Wisconsin land inventory. [1930/31]

[s.l.]: [s.n.], [1930/31]

GROWTH, TAPER, and MERCHANTABLE VOLUME TABLES for HEMLOCK SAWYER and ASHLAND COUNTIES, WISCONSIN

GROWTH, TAPER, and MERCHANTABLE

VOLUME TABLES for

HEMLOCK

SAWYER and ASHLAND COUNTIES,

WISCONSIN

Wis. Land Inventory
1930

Growth Table for Hemlock

Flambeau River
Sawyer County, Wis.

Age at Stump	Av. Diam. at Stump	Max. Diam. at Stump	Av. Total Height	Max. Total Ht.	Av. Total Merch. Ht. (including stump)	Av. Vol. Bd. Ft.	Max. Vol. Bd. Ft.	Av. Vol. Cu. Ft.	Max. Vol. Cu. Ft.
Years	Inches	Inches	Feet	Feet	Feet				
10	.4	.8	2	6					
20	1.0	1.6	5	16					
30	1.5	2.5	9	22					0.1
40	2.1	3.4	12	29					1.0
50	2.7	4.5	16	35	10				1.9
60	3.3	5.6	20	41	12			0.2	2.5
70	4.0	6.5	24	47	13			0.7	4.1
80	4.7	7.6	29	52	15			1.1	7.0
90	5.4	8.7	33	56	17		30	2.0	10.0
100	6.3	9.9	38	59	20		50	2.6	13.5
110	7.2	11.1	43	63	22		80	4.5	18.2
120	8.2	12.4	47	67	24		110	7.5	20.4
130	9.3	13.7	51	70	27	30	140	10.3	30.0
140	10.4	15.3	54	73	30	60	170	14.0	37.0
150	11.6	17.0	58	76	31	90	210	18.5	44.0
160	12.7	18.6	61	78	36	120	250	24.0	52.0
170	14.1	20.0	65	81	39	150	290	30.0	61.5
180	15.7	21.0	69	84	42	190	350	36.5	70.0
190	17.3	21.9	73	86	46	230	420	43.9	79.0
200	18.8	22.8	76	89	49	290	510	52.0	89.0
210	20.2	23.6	80		53	360	590	60.5	99.0
220	21.4	24.3	84		58		680	70.0	110.0
230	22.6	24.9	88		62		760	83.0	123.0
240	23.7	25.7	92		67		860		138.0
250	24.7	26.3							
260	25.7	26.8							
270	26.5	27.4							
280	27.5	28.0							

Note: 1. Based on 20 large trees cut on an operation along Flambeau R.
2. Average stump height is 2.4 ft.
3. Trees cut to an average top diameter at 8.9 inches.
4. All diameters given are inside bark.

Wis. Land Inventory
1930

Table of Merchantable Height and Taper for Hemlock Sawyer Co., Wisconsin

Merch. Height from Stump to an average Top Diam. of 8.9 inches as actually cut	Taper (Diff. between diam. inside bark at stump and at any given point on stem)	Av. Taper per Foot for 10 ft. intervals
Feet	Inches	Inches
5	1.3	
10	2.2	0 - 10 ft. .22
15	2.9	
20	3.5	10 - 20 ft. .13
25	4.2	
30	5.0	20 - 30 ft. .15
35	5.9	
40	7.0	30 - 40 ft. .20
45	8.5	
50	10.1	40 - 50 ft. .31
55	12.0	
60	14.4	50 - 60 ft. .43
65		
70		

Note: 1. Based on 20 trees in logging operation.

2. Taper table may be used when estimating hemlock to determine the diameter inside bark at any point in the tree and also the merchantable height to any top diameter limit, the diameter breast high being known.

3. The average diameter inside bark at the stump is practically the same as the average diameter at breast height (4½ ft. from ground) outside bark.

Wis. Land Inventory
1930.

Merchantable Volume Table for Hemlock Flambeau River District Sawyer Co., Wis.

Diameter Breast High ($4\frac{1}{2}$' above ground) Inches	Merch. Ht. Above Stump to a 6" Top - Feet	Av. Volume in Bd. Ft. (Actually cut to 8.9 inches av. top diam.)	Av. Volume in Cu. Ft. (Actually cut to 8.9 inches av. top diam.)
2			
3			5
4			1.7
5			2.5
6			4.5
7			7.0
8	23		10.0
9	28	25	12.8
10	32	45	16.1
11	36	70	20.5
12	40	95	25.0
13	43	120	30.0
14	46	150	35.0
15	50	170	38.0
16	52	195	42.5
17	54	230	47.9
18	56	260	52.2
19	58	290	59.0
20	60	345	66.0
21	61		76.0
22	63		86.0
23	64		
24	65		
25	67		
26	68		
27	69		
28	70		
29	71		
30	72		

Note: 1. Based on 20 hemlock on logging operation.

2. Cut to an average top diameter of 8.9" (inside bark)

3. Diameter breast high ($4\frac{1}{2}$ ft. outside bark) averaged practically the same as stump diameter inside bark.

4. Cubic foot volume figured to approximately 2 inches diameter in stem.

Wis. Land Inventory
1930

Growth Table for Hemlock

Clam Lake Area
Ashland County, Wis.

Age at Stump	Av. Diam. at Stump	Max. Dia. at Stump	Av. Total Height	Av. Total Merch. Height (Including stump)	Av. Vol. Bd.Ft.	Max. Vol. Bd.Ft.	Av. Vol. Cu.Ft.	Max. Vol. Cu.Ft.
Years	Inches	Inches	Feet	Feet				
10	.3	.6	2					
20	.7	1.2	4					
30	1.1	1.7	8					
40	1.5	2.3	12					.8
50	2.0	3.0	16				.1	1.2
60	2.5	3.8	18	9			.3	2.1
70	3.0	4.5	21	10			1.0	3.0
80	3.6	5.3	24	12		20	1.3	4.2
90	4.2	6.4	27	14		30	2.0	5.5
100	4.8	7.1	30	16		30	2.5	7.5
110	5.6	8.0	32	17		30	3.1	10.0
120	6.8	8.7	35	19		40	4.0	13.0
130	7.3	9.3	38	21		70	5.0	16.0
140	8.2	10.0	41	23		90	6.7	19.0
150	8.8	10.5	44	25	20	110	8.5	22.7
160	9.7	11.2	47	27	25	130	10.2	26.8
170	10.7	12.0	49	29	30	160	12.5	31.0
180	11.4	12.5	52	31	40	190	15.2	36.7
190	12.2	13.5	54	33	50	220	18.5	43.3
200	12.9	15.0	57	35	60	260	22.0	50.5
210	13.6	16.4	59	38	75	320	26.0	59.0
220	14.3	18.0	61	40	90		29.5	69.0
230	15.0		63	42	100		34.0	
240	15.6		65	44	140		37.5	
250	16.3		66	46	160		42.0	
260	16.8		67	47	190		47.0	
270	17.4		69	48	220		51.5	
280	18.0		70	50	250		56.0	
290	18.4		71	51	280		60.0	
300	19.0		72	51	300		64.0	
310	19.4		73	52	330		67.0	
320	19.8		74	53	360		71.0	
330	20.2		75	54	390		74.0	
340	20.6		77	55	410		77.0	
350	20.9		78	55	430		79.5	
360	21.2		79	56	450		81.0	
370	21.5							

Note: 1. Based on 13 trees cut on logging operation.
2. Average stump height is 1.6 ft.
3. Trees cut to an average top diameter of 6.3 inches.
4. All diameters given are inside bark.

Wis. Land Inventory
1930

Table of Merchantable Height and Taper for Hemlock

Clam Lake Area
Ashland County, Wis.

Merch. Ht. from Stump to an Av. Top Diam. of 6.3 inches as actually cut	Taper (Diff. between diam. inside bark at stump and at any given point on stem)	Av. Taper per foot for 10 ft. Intervals
Feet	Inches	Inches
5	1.6	
10	2.2	0 - 10 ft. .22
15	2.9	
20	3.6	10 - 20 ft. .14
25	4.4	
30	5.3	20 - 30 ft. .17
35	6.2	
40	7.0	30 - 40 ft. .18
45	8.0	
50	8.8	40 - 50 ft. .18
55	9.7	
60	10.6	50 - 60 ft. .18
65	11.5	60 - 65 ft. .18

Note:

1. Based on 13 trees cut on logging operation.
2. Taper table may be used when estimating hemlock to determine the diameter inside bark at any point in the tree and also the merchantable height to any top diameter limit, the diameter breast high being known.
3. The average diameter inside bark at the stump is practically the same as the average diameter at breast height (4½ ft. above ground) outside bark.

Wis. Land Inventory
1930.

Merchantable Volume Table
for
Hemlock
Ashland County, Wis.

Diameter Breast High ($4\frac{1}{2}$' above ground) inches	Merchantable Ht. above Stump to a 4" top Feet	Av. Volume in Bd. Ft. (Actually cut to 6.3 inches av. top diam.)	Av. Volume in Cu. Ft. (Actually cut to 6.3 inches av. top diam.)
2			0.4
3			1.0
4			2.0
5			3
6	14		4
7	18		5
8	21	8	7
9	25	18	9
10	29	23	11
11	33	38	14
12	37	48	19
13	41	63	24
14	45	85	29
15	49	112	36
16	53	158	44
17	57	200	52
18	61	250	60
19	65	304	69
20	69	370	78
21	73	431	
22	77		

Note:

1. Based on 13 trees cut on logging operation.
2. Cut to an average top diameter of 6.3 inches (inside bark)
3. Diameter breast high ($4\frac{1}{2}$ ft. outside bark) averaged practically the same as stump diameter inside bark.
4. Cubic foot volume figured to approximately 2 inches diameter in stem.

GROWTH STUDIES

of

YELLOW BIRCH
HARD MAPLE
HEMLOCK
HARDWOOD STANDS
BLACK SPRUCE

VILAS and BAYFIELD COUNTIES, WIS.

YELLOW BIRCH

By number of trees yellow birch forms only approximately 4% of the hardwood stand of Bayfield County and most of these are in the adult stand, four inches or more in diameter. There is very little yellow birch in the young reproduction of the dark virgin stands of hardwood, the reproduction on these areas being mainly young maple. Studies in the Adirondacks of New York have shown that yellow birch comes in to best advantage on clear cut areas where it can get plenty of light, and our own studies here in Wisconsin also, bear out the fact, that if yellow birch is to continue with us as an important commercial tree, it must be given more light for its germination and reproduction. At present yellow birch is the most valuable of our hardwood species, and the state is getting a stumpage price of $9.00 per thousand board feet for it.

MERCHANTABLE ~~YIELD~~ Vol. TABLE

for

YELLOW BIRCH

VILAS COUNTY, WISCONSIN.

~~(1 Acre~~)

Age	Av. Vol. Cu. Ft.	Max. Vol. Cu. Ft.	Av. Vol. Bd. Ft.	Max Vol. Bd. Ft.	Av. Dia. Inches At Stump - Inside Bark	Max. Dia. Inches at Stump Inside Bark	Av. ht. Ft.	Max. ht. Ft.
5					.3		5	7
10					.7	.9	9	15
15					1.2	2.0	14	23
20		.4			1.8	2.9	18	28
25		.8			2.3	4.8	23	33
30		1.2			2.8	5.6	28	38
35		2.0			3.5	6.5	32	42
40	1	2.8		15	4.2	7.3	36	45
45	2	4.0		25	4.8	8.2	40	49
50	2.5	5.0		30	5.6	9.0	43	52
55	4.0	6.7		40	6.4	9.9	46	54
60	5.0	8.3	10	50	7.2	10.7	48	57
65	6.0	10.0	20	60	7.8	11.4	51	59
70	7.0	13.0	30	70	8.7	12.2	53	61
75	9.0	16.0	30	80	9.5	13.0	55	63
80	10.0	19.0	50	95	10.2	13.7	58	65
85	12.0	22.5	60	110	11.0	14.3	60	67
90	14.0	26.0	70	120	11.8	15.0	62	69
95	16.0	29.5	80	135	12.5	15.6	63	71
100	18.0	33.0	90	150	13.3	16.2	65	73
105	20.0	36.0	105	165	14.0	16.7	67	75
110	22.0	39.5	120	180	14.7	17.3	68	77
115	25.0	42.5	130	195	15.3	17.8	70	79
120	28.0	45.5	150	210	16.0	18.3	72	81
125	30.0	48.0	165	230	16.7	18.9	73	82
130	33.0	51.5	180	240	17.4	19.4	75	84
135	36.0	54.0	195	255	18.0	19.8	77	86
140	39.0	57.0	210	270	18.6	20.3	79	87
145	41.5	60.5	225	285	19.2	20.8	80	88
150	44.4	64.0	240	300	19.7	21.3	82	89

Tops taken to approx. 10" inside bark
No limb wood included
Average merchantable length 36½ feet
Table based on 20 trees, on just what was actually taken as merchantable on a logging operation.

COMPARISON of GROWTH of YELLOW BIRCH in Diameter & Height in Bayfield and Vilas Counties Wisconsin.

Bayfield County

Age	Av. Dia. inches	Av. Ht. Growth Ft.	Av. Vol. Bd. Ft.
10	.5	10	
20	1.3	22	
30	2.4	31	
40	3.6	38	
50	4.7	43	
60	5.8	48	
70	7.0	51	
80	8.3	54	10
90	9.6	57	20
100	10.8	59	30
110	12.0	61	50
120	13.2	63	70
130	14.4	65	90
140	15.6	67	110
150	16.8	69	140

Soil - Superior fine sandy loam

Based on actual cut taken from seven trees.
Average merchantable length 30'
Cut to 10" in tops
No limbwood taken.

Vilas County

Age	Av. Dia. Inches	Av. Ht. Growth Ft.	Av. Vol. Bd. Ft.
10	.7	9	
20	1.8	18	
30	2.8	28	
40	4.2	36	
50	5.6	43	
60	7.2	48	10
70	8.7	53	30
80	10.2	58	50
90	11.8	62	70
100	13.3	65	90
110	14.7	68	120
120	16.0	72	150
130	17.4	75	180
140	18.6	79	210
150	19.7	82	240

Soil - Vilas sandy loam

Based on actual cut taken from twenty trees.
Average merchantable length 36½'
Cut to 10" in top.
No limbwood taken.

HARD MAPLE

This species comprises 41% of all of the trees in the hardwood stands of Bayfield County and forms a large per cent of all the reproduction now coming in under all the dense dark stands. It is very tolerant of shade, and therefore will form more and more the climax or final forest unless fire or the hand of man disturb the balance of nature.

In natural stands, as it is found, growing for the greater part of its life under suppression, it is a very slow grower as the tables indicate. Hard maple is probably out of its range in Bayfield County, but further south and east in the state it grows more rapidly. The tables show that both hard maple and yellow birch grow faster in Vilas County than in Bayfield County even under similar soil conditions.

Vol. ~~YIELD~~ TABLE

for

HARD MAPLE

VILAS COUNTY, WISCONSIN

Age	Av. Vol. Cu. Ft.	Av. Vol. Bd. Ft.	Av. Stump Diameter Inches Inside Bark	Max. Stump Diameter Inches Inside Bark	Av. Height Feet
5			.2	.2	.7
10			.4	.4	1.5
15			.5	.5	2.5
20			.7	.8	4.0
25			.9	1.1	5.6
30			1.2	1.4	8.0
35			1.3	1.7	10.0
40			1.6	2.1	13.0
45			1.8	2.5	16.0
50			2.2	2.8	19.5
55			2.5	3.2	23.5
60			2.7	3.6	27.5
65			3.1	4.0	31.5
70	.7		3.4	4.3	35.0
75	1.0		3.7	4.8	38.5
80	1.5		4.1	5.2	41.5
85	1.8		4.5	5.7	44.0
90	2.0		4.8	6.1	47.0
95	2.5		5.3	6.6	49.0
100	3.5		5.7	7.1	52.0
105	4.3		6.2	7.6	54.0
110	5.2	15	6.6	8.2	56.0
115	6.5	20	7.2	8.7	58.0
120	7.5	25	7.7	9.2	60.0
125	8.5	32	8.2	9.8	62.0
130	10.0	40	8.7	10.3	64.0
135	11.5	48	9.2	10.9	66.0
140	13.0	55	9.8	11.5	67.5
145	15.3	65	10.3	12.1	69.0
150	17.2	75	10.9	12.8	70.5

Note*
Based on cut from only 4 trees
Small height growth in early life due to suppression
Average merchantable length 34'
Cut to approximately 9" in tops
No limbwood taken

COMPARISON of GROWTH

of

HARD MAPLE

for

Bayfield and Vilas Counties, Wisconsin.

Bayfield County

Age	Av. Dia. Inches	Max. Dia. Inches	Av. Ht. Growth Feet	Av. Vol. Bd. Ft.
10	.2	.4	7	
20	.7	1.0	18	
30	1.2	1.9	30	
40	1.6	2.9	38	
50	2.2	3.8	43	
60	2.8	4.8	46	
70	3.4	5.9	48	
80	4.0	6.9	51	
90	4.5	7.9	53	
100	5.1	8.9	54	
110	5.7	9.9	56	
120	6.4	10.8	57	
130	7.0	11.7	59	10
140	7.7	12.7	60	20
150	8.4	13.6	61	25

Note*

Based on cut from 15 trees
Average merchantable length 24'
Cut to 9" in tops
No limbwood taken

Vilas County

Age	Av. Dia. Inches	Max. Dia. Inches	Av.Ht. Growth Feet	Av. Vol. Bd.Ft.
10	.4	.4	2	
20	.7	.8	4	
30	1.2	1.4	8	
40	1.6	2.1	13	
50	2.2	2.8	20	
60	2.7	3.6	28	
70	3.4	4.3	35	
80	4.1	5.2	42	
90	4.8	6.1	47	
100	5.7	7.1	52	
110	6.6	8.2	56	15
120	7.7	9.2	60	25
130	8.7	10.3	64	40
140	9.8	11.5	67	55
150	10.9	12.8	70	75

Note*

Based on cut from only 4 trees
Small height growth in early life due to suppression
Average merchantable length 34'
Cut to approximately 9" in tops
No limbwood taken
Maximum diameter growth for Bayfield County is greater than maximum for Vilas County as no unsuppressed trees were included in the 4 examined for Vilas County.

COMPARISON of GROWTH

of

NORWAY PINE

on the so-called

"Barrens" of Bayfield and Vilas Counties, Wisconsin[1]

Bayfield County				Vilas County			
Age Years	Diameter Inches	Height Feet	Av. Volume Bd. Feet	Age Years	Diameter Inches	Height Feet	Av. Vol. Bd.Ft.
50	8.5	38	20	50	13.8	67	100
60	10.4	44	60	60	15.7	75	160
70	12.0	48	85	70	17.5	81	230
80	13.5	52	125	80	19.0	86	300
90	15.0	56	170	90	20.3	90	380
100	16.3	60	220	100	21.7	94	470
110	17.4	64	270	110	23.0	98	550
120	18.2	68	310	120	24.2	100	650
130	19.0	73	350	130	25.3	101.5	750
140	19.4	76	375	140	26.7	102.2	870
150	19.8	80	400	150	27.7	102.5	1000

HEMLOCK

Very little hemlock in commercial quantities is found in Bayfield or Vilas counties. A few heavy stands of small area near Phelps, and on the shores of Star Lake were found, and study plots made in these.

Hemlock is one of the most tolerant of shade of all of the trees of this state, but does not reproduce itself under its own mature dense stands as the following table indicates, as the accumulation of hemlock needles on thick duff under such stands, does not contain moisture enough for the germination and growth of the young seedling. Young maple and balsam, however, can germinate even under these conditions. When dense stands are opened up extensively by cutting the remaining hemlock usually dies or is blown down. The sudden exposure to the light, and drying winds probably accounts for this mortality. Only in moist conditions with plenty of humous in the soil will hemlock reproduce to advantage. The vast clean cutting of our northern woodlands and subsequent fires, removing the moist humous has stopped to a great extent the reproduction of this species and its practical annihilation is only a question of time. It is a slow grower and will probably never be used for planting purposes.

A study of the composition of hemlock stands of Vilas County shows that while the mature stands have a heavy per cent of hemlock with considerable yellow birch and hard maple, the reproduction under these stands is mainly maple and balsam.

STUDY of the COMPOSITION and VOLUME of
HEMLOCK STANDS
VILAS COUNTY, WISCONSIN

Plot No.	Density of stand	Area	Reproduction	Location	No. of trees per acre	Volume per acre Cu.ft.	Bd. ft.	Total Vol. Cds.	% of Species in mixture by number of tree		% of Species by Volume	
2	80%	¼ acre	Forest floor clean except for young balsam and maple	near Phelps	464	Hemlock 2400 Maple 1000 Yellow birch 856	9760	47	Hemlock Maple Yellow birch Misc.	72 13 9 6	Hemlock Maple Yellow birch Misc.	56 23 21 None
3	85%	¼ acre	Forest floor clean except for young balsam and maple	near Phelps	392	Hemlock 3248 Yellow b.548 W. pine 1220 Maple 264	14560	59	Hemlock Yellow birch W. pine Maple	81 8 6 5	Hemlock Yellow birch W. pine Maple	61 10 23 16
28	80%	¼ acre	Mainly young balsam and maple	Forest Lake	532	Hemlock 2568 Yellow b.620 W.Pine 696 Maple 136	8840	45	Hemlock Balsam Yellow birch W. pine Maple	80 8 6 5 1	Hemlock Yellow birch W. pine Maple	64 15 17 4
34	85%	¼ acre	Clean - a few young hemlock maple and balsam	Island Star Lake	404	Hemlock 2514 Yellow b.906 W.pine 292	17720	41	Hemlock Balsam Yellow birch W. pine	80 3 16 1	Hemlock Yellow birch W. pine	68 24 8
39	85%	¼ acre	Actual count 1168 maple, 22 balsam, 98 cedar, 4 w.pine, 95 hemlock	Star Lake	604	Hemlock 2300 W.birch 1776 Maple 168	4600	47	Hemlock W.birch Maple	76 20 4	Hemlock W.birch Maple	52 42 6
46	75%	¼ acre	Young maple and balsam	Partridge Lake	668	Hemlock 716 W.birch 1064 Maple 136 Balsam and cedar 392		25	Hemlock W.birch Maple Balsam Spruce and cedar	17 10 13 40 20	Hemlock W. birch Balsam Maple	31 46 17 6
53	60%	¼ acre	Heavy to young maple no hemlock	Wolf Lake	236	Hemlock 5412 Yellow b.312 Maple 136	27420	65	Hemlock Maple Yellow birch Balsam & Ironw.	61 19 15 5	Hemlock Maple Yellow birch	92 2 6
64	85%	¼ acre	Clean, a few maple and balsam	near Jute Lake	492	Hemlock 1176 Norway 2564 W.pine 3748	2300 13280 13520	75	Hemlock Norway W.pine Maple, balsam, bir.	68 7 17 8	Hemlock Norway W.pine	16 34 50

~~YIELD~~ Vol. TABLE

for

H E M L O C K ~~(1 acre)~~

VILAS COUNTY, WISCONSIN

Age	Av. Vol. Cu. Ft.	Max. Vol. Cu. Ft.	Volume Bd. Ft.	Average Diameter Growth (Inches)	Max. Dia. Growth (inches)	Av. Ht. Growth (Feet)
5				.2	.4	
10				.4	.7	
15				.6	1.0	
20				.8	1.4	6
25				1.0	1.8	8
30				1.2	2.2	10
35				1.5	2.7	12
40				1.9	3.0	13
45				2.2	3.5	15
50		.3		2.5	4.0	17
55		.5		3.0	4.2	19
60		.7		3.3	4.8	21
65		1.0		3.8	5.2	24
70	.1	1.2		4.2	5.7	26
75	.5	1.8		4.7	6.2	28
80	1.0	2.2		5.1	6.7	30
85	1.5	2.8		5.6	7.2	32
90	2.2	3.6		6.0	7.8	35
95	2.9	4.5		6.4	8.2	37
100	3.5	3.6		7.0	9.0	40
105	4.4	6.8		7.5	9.4	42
110	5.3	8.0	10	8.0	10.0	45
115	6.4	9.5	15	8.6	10.7	47
120	7.6	11.2	25	9.2	11.2	50
125	9.0	13.2	30	9.8	12.0	52
130	10.2	15.4	40	10.2	12.6	55
135	11.5	17.7	55	10.8	13.2	57
140	13.0	20.0	65	11.4	14.0	60
145	14.8	22.0	80	12.0	14.9	62
150	16.5	24.5	90	12.5	15.7	64

Note* Cut to approx. 9" in the top.

ANALYSIS of HARDWOODS

VILAS COUNTY

WISCONSIN (1929)

Generally speaking Vilas County is not what would be termed a desirable site for the growth of hardwood timber, as the soil is mainly of a sandy nature, and favors an optimum growth for pine and spruce. In the eastern part of the county, however, on some of the agricultural soils of kennan silt loams, are found a few very good hardwood stands, with maple and basswood predominant, but none of large area. The heaviest volume found on one acre, was 68 cords as compared to 41 cords on the best mature hardwood stand found in Bayfield County. This does not include the limb wood. Although there is considerable basswood and yellow birch in the mature stands, the reproduction coming in under these stands is mainly hard maple.

Over eighty per cent of the species in mixture by number of trees is hard maple. By volume 79% is maple.

The diameter classes average as follows: Above one inch in diameter there are 204 trees per acre, above 4 inches there are 144, above six inches there are 120, above 10 inches there are 91, and above 18 inches there are 20 trees per acre. The number of trees in the various diameter classes are as follows:

1" diameter class	.....	87
2-4" "	inclusive.....	60
5-6" "	inclusive.....	24
7-10" "	inclusive.....	29
11-18" "	inclusive.....	71
Above 18"	.....	20
Total trees per acre	.....	291

ANALYSIS OF BEST

HARDWOOD STANDS

EASTERN VILAS COUNTY, WISCONSIN

(One acre)

Plot No.	Location	Estimated Density	No. of trees per acre	Av. Dia. Inches	Basal Area per acre sq. ft.	% of Species in mixture by no of trees	Volume cu.ft.	Volume cords	Volume bd. ft.	% of Species in mixture by bd.ft. volume	Reproduction
4	Sand Lake	85	496	13"	168	Maple 94% Basswood 2% Balsam 2% Yellow Birch 1% Ironwood 1%	4792	53	Maple 17,400 Bass 2,640 Yellow Birch 2,600 22,640	Maple 77% Bass 12% Yellow Birch 11%	Young maple
5	Near Mich. line N.E.N.E. Sec.11,T.41, R.12 E.	75	272	14"	188	Maple 70% Ironwood 15% Hemlock 10% Bass 5%	6100	68	Maple 14,920 Bass 2,560 17,480	Maple 84% Bass 16%	Young maple
6	Near Kentuck Lake	60	164	14"	159	Maple 80% Bass 10% Yellow Birch 6% Ironwood 2% Hemlock and Balsam 2%	4772	53	Maple 11,360 Bass 4,000 15,360	Maple 74% Bass 26%	Mainly maple some birch, bass and elm
7	Near Kentuck Lake	70	212	11.5"	151	Maple 90% Elm 4% Birch 4% Bass 2%	3788	42	Maple 13,480 Birch 1,360 Elm 1,800 16,640	Maple 81% Elm 11% Birch 8%	Young maple some birch and elm

Plots $\frac{1}{4}$ acre

Soil: Kennan Silt Loam.

VOLUME TABLE

for

BLACK SPRUCE

VILAS COUNTY, WISCONSIN

Age	Vol. Cu. Ft.	Av. Stump Diameter Inches	Av. Height Feet
5		.2	.9
10		.6	3.0
15		1.0	6.0
20		1.4	10.0
25		1.8	14.0
30	.1	2.3	18.0
35	.4	2.7	22.0
40	.7	3.2	27.0
45	1.1	3.6	31.0
50	1.5	4.1	35.0
55	2.0	4.5	39.0
60	2.5	5.0	42.0
65	3.2	5.5	45.0
70	3.9	5.8	49.0
75	4.8	6.3	52.0
80	5.5	6.8	54.0
85	6.0	7.2	58.0
90	6.5	7.7	61.0
95	7.0	8.7	64.0
100	7.3	9.1	67.0

Taken to 4" in the tops.

COMPARISON in DIAMETER AND HEIGHT GROWTH for BLACK SPRUCE in Bayfield and Vilas Counties, Wisconsin

	Bayfield County		Vilas County	
Age	Diameter	Height	Diameter	Height
10	.4	3	.6	3
20	.8	8	1.4	10
30	1.6	14	2.3	18
40	2.1	21	3.2	27
50	2.8	24	4.1	35
60	3.5	29	5.0	42
70	4.1	31	5.8	49
80	4.7	32	6.8	54
90	5.2	33	7.7	61
100	5.7	34	9.1	67

Wm. W. Morris
In Charge of Growth Study Investigations
Land Economic Inventory
Wisconsin Department of Agriculture & Markets.

GROWTH STUDIES OF THE THREE PRINCIPAL SPECIES OF CONIFERS FOUND IN VILAS COUNTY, WISCONSIN.

c 3

In connection with the Wisconsin Land Economic Inventory made in Vilas County in the summer of 1929, a complete stem analysis was made of twenty-three large white pine, fifteen large Norway and twenty-four large white spruce. This study was made on lands being cut over by the Stang Lumber Company of Merrill in township 43 North, Range 8 East, Vilas County, Wisconsin. The white pine averaged twenty-six inches in diameter breast high, the largest one being forty-four inches, the Norway pine averaged twenty-four inches in diameter, the largest one being twenty-nine inches and the white spruce averaged nineteen inches, the largest one being twenty-eight inches in diameter. These trees had been cut up into log lengths (mainly sixteen feet), enabling measurements to be taken at each cross section. The age of the section was counted along the average radius from the outside to the center, every ten year period being marked off by placing a pin or pencil mark at the ten year interval. Measurements of the growth of these periods were made from the center of the tree outward in inches and tenths. These measurements enabled an accurate computation of the volume in cubic and board feet, diameter and height growth at any period in the life of the tree. These figures of growth were placed on coordinate paper and curves made showing the average and maximum growths at any given year. Tables showing average and maximum volumes and diameters and heights were made from these curves.

The stumps for white and Norway pine were cut down to one foot in height. The stumps of white spruce averaged 1½ feet in height due to the unusual flare or swelling at the butt of the white spruce, often taking a square form.

The trees were cut in the tops to an average diameter of seven inches for white pine, eight inches for Norway, and six inches for white spruce. The volume in cubic feet was figured to approximately two inches in the diameter of the logs and the volume in board feet to six inches.

The relationship between diameter breast high and stump diameter inside the bark for white pine is 2.5 inches, for Norway pine 1 inch, and for white spruce 3.5 inches greater than the diameter breast high.

(A) Average and Maximum Growths

The growth tables show the maximum growth of all the trees measured as well as the average growth found. A comparison of the growth of tolerant or shade enduring species, such as white spruce, with the intolerant species such as Norway pine, in their natural state would not be just, as the shade endurers have often grown in a suppressed condition for years, while the light loving species cannot do this, and have therefore grown under more favorable light conditions. The maximum growth therefore represents more what can be expected under more optimum conditions of light and less root competition, such as are found in planted stands, and those grown under forest management.

Table I

VOLUME TABLE

for

WHITE PINE

VILAS COUNTY, WISCONSIN

Age at Stump	Av. Vol. Cu. Ft.	Max. Vol. Cu.Ft.	Av. Vol. Bd. Ft.	Max. Vol. Bd.Ft.	Av. Dia. Growth Inches	Max. Dia. Growth Inches	Av. ht. Growth Ft.	Max. ht. Growth Ft.
5	0	0	0	0	1.	2.	3	8
10	0	0	0	0	2.1	4.0	7	15
15	0	1	0	0	3.1	5.5	11	22
20	0	2	0	0	4.2	7.3	16	27
25	1	3	0	0	5.3	9.0	22	32
30	2	6	0	10	6.3	10.5	27	38
35	3	9	0	20	7.2	11.8	32	44
40	4	13	10	30	8.0	13.1	37	48
45	7	18	20	50	8.9	14.4	42	54
50	10	25	30	70	9.7	15.6	47	59
55	15	33	50	100	10.5	16.8	51	64
60	19	43	60	140	11.3	18.0	55	69
65	25	52	70	180	12.2	19.3	60	73
70	32	63	100	230	13.1	20.4	65	78
75	38	73	120	280	14.0	21.5	69	83
80	45	83	150	340	15.0	22.5	73	87
85	52	93	180	420	15.9	23.5	77	92
90	59	104	220	490	16.9	24.5	81	95
95	66	114	270	570	18.0	25.5	84	99
100	73	125	330	650	18.8	26.5	87	102
105	82	137	400	750	19.9	27.3	91	105
110	90	148	460	860	20.9	28.2	93	107
115	100	160	540	970	21.9	29.2	96	108
120	110	172	620	1090	23.0	30.2	98	110
125	123	185	710	1200	24.0	31.0	100	111
130	135	197	800	1320	25.2	31.8	102	112
135	143	210	900	1450	26.3	32.7	104	113
140	162	223	1000	1600	27.3	33.5	106	114
145	175	235	1100	1720	28.6	34.4	108	114.5
150	187	248	1200	1850	29.7	35.2	109	115

Note*
Based on 23 trees
Stump height 1 ft.
Add 4 years to age at stump for total age
Trees cut to 7" in top. No volume below 2" in diameter.

Table II

VOLUME TABLE

for

NORWAY PINE

VILAS COUNTY, WISCONSIN

Age at Stump	Av. Vol. Cu. Ft.	Max. Vol. Cu. Ft.	Av. Vol. Bd. Ft.	Max. Vol. Bd. Ft.	Av. Dia. Inches	Max. Dia. Inches	Av. Ht. Growth Ft.	Max. Ht. Growth Ft.
5	0	0	0	0	1.5	2.0	6.0	10
10	0	0	0	0	3.0	5.0	14.0	20
15	0	2	0	0	4.5	8.2	22.0	29
20	1	5	0	0	6.0	11.2	31.0	37
25	4	9	0	25	7.6	13.0	40.0	45
30	7	16	0	50	9.0	14.5	46.0	53
35	13	24	20	100	10.3	15.8	53.0	60
40	19	32	50	140	11.6	17.0	58.0	66
45	24	40	70	180	12.7	18.0	63.0	72
50	30	48	100	230	13.8	19.2	67.0	77
55	36	57	130	280	14.8	20.0	71.0	81
60	43	65	160	330	15.7	20.7	75.0	84
65	48	72	200	380	16.5	21.5	78.0	87
70	56	80	230	430	17.5	22.1	81.0	89
75	63	87	270	470	18.2	22.7	83.0	91
80	69	95	300	500	19.0	23.3	86.0	93
85	76	102	350	550	19.7	23.8	88.0	95
90	82	108	380	580	20.3	24.3	90.0	97
95	88	116	420	650	21.0	24.9	92.0	99
100	95	124	470	700	21.7	25.5	94.0	101
105	101	132	510	760	22.3	26.0	96.0	103
110	107	140	550	820	23.0	26.4	98.0	104
115	113	147	600	880	23.6	26.9	99.0	106
120	118	156	650	950	24.2	27.3	100.0	107
125	125	163	700	1000	24.8	27.7	101.0	108
130	132	170	750	1070	25.3	28.2	101.5	109
135	137	178	800	1120	26.0	28.7	102.0	110
140	143	186	870	1180	26.7	29.1	102.2	111
145	150	194	940	1250	27.2	29.5	102.4	112
150	155	202	1000	1300	27.7	30.0	102.5	113

Note*
Based on fifteen trees
Stump height 1 ft.
Add 4 years to age at stump for total age
No volume figured below 2" in diameter.

Table III.

VOLUME TABLE

for

WHITE SPRUCE

VILAS COUNTY, WISCONSIN

Age at Stump	Av. Vol. Growth Cu. Ft.	Max. Vol. Growth Cu.Ft.	Av. Vol. Bd. Ft.	Max. Vol. Bd. Ft.	Av. Dia. Growth Inches	Max. Dia. Growth Inches	Av. Height Growth Feet	Max. Height Growth Feet
5	0	0	0	0	.2	.9	1.5	4
10	0	0	0	0	.5	1.9	4.0	10
15	0	0	0	0	1.0	3.5	7.0	17
20	0	0	0	0	1.5	5.2	10.0	24
25	0	2	0	0	2.0	6.8	13.0	34
30	0	5	0	0	2.6	8.5	18.0	42
35	0	8	0	20	3.3	10.0	24.0	50
40	1	13	0	40	4.3	11.7	31.0	58
45	2	18	0	70	5.3	13.2	38.0	64
50	5	23	10	100	6.5	14.5	46.0	70
55	7	29	20	120	7.7	16.0	53.0	76
60	10	35	30	150	9.0	17.3	58.0	80
65	13	42	40	180	10.1	18.5	63.0	84
70	17	48	60	200	11.2	19.5	68.0	88
75	20	53	70	230	12.3	20.6	72.0	91
80	23	60	90	270	13.3	21.5	76.0	94
85	28	67	120	290	14.3	22.4	79.0	96
90	33	72	140	320	15.3	23.3	82.0	98
95	40	79	170	360	16.3	24.0	85.0	100
100	45	85	200	400	17.2	24.7	88.0	102
105	52	91	230	430	18.2	25.3	90.0	103
110	58	97	270	470	19.0	26.0	92.0	104
115	65	103	320	520	19.8	26.6	93.0	105.5
120	72	110	350	550	20.7	27.0	95.0	106.5
125	78	117	400	600	21.5	27.5	96.0	108.0
130	85	122	440	640	22.2	28.0	98.0	109.0
135	91	127	480	680	23.1	28.5	99.0	110.0
140	97	132	530	730	23.8	29.0	100.0	110.5
145	103	137	570	770	24.5	29.5	101.0	111.0
150	110	142	620	820	25.2	30.0	102.0	112.0

Note*
Based on 24 trees
Stump height 1½ feet.
Add six years to age at stump for total age
Trees cut to 6" in tops
Maximum volume shows probable growth under optimum conditions.

The average growth of the white spruce under natural conditions, being a tolerant species, would likely be less than the white pine, a less tolerant species, and both the average growths of white spruce and white pine would be less than that of Norway, which is the least tolerant of shade. The comparison of maximum growths therefore, is probably more just, as showing the real merits of the growth of the various species considered, and what might be expected if growing under optimum conditions, such as in planted stands. The average growth shows, however, the relative merits of the species as they grow under natural conditions, and also shows to some extent how they are kept back by suppression.

THE SOIL

The soil on which the species were growing was mainly Vilas sandy loam, some of it ranging into Vilas sand. None of it was agricultural in nature but the pine measured had grown intermixed with hardwoods, mostly yellow birch, and maple of small size.

HEIGHT GROWTH

Norway pine leads the other two species in height growth in early life. At twenty-five years from the stump the maximum height growth of Norway pine is eleven feet higher than the maximum height growth of white spruce and thirteen feet higher than the maximum height growth of white pine. The average height growth of the Norway pine at this period is greater than the maximum height growth of the other species. White spruce, at this period, leads white pine by two feet in a comparison of maximum height growths.

At fifty years of age Norway pine still leads in height growth followed by white spruce rapidly coming to the front and lastly white pine.

At one hundred years of age a change is seen for white pine and white spruce show practically the same height growth, and their maximum height growth has now gone ahead of the Norway pine.

At one hundred and fifty years white pine leads slightly in maximum growth, leads Norway pine in average height growth, and is lead slightly by white spruce in average growth. This is probably due to the fact that in these last years white spruce that has survived has come out of suppression and has its crown high in the light in the dominant stand. A comparison of the maximum height growths of white pine and white spruce shows that white spruce leads white pine in height growth up to about its one hundredth year and then falls slightly in the rear of white pine staying about the same as Norway pine up to its one hundred and fiftieth year.

Table Showing Comparative Height Growths at Various Ages

Stump Age	White Pine		Norway Pine		White Spruce	
	Av. Ht. Growth Ft.	Max. Ht. Growth Ft.	Av. Ht. Growth Ft.	Max. Ht. Growth Ft.	Av. Ht. Growth Ft.	Max. Ht. Growth Ft.
25	22	32	40	45	13	34
50	47	59	67	77	46	70
75	69	83	83	91	72	91
100	87	102	94	101	88	102
125	100	111	101	108	96	108
150	109	115	102.5	113	110	112

Note* Age computed at stump
Add 4 years to reach stump height of pines
and six years for white spruce

GROWTH in DIAMETER

Norway pine leads the other two species in diameter growth in the early life of the stand. A comparison of maximum diameter growths shows that Norway pine leads up to ninety years of age when white pine overtakes it and forges rapidly ahead, until at one hundred and fifty years the maximum diameter of white pine is five inches greater than Norway pine. White pine has the ability of putting on excellent diameter growth even up to two hundred years of age, while Norway begins to slow down in diameter growth at about ninety years of age.

A comparison of average diameter growths of the two species shows Norway to be well in the lead until its one hundred and thirtieth year when white pine catches up with it and rapidly forges ahead. The average diameter growth of an intolerant species is liable to be greater than the average growth of one possessing the ability to endure shade, as the former cannot grow under the suppressed conditions of the later, and hence the whole stand must approach more nearly the maximum growth.

White spruce remains somewhat behind the others in diameter growth at all its early life until it catches up to Norway at the latter part of its life, at about one hundred and forty years, but never quite approaches the diameter growth of white pine. Under optimum conditions of light such as in planted stands this condition might be different.

COMPARISON OF DIAMETER GROWTHS

of

WHITE & NORWAY PINE & WHITE SPRUCE

Age at Stump	WHITE PINE Av. Dia. Inches	WHITE PINE Max. Dia. Inches	NORWAY PINE Av. Dia. Inches	NORWAY PINE Max. Dia. Inches	WHITE SPRUCE Av. Dia. Inches	WHITE SPRUCE Max.Dia. Inches
25	5.3	9.0	7.6	13.0	2.0	6.8
50	9.7	15.6	13.8	19.2	6.5	14.5
75	14.0	21.5	18.2	22.7	12.3	20.6
100	18.8	26.5	21.7	25.5	17.2	24.7
125	24.0	31.0	24.8	27.7	21.5	27.5
150	29.7	35.2	27.7	30.0	25.2	30.0

GROWTH in VOLUME

Norway pine leads the other two species in early volume production. The maximum tree observed shows a production of two cubic feet at fifteen years from stump height and 25 board feet at twenty-five years from stump height.

Norway pine leads all others until approximately one hundred years when the maximum volume growth of white pine becomes greater, and at one hundred and thirty years the average volume growth of white pine overtakes the Norway, and from that time on maintains a strong lead in volume production. The maximum cubic feet production of white spruce seems to be about equal to that of white pine up to approximately fifty years, after which it falls behind both other species.

COMPARISON OF VOLUME PRODUCTION

of

WHITE & NORWAY PINE & WHITE SPRUCE

Age of Stump	WHITE PINE Av. Vol. Cu. Ft.	WHITE PINE Max. Vol. Cu. Ft.	WHITE PINE Av. Vol. Bd. Ft.	WHITE PINE Max. Vol. Bd. Ft.	NORWAY PINE Av. Vol. Cu. Ft.	NORWAY PINE Max. Vol. Cu. Ft.	NORWAY PINE Av. Vol. Bd. Ft.	NORWAY PINE Max. Vol. Bd. Ft.	WHITE SPRUCE Av. Vol. Cu. Ft.	WHITE SPRUCE Max. Vol. Cu. Ft.	WHITE SPRUCE Av. Vol. Bd. Ft.	WHITE SPRUCE Max. Vol. Bd. Ft.
25	1	3	0	0	4	9	0	25	0	2	0	0
50	10	25	30	70	30	48	100	230	5	23	10	100
75	38	75	120	280	63	87	270	470	20	53	70	230
100	73	125	330	650	95	124	470	700	45	85	200	400
125	123	185	710	1200	125	163	700	1000	78	117	400	600
150	187	248	1200	1850	155	202	1000	1300	110	142	620	820

Note* Add 4 years to pines for total age
and 6 years for white spruce.

PREDICTED YIELD per ACRE from FULLY STOCKED STANDS

In order to predict the yield per acre it is necessary to have information on the number of trees of the approximate diameters of those in the table that one acre of land will best support.

A comparison of the rates of growth of the three species studied in Vilas County compared with the rates of growth of the species found in European yield tables and Bulletin 142 for the Northeastern United States would tend to show that the Vilas County Species are growing under optimum conditions of site, which would be classified as Site 1.

From a study of the European yield tables for spruce and Technical Bulletin No. 142 on "Yields of Second Growth Spruce and Fir in the North East" by Walter H. Meyer, the number of trees per acre in the tables given below has been ascertained.

The number of trees used for white and Norway pine per acre was obtained from studies made of fully stocked stands of Scotch pine in Germany by Schwappach. It is likely in the late life of the stand that there would be more white pine trees per acre than in a stand of Norway or Scotch pine, but this figure for Scotch pine has been used.

The maximum yields are based on the greatest yield found in a given species multiplied by the number of trees per acre and of course is theoretical as it assumes that every tree could be made to produce as great a volume as the one maximum tree produced. This is not improbable, however, with better light conditions, less root competition, and the possibility of cultivation and fertilization.

The maximum predicted yields could probably seldom be obtained, but the yields of a planted stand should range from the present average towards the maximum with the more optimum conditions for growth that planted stands afford.

YIELD TABLE WHITE SPRUCE

One acre

Age from seed	No. of Trees	Av. Vol. Cu. Ft.	Av. Vol. Bd. Ft.	Max. Vol. Cu. Ft.	Max. Vol. Bd. Ft.
40	1120	0	0	7,840	22,400
50	716	1432	0	12,172	42,960
60	500	3500	10,000	14,000	60,000
70	380	4940	15,200	15,580	64,000
80	308	6160	21,560	16,324	67,760
90	256	6912	28,160	16,640	71,680
100	220	8360	35,200	16,940	77,000
110	200	10000	46,000	17,600	84,000
120	189	12285	56,700	19,278	94,500

YIELD TABLE WHITE PINE

One acre

Age from seed	No. of Trees	Av. Vol. Cu. Ft.	Max. Vol. Cu. Ft.	Av. Vol. Bd. Ft.	Max. Vol. Bd. Ft.
40	696	1392	6960	None	13,920
50	464	3248	8816	9280	23,200
60	328	4920	11480	16400	36,080
70	256	6400	13312	17920	46,080
80	218	8284	16350	22236	61,040
90	196	10092	18620	35280	82,320
100	160	10720	18400	44800	92,800
110	140	11620	19320	56000	107,800
120	120	12240	19440	66000	117,700

YIELD TABLE NORWAY PINE

One acre

Age from seed	No. of Trees	Av. Vol. Cu. Ft.	Max. Vol. Cu. Ft.	Av. Vol. Bd. Ft.	Max. Vol. Bd. Ft.
40	696	9,744	17,400	13,920	69,000
50	440	11,000	18,500	30,800	83,600
60	320	11,840	18,600	41,600	89,600
70	260	13,000	18,800	52,000	98,600
80	218	13,734	19,184	61,000	102,400
90	196	15,000	20,000	68,600	107,800
100	160	14,400	18,700	68,800	104,000
110	140	14,280	18,600	71,400	106,400
120	120	13,560	18,000	72,000	108,000

Note* The ages given in these tables represent total age of tree.

Comparison of Natural With Planted Stands.

A study was made of the growth of the Norway pine plantation at Star Lake planted in 1913 and now sixteen years of age. This stand was planted 6 x 6 feet and now at sixteen averages 900 trees to the acre. The average diameter is 4.5 inches, and the average height twenty feet. It averages about fifteen feet in height to a 2" top and has produced an equivalent of 819 cubic feet per acre in the best portions of the stand. Its total basal area, at breast height, is 91 square feet per acre.

A dense natural stand of Norway pine near Land O'Lakes was also studied and the comparison of growth between this overstocked natural stand and the plantation is interesting. This stand is now twenty-six years of age with a total basal area of 165 square feet. The average diameter is 3.5 inches and the average height 27 feet. The stand averaged 2416 dominant and intermediate trees per acre and produced a volume of 956 cubic feet per acre at twenty-six years of age.

At sixteen years of age this overstocked stand had an average diameter of 2.3 inches, an average height of sixteen feet, a basal area of 70 square feet, and practically no volume figured to a 2" diameter.

A table of comparison of the two stands follows:

PLANTED STAND		OVERSTOCKED NATURAL STAND	
Age	16 years	At age of 16	
No. of trees	900	No. trees	2416
Average height	20 feet	Average height	16 feet
Average diameter	4.5 inches	Average diameter	2.3 inches
Basal area	91 square feet	Basal area	70 square feet
Volume	819 cubic feet to 2"	Volume	None to 2"
PREDICTED YIELD (at 26 years)		**PRESENT YIELD (at 26 years)**	
Age	26 years	Age	26 years
No. of trees	800	No. of trees	2416
Average height	40 feet	Average height	27 feet
Average diameter	7.5 inches	Average diameter	3.5 inches
Basal area	245 square feet	Basal area	165 square feet
Volume	3200 cubic feet	Volume	956 cubic feet

Very few stands average as many trees to the acre as the above mentioned natural stand. Ordinarily they are not stocked to half the extent of a planted stand, and although the diameter growth is then greater than it would be in a heavy stocked stand, yet the small and uneven stocking reduces the volume as compared with the evenly spaced planted stand.

REPRODUCTION UNDER PINE STANDS

A careful study of the reproduction coming in under old pine stands made on approximately thirty pine plots, shows that at least on one-third of them young maple is coming in as the understory, and this will eventually be the climax forest unless fire or cutting change this sequence. About one-third of them are coming up to a good reproduction of white and Norway pine. In most of these cases where the pine reproduction is especially dense, fire has preceded the pine reproduction, opening up the mineral soil, but not completely killing seed trees. Those plots where maple is the predominant reproduction, show an average density of 80%. Those plots where white and Norway pine reproduction is coming in have an average density or stocking of 60%, showing the need of light for these trees to appear, and the shade tolerance of maple.

Under Norway and jack pine stands the principal reproduction that is found is white pine. On a 1/4 acre Norway pine plot, No. 42, on St. Germain Lake, consisting of 38 Norway pine 13 inches in diameter, twenty jack pine 9 inches in diameter, and one seven inch white pine, the only reproduction found were 84 white pine seedlings.

On a 1/4 acre jack pine plot, No. 43, about 70% stocked and consisting of one hundred and fifteen jack pine and one Norway pine, the reproduction consisted of a good sprinkling of white pine with a few Norway. No jack pine was coming in.

This shows therefore that unless open cutting or fire take place Norway and jack pine do not succeed themselves but will gradually be eliminated by the more tolerant species. White pine on account of having a greater degree of tolerance can hold its own somewhat better than the other two on good sandy soils; but on the better heavier soils, maple and the other shade tolerant hardwoods, will eventually be the climax forest under natural conditions.

ESTIMATES of MATURE STANDS of TIMBER FOUND in GROWTH STUDY

In conducting the growth study in Vilas County studies and estimates were made in the heaviest stands of mature pine obtainable. It is interesting to compare these with the predicted yields for any given age as given above.

These plots were mainly one-fourth of an acre in an area and the volume obtained multiplied by four for one acre. The best stands observed are as follows:

ESTIMATE of SOME of the BEST PLOTS of TIMBER FOUND

in

VILAS COUNTY, WISCONSIN

Age of Stand	Species	Volume Board Feet per acre
Approx. 100	Norway	11,600
Approx. 125	Norway	19,760
Approx. 150	White pine	39,280
Approx. 150	White pine	44,280
Approx. 150	White pine	71,280

The last stand is about the average as given in the predicted yield for a normal or fully stocked forest for white pine at one hundred and fifty years of age.

Wm. W. Morris.
In Charge of Growth Study Investigations
Land Economic Inventory
Wisconsin Dept.of Agriculture and Markets.

Paper given at Third Timber Conference - January 28, 1930.

C-4

CUTTING FOR THE FUTURE FOREST

The growth study made in connection with the Wisconsin Land Economic Inventory has developed a few fundamental facts relative to the present forest cover. The figures presented are for Bayfield County but they are probably fairly representative of conditions in a large part of the northern section of the state.

1. Only 15% of the area is now growing to pine of some kind as compared to possibly 75% formerly.

2. 31% of the area has some into popple, practically all of which area was formerly growing to pine, and 17% is growing to hardwoods.

3. 17½% is bare and not doing anything, but is valuable potential planting land.

4. The reproduction coming in under most of these stands is of an inferior nature, or mostly hard maple to the exclusion of other species. By number of trees maple composes 41% of the stand as compared to yellow birch composing under 4% of the stand.

In other words a large per cent of our pine area is now taken up by an inferior species of little commercial value.

The great forestry problem, therefore, is as I see it, to restore these areas by scientific forestry management to the original valuable species. This can be done partly through planting, and partly through proper methods of cutting on timber sales to encourage the most valuable species. Here the problem is to increase our yellow birch and basswood in our hardwood stands and to encourage the growth of pine in our popple and worthless brush areas as well as on pine areas.

The same problem of inferior species coming in, presented itself to us twenty years ago in the Forest Service, in the great white pine forests of northern Idaho. The reproduction under these forests was found to be of an inferior type, white fir, hemlock, etc. To encourage the reproduction of white pine, therefore, a clear cutting strip method was adopted cutting a strip 450 feet wide and leaving a strip 150' wide for seeding purposes. This clear cut strip enabled a better disposal of slash, a more systematic management and eliminated the necessity of marking the individual trees for cutting. Later on this method was modified leaving groups of seed trees instead of strips. The point was that the necessity of having light, so as not to eliminate the valuable species,(pine),which could not develop in the shade was soon recognized.

Silvicultural studies of all these species therefore are important in order that their requirements for germination and subsequent growth be ascertained. A silvicultural system of cutting that keeps the able forest too dark may prove to be a method of eliminating our most valu species from the stand and encouraging the shade endurers. On the other hand too open methods of cutting might bring in grass or induce windfall.

Cutting of timber must be justified both from the silvicultural as well as the economic viewpoint. Cutting methods which make logging unprofitable are not practical, and logging without considering the future of the forest is not forestry.

In cutting for the future of the forest one of the first things necessary to know is what species we want to favor, that is, those bringing the best price and always in demand. I believe here in Wisconsin white and Norway pine, white spruce among the soft woods, and yellow birch and basswood among the hardwoods, are our most valuable species. Assuming that they are the most valuable the object of our management should be to encourage their growth by a method of cutting which will favor them to the greatest possible extent. Studies of these species have shown that none of them are especially tolerant or shade enduring, that is, they will not grow to advantage when the stand is dark, as in the case of hard maple, hemlock, balsam, etc. These last mentioned, the tolerant shade endurers, will eventually form our climax or final forest - unless disturbed by some unnatural cause such as fire or the hand of man.

I have just recently made a study of the growth of our three leading species of conifers in Vilas County. I find that in fifty years from the stump for instance - the average volume of a white pine tree is ten cubic feet, while the maximum volume found is twenty-five cubic feet. For Norway pine the average volume of the individual tree at fifty years from the stump is thirty cubic feet, while the maximum volume is forty-eight cubic feet. Most of this difference in volume production is caused by difference in light conditions and root competition. In planted stands this is eliminated to a considerable extent by regular spacing causing maximum production.

From such a study it becomes quite apparent that unless a cutting method is determined upon that will give sufficient light for the development and subsequent growth of the seedlings of the species to be favored the forest will more and more be dominated by the weed tree, and be greatly retarded in growth.

Two methods of cutting have been in use in a rough way in Wisconsin. The first might be termed clear cutting but it has been without forestry management to provide for the future which enables the tolerant species to come in in the light open spaces, and is applicable to the even aged pine stands especially.

Clear Cutting

It must be borne in mind that clear cutting does not mean desolation as has been practiced here in this state, but it is a systematic form of forestry management producing the greatest returns.

"The popular impression is that forestry consists of thinning the forest in the manner described for the selective system. The method of cutting only the largest trees and leaving the smaller ones is applicable to stands having trees of different age classes. In handling a stand in which all or nearly all the trees are mature, the design is to remove the whole stand, and replace it with new growth in as short a time as possible. This is accomplished by the clear cutting or shelter wood systems." (Methods of Handling Woodlands by Graves)

Conditions requiring clear cutting are

1. Danger from windfall.

2. Where all the trees are large and mature

3. Where a clearing is necessary to remove trees of undesirable form or poor species in order to establish a better species artificially, or to secure good natural reproduction of a species that cannot thrive under shelter.

Shelter Wood System. I want to refer briefly to this system as a possibility here in this state in cutting second growth pine. It is a system lying between clear cutting and selection. The stand is removed in 2 - 4 cuttings.

1. Preparatory cutting to encourage seeding
   20% of volume removed
   Open up crowns.

2. Reproduction cutting
   30% volume removed.

3. Final cuttings after reproduction established.

The second is what is known as the selection method, a shelter wood system which keeps the forest more or less dark, and has generally consisted in cutting trees to a diameter limit, taking out the largest mature timber, defectives, etc. It is of course especially adapted for the uneven aged hardwood forests. The tree favored in this system is theoretically cut lightest that is to the highest diameter limit while the inferior ones should be cut to a lower diameter limit. Unfortunately, the reverse has generally been true and those trees most in demand have suffered most, at the expense of the reproduction as well. The selective method is used in mountain countries as a protective method, and is nature's method in hardwood stands of uneven age, but does not favor those species demanding light. It is not a method for even aged stands of pine, where nature's method is a form of clear cutting with seeding from the side or seed trees.

About 7% of all German Forests are selective forests. Clear cutting with artificial reproduction has displaced all others in most of the German and Swiss forests.

In the bulletin on Yellow Birch and its relation to the Adirondacks Forest the author shows the need of light as essential for its reproduction. On one area in that region where selective cutting has been employed the following statement is made:

"Reproduction is shown to be largely hard maple and beech on the hardwood type at the expense of the yellow birch, where the light cutting was not enough to open up the crownsto allow birch to succeed. This characteristic is so pronounced and important that a table is given to show reproduction under these conditions as compared to clear cutting. The table shows that on an area logged to a diameter limit by the selection method thirty years ago there are now 224 yellow birch and 3779 sugar maple seedlings and trees under 1.5 inches in diameter per acre as compared with 2530 yellow birch and 83 sugar maple seedlings and trees under 1.5 inches in diameter per

acre in a clear cut area of largest extent where all the merchantable timber was taken. This I think shows pretty conclusively the need of more light for the reproduction of yellow birch.

Most of our cuttings at the present time are in hardwoods or mixed stands and the problems of cutting in such uneven aged stands are more complicated than in even aged stands of pine. Roth says the selection method costs more to log, produces less lumber and is more difficult to manage as compared to other cutting systems.

In writing of the selection system, Mr. Graves, our former forester and Professor of Forestry at Yale, states in his "Principles of Handling Hardwoods" - "Successful reproduction depends not only on a proper distribution of seed, but also on the conditions for germination and for the development of seedlings. The problem is very simple with tolerant species, for these are able to grow in very small openings and often a good reproduction is already established where the openings are to be made.

With intolerant species on the other hand special measures often have to be taken if they are to be reproduced successfully. If such measures are not taken other more tolerant species may occupy the opening to their exclusion. The opening must be large enough not only to give the trees a start but also to allow them to make straight and thrifty growth. It is therefore sometimes desirable to enlarge an opening beyond what is necessary to remove a single mature tree. In such a case one would aim to cut several trees in a group and in so doing it would often be necessary to cut trees under the diameter limit."

Often improvement cuttings are made. The aim is to leave enough trees close enough together to protect them from windfall, and to form a basis for a second cut, and to reseed the ground with the most valuable species taking out the defective and inferior trees.

In Bayfield County an average of sixteen hardwood plots of virgin timber showed 635 trees per acre above 1' in diameter, 252 trees above 4" in diameter, 149 trees above 6" in diameter and 60 above 10" in diameter. Only 7 plots had trees over 18" in diameter, and these 7 plots averaged 8 trees per acre over 18" in diameter. Therefore cutting only to an 18" diameter in those areas could not be justified.

These young trees are now growing under suppression and releasing them to the light would accelerate tremendously this young growth. Maple particularly has the ability to recover quickly and grow rapidly after years of suppression. Thence 16 hardwood stands indicate that the age classes are well represented.

If all merchantable timber of 60 trees down to 10" were removed, after 20 years 89 trees would be left 110 years old and averaging 10" in diameter. In forty years 103 trees ninety years old would be ready to cut and in 60 years we would have 383 trees 85 years old, hardly large enough to produce merchantable material. I doubt if it would be possible to cut this timber on a twenty year cycle and get enough to justify a logging operation after the second or third cut.

Summary. I have endeavored to point out the fact that light is essential for the growth and perpetuation of our most valuable species.

(1) A study of the species is necessary before any cutting system can be adopted.

(2) The system of cutting must depend on the species wanted and the tolerance of these species.

(3) The selection method is generally used in hardwoods, but is not adapted to pine. If used in hardwoods larger openings should be made to encourage intolerants like yellow birch, as the studies in the Adirondacks have shown as well as our studies here, that yellow birch produces itself to best advantage when it has plenty of light.

Wm. W. Morris
In Charge of Growth Study Investigations
Wisconsin Land Economic Inventory
Wisconsin Dept. of Agriculture &
Markets.

W. W. Morris

Paper given at Fourth Timber Conference, Madison, Wis., March 6, 1930.

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Lessons from the Forest Service Experience Applied to Wisconsin.

Given a vast unknown inaccessible mountainous region of several million acres to manage so as to produce the greatest possible sustained income from the land was the problem that confronted us in the Forest Service over twenty years ago in the West.

Today, in Wisconsin, the same problem confronts us and is especially acute in the northern half of the state, although the land is not so rough or inaccessible. One of the first essentials of the management of anything is a plan, and so the first thing done by the Forest Service was to have some plan of management, crude though it might be, which could be improved and modified with better knowledge of conditions.

Essentials of a Forest Working Plan.

In order to have any kind of a rough plan for the forest I found it was necessary to know the following things:

1. How much timber there was and where it was located.

2. The age classes of timber, its rate of growth, and whether it was going backward or not. This decrement or loss due to over-maturity of the timber is of great importance, for in the case of over-maturity, where the market would warrant, we would cut there first, before windfall and disease got the upper hand. I just recently received a letter from a friend of mine in the Canadian Service who states that Canada is putting on a big National Forest Inventory and will have twenty growth study parties in the field, and will not only study the annual increment that its forests are putting on each year, but will also make studies of the annual decrement or loss going on due to over-maturity of its forests. That is the way Canada is meeting the need of a land inventory and appreciates the use of growth studies and the necessity of selling and cutting timber before it goes backward.

3. The burned areas and the areas of no timber where planting might be resorted to.

4. The areas of better soils which might be blocked out as agricultural.

5. A study of the silvicultural requirements of the trees and the reproduction in order to determine cutting methods to perpetuate the valuable species.

In order to ascertain the above it involved a land inventory. My bear paw snowshoes were in demand all winter taking me in many inaccessible regions mapping timber, old burns, etc., that we might better know our forest, and its most marketable timber.

How does this apply to us here? The Wisconsin Land Economic Inventory is making just such a study to determine the above facts

which were considered necessary by the forest service before any crude plan of forest management could be adopted. Our present inventory will give us maps showing the location of the timber of the state, its kind, size, age, etc. It will give the total estimate of timber on the ground by species, its rate of growth and predictions for the future yield. It will give all the open and burned over areas where planting might be desirable, the areas of swamps, lakes, land now in agriculture, etc., besides many things on game and fish not pertaining to this article.

And so then we are just starting something (we have only been in two counties) to give us such facts which are essential before any kind of a working plan or system of management for the northern part of the state can be attempted.

In any plan of timber management one of the first essentials is to know the kind of timber producing the greatest income and its silvical requirements so that a proper method of cutting may be used to perpetuate this desired species. I think here in this state we are inclined to consider all areas of green as satisfactory timber land, where as a matter of fact, we have many thousands of acres that are producing no income whatever, I refer to our vast forests of pin-cherry, scrub-oak, and scattered popple. Mr. Goodman rightly pointed out that rather than talk of selective cutting as applied to all timber, it is better to say a plan of management, as selection cutting does not, in my judgment, apply to pine timber, and if practiced too restrictively in this state is liable to lead to the predominance of maple, and the exclusion of yellow birch and basswood. Restrictive cutting may lead, therefore, to the predominance of the weed tree and the exclusion of the desirable.

I quote the following from a technical report I wrote for the Coeur d' Alene National Forest over twenty years ago, which shows a similar problem to that here. "The problem of maintaining the white pine stand on this forest will not be an easy one. Actual counts of seedlings and young trees made on plots where white pine runs over fifty per cent of the mature stand, show that for every young white pine tree found in the reproduction, there are from one to three hundred white fir or hemlock. Numerous examples of this inferior reproduction can be found on all parts of the forest.

The loss incurred by allowing fine stands of white pine to deteriorate into stands of white fir and hemlock is great, as the following stand of merchantable timber is not only poorer, but the forest has no longer the ability to seed up with the proper species. It is noticeable, however, on this forest that wherever there are old burns or open places the reproduction is in most all cases of the more desirable kinds of timber. Such examples as these have helped in the solution of a proper cutting system. The problem has been to find some method of cutting that would meet the silvical demands of the species to be favored, and keep the poorer species from becoming the predominant stand." This lead to clear cutting in strips and the group seed tree method.

In my last paper I endeavored to show how much more favorable clear cutting methods were for the reproduction of yellow birch than a restrictive or selective system, as shown by a recent study made in the Adirondacks. Clear cutting does not mean desolation or destruction of our forests as so many seem to think, but it is a

scientific method of forestry management adapted for the reproduction and better growth of intolerant species such as our yellow birch, basswood and pine.

Knowledge of Rate of Growth Fundamental.

In any plan for forest management it is necessary to know how fast the various species grow so that we may determine the most valuable species to raise, predict its growth in fully stocked stands at any age, and the financial return. The growth study recently made in Vilas County, Wisconsin, reveals a wide range in the rate of growth of the various species in board feet production and I think is quite conclusive as the most desirable species for financial return.

	Volume in 50 years Bd. Ft.	Volume in 100 years Bd. Ft.	Volume in 150 years Bd. Ft.
White pine	30	330	1200
Norway "	100	470	1000
White spruce	10	200	620
Yellow birch	none	90	240
Maple	none	Av. Dia. 6 in. None	75

In one hundred and fifty years the white pine has produced a board foot volume of sixteen times that of the hard maple, and in one hundred years Norway pine has produced twenty-seven times the cubic foot volume of the hard maple. Can there be any doubt, therefore, as to the species to encourage in the northern part of the state, especially as most of our land is adapted to the growing of pine and spruce as well as having a favorable climate for these species?

In fifty years Norway pine has a big lead over the others and probably would be most valuable for short rotations for the production of pulp. Spruce will probably do much better in planted stands as in natural stands it is growing the greater part of its life under suppression. Therefore the figure of 820 board feet, the maximum growth found for white spruce for one hundred and fifty years, would probably be nearer correct for this species.

Planting

One of the first things we endeavored to do on our National Forest twenty years ago was to locate old burns and open areas not restocking with timber, and endeavor to restock them either by seeding or planting. I had charge of seeding twenty-four hundred acres with corn planter and planted possibly two hundred acres to white pine and Douglas fir another time and we endeavored to seed and plant on the most open and most favorable planting areas first. Planting was soon found to be the most successful method.

Here, in Wisconsin, therefore I believe it would be very desirable to plant up with pine or spruce our most favorable open areas first, as mapped by the inventory, then underplant with the same species our scattered popple, pin-cherry and scrub-oak lands, gradually converting them back to their original pine type and to a species that

will yield good financial returns. The growth study has shown that white pine will grow well under popple stands up to a density of about 50%. After that it is shaded out.

I do not believe it would be possible to convert our hardwood stands, even if we so desired, over to pine and spruce and therefore, I believe they should be left under a good form of management to produce the most rapid growth of the most desirable species. Growing as they do on the more valuable soils they will doubtless be used more and more as a woodlot proposition.

The popple, pin-cherry and scrub-oak stands, however, could be converted by planting into pine and spruce. This, of course, would call for a far greater nursery output which would be the first thing necessary in any planting plan.

Financial Rotation or When to Cut

There was one other important point we endeavored to ascertain on our national forest. This was as to the best rotation or when to cut or what is known as the best financial rotation. I believe we found this to be only about seventy-five years even for saw log timber.

Here we find that for pulp material in a planted stand the best financial rotation for white pine would be about sixty or seventy years and for Norway pine about forty years, figuring 3% compound interest on the investment.

For saw log material the best financial rotation for white pine would be probably from 110 to 130 years and for Norway pine about ninety years, at 3% compound interest on the investment. This would mean a diameter at breast height for pulpwood on an average of eleven inches for both white and Norway pine and twenty three or twenty-four inches for white pine and twenty inches for Norway when cut for saw timber.

Summary

The experience from National Forest work shows the following needs:

1. An inventory of our stock. (To show our timber, its kind, location, age, rate of growth, decrement, and its silvical requirements to perpetuate itself.)

2. To know our large areas of open non-agricultural lands that are not restocking to a species of value.

3. To plant first, these very favorable areas, to pine and spruce, and second, underplant our vast areas of popple, pin-cherry and scrub-oak gradually converting them into revenue producing species, so they will be assets and not losses to the community.

W.W.Morris,
In Charge of Growth Study
Investigations
Wisconsin Land Economic Inventory
Wisconsin Dept. of Agriculture & Markets.

TABLES SHOWING GROWTH AND MERCHANTABILITY
FOR
WHITE, NORWAY, and JACK PINE
NORTHERN WISCONSIN

Wisconsin Land Inventory
1931.

Wis. Land Inventory
1931

Merchantable Table for White Pine

Vilas County, Wis.

Diameter Breast High	Av. Merch. Height Above Stump to 7 Inches Top Diam.	Average Total Volume		Merchantable Units
Inches	Feet	Cu.ft.	Bd.ft.	
1				
2				
3				
4				
5		1		
6		2		
7		3		
8	8	6	20	1 - 8' pulpwood stick
9	15	11	30	1 - 14' sawlog
10	24	17	50	1½ - 16' sawlog
11	32	24	70	2 - 16' sawlogs
12	41	31	100	2½ - 16' "
13	48	38	130	3 - 16' "
14	55	46	175	3 - 14' " and 1 - 12' sawlog
15	61	54	215	3 - 16' " " 1 - 12' "
16	67	62	270	4 - 16' "
17	72	70	325	4½ - 16' "
18	76	79	385	4 - 16' " " 1 - 12' "
19	79	87	450	4 - 16' " " 1 - 14' "
20	82	97	525	2 - 16' " " 2 - 14' " "
				1 - 12' " " 1 - 10' "
21	84	107	600	4 - 16' " " 2 - 10' "
22	87	118	670	4 - 16', 1 - 12', and 1 - 10' sawlog.
23	88	128	750	5½ - 16' sawlog
24	90	140	830	5 - 16' " and 1 - 10' sawlog
25	91	150	925	5 - 16' " " 1 - 10' "
26	92	162	1015	5 - 16' " " 1 - 12' "
27	93	175	1120	5 - 16' " " 1 - 12' "
28	94	187	1220	5 - 16' " " 1 - 14' "
29	95	201	1320	5 - 16' " " 1 - 14' "
30	96	215	1425	6 - 16' "
31	96	230	1525	6 - 16' "
32	97	243	1625	6 - 16' "
33	97	258	1725	6 - 16' "
34	98	272	1825	3 - 16', 2 - 14', 1- 12' & 1-10' sawlog
35	98	286	1930	3 - 16', 2 - 14', 1-12' & 1-10' "
36	98	301	2040	3 - 16', 2 - 14', 1-12' & 1-10' "
37	99	315	2135	3 - 16', 2 - 14', 1-12' & 1-10' "
38	99	330	2240	3 - 16', 2 - 14', 1-12' & 1-10' "
39	99	343	2340	3 - 16', 2 - 14', 1-12' & 1-10' "
40	100	357	2440	5 - 16' sawlogs and 2 - 10' sawlogs
41	100	372	2550	5 - 16' " " 2 - 10' "
42	100	385	2650	5 - 16' " " 2 - 10' "
43	100	400	2750	5 - 16' " " 2 - 10' "
44	100	414	2850	5 - 16' " " 2 - 10' "

(See Note on following page)

Note:

1. Based on 26 trees on logging operations.

2. Av. stump height is 1.0 foot.

3. Diameter breast high is measured at 4½ feet above ground, outside bark.

4. D.B.H. x 1.08 = D.I.B. stump.

5. An average tree will produce its first 10 foot sawlog, 6 inches at top, in 38 years. Stump diameter is 7.8 inches, volume is 2.5 cubic feet.

6. The Scribner Decimal "C" log rule was used in computing board foot volumes.

7. Trees were cut to 7 inches average top diameter, and ranged from 18 to 44 inches D.B.H.

Wis. Land Inventory
1931

Taper Table for White Pine

Vilas County, Wis.

Height Above Stump	Taper (Av. difference between diameter at stump and at any given height above stump)			Av. taper per foot for 5 foot intervals			
	Trees 0-9 inches D.I.B.stump	Trees 10-19 inches D.I.B. stump	Trees 20-44 inches D.I.B.Stump	Intervals	Diameter Groups		
					0-9"	10-19"	20-44"
Feet	Inches	Inches	Inches	Feet	In.	In.	In.
5	1.0	1.7	3.5	0-5	0.20	0.34	0.7
10	1.8	2.7	5.5	5-10	0.16	0.20	0.4
15	2.5	3.3	6.5	10-15	0.14	0.12	0.2
20	3.1	3.7	7.0	15-20	0.12	0.08	0.1
25	3.6	4.3	7.5	20-25	0.10	0.12	0.1
30	4.2	4.8	8.0	25-30	0.12	0.14	0.1
35	4.7	5.3	8.5	30-35	0.10	0.10	0.1
40	5.2	6.0	9.0	35-40	0.10	0.14	0.1
45	5.8	6.7	9.5	40-45	0.12	0.14	0.1
50	6.3	7.6	10.5	45-50	0.10	0.18	0.2
55	7.0	8.7	11.5	50-55	0.14	0.22	0.2
60	7.7	9.7	12.5	55-60	0.14	0.20	0.2
65	8.5	10.8	13.5	60-65	0.16	0.22	0.2
70	9.4	12.0	14.5	65-70	0.18	0.24	0.2
75		13.4	16.0	70-75		0.28	0.3
80		14.6	17.5	75-80		0.24	0.3
85		16.1	19.5	80-85		0.30	0.4
90		17.5	21.5	85-90		0.28	0.4
95		19.1	24.0	90-95		0.32	0.5
100			27.0	95-100			0.6
105			30.5	100-105			0.7
110			34.0	105-110			0.7
115			39.0	110-115			1.0

Note:

1. Based on 26 trees on logging operation.
2. Diameter groupings are inclusive (0-9", 10-19", 20-44")
3. The difference in taper between the diameter groupings lies mostly in the first 15 feet above the stump, the larger trees having more taper.
4. This table may be used in estimating white pine to determine average diameter at any height, or the average merchantable height to any desired top diameter, on good sites.

Wis. Land Inventory
1931

Comparison of D.B.H. and D.I.B. Stump for White Pine

Diameter Breast High Inches	Diameter at Stump inside bark Inches
1	1.0
2	2.1
3	3.2
4	4.3
5	5.4
6	6.5
7	7.6
8	8.7
9	9.8
10	11.0
11	12.0
12	13.1
13	14.2
14	15.3
15	16.4
16	17.5
17	18.6
18	19.7
19	20.8
20	21.9
21	23.0
22	24.1
23	25.2
24	26.3
25	27.4
26	28.4
27	29.5
28	30.6
29	31.8
30	33.0
31	34.0
32	35.0
33	36.1
34	37.2
35	38.2
36	39.0
37	40.0
38	40.7
39	41.5
40	42.2
41	42.8
42	43.4
43	43.8
44	44.2

Note:
Average stump height is approximately one foot.

Wis. Land Inventory
1931

Taper Table for Norway Pine

Vilas County, Wis.

Height Above Stump	Taper (Av. difference between diameter at stump and at any given height above stump)			Av. Taper per Foot for 5-foot intervals			
	Trees 0-10 inches D.I.B. Stump	Trees 11-20 inches D.I.B. Stump	Trees 21-30 inches D.I.B. Stump	Intervals	Trees 0-10 inches D.I.B. stump	Trees 11-20 inches D.I.B. stump	Trees 21-30 Inches D.I.B. stump
Feet	Inches	Inches	Inches	Feet	Inches	Inches	Inches
5	0.8	1.3	2.6	0-5	.16	.26	.52
10	1.5	2.5	4.3	5-10	.14	.24	.34
15	2.2	3.4	5.4	10-15	.14	.18	.22
20	2.9	4.3	6.3	15-20	.14	.18	.18
25	3.6	5.0	7.0	20-25	.14	.14	.14
30	4.3	5.7	7.6	25-30	.14	.14	.12
35	5.1	6.4	8.3	30-35	.16	.14	.14
40	5.8	7.1	8.9	35-40	.14	.14	.12
45	6.6	7.8	9.5	40-45	.16	.14	.12
50	7.3	8.7	10.2	45-50	.14	.18	.14
55	8.0	9.7	10.9	50-55	.14	.20	.14
60	8.7	10.5	11.6	55-60	.14	.16	.14
65	9.4	11.7	12.7	60-65	.14	.24	.22
70	10.2	12.8	13.7	65-70	.16	.22	.20
75	10.9	14.1	15.0	70-75	.14	.26	.26
80		15.3	16.3	75-80		.24	.26
85		16.7	18.0	80-85		.28	.34
90		18.2	19.8	85-90		.30	.36
95		19.7	22.0	90-95		.30	.44
100			24.8	95-100			56

Note:

1. Based on 17 trees on logging operation.
2. Diameter groupings are 0 - 10.5 incl., 10.6-20.5 incl., and 20.6 - 30.5 incl.
3. This table may be used in estimating Norway pine to determine average diameter at any height, or the average merchantable height to any desired top diameter, on good sites.

Wis. Land Inventory
1931

Merchantable Table for Norway Pine

Vilas County, Wis.

Diameter Breast High	Av. Merch. Height (above stump) to 4 inches Top Diameter	Average Total Volume		Merchantable Units (Pulpwood is taken slightly below 4 inches in top in some cases)
Inches	Feet	Cu.ft.	Bd. Ft.	
5	8	1.0		1 - 8' pulpwood stick
6	16	1.5		2 - 8' " "
7	24	3.5	10	1 -16' sawlog, 1 - 8' pulp stick
8	31	6.5	20	1 -16' " 2 - 8' " "
9	36	9.5	30	1 -16' " 2½- 8' " "
10	42	12.5	40	2 -16' " 1 - 8' " "
11	47	17.0	60	2 -16' " 2 - 8' " "
12	52	22.0	80	2 -16' " 2½- 8' " "
13	56	27.0	100	2 -16' " 3 - 8' " "
14	60	32.5	130	3 -16' " 1½- 8' " "
15	64	38.5	165	3 -16' " 2 - 8' " "
16	68	45.5	205	3 -16' " 2½--8' " "
17	72	53.0	250	4 -16' " 1 - 8' " "
18	75	60.0	295	4 -16' " 1 - 8' " "
19	79	70.0	355	4 -16' " 2 - 8' " "
20	82	80.5	415	4 -16' " 2 - 8' " "
21	85	93.0	490	4 -16' " 2½- 8' " "
22	88	106.0	570	5 -16' " 1 - 8' " "
23	91	119.0	660	5 -16' " 1 - 8' " "
24	93	130.5	740	5 -16' " 1½- 8' " "
25	95	143.0	840	5 -16' " 2 - 8' " "
26	97	154.0	925	5 -16' " 2 - 8' " "
27	99	165.0	1015	6 -16' " ½ - 8' " "
28	101	176.0	1105	6 -16' " ½ - 8' " "
29	102	186.5	1190	6 -16' " ½ - 8' " "
30	103	198.0	1295	6 -16' " 1 - 8' " "

Note:

1. Based on 17 trees on logging operation.
2. Av. stump height is 1.0 foot.
3. Diameter breast high is measured at 4½ feet above the ground, outside bark.
4. Trees were cut to 8 inches in top, and ranged from 20 to 30 inches D.B.H.
5. An average tree will produce its first 10 ft. log, 6 inches at top, in 25 years. D.I.B. stump = 7.5 inches. Volume = 2.4 cubic feet.
6. The Scribner Decimal "C" log rule was used in computing board foot volumes.

Comparison of D.B.H. and D.I.B. Stump for Norway Pine

Diameter Breast High	Diameter at Stump Inside bark
Inches	Inches
1	1.0
2	2.1
3	3.2
4	4.2
5	5.2
6	6.3
7	7.4
8	8.5
9	9.5
10	10.5
11	11.6
12	12.7
13	13.7
14	14.7
15	15.8
16	16.9
17	18.0
18	19.0
19	20.1
20	21.1
21	22.2
22	23.3
23	24.4
24	25.4
25	26.5
26	27.5
27	28.5
28	29.6
29	30.6
30	31.7

Note: Average stump height is approximately one foot.

Wis. Land Inventory
1931

Growth Table for Jack Pine in Northern Wisconsin

Age at Stump	Av. D.I.B. Stump	Max. D.I.B. Stump	Av. Total Height	Av. Merch. Height (including stump) to 4" top	Av. Merch. Volume to 4" top
Years	Inches	Inches	Feet	Feet	Cu. ft.
5	.9	2.4	2		
10	2.2	4.6	6		
15	2.7	6.6	13		.3
20	3.6	8.3	22		.7
25	4.6	10.0	31		1.5
30	5.5	11.4	38	20	2.4
35	6.4	12.7	43	29	3.5
40	7.3	13.8	47	34	4.9
45	8.2	14.9	51	37	6.4
50	9.1	15.8	54	40	8.2
55	10.0	16.7	57	44	10.1
60	11.0	17.5	60	47	11.0
65	11.9	18.2	64	49	14.4
70	12.8		67		
75	13.7		70		

Note:

1. Based on stump and stem measurements of 78 trees in Bayfield, Vilas, and Oneida counties.

2. Usual stump height is 1 foot, although some are cut at ground.

Wis. Land Inventory
1931

Taper Table for Jack Pine in Northern Wisconsin

Height Above Stump	Average Taper (Difference between diameter at stump and at any given height above stump)	Av. Taper per foot for 5-foot intervals	
Feet	Inches	Feet	Inches
5	.5	0-5	.10
10	.9	5-10	.08
15	1.4	10-15	.10
20	2.0	15-20	.12
25	2.5	20-25	.10
30	3.2	25-30	.14
35	3.8	30-35	.12
40	4.6	35-40	.16
45	5.6	40-45	.20
50	6.8	45-50	.24
55	8.1	50-55	.26
60	9.8	55-60	.34

Note:

1. Based on 24 trees in Bayfield and Vilas counties.
2. All diameter measurements were made inside bark.
3. This taper table may be used to indicate average diameters at different heights, and also the average height to any given top diameter.

Wis. Land Inventory
1931

Merchantable Table for Jack Pine in Northern Wisconsin

Diameter Breast High	Av. Merch. Height Above Stump to 4" top	Av. Merch. Volume to 4" top	Merchantable Units
Inches	Feet	Cu. Ft.	
1			
2		.1	
3		.5	
4		1.1	
5	14	1.9	1½ - 8 ft. pulp sticks
6	25	3.1	3 - 8 " " "
7	32	4.6	4 - 8 " " "
8	36	6.2	4½ - 8 " " "
9	40	8.4	5 - 8 " " "
10	43	10.5	1 -10 " sawlog, 4-8-ft. pulpsticks
11	46	12.8	2 -10 " " 3-8 " "
12	48	15.0	3 -10 " " 2-8 " "

Note:

1. Merchantable height based on 15 trees, volume based on 38 trees.
2. Usual stump height is 1 foot, although some are cut at ground.
3. Diameter breast high is measured at 4½ feet above ground, outside bark.
4. An average tree (according to these figures) will produce one 8 foot log, 4 inches at the small end, in 26 years at the stump. Stump diameter inside bark is about 4.8 inches and volume is 0.85 cubic feet. The best single tree produced the same in 19 years.

Comparison of
D.B.H. and D. I. B. Stump
for
Jack Pine

Diameter Breast High	Diameter at Stump Inside Bark
Inches	Inches
1	1.2
2	2.3
3	3.2
4	4.1
5	5.1
6	6.1
7	7.1
8	8.1
9	9.2
10	10.2
11	11.2
12	12.2
13	13.2
14	14.2
15	15.2

Note:

1. Usual stump height is 1 foot, although some are cut at ground.

2. Jack pine in Bayfield and Vilas counties, Wisconsin.

Number of Years Required by Various Species of Trees to Produce the First Merchantable Unit Northern Wisconsin

Species	Age at stump to produce 1-8' log, 3" top		Age at stump to produce 1-8' log, 4" top		Age at stump to produce 1-10' log 6" top		Age at stump to produce 1-16' log 6" top		Age at stump to produce 1-7' post 4" top		Basis
	Max. tree	Av. tree	Max. tree	Av. tree	Max. tree	Av. tree	Max. tree	Av. tree	Max. tree	Av. tree	Number trees
White pine			19	27	25	38	33	43			26
Norway pine			11	18	17	25	22	28			17
White spruce	17	40			29	56	32	59			13
Jack pine			19	26	31	38					23
Hemlock			53 (Flambeau River)	96	83 (Flambeau River)	120					20
Balsam			24	76							32
Black spruce	34	54									42
White cedar									39	89	32
Aspen	12	23									11
Yellow birch							51 (Bayfield)	75			27
Hard maple							89 (Bayfield)	131			7

Note: White pine, Norway pine, and white spruce figures are from a logging operation in Vilas County. Jack pine data were largely from Bayfield County. Hemlock figures are from the Flambeau River in Sawyer County. Near Clam Lake, Ashland County, the growth was poorer, hemlock requiring 69 years and 115 years respectively, for maximum and average growth, to produce an 8 ft. log, 4 inches at the top, and requiring 87 years and 140 years, respectively, for maximum and average growth, to produce a 10 ft. log, 6 inches at the top. Yellow birch and hard maple show a little faster growth in Bayfield County than in Vilas County, according to the few trees measured. Balsam, black spruce, white cedar, and aspen figures are from southwestern Ashland County. The aspen is growing under optimum conditions. The age given in these tables does not include the number of years required for the tree to reach stump height.

C

DETAILED STUDY of the

GROWTH

of

WHITE SPRUCE in

VILAS and ASHLAND Counties

With

GROWTH, TAPER and MERCHANTABLE VOLUME TABLES

Wisconsin Land Inventory
1931

Possibilities of White Spruce for Reforestation Purposes

White Spruce. White spruce in northern Wisconsin by reason of its value for paper pulp as well as for other important uses, and from the fact that it is one of our most rapidly growing trees, especially in early life, bids fair to become an important tree for reforestation purposes. Red spruce, Norway spruce, and white spruce, all make a very desirable paper pulp of about equal merits regarding strength, color, etc., and experiments should be made to determine the relative rate of growth of these three species growing under similar conditions in the northern part of the state. White spruce, being the only one that is native to the state, would naturally be the one to use for reforestation until any of the others prove by experimentation to be more desirable. Unlike the black spruce, white spruce is not a swamp species, but grows to its best advantage on moist upland conditions, and is usually found growing in mixture with white and Norway pine or with hemlock hardwood stands. It has a very cylindrical bole, a scant crown, a short top to a three inch diameter, and very little of the tree is wasted in branches and tops.

Opportunity was offered to make a complete stem analysis of 24 large white spruce cut for sawlogs on a logging operation in Vilas County, and 13 smaller white spruce cut for sawlogs and pulp in Ashland County. The largest white spruce measured had a diameter breast high of 28" and a height of 107½'. Five 16' logs were taken from this tree to a 8" top and two more 8' pulpwood sticks could have been taken from it to a 3" top. It had a total volume to a 3" top of 134 cubic feet and 730 board feet to a 6" top. The fastest growing white spruce which produced the greatest volume in the shortest time was 23.5" in diameter breast high and 112½' tall when cut. This spruce not only grew in diameter faster in its early life than any of the other spruce, but also in height. It produced a total volume of 600 board feet and 120 cubic feet when cut. At 17 years of age from the stump it produced its first merchantable unit, an 8' pulpwood stick 4.3" at the stump and 3" in diameter inside bark at the top. At 60 years of age it was 79½' tall. Another white spruce measured in Ashland County, made its first merchantable pulpwood stick 8' long and 3" at the top in 18 years from the stump. This tree was about 46' in height at 35 years of age as compared to 47' in height at this age for the preceding tree. The average time required to produce the first pulpwood stick 8' long with a 3" top is 40 years.

Detailed Analysis of Growth

The following table shows the rate of growth in diameter, height, and volume for the average tree taken from all the white spruce studied, and the diameter growth of the maximum tree:

TABLE Showing Growth for Every Five Year Period for White Spruce Vilas Co., Wis.

Five Year Period in Life of Tree	Dia. growth at stump every five years inches		Height growth every five years Feet		Volume growth every five years Cubic feet	
	Average tree	Max. tree	Average tree	Max. tree	Average tree	Max. tree
0-5	0.2	1.0	3	5	.0	.0
5-10	0.3	1.0	2	4	.0	.0
10-15	0.4	1.6	3	5	.0	.15
15-20	0.5	1.6	2	6	.0	.85
20-25	0.6	1.6	4	7	.0	1.5
25-30	0.7	1.6	5	9	.1	2.5
30-35	0.8	1.6	5	10	.1	4.5
35-40	0.9	1.6	5	9	.4	3.5
40-45	0.9	1.6	4	8	1.1	4.0
45-50	0.9	1.6	7	6	1.1	6.0
50-55	1.1	1.4	9	6	1.7	6.0
55-60	1.1	1.2	7	4	2.5	6.0
60-65	1.2	1.2	6	4	3.1	6.0
65-70	1.2	1.0	5	3	3.6	6.0
70-75	1.2	1.2	4	2	4.3	6.0
75-80	1.1	0.8	4	3	3.5	6.0
80-85	1.0	0.8	3	2	4.5	6.0
85-90	1.1	0.8	3	2	5.4	6.0
90-95	1.0	0.8	3	2	5.0	6.0
95-100	1.0	0.6	2	2	5.3	6.0
100-105	0.9	0.7	3	2	4.9	6.0
105-110	0.9	0.6	2	1	5.1	6.0
110-115	1.0	0.6	2	2	5.9	6.0
115-120	0.9	0.5	2	2	5.5	6.0
120-125	0.9	0.6	2	1	6.0	6.0
125-130	0.8	0.5	2	2	5.0	6.0
130-135	0.8	0.4	1	1	5.5	6.0
135-140	0.9	0.4	2	1	7.2	6.0
140-145	0.9		1	2	7.4	6.0
145-150	0.8		2	1	6.9	6.0

Based on 24 large trees.

Diameter Growth. It will be noticed that a comparison of average and maximum diameter growth shows a growth in diameter of 1.6" for the period of 10 to 15 years for the maximum tree, with only a quarter as much as this for the average tree for the same period. The diameter growth of the average tree never equals the most rapid growth of the maximum, which attains its greatest diameter growth in early life; but at the age of 60 to 65, the average growth has increased until it equals the growth of the maximum tree which has now begun to diminish. From then on the diameter growth per year of the average exceeds the growth of the maximum tree, but it never attains the total diameter of the maximum.

Height Growth. In height growth the maximum tree is making its best growth (2' a year) at the age of 30 to 35 years. This growth is nearly attained by the average tree at the age of 50 to 55 years. The most rapid growth in height of the maximum tree is made in early life up to about 45 years, after which its height growth diminishes below that of the average tree.

Volume Growth. Volume growth is always of importance for it is directly proportional to the actual value which the tree is producing yearly. It will be seen that the maximum tree first puts on its greatest volume of 6 cubic feet in a five-year period, at the age of 45 to 50 years. From this time on, the volume increased regularly at 6 cubic feet every five years until the tree was cut. It was not until the five-year period of 120 to 125 years, that the average tree first put on a volume of 6 cubic feet. Seventy-five such trees growing at this rate would produce a cord a year. A fully stocked stand at 50 years of age should have approximately 500 trees to the acre.

The analysis of the growth shows that what is needed for raising pulpwood material is a growth in early life corresponding to the growth of a maximum tree. The great difference in growth is due to lack of sufficient light in early life of the white spruce growing under average conditions. A study of the maximum tree shows no suppression due to this cause. Planting will do away with suppression as every tree of a planted stand has light on all sides in early life. A planted stand, therefore, should grow more nearly like the growth made by the maximum tree which was not suppressed by too much shade and root competition. The growth, therefore, of a stand of white spruce growing under natural conditions is not a just criterion as to its rate of growth if given light in early life as in a planted stand.

The study shows that a tree like the white spruce can endure a great deal of suppression in early life, but when finally its crown becomes dominant and it receives full sunlight, it makes a quick recovery, and if not too badly suppressed, ends its life having approximately the same volume as its neighbor which made the greater part of its most rapid growth in early life. It makes a vast deal of difference, however, from the standpoint of financial returns whether the tree produces this volume early or late in life,

and a planted stand has this great advantage, namely: Of quick growth in early life by reason of its having desirable light conditions at this stage.

Soil. As this area grew the finest white spruce and pine thus far in the inventory work, a study of the soil is interesting and important. This fine growth was made on soil classified generally as Vilas sandy loam. The spruce was intermixed with beautiful large white and Norway pine and rather poor hardwoods. The soil was greatly mixed grading from a fine sandy loam to sand with here and there a little clay mixture. A cross-section of the soil down to 3', which would include practically all the main tree roots, showed the following: Needles and duff down to 2 inches, a loamy sand or gray podsil 2-6", a coffee brown sandy loam 6-14", transitional soil 14-18", angular sand and fine gravel 18-26", gray fine sand 26"-3'. If level this area would probably have been classified as Plainfield sandy loam instead of Vilas sandy loam. No fire had burned over this area for years except in local spots leaving the humus still available, and this fact together with desirable soil and moist conditions probably accounts for the remarkable growth of the timber. It is interesting to note that this splendid white spruce and pine was growing on land that is not good hardwood land, as the hardwoods are small and more or less defective.

Desirability for Paper Pulp. White spruce has a fiber length of 2.8 millimeters and an oven dry weight per cubic feet of 24 pounds. By the sulphite process it makes an excellent pulp, is strong, and bleaches easily to excellent white. Used for news, wrapping, book, high-grade printing and bond papers. By the sulphate process it makes an excellent pulp, very strong and of fine texture. It is used for high grade kraft, wrapping papers, and fiber board. By the mechanical process, it reduces readily, is of excellent color and standard strength, and is used for all purposes requiring ground wood.

The following tables show the growth, taper, and volume in cubic feet, board feet, and merchantable units for white spruce.

Wm. West Morris
In charge Growth Study Investigations
Wisconsin Land Inventory

Assistance in the preparation of the following tables was given by Lamar Wood of the Forestry School of Michigan State College.

Growth Table
for
White Spruce
Under Best Growth Conditions
Site I - Vilas County

Age at Stump	Av. Diam. at Stump	Max. Diam. at Stump	Av. Total Height	Max. Total Height	Av. Merch. Vol. to 3" top	Max. Merch. Vol. to 3" top.	Av. Merch. Height (incl. stump) to 3" top Diam.
Years	Inches	Inches	Feet	Feet	Cu. Ft.	Cu. Ft.	Feet
5	.2	1.0	3	5			
10	.5	2.0	5	9			
15	.9	3.6	8	14		.15	
20	1.4	5.2	10	20		1.0	
25	2.0	6.8	14	27		2.5	
30	2.7	8.4	19	36	.1	5.0	
35	3.5	10.0	24	46	.2	9.5	
40	4.4	11.6	29	55	.6	13.0	10
45	5.3	13.2	35	63	1.7	19.0	18
50	6.2	14.8	42	69	2.8	25.0	24
55	7.3	16.2	51	75	4.5	31.0	31
60	8.4	17.4	58	79	7.0	37.0	36
65	9.6	18.6	64	83	10.1	43.0	42
70	10.8	19.6	69	86	13.7	49.0	47
75	12.0	20.8	73	88	18.0	55.0	53
80	13.1	21.6	77	91	22.5	61.0	57
85	14.1	22.4	80	93	27.0	67.0	62
90	15.2	23.2	83	95	32.4	73.0	67
95	16.2	24.0	86	97	37.4	79.0	71
100	17.2	24.6	88	99	42.7	85.0	75
105	18.1	25.3	91	101	47.6	91.0	78
110	19.0	25.9	93	102	52.7	97.0	81
115	20.0	26.5	95	104	58.5	103.0	84
120	20.9	27.0	97	106	64.0	109.0	87
125	21.8	27.6	99	107	70.0	115.0	89
130	22.6	28.1	101	109	75.0	121.0	90
135	23.4	28.5	102	110	80.5	127.0	91
140	24.3	28.9	104	111	87.7	133.0	92
145	25.2	29.0	105	113	95.1	139.0	93
150	26.0	29.2	107	114	102.0	145.0	94

Note: 1. Based on 24 large trees cut on logging operation.
2. Average stump height is 1.5 feet.
3. Merchantable height includes stump height.
4. All diameters given are inside bark.
5. Note great height growth as compared to that under open conditions on area in Ashland.

Growth Table
for
White Spruce
Open Grown With Popple
on Burned-over and Cut-over Land.
Soil poorly drained, fine sandy loam
Ashland County

Age at Stump	Av. Diam. at Stump	Max. Diam. at Stump	Av. Total Height	Max. Tot. Ht.	Av. Merch. Vol. to 3" top	Max.Merch. Vol. to 3" top	Av.Merch. Height (incl.stump) to 3" top Diam.
Years	Inches	Inches	Feet	Feet	Cu. Feet	Cu. Feet	~~Cu.~~ Feet
5	.2	1.6	3	6			
10	.4	3.2	5	12			
15	.7	4.8	8	18		.1	
20	1.0	6.4	10	24		1.8	
25	1.2	8.0	13	32		3.3	
30	1.5	9.6	16	39		6.0	
35	1.9	11.2	19	45		9.5	
40	2.3	12.8	22	50		13.4	
45	2.7	14.4	25	55		17.3	
50	3.2	16.0	29	60		21.0	
55	3.8	17.6	33	64		24.5	
60	4.4	19.2	37	68	1.0		10
65	5.2		41		1.5		17
70	6.0		44		2.4		23
75	6.9		48		3.7		29
80	7.9		51		5.0		34
85	8.8		55		6.6		38
90	9.8		58		8.5		43
95	10.7		61		10.5		47
100	11.6		64		13.2		51
105	12.6		66		16.7		55
110	13.5		69		20.5		60
115	14.5		71		25.0		64
120	15.4		74		29.5		68
125	16.4		76		35.0		72
130	17.3		78		40.0		76
135	18.2		80		45.5		79
140			82				82
145			84				
150			86				

Note: 1. Based on 13 trees cut on small pulpwood operation.
2. Average stump height is 1.3 feet.
3. Merchantable height includes stump height.
4. All diameters given are inside bark.
5. Note smaller height growth and slightly greater diameter growth of maximum trees as compared to those on area in Vilas County, on account of open growth.

Wis. Land Inventory
1930.

Taper Table
for
White Spruce
Vilas and Ashland Cos.

Height Above Stump	Taper for Trees 0-9" D.I.B. Stump	Taper for Trees 10-19" D.I.B. Stump	Taper for Trees 20-30" D.I.B. Stump	Av. Taper per ft. for 5' intervals			
				Intervals	Trees 0-9" D.I.B. Stump	Trees 10-19" D.I.B. Stump	Trees 20-30" D.I.B. Stump
Feet	Inches	Inches	Inches	Feet	Inches	Inches	Inches
5	.9	2.3	5.6	0-5'	.18	.46	1.12
10	1.6	3.3	6.9	5-10'	.14	.20	.26
15	2.1	4.0	7.7	10-15'	.10	.14	.16
20	2.7	4.7	8.4	15-20'	.12	.14	.14
25	3.2	5.2	9.0	20-25'	.10	.10	.12
30	3.8	5.8	9.6	25-30'	.12	.12	.12
35	4.5	6.4	10.3	30-35'	.14	.12	.14
40	5.2	7.1	11.0	35-40'	.14	.14	.14
45	6.1	7.9	11.8	40-45'	.18	.16	.16
50	6.9	8.8	12.6	45-50'	.16	.18	.16
55	7.9	9.7	13.5	50-55'	.20	.18	.18
60	9.0	10.7	14.5	55-60'	.22	.20	.20
65		11.7	15.5	60-65'		.20	.20
70		12.7	16.5	65-70'		.20	.20
75		13.8	17.6	70-75'		.22	.22
80		14.9	18.8	75-80'		.22	.24
85		16.3	20.2	80-85'		.28	.28
90			21.7	85-90'			.30
95			23.5	90-95'			.36
100			25.8	95-100'			.46
105			28.8	100-105'			.60

Note:
1. Based on 37 trees (24 in Vilas Co., 13 in Ashland Co.)
2. Diameter classes are all inclusive (0.9", 10-19", 20-30")
3. Above 20 feet from stump, rate of taper is practically the same for trees of all diameters. The great difference in taper lies below 20 feet. The larger trees have much more taper (below 20 ft.) than have small trees.
4. This taper table may be used when estimating white spruce to determine the diameter at any point in the tree, and also the merchantable height (approximate) of any white spruce to a 3-inch top or any desired diameter in the top.

Merchantable Table
for
White Spruce
Vilas County

Diam. Breast High	Av. Merch. Height Above Stump to 3" top	Av. Merch. Vol. to 3" top	Av. Mer. Vol. to 6" top	Merchantable Units
Inches	Feet	Cu.ft.	Bd. ft.	
1				
2				
3				
4	9	.5		1 - 8' pulpwood stick
5	19	2.0		2 - 8' " "
6	26	4.0		3 - 8' " "
7	32	6.5	10	4 - 8' " "
8	37	9.5	15	1 - 10' sawlog (6" top), 3 - 8' pulp sticks
9	42	12.5	20	1 - 16' " 3 - 8' pulp sticks.
10	48	16.5	40	1 - 16' and 1-10' sawlog. 2-8' and 1-4' pulp sticks
11	53	21.0	65	2 - 16' sawlogs, 2-8' & 1-4' pulp sticks
12	57	26.0	100	2 - 16' " 3-8' pulp sticks
13	62	32.0	135	2 - 16' " 3-8' and 1-4' pulp sticks.
14	67	38.0	175	3 - 16' " 2-8' pulp sticks
15	72	44.5	210	3 - 16' " 3-8' " "
16	76	52.0	255	3 - 16' & 1-12' sawlogs, 2-8' pulp sticks
17	81	60.0	295	4 - 16' sawlogs, 2-8' pulp sticks
18	84	68.0	335	4 - 16' sawlogs, 2-8' & 1-4' pulp sticks
19	87	77.5	380	4 - 16' and 1-12' sawlogs, 1-8' pulp stick
20	89	86.5	425	4 - 16' and 1-14' " 1-8' " "
21	91	96.0	475	5 - 16' sawlogs, 1-8' pulp stick
22	92	105.0	520	5 - 16' " 1-8' & 1-4' pulp stick
23	93	114.0	570	5 - 16' " 1-8' & 1-4' " "
24	94	121.0	610	5 - 16' " 1-8' & 1-4' " "
25	95	127.0	660	5 - 16' " 1-8' & 1-4' " "
26	95	131.5	700	5 - 16' " 1-8' & 1-4' " "
27	96	136.0	730	5 - 16' " 2-8' pulp sticks
28	96	139.5	760	5 - 16' " 2-8' " "
29	97	142.5	785	5 - 16' " 2-8' " "
30	97	145.0	805	5 - 16' " 2-8' " "

Note:
1. Based on 24 large trees cut in logging operation.
2. Average stump height cut was 1.5 feet.
3. Diameter breast high is measured at 4½ feet above the ground, outside bark.
4. To convert D.B.H. to diameter inside bark at stump, multiply by 1.1 for D.B.H.'s of 0.19 inches inclusive, and by 1.2 for D.B.H.'s of 20 inches and above.
5. To produce one 8-foot pulpwood stick, 3inches at small end, an average tree must be 4.3 in. at the stump, or 3.9 in.D.B.H. The age of this average tree is 40 years at the stump. The stick has a volume of 0.55 cu. feet.
6. The Scribner Decimal "C" log rule was used in computing board foot volumes.

Information on Tree Planting for Commercial Purposes

Forestry for Profit. It should always be borne in mind by those about to engage in reforestation projects that a forest is a long time crop. No return can possibly be expected on timber for most commercial purposes, as for instance pulpwood, for at least thirty years. Returns at this time will probably only be in the nature of thinnings to provide enough money to retire the initial cost of producing and caring for the forest. For this reason a corporation, state or government, is best able to care for and follow out a forest plan of planting, thinning, and harvesting as well as protection, over a long time period. Individuals may, however, make a start on a forest project, and they themselves may have the pleasure and benefit of seeing the trees they have planted grow to good size. The planted forest will give protection and added value to their land, and finally may be turned over to their children as a rapidly growing insurance policy, for as soon as land is planted to timber of a valuable species, the young growing stock has a definite value which increases with every year of growth. Such a forest could be dedicated from generation to generation as a family forest.

Size of Planting Unit. In planting any area for financial returns enough land should be reforested to warrant a logging operation at a reasonable figure. As a rule the larger forest unit can be planted and maintained at a lower cost per acre. Forty acres would be a good working unit to use, as the smallest area to plant for a profitable forestry investment.

Choice of Land. As a general thing the lighter soils raise pine and spruce more rapidly than the heavier soils, and thus a forestry crop need not encroach on agriculture. On such land a good financial return can be made from growing the right kind of a forest crop such as pine and spruce under proper forest management, but owing to the long time element involved, few individuals attempt it. Idle land, however, whether held by the individual or the nation, is non-productive and all such should be put to some work wherever possible.

Protection of Area. Before any planting is done the area must have adequate protection from fire. Stock also must be kept out. Unless the area to be planted can have this protection it is useless to plant.

When to Plant. Planting should be done in the spring or fall; in the spring from the time the ground is open until about the end of May, depending on the year, and in the fall from about the first of September until the ground freezes. One advantage of spring planting is that the young stock is not injured by winter heaving the first year, before their roots get a foothold. This is especially true for a heavy soil. A hard and fast rule giving a definite date for planting, or not planting, is not always reliable, as planting conditions are controlled by the weather. It must always be remembered that the roots shoudd never be allowed to dry out as might occur in planting in very hot or dry weather, and that the soil should be moist but not too wet. Tnese conditions in spring or fall should be the determining factors.

Species to Plant. In the northern part of the state white and Norway pine and white spruce are recommended for general planting, and possibly jack pine on a few of the driest sites. There is very little land in Bayfield or Vilas counties too poor for Norway or white pine. In the southern part of the state Norway spruce on the moist soils is recommended. All these species make good paper pulp especially white and Norway spruce, and all are fast growers. Growth tables for these various species can be furnished on request to the State Department of Agriculture and Markets, Madison.

Soils Jack pine is found growing on the poorest and driest sandy soils of the northern part of the state. Norway pine grows on the poorer light sandy soils also, where it can get moisture. Jack and Norway pine need plenty of light for good growth, and are not desirable to plant under old stands. White pine will grow on most of the sandy soils of the state, but needs moisture and grows most rapidly on a sandy loam. It can stand a little more shading than Norway pine. It will grow well under a thin stand of popple, but not a dense stand above approximately 50 per cent stocking. White spruce needs moist soil, and prefers a moist fine sandy loam. It can stand considerable shade, and therefore is good for underplanting moist popple lands. However, its most rapid growth is made in full light. A stand of popple or any other forest cover, however, serves to improve the soil and hold the moisture on the surface for the young spruce to get a start.

How to Plant

Heeling in. As soon as a shipment of young trees is received from the nursery, if they are not to be set out immediately, they should be heeled in in order to keep them from drying out. Before opening the bundle, dig a trench in cool moist ground, open bundle of seedlings, and place in trench. Cover roots with earth, firm down, and place a little loose earth on top. They can be kept in this manner for several weeks without injury.

Spacing. A spacing of 6 x 6' apart, making 1210 trees per acre, is recommended. When plowing is possible, furrows can be made 6' apart, and the young trees planted every 6' in these furrows.

Care of Young Trees. The roots of the young trees should never be allowed to dry out. Conifers are especially susceptible and will soon be killed from this cause. In planting it is well to keep them in a wet burlap sack, taking them out one by one as each hole is planted. They should be planted in loose moist ground, the little rootlets well spread out, and firmed in well with the hands or heel, after which a little loose soil should be placed as a mulch on the top. They should be planted at about the same depth as they were formerly growing. The general tendency is to plant them too deep. Moisture is needed in early life. Usually this is supplied naturally, but sometimes a little watering in a dry time will save the day. Cultivation is desirable, but not necessary. Sod should be removed around young trees, as it will choke them out, and overtopping brush should also be removed where possible.

Species in Mixture. To avoid serious insect damage or a possible total loss of one species, it is well to mix the three

species, white and Norway pine and white spruce together, as they are found growing naturally in these mixed stands. In planting, a bunch of each of these three species of young trees can be put together and planted by chance just as they are taken from the burlap sack.

Slow Growth at Start. It should be remembered that all conifers grow very slowly the first few years, usually until they are over five years old. During this period some of them may not appear to grow at all, but after this period they should quickly respond and eventually grow from two or even three feet in height a year. This slow growth at the start is the hard period for the owner, and the cause of many failures in forest plantations through neglect at this stage.

History of a Planted Stand. A young planted stand with 6 x 6' planting starts out with 1200 trees per acre. Some of these trees will die at the start, and others will gradually be suppressed until at the end of 30 years a fully stocked stand may have about 800 trees and be approximately 6" in diameter. The fewer the trees, the greater the diameter and the less the height growth. The trees that are suppressed and die are useful as they help to prune and force the height growth of their neighbors. At 60 years the fully stocked stand may have only 400 trees per acre and be approximately 12" in diameter. At 80 years, it may have only 250 trees approximately 17" in diameter, and at 100 years, only 100 or 200 trees, maybe less, with an average diameter of approximately 20".

Suggested Plans of Forest Management for Pulpwood and Sawlogs

A very good plan of forest management for a planted timber tract at present would be to manage it for the production of pulpwood and sawlogs, cutting the pulpwood from thinnings as early in the life of the stand as possible. In following out this plan for a plantation of mixed white and Norway pine and spruce, a thinning should be made at about 30 years in which 10 cords (or approximately 250 trees) of pulpwood could be sold, which should have a value of $40.00. This would cancel the initial cost of planting and expenses up to 30 years and leave a small net income. An early return is very necessary for a profitable investment. The demand for pulp material, taking spruce to 3" in the tops, makes a market for a thinning of this nature. At the end of 60 years, 30 or 40 more cords could probably be sold for pulp. After this time the stand could be allowed to grow on to be cut for sawlogs and a better grade of material, at possibly 80 years, and the balance taken at 100 years, after which it should again be replanted and another timber crop raised. As much as possible of the early thinning should be taken from the Norway pine and white spruce. White pine is the best tree to leave for growth in late life, for high quality sawlogs and dimension material. Even at the age of 200 years and above, white pine has the ability to grow on in diameter, long after the other two species have practically stopped making any growth.

Wm. West Morris
In Charge of Growth Study
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Wisconsin Land Inventory.

POSSIBLE PRODUCTION from THINNINGS and FINAL CUTTING of a planted stand of SPRUCE or WHITE PINE under FOREST MANAGEMENT

Rotation 100 years — Clear Cut and Plant

Age	No. of trees	Per cent removed	No. of trees removed	Vol. removed per tree	Total vol. removed per acre	Stumpage value	Cost of planted stand	Net income per acre
30	800	31% 1st thinning	250	4 cu.ft.	10 cds.	$40.00	$34.04	$ 5.96
60	400	30% 2nd thinning	120	32 cu.ft.	38 cds.	$152.00	Cost from 30th to 60th yr. $10.09	141.91
80	250	40% 3rd thinning	100	245 bd.ft.	25,000 bd. ft.	$375.00	Cost from 60th to 80th yr. $5.36	369.64
100	100	100% final cutting	100	500 bd. ft.	50,000 bd. ft.	$750.00	Cost from 80th to 100th yr. $5.36	744.64
						$1317.00		$1262.15

Accumulated interest
$5.96 for 70 yrs. @ 4%
141.91 for 40 yrs. @ 4%
369.64 for 20 yrs. @ 4% 1065.97
$2328.12

Based on the following figures

Allow for the death by disease or suppression for 640 trees per acre which is probably high where thinning is practiced.
Stumpage value per cord $4.00
Stumpage value per M. bd. ft. $15.00
Cost of planting $6.00 per acre
Cost of land $2.00 per acre
Protection and taxes 18¢ per acre
Interest - 4% compound

Growth of timber based on Growth Studies for white pine made by the Wisconsin Land Economic Inventory,
Vilas County, 1929
Bayfield County, 1928

Based on the formula
$^{m}G_{c} = c(1.0\ p^{m}) + (S_{c} + E)(1.0p^{m} - 1) - (\text{value of thinnings})$
when $^{m}G_{c}$ means the cost at m years, c the cost of planting, 1.0p one plus the interest rate, S_{c} cost of land, and E capitalized annual expenses.

Value of Reproduction and Young Forest Growth

There is often an occasion to place a value on young growing crops of timber before they are mature or large enough to cut. For instance, if a considerable amount of reproduction is destroyed by fire, it is well to have a scientific basis on which a value for this young growth can be determined. The following tables show two methods by which the value of such young growth at any age can be found.

The expectation value of the growing young crop of timber is obtained by adding together all gross incomes from thinnings with interest to the end of the rotation, and the value of the final cut, and subtracting all expenses incurred such as cost of land and yearly expenses for protection, taxes, supervision, etc., with interest to the end of the rotation. This net income is then discounted by the number of years which will elapse before cutting. This is obtained by subtracting the present age of the stand of young growth from the age at which the stand will be cut to produce the estimated yield. The growth studies give very reliable information as to this final yield at any period. Under the forest crop law, our taxes are also known, namely; 10¢ an acre per year.

The cost value of the growing young crop of timber is based on the cost of planting a similar stand, the cost of the land, and the yearly expenses, taxes, protection, supervision, etc., with compound interest to the age of the young growth in question.

TABLE SHOWING THE COST and INCOME VALUE of ONE ACRE of YOUNG GROWTH of WHITE PINE.

(Raised for Pulp or Box Board Material before it is large enough to have a merchantable value)

if

PLANTED and PROTECTED

$$\text{Expectation Value} = \frac{Y_r + \text{Thinnings} - (S_c + E)(10p^{r-m} - 1)}{10p^{r-m}}$$

$$\text{Cost Value} = c(10p^m) + (S_c + E)(10p^m - 1) - \text{Thinnings}.$$

Y_r = stumpage value of final yield
S_c = cost of land per acre
E = capitalized annual expenses
$1.0p$ = 1 plus the rate of interest
m = the age of the young growth
r = rotation, 50 years in this case
c = cost of planting

Based on the following interest rate 3% - Rotation 50 years.

Value at 50 years 52 cords @ $2.00 a cord $104.00

Cost of planting $6.00 per acre

Cost of land $2.00 per acre

Protection, Administration and Taxes 24¢ per acre.

Age	Cost Value of Growing Stock	Income Value of Growing Stock
5	$ 8.54	$20.15
10	11.44	23.91
15	14.93	30.51
20	18.80	36.97
25	23.50	44.44
30	28.72	53.00

Note*

The income or expectation value would be the maximum one could afford to pay. Theoretically it would pay the investor 3% compound interest on the investment with no profit.

Values for Commercial Popple on Good Soil

Expected Return - 30 cords at 50 years - $1.00 per cord.

Formula for Expectation Value = total income - the total expense carried to the end of the rotation and this net income discounted to the present.

Cost of land = $2.00. Rotation 50 years. e or expenses capitalized at 3% = $8.00.

$$\text{Formula} = {}^{m}Ge = \frac{Y_{\text{¥}} + \text{thinnings } (S_c + E)(10p^{r-m})}{10p^{r-m}}$$

$$\text{For 10 years} = \frac{30 - 22.62}{3.36} = \$2.20$$

$$\text{For 20 years} = \frac{30 - 14.27}{2.43} = \$6.50$$

$$30 \text{ years} = \frac{30 - 8.06}{1.81} = \$12.12$$

$$40 \text{ years} = \frac{30 - 3.44}{1.34} = \$19.82$$

Value of Virgin Stand of Hardwoods Under Natural Conditions of Growth

Rotation 200 years. Interest 3%. Young growth now 20 years old. Value of most hardwood land at least $5.00 an acre. Expected returns, 10,000 board feet per acre. Value at end of rotation at stumpage price of $10.00 per thousand, $100.00. Thinnings removed during life of stand, 50 cords at $1.00 a cord, $50.00.

$$\text{Value of young growth at 20 yrs} = \frac{150 - (5+8)(1.03^{180}-1)}{1.03^{180}} = -\$12.25 \text{ per acre}$$

These values are of interest in the case of determining the value of young growth destroyed and in land sales where the land has a growth of young timber upon it. With a crop of valuable pine or spruce which grows rapidly and from which early returns can be expected, it will be seen that the expectation value of the young growth at only five years of age is worth $20.00 an acre. With commercial popple on good soils under present conditions the expectation value at five years is practically nothing, and at ten years it has a value of $2.20 an acre. On sandy soils popple has no expectation value because it will not produce a merchantable crop.

The negative value for hardwoods growing under natural conditions shows that it would not pay to protect and pay taxes for very young hardwood timber growth hoping to make any financial profit from same, unless the area is put under forest management and thinnings made for which there is a market, and the growth of the remaining timber thereby stimulated. There are, however, other values in natural hardwood stands to be considered, such as the aesthetic value for recreational purposes, and for protection for wild life, watersheds, etc., which values cannot be figured from a financial point of view.

It should be remembered that in logging off our present hardwood and hemlock stands, we are cutting the accumulated accretion of ages which has grown in merchantable volume too slowly under natural conditions to pay for its care and protection. Some of these old stands now are very valuable, but they have taken years to develop. It may be possible that by planting some hardwood stands or by proper methods of thinning, volume production may be so speeded up that raising hardwoods can be made profitable from a financial point of view.

Wm. West Morris,
In Charge of Growth Study Investigations
Wisconsin Land Inventory.

Growth, Taper, and Merchantable Volume Tables for Three Important Swamp and Low Land Species of Timber Growing in the State of Wisconsin

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General Nature of Swamp Land. A large per cent of the land area in northeastern Sawyer County and southwestern Ashland County consists of timbered swamp. It is, therefore, of interest to know what kind of timber these swamps contain, what it is utilized for, and its rate of growth and ability for natural restocking, especially as a considerable amount of this land is owned by the state and industrial concerns. From the standpoint of the forest cover those swamps which contain any timber of commercial value are of two distinct types, namely: Black spruce and cedar-balsam.

There is a larger amount of the cedar-balsam type in this region than of the pure black spruce type, but both types are well represented. Sixteen miles of strip covering an area of 22 acres were run in this vicinity, and all timber tallied down to a one-inch diameter class to determine just what amount these swamps contain, the diameter classes of each, and the per cent of each species in mixture. Opportunity was offered to make a complete stem analysis of 34 balsam, 32 cedar, and 42 black spruce on a logging operation in southwestern Ashland County.

The table on page 2 shows the total number of trees of all diameter classes and the average per acre found on a strip 8 miles in length covering 8 acres run through southwestern Ashland County.

Management. Planting of these species in swamps will probably never be resorted to. Therefore, natural reproduction must supply the forest cover. From the standpoint of a forest property to be placed under forest management for raising timber on the shortest possible rotation such as in the case of an industrial concern interested in the production of paper pulp, swamp land would not be desirable. The growth of the timber is too slow as compared to growth on upland conditions, planting cannot be done advantageously, the cost of logging, road building, etc., would be greatly increased, and the large area of more desirable open uplands now available for planting would make them the first natural choice for the production of pulp timber under a plan of forest management. Some of these swamps may eventually be drained, but the high initial cost per acre would not now be warranted. The swamps are a very desirable refuge for wild life and should naturally be held as such by the state or federal government, given careful fire protection, and a silvicultural cutting policy adopted for the removal of the large timber when it arrives at a merchantable age.

Balsam. Although not occurring in such dense stands as some other species, balsam is more widely distributed over the northern section of the state than any other species. It is the one tree found in all types from the dry Jack pine sands to the hardwood and swamp types where it occurs in its greatest numbers. In the dense hardwood types though present, it is not found in such great amounts. In a count on 17 acres of hemlock-hardwood state timber land on the

Stand Table Showing Average Number of Trees per Acre and Diameter Classes for the Bear Lake Region, Southwestern Ashland County. (The area covered by this table is fairly representative of the general swamp and low land region in southwestern part of Ashland County.)

	Balsam		Cedar		White birch		Popple		Soft maple		Black spruce		Tamarack		Ironwood		Ash		Basswood		Cherry		Hemlock		Hard maple		White pine		Yellow birch		White Spruce		Elm		Av. per A.
	Tot.	per acre	Tot.	per acre	Tot.	per acre	Tot.	per acre	Tot.	per acre	Tot.	per acre	Tot.	per acre	Tot.	per acre	Tot.	per acre	Tot.	per acre	Tot.	per acre	Tot.	per acre	Tot.	per acre	Tot.	per acre	Tot.	per acre	Tot.	per acre	Tot.	per acre	
1	1005	125.6	142	17.7	128	16.0	66	8.2	32	4.0	103	12.8	97	12.1	79	9.8	84	10.5	4	.5	53	6.6	2	.2	39	4.8	6	..7	14	1.7	14	1.7	5	.6	233.5
2	507	63.3	97	12.1	110	13.7	61	7.6	62	7.7	76	9.5	55	6.8	19	2.3	44	5.5			9	1.1	5	.6	32	4.0	11	1.3	14	1.7	8	1.0	2	.2	138.4
3	248	31.0	101	12.5	77	9.6	73	9.1	38	4.7	53	6.6	13	1.6	1	.1	24	3.0	1	.1	2	.2	3	.3	13	1.6	6	.7	16	2.0	9	1.1	1	.1	84.3
4	222	27.7	92	11.5	67	8.3	99	12.3	27	3.3	36	4.2	8	1.0	4	.5	15	1.8	2	.2	1	.1	5	.6	16	2.0	9	1.1	12	1.5	6	.7	2	.2	77.0
5	125	15.6	92	11.5	35	4.3	75	9.3	15	1.8	49	6.1	1	.1	2	.2	7	.8	1	.1			4	.5	9	1.1	5	.6	5	.6	7	.8	5	.6	54.0
6	80	10.0	66	8.2	20	2.5	42	5.2	11	1.3	33	4.1	2	.2	1	.1	8	1.0	2	.2	1	.1	5	.6	7	.8	3	.3	6	.7	2	.2	1	.1	35.6
7	27	3.3	38	4.5	5	.6	42	5.2	6	.7	10	1.2	2	.2	1	.1	1	.1	1	.1	1	.1	2	.2	2	.2	1	.1	4	.5	1	.1			17.2
8	22	2.7	39	4.8	7	.8	27	3.3	1	.1	9	1.1			2	.2	2	.2	1	.1			3	.3	4	.5	2	.2	3	.3					14.6
9	7	.8	13	1.6	3	.3	8	1.0			6	.7					1	.1					2	.2	1	.1			1	.1					4.9
10	9	1.1	17	2.1	1	.1	4	.5	1	.1	1	.1					2	.2					3	.3	3	.3	2	.2	7	.8					5.8
11	3	.3	13	1.6	1	.1	2	.2			1	.1							1	.1	1	.1	1	.1	3	.3			3	.3					3.2
12	3	.3	18	2.2	3	.3	1	.1															1	.1					4	.5					3.5
13			8	1.0							1	.1							1	.1			2	.2			1	.1	4	.5					2.0
14			9	1.1					1	.1																	1	.1	3	.3					1.6
15			1	.1																			1	.1			1	.1	1	.1					.4
16			1	.1																			2	.2	1	.1			2	.2					.3
17																																			.5
18																													1	.1					.1
19																																			
20																													1	.1					.1
21																																			
22																																			
Total per ac.		281.7		92.6		56.6		62.0		23.8		46.6		22.0		13.3		23.2		1.5		8.3		4.5		15.9		5.5		12.1		5.6		1.8	677.0

Acres - 8
Length of strip - 8 miles
Dead - 1026
Dead per acre - 128.2

Flambeau River, it averaged 6.4 trees per acre, the trees ranging from 1 to 11 inches in diameter. In southern Ashland County balsam occurs in largest amounts mixed with cedar in what are designated as cedar-balsam swamps. Under these conditions in southwestern Ashland County it averaged 282 trees to the acre ranging in diameter from 1 to 12 inches as compared to 47 black spruce and 93 cedar per acre.

The average growth of balsam under natural conditions is not fast, and as is the case of all trees tolerant of shade, probably does not represent the possible growth under better light and soil conditions. The average time required to produce one 8 foot log 4 inches in diameter at the top under average swamp conditions is 76 years. The base of this log is about 5.8" and the diameter breast high of the tree from which it is produced, 5.3". However, one tree observed not growing under suppression and on upland soil, made this same growth in 24 years, showing that under optimum conditions of soil and light, balsam has some possibilities, but that the natural growth of average swamp timber must be a fairly slow process.

Balsam is at present being cut considerably for pulp material. The average diameter of all balsam logs observed cut for pulp was 6.2", with an average volume of 1.8 cubic feet, making an average number of logs per cord of 50. The total volume of the average tree cut was 5.4 cubic feet, or it takes 16.7 balsam trees in this section to make one cord of pulpwood (based on 90 cu. ft. of solid wood per cord).

Balsam has a medium long fiber of 2.7 millimeters as compared to 2.8 for white spruce, 2.6 for black spruce, 3 for hemlock, 2.5 for Jack pine, 4.1 for white pine, and 1.0 millimeter for poplar.

A stand table for the cedar-balsam type, Ashland County, giving total number of trees found in the various diameter classes for the cedar-balsam type follows:

	Diameter Classes		
	0-3"	0-6"	0-9"
Total number of trees in fully stocked stand, 1" in diameter and above, 66 2/3 - 100%	1220	1000	464
Total number of trees in medium stocked stand, 1" in diameter and above, 33 1/3 - 66 2/3%	720	540	206
Poorly stocked stand, 1" in diameter and above, 0 - 33 1/3%	236	158	64

The cedar and balsam constitute about 55 per cent of the total number of trees and the balsam about 75 per cent of the total number of cedar and balsam.

In the eight miles of strip run in southwestern Ashland County the merchantable balsam (5.3" in diameter breast high and above) ran 104 cubic feet, or 1 1/6 cords to the acre, with a total of 58 - 8' pulpwood sticks per acre.

The reproduction consisting of all trees up to 10' in height was also counted on these strips and balsam led all other species in this area, averaging 180 small trees per acre, which was 72 per cent of the total amount of reproduction.

The growth, taper, and average volume tables for balsam follow.

Growth Table for Balsam

Ashland County, Wis.

Age at Stump	Av. Diam. at Stump inside bark	Max. Diam. at stump inside bark	Av. Total Height	Max. Total Height	Av. Total Merchantable Ht. to 4.1" Top Diameter	*Av. Absolute Vol. to 4.1" Top Diam. (Cu.ft.)
Years	Inches	Inches	Feet	Feet	Feet	
5	.2	.3	1	6		
10	.4	.8	2	14		
15	.7	1.2	3	22		
20	1.0	1.7	5	29		
25	1.4	2.2	7	36		
30	1.7	2.8	9	41		
35	2.1	3.5	11	45		.1
40	2.5	4.3	14	49		.2
45	2.9	5.1	17	52		.3
50	3.3	5.9	20	54		.5
55	3.7	6.8	24	56		.7
60	4.2	7.8	29	59		.9
65	4.7	8.9	35	61		1.3
70	5.2	10.1	39	63		1.6
75	5.7	11.3	43	65	7	2.1
80	6.2	12.5	47	66	15	2.6
85	6.8	13.7	50	68	21	3.3
90	7.4	14.9	53	70	25	4.2
95	8.0	16.1	56		28	5.2
100	8.6	17.3	59		31	6.3
105	9.3	18.6	62		33	7.7
110	10.0		64		35	9.1
115	10.7		67		36	10.6
120	11.4		69		38	12.1
125	12.1					14.0
130						

Note: 1. Based on average of 32 trees.
2. Average stump height is 1.2 ft.
3. Average total merchantable height includes stump height, and is computed to an average top diameter of 4.1 inches (as was actually cut).
4. Cubic volume is computed to a top of 4.1 inches.

*The absolute volume includes the total volume for all trees to a 4" top and also shows the diameter and the volume of the smaller trees that are not yet large enough to cut. Merchantable volume and absolute volume are nearly the same after tree becomes merchantable.

Table of Merchantable Height and Taper for Balsam Ashland County, Wis.

Merch. Ht. from stump feet	Taper (Av. diff. between diameter at stump and at any given height) inches	Av. Taper per ft. for 10 ft. intervals - inches
5	1.4	
10	1.9	0-10 ft.- .19
15	2.4	
20	3.0	10-20 ft.- .11
25	3.8	
30	4.8	20-30 ft.- .18
35	6.0	
40	7.7	30-40 ft.- .29

Note:

Based on average of 32 trees.

This taper table may be used when estimating balsam to determine the diameter at any point in the tree, and also the merchantable height of any balsam to a 4" point, or any desired diameter in the top.

To convert D.B.H. (Diameter breast high, outside bark, $4\frac{1}{2}$' from ground) to diameter at stump inside bark, multiply D.B.H. by 1.1.

Ashland County
Wis.Land Inventory
1930.

Merchantable Table for Balsam Showing D.B.H. and Merchantable Height from Stump to a 4.1" Top Diameter Inside Bark with Merchantable Units and Money Value

D.B.H.	Merch.Ht. from Stump to 4.1" in Top	Av. Merch. Volume	Merchantable Units to 4" top	Stumpage Value at $4.00 a cord
Inches	Feet	Cu. ft.		
5.3	8	1.7	1 - 8 ft. pulpwood stick	$.08
6	19	2.9	2 - 8 " " "	.13
7	27	4.7	3 - 8 " " "	.21
8	31	6.6	3½ - 8 " " "	.30
9	34	8.9	4 - 8 " " "	.40
10	37	11.2	4½ - 8 " " "	.50
11	39	13.7	4½ - 8 " " "	.61
12	41	16.2	5 - 8 " " "	.73
13	43	18.9	5 - 8 " " "	.80

Note: Based on 32 trees cut on logging operation.
Cut to an average top diameter at 4.1 inches (inside bark).
Diameter breast high (4½ ft. outside bark) can be converted into diameter inside bark at the stump by multiplying the D.B.H. by 1.1.

Average number of pulpwood sticks to cord, 50.

Arbor Vitae or white cedar. White cedar is found in quite dense stands mixed with balsam in many of the swamps of southwestern Ashland and northern Sawyer counties. It is not of great size, the merchantable timber (6" and over in diameter) averaging about 27 cedar trees to the acre on a count of 8 acres in this section, with an average diameter for the merchantable trees of approximately 8". The total number of cedar trees to the acre is 93. It is cut into poles, posts, and ties, and utilized in the tops to a diameter inside the bark of 4".

Cedar growing under natural conditions in these swamps grows quite slowly and evenly, averaging about 0.8 of an inch in diameter for every ten years over the periods from 30 to 180 years at the stump, after which time it drops to 0.4 of an inch in diameter every ten years at the stump at 180 to 190 years of age.

It makes its first merchantable post 7' long with a 4" top when it has a diameter breast high of 6 inches, which occurs at the age of 89 years. The maximum growth of cedar showed the production of a merchantable post 7' long with a 4" top in a period of 39 years from the stump. This probably represents the best growth cedar is capable of making under most favorable conditions in this area. The preceding stand table for this type shows the average number of cedar trees in mixture with balsam and other species for different diameter classes for fully stocked, medium stocked, and poorly stocked stands. The total number of merchantable cedar trees per acre as found in the strip run in southwestern Ashland County, consisting of 27 trees per acre, has a total volume of 225 cubic feet, or 2 1/2 cords per acre. From this could be cut the following: 2 - 20' telephone poles, 6" top; 1 - 25' telephone pole, 6" top; 2 - 25' telephone poles, 7" top; 2 - 30' telephone poles, 7" top; 2 ties 8' long, 7" top; 22 - 10' posts, and 16 - 7' posts per acre.

Cedar is not reproducing itself heavily. A count of the reproduction over 24 acres on a strip 16 miles in length showed only 10 trees per acre for seedlings and all small trees up to 10' in height.

The growth, taper, and merchantable volume for cedar follow.

Wis. Land Inventory
1930.

Growth Table
for
White Cedar
Ashland County, Wisconsin

Age at Stump (feet)	Av. Dia. at Stump Inside Bark (Inches)	Max. Dia. at Stump Inside Bark (inches)	Av. Total Height (feet)	Max. Total Height (feet)	Av. Total Merch. Ht. to 4" Top (ft.)	Av. Volume Stem (cu.ft)	Max. Volume Stem (cu.ft)
10	0.6	1.1	2	9			
20	1.2	2.6	7	19			0.5
30	1.8	4.6	14	25			1.9
40	2.6	6.7	18	31			3.5
50	3.4	8.4	22	34		0.2	5.3
60	4.2	7.7	26	38		0.7	7.2
70	5.0	10.7	29	41	5	1.2	9.3
80	5.8	11.6	33	43	10	2.0	11.6
90	6.6	12.5	36	46	15	2.8	14.2
100	7.3	13.3	39	49	18	3.7	16.5
110	8.1	14.0	42	51	23	4.7	18.4
120	8.9	14.6	45	54	26	5.8	19.8
130	9.6	15.2	47	56	29	7.1	21.3
140	10.3	15.6	50	58	32	8.7	22.4
150	10.9	15.8	52	59	34	10.4	23.5
160	11.5		54	61	37	12.5	
170	12.0		56	62	38	14.6	
180	12.5		57	63	40	17.0	
190	12.9		59	64	41	19.0	
200	13.3		60	65	42	21.0	
210	13.7		61	65	42		

Note: 1. Based on 32 trees in cutting operation.
2. Stump height is 2 feet.
3. Average total merchantable height to 4 inch top diameter inside bark includes stump height.
4. Cubic volume computed to a 5 inch top in the tree, and no volume computed below 2 inches in diameter in the stem.

Wis. Land Inventory
1930

Table of Merchantable Height and Taper for White Cedar Ashland County, Wis.

Merch. Ht. from Stump Feet	Taper (Av. diff. between diameter at stump and at any given height) Inches	Av. Taper per ft. for 10 ft. intervals Inches
5	1.5	
10	2.8	0-10 ft. - 0.28
15	3.9	
20	4.9	10-20 ft. - .21
25	5.8	
30	6.7	20-30 ft. - .18
35	7.6	
40	8.5	30-40 ft. - .18
45	9.5	
50	10.6	40-50 ft. - .21
55	11.8	
60	13.2	50-60 ft. - .26

Note:

Based on an average of 32 trees.

This taper table may be used when estimating cedar to determine the diameter at any point in the tree and also the merchantable height of any cedar to a 4-inch point or any desired diameter in the top.

To convert diameter (inside bark) at stump to diameter breast high (outside bark) multiply stump diameter by .08 and subtract from stump diameter.

Merchantable Table for White Cedar Showing D.B.H. and Merchantable Height from stump to a 4" diameter inside bark with Merchantable Units and Money Value

Ashland Co. Wis Land Inventory 1930.

D.B.H. inches	Mer. Ht. from stump to a 4" top	Merchantable units when poles are cut	Value on cars	Merchantable units when poles are not cut and only posts and ties taken	Value on cars
5	6	nothing		nothing	
6	12	1-4"-8' post	.13	1-4"-8' post	.13
7	18	1-5"-10' post. 1-4"-7' post	.36	1-5"-10' post. 1-4"- 7' post	.36
8	23	1-6"-10' post. 1-4"-8' post	.43	1-6"-10' post. 1-4"-8' post	.43
9	28	1-7¼-8" tie-8'. 1-6"-10' & 1-4"-8' post	.63	1-7"-8' tie. 1-6"-10' post. 1-4"-8' post	.58
10	32	1-6"-20' tel. pole. 1-4"-8' post	1.13	2-7" & 8"-8' ties. 2-4" & 5" 8' posts	1.09
11	36	1-6"-25' tel. pole. 1-5"-10' post	1.75	3-7", 8" & 9"-8' ties. 1-4"-8' post	1.18
12	40	1-7"-25' tel. pole 2-4" & 5"-7' posts	2.25	3-8", 9" & 10"-8' ties. 2-4" & 5"-7' posts	1.30
13	43	1-7"-30' tel. pole. 1-4"-13' post	3.38	3-8",9" & 11" -8' ties. 1-6"-10' and 1-4"-7' post	1.86
14	46	1-7"-30' tel. pole, 2-4" & 6"-7' posts	3.52	4-7",9",10" & 11"-8' ties. 2-4" & 5"-8' posts	1.94
15	48	1-7"-35' tel. pole. 1-4"-8' post	5.13	4-7", 9", 10" & 11"-8' ties, 1-4"-8' post	1.78
16	51	1-7"-35' tel. pole. 2-4" & 6" -7' posts	5.27	4-8",9", 10" & 11"-8' ties. 1-4"-8' post	1.78
17	53	1-7"-40' tel. pole. 1-4"-8' post	7.13	5-7",8",10" & 2-11"-8' ties	2.25

Note: D.B.H. means diameter breast high (4½ feet above ground)
Measurements obtained from 32 cedar trees cut on logging operations. Average top diameter taken to 5.1".
Cedar can be utilized to 4" top diameter. Heights of stumps averaged 2'.

All fence posts figured to a 4" top.

Telephone poles figured as follows:

1-20' x 6"	telephone pole	$1.00
1-25' x 6"	" "	1.50
1-25' x 7"	" "	2.00
1-30' x 7"	" "	3.25
1-35' x 7"	" "	5.00
1-40' x 7"	" "	7.00

Tie cuts figured as follows:

7¼-8"	top, 8' long	20¢
8"-9"	top, 8' long	35¢
9-10"	top, 8' long	50¢
10-11"	top 8' long	60¢

Posts as follows:

5"-10'	- 25¢	6"-8'	- 20¢
6"-10'	- 30¢	4"-7'	- 11¢
4"-8'	- 13¢	5"-7'	- 14¢
5"-8'	-16¢	6"-7'	- 16¢

In some localities on account of the rigid inspection of cedar poles some dealers can make a better profit, with the prevailing market conditions by only cutting posts and ties. A table is therefore given showing the possible merchantable units when only posts and ties are cut. Trees above 14 or 15 inches in diameter are too large at the base for the specifications required and therefore the first 8' butt cuts are not included in the table for merchantable units when only posts and ties are taken for trees above 14" in diameter.

Black Spruce. Black spruce is found growing almost entirely in the swamps of the state. It usually is growing practically pure or mixed with tamarack. It is rarely above 9" in diameter, most of the black spruce stands running from 0 to 6" D.B.H. Nearly all the large tamarack is now dead, having been killed by the saw fly about eighteen or twenty years ago. This type also often contains a few slow growing white pine, dwarf yellow and white birch, and an occasional soft maple.

A fully stocked stand of black spruce from zero to 3" in diameter contains from 1,000 to 1,300 trees per acre. A stand table for black spruce obtained from studies in Vilas, Ashland, Oneida, and Sawyer counties showing diameters and densities follows:

Stand Table for Black Spruce

Diameter Classes D.B.H. inches	Poorly stocked 0 - 33 1/3%	Medium stocked 33 1/3 - 66 2/3%	Fully stocked 66 2/3 - 100%
0 - 3	180	580	1100
0 - 6	150	465	820
0 - 9	50	155	300

Black spruce is now being cut almost entirely for paper pulp. It is utilized to a top diameter of 3" and cut into 8 ft. lengths. The average stump height at which it is cut is about 6".

An average of 112 black spruce logs cut for paper pulp showed them to contain 1.2 cubic feet to the log, or a total of 70 logs to the cord, with an average diameter of 5.3" (based on 85 cubic feet of solid wood per cord). The first merchantable log 8' long and 3" at the small end is produced under average conditions in 54 years. Under the most favorable conditions such a log can be produced in 34 years. The average volume of all the 42 trees cut was 3.1 cubic feet per tree, or about 1/27 of a cord. The average number of logs per tree was 2.6. It takes, therefore, about 27 merchantable black spruce trees above 3.6" in diameter breast high to make a cord. About 38 per cent of the total number of black spruce trees in southwestern Ashland County are large enough to be merchantable according to the average conditions found. This would make on some fully stocked stands as many as 450 merchantable trees to the acre, or about 17 cords per acre for a fully stocked stand.

Black spruce has a fiber length of 2.6 millimeters, and makes a good strong grade of paper.

The reproduction of black spruce including all seedlings and trees up to 10 ft. high on a count of 24 acres in this vicinity averaged 50 such trees per acre.

The growth, taper, and merchantable volume tables for black spruce follow.

Wis. Land Inventory
1930

Growth Table for Black Spruce

Ashland County

Age at Stump	Av. Diam. at Stump	Max. Diam.at Stump	Av. Total Height	Max. Total Height	Av. Merch. Height to 3" top Diameter	Av. Absolute Volume to 3" top Diameter (Cu. ft)
Years	Inches	Inches	Feet	Feet	Feet	
5	0.2	0.4	1	4		
10	0.4	1.0	2	8		
15	0.6	1.6	4	12		
20	0.9	2.3	6	16		
25	1.2	3.0	8	22		
30	1.6	4.0	10	28		0.05
35	2.1	5.1	13	31		0.1
40	2.7	6.3	18	35		0.2
45	3.3	7.6	23	38		0.4
50	4.0	8.8	29	41		0.7
55	4.8	9.9	34	44	9	1.1
60	5.5	10.7	38	46	14	1.6
65	6.2		41	49	18	2.3
70	6.8		45	52	22	2.9
75	7.4		47	54	26	3.6
80	7.9		50		29	4.3
85	8.4		52		32	5.2
90	8.7		55		34	5.9
95	9.0		57		36	7.1
100	9.3		58		38	7.9
105	9.5		60		39	8.6
110	9.7		62		40	9.4
115	9.8		63		41	9.7
120	10.0		64		42	10.4
125	10.0		65		42	10.5

Note: 1. Based on an average of 42 trees cut for pulpwood.

2. Average stump height is 0.6 ft.

3. Merchantable height includes stump height.

4. All diameters given are inside bark.

5. Absolute volume includes the total volume for all trees to a 3" top and also shows diameter and volume of smaller trees that are not yet large enough to cut. Merchantable volume and absolute volume are nearly the same after a tree becomes merchantable.

Wis. Land Inventory
1930

Taper Table
for
Black Spruce
Ashland County.

Merch. Height From Stump	Taper (Av. difference between diam. at stump and at any given height)	Av. Taper per foot for 5 foot intervals
Feet	Inches	Inches
5	1.3	0-5 ft. - 0.26
10	2.0	5-10 " - 0.14
15	2.7	10-15 " - 0.14
20	3.4	15-20 " - 0.14
25	4.2	20-25 " - 0.16
30	5.0	25-30 " - 0.16
35	5.8	30-35 " - 0.16
40	6.6	35-40 " - 0.16
45	7.4	40-45 " - 0.16
50	8.2	45-50 " -- 0.16

Note: 1. Based on an average of 42 trees cut for pulpwood.

2. This taper table may be used when estimating black spruce to determine the approximate diameter at any point in the tree and also the approximate merchantable height to a 3-inch point or any desired diameter in the top.

3. To convert diameter breast high (outside bark) to diameter at stump (inside bark), multiply by 1.1. For example: D.B.H. 7.3" x 1.1 = 8.0" D.I.B. stump.

Wis. Land Inventory
1930

Merchantable Table for Black Spruce

Ashland County.

Diameter Breast High (D.B.H.)	Merch. Ht. From Stump to 3" Top Diameter (Inside bark)	Av. Merch. Volume to 3" top	Merchantable units to 3" top diameter	Stumpage value at $4.00 per cord
Inches	Feet	Cu. ft.		
3.6	8	0.65	1 - 8 ft. pulpwood stick	$0.03
5	13	1.4	1½ - 8 " " "	0.05
6	20	2.6	2½ - 8 " " "	0.12
7	27	4.1	3 - 8 " " "	0.15
8	34	6.2	4 - 8 " " "	0.24
9	41	10.1	5 - 8 " " "	0.42
10	48	13.8	6 - 8 " " "	0.61

Note: 1. Based on an average of 42 trees cut for pulpwood.

2. Diameter breast high is measured at 4½ ft. above the ground, outside bark.

3. To convert D.B.H. to diameter inside bark at stump, multiply by 1.1.

4. Average number pulpwood sticks per cord = 70.

Age of Merchantability. The following table answers the question, how many years will it take for any of these species to produce a merchantable unit of some kind such as a stick of pulpwood or a post? Among the three swamp species noted here, balsam seems to be capable of the most rapid growth when growing under optimum conditions.

Table Showing Time Required to Reach Merchantable Age for Three Swamp Timber Species of Northern Wisconsin

Species	Age at stump when first merchantable		Dia. breast high at merchantability - inches	Merchantable unit cut	Volume Cu. ft. of merchantable unit
	Av. age years	Age of max. growth years			
Balsam	76	24	5.3	8' pulp stick 4" top	1.0
Cedar	89	39	6.0	7' post, 4" top	1.0
Black spruce	54	34	3.6	8' pulp stick, 3" top	0.65

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Assistance in the preparation of the above tables was given by Mr. Lamar M. Wood, M.S.F. of Michigan State College, and Philip DeWalt of Ladysmith, Wisconsin.

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GROWTH STUDY

OF

POPPLE

With

GROWTH, TAPER, and VOLUME TABLES

Made in

BAYFIELD, VILAS, and ASHLAND COUNTIES, WIS.

WISCONSIN LAND INVENTORY
1931

Popple. In view of the fact that popple lands now constitute at least one-third of the total forest cover crop of the northern part of the state, a knowledge as to their present and future value is desirable. Thirty-four and nine-tenths per cent of the total area of Vilas County is covered with a stand of popple. It is only a temporary crop and most of these popple stands have come in on land areas once supporting valuable stands of white and Norway pine and spruce. Stump counts of pine on these areas reveal the fact that in many instances this popple land once supported a pine growth of forty to fifty thousand board feet per acre. Most of this is found on sandy soils where popple will never amount to anything from a commercial point of view. Only one-sixth of the 228,000 acres of popple land in Vilas County is now growing on land that will produce a merchantable crop. A careful examination of this sandy land popple shows that much of it is diseased with a black knot or canker which appears at the base of the limbs and causes large swellings on the bole of the tree and often a rotten or discolored heart. There is no justification in holding popple land of this sandy type with the idea of future returns from the popple itself. The only possible way for financial returns on this sort of land is to restore it to pine and spruce by underplanting. Many people have the idea that by holding land with any kind of forest cover, it will soon grow into value. This is a mistake, for it is very necessary to have the right kind of timber growth on the land, which the industries of the state and nation demand before one can figure on any future returns. This is particularly true of sandy land popple which will never be of value except possibly for fuel.

The difference in present day stumpage value between a fully stocked stand of mature pine as compared to the value of a stand of popple raised on the same land is about five hundred and seventy dollars per acre. Four rotations of thirty-five year old popple could be raised in the time the above amount of pine was produced, but even then the four crops of popple would be worth only one hundred and twenty dollars, as compared to approximately six hundred per acre for the pine. It is evident, therefore, that our aim should be to convert our popple areas back into the original stands of pine.

Reproduction Under Popple

As the popple stands cover such a widespread area in the northern part of the state, it is interesting to know what reproduction is coming in, and what the climax forest will be. On most of the popple areas studied sweet fern and bracken were the usual undercover with very little pine coming in. In two plots studied hard maple was coming in, and two plots were studied where young white pine averaged four hundred and thirty trees per acre growing as an understory in the popple. The first of these stands of popple, which was thirty-three years of age, had an estimated density of 50 per cent. In this stand the 280 white pine per acre averaged 3" in diameter. The pine has come along fairly well and will doubtless soon be the dominant stand. A popple stand with a density as great as fifty per cent could probably be underplanted to white pine and spruce with good results.

On the other hand a nearby area on a similar soil and site condition, and the same age of thirty-three years, with an estimated density of 80% popple was studied. Although this stand had 552 white and Norway pine to the acre growing as an understory, none of it had developed in diameter or height to any extent. It had produced practically no height growth in the last few years and in many instances was dying at the top. It appears, therefore, that underplanting with pine would probably not be very successful in a dense popple stand of 80% stocking, unless the popple stand is thinned to a density of approximately 50% or less.

In general most of the areas now occupied by popple, if left to themselves, will gradually be converted into maple and inferior species unless underplanted or changed by man. This represents a tremendous loss in land potential when one considers the value of the pine crop which this same land formerly supported.

Estimated former Pine Stand on Popple Plots made from Stump Measurements.

Stump counts and measurements taken under two dense popple stands of approximately 80% density, the popple in each case being diseased and of no value, shows the amount of pine formerly growing on this land.

Plot No.	Former Stand of Pine Bd. Ft. per acre	Soil
25	48,960	Plainfield sand
61	47,160	" "

No pine reproduction was coming in under these areas, and planting of pine or spruce would be the only means of restoring this land to its former commercial value.

Table I.

Comparison of the Average Rate of Growth for Popple in Bayfield and Vilas counties.

Bayfield County				Vilas County			
Age	Average Dia. of stands Inches	Av. ht. Feet	Volume Cu. ft.	Age	Average Dia. of stands Inches	Av. ht. Feet	Volume Cu. ft.
5	.4	8		5	.7	8	
10	1.0	16		10	1.5	17	
15	1.7	24		15	2.2	25	
20	3.2	33	.6	20	3.0	33	.6
25	4.2	40	1.6	25	3.8	41	1.1
30	5.2	47	3.2	30	4.5	48	2.1
35	6.1	53	5.1	35	5.2	56	3.4
40	6.9	57	6.8	40	6.0	63	4.8
45	7.6	60	8.2				
50	8.2	62	9.6				

Table II.

Growth Table for Popple per Acre

(Vilas County Fully Stocked Stand)

Age	Av. Dia. Inches	No. Dom. and Inter. Popple per acre	Yield cu. ft.	Yield cords	Av. Height feet
5	.7				8
10	1.5	2100	200	2	17
15	2.2	1800	540	6	25
20	3.0	1500	900	10	33
25	3.8	1250	1400	15	41
30	4.5	950	2000	22	48
35	5.2	650	2200	24	56
40	6.0	500	2400	27	63

Table III

Table Showing
Diameter and Yield
for
Popple
Vilas County
Fully Stocked Stand

Av. Dia. of Stand - inches	Yield Cu. ft.	Approx. Yield Cords
2	400	4
3	900	10
4	1600	18
5	2150	24
6	2400	27
7	2610	29

Note: First three volumes are for popple stands too small to be merchantable.

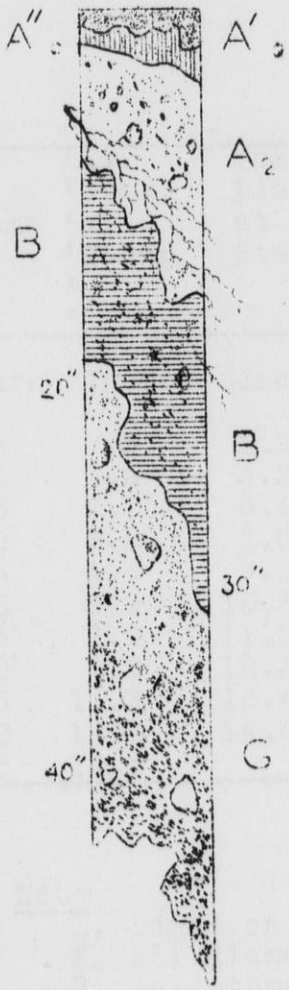
Table IV

Volume Table
Diameter and Volume
for
Popple
Vilas County, Wisconsin

Diameter	Volume Cu. ft.
2	.2
3	.6
4	1.3
5	3.0
6	4.8
7	6.3

There are only a comparatively few areas of popple land in the county studied by the inventory to date which is producing commercial popple, and it is found only on the best sandy or silt loam soils and here its remarkable volume growth shows that it is growing on a site which is favorable to its optimum development. On one such area in Ashland County which was growing splendid tall commercial popple, a stem analysis was made of 13 of the trees. All of this popple had been bought either for excelsior or to be made into pulpwood or woodenware. At 40 to 45 years of age it was sound and white with little heart discoloration. A comparison of the average volume growth for Vilas and Bayfield counties shows that this stand of popple far surpassed the average of these especially in their growth in later life. A careful study and profile of the soil was made on this area to determine the cause of such remarkable growth. It showed the soil to be a poorly drained Kennan fine sandy loam with a slightly cemented layer at about 15 inches in depth holding the moisture on the surface. The roots of the popple penetrated all through this moist area and obtained all the moisture they needed to produce quick growth. Moreover, no fire had run over this region for approximately 50 years so that the organic matter had not been destroyed. A profile and description of this soil follows together with tables showing growth, taper, and merchantable volume of this stand of fast growing popple.

Description of Profile of poorly drained Kennan fine sandy loam.



A'_o - undecomposed forest litter (leaves of aspen, needles of balsam fir, mosses etc.);

A''_o - half-decomposed organic matter of dark-brownish color, penetrated by mycelium (raw-humus);

A_1 - not present;

A_2 - light-grey, ashlike podsolized fine sandy loam, penetrated by the roots of vegetation;

B - reddish-brown fine sandy loam, with some gravel; slightly cemented;

G - compacted loamy sand with reddish mottling and considerable amount of gravel and stones. The lower part of horizon is forming a sticky layer, saturated with clay particles.

Soil is grading into unsorted glacial till. Water table starts in the depth of about five feet. Root penetration reaches the upper part of B- horizon.

Note: We are indebted to Dr. Sergius Wilde, expert on forest soils, for the Soil Profile of this area.

Growth Table for Aspen (Populus tremuloides) under optimum growth conditions Ashland County.

Age at Stump	Av. Diam. at Stump	Max. Diam. at Stump	Av. Total Height (Including Stump	Max. total Height (including Stump	Av.Merch. Height to 3" Top Diam. (incl. stump)	Av.Merch. Volume to 3" Top Diam.
Years	Inches	Inches	Feet	Feet	Feet	Cu.Ft.
5	.5	1.2	6.5	13.0		
10	1.2	3.2	14.5	24.5		.05
15	2.1	5.4	24.5	36.0		.25
20	3.2	7.6	37.0	47.5		.8
25	4.4	9.1	47.5	58.0	20.0	2.0
30	5.9	10.3	56.5	67.0	34.5	4.5
35	8.0	11.2	63.5	75.0	45.5	9.0
40	9.8	12.3	69.0	82.0	51.5	13.9
45	11.3	13.4	74.5	88.0	55.5	19.3
50	12.8	14.4	79.5		58.5	25.8
55	14.0		84.0		61.0	33.5

Note

1. Based on 11 trees cut for woodenware, pulp, and excelsior.
2. All diameters given are inside bark.
3. Av. stump height is 1.0 foot.
4. Av. D.B.H. = Av. D.I.B. stump divided by 1.02, or practically the same.

Taper Table
for
Aspen
(Populus tremuloides)
Under optimum growth conditions
Ashland County.

Height Above Stump	Taper (Av. difference between diameter at stump and at any given height above stump)	Av. Taper per Foot for 5 ft. intervals
Feet	Inches	
5	.5	0 - 5 ft. - .1 inch
10	1.0	5 - 10 ft. - .1 inch
15	1.4	10 - 15 ft. - .08 inch
20	1.9	15 - 20 ft. - .1 inch
25	2.2	20 - 25 ft. - .06 inch
30	2.6	25 - 30 ft. - .08 inch
35	3.3	30 - 35 ft. - .14 inch
40	4.1	35 - 40 ft. - .16 inch
45	5.4	40 - 45 ft. - .26 inch
50	6.7	45 - 50 ft. - .26 inch
55	8.1	50 - 55 ft. - .28 inch
60	9.5	55 - 60 ft. - .28 inch
65	10.9	60 - 65 ft. - .28 inch

Note:

1. Based on 11 trees cut for woodenware, pulpwood, and excelsior.
2. This taper table may be used when estimating aspen of similar growth, to determine the approximate diameter of any point in the tree and also the approximate merchantable height to a 3" point or any desired diameter in top.
3. Av. D.B.H. = Av. D.I.B. stump divided by 1.02, or practically the same.

Merchantable Table
for
Aspen
(Populus tremuloides) Under
optimum growth conditions.
Ashland County.

Diameter Breast High (Outside bark)	Av. Merch. Height from stump to 3" top (inside bark)	Av. Merch. Volume to 3" top (inside bark)	Merchantable Units
Inches	Feet	Cu. ft.	
1			
2			
3.6	8.0	0.5	1 - 8 ft. log
4	17.5	1.8	2 - 8 " "
5	27.5	3.2	3 - 8 " "
6	35.5	5.0	4 - 8 " "
7	41.5	7.3	5 - 8 " "
8	45.5	9.7	5½ - 8 " "
9	48.5	12.4	6 - 8 " "
10	51.5	15.1	6 - 8 " "
11	54.0	18.5	6½ - 8 " "
12	56.0	22.7	7 - 8 " "
13	58.0	27.4	7 - 8 " "
14	60.0	33.5	7½ - 8 " "

Note:

1. Based on 11 trees cut for woodenware, pulpwood, and excelsior.
2. Av. D.I.B. stump = D.B.H. x 1.02, or practically the same.
3. 3.6" in D.B.H. makes first 8' log 3" at the top.

The above popple stand averaged 333 popple to the acre with a volume of 2292 cubic feet, or 25 cords per acre as determined by a strip run through it in two directions. The total number of trees of all species in this stand averaged 925, balsam being the prevailing understory and averaging 500 trees per acre.

One other stand observed in Bayfield County grew with about the same rapidity as this one for 35 years, the age at which it was measured. A plot of one-fourth acre taken on this area and representing almost a fully stocked stand averaged 2600 cubic feet, or about 29 cords per acre. It was 63' in height, 6.3" in diameter, with an average of 468 trees per acre. Naturally, a small picked plot like this one would be better stocked than the average strip run through an entire forty as in Ashland County, but the trees averaged practically the same height and diameter at 35 years of age. Both of these areas represent Site I for popple in this portion of the state of Wisconsin.

The best plot of popple found in Vilas County was also 35 years of age, 52' in height, with an average diameter of 5" and had 684 trees per acre, producing 27 cords not all merchantable. The poorer the site, the greater is the number of trees found upon it as a general thing. The volume produced by the stand of popple in Ashland County, especially in its later life, was far greater than the average volume produced in Bayfield or Vilas county. The heavier soils of Bayfield County produced greater volume growth of popple than the sandy soils of Vilas County, but the growth of pine and spruce in Vilas County was the best found to date. The average popple of this stand produced its first pulpwood stick at 23 years. The maximum tree produced this same pulpwood stick in 12 years. Such a pulpwood stick is 3.8" at the stump when it is 3" inside bark at a height of 8' above the stump.

The following prices have been paid this year for logging popple on one operation:

Cutting Popple

	Cost per cord
Cutting and peeling	$3.00
Skidding to roads for loading	.50
Hauling	1.50
Loading	.50
Cost on car	$5.50

The owner of this operation was paid $7.00 a cord on the car, making a net profit of $1.50 a cord. The pulpwood sticks were taken to 3" in the tops.

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Wisconsin Land Inventory.

Assistance in the preparation of the popple tables for Ashland County was given by Mr. Lamar Wood, Forester, a graduate of Michigan State College.