4	2 3/4	19	2	7 1/2
White Oak	19	1	5 1/4	1	....	1/4	2 1/2	1	1 1/2	3/4	3/4	1/4	4 1/2	1/2	2 1/2	3 1/4	1/2	3/4	2	....	1
White Birch	17	....	4	1 1/2	....	1	2	....	1	1 1/2	1	1 3/8	13	1	8 1/2	2 1/2	1 1/2	2	13	1	4 1/2
White Elm	36†	....	9 3/4	2 1/2	....	1 1/4	6 1/2	1/2	2 1/4	4 1/2	1	1 3/4	16 1/2	3 1/2	10 1/2	8	1 1/2	4 1/2	13	5	6 3/8
Black Wild Cherry	8	....	2	1 1/2	....	1	1 1/2	1/2	1 1/4	3 1/2	1/2	2 3/4	5 1/2	1 3/4	3 1/4	3 1/2	2	2 3/4	9	4	7
Soft Maple	2	....	1 1/2	1/2	....	1/8	3 3/8	1/4	1 3/8	2	1/2	1	10 3/8	4	7 3/4	4 1/2	1 1/2	3 3/4	16	7	9 1/4
Salix Frigilis	10	....	5 1/2	1/2	....	1/2	4	1 1/2	2 1/2	2 1/2	1/2	1 1/2	11	6	12 3/4	10	4	8	19	4	6 3/4
Scotch Pine	....	....	....	1 1/2	1/8	1/2	3 1/2	1/2	1	1 1/2	1/2	1 1/8	3	1	1 1/2	2 3/4	1/2	2	2	1/2	1
Larch	4	....	1 1/2	1/4	1/8	1/4	2	1/2	1 1/4	2 1/4	1/8	1 1/4	4 1/2	3/4	3	2 1/4	1	1	4	2	3 1/2
Black Hills Spruce	1	....	1 1/2	1	1/4	3/8	2	1/2	1	2 1/2	1/4	1 1/4	3	1/4	1/2	1 1/2	1/2	1	1	1/2	3/4
White Pine	....	....	....	1/2	1/8	1/4	2 1/2	1/2	1 1/2	4	....	2	3 1/4	1/2	1 1/2	2	....	1 1/2	1	1/2	1
Populus Certinensis	25†	....	2	2	....	1/2	4 1/2	1/4	2 1/2	6 1/2	2	5	15 1/2	6 3/4	9 1/4	11	3	8 1/2	16	1	11 1/2
Box Elder, 1 year old*	30†	....	13	2 1/2	....	1	6	1/2	2 1/4	4 1/2	1/2	2 1/4	18	4 3/4	17	15	1/2	5	9	3	6
Box Elder, 2 years old*	25†	....	3	4	....	2 1/4	6	4	4 3/4	12	1 1/4	5 1/2	22	7	16 3/4	12	2 3/4	6 1/4	15	2	14
Cottonwood, 1 year old*	11	....	6	1/2	....	1/4	3 1/2	1/8	2	7 1/2	1/8	2	21	1 1/2	16	9	1 1/4	4 1/4	23	9	15 1/2
White Ash	15	....	2 1/2	2 1/2	....	1/2	6	1/2	2 1/4	8	1	3	15	3 1/2	13 3/4	6	2 1/2	3 3/4	6	2 1/2	3

*When transplanted.
†Barked by Jack Rabbits.

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VARIETY.	AUGUST. Growth in inches. 1889. Max.	Min.	Avg.	1890. Max.	Min.	Avg.	SEPTEMBER. Growth in Inches. 1889. Max.	Min.	Avg.	1890. Max.	Min.	Avg.	TOTAL. Growth in inches. 1889. Max.	Min.	Avg.	1890. Max.	Min.	Avg.
Populus Pyramidalis	3	½	2⅛	3	....	2	1	....	½	....	....	....	23	10	16	49	18	36
Populus Nolester	1	½	1¼	7	2	5	....	....	....	....	....	....	20	5	18⅛	38	18	25
Black Walnut	½	....	½	1	....	½	....	....	....	....	....	....	7½	1½	4¼	9	3	6
White Walnut	½	....	½	....	....	....	....	....	....	....	....	....	9½	1½	6½	....	....	....
Yellow Birch	2	¼	1⅛	4	1	3	....	....	....	2	....	1	10	3	6	30	7	20¾
White Oak	....	¼	¼	1	....	½	....	....	....	....	....	....	5	1	1⅞	9	2	5½
White Birch	1½	....	¾	3	1	1½	1	....	½	3	....	1	7½	2½	5¼	29	12	16
White Elm	½	½	½	4	1	3	3	....	1	3	....	1	24	3	9½	45	19	29¾
Black Wild Cherry	½	....	½	4	1	3½	1	....	½	2	....	1	12	4	8	26	6	16
Soft Maple	3¾	½	2	1	....	½	....	....	....	1	....	½	12¾	4	8⅝	35	16	22½
Salix Fragilis	5	3	4½	1½	....	¾	2	....	1	....	....	....	31	8	15¼	30	18	24
Scotch Pine	½	....	¼	½	....	½	....	....	....	....	....	....	7¾	2¾	4¾	9	2	5
Larch	4½	1	3¼	1¼	½	2¾	1	....	½	2	....	1½	7½	2⅜	5	14	8	11¼
Black Hills Spruce	½	....	¼	½	....	¼	....	....	....	....	....	....	5½	1	2¾	4	1	2½
White Pine	1	....	½	½	....	¼	....	....	....	....	....	....	7½	½	4½	8	1	4½
Populus Certinensis	16	4	10	10	2	4	4	....	1¼	....	....	....	39	0	25⅝	40	14	27
Box Elder, 1 year old	8	1	3	5	2	3½	2	⅛	½	....	....	....	32	8½	10¾	38	10	28⅜
Box Elder, 2 years old*	4	1	2½	4½	2	2½	2	....	1½	....	....	....	34	5½	18	45	20	37½
Cottonwood, 1 year old*	5	2	12	4	3	5	3	½	2	4	1	2	25	4½	15½	66	16	40¾
White Ash	3	½	1¾	4⅜	2	3¼	2	....	1	2	1	1	14	3	9½	34	8	22⅜

*When transblanted.

FOREST TREE NURSERY.

The varieties of seeds noted in the subjoined table were secured during the fall and winter of 1889-90. In November, 1889, twelve rows each of native box elder and green ash seeds were drilled in deep plowed ground, and covered to a depth of two and one-half inches, the soil being tramped over the seeds The box elder germinated before the middle of April, and an excellent stand seemed assured. While the little seedlings were in the third leaf, dry wind storms whipped them and blew the soil so as to expose the roots, so that hardly a tree survived. The ash seeds were uncovered by the same winds and very few of them germinated. Ash seeds gathered at the same time, and kept over winter mixed with moist sand and frozen, were planted the middle of April, adjoining the plat just mentioned. These germinated freely and a splendid stand was secured; it seemed as though every tree grew. Native box elder seed, treated in the same way, gave a very poor stand. The nuts (walnut, butternut and the hickories,) germinated well and made much better growth than the year before. Seeds of black wild cherry sprouted the last of April, but were almost entirely killed by the snow and heavy frost of the first week in May; the ash trees were hardly injured by the same weather, though fully as much exposed as the black wild cherry.

Seeds of the wild plum (*Prunus Americana*,) were secured from Bismarck, N. D., and from Oahe, Hughes Co., S. D. They were kept frozen over winter and until planting time, germinated freely and made good growth. The thorns (*Crataegus tomentosa* and *C. crusgalli*,) kept frozen over winter and until planted, did not germinate; this is the second failure with this treatment, and it indicates that the seed must be subjected to the action of ferments or other agencies that will soften them before planting.

The nuts, shell bark hickory, (*Carya alba*,) bitter hickory, (*Carya amara*,) pignut, (*Carya porcina*,) butternut, (*Juglans cinerea*,) black walnut, (*Juglans nigra*,); and the oaks—burr oak, (*Quercus macrocarpa*,) white oak, (*Q. alba*,) red oak, (*Q. rubra*,)

and pin oak, (*Q. palustris*,) were received in March, mixed with sand and kept frozen until the time of planting.

They germinated freely. As soon as the striped gophers discovered them they began digging for the seed, and many were destroyed in this way. Corn soaked in a solution of strychnine checked but did not entirely stop the depredations of the gophers. These pests also destroyed the larger seeds of the evergreens. They did not disturb any other deciduous tree seeds.

The sycamore, when it first appears above ground, has a striking resemblance to the young pig-weed, and in weeding, nearly all the seedlings were destroyed; the few that escaped grew well.

The seed of dwarf cherry, (*Prunus Virginiana*,) were dry when received and did not germinate. Bass wood, (*Tilia Americana*,) seed also failed to germinate.

All the tree seeds were sown during the second and third weeks in April, in ground that had been plowed twelve inches deep the previous Autumn. The land has never been manured and has produced five crops; it is near the crest of a ridge. The surface soil is light and of comparatively slight depth: one of the poorest plats on the farm. The seedlings were hand-weeded June 14th to 18th, and were cultivated on the following dates: June 11, 24, July 2, 12, 18. In addition to this the plat was hoed four times during the season, all the weeds being removed by hand from among the trees in the drills at each hoeing. By this treatment the soil was kept in fine condition throughout the season. The record of growth for the season is shown in the following table:

VARIETY.	FIRST UP.	WELL UP.	JUNE. Growth in inches.			JULY. Growth in inches.			AUGUST. Growth in inches.			SEPTEMBER Growth in inches.			TOTAL. Growth in inches.		
			Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
White Ash	May 12	May 18	3	...	2¼	5½	1	2	1	1½	¾	....	....	....	9	2	5
Native Oak (Burr Oak)	June 1	June 6	5	1	3¾	1½	1	1⅓	⅓	...	⅓	....	....	....	7	2	4¼
Red Oak	June 9	June 12	4	1	3	2	1	1	....	....	....	....	....	....	6	2	4
Burr Oak	June 9	....	4	1	2	3	1	1	....	....	....	....	....	....	6	1	3
White Oak	June 24	....	3	3	3	2	....	1½	....	....	....	....	....	....	5	3	4½
Oahe Plum	June 1	June 10	6	1	4½	15	1	5½	3	1	2	2	....	1½	25	4	14
Bismarck Plum	June 8	June 19	5	1	3½	12	1	4½	3	....	1	....	....	....	20	2	9
Sycamore	June 24	....	½	....	....	4½	....	....	3½	....	....	1	....	....	9½	....	....
Honey Locust	June 6	June 15	5	½	4	9	1	3	7	1	3	1	....	½	21	3	9½
Cockspur Thorn*	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Black Thorn*	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Black Wild Cherry	June 12	June 25	2	1	1½	5	1	2	2	....	1	2	....	1	11	2	5
Dwarf Cherry*	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Basswood	July 1	....	....	....	....	2	1	1½	....	....	....	....	....	....	3	1	1½
Norway Maple	June 4	....	3	½	1½	1	....	1½	....	....	¼	....	....	....	3½	1	2¾
Green Ash	May 12	....	3	1	2½	7	1	3	3	....	1½	....	....	....	12	2	7
Scarlet Oak	June 9	....	3½	1	2½	1	1	1	....	....	....	....	....	....	4	2	3½
Pig-nut	June 9	....	3½	1½	2	1½	½	1	....	....	....	....	....	....	4	1½	3
Shell-bark Hickory	June 9	....	3	1	2	1½	1	1	....	....	....	....	....	....	4	1	3
Bitternut Hickory	June 24	....	3	1	1½	3	½	1	....	....	1½	....	....	....	8	1	5
Pin Oak	June 24	....	3	1	2½	2	1	1½	2	....	¾	....	....	....	5	2	4
Black Walnut	June 1	June 8	9	2	5	4½	1	3½	2	1	1½	....	....	....	13	3	11
White Walnut	June 24	June 30	7	1	5	4	2	2½	2	....	1	....	....	....	11½	4	7

*Did not come up.

THE EVERGREENS.

The Evergreen nursery was planted in the Spring of 1888, 10,000 trees from four to ten inches high being used. The trees were mulched with straw to their tops, and the only cultivation given was that twice a season the mulch was removed and a harrow tooth cultivator was passed several times between the rows, when the mulch was replaced. This treatment was continued two years. Last spring in the month of March, it was noticed that the foliage of all the conifers was browned—the amount of damage ranging from very little in Scotch pine, through Colorado blue spruce, white spruce, balsam fir, Menzie's spruce, white pine and arbor vitae, the last four being very much damaged. When growth began in May it was found that the white pine was severely killed back, and many arbor vitae were entirely killed. Menzie's spruce, (*Psuedo-tsuga Engelmanni*,) and balsam fir, (*Abies balsamea*,) were badly injured, losing nearly all their leaves. Norway spruce, (*Picea excelsa*,) was browned almost as though dead; the foliage of white spruce was much discolored, and the Colorado blue spruce was a little damaged. Scotch pine, one and one-half to two feet high, showed the least injury, but the entire plat looked as though there was but little to hope for in it. As the season advanced the Scotch pine and white spruce seemed entirely to recover from the effects of winter and spring, and made very fair growth during the season.

During the early part of May 342 Scotch pines were transplanted from the nursery into a plat lying at the northwest corner of the College Farm, on a gravelly knoll. The location is one of the dryest on the College grounds. As the trees were dug they were placed in a half barrel so that the roots were covered with water. The holes were dug the same day that the trees were set, and the soil was moist at the time of planting. The trees were set firm, the earth over the roots being well tramped. The plat received good cultivation during the season, but was not quite as well cultivated as the forest tree plats above described. The trees were set at irregular distances, as the plat is designed to form a part of the College lawn. No mulch was

used, but the surface soil was kept loose throughout the growing season. Of the 342, trees set 285 were in good condition in November.

The small evergreens that were set in beds in the spring of 1889 and shaded with slats, did not suffer at all from leaf burning, as did the trees in the open nursery. The slats held the snow and shaded the little trees, so that they were completely protected. Their growth during the season has been reasonably satisfactory, but I am unable to see sufficient advantage, either in stand secured or growth, to warrant the extra expense of building a shade. If tree boughs were available for making the shade it would pay, but when all the material must be bought it becomes too expensive.

The small seedlings of white pine, which came from seed planted in the Spring of '89, made on the average an inch growth during the Summer. Seeds of Scotch and white pine, white and blue spruce, and balsam fir planted in the latter part of April, failed to germinate, save in a few cases.

The total growth for the year, with the growth for the previous year, is shown in the following table:

VARIETY.	MAY. Growth in inches.						JUNE. Growth in inches.						JULY. Growth in inches.					
	1889.			1890.			1889.			1890.			1889.			1890.		
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
Scotch Pine	6	1	4	9⅛	2	5⅛	5½	2	3	8	1	4¾	3	1	2¾	4	½	1
White Pine	3	½	1½	....	....	....	2	⅜	¼	3	⅛	⅝	1	⅛	⅜	1	¼	⅜
White Spruce	2½	1	1⅝	2½	1	1⅝	4½	¾	¾	3½	¼	1¼	1½	⅜	¾	9½	1½	5⅝
Norway Spruce	⅜	⅛	⅛	1	¼	½	2	¼	⅜	3	¾	2⅛	2	1	1⅜	2	⅛	⅞
Balsam Fir	2	¼	1⅛	1	⅛	½	1½	½	⅞	4	¾	1⅞	1	¼	¾	2¼	½	1½
Colorado Blue Spruce	2½	½	1	1½	¾	¾	2	½	¾	3	1½	1⅞	1	⅛	⅜	2	¼	1½
Douglas Spruce	1⅛	....	1	....	....	....	1	½	¼	....	....	....	½	¼	⅜	1½	¼	⅞
Gray Pine	½	....	1	3	½	2	3	½	2	3	1	1½	1¼	½	1	1½	½	⅞
Black Hills Pine*	1½	....	1	....	....	....	1	⅜	⅜	....	....	....	¾	⅛	⅜	....	....	....
Red Cedar*	1	....	½	....	....	....	1	....	½	....	....	....	1¼	1	1⅛	....	....	....
Arbor Vitæ*	1	....	½	....	....	....	2	1	2¼	....	....	....	2¼	1	1⅝	....	....	....

VARIETY.	AUGUST. Growth in inches.						SEPTEMBER. Growth in inches.						TOTAL. Growth in inches.					
	1889.			1890.			1889.			1890.			1889.			1890.		
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
Scotch Pine	½	....	⅛	....	....	....	....	....	....	....	....	....	15	5	9¾	19	5	11¼
White Pine	⅛	....	⅛	1	....	⅜	....	....	....	....	....	....	6½	1¼	3¾	8	½	4⅜
White Spruce	⅛	....	⅛	1	....	¼	....	....	....	....	....	....	6½	2	4⅛	14	2	7¼
Norway Spruce	1½	⅛	¾	3	....	⅝	1	⅜	⅜	....	....	....	3	1	2⅛	9	2	4½
Balsam Fir	1	⅛	¾	1	....	¾	½	....	⅛	....	....	....	6	1¼	4⅛	7	3	5
Colorado Blue Spruce	¾	⅛	½	1	....	½	⅛	....	⅛	....	....	....	6⅛	1¼	4⅛	8	1½	4½
Douglas Spruce	½	....	⅛	1	....	¾	½	....	⅛	....	....	....	3¾	¾	3	3	1	2¼
Gray Pine	⅛	⅛	⅛	1½	¼	1	....	....	....	....	....	....	3¾	¾	3	8	1½	5
Black Hills Pine*	¾	....	⅛	....	....	....	....	....	....	....	....	....	4	1	3⅛	....	....	....
Red Cedar*	¼	⅛	⅛	....	....	....	....	....	....	....	....	....	4	1¼	2⅝	....	....	....
Arbor Vitæ*	1¼	¼	½	....	....	....	....	....	....	....	....	....	7	2½	5½	....	....	....

*Nearly all dead.

THE SEEDLING FOREST TREE PLAT.

This plat, containing two acres forty-nine rods of ground, was planted to forest tree seeds in the Fall of 1887. Seeds of the following varieties were used: Box elder, white ash, black wild cherry, honey locust, white oak, burr oak, red oak, black walnut, white walnut (butternut,) chestnut, hard maple, shell bark hickory, basswood, black locust. At the end of the season the number of trees alive in the plantation, with growth, was as follows:

No. Hills.	Variety.	Greatest Growth.
754	Box Elder	24 inches.
12	Oak (all kinds)	5 "
23	Black Wild Cherry	13 "
665	White Ash	11 "
75	Hard Maple	4 "
24	Butternut	7½ "
29	Walnut	8 "
61	Honey Locust	11 "

The only varieties of the original planting now growing in the plat are box elder and white ash, both of which have grown very well, a few black walnut, several hard maples, and one burr oak. The butternut, honey locust, black wild cherry, oaks and nearly all the black walnuts, survived less than two years. In the spring of 1889 the blank spaces were all filled with small trees of the varieties set in the plantation of that year. The past spring no further planting was done.

This plat occupies the poorest soil on the College farm, the northern end of a ridge, which slopes toward the north, east and west. A gravelly stratum lies less than a foot below the surface, and is underlaid with a rather stiff clay subsoil. In dry weather this plat is the first to show indications of a lack of moisture.

During the year just closed it has received somewhat less culivation than the other forest plats, but couch grass and perennial weeds have not been permitted to grow, and the soil has been kept loose.

The growth for the season, and for the previous year, is shown in the following table:

CONTINUED ON PAGE 51.

VARIETY.	Froze back during the winter of 1889-1890.			MAY. Growth in inches. 1889.			MAY. Growth in inches. 1890.			JUNE. Growth in inches. 1889.			JUNE. Growth in inches. 1890.			JULY. Growth in inches. 1889.			JULY. Growth in inches. 1890.		
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
Box Elder	24	3	9½	[illegible]	[illegible]	[illegible]	6½	2	4½	22	1	14	17½	15	16½	25	1	14	15	5	10
Box Elder (T)	20	....	12½	[illegible]	[illegible]	[illegible]	5	1	3½	5½	1	3½	17	9	13¾	7½	1	5½	11	2	10¼
White Ash	3	....	½	[illegible]	[illegible]	[illegible]	8	....	3¾	9	1	3½	14	8	4¼	8½	2½	8¾	11	3	9
Black Wild Cherry	3	....	1	[illegible]	½	1¾	1½	¾	½	2	½	1¼	....	1	2¾	7	1½	2¾	17½	6	13¼
Honey-Locust*	....	....	....	1	....	1½	....	....	....	4	1½	2¾	9	....	....	8	½	2¾	....	....	....
Oak (1 tree)	....	....	....	[illegible]	½	1¾	¾	....	....	1¼	¼	¾	2¾	....	....	1¼	½	1	3	....	....
Walnut	7	....	3	[illegible]	....	½	....	....	....	3½	2½	3	7	1	3½	3	2	2¼	5	1	3¼
Butternut*	....	....	....	[illegible]	....	½	....	....	....	3	1½	2¼	....	....	....	1½	1	1¼	....	....	....
Hard Maple	20	....	5½	[illegible]	....	½	....	....	....	1½	½	1¼	5	1	4½	1¼	¼	¾	14	4	11¼
Norway Poplar (T)	2	....	¾	[illegible]	....	¾	3	1	1½	7½	1	3¾	10	2	4¼	3	2	2¾	13	2	8
White Birch (T)	11	....	4	....	....	....	3	....	2½	4½	1½	2¾	10	3½	6	3½	3	3¼	11	1	6
White Elm (T)	5	....	2½	....	....	....	2	½	3	2	1	1½	20	3	14	3	2	2½	8	3½	5
Populus Certinensis (T)	6	....	2½	....	....	....	3	....	8½	9½	6½	7¾	12	3	9	4½	1½	2¾	9	4	5½
Salix Laurifolia (T)	18	....	3	....	....	....	3	1	2½	12	3	6½	14	8½	10¾	6½	5	6	9	4	7
Populus Nolester (T)	....	....	....	....	....	....	8	2½	2¾	11	3	6	13	11½	11¾	7	2½	5¾	18	1	6
White Pine (T)	....	....	....	....	....	....	3	2¼	2⅝	3½	1	2	....	....	....	1	½	¾	....	....	....
Scotch Pine (T)	....	....	....	....	....	....	4½	1½	2	2½	1	2	2	½	1½	1	¾	⅞	1½	½	1

Dead.

CONTINUED FROM PAGE 50.

VARIETY.	AUGUST. Growth in inches.						SEPTEMBER. Growth in inches.						TOTAL. Growth in inches.								
	June 1 to 1889.			1890.			1889.			1890.			1888	1889.			1890.				
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max	Max.	Min.	Avg.	Max.	Min.	Avg.		
Box Elder	3½	....	1	6	2½	3½	....	....	....	....	....	....	24	53	8	33	45	25	31		
Box Elder (T)	5	4	4½	3	3	3	....	....	....	....	....	....	....	20	5	14	36	14	28¾		
White Ash	1½	....	1	3	3	3	....	....	....	2	....	1½	13	22	3½	14¾	35	8	21		
Black Wild Cherry	1½	½	1	3	....	2	....	....	....	2	....	1	11	13½	3½	6¾	23	9	19½		
Honey Locust*	6	1	2½	....	....	....	....	....	....	....	....	....	11	20	4	9⅜	....	....	....		
Oak (Three)	½	....	¼	1	....	1	....	....	....	....	....	....	8	5	1¼	3¾	7	....	....		
Walnut	½	....	¼	2½	1	2	....	....	....	....	....	....	8½	9	4½	6⅜	14	3	8¾		
Butternut*	½	....	¼	....	....	....	....	....	....	....	....	....	7	7	2½	4¼	....	....	....		
Hard Maple	1	½	¾	10	....	2	....	....	....	....	....	....	4	5¾	1¼	3½	32	13	20		
Norway Poplar (T)	2½	½	1	....	....	2	....	....	....	....	....	....	....	15	3½	7¾	23	8	15¾		
White Birch (T)	1	....	½	2	1	1½	½	....	¼	2	....	1	....	9¾	4½	6¾	27	7	15½		
White Elm (T)	2	1	1½	....	....	....	¾	....	¼	....	....	....	....	7¾	4	5¾	28	8	20½		
Populus Certinensis (T)	4½	1	2¾	3	1	2	1	....	½	....	....	....	....	19½	9	13½	26	10	19		
Salix Laurifolia (T)	2	1	1½	2	....	1	1	....	¾	....	....	....	....	21	9	14	31	15	23		
Populus Nolester (T)	3	1	1½	4	1	3	1	....	¾	....	....	....	....	24	6½	14	38	11	23		
White Pine (T)	½	....	⅛	....	....	....	....	....	....	....	....	....	....	5	1½	3	....	....	....		
Scotch Pine (T)	½	¼	⅜	....	....	....	....	....	....	....	....	....	....	4	2	3¼	7	2½	4½		

*Dead.

SOIL ANALYSES.

During the Summer Professor Shepard made a physical analysis of two samples of soil from the forest plats. A sample taken from near the center of the plantation of 1889 resulted as follows:

	Surface, 12 inches Black Soil.	Second, 12 inches Mixed Soil.	Third, 6 inches Subsoil.
Sand	38.2 Per Ct.	42 Per Ct.	35.8 Per Ct.
Organic matter	7.4	4.7	4.2
Clay	54.4	53.3	60.

A sample taken from the southeast corner of the plantation of 1890, showed the following constituents:

	Surface, 12 inches Black Soil.	Second, 12 inches Mixed Soil.	Third, 6 Inches Subsoil.
Sand	32.4 Per Ct.	46.4 Per Ct.	29.3 Per Ct.
Organic matter	7.9	3.5	3.4
Clay	59.7	50.1	67.3

In selecting samples for analysis, it was thought that a total depth of thirty inches, divided as indicated in the tables, would include all the strata down to the clay, which is here a stratum of yellowish brown color, averaging thirty feet in thickness, containing white spots of carbonate of lime; but in subsequent measurements, the black surface soil, and the mixture of black soil and clay, were found to be more than twenty-four inches deep. Hence it may be that an analysis of the soil to a depth of four feet might vary somewhat from the records here given. The variation would not be great, however, and for all practical purposes the analyses here given fairly represent the character of the soil in which the trees stand. In some places the black surface soil is a few inches deeper than in others; in some places the change from black surface soil to the underlying clay is so gradual as to show no marked line of separation. The general character of all the land devoted to tree culture is well shown in the analysis.

Dr. Schlich, in his excellent Manual of Forestry, says that "the substances required by forest trees are, qualitatively, the same as those required by field crops." "For the production of

wood alone, (excluding the leaves,) forest trees require much smaller quantities of the mineral substances necessary for growth than do field crops." "Almost any soil can furnish a sufficient quantity of mineral substances for the production of a crop of trees, provided the leaf mould is not removed." By far the greatest amount of mineral substances found in ligneous plants is contained in the leaves. So that if the leaves are not removed from the soil—if they are left to rot beneath the trees—they form the leaf mould referred to by Schlich, than which there is no better fertilizer or soil improver.

The fertility of the soil, not only in this immediate vicinity, but throughout the settled portion of the State, has been proven by the immense crops that it has produced. If then, it is of sufficient depth to accommodate the root growth of trees, there remains but one natural obstacle to their successful culture—a bountiful supply of water.

ROOT GROWTH OF TRANSPLANTED TREES.

In a study of the root system of transplanted trees of box elder, cottonwood, Populus certinensis, white elm, black wild cherry and green ash, from one to four years of age, an effort has been made to determine the direction of growth, and the ability of the several species to penetrate the subsoil. For purposes of comparison one-half the root system of seedling trees of box elder and ash, the seeds of which were planted in April, 1890, was compared with an equal amount of the root system of one-year-old transplanted trees of the same species. In December, when the comparison was made, the seedling ash was nine and one-half inches high. The root system consisted of a tap-root extending almost straight down, with fine lateral rootlets. The tap-root was followed to a depth of twenty-four inches, where its diameter was one-sixteenth of an inch. At this depth the subsoil ot yellowish clay began.

The transplanted ash was one year old when transplanted in April, 1890; total height, seventeen inches, fourteen and one-half inches of which grew during the season after transplanting. In digging the root had been cut off nine inches below the surface. No tap-root, nor deep growing roots were found, but three large lateral roots grew out near the surface, and two strong laterals appeared at the point where the root had been cut off.

The seedling box elder was seven inches high when the examination was made. It had an almost straight tap-root which was followed to a depth of twenty-one inches, where it was one-twentieth of an inch in diameter.

The transplanted box elder was one year old and ten and one-half inches high when set, in April. The tap root had been cut off at a depth of ten inches. During the season a number of new roots were formed. One-half of the root system was exposed to a depth of forty-five inches in December. Six deep growing roots were found, each liberally supplied with fine rootlets. The longest was followed forty-five inches, when it was about one-thirty-second of an inch thick. It slanted but little from the perpendicular. Five others were traced down forty inches deep, where they were broken off, but were not much thicker than coarse cotton thread. From this and previous examinations, noticed in Bulletin No. 15, the box elder would seem to have no difficulty in penetrating our clay subsoil.

In examining the root system of a four-year-old ash tree which had been twice transplanted, the last time in the Spring of 1889, one root was followed sixty inches, when it had a diameter of three-thirty-seconds of an inch. At this distance from the crown it was only ten inches below the surface; eight strong roots were exposed in digging half way round the tree, and none grew at a greater depth than fourteen inches. The tree was forty-nine inches high, and had made a growth of twenty-seven and one-half inches this season.

Four transplanted ash trees were examined, and in none were deep growing roots found. It may be the roots seek the lower strata as the trees grow older. If not, the argument against using trees instead of seeds in making plantations, would seem to have force in the case of the ash.

A four-year-old elm, twice transplanted, the last time in 1889, was examined. The tree is four feet high, and made twenty-five and one-half inches of new wood the past season. At a depth of three inches from the surface the main root divided in two, one of which was cut away in digging; the other again divided into six, two of which descended vertically. They were followed to a depth of three feet, where one was three-sixteenths of an inch

in diameter and the other a little smaller. Another root descended at a slight slant from the perpendicular, and two others seemed deep growers, but were not exposed. The soil where this tree stood was: Black soil, eighteen inches, then eleven inches mixed soil and gravel, then the clay referred to above.

A four-year-old black wild cherry, twice transplanted, the last time in the Spring of '89, stood thirty-three inches high when examined. The growth the past season was fourteen and one-half inches. In one-half the circumference of the tree, eight surface roots and two deep growing roots, besides numerous fibrous rootlets near the surface, were exposed. The deep growing roots were traced to a depth of twenty-two inches. They grew in a slanting direction, one being twenty-seven inches and the other twenty-two inches long. Where broken off they were like fine thread in thickness.

A three-year-old maple (*Acer dasycarpum*,) once transplanted, in the Spring of 1889, was forty-seven inches high, and made thirty-four inches of growth during the past season. Most of the roots exposed in one-fourth the circumference of the tree were near the surface. One root was traced which at twenty-two inches from the crown was twelve inches below the surface; here it turned almost straight down and was followed to a depth of thirty-five inches from the surface, where it divided into two branches, each one-sixteenth of an inch in diameter, with four others but little smaller.

A three-year-old cottonwood which had been transplanted in the Spring of 1889, when one year old, showed a growth for the past season of forty-two inches. The root system was much branched, beginning an inch below the surface. Three roots were traced almost straight down a distance of three feet, where the largest was almost three-eights of an inch in diameter. Four large surface roots were exposed, which grew almost parallel to the surface at depths of from two to five inches. One-half the circumference of the tree was examined.

A Certinensis Poplar, three years old from cutting and once transplanted, in the Spring of 1889, was fifty-six inches high when examined, the growth of the past season being twenty-eight inches. In one-half the circumference of the tree five surface roots and two deep growing roots were exposed. The deep roots

were traced to a depth of forty inches, where the larger one was one-sixteenth of an inch in diameter.

It will be seen that the green ash is the only species of those examined in which no deep growing roots were found, after the tree had been transplanted

The seedling ash, however, showed a great depth of root in proportion to its height. The above figures demonstrate the ability of the trees to penetrate the subsoil in this locality. If, as I have been informed, this clay subsoil is common throughout the State, there can be little doubt that forest trees will have no difficulty in becoming established in it. The figures also indicate that most of the species commonly grown in the State, send out deep growing roots when transplanted the same as though the seed were sown where the trees are to stand.

INSECT ENEMIES.

The chief pest of the year has been the cottonwood leaf beetle, *Lina scripta*, which it was found impossible to entirely destroy. The beetle appeared about the middle of June, and at first attempts were made to prevent its ravages by destroying the mature insects before the eggs were laid; but as the adults continued to appear during quite a long time this method was not effective, though doubtless the pest was materially lessened.

The trees were sprayed with a solution of London Purple (100 gallons of water to one pound) twice during the season; in treating cuttings set out last season spraying proved effective, but in the treatment of the trees in the plantation, which were from four to seven feet high, the poison was apt to miss a few of the infested leaves, and enough insects were thus left to do considerable damage, though no trees were killed by them.

All the species of *Popnlus* (poplars) and *Salix* (willows) were more or less infested. *Populus certinensis* suffered most, and the remainder were injured in the following order: Cottonwood, *Populus nolester*, *P. pyramidalis*, Salix laurifolia (Laurel-leafed willow,) Salix fragilis, *P. bolleana*.

It becomes a serious question whether it would not pay to cease the cultivation of the cottonwood, poplars and willows, if this beetle continues to increase. The farmers of the State can-

not afford to buy spraying apparatus and insecticides, and take valuable time for their application to save trees which at their best are inferior to soft maple in economic value. Moreover, successful spraying in tree claims that have reached a height of fifteen feet is almost an impossibility. I was impressed with this fact during a visit to the excellent plantation of Mr. Perry Lewis. About five acres had been planted with alternate rows of cottonwoods and boxelders. They had made good growth and at the age of seven years the trees averaged fifteen to twenty feet high. At the time of our visit, in July; the cottonwoods were badly infested with the leaf beetle, and I have since learned that very great damage resulted. The trees were planted close in rows six feet apart. It would have been impossible to have handled a spraying machine among them. The question is so serious as to almost warrant one in recommending a boycott of the poplar and willow tribe for a number of years, or at least until the entomolgists can discover some practical way of destroying their insect enemies.

In some parts of the State neither the cottonwood leaf beetle nor the elm saw-fly have made their appearance, and in such localities the suggestion to discontinue their culture for a time will have no weight. Indeed, notwithstanding the low value of cottonwood and the difficulty of bringing it to maturity, it has filled a peculiar place in the tree planting of the West, and perhaps nothing can exactly fill its place. It will probably continue to be the pioneer tree, to be supplanted as the country is more fully occupied, with more enduring and valuable species.

The larvae of the elm saw-fly (*Cimbex Americana*) worked a little on the leaves of the willows, but as there are only a few trees of the genus in the plantation little damage resulted. This worm readily succumbs to arsenical poison.

The large green worm which is the larval form of the emperor moth (*Platysamia cecropia*) denuded a few box elder trees, but the number was not great, and they were easily removed by hand. This pest is quite as serious in some parts of the State as the cottonwood beetle and elm saw-fly here.

In this vicinity a parasite is rapidly destroying the emperor moths.

The cut worm did very little damage during the past season.

Its depredations were confined to the plats where seeds were planted, noted above.

A borer (*Aegeria syringæ*) made its appearance in the trunks of the ash trees two years ago, and seems to be increasing to an alarming extent. At first it was only found in street trees and in isolated groups on the College lawn. The past season it was discovered in the seedling plat north of the College buildings which contains a large group of ash trees, the seed of which were planted in the fall of 1887. It works in the trunk only, and so weakens the trees that they are easily blown down by the winds.

The box elder twig borer has done considerable damage through the year. It works in the joints of the young twigs, which enlarge somewhat and thus indicate its presence.

THE VALUE OF LEAF CANOPY.

In planting trees in this State, all natural aids to cultivaton should be secured by the planter. The most important of these, probably, is the use of dense shading trees for the great part of the plautation; this will most quickly enable the trees to care for themselves. All plantations should embody at least three purposes: protection, fuel supply and wood suitable for farm uses. To these may oftentimes be added a fourth purpose—the saving of snow and rain-water to the fields of the farm. Protection demands the use of quick growing species, and to a great extent, tho' never satisfactorily, a fuel supply is insured by the planting of such trees. But for the many uses to which timber is put on the farm—for fence posts, and machine repairs, and parts of farm buildings, hard wood species are necessary. Hence it would seem that a judicious mixture of rapid growing soft wood and hard wood species would be most profitable for the prairie planter.

In rapidity of growth nothing that will grow in the State equals the several forms of poplar or cottonwood. In many plantations I have noticed that the cottonwood trees are a third taller than boxelder planted at the same time. This, with the availability of the species, is doubtless the reason why it has been so largely planted in South Dakota and the prairie states generally. But for planting in this state the boxelder possesses

many points of superiority over cottonwood, the principle of which is the *density of its foliage*. The leaves of the cottonwood are comparatively small, and they have a tendency to hang with the edges toward the ground, the two surfaces thus being equally exposed to the light. The leaf-stems are very flexable, and the slightest breeze stirs the leaves. These things prevent dense shade, and cottonwoods thirty feet high will not begin to shade the soil as well as boxelders of half their size.

The crowns of the trees touching each other is called the leat canopy, and just in proportion to the density of the leaf canopy will be the herb growth. Until the trees are firmly established all grass and weed growth should be prevented. During the first years the planter secures this condition by good culture, but this is a heavy item of expense, and the time taken for tree culture, which brings no cash return, is regarded too often as wasted. Varieties should therefore be selected that will shade the ground as quickly as possible. Nothing that succeeds in the Northwest is so available for this purpose as box-elder. It is native along all the rivers of the State, it produces seed in great abundance, and the seed germinate readily. If the planter prefers to buy young trees, nothing is cheaper. It is hardy and grows only less rapidly than the poplars and willows. In our own plantations trees that had been grown in the nursery one year, and set in the plat at two years of age, are now seven feet high, and the shade they gave the past season was very noticeable. Our plantations are not yet old enough to show the effect of boxelders as nurses for the slower growing hard wood trees that are planted with them. During the inspection of Mr. Lewis' trees, referred to above, it was found that white walnut, over a hundred of which are scattered through a plantation composed principally of box elder, had grown straight and tall, almost equalling the boxelder trees in height. The ash also showed a much straighter trunk in this plantation, than in another part of the tree claim where it composed the entire planting. The trees are seven years old, and the leaf canopy is perfect. They stand four feet apart, and are now about ready for their first thinning. Mr. Lewis practiced clean culture and only trimmed his trees sufficiently to permit the cultivator to pass

among them. The silver maple also may be regarded as an excellent quick growing species that makes a dense leaf canopy and is hence suitable for the larger part of a plantation in which elm, ash and other hard wood species are intended as the permanent trees. In any system of mixed planting the dense foliaged trees should form the greater part of the planting, and the more valuable species should be placed at wide intervals, so that whatever thinning is necessary will serve to give them additional room for development. Fortunately certain of the most valuable species that can be grown in South Dakota, preserve a dense leaf canopy until they are fully grown. Of these, the maples and boxelder, elm and ash may be named. The thicker the crop of leaves produced by the plantation the more leaf-mold will be formed. And a dense leaf canopy will insure the perfect and gradual formation of humus. Hence it is important, in selecting varieties for a plantation, to bear in mind not only the early formation of a dense leaf canopy, but to include species that shall insure the dense leaf canopy when the plantation is mature.

From observations made in numerous plantations in the eastern part of the State, and from such reliable information as I have been able to gain, I regard the following as the best species for forest plantations in South Dakota:

Quick growing, dense shading trees: Box Elder (*Negundo Aceroides*), Silver Maple (*Acer dasycarpum*).

Slower growing, more valuable trees: Ash (*Fraxinus viridis* and *F. Americana*), White Elm (*Ulmus Americana*), Black Wild Cherry (*Prunus serotina*); and for deep soils in the southern part of the State, Black Walnut, (*Juglans nigra*) and Butternut (*J. Cinerea*).