"THE COTTONWOOD (POPULUS DELTOIDES) A TREE STUDY"

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A THESIS

SUBMITTED TO THE FACULTY

OF THE

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BY

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FOR THE DEGREE OF

MASTER OF FORESTRY

- 0 -

Preface.

The thesis which follows is based on the facts obtained in a study carried on from February, 1911, to April, 1912, and while many facts have been brought out, it is the author's belief that many things in favor of the Populus deltoides and its development are yet to be found and that in future years much may be added to the study presented here.

Many photographs are used in the presentation of this work because the pictures show the conditions in a more natural and realistic way than could be portrayed in words. All of the photographs are original except those for which credit is given to the persons I am indebted to for their use. Most of the data was gathered in the vicinity of Red Wing, Minnesota, upon the lands of The Forest Products Company. The data gathered here for curves and tabulations will necessarily be accurate only for the bottom-land types as the variations from the bottom-land to the plateau or plain type are too great to accurately apply tables, constructed from only one type, to both.

Julius V. Hofmann.

Frontispiece.

This Monarch of the Forest stands on the Minnesota River bottom flats at Shakopee, Minnesota.

It is 29 ft. in circumference at the base and 21 ft. in circumference at a height of 5 ft. from the ground and is 130 ft. high, with a clear length of 36 ft.

The first view shows the trunk with comparative size by the man in the picture and the second shows the entire tree surrounded by mature willows.

Photo by H.D. Ayer.

Photo by M.D.Nyen

Introduction.

In the struggle among the various species of timber in the United States, for supremacy of the lumber and timber production and utilization, the Cottonwood has in the past assumed a modest, yet slowly progressing, role. The early recognition of the Cottonwood came, when, before railroads crossed the western plains, the pioneers settlers found shelter from the hot rays of the noon-day sun, under its inviting and magnificently spreading crown, and found in its trunks material for building purposes, from the rough stockade to the houses and buildings of theirfirst villages and fuel with which to cook their food and keep them warm during the cold wintry blasts of the open plains. Since the Cottonwood has migrated along the streams far in advance of its associates in the wooded areas, it has provided well for the otherwise timberless areas. After the great plains be-came covered with a network of railroads the natural right and utilization of the Cottonwood gave way to the more easily handled and more durable species of timber now flooded upon the markets by rapid and cheap transportation. For several decades the people were satisfied with the conditions so long as their lumber yards were filled with the desirable grades at prices which they considered reasonable, but supply and demand, the final check on any commodity, together with the combinations, gradually advanced the prices of lumber until the people complained of the high prices of building materials. These conditions led to investigations which revealed the fact that our timber resources were not unlimited nor inexhaustible as was generally considered, but that our timber was a crop grown in a certain time and when cut must be replaced if the supply is to be perpetuated. Further investigations showed the long periods necessary to produce the desirable species as cedar and pine to produce the nec-

essary lumber and fuel. Then began the search for a cheaper material and faster growing species. The cheapness of production and rapidity of growth of the Cottonwood at once commended itself as the logical species to bring about the equilibrium of production and consumption, especially in these river bottom-land areas, running through the less wooded regions. Hence in the past few years the Cottonwood has been steadily raising in amount of consumption and price until today it has a place among the species supplying our markets in various lines of utilization.
The field to which it is adapted was very much enlarged by the introduction of wood preservation, as the less durable woods now rank side by side with the more durable in places where decay readily takes place when untreated.

Table of Contents

Botanical Classification.

Order - Salicales

Family - Salicaceae

Genus - Populus

Species - deltoides

Scientific name - Populus deltoides

Botanical Description

Leaves deltoid or broadly ovate acuminate with entire points, or rarely rounded at the apex, truncate, slightly cordate or occasionally abruptly wedge-shaped at the entire base, or the entire base at right angles with the petiole forming a triangular leaf, coarsely crenately serrate above, with incurved glandular teeth, as they unfold, gummy, fragrant with a balsamic odor, covered more thickly below than above with soft white caducous hairs, and tomentose on the margins, at maturity thick and firm, light bright green and lustrous, paler on the lower than on the upper surface, 2"- 7" long and 2" - 6" broad, with stout yellow midribs often tinged with red toward the base, raised and rounded on the upper side, and conspicuous primary veins; their petioles slender, pilose at first soon glabrous, compressed laterally yellow, more or less tinged with red, 2" - 4" long. Flowers appear in April to May, Dioecious, in aments, staminate, densely flowered, 3" - 4" long, ½" thick, with short glabrous stems, the pistillate sparsely flowered, thin-stemmed, often becoming a foot long before the fruit ripens, their scales scarious, light brown, glabrous, dilated and irregularly divided at the apex into filiform lobes, slightly thickened and revolute on the margins; stamens 60 or more, with short filaments and large dark red anthers, disk of the pistillate flower broad cup-shaped; ovary subglobose, with 3 or 4 nearly sessile dilated or laciniately lobed stigmas.

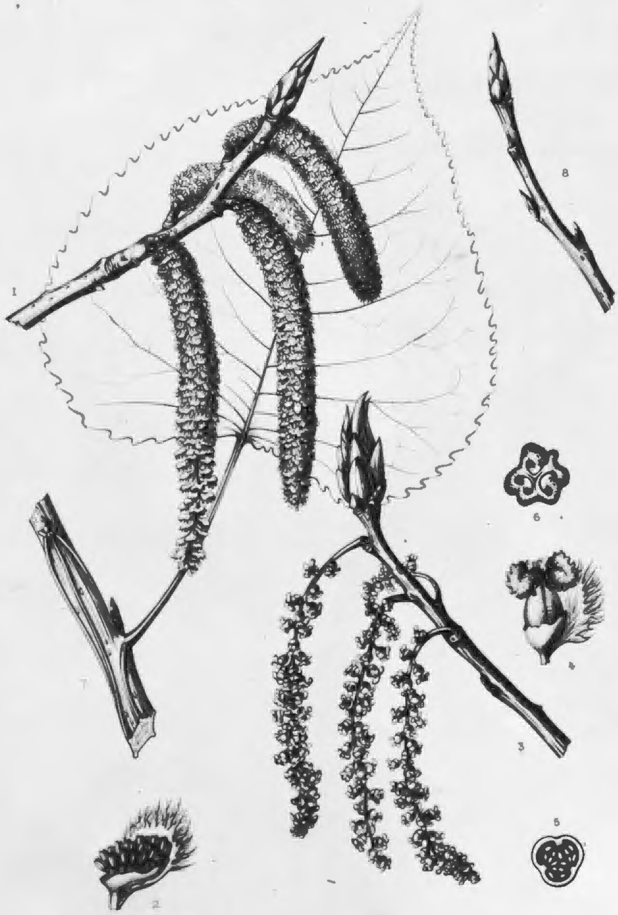
Fruit oblong-ovate, rather abruptly contracted and acute at the apex, slightly pitted, thin-walled, 1/4' - 1/2' long, dark green, 3 or 4 valved, its stem 1/3' - 1/2' long.

Seeds oblong-obovate, rounded at the apex, light brown, about 1/2' long, cotton attached to seed for distribution, mature May to June.

Winter buds very resinous, ovate, acute, the lateral much flattened, 1/2' long, with 6 or 7 light chestnut-brown lustrous scales.

Silva of North America

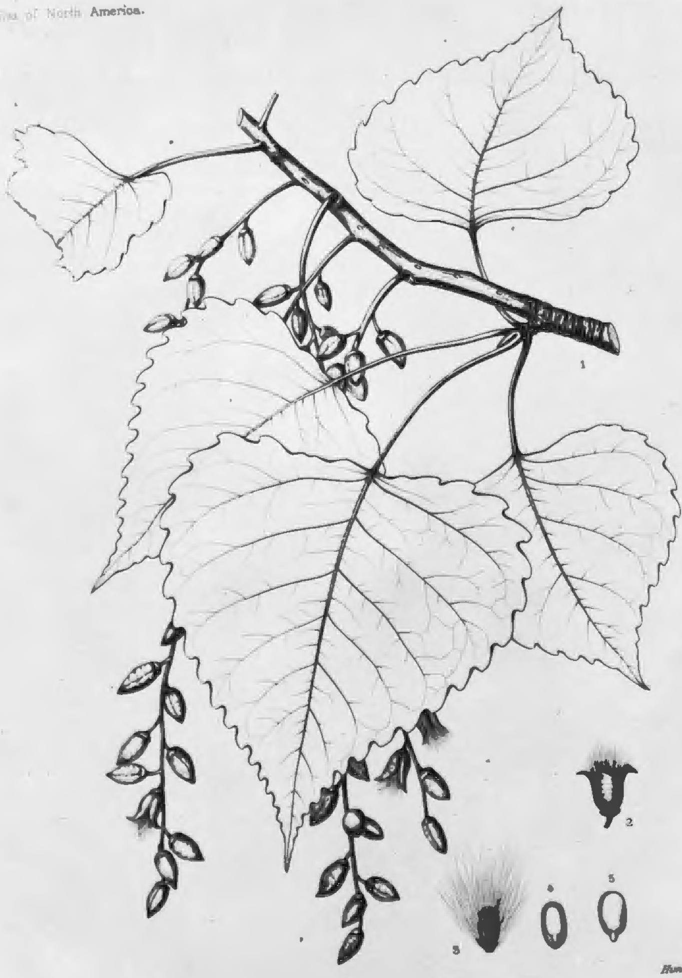
Tab. CCCCXCIV.



POPULUS DELTOIDEA, Marsh.

Fig 1

After Sargent.



C. E. Faxon del. Humbelot sc.

POPULUS DELTOIDEA, Marsh.

A. Riocreux direx. Imp. J. Taneur, Paris.

Fig 2. After Sargent.

Explanation of the Plates

Fig. 1 Populus deltoides

1. A flowering branch of the staminate tree.
2. A staminate flower with its scale,enlarged.
3. A flowering branch of the pistillate tree.
4. A pistillate flower with its scale,enlarged.
5. Cross section of an ovary,enlarged.
6. A stigma seen from above, enlarged.
7. Portion of a branch with a leaf.
8. A winter branch.

Fig. 2

1. A fruiting branch.
2. A fruit with open valves, enlarged.
3. A seed, magnified.
4. Vertical section of a seed, magnified.
5. An embryo, magnified.

<u>Form of Tree</u>.

A tree usually 75' - 85' high but sometimes exceeding 100' in height. Usual diameter 2½' - 3½' often reaching 7' - 8' with a clear length of bole 40' - 75' when grown in a forest stand where self pruning takes place. Grown in the open, the trunk divides into large branches at 10' - 30' high spreading gradually and becoming pendulous toward the ends and forming a graceful, rather open crown from 80' - 100' across while in the trees the branches are at right angles with the stem and form symmetrical pyramided crowns. In the forest the crowns are more even at the top, forming a flat topped forest where the stand is of even heights, In forest stands the spread of crown is 10' - 30'. The stout branchlets are marked with long pale lenticels, terete or, especially on vigorous trees, becoming angled in their second year, with thin, more or less prominent wings extending downward from the two sides and the bases of the large three-lobed leaf scars.

<u>Bark</u> thin, smooth, light yellow, tinged with green on young stems and branches, becoming on old trunks 1½' - 2' thick, ashy grey, and deeply divided into broad rounded ridges broken into closely appressed scales.

The seedlings form a tap root which develop strongly for the first two years and then the lateral roots develop, while the tap root grows slowly, so when the seedling reaches the sapling stage, the root system has changed into a lateral system which is the system of the mature tree. The mature trees have a wide spreading root system near the surface of the ground when growing in their favorite localities, such as the river bottom-lands, but the roots grow deeper when grown on drier soils. The seeds germinate on the wet sandy soil along streams in spring when the streams are high and as the seedlings develop, the water lowers and the main root of the seedling naturally follows the receding water level, thereby developing a tap-rootuntil it is firmly established when the lateral roots develop.

Range and Occurrence of Species.

The Populus deltoides has a wide distribution ranging along the banks of streams and often forming extensive open groves. From the Province of Quebec and the shores of Lake Champlain, through western New England and New York, Pennsylvania west of the Allegheny Mountains and the Atlantic States south of the Potomas River to Northern Florida westward to the Rio Grande River to Central New Mexico and northward along the Rocky Mountains to Southern Alberta eastward north of the Great Lakes. Comparatively rare and of smaller size in the East and in the Coast region of the South Atlantic and East Gulf States, and one of the largest and most abundant trees along the streams between the Appalachian and the Rocky Mountains, marking their course over the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UNITED STATES
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NEW YORK

Fig 3.

mid-continental plateau to the extreme limit of tree growth, and growing to its largest size as far west as the 100th meridian. It forms the most extensive stands in Arkansas and northward to the Ohio Valley; often planted for shelter and ornament on the treeless plains and prairies between the Mississippi River and the Rocky Mountains and as an ornamental tree in the eastern United States and largely in Western and Northern Europe.

Fig. 3 shows the extreme limits of the range of the species.

Region Studied.

This study was made along the river bottom flats of the Minnesota and Mississippi Rivers extending from about four miles above Fort Snelling on the Minnesota River to the junction of these rivers and along the Mississippi to Wabasha, work being done on both the Wisconsin and Minnesota sides of the river. General observations were made all through this region

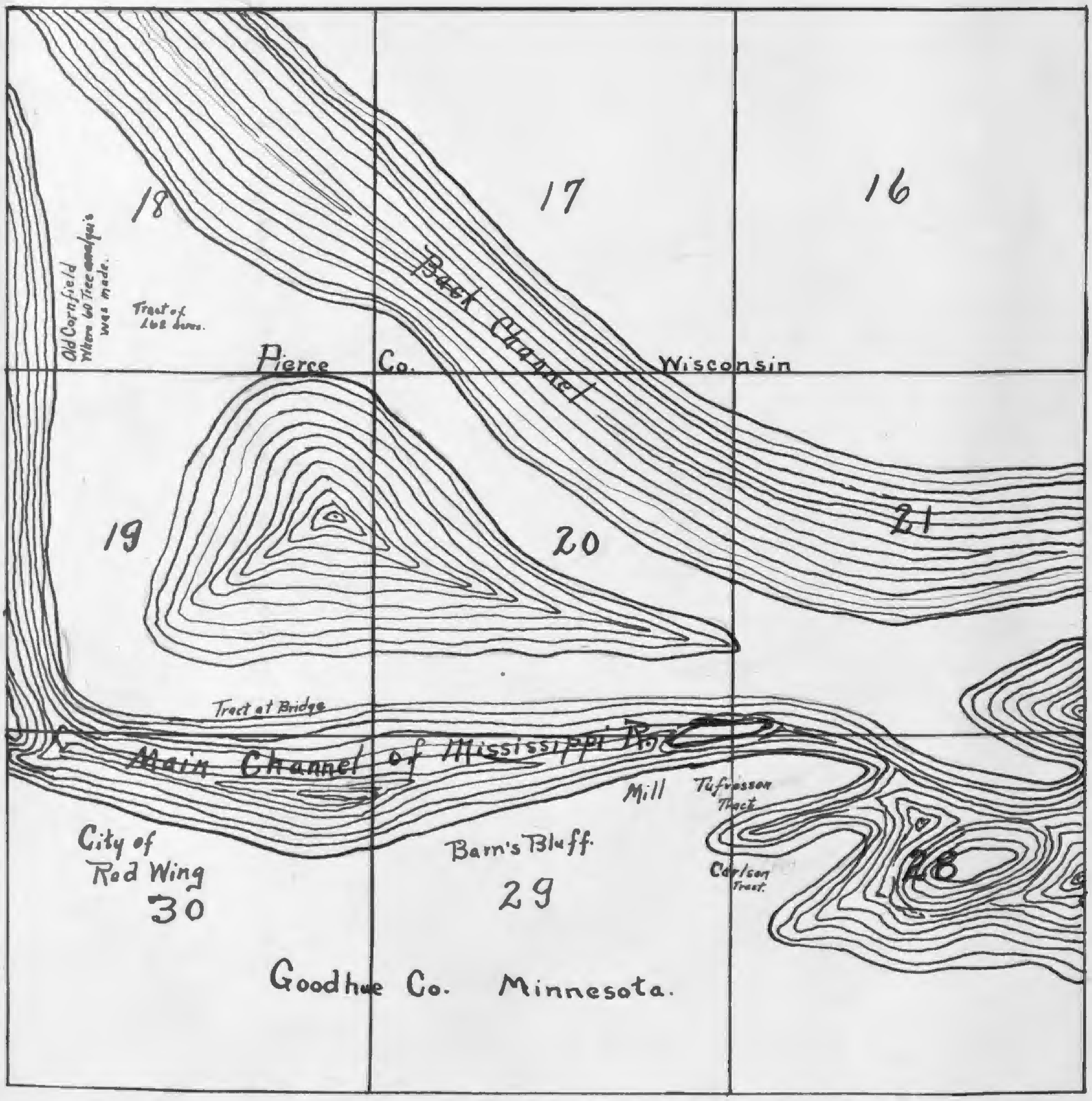

18
17
16
Old Cornfield
Where 60 Tree analysis
was made.
Back Channel
Pierce Co.
Wisconsin
19
20
21
Tract at Bridge
Main Channel of Mississippi R.
Mill
Tufrosson
Tract
City of
Red Wing
30
Barn's Bluff
29
Carlson
Tract.
28
Goodhue Co. Minnesota.

Fig 4

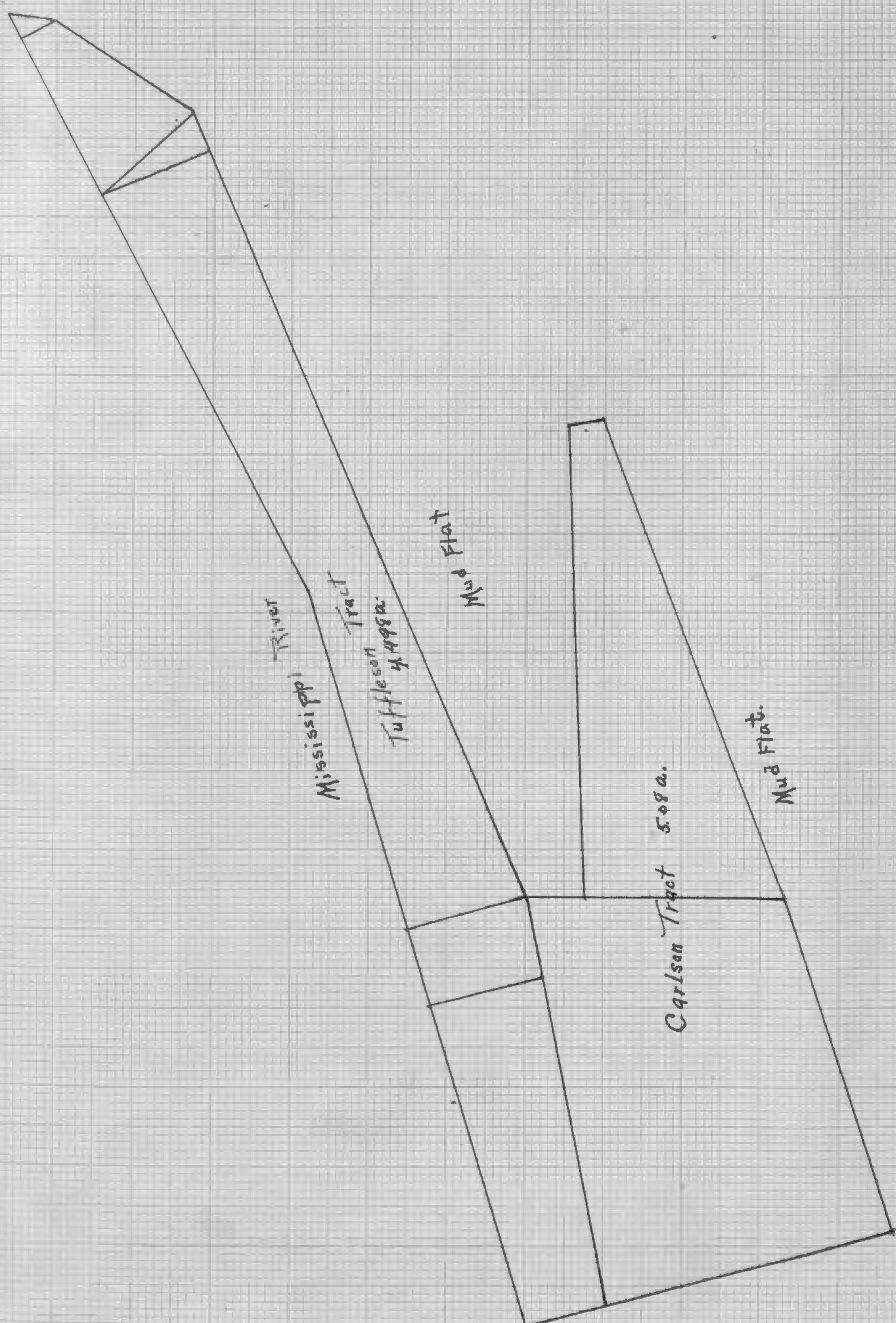

Mississippi River
Tuffleson Tract
4.498a.
Mud Flat
Carlson Tract 5.08a.
Mud Flat.

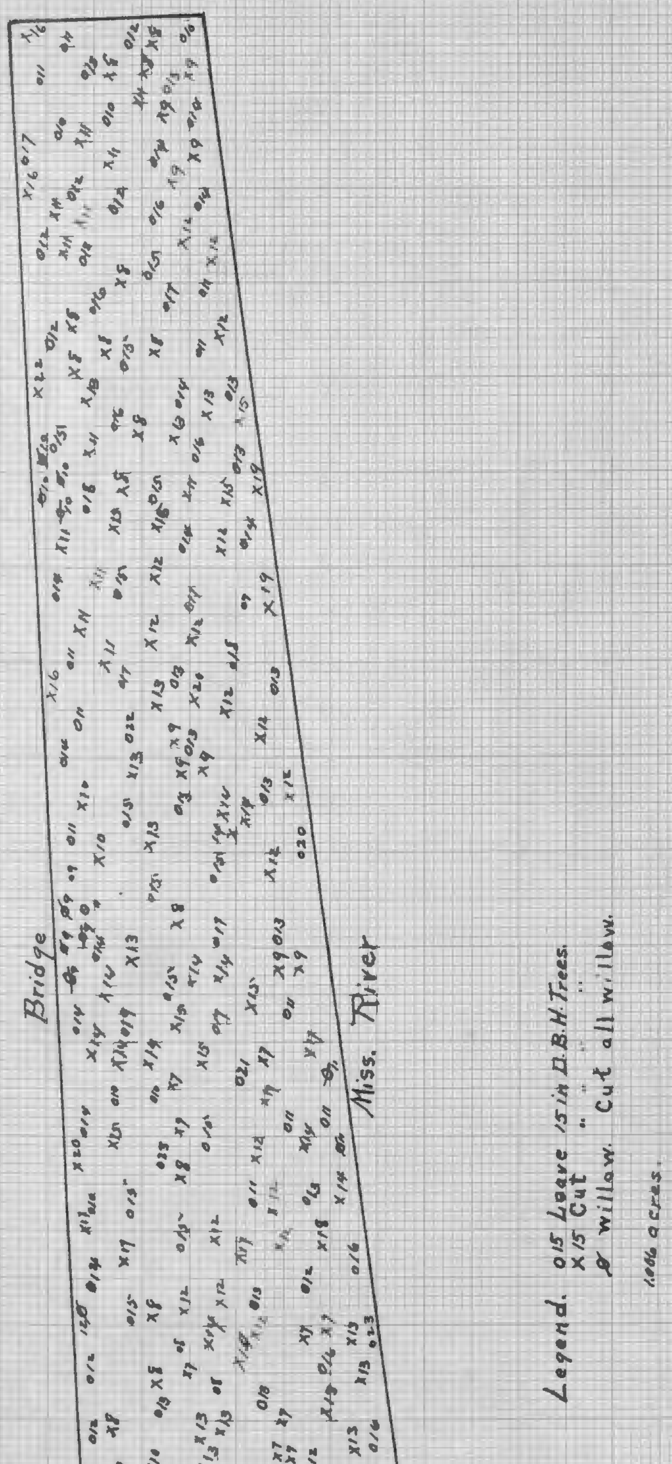
Fig 5

with specific detailed studies at various places. Most of the detailed work was done near Red Wing, Minn. because the opportunities to obtain desirable data presented themselves on the tracts being logged by the Forest Products Company of Red Wing. Through the courtesy of this Company I was able to study these tracts before logging, during the logging and after the logging was completed so the data shows what the actual conditions on these tracts were.

Fig. 4 shows the region in which the studies were made with the locations of the smaller areas which were studied in detail.

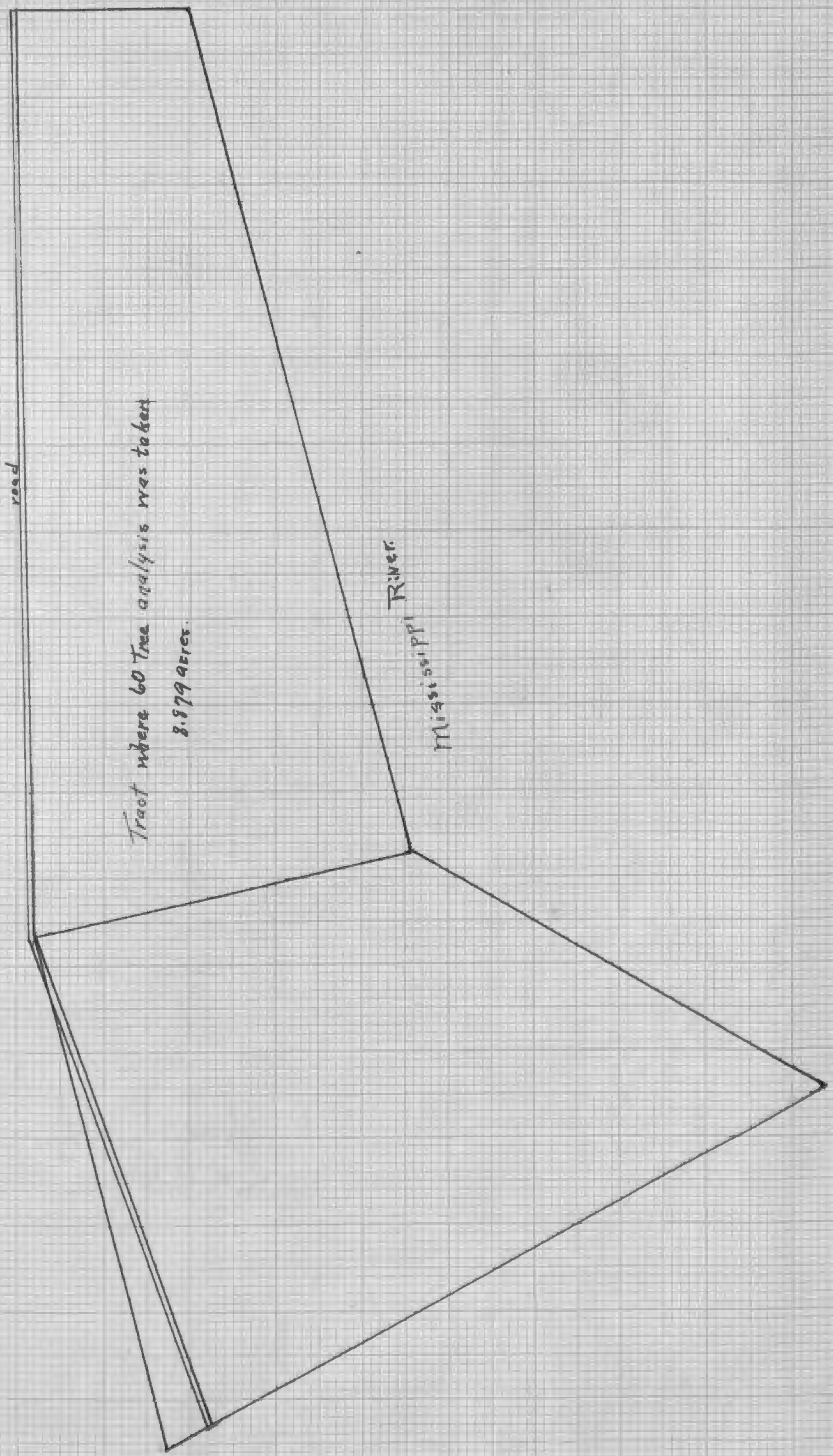
Fig. 5 is an accurately measured area, platted to a scale of 186 ft. to 1 in., including both the Carleson Tract of 5,080 acres and the Tuffleson Tract of 4,498 acres. These tracts are located just below Barn's Bluff on the Minnesota side of the river as seen in Chart 4.

Fig. 6 is a plat of the area between the



Bridge
Miss. River
Legend. 015 Leave 15 in D.B.H. Trees.
X15 Cut " "
∅ willow. Cut all willow.
10.06 acres.

Fig 6.



road
Tract where 60 tree analysis was taken
8.879 acres.
Mississippi River

Fig 1

bridge approach and the Mississippi River on the Wisconsin side just across from Barn's Bluff. It is platted to the scale 60 ft. 1 in. and contains 1.006 acres.

Fig. 7 is a plat of the area on the Wisconsin side between the main channel and a back channel or slough. This tract is on an old deserted cornfield which was under cultivation some 37 years ago, but was abandoned due to over flows of the river. This area is platted to a scale of 150 ft. to 1 in. and contains 8.879 acres. All of the cross lines shown on the above mentioned plats were run for checks on the distances and areas.

Fig. 8 shows the distribution of the trees on an 1.62 acre plat just east of plat shown on Fig. 7.

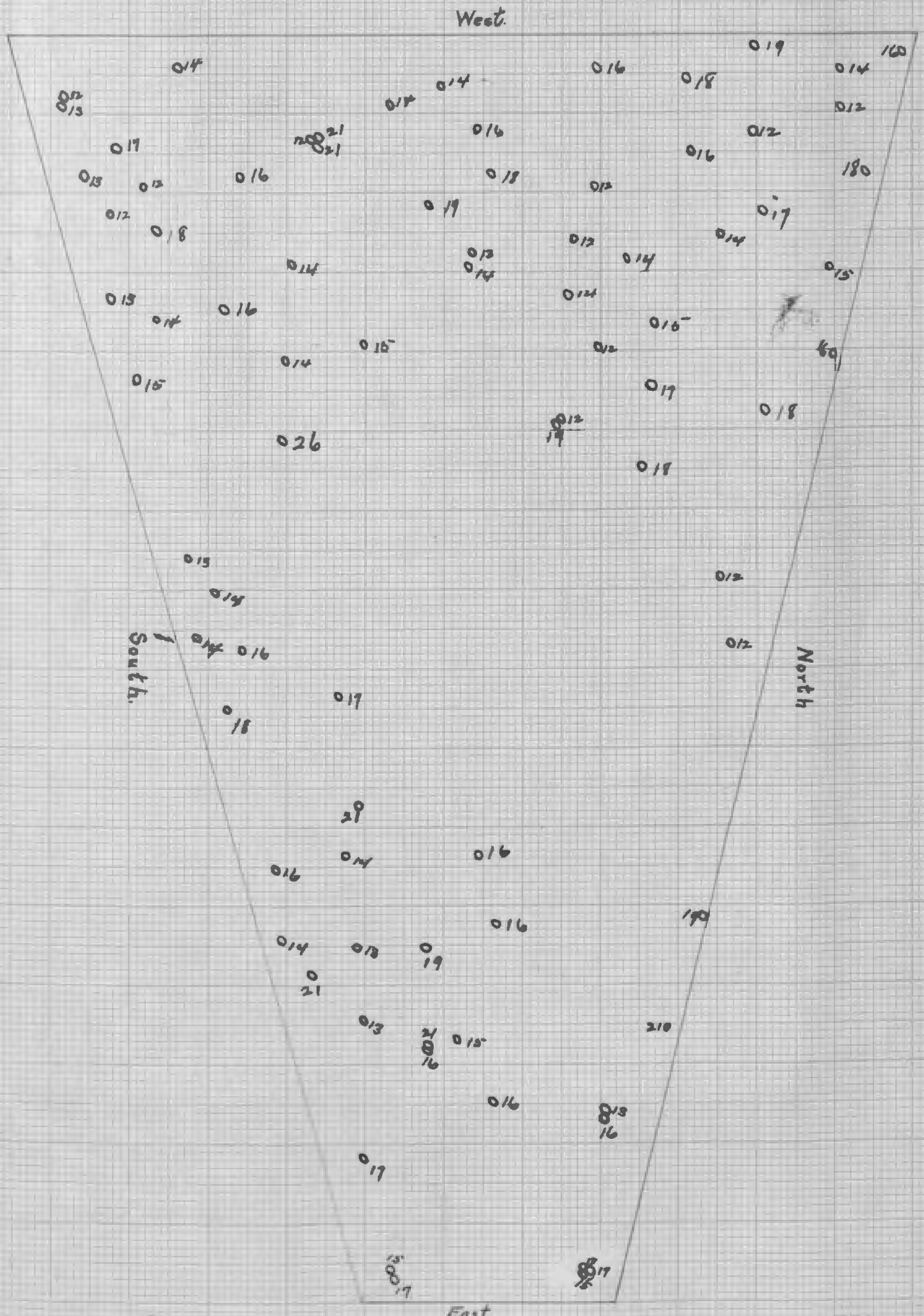
Table I.

Tract at Bridge - Fig. 6

Valuation Survey

	Cottonwood		Willow		Boxelder
D.B.H. in in.	Cut Out	Leave	Cut Out	Leave	Cut Out
5	1		1		
6	3				
7	10	2	3		
8	21	2	4		
9	9	1	4		
10	12	8	4		
11	12	12	2		
12	17	10	1		
13	16	19	1		
14	13	13	20		1
15	7	12			
16	3	8			
17	8	10			
18	2	2			
19	2	1			
20	3	1			
21		1			
22	1	1			
23		2			
29		1			
	140	106			

160
300
21
321



Plat East of road acoss from plat on old cornfield *Area 1.62 acres*
Scale 1in = 40 ft.

Fig 8

Thinning at 30 yrs. old yielded	14,233	B.F.	Cottonwood
	718	"	Willow
	32	"	Boxelder
	14,983	"	Total
Left standing	17,412	"	Cottonwood
Total yield at 30 yrs. old	32,395	"	on 1.006 A.

Fig. 13 shows a part of the stand on this area and from this it can be readily seen that the stand and yield could be much improved by scientific management with thinnings.

Table 2.

Stand on 1.62 acre plat - Fig. 8.

No. of Trees	D.B.H.
12	12
8	13
15	14
8	15
14	16
6	17
7	18
5	19
6	21
1	26
Total 82	16.8 Average D.B.H.

Produced 17,116 B. F. by scale

Cord wood 34 cds.

Age of stand 38 yrs. Cultivated field prior to that time.

Value of land $10.00 per acre.

Taxed at 2%

Value of lumber $25.00 per M	$428.00	
" " cordwood $2.50 per cd.	85.00	
Total income from plat		$513.00
Taxes annual $.324 compounded at 5% interest for 38 yrs.	$ 3.30	
Land value $16.20 compounded at 5% for 38 yrs.	82.55	
Cost of Logging @ $7 per M	119.81	
Cost of cutting cordwood @ $1.00 per cd.	34.00	
Estimated cost of manufacturing	100.00	
Total expense		339.66
Net profit from area		173.34

An annual net profit of $2.81 per acre allowing 5% compounded interest on the investment.

Photo by J.P. Wentling.

Fig 9

Photo by J.P. Wentling

Fig 10

Fig 11

Photo by J. P. Wentling.

Photo by J.P. Wentling.

Fig. 12

Photo by J.P.Wentling.

Fig 13

Fig 14.

Photo by J.P. Wadling.

Fig. 15 Photo by J.P. Wentling.

Figures 14 and 15 show parts of the stand on this area. These show the uneven stand and grouping of trees which naturally tends to retard growth, cause suppression and hence lower the yield.

This region was studied from February, 1911, to April, 1912, checks being kept on quadrats laid out to study reproduction and the lumbering and marketing conditions were studied during the logging operations and milling. The purpose of the entire study being to get as far as possible the production, rate of growth, value and management of the Cottonwood with the ultimate aim of arriving at some conclusion as to the productive value of the river bottom-lands which are now of little or no value.

Soil and Moisture Requirements.

The hardwood bottoms are for the greater part overflow land. The soil is alluvial and generally of great fertility and tree growth for this reason is extremely rapid for the most part. If these lands could be drained, they would form some of the richest bottom-land farms, but they are subject to heavy floods in the spring and in wet seasons. These bottom-lands vary considerably in width from 1 to 6 miles, and are bounded by the sharp banks of the upland plain, the river sometimes becoming a meandering stream from side to side and more often the bottom-land is cut up by shallow channels and sloughs. The bottoms are practically flat, the elevations above the ordinary level of the river being from 10 to 20 ft. The height of the overflow and the stands of Cottonwood produced in these overflowed lands are shown in Figures 9 and 10. The flat character of the land is shown, and in Fig. 10 a mud lake or slough can be seen through the trees in the background. The white mark on the bark at about 5 ft. from the ground shows the level at which the water stood. The high water remained for nearly 3 weeks before it had receded so the ground appeared again,yet the growth of the trees was neither checked nor injured. These flats end abruptly at the bluffs as shown in Fig. 11. This is a view of Barn's Bluff at Red Wing and shows the flat plain in the fore ground, with the bluff rising abruptly from it. According to the U. S. G. S. the top of this bluff is covered with loam, which hides the rocks from sight down a sloping descent of about 70 ft. The general section consists as following in descending order:-

1. Slope and lime rock - 120 ft.

2. Sand and green sand and lime rock - 40 ft.

3. Massive sand, the upper portion being white, the lower portion yellow. From this the glass sand is taken, - 50 ft.

4. Sand and green sand with cement of lime and magnesia, with distinctly aluminous portions to the flood plain - 80 ft.

Barn's Bluff dips to the east a few degrees.

This composition of the banks and bluffs shows what the deposits in the bottoms contain since these bluffs have been worn away and the sediment deposited to form the alluvial flats or carried away by the stream. The alluvial deposits are about 10 to 15 ft. deep on an average and in some places are underlaid with clay or hardpan. The top soil, formed by admixture with organic matter, is a deep loamy sand or clay loam, according as sand or clay subsoil prevails. The undrained forest soil is wet in winter and moist in summer, but where the soil is exposed it becomes dry and cracks during the hot summer months. Decomposition is extremely rapid in these bottoms and there is very little humus. In the forest there is usually a layer of from 3 to 6 inches of organic soil. This land will produce good crops when dry enough and large crops of corn have been raised on the soil where the stands of Cottonwood,shown in the above pictures,now stand. The type of soil described and moisture conditions are ideal for the Cottonwood and in these localities it reaches its best development, but it will grow very well on upland soil if it has moisture. Where the Cottonwood is seen growing on the hillsides or on sandy soil where it apparently is on dry soil, a closer investigation will invariably show springs or an understrata of wet or moist soil near enough to the surface to furnish the tree with sufficient moisture. This is the reason this species is seen following along draws and gulches far into the plains regions where other trees have not matured.

Forest Types

Much of the land is overflowed annually along the bottoms and the Cottonwood has taken possession of this land, forming a pure stand on these areas. The forest is usually open with a clean forest floor. Its only associate in these regions is the willow which usually gives way to the more vigorous growing and taller Cottonwood. In the more upland or less flooded areas the boxelder, red maple, soft maple, white elm and green ash are the associates of the Cottonwood with an occasional area of river birch. Near Wabasha,at the foot of Lake Pepin, the river birch (Betula nigra) forms pure dense stands, as shown in Fig. 12. These stands are too dense to produce any merchantable timber except cordwood unless they are thinned. Near the bluffs and on the higher land the Cottonwood - maple type gives way to the maple - elm - oak forest, which, as it ascends the sides of the valley, changes into the scrub oak type. Hence, a transect line in many places from the swamp to the bluff, starting at the river,would lead through successive forest types of (1st) Cottonwood; (2nd) Mixed Cottonwood, elm, ash and boxelder; (3rd) elm, ash, boxelder and oak and finally (4th) into the oak type in the order named.

Whether these types are permanent depends more on the conditions than on the species with the exception of the oak type, which is permanent. If the water level remained low enough to allow the maple, ash, boxelder and elm to grow, they would crowd out the Cottonwood due to their greater tolerance of shading, but the moisture conditions are in favor of the Cottonwood, so it remains in these localities. Hence the mixed types change and shift about.

Reproduction

The Cottonwood blooms in April to May according to the season and the fruit matures about three weeks after flowering. The seed has a cotton-like mass attached to it, which aids its distribution. By this parachute arrangement the seeds are carried for long distances by the wind and, if they land in favorable locations, they germinate immediately. The seeds are vital for only a short time after leaving the tree and to produce a high per cent of germination must reach favorable places within twenty-four hours after leaving the tree, although some will germinate after a longer period. The best place for the germination of the seeds is on the water's edge of streams or lakes where the seed reaches the soil and plenty of moisture at the same time. Fig. 16 shows a bar running out into the Mississippi River where the Chippewa River empties into it. This bar is covered with a mat of Cottonwood seedlings as the conditions here are very favorable for seed germination. Fig. 17, taken near the mouth of the Chippewa River, shows the Cottonwood seedlings thriving on the bare sandbank of the river out beyond where any other vegetation has migrated. These seedlings develop deep tap roots and reach the moisture even though the surface appears to be dry sand. Fig. 18 shows where the seedlings have started on a railroad grade and the height growth can be seen in the pic-

Fig 16

Fig 17

Fig 18 Photo by J.P. Westling.

Fig 19.

Fig 20.

Fig 21

Fig 22.


Fig 23


Fig 24


Fig 26

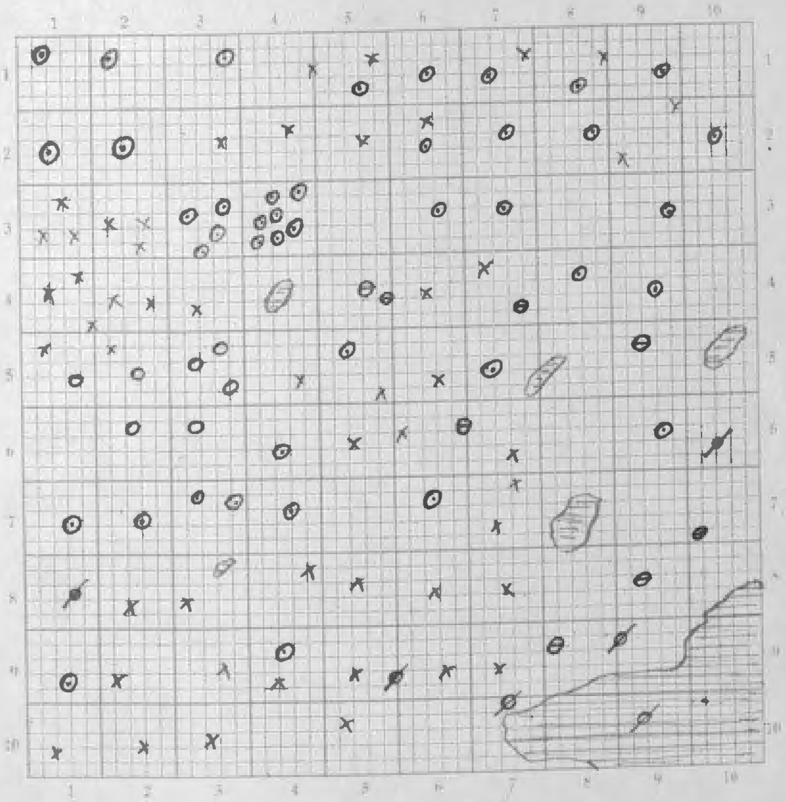

Fig 25

QUADRAT 10 x 10 Ft LOCATION Junction of Miss. & Minn R DATE Oct 9, 1911.

FORMATION River Bottom, sandy Loam, Populus-Salix

CONSOCIES Populus-Salix

SOCIETY Populus deltoides - Salix. spp.



LEGEND: o Populus deltoides 3 yrs old. (Cottonwood)
⊙ " " 2 " ". "
x Salix spp. 2 yrs. old (Willow).
Grass areas.
● Chenopodium album (Lambs quarter).
Chrysanthemum Leucanthemum (Ox-eye Daisy)

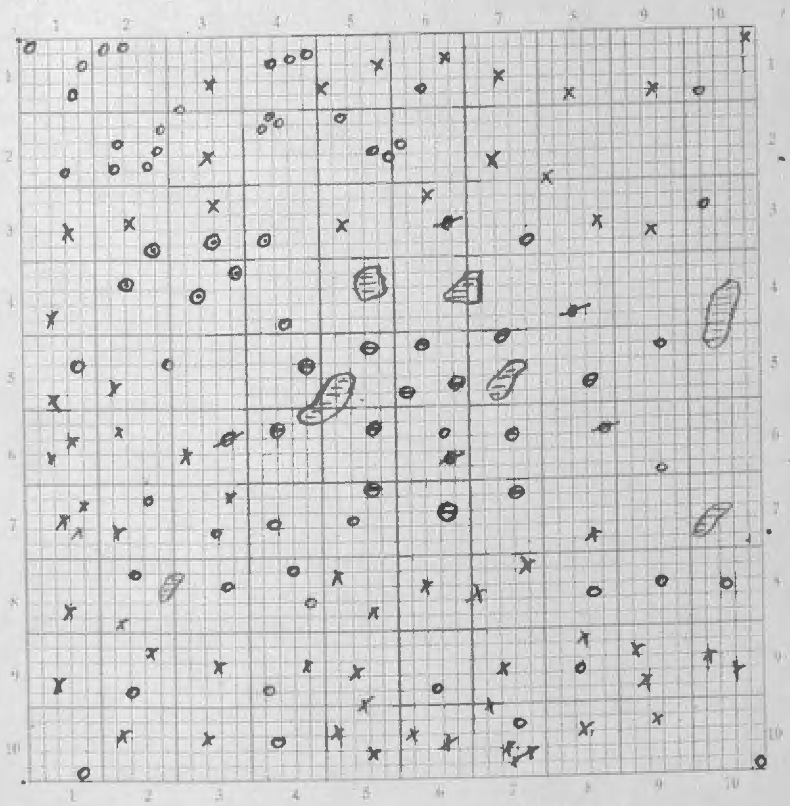
Fig 27

QUADRAT *10 X 10 Ft.* LOCATION *Junction of Minn & Miss R.* DATE *Oct 9, 1911*

FORMATION *River Bottom, sandy loam, Populus-Salix.*

CONSOCIES *Populus - Salix*

SOCIETY *Populus deltoides - Salix spp.*



LEGEND:
- o *Populus deltoides 3 yrs. old. (Cottonwood).*
- ⊙ *" " 2 " ".*
- x *Salix spp. 3 yrs old (Willow).*
- *Grass bunches.*
- θ *Chenopodium album (Lamb's quarter).*
- *Chrysanthemum Leucanthemum (Ox-eye Daisy)*

Fig 28

ture. These seedlings are one year old.

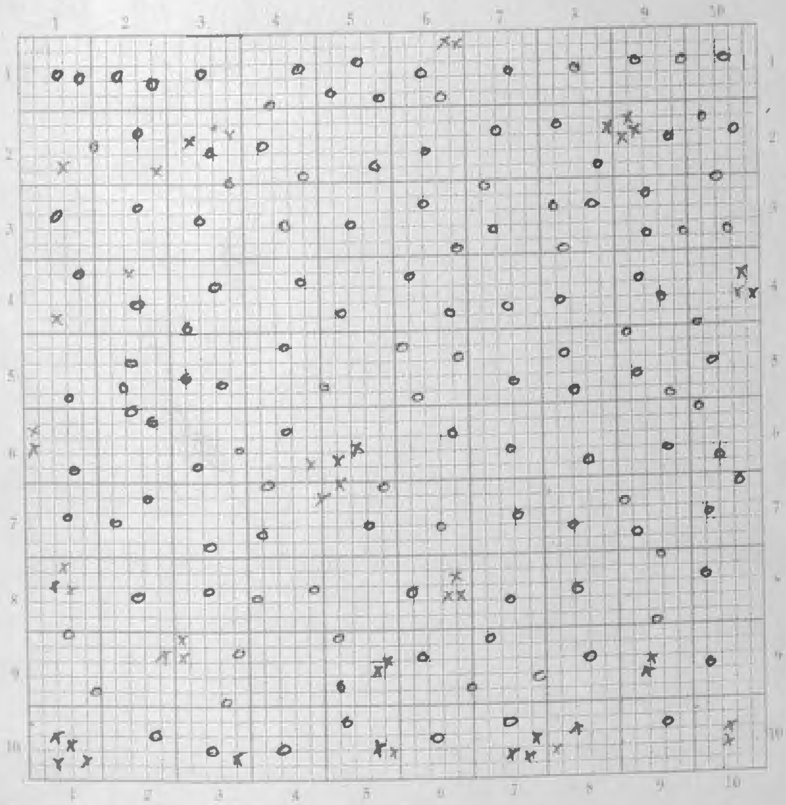
Figs. 19 to 25 inclusive show the conditions, along the Minnesota River, and at the junction of the Minnesota and Mississippi Rivers, under which the Cottonwood establishes itself. These plats are overflowed every spring and at high water during the summer. The competitors of the Cottonwood on these areas are shown in quadrats taken at these places. Figs. 27 and 28 show the conditions and the species of plants the Cottonwood competes with, while the above views show the relative growths of the different plants. As seen in Fig. 19, the Cottonwood one-year-old seems doomed and under those conditions few survive, while Fig. 20 shows Cottonwood three years old and two years old, where quadrat shown in Fig. 27 is taken. This has established itself and now overtops all other growths. The same is shown in Fig. 22 where quadrat in Fig. 28 was taken. While in Fig. 24 the one year old seedlings are well estab-

QUADRAT 5 X 5 Ft. LOCATION Lower end of 60 Tree tract, Red Wing. Minn. DATE May 15, 1911.

FORMATION River Bottom Populus deltoides

CONSOCIES Populus deltoides

SOCIETY Acer.



LEGEND: O Acer negundo (Boxelder) 1 yr old.
x Water leaf.

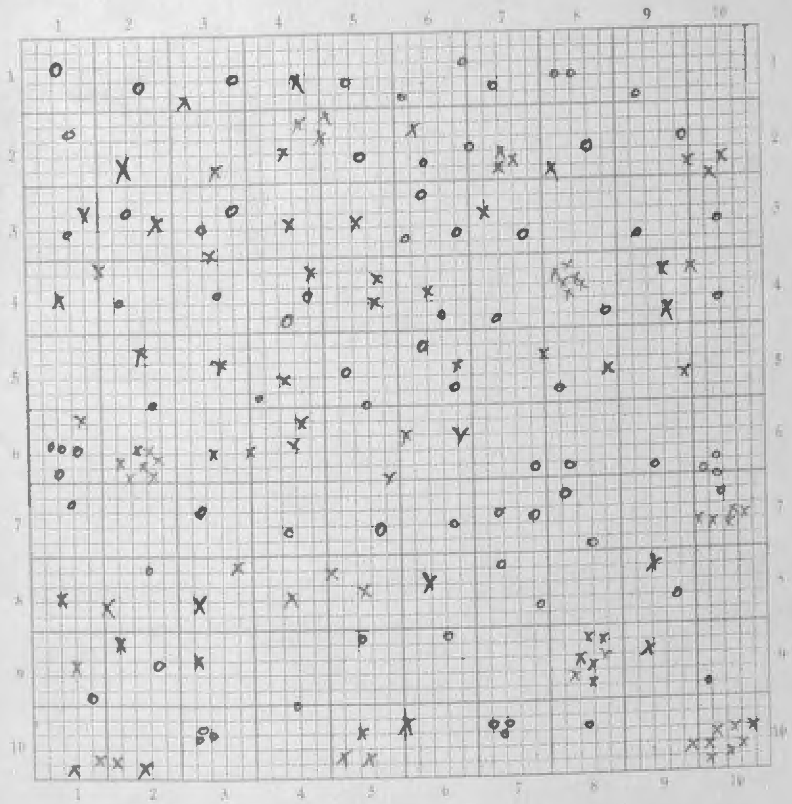
Fig 29

QUADRAT 10X10 Ft LOCATION 60 Tree Tract Red Wing Minn DATE June 15, 1911

FORMATION River Bottom - Populus deltoides

CONSOCIES Populus deltoides.

SOCIETY Acer.



LEGEND:
o Acer negundo (Box elder) - 1 yr. old.
x " rubrum (Red maple) " ".
o Water Leaf.
x Grass tufts.

Fig 31

Fig 30

Fig 32

lished on the edge of the thicket where they could get plenty of light.

Fig. 26 is a view of the seed trees that are seeding this area. They are across the Minnesota River from these bars and shores where these thickets occur.

Quadrat in Fig. 29 was taken where cap is shown in Fig. 30. Although it is under a Cottonwood stand of seed trees there are no Cottonwood seedlings and the boxelder, if left to mature, will replace the temporary stand of Cottonwood. Fig. 31 shows a quadrat taken where the cap is shown in Fig. 32. This also shows reproduction of maple and boxelder, but no Cottonwood seedlings. For planting, Cottonwood seedlings can best be obtained along banks and bars of streams and lakes where it is native as they grow in mats in these favorable localities.

Cuttings.

Reproduction by cuttings is often more practical and feasible than by seeding or transplanting seedlings because the cuttings are easier handled and cheaper to plant. Cuttings of almost any size are all right and should be selected to suit the locality. Where much erosion occurs, or strong competition is met with, stronger and larger cuttings must be used. Desirable cuttings are about one-half inch in diameter and eighteen to twenty-four inches long, but may be used much larger or smaller. I found that cuttings taken from vigorous growing trees, sprouts and seedlings all grew very well and it seemed to make no difference what part of the tree or branch they were found, if they were not more than three years old.

Figs. 33 and 34 show flats with cuttings from various parts of trees, seedlings and sprouts and they all grow alike, but I found that the cuttings from the top of the crowns of old trees were slower in starting and much less hardy, in many

Fig 33

Fig 34

Fig 35

Fig 36

Fig 37

Fig 38

Fig 39

Fig 40

cases not being able to establish themselves after starting growing and dying after a short period.

Figs. 35-40 inclusive show cuttings in various stages of callousing, sprouting and rooting. The buds on the cuttings invariably form stems and shoots while the adventitious buds form the roots. In Figs. 35-36 and 37 the points marked with an X show where the adventitious buds are developing and beginning to push through the bark where there are no lenticels. Very often these roots break out through the lenticels, but they do not necessarily come out through them.

Figs. 41 and 42 are views at the nursery at Wabasha, Minnesota. Fig. 41 shows the seedlings heeled in for the winter, but not taken out for planting in the spring. These should have been planted early in the spring as soon as the frost left the ground. Fig. 42 is a view of nursery stock two years old and in thrifty condition for transplanting to

Fig 41

Fig 42

Fig43

Fig44

the field. Plantations that were made from cuttings in sod and in brush showed a stand of 30% to 50% after two years where the cuttings were healthy and from good stock. In other instances the plantings failed altogether. The chief trouble with these plantations was the damage done by mice and rabbits by chewing the bark ofthe young seedlings and cuttings and killing them. Poison was tried in some localities and proved effective where the rodents could be reached.

Figs. 43 and 44 show a plantation three years old on the shore of Lake Elysian in Waseca County, Minnesota. This planting was made with cuttings about one-half inch in diameter and 12 to 24 inches long. The cuttings were simply cut into the sand in a locality where no other vegetation grew. A stand of 100% resulted and Fig. 44 shows the growth that has been made in three years, some of the more vigorous ones being 16 ft. high.

These bottom-lands will produce very rapid


Fig 45


Fig 46

growths of other species as is shown in Fig. 45, where a ~~Honey~~ black locust grown from a ~~cutting~~ 2 ft. seedling grew to a height of 11 ft. this first season. This is near Red Wing. The vegetation in these localities is all fast growing, hence any plantations have the competition of all these weeds to deal with.

<u>By Sprouts</u>:

The results I have obtained in studying reproduction of Cottonwood lead me to believe that where a stand of Cottonwood is established the cheapest, surest and most expedient method of replacing a stand that has been cut is by sprouts. This, however, must be done the best way possible or the stand will fail, as I will show later. Stumps sprout, either from roots that run near the surface, from the root collar, that is, where the stump comes in contact with the ground, or upon the stump from the cambium ring, where it has been cut. The success of the sprout for a future stand is just as mentioned above. Those from the root are soon established and can grow on independently, those from the root collar can also soon develop a root system of their own, but the sprout upon the stump is entirely dependent on the stump for nourishment and support, hence its carrer ends with that of the stump. Fig. 46 shows a stump with its roots near the surface which has established a colony of sprouts about itself. The stump is 24 inches high and 31 years old with a diameter of 22 inches. It has 47 sprouts upon the stump at the cambium ring, with an average height of 5 ft. 2 in. and 30 sprouts from the roots near the surface of the ground, spreading over an area of 20 ft. square. These sprouts average 6 ft. 1 in. high. All the sprouts are one year old. Hence this stump has established a permanent colony, as the sprouts from the roots will soon be independent, regardless of what becomes of the sprouts upon the stumps. This method of sprouting is rare and cannot be depended upon to replace a stand when cut.

Fig 47

Fig 50

Tree showing galls on terminal buds
caused by Pemphigus Vagabundus.
Described on p. 44

Fig 49

Fig 48

Figs. 47 and 48 show stumps that have produced root collar sprouts. These are the most desirable and soon establish themselves independently. These are two year old sprouts and, as seen in Fig. 48, the stump is already covered with fungus growth, hence its life is short, but the sprouts will not be affected by the decay of the stump. In Fig. 49 the sprouts are produced from the cambium ring where cut and their fate is clearly shown. These are also two years old and the most vigorous of them have met their inevitable fate by spreading off from the stump. The stump soon becomes weakened by fungi and weather and the sprout loses its support, hence this method of sprouting is objectionable and not satisfactory.

As to the control of methods of sprouting, nothing can be done artificially to the individual stump after it is cut, but investigations show that the low stump is much more inclined to sprout from the root collar than a higher stump.

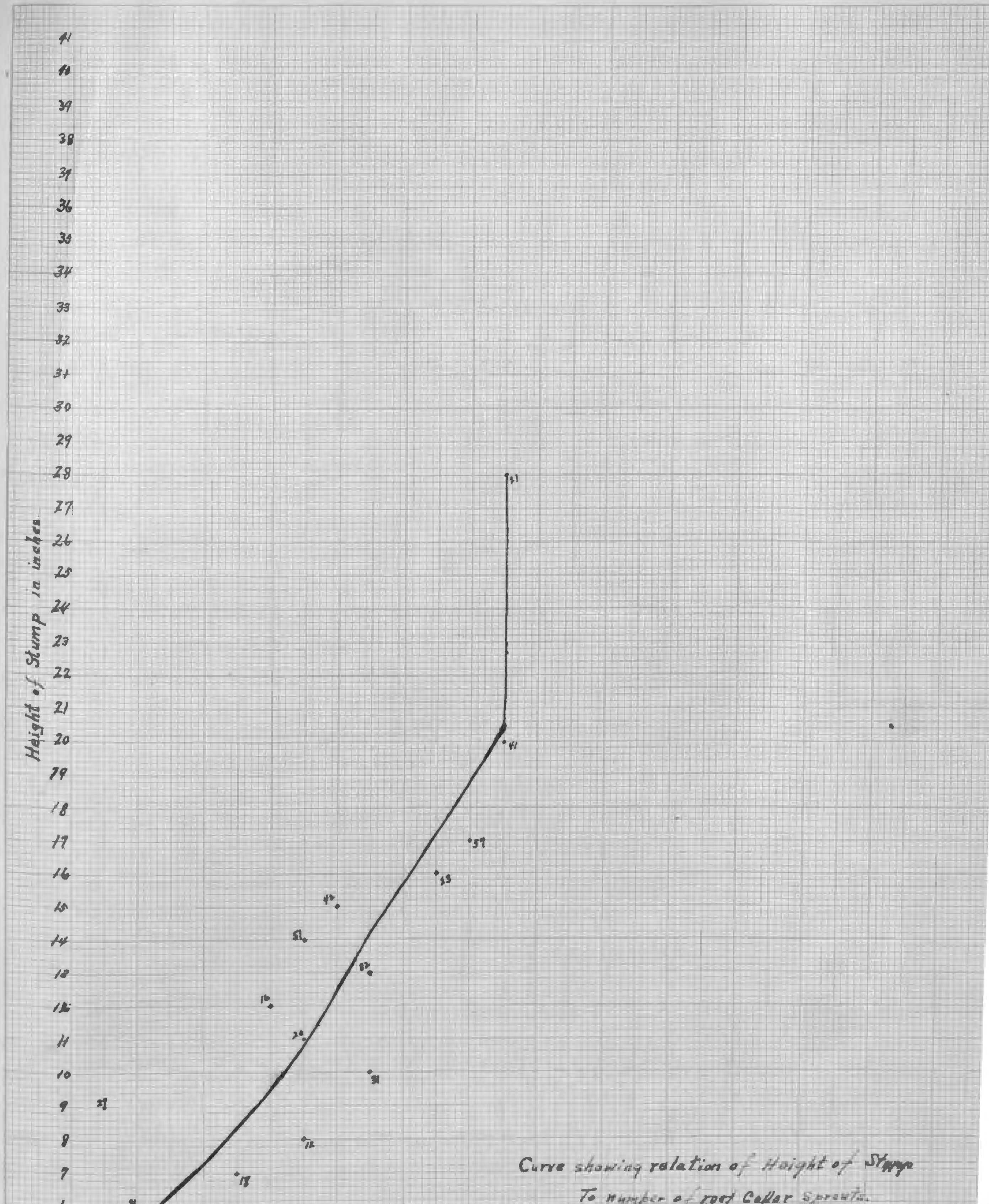

Height of Stump in inches
Number of sprouts on root collar
Curve showing relation of Height of Stump
To number of root Collar Sprouts.

Fig. 51

Table 3 shows that the root collar sprouts cease to appear on stumps more than 17 in. high and are best on stumps under 10 in. in height. It also shows that the number of cambium ring sprouts upon the stumps decreases with the low stump while the proportion of vigorous sprouts increases. Hence, to cut for reproduction by sprouts, cut the stumps low, under 15 in., and as much lower as practical methods will permit.

Curve in Fig. 51 shows the results of height of stumps on root collar sprouts in a graphic way.

Table 3

Table showing number of root collar sprouts and sprouts upon stump according to height of stump.

Number of Stumps	Height of Stump in in.	Aver. No. Sprouts on Root Collar	Aver. No. of Sprouts on Cambium Ring of Stump Where Cut	Aver. No. of vigorous Sprouts on Stump	Aver. Height of Sprouts	Age of Sprouts in Years
11	4	14	0	14	10'	1
16	5	11	0	11	6' 8"	1
21	6	12	2	14	7' 3"	1
18	7	9	5	12	9' 2"	1
12	8	7	14	20	9' 4"	1
27	9	13	20	25	8' 9"	1
31	10	5	8	13	7' 5"	1
20	11	8	2	10	8' 3"	1
16	12	9	30	39	6' 8"	1
32	13	5	48	53	7'	1
51	14	7	21	28	7' 2"	1
42	15	6	17	23	7' 8"	1
23	16	3	32	35	6' 2"	1
57	17	2	36	32	7' 1"	1
37	18	0	42	35	7' 2"	1
7	19	0	62	20	6'	1
41	20	1	44	30	5' 6"	1
23	21	0	24	18	6' 2"	1
10	22	0	37	22	5' 3"	1
9	23	0	42	31	5' 7"	1
26	24	0	26	12	6' 3"	1

Number of Stumps	Height of Stump in in.	Aver.No. Sprouts on Root Collar	Aver. No.of Sprouts on Cambium Ring of Stump Where Cut	Aver.No. of vig- orous Sprouts on Stump	Aver. Height of Sprouts	Age of Sprouts in Years
16	25	0	45	20	5'	1
11	26	0	38	16	4' 6"	1
14	27	0	38	18	4' 9"	1
21	28	1	56	18	4' 6"	1
8	29	0	46	18	4' 8"	1
36	30	0	60	20	4'	1
29	31	0	51	22	4' 2"	1
31	32	0	44	15	5' 1"	1
20	33	0	54	21	4' 6"	1
27	34	0	63	14	3' 8"	1
18	35	0	37	8	4' 3"	1
25	36	0	67	10	3' 2"	1
13	37	0	74	9	3' 8"	1
9	38	0	35	10	4' 7"	1
5	39	0	57	12	3' 5"	1
2	40	0	65	10	3' 2"	1
3	41	0	61	16	4' 7"	1

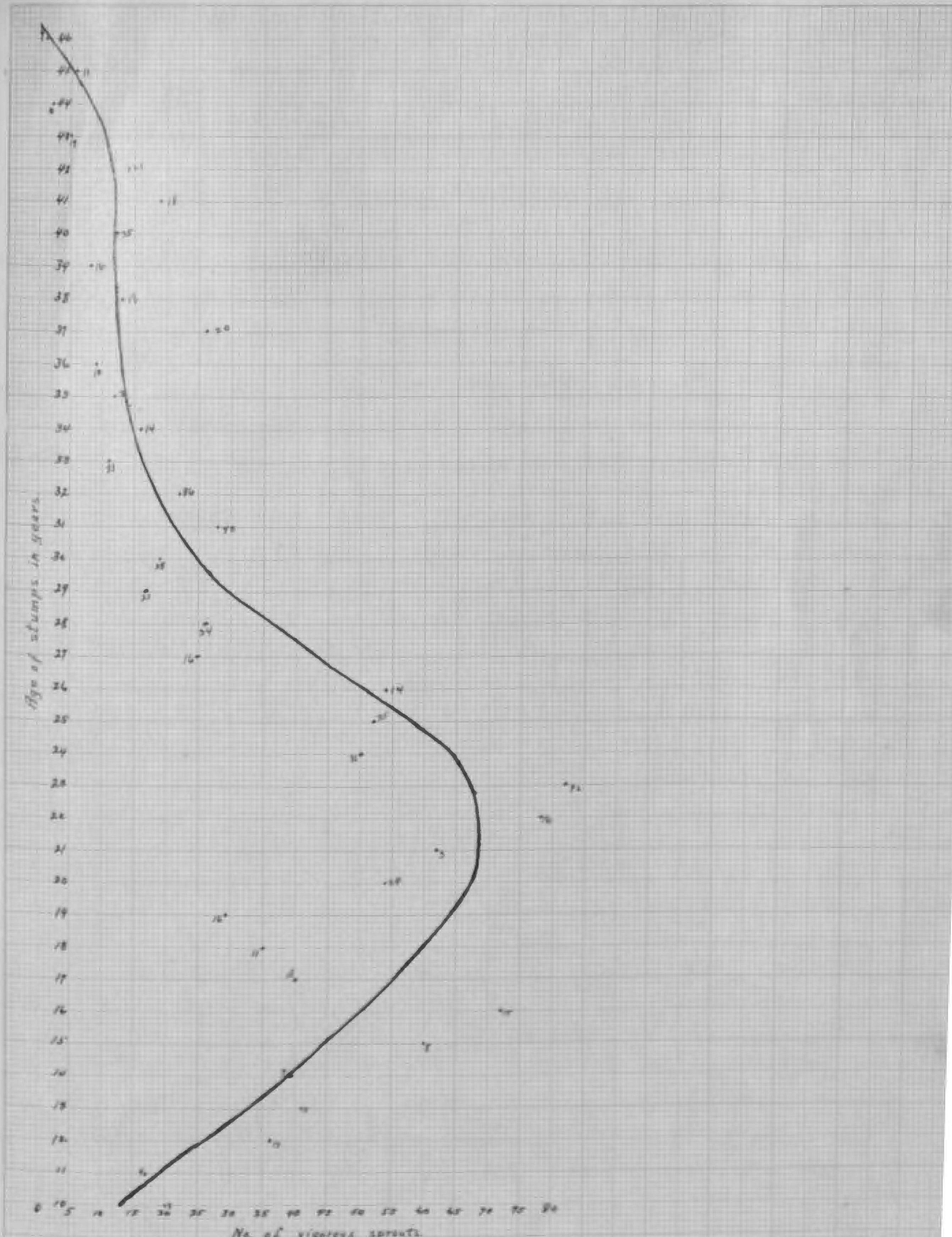


Fig 52

The age of stumps does not seem to enter into the method of sprouting but has a decided effect on the vitality and vigor of growth of the sprouts.

Table 4 shows the effect of the age. The results are graphically shown in the curve in Fig. 52. It will be noticed by this curve that the period of most vigorous sprouting lies between 15 and 30 years with the maximum reached at 20 to 24 years of age.

Table 4

The Effect of Age of Stump on Sprouting

Age of Stumps	No. of Stumps	Aver.No.of Vigorous Sprouts	Aver. Diam. of Stumps
10	3	21	6.
11	4	17	6.2
12	13	36	6.8
13	5	41	7.1
14	7	39	7.6
15	8	60	8.
16	15	72	8.3
17	18	40	8.9
18	11	35	9.4
19	16	29	9.7
20	24	54	10.
21	3	62	10.6
22	16	78	11.3
23	42	82	12.
24	31	50	13.
25	35	52	13.8
26	14	54	14.5
27	16	25	15.2
28	34	26	1.6
29	21	17	16.7
30	28	19	17.6
31	43	28	18.
32	36	27	19.
33	31	11	20.1
34	14	16	22.
35	3	12	22.8
36	23	9	23.2
37	20	26	24.
38	18	13	24.6
39	16	8	25.2
40	35	7	26.

Age of Stumps	No. of Stumps	Aver. No. of Vigorous Sprouts	Aver. Diam. of Stumps
41	18	14	26.
42	21	9	26.9
43	17	5	27.2
44	6	2	27.5
45	11	6	27.9
46	9	1	28.3

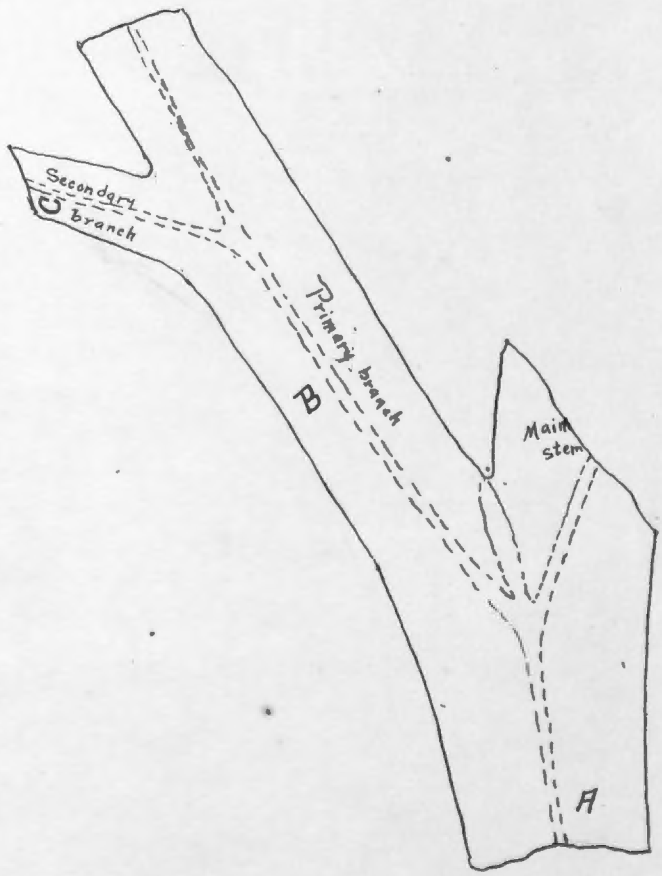


Fig 53

The number of rings in a vigorous sprout or seedling is no indication of its age. That is, a sprout with three rings in cross section does not mean it is threeyears old as I have found many with three and four rings that were one year old. On the other hand the number of rings correspond identically with the number of branching systems. Any sprout with three branching systems as shown in Fig. 53 would have three rings in cross section at A, two rings in section at B, and one ring in cross section at C. Every time a new branching system is developed another ring is added all through the young sprout back to its base. As to the cause I am not certain but the indications are that the more vigorous growth, every time new branches and hence new leaves develop, causes larger cells and hence produces the ring effect in cross section.

Fig. 54 shows the method of counting rings to determine the age and growth of a stump. The talley pins set in line AB show the method of counting from

Fig 54

center to outside to determine periodic growth in 10 year periods. The pins are set in every tenth annual ring. Pins in line AC show the method when rings are counted from outside to center to determine the age. The latter method is the common one used. The lines AB and AC show the average radii of the stump.

Tolerance

The Cottonwood is very intolerant and will not reproduce itself under its own shade or that of other species, hence usually forms a temporary stand or type. When grown in full sunlight and with plenty of moisture it produces very vigorous growth due to the large leaves, as shown in Figs. 56 and 57, while the shade form of the leaves are smaller and less active. These plates show the leaves in actual size taken from leaf prints. The average Cottonwood leaf is about midway between the sizes shown here.

Fig. 58 is a cross section of leaf shown in

Fig 55

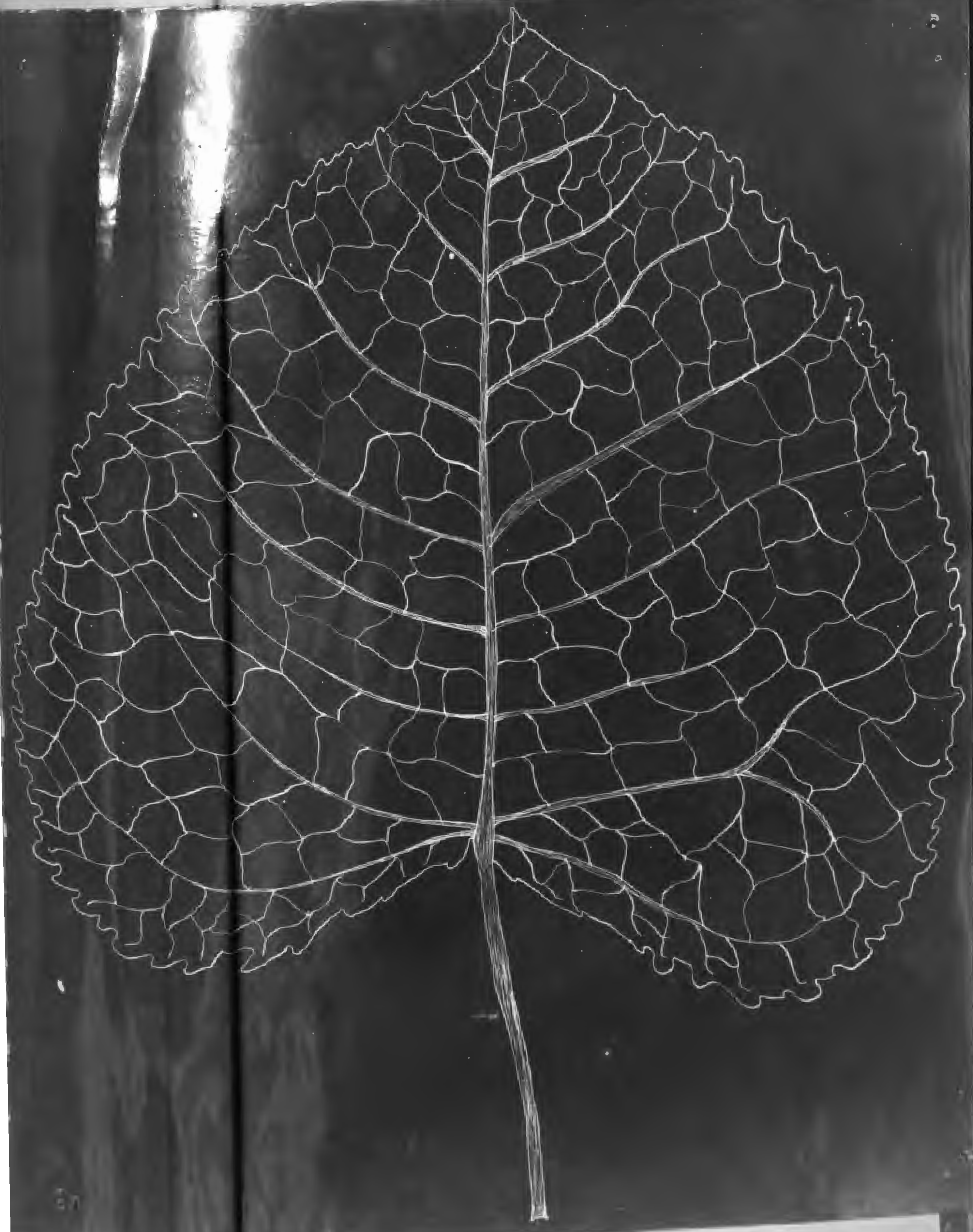


Fig 56

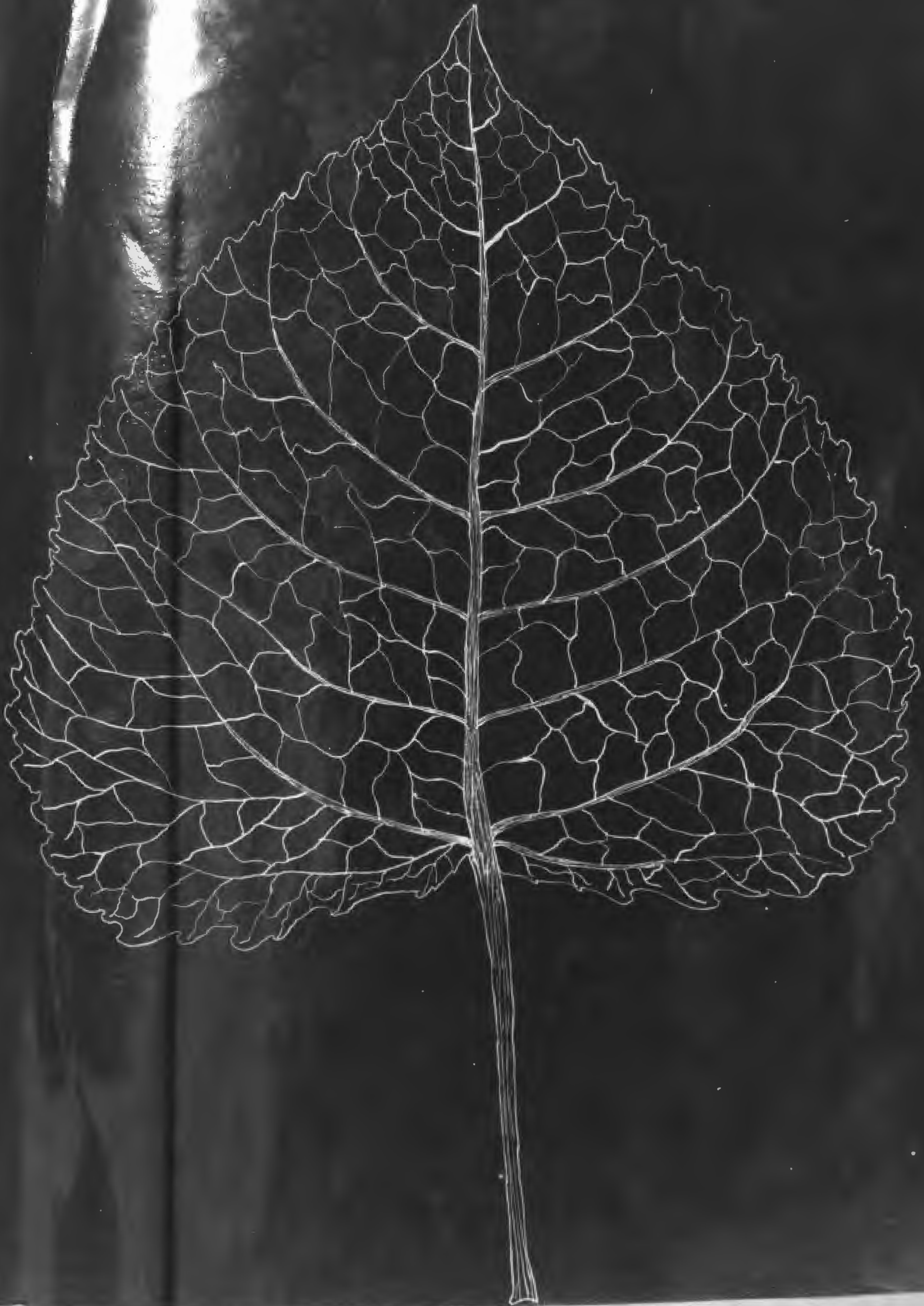
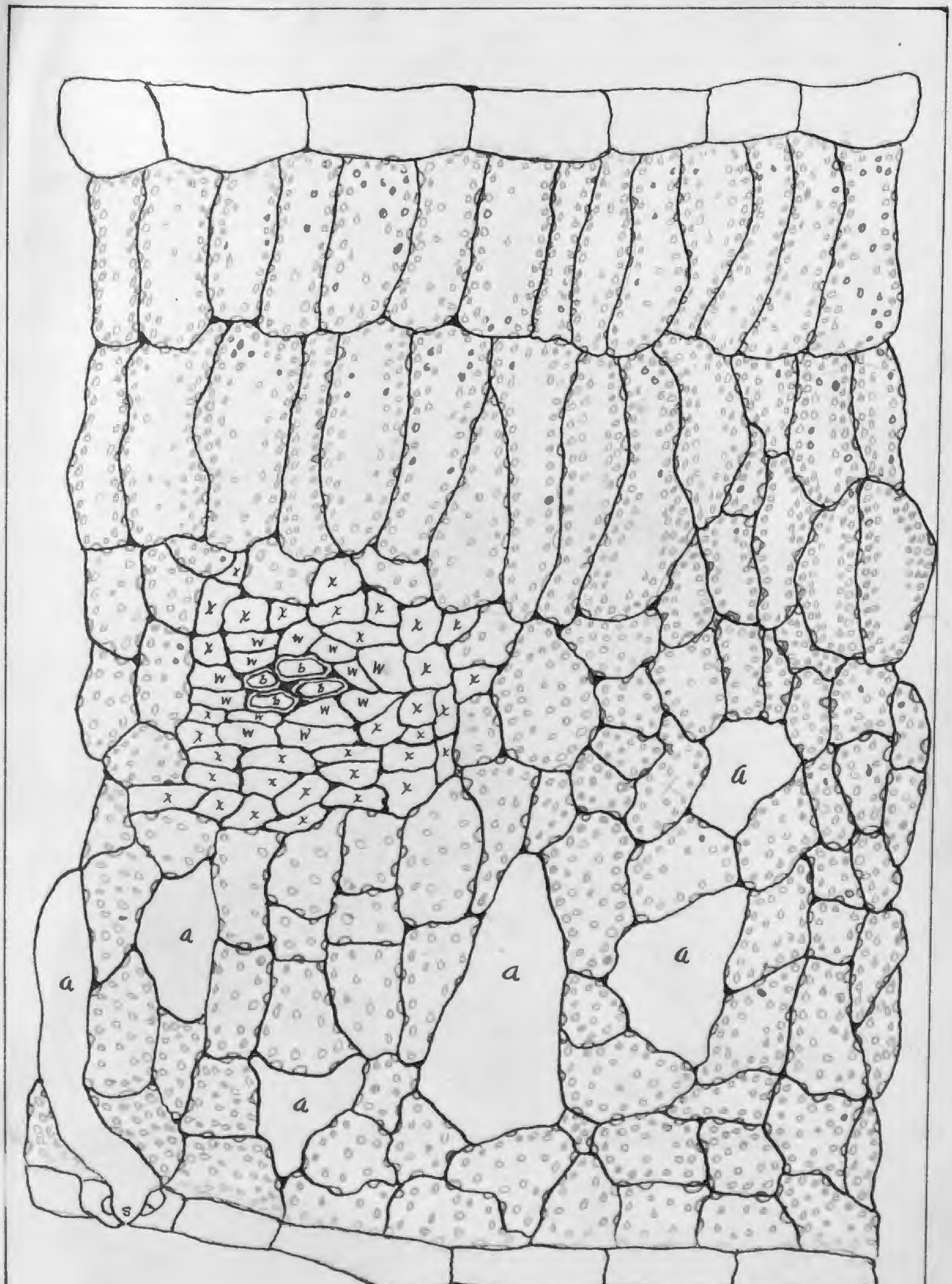


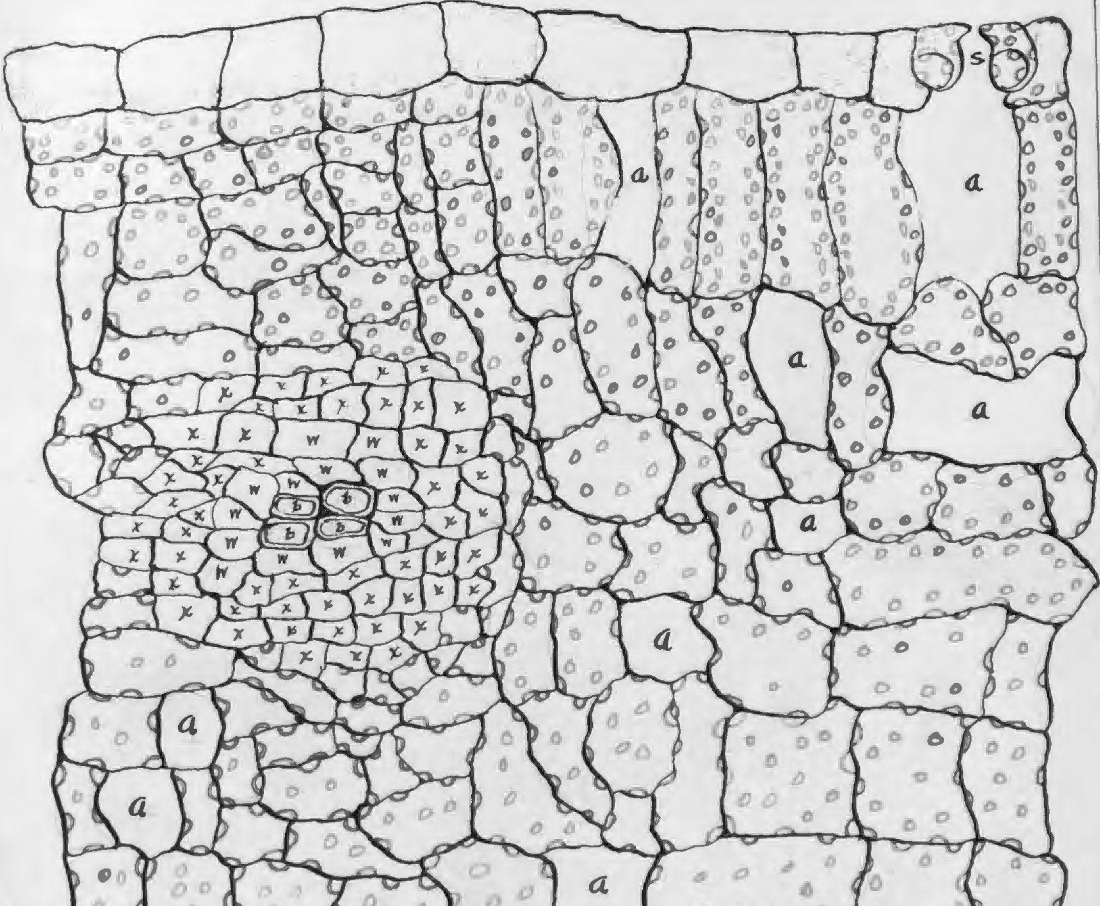
Fig 57



Grown in Sunlight

a = air cells
b = bundles
w = Water storage cells
x = Lignified cells.
s = stoma

Fig 58



Grown in Shade

a = air spaces
b = bundles
w = water storage cells
x = lignified cells.
s = stoma

Fig 59

Fig. 56 and Fig. 59 is a cross section of C in Fig. 55. These cross sections were drawn with a camera lucida and both are enlarged in the same proportion. The chief feature noticeable is the amount of palisade tissue in the leaf grown in the sunlight as compared with the one grown in the shade.

Fig. 55. Leaves grown in shade under leaves shown in Fig. 56 and Fig. 57. All of these were on the same sprout in a clump of vigorous growing sprouts. They show the influence of sun and shade on the size of the leaf, also the influence on the number of stomata to enable the leaf to do its work.

Fig 60

Fig. 61

Table No. 5.

	Area of Leaf	No. of Stomata on upper Epidermis	No. of Stomata on lower Epidermis	Where Grown
Fig.55 A	5.24 sq.in.	1834	2334	In shade
" 55 B	4.38 " "	1509	1920	" "
" 55 C	3.48 " "	1216	1550	" "
" 56	46.37 " "	61219	48654	In sun
" 57	29.93 " "	38401	30521	" "

Fig. 60 shows a clump of Cottonwood seed trees on the Minnesota River bottom near Fort Snelling. Fig. 61 is a near view of one of these trees. The 3 ft. rule on the side of the tree shows its size. While these trees are doing very effective work in seeding the opposite banks of the river and the open areas surrounding them they nevertheless form a temporary stand where they are as is shown by quadrats laid out under them.

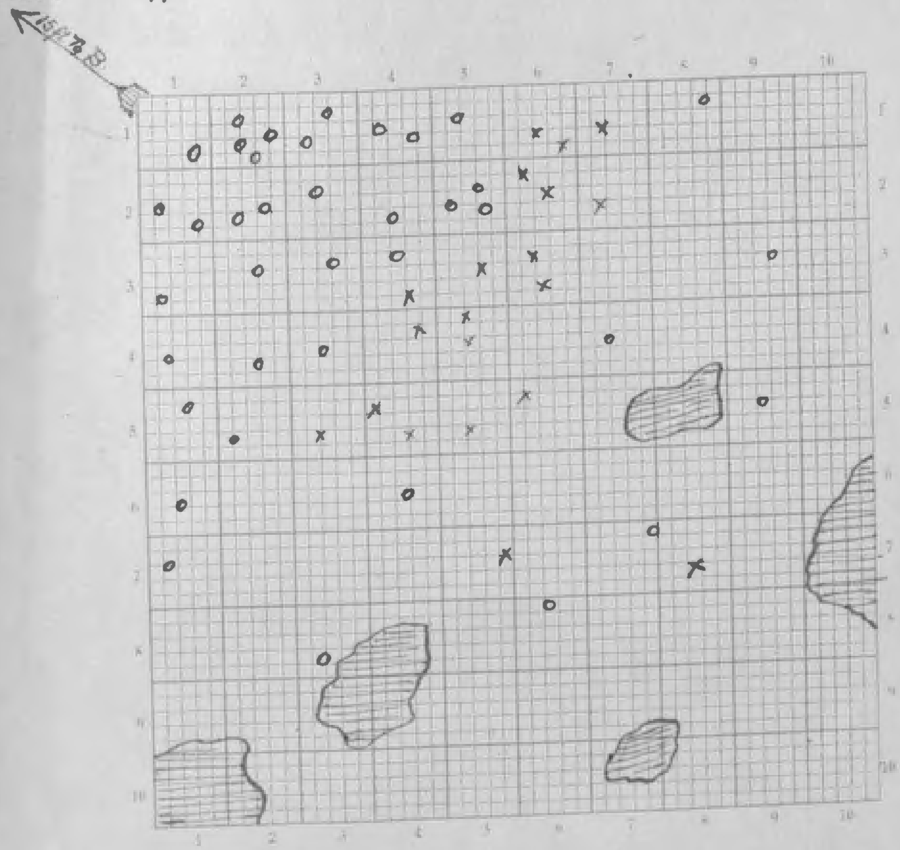
Fig. 62 is a quadrat taken under the large

QUADRAT *10 X 10 Ft. - A.* LOCATION *Minn. R. bottom Ft. Snelling* DATE *Sept 20, 1911*

FORMATION *River Bottom Populus deltoides.*

CONSOCIES *Populus deltoides.*

SOCIETY *Acer.*



LEGEND: o *Acer negundo (Boxelder).*

x *Acer saccharinum. (Soft maple)*

Grass areas.

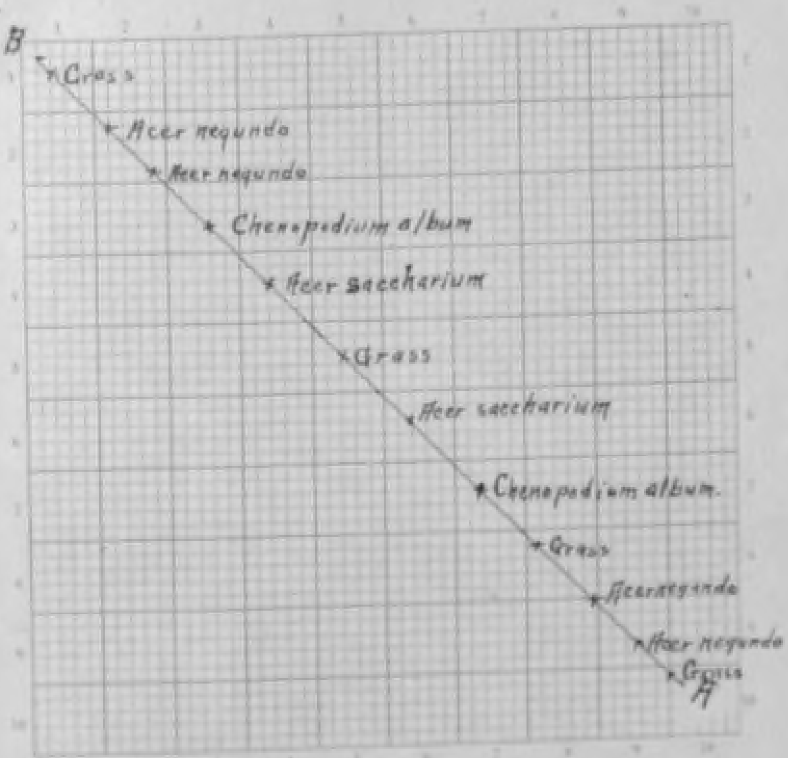
Fig 62

QUADRAT LOCATION DATE Sept. 20, 1911.

FORMATION

CONSOCIES

SOCIETY



LEGEND: Transect from Quadrat A to B as shown by arrows.
Scale 1in = 3ft. Distance 15ft. Line transect.

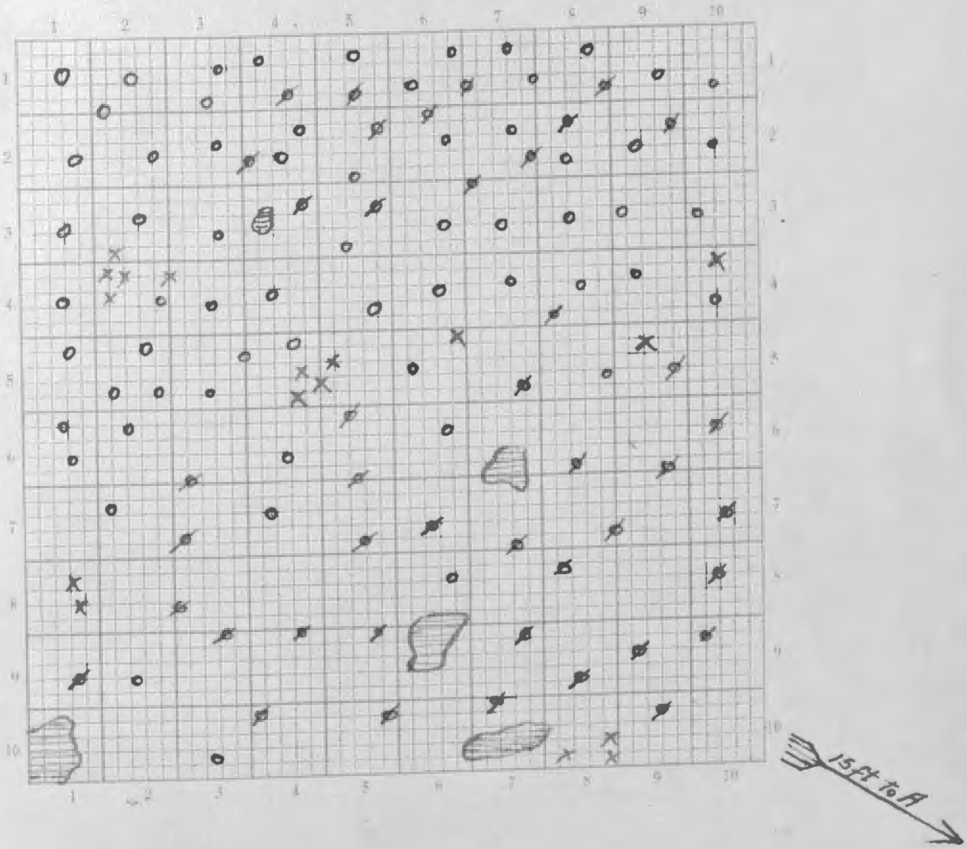
Fig 63

QUADRAT 10X10Ft-B. LOCATION 15ft from A. DATE Sept. 20, 1911.

FORMATION River Bottom Populus deltoides.

CONSOCIES Populus deltoides.

SOCIETY Populus-Acer.



LEGEND: O Populus deltoides 1yr old (Cottonwood).
Ø Acer negundo 1yr old (Boxelder).
Grass areas
x Chenopodium album (Lamb's quarter)

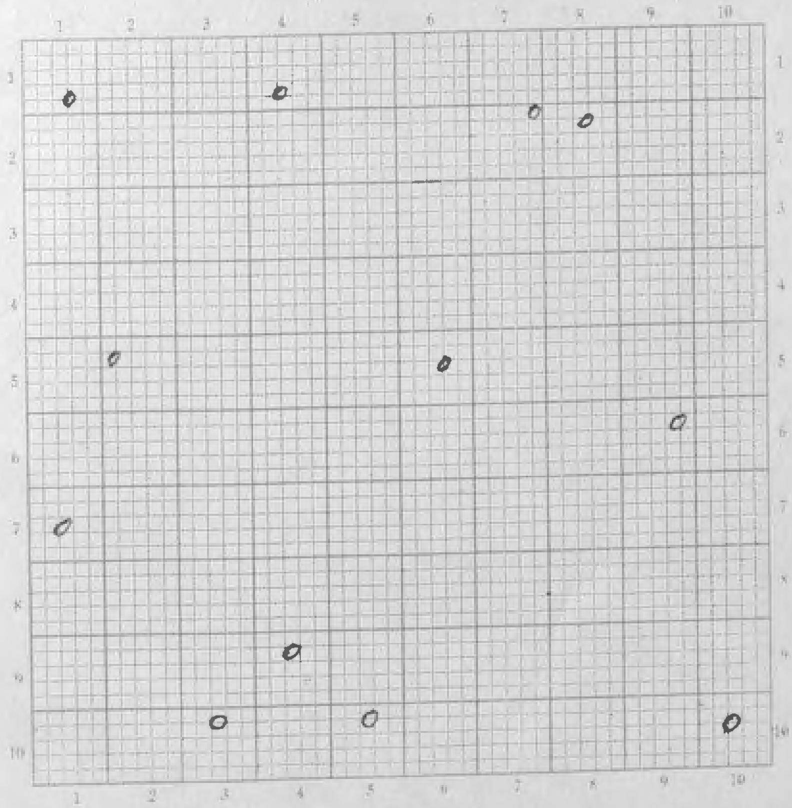
Fig 64

QUADRAT 50 x 50 Ft LOCATION 60 Tree tract, Redwing DATE Mar. 25, 1912

FORMATION River-bottom Cottonwood.

CONSOCIES

SOCIETY



LEGEND: O = Cottonwood Trees.

Fig 65

tree shown at a distance of 5 ft. from its base on the open side of the forest. This shows clearly how the boxelder and the maple are replacing the stand. Then the transect line shown in Fig. 63 running out from the seed trees show the reproduction encountered there and the quadrat in Fig. 64 shows the conditions at a distance 30 ft. from the base of the clump of trees. Here the Cottonwood has just begun to establish itself on this quadrat. The area of reproduction around Cottonwood trees shows this characteristic of intolerance of shade in all instances. That the failure of reproduction is due to light more than any other factor is shown by the fact that other species establish themselves under shade where the Cottonwood fails, these same species being such as require about the same moisture conditions as the Cottonwood.

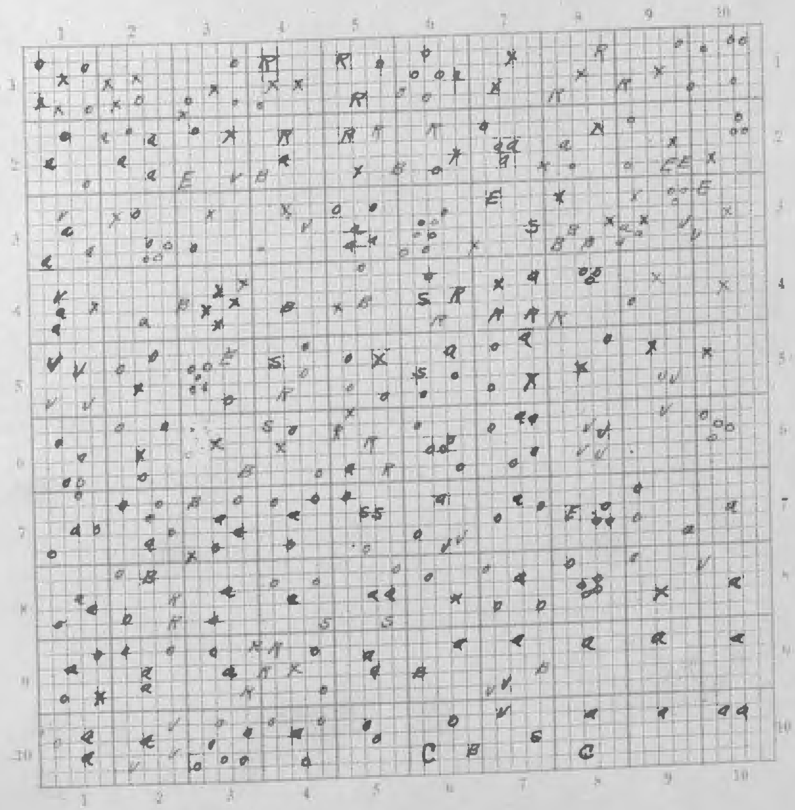
Fig. 65 is a quadrat on the river bottom near Red Wing to show the distribution of trees on this area. These trees producedsufficient shade to

QUADRAT 10 X 10 Ft. LOCATION 60 Tree Tract at Redwing DATE Mar 25, 1912.

FORMATION River-bottom herbaceous.

CONSOCIES

SOCIETY



LEGEND: O = Onagra biennis
X = Lappula virginiana
a = Ambrosia trifida
S = Scophularia leporella.
V = Verbena hastata
R = Rudbeckia lacinata
o = Chrysanthemum spp.
C = Cottonwood
B = Box elder
E = Elm.

Fig 66

Fig 67

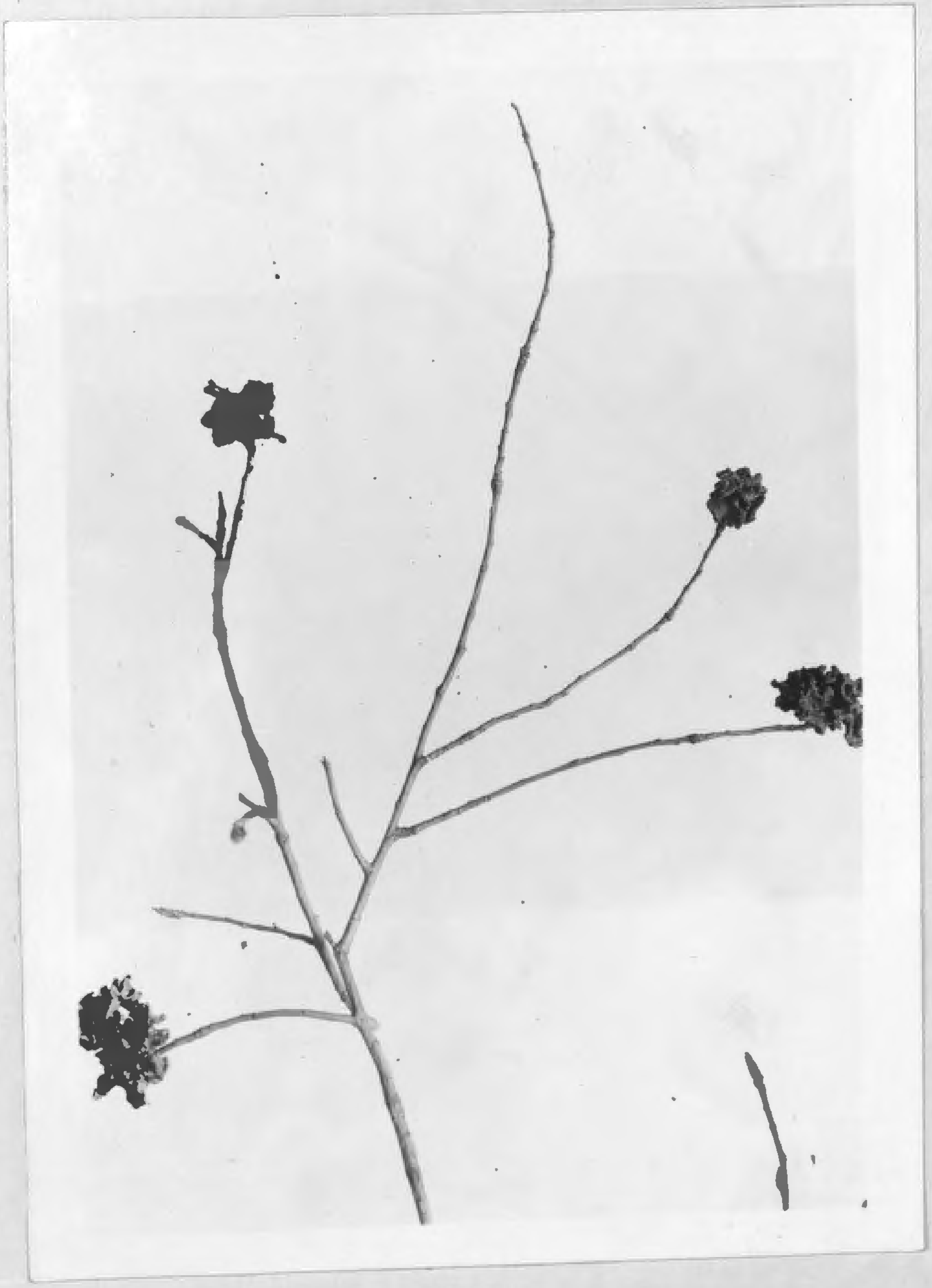


Fig 67 a

Galls caused by Pemphigus vagabundus. p. 44.

keep out reproduction and allowed a scanty growth of weeds. In February, 1911, these trees were cut and the quadrat shown in Fig. 66 was taken on this area. The quadrat itself shows the conditions the first season after cutting and explains why seedlings fail to establish themselves. The view shown in Fig. 67 is a view of this quadrat and shows the rank growth these weeds produce in the first season after the timber is removed. This growth averages about four to five feet in height.

Hostile Influences

The forests of these bottom lands are particularly free from injurious influences, and except, in a few cases, little fear need be entertained of loss of standing timber. The principal causes of injury to forest trees are windfall, fire, insects and fungi.

<u>Windfall</u>.

Windfall is rare on these bottoms. The Cottonwood has a strong root system, and, growing as it does on a heavy soil and in a flat location, it is seldom windthrown. There is, moreover, little exposure to wind, as the trees vary little in height and there are no hills or exposed places except some few points on the river and here its root system protects it so the Cottonwood is very seldom windthrown along the bottom-lands.

<u>Fires</u>.

Throughout the greater portion of the year, the soil of the bottom-lands is too wet to permit the spreading of fire. This is particularly true of the spring, during which fires are very common on pine land, while the bottoms are often flooded. During dry seasons, however, these bottoms sometimes become very dry and in many localities they are burned over to improve grazing. These grass fires do a great deal of damage to the younger trees and often leave scars in the butts of the trees through which fungi and insects enter. The greatest damage is done to the reproduction. A grass fire completely kills all reproduction, still some places are benefited by fire as the Cottonwood seed very readily germinates in ashes or on the exposed mineral soil. These fires likewise destroy the humus and leaf litter and are not to be recommended. These forests are, however, usually very free from fire.

Insects.

Very little damage, in this region, is done by insects, none being brought to my attention on the tree or timber with the exception of a plant louse which causes the galls on the buds and tips of branches. The damage done is slight and need not attract the attention of any interested in the welfare of the Cottonwood and its development.

Pemphigus vagabundus (The Vagabund Gall louse).

Pemphigus vagabundus causes irregular galls on the ends of twigs of Populus. These galls cause considerable injury to the tree as the terminal bud is destroyed and the shoots branch or are crooked by the development of lateral buds. The winged plant lice make their appearance in September, and the green, shining, hollow gall appears the following summer. The skin of the latter is quite thin and contains a single wingless plant louse, which is the parent of the colony subsequently inhabiting this peculiar shelter. As the colony develops each forms an addition to the gall, causing the irregular convolute mass. All become winged in September and desert the gall. The galls are green when young and turn black later in the season usually in August. The only remedy known is to remove the galls while green and burn them. If they are left until they turn brown or black the cradle of the lice is simply removed, but not the lice themselves, as they have already left to spend the rest of their existence elsewhere.

Fungi.

Six species of fungi have been found on the Cottonwood that are very prevalent. Many others occur. The only important ones are the Polystictus and Lenzites.

The Lenzites betulina is the destructive species which enters the stumps the same season they are cut and penetrates all through the wood. This species breaks down a stump in three or four years so it is decayed. The quick decay of stumps caused by these diseases emphasizes the importance of getting sprouts established independently as soon as possible if reproduction by sprouts is desired as mentioned before. The six more common species found are described in the following pages.

Lenzites betulina. This has a somewhat corky, leathery cap, firm and without zones, wooly, sessile, deeply grooved concentricallym margin of the same color. The gills are radial, somewhat branched, and coming together again, sordid white or tan-color. This species is common and attacks the stumps the first summer after the trees are cut and soon the stump succumbs to the attack and sprouting ceases. It is the first fungus to attack the fresh cut timber and hence is the most harmful.

Daedalea unicolor. This species is villose-strigose, cinereous with concolorous zones; hymenium with flexuous winding, intricate, acute dissepiments, at length torn and toothed. The pores are whitish, cinereous, sometimes fuscous; variable in thickness, color, and character of hymenium; sometimes with white margin; often imbricated and fuliginous when moist. Very common on dead trunks and stumps. Enters after the wood is dead for sometime.

Polystictus pergamenus. Pergamenus means parchment. The pileus is coriaceous, thin, effused, reflexed, villous, zoned, cinereous-white, with colored zone, pliant when fresh. The pores are unequal, torn, violaceous, then pallid. It is very common on beech, maple, wild cherry and Cottonwood. The pores become so torn that they resemble the teeth of the hydnum. Attacks the stump and dead trunks the second year after they are dead or later.

Polystictus versicolor. Versicolor means varying colors. The pileus is coriaceous, thin, rigid, plane, depressed behind; quite velvety, nearly even and shining, variegated with colored zones, sometimes entirely white or grayish white, not unfrequently the whole surface is villous or woolly, and the zones mere depressions. The pores are minute, round, acute, lacerated, white or cream color. It is very common and very variable in form and color. Found on stumps and dead stumps and twigs.

Pleurotus ostreatus.- The Oyster Mushroom. Pileus two to six inches broad, soft, fleshy, convex, or slightly depressed behind, subordinate, often cespitosely imbricated, moist, smooth, margin involute; whitish, cinerous or brownish; flesh white, the whole surface shining and satiny when dry. Gills broad, decurrent, subdistant, branching at the base, white or whitish. The stem when present is very short, firm, lateral, sometimes rough with stiff hair, hairy at the base. Spores oblong, white, .0003 to .0004 inch long, .3016 inch broad. This is common on the dead timber and stumps of Cottonwood. It is an edible species.

Clitocybe multiceps.- The Many-Headed Clitocybe. Multiceps means many heads, so called because many caps are found in one cluster. The pileus is white or gray, brownish-gray or buff; smooth, thin at the margin, convex, slightly moist in rainy weather. The gills are white, clouded, narrow at each end, decurrent. The stem is tough, elastic, fleshy, solid, tinged with the same color as the cap. The pileus is one to three inches broad; grows in dense tufts. Spores are white, smooth and globose. Found by old logs and stumps. This species is edible.

Other Influences.

In addition to the damage done to the trees by the agencies mentioned very considerable damage is done by rodents and grazing. The rodents, as rabbits and mice, are the chief menace to reproduction by barking the seedlings or sprouts. Grazing keeps reproduction out because the seedlings are trampled down and broken and the cattle eat the young shoots. Satisfactory reproduction can never be established with grazing in the forest unless it is very limited, but preferably none should be allowed.

Height and Diameter.

The data gathered to determine height and diameter was obtained by stem analysis of the trees as they were cut by the logging crews. The cards in Fig. 68 show the data taken on each tree, from which the tables and curves were worked out. Some of the tables are based on comparatively few trees, but the slight variation in the stands on these bottoms justify the use of less trees to base data on referring to the general stand.

SPECIES Cottonwood DATE Feb. 17, 1911 NO. 1

D. B. H. 19.8 in. Stp. Ht. 1.5 ft. PLACE Old Cornfield Red Wing, Minn.

Average diameter, inches				
Age 10	20	30	40	50
3.4	10.8	16.7	20.8	
~~60~~ 2	~~70~~ 12	~~80~~ 22	~~90~~ 32	100
1.	5.4	10.5	14.6	
~~110~~ 6	~~120~~ 16	~~130~~ 26	140	150
3.	9.8	13.8		
~~160~~ 10	~~170~~ 20	180	190	200
4.5	12.1			
~~210~~ 6	~~220~~ 16	230	240	250
2.7	10.9			

Age sap	Wd.sap	Class	Den.	Form
9 - 11 9 - 7	2.1 - 2.2 2.2 - 2.1	Dominant	7	1
T. Ht.	Cl. Lgh.	L. Cr.	W. Cr.	
65	45	20	16	

Vol.	Tot. cu. ft.	Mer. cu. ft.	Mer. bd. ft.	Mer. Cords
Stem	51.968	48.428	262	
Branch Top	4.932	4.92	26.57	
Total	56.900	53.348	288.57	

Sec.	L'g't'h	D. O. B.	Bk.	D. I. B.	Cont. cu. ft.	Cont. bd. ft.	Defects	In.
Stp.	1.5	23.0	1.1	20.8	3.540		None	
Tr.	14.22	16.5	.95	14.6	24.302	125	"	
	8.2	15.2	.7	13.8	9.02	58	"	
	8.3	13.5	.7	12.1	7.536	39	"	
	10.5	12.3	.7	10.9	7.57	40	"	

SPECIES Cottonwood DATE Feb 17, 1911 NO. 1 Cont.

D. B. H. in. Stp. Ht. ft. PLACE

Average diameter, inches				
Age 2	~~20~~ 12	30	40	50
1.4	9.3			
60	70	80	90	100
7.1				
~~110~~ 7	120	130	140	150
5.3				
~~160~~ 5	170	180	190	200
2.1				
~~210~~ 3	220	230	240	250
1.9				

Age sap	Wd.sap	Class	Den.	Form
9-9-8 8-8	2.1-2.1-2 1-.6			
T. Ht.	Cl. Lgh.	L. Cr.	W. Cr.	

Vol.	Tot. cu. ft.	Mer. cu. ft.	Mer. bd. ft.	Mer. Cords
Stem				
Branch				
Total				

Sec.	L'g't'h	D. O. B.	Bk.	D. I. B.	[illegible] cu. ft.	Cont. bd. ft.	Defects	In.
Stp	4	10.3	.5	9.3	2.224	13	None	
Tr.	4	8.1	.5	7.1	1.468	8	"	
	4	6.3	.5	5.3	.840	4	"	
	4	2.7	.3	2.1	.300	1	"	
	4	2.5	3	1.9	.088	.5	"	
			Top		.012	.07	"	
					4.932	26.57		

Top 2.28 Feet long.

Totals on 1st Card.

Fig 68

Analysis of a Cottonwood Tree, shown in Fig. 68. The tree was cut up into 11 pieces which gave the following cross sections:-

Table 6

Sec.I	taken	at	1.5'	above	ground	showing	40	concentric	rings.
" II	"	"	15.72'	"	"	"	32	"	"
"III	"	"	23.92'	"	"	"	26	"	"
" IV	"	"	32.22'	"	"	"	20	"	"
" V	"	"	42.72'	"	"	"	16	"	"
" VI	"	"	46.72'	"	"	"	12	"	"
"VII	"	"	50.72'	"	"	"	10	"	"
"VIII	"	"	54.72'	"	"	"	7	"	"
" IX	"	"	58.72'	"	"	"	5	"	"
" X	"	"	62.72'	"	"	"	3	"	"
" XI	Top		2.28'	long.					

Total height 65 ft.

Analysis - Table 7

Height of Section Feet	Number of Rings -	No. of Yrs. which the tree took to reach that height.
1.5	40	2
15.72	32	10
23.92	26	16
32.22	20	22
42.72	16	26
46.72	12	30
50.72	11	31
54.72	9	33
58.72	7	35
62.72	4	38
65.	0	42

The tree grew in a crown density of .7 on a basis of 10 which accounts for its rapid height growth at some periods.

Table 8

Calculation of the Volume of the Tree at Different Ages.

No. of Section	Diam. in inches	Basal Area in Ave. Sec. in Sq. Ft.	Length in ft.	Volume, in Cubic Ft.
Whole Tree, including Bark; Age - 40 years.				
1	23.	2.885	1.5	4.327
2	16.5	2.117	14.22	30.103
3	15.2	1.362	8.2	11.168
4	13.5	1.115	8.3	9.254
5	12.3	.908	10.5	10.534
		Total timber - - - - - - -		61.059
6	10.3	.697	4.	2.788
7	8.1	.462	4.	1.848
8	6.3	.283	4.	1.132
9	2.7	.136	4.	.544
10	2.5	.037	4.	.148
11	2.	.022	2.28*	.088
		Total timber and fuel - -		67.607
		Total volume with stump -		71.934

*The top is considered as representing a cone, the volume of which = basal area x 1/3 of the height.

Table 9

No. of Section	Diam. in inches	Basal Area in Ave. of Sec. in Sq. Ft.	Length in Ft.	Volume in Cubic Ft.
Whole tree, without bark; Age - 40 years.				
1	20.8	2.360	1.5	3.540
2	14.6	1.709	14.22	24.302
3	13.8	1.100	8.2	9.02
4	12.1	.908	8.3	7.536
5	10.9	.721	10.5	7.57
		Total timber - - - - - -		48.428
6	9.3	.556	4.	2.224
7	7.1	.367	4.	1.468
8	5.3	.210	4.	.840
9	2.1	.075	4.	.300
10	1.9	.020	4.	.080
11	1.	.006	$\frac{2.28}{3}$*	.004
		Total timber and fuel - -		53.444
		Total volume with stump -		56.984

Table 10

No.of Section --	Diam.in inches --	Basal Area in Aver.of Sec.in Sq.Ft.	Length in Ft.	Volume in Cubic Ft.
		Tree - 30 years old - without bark		
			1.5	2.281
1	16.7	1.521	14.22	14.347
2	10.5	1.009	8.2	4.559
3	9.8	.556		
		Total timber - - - - - - -		18.906
4	4.5	.283	8.3	2.348
5	2.7	.071	10.5	.745
6	1.4	.022	4.	.088
7	.8	.005	4/* /3	.006
		Total timber and fuel -		22.083
		Total volume with stump -		24.364

Table 11

No.of Section	Diam.in inches	Basal Area in Aver.of Sec.in Sq.Ft.	Length in Ft.	Volume in Cubic Ft.
		Tree - 20 years old - without bark		
1	10.8	.636	1.5	.954
2	5.4	.358	14.22	5.086
3	3.	.012	6/3*	.024
			Fuel - - -	5.110
			Timber - -	0.00
			Total with stump -	6.064

Table 12

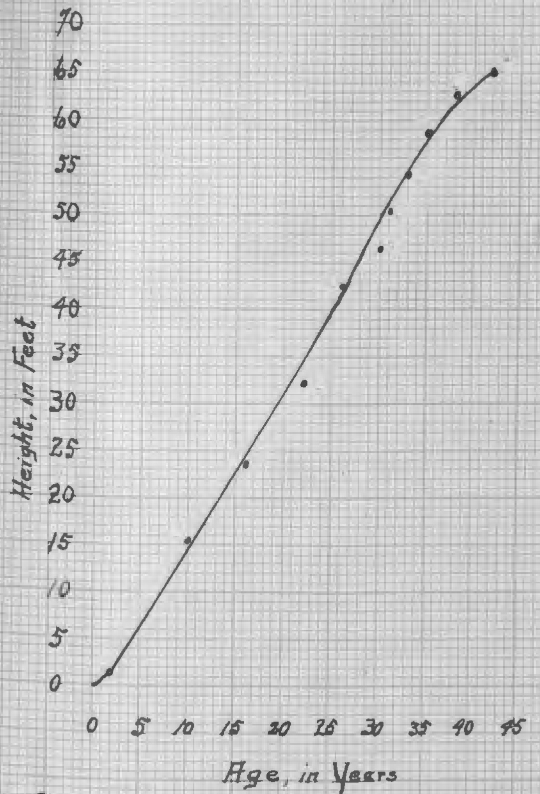
No.of Section	Diam.in inches	Basal Area in Aver.of Sec.in Sq.Ft.	Length in Ft.	Volume in Cubic Ft.
		Tree - 10 years old - without bark.		
1	3.4	.063	1.5	.094
2	1.	.026	9/3*	.078
			Total timber -	0.000
			Total fuel -	.078
			Total volume with stump -	0.172

Table 13

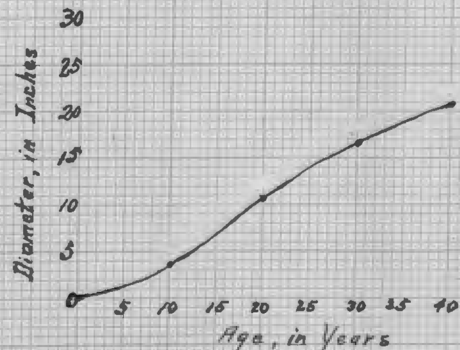
Analysis

At 1.5 ft. from the ground

Diameter in inches	Age
3.4	10
10.8	20
16.7	30
20.8	40



Graphic representation of the Height Increment



Graphic representation of the Diameter Increment at 4.5 ft. from the ground. D.I.B.

Of Tree analyzed on card in Fig 68

Fig 69

Table 14

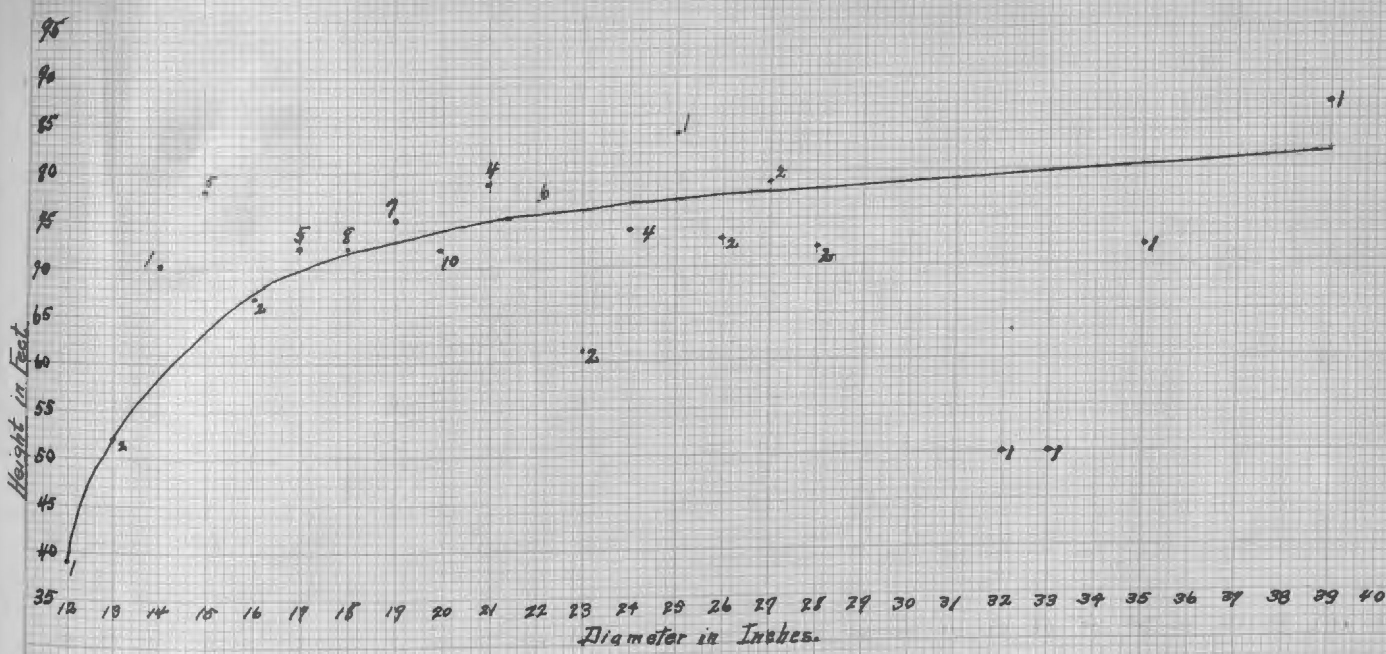
Average Heights of Trees of Different Diameters

Diam. Class	Aver. Diam. of Trees measured inches	Aver. Ht. of Trees Measured Feet	No. of Tree Measured	Aver. Height from Curve Feet
12	12.1	39.	1	39.
13	12.9	52.	2	52.
14	14.	70.	1	59.
15	15.1	78.2	5	64.
16	15.8	67.	2	67.5
17	17.04	72.8	5	70.
18	18.06	71.8	8	71.5
19	19.	75.6	7	73.
20	20.02	72.	10	74.
21	21.07	79.25	4	75.
22	21.95	77.3	6	75.5
23	23.05	61.	2	76.
24	24.05	74.	4	77.
25	25.2	83.	1	77.
26	26.35	73.5	2	77.5
27	26.75	79.	2	77.9
28	27.9	72.	2	78.
29				78.4
30				78.9
31				79.
32	31.7	50.	1	79.5
33	33.	50.	1	80.
34				80.2
35	35.	72.	1	80.7
36				81.
37				81.3
38				81.6
39	39.	87.	1	82.

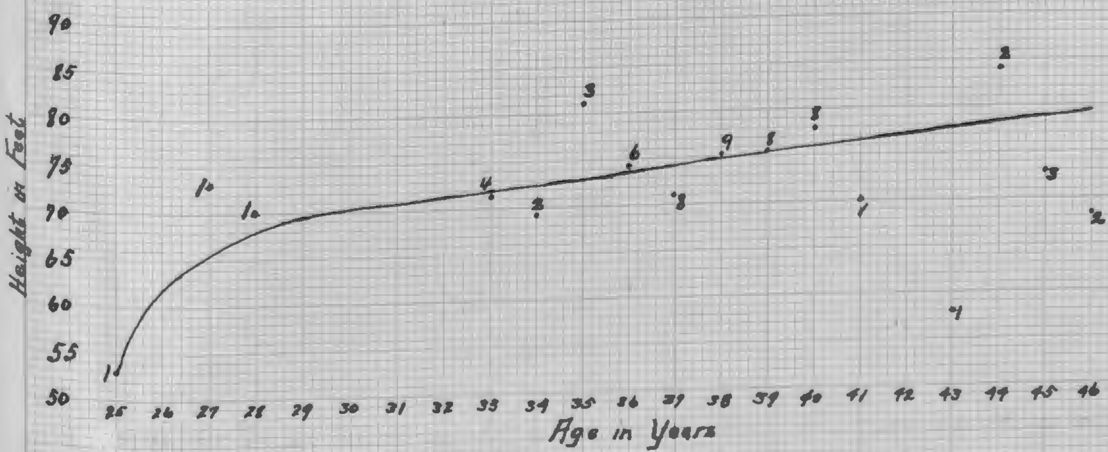
Table 15.

Table showing Height Growth.

Age	Aver.Height of Trees Measured Feet	No. of Trees Measured	Aver.Height from Curve
25	53.	1	53.
26			62.
27	73.	1	66.
28	70.	1	68.
29			69.4
30			70.1
31			70.9
32			71.2
33	71.75	4	72.
34	69.	2	72.3
35	81.3	3	73.
36	74.	6	73.8
37	70.5	8	74.1
38	75.	9	75.
39	75.5	8	75.5
40	78.25	8	76.1
41	70.	1	76.9
42.			77.2
43	58.	1	78.
44	84.	2	78.5
45	73.	3	79.
46	68.5	2	79.5



Curve showing Height of Trees of Different Diameters



Curve showing Height Growth.

Fig 70

Table 16

Sapwood in Cottonwood

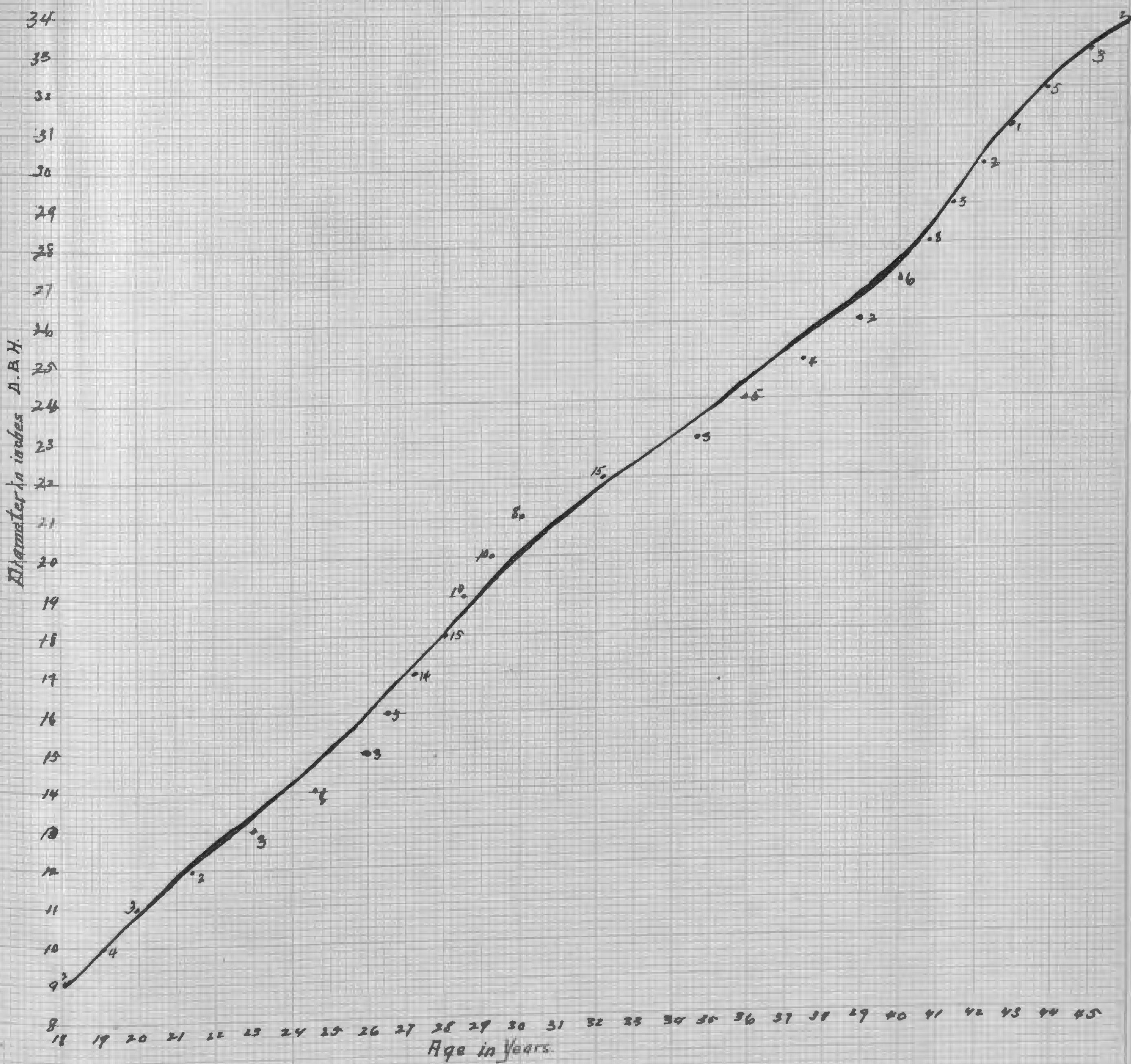
D.B.H.	D.I.B.at Stump	Widths of Sapwood at Stump	% of Cross Sec.Area that Is Sapwood
10	12.	.5	16
11	11.6	.8	26
12	12.5	.8	24
13	15.2	1.	25
14	14.7	1.5	37
15	15.4	1.5	36
16	16.8	2.1	44
17	18.	1.5	31
18	17.4	1.6	34
19	19.5	2.2	40
20	21.8	1.9	40
21	21.5	2.2	37
22	22.2	2.4	38
23	26.2	2.1	30
24	24.	2.2	47
25	27.6	1.9	26
26	27.4	2.	28
27	27.6	2.1	29
28	28.5	1.8	24
29	30.	1.5	20
30	30.6	1.5	20
31	32.1	1.4	18
32	33.	1.2	16
33	33.8	1.3	16
34	34.7	1.5	18
35	36.2	1.4	16

*This table compared with Table 17 shows that during the time the Cottonwood is producing the greatest diameter increment it has the largest per cent of sapwood also. This period is approximately from 20 to 35 years.

Table 17

73 Trees arranged according to D.B.H. and age.

D.B.H. Diam. Class	Age	Trees	Vol. Cu.Ft. per Tree	Vol. Cu.Ft. All Trees	% of Total Vol.	Yield B.F.in Logs by Scale	Age Corrected by Curve	No.Yrs.to Grow into Next Age Class
9	18.	1	11.08	11.08	.24	18	18.	1.
10	19.	2	19.74	39.48	.66	84	19.	1.
11	20.	5	21.5	107.5	1.85	350	20.	1.5
12	21.5	1	26.19	26.19	.47	90	21.	1.5
13	23.	8	42.8	342.4	5.76	960	22.4	1.7
14	24.7	3	44.15	132.45	2.24	450	23.8	1.3
15	26.	4	52.58	210.32	3.56	740	25.	.5
16	26.5	5	39.65	298.25	5.05	1100	26.	.7
17	27.2	10	77.29	772.90	13.05	2600	27.	.8
18	28.	10	75.50	775.00	13.1	3050	28.	.5
19	28.5	5	102.11	510.55	8.63	1700	28.8	.7
20	29.2	5	87.56	437.80	7.31	1900	29.	.8
21	30.	3	113.82	341.47	5.76	1290	31.	1.5
22	32.5	2	135.31	270.62	4.56	980	32.4	2.3
23	34.8	3	110.21	330.63	5.57	1650	34.	1.2
24	36.	2	160.00	320.00	5.43	1250	35.4	1.5
25	37.5	1	165.44	165.44	2.79	710	36.8	2.5
27	40.	1	166.24	166.24	2.88	960	39.5	3.
31	43.	1	243.64	243.64	4.14	1232	43.	4.
35	47.	1	407.86	407.86	6.95	1872	45.	



Curve showing increment for given Age of Tree.

Fig 71

Taper and Form Factor

Table 18 shows the taper of the Cottonwood arranged in diameter classes. The proportion of taper remains almost constant throughout the growth of the tree, but the taper for each 10 ft. length is greater in the larger trees often reaching 3 and 4 inches while in the trees under the 22 inches class it drops as low as .5 to 1.5 inches.

This character of the tree shows that the best possible utility in manufacture is before it reaches the 20 inch class and the growth tables show that at about this same period the growth decreases so this point is about the point of the greatest volume production for a given time.

Table 18

Showing taper at 10 ft. lengths of Cottonwood arranged in diameter classes.

D.B.H.	10'	20'	30'	40'	50'
10	6.3				
11	8.5	7.			
12	9.7	9.	8.2	7.8	
13	9.	8.2	7.5	7.	
14	10.8	9.2	8.7	8.	
15	11.7	10.5	9.6	8.4	7.3
16	12.8	10.9	9.8	9.	7.8
17	13.	11.4	11.	9.1	8.5
18	14.3	12.9	11.1	9.4	8.5
19	16.1	14.4	12.3	11.7	9.3
20	16.8	15.1	12.8	11.8	9.4
21	17.5	15.5	14.4	12.	10.1
22	18.5	16.6	15.4	12.2	10.2
23	20.	17.5	15.5	13.	12.3
24	20.2	17.6	15.8	13.8	13.
25	22.	18.1	16.	14.3	13.6
26	22.6	20.2	16.8	15.	14.1
27	22.7	20.5	17.	15.1	14.3
28	23.5	21.3	18.1	16.	14.9
29	24.8	22.9	19.4	17.2	15.3
30	26.	23.6	20.3	17.4	16.1
31	26.7	25.1	21.7	18.2	16.4
32	27.8	25.8	22.1	18.7	17.
33	28.4	26.3	22.5	19.1	17.4

Form Factor

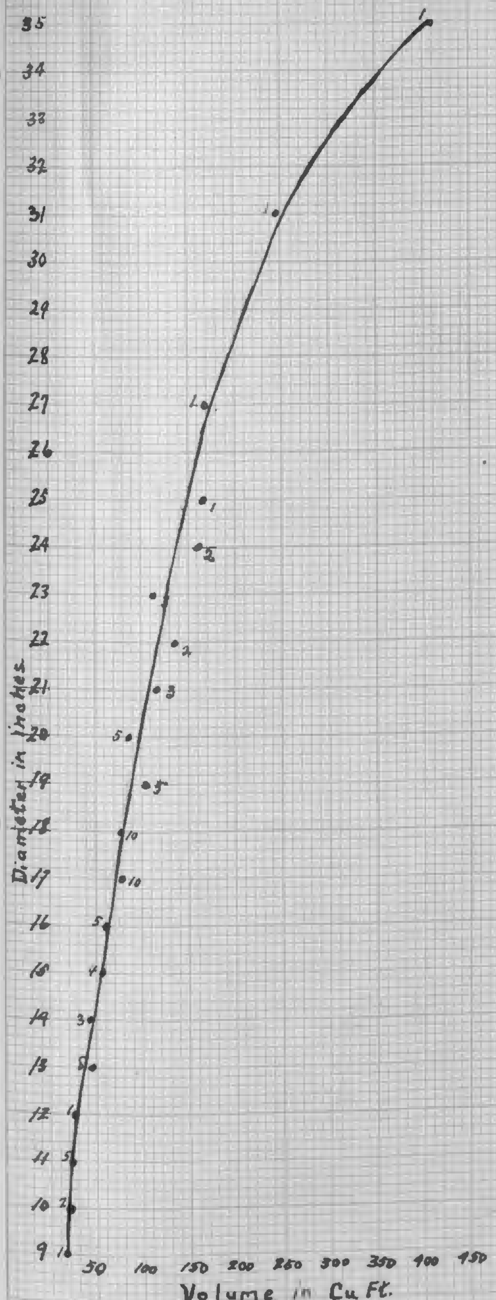
Cottonwood of the river bottom type has a form factor of .46 based on the breast high form factor where $F = \frac{V}{BH}$, or $V = BHF$ in which F is the form factor, V the volume, B the based area and H the height of the tree. The diameter of the cylinder to which the tree is compared is the same as the breast high diameter of the tree. The final factor of .46 was found by averaging together the form factors of trees of different diameters without regard to height.

Volume and Yield

The Cottonwood, under favorable conditions, is a faster growing tree than any of its associates and in the usual even aged stands it varies little in form and height hence volume tables based on this type will apply very well to this region but would not be accurate for the upland type.

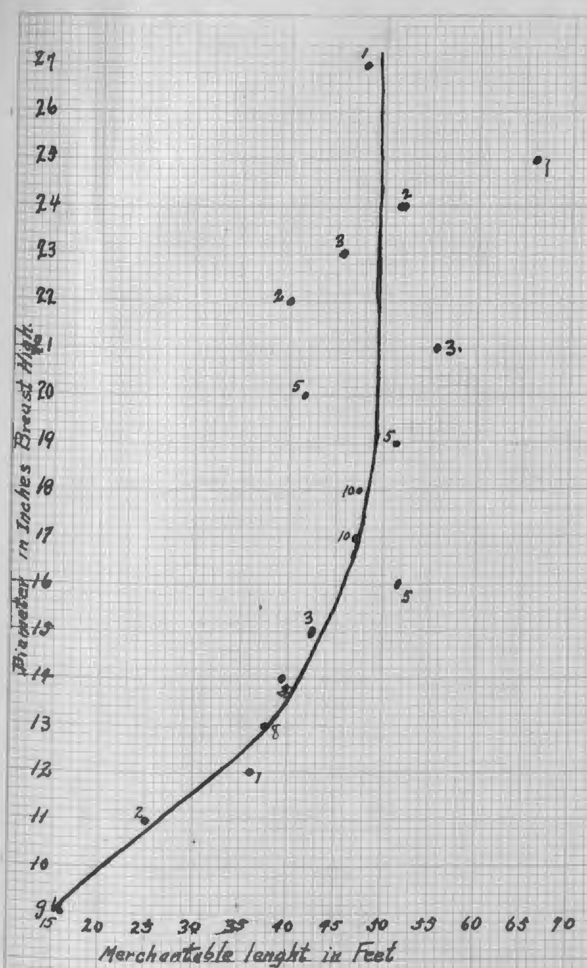
Table 19 shows the uniformity of the merchantable length based on diameter classes D.B.H. also the general uniform increase in scale B. F.

Table 20 gives the same result in regard to the cubic contents and the results of these averaged by curves in Fig. 73 and Fig. 74 give the volume table given in Table 21.



Curve showing volume for given Diam. D.B.H.

Fig 72


Diameter in Inches Breast High.
Merchantable lenght in Feet


Diameter in Inches Breast-High.
Volume - Scale in Board Feet.

Fig 73

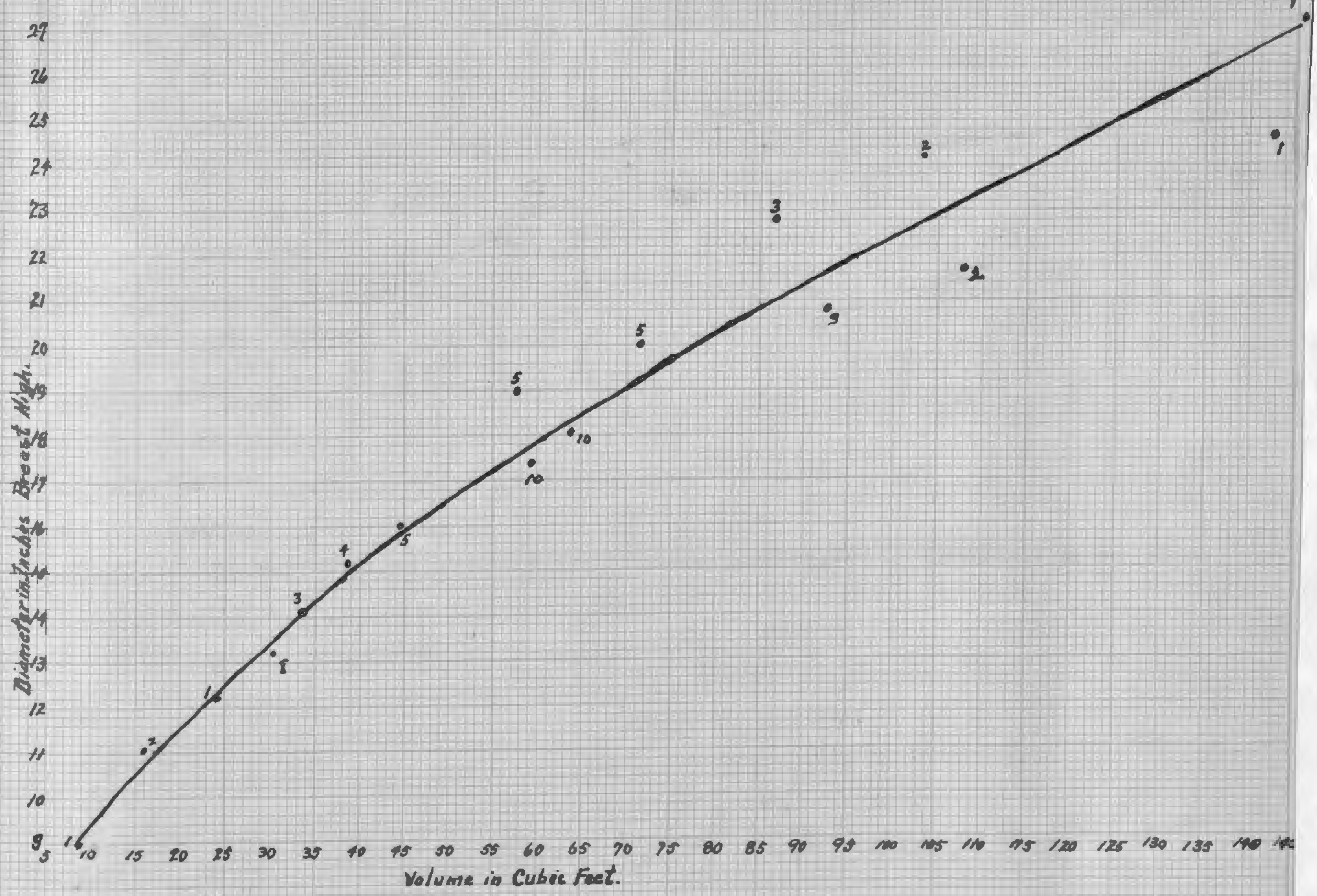


Fig 74

Table 19

Table showing merchantable length and volume according to diameter classes.

D.B.H.	No.of Trees Measured	Ave.Mer. Length Measured in ft.	Ave.Mer. Length From Curve Col.3 In even ft.	Ave.B.F. By Scale	Ave.B.F. From Curve Col.5
9	1	16.	16	18.	18
10			20		42
11	2	25.	26	62.	70
12	1	36.	32	90.	90
13	8	37.5	38	123.3	120
14	3	39.3	42	150.3	150
15	4	42.5	44	187.	185
16	5	51.2	46	233.6	220
17	10	47.	48	293.3	260
18	10	47.2	48	304.3	305
19	5	51.2	50	361.8	340
20	5	41.6	50	351.8	380
21	3	55.3	50	525.	430
22	2	40.	50	443.	490
23	3	45.3	50	466.3	550
24	2	51.5	50	574.5	625
25	1	66.	50	834.	710
26			50		820
27	1	48.	50	928.	960

Table 20

Volume Table for Trees of Different Diameters.

Based on Measurement of 66 Trees at Red Wing, Minn.

Diam. Class D.B.H.	Ave.Diam. of Trees D.B.H.	No.of Trees Measured	Ave.Vol. of Trees Measured Cu.Ft.	Ave.Vol.Results of Col.4 Evened off by Curve in Cu.Ft.
9	8.8	1	8.08	8.08
10				12.5
11	11.1	2	15.24	17.2
12	12.3	1	24.59	22.5
13	13.25	8	30.57	27.4
14	14.1	3	33.10	32.5
15	15.27	4	38.12	38.4
16	16.	5	44.89	45.5
17	17.29	10	59.28	53.5
18	18.03	10	63.53	61.
19	19.	5	57.85	70.
20	20.08	5	71.35	77.5
21	20.86	3	92.57	86.5
22	21.7	2	107.07	95.
23	22.9	3	86.46	105.
24	24.2	2	103.25	115.
25	24.7	1	142.94	125.
26				135.
27	27.5	1	143.74	145.

Table 21

Volume Table for B. F. and Cu. Ft. based on D. B. H.

Based on Measurement of 66 Trees at Red Wing, Minn.

D.B.H.	Vol. in Board Feet	Vol. in Cu. Ft.
9	18	8.08
10	42	12.5
11	70	17.2
12	90	22.5
13	120	27.4
14	150	32.5
15	185	38.4
16	220	45.5
17	260	53.5
18	305	61.
19	340	70.
20	380	77.5
21	430	86.5
22	490	95.
23	550	105.
24	625	115.
25	710	125.
26	820	135.
27	960	145.

The yield has been shown on some of the plats as the one near the bridge approach containing 1.006 acres and the plat of 1.62 acres. Table 22 gives a detailed account of actual operations on the Carleson Tract of 5.08 acres below the Forest Products Mill. This shows what a mixed stand left as a thicket will do on these lands.

Table 23 gives a complete account of a tract of 8.88 acres which were also left unthinned and unmanaged, still yielding a good margin on the investment. These figures are taken from actual operations and the prices are those received in the markets.

Figs. 75 and 76 show views on this tract before cutting. The stand can plainly be seen to be lacking in uniformity of distribution, also the suppressed trees are noticeable. This is an even aged stand approximately but does not appear as such.

Figs. 77 and 78 are taken on this area after cutting. Fig. 77 shows the poor trees left. These

Fig 75

Fig 76

Fig 77

Fig 78

Fig 79

Fig 80

should be cut for cordwood. All of the standing timber on this area was calipered and accounted for in the following table.

Fig. 78 is part of the landing of logs taken from this area with Figs. 79 and 80 closer views of the skidways. The calipers shown are 36 inches long.

Table 22.

Carleson Tract (below mill).

Stand 23 yrs. old. Area 5.08 acres.

Yield.

82 3/4	cds. Cottonwood	@ $1.50 on ground	$124.12	
30	" Willow	@ $1.50 " "	45.00	
111	" Soft Maple	@ $2.50 " "	277.50	
		Total - - - - - - - - - - -		$446.62
2400	B.F. Cottonwood	@ $7.50 per M on ground		18.00
		Total income - - - - - - -		$464.62

Expenses

Cost of cutting cordwood @ $1 per cd.	$223.75	
Value of land $10 @ 5% compound int. for 23 yrs.	105.22	
Taxes @ 2% compounded @ 5% for 23 yrs.	3.12	
Total expense - - - -		$332.09
Net profit - - - - - -		$132.53

Making a net profit of $1.13 per acre annually for this tract after 5% compound interest has been paid on all investments.

Table 23

Tract where 60 Tree analysis was taken

Stand 37 years old. Area 8.88 acres.

Yield

Cut 132,000 B.F.Cottonwood @ $25 per M	$3300.00	
" 158 cds.Cottonwood, willow, elm, boxelder @ $2.50 per cd.	395.00	
Left standing 40,400 B.F.Cottonwood worth	1010.00	
Left standing 50 cds.mixed wood worth	125.00	
Total value of timber - - - - - - - - -		$4830.00

Expenses

Land value @ $16 per A.compounded int. at 5% for 37 yrs.	721.76	
Taxes at 2% rate compounded int. at 5% for 37 yrs.	17.26	
Cost of cutting cordwood and hauling @ $2 per cd.	416.00	
Cost of logging at $5 per M	862.00	
Estimated cost of milling	1000.00	
Total expense - - - - - - - - - - - - - -		$3017.02
Net profit - - - - - - - - - - - - - -		$1812.98

Yielding a net profit of $5.51 per acre after 5% compounded interest has been realized on the investment.

This tract had an average stand of 73 trees per acre with an average diameter of 18 inches D.B.H.

Management

The conditions in the bottom lands are to a large extent more favorable to good management with less expense than on the uplands as the fire problem is almost eliminated. The species grown and the length of rotation also make it a much simpler problem. In the cutting or limiting of rotation the time would depend on the market,for example, if a rotation was run for fence-posts, it would necessarily be shorter than one for lumber,still if the demand for post material could be supplied with the small trees removed in thinnings,then the remainder of the stand could be left to produce lumber. The main problem would be the afforestation and reforestation with Cottonwood, as shown above. The intolerance of shade of the species makes it difficult to reproduce under stands and hence the selection system could not be applied. Clear cutting the final cut would be the most profitable and give best results. Figs. 77, 81 and 82 show the crooked trees left after the desirable ones were cut, also

Fig 81

Fig 82

Fig 83

the small trees, which are not young trees, but the ones that have been suppressed and hence will never be of any future value. Fig. 83 is a group of small trees left after a cutting made in February, 1911. Picture taken February, 1912. These slender trees grown in the forest cannot withstand the wind when left alone. They are root firm but the stems are too weak to support them. All of these should be removed and cut into cordwood when the logging is done. The brush is easily handled as shown in Fig. 82. It does not need piling as there is little of it and it disappears the first season so it will not bother unless cultivation for reproduction is desired. The method of reproduction to be applied will to some extent affect the method of cutting. If reproduction by sprouts is expected, the stumps should be cut low, not over 14 inches high and lower where possible as this this tends to produce root collar sprouts which are by far the most desirable, also the age at which to cut. As shown before, the period of most vigorous sprouting is between 20 and 26 years but remained fairly good up to 35 years. Stumps 40 years old or more will sprout but the sprouts are not vigorous and will not establish themselves. On the Carleson tract, which was cut at 23 years, a reproduction of 100% by sprouts occurred while on another tract cut at 37 years of age 62% of the stumps sprouted and all the sprouts showed less vigor and indications of establishing a permanent growth.

After a clear cutting the area should be planted the first season with cutting in places where the stand is thin or where the stumps are not in good condition for sprouting. Seeding cannot be depended upon as the weeds soon cover the ground and the seedlings are crowded out or never get started. The only places seedlings have been found successful is along open shores where they had full light and sandy or mineral soil. In the matter of taking a forest on the bottom-land to handle it for a better production

Photo by J.P. Wentling.

Fig 85 !

Photo by J.P. Westling.

Fig 86

Photo by J.P. Wentling

Fig 87

Photo by I.P. Wentling

Fig 88

Photo by J.P. Wentling

Fig 89

many trees such as shown in Fig. 85 should be removed. This was a large spreading elm, valueless for timber, yet, as the picture shows, taking possession of a large area preventing reproduction under its spreading branches to establish a full stand of Cottonwood, because when left to mature such conditions as appear in Figs. 86 and 87 exist where the small maples hold the soil and are not producing any increment and only occasional Cottonwoods appear and these are unable to start any other reproduction in their vicinity.

The cutting made on that tract, shown in Fig. 88 is a condition that almost always occurs because only the merchantable trees are removed. A stand like the one shown here is invariably a losing proposition to the holder because the trees left are crowded and to a large degree suppressed, producing a slow growth. On the other hand the Cottonwood produced a clear, straight bole only when grown in a stand dense enough to prevent lateral branching so the stand should be dense enough when young to afford these conditions and then thinned to allow diameter increment after the height is established. Fig. 89 is a type of trees grown in the open from their youth and shows the influence of too much crown space.

Thinnings can be made at a profit after 12 to 15 years of growth as the trees have reached most size at that age.

Manufacture and Uses.

Cottonwood is taking a place among the lumber producing species of timber in the United States. At the present time it ranks 20th in order of production of lumber by species. In 1905 the cut of Cottonwood in the United States was 236,000,000 B.F. Arkansas lead with a cut of 90,920,000 B.F. or 38.5% of the total. Minnesota produced such a small amount that it was not rated separately.

In 1909 the cut of the United States was 265,600,000 B.F., valued at $4,794,424. Of this amount Minnesota produced 16,668,000 B.F., valued at $256,020 with Arkansas still leading with a production of 54,507,000 B.F., valued at $1,035,088.

The average value at the mill of all Cottonwood lumber sawed in 1909 was $18.05 per M feet. The state averages ranged from $22.07 in Tennessee to $8.54 in Idaho. Only a small quantity was cut in the latter state, however, and that for local use.

The Cottonwood is now used as cooperage, pulp, posts, lumber and fuel.

Table 24 shows the growing increase in cooperage.

Table 24

Slack Cooperage Stock

Showing the increase in use for staves and heading.

In 1907 - 46,923 M staves
" 1908 - 51,062 M "
" 1909 - 66,260 M "

Heading.

In 1907 - 1784 M sets
" 1908 - 2067 M "
" 1909 - 6742 M "

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Average values for fence posts-Kansas, Nebraska, Iowa and Minnesota.

Table 25

Species	Value per post Class I	Class II	Class III	Class IV (Stakes)
Cottonwood	$0.10	$0.08	$0.05	$0.02
Willow	.11	.08	.05	.02
Green Ash	.16	.12	.08	.03
Honey Locust	.16	.12	.09	.04
Black Locust	.22	.17	.12	.05
Osage Orange	.24	.18	.12	.06
Russian Mulberry	.20	.16	.08	.03
Soft Maple	.12	.09	.05	.02
Catalpa	.20	.15	.08	.03

The posts have been classified according to the following classifications: Class I, Length 7 ft.; 4 in. at small end, round, or 3½ quartered; free from crooks. Class II, Length 7 ft.; 3 in. at small end if straight, or proportionately larger if moderately crooked; bad crooks culled to thirds. Class III, Length 7 ft.; 2in. at small end if straight, or proportionately larger if crooked. Class IV (stakes)

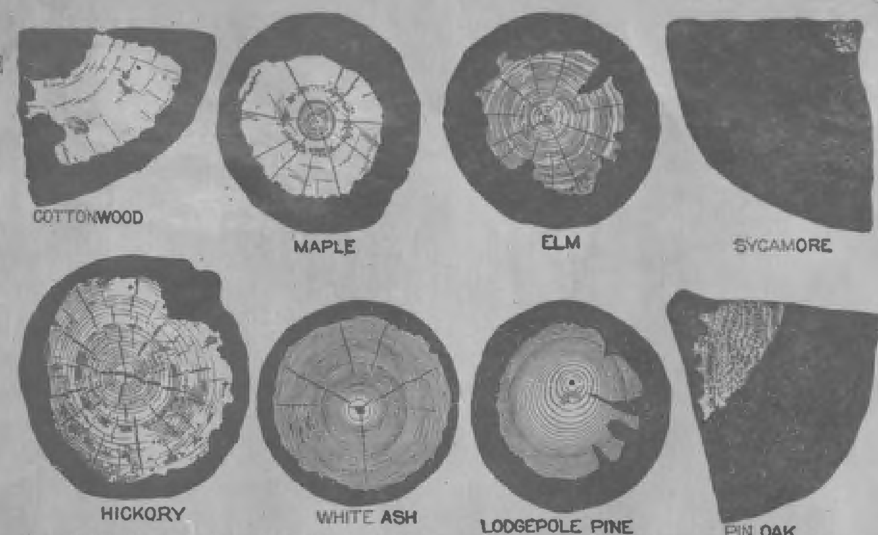


FIG. 1.—Sections of posts of various woods treated with creosote by the open-tank process. All the posts are drawn to the same scale, and are approximately 5 inches across. The black areas show the creosote penetration, which corresponds generally to the sapwood.

Copy from Farmers Bul.

Fig 90

Length 5 ft.; 1½ in. at small ends; free from bad crooks which would prevent driving.

Cottonwood has only been used as post material since the wood treatment has come into use as it is not durable in contact with the soil when untreated. It takes preservatives very well especially in the sapwood. For this reason round posts should be used for treatment. Fig. 90 shows the way the Cottonwood, sapwood and heartwood take treatment compared with other species. The fast growth and easy treatment make the Cottonwood post cheap and desirable.

Table 25 shows the comparative value of Cottonwood posts with other species. Table 26 shows the comparative stumpage values and the change in values during different years.

The following is a letter received from Lowry Smith, Supt. of Tie Treating Plants, of the Great Northern Ry., in reply to an inquiry as to the value of Cottonwood for ties. The letter is self-explanatory. The treating was done at Paradise, Montana.

"In reply to your letter of Feb. 5th in regard to cottonwood ties, beg to advise that in the latter part of 1909 we treated several hundred cottonwood ties at this plant for experimental purposes. They were given about the same treatment that we give all our ties, which is about 6-1/2# of oil per cubic foot, and were placed in the track some time in February of 1910. Of course it is entirely too short a time to come to any conclusion as to the service that may be expected from such ties, but so far they are showing up very well. Cottonwood takes the treatment excellently. It is a wood that has a great deal of moisture in its green state, and should necessarily be thoroughly seasoned before treating. After treatment, and having time for the oil to dry, the ties become very hard. On account of their peculiar fibrous structure they hold a spike exceptionally well. So far as we have been able to see, think the cottonwood tie will give very good service after treatment."

Table 26

Comparison of Stumpage Values 1899, 1904, 1907.

Kind	Average Value per M Feet. 1899	1904	1907
White Pine	$3.66	$4.62	$8.09
Ash	3.03	3.95	7.58
Basswood	1.50	3.89	6.79
Hickory			6.69
White Oak	3.18	3.83	6.52
Eastern Spruce	2.26	3.70	5.49
Chestnut	2.71	3.39	4.97
Elm	3.30	5.58	4.94
Poplar	2.81	3.89	4.64
Cedar	1.32	1.49	4.63
Hemlock	2.56	3.51	4.51
Birch			4.40
Cypress	1.58	3.42	4.37
Cottonwood	1.45	2.61	3.97
Beech			3.56
Yellow Pine	1.12	1.68	3.16
Maple	2.66	3.82	2.50
Red Gum	1.68	1.67	2.46
Redwood	1.06	1.55	2.35
Western Pine			1.66
Douglas Fir	.77	1.05	1.44
Tupeto			1.27

Based on 1500 reports from the leading lumber manufacturers in their respective localities.

The main factors which influence the stumpage price of anyspecies in a given locality are quantity, quality, market conditions and accessibility, but it is difficult to determine which of these has the most weight in fixing the average stumpage value for a species over its entire range. In accordance with the general law of supply and demand, relatively high stumpage values obtain with those woods, the virgin supply of which are most nearly exhausted or which have passed largely into the possession of a few owners.

Two hundred and twenty one reports gave the average value of Cottonwood stumpage as $3.97 per M. State averages ran from $1.57 in the western range to $11.64 in Ohio. In the Mississippi Valley section of Arkansas, the largest Cottonwood producing section of the United States quotations ran from $1 to $7 per M, with one average of $2.91. In the same relative situation in Mississippi the ranges were from $1 to $4 per M, with an average of $2.39 and similar prices were quoted from northern Louisiana. Some interesting figures from the west show the direct bearing of the supply of woods of other species and hence less demand since in Washington Cottonwood is quoted at 25 cents per M to $2.50. Although this is not Populus deltoides the quality of the wood is much similar and is equal on the market. The western species cut is Populus balsamifera.

Table 27

Lumber, lath, and shingles - Cottonwood lumber - Number of active mills reporting and quantity and value of cut, by states; 1909.

State	Number of active Mills Reporting	Quantity: M ft. b.m.	Quantity: Per Ct Distribution	Value: Total	Value: Ave. Per M Ft.
United States	2922	265000	100.0	$4794424	$18.05
Arkansas	128	54507	20.5	1035088	18.99
Louisiana	45	47509	17.9	854687	17.99
Mississippi	172	46222	17.4	920280	19.91
Missouri	509	17987	6.8	326824	18.17
Minnesota	192	16668	6.3	256020	15.36
Tennessee	59	12380	4.7	273227	22.07
Iowa	234	10778	4.1	224490	20.81
Oklahoma	106	9585	3.6	133615	13.94
Michigan	203	6384	2.4	92887	14.55
Idaho	9	5446	2.1	46509	8.54
Wisconsin	131	4338	1.6	54789	12.63
Indiana	272	4143	1.6	74284	17.93
Illinois	188	3939	1.5	75274	19.11
Texas	21	3354	1.3	63290	18.87
Ohio	202	2944	1.1	64709	21.98
Georgia	5	2260	0.9	34940	15.46
South Carolina	10	2048	0.8	32686	15.96
All other states	436	15108	5.7	231015	15.29

The use of Cottonwood for pulp has not been definitely established although in 1908 it ranked 7th in production by species with a consumption of 45,679 cords for pulp and 36,898 cords in 1909. The use of Cottonwood since then has been declining and the indications are that within a few years this wood will be superseded as a pulpwood. Its long fiber and absence of oils or resins would seen to make it a desirable species for pulp but its use as such has benn restricted.

It is in common use as veneer stock as shown by Table 28. Cottonwood has proven satisfactory as flooring in stables. The long fibered wood tending rather to harden than wear and has been known to out last tamarack flooring when put in the same barn.

Table 28

Veneers - Quantity of wood consumed, by kind: 1909, 1908 and 1907.

Kind of Wood	Quantity (M feet, log scale) 1909	1908	1907
Red Gum	129,930	119,485	102,932
Yellow pine	48,143	42,342	32,450
Maple	35,444	27,886	28,175
Cottonwood	30,842	33,904	33,174
Yellow poplar	28,826	22,898	28,764
White oak	28,742	20,700	23,872
Birch	24,643	17,769	18,079
Tupelo	18,476	16,442	15,097
Elm	16,254	12,714	12,615
Basswood	13,715	11,609	13,561

This table shows the ten most important woods used in veneers, and includes approximately two-thirds of the total consumption.

Fig 91.

Photo by J.R.Wertling

Fig 92

Photo by J.P. Wentling.

Fig 93

Photo by J.P. Wentling

Fig 94

Photo by J.P. Wentling

Fig 95

Photo by J.P. Wentling.

As shown in Table 27 there are a number of mills operating in Minnesota as Cottonwood mills. Fig. 91 shows the mill of the Forest Products Company at Red Wing where the logs taken from the regions studied are sawed. Fig. 92 is a view of a landing at the mill showing some of the large elm logs taken from these bottoms and mixed with the Cottonwood. The lumber is all sold as mixed and is not separated into species. A close utilization of all timber at this mill is practiced and Figs. 93 and 94 show one of the methods employed to utilize the short pieces and slabs. The cordwood and short pieces are loaded on barges and brought up or down the river and unloaded by the endless chain or elevator shown in Fig. 93, then sawed and the wood put in a pile by the carrier as shown in Fig. 94, which is a continuation of the part shown in Fig. 93. The past year this company marketed $10,000 worth of wood handled by this method.

These barges are used for transporting logs as well. The Cottonwood will water soak and cannot be driven for long distances but if left on the skidway or in the woods for some time it can be floated for short distances.

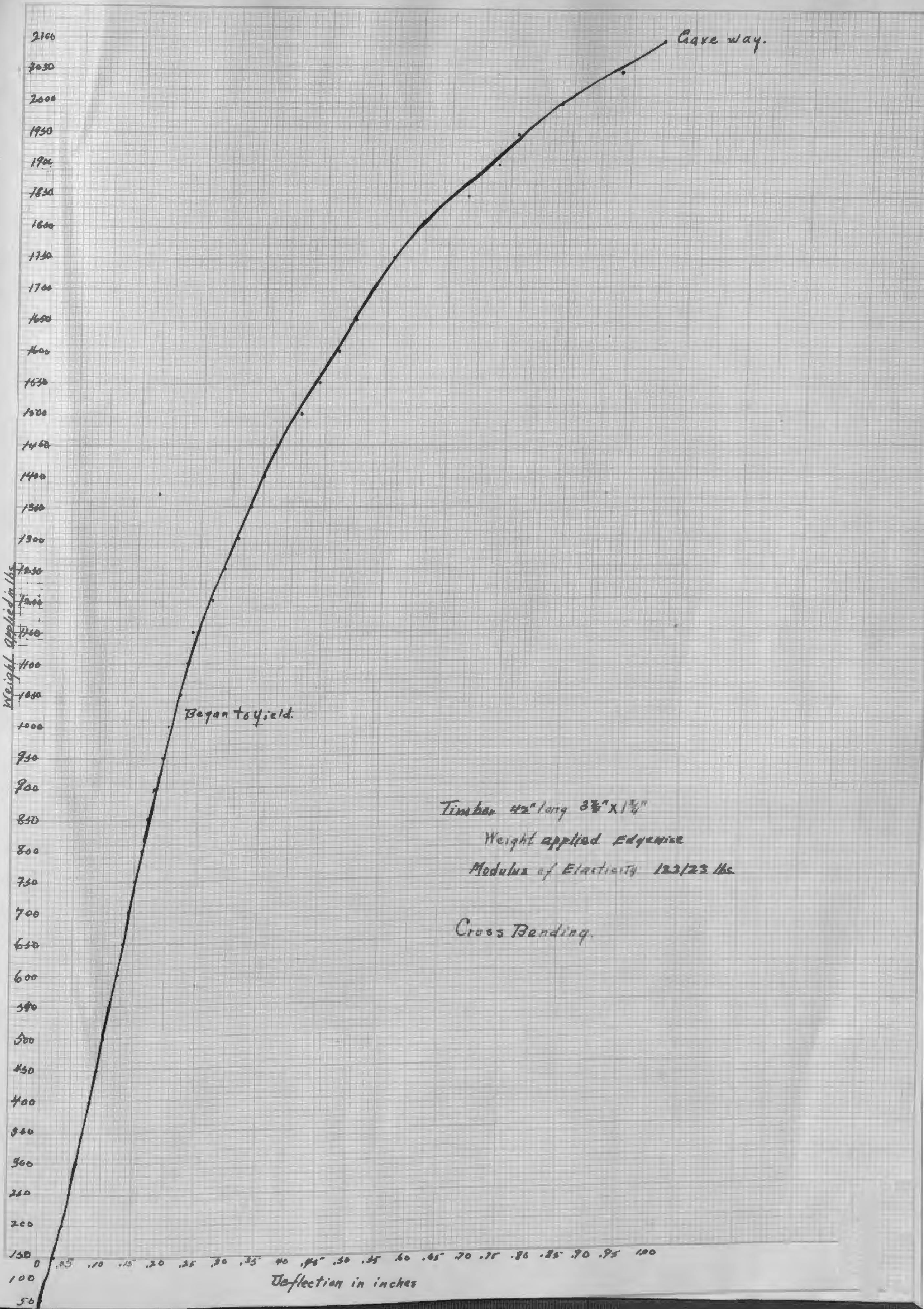
Fig. 95 shows a house-boat used by the Forest Products Company to house and feed the men at work along the river.

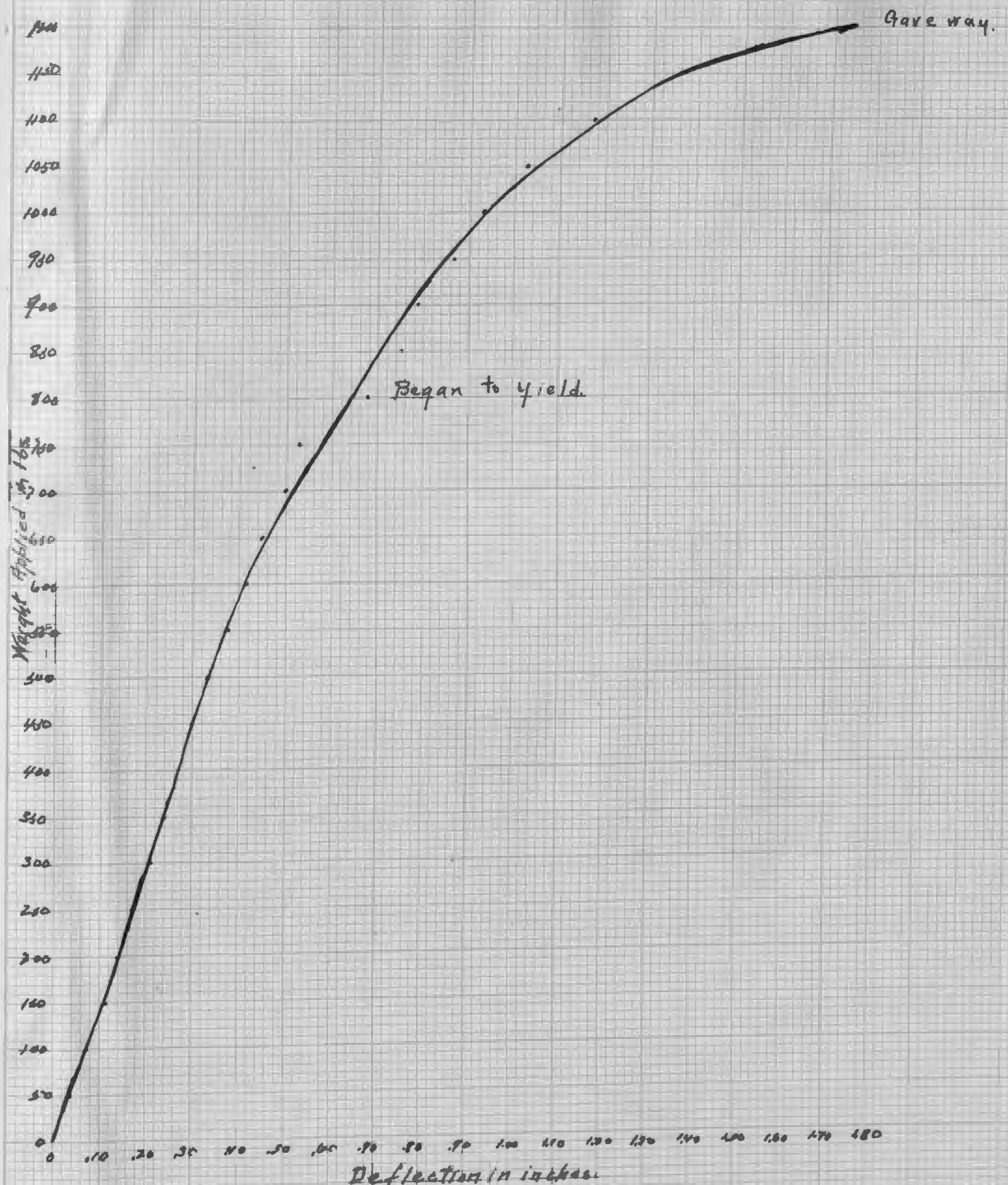
Structural Features.

The wood of Populus deltoides is light, soft, and not strong, although close grained. It is dark brown, with nearly white sapwood, and contains numerous obscure medullary rays and minute scattered open ducts. The specific gravity of the absolutely dry wood is 0.3889, a cubic foot weighing 24.24 lbs. In kiln drying it loses from 40% to 45% in weight from the green lumber.

Resistance to lateral compression, across rings, 1060 lbs. per sq. in.; in the same direction as rings, 804 lbs. per sq. in. Resistance to end compression, yielding point per sq. in. is 3074 lbs. and the maximum, 3536 lbs. per sq. in.

Resistance to cross bending: beam 42 in. long, 3-3/4 in. by 1-3/4 in. turned edgewise, showed a modulus of elasticity of 122,123 lbs. and turned flatwise, 48,313 lbs.

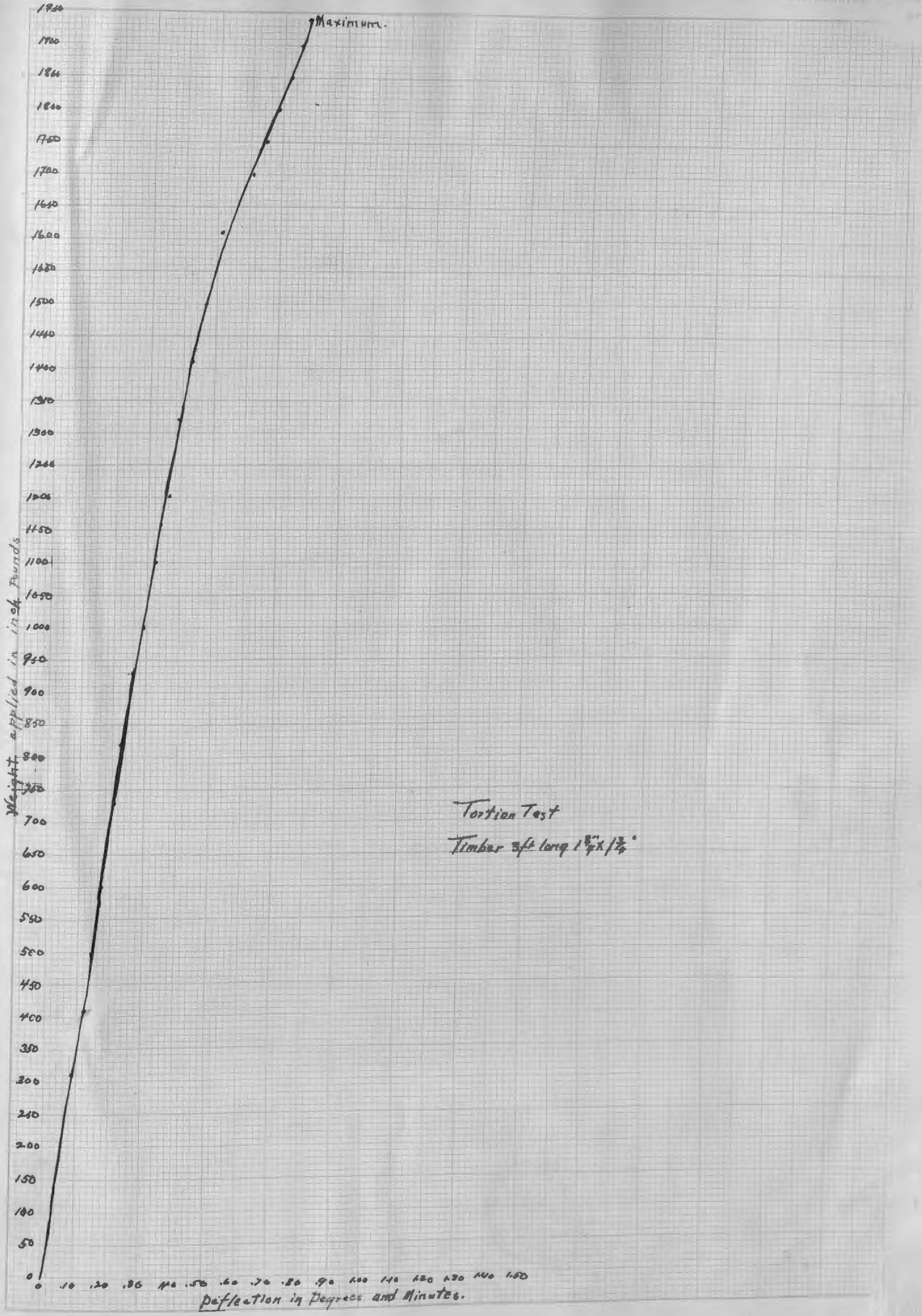

Gave way.
Began to yield.
Weight applied in lbs
Deflection in inches
Timber 42" long 3¾" x 1¾"
Weight applied Edgewise
Modulus of Elasticity 1221123 lbs
Cross Bending.



Timber 42" long 3¾" x 1¾" Weight applied flatwise

Modulus of Elasticity 48313 lbs

Cross Bending


Maximum.
Weight applied in inch Pounds
Deflection in Degrees and Minutes.
Tortion Test
Timber 3ft long 1 3/4" x 1 3/4"

Synonyms

The wide range of this species under varying conditions has led to the application of various names in different regions and often in the same locality. In Minnesota much is said about the Norway Poplar which, as all investigations show, is the Populus deltoides. The smooth base of the leaf is claimed to be a characteristic of the Norway Poplar but, as is shown in the plates, where the leaves are taken from the same branch, this variation occurs and the Cottonwood contains leaves with a straight margined base, a serrate base and a cordate base. Also the belief that some species of Cottonwood do not produce cotton is prevalent. While it is true that some trees do not produce cotton, due to the fact that they are staminate trees, and hence do not produce seed, the fact remains that it is not a species and if seed is desired the cotton cannot be avoided. If plantings without cotton are desired, the cuttings should be taken from staminate trees.

Many of the nurserymen handling the so-called Norway Poplar admit it is a selected Cottonwood, but it is a better seller under the name of Norway Poplar than under its own name, the Cottonwood. The ridged bark of the fast growing young shoot so characteristic of this sold in the nurseries is just as characteristic of the Populus deltoides.

The following is a list of synonyms used for Populus deltoides, according to Sargent:

Populus deltoidea, Marshall, Arbust.Am.106 (1785)- Sudworth, Bull.Torrey Bot.Club, XX.43.

Populus heterophylla, Du Roi, Harbk. Baumz. ii.150 (not Linnaeus) (1772).

Populus nigra, Marshall, Arbust. Am. 107 (not Linnaeus) (1785).

Populus Carolinensis. Moench, Baume Weiss. 81 (1785). Burgsdorf, Anleit. Anpfl. pt ii. 176. - Borkhausen, Handb. Forsthot. 1.550.

Populus Canadensis, Moench, Baume Weiss. 81 (1785).- Burgsdorf, Anleit. Anpfl. pt.ii, 177. - Castiglioni, Viag.negli Stati Uniti, ii, 334.-Borkhausen, Handb. Forstbot.1. 552.-Michaux f. Hist.Arb.Am.iii. 298, t.11.-Apach, Ann.Aci.Nat.ser.2, XV. 32 (Revisio Populorum); Hist.Veg.X.390.-Seringe, Fl.des Jard. ii.65.-Fiscali, Deutsch.Forstculturpfl.128, t.8, f.10-14.-Wesmael, Bull.Fed.Soc.Hort.Belg.1861, 330, f.8 (Monogr.Pop.); DeCandolle Prodr.XVI, pt.ii.329

(excl. angustifolia); Mem.Soc.Sci.Hainaut, ser.3, iii.242(Monogr.Pop.)(excl. angustifolia). - K.Koch, Dendr.ii.pt.i.491.- Beal,Am.Nat.XV.34,f.3.- Lauche, Deutsche Dendr.ed.2,317.-Dippel, Handb.Laub holzk.ii.199. - Koehne, Deutsche Dendr. 81.

Populus Virginiana, Fougerous, Mem.Agric. Paris, 87 (1786). - Du Mont De Courset, Bot.Cult. ed. 2, VI. 400. - Nouveau Duhamel, ii.186.

Populus laevigata, Aiton, Hort. Kew.iii. 406 (1789). - Willdenow, Spec.IV.pt.ii.803. - Pursh, Fl. Am. Sept. ii. 619. - Poiret, Lam. Dict. Suppl.IV.378. - Nuttall, Gen. ii. 239; Sylva, i. 54. - Sprengel, Syst. ii. 244. - Emerson, Trees Mass. 246; ed. 2, i. 283.

Populus angulata, Aiton, Hort. Kew. iii. 407 (1789) - Willdenow, Berl. Baumz. 234; Spec. iv. pt.ii.805; Enum. 1017. - Borkhausen, Handb. Forstbot. i. 548. - Nouveau Duhanel, ii. 186. - Desfontaines, Hist. Arb. ii. 466. - Michaux f. Hist. Arb. Am. iii. 302, t. 12. - Pursh, Fl. Am. Sept. ii. 619. - Rafinesque, Fl. Ludovic. 116. - Nuttall, Gen. ii. 239. - Torrey, Am. Lyc. N.Y. ii. 249. - Elliott, Sk. ii. 711. - Sprengel, Syst. ii. 244. - Jaume St. Hilaire, Traite des Arbres Forestiers, t. 53. - Loudon, Arb. Brit. iii. 1670, f. 1533, t. - Spach, Ann. Sci. Nat. ser. 2, xv. 32 (Revisio Populorum) ; Hist. Veg. x. 391. - Seringe, Fl. des Jard. ii. 64. - Chapman, Fl. 431. - Curtis, Rep. Geolog. Surv. N. Car. 1860, iii. 72. - Gray, Man. ed. 5, 467. - Wesmael, Bull. Fed. Soc. Hort. Belg. 1861, 328, f. 7 (Monogr. Pop.) - De Candolle Prodr. xvi. pt. ii. 328; Mem. Soc. Sci. Hainaut, ser. 3, iii. 240, t. 20(Monogr.Pop.). - K.Koch, Dendr.ii.pt.i. 494. - Porter & Coulter, Fl. Colorado; Hayden's Surv. Misc. Pub. No. 4, 129. - Lauche, Deutsche Dendr. ed. 2, 317.- Coulter, Man. Rocky Mt.Bot. 339. - Dippel, Handb. Laubholzk. ii. 201. - Koehne, Deutsche Dendr. 82.

Populus monilifera, Aiton, Hort. Kew. iii. 406 (1789) - Abbott & Smith, Insects of Georgia, ii. 141, t. 71. - Willdenow, Berl. Baumz. 231; Spec. iv. pt. ii.805; Enum. 1017. - Nouveau Duhamel, ii. 186. - Persoon, Syn.ii.623. - Desfontaines, Hist. Arb. ii. 465. - Du Mont - de Courset, Bot. Cult. ed. 2, VI. 400. - Michaux f. Hist. Arb. Am. iii. 295, t. 10, f. 2. - Pursh, Fl. Am. Sept. ii. 618. - Nuttall, Gen. ii. 239. - Hayne, Dendr. Fl. 202. - Sprengel, Syst.ii. 244. - Watson, Dendr. Brit. ii. 102, t. 102. - Loudon, Arb. Brit. iii. 1657, f. 1517, t.- Spach, Ann. Sci. Nat. ser. 2, xv. 32 (Revisio Populorum); Hist. Veg. x. 389 - Torrey, Fl. N.Y. ii. 215.- Emerson, Trees Mass. 249; ed. 2, i. 287. - Waga, Fl. Pol. ii. 669. - Seringe, Fl. des Jard. ii.63. - Watson, Am. Jour. Sci.ser. 3, xv. 136. - Ward, Bull. U. S. Nat. Mus. No.22, 116 (Fl. Washington). - Chapman, Fl. ed. 2, Suppl. 649. - Sargent, Forest Trees N. Am. 10th Census U. S. ix. 174. - Trautvetter, Act.Hort. Petrop. ix. 191 (Incrementae Fl. Ros). - Watson & Coulter, Gray's Man. ed. 6, 487. - Koehne, Deutsche Dendr. 82.- Coulter, Contrib. U.S. Nat. Herb. ii.420 (Man.Pl. W. Texas).

Populus nigra, Virginiana, Castiglioni, Viag. negli Stati Uniti, ii. 334 (1790).

Populus latifolia, Moench, Meth. 338 (1794).

Populus glandulosa, Moench, Meth. 339 (1794).

Populus dilatata, Caroliniensis, Willdenow, Berl. Baumz. 230 (1796).

Populus Angulosa, Michaux, Fl. Bor. - Am. ii. 243. (1803).

Populus nigra, B Helvetica, Poiret, Lam. Dict. V. 234 (1804).

Populus Marilandica, Poiret, Lam. Dict. Suppel, iv.378 (1816). - Sprengel, Syst. ii. 244.

Populus serotiana, Hartig, Forstculturpfl. Deutschl. 437 (1851).

Populus angulata tortuosa, Carriere, Rev. Hort. 1867, 360. - Wesmael, De Candolle Prodr. xvi. pt. ii. 328; Mem. Soc. Sci. Hainaut, ser. 3. iii. 241 (Monogr. Pop.).

Populus Canadensis, Discolor, Wesmael, De Candolle Prodr. xvi. pt. ii. 329 (1868); Mem.Soc.Sci.Hainaut, ser.3, iii. 243 (Mongr. Pop.).

Populus angulata, a serotina, Dippel, Handb. Laubholzk. ii. 202 (1892).

Summary

A botanical study of Populus deltoides and the commonly planted Norway Poplar shows them to be the same species, the only difference being that the Norway Poplar is a selected type for faster growth.

Adaptability of the Cottonwood to the overflow lands and river-bottom regions makes it a valuable tree in the utilization of thousands of acres of these lands now practically worthless and non-productive.

Reforestation and aforestation must necessarily be in part artificial, due to the intolerance of the species and the short time the seed is viable, hence being unable to germinate except under very favorable conditions.

Returns on the investment in a rotation of Cottonwood justify taking under management these waste lands by private individuals, corporations, state or government.

The small risk on the investment due to insect, wind, fungi, and fire losses is a strong factor in favor of the growing of Cottonwood.

Uniformity of growth of bole in height and taper makes possible a high per cent of utilization.

Large volume production in short periods as 25 to 40 years makes it possible to realize early on the investment.

Management problems are not difficult as the fire and insect problems, the most important in pine forests, are almost nil and the brush can be left where cut. Clear cutting should be used and low stumps where sprout reproduction is desired.

The increasing demand and variety of uses for the timber of the Cottonwood promise well for its future. It is used in lumber, lath, pulp, ties, posts and fuel.

Structurally the Cottonwood compares well with other woods in the softer woods of the hardwoods. It is very strong in bending or breaking, due to its long fiber.

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