Paper and yellow birch,
their properties and uses.

Thesis by

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Paper birch and yellow birch, their properties and uses.

. Paper birch
. Yellow birch
. Wood - Quality
. Wood - Utilization

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A.D.

Foreword

This paper is intended primarily to present a discussion of the most important aspects of paper birch (Betula papyrifera Marsh.) and yellow birch (Betula lutea Michx.) growing in the Province of Quebec. This study arises from the fact that many people are not fully aware of the valuable properties of these two species, and consequently fail to utilize them at best. Yet, these birches rank among our first hardwoods.

Before going into any discussion of the properties and uses, it has been deemed necessary to study the distribution and identification, the logging and the seasoning of paper and yellow birch. Two chapters are also included which deal with destroying organisms and the grading rules.

In the Appendix, some laboratory tests concerning the bending and the coloring of the wood of birch are described and some indications therefrom are recorded.

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Chapter I

ESTIMATED STANDS AND DISTRIBUTION OF PAPER AND YELLOW BIRCH [1]

With reference to the forest area, the Province of Quebec exhibits two main regions, that is: North and South of the 52nd. degree of latitude. This division is based primarily upon the inaccessibility and the accessibility of timber stands. Inaccessible stands, as we understand, do not offer any prospect of commercial utilization at existing market prices and with present transportation facilities.

Stands north of 52°.

The northern limit of yellow birch coincides with the 49° of latitude.[2] This species therefore is not present or its presence is merely accidental in the inaccessible areas. But paper birch extends northward up to the 57° of latitude.[2] No complete survey, so to speak, has been made in the northern regions; however it appears that paper birch reaches a maximum height of 50 feet, perhaps less, the diameter averaging 8 to 10 inches. Due to the length of the winter-time, its growth rate is greatly reduced.

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[1] Acknowledgement is due to Mr. J.E. Guay, F.E., Head of the Forest Survey Bureau, Forest Service, Quebec, P.Q., who kindly supplied the data as to the volume and distribution of paper and yellow birch.

[2] Native Trees of Canada, Forest Service Bulletin 61, page 107 (map).

The estimated volume of inaccessible paper birch stands amounts to 2040.3 mil. cu. ft., or 17.3% of its total volume in the province. This species is ordinarily associated with black and white spruce, balsam fir and jack pine.

Notwithstanding the importance of such a volume, for all practical purposes we are going to pay but little attention to the stand situated north of the 52° of latitude.

Stands south of 52° latitude

Paper birch.

This species acquires more importance as it grows in southern regions, due chiefly to its commercial size and its accessibility. The height of this tree may reach a maximum of 70 feet in good situations, the diameter being in the neighbourhood of 18 inches.[3] It then becomes associated with yellow birch, aspen, poplar, besides the coniferous species already referred to above. Pure stands of paper birch occur mostly on burned-over and cut-over areas.

Volume: Table 1 gives in thousand cubic feet the estimated stands of paper birch per region.[4] The volumes listed in this table include trees with a diameter of 5 inches and up (D.B.H.).

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[3]Native Trees of Canada. Op. cit., page 103

[4]The word region does not refer to a political division so-called county; therefore a region may include several counties. (see Fig.1)

Table 1:- Estimated stands of Paper Birch per region (south of 52°).

Region	All timber					Sawtimber
	Volume (1000) (cu.ft.)	Percent of				(1000) (cu.ft.)
		North Shore	Total	Region (P.& Y.B.) (compared)	Hard-wood	
North shore	1	2	3	4	5	6
A.....	1,379,800	16.7	14.1	100.0	9.1	275,960
B-1...	1,118,800	14.3	11.4	45.7	7.3	223,760
B-2...	1,315,100	16.0	13.5	62.5	8.6	263,020
B-3...	452,500	5.3	4.6	84.5	2.9	90,500
C.....	2,642,400	32.1	27.0	100.0	17.2	528,480
D.....	1,284,000	15.6	13.1	100.0	8.3	256,800
Total	8,192,600	100.0	83.7	77.8	53.4	1,638,520
South shore		South shore				
E.....	374,300	23.3	3.8	100.0	2.4	74,860
F.....	821,600	51.2	8.4	66.7	5.3	164,320
G.....	223,000	14.4	2.3	65.0	1.4	44,600
H.....	180,000	11.1	1.8	48.0	1.2	36,000
Total	1,598,900	100.0	16.3	68.6	10.3	319,780
Grand total	9,791,500	.....	100.0	76.1	63.7	1,958,300

A :Abitibi region
B-1:Ottawa "
B-2:St.Maurice "
B-3:Quebec-Charlevoix
C :Lake St.John
D :North Shore

E : Gaspesia region
F : Rimouski, Matane, Matapédia
G : South Shore
H : Eastern Townships & Richelieu Vallée
I : Inaccessible regions

Region C, the Lake St. John region, has the greatest amount of paper birch, that is 2642 mil. cu. ft. On a stand per acre basis, region F is the richest, containing 821.6 mil.cu. ft. for an area about 4 times smaller than C. In both cases, intensive and extensive logging operations have been carried out and are still going on for the profit of pulp and paper and lumber industries. Spruce and balsam fir are the principal trees felled in those areas.

Most of the paper birch stands grow on the lands situated north of the St. Lawrence river, that is 83.7% of the total amount of this species in the accessible areas. It is interesting to note that in all but two regions, Ottawa and Eastern Townships with the Richelieu Vallée, the volume of paper birch exceeds the volume of yellow birch. Taken in the aggregate, the percentage of paper birch is 76.1% of the total volume of these two species; in other words, the volume of paper birch is greater than the volume of yellow birch by nearly 220%.

Finally, it must be remembered that paper birch ranks first among the hardwoods, its volume representing 63.7% of the total volume of hardwoods growing in the accessible regions.

The data available in Table 1 are shown in Charts 1 and 2. Note that the amount of paper birch growing south of the St. Lawrence river is very small compared to the north shore. Region H is particularly poor with regard to its area which is nearly 4/5 of region C. The explanation lies in the fact that the Eastern Townships and the Richelieu Vallée are particularly fit to farming. Those regions have been cleared many years ago and, to-day, they exhibit the most valuable agricultural lands of the province. Needless to say that the population per unit of area is the greatest of all regions.

CHART I

ESTIMATED STANDS OF PAPER BIRCH PER REGION. NORTH SHORE OF ST. LAWRENCE RIVER (South 52° Lat.)

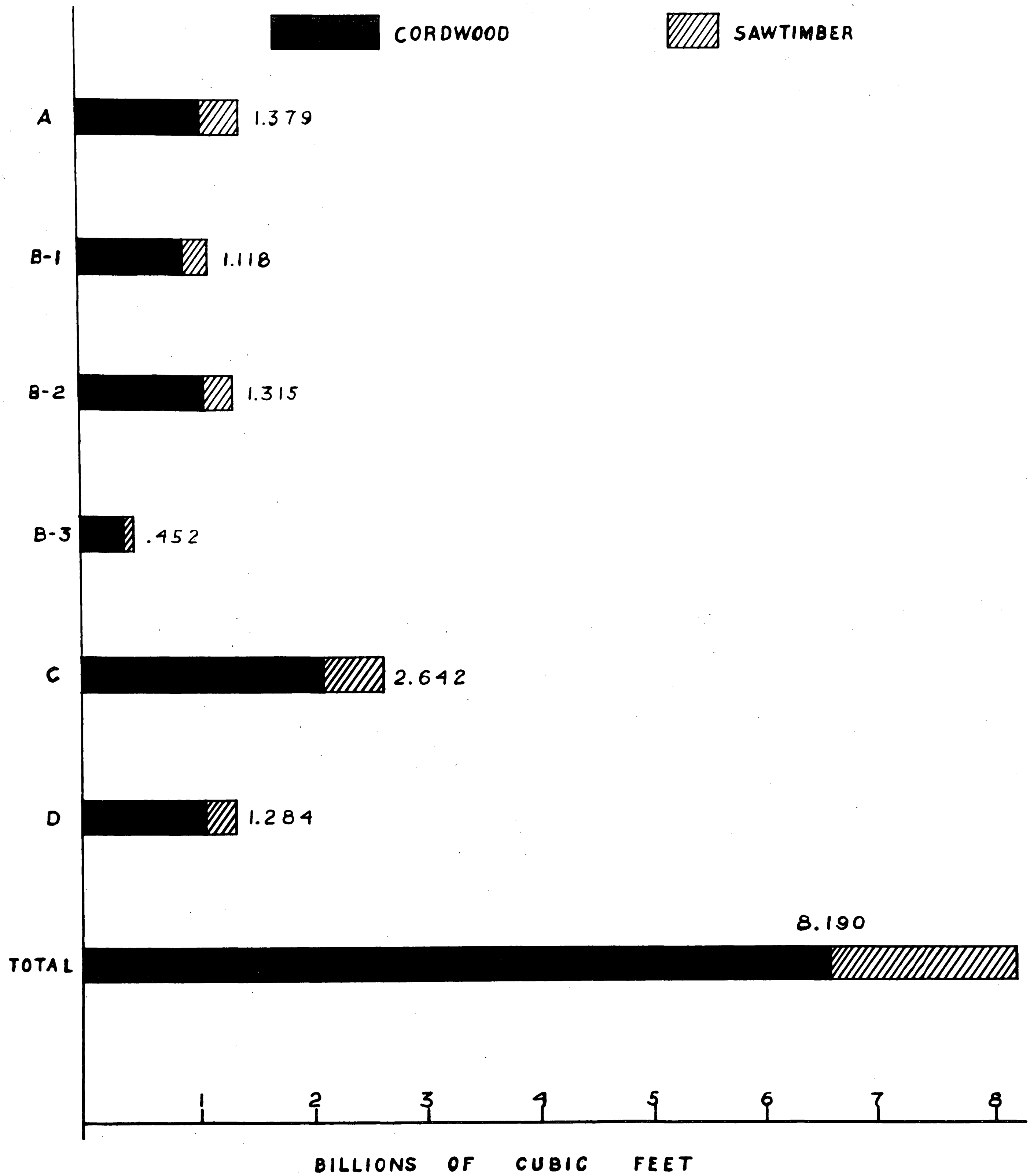
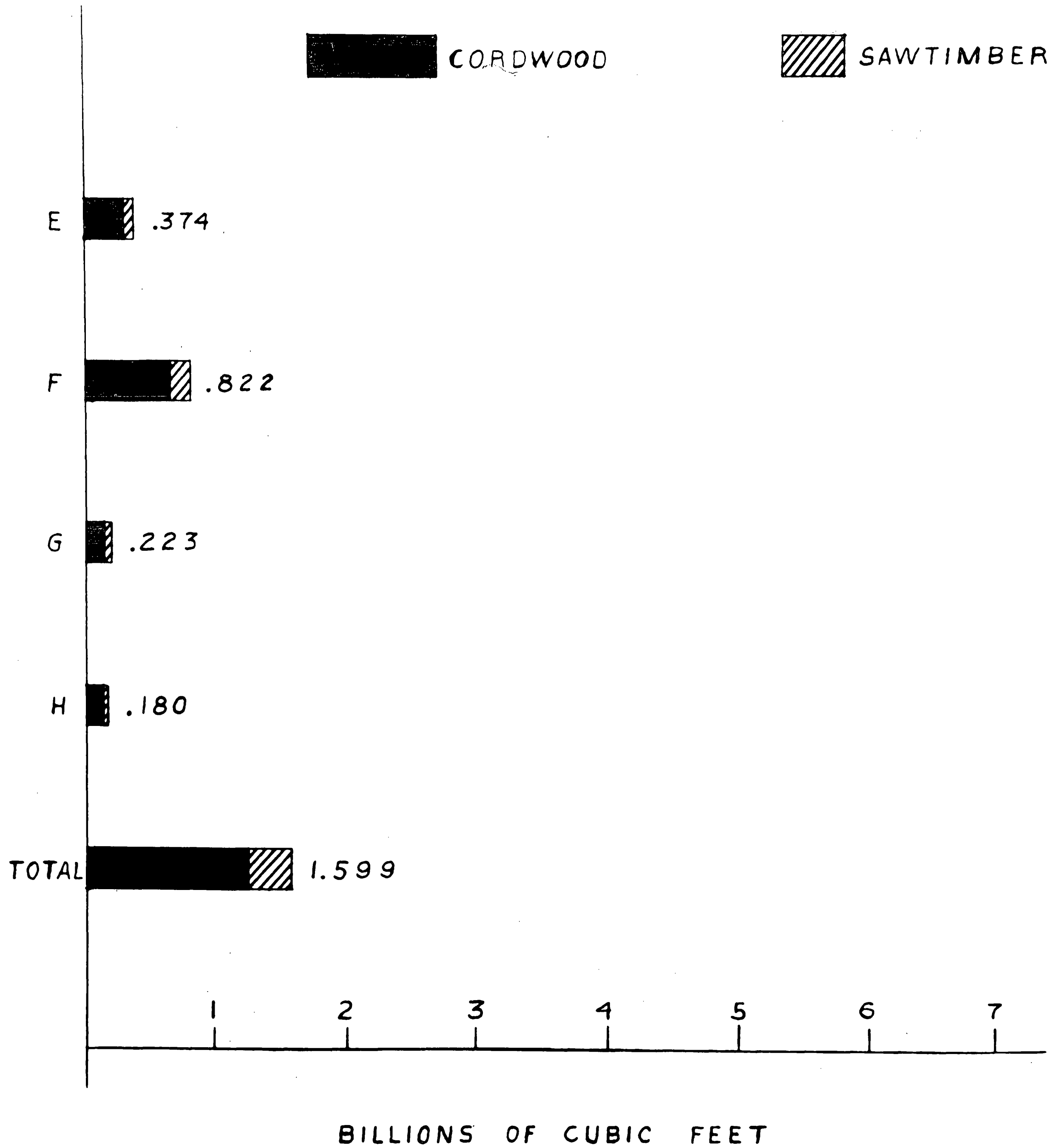


CHART 2

ESTIMATED STANDS OF PAPER BIRCH PER REGION SOUTH SHORE OF SAINT LAWRENCE RIVER.



To illustrate the foregoing discussion, Table 2 gives the volume per acre of paper birch and yellow birch per region.

Region	Area (mil. acres)	Paper birch (cu. ft.)	Yellow birch (cu. ft.)	Total (c.f.)
A	17.74	77.8	....	77.8
B-1	20.42	54.7	72.0	126.7
B-2	11.02	119.3	71.4	190.7
B-3	2.64	171.2	31.4	202.6
C	13.63	194.2	....	194.2
D	13.34	96.3	....	96.3
E	3.67	101.8	....	101.8
F	3.35	245.0	122.4	367.4
G	3.30	67.7	36.5	104.2
H	10.05	17.9	19.5	37.4
		Average	Average	Aver.
Total	99.16	98.8	30.9	129.7

Table 2:- Volume of paper and yellow birch per acre and per region.

From this table, we find that the accessible area north of the St. Lawrence river covers 78.79 million acres: the average volume per acre is the following:

Paper birch...................104 cu.ft.
Yellow birch.................. 29.8 cu. ft.

Total.........................133.8

South of the St. Lawrence river, the area is 20.37million acres and the volumes per acre read as follows:

Paper birch................... 98.6 cu. ft.
Yellow birch.................. 35.7 cu. ft.

Total.........................114.3

Yellow Birch

As already stated, yellow birch extends northward up to the 49° of lat. Therefore, we may expect that this species does not show in some regions, due to the small amount or the total abscence of timber.

Yellow birch does not occur in pure stands, but it is ordinarily associated with spruce, balsam fir, paper birch, aspen and maple (to name the principal species).

Volume: Table 3 gives the estimated stands, in thousand cubic feet, of yellow birch per region.

Region	All timber					Sawtimber
		Percent of				
	Volume (1000) (cu.ft.)	North shore	Total	Region (P.& Y.B.) (compared)	Hard-wood	(1000) (cu. ft.)
North shore	1	2	3	4	5	6
A	....	....	....	.....	...	....
B-1	1,472,000	62.8	48.0	54.3%	9.6	294,400
B-2	787,500	33.6	25.6	37.5%	5.1	157,500
B-3	82,700	3.6	2.7	15.5%	0.6	16,540
C	......	...	...	.....	...	......
D	......	...	...	.....	...	......
Total	2,342,200	100.0%	76.3	22.2%	15.3	468,440
South shore		South shore				
E	....	....	....	.....	...	......
F	410,100	56.4	13.3	33.3%	2.7	82,020
G	120,400	17.0	4.0	35.0%	0.8	24,080
H	195,700	26.6	6.4	52.0%	1.3	39,140
Total	726,200	100.0%	23.7	31.4%	4.8	145,240
Grand total	3,068,400	......	100.0%	23.9%	20.1	613,680

Table 3:- Estimated stands of Yellow Birch per region (south of 52°).

The amount of yellow birch in regions A, C, D and E may be neglected.[5] This species predominates in the south-western Quebec (region B-1) as compared to paper birch. The same is true for region H, which is adjacent to the States of Maine, New-Hampshire, Vermont and New-York.

The data available in Table 3 are expressed graphically by Chart 3 and Chart 4, and the volume per acre for each region is given in Table 2.

The total amount of yellow birch north of the St. Lawrence river is greater than in the south. However, on a volume per acre basis, we find 35.7 cu.ft. in the south shore against 29.8 on the north, while region F (Rimouski, Matane and Matapédia counties) is the richest with 122.4 cu.ft. In this particular region the author has found yellow birches up to 5 feet in diameter with an average height of 70 feet. Undoubtedly, yellow birch reaches its best development near the international boundary in the Southern part of the Province. According to Betts,[6] this statement holds for yellow birch growing in North America.

Kind of Timber and Ownership

Due to an incomplete forest survey (presently under way), very little is known as to the amount of paper birch and yellow birch fit for lumber production in each region. We are likely to rest on a general estimate based on the data hitherto available.

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[5]See Fig.1

[6]Betts, H.S., "Birch" American Woods Series, U.S.D.A. For. Serv., 1940, page 2.

CHART 3

ESTIMATED STANDS OF YELLOW BIRCH PER REGION NORTH SHORE OF ST. LAWRENCE RIVER (South 52° Lat.)

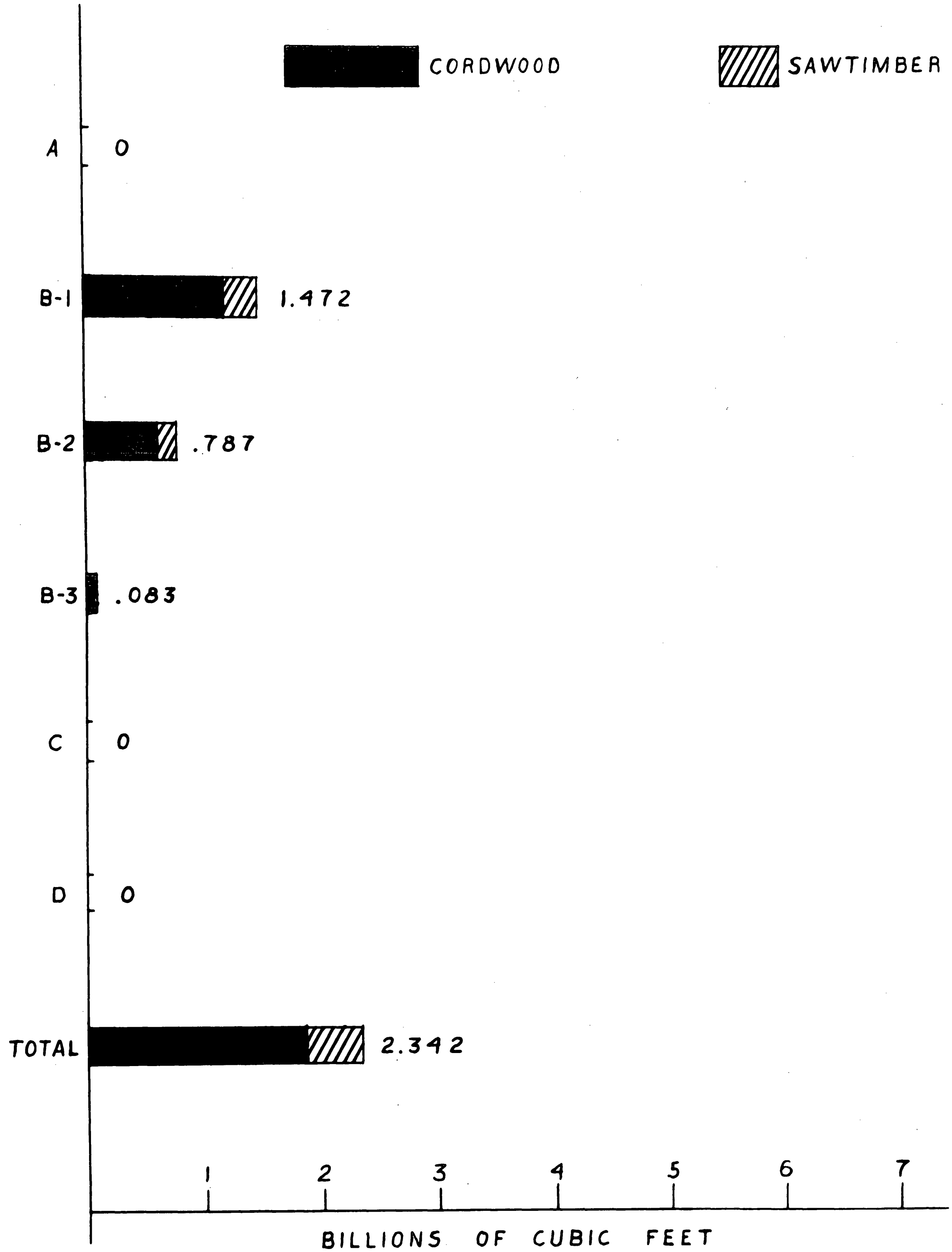
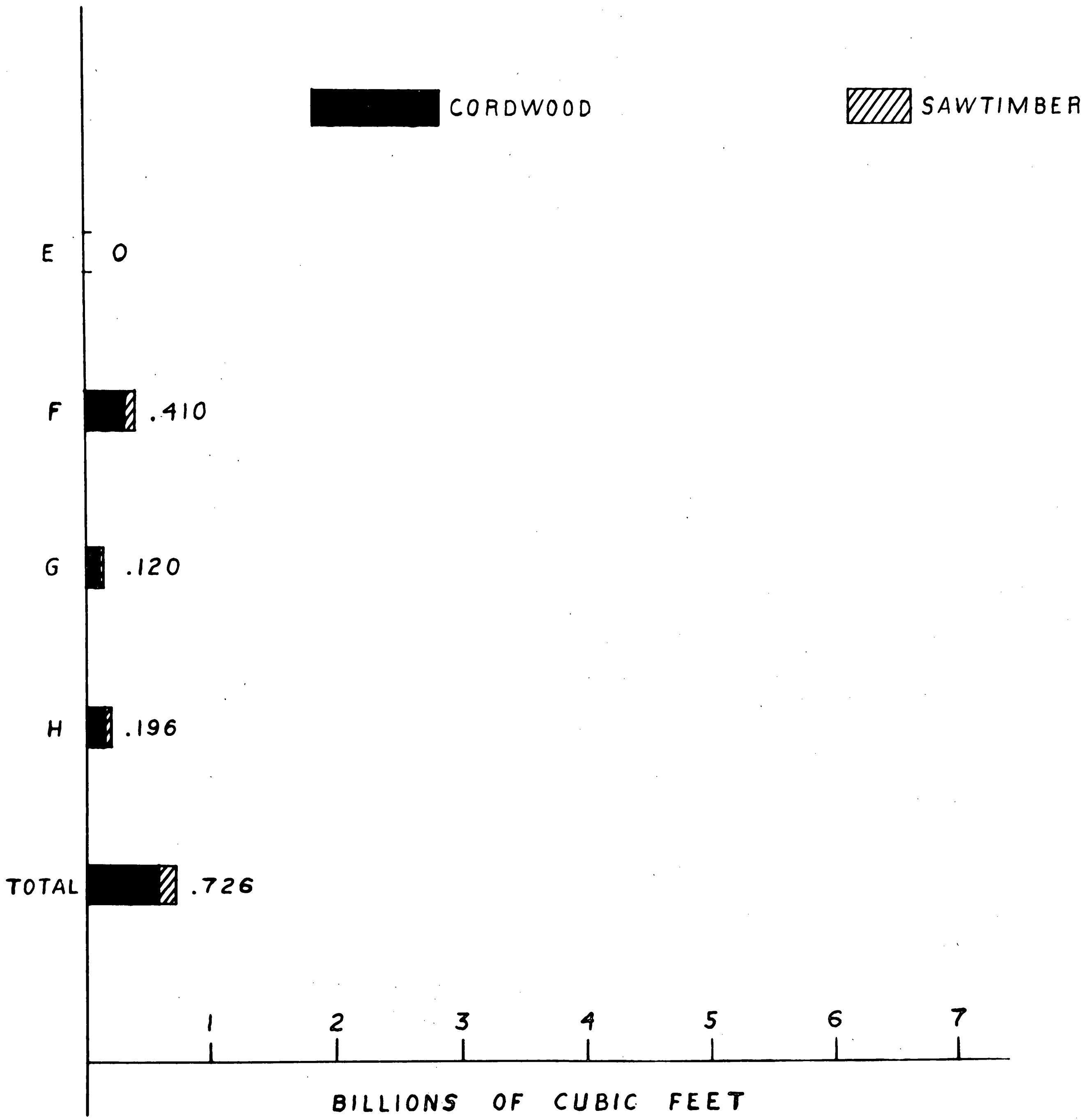


CHART 4

ESTIMATED STANDS OF YELLOW BIRCH PER REGION SOUTH SHORE OF SAINT LAWRENCE RIVER.



Taking 20% of the total stand as a conservative figure, the amount of sawtimber per species per region has been computed and included in Tables 1 and 3 and shown in charts 1 to 4 inclusive.

As to the ownership, Table 4 and Chart 5 gives the volume of paper birch and yellow birch belonging to the Crown and to the private industry.

Species	Public			Private			Total	%
	Volume in million cu.ft.	Percent of Species	Percent of Total	Volume in million cu.ft.	Percent of Species	Percent of Total		
Paper Birch	9430.5	96.4	73.3	361	3.6	2.8	9791.5	76.1
Yellow Birch	3012.4	98.4	23.5	56	1.6	0.4	3068.4	23.9
Total	12442.9	....	96.8	417	...	3.2	12859.9	100.0

Table 4 :- Estimated stands of Paper Birch and Yellow Birch given by ownership (south of 52° l.)

It will be noted that 96.4% of yellow birch (south of 52°) is publicly owned. Taken in the aggregate, only 3.2% of the total stand of birch is privately owned.[7]

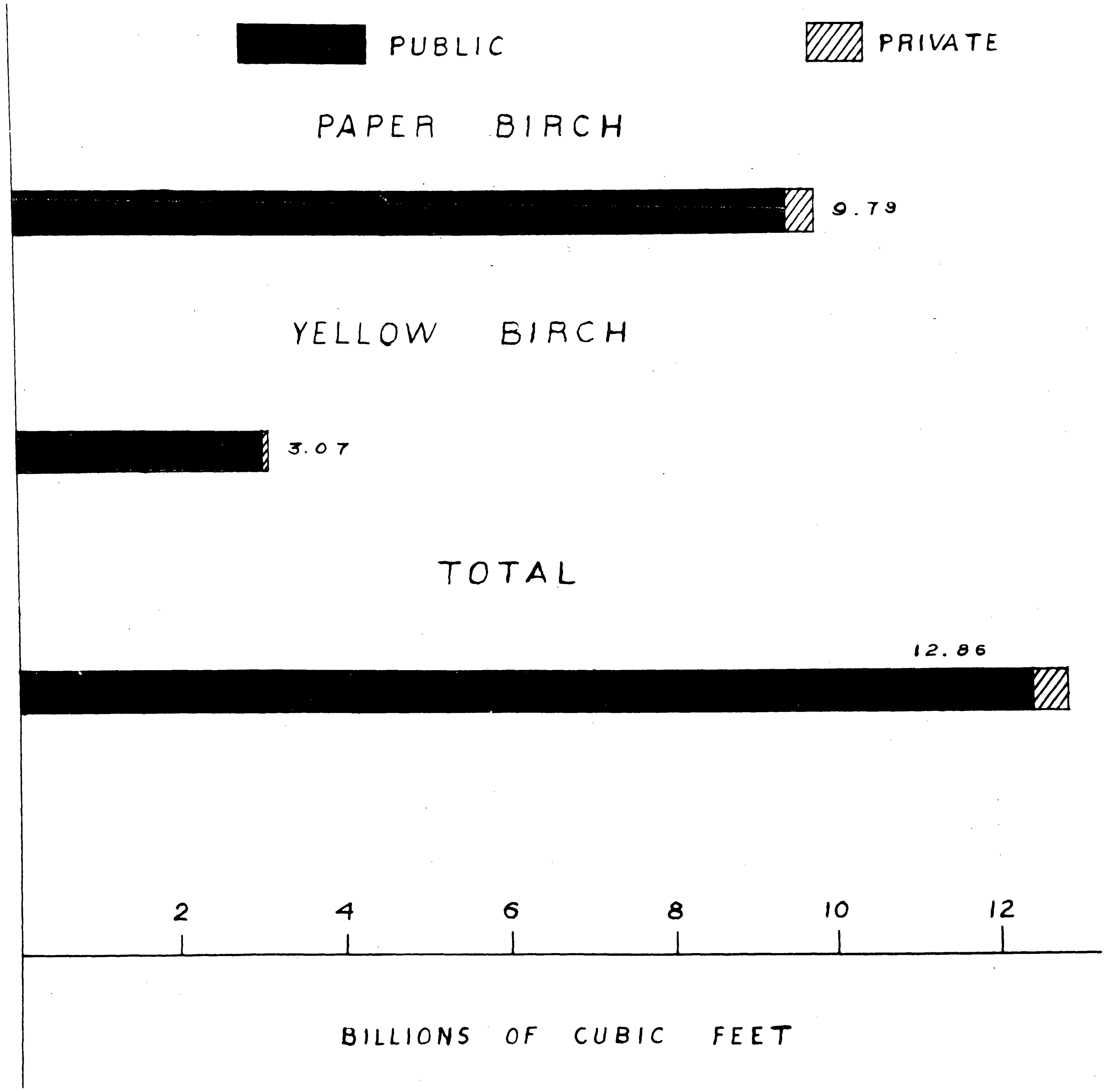
Depletion and Growth

Growth is discussed in Chapter III in connection with silvical characteristics. Suffice it to note here that the general growth rate of both species is estimated to

[7]It must be remembered that other species of birch grow in the Province of Quebec, f.i.: wire birch (populifolia), sweet birch (lenta), but their volume as compared to the two species discussed in this study may be neglected.

CHART 5

ESTIMATED STANDS OF PAPER AND YELLOW BIRCH GIVEN BY OWNERSHIP (South of 52° Lat.)



be in the neighbourhood of 2%. Thus, the annual increment in volume of paper birch amounts to 195.83 million cu.ft. and that of yellow birch is 61.368 million cu.ft. On the other hand the volume of timber cut during the period 1937-39 reads as follows:

	1937-38	1938-39	Average
Paper birch	3,729,097cu.ft.	5,612,497	4,670,748
Yellow birch	15,979,367 "	11,505,698	13,742,532

In order to compute the total depletion, losses on account of fire, insects, fungi and miscellaneous causes (wind, ice, snow, etc.) must be added to the averages given above. Nevertheless, even with a growth rate of 1%, it is safe to state that the volume lost each year is largely compensated for by the increment. This is particularly true for paper birch.

Volume of birch as compared to other species

Table 5 (page 10) gives the total timber stand of the province by species. It is interesting to note that paper and yellow birch are the most important of hardwoods, representing over 80% of the volume. As compared to the total timber stand, paper birch ranks third and yellow birch fifth. Chart 6 gives the total stand of paper and yellow birch both on north and south shore of the St.Lawrence river. The total volume of paper and yellow birch is compared to the total stand in Chart 7.

CHART 6

ESTIMATED STANDS OF PAPER AND YELLOW BIRCH NORTH AND SOUTH OF 52° LATITUDE

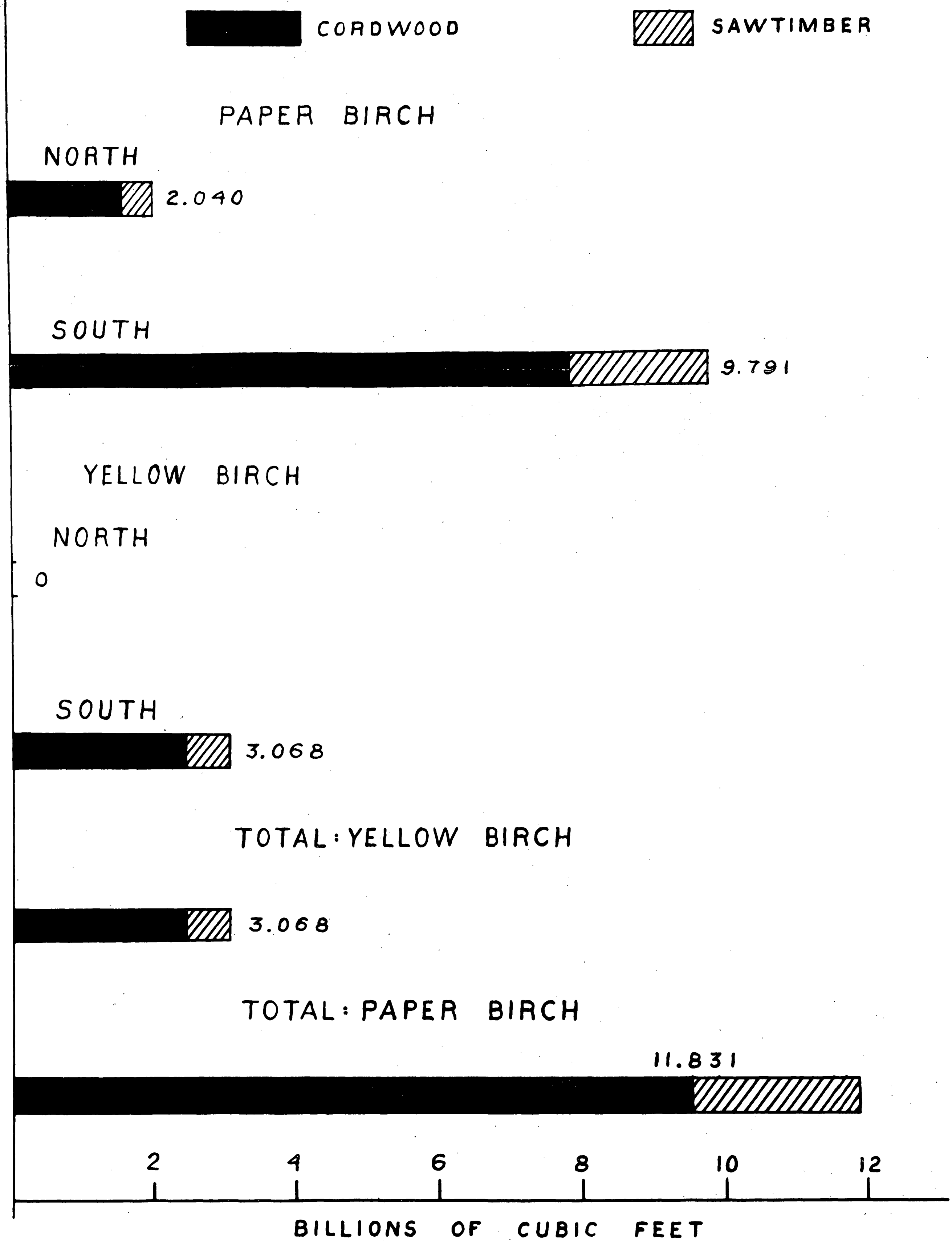
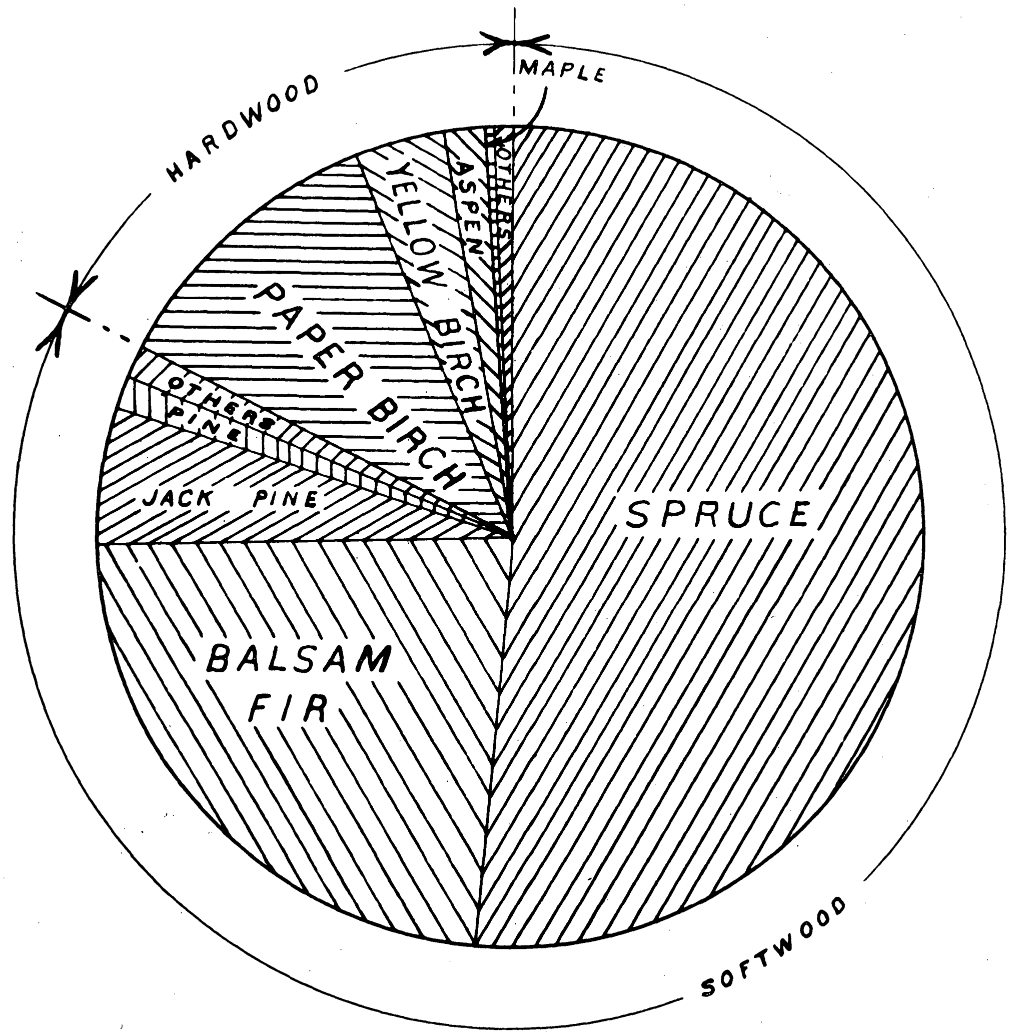


CHART 7
STOCK OF PAPER AND YELLOW BIRCH COMPARED TO OTHER SPECIES
SOUTH OF 52° LAT.



SPECIES	VOLUME - 1000 cu.ft.
SPRUCE	44,635,000
BALSAM FIR	20,205,000
JACK PINE	4,634,000
PINE	1,067,000
OTHER SOFTWOODS	1,010,000
PAPER BIRCH	9,791,500
YELLOW BIRCH	3,068,400
ASPEN	1,566,000
MAPLE	290,000
OTHER HARDWOODS	626,000
TOTAL	86,892,900

Table 5:- Estimated stands of Yellow Birch per region (south of 52°)

Species	Volume (million cu.ft.)	Percent of Softwood	Percent of Hardwood	Percent of Total
Spruce	44,635	62.4	....	51.4
Balsam Fir	20,205	28.2	....	23.2
Jack Pine	4,634	6.5	....	5.3
Pine	1,067	1.5	....	1.2
Other	1,010	1.4	....	1.1
Total (softwoods)	71,551	100.0	....	82.2
Paper Birch	9,791.5	....	63.7	11.3
Yell. Birch	3,068.4	....	20.1	3.6
Aspen	1,566.0	....	10.1	1.8
Maple	290.0	....	1.9	0.3
Other	626.0	....	4.2	0.8
Total (hardwoods)	15,341.9	....	100.0	17.8
Grand Total	86,892.9	....	....	100.0

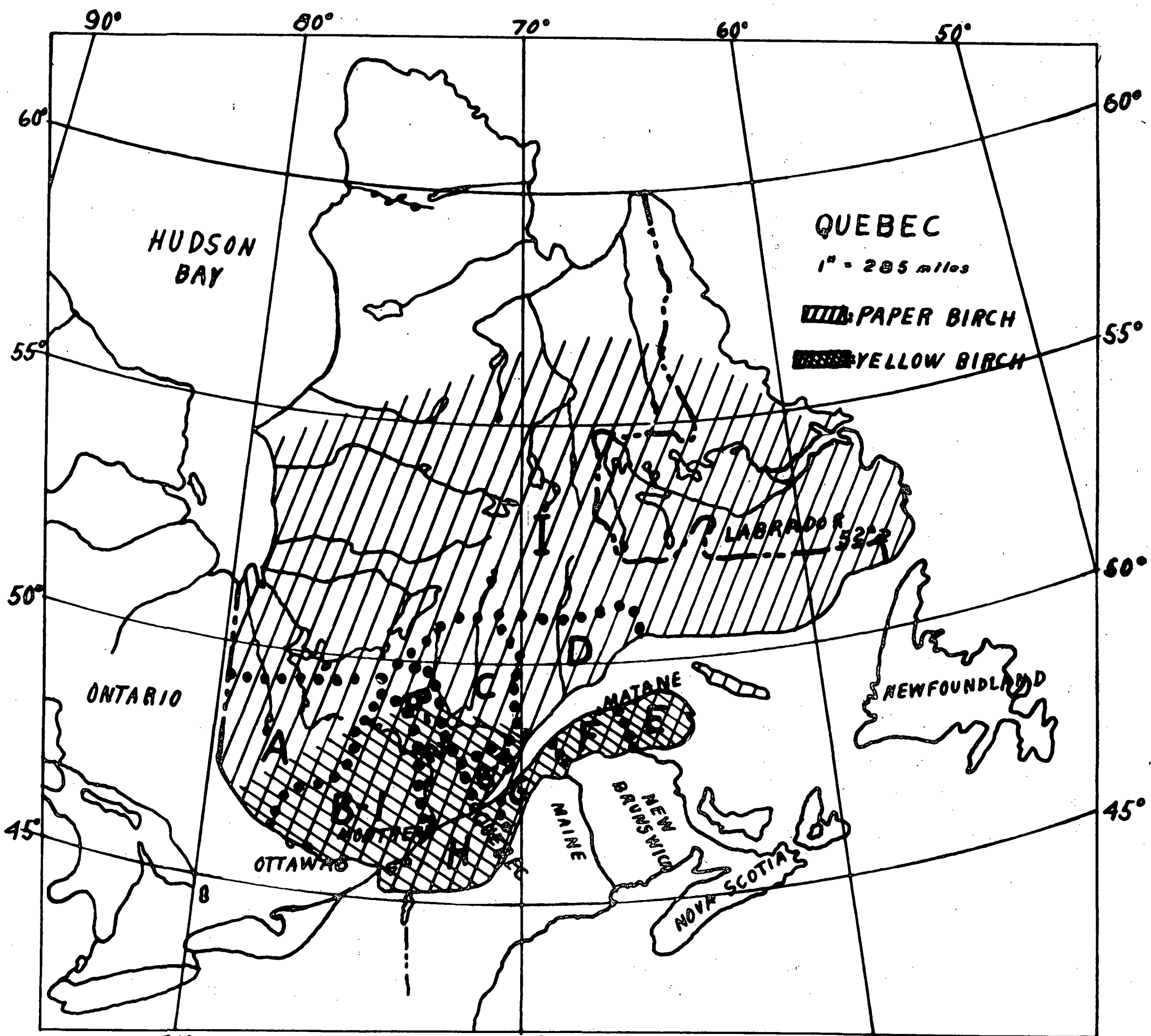


FIGURE I. - DISTRIBUTION OF PAPER AND YELLOW BIRCH IN THE PROVINCE OF QUEBEC, GIVEN PER REGION.

Chapter II

Management

Logging

The cutting of paper and yellow birch begins as a rule late in fall. It seldom takes place in summer-time due to the danger of staining, and it can no longer be carried out past March 1 of the following year.[8]

Both an ax (single-edge) and a saw are used for the felling of the tree: the method consists in notching the trunk a few inches on the side corresponding to the direction toward which the tree is intended to fell, and then sawing through from the opposite side a few inches above the level of the notch. Mechanical saw are not used a great deal.

Government regulations state that every tree felled on public lands must be utilized down to a diameter of 3 1/2 inches in the crown (except 8.5" for logs of birch and some other species, destined to be sawn). Also, stumps must not be more than 12 inches high above the ground line, and complete utilization of service wood contained in wind-thrown timber is required.[8] The timber cut on public lands must be piled on the cutting area protected against high waters, so that scaling may take place before the final transportation.[8]

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[8]Order-in-Council No. 1941, July 17, 1937, of the Executive Council of the Province of Quebec. This order applies only to public timber lands (crown lands). However, as stated elsewhere, 96.8% of the total stand of birch is publicly owned.

As to the handling of the tree, men work ordinarily by crews some being affected to the felling, others to the chopping and the cutting of the bolts. At the same time, they mark out and clear roads as they go.

Except in particularly difficult conditions, all the roads open for the transportation of the forest products must be distant at least 300' one from the other.

It is doubtful whether the practice usually resorted to in the logging of pulpwood should be accepted in the case of birch. This practice consists in building the wage scale on a cord basis instead of a work-day basis (although some concerns prefer the latter method). This policy is fair when timber stands are dense, which is not the case for birch. Most of paper and yellow birch is associated with other species, and we have indicated above that pure stands of paper birch are not, as a rule, of a commercial size. Moreover, we have seen that the richest region in birch (Rimouski, Matane, Matapédia) amounts to 367.4 cu.ft. per acre or approximatively 4.1 cords per acre. Therefore, due to selective logging made necessary by mixed stands and on account of a relatively small volume per acre, workers should be paid on a work-day basis, so much by work-day (or by month).

Stumpage dues: As already said, wood must be piled up on the cutting area. The stacks must lay down on wooden skids, far beyond the reach of rising waters, be clear on every side and present one face vertical. The top should be as horizontal as possible.

4-foot logs are generally piled up in stacks of 4 feet high by 8 feet long, thus giving one cord of 128 cu.ft. (apparent volume). All woods must be scaled by the solid cubic foot, whether they are scaled piece by piece or by the cord. It seems important to include here the stumpage dues as fixed by O-in-C. No. 2523 regarding all wood cut after May 1st., 1938, since pratically every stand of pa-per and yellow birch belongs to the Crown. Although these dues do not add to the logging cost itself, they ought to be given consideration should any one intend to secure his raw material from public lands. Table 6 gives the rates according to the divisions set forth in the Order-in-Council (birch only is given).

Table 6:- Current stumpage dues on birch cut on public lands.

Item	Dues (1) Y.B.	(1) P.B.	(2) Y.B.	(2) P.B.	(3) Y.B.	(3) P.B.
Wood for pulp and paper	$0.75	$0.75[9]	....	....	$1.00	$1.00[9]
(per 128 apparent cu.ft.)	.85	.85	....	....	1.15	1.15
(per 100 solid cu.ft.)	.90	.90	....	....	....	....
Sawlogs (100 cu.ft.)[10].....	1.25	.85	$1.25	$0.85	2.35	1.75
Rough (unbarked) timber[11] (per 100 cu.ft.).........	.75	.75	....	....	.90	.90
Square, waney and flat timber (per cu. foot).........	.10	.08	....	....	....	....
Dimension timber (per cu. ft.)..........	.02	.02	....	....	.03	.03
Wood for charcoal and distillation (per 128 app.cu.ft.)	1.00	1.00	....	....	1.00	1.00
Firewood (cord)[12]...........	.60	.40	.60	.40	.75	.60
Spoolwood (cord)...........	.70	.70	....	....	.85	.85
(per 100 cu.ft.)....	.90	.90	....	....	1.10	1.10
Railway ties (each)........	.10	.10	....	....	.10	.10
Fence wood.................	.02	to.04	.02	to.04	.03	to.05

Column 1:- Woods cut on licensed lands
Column 2:- Woods cut on township forest reserves
Column 3:- Woods cut on unlicensed lands (special permits)

[9] Refers to unbarked timber.

[10] Include logs from 8 to 20 feet in length, destined to be sawn, split or veneered.

[11] Timber used for the construction of corduroy roads, dams and camps of all kinds.

[12] The rate is $0.30 per cord when firewood or wood for charcoal comes from the tops of trees utilized from saw lumber.

Transportation

The logging industry comprises the manufacturing of logs and their transportation to the mill. To a very large extent, the logging problem is a problem of delivery. When the cutting area happens to be close to existing transport facilities, good management of the skidding operations will keep the cost at a satisfactory level.

In fact, many concerns engaged in the logging and utilization of birch draw their supply from timberlands situated close to such facilities, either public or private.[13] However the situation is reversed in many occasions and will be worse as the source of supply becomes exhausted in the accessible regions. Then,transportation facilities must be created and both hauling and skidding must be given close attention.

<u>Skidding or pre-hauling:</u> They constitute the first chapter in the whole story of log transportation. More explicitly, skidding (or pre-hauling) consists in the moving of the logs from the place they were made to the first collection place, the so-called skidways. Many questions arise here as to which method of skidding should be adopted.

In many localities characterized by rough topography, the use of slides, chutes or flumes (when water is available) is often resorted to. The author has never heard of such

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[13] Opportunities present themselves sometimes with regard to the exploitation of hardwoods growing on areas granted to the pulp and paper industry.

methods being put in practice except in the logging of softwood, especially pulpwoods. It is doubtful whether such methods will not deteriorate birch logs and the final products in some instances. Moreover, these methods of transportation are feasible only in particular areas; therefore we are not going to pay much attention to them.

Consequently, people are likely to rest on some sort of traction in order to have the logs piled on the skidways. The problem comes out to be how to select either animal or mechanical traction. Professor D.M. Matthews gives a simple and clear formula in order to find the limit distance for which a given type of hauling equipment will cease to be economical.[14] This formula is based on the principle that

> "any two machines, one of which has a low fixed and high variable cost and the other a high fixed and low variable cost, will show the same cost at some skidding distance which we can call the break-even distance."

In other words:

$$F + D V = F' + D V'$$

and

$$D = \frac{F' - F}{V - V'}$$

F:- fixed cost

D:- number of variable units of distance

V:- variable cost per unit distance

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[14]Matthews, D.M., Selection of Equipment, Road Standards and Road Spacing, Paper read at the Summer Meeting of the Woodlands Section, Canadian Pulp and Paper Association, August 3 - 5, 1939, page 2.

For illustrative purposes, we will apply the cost and production figures, as given by the author, for pre-hauling tree length logs in stands averaging four trees per cord. These figures have been adjusted to canadian conditions.

Load per turn, cords	Hook & unhook time in minutes	Delay time, mn.	Total fixed time per turn, cents	Cost of fixed time per turn, cents	Fixed time cost per cord, cents	Variable cost per cord per 100' of hauling distance cents
		Teams at 1.2 cents per minute				
0.25	2	3	5	6	24	5.3
		D-2 Tractor at 2.8 cents per minute				
0.65	5	2	7	19.6	30	3.7
		D-4 Tractor at 3.36 cents per minute				
0.85	7	2	9	30	35	3.4
	D-4 Tractor and Sulky at 3.85 cents per minute					
1.7	22	2	24	93	54	1.7

Table 7:- Cost and production figures for pre-hauling tree length logs in stands averaging four trees per cord.

Now, let us apply the cost figures of teams and of a D-2 Tractor (small).

$$D = \frac{30-24}{5.3-3.7} \text{ or } \frac{6}{1.6} \text{ or } 3.75$$

The unit distance being 100 feet, the answer tells us that 375 feet is the limit distance on which animal traction will prove to be more economical than a D-2 Tractor for these particular conditions.

Similarly, distances for which another type of tractor will be more economical than teams or other tractors may be figured out.

Standard for Branch Logging Roads: From the skidways, logs reach the main road through secondary or branch logging roads the service standard of which must be decided upon. A skill operator aims to bring into a balance the cost of branch road construction, of hauling on these roads and of pre-hauling to them in order to achieve a minimum total cost.

The pre-hauling cost varies with the spacing between the secondary roads. Matthews[15] proposes the following formula to determine the spacing:

$$S = \sqrt{\frac{.33\ R}{VC}}$$

S: economic spacing of roads, in 100 feet.

R: cost of road construction per mile.

V: volume to be removed per acre.

C: cost of pre-hauling per volume unit per 100 feet of distance.

With this formula, the spacing of every road standard should be computed and tabulated. Next, the relative economy of each type of road must be determined with a view to arrive at the balance just referred to. Therefore, the total cost (branch road construction, hauling and pre-hauling) must be computed. The same study[15] proposes a total cost formula which is given on the next page.

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[15]Op. cit., p.4

$$2\,C\frac{S}{4} + H\frac{D}{2}$$

H: the hauling cost on the road standard chosen.

D: the hauling distance on branch roads.

As these two formaulae are closely related, particular attention is required during the computations so that the accepted set of conditions must remain unchanged throughout. The example of the author will illustrate the case.

Suppose a valley 2 miles in width, a main logging road running up the center. The stand averages 10 cords per acre (4 trees per cord) to be skidded by a D-2 tractor with a variable cost per 100 feet per cord of 3.7 cents. The spacing between secondary roads and the total cost are as follows:

Class of road	Spacing		Total cost	
	Spacing calculation	Spacing hundred feet	Total cost calculation	Total cost per cord
1	$\sqrt{\frac{.33x10000}{10x3.7}}$	9.6	$(2x3.7x\frac{9.6}{4})+(\frac{52.8}{2}x.833)$	39.7¢
2	$\sqrt{\frac{.33x25000}{10x3.7}}$	15.0	$(2x3.7x\frac{15}{4})+(\frac{52.8}{2}x.467)$	40.0
3	$\sqrt{\frac{.33x50000}{10x3.7}}$	21.0	$(2x3.7x\frac{21}{4})+(\frac{52.8}{2}x.27)$	45.9
4	$\sqrt{\frac{.33x75000}{10x3.7}}$	26.0	$(2x3.7x\frac{26}{4})+(\frac{52.8}{2}x.213)$	53.6
5	$\sqrt{\frac{.33x125000}{10x3.7}}$	33.0	$(2x3.7x\frac{33}{4})+(\frac{52.8}{2}x.113)$	64.0

Table 8:- Spacing between secondary roads and comparative total cost calculation.

From this example, we see that a Class 1 or 2 is desirable in these particular conditions with a hauling distance of one mile on the branch roads.[16]

Another break-even formula may be constructed in the following way:

$$2\,C\frac{S}{4} + H\frac{D}{2} = 2\,C\frac{S'}{4} + H'\frac{D}{2}$$

S': spacing of another roads standard.

H': hauling cost on that new standard.

By reduction we find: $D = \dfrac{CS' - CS}{H - H'}$

The answer, in 100 feet, will give the hauling distance above which a higher class of road is more economical. With the figures assumed above, let us figure D for a Class 1 and 2.

$$D = \frac{(3.7 \times 15) - (3.7 \times 9.6)}{.833 - .467}$$

$$D = 54$$

This indicates that roads of Class 2 should be constructed when the maximum hauling distance on the branch roads exceeds 5400 feet. This holds true with a D-2 Tractor hauling in the particular conditions assumed above.

Main logging roads: Nothing so far has been said here in connection with exterior or interior main logging roads. A definite standard has to be chosen simce the cost of

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[16]Road standards may be roughly classified as follows:
- Class 1: creeper gear,
- " 2: creeper and first gear,
- " 3: considerable first and second gear,
- " 4: fairly smooth,
- " 5: light gravel, about 20% second and first gear.

construction may run from \$100. or so a mile up to \$1250. or more. For a certain volume of timber to be removed V, the total cost of two standards of exterior roads including hauling will be equal. In other words,

$$R + V H = R' + V H'$$

$$\text{Then } V = \frac{R' - R}{H - H'}$$

R and R': cost of construction per unit of distance of two standards.

H and H': hauling costs per unit of distance per cord for the two standards respectively.

The unit of distance for the cost of construction and hauling must be the same in either case. Also, the hauling cost per unit of distance must be divided by the number of cords (the load) which a truck or any other equipment carries in order to give the value H or H'. The items R and R', and H and H', can be computed, with some experience, to a surprising accuracy.

Suppose now that the road must be 8 miles in length; the cost of construction and hauling have been estimated as follows for two classes which must be decided upon.

Class of road	Construction cost per mile	Hauling cost per truck per mile
2	\$300.	\$0.75
3	500.	0.45

The truck takes a charge of 3 cords per round trip.

$$V = \frac{5000 - 3000}{\frac{.75 \times 10}{3} - \frac{.45 \times 10}{3}} = \frac{2000}{2.50 - 1.50}$$

$$V = \frac{2000}{1} = 2000$$

In other words, if the stands exceeds 2000 cords of timber, Class 3 should be used.

The problem is a little different with an interior main logging road. Obviously, it will not be of good economy to have the same road standard until the remote parts of the timber stand have been reached. Savings are accomplished by improving the road, but the nearer we are of the end of the road, the less we save and a certain point is reached where cost is equal to savings. The total saving per unit of distance will be V x H or S: V being the volume of timber tributary to each distance unit of the road as it penetrates into the area, and H, the reduction in hauling cost per unit of volume. The savings are likely to increase at an arithmetical rate, S for the first distance unit, 2 S for 2 units and n S for n units. Thus the formula may be written:

$$\frac{n}{2} (S + n S)$$

On the other hand, the cost (R) of improving the road from one standard to another will increase with every distance unit, being n R for n units. A "break-even point formula" may be written as follows:

$$n\,R = \frac{n}{2}\,(\,S + n\,S\,) \quad \text{or by developing:}$$

$$n = \frac{2\,R - S}{S}$$

For example, let us assume a stand averaging 300 cords for every 100 feet of road. Suppose we have to make our choice between a certain class of road carrying a hauling cost per cord for every 100 feet of .273 cents and another class with a hauling cost .213 cents.

The saving, if we adopt the latter class, will be 300 (.273 - .213) or V H or S = 18 cents. The extra cost of construction for those particular types of road will be $15. - $10. or $5. (500 cents, to keep the same units).

$$n = \frac{(\,2 \times 500\,) - 18}{18} = 54.5$$

That means that if the interior road exceeds 5450 feet and taps 54.5 x 300 or 16350 cords of timber, the second road carrying higher construction cost (hence a higher standard road) will prove more economical. With other conditions, the best standard of road may be figured in a similar way.[17]

Before closing this discussion, a word must be said about the loading equipment. The type of loading equipment must be chosen on the basis of its operating cost and its efficiency. When the efficiency is high, the stand-by charges of the hauling equipment are likely to decrease very much, and this point is very important. Therefore,

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[17]The formulae and some of the figures given above are from Matthews, Op. cit., p. 2-3.

a sort of compromise should be arrived at so that the whole transportation cost be reduced to a minimum.

No attempt was made here to give examples based on actual logging practice in the Province of Quebec. Suffice it to say that the problems presented above are similar to those encountered in Eastern Canada, since mechanical equipments are used intensively now.

Driving birch: Water transportation so far has not been given any consideration although it is very popular in Quebec. The floating of logs to the mill presents an outstanding advantage: it is very cheap. However, mill men do not agree on the feasibility of such a transportation as far as hardwoods are concerned. Some contend that it is impossible, others claim it is feasible on short distances, others believe that this method is entirely reliable on long distances. Does the floating affect the qualities of birch logs? People do not agree.

As to the floatability of white birch, Fensom[18] reports the following:

Birch logs	Floating period
green	9 weeks
seasoned to 20% of original green m.c.	up to 14 months.

Further seasoning did not show any appreciable increase of the floating period. And the author recommends the following in order to increase the floatability:

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[18]Fensom K.G., "Some effects of seasoning on the floatability of logs", Forestry Chronicle, 7, 29-44, 1931.

1) Birch saw logs should be felled in September and October, bolted and piled in loose piles well above the ground, barked in the spring, repiled for two weeks and floated immediately to the mill.

2) Birch pulpwood should be felled in June or July, stripped on one side of the bole, bolted, piled in raised piles, and floated the following spring.

Nothing is said about yellow birch which is a heavier wood. Undoubtely, driving birch logs is likely to make remote stands accessible. But great care should be taken on any large-scale operation to prevent losses. Bad weather with heavy winds is likely to make the logs to find their way under the boom and escape.

Another factor affecting the cost of drying is the drying or seasoning period. Everything therefore must be weighed accurately before putting any such method into practice. It does not seem advisable to recommend the driving of logs on a distance exceeding 20 miles.

Methods of management

The problem of managing paper and yellow birch must be approached from a different angle for each species. Paper birch, because it is a short-lived tree requiring an abundance of light to develop, is not to reproduce itself indefinitely except by planting or burning over some areas, where this species is desirable. From the other hand, yellow birch is a longer-lived species, more tolerant, so that regeneration under forest cover, even dense, is possible.

Those two points must be borne in mind when a system of management is to be decided upon.

Pure stands: As already said, pure stands of yellow birch seldom occur. However, paper birch may form pure stands or relatively so with a small amount of aspen. In this case, clear cutting is usually resorted to

a) when it is intended to help the understory to develop into more valuable species. However, clear cutting should be done before the birch exceeds 70 or 80 years of age, for older trees are more subject to heart rot. In a fully stocked stand, a partial cutting carried out before the final clearing will help in saving some material which otherwise would be lost. For, paper birch is unable to endure crowding and mortality is likely to be high. The partial cutting may take place when the stand is 40 to 50 years of age;

b) when, in some cases, other species failed to reproduce themselves at the time a policy is to be decided upon. As a direct result, sprouts of paper birch grow up rapidly (the stand should be about 60 years of age or less at the moment of cutting).

However, it may be desirable sometimes to continue the production of paper birch even when a good understory is under way. Perhaps the most reliable method consists in burning the area lightly after clear cutting. This will expose the mineral soil and so prepare the best conditions for a new growth of birch. But, on account of many dangers of fire spreading, this last method cannot be relied upon.

Cutting to a diameter limit is recommended in pure, middle-aged stands, more or less even aged and showing a great variation in diameter. The idea is to give to younger tree a better chance to grow: that is a way to utilize at best the resources of a given stand. Such stand should be cut at the age of 40 to 50 years with a diameter limit of 7 to 8 inches.

Mixed stands: Old-growth and second-growth of paper birch and yellow birch mixed-stands require a different treatment. In the former type, clear cutting is advisable whenever the reproduction is satisfactory. Neverthless, this method might not be economical because of the absence of a market. When the reproduction is scanty, the shelter-wood method, though more expensive from the logging viewpoint, seems to be the best one. The first cutting should leave about half of the stand in the form of evenly distributed trees, capable of bearing full crops of seed, then the remaining of the stand may be clear cut a few years later when the reproduction is well established.

Whenever practicable, thinnings or selection cuttings should take place in uneven-aged stands so that a few trees at a time are removed. Thus the new stand is given a chance to come in gradually.

Second-growth stands should be handle by the shelter-wood method whenever a dense crown cover tends to prevent abundant reproduction. Selection cutting is advisable in uneven-aged stands.

Because highly injurious to hardwood reproduction grazing should not be permitted in both old-growth and second-growth stands.

According to government regulations, the burning of slash or the disposition thereof in any permissible way must take place in order to annhilate any danger of fire, insect and fungus attacks.[19] However, it does not seem advisable to carry on these procedures after the cutting of paper and yellow birch since the slash decays rapidly in ordinary conditions. [20]

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[19]A.C. No.1941, July 17th, 1937.

[20]Boyce, J.S., Forest Pathology, p.495.

Chapter III

IDENTIFICATION OF PAPER AND YELLOW BIRCH

The birches belong to a group of trees called Betula in scientific language. This appellation is claimed by some people to come from the word "bitumen"; others contend it is derived from "betu", the Celtic name for birch. There are still others who believe that it comes directly from the latin verb "batuere" meaning "to beat", because in the ancient Rome the Roman lictors used to drive back the people with fasces made out of birch rods.[21] At any rate, the word Betula has been universally accepted for a long time.

The following pages, dealing with the identification of paper birch (Betula papyrifera) and yellow birch (Betula lutea) will consider the botanical, anatomical and sylvical characteristics of these two species.

Botanical characteristics

General appearance: In the forest, paper and yellow birch present long clear trunks, the latter exhibiting a moderate amount of taper. In the open, paper birch is characterized by a short trunk provided with many upright branches. Its crown is also very large and irregular. The same remarks apply to yellow birch; however, the axis of the tree is fairly

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[21] Illick, J.S., 1922, The Birches, Amer. For., 28, p.355.

well defined.

Yellow birch is the largest of birches, probably the largest of all hardwoods growing in the province.

Bark: All birches are characterized by typical long slits or lenticels readily visible on the bark. Due to the presence of resinous oils, the bark is durable; it is water-tight, smooth, pliable and is separable into thin layers at least on young trees.

Paper birch (papyrifera) is distinguished from wire birch (populifolia) by its white bark whereas the latter has a dirty white, chalky bark not so readily separated into thin sheets.

Yellow birch gets its name from its yellowish, straw-coloured bark when young. When the tree is matured, the bark peels in papery bands with curled ends, thus forming a fringe alongside the trunk. Young trees have smooth, glistening, silver bark, hence the name of silver birch.

Branches, buds and leaves: The branches of paper birch are stouter than those of any other birch; they do not tend to droop like the branches of wire birch. Likewise the twigs are coarser and smoother than those of the latter species. On the other hand, yellow birch exhibits smooth, skiny, light-brown twigs; its winter buds are chestnut-brown, pointed and about 1/4" in length. The buds of paper birch are the largest and are somewhat sticky in winter,

The leaves constitute by far the best criterion from which the different species of birch may be identified with safety.

Paper birch leaves are 2 to 3 inches long, oval in general outline with coarse and irregular teeth. The upper surface is smooth and dull green in color. Yellow birch grows larger leaves from 3 to 4 inches in length with a base more deeply heart-shaped. The upper surface is dull green while the lower is downy, especially along the veins. The coarse teeth are more widely separated. For the sake of a better comparison, part of a table taken from Native Trees of Canada[22] is given on page 32.

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[22] Op. cit., p.108.

Table 9:- Botanical features of some Birches (Betula).

	White (B.papyrifera)	Yellow (B. lutea)	Sweet (B.lenta)	Wire (B.populifolia)
Bark	White outside and brown beneath outer layers. Splits readily into thin, tough layers.	Yellowish straw colour. Forms a fringe of curly strips on older trees. Not so aromatic as the sweet birch.	Dark brown, smooth and never peels. Resembles that of cherry. Inner bark is very aromatic.	Dirty white chalky surface. Does not peel. Black triangular patches below the branches are characteristic.
Twigs Branches and winter buds	Twigs coarser and smoother than those of the white birch. Smooth and slightly sticky where the buds join the stem. Buds sticky and larger than those of other birches. Branches stouter than those of other birches	Twigs shiny, smooth and light brown, resemble those of sweet birch but not so distinctly sweet or aromatic.	Twigs shiny, smooth and dark brown. They have a very aromatic winter-green flavour. The buds are more divergent than those of the yellow birch.	Twigs wiry and have a tendency to hang down. End of twig is very rough to the touch. Buds small, pointed, and waxy.
Leaves	Oval in outline with base rounded or wedge-shaped rather than square as with the white birch. The upper surface is dull and the margin is doubly toothed. The stems are short and downy.	Much like sweet birch but is larger toothed. Teeth more widely separated Thicker in texture than those of the sweet birch. Dull green above. Stems exceedingly downy.	The base of the leaf is more deeply scalloped or heart-shaped than those of the other birches. Teeth fine and of fairly uniform size. Softer hair on underside than on the yellow birch.	Triangular in outline with a long tapering point. Bright-shiny green. The margin is doubly toothed. Stems smooth, and longer than those of paper birch.
Fruit	Catkins sometimes clustered in 2's but usually in 3's.	Catkins not clustered. Larger in diameter than those of the sweet birch Cone scales hairy.	Catkins not clustered as a rule. Cones not so large as those of the yellow birch.	Catkins singly or in pairs, usually singly.

Sweet birch is included because it is often associated with yellow birch in the lumber trade: in fact the wood of both species is not separated as a rule although sweet birch produces a material more deeply colored with a satiny lustre. Wire birch is described because it is sometimes confused with paper birch. Both sweet and wire birch, the latter seldom reaching a commercial size, are negligible species in the Province of Quebec. Sweet birch particularly is thought to be confined near the international boundary where the trees enters Canada from the south.[23] Its volume therefore is very limited.

Anatomical features

Well differentiated by their botanical characteristics paper and yellow birch present nothing but common features in their anatomy. At least, no differences so far have been brought out. The following discussion therefore will confine itself to a general description of the wood anatomy.

First of all, the wood is diffuse porous, that is: the vessels appear in the entire annual growth ring, no striking difference showing between spring and summer vessels. Contrary to maple, sycamore, alder, birch presents rays less broad than the largest vessels. Usually, rays are not plainly visible without a hand lens. Rock elm is distinguished from birch by its summer wood figured with wavy, concentric bands of pores.

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[23]Native Trees of Canada. Op. cit., p.109.

A fine line of denser fibrous tissues constitutes the outer of the growth rings; however this margin is not, as a rule, plainly visible without a hand lens.

Considering the minute anatomy, we find that the vessels vary in width from 60 to 160 microns; the perforation plates are scalariform. Also, the intervessel pits are orbicular to hexagonal.

The parenchyma appears in the outer portion of the ring (terminal), between the pores (vessels), without any relation to them (metatracheal) and associated with the pores (paratracheal).

The fibers are relatively thick-walled, 20-36 microns in diameter. Like in many hardwoods, the rays are not arranged in tiers as viewed from the tangential surface (unstoried); they are made of 1 to 5 cells in width and are homogeneous. (no vertical or "upright cell"appears in the rays).

As a final remark, perhaps the best way to distinguish the wood of paper from that of yellow birch is to remember that yellow birch, as a rule, is heavier and stronger than the former.

Silvical characteristics

Among the most important sylvical characteristics, let us examine the soil, moisture and light requirements, the growth and the reproduction.

<u>Soil and Moisture:</u> Paper birch does not require a very deep soil to grow on, especially when young because the root system is decidely shallow. This species develops the best on

a loose, well-drained sandy loam, and it can grow on soils intermediate between dry, sandy barrens and submerged swamps. Sometimes, it is found on thin-soiled rocky slopes not because it prefers such stations but rather because it is able to grow there while other trees are not.

Yellow birch develops on moist, well-drained soils. This species is sometimes found standing on high, spreading roots, two to four feet above the ground. That peculiar situation is due to the way the seed begins to grow: when it happens to fall on the moss covering decaying logs or stumps, the amount of moisture present brings about the germination of the seed. Roots come down the sides of the log or the stump, strike the mineral soil and fix themselves firmly. The log or stump eventually decays and the roots sustain the trunk above the ground. A similar process of germination accounts for the growing of yellow birches on large rocks.

Light: Not exacting in respect to soil and moisture requirements, paper birch is much more so as far as light is concerned. It comes next to aspens as a most intolerant species. The young seedlings will suffer a light shade, but not the heavy one prevailing in virgin forests. Paper birch needs free crowns in order to thrive, and contrary to spruce and balsam fir, it will not recover after being once suppressed.

On the contrary, yellow birch has a fair degree of tolerance and is classed as the most tolerant of birches. Nevertheless, the seeds germinate best where there is plenty of shade and moisture.

Growth: Paper birch is a rapid grower in early youth and shoots up more rapidly than the other species which it is associated with. After the age of 30 is reached, sometimes before, the rate of growth decreases until it is almost negligible in old age. When dealing with the growth rate of paper birch, a distinction between seedlings and sprouts is indispensable, and the locality must be taken into consideration as well. For instance, Dana[24] reports that an analysis of 50 stems growing in low, rocky ground near the shore of Hardy Pond in Piscataquis County, Me., showed that the height growth of sprouts was more rapid than that of the seedlings. Similary, the growth in diameter (D.B.H.) exceeded that of the seedlings up to the age of 45. In volume the sprouts were still larger, having 82 cu. ft. at the age of 65 compared to 71 for the seedlings. However, the seedlings prove to be longer-lived, with an average difference of 25 years.

To what extent we may apply these statements to similar stands in the Province of Quebec is not known; but there are certainly many points of similarity between Maine and Southern Quebec at least. It is obvious that second-growth sprout stands may be advantageous when large-sized material is not needed and a short rotation desirable.

As far as we know, no such experiments have been carried out in the Province of Quebec. However, in some regions (Quebec and Rimouski) growth rates have been determined without paying any attention to the way of reproduction.

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[24] Dana, S.T., 1909, Paper Birch in the Northeast, U.S.D.A. For. Ser. Circ. 163 p. 19.

Roy[25] has found for the period of 1923-1933 the following data as to the growing of paper birch at the Valcartier Station (a few miles west of Quebec city):

Total Volume in 100 cu. ft. (1" and up):	7,376
Annual rate of growth in 100 cu.ft. :	173
Gross growth rate of	2.3%

Matte[26] made a special study of the growth rate in the Rimouski county. Table 10 gives the data which he arrived at.

Age class	Per cent of volume	Annual growth rate
Years	%	%
1-20	6.9	7.9
21-40	3.5	5.4
41-60	11.6	3.1
61-80	34.9	2.2
81-100	25.0	1.6
100 & +	18.1	1.8

Table 10:- Annual gross growth rate of paper birch in Rimouski county.

The mean annual growth rate is 2.59 (compare with 2.3% at Valcartier).The mean volume per acre of paper birch was 445 cu. ft., or 24% of the total volume per acre. In other words, the mean volume per acre of the total stand was 1854 cu. ft. or approximately 21 cords per acre, a fairly dense stand which seems to be a good average whenever paper birch is found in mixed stands. In the table given above,

[25]Information kindly supplied by Mr. E. Guay, F.E., Bureau of Forest Survey, Quebec, P.Q.

[26] F.E. at the Quebec Bureau of Forest Survey.

note that birch of commercial size (61-100) amounts to nearly 60% of the volume per acre of paper birch on the area under study. For all these reasons, the study just presented is likely to give a good idea of the average conditions.

Due to a lack of information, an average figure cannot be given in connection with the annual growth rate of paper birch in the Province of Quebec. However, we assume it is in the neighbourhood of 2% for all the accessible areas.

Yellow birch grows with sufficient rapidity to compete with tolerant hardwoods. However, it is a longer-lived species being considered at maturity between the ages of 100 and 125 years. At that time the rate of growth has been gradually reduced.

Like paper birch, yellow birch reproduces by seeds and sprouts, and the latter grow more rapidly than the seedlings as a rule, but they are also shorter-lived.

As to the growth rate, the only data in hand are from Roy and Matte whose figures are taken from the experiments referred to above.

Roy has found in his Valcartier station the following gross growth rate based on a 10 years period:

Total Volume, 1" and up (100 cu. ft.).......	21,324
Growth (100 cu. ft.)........................	359
Percentage..................................	1.7

On the other hand, Matte reports the following for the Rimouski county (see page 39).

Table 11:- Annual gross growth rate of yellow birch in Rimouski county.

Age class	Per cent of volume	Annual growth rate
Years	%	%
1-20	11.5	7.0
21-40	0.7	5.3
41-60	5.4	3.0
61-80	34.4	2.4
81-100	26.8	2.3
100 & +	4.1	1.9

The mean annual growth rate is given as 2.85 (1.7 was found at Valcartier). This wide variation may be accounted for by different soil conditions or stand compositions or other factors not be discussed in this paper. For instance, more than half of the volume of the stand per acre in the area under study (Rimouski) was composed of young or relatively young trees (which grow up fairly rapidly). Many more studies of this kind would permit the calculation of a general growth rate of yellow birch in the Province of Quebec. In this paper, this rate is tentatively put at 2%.

Reproduction: Paper birch produces seeds in abundance, the full-crowned tree being the best seeder. But germinating percent is rather low. Dana tells of 68% of the seeds were found fertile by inspection in a simple count. This figure is likely to decrease much under natural conditions.

The seeds of paper birch are very light. In fact, they are the lighest, except cottonwood, as far as common hardwoods are concerned.[27] Provided with wings, seeds are carried readily by the wind over great distances. This accounts for the wide distribution of paper birch and for its appearance on cut-over and burned-over areas, even when there is no such tree in the immediate vicinity. Young paper birches, up to the age of 40 or 50 reproduce themselves as readily by sprouts as by seeds. If reproduction by sprouts is desired, birches should be felled at the age of 50 or less, but not later. Also stumps will not produce sprouts for any length of time, for they eventually become exhausted.

Contrarily to yellow birch, paper birch is a short-lived tree seldom exceeding 150 years of age. As a rule, trees of 20 inches in diameter are considered as over-matured. Mature stands run from 60 to 80 years.

Yellow birch is also a prolific seeder, bearing crops in quantity every year. It seems reasonable to state, however, that the percentage of fertility is rather low.

The seeds, though very light, are about two times as heavy as those of paper birch, They are provided with large wings and can be carried by the wind over long distances.

Yellow birch may also reproduce by sprouts, but not so readily as paper birch. If this method of reproduction is desirable, trees should be cut not later than the age of 70 to 80 years, long before maturity is reached. As stated above, the reproduction by sprouts gives shorter-lived trees.

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[27] 700000 seeds of paper birch make 1 pound; yellow birch takes 400,000 and cottonwood, 1,350,000. See Tillotson, C.R., 1932, Growing & Planting Harwood Seedlings on the Farm, U.S.D.A. Farmers' Bull. 1123, p.25.

Chapter IV

THE SEASONING OF PAPER AND YELLOW BIRCH[28]

In typical operations in Eastern Canada, most of birch logs are sawn into lumber and dimension stock. When the shipper of birch lumber desires a reduction in the weight of his shipment, when the manufacturer and user want a product characterized by stability in size, maximum strength, appearance and durability, birch lumber must be seasoned either naturally or by means of a kiln.

Air seasoning

This method is usually resorted to when it is not desired to bring the lumber to a very low moisture content (air-dry lumber ranges from 12 to 20% moisture content). Because of a lack of perfect control over the 3 factors which directly affect the drying of wood namely, temperature, humidity and air circulation,the seasoning of wood by natural means requires care and good sense. Not infrequently, the simple and fundamental principles regarding the handling of lumber in the yard are disregarded by people engaged in the lumber production, especially by people running a small business. For that very reason, let us summarize here what experience and logical procedure recommend.

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[28]For the writing of this chapter, the author often referred to "The Seasoning of Lumber", Chapter V of Canadian Woods, their Properties and Uses, T.A. McElhanney and Associates, Canada Forest Service, Dpt. of the Interior, 1935.

Lumber yard: Although full consideration must be paid to fire underwriters' regulations, cost of land and convenience of shipping, the yard site should be located on a mineral soil (for good drainage), be clean from weeds, shrubs and it should be laid out to provide the best possible air circulation. In addition, the yard should be convenient and compact without requiring unnecessary high piling.

Piling: As to the piling itself, suggestions only can be made because too many unknown factors are involved in the air-seasoning of birch and wood in general. In no two yards, f.i., can identical conditions exist. In connection with the piling of birch lumber and hardwood as a whole, the principles or rules to be complied with may be summarized as follows:

a) in every pile, the supporting blocks, or piers should have a sufficiently wide bearing area as to prevent sinking under the load. At the low end, they should have at least 18 inches in height above the ground, clear space. The stringers must be strong enough so as not to bend under the load. Whenever timber is used in the foundations, it should be treated with some preservative, otherwise natural durable species must be used;[29]

b) lumber of 14' long or more should be separately piled: overhanging must be avoided. Crossers or stickers should be placed at every 2 feet or 2 1/2 feet, not more, so as to

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[29]Generally speaking, the sapwood of every species decays readily. When dealing with durable wood, it must be understood that heartwood only is involved.

prevent any distortion. In every case, the stickers must be placed in a perfect vertical line. As a rule, the crossers do not exceed two to three inches in width so that they do not slow up appreciably the drying of the boards which they are in contact with. Lumber under 14 feet in length should be box-piled at 14 feet, and the stickers so disposed as to provide a support for 4-foot, 6-foot, 8-foot, 10-foot, 12-foot and 14-foot lengths. In case of high grade lumber, it is a good practice to have the crossers projecting about half an inch so as to protect the ends of boards;

c) a pitch of 1 in 12, both horizontal and vertical, is recommended for a good piling. Too much pitch will result in overhanging, exposure of board ends and difficulty in aligning the crossers.

d) in every case, the roofs of the piles should be as tight as possible, especially when high-grade stock is involved.

Other methods of piling are sometimes used, like edge-piling, pole-piling or vertical piling. Their chief advantage is a rapid drying, but unless some sort of mechanical devices are employed the lumber is likely to warp or to be distorted in some way or another.

No general rule so far has been stated as to the distance between each pile. When too short, every kind of lumber, birch included, is inclined to sapstain and decay; when too wide a space is allowed, birch will dry too fast and checking will result.

Henderson[30] states that birch will check within 24 hours if exposed to direct action of the sun. Therefore, people are likely to rest on their own experience and base their decision on the particular conditions prevailing in their lumber yard. Under proper piling methods, green birch lumber (presumably 1" stock) is said to reach a moisture content of 20% within 150 to 200 days, and yellow birch ties will take 4 to 8 months according to whether they are piled in spring or during fall[31].

Seasoning defects: Air-dry birch lumber is sometimes charged with serious defects due primarily to uneven shrinkage, fungus attack or chemical action.

The ratio of tangential to radial shrinkage is a fairly definite index of the amount of twist and warping. As the ratio for both paper and yellow birch is rather low, these two species may be classed as moderately easy to dry. According to the Wood Handbook[32], the shrinkage (percent of dimension when green) from green to air dried to 12 to 15% m.c. is as follows:

	Radial	Tangential	Ratio
Birch, paper	3.2	4.3	1.34
Birch[33]	3.4	4.4	1.29

[30] Henderson, Hiram L., The Air Seasoning and Kiln Drying of Wood, p. 20.

[31] Henderson, H. L., Op. cit., 1935, p. 109.

[32] U.S. Dept. Agr., 1935, p. 195.

[33] Average of sweet and yellow birch.

Then these two species are not susceptible to change much after their final manufacture. However, the place of growth may have a direct effect on the specific gravity of wood and the figures given above may vary, causing sometimes very bad distortion. Not too much attention should be paid during the air-seasoning, and as stated before, the piling should be made carefully. Surface and end checks may appear on birch lumber when the drying is too fast; in that case the piles should be so located as to avoid direct sunshine and blast of dry wind.

With respect to dimension stock, the seasoning should be watched still more carefully because splits, checks or any distortion are likely to cause total losses. It is recommended that it be close- piled, preferably under shelter when the conditions in open air are too bad. End checks may be avoided by an application of wax at the extremities of the pieces.

Among the defects due to fungus attack, dote is well known among the lumbermen. Care in piling, well-drained sanitary yards and the steaming or the dipping of birch lumber in a soda solution before drying starts are the principal means of combating such attack. Dote will not occur once the lumber is thoroughly air-dried.

However, the use of soda may impart what is termed dip stain, which may be objectionable in certain cases. As a rule, defects due to chemical action, unless decay is present, do not occur on air-dry lumber.

Storage: Birch lumber which has been air-dried under proper conditions is not always disposed of immediately, and good storage conditions must be provided for. Bulk piling in open air is recommended provided there is ample clearance under the pile; tight, amply projecting roofs are also necessary. A good practice often adopted in Canada consists in the building of a separate roof for the protection of piles in sections. Thus, stock may be extracted without the removal and replacement of the roof.

If the lumber is stored in closed sheds, ventilation should be provided. In that connection, sheds are often heated and the lumber looses more moisture so that it may eventually be considered as kiln-dried stock.

Dry-kiln seasoning

Air-dry lumber may have a moisture content ranging from 12 to 20% depending on many factors, like the location of the yard, the species and thickness of lumber, the climateric conditions, etc. However, birch lumber very often must be dried to a lower m.c. either for reducing the shipping losses or to prevent shrinkage or swelling when in use. Then, the drying by means of a kiln is resorted to. In Eastern Canada, the term "kiln-dried" applies to lumber of 10% m.c. or less, while this term may have another signification in British Columbia, where it is common practice to kiln-dry certain lower grades from the green state to approximatively 20%. To avoid misunderstandings, the moisture content should always be given together with the method of drying.

Types of kilns: Kilns may be divided in two general classes: progressive and compartment. The former type, very popular when the "artificial drying" came into practice, is now forgotten more and more chiefly because the control over temperature, humidity and air circulation is far from perfect. The conditions inside are changed by the moving of the charge from the wet end to the dry end. The operation is recognized to be less flexible and becomes less economical in case of sporadic production. Therefore, the compartment type of kiln is resorted to.

Needless to give any description of a compartment kiln. Suffice it to say that the charge of lumber is stationary, and the conditions inside the kiln can be controlled very closely.

Piling: The charge of lumber to be dried is piled on a truck. The piling itself must be made with care and usually the same suggestions given for the piling of lumber in open air apply here. However, the chimney usually runs 2/3 of the height of the charge so that air circulation may take place between each layer of lumber.

In Eastern Canada, people usually prepare special stickers by running them through thicknessing machines which give the following sizes:

7/8 inch	Thick	for	stock	up to 6/4 inches thick
1 1/4 inches	"	"	"	from 7/4 to 9/4 in. thick
1 1/2 "	"	"	"	10/4 inches and up.

Stickers may be placed from 18 to 36 inches apart depending on the thickness of the stock and its tendency to warp.

It is also recommended to put concrete weights on top of the pile to prevent any distortion in lumber of the upper layers.

Schedules: Proper drying schedules must be used in the case of birch and other species as well. As we know, the drying starts at the surface and as it progresses the moisture transfuses from the center to the outer layers of the board. Therefore, a proper balance of evaporation and transfusion must be maintained; otherwise serious defects may result, from induced stresses. Birch in general should be dried according to the following schedule[34]:

Stock	Moisture content %	Dry-bulb temp. °F.	Wet-bulb temp. °F.	Relative humidity %
	Initial	140	132	80
4/4	40	145	135	75
	30	150	137	70
to	25	155	136	60
	20	160	135	50
6/4	15	165	127	35
	10	170	116	20
	Initial	135	128	80
7/4	40	140	130	75
	30	145	133	70
to	25	150	132	60
	20	155	131	50
9/4	15	160	124	35
	10	165	112	20

Table 12:- Drying schedule of paper and yellow birch.

The above schedule has been arrived at through laboratory

[34] From Canadian Woods, op. cit., p. 172. The above schedule applies to both paper and yellow birch, as well as to basswood.

experiments and should be deemed merely as a guide. For no one reason should the operator neglect the charge during the drying, fail to take measurements of the moisture present in the lumber by means of samples, or simply rely upon the recording instruments without any personal checking of the conditions inside the kiln.

The period of drying, as stated by Henderson[35], varies from 5 to 8 days for birch seasoned from 20% to 6% m.c., 11 to 15 days for birch kiln-dried to 6% green from the saw. This last point rises the question as whether air-seasoning before kiln-drying is advisable or not. There is only one answer: birch lumber should be kiln-dried green from the saw, because the different factors which bring about the drying of wood can be checked up with much more accuracy in a kiln than in open air. A skill operator will generally be able to prevent the usual defects accompagnying natural seasoning like checking, casehardening and honeycombing, and stain (proper conditioning treatment at the end of the drying period will relieve stresses induced into the lumber by uneven drying or differential shrinkage). Also, birch lumber kiln-dried green from the saw will not be exposed to the danger of decay or insect attack.

However, low grade lumber (when it is necessary to dry it artificially) may be well air-seasoned before. This will reduce the handling charges and the cost of kiln-drying. At the same time, the construction of unnecessary large storage rooms may be avoided.

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[35]Op. cit., p.109.

<u>Storage and shipment:</u> Kiln-dried birch lumber must be stored in closed sheds, heated during the most humid seasons of the year. The most valuable material, as high-grade mouldings and flooring should be bundled and wrapped, at least at both ends, with paper.

Kiln-dried material of 10% or less should be carried under cover to the points of shipment. In each case, exposure to rain or drip caused by condensation on the roofs and walls of railroad cars or the decks and bulkheads of ships must be avoided. As a last protection, it is recommended that the manufacturer provide the user with definite instructions as to the handling of kiln-dried material.

Chapter V

THE PROPERTIES OF PAPER AND YELLOW BIRCH

The properties of a given species of wood indicate to what use it can be put and therefore constitute a fairly good index of its economic importance. In the following discussion, we are going to deal with the physical and mechanical properties of paper and yellow birch. Some attention will also be given to other related properties like weathering, thermal and electrical conductivity.

The physical properties

They are the properties which pertain chiefly to the structure such as color, texture, specific gravity, thermal and electrical conductivity, etc.

Wood color and texture: The heartwood of paper birch is creamy-white to light brown in color, while that of yellow birch is reddish brown. The sapwood of both species is generally white when not stained by fungi or chemical agents; however, the sapwood of yellow birch exibits a somewhat light yellow color.

Birches as a rule are well known for their fine even grain, and their uniform structure. Yellow birch particularly takes the most of these qualities, and it ranks among the finest-grained of hardwoods. The architects recognize it as an excellent wood for enamel base.

Flat sawed paper birch lumber shows a faint growth ring while quarter-sawed boards do not present any special feature. Yellow birch lumber has a distinct, but not conspicuous growth ring, and the grain is occasionnally wavy when the board is flat-sawed; the quarter-sawed boards may present occasional wavy grain[36]. Obviously, the same remarks apply to rotary-cut and quarter-sliced veneer.

In connection with grain and texture, we often meet such expressions as silky wood. In fact, some varieties of yellow birch are known in England[37] as canadian silky wood. This wood is characterized by wavy or curly grain. Curly grain refers to the position of the fibres which lie in an abnormal twisting position. Such wood is often given greater hardness and toughness. This type of grain is very beautiful and may be obtained by cutting through the junction of a branch with the stem.

Wavy or flamy birch is wideley used in fine furniture. It is obtained from certain birches the trunk of which is wavy in structure. This typical growth causes a wavy regular appearance with horizontal as well as other undulations. Very attractive wood is also obtained in the veneer industry through the use of birch stumps. Ebonists take great advantage of burl figures, caused by an abnormal or diseased growth on the tree. Other unusual figures met with in birch lumber or veneer are crotch figures (due to the crowding of grain when there is a limb separation from the tree trunk proper), bird-pecks and others.

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[36] Wood Handbook, Op. cit., p.35 (table).

[37] Wood (magazine published in London, England), Dec.1937 page 535.

Specific gravity, etc.: Paper and yellow birch are moderately heavy, the former being lighter than Betula lutea. Air-dry paper birch shows a specific gravity of .59 and yellow birch .66 as tested at the Canadian Laboratories[38]. This corresponds to about 40 pounds per cubic foot for paper birch and 44 pounds for yellow birch.

As to the strength, both paper and yellow birch are relatively strong. Yellow birch resists wear particularly well because it is hard, but not unnecessarily hard so as to be difficult to work.

Weathering: Unprotected boards exposed to the weather undergo what is termed weathering. This phenomenon translates itself by a change in color, roughening and checking the surface and sometimes by twisting cupping and tearing loose from fastenings. Birch is said to weather with light-gray color and moderate sheen. Checks are conspicuous, cupping and the tendency to pull loose from fastenings are very pronounced. Birch also is likely to twist because of interlocked grain[39].

Thermal and electrical conductivity: The ability of any material to transfer heat varies indirectly with its heat-insulating power, and as far as wood is concerned, the lighter species are the best insulators. A table follows including some common hardwoods and their thermal conductivity. This table is taken partly from the Wood Handbook, p.44.

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[38]Canadian Woods, Op. cit., p.296.

[39]Wood Handdbook, Op. cit., p.40-41.

Table 13:- Thermal conductivity across the grain of some common hardwoods at 12 per cent moisture content.

Species	Moisture content	T	D	K
	%	°F.	Lb. per cu.ft.	B.T.U.
Birch, yellow	12	75	43.0	1.00
Maple (soft)	12	75	39.0	1.04
Maple (hard)	12	75	44.5	1.16
Oak (red)	12	75	45.0	1.20
Oak (white)	12	75	46.5	1.22

(T = mean temperature in degrees Farenheit; D = weight in pounds per cubic foot; K = thermal conductivity in British thermal units per hour and per square foot of conducting material, with a temperature gradient of 1° F. per inch of thickness).

The electrical resistance of wood varies a great deal with change in moisture content, decreasing as the m.c. increases. "It also varies slightly with species, is greater across the grain than along it and approximatively doubles for each drop in temperature of 22.5° F." The Wood Handbook gives on page 45 a table of electrical resistances for different species, from which values applicable to birch are extracted. The figures given comprise moisture content and corresponding megohms[40] (see page 55).

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[40]One megohm = 1×10^6 ohms. The ohm is that resistance through which a difference of potential of one volt will produce a current of one ampere.

Table 14:- The average electrical resistance along the grain in megohms, measured at 80° F. between 2 pairs of needle electrodes 1 1/4 inches apart and driven to a depth of 5/16 of an inch, of birch at different values of moisture content.

Moisture content	Megohms	Moisture content	Megohms
7	87,000	17	11.5
8	19,950	18	7.6
9	4,470	19	5.13
10	1,290	20	3.55
11	470	21	2.51
12	200	22	1.78
13	96	23	1.32
14	53	24	.95
15	30.2	25	.70
16	18.2		

If the most important commercial species had been included above, it would have been shown that birch at 7% moisture content is the most resistant of all, maple sugar coming second with 72,400 megohms at 7% m.c. and then white fir with 57,600 megohms at the same moisture content. Note however the rapid decrease of resistance with an increase in moisture. The reference just given above, will enable the reader to make further comparisons.

The mechanical properties

"The inherent properties of wood which enable it to resist deformation when subjected to slowly or suddenly applied forces are known as its mechanical properties"[41].

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[41]Rochester, G.H., 1933. The mechanical Properties of Canadian Woods, Canada Dept. of Interior, For. Serv. Bull. 82, page 77.

Tests have been conducted at the Canadian Forest Products Laboratories on the mechanical properties of 49 native species and the data pertaining to paper and yellow birch are given in table 15. Some physical properties have been included because they have a direct relation with the different strength functions of wood.

Table 15:- Mechanical and some physical properties of paper and yellow birch (in air-dry condition).

Strength functions	Yellow birch	Paper birch
Shrinkage		
Volumetric to oven-dry condition .... (percentage of vol. green)	15.5	14.1
Linear from gr. to oven-dry Tangential.	7.1	7.2
(% of dimensions green) radial.	5.8	5.2
Specific gravity: wt. o-d & vol. as tested..	0.62	0.57
Moisture content, based on wt. oven-dry (%).	14.0	13.0
Static Bending		
Fibre stress at elastic limit (p.s.i.)....	8900.	8000.
Equiv. fibre stress at max. load (p.s.i.).	15600.	13700.
Modulus of elasticity (1000 p.s.i.).......	2150.	1910.
Work in bending, inch-pounds per cu. in.		
To elastic limit................	2.09	1.88
To maximum load................	20.8	18.8
Total........................	45.1	41.5
Impact Bending		
Fibre stress at elastic limit (p.s.i.)....	17300.	13200.
Modulus of elasticity (1000 p.s.i.)......	3030.	2520.
Work to elastic limit per cu.in. (in.-lb.).	5.70	3.87
Drop of 50-pound hammer at complete failure (inches)...........................	60.	49.
Compression parallel to the grain		
Compressive stress at elastic limit(p.s.i.)	4250.	4110.
Maximum crushing strength (p.s.i.)........	7790.	6570.
Modulus of elasticity (1000 p.s.i.).......	2320.	2080.
Compression perpendicular to grain - stress at elastic limit (p.s.i.)................	1130.	900.
Hardness (load to imbed 0.444 in. sphere to half diameter pounds)		
Radial surface............................	1360.	980.
Tangential surface........................	1330.	960.
End surface...............................	1620.	960.

Table 15:- (concluded)

Strength functions	Yellow birch	Paper birch
Shear parallel to the grain(max.stress)(p.s.i.)		
Radial plane............................	1830.	1590.
Tangential plane........................	2140	1740.
Cleavage (Splitting strength p.i.w.length 3")		
Radial plane............................	510.	440.
Tangential plane........................	630.	510.
Tension perpendicuar to the grain (maximum stress (p.s.i.)		
Radial plane............................	1030.	1020.
Tangential plane........................	1280.	1130.

As it can readily be seen, yellow birch is stronger than paper birch in every respect. However, in tension perpendicular to grain, both species exhibited about the same maximum stress on the radial and tangential plane. Note that paper birch is only 2/3 as hard as yellow birch.

It is important to realize that a change in moisture content causes variations in the strength of the wood when it is below the fiber-saturation point. Therefore, the strength functions of different species are not comparable unless the moisture content is the same. A higher moisture content means a corresponding decrease in strength. When the point of fiber-saturation is reached, in other words when the cell walls are saturated and the water is about to penetrate into the cell cavities, a higher moisture content will not bring about a corresponding decrease in strength. The data given above may be compared together because the difference in the moisture condition is very small.

Specific gravity is another important factor to be given consideration to. It has been found experimentally that for an increase in specific gravity there is an increase in strength. On the other hand, birch like other species, is susceptible of fairly wide variations in that respect and consequently to variations in strength, unless the variation in specific gravity is due to the presence of inert substances.

During the tests referred to above, it has been found that the rate of growth did not affect in any way the strength of hardwoods. However, differences in strength have been found between the sapwood and heartwood of yellow birch. After having running tests, Wakefield[42] states the following conclusions:

> "1) that heartwood is slightly stronger than sapwood when used as a beam under static loads;
>
> 2) that heartwood is somewhat stiffer than sapwood when used as a post and will support a little greater load;
>
> 3) that the heartwood is more brittle than the sapwood;
>
> 4) that the sapwood is tougher than the heartwood."

For all practical purposes, where safety factors are introduced, the author states that the differences just mentioned may be disregarded.

Strength of ties: Ties made out of birch, especially yellow birch, are often used on the canadian railroads.

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[42] A Comparison of the Mechanical and Physical Properties of the Heartwood and Sapwood of Yellow Birch, Canada Dept. of Mines and Resources, For. Serv. Circ. 51, page 5.

Their mechanical suitability may be measured by the resistance they offer to bending (caused by loads on the rails near the ends of the ties), to the compression perpendicular to grain (exerced by tie plates) and to the penetration of rock or gravel ballast (hardness). These values can be found in table 15.

Some other interesting tests carried out at the canadian laboratories show for example that 1 1/2 inch diameter top-pins made out of yellow birch sustained an average load of 1060 pounds.

Nail-holding power: The nail-holding power of wood is dependent on the density of wood, the amount of surface contact between the nail and the wood, the type and finish of the nail, the angle of driving, the moisture content and the change in moisture content in the wood, and several other factors. For the sake of comparison, table 16 gives the nail-holding power of several canadian species. The tests are reported on page 126 of Canadian Woods, op. cit.; 3-inch bright common nails were driven to a depth of 2 inches.

(see page 60)

Table 16:- Nail-holding power of paper and yellow birch compared to some other canadian timbers.

Species	Specific gravity	Driven green		Driven air-dry	
		pulled green	pulled air-dry	pulled air-dry	pulled green
Ash, White	0.57	774	408	604	597
Beech	0.58	778	417	352	408
Birch,Paper	0.51	479	198	312	325
Birch, Yellow	0.56	758	229	383	399
Elm, Red	0.54	606	312	691	496
Elm, Rock	0.68	718	396	781	542
Hickory,Shagbark	0.66	952	717	966	559
Maple, Red	0.52	808	530	643	508
Maple, Sugar	0.60	1,006	429	400	497
Oak, Red	0.58	728	656	760	446
Oak, White	0.65	893	605	829	653

Note the great difference in holding power when the nail is pulled green and air-dry after it has been driven in green timber. Yellow birch is classed intermediate in nail-holding power while paper birch ranks rather low. Unfortunately, no reference is given as to the plan on which nails were driven, either on the radial or tangential. Will the difference be significant as far as birch is concerned? Some few tests conducted in May 1940 at the University of Michigan Wood Utilization Laboratory under the direction of professor W. Kynoch[43] showed an increase in the pulling force of 31% for Douglas fir and 25% for white oak when pulled from the radial face. In the first case, the nails were driven to a depth of 1.92 inches (radial face and tangential face), and

[43] Course of Timber Mechanics.

in the second case the depths varied from 1.97 inches, (radial face) to 1.95 inches (tangential face). The same type of nails (the one in ordinary woodwork) with a diameter of .14 inch was employed in both cases.

Safe working stresses: Table 15 gives the mechanical properties of paper and yellow birch, but these figures must be reduced by a certain factor of safety in actual practice. Tables giving the safe allowable working stresses for canadian timbers, colums, beams, joists, etc. have already been published and may be referred to in the Appendix to Canadian Wood, op. cit., page 294 and following. The space here does not permit the reprinting of all these tables. However, we are going to include the most important one and give the safe allowable working stresses for some well-known species which rank among the strongest in structural building. (grade is Select, A.S.T.M.)

	Bending (Pounds per square inch)			Compression (Pounds per square inch)	
Species	Stress at extreme fibre	Modulus of élasticity	Horizontal shear	Perpendicular to grain	Parallel to grain (short) colums)
Maple, Hard	1,700	1600000	140	500	1,200
Birch, Yel.	1,600	1600000	130	350	1,200
Beech.....	1,600	1500000	120	350	1,200
Douglas Fir Coast.....	1,600	1600000	100	350	1,200
Oak Red&Wh.	1,400	1500000	100	400	1,000
Elm, White	1,300	1400000	110	325	900
Hemlock West.	1,300	1400000	85	300	1,000
Larch, West.	1,300	1400000	90	325	1,000
Pine, Red..	1,200	1300000	85	300	900
Douglas Fir Mountain...	1,200	1400000	90	325	1,000

Table 17:- Safe allowable working stresses for some canadian timbers including yellow birch (continuously dry).

The select Grade will admit minor defects, like sound stain, scattered pin-, spot-, and shot-worm holes, sounds knots not less than 12" apart and not exceeding in diameter one-sixth the width of the face in which they appear, but splits, rot and unsound knots are not permissible. This grade calls also for a grain slope not exceeding 1 in 12 in the half center of the piece.

As seen by the table, yellow birch ranks very high among the timbers fit for use where strength is of first importance.

The gluing properties

As we have seen under the Identification of Paper and Yellow birch, the "Betula" are diffuse-porous woods. In gluing operations, much care must be given to such woods because the glue, especially when thin, may penetrate too far into the vessels and thus cause a starved joint. Therefore, we will consider the preparation of birch for gluing, the gluing operation itself and the gluing characteristics of this wood. The gluing of birch veneer will be dealt with in Chapter VIII.

Preparation of birch for gluing: The first requisite is that the moisture content be such that the finished article have the proper amount of moisture in it after the gluing has taken place. This depends obviously on the use which the article is going to be put at. For instance, wood will have an average of 7% m.c. in heated buildings while it may reach 12 or more if used out of doors. Also, thick wood will be less affected than thinner wood by an absorption of the same amount of water during the gluing. Part of a table given by Truax[44] will illustrate the foregoing (assuming that all the water contained in the glue will be absorbed by the wood).

(see page 64)

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[44] Truax, T.R., 1940, The Gluing of Wood. U.S. Dept. Agric. Dept. Bull. No.1500, page 30.

Table 18:- Percentages of moisture added to wood in gluing.

Number of plies or laminations	Face	Core	Total thickness unsanded	Percentage of moisture added by-		
				Glue mixed 1 to 2 1/4, if spread 60 square feet[1]	Glue mixed 1 to 2, if spread 50 square feet[1]	Glue mixed 1 to 1 3/4 if spread 30 square feet[1]
			inches	%	%	%
3	1/40-in. y.b.	1/40-in. y.b.	3/40	30.5	32.5	47.3
3	1/28-in. y.b.	1/20-in. y.b.	17/140	18.8	20.1	29.3
3	1/16-in. y.b.	1/16-in. y.b.	3/16	12.2	13.0	19.0
5	1/16-in. y.b.	1/16-in. y.b.	17/48	12.9	13.8	20.1
9	1/8 -in. y.b.	1/8 -in. y.b.	9/8	8.1	8.7	12.6
10	3/4 -in. y.b.	....	7 1/2	1.4	1.5	2.1

[1]Single glue line per pound of dry glue.
In the case of 5 plies, the crossband was 1/12-in. yellow birch
" " " " 9 " , " " " 1/8 -in. " "
The 10 plies or laminations were parallel.

As we know, improper drying may cause casehardening or other kinds of stresses in birch lumber. These stresses should be relieved so as to prevent warping and checking after the gluing is made.

As another important precaution, birch should be machined just prior to the gluing. Machine marks are to be avoided because they prevent a perfect and continuous contact between the wood and the glue line. The same care and attention must be paid during the making of special joints required, for instance, in the furniture industry.

The gluing operation: The method of gluing birch as well as other species depends upon the class of glue which is used. In every case, however, the consistency of the adhesive should be such as not to cause starved joints, as pointed out above.

For medium grade animal glues a ratio of 1 pound of dry glue to 2.5 pounds of water will give most satisfactory results with birch. For higher grade glues a ratio of 1 to 3.5 is recommended[45]. During the preparation and application of glue, the temperature should in any case exceed 150°F. and be lower than 140°F. because of the danger of deterioration by chemical action in the first case and bacterial action in the second. The period between the moment the glue is applied and the assembly closed (open-assembly time) may vary from a few minutes to 20 or 30 minutes according to the consistency of the adhesive. A pressure of 100 to 200 pounds per square inch for 1/2 to 4 hours will give good results although higher or lower pressures may sometimes be necessary. It is important that the pressure be even and not exceed the crushing strength of the wood under pressure. Also whatever be the class of glue used, the spread should be even and continuous over the entire surface of the wood.

Truax[46] carried out tests on the gluing of different species of wood and found that yellow birch gave in shearing about 65% wood failure with a breaking strength of approximatively 2800 pounds per square inch. The test specimens were

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[45]Canadian Woods, op. cit., page 127.

[46]Op. cit., page 43.

cut from blocks 1 1/2 x 5 x 12 inches (original thickness of pieces, 3/4 inch) so as to give a shearing area of4 square inches.

Vegetable and casein glue: The working life of animal glue is one day or less and its water resistance is usually low. It may become advisable to use glues with a longer working life (vegetable glue) or a higher water resistance (casein glue). These two glues have the outstanding advantage of not requiring any heat when applied. Both have a tendency to stain wood but this drawback has no signifiance when thick stock is glued together.

As to the spreading, the assembly time and the amount and duration of pressure, the same remarks apply here as they were given under the heading of animal glue.

The results found by Truax were about the same with both vegetable and casein glues. For instance, the first glue gave 35% wood failure with a breaking strength of 2800 pounds per square inch; and the casein glue gave 40% wood failure and a breaking strength of approximatively 2750 pounds per square inch.

Liquid and blood albumen glue: Liquid glue varies greatly in quality the thinner glues being ordinarily cheaper. They may give very strong joints to very poor, and because people cannot rely upon them with much certainty, they are not used a great deal except for patchwork and small gluing operations.

The blood albumen glue is not used widely on this side of the ocean. Therefore no data are avalaible as to the gluing properties of our birches. As we know, this glue requires a hot-pressing process. A "cold" formula has been developed at Madison, yet it does not give uniformly good results.

There is another class of glue which has been developed during the last few years: the synthetic resin glues. Birch in relation with this new glue will be discussed in Chapter VIII.

Some factors affecting the gluing of birch: Enough tests now have been carried out to permit the statement that a change in specific gravity affects the glue joint in the same way as it does affect the strength of the wood itself.

Significant results after tests on the heartwood and sapwood of yellow birch showed that the sapwood glued better, presumably because it is more porous and contains less infiltrated material.

Table 19 gives the results of some 20 tests carried out by Truax at the Madison Forest Products Laboratory. For other woods, the reader may refer to page 47 of "The Gluing of Wood".

Table 19:- Results of tests on gluing properties of heartwood and sapwood of yellow birch.

		Animal glue	Casein glue	Vegetable glue
Shear strength	H	2,711 p.s.i.	2,321 p.s.i.	2,711 p.s.i.
	S	3,174 "	2,957 "	2,879 "
Wood failure	H	73%	32%	36%
	S	64%	49%	48%
Specific grav.	H	.66	.65	.66
	S	.64	.66	.66

H means heartwood
S means sapwood.

Treating birch before Gluing: The treatment of surfaces to be glued with a 10% solution of caustic soda proved to be generally most effective according to Truax. The surfaces were brushed with the solution and after 10 minutes they were wiped with a cloth to remove any excess of soda; then the pieces were allowed to dry before gluing. This process is recommended also to improve the strength of starved joint. However, this method is time consuming and can hardly be used in mass production.

Gluing schedules recommended: Truax recommends the following schedules for the gluing of sapwood or heartwood of birch (see The Gluing of Wood, pp. 50-51):

Animal glue	Schedule A 3
Casein glue	Schedule C 2
Vegetable glue	Schedule V 2

These schedules are described below:

Schedule	Glue-water proportion by weight	Glue spread	Temperature of the wood	Pressure	Closed assembly time
		Lbs. per 1000 sq. ft.	°F.	Lbs. per sq. in.	Minutes
A 3	1 to 2 1/4	65 to 70	70	150 to 200	1/2 to 1
	1 to 2 1/4	70 to 75	80	150 to 200	3 to 5
	1 to 2 1/4	75 to 80	90	150 to 200	10 to 18
	1 to 2 1/2	75 to 80	90	150 to 200	12 to 18
C 2	1 to 1 4/5	70 to 75	70 to 90	150 to 200	0 to 12
	1 to 2	75 to 80	70 to 90	150 to 200	5 to 20
V 2	1 to 2 1/8	70 to 75	70 to 90	150 to 200	5 to 20
	1 to 2 1/4	75 to 80	70 to 90	150 to 200	5 to 25

Table 20:- Gluing schedules of birch.

The conditioning of glued thick stock: After thick stock has been glued, only a conditioning treatment is recommended to bring the pieces to a uniform moisture content. Edge-glued lumber must be handled with great care because of the danger of sunken joints: it is obvious that the wood will absorb more moisture along the glue line, and if surfaced immediately after gluing, subsequent drying will cause depressions due to a greater shrinkage at the edge. To avoid this defect in 1" stock, it is recommended to pile the glued stock on stickers and to dry in a kiln during two days at 100°F. or 5 to 7 days at 70°F.

The finishing of paper and yellow birch

Lumber is finished for two reasons: (1) to enhance its beauty; and (2) to preserve it against the destroying elements. To arrive at this end, two general steps are necessary: the preparation of the wood for the final finishing and the finishing itself.

Preparation of birch to final finish: This operation is very simple when birch lumber has to be used out of doors: the planks or boards are usually passed through a planer or simply a jointer in order to give smooth surfaces for the application of coatings.

For interior use like flooring, moulding or simply furniture, birch must be "prepared" carefully. It is easily machined and finishes smoothly due its fine texture and the eveness of its grain.

The final finish: For exterior use (we should point out that birch is not ued a great deal for exterior woodwork in the Province of Quebec) birch must be protected by some kind of coating to prevent any deterioration through weathering or decay.

Most of time, birch does not require any filler and paint may be applied directly (we have seen that the pores of birch are relatively small). As a moisture-retardant coating, the best practice consists in the use of aluminium powder mixed in with paints. This coating may be easily applied and is inexpensive. The effectiveness of this moisture-retardant treatment may be increased by the application of several coatings of this same nature. One can readily see that outdoor woodwork is subject to rain, cold and heat and, as birch shrinks and swells considerably with a change of moisture content, the paint coating is not likely to last long (shrinking less than birch) unless it is a moisture-retardant.

In interior woodwork or furniture, birch is considered by many architects as without an equal for enamel finishes. Its smooth and hard surface forms the ideal base and resists wearing. Presumably, yellow birch ranks higher than paper birch from that stand point because it is about twice as hard as the latter species.

To avoid confusion let us point out here that the chief difference between paints and enamels is that in paints linseed oil carries the pigments and in enamels varnish is the vehicle used.

Lacquers are not infrequently used for interior finish. As we know, modern lacquers are composed of five ingredients: nitro-cellulose (for waterproofness, hardness and durability), solvents, thinners and non-solvent liquids (used to dissolve the nitro-cellulose and resins, to provide a quick drying, ease of application and to prevent blushing), the gums or resins (for thicknessing the solution), the softeners or plasticizers (to prevent brittleness) and the pigments (for color and hiding power). Birch is recognized to take lacquers remarkably well.

Enamels, lacquers and sometimes paints are used for interior finish when it is intended to obscure the grain.

However, we have seen that birch may exhibit very attractive figures due to "accidents" during the growth. Then it is most desirable that these figures show in the final finish. For that purpose, the use of oil wax finishing, of stains or varnishes is resorted to with great success. Even for interior finish, no filler is necessary on birch.

Heating values of paper and yellow birch and their use for motor fuel.

<u>The calorific value of paper and yellow birch</u>: Heavier wood (not including the amount of water in it) will generally have a higher calorific value than lighter wood, and it is expected that yellow birch will surpass paper birch in that respect.

The moisture content is another important factor controlling the amount of heat evolved during the combustion of wood. The water in wood is a cause of loss because thermal energy is used up to evaporate the liquid. It is calculated that so many as 1150.4 B.T.U. are necessary to heat up 1 pound of water at 32°F. and to evaporate it under atmospheric pressure (14.696 p.s.i.). Therefore it is most desirable that birch and wood in general used for fuel should be air-dry.

Tests carried out by the staff of the Canadian Forest Products Laboratories[47] gave the following heating values for paper and yellow birch:

	Species	
	Yellow birch	Paper birch
Gross calorific value (millions of B.T.U. per air-dry cord)	26.2	23.4
Number of air-dry cords required to equal 2000 lbs. anthracite coal	1.20 to 1.44	1.34 to 1.60

Table 21:- Gross calorific values of paper and yellow birch.

One B.T.U. is the amount of heat required to raise the temperature of one pound of water through 1 degree Fahrenheit. Yellow birch was classed among the best hardwood fuels and paper birch among the fair hardwood fuels. The reader should refer to the reference just given for further information concerning the heating values of other species.

The values given above apply to air-dry material, but green birch, especially paper birch, is unsurpassed when it is desired just to keep fire alive in the fire place or in

[47] Hale, J.D., 1933. Heating Values of Wood Fuels, Canada Dept. of the Interior, For. Prod. Lab., 12 pp. (mimeographed).

the furnace.

From the tests reported, it appeared that wood can be burned successfully in a coal furnace. It is a clean fuel with a low ash content and is very economical due to the low price of cord wood. However, it requires frequent firing when a hot fire is needed.

Wood briquettes: Although created recently, wood briquettes get more and more favor as a fuel. They appear under several trade names one of which the author happened to be acquainted with namely, the Pres-to-logs.

Pres-to-logs are a log-shaped fuel made by compressing at 165,000 pounds clean dry dust and shavings previously ground to a uniform size. According to the General Manager of Wood Briquettes Inc., Mr. Roy Huffman[48],

> "Any species of wood may be made into a Pres-to-log, and after being so made the heat value will be about the same regardless of the species from which it is made. The B.T.U. value per pound of different species of wood varies very little. The reason some woods are considered better fuel than others is because they are denser thus giving the customer more pounds per volume of measurement. When compressed into Pres-to-logs the maximum density of each wood would result in exactly the same weight per unit of volume.
>
> The B.T.U. value of Pres-to-logs on an as fired basis is about 8,500 B.T.U.'s per pound but the effeciency is a great deal higher than with most other fuels due to the fact that the fuel is easily controllable, requires very little oxygen to burn and is always uniform."

Pres-to-logs are claimed to present many advantages over other fuels: they are clean, burn with pratically no smoke,

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[48]Letter to the author, November 25, 1940.

do not spark or produce any soot and they are long-burning. In addition, the combustion is pratically complete leaving a small amount of ash (about 3/10%). The size of Pres-to-logs is 4 by 12 1/2 inches so that one ton can stack in less than 35 cubic feet of space. The price is $10.50 per ton. Undoubtedly a greater demand for such a product will bring the price to a lower level and one can see the many advantages which will result from the utilization of Pres-to-logs and wood briquettes in general as a fuel.

Use of birch as a motor fuel:[49] The shortage of gasoline resulting from war conditions in Europe attracted attention towards the end of 1918 to the possible use of wood and charcoal as a source of power for vehicles. Much progress have been done since that time in England, France and Germany. In North-America, less studies were made in the adaptation of gas from wood and charcoal as a substitute for gasoline in internal-combustion engines. This is due mainly to the low cost and abundant supply of gasoline, especially in the United-States. But there are many areas in Canada where gasoline must be transported over long distances and consequently the cost per gallon is likely to be high.

The use of producer-gas is likely to present many advantages to-day even if more intensive research has to be carried out.

The gas-producer plant used for stationary motors or for vehicles is made of three parts: the generator or gas producer, the cleaning apparatus and the mixing valve. After leaving

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[49]See Jenkins, J.H., and Guernsey, F.W., 1936, Wood and Charcoal as Motor Fuel, Canada Dept. of Mines and Resources, For. Serv. Cir.47, 16 pp., illus.

the generator, the gases must be purified before entering the cylinders through the mixing valve. The use of wood as a source of gas supply requires an elaborate equipment because of the presence of wood-tar, but on the vehicles charcoal may replace wood and no tar is present in the gases. The cleaning equipment in that instance is very simple. The mixing valve, admitting the proper amount of gas and air, is under the direct control of the driver.

As noted above, the supply of fuel may present itself under the form of wood or charcoal. But the last one offers some advantages over wood for vehicles: there is less risk of fouling the engine, the charcoal gives a greater milage pound for pound and the bulk and weight to be carried is much reduced. The briquetting of charcoal, though adding extra cost, is recommended for automobiles to avoid the dust in refueling.

The author does not know of any test being carried out in Quebec where paper and yellow birch served as fuels. In England, it is reported that for general purposes 1 pound of charcoal is sufficient for every brake-horsepower-hour. In Germany, tests on coaches (railroad cars, 6-cylinder 75 H.P. motors) made out clear that one gallon of gasoline is the equivalent of 10 to 12 1/2 pounds of charcoal or 20 to 24 pounds of wood (beech, oak and birch at 20% m.c. were used as fuel).

In British Columbia, tests were conducted on trucks (see foot-note 49) with the following results (charcoal being used):(see page 76).

1st - Douglas fir cordwood	4.2	ton-miles per lb. of charcoal
2nd - Red alder	3.9	" " " " "
3rd - Lodgepole	3.7	" " " " "
4th - Douglas fir edgings	3.4	" " " " "
5th - Cottonwood	3.3	" " " " "
6th - Sitka spruce	2.9	" " " " "

On the basis of hardness and freedom from dust, the table is given in this way:

Species	Power development	Hardness and freedom from dust
Red alder	2nd	1st
Douglas fir cordwood	1st	4th
Lodgepole pine	3rd	3rd
Sitka spruce	6th	5th
Cottonwood	5th	2nd
Douglas fir edgings	4th	6th

The relative operating costs were as follows:

Red alder charcoal	0.26	cent per ton-mile
Douglas fir corwood	0.24	" " "
Lodgepole pine	0.27	" " "
Cottonwood	0.30	" " "
Gasoline	0.57	" " "

It seems therefore that there is a promising field in the utilization of wood as a motor fuel, especially in remote regions where the cost of gasoline and Diesel oil is very high. Present and new developments will certainly contribute to a better utilization of our waste wood and our birch as well.

Chapter VI

PAPER AND YELLOW BIRCH AS AFFECTED BY DESTROYING ORGANISMS AND PROTECTED BY PRESERVATIVE TREATMENT.

Paper and yellow birch must resist certain dangerous enemies which are recruited primarily among insects and fungi. To be sure, light ground fires are great destroying agents of the young seedlings, and even older trees with their inflammable bark may be seriously damaged or killed by a fire of some importance. Nevertheless, this threat is taken care of by such a good organization as the Quebec Forest Protection Service.

Birches may also suffer from heavy winds, but not to a large extent because the root system, though shallow, has a considerable lateral spreading which affords a good support to the tree. Moreover, the branches bend readily under the action of the wind. But when we come to examine the action of destroying organisms upon those two species, we find the situation more serious. Insects and fungi will be dealt with separately, and recognized methods of preservative treatment will be discussed.

The insects.

The scope of this study does not permit a detailed discussion of all the insects which feed on birches on one way or another. Therefore, only the most important will be dealt with.

The Birch Leaf Skeletonizer: This insect belongs to the group of the Lepidoptera. Native to North America, the Skeletonizer (Bucculatrix canadensisella Cham.) is particularly injurious to the foliage of birches. During invasions of some importance, all the trees of a stand may be attacked, and the leaves, reduced to their skeleton, become brownish and sometimes drop on the ground, leaving the stems entirely denuded. Ordinarily, the invasion is detected when the trees turn to a light-brown color.

The adult is very small: 3mm in length with a wing-spread of 7 mm.; the head is brown and the antennae are formed of rings alternately white and brown. The mating period extends from June to the end of July. The eggs are deposited either on the upper or lower surface of the leaves and they hatch after 15 days. The young caterpillars immediately bore into the leaf and excavate a narrow winding gallery about 3/4" in length. After a period of 24 to 31 days, the caterpillar has undergone three moultings and emerges at the surface of the leaf where she feeds until the beginning of September. At this stage, the larva is readily recognized by its brown head, its pale green body provided with white, hairy discs. Then, the winter is passed in a cocoon.

The principal effect of the attacks of the Birch Leaf Skeletonizer on birches is a retardation of growth. This is plainly visible when we examine the cross sections of some victims a few years later. The annual rings corresponding to the period of attack are decidely narrower. Too severe defoliation during consecutive years will bring about the death of the tree.

This insect is found throughout the province and it deserves a careful attention from the entomologists and the foresters as well. Some good treatment has to be found in order to stop the destruction where it occurs. The ideal way to get rid of this insect is by destroying the eggs. This method is praticable only on shade-trees. In forest, great damage is done long before people can notice the presence of this insect, since the young larva, immediately after hatching, excavates a gallery inside the leaf. Whenever practicable, the spreading on the foliage of a good insecticide, like lead arsenate, is recommended.

The Sawfly Leaf Miner: This insect of the order of the Hymenoptera is very often associated with the Skeletonizer. It is an immigrant from Europe found for the first time in Nova-Scotia in 1905. Paper birch espacially has to suffer from this sawfly the larva of which feeds on the parenchyma of the leaves between both epidermis. The adult, a female of about 1/4" in length with a black color, emerges during the spring. The eggs are deposited between the teeth of the leaves (8 to 12 eggs per leaf). The eggs hatch after a period of 20 days and the young larvae start immediately to excavate their galleries. Late in fall, a pupal cell is formed in the leaf and the winter is passed in the pupal stage. This insect has only one generation a year in North America. Like the Skeletonizer, this Sawfly tends to reduce the growth of its host greatly and it is likely that birch cannot resist to heavy attacks during consecutive years. As to the methods of controls, the same may be said here as in the case of the Bucculatrix.

<u>The Bronze Birch Borer:</u> This insect (Agrilus anxius) belongs to the order of the Coleoptera. It is a wood-borer which is especially injurious to the birch stands of New-Brunswick. It is also present in Quebec, but not to a large extent.

Back and Prebble[50], after a careful study of the situation, pointed out that three factors may have rendered possible all the damages caused by this slender-body insect: the presence of large areas of mature and overmature stands, the exposure of birch and the repeated attacks of some defoliators.

As suggested, this borer prefers mature, overmature and unhealthy trees. Branches at the top are first attacked, and the galleries running in the phloem region interferes with the conduction of food materials upward and downward. As a result, the leaves die soon and the balance between the foliage and the root system is destroyed thus bringing about the death of the tree.

The control of this insect is a problem of forest utilization and silvicultural management. It is obvious that the cutting of birches to check the borer is not economical when there is no market for the products. When practicable, stands should be handled so as to assure a proper balance of age classes and a favourable density (the Birch-Borer is a light lover). In mixed stands, the cutting of pulpwood should be accompanied

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[50]See For. Chron., 16, 179-201.

or followed by the felling of birches. In woodlots subjected to a close management, trees with drying branches should be removed and the slash disposed of by burning or any other method so as bring down the borer population.

Gobeil[51], in a letteraddressed to the author on April 28, 1941, mentions some other insects injurious to birch, like Fenusa pumila, Malacosoma americana, Coleoptera cinerella, Dickelonyx elongata, but he does not give too much importance to these species for the time being.

The fungi

So far, fungi have been thought of as secondary enemies to paper and yellow birch. No systematic survey can tell of the amount of damage caused by these organisms. Nevertheless, there are some species which deserve more importance than others because of their wide distribution in the province.

Among the Fomes, let us mention Fomes fomentarius and Fomes igniarius. The former chiefly decays dead timber but occasionally causes heart rot of living trees and also attacks living sapwood; the infection of living trees takes place through branch stubs and wounds and progresses downward. At start, the wood is brownish in color and firm, but in the advanced stage of decay it becomes yellowish-white, soft and spongy with a mottled appearance. Silvicultural measures have to be resorted to in order to check the growth of the disease caused by this fungus. The reproduction by seedlings should be preferred to the sprouts. The heartwood rot decay may be checked by adoption a shorter rotation. Also when the logging

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[51]Director of the Provincial Service of Entomology, Dept. of Lands and Forests.

is carried out, infected trees should be felled and great care should be taken so as not to cause wounds to the trees which are not felled.

The white trunk rot is caused by Fomes igniarius. Incipient decay appears as yellowish-white spots, streaks or larger areas in the heartwood. In the advanced stage, wood becomes soft, light, whitish and rather uniform in texture, but with fine black lines running throughout. As as rule, the decay is confined to heartwood, but it may occasionally kill living sapwood and inner bark of yellow birch. Rot is most often centered in the main portion of the trunk. Even after the death of the tree, this fungus keeps on developing and may cull logs in the forest. However, it has not been found in lumber piled in storage yard or put into service[52].

As this fungus penetrates into the trunk through the wounds, great care is recommended during the logging in order to avoid injuries to the standing trees.

There are some other fungi met with either on paper or yellow birch, but the damages which they are responsible for are not important. Thus, armillaria mellea is often seen on stumps and unhealthy trees, and poliporus betulinus attacks mostly dead or dying trees. Taphrina bacteriosperma causes a red blister on birches. Pomerleau[53] claims to have discovered it on yellow birch for the first time in North-America at Duchesnay, Quebec, in 1939, but he does not give too much importance to this new disease.

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[53] Provincial forest pathologist. Acknowledgement is made of the valuable information given in a letter addressed to the author on April 28, 1941.

[52] Boyce, J.S., For. Pathology, p.443.

Torula ligniperda is believed to be the principal agent causing what is universally known as red heart. Birches growing in the open on poor sites, or damaged by a severe glaze or injured at the top are most subject to this defect.

Red heart is the name applied to the central reddish-brown discolored area of paper birch. It appears first in the lower part of the trunk and extends more rapidly along the longitudinal axis of the tree than along the rays. It is wetter than sapwood and contains fungi and bacteria as a rule. On drying, it has a tendency to check and crack more than the surrounding sapwood.

Although objectionable in many turned articles, red heart is not considered as decay because it appears that hyphae follow the cell cavities and cell pits and attack the walls only occasionally. Therefore the strength of the wood of paper birch is not likely to be affected a great deal.

A short rotation is about the only means to check red heart and birches should be cut around the age of 50 or less.

The preservative treatments

Birch lumber in use is subject to the attacks of the wood-destroying organisms which are recruited chiefly among the fungi. We have seen that this species may decay in less than 4 years when in unfavorable conditions: for that reason, it is considered on the border line between intermediate and nondurable species. Therefore, some preservative treatment must be applied so as to increase the durability of this hardwood.

Railroad ties: In Eastern Canada, paper and yellow birch (to a much greater extent) are oftentimes sawed into railroad ties. As we know, ties are in the most favorable conditions to the development of decay during summer-time.

Before applying any preservative, ties must be removed of any presence of bark that might occur. For the seasoning, ties are piled in suitable places and allowed to air-dry for a period varying from 6 to 12 months according to the conditions prevailing at the location of the pile. Although the heartwood of birch is considered as moderately difficult to penetrate, the incizing of the lumber is often resorted to. Ties are passed between rollers provided with projecting members (knives). This process controls the depth of penetration (about 1/2 inch) and makes it more uniform. It also permits a saving of preservative through a shorter treating period and means a considerably increased plant capacity[54].

The majority of ties treated in Canada are pressure treated with coal-tar creosote, creosote-coal-tar solutions or creosote-petroleum mixtures. The specifications of the canadian railroads call for an absorption varying from 6 to 12 pounds of preservative per cubic foot. Greater absorptions could be required but it must be remembered that ties suffer mechanical wear and thus their life is limited by the cutting action of rails, the "spike killing" and the erosive action from the ballast.

The usual process resorted to is the so-called empty-cell process in which air is imprisoned in the wood under the pressure of the entering preservative and then expands after the

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[54]Kynoch, W., and Coderre, J.A., 1923, The creosote treatment of railway sleepers by the incising process, Emp. For. Journ. 2, 120-122.

pressure of the entering preservative is driven out. This process does not suppose any initial vacuum. The Lowry process is especially in favor because of its simplicity. It differs from the Rueping in that no preliminary pressure is applied. The temperature of the preservative ranges between 180°F. and 200°F. with a maximum of 210°F. The pressure rarely exceeds 200 pounds per square inch. The pressure period depends chiefly upon the operator. He ought to know by experience how long he must keep the pressure on inside the treating cylinders. Also, he ought to know the period during which the final vacuum is drawn. This operation usually lasts from 30 to 60 minutes.

For the sake of comparison, we include some data as gathered by MacLean[55] about the two processes referred to above. These conditions are said to exist in the Eastern and Southern States. Birch will be the only species mentioned.

Table 22:- Commercial treating conditions and absorptions in use for birch in the Eastern and Southern States.

Preservative		
Coal-tar creosote	..........60% (1)	........60% (2)
Coal-tar	..........40%	........40%
Preliminary air press.	60-65 p.s.i.	....
Max. treating press...	..200 p.s.i.	175 p.s.i.
Preservative temper...	....175-190°F.	195°F.
Net absorption.......	6-7 lbs./cu,ft.	8-9 lbs./cu.ft.

(1) Rueping process.
(2) Lowry process.

[55] MacLean, J.D., 1935, Manual of Preservative Treatment of Wood by Pressure, U.S. Dept. Agric., Misc. Public. No.224, p.101.

Zinc chloride affords also a good protection to railroad ties, but it is not used a great deal because it leaches out easily. However this preservative is often used where the black color imparted to birch by creosote oils would be objectionable, for instance in the flooring of certain factories or in the flush doors.

Creosote oils and zinc chloride are by far the most important preservatives employed to afford protection to birch lumber in use. As a matter of fact, if we except the products which we have just mentioned, birch is mostly converted into articles not subject to deterioration to decay because of a low moisture content.

Results obtained by preservative treatment: Birch by its very nature is subject to decay readily; therefore a good preservative treatment is likely to increase its durability a good deal. The life of ties, particularly, is said to be increased from 3 or 4 years to 20 to 25 years. This is of importance to railroads, because they make considerable savings through less replacements. Thus in 1911, 22 important american railroads reported an average replacement of 262 ties per mile of line for 136,129 miles of track, and in 1935, 27 reported a figure of only 95 for 199,231 miles[56].

Savings of similar importance are done in other fields where birch is exposed to danger of deterioration.

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[56]Hunt, George M., and Garratt, George A., 1938, Wood Preservation, p. 288.(Figures apply to ties in general).

<u>Birch as affected by preservative treatment</u>: The standard preservatives are not harmful to birch generally speaking; however the procedure followed may reduce the strength of the wood and make it more brittle under impact. The temperature adopted during the process should be as low as possible: a temperature of 150°F. sustained for several hours is said to injure the wood, especially the hardwoods.

Incising also tends to reduce the strength of ties, but the disavantage of this loss is more than offset by the increase in protection resulting from a better and more uniform penetration.

The painting characteristics of treated birch are not affected seriously as far as zinc chloride is concerned. A primary coat of aluminium paint will greatly increase the durability of ordinary white paint on wood treated with zinc.[57]

<u>Chemical dips</u>: We have seen that birch lumber is subject to blue-stain when drying in open air. Thick pieces are especially affected because of a longer drying period. Chemical dips have been developed since 1905 to prevent or at least retard the development of blue stain until lumber is dry enough to be immune from attack.

Mercuric chloride is highly effective in that respect but it is poisonous, corrosive and expensive. Soda dips are recommended though they fail sometimes to protect lumber during warm rainy weather, and may impart a yellow color to the wood. For hardwood, Scheffer and Chapman[58] recommend borax (5% solution),

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[57] Hunt and Garratt, Op. cit., p.316.
[58] See Southern Lumberman, 149, 1881: 37-40 (August 15, 1934).

ethylmercury chloride (Lignasan), sodium tetrachlorophenoxide (Dowicide H) and phenylmercury acetate (all 1% solution).

The usual way to treat lumber is to carry it mechanically through vats of unheated solution immediately after being sawed.

Fire-retarding treatment of birch: It is often highly desirable to render birch "fire-proof". Tests conducted at the British Forest Products Laboratory[59] indicated that yellow birch, for instance, has a medium fire resistance. Hunt and Garratt report (op.cit., p. 407) that an absorption of about 3 to 3 1/2 pounds of diammonium phosphate by cubic foot afforded a good protection to yellow birch tested by the fire-tube test developed at the Madison Forest Products Laboratory. A somewhat lighter treatment is even recommended. Zinc chloride in 5% or more solution is also claimed to work well. Many other chemicals seem to be promising but it is not within the scope of this study to enumerate and analyze every chemical involved.

It must be borne in mind that a fire-retardant treatment does not afford complete protection, but simply, as the term indicates, retards the destructive action of fire.

When treated wood has to be kiln-dried, a very mild schedule is recommended[60] because after seasoning there seems to be a pronounced a drop in concentration from the outside to the inside and furthermore, "salt contents for different sections are less closely grouped about an average value" (p.3).

These conclusions apply to wood treated with water soluble salts.

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[59] See Wood, January 1940, p.20.

[60] Moore, G.E., 1936. Distribution of salts after Kiln-Drying, For. Prod. Lab. of Canada (mimeographed).

Chapter VII

GRADES AND SIZES OF PAPER AND YELLOW BIRCH

Canadian birch is not only marketed in Canada but is exported to many countries, each having its own requirements. So that the grading of birch in a mill serving the domestic and export markets is quite a problem.

In general the lumber associations adopt and publish grading rules and sizes applicable to the species which they are interested in. As far as we know, the rules as published by the National Hardwood Lumber Association are generally accepted throughout Canada.

Birch is divided into two general classes:unselected and selected.

Selected birch, as the term implies, is separated according to the color of the wood: red birch refers simply to heartwood lumber and sap or white birch refers to sapwood lumber.

The grading rules do not differentiate between any species of birch.

Unselected birch

The different grades comprise Firsts, Seconds (or Firsts and Seconds), Selects, No.1 Common, No.2 Common, Sound Wormy, No.3 A Common and No.3 B Common.

A shipment of birch of F & S shall not comprise less than 20% of Firsts.

Except in Firsts and Seconds where 30% of the boards may average a length of 8' to 11', half of this 30% admitting lengths of 8 and 9 feet, all the Standard Grades apply to Birch.

We give below the requisites pertaining to each Standard Grade as published by the Association for the year 1940.

Firsts

Width: 6" and wider
Lengths: 8 feet to 16 feet

Percentage of clear face	4' to 9': 91 2/3% in 1 cut
required for different	10' to 14': 91 2/3% in 2 cuts
surface measures	15' + : 91 2/3% in 3 cuts

The minimum size cuttings for Firsts, Seconds and Selects are 4" x 5' and 3" x 7'. The word cutting means a portion of a board or a plank obtained by ripping, cross-cutting or both. A unit of cutting is 12 square inches.

Clear face means, unless otherwise specified, that the poor side of the board must be clear and the reverse side free from rot, heart-center, shake, wane and any other defects tending to reduce the strength of the wood.

Seconds

Width: 6" and wider
Lengths: 8 feet to 16 feet

Percentage of clear face	4' to 5': 83 1/3 in 1 cut
	6' to 7': 83 1/3 in 1 cut
required for different	8' to 11': 83 1/3 in 2 cuts
	12' to 15': 83 1/3 in 3 cuts
surface measures	16' and up: 83 1/3 in 4 cuts

For surface measures of 6 to 15 feet, an additional cut is permitted provided it yields 91 2/3% clear face.

In Firsts and Seconds, the portion of the board not included in the required clear face cutting must meet the following requirements:

"Heart center, boxed or showing on the surface, will not be admitted when exceeding in the aggregate in inches in length, an amount equal

to the surface measure of the piece in feet. Wane (bark or the lack of wood) exceeding in the aggregate one-twelfth the surface measure of the piece shall not be admitted; nor shall either edge of the piece have wane in the aggregate exceeding one-half the length of the piece.
Splits exceeding in the aggregate in inches in length twice the surface measure of the piece in feet will not be admitted, nor when diverging more than one inch to the foot in length, excepting when one foot or shorter and covered by Paragraph 40. (end rule) In any series of special widths sold 10" or wider, splits exceeding in the aggregate in inches in length, the surface measure of the piece in feet, will not be admitted, nor when diverging more than one inch to the foot in length excepting when one foot or shorter and covered by Paragraph 40. (end rule)
The average diameter of any knot, or hole, shall not exceed in inches one-third the surface measure of the piece in feet."

Other specifications for this combined grade require that

"Boards containing, in the area within one foot lineal from the end, less than 50% clear face or more than 25% unsound wood or wane will not be admitted. The required 50% clear face must be computed in not more than two pieces.
Warp and cup will not be admitted if sufficient to prevent the board from dressing two sides to standard thickness in accordance with the rules for lumber dressed two sides, except that slightly cupped or warped 12" and wider may be admitted if they may be ripped to produce two pieces each of which would grade Firsts and Seconds and then not contain warp and cup which would prevent the ripped pieces from dressing two sides to standard thickness in accordance with the rules for lumber dressed two sides. The exception as to pieces 12" and wider shall not apply to orders specifying lumber, or a percentage of lumber, in widths 10" and wider.

Selects

Widths: 4 inches and wider
Lengths: 6 to 16 feet, admitting 30% 6 to 11 feet. One-sixth of this 30% may be 6 and 7 feet.

Percentage of clear face required for different surface measures	2' to 3': 91 2/3 in 1 Cut. 4' and over: must grade on one face as required in Seconds, the reverse side of board not being below No. 1 Common, or the reverse side of cuttings being sound.

The face required to grade as in Seconds is the better face of the board in the case of Selects. In addition to these specifications, Selects require that

> "Pieces 4" and 5" wide shall have, on the reverse side two edges free from unsound defects, except wane or its equivalent in other unsound defects, not exceeding one-third the length, one-third the widt, or one-third the thickness of the piece."

No. 1 Common

Widths: 3" and wider (only 5% of 3" widths)
Lengths: 4 to 16 feet, 10% of 4 to 7 feet. One-half of this 10% may be 4 and 5 feet.

Percentage of clear face	1 foot:	clear
	2 feet:	75% in 1 Cut
	3' and 4':	66 2/3 in 1 Cut
required for different	5' to 7':	66 2/3 in 2 Cuts
	8' to 10':	66 2/3 in 3 Cuts
	11' to 13'	66 2/3 in 4 Cuts
surface measures	14' and up	66 2/3 in 5 Cuts

Pieces of 3 to 7 feet surface measure will admit one additional cut to yield 75% clear face. The minimum size of cuttings is 4" x 2' and 3" x 3',

> "except that in pieces less than 3" wide, under the minimum width rule, ... cuttings the full width of the piece shall be admitted." The minimum width rule states that:

> "Ninety per cent of the minimum widths mentioned in all grades of lumber must be full width; the remaining ten per cent may be 1/4" scant in width. This rule also applies to each stock width and to any specified width."

No.2 Common

Widths: 3" and wider
Lengths: 4 to 16 feet; 30% may be 4 to 7 feet in length, of which 30% one-third may be 4 to 5 feet.

Percentage of clear face	1' :	66 2/3	in 1 Cut
	2' & 3':	50	in 1 Cut
	4' & 5':	50	in 2 Cuts
required for different	6' & 7':	50	in 3 Cuts
	8' & 9':	50	in 4 Cuts
	10' & 11':	50	in 5 Cuts
	12' & 13':	50	in 6 Cuts
surface measures	14' & up:	50	in 7 Cuts

The minimum size of cuttings in this grade are 3" wide by 2' long,

> "except that in pieces less than 3" wide under the minimum width rule, cuttings the full width of the piece shall be admitted."

Other specifications also state that

> "Heart center, boxed or showing on the surface, will not be admitted when exceeding in the aggregate three-fourths the length of the piece."

Sound wormy

> "Sound wormy shall admit pieces not below the grade of No. 1 Common, except that worm holes, bird pecks, sound stain, small sound knots not exceeding 3/4" in diameter, and other sound defects which do not exceed in extent or damage the defects described, shall be admitted in the cuttings. Unless otherwise specified, Sound wormy shall include the full product of the log in No. 1 Common and Better Sound wormy.
>
> Note: When lumber is purchased under specifications combining the term "Sound Wormy" with the names of Standard Grades, such as "Firsts and Seconds Sound Wormy", "No. 1 Common and Better Sound Wormy", it shall be understood that the required yield shall be the same as specified under the Standard Grades, except that the defects and blemishes admitted in the cuttings as defined in the Standard Grade of "Sound Wormy" shall be admitted.

When lumber is purchased under specifications combining the term "Worm holes no defect" with the names of Standard Grades, such as "Firsts and Seconds, worm holes no defect", No.1 Common and Better, worm holes no defect", it shall be understood that the required yield shall be the same as specified under the Standard Grades, except that worm holes shall be admitted without limit".

No.3 A Common

Widths: 3" and wider
Lengths: 4 to 16 feet, admitting 50% 4 to 7 feet lengths of which 50% one-half may be 4 and 5 feet.

"No. 3 A Common shall admit pieces that will cut 33 1/3% clear face in cuttings not less than 3" wide by 2' long. This grade shall also admit pieces which grade not below No.2 Common on the good face, the reverse side of the cuttings sound."

No.3 B Common

Widths: 3" and wider
Lengths: 4 to 16 feet, admitting 50% 4 to 7 feet lengths of which 50% one-half may be 4 and 5 feet.

"No.3 B Common shall admit pieces that will cut 25% sound in cuttings not less than 1 1/2" wide, no cutting considered which contains less than 36 square inches."

Below Grade

"Lumber of standard widths and lengths as described in these rules, but poorer in quality than the lowest grade described, shall be tallied and reported as "Below Grade".

Selected birch

Red birch
When specified

Each required cutting must have one clear red face.

Firsts: Standard.
Seconds: Standard, except:
Widths 5" and over; pieces 5" wide containing 3' and 4' surface measure must be clear, pieces 5" wide containing 5' to 7' surface measure must cut 11/12 (91 2/3%) clear face in one cutting.
Selects: Standard.

No.1 Common: Standard, except:
Will admit 30% 4 to 9 feet lengths, of which 30% one-third may be 4 and 5 feet lengths.

Sap birch
(When specified)

Same as Red Birch except that each required cutting must have one clear sap face.

It must be borne in mind that the grades discussed above govern the contracts between buyers and sellers only when it is specified that the inspection will be done according to these grades.

Current wholesale prices of birch

The following prices are given for the month of March of the past five years. They are taken directly from the Canada Lumberman. No prices were given for April and May 1941 because a revision of the prices is in course.

The figures given are f.o.b., at Toronto rate of freight, per M.ft. (see page 96).

Standard thicknesses

"Standard thicknesses are 3/8, 1/2, 5/8, 3/4, 1, 1 1/4, 1 1/2, 2,2 1/2, 3, 3 1/2, 4, 4 1/2, 5, 5 1/2,and 6inches.
Note: For lumber thinner than 3/8" see veneer rules.
Standard thicknesses for surfaced lumber are as follows:

Rough	Surfaced	Rough	Surfaced
3/8"S2S to	3/16"	1 1/2"S2S to	1 5/16"
1/2"S2S to	5/16"	2 "S2S to	1 3/4"
5/8"S2S to	7/16"	2 1/2"S2S to	2 1/4"
3/4"S2S to	9/16"	3 "S2S to	2 3/4"
1 "S2S to	13/16"	3 1/2"S2S to	3 1/4"
1 1/4"S2S to	1 1/16"	4 "S2S to	3 3/4"

Thickness of lumber surfaced on one side only, shall be subject to special contract.

Table 23:- Current wholesale prices of birch.

Year	Thickness	Grade				
		FAS	Selects	No.1 C.	No.1 C & Sel.	No.2 C.
1941	4/4	$94.	$84.	$55.	....	$43.
	5/4	$97.	$87.	$65.	....	$49.
	6/4	$99.	$89.	$67.	....	$50.
	8/4	$102.	$92.	$69.	....	$52.
	10/4	$109.	$99.	$82.	....	$55.
	12/4	$115.	$105.	$87.	....	$55.
	16/4	$132.	$122.	$110.	....	$56.
1940	4/4	$80.	......	......	$49.	$37.
	5/4	$82.	......	......	$55.	$42.
	6/4	$84.	......	......	$57.	$43.
	8/4	$86.	......	......	$59.	$45.
	10/4	$92.	......	......	$67.	$47.
	12/4	$97.	......	......	$72.	$47.
	16/4	$112.	......	......	$92.	$47.
1939	4/4	$72.	......	......	$49.	$36.
	5/4	$75.	......	......	$54.	$39.
	6/4	$75.	......	......	$54.	$39.
	8/4	$77.	......	......	$55.	$41.
	10/4	$87.	......	......	$64.	$47.
	12/4	$92.	......	......	$69.	$52.
	16/4	$105.	......	......	$85.	$58.
1938	4/4	$72.	......	......	$50.	$38.
	5/4	$74.	......	......	$54.	$40.
	6/4	$75.	......	......	$55.	$40.
	8/4	$77.	......	......	$57.	$42.
	10/4	$82.	......	......	$66.	$50.
	12/4	$88.	......	......	$72.	$52.
	16/4	$105.	......	......	$88.	$55.
1937	4/4	$70.	......	......	$53.	$39.
	5/4	$73.	......	......	$56.	$45.
	6/4	$73.	......	......	$56.	$45.
	8/4	$75.	......	......	$60.	$48.
	10/4	$82.	......	......	$70.	$55.
	12/4	$90.	......	......	$73.	$55.
	16/4	$115.	......	......	$90.	$60.

In the aggregate, we notice a slight increase from 1937 to 1941. It seems that the lumber industry is recovering, although slowly, from the depression of 1929.

Chapter VIII

PAPER AND YELLOW BIRCH VENEER AND PLYWOOD

The use of birch veneer presents this outstanding advantage that the maximum surface of matched and uniformly patterned figure may be secured without resorting to stock of full thickness. Generally speaking, the different patterns obtained look nicer and in the same time maximum economy of rare stock is achieved through the cutting in thin layers. Also, and this is true especially in the furniture industry, more attractive products are obtained at a cheaper price.

Birch plywood, on the other hand, is characterized by a greater strength as compared to a solid piece of same thickness, and a decrease in shrinkage and swelling when properly constructed. Both veneer and plywood will be dealt with separately.

Birch veneer

Preparation of birch veneer: Birch logs cut for veneer production must be clean, straight and sound. Logs smaller than 15" in diameter are rarely rotary cut.

After the logs have been cut into bolts, they are rolled into hot water vats and soaked at temperatures not exceeding 180°F. After this treatment, the remaining of the bark is removed and the bolts are ready to be turned into veneers. The great bulk of birch veneer is rotary cut. The sawing, slicing and half round cutting are chiefly resorted to when the main purpose is to obtain figured woods and not great production.

However, curly birch is best cut on the rotary because the figures show better when cut across.

Since some bolts are suited for face veneer, others for selected red, curly or simply crossband or core veneer the operator has to use his own judgment to set the lathe at the right point for the right thickness. The next step consists usually in the cutting of the veneer into the desired dimensions by means of clippers. Then the sheets are dried to the proper moisture content depending on the purpose they are going to serve.

The Drying of birch veneer: Birch veneer undergoes a preliminary drying designed to bring the moisture content down to 12%. This drying ordinarily takes place in suitable rooms where humidity and temperature may be controlled to a certain extent. Artificial driers are used if it is necessary to speed up the operations. After the drying is over, veneers are sorted according to their qualities.

Properties and Uses of Birch Veneer: Birch veneer can be produced in thicknesses up to 1/150 inch. The tendency to warp and to cup upon a change in moisture content are marked especially in very thin sheets. Also, when reduced to these thicknesses, birch veneer dry very rapidly in suitable locations and must be handled with care because of its great tendency to split.

The strength of birch veneer is claimed to be greatly increased by a new treating process. Casselman discusses this process in the Hardwood Record of January 1939. The veneer is simply impregnated with synthetic resins of the phenol type. This can be done either under pressure in a cylinder or simply by soaking green veneers in a solution of resin. Then the resin is allowed to diffuse for a certain period of time and after that it is set by a heat treatment. Tensile strengths as high as 50,000 pounds per square inch have been found during tests carried on with birch veneer treated in that way.

Birch veneer may be used as veneer or plywood. The industry of crates and boxes calls for a large amount of veneer of second quality. Next in importance is the basket industry which also draws a large supply of birch veneer. Very often furniture drawers are made of this veneer (sides and bottom).

Selected and unselected beautiful birch veneer is well adaptable to doors, furniture tops, panels, and for all purposes requiring attractively figured wood over areas larger than can be obtained in one piece of solid birch.

Birch veneer for cabinet work is usually available in the following dimensions:

Quartered veneer:	9" by 16 feet
Flat-cut veneer :	18" by 16 feet
Rotary-cut veneer:	36" by 10 feet

Although varying from month to month, birch veneer prices are considered to be in the low-medium range[61].

"Flexwood", a new product jointly manufactured and marketed by The Mengel Company, Louisville, Ky., and the United States Plywood Corp. N.Y.,seems to offer promising opportunities for the use of birch veneer and veneers of other species as well.

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[61] "Veneers". Folder prepared by The Veneer Association of Chicago.

As described in the leaflet "Flexwood for Modern Decoration" published by the U.S. Plywood Corporation,

> "Flexwood is genuine wood veneer cut to 1/85 of an inch, and glued under heat and hydraulic pressure to cotton sheeting with a waterproof adhesive. Flexwood is not a synthetic.
>
> A patented flexing operation alters the cellular unity of the wood to produce a limp, pliable sheet which will not split or crack. It may be applied by hand to any smooth surface, flat or curved. Flexwood cement, which makes a permanent bond, is used to apply Flexwood. Standard sizes of stock materials are 18-in. and 24-in. widths and 8-ft. and 10-ft. lengths."

One important drawback of Flexwood is the high price at which it sells. Birch Flexwood is marked at $0.40 per square foot (effective March 1, 1940).

Birch plywood

By far, the bulk of birch veneer is used in the manufacture of plywood. The principles of plywood manufacture are too well known to be discussed here. However, let us remind that the moisture content of the pieces to be glued up together has an important bearing on the strength of the finished product, and varies with the type of adhesive (dry film) used.

Synthetic resins are now generally used for the manufacture of plywood. They are divided into two classes: the phenol-formaldehyde and urea-formaldehyde types. The former is much more in favor and therefore we will discuss it briefly.
The phenol-formaldehyde is prepared by the mixing of phenol and formaldehyde under certain conditions so that they remain on a reactive state. With the application of heat, they set or harden (polymerisation). This type of synthetic resin

can be produced in various forms, e.g., as sheets, powders, lumps and solutions. The sheet form is the most usual, especially when thin veneers are involved.

The moisture content recommended in a 3-ply construction is 10% for the core and about 5% for the faces. A 5-p ly plywood requires that the crossbands should be at 10% and the other plies at about 5%.

The gluing of plywood with a dry film of synthetic resin requires a hot press. The temperature in every case should not exceed 350°F. and the pressure is limited by the crushing strength of wood at the temperature of the pressing. The pressure period varies with different jobs; but the proper conditions are always specified by the seller of dry film glues.

The drying of plywood is an important phase in its manufacture. When dry film resin glue has been used for the bonding, the plywood is usually piled and allow to condition in the workroom. On the other hand the drying of panels made with thick cores requires more care because the adhesive which is ordinarily used in that case is mixed with water. Therefore birch panels should be piled on stickers and dried in panel kilns. Birch plywood can also be dried on mechanical veneer driers and on hot-plate presses. This is done chiefly when the moisture content of plywood is high on account of the use of water-resistant glues.

In connection with the manufacture of birch panels and plywood, and in facing work, it should be remembered that this species has a marked tendency to be stained by strongly alkaline glues. These glues should therefore be avoided when the color imparted to wood is likely to be objectionable.

Difficulties are often experienced due to the warping of thick lumber cores. Sorensen and Perry[61] suggest to cut one or more saw slots in the back side of the core. The depth of cut can be about 75% of the thickness of the core, and the width such that the slots can be plugged up with the veneer used for the assembly. Besides preventing warp, these slots facilitate the escape of moisture when the plywood is pressed.

Similary the same authors[62] propose the cutting of slots in the lumber core of banded plywood in such a way that the moisture can escape; otherwise steam blisters may be formed when plywood is hot-pressed.

Birch plywood properties and uses: Birch plywood, properly constructed, presents important advantages over solid wood. Thus, the strength properties along and across the grain are more nearly equalized. Theoretically, the more plies in a panel, the more equal the strength in various directions. Birch plywood is also more resistant to checking and splitting, and it is less affected in its dimensions with changes in moisture content.

With respect to the use of glue in the dry film form, it is claimed that the shear strength of birch veneer increases from 298 to 400 pounds per square inch with the use of 2 films of resin (paper impregnated on both sides)[63].

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[61] Sorensen, Ray and Perry, Thomas D. See Ven. & Plywood May 1940.

[62] See Ven. & Plywood, June 1940.

[63] Kynoch, W., 1941. Lectures in "Plywood and Laminated Construction", School of Forestry and Conservation, U. of Mich.

Birch laminated construction (different layers glued together with the grain parallel) is generally not stronger than a solid piece of wood of the same size, but the tendency to check and to warp is sensibly reduced especially in wide articles. The laminated construction permits the use of cheaper material; thus, the remaining of the log in rotary veneer can often be sawed and turned into laminated cores for the construction of plywood.

We should point out that the laminated construction, when worked into curved members, offer greater strength than solid wood band-sawed to the proper shape because of the continuity of the grain. In that connection, we will explain in the Appendix a new process through which solid wood may be bent rather easily. This process, if developed on a commercial scale, will prevent in many instances the resorting to the band-saw for the turning of curved-shape members.

Birch plywood can be used with advantage for the making of baskets, crates, bodies of light vehicles, moldings and other articles.

Plywood of good quality, like curly birch plywood, is used advantageously in the furniture manufacturing. As we have pointed out elsewhere, veneer cut from birch stumps are often very attractively figured and thus contribute to the making of choice tables, desks, etc.

Laminated birch, as we have seen, is often used in the making of seats, benches and other similar articles requiring curved and rather strong members. Presumably, yellow birch laminated construction should well fit also in the making of laminated arches developed fairly recently at the Madison Forest Products Laboratory.

A new promising field for birch plywood seems to be the aircraft industry. For, birch is recognized to be tough, elastic and firm in texture. Its relatively smooth structure, and straight grain, its fairly constant strength values recommend it for the manufacture of airplanes.

New possibilities in that field and others arise from a new process developed recently. Numerous sheets of thin veneers are interlaced with synthetic resins, highly compressed at a temperature above the boiling point. The product is a brownish, heavy material, stronger than solid wood of same dimensions with a greatly reduced tendency to shrink and swell. This material can possibly be used for press tools, air-screw blades, patterns and similar purposes.

The grading

We include here the rules, as defined by the National Hardwood Association in 1940, concerning the grading of rotary cut birch veneer. It must be understood that the National Hardwood Code shall bind any contract only when it is specified that such shall govern.

No.1 Grade (Faces)

"Sheets of any thickness will admit sap, splits that close, and slight discolorations, otherwise must be clear.

Select No.1

Sheets of any thickness, graded the same as the No.1 grade except that it shall be selected as to color.

No.2 Grade
(Sound Backs, Cross Banding Center Stock and Drawer Bottoms)

Sheets of any thickness shall admit sound knots, firm doze, splits that close, pin worm holes, discolorations, smoothly cut.

NO.3 Grade
(Reject Backs and Box Stock)

Sheets of any thickness shall admit knots, worm holes, discoloration, grub or knot holes, not over 1" in diameter, rough or loose cutting, open splits and checks, not to exceed 1/2" in width and 25% of length of piece.

Selected Sheet Stock

Each sheet must be clear face, unselected for color, random widths, 5 1/4" to 38" wide; 42" long and longer. In all thicknesses up to and including 1/15" the sheets shall be 9" to 38" wide; to be 42" and longer with 75% 62" and longer. In all thicknesses of 1/12" to 1/8", inclusive, the sheets shall be 5 1/4" to 38" wide, 50% 11" and wider; to be 42" and up long, 75% to be 82" and longer.

No.1 Sheet Stock

Unselected for color and random widths, 5 1/4" to 38" wide; 42" long and longer. In all thicknesses up to and including 1/15", the sheets shall be 9" to 38" wide; to be 42" long and longer, with 75% 62" and longer. Each sheet to grade 75% clear face cutting and each cutting to be either full length or full width of the sheet. No cutting considered less than 9" wide or 21" long. In all thicknesses of 1/12" to 1/8" inclusive, the sheets shall be 5 1/4" to 38" wide, 50% 11" and wider; to be 42" and up long, 75% to be 82" and longer. Each sheet to grade 75% clear face cutting, and each cutting to be either full length or full width of the sheet. No cutting considered less than 5 1/4" wide or 21" long."

No definite rule has been laid down by this Association with respect to the grading of hardwood plywood, except that the inspection shall be made according to the specifications governing individual contracts.

Chapter IX

USES OF PAPER AND YELLOW BIRCH

This chapter deals primarily with the actual uses of birch in the Province of Quebec. Nevertheless, a word will be said about other possible uses which can help in the solution of a better utilization of this important hardwood. The chemical utilization of birch will be dealt with in a separate section.

Actual Uses

The total quantity of paper and yellow birch cut in the Province of Quebec during 1937-38 and 1938-39, together with the average price per thousand cubic feet and the total value are given in the table below. These values apply to timber cut both on crown and private lands.

Year	Species	Total cu.ft.	Av. price (M.cu.ft.)	Total value
1937-38	Paper birch	3,729,097	$112.00.	$417,658.86
	Yellow birch	15,979,367	124.85	1,995,023.96
1938-39	Paper birch	5,612,400	103.95	583,358.98
	Yellow birch	11,505,698	124.75	1,435,335.82

Table 24:- Volume, average price per thousand cubic feet and total value of paper and yellow birch timber cut in Quebec during 1937-38 and 1938-39[64].

[64] Statistics of the Quebec Forest Service, Office of the Forest Products.

Note that the ratio of the volume of yellow birch cut to the volume of paper birch has dropped from 4.3 to about 2 from 1938 to 1939. Fluctuations of the markets can only explain this difference, inasmuch as the table above does not give enough data to ascertain that paper birch products have gained more importance in 1939 than 1938.

It is interesting to point out here that

a) in 1937-38, the volume of paper and yellow birch cut on private lands exceeded the volume cut on crown lands by 210% and 146% respectively;

b) in 1938-39, corresponding figures were 1100% and 220% respectively.

At this rate private lands will be soon exhausted inasmuch as they contain about 3.2% of the total volume of birch in the province (see table 4, page 8)

Among the typical uses of yellow birch, let us mention the following:

Flooring	Railway ties
Furniture	Railway coach work
Flush doors	Turnery
Interior finish	Tin-plate boxes
Cabinet-work	Shuttles, spools, bobbins
Automobile bodies	Parquetry
Boxes and crates	Cooperage
Veneers and plywood	

Unfortunately, it was impossible to secure data as to the importance of each item. However, the number of ties manufactured in Quebec during 1936-1937 amounted to 328,252 pieces for a value of $176,824.00[64].

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[64]The Lumber Industry 1936-1937, Canada Dept. of Trade & Commerce, Dominion Bureau of Statistics For. Branch, p.60.

The same remark applies to paper birch and we must confine ourselves to a simple mention of its typical uses.

Spools	Brushes
Bobbins	Hoops
Dowels	Novelties
Clothes-pins	Wash-boards
Shoe-pegs	Crates
Woodenware	Toys
Buckets	Crutches

In connection with the furniture industry, light-colored woods like birch seem to fit better than darker wood in modern houses because, as Butt[65] put it,

> "light-toned woods give an effect of greater spaciousness in small interiors. The modern home, house or flat, is generally of limited dimensions: if dark-coloured woods are used, like chestnut and mahogany, the least unsuitability in size or proportions is at once apparent. But off-white wood does not seem to bulk so heavily; it may be even toned-in with its background, and it is less liable to suggest overcrowding."

Possible Uses

In this section, we include the minor products which can be made out of paper and yellow birch. It is difficult to know which of the following articles are turned out in Quebec inasmuch as many people fail to report in detail the nature of their business. For the same reason, it is not known what is the relative importance of each item mentioned below (see page 108).

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[65]Butt, Baseden, 1937, Light-coloured woods for furniture, Wood, 377-79.

Paper birch	Yellow birch
Buckets and pails	Buckets and pails
Camp stools (parts)	Balusters
Dry measure (peck)	Banjo hoops
Handles	Bobbins
Hosiery boards	Cradles (baby)
Hoops woodenware	Cribs (children)
Moulding (window)	Crutches
Paint brushes	Handles
Piano stools	Hayrakes
Quills	Hubs (wagons)
Rungs (turned chair)	Patent table(invalid furn.)
Sawhorses	Sheating
Speeders	Sieve runs
Spindles (turned chair)	Speeders
Spinning wheels	Spindles
Table slides	Spokes
Toy wheelbarrow	Stairwork
Twister	Street sprinkler parts
Wheels (toy wagons)	Tables
Wheels (toy wheelbarrows)	Tail board (wagon)
	Toy wagon parts
	Twisters
	Washstands

For the uses of birch veneer and plywood, the reader is referred to Chapter VIII.

Chemical utilization of paper and yellow birch

Bark: Outside the chemical utilization, birch bark does not find important uses in commercial practice. We know that before paper was introduced, birch bark served as a writing paper. In North America, the Indians were unsurpassed in the utilization of birch bark for the making of canoes, tents troughs and buckets. Snow[66] points out that it has already been utilized for covering houses and for the making of cordages, utensils and even rude clothing.

However, birch bark used as such without any chemical process is to-day utilized chiefly for turning small and

[66] Snow, Charles Henry, 1910, The Principal Species of Wood, 2nd edition, page 74.

attractive articles sold to tourists.

So far, tannin has been obtained chiefly from hemlock, white spruce, tamarack and balsam fir in Eastern Canada. It seems that birch offers some possibilities in that respest. Yakimov and Tolski[67] carried out some experiments with birch bark. They discovered that the tannin content of bark decreases with an increasing distance up the trunk and increases with the age of the tree: it varies from 5.4% to 10.6% in bark 20 to 80 years old. In the laboratory, a light-weight, light-brown leather was produced. The question arises as to the economy of such a process, because the tannin content of birch bark does not compare with hemlock (14%).

Oil may be prepared from the bark of birch and as a fact much of the natural oil produced in the United States comes from that source. This oil is used as a flavouring material for drugs, candies and toilet preparations[68]. It is prepared by reducing the bark to chips and then by soaking in warm water for 12 to 14 hours. During the soaking, methyl salicylate is formed through enzymic action. Then, a distillation process follows. Huerre[69] reports that during his laboratory experiments, the oil produced had an almost constant composition. The yield varied from 7% to 8.4% of the weight of bark.

So far (1935), no wintergreen oil or birch oil has been produced in Canada.

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[67] "Birch bark as a tanning material", Ch. Abst.24, 1930,p.4652.

[68] Canadian Woods, op.cit., p.276.

[69] Huerre, R., 1929. Birch oil, Cuir Tech., 18. 231-2.

Sap: Voss[70] calls the attention to the possible use of birch sap for the manufacture of cosmetics and soaps. The sap is collected during early spring. Trees of 12 to 14 inches in diameter are said to yield about 2 liters (2.1 liquid quarts) each. An alkaline is added to the sap and the product used as outlined above.

Leaves: A product with diuretic properties has been prepared with birch leaves. Zellmann[71] treated the leaves with a dilute aqueous solution of $NaHCO_3$; the extract was then treated with an absorbent at a ph 3.5 to 6.8 and the absorbent removed later by a dilute solution of $NaHCO_3$. The final extract was evaporated.

Wood distillation: Charcoal is the only directly marketable product of destructive wood distillation. Birch is extensively used in Quebec for the production of charcoal. In 1937, there were 194 producers with a capital of $80,020.[72]; the volume of birch utilized is not known.

The other products derived from the destructive distillation of birch are acetic acid, methyl alcohol and wood tar. It is estimated that 25% of the wood employed in Canada for that process is birch, maple and beech coming out with 50% and 25% respectively.[73]

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[70] See Chem. Abst. 28, page 3260.

[71] See Chem. Abst., Feb. 1938, "Therapeutic preparation".

[72] See les Statistiques sur les transformations mécaniques et chimiques des bois, page 45, Lands and Forests Dept.,Quebec1937.

[73] Canadian Woods, op.cit., p.267.

Pulp and paper: The utilization of hardwoods for the making of pulp and paper has been called to the attention of the newsprint people in Quebec due to a possible shortage of accessible softwood stands within the near future.

Researches have been carried out along that line which are summarized by Hill in an article printed in the Journal of Forestry, Volume 28, page 1146-52.

For the mechanical pulp, it is recommended first to steam the logs slightly (too severe a steaming imparts a dark color to the pulp). Paper birch is said to give short but very fine fibers. The yield is 2950 pounds of pulp per 100 cu.ft. of wood, or 500 pounds more than with spruce. The pulp is slightly pink.

The sulphite process gave a strong pulp with a yield of 1330 pounds per 100 cu. ft., or 300 pounds more than spruce. This process proved to be the best one for the pulping of birch.

The sulphate and semi-chemical processes turned out a satisfactory pulp with a yield of 43.2% and 75 to 85% respectively.

Kang and Libby[74] applied the De Vains process to the pulping of yellow birch. A first batch of chips was treated with soda at concentrations of 4,8,12 and 15%. Another batch was treated by chlorination with 20,25,30,35 and 40% Cl. The concentrations are based on the weight of the air-dry chips.

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[74] See Chem. Abst., 24, page 4151.

The conclusions were as follows:

a) Pulp made by chlorination was stronger and had a superior color in every case;

b) this pulp was also more flexible and contained practically no lignin;

c) the loss on bleaching the chlorinated pulp was 1% against 2% for the soda pulp.

However, the strength of the chlorinated pulp was reduced by the bleaching proving that this last operation has to be carefully controlled;

d) The chlorination process yielded 1% more pulp than the soda process.

No doubt can exist after these experiments as to the possibility of converting our birch into pulp and paper. The next step is to find out an economical way to take the raw material to the mill.

Plastics: Considerable work is being carried out at the Madison Forest Products Laboratory as to the utilization of wood in the form of plastics. Experiments were conducted with mill-run hardwood sawdust, such as maple, oak, hickory, gum and aspen or a mixture of these species. The sawdust first undergoes a hydrolisis pretreatment with sulphuric acid in a digester, then the plasticizers are added to the hydrolized material and the whole is molded into the desired shape under proper conditions of temperature, pressure and pressure period. The finished product is hard, dense and exhibits many of the useful properties of more expensive pressed materials.

Indications so far permit to believe that any of the common commercial woods may be processed into plastics. There is no doubt that our birches will easily fit in the plastic industry when this new treatment will operate on a commercial scale. And much of our waste wood will be utilized to the best.

Conclusion

It is hoped that this study has made clear the importance which paper and yellow birch deserve in the Province of Quebec. A constant attention given to these species from the very beginning of their growth until the final product is turned out will prove very profitable by making possible full crops of good quality and a better utilization. Thus, sound economy will be achieved out of an important portion of the natural forest resources of Quebec.

Undoubtedly, more intensive researches are needed in connection with the production of this raw material and its conversion into articles designed to satisfy human wants. And it is hoped that progressive steps will be soon made along that line.

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APPENDIX

The following pages deal with some laboratory experiments as to the effect of treatment with crystal urea on the bending properties and strength of paper and yellow birch. These experiments were divided in two parts: the bending itself and the tests in static bending with urea-treated specimens. The results are analyzed and the possibilities carried by this new treatment are emphasized.

Successful commercial operations of this new process will mean products at lower cost, inasmuch as crystal urea sells at only $80.00 a ton or $0.04 a pound, and the apparatus involved is not likely to be complicated.

Finally, several procedures carried out in an effort to color yellow birch throughout the wood are described briefly and analyzed.

CONTENTS Page

LIST OF TABLES AND ILLUSTRATIONS

EFFECT OF TREATMENT WITH CRYSTAL UREA ON THE BENDING PROPERTIES AND STRENGTH OF YELLOW AND PAPER BIRCH

The idea of treating wood with a saturated solution of crystal urea in an effort to facilitate its bending properties was discovered by accident at the Madison Forest Products Laboratory, where people have been engaged for some years now in research as to the possibility of seasoning wood by chemical means. Mr. W.K. Loughborough happened to soak samples of swamp oak in a saturated solution of crystal urea. After a heat treatment at 212°F. in an oven, the samples appeared to be thermoplastic and, as a fact, Mr. Loughborough was able to bend them into various forms while they were hot[1].

But the question arises as to how different species of wood will behave after such a treatment. Will they bend readily and assume a permanent shape? Does the strength of the wood decrease on account of the treatment? We have carried out some experiments along that line with samples of paper and yellow birch in an effort to answer these two questions.

The bending test

Procedure: Sound logs of paper and yellow birch were obtained from people living in the vicinity of Ann Arbor. They averaged a diameter of about 12 inches and they were presumably cut in the central portion of the trunk. They were sawed while green in short sticks of 1/2 by 1/2 x 12 inches, no effort being made

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[1] See American For., 47, 178-179. Molding Wood to Man's Will, by F.J. Champion.

to secure sticks along the tangential or the radial plane of the logs.

Then a saturated solution of crystal urea was prepared by dissolving 14 pounds of salt in 14 pints of cold water(room temperature), or a proportion of 1 in 1 based on weight. 50 green sticks of yellow birch and 30 of paper birch were then immersed in the solution. The soaking period varied in geometric progression from 4 days to 16 days. Then the pieces were allowed to dry at room temperature, under the conditions which exist in the laboratory rooms. The average drying period lasted one month and a half.

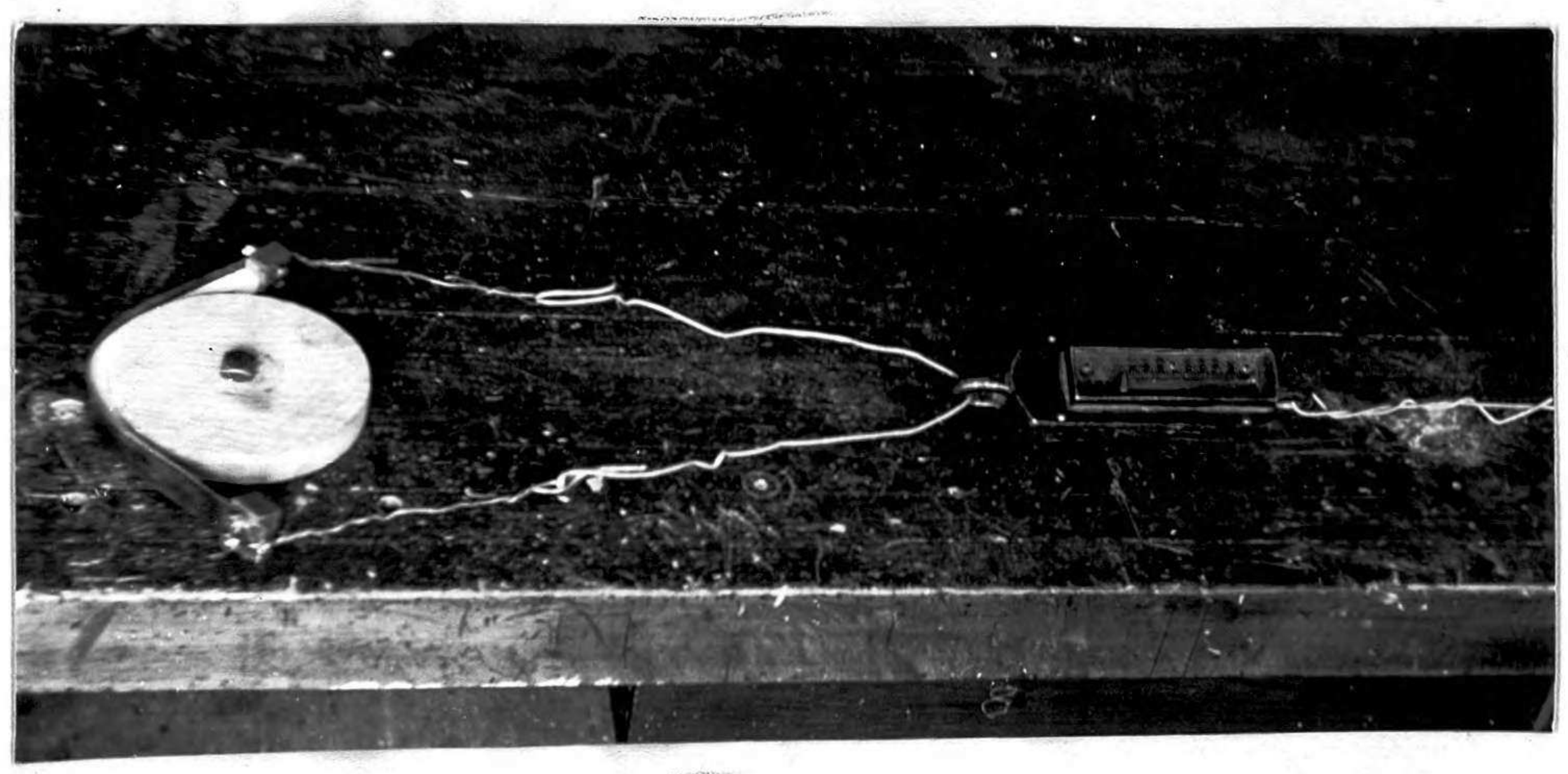
Apparatus: Picture 1 shows the apparatus used for the bending of the sticks. The six-inch disc is made of oak. The reason why a wooden disc was used to bend the pieces around is that we must avoid too rapid conduction of heat from the heated test piece to the support. Better results were obtained in the bending of hot birch pieces. As seen, the disc was anchored to a working table by means of a bolt.

The steel strap is made of spring steel 1" wide by about 1/32" thick. Picture 3, NO.5, shows well how the test piece fitted in the steel form. It is important to have as tight a fit as possible so that the stresses developing in the stick during the bending can be checked by the strap. For the same reason, the metal stops, at both ends of the steel form must be at 90 degrees with the strap.

Again on Picture 1, we see(although hardly) a bolt driven into the table just back the bent piece. This bolt was intented to keep the bending stick close to the disc so as to prevent local crushing at the point of greatest curvature.

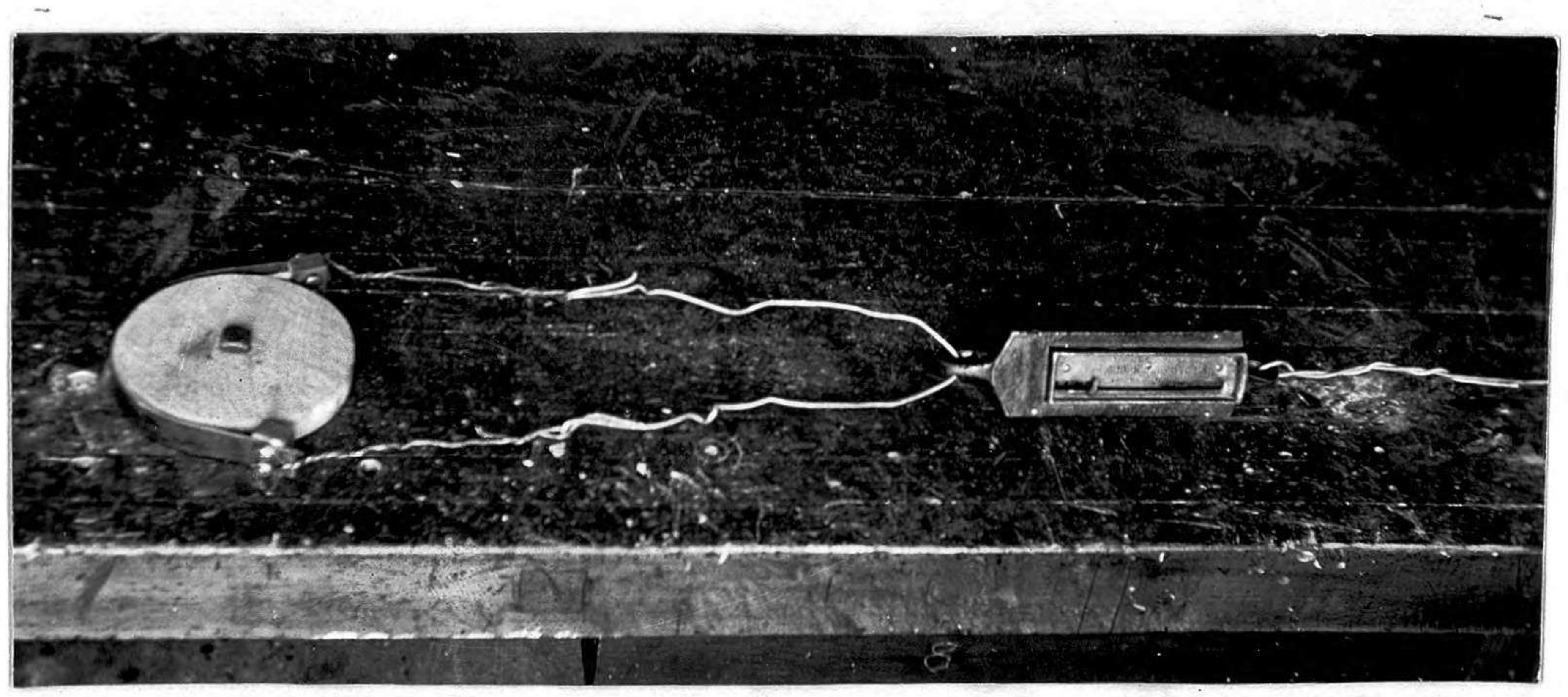
Finally, a dynamometer scale was introduced into the whole apparatus in an effort to measure the strength required during the test. This scale is marked from 0 to 500 pounds with an accuracy of 5 pounds. The bending test was made by hand through the wire partly shown at the right end of the picture.

Picture 1



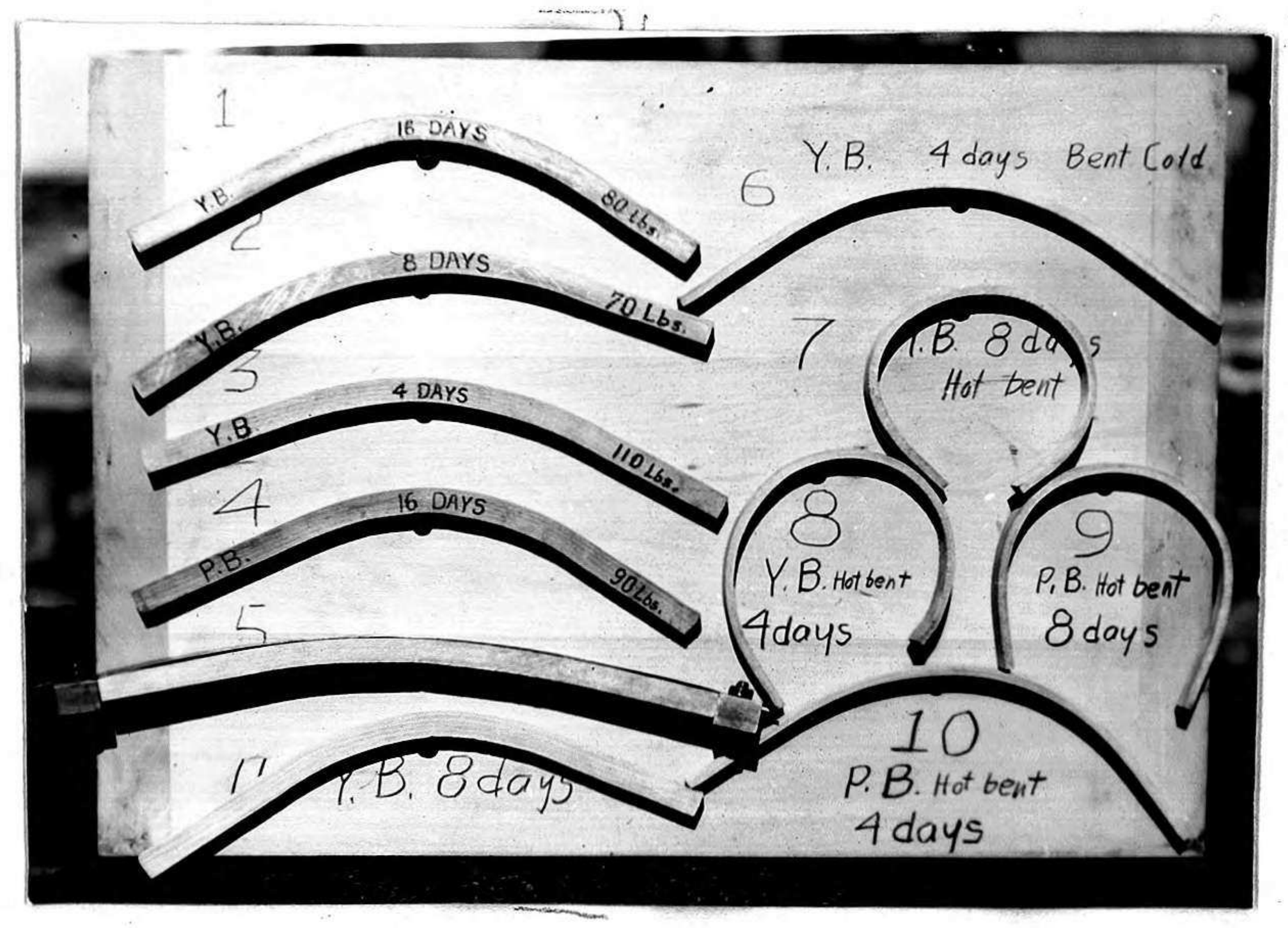
Picture 1: Bending a yellow birch stick, 1/2" by 1/2" by 12 inches.

Picture 2



Picture 2: Bending a small birch stick, 1/4 inch thick by 1/2" by 12 inches.

Picture 3



Picture 3: Effect of crystal urea treatment on the bending properties of small birch sticks.

The testing: Dry sticks were placed in an oven and heated up to 212°F. for an average period of one hour and a half. As noted above, the pieces were tested hot, immediately after being removed out of the oven. The force required for the bending varied from 80 to 110 pounds as indicated by the scale, and was applied during 5 minutes in each case. The piece of birch shown in Picture 1 appears on Picture 3 as No.11, 8-day soaking period. Note the slight outside curvature at both ends of the piece. When this curvature began to develop, it proved to be almost impossible to give the piece greater bending by hand.

The effect of outside curvature was less sensible as shown in Picture 3 when pieces of 1/4" thick were involved.

Results and remarks: With the apparatus just described, exact measurements of the strength necessary to bend the different pieces proved to be difficult to take. A more accurate balance is suggested. Some of the results appear in Picture 3. All the details are given, except that pieces No.6,7,8,9and 10 were 1/4" thick by 1/2" by 12 inches. Note that piece No.1 has been bent across the growth rings; in other words, the curvature developed along the radial plane. Local crushing was done on the concave side at the middle of the stick. In piece No.2, the grain runs at approximatively 45°: no crushing at all. Piece No.3 bent along the growth rings after only 4 days of soaking: the result was perfect although the curvature is not pronounced.

Piece No.4 is curved along the growth rings: perfect result. Approximatively 30 tests were run with yellow birch and 20 with paper birch. About half of the sticks were spoiled for excellent reasons as will be explained below. These experiments lead the author to the following remarks:

1) good results were achieved in pieces characterized by straight grain, running in a direction parallel to the axis. It is important that the continuity of the grain be not broken on the tension and compression sides;
2) as a rule, the tests were carried out with more facility and better results with pieces bending along a tangential plane. However, no appreciable difference was found in pieces with grain running at 45 degrees. Pieces bending along radial planes failed to give so good results;
3) the bending of pieces having soaked for 8 days proved not to be more difficult than the bending of the 16-day soaked sticks, and the results were good in both cases. However, a soaking period of

4 days apparently does not allow enough salt to diffuse into the wood: consequently the performance was not so good.

Obviously, the sizes and shape of the pieces is an important factor to take into consideration. For instance, the factors mentioned in 1) and 2) apparently did not affect the 1/8" thick pieces, but the soaking period did, as shown in Picture 3. Some pieces of birch were bent cold with a fair success, but the author cannot afford to draw any conclusion on account of the few experiments carried out.

4) The author did not encounter more trouble in bending paper birch than in bending yellow birch. However, as noted elsewhere, means of taking measurements of the force applied have to be improved. Presumably, a better apparatus will show that yellow birch requires more strength to be bent than paper birch, and this will be true especially with larger pieces.

The strength test

Procedure: Test specimens were cut from the same logs referred to in the bending test. These logs had previously been end-coated to prevent the escape of moisture.

Green sticks were sawed in lengths of approximatively 20 inches by 1/2" by 1/2". Then each stick was cut off in two so as to give test specimens of 10 inches long by 1/2" by 1/2". Each of the two pieces coming from the original 20-inch stick was carefully labelled with odd and even numbers. Thus, the first 20-inch stick gave pieces 1 and 2, the second gave pieces 3 and 4, and so on. Fifteen paper birch 20-inch sticks were sawed thus giving 30 test specimens all matched two by two. The same amount of yellow birch specimens were prepared in a similar way. As far as possible, the specimens were all heartwood. No special attention was paid to the direction of the grain.

Treatment: A saturated solution of crystal urea was prepared as indicated in the previous test, except that the proportions by weight changed to 3.5 pounds of urea for 5 pounds of water. The weight of urea was reduced in this instance because it was found that the solution was still saturated. The 30 odd-numbered specimens of paper and yellow birch were then immersed in the solution and allowed to soak for 12 days. The corresponding 30 even-numbered pieces were immersed in cold water and soaked for the same period of time.

The test: Three series of static bending tests were carried out as follows:

1) in the first series, 20 specimens were tested wet immediately after being removed from the solution or the water. These specimens were distributed as follows:

Paper birch

5 specimens treated in the crystal urea solution
5 corresponding specimens soaked in water

Yellow birch

5 specimens treated in the crystal urea solution
5 corresponding specimens soaked in water.

2) in the second series, 20 other specimens were tested after having been allowed to dry at room temperature for an average period of three weeks. The distribution of these specimens is the same as in series 1);

3) in the third series, the remaining 20 specimens, dried at room temperature (3-week drying period), were put in an oven at 212°F., removed after 1 hour and a half and allowed to cool down at roo tamperature. The testing followed this treatment. The distribution of specimens was the same as in series 1).

The tests were carried out on a standard testing machine (motor-driven). The head speed was .10 inch per minute, and the load applied on the center of the specimen (9inches of span). The pressure was applied by increments of 5 pounds in the first series (wet specimens). But it was found necessary to adopt increments of 10 pounds for the two other series of tests in order to allow enough time for the readings of the deflections corresponding to the loads.

Results: Table 1, on page 10, gives the results of the tests. The moisture content of the green specimens may look to be a little low, but it varied widely and the figure given is an average. This had no effect on the strength properties inasmuch as the specimens were above or close to the fiber-saturation point. All the strength functions have been adjusted to 12% m.c. except in the case of wet specimens. For this adjustment, the graphical method, as outlined on page 54 of U.S. Dept. Agric. Techn. Bull. No.479, was followed. Likewise, the formulae used for the computation of the strength functions were taken from the same bulletin, page 98.

The following remarks apply to the results arrived at by the tests described above:

1) there was a marked reduction of the load at proportional limit due to the treatment with crystal urea: paper birch proved to be more affected than yellow birch, as it can be seen on Figures 1 and 2 (page 11) and Figures 3 and 4 (page 12);

2) correspondingly, the stresses developed in the fibers at the proportional limit were less in the case of urea-treated specimens than in plain pieces (soaked in water), and this fact proved to be true in every series of tests

Table 1:- Some strength properties, in static bending, of paper and yellow birch after being soaked in a solution of crystal urea.

Species 1	Samples tested 2	Moisture content % 3	Stress at proportional limit p.s.i. 4	Modulus of rupture p.s.i. 5	Modulus of Elasticity 1000 p.s.i. 6	Work at proportional limit in-lb. per cu.in. 7
			Tested green			
# P.birch	5	38.6	4000	5500	743	1.2
§ P.birch	5	23.7	6040	7770	1088	1.9
# Y.birch	5	37.2	4640	6260	865	1.4
§ Y.birch	5	34.6	7010	8310	1150	2.4
			Tested when dry at room temperature			
# P.birch	5	14.4 12.0	6040 6760	9280 10560	1417 1660	1.4 1.5
§ P.Birch	5	8.4 12.0	11850 7500	15100 9630	1395 1304	5.6 4.3
# Y.birch	5	10.2 12.0	8640 8070	11660 10900	1665 1550	2.5 2.4
§ Y.birch	5	7.6 12.0	12730 10950	16220 13850	1496 1395	6.0 4.8
			Tested after being heated up to 212° and then cooled down to room temperature.			
# P.birch	4	11.1 12.0	7120 6840	9830 9450	1594 1535	1.7 1.7
§ P.birch	5	4.6 12.0	14800 10560	17830 13100	1378 1254	8.8 5.0
# Y.birch	5	9.7 12.0	12740 11080	15950 14130	1720 1550	5.2 4.3
§ Y. birch	5	4.1 12.0	14260 11800	18350 13800	1640 1450	6.9 4.7

Means that test specimen was soaked in a solution of urea.
§ Means that test specimen was soaked only in water.

FIG. 1 - LOAD-DEFLECTION DIAGRAM (STATIC BENDING) OF PAPER BIRCH AFTER SOAKING IN CRYSTAL UREA SOLN.

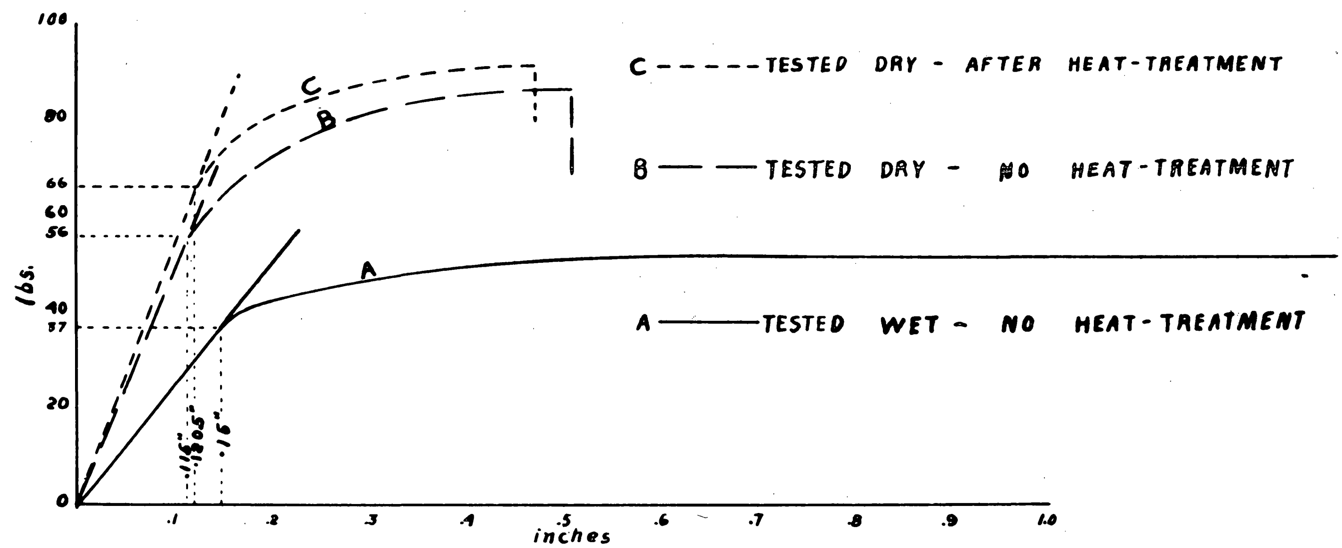


FIG. 2 - LOAD-DEFLECTION DIAGRAM (STATIC BENDING) OF PAPER BIRCH AFTER SOAKING IN WATER ONLY

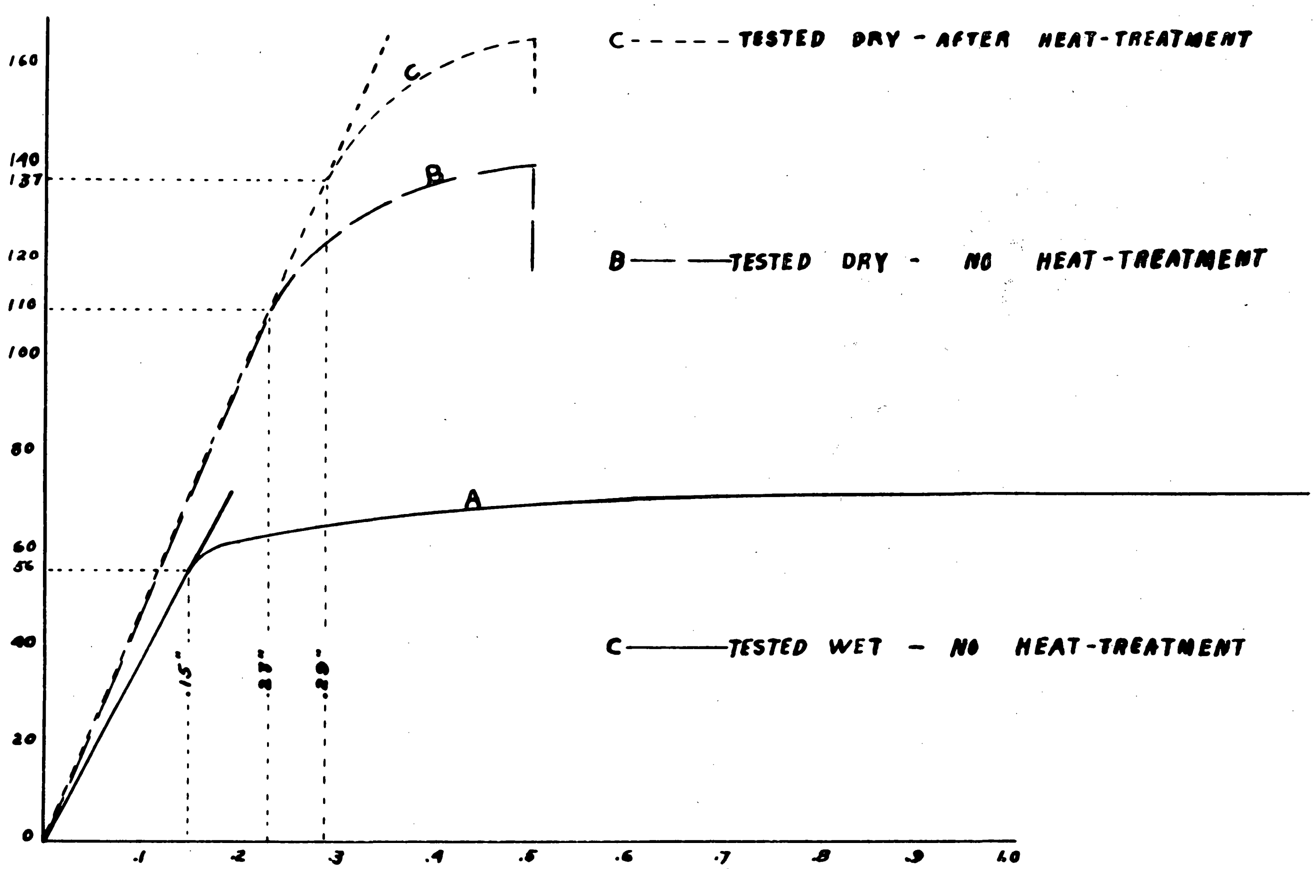


FIG. 3 - LOAD-DEFLECTION DIAGRAM (STATIC BENDING) OF YELLOW BIRCH AFTER SOAKING IN CRYSTAL UREA SOLN.

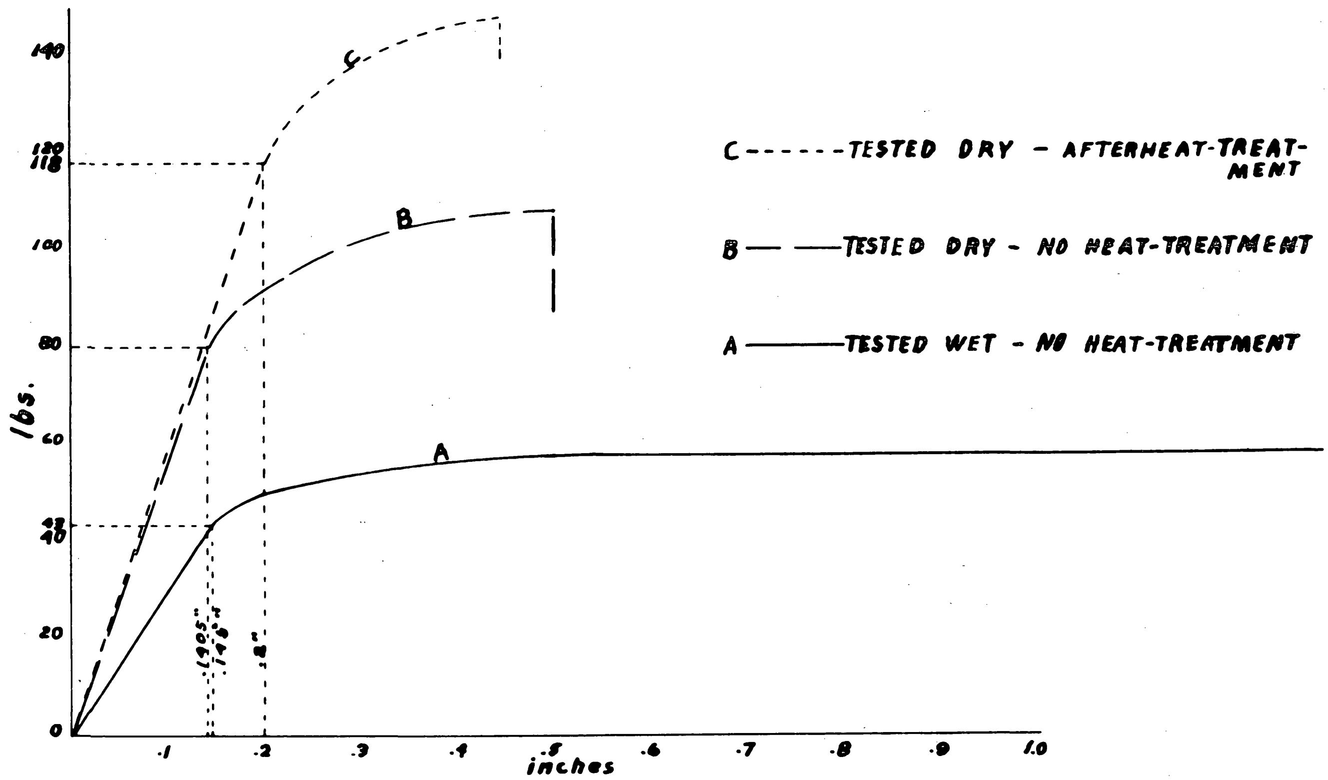
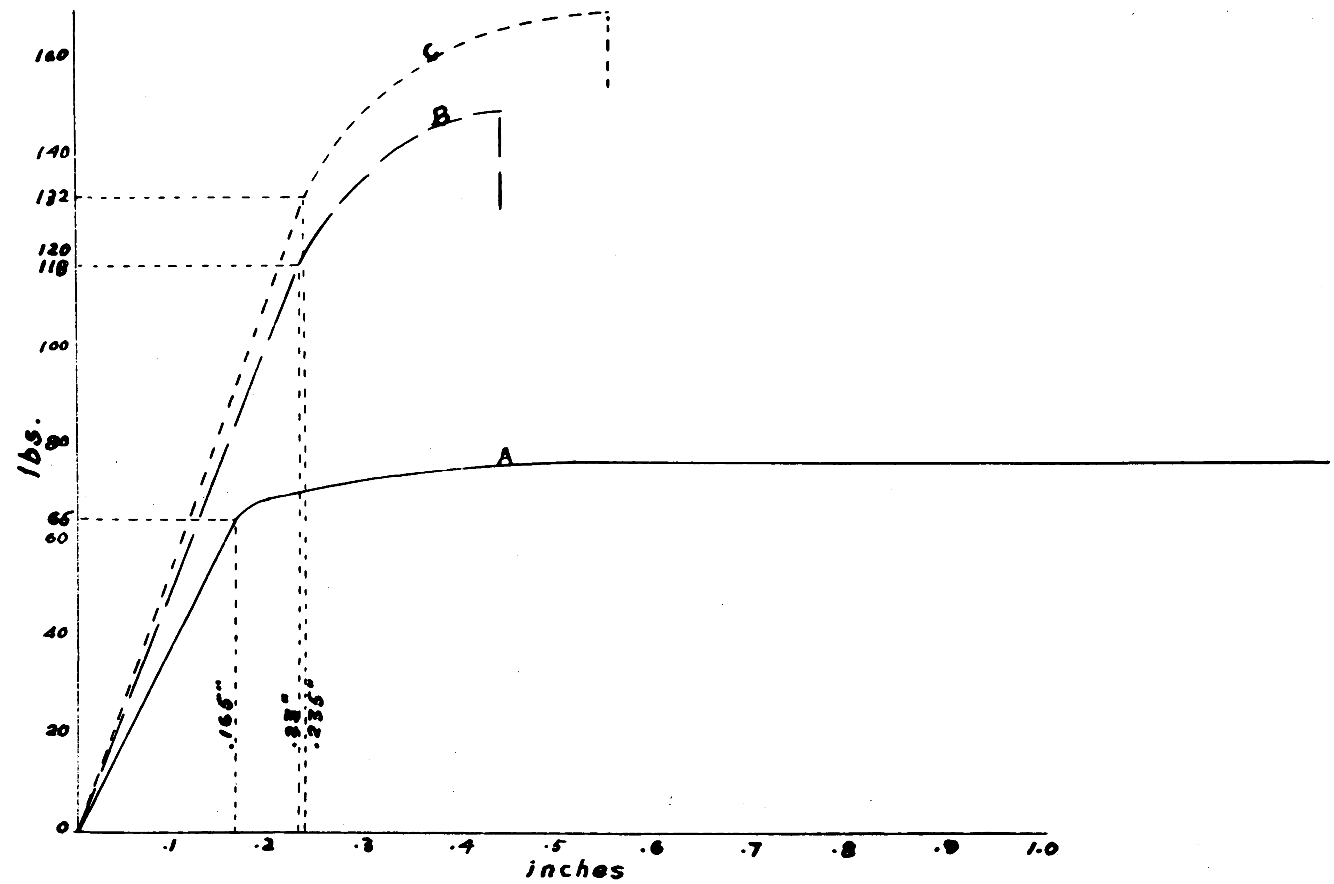


FIG. 4 - LOAD-DEFLECTION DIAGRAM (STATIC BENDING) OF YELLOW BIRCH AFTER SOAKING IN WATER ONLY



In that respect, note that the greatest difference for paper birch appeared after heat treatment, and for yellow birch, it appeared in pieces tested dry (see Fig.5, page 4);

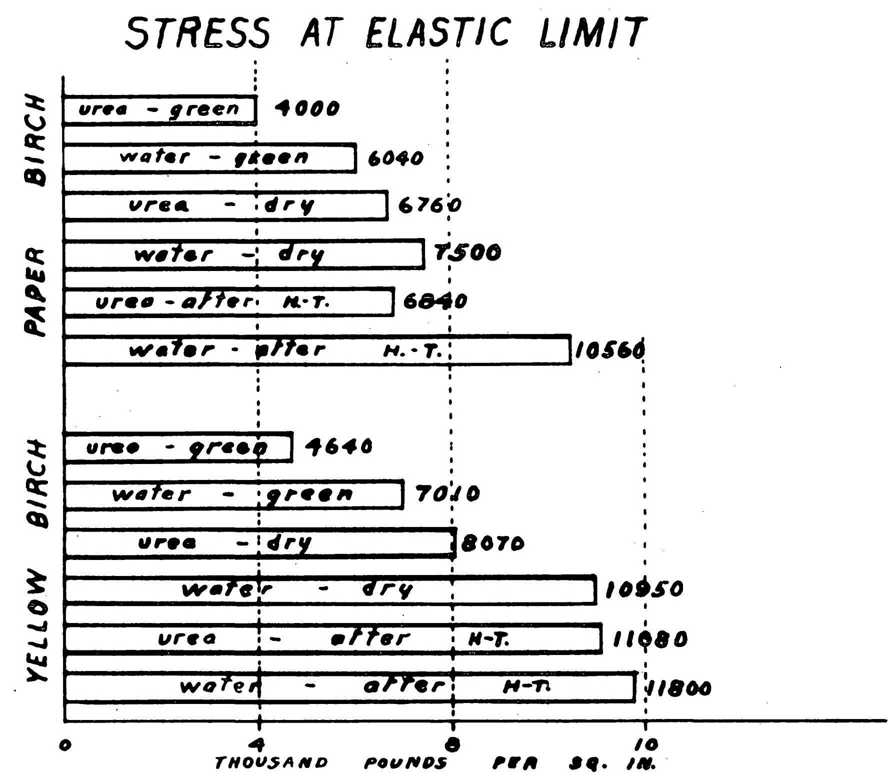
3) except in green specimens, the modulus of elasticity was increased by urea treatment in both species (Fig. 5)

4) the moduli of rupture as given in Table 1, column 5, are not very reliable on account of difficulties encountered during the tests with urea-treated specimens. This is especially true with green pieces, because it was impossible to determine the exact maximum load. The scale beam of the testing machine kept in balance for several minutes even when small cracks appeared on the tension side of the specimen

To summarize the remarks, let us point out that urea treated specimens required a lighter load to be deformed permanently, but they proved to be stiffer than untreated specimens.

Indications: No doubt exist as to the feasibility of bending paper and yellow birch after it has been treated with crystal urea in the way discussed above. A soaking period of 8 days or so under atmospheric pressure is suggested. Under this condition, an average of 5 grams of urea diffused into the specimen, which seemed satisfactory.

The soaking period will presumably be greatly reduced by soaking the wood into the solution under pressure. Obviously,



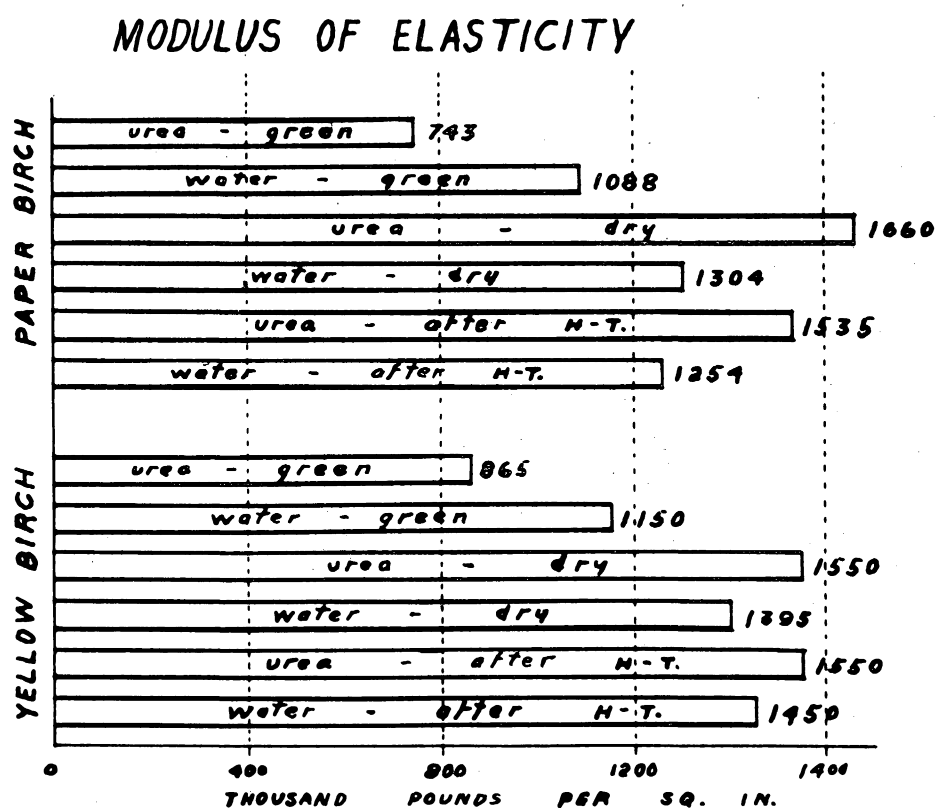


FIG. 5 - EFFECT OF TREATMENT WITH CRYSTAL UREA ON SOME OF THE MECHANICAL PROPERTIES OF PAPER AND YELLOW BIRCH

the author has not carried enough tests to specify what should be the right procedure to follow. Besides that, this new way of treating wood is only on the experimental stage.

We have seen how some paper and yellow birch strength properties were affected by this new treatment. It is impossible to draw general conclusions at the present time. However, we do not see why furniture with curved members could not be manufactured out of wood treated with crystal urea.

The next step should be to find out the finishing properties of such a wood.

THE COLORING OF PAPER AND YELLOW BIRCH

Various attemptshave been made with a view to impart to birch the color of more valuable woods, like mahogany. In mostof instances, the wood was simply stained but not colored throughout. However, a new product appeared quite recently under the trade name of "Birnut": it is said that yellow birch is treated with ammonium under pressure. To be sure, the wood is colored throughout, but it is claimed that the fibers are burnt by the acid and consequently the natural strength of yellow birch is reduced[2].

We are going to describe below some attempts which we have made in order to color air-dry pieces of yellow birch.

<u>Procedures</u>: 1) The first test consisted in heating up 3 pieces of yellow birch (3/4" x 6" x 6") in an oven at 212°F. After two hours, the specimens were put in a small tank and then fumed with NH_3 under atmospheric pressure. For comparison, 3 other pieces of the same wood were introduced in the tank without undergoing any heat treatment. The fuming lasted 13 days.

2) Similar pieces of yellow birch were first soaked during 5 days in a solution of tannin prepared by boiling oak bark reduced to fine particles.

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[2]Gauvreau, J.M., 1935, Notes de Technologie du Bois, édité par la Direction Générale de l'Enseignement Technique de la Province de Québec, p.67.

Then, the treated pieces were introduced into the tank and fumed during 7 days under atmospheric pressure. For comparisons, other pieces were allowed to soak in the solution of tannin but were not fumed.

3) Similar pieces of yellow birch were first allowed to soak in a solution of ferric chloride ($FeCl_3 + 6H_2O$) during 5 days and then they were transferred to the tank to be fumed during 7 days. Other pieces soaked in the solution of iron, but were not fumed. The solution was prepared by dissolving one pound of ferric chloride into 2 pints of water.

4) A solution of potassium dichromate was prepared by dissolving 20 grams of salt in 2 pints of water. Then, pieces previously treated with the tannin solution and fumed in ammonia gas were allowed to soak in the new solution for a period of 7 days.

5) A similar solution of potassium dichromate was prepared. The pieces, previously treated with ferric chloride and fumed with ammonia gas were allowed to soak in the new solution for a period of 7 days.

6) Pieces previously heated up to 212^{o}F. and fumed in ammonia gas were allowed to soak in a similar solution of potassium dichromate for a period of 7 days.

<u>Results</u>: Table 2 gives the results of the different tests just described.

Procedure	New coloration (throughout the piece)		
	None to slight	Moderate	Pronounced
1	X		
2		X	
3		X	
4			X
5			X
6	X		

Table 2: Results obtained in the coloring of yellow birch through different procedures.

With procedure No.1 where hot pieces were exposed in an atmosphere of ammonia, a very slight new coloration was imparted to the wood, inside and outside: the red heartwood tended to brown. The same pieces, after a soaking period of 7 days in the solution of potassium dichromate (Procedure6), showed no great alteration in color.

Procedures 2 and 3 gave better results: in both cases the wood was given a moderate brownish color while the surfaces were stained brown red (tannin) or brown green (ferric chloride). The best results were obtained through Procedures 4 and 5. The wood turned to a rather pronounced brown chocolate color, irregular in appearance, showing scattered white brown spots. The green color of ferric chloride diffused a little into the wood after the pieces had been soaked in the solution of potassium dichromate (Procedure 5). In both cases, the previous brown red and brown green colors of the surfaces darkened a little.

These results, although not conclusive, suggest at least the freasibility of coloring yellow birch throughout the wood. It is believed that more successful achievements could be done by utilizing wet pieces for soaking in the different solutions mentioned. Time did not permit to try pressure methods although they are likely to facilitate the penetration of the solutions and eventually help to secure better results.

One important point has to be determined, namely: what is the effect of the ammonia gas on the cell walls. If any chemical reaction takes place with the component parts of the cell calls, what effect is produced on the structure of the wood, on its mechanical and physical properties? Further investigations will probably bring more light on these problems.

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