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FOREST PLANTING IN WESTERN KANSAS.

By

R. S. KELLOGG,
ASSISTANT FORESTER.

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INTRODUCTION.

The investigations upon which this report is based were made for the purpose of determining the kinds of forest trees best adapted to western Kansas and the methods of treatment which have proved most successful. Since there is little likelihood that more than small local areas of the region can ever be irrigated, only the species which can be grown without irrigation are described. With an artificial supply of water better results can be obtained with these species, and others that could not be grown without it can be introduced.

Whatever may be the reasons for the absence of natural forests on the Great Plains, a close study of established plantations proves that, with an intelligent selection of species and proper care, planted trees can, to some extent, be made to supply the deficiency.

It is generally accepted that for the most successful agricultural conditions from 10 to 25 per cent of the land should be forested. There is little likelihood that this proportion will ever be attained in western Kansas. Yet the planting that will come as the State increases in age and wealth will be sufficient to exercise a marked effect on the landscape, and to supply wood for many domestic purposes. In favored localities commercial returns may be expected; elsewhere the recompense to the planter will take the form of increased comfort and convenience. The American has in many regions ruthlessly destroyed his natural forests, but with characteristic energy he is creating woodland where none existed before.

On the Plains the most extensive early plantings were made to secure title under the timber-culture law. They generally resulted in failure because of poorly chosen species and neglect. The man who made a timber-culture filing did so to get 160 acres of land, not because he cared for trees, or had sufficient experience to grow them. If he could evade the law and "prove up" without any trees whatever, he was altogether too likely to consider himself that much ahead. There were some well-planted and conscientiously cared-for claims, which now speak for themselves. The majority, however, amounted to little or nothing. After various modifications, the law was repealed in 1891.

The landowner now plants because he wants trees. Consequently he is careful in his choice, and gives more after attention than did his predecessors.

TERRITORY COVERED.

The region most closely examined for this report was that part of the State westward of the ninety-ninth meridian, which passes near Kearney, Nebr., along the western edge of Smith, Osborne, Russell, Barton, Stafford, Pratt, and Barber counties, in Kansas, and a few miles west of Alva, Okla. But since the State boundary is wholly artificial, the conclusions reached apply equally well to neighboring portions of other States. The study may therefore be said properly to cover the territory lying between the Platte and the Cimarron rivers, and between the ninety-ninth and one hundred and third meridians. It thus includes a little of northern Oklahoma, a considerable strip of eastern Colorado, and a portion of southwestern Nebraska.

PHYSICAL FEATURES.

This region is a part of the long eastward slope from the Rocky Mountains called the "Great Plains," and on the west includes much of the subdivision which geologists have named the "High Plains." The altitude runs from between 1,500 and 2,000 feet on the eastern border to 4,000 and over on the western. Although the rise is so uniform as to be scarcely perceptible, with the increasing elevation and diminishing precipitation fewer forest species can be grown successfully.

The principal rivers are the Republican, Solomon, Saline, Smoky Hill, and Arkansas. Smaller tributary streams and creeks are quite numerous.

The soil on the uplands is generally of the type named by Professor Hay "plains marl," and has great depth and fertility. Much of the soil in southern Nebraska is loess, the good qualities of which are well known. In Oklahoma and southern Kansas occur the strikingly red sands and clays of the Red Bed formation. Valley soils are frequently loamy sand or sandy loam along the main streams, and of heavier character in the minor creek bottoms. Correlated with this difference in soil between the main and tributary streams is the noticeable preponderance of natural timber along the latter. Along the south side of the Arkansas is a belt of sand hills, narrow in the upper part, but widening to some 30 miles south of Great Bend.

Since soil conditions are very uniform, only the types of location based on relative situation, viz, valley and upland, are used in this report. Valley or lowland areas are those along streams, where permanent water exists at not more than 25 feet, a depth beneath the sur-

face not too great for trees to be benefited by it. The upland areas comprise the main part of the region. On them the tree roots never reach water, which is often 100 to 200 feet below the surface.

A sandhill region has more in common with the valleys than the uplands, even when its situation is relatively high. Few people

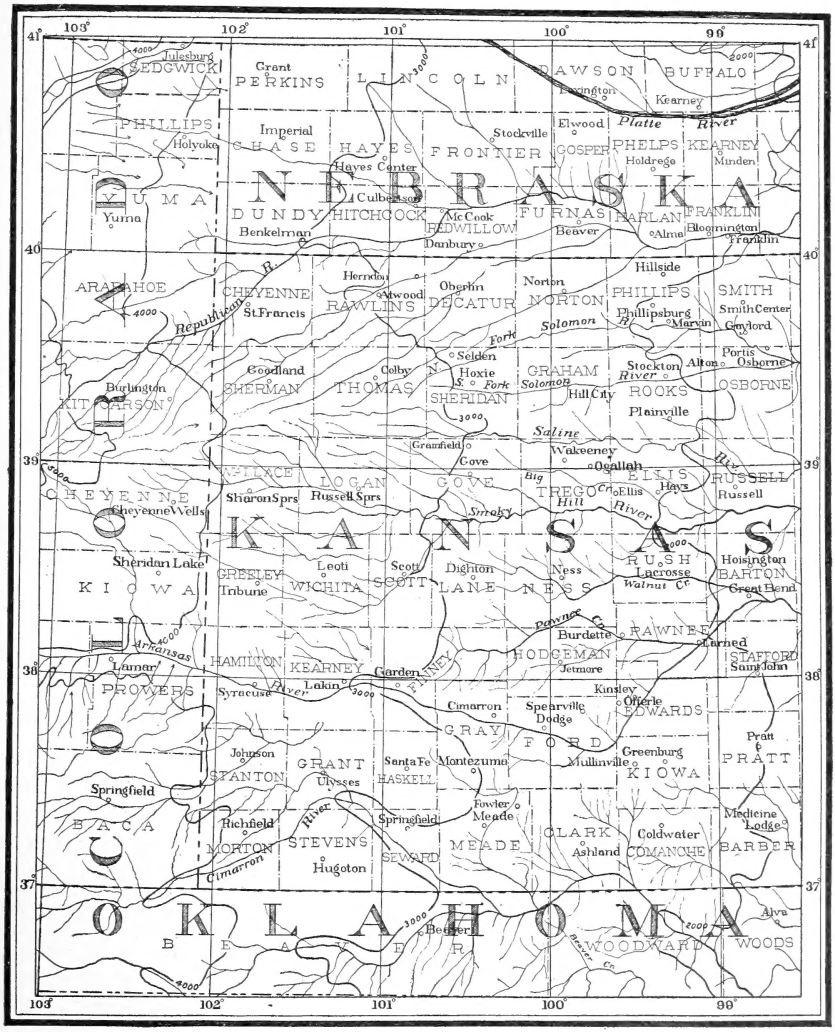

FIG. 1.—Western Kansas and adjacent regions.

realize how much moisture a sandhill soil contains. There is practically no surface run-off; all the water which falls sinks into the ground. The soil never bakes, but is always in a receptive condition. The evaporation is less than from a clay soil, and a larger percentage of the moisture is available for plant use. The cottonwood and the

sandbar willow are found growing naturally in the sandhills of Kansas and Nebraska, which is evidence that good conditions of soil moisture exist. The sandhills, therefore, are favorable localities for tree planting.

CLIMATE.

The climate of western Kansas is ordinarily classified as subhumid or semiarid. Its chief characteristics are those common throughout the Great Plains. The average annual precipitation is sufficient for paying crops. The distribution, however, is subject to great fluctuations. The summer rainfall comes mostly from local thunderstorms, whose erratic courses may or may not overlap. Consequently one locality often receives enough rain during the season, while another a few miles away suffers from drought.

There is also a marked tendency to a succession of wet and dry seasons over the entire region. This is well illustrated by comparing the records at Dodge City for 1883 and 1884 with those for 1893 and 1894. It happens that there is a ten-year period in this case, but observations do not prove any regular periodicity.

Annual precipitation at Dodge, Kans.

Year.	Inches.	Departure from normal.
1883	28.50	+ 8.12
1884	30.36	+ 8.98
1893	10.12	−10.26
1894	12.60	− 7.78

The wet years of 1883 and 1884 were largely responsible for the "boom," which resulted in the rapid settling up of the country between the years 1885 and 1887, while the dry seasons of ten years later caused wholesale depopulation.

The average precipitation at the principal Weather Bureau stations, with the number of years that the record has been kept, is given in the following table:

Average annual precipitation.

Station.	Years.	Inches.	Station.	Years.	Inches.
Wallace	22	17.42	Hays	10	20.88
Lakin	12	14.35	Achilles	10	20.94
Colby	11	17.49	Phillipsburg	11	21.89
Viroqua	10	18.83	Medicine Lodge	10	23.57
Eureka Ranch	12	18.92	Pratt	7	23.78
Garden City	8	18.92	Oberlin	10	23.80
Dodge City	28	19.84			
Gove	13	20.37	Average		19.78
Englewood	10	20.71			

While the record at Dodge City is the only one covering a sufficient period to be considered approximately correct, the others are good

indications, and it may be assumed that the average for the entire region is not far from 20 inches. With this may be compared 26.32 inches, the average annual precipitation for the middle of the State, and 34.33 inches for the eastern part.

It is noteworthy that most of the precipitation on the plains is during the growing season. Dodge City, for instance, with only 19.84 inches annually, has 15.5 inches in the six months from April 1 to October 1. Rochester, N. Y., with 35 inches annually, has but 17.5 during the same period. In other words, 78 per cent of the precipitation at Dodge City comes at the time when it is most needed, while Rochester receives but 50 per cent of its total in the same time.

One of the most disagreeable characteristics of the climate of the Plains is the high winds, which sweep across them unhindered by either natural or artificial barriers. The prevailing direction is northwest in winter and southerly in summer, and soil moisture is absorbed with extraordinary rapidity, especially in the warm season. The dreaded "hot wind," which strikes growing crops with such deadly effect, is a hot, dry blast of air that takes water from the leaf surfaces of vegetation faster than it can be supplied by the roots; consequently plants wilt, and even die, if the wind is long continued. The northerly winter winds, while causing much less evaporation, are hard upon stock and trying for men.

The average wind velocity at Dodge City, Kans., is 12 miles per hour. In spring, however, it is considerably higher, especially in the afternoon hours, when an average speed of 20 miles an hour may be maintained for a month at a time. High winds are also quite frequent. In the ten years ending with 1903 there were eighty-one occasions on which the wind blew at the rate of 40 miles and upward an hour.

As a result of these constant drying winds, taken in connection with other meteorological conditions which prevail in western Kansas, the annual evaporation from a water surface is about 54 inches. This means that if it were possible to have a lake in western Kansas whose level depended wholly upon direct precipitation and evaporation, its annual decrease in depth would be 34 inches. The relative humidity, according to the Dodge City record, averages 60 to 65 per cent. The following table is especially instructive:

Annual precipitation and evaporation.

Station.	Precipitation.	Evaporation.	Excess of evaporation.
	Inches.	*Inches.*	*Inches.*
Amarillo, Tex.	21.94	55.40	33.46
Dodge City, Kans.	19.84	54.60	34.76
North Platte, Nebr.	18.27	41.30	23.03
St. Vincent, Minn.	19.50	22.10	2.60

Thus it will be seen that the great wheat-growing district of the valley of the Red River of the North has a precipitation practically identical with that of western Kansas, and slightly less than the Staked Plains of Texas. The southern region, however, has more wind, higher temperature, greatly increased evaporation, and a more uneven distribution of rainfall. These are adverse conditions for planting and growing trees, and to overcome them requires an intelligent selection of species and a system of cultivation which reduces the evaporation of soil moisture to a minimum.[a]

EFFECT OF FORESTS ON CLIMATE.

Many of the residents of the Plains region believe that increased cultivation of the soil, forest planting, and the building of reservoirs to catch storm waters will cause a permanent increase in the precipitation. But this theory is unsupported by proof. The records that have been kept long enough to warrant any general conclusions indicate simply wet and dry periods of variable length, which result in a fixed average precipitation. Much has been said concerning the effect of forests on climate, but little is known exactly, and most of what is known contradicts the popular beliefs. The most that can be said from the facts at hand is that an increase of precipitation by forests is not demonstrated. Even were it otherwise, planting sufficient to affect general climatic conditions would need to be on so large a scale as to be wholly impracticable.

On the other hand, observations show that within the forest extremes of both heat and cold are modified and that the evaporation from a water surface is less than one-half that in the open, while the evaporation from soil covered with forest litter is about one-eighth that from bare fields. Forests check the run-off to a great extent. The amount of water transpired by a forest is considerably less than that given off by a similar area of ordinary agricultural crops.

These facts point to conclusions about which there is no doubt. Forests are conservers of moisture. They are the best natural means of saving the water that falls, and are of great utility for this reason, regardless of their problematical effect upon the amount of precipitation.

The principal effect of tree planting on the climate of western Kansas will be to check the winds and lessen evaporation in the immediate vicinity of the plantation.

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[a] For a detailed discussion of the climate and geology, the reader is referred to publications of the U. S. Weather Bureau, and the paper, "The High Plains and Their Utilization," in Vol. IV of the Twenty-first Annual Report of the U. S. Geological Survey.

SHELTERBELTS AND WINDBREAKS.

The terms "shelterbelt" and "windbreak" are often used interchangeably. When distinguished, shelterbelt is applied to trees planted in groups of considerable size, while one or two rows to check the wind is called a windbreak. Since this discussion applies equally well to both shelterbelts and windbreaks, the latter term is chosen for the sake of simplicity.

In an open country of high winds, nothing adds more to the comfort of existence than a protecting belt of trees about the home. Whether the wind be the hot one of summer or the snow-laden blast of winter, its force is spent on the trees, and the house within is not swept by every passing gust. Orchards need windbreaks to save them from injury in the gales that accompany summer storms as well as to protect them from ordinary winds throughout the year. Gardens are more successful when surrounded by trees. Windbreaks benefit animals as much as their owners.

Any species that is adapted to the region and suits the taste of the planter may be used for a windbreak. Where they will succeed, evergreens are desirable, since they afford better winter protection than the deciduous species. The man who wants a windbreak, however, does not care to wait for slow-growing trees. The Austrian and Scotch pines grow quite rapidly and serve the purpose well. A windbreak consisting of a single row, to be effective, should be of a densely growing type that branches close to the ground. For low breaks of this character the Russian mulberry and Osage orange are excellent. The tamarix, while more like a large shrub than a tree, does well for low windbreaks around garden patches and similar areas. It is easily propagated by cuttings, grows rapidly, and is quite hardy. The cottonwood is the common tree used for windbreaks in the valleys.

One of the most important functions of the windbreak is the saving of soil moisture within the protected area. In the Monthly Weather Review for September, 1888, were published the results of experiments made by the United States Signal Service to determine the effect of the rate of wind on evaporation from a water surface. The experiments were made with a Piche evaporometer, under constant conditions of humidity and temperature. The figures obtained are given in the following table, in which wind velocity is expressed in miles per hour and the unit of evaporation is that in a calm:

Wind.	Evaporation.	Wind.	Evaporation.
5	2.2	20	5.7
10	3.8	25	6.1
15	4.9	30	6.3

A 25-mile wind is not uncommon on the Plains, and since it causes six times the evaporation that would occur in a calm at the same humidity and temperature, one can easily understand the rapidity with which the moisture from a summer shower disappears. Taken the year through, the wind averages more than 10 miles an hour, which is sufficient to cause four times the evaporation there would be in a calm.

An experiment made by King[a] furnishes some interesting information in regard to the checking of evaporation by a windbreak. He used a modified form of the Piche instrument, placed so as to give the evaporation from a water surface 1 foot above the ground at varying distances from an oak grove. Taking the evaporation at 20 feet from the grove as unity, the following results were obtained:

Distance.	Evaporation.	Distance.	Evaporation.
20	1.00	200	1.41
100	1.29	300	1.66

Neither the height of the grove nor the rate of wind is given, though the statement is made that a light wind was blowing. The table shows that the evaporation at 200 feet from the windbreak was 41 per cent more than at its base, and at 300 feet 66 per cent more. The evaporation from 300 feet onward was practically constant, showing that to be the limit of the influence of the windbreak in this experiment.

While a few accurate experiments have been made to determine how far a windbreak is effective, it is a safe practical assumption that it protects the ground for a distance equal to ten or fifteen times its height—some observers say a rod for every foot. If a large field were crossed by a series of windbreaks 30 feet high and 20 rods apart, there is no doubt that they would be very effective, since the wind would reach each succeeding break with diminished force.

WOODLOTS.

In many situations it will be a paying investment for the farmer to put out a small plantation, simply to produce his own wood for fuel and other purposes. It is true that some time must elapse before the plantation begins to be productive, but by choosing rapid-growing species and planting closely the thinnings which will be necessary in a few years, even though the trees be small, will do for the wood pile and help make the owner independent of coal famines.

[a] F. H. King, Bulletin No. 42, Agric. Exp. Sta., University of Wisconsin, October, 1894.

One may well be thankful if, when the supply of fuel gets low, he can go into his woodlot and cut a load without expense instead of hauling high-priced coal from the distant town.

The choice of species for a woodlot depends somewhat upon the location. Trees that grow rapidly, and at the same time produce good wood, are, of course, preferable. If they also sprout from the stumps, a little care will maintain the supply indefinitely. Where it succeeds, the black locust combines these desirable qualities in the highest degree, and, as mentioned further on, a proper method of handling will generally enable good results to be obtained despite the troublesome borer. The Osage orange also is an excellent tree for the woodlot. Its wood is exceedingly durable, and the sprout growth abundant. While it grows more slowly than the locust, it is hardier, and is free from borers, so that it can be given more time in which to develop. Green ash, Russian mulberry, and hardy catalpa are also good trees for the woodlot, though the range of the last is more restricted than that of the other species.

A mixture of species is often advantageous. By its use differences in habits of growth and ability to withstand shade can be made to assist the development of trees of good form, and at the same time the owner can have both fast and slow growing trees and a wider choice of timber for varying needs. A mixed plantation of hardy catalpa and Osage orange or Russian mulberry has been found to be valuable, since the catalpa forces the Osage orange and mulberry to grow rapidly upward in order to obtain light, while itself shedding its lower branches in the denser shade of its neighbor sooner than it would if it grew by itself.

DETAILS OF PLANTING.

CONIFERS.

The best time for the planting of forest trees is in the spring, just before growth starts. This is also the best time for pruning, which usually accompanies transplanting. Many people hold to the idea that evergreens should be set out in June or August. Evergreens can be successfully transplanted at any season of the year, provided sufficient care is taken. Coniferous trees transpire only one-tenth to one-sixth as much water as the broadleaf species; consequently their roots are not called upon to furnish such great quantities of water to the thirsty leaves before getting established in the new abode. For this reason pines and cedars do not require trimming back when set, and the time of the year is less important than with other species. Nevertheless, the best time for transplanting any tree is the dormant period.

Great care must be taken, however, to keep the roots of conifers moist in transplanting. If the resinous liquids in them once dry out, the tree will not live, no matter how abundant the subsequent supply of water. A young cottonwood may be dug up, shaken free from dirt, and thrown down in the sunshine for several hours without killing it, if the roots are given a good soaking when it is set. The same treatment of cedar or pine would insure death. Nursery stock often dies, either because it dried out on the road or because it was not properly cared for on arrival. Trees that have been shipped should have their roots dipped in a puddle of water and earth, about the consistency of cream, and should be planted as soon as possible. If the conditions are not favorable for planting immediately, they should first be puddled and then heeled in.

To heel in trees, a trench running east and west, and deep enough to hold the roots and about half the tops, should be dug, with its south bank making an angle of about 30 degrees with the surface of the ground. In this is put a layer of trees with the tops leaning to the south. The roots and lower part of the trunks are then covered with fine, firmly packed soil, and water is liberally poured on. In the same way successive layers may be put in until the trench is full. A temporary shade of some sort will lessen the danger of drying out. In the case of evergreens this is very important.

It is often asserted that the native red cedar is sure to die when transplanted, but such is not the case. The experience of a resident of McCracken, Kans., is instructive. He went to the bluffs of the Smoky Hill River, dug up a number of red cedars about a foot in height, immediately rolled the roots in a near-by mud puddle, and kept them moist until set. As a result every tree lived, and growth was scarcely checked. At the same time he received a shipment of cedar from a nursery, used equal care, and lost every tree. The nursery stock had dried out either before or during shipment, while the native trees had been properly handled.

BROADLEAF SPECIES.

For plantations of broadleaf species 1-year-old seedlings are best, because they are easier to handle and also much cheaper than older trees. They ordinarily run from 1 to 2 feet high, and have practically no branches, so that little or no pruning is required. If the ground has been well prepared and is moist, the setting can be done very rapidly. A man and a boy can work together. The boy carries the trees and hands them to the man as wanted. The latter sets his spade full length in the ground, throws the handle forward, sticks a seedling in behind the blade, removes the spade, steps firmly with

both feet on the ground around the tree, and the operation is complete, taking not more than half a minute in all. A number of seedlings can be carried in a bucket partially filled with water, or in a basket with a wet cloth covering the roots. The remainder of the stock should be left heeled in until needed. By this method a thousand trees can be set much more quickly than by the orthodox method of digging a hole, spreading the roots out, filling in with fine dirt by hand, and finally mulching; and with good soil and moisture conditions it is very successful. The writer set out over 500 yearling honey locusts in this manner on March 31, 1903. They were nicely started when frozen back by the snowstorm of April 29, in spite of which all but three lived, and made an average height growth of 3 feet during the season. Similar results have been obtained with black locust, cottonwood, ash, elm, and mulberry.

Another rapid method is to plow a furrow where the row of trees is wanted, lay them against the side of it, cover with a hoe, and tramp firmly. The remaining dirt may be thrown into the furrow with a cultivator. Of course it should be distinctly understood that these methods are only for common broadleaf seedlings when the right conditions exist, and are likely to fail elsewhere.

For large trees much more care is necessary. Little top should be left—a heavy mass of foliage will transpire more water than the roots can supply at the start. Bruised or broken roots should be cut off clean. The roots should be well arranged in the hole and the dirt solidly tramped about them. Unless the earth comes into close contact with the roots the air will get in and dry out both soil and roots and the trees will die. If the setting is done in a dry time, water and puddling are necessary. A good way to water is to have the hole nearly filled with fine, firm dirt, then pour on the water and cover with dry soil. This prevents baking and evaporation.

Trees should be set so that when the ground settles into permanent shape the roots will be covered to the same depth as before transplanting. This means setting 2 or 3 inches below the "collar."

It is a good practice to set deep enough so that when the operation is completed the trees will stand in a shallow depression. This will catch the rain and materially increase the chances of success in a dry season.

An essential requisite in planting is suitable weather. Occasionally there are springs in western Kansas when it is altogether useless to set trees unless water can be supplied whenever needed. The planter who raises his own seedlings can take advantage of favorable conditions, have his trees perfectly fresh, and set when he pleases, or even let them wait until another season.

CUTTINGS.

Willows and cottonwoods and other poplars are very easily propagated from cuttings. Cuttings should be of strong, healthy wood of the previous season's growth, which ripened well and did not shrivel during the winter. A good length is 8 to 12 inches, with the upper cut just above a bud. They may be made when wanted for planting and set with a spade or in a furrow, as described for seedlings. If the ground is mellow, they can be merely shoved into the soil until only one bud is above the surface, and then tramped. Better soil contact is secured if they are put in slanting; the growth will be upright in any case. In favorable seasons cottonwood cuttings often make a height growth of 5 or 6 feet.

RAISING FROM SEED.

Such common species as ash, mulberry, Osage orange, black and honey locust, catalpa, and black walnut are easily raised from seed, and the person who intends planting a large area will find it both cheaper and more convenient to buy seed of some reliable house and raise his own trees.

To insure prompt germination the seeds of the two locusts are treated with hot water before sowing. A leading Nebraska nurseryman who is very successful with his seedlings pours water, at a temperature of 175° F. for honey locust or 120° F. for black locust, on the seed, and allows it to stand for several hours. Boiling water should not be used, since it is likely to destroy the vitality of the seed. There is no doubt that a safe and reliable method for the honey locust is to use water at an initial temperature of 25° to 50° under the boiling point, and then let the seeds soak in lukewarm water until they swell. Seeds which have become very dry must soak longer than those which are fresh. Black locust seeds grow very well without any treatment, but the use of hot water causes more uniform germination.

Heavy-coated seeds, like nuts and acorns, are best sown in the fall, so that they will be opened by the frost. Ordinary seeds may be sown in corn-planting time. The soil should be moist and well prepared. Only a shallow covering of earth is necessary. If the ground is dry, the sowing should be delayed until moisture comes.

With a good season the little trees will be of suitable size to transplant the following spring, and will not require much pruning. The great advantage in having home-grown seedlings is, that they are at hand and ready to take up and set where wanted any favorable day with little danger of drying out. Handled properly they will begin

the second season's growth promptly, and with scarcely any check from transplanting.

Pine seeds germinate readily, but to avoid losing the young seedlings requires so much care for light and moisture conditions that the ordinary planter will do well not to experiment with them. The germination of the red cedar is one of the troublesome problems of nurserymen; so much so that many prefer to buy 1-year-old seedlings, which they transplant and prepare for their own trade.

SPACING.

Spacing is largely a question of utility and taste, with some variation for different species. In general, however, closer planting is advisable on the Plains than most people imagine or are willing to concede. A single tree or row of trees in the sod has little show for life. If an artificial forest is to succeed in the struggle against native vegetation, wind, sunshine, and dry weather, it must stand in a dense mass and present a solid front to its foes. Cultivation is the best method of conserving soil moisture, and if cultivation can be continued indefinitely and the abundant pruning required to produce the proper form where the trees are not crowded can be given, rather wide spacing is beneficial; but the average planter will prefer a method which does not require so much time and work. The less care the trees are to have, the thicker they should be set. They must be close enough to establish forest conditions of shade, litter, and undergrowth when evaporation and weeds are no longer checked by cultivation.

Shelterbelts should be close planted in order to give protection quickly. It is well to plant thickly enough to be able to thin as the growing trees need more room. In this way one can be certain of having good trees. If the ultimate object is to have spaces 4 by 8, or 8 by 8, and the trees are set 4 by 4, the poorer trees can be cut out and a final stand left of better individuals than if the wider spacing had been used at first. The crowding also prevents the trees from heading too low. The thinning will give fuel, posts, and stakes, always useful on a farm or ranch.

The practical consideration is the spacing of the rows in a manner that will admit ready cultivation with the harrow, disk, or other tool for surface cultivation which the farmer possesses. The method of wide spaces between the rows with trees set closely in them is an excellent one, since it permits of cultivation for a much longer time than the 4 by 4 spacing, gives room for a team and wagon when thinnings are made, and still allows a large number of trees to the acre. A 2 by 8 spacing gives the same number of trees per acre as a 4 by 4 spacing, and 3 by 8 the same as 4 by 6.

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The following table shows the number of trees per acre with various spacings:

Spacing.	Number of trees per acre.	Spacing.	Number of trees per acre.	Spacing.	Number of trees per acre.
Feet.		*Feet.*		*Feet.*	
3 by 3..	4,840	3 by 6..	2,420	4 by 6..	1,815
3 by 4..	3,630	3 by 8..	1,815	5 by 5..	2,742
3 by 5..	2,904	2 by 8..	2,722	4 by 8..	1,361
4 by 4..	2,722	4 by 5..	2,178	8 by 8..	680

The number required for any system is found by dividing the number of square feet in an acre (43,560) by the product of the two dimensions. For example, the last number in the table, 680, is the quotient obtained by dividing 43,560 by 64.

COST.

The cost of planting is not great. At ordinary prices $1.50 per acre will cover the expense of plowing and harrowing. After the ground is prepared the planting of small broadleaf trees will cost about $2.50 to $4 a thousand, according to the method used and the soil conditions.

The planting of ground occupied by virgin sod is not only laborious and expensive, but is generally unwise. The treatment of such land requires the breaking of the sod, followed by a second plowing and the cultivation incident to the growing of cereal crops for two or three seasons, before the ground is in suitable condition for the planting of trees. Soils containing a large amount of sand can frequently be put into condition for planting the year following the breaking of the sod.

The price of broadleaf seedlings at the nurseries in Kansas and Nebraska runs from $1 to $6 per thousand. Some nurseries pack free and pay freight on orders amounting to $10 or more. The planter will do well to consult several catalogues before placing his order.

Evergreens are more costly, since they are transplanted in the nursery to give better root development, and may be several years old when finally disposed of. It is possible to obtain red cedar seedlings as low as $4 per thousand, but transplanted nursery-grown cedar and pine of suitable size will cost 10 to 20 cents each and more.

WHERE TO PLANT.

In a naturally treeless region there is occasion for planting almost everywhere. Houses, sheds, corrals, and garden patches need protection and ornament; planted groves will yield timber for posts, fuel,

and the numberless uses which a stick of timber supplies; in parks and along streets trees make a town "a good place to live in;" schoolhouse, church, and court-house yards require embellishment. A good plantation for commercial purposes will afford a steady income, aside from much pleasure and convenience, while it is surprising how greatly a few trees improve the farmstead.

Although general soil conditions vary little throughout western Kansas, there is abundant room for selection. Trees, like other forms of vegetation, respond quickly to good soil and moisture. The species which will grow on the uplands may be depended upon to do as well or better in the bottoms, because of the better conditions. Some trees which grow naturally along water courses do well under cultivation on the upland, while others found in company with the hardy species fail entirely when the change is attempted. Hundreds of failures in upland planting in Kansas and Nebraska have resulted because cottonwood, willow, silver (soft) maple, and boxelder were expected to thrive in dry situations.

Experiment has proved, however, that there are species adapted to almost every locality. On the upland there are local depressions which catch considerable run-off, and so are suited to trees which need more than the normal precipitation of the region. In such a situation on the high upland in the extreme western part of Kansas the writer once found, to his surprise, a row of black walnut growing in the sod, yet looking well and bearing nuts, though the settler who planted the trees had long since moved away and of his sod house only a heap of dirt remained. A cattle trail and wheel tracks served to conduct the rainfall down the gentle grade to the trees, permitting water to collect occasionally at this point. That the original plantation had covered a larger area was shown by a few small stumps farther on, which were all that was left to show the effect of drought and neglect. Nearly every quarter section has an acre or more of depressed land which can be well utilized for tree planting. By putting the moisture-requiring species in the favored situations, and the hardy, drought-resisting ones elsewhere, the planter's range of choice is extended, greatly to his advantage.

CULTIVATION.

The object of cultivation is, first, to prevent the growth of weeds and grass, and, second, to conserve soil moisture. Cultivation is essential for the first few years after planting, and in many cases necessary for a long period. Before trees are set or seed is sown the ground should be put in good condition. Deep plowing, followed immediately by the harrow, saves moisture and prepares the soil for penetration by the roots. After the trees are set, cultivation should be shallow and frequent. An ideal method is surface cultivation as

soon as possible after every rain. The nearer this ideal is approached the better the results will be. A dust mulch is the best of all mulches for saving the water already in the ground and keeping the soil receptive for more.

The pulverizing harrow is an excellent tool for shallow cultivation, and, used frequently enough, it is all that is necessary most of the time. Where weeds have made a good start, an ordinary cultivator may be put in, or a shallow disking given, but the disk should be followed by a harrow to produce proper surface conditions.

After the trees are planted a plow should never be used. Too often the plantation is neglected until weeds have formed a dense mass 3 or 4 feet high, and then, in desperation, a plow is resorted to, without subsequent harrowing. This leaves the ground rough, increasing greatly the loss of soil moisture through evaporation, and forms a dead furrow between the rows, or throws the earth away from the base of the trees, and cuts many roots, both injuring the root system and causing the growth of sprouts. The man who is not willing to take proper care of his trees deserves to lose them, and probably will.

The Rainbelt Experiment Station, at Cheyenne Wells, Colo., furnishes an excellent example of the extent to which cultivation can replace irrigation. This station was established in 1894 in a typical high plains region. The elevation is 4,200 feet, with water 260 feet below the surface. The annual precipitation is about 13 inches. An apple orchard was planted in 1895 with trees of the varieties common farther east, such as Ben Davis, Janet, Winesap, etc., which are in excellent condition, and produce good fruit. The intention is to give two shallow cultivations monthly if possible. The tools used are a 5-tooth cultivator and a dagger-tooth harrow with the teeth set slanting. There are some green ash trees around the orchard a year older than the apple trees, which are thriving finely. Young honey locusts are also in promising condition. There is no doubt that under the same method of cultivation several forest species could be successfully grown.

The Pomeroy Model Farm, at Hill City, Kans., which has been practicing the "Campbell system" of cultivation since 1900, is a valuable experiment. While the main object is the production of wheat and other crops, fruit trees, Russian mulberry, silver maple, and white elm have been set out. They are doing finely so far, although it is a very unfavorable situation for the maple, and only fair for the elm. Cultivation is given after every rain as soon as the ground can be worked. A pulverizing harrow is generally used, preceded by a disk if the weeds are too large.

Cultivation should not be continued too late in the fall, for it tends to produce a growth of young shoots after the normal period, which may be too tender to withstand the winter. The wood should have time to harden before cold weather sets in. There is more likelihood

of injury in this way to fruit trees, however, than to forest trees. If the ground has been previously kept clean, weeds will make little trouble after the middle of August. In river and creek valleys, where water is from 5 to 20 feet below the surface, cultivation is not ordinarily necessary after the trees get thoroughly established. The same is true on the upland where shallow basins catch the run-off from a considerable area.

In ornamental planting a combination of trees and lawn is often desirable. Yet a single tree, or row of trees, has small chance for survival in the struggle with the aggressive grass roots. Consequently a compromise is necessary. Before planting a single tree the ground should be dug up and thoroughly pulverized over a circular space 5 to 10 feet in diameter, and to a depth somewhat greater than that at which the tree will be set. Afterwards the surface may be stirred by hand or mulched. For a row of trees, a strip 5 to 10 feet wide should be given similar treatment.

In much ornamental planting, however, it is advisable to put the trees in groups, so that they protect one another and may be cultivated. A group system in landscape work gives an excellent effect, which is wholly lost if the trees are restricted to formal rows or scattered about promiscuously.

Mulching with hay, straw, or manure is practiced to some extent. It is better to mulch than to let the weeds grow. The mulch also checks evaporation, prevents baking of the soil, and keeps it in good condition. The complaint is sometimes made, however, that long-continued mulching brings the roots too close to the surface, and then if it chances to be removed they are exposed. The mulch certainly furnishes a congenial harbor for all kinds of insects.

The best mulch in all respects is the dust mulch secured by cultivation, while the most suitable place for the one of hay or straw is around trees set in the sod where it is inconvenient or undesirable to cultivate.

Occasionally field crops are planted between rows of young trees, but the person who has any regard for their welfare will not do so. The trees need all the moisture, and should not be forced to divide with other vegetation. Corn is especially harmful. The roots will spread both down and out for 3 or 4 feet, and take much more soil moisture than the young trees. If any crop is to be planted, it should be potatoes or other short-lived vegetables. Their roots do not spread far and are soon gone, while the return from them will be sufficient to pay for the cultivation which should be given to the trees, even were they planted alone.

A sure way to ruin a young plantation is to turn cattle into it. Even if the trees are too large to be broken by rubbing, every branch within reach will be destroyed, as will also the forest conditions of

shade and undergrowth, so that weeds and grass can easily get a foothold. Large trees, however, are usually not much damaged where moisture is abundant, and the protection furnished to stock in such a case may be worth the loss. The principal injury to old trees is from trampling. A heavy soil becomes packed until it is nearly impervious to water, while sandy ground is worn away and the roots are left exposed.

PRUNING.

The necessity for pruning depends upon the purpose of the plantation. In windbreaks and shelterbelts the trees should be allowed to branch freely near the ground in order that the density may be increased. This will furnish better protection, and will also retard the growth of weeds and grass.

Broadleaf species that are planted for ornamental purposes need more or less judicious pruning. Nature prunes heavily, as is shown by the multitude of small dead branches in the forest. Man aids in the development of a symmetrical tree by removing unnecessary or unsightly branches before they die. The removal of numerous laterals concentrates the growth more on the leading shoots, and increase their length. Slender growth should not be encouraged, however, unless in a well-protected situation.

The natural habit of the Plains species is low and spreading, and nature is generally successful in evolving types suited to her needs. In a certain sense pruning accompanies cultivation; care makes pruning more advantageous. Trees left to fight for life with weeds and grass should be allowed to do it in their own way. But all the deciduous trees mentioned in this report will have a better form with pruning and care than otherwise. In the case of the Osage orange and Russian mulberry in particular, severe trimming is necessary to force them into good proportions. In figure 5 is shown an Osage hedge that has been long neglected, which will now, by thinning and pruning, be made to produce posts. The results of the same treatment of a mulberry row are given in figure 4.

A good method for securing straight, vigorous young trees is to cut them back to the ground one or two years after planting. The root system is so well established at this age that strong, rapidly growing sprouts are sent up. By removing all but the thriftiest one a tree is soon obtained which is better than the original. This method has given excellent results in catalpa plantations, and should be used with any young tree that is not developing properly, provided it is a species that will sprout.

There is ordinarily no need of pruning conifers. A thriving pine or cedar develops symmetrically and appears better when untouched by the knife. The red cedar, however, may be cut down to a very good evergreen hedge.

Pruning may be done with success at any time, "whenever your knife is sharp," as is sometimes said; but the best time seems to be late winter or early spring, just before growth starts. Wounds made then begin to heal quickly and have the whole growing season in which to recuperate.

More important than the time of pruning is the kind of cut made. Branches should be severed close to the parent stem and in such a manner that the exposed surface conforms to its shape. The cut should always be clean and smooth. When the ends of twigs are removed, a slanting cut is best. Ragged wounds are almost as bad for trees as for human beings. In both cases they delay the healing process and are likely to have serious effects. A projecting stub left by ignorant or careless pruning dies before it can be covered by new tissue, and gives disease and insects easy access to the heart of the tree. Clean wounds made in pruning forest trees (except some conifers) heal quickly, and no treatment is necessary for them unless they are very large. A dressing aids healing only by keeping out water and fungous enemies; therefore it should be durable and antiseptic. Coal tar is a cheap and effective material for dressing the wounds of forest trees. Lead paint is recommended for all species.

SEED BEARING.

Persons who desire to plant trees often ask, "Do all trees of this species bear seed, or only part of them?" It is a matter of common knowledge that the flowers of many kinds of trees are not perfect, but consist of staminate and pistillate forms, the latter of which only produce seed, and that only when fertilized by pollen from the former. Sometimes the same tree produces both kinds of flowers, but in many cases only pistillate or only staminate flowers. When the latter is true something like half of the trees will be seedless; nor will even those which bear pistillate flowers produce seed unless a tree with staminate flowers stands near enough for the pollen to reach them.

In the following list the trees are placed on the first and second columns according as the individuals do or do not possess the power to fertilize their own flowers.

Trees all of which may bear seed.	Trees of which some individuals can not bear seed.
Honey locust.	Osage orange.
White elm.	Russian mulberry.
Austrian pine.	Green ash.
Scotch pine.	Red cedar.
Black locust.	Cottonwoods.
Hackberry.	Willows.
Black walnut.	Boxelder.
Hardy catalpa.	Silver maple.
	Ailanthus.
	Wild China.

Since cottonwoods fall in the second group, and are easily grown from cuttings, there need be little difficulty in getting trees that are free from the objectionable "cotton." All that is necessary is to propagate by cuttings from staminate individuals. A little observation will show which trees have no cotton, and cuttings can be made from them the next season.

SPECIES PLANTED.

All of the trees in the list on page 23 have been planted more or less widely in western Kansas, except wild China and the willows. Other trees which have received some trial, though not very commonly planted, are bur oak, white poplar, Lombardy poplar, Russian olive, Chinese arborvitæ, blue spruce, sycamore, and coffee-tree. The number of species which have been tried is an indication of the experience which the tree planting of thirty years has yielded. With the information thus gained to draw on, the planter is now in a position to avoid many past mistakes.

USES OF DIFFERENT SPECIES.

UPLAND SPECIES.

For upland planting under ordinary conditions, the trees which have established their superiority are honey locust, Russian mulberry, Osage orange, and red cedar. Next in hardiness to these, and of good promise, are white elm, green ash, hackberry, Scotch pine, and Austrian pine.

VALLEY SPECIES.

All upland species are excellent for valley planting as well. To them may be added, in many localities, cottonwood, silver maple, box-elder, black walnut, and hardy catalpa. Several other species not suitable for general use may be grown in selected situations.

HEDGE SPECIES.

For hedges should be used, according to the style and purpose of the hedge desired, honey locust, Osage orange, Russian mulberry, or Russian olive.

COMMERCIAL SPECIES.

The best species to plant for posts and other timber are Osage orange, black locust, Russian mulberry, and hardy catalpa.

STREET SPECIES.

For street and roadway planting the most suitable trees are honey locust, green ash, white elm, and hackberry.

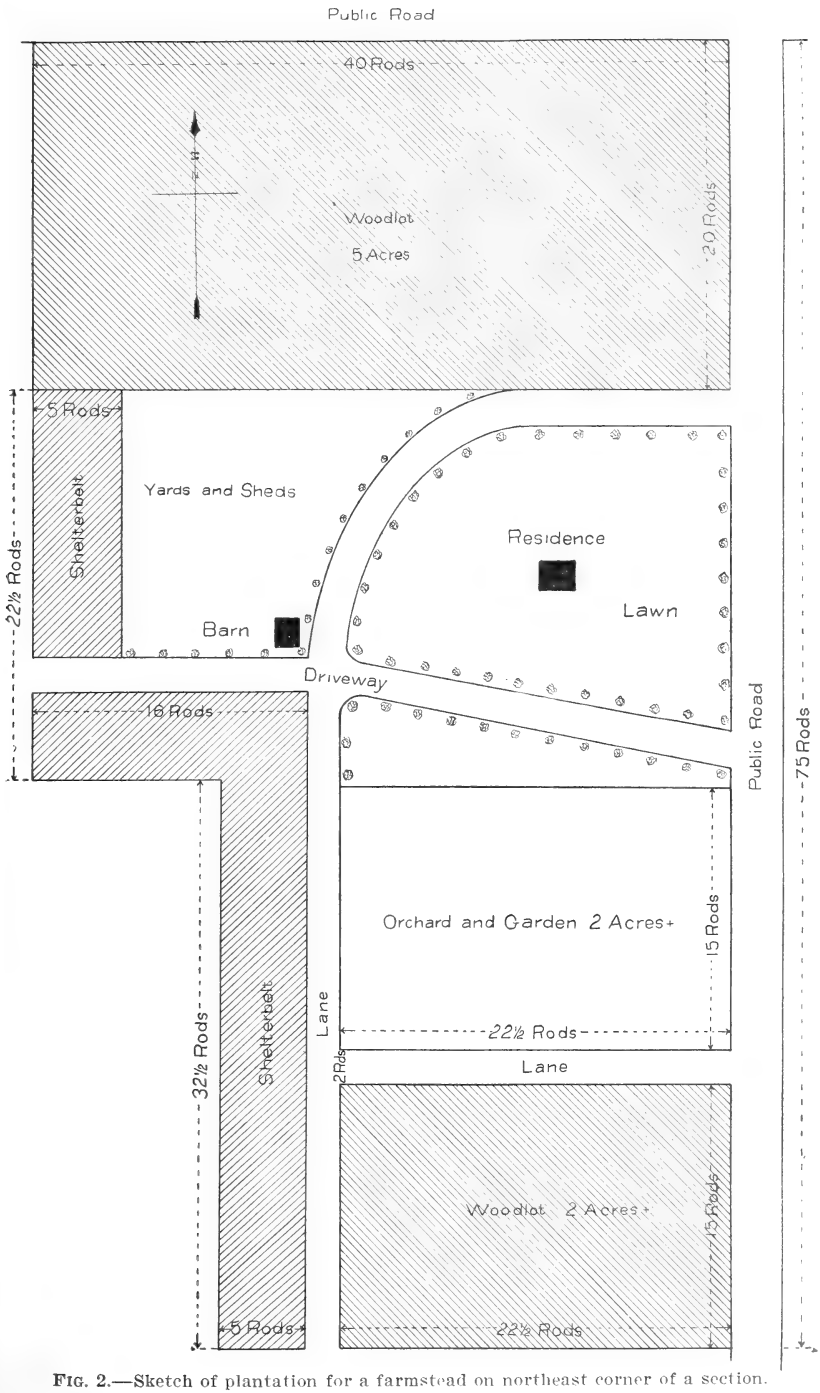

FIG. 2.—Sketch of plantation for a farmstead on northeast corner of a section.

PLANTING PLANS.

The following plans show the kind of planting best suited to the needs of the average farmer and ranchman in western Kansas. Two locations are given, one at the northeast corner of the farm and the other at the southwest corner. The object of these plans is to indicate methods which are practical and inexpensive. Their details may readily be modified to meet individual requirements. While most people are not in the habit of using 15 acres or more for their buildings and grounds, it is believed that they will find it both convenient and profitable to use a greater area than they do at present. Ten acres of artificial timber would be a valuable addition to any farm, and would pay good interest on its cost in increased comfort and convenience, if in no other way.

A NORTHEAST CORNER.

Figure 2 gives a sketch of a farmstead on the northeast corner of a section or quarter section. The extreme dimensions are 75 rods north and south and 40 rods east and west. The total area is 16 acres. A woodlot 20 by 40 rods, containing 5 acres, extends across the north end and serves also as a shelterbelt. Another woodlot 22½ by 15 rods, or a little more than 2 acres, serves the same purpose on the south. The entire west side is protected by a belt of timber 5 rods in width. The orchard and garden are set next to the south woodlot, in order to be fully sheltered from the hot, dry southwest winds of summer. The barn and yards are placed so as to receive the most protection from the north and west, to secure warmth in winter. The residence is put in the open space, far enough from the trees to secure a good circulation of air, and yet close enough to be sheltered from heavy winds. It should be well back from the public road and at the same time some distance from the barn and sheds. Lanes and driveways 2 rods in width give ready access to the public road, fields, woodlots, and orchard. Trees set along the road and driveways 2 rods apart improve the appearance greatly, and do not seriously obstruct the view. This plan calls for practically 7 acres of woodlots and 2 acres of shelterbelt.

A SOUTHWEST CORNER.

Figure 3 gives a sketch of a farmstead on the southwest corner of a section. It is 60 rods north and south and 40 rods east and west, and contains exactly 15 acres. As in the other case, a 5-acre woodlot extends across the north side, and one of a little more than 2 acres across the south. The west side is protected by a shelterbelt 1 acre, 5 rods wide and 32 rods long, leaving 8 rods on the public road open in front of the residence. Lanes and driveways are 2 rods wide, as before, and lined with trees 2 rods apart. This plan provides for

7 acres of woodlot and 1 acre of shelterbelt, and has the advantage of being simpler and more compact than the previous one.

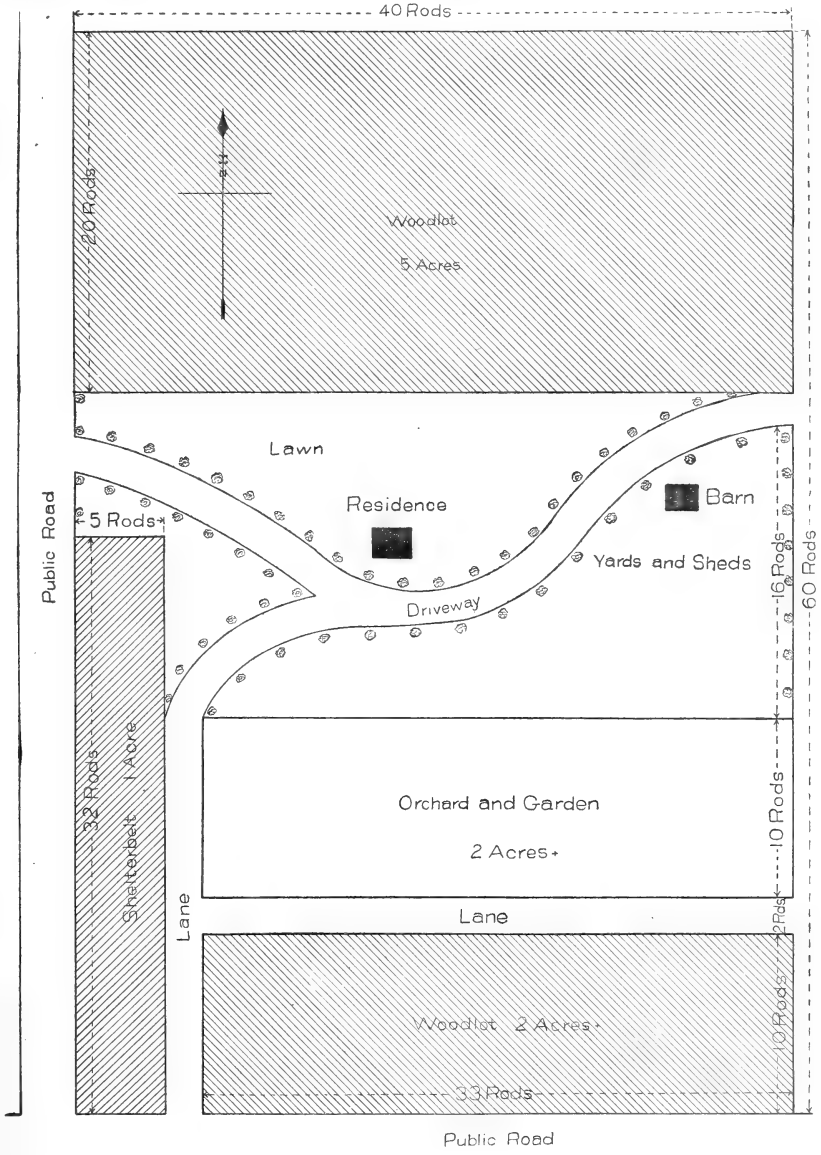

FIG. 3.—Sketch of plantation for a farmstead on southwest corner of a section.

PLANTING THE SHELTERBELTS.

The rows of trees in the shelterbelts run north and south. They should be planted 4 by 8, and thinned to 8 by 8 when the trees get

larger. The original distance may be 4 by 4, if the planter wants to be certain of a dense stand and is willing to do more thinning. He will gain additional fuel by so doing. Cottonwood is the best shelterbelt tree for most valley situations, and honey locust for the upland. It is an excellent plan to have either cottonwood or honey locust for the primary shelterbelt tree, with provisions for eventual replacement by pine or red cedar. Cedar is the best to mix with cottonwood, since it is more shade-enduring than pine. The trees should be mixed in the following manner, C indicating cottonwood and R cedar:

R C R C R C

C R C R C R

R C R C R C

As the cedar needs more room, the cottonwood should be gradually removed until a pure stand of cedar is left.

For an upland shelterbelt, honey locust and Austrian pine may be mixed in the same manner and with the same spacing. The final removal of the locust here gives a belt of pure pine. Red cedar may be substituted for the pine if preferred.

PLANTING THE WOODLOTS.

The rows in the woodlots run east and west. They should be 8 feet apart, with the trees 2, 3, or 4 feet apart in the rows, according to the species planted. In the valleys the trees used should be Russian mulberry, Osage orange, black locust, green ash, or, in some situations, hardy catalpa. If planted exclusively to Russian mulberry or Osage orange, the spacing should be 2 by 8 to overcome the low-branching habit of these trees. If green ash or catalpa is used, a 4 by 8 spacing is best, as also for black locust if the planter will give good cultivation, since in this way the tree will probably reach post size before the borers do much damage. A mixture of catalpa and Osage orange does well, since the Osage orange protects the delicate foliage of the catalpa from the wind to some extent, and at the same time aids the latter tree in shedding its lower limbs and making better form, while the greater height growth of the catalpa forces the Osage orange upward.

For the north woodlot the planting should be as follows, the spacing being 4 by 8. The catalpa and Osage orange are indicated by C and O, respectively:

NORTH.

O O O O O O O O O
O C O C O C O C O
O O C O C O C O C
O C O C O C O C O

The outside rows on the north and west sides are of pure Osage orange, to furnish a windbreak for the catalpa. For the south woodlot the outside row on the south should be wholly Osage orange, for the same reason. In this case the west side is protected by the shelterbelt; if it were not, the row on the west side should be Osage orange also. Russian mulberry may be substituted for the Osage orange, either wholly or partially, as the planter chooses.

On upland situations the best trees for the woodlot are Russian mulberry, Osage orange, green ash, and black locust, with the same spacing as in the valleys. Little except variety is gained by mixing these species, and the matter may be left to the individual taste of the planter. Since after a few years there will be constant cutting in the woodlot, thus affording an opportunity for weeds and grass to get a foothold, cultivation should be kept up as long as possible. The trees will be thriftier as a result, and reproduction from the stump will be stronger. The 8-foot space between the rows allows easy cultivation, and access for a wagon where cuttings are made. Cutting should be selective instead of clean, the object being to improve the condition of the plantation as well as to secure posts and wood. It is better to cut a scrubby tree and let it sprout up again than to try to help it by removing its healthier neighbors. A number of sprouts will start from the stump the first season after cutting. At the beginning of the second season all but the strongest one should be cut off, leaving it to form the new tree.

ROADSIDE PLANTING.

Both plans call for trees 2 rods apart along the driveways and public road. These are a great improvement to the place, and are so few in number that they will make little extra expense or work. Whether the situation be valley or upland, the most suitable species are honey locust, white elm, and Austrian pine. These should not be mixed; a single row of trees appears better when it contains the same species throughout. A small area should be cultivated around each tree until it is thoroughly established.

NOTES AND MEASUREMENTS.

The material for the notes and measurements which follow was secured from typical examples of planted trees now growing in western Kansas and adjoining territory. The figures, however, should be regarded as approximate and suggestive rather than as accurately indicating what may be expected in any given case. Conditions differ so widely that it is impossible to lay down any fixed standard or average rate of growth. The same species, which in one place planted in a single row, reaches large diameters, forms in another a dense

plantation, with correspondingly small diameters for the same age. Cultivation likewise ranges from the best of care to total neglect. Nevertheless the best basis of classification is relative situation. In general, growth is more rapid in the valleys than on the uplands. This rule, it is true, is not without its exception. Good cultivation on the upland will often cause trees to grow as rapidly for a few years as those in the valleys which have received less care. Some kinds of trees also show very little increase in rate of growth in the more favorable situations, while others respond strongly. The red cedar measurements, for instance, are so nearly identical on upland and in the valleys that all are put in one table. On the other hand, the rate of growth of the upland Osage orange is but little more than 60 per cent of that in the valleys.

Since the superiority of valley over upland situations consists in the better supply of water, upland plantations which are irrigated conform closely to the valley type. The measurements for each species are therefore arranged (except in the case of red cedar) under the two heads of "upland" and "valley or watered." In selecting trees for measurement, examples have been sought which grew under something like average conditions of care and density, thus avoiding cases of exceptionally rapid or slow growth due to special circumstances.

The age of a tree in the natural forest can be determined by cutting it down and counting its annual rings. This liberty can seldom be taken with trees planted in yards, hedges, and shelterbelts. The owner's recollection of the date of planting is generally the sole source of information available. This is frequently inaccurate, and the investigator must make allowance accordingly.

In the tables, the place where the measurements were made, or the nearest town, if in the country, is given in each case. The height, diameter breasthigh, and time required to grow 1 inch in diameter are obtained by averaging together trees of the same age and growing under similar conditions. For example, the first entry under honey locust is Smith Center, Kans. The trees selected for measurement there were all planted at the same time, in the court-house yard, and had made about even growth.

HONEY LOCUST.

The honey locust, which grows naturally in the valleys of eastern Kansas and Nebraska, has proved to be one of the hardiest trees for planting on the uplands in the western part of both States, even where the precipitation is not more than half that of its native habitat. It is equaled in drought-resisting power by the Russian mulberry and

the Osage orange, but both of them freeze back in winters which the locust endures uninjured. It can withstand even the climate of eastern Wyoming, having succeeded at Cheyenne. The red cedar is unsurpassed in ability to survive general adverse conditions, but the locust is more easily handled and, with care, grows twice as fast. It must have good soil, however; it has failed conspicuously with plenty of rainfall on ground where pine and cedar do well. Unlike the black locust, which is often ruined by borers, the honey locust is usually free from insect enemies and so far has been a uniformly healthy tree. The value of the wood is not great, though it is sometimes used for fence posts, and has proven fairly satisfactory. Honey locust has a strong claim for preference over cottonwood and boxelder. It does well for hedges, shelterbelts, and ornament in a country where any tree growth is welcomed, and, moreover, makes a handsome, shapely tree, with a fine trunk, a spreading crown, and a foliage that is both delicate and attractive. The clusters of large thorns are occasionally objectionable, but as a general rule they are not excessive and may be easily removed by pruning, if desired. Many trees are partially or wholly free from thorns, and the nurseryman who will propagate a stable thornless variety will find a good market awaiting him. Some nurserymen are already taking this up.

The natural habit of growth in the open is low, with heavy, spreading branches, so that a single closely set row forms a good windbreak if left unpruned. There is no trouble about sprouts from the roots unless they are cut in cultivation. After it is established, honey locust holds its own against grass and grows much faster than the Osage orange. It will also stand cutting down to a hedge, for which it is well adapted.

Honey locust makes an excellent street tree, and is increasing in favor for this purpose. It has been much planted in many towns, but perhaps its best development is at Osborne, where it determines the whole aspect of the streets. Many are growing finely in Wakeeney, Spearville, and other places.

On the high upland 25 miles southwest of Dodge City, in a region about as dry as any in the State, honey locust has done well during the variable seasons of the last fifteen years, and increased nearly one-third of an inch in diameter annually. At the State forestry station at Dodge City, also on the upland, it is proving itself superior to all its associates, and has made an inch in diameter every three years for sixteen years, despite the fact that no recent cultivation has been given and though grass is coming in thickly, owing to wide planting. Among several species planted at the Rainbelt Experiment Station at Cheyenne Wells, Colo., the honey locust, though small at present, gives promise of the best ultimate results.

Honey locust is easily propagated from seed, and those who wish to put out a plantation of any size will do well to raise their own seedlings. For planting in yards or along streets where a few large trees are desired quickly, and expense is no consideration, the trees may be 2 to 4 inches in diameter when transplanted. They should be cut back to a height of 6 to 8 feet, with a few stubby laterals to form the base of the crown, and handled carefully. Treated in this manner, fine trees can be secured in a few years. People who wish trees of this size to set out will do better to get them from some plantation in the neighborhood than to send to nurseries. Large trees are less easily shipped and more likely to suffer in the operation than small ones.

The following table gives a few representative measurements of upland honey locust:

Growth of upland honey locust.

Place.	How standing.	Age.	Average height.	Average diameter breast-high.	Time required to grow 1 inch in diameter breasthigh.	Number of trees measured.
		Years.	*Feet.*	*Inches.*	*Years.*	
Spearville, Kans.	Grove	10	15	1.7	5.9	30
Dighton, Kans.	Row	10	18	2.6	3.8	26
Spearville, Kans.	Grove	10	15	3.9	2.6	20
Sharon Springs, Kans.	...do	11	16	4.4	2.5	20
Oberlin, Kans.	Row	12	20	3.5	3.4	25
Mullinville, Kans.	...do	13	14	3.5	3.7	20
Beaver City, Nebr.	...do	13	15	3.7	3.6	46
Wakeeney, Kans.	Grove	14	20	4.5	3.1	41
Montezuma, Kans.	Row	15	20	4.6	3.3	24
Dodge City, Kans.	Grove	16	20	5.4	3.0	20
Hays, Kans.	Row	16	20	6.0	2.7	20
Smith Center, Kans.	Grove	16	22	7.0	2.3	15
Phillipsburg, Kans.	...do	20	24	5.7	3.5	40

The following examples illustrate the increased rate of growth in valleys or watered situations:

Growth of valley or watered honey locust.

Place.	How standing.	Age.	Average height.	Average diameter breast-high.	Time required to grow 1 inch in diameter breasthigh.	Number of trees measured.
		Years.	*Feet.*	*Inches.*	*Years.*	
Syracuse, Kans.	Grove	6	10	1.9	3.2	10
Sharon Springs, Kans.	Row	7	10	2.4	3.0	6
Gove, Kans.	Grove	8	11	3.5	2.3	7
Garden City, Kans.	...do	9	24	4.3	1.9	12
Spearville, Kans.	Row	10	17	6.4	1.6	10
Oberlin, Kans.	Grove	13	16	4.7	2.8	5
Grainfield, Kans.	Row	14	23	7.4	1.9	6
La Crosse, Kans.	Grove	15	18	5.9	2.5	20
Scott, Kans.	...do	15	18	6.3	2.4	17
Gove, Kans.	Row	16	20	4.3	3.7	19
Ellis, Kans.	...do	32	45	8.3	3.9	7

OSAGE ORANGE.

Osage orange is the common hedge tree of the Middle West; in fact the name given to it in many places is simply "hedge," with no other designation. It is the slowest-growing tree in the list, but this is compensated for by its hardiness. Osage orange is one of the best species for upland planting, and when once started will live without cultivation almost anywhere in western Kansas. Like the red cedar, its tenacity is great, and it looks well even when the grass crowds it so that a dozen years are required for it to increase an inch in diameter. Favorable situations and good care bring corresponding results in the rate of growth, as will be noted in the table, which shows an increment varying from one-third to one-thirteenth of an inch in diameter a year.

Osage orange adapts itself to a wide range of soil, and in this respect is somewhat superior to honey locust, but it winterkills in places in Nebraska where the latter does not. In sandy regions considerable complaint is made of damage to the roots by pocket gophers. The wood is extremely tough and durable, and is unsurpassed for fuel and fence posts. Because Osage orange is so generally planted for hedges it is only occasionally practicable to make measurements and estimate possible commercial returns. A good example was found, however, in southern Barber County, in the valley of a small creek, where permanent water is 10 feet below the surface, with a coarse sandy soil of the Red Bed type. Here an 18-year-old hedge has been kept pruned up 6 feet from the ground and forced to develop into good form. Twenty-five rods of the hedge contain 193 trees, averaging 25 feet high and ranging from 1.6 to 9 inches in diameter breasthigh, with an average of 3.7 inches. If cut, these 193 trees would make 340 stakes and 151 posts, worth 10 and 15 cents each, respectively, or a total of $56.65. As it is practicable in a like situation to grow 2,500 posts per acre in twenty years, it is evident that in favored localities commercial planting of the Osage orange would be profitable. The best method of treatment is to plant thickly, so that less pruning will be necessary, and then cut as soon as post size is reached. A new crop will quickly be made by the sprouts.

Another case of excellent growth is at Hays. A 17-year-old hedge in the valley of Big Creek has been trimmed up like the one just mentioned, and though water is about twice as far from the surface, the rate of growth is even better. Twenty trees taken consecutively in the row averaged 25 feet high and 6.4 inches in diameter, the best tree being 13.6 inches in diameter at breastheight. These 20 trees will make 22 stakes and 47 posts of the usual size.

A method of trimming is sometimes adopted by which full-sized trees are allowed to develop in a hedge every rod or two. In figure 5

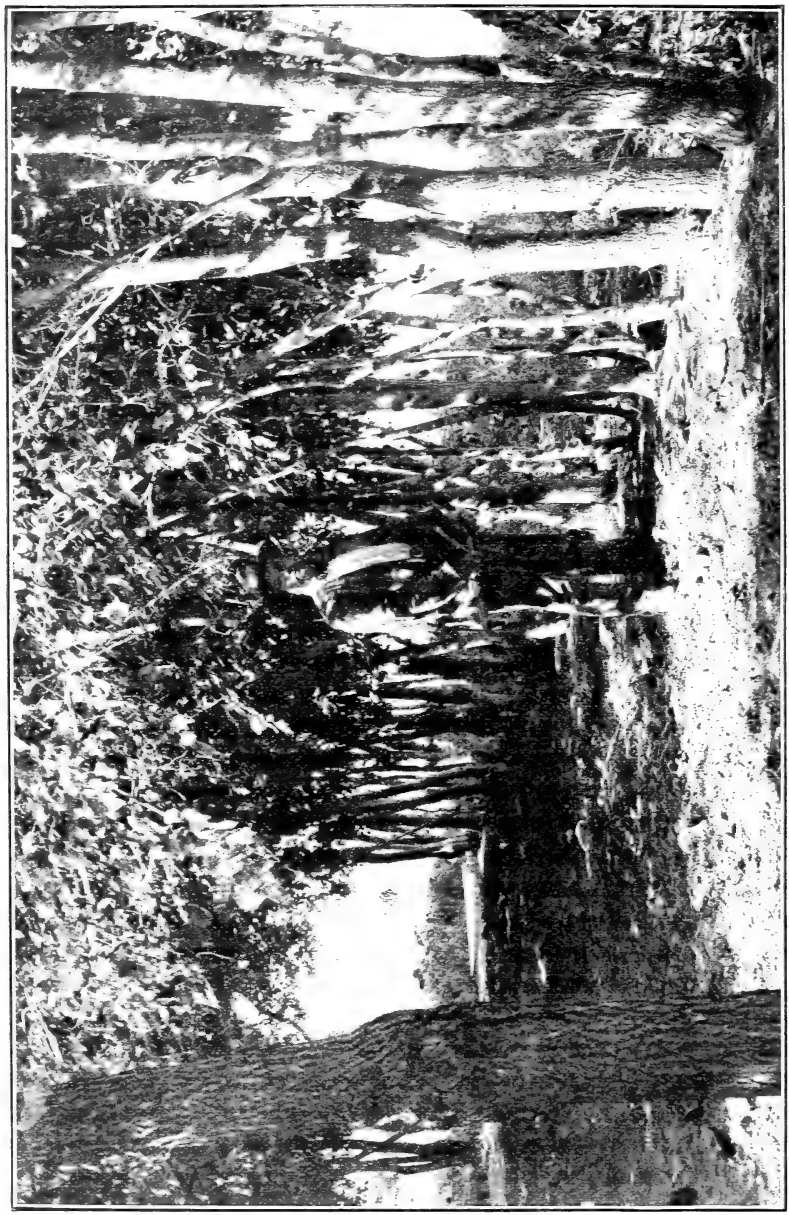

FIG. 4.—Row of Russian mulberry at Ashland, Kans., 10 years of age. Twenty rods of this row would make 142 fence posts and 151 stakes.

is shown the operation of pruning up for posts, which will be ready to cut after a little more growth.

Some measurements in upland situations are given, though it must be remembered that the hedge system is not very conducive to good growth.

Growth of upland Osage orange.

Place.	How standing.	Age.	Average height.	Average diameter breast-high.	Time required to grow 1 inch in diameter breasthigh.	Number of trees measured.
		Years.	*Feet.*	*Inches.*	*Years.*	
Burdette, Kans.	Grove	10	12	2.3	4.3	25
La Crosse, Kans.	do	11	12	2.0	5.5	20
Hays, Kans.	Row	15	16	4.7	3.2	15
Russell, Kans.	do	19	14	2.4	7.9	30
Do.	do	19	15	3.4	5.6	25
Do.	do	20	15	3.6	5.6	40
Do.	do	26	20	4.8	5.4	71
Do.	do	27	12	2.1	12.9	100
Hoisington, Kans.	do	27	18	3.7	7.3	30

RUSSIAN MULBERRY.

This hardy variety of the white mulberry was brought into the Western States by the Russian Mennonites nearly thirty years ago. It is one of the hardiest trees planted on the Plains, and serves a number of useful purposes. Mulberry hedges and shelterbelts are common, and the fruit is often gathered for domestic use. The wood is said to make as durable posts as that of the native red mulberry. The Russian mulberry grows quite rapidly, and endures almost any amount of drought and neglect. The leading shoots frequently winterkill for a foot or two, however, and this increases still more the natural tendency toward low, bushy growth. It branches diffusely near the ground, and only severe pruning can make it develop a respectable trunk.

The Russian mulberry is well suited to form a low, dense windbreak around an orchard, and when so used the birds are likely to take its berries instead of the more valuable orchard fruit. It makes an excellent sheared hedge, some handsome examples of which are found in western Kansas. In the court-house yard at Phillipsburg are mulberries planted for both ornament and shelter. The trees were set approximately 10 by 10 in 1883 and cultivated about fifteen years, but stand in a dense sod at present. They average 15 feet in height and 4.5 inches in diameter in the better part of the yard, where there is a very slight depression.

The court-house yard at Ashland is surrounded by a thickly set row of mulberry put out for shelter in 1893. After seven years the trees were pruned into the form shown in figure 4. When 10 years old all the trees in the row—200 in number, extending for 20 rods—were measured and found to average 3 inches in diameter and 20

feet in height. If cut, these 200 trees would make 142 posts worth 15 cents each, and 151 stakes worth 10 cents each, or a total of $36.40. A well-cared-for plantation at this place would evidently be a profitable investment. The situation at Ashland is no more favorable than in many places on the upland, for, although in the shallow valley of Bear Creek, water is 40 feet below the surface and consequently beyond the reach of tree roots.

A commercial plantation should be thickly set in order to diminish the lateral branches as much as possible. With good care the rate of

FIG. 5.—Pruning an Osage orange hedge to produce fence posts.

growth is sufficient to produce post timber almost anywhere in western Kansas in ten years or less. Since most people have let their mulberries branch at will, satisfactory measurements are difficult to obtain. The average rate of diameter increase on 400 trees in various places was found to be practically an inch in three years, ranging from 1.4 to 4.6 years.

Mulberry has been used considerably for a street tree, but its habit of growth is not suitable for this purpose. It is an added objection that the berries fall upon the walks.

GREEN ASH.

Native green ash was used for timber-claim planting more extensively, perhaps, than any other one species. It grows slowly, but is hardy with respect to both drought and cold. The tough, straight-grained wood has considerable value and is frequently used for fence posts. Ranchmen say that a seasoned ash post will last about ten years.

Green ash is a fine street tree. It is easily trained to excellent form, attains a good height, and has a neat, clean appearance. Borers are the principal drawback, with some trouble from leaf-aphis and heart-rot. The ash borer is not nearly so serious as the black-locust borer, but it has done much damage in some localities. The green ash is frequently called "white ash" by tree planters and even by nurserymen.

Ash responds well to good care, and the slow average growth given in the table is due to the fact that many of the measurements were made in neglected plantations. In the valleys, under the most favorable conditions, the tree may grow an inch in diameter in two years, while in neglected upland growths it sometimes requires nine years. The growth in plantations is generally much slower than in the case of well-cared-for rows and individuals in parks and along streets. It is doing well at Cheyenne Wells, Colo., thus showing that care is more important than climate.

The following table gives upland measurements. Whole groves were not measured, but enough individuals were taken in each case to insure a fair estimate.

Growth of upland green ash.

Place.	How standing.	Age.	Average height.	Average diameter breast-high.	Time required to grow 1 inch in diameter breasthigh.	Number of trees measured.
		Years.	*Feet.*	*Inches.*	*Years.*	
Selden, Kans	Grove	10	10	2.0	5.0	20
Smith Center, Kans	do	12	10	3.0	4.0	20
Leoti, Kans	do	13	11	2.6	5.0	15
Jetmore, Kans	do	14		2.0	7.0	20
Scott, Kans	Row	15	12	2.7	5.6	20
Pratt, Kans	Grove	16	18	2.2	7.3	20
Norton, Kans	do	16	10	2.5	6.4	20
Dodge City, Kans	do	16	15	3.9	4.1	10
Smith Center, Kans	do	16	15	5.6	2.9	10
Plainville, Kans	do	18	12	2.5	7.2	20
Herndon, Kans	do	18	16	2.6	6.9	20
Marvin, Kans	do	20	10	2.2	9.0	20
Hillside, Kans	do	20	14	2.5	8.0	20
Smith Center, Kans	do	21	17	3.7	5.7	20

A few representative measurements in lowland or watered situations follow:

Growth of valley or watered green ash.

Place.	How standing.	Age.	Average height.	Average diameter breast-high.	Time required to grow 1 inch in diameter breasthigh.	Number of trees measured.
		Years.	*Feet.*	*Inches.*	*Years.*	
Greensburg, Kans.	Row	11	14	4.0	2.8	24
St. John, Kans.	Grove	12	18	6.1	2.0	14
Leoti, Kans.	...do	13	16	3.5	3.7	20
Danbury, Nebr.	...do	17	27	6.6	2.6	18
Garden City, Kans.	Row	17	27	6.7	2.5	7
Beaver City, Nebr.	Grove	20	22	3.9	5.1	18

RED CEDAR.

Native red cedar occurs scatteringly throughout the State. It seems supremely indifferent to conditions of climate, soil, or moisture. It grows in limestone, sandstone, shale, or clay formations. Sometimes it is found on the face of a rock held only by a few roots penetrating the crevices, and, again, with cottonwoods and willows along a sandy stream where water is within 5 feet of the surface. It cares for neither cold nor heat; and, under like conditions of soil and moisture, grows nearly as fast without cultivation as with it. This extreme hardiness and adaptability fit it for planting anywhere on the Plains. It matters little how unfavorable the situation, the planter may feel confident that red cedar will live and make a tree some time, if he gets it transplanted successfully. The growth may not average more than 8 inches in height and one-fifth of an inch in diameter yearly, for the cedar seems to realize that it has centuries in which to make its sturdy way. It is the longest-lived tree in the list, and should be planted only where a permanent tree is wanted.

So far, in western Kansas, red cedar has been used somewhat for ornament, but very little for any other purpose. It will make an excellent shelterbelt in time, equally good in winter and summer. It might well be one of the components of a mixed plantation, ready to attain its full development after its shorter-lived and more rapid-growing associates have served their purpose and been removed. It does well mixed with cottonwood, the shade of which is not too dense for it. In some of the old cottonwood groves of the Platte Valley red cedar is coming in by hundreds through the agency of birds. There is some danger, however, in planting the red cedar in the vicinity of an apple orchard. The ball of yellow fungus growth, the "cedar apple," is one stage of the apple-leaf spot, and apple trees are likely to be infected from the cedar. The writer has heard no com-

plaint from this source in western Kansas, but the fungus is common farther east, and may travel westward.

In the court-house yard at Smith Center, Kans., is a thrifty double row of red cedars that have been set sixteen years. During that time the average growth has been 9 inches in height and a little more than one-fourth of an inch in diameter yearly. Reasonably good conditions will secure similar results anywhere. Although used nearly altogether as an ornamental tree, the cedar as it grows in western Kansas is not particularly handsome. It is often dingy in appearance as compared with the freshness of pine foliage or the delicate forms of some broadleaf species; but the planter on the plains must choose trees with more consideration for hardiness than beauty. Red cedar will grow where all else would fail, and it will give him service throughout the year.

The red heartwood makes wonderfully durable posts, and is valuable in many ways. Commercial planting has not been undertaken as yet. Owing to the high price of the trees and the care necessary in setting, the experiment would be costly. There is no doubt, however, that a successful plantation would eventually bring good returns.

The rates of growth were found to be practically identical for upland and valley situations, so no distinction is made in the table. As the planting is almost entirely in yards, only a few trees were found in a place, and the number of measurements is correspondingly small.

Growth of upland and valley red cedar.

Place.	How standing.	Age.	Average height.	Average diameter breast-high.	Time required to grow 1 inch in diameter breasthigh.	Number of trees measured.
		Years.	*Feet.*	*Inches.*	*Years.*	
Stockton, Kans	Row	7	10	2.3	3.0	10
Hays, Kans	do	8	9	2.2	3.6	13
Russell, Kans	do	12	12	2.3	5.2	10
Do	Grove	12	12	2.5	4.8	24
Alton, Kans	do	12	14	4.2	2.9	5
Kinsley, Kans	Row	15	10	2.6	5.8	4
St. Francis, Kans	do	15	10	3.1	4.8	4
Smith Center, Kans	do	16	14	4.2	3.8	14
Pratt, Kans	do	17	14	4.4	3.9	11
Franklin, Nebr	do	19	15	3.8	5.0	6
Osborne, Kans	do	24	17	4.4	5.5	7
Stockton, Kans	do	27	17	5.6	4.8	6

WHITE ELM.

White elm is a native tree that does excellently under cultivation. It likes a heavy soil, and will grow well where cottonwood fails entirely. It is slow to start and requires a few years to get established, but afterwards grows rapidly. The elm is a long-lived tree, and one that should have a place in permanent plantations. It has no supe-

rior for streets and parks. It makes a well-proportioned tree, while the wide-spreading crown with the abundant shade-producing foliage is a welcome sight anywhere. The wood is tough, so the tree is not easily injured by storms. Leaf-destroying insects sometimes defoliate the elm, and borers occasionally attack it, but neither are serious pests in western Kansas.

White elm is not quite so hardy as honey locust, but it is suitable for both upland and valley planting throughout nearly all of western Kansas, and with care will grow almost as rapidly in one situation as another.

Some representative measurements are given. Owing to the fact that elms are so frequently large and of uncertain age when set, an estimate of the rate of increase is difficult, but it is thought that the figures fairly indicate the average.

Growth of upland white elm.

Place.	How standing.	Age.	Average height.	Average diameter breast-high.	Time required to grow 1 inch in diameter breasthigh.	Number of trees measured.
		Years.	*Feet.*	*Inches.*	*Years.*	
Bloomington, Nebr	Row	10	14	4.3	2.3	10
Ashland, Kans	Grove	10	.....	5.7	1.8	10
Kinsley, Kans	Row	12	15	3.2	3.7	13
Burdette, Kans	Grove	12	25	8.2	1.4	16
Ashland, Kans	do	14	.....	4.5	3.1	10
Smith Center, Kans	do	16	19	7.1	2.3	9

Growth of valley or watered white elm.

Place.	How standing.	Age.	Average height.	Average diameter breast-high.	Time. required to grow 1 inch in diameter breasthigh.	Number of trees measured.
		Years.	*Feet.*	*Inches.*	*Years.*	
Ashland, Kans	Grove	10	28	5.9	1.7	20
St. John, Kans	do	12	25	7.2	1.7	20
Kinsley, Kans	do	14	25	7.7	1.8	35
Pratt, Kans	do	15	20	5.0	3.0	30
St. Francis, Kans	Row	15	22	7.2	2.1	6
Jetmore, Kans	do	16	18	5.4	2.9	8
Beaver City, Nebr	do	16	23	7.9	2.0	7
Grainfield, Kans	do	20	20	7.9	2.5	5

PINES.

The pines have been neglected in the selection of species for planting largely through ignorance of their desirable qualities and suitability for western Kansas. They are not so hardy as red cedar, but grow more rapidly, the rate comparing favorably with that of the honey locust. A third of an inch in diameter and 1½ feet in height is not an uncommon annual growth. Pines are excellent for shelterbelts,

and as ornamental trees for parks and yards are neat and pleasing in appearance.

But two kinds of pine are planted to any extent in western Kansas. Both are foreign species—Scotch and Austrian. So far as noted, there is little difference between them in hardiness, though nurserymen are inclined to think the Austrian pine the hardier. The rate of growth is slightly in favor of the Scotch pine. The foliage of the Austrian species is heavier and darker colored, thus making it both a better windbreak and more ornamental than the Scotch pine.

With care either species will thrive on the uplands. Scotch pine is doing fairly well at Dodge City in spite of neglect, and growing well at Smith Center under cultivation. These are upland situations with heavy soil. At Stockton, with a sandy loam soil and water 20 to 25 feet below the surface, a good deal of Scotch pine has been planted, which is doing excellently. The diameter growth is practically the same as at Smith Center—one-third of an inch a year—but the height increase is much better, often running up to 2 feet. There is a striking clump of Austrian pine near Offerle, Kans. These trees are on an upland situation and have not been cultivated for many years, yet they are in fine condition and make an average yearly increase in diameter of one-third of an inch. Since so few measurements could be made in one locality, no table is given for pine.

There seems little reason to doubt that jack pine will grow in many places where Scotch and Austrian pines have proved successful. Its ability to thrive on poor soil is notable, and the growth is rapid. The western yellow (or bull) pine grows naturally in New Mexico within 75 miles of the Kansas line, where the precipitation is no greater than in western Kansas. It is a hardy pine of great adaptability, occurring in the mountains from Arizona to Washington, through all the varying degrees of temperature and humidity. Jack pine promises to be the most valuable species in the forestation of the Nebraska sandhills, and there is reason to think that it will do well in the sandhills of Kansas.

BLACK LOCUST.

Black locust would be one of the most desirable species for Plains planting, were it not for the borers. It grows rapidly and withstands both cold and drought well, while the wood ranks high in strength, durability, and fuel value. Like mulberry, Osage orange, and catalpa, it produces fence posts of the highest quality. Black locust does well on the uplands, where the measurements show an average diameter increase of one-third of an inch yearly, and still better in the valleys, where the average is one-half inch per year. The tenacity with which black locust holds to life is well shown by a small group

at Johnson, Kans., on the high upland, only 18 miles from the Colorado line. They are a remnant of better days, but are looking fairly well despite the dense sod and the constant tramping and rubbing of cattle. The borers have not found them, so in their nine years of life they have not been handicapped in the struggle against adversity and neglect. The borers, however, can not be avoided in many places, and they have brought ruin to thousands of promising trees.

The planter who wishes to put out black locust in regions infested by borers should have a definite object in view and be prepared to carry it out. By locating his plantation on good ground and giving it first-class care, the trees will reach fence-post size before the borers do much damage. They should then be cut and utilized. The rapid sprout growth will soon make a new crop. A stump sprout sometimes attains a height of 10 feet the first season. Handled in this manner, black locust can be profitably raised in many places where it is altogether unsuited for a permanent tree.

At present borers are a menace to black locust trees throughout western Kansas and Nebraska, though there are occasional local areas that are not affected. They have so far done little damage in southwestern Kansas, but they are moving both southward and westward. They are abundant at Pratt, Kinsley, Dodge City, and Scott, and are appearing at Medicine Lodge, Coldwater, Meade, and Garden City. Yet of the numberless trees that have been killed or seriously injured nearly all reached a size that could well be used for posts or stakes before succumbing. This shows that black locust may be successfully grown in commercial plantations if cut as soon as large enough for posts.

A typical case of southern Kansas growth is at Ashland, with the same soil conditions as those noted in the section describing the Russian mulberry at that place. Part of the park planting is black locust set about 16 by 16 feet, and cultivated, but not watered. The planting was done ten years before the measurements were made. Forty trees averaged 7.6 inches in diameter, giving an inch of increase for every one and one-third years. These 40 trees, if cut, would make 77 stakes and 106 posts, worth locally 10 and 15 cents each. This gives an average value of 57 cents per tree, exclusive of firewood, and is not a bad result for ten years of care. For commercial returns, of course, the planting should be much thicker, thus utilizing all the ground and causing a better form development.

Just south of the Kansas line, in Woods County, Okla., black locust grows remarkably well, and has not yet been molested by borers. The sandy loam soil, with water in many places not more than 20 feet below the surface, furnishes right conditions for rapid, healthy

growth. A typical plantation is that of Mr. W. B. Updegrove, 4 miles east of Byron. In the spring of 1900 Mr. Updegrove set 8 acres to locally grown seedlings, averaging 2 feet high. The rows were 6 feet apart and the trees 4 to 5 feet apart in the rows. The ground had been plowed the fall before. The plantation was given two cultivations the first season, one plowing in 1901, no care at all the next year and one cultivation in the spring of 1903. When the examination was made, in June, 1903, the shade was found to be so dense that grass and weeds were unable to get a foothold. The tops met overhead in a thick canopy, the lower lateral branches were dying, and a good form was being developed. The trees averaged 18 feet high and 2 inches in diameter at breastheight, with almost a perfect stand. Three years more of growth at the same rate will result in an average of at least one good post and one stake for every tree in the plantation, and at current prices it will be difficult to find another agricultural crop approaching this in profit, when the slight expense for care is considered.

A few typical measurements follow:

Growth of upland black locust.

Place.	How standing.	Age.	Average height.	Average diameter breast-high.	Time required to grow 1 inch in diameter breasthigh.	Number of trees measured.
		Years.	*Feet.*	*Inches.*	*Years.*	
Dodge City, Kans	Grove	10	12	2.4	4.2	30
Sharon Springs, Kans	...do	10	12	2.5	4.0	20
Ashland, Kans	...do	10	20	7.6	1.3	40
Do	Row	11	25	7.8	1.4	17
Fowler, Kans	Grove	14	22	3.5	4.0	30
Sharon Springs, Kans	...do	14	18	4.0	3.5	20
Scott, Kans	...do	15	14	5.5	2.7	26
Herndon, Kans	Row	18	.....	6.8	2.6	10
Do	Grove	21	20	4.5	4.7	16

Growth of valley or watered black locust.

Place.	How standing.	Age.	Average height.	Average diameter breast-high.	Time required to grow 1 inch in diameter breasthigh.	Number of trees measured.
		Years.	*Feet.*	*Inches.*	*Years.*	
Syracuse, Kans	Grove	6	12	3.2	1.9	10
Meade, Kans	Row	8	14	4.0	2.0	19
Garden City, Kans	...do	8	27	6.3	1.3	16
Kinsley, Kans	Grove	9	27	5.9	1.5	20
Greensburg, Kans	Row	10	17	6.1	1.6	20
Sharon Springs, Kans	...do	13	14	4.9	2.7	23
Pratt, Kans	Grove	15	20	5.2	2.9	30
Scott, Kans	...do	15	18	6.5	2.3	19

HACKBERRY.

The hackberry is one of the hardiest native trees, and deserves more extensive planting than has yet been given. Naturally it is often stunted and slow growing, but it does well under cultivation, grows with fair rapidity, and develops into good form. It resembles the elm in general habits, but is smaller and hardier. It is not very particular as to soil, and is not seriously injured by insects.

Hackberry is best adapted to street and yard planting by its appearance, good shade, and medium size. The merits of hackberry are known by many who have not the patience to wait for its slow growth, but the time has come for permanent planting, and it should have attention. Since few trees were found, no tabulated measurements are given. A fair average diameter increase is about one-third inch yearly for the valleys and one-fourth inch for the uplands. Columbus, Nebr., is one of the few towns that has given much attention to hackberry. There it is the principal street tree, with excellent effect.

COTTONWOOD.

Cottonwood is the most extensively planted tree in the Middle West. It attains its best development in the wide, sandy valleys of the Platte and the Arkansas, where never-failing water is within 5 to 20 feet of the surface, and the soil is easily penetrated by the thirsty roots. The cottonwood is closely related to the willows, and, like them, does not succeed well without abundant moisture. Had the early tree planters better realized its habits, they would not have planted the thousands they did upon the high uplands. The trees frequently grew well for a few years, and then succumbed to a summer drought, leaving unsightly dead branches and crowns in testimony of the unequal struggle. Cottonwood can not be recommended for the uplands of western Kansas and Nebraska, except in favored localities that catch some run-off, but it will thrive to the extreme limits of both States in sandhills or valleys which contain living streams during at least a portion of the year. It is often the only tree found growing naturally along sandy streams.

Cottonwood is to be regarded generally as a temporary tree. It is not long-lived, and attains large size in a short time. It grows the most rapidly of any tree adapted to this region, and is therefore often selected for planting by those who do not have the patience to wait for the slower development of more valuable species. An inch in diameter and 5 feet in height is not an uncommon average for the first ten or more years after setting, in favorable situations, and this suggests its best use. Cottonwood furnishes fuel and shelter quickly,

and for these purposes it has been almost indispensable to numberless settlers. A man does not have to reach a very old age to have trees of his own planting make respectable sawlogs. The writer recalls distinctly the pride with which an early settler built a barn of cottonwood lumber cut from trees raised by himself.

Originally, countless cottonwoods were planted in the towns. A reaction took place when the trees reached the age of seeding and the abundant cotton in the spring filled the air and formed miniature snowdrifts on the sidewalks and in dooryards, while the tall crowns continued to shoot upward quickly after each pollarding. For town planting it should be used sparingly, and is best in parks. A typical case of park planting is at Dodge City, which is the result of eighteen years of growth.

As already said, cottonwood grows easily and rapidly from cuttings, and by taking them from staminate trees the production of cotton may be avoided. Agents often advocate the Carolina poplar, and tell the unsophisticated purchaser that it does not make the objectionable cotton. This is simply an eastern variety of cottonwood, which is not even recognized by some botanists, and if cotton is not formed it is because cuttings have been made as recommended. The person who intends to put out cottonwoods can do no better than to go to the nearest stream where they grow well and there dig up his seedlings or make his cuttings.

A few measurements follow:

Growth of valley or watered cottonwood.

Place.	How standing.	Age.	Average height.	Average diameter breast-high.	Time required to grow 1 inch in diameter breasthigh.	Number of trees measured.
		Years.	*Feet.*	*Inches.*	*Years.*	
Scott, Kans.	Grove	8	40	6.4	1.3	10
Do	...do	8	48	8.3	1.0	10
Burdette, Kans.	...do	10	40	8.4	1.2	9
Garden City, Kans.	Row	10	40	10.4	1.0	5
Hoisington, Kans.	Grove	21	55	11.0	1.9	24
Stockton, Kans.	Row	28	65	16.8	1.7	35
Portis, Kans	Grove	30	60	14.9	2.0	21

BOXELDER.

The boxelder is the only native maple in western Kansas, and like the cottonwood has often been planted in unsuitable localities. It naturally grows in moist situations, and does not thrive away from them. Consequently it can not be recommended for the uplands, except in local depressions that are benefited by the run-off of surrounding territory. It prefers a heavy soil to a sandy one, grows

well in the valleys where the roots can eventually find water, and is probably a little more drought resistant than cottonwood.

Boxelder is a short-lived tree, and attains no great diameter. The wood takes low rank for fuel and has little other value. A straight trunk seldom forms, because the terminal buds generally die, leaving the lateral ones to continue the upward growth, so that many crooks are produced. Attacks by borers are frequent, and a leaf-aphis often spoils the appearance of the tree. This insect was common on boxelder over a wide range during the season of 1903. Probably it could be checked by spraying if one cared to take sufficient trouble.

A very respectable street tree is sometimes made of the boxelder by a combination of good care and favorable situation, but its principal use should be for shelterbelts in the valleys. The rate of growth is rapid and the height medium. In a 27-year-old plantation in the Arkansas Valley near Great Bend the trees have an average diameter of about 7 inches and a height of 25 feet.

While the boxelder does not ordinarily make a permanent tree on the upland, the rate of growth for a few years is likely to be as good as that in the valleys, so no distinction is made in the following table.

Growth of upland and valley boxelder.

Place.	How standing.	Age.	Average height.	Average diameter breast-high.	Time required to grow 1 inch in diameter breasthigh.	Number of trees measured.
		Years.	*Feet.*	*Inches.*	*Years.*	
Stockton, Kans	Grove	9	22	5.2	1.7	19
Ashland, Kans	...do	10	22	4.6	2.2	20
Kinsley, Kans	Row	12	16	5.4	2.2	20
St. John, Kans	Grove	12	20	6.5	1.8	14
La Crosse, Kans	...do	15	15	4.8	3.1	10
Pratt, Kans	...do	15	18	5.1	2.9	26
Greensburg, Kans	Row	16	18	7.1	2.3	20
Gaylord, Kans	Grove	20	25	6.3	3.2	20

SILVER MAPLE.

In congenial situations the silver maple is one of the most rapid-growing trees, but it is not so hardy as either cottonwood or boxelder, and so has a more restricted range. The wood has no especial value, and the chief use of the tree is for ornamental and shelterbelt planting. It is decidedly brittle, and large branches are often broken off in heavy windstorms. Silver maple can be recommended only for valley planting, where the roots will eventually go down to water. In such places it will quickly produce shade and shelter: the average growth is nearly one-half inch in diameter yearly.

The measurements which follow were made in lowland or watered situations.

Growth of valley or watered silver maple.

Place.	How planted.	Age.	Average height.	Average diameter breast-high.	Time required to grow 1 inch in diameter breasthigh.	Number of trees measured.
		Years.	*Feet.*	*Inches.*	*Years.*	
Greensburg, Kans	Row	11	13	4.8	2.3	15
St. John, Kans	Grove	12	25	9.0	1.3	20
Kinsley, Kans	do	14	27	7.1	2.0	15
Pratt, Kans	do	15	20	5.1	2.9	23
La Crosse, Kans	do	15	16	5.2	2.9	10
Beaver City, Nebr	Row	16	22	7.9	2.0	7
Stockton, Kans	do	19	25	7.2	2.6	4
Great Bend, Kans	do	20	.....	13.0	1.5	10
Ellis, Kans	do	32	45	14.9	2.1	6

BLACK WALNUT.

Black walnut has been extensively tried, but has succeeded only in favored localities, and can not be recommended for general planting. The rate of growth is very good, and excellent results are sometimes obtained in the valleys. It is a desirable tree, and should be raised wherever possible. It is easily grown by planting the nuts where the trees are wanted. Owing to the long taproot, transplanting is somewhat difficult. While in a number of cases a more rapid rate of growth was found on the uplands than in the valleys, they should be regarded as anomalous, and not a true index of the habits of the species. After a few years of rapid progress the upland tree is likely to die. For instance, a row of black walnut at Smith Center at 16 years of age averaged 5.9 inches in diameter, thus giving an inch of increase for every 2.7 years—an excellent rate of growth; but when measured these trees had reached their limit, in spite of good care, and were either dead or dying. Contrasted with this is a row of black walnut along the road 5 miles south of Great Bend, where the soil is sandy and water not over 25 feet below the surface. At 20 years of age these trees were 25 feet high, ran from 6 to 12 inches in diameter, with an average of 9 inches, and were in excellent condition, while seedlings were appearing in numbers beneath them.

Growth of valley or watered black walnut.

Place.	How standing.	Age.	Average height.	Average diameter breast-high.	Time required to grow 1 inch in diameter breasthigh.	Number of trees measured.
		Years.	*Feet.*	*Inches.*	*Years.*	
Byron, Okla	Grove	8	16	3.1	2.6	22
Danbury, Nebr	do	12	16	3.4	3.5	38
Greensburg, Kans	Row	14	16	6.2	2.3	7
St. John, Kans	do	16	13	3.2	5.0	20
Danbury, Nebr	Grove	17	28	8.2	2.1	14
Beaver City, Nebr	do	20	22	4.1	4.9	8
Great Bend, Kans	Row	20	25	9.0	2.2	30

HARDY CATALPA.

Catalpa may be expected to thrive in western Kansas in localities where permanent water occurs at a depth of 10 to 20 feet under a sandy loam soil. Since its chief value is for posts, there is little use in planting it outside the territory where it grows rapidly and makes profitable returns.

Growth of valley or watered hardy catalpa.

Place.	How standing.	Age.	Average height.	Average diameter breast-high.	Time required to grow 1 inch in diameter breasthigh.	Number of trees measured.
		Years.	*Feet.*	*Inches.*	*Years.*	
Ashland, Kans.	Park	10	20	5.7	1.8	10
Oberlin, Kans.	Row	12	18	6.1	2.0	6
St. John, Kans.	Grove	12	24	7.2	1.7	20
Stockton, Kans.	Row	15	20	5.8	2.6	9
Beaver City, Nebr.	do	16	22	5.2	3.1	5
Kinsley, Kans.	Grove	17	22	5.2	3.3	10
Beaver City, Nebr.	do	17	15	5.8	2.9	10
Meade, Kans.	do	18	25	3.6	5.0	10

AILANTHUS.

The ailanthus is of Chinese origin. The wonderful claims made for it when first introduced have scarcely been justified so far as western Kansas is concerned. Thousands of trees were set in timber claims and elsewhere, but those which succeeded are few. The ailanthus grows rapidly, is not very particular as to soil, and is capable of withstanding considerable drought and neglect, but it winterkills badly while young. Trees which manage to get past this stage seem to have no further trouble. Were it not for this tenderness, alianthus would do very well, but even then it would hardly deserve preference over several species whose especial fitness has been proved.

BUR OAK.

Natural bur oak extends well westward, so it must be counted as one of the more hardy species, though little used for planting. Occasional thrifty specimens are found in the valleys, and there is no doubt that success would result from more extensive trials. Several species of more value are doing so well on the upland, however, that there is no chance for the bur oak to equal them, and only variety is to be gained by experimenting with it.

POPLARS.

The white and Lombardy poplars are closely related to the cottonwood, but are less hardy. They will succeed in many valley situations, but their value is slight.

White poplar, sometimes erroneously called "silver maple," is a nuisance, because of the numerous sprouts from the roots, and unless protected from the wind generally stands slanting instead of straight.

Lombardy poplar has admirers on account of its tall, slender form; but it, too, suckers from the roots, and is short-lived as well. When the numerous lateral branches begin to die, all the beauty the tree once had quickly disappears.

WILD CHINA.

The wild China, or chinaberry, is a native of southern Kansas and the Southwest, so it has become inured to aridity. It is a small tree with grayish bark, rather delicate compound leaves, and characteristic clusters of translucent, golden berries containing black seeds. It is hardy, and an excellent tree for occasional use in ornamental planting. Wild China is also called "soapberry," since the berries of a closely allied species are used in the place of soap.

RUSSIAN WILD OLIVE.

Russian wild olive, or oleaster, is a hardy tree of small size that will evidently succeed over most of the State, though it has been little planted as yet. More extensive trials in Nebraska and South Dakota show it to be an excellent species for hedges and windbreaks in dry regions. The growth is rapid and the grayish foliage pleasing in appearance.

OTHER SPECIES.

Sycamore and coffeetree have been planted very little, but are excellent for ornamental purposes. The former makes a particularly good street tree. Both can be grown to a considerable extent in the Arkansas Valley and similar situations.

Blue spruce is considered to be hardy, but has not yet been planted sufficiently to warrant conclusions.

A few planters who are familiar with it think that Chinese arborvitæ will give excellent results when more extensively tried.

There is no doubt that as time goes on valuable new species will be introduced and forest trees will be planted in increasing numbers. The field for experiment is large, and many problems are yet to be solved.

SUMMARY.

Some of the leading conclusions of this bulletin are briefly recapitulated. They are points which should be borne in mind by the tree planter in western Kansas.

The effect of forest planting on climate is problematical as to increased precipitation, but definitely determined as to its favorable results in the conservation of moisture and the checking of wind.

The results to be obtained are sufficient to justify the expenditure of time and labor, and it is useless to expect success without such efforts. An intelligent selection of species, followed by good care, is essential. Not every man can set trees and make them prosper. Consequently it often happens that one thriving plantation tells more of the inherent possibilities of a given region than do a dozen failures.

The planting should be carefully done in all cases, but conifers require unusual care. For ordinary plantations the best practice is to use small trees and home-grown seedlings so far as possible.

Cultivation is essential to success, and should be such as to conserve the largest possible amount of soil moisture.

Whether to prune or not depends entirely upon the kind of tree and the purpose of the plantation. The best time to prune is in early spring, just before growth begins. The cuts should be clean and close to the trunk.

To a hitherto unappreciated extent cultivation can be made to replace irrigation or natural supplies of moisture; but, nevertheless, upland and lowland planting should be treated as distinct problems, as regards both the choice of species and the period for which cultivation should be given. It is likewise true that every species presents problems of its own, which must be worked out if the highest efficiency is to be obtained.

All planting, whether shelterbelt, ornamental, or commercial, should be for a definite purpose and the most suitable trees chosen accordingly. The time for the temporary planting of rapid growing, short-lived species is passing, except in special cases. That of the future should be of a permanent character and such as will give lasting benefit, even though not so quickly.

BOTANICAL NAMES OF TREES MENTIONED.

Austrian pine	*Pinus laricio austriaca* Endl.
Scotch pine	*Pinus sylvestris* Linn.
Blue spruce	*Picea parryana* (André) Parry.
Chinese arborvitæ	*Thuya orientalis* Linn.
Red cedar	*Juniperus virginiana* Linn.
Black walnut	*Juglans nigra* Linn.
Willows	*Salix* sp.
Cottonwood	*Populus deltoides* Marsh.
White poplar	*Populus alba* Linn.
Lombardy poplar	*Populus nigra italica* Du Roi.
Bur oak	*Quercus macrocarpa* Michx.
White elm	*Ulmus americana* Linn.
Hackberry	*Celtis occidentalis* Linn.
Russian mulberry	*Morus alba tatarica* (Linn.) Loud.
Osage orange	*Toxylon pomiferum* Raf.
Sycamore	*Platanus occidentalis* Linn.
Honey locust	*Gleditsia triacanthos* Linn.
Coffeetree	*Gymnocladus dioicus* (Linn.) Koch.
Black locust	*Robinia pseudacacia* Linn.
Ailanthus	*Ailanthus glandulosa* Desf.
Silver maple	*Acer saccharinum* Linn.
Boxelder	*Acer negundo* Linn.
Wild China	*Sapindus marginatus* Willd.
Green ash	*Fraxinus lanceolata* Borkh.
Russian wild olive	*Elæagnus angustifolia* Linn.
Hardy catalpa	*Catalpa speciosa* Warder.

A LIST OF FOREST SERVICE CIRCULARS OF INTEREST TO TREE PLANTERS IN WESTERN KANSAS.

(May be obtained free upon application to the Forester, Forest Service, Washington, D. C.)

29. Tree Planting on a Model Prairie Farm.
54. How to Cultivate and Care for Forest Plantations on the Semi-Arid Plains.
56. Bur Oak.
57. Jack Pine.
64. Black Locust.
66. White Elm.
68. Scotch Pine.
69. Fence Post Trees.
72. Western Yellow Pine.
73. Red Cedar.
74. Honey Locust.
75. Hackberry.
76. Silver Maple.
77. Cottonwood.
82. Hardy Catalpa.
83. Russian Mulberry.
84. White Ash.
86. Boxelder.
90. Osage Orange.
92. Green Ash.
96. Arbor Day.

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