Timber Management Field Book

2008 Edition

United States
Department of Agriculture
Forest Service
Northeastern Area
State and Private Forestry
Newtown Square, PA
NA–MR–02–08
August 2008
www.na.fs.fed.us

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This Field Book revises and supersedes NA-MR-7 “Timber Management Field Book” and NA-FR-15 “Reference Handbook for Foresters.” Any corrections, additions, and updates should be sent to ksykes@fs.fed.us, 304.285.1532.

Surveying and Cruising

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1.1 Areas and Dimensions of Plots Which Are Convenient Fractions of an Acre

Plot Area (Acres)	Square Plot Side	Circular Plot Radius
	Feet	Feet
1/1	208.7103	117.7522
1/2	147.5805	83.2634
1/3	120.4990	67.9843
1/4	104.3552	58.8761
1/5	93.3381	52.6604
1/6	85.2056	48.0721
1/7	78.8851	44.5061
1/8	73.7902	41.6317
1/9	69.5701	39.2507
1/10	66.0000	37.2365
1/12	60.2495	33.9921
1/20	46.6690	26.3302
1/30	38.1051	21.4985
1/40	33.0000	18.6183
1/50	29.5161	16.6527
1/60	26.9444	15.2017
1/70	24.9457	14.0741
1/80	23.3345	13.1651
1/90	22.0000	12.4122
1/100	20.8710	11.7752
1/120	19.0526	10.7493
1/250	13.2000	7.4473
1/500	9.3338	5.2660
1/750	7.621	4.30
1/1000	6.600	3.724

1.1a Basal Area Table

Diameter (Inches)	Area (Square Feet)	Diameter (Inches)	Area (Square Feet)
1	.006	21	2.405
2	.022	22	2.640
3	.049	23	2.885
4	.087	24	3.142
5	.136	25	3.41
6	.196	26	3.69
7	.267	27	3.98
8	.349	28	4.28
9	.442	29	4.59
10	.545	30	4.91
11	.660	31	5.24
12	.785	32	5.59
13	.922	33	5.94
14	1.069	34	6.30
15	1.227	35	6.68
16	1.396	36	7.07
17	1.576	37	7.47
18	1.767	38	7.88
19	1.969	39	8.30
20	2.181	40	8.73

1.2 Composite Board Foot Volume Table for Basal Area Factor 10

Volume Per Acre International 1/4 Inch Per Sq. Ft. of Basal Area

DBH	Number of 16' Logs								
	½	1	1½	2	2½	3	3½	4	5
8	429	686	1001	1315					
10	385	715	990	1247	1393	1485			
12	382	726	1019	1273	1451	1579	1655		
14	393	739	1029	1310	1525	1721	1815	1918	
16	423	752	1053	1289	1526	1769	1962	2113	2335
18	419	764	1064	1330	1573	1811	2037	2264	2490
20	422	779	1082	1352	1604	1834	2063	2292	2613
22	424	792	1099	1371	1629	1875	2102	2311	2708
24	423	802	1101	1369	1623	1894	2133	2355	2769
26	428	814	1112	1383	1641	1898	2142	2387	2766
28	437	814	1123	1392	1637	1895	2152	2386	2783
30	448	835	1120	1395	1650	1894	2159	2404	2770
32	455	841	1137	1414	1665	1915	2166	2416	2775
34	462	841	1150	1427	1681	1919	2189	2427	2791
36	471	849	1160	1429	1684	1939	2193	2441	2830
38	475	851	1156	1422	1689	1943	2197	2451	2845
40	476	854	1157	1432	1696	1948	2212	2475	2842

USDA Tech. Bull. #1104 Table #2

1.2a Volume Table B.F. Per Acre Scribner for Basal Area Factor 10

Tree DBH	Volume Per Acre for each 10 Sq. Ft. of Basal Area, or for Each Tree									
	½ Log	1 Log	1½ Log	2 Log	2½ Log	3 Log	3½ Log	4 Log	4½ Log	5 Log
10	312	550	734	880						
12	357	612	841	993	1236	1360	1455			
14	374	655	898	1085	1319	1497	1677			
16	387	666	924	1132	1368	1605	1776	1884	1991	2090
18	408	690	951	1172	1404	1652	1839	2009	2122	2235
20	412	715	972	1201	1453	1677	1902	2062	2223	2383
22	420	735	992	1242	1485	1704	1932	2121	2311	2500
24	436	751	1015	1273	1496	1750	1973	2196	2371	2546
26	448	762	1033	1302	1532	1763	2007	2224	2400	2577
28	456	774	1052	1310	1567	1777	2011	2245	2432	2619
30	462	780	1059	1324	1569	1813	2037	2261	2444	2628
32	466	788	1074	1325	1594	1826	2059	2292	2462	2632
34	466	793	1078	1332	1602	1840	2062	2316	2482	2649
36	467	799	1089	1358	1613	1853	2094	2334	2511	2688
38	463	800	1092	1359	1612	1866	2108	2336	2514	2692
40	464	802	1089	1352	1604	1868	2120	2349	2521	2693

From Table 1, pg. 5 Tech. Bull. No. 1104, Jan. 1955, USDA.

1.3a Point Sampling Limiting Distance in Feet Basal Area Factor 5

Horizontal Distance in Feet from the Plot Center to Tree Center for Trees of Indicated DBH - Radius Factor 3.8891

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	0.00	0.38	0.78	1.17	1.56	1.94	2.33	2.72	3.11	3.50
1	3.89	4.28	4.67	5.05	5.44	5.83	6.22	6.61	7.00	7.39
2	7.78	8.17	8.56	8.94	9.33	9.72	10.11	10.50	10.89	11.28
3	11.67	12.06	12.44	12.83	13.22	13.61	14.00	14.39	14.78	15.17
4	15.56	15.94	16.33	16.72	17.11	17.50	17.89	18.28	18.67	19.06
5	19.44	19.83	20.22	20.61	21.00	21.39	21.78	22.17	22.56	22.95
6	23.33	23.72	24.11	24.50	24.89	25.28	25.67	26.06	26.45	26.83
7	27.22	27.61	28.00	28.39	28.78	29.17	29.56	29.95	30.33	30.72
8	31.11	31.50	31.89	32.28	32.67	33.06	33.45	33.83	34.22	34.61
9	35.00	35.39	35.78	36.17	36.56	36.95	37.33	37.72	38.11	38.50
10	38.89	39.28	39.67	40.06	40.45	40.84	41.22	41.61	42.00	42.39
11	42.78	43.17	43.56	43.95	44.34	44.72	45.11	45.50	45.89	46.28
12	46.67	47.06	47.45	47.84	48.22	48.61	49.00	49.39	49.78	50.17
13	50.56	50.95	51.34	51.72	52.11	52.58	52.89	53.28	53.67	54.06
14	54.45	54.84	55.22	55.61	56.00	56.39	56.78	57.17	57.56	57.95
15	58.34	58.72	59.11	59.50	59.89	60.28	60.67	61.06	61.45	61.84
16	62.23	62.61	63.00	63.39	63.78	64.17	64.56	64.95	65.34	65.73
17	66.11	66.50	66.89	67.28	67.67	68.06	68.45	68.84	69.23	69.61
18	70.00	70.39	70.78	71.17	71.56	71.95	72.34	72.73	73.11	73.50
19	73.89	74.28	74.67	75.06	75.45	75.84	76.23	76.61	77.00	77.39
20	77.78	78.17	78.56	78.95	79.34	79.73	80.11	80.50	80.89	81.28
21	81.67	82.06	82.45	82.84	83.23	83.62	84.00	84.39	84.78	85.17
22	85.56	85.95	86.34	86.73	87.12	87.50	87.89	88.28	88.67	89.06
23	89.45	89.84	90.23	90.62	91.00	91.39	91.78	92.17	92.56	92.95
24	93.34	93.73	94.11	94.50	94.89	95.28	95.67	96.06	96.45	96.84
25	97.23	97.62	98.00	98.39	98.78	99.17	99.56	99.95	100.34	100.73
26	101.12	101.51	101.89	102.28	102.67	103.06	103.45	103.84	104.23	104.62
27	105.01	105.39	105.78	106.17	106.56	106.95	107.34	107.73	108.12	108.51
28	108.89	109.28	109.67	110.06	110.45	110.84	111.23	111.62	112.01	112.39
29	112.78	113.17	113.56	113.95	114.34	114.73	115.12	115.51	115.89	116.28
30	116.67	117.06	117.45	117.84	118.23	118.62	119.01	119.39	119.78	120.17
31	120.56	120.95	121.34	121.73	122.12	122.51	122.90	123.28	123.67	124.06
32	124.45	124.84	125.23	125.62	126.01	126.40	126.78	127.17	127.56	127.95
33	128.34	128.73	129.12	129.51	129.90	130.28	130.67	131.06	131.45	131.84
34	132.23	132.62	133.07	133.40	133.79	134.17	134.56	134.95	135.34	135.73
35	136.12	136.51	136.90	137.29	137.67	138.06	138.45	138.84	139.23	139.62

1.3b Point Sampling Limiting Distance in Feet Basal Area Factor 10

Horizontal Distance in Feet from Plot Center to Tree Center for Trees of Indicated DBH - Radius Factor 2.750

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	0.00	0.28	0.55	0.82	1.10	1.38	1.65	1.92	2.20	2.47
1	2.75	3.02	3.30	3.57	3.85	4.12	4.40	4.67	4.95	5.22
2	5.50	5.77	6.05	6.32	6.60	6.87	7.15	7.42	7.70	7.97
3	8.25	8.52	8.80	9.07	9.35	9.62	9.90	10.17	10.45	10.72
4	11.00	11.27	11.55	11.82	12.10	12.37	12.65	12.92	13.20	13.47
5	13.75	14.02	14.30	14.57	14.85	15.12	15.40	15.67	15.95	16.22
6	16.50	16.77	17.05	17.32	17.60	17.87	18.15	18.42	18.70	18.97
7	19.25	19.52	19.80	20.07	20.35	20.62	20.90	21.17	21.45	21.72
8	22.00	22.27	22.55	22.82	23.10	23.37	23.65	23.92	24.20	24.47
9	24.75	25.02	25.30	25.57	25.85	26.12	26.40	26.67	26.95	27.22
10	27.50	27.77	28.05	28.32	28.60	28.87	29.15	29.42	29.70	29.97
11	30.25	30.52	30.80	31.07	31.35	31.62	31.90	32.17	32.45	32.72
12	33.00	33.27	33.55	33.82	34.10	34.37	34.65	34.92	35.20	35.47
13	35.75	36.02	36.30	36.57	36.85	37.12	37.40	37.67	37.95	38.22
14	38.50	38.77	39.05	39.32	39.60	39.87	40.15	40.42	40.70	40.97
15	41.25	41.52	41.80	42.07	42.35	42.62	42.90	43.17	43.45	43.72
16	44.00	44.27	44.55	44.82	45.10	45.37	45.65	45.92	46.20	46.47
17	46.75	47.02	47.30	47.57	47.85	48.12	48.40	48.67	48.95	49.22
18	49.50	49.77	50.05	50.32	50.60	50.87	51.15	51.42	51.70	51.97
19	52.25	52.52	52.80	53.07	53.35	53.62	53.90	54.17	54.45	54.72
20	55.00	55.27	55.55	55.82	56.10	56.37	56.65	56.92	57.20	57.47
21	57.75	58.02	58.30	58.57	58.85	59.12	59.40	59.67	59.95	60.22
22	60.50	60.77	61.05	61.32	61.60	61.87	62.15	62.42	62.70	62.97
23	63.25	63.52	63.80	64.07	64.35	64.62	64.90	65.17	65.45	65.72
24	66.00	66.27	66.55	66.82	67.10	67.37	67.65	67.92	68.20	68.47
25	68.75	69.02	69.30	69.57	69.85	70.12	70.40	70.67	70.95	71.22
26	71.50	71.77	72.05	72.32	72.60	72.87	73.15	73.42	73.70	73.97
27	74.25	74.52	74.80	75.07	75.35	75.62	75.90	76.17	76.45	76.72
28	77.00	77.27	77.55	77.82	78.10	78.37	78.65	78.92	79.20	79.47
29	79.75	80.02	80.30	80.57	80.85	81.12	81.40	81.67	81.95	82.22
30	82.50	82.77	83.05	83.32	83.60	83.87	84.15	84.42	84.70	84.97
31	85.25	85.52	85.80	86.07	86.35	86.62	86.90	87.17	87.45	87.72
32	88.00	88.27	88.55	88.82	89.10	89.37	89.65	89.92	90.20	90.47
33	90.75	91.02	91.30	91.57	91.85	92.12	92.40	92.67	92.95	93.22
34	93.50	93.77	94.05	94.32	94.60	94.87	95.15	95.42	95.70	95.97
35	96.25	96.52	96.80	97.07	97.35	97.62	97.90	98.17	98.45	98.72

1.3c Point Sampling Limiting Distance in Feet Basal Area Factor 20

Horizontal Distance in Feet from the Plot Center to Tree Center for Trees of Indicated DBH - Radius Factor 1.9445

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
3	5.83	6.03	6.22	6.42	6.61	6.81	7.00	7.19	7.39	7.58
4	7.78	7.97	8.17	8.36	8.56	8.75	8.94	9.14	9.33	9.53
5	9.72	9.92	10.11	10.31	10.50	10.69	10.89	11.08	11.28	11.47
6	11.67	11.86	12.06	12.25	12.45	12.64	12.83	13.03	13.22	13.42
7	13.61	13.81	14.00	14.19	14.39	14.58	14.78	14.97	15.17	15.36
8	15.56	15.75	15.94	16.14	16.33	16.53	16.72	16.92	17.11	17.31
9	17.50	17.69	17.89	18.08	18.28	18.47	18.67	18.86	19.06	19.25
10	19.44	19.64	19.83	20.03	20.22	20.42	20.61	20.81	21.00	21.19
11	21.39	21.58	21.78	21.97	22.17	22.36	22.56	22.75	22.94	23.14
12	23.33	23.53	23.72	23.92	24.11	24.31	24.50	24.69	24.89	25.08
13	25.28	25.47	25.67	25.86	26.06	26.25	26.44	26.64	26.83	27.03
14	27.22	27.42	27.61	27.81	28.00	28.19	28.39	28.58	28.78	28.97
15	29.17	29.36	29.56	29.75	29.94	30.14	30.33	30.53	30.72	30.92
16	31.11	31.31	31.50	31.69	31.89	32.08	32.28	32.47	32.67	32.86
17	33.06	33.25	33.44	33.64	33.83	34.03	34.22	34.42	34.61	34.81
18	35.00	35.19	35.39	35.58	35.78	35.97	36.17	36.36	36.56	36.75
19	36.95	37.14	37.33	37.53	37.72	37.92	38.11	38.31	38.50	38.70
20	38.89	39.08	39.28	39.47	39.67	39.86	40.06	40.25	40.45	40.64
21	40.83	41.03	41.22	41.42	41.61	41.81	42.00	42.19	42.39	42.58
22	42.78	42.97	43.17	43.36	43.56	43.75	43.95	44.14	44.33	44.53
23	44.72	44.92	45.11	45.31	45.50	45.70	45.89	46.08	46.28	46.47
24	46.67	46.86	47.06	47.25	47.45	47.64	47.83	48.03	48.22	48.42
25	48.61	48.81	49.00	49.20	49.39	49.58	49.78	49.97	50.17	50.36
26	50.56	50.75	50.95	51.14	51.33	51.53	51.72	51.92	52.11	52.31
27	52.50	52.70	52.89	53.08	53.28	53.47	53.67	53.86	54.06	54.25
28	54.45	54.64	54.83	55.03	55.22	55.42	55.61	55.81	56.00	56.20
29	56.39	56.58	56.78	56.97	57.17	57.36	57.56	57.75	57.95	58.14
30	58.33	58.53	58.72	58.92	59.11	59.31	59.50	59.70	59.89	60.08
31	60.28	60.47	60.67	60.86	61.06	61.25	61.45	61.64	61.83	62.03
32	62.22	62.42	62.61	62.81	63.00	63.20	63.39	63.58	63.78	63.97
33	64.17	64.36	64.56	64.75	64.95	65.14	65.33	65.53	65.72	65.92
34	66.11	66.31	66.50	66.70	66.89	67.08	67.28	67.47	67.67	67.86
35	68.06	68.25	68.45	68.64	68.83	69.03	69.22	69.42	69.61	69.81
36	70.00	70.20	70.39	70.58	70.78	70.97	71.17	71.36	71.56	71.75
37	71.95	72.14	72.33	72.53	72.72	72.92	73.11	73.31	73.50	73.70
38	73.90	74.08	74.28	74.47	74.67	74.86	75.06	75.25	75.45	75.64
39	75.83	76.03	76.22	76.42	76.61	76.81	77.00	77.20	77.39	77.58
40	77.78	77.97	78.17	78.36	78.56	78.75	78.95	79.14	79.33	79.53

1.3d Point Sampling Limiting Distance in Feet Basal Area Factor 40

Horizontal Distance in Feet from the Plot Center to Tree Center for Trees of Indicated DBH - Radius Factor 1.3750

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
3	4.12	4.26	4.40	4.54	4.68	4.81	4.95	5.09	5.22	5.36
4	5.50	5.64	5.77	5.91	6.05	6.19	6.32	6.46	6.60	6.74
5	6.87	7.01	7.15	7.29	7.42	7.56	7.70	7.84	7.97	8.11
6	8.25	8.39	8.52	8.66	8.80	8.94	9.07	9.21	9.35	9.49
7	9.62	9.76	9.90	10.04	10.17	10.31	10.45	10.59	10.72	10.86
8	11.00	11.14	11.27	11.41	11.55	11.69	11.82	11.96	12.10	12.24
9	12.37	12.51	12.65	12.79	12.92	13.06	13.20	13.34	13.47	13.61
10	13.75	13.89	14.02	14.16	14.30	14.44	14.57	14.71	14.85	14.99
11	15.12	15.26	15.40	15.54	15.67	15.81	15.95	16.09	16.22	16.36
12	16.50	16.64	16.77	16.91	17.05	17.19	17.32	17.46	17.60	17.74
13	17.87	18.01	18.15	18.29	18.42	18.56	18.70	18.84	18.97	19.11
14	19.25	19.39	19.52	19.66	19.80	19.94	20.07	20.21	20.35	20.49
15	20.62	20.76	20.90	21.04	21.17	21.31	21.45	21.59	21.72	21.86
16	22.00	22.14	22.27	22.41	22.55	22.69	22.82	22.96	23.10	23.24
17	23.37	23.51	23.65	23.79	23.92	24.06	24.20	24.34	24.47	24.61
18	24.75	24.89	25.02	25.16	25.30	25.44	25.57	25.71	25.85	25.99
19	26.12	26.26	26.40	26.54	26.67	26.81	26.95	27.09	27.22	27.36
20	27.50	27.64	27.77	27.91	28.05	28.19	28.32	28.46	28.60	28.74
21	28.87	29.01	29.15	29.29	29.42	29.56	29.70	29.84	29.97	30.11
22	30.25	30.39	30.52	30.66	30.80	30.94	31.07	31.21	31.35	31.49
23	31.62	31.76	31.90	32.04	32.17	32.31	32.45	32.59	32.72	32.86
24	33.00	33.14	33.27	33.41	33.55	33.69	33.82	33.96	34.10	34.24
25	34.37	34.51	34.65	34.79	34.92	35.06	35.20	35.34	35.47	35.61
26	35.75	35.89	36.02	36.16	36.30	36.44	36.57	36.71	36.85	36.99
27	37.12	37.26	37.40	37.54	37.67	37.81	37.95	38.09	38.22	38.36
28	38.50	38.64	38.77	38.91	39.05	39.19	39.32	39.46	39.60	39.74
29	39.87	40.01	40.15	40.29	40.42	40.56	40.70	40.84	40.97	41.12
30	41.25	41.39	41.52	41.66	41.80	41.94	42.07	42.21	42.35	42.49
31	42.62	42.76	42.90	43.04	43.17	43.31	43.45	43.59	43.72	43.86
32	44.00	44.14	44.27	44.41	44.55	44.69	44.82	44.96	45.10	45.24
33	45.37	45.51	45.65	45.79	45.92	46.06	46.20	46.34	46.47	46.61
34	46.75	46.89	47.02	47.16	47.30	47.44	47.57	47.71	47.85	47.99
35	48.12	48.26	48.40	48.54	48.67	48.81	48.95	49.09	49.22	49.36
36	49.50	49.64	49.77	49.91	50.05	50.19	50.32	50.46	50.60	50.74
37	50.87	51.01	51.15	51.29	51.42	51.56	51.70	51.84	51.97	52.11
38	52.25	52.39	52.52	52.66	52.80	52.94	53.07	53.21	53.35	53.49
39	53.62	53.76	53.90	54.04	54.17	54.31	54.45	54.59	54.72	54.86
40	55.00	55.14	55.27	55.41	55.55	55.69	55.82	55.96	56.10	56.24

1.3e Point Sampling Limiting Distance in Feet Basal Area Factor 80

Horizontal Distance in Feet from the Plot Center to Tree Center for Trees of Indicated DBH - Radius Factor 0.972

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
3	2.92	3.01	3.11	3.21	3.31	3.40	3.50	3.60	3.70	3.79
4	3.89	3.98	4.08	4.18	4.28	4.37	4.47	4.57	4.67	4.76
5	4.86	4.96	5.05	5.15	5.25	5.35	5.44	5.54	5.64	5.73
6	5.80	5.93	6.03	6.12	6.22	6.32	6.42	6.51	6.61	6.71
7	6.80	6.90	7.00	7.10	7.19	7.29	7.39	7.48	7.59	7.68
8	7.77	7.87	7.97	8.07	8.16	8.26	8.36	8.46	8.55	8.65
9	8.75	8.84	8.94	9.04	9.14	9.23	9.33	9.43	9.53	9.62
10	9.72	9.82	9.91	10.01	10.11	10.21	10.30	10.40	10.50	10.59
11	10.69	10.79	10.89	10.98	11.08	11.18	11.28	11.37	11.47	11.57
12	11.66	11.76	11.86	11.96	12.05	12.15	12.25	12.34	12.44	12.54
13	12.64	12.73	12.83	12.93	13.02	13.12	13.22	13.32	13.41	13.51
14	13.61	13.70	13.80	13.90	14.00	14.09	14.19	14.29	14.38	14.48
15	14.58	14.68	14.77	14.87	14.97	15.07	15.16	15.26	15.36	15.46
16	15.55	15.65	15.75	15.84	15.94	16.04	16.14	16.23	16.33	14.43
17	16.52	16.62	16.72	16.82	16.91	17.01	17.11	17.20	17.30	17.40
18	17.50	17.59	17.69	17.79	17.88	17.98	18.08	18.18	18.27	18.37
19	18.47	18.56	18.66	18.76	18.86	18.95	19.05	19.15	19.25	19.34
20	19.44	19.54	19.63	19.73	19.83	19.93	20.02	20.12	20.22	20.31
21	20.41	20.51	20.61	20.70	20.80	20.90	20.99	21.09	21.19	21.29
22	21.38	21.48	21.58	21.68	21.77	21.87	21.97	22.06	22.16	22.26
23	23.36	22.45	22.55	22.65	22.74	22.84	22.94	23.04	23.13	23.23
24	23.33	23.42	23.55	23.62	23.72	23.81	23.91	24.01	24.11	24.21
25	24.30	24.40	24.49	24.59	24.69	24.79	24.88	24.98	25.08	25.18
26	25.27	25.37	25.47	25.56	25.66	25.76	25.86	25.95	26.05	26.15
27	26.24	26.34	26.44	26.54	26.63	26.73	26.83	26.92	27.02	27.12
28	27.22	27.31	27.41	27.51	27.60	27.70	27.80	27.90	27.99	28.09
29	28.12	28.28	28.38	28.48	28.58	28.67	28.77	28.87	28.96	29.06
30	29.16	29.26	29.35	29.45	29.55	29.65	29.74	29.84	29.94	30.04
31	30.13	30.23	30.33	30.42	30.52	30.62	30.72	30.81	30.91	31.01
32	31.10	31.20	31.30	31.40	31.49	31.59	31.69	31.78	31.88	31.98
33	32.08	32.17	32.27	32.37	32.46	32.56	32.66	32.76	32.85	32.95
34	33.05	33.14	33.24	33.34	33.44	33.53	33.63	33.73	33.83	33.92
35	34.02	34.12	34.21	34.31	34.40	34.51	34.60	34.70	34.80	34.90
36	34.99	35.09	35.19	35.28	35.38	35.48	35.52	35.67	35.77	35.87
37	35.96	36.06	36.16	36.26	36.35	36.45	36.55	36.64	36.74	36.84
38	36.94	37.03	37.13	37.23	37.32	37.42	37.52	37.62	37.71	37.81
39	37.91	38.00	38.10	38.20	38.30	38.40	38.49	38.59	38.69	38.78
40	38.88	38.98	39.07	39.17	39.27	39.37	39.46	39.56	39.66	39.76

1.4a Point Sampling
Number of Stems per Acre by DBH and Basal Area

DBH	Basal Area Factor						
	5	10	20	40	60	80	100
3	101.9	203.7	407.4	814.9	1222.3	1629.7	2037.2
4	57.3	114.6	229.2	458.4	687.5	916.7	1145.9
5	36.7	73.3	146.7	293.4	440.0	586.7	733.4
6	25.5	50.9	101.9	203.7	305.6	407.4	509.3
7	18.7	37.4	74.8	149.7	224.5	299.3	374.2
8	14.3	28.6	57.3	114.6	171.9	229.2	286.5
9	11.3	22.6	45.3	90.5	135.8	181.1	226.4
10	9.2	18.3	36.7	73.3	110.0	146.7	183.3
11	7.6	15.2	30.3	60.6	90.9	121.2	151.5
12	6.4	12.7	25.5	50.9	76.4	101.9	127.3
14	4.7	9.4	18.7	37.4	56.1	74.8	93.5
16	3.6	7.2	14.3	28.6	43.0	57.3	71.6
18	2.8	5.7	11.3	22.6	34.0	45.3	56.6
20	2.3	4.6	9.2	18.3	27.5	36.7	45.8
22	1.9	3.8	7.6	15.2	22.7	30.3	37.9
24	1.6	3.2	6.4	12.7	19.1	25.5	31.8
26	1.4	2.7	5.4	10.8	16.3	21.7	27.1
28	1.2	2.3	4.7	9.4	14.0	18.7	23.4
30	1.0	2.0	4.1	8.1	12.2	16.3	20.4
32	0.9	1.8	3.6	7.2	10.7	14.3	17.9
34	0.8	1.6	3.2	6.3	9.5	12.7	15.9
36	0.7	1.4	2.8	5.7	8.5	11.3	14.1
38	0.6	1.3	2.5	5.1	7.6	10.2	12.7
40	0.6	1.1	2.3	4.6	6.9	9.2	11.5

1.4b Slope Correction Factors
For Use with Point Sample Cruising

Slope%	Factor	Slope%	Factor
0-9	1.00	68-69	1.21
10-17	1.01	70	1.22
18-22	1.02	71-72	1.23
23-26	1.03	73-74	1.24
27-30	1.04	75	1.25
31-33	1.05	76-77	1.26
34-36	1.06	78-79	1.27
37-39	1.07	80	1.28
40-42	1.08	81-82	1.29
43-44	1.09	83	1.30
45-47	1.10	84-85	1.31
48-49	1.11	86	1.32
50-51	1.12	87-88	1.33
52-53	1.13	89	1.34
54-55	1.14	90-91	1.35
56-57	1.15	92	1.36
58-59	1.16	93-94	1.37
60-61	1.17	95	1.38
62-63	1.18	96-97	1.39
64-65	1.19	98	1.40
66-67	1.20	99-100	1.41

Correction factor for steeper slopes is $\sqrt{1+\left(\frac{\text{Slope Percent}}{100}\right)^2}$

Required horizontal distance = 50 feet
Distance along a slope of 30% = 50 ft * 1.04 = 52 feet

1.5a Elementary Statistical Considerations for Cruising

A. Formulas

1. Mean (M) – $\dfrac{\text{Total for samples}}{\text{Number of samples}}$

2. Standard Deviation (SD) – $\sqrt{\dfrac{\sum x^2 - \dfrac{\left(\sum x\right)^2}{N}}{N - 1}}$

3. Coefficient of Variation C – $\sqrt{\left(\dfrac{N}{N - 1}\right)}\left(\dfrac{N\sum x^2}{\left(\sum x\right)^2} - 1\right)$ or $\dfrac{SD}{M}$

4. Limit of Error (E) – $\dfrac{C}{\sqrt{N}}$ (number of samples)

5. Number of Samples (N) – $\dfrac{C^2}{E^2}$ for 68% accuracy level;

$\dfrac{4C^2}{E^2}$ or for 95% accuracy level

B. Shortcut Procedure for Computing Error (E):

1. Determine range of samples by subtracting low sample from high sample. This is (R).

2. Refer to 1.5b on page 18 to determine factor.
   Example: (N) = 20; Factor = .268

3. Multiply (R) by factor – answer is (SD).

   Example: (R) = 18; 18 × .268 = 4.82 (SD)

4. Divide (SD) by (M) – answer is (C).

   Example: (M) = 15; $\frac{4.82}{15}$ = 32.1% (C)

5. Use formula E = $\frac{C}{\sqrt{N}}$

   Example: E = $\frac{32.1}{\sqrt{20}}$ = ± 7.18%

6. For specific accuracy level, multiply (E) by factor from 1.5c Table on page 19.

   Example: E = 7.18% — accuracy level desired 95%
   N -1 = 19
   19 @ 95% level = 2.093
   7.18 × 2.093 ± 15.03%

C. Rules of Thumb

1. Four times as many samples are required to obtain 95% accuracy level as are required to obtain 68% accuracy level.

   Example: N = 10 — 68% accuracy level
   N = 40 — 95% accuracy level

2. The limit of error (E) for the 95% accuracy level is two times that of the 68% accuracy level.

   Example: E = ± 20% — 95% accuracy level
   E = ±10% — 68% accuracy level

1.5c Ratio of Standard Deviation to Range for Simple Random Samples

N	$\frac{SD}{R}$	N	$\frac{SD}{R}$
2	0.886	12	0.307
3	.591	14	.294
4	.486	16	.283
5	.430	18	.275
6	.395	20	.268
7	.370	30	.245
8	.351	40	.231
9	.337	50	.222
10	.325		

From Snedecor's Statistical Methods (ed. 5), Iowa State University Press.

1.5d Accuracy Level Table
Compensating for Small Number of Samples

(N-1)	Accuracy Level t factors		
	70%	95%	99%
4	1.190	2.776	4.604
5	1.156	2.571	4.032
6	1.134	2.447	3.707
7	1.119	2.365	3.499
8	1.108	2.306	3.355
9	1.100	2.262	3.250
10	1.093	2.228	3.169
11	1.088	2.201	3.106
12	1.083	2.179	3.055
13	1.079	2.160	3.012
14	1.076	2.145	2.977
15	1.074	2.131	2.947
16	1.071	2.120	2.921
17	1.069	2.110	2.898
18	1.067	2.101	2.878
19	1.066	2.093	2.861
20	1.064	2.086	2.845
21	1.063	2.080	2.831
22	1.061	2.074	2.819
23	1.060	2.069	2.807
24	1.059	2.064	2.797
25	1.058	2.060	2.787
26	1.058	2.056	2.779
27	1.057	2.052	2.771
28	1.056	2.048	2.763
29	1.055	2.045	2.756
30	1.055	2.042	2.750

1.6 Number of 10-Factor Sample Points Suggested

Type of Stand	Limits of Error in Percent 19 Times Out of 20						Estimated Coeff. of Variation in Percent
	8	10	12	15	20	30	
	Required Number of Points						
Sawtimber Volume Only							
Poorly Stocked	980	625	430	280	150	70	125
Medium Stocked	230	150	100	70	40	20	60
Well Stocked	230	150	100	70	40	20	60
Sawtimber and Cordwood Volume							
Poorly Stocked	620	400	280	180	100	45	100
Medium Stocked	230	150	100	70	40	20	60
Well Stocked	160	100	70	50	25	15	50
Cordwood Volume Only							
2 cd. per acre	900	580	400	260	150	60	121
4 cd. per acre	580	370	260	160	90	40	96
6 cd. per acre	420	270	190	120	70	30	82
8 cd. per acre	310	200	140	90	50	20	71
10 cd. per acre	250	160	110	70	40	20	63
12 cd. per acre	200	130	90	60	30	15	57
14 cd. per acre	170	110	80	50	30	15	52
16 cd. per acre	140	90	60	40	20	10	47
18 cd. per acre	120	80	50	40	20	10	44
20 cd. per acre	90	60	40	30	15	10	40

From R9 FSH 2431.23

1.7 Volume Table - Cords Per Acre for a 10-Factor Prism

Tree DBH	Volume per Acre for Each 10 Sq. Ft. of Basal Area or for Each Tree							
	1 Stick	2 Sticks	3 Sticks	4 Sticks	5 Sticks	6 Sticks	7 Sticks	8 Sticks
6	.87	1.43	2.04	2.40	2.90	3.20	3.50	
8	.89	1.43	1.95	2.49	3.04	3.30	3.70	4.10
10	.90	1.50	2.04	2.44	2.94	3.45	3.90	4.20
12	.89	1.54	2.10	2.52	2.87	3.31	3.82	4.20
14	.89	1.56	2.13	2.55	2.91	3.30	3.74	4.39
16	.87	1.58	2.15	2.63	3.01	3.36	3.80	4.22
18	.88	1.60	2.16	2.66	3.11	3.40	3.68	4.13
20	.89	1.62	2.20	2.70	3.11	3.48	3.71	4.08
22	.91	1.67	2.27	2.77	3.18	3.52	3.79	4.06
24	.92	1.65	2.29	2.80	3.18	3.56	3.85	4.07
26	.92	1.68	2.28	2.82	3.22	3.60	3.90	4.09
28	.91	1.68	2.27	2.81	3.23	3.63	3.91	4.12

From Table 6, pg. 9, Tech. Bull. No. 1104, Jan. 1955, USDA

1.8 Composite Table: Gross Volume[1] in Board Feet (Scribner Rule) by Number of 16-Foot Logs

DBH	Volume when number of 16-foot logs is:								
	½	1	1½	2	2½	3	3½	4	5
	Board feet	Board Feet	Board Feet	Board Feet	Board Feet	Board Feet	Board Feet	Board Feet	Board Feet
8	**10**	**16**	**24**	**31**					
9	13	**23**	**31**	**39**	**46**				
10	17	30	**40**	**49**	**57**	**62**			
11	22	38	51	**62**	**71**	**78**			
12	28	48	66	78	**89**	**100**	**108**		
13	34	59	81	96	112	**126**	**138**	**145**	
14	40	70	96	116	141	160	**170**	**178**	
15	47	81	113	137	166	188	204	**220**	
16	54	93	129	158	191	224	248	263	
17	63	106	148	182	218	257	285	308	340
18	72	122	168	207	248	292	325	355	395
19	81	137	190	234	280	328	368	405	455
20	90	156	212	262	317	366	415	450	520
21	100	173	238	293	351	405	460	505	585
22	111	194	262	328	392	450	510	560	660
23	123	215	290	360	435	500	560	620	730
24	137	236	319	400	470	550	620	690	800
25	149	258	348	440	520	600	680	760	880
26	165	281	381	480	565	650	740	820	950
27	179	305	415	520	620	710	800	890	1,030
28	195	331	450	560	670	760	860	960	1,120
29	210	356	485	600	720	830	930	1,030	1,200
30	227	383	520	650	770	890	1,000	1,110	1,290
31	245	410	560	700	830	950	1,080	1,200	1,380
32	260	440	600	740	890	1,020	1,150	1,280	1,470
33	279	470	640	790	950	1,080	1,230	1,370	1,560
34	294	500	680	840	1,010	1,160	1,300	1,460	1,670
35	312	530	720	900	1,080	1,230	1,390	1,560	1,790
36	330	565	770	960	1,140	1,310	1,480	1,650	1,900
37	349	600	820	1,020	1,210	1,390	1,570	1,750	2,010
38	365	630	860	1,070	1,270	1,470	1,660	1,840	2,120
39	384	660	900	1,130	1,330	1,550	1,750	1,940	2,240
40	405	700	950	1,180	1,400	1,630	1,850	2,050	2,350

[1]The bold figures in the upper portion of the table show volume to a top diameter of 6.0 or more, but less than 8.0 inches and hence are applicable only to softwoods.

From USDA Tech. Bull. #1104, Jan. 1955.

1.9 Composite Table: Gross Volume in Rough Cords to a Variable Top Diameter Inside Bark, by Number of Bolts[1]

DBH	Volume When Number of Bolts is:							
	1	2	3	4	5	6	7	8
	Cords	Cords	Cords	Cords	Cords	Cords	Cords	Cords
4	**0.007**	**0.011**						
5	.011	.019	**0.022**					
6	.017	.028	.040	**0.047**				
7	.023	.038	.053	.068	**0.076**			
8	.031	.050	.068	.087	.106	**0.116**		
9	.040	.065	.088	.109	.130	.153	**0.170**	
10	.049	.082	.111	.133	.160	.188	**.211**	
11	.060	.100	.137	.165	.190	.221	**.250**	**0.270**
12	.070	.121	.165	.198	.225	.260	.300	**.330**
13	.082	.143	.197	.236	.268	.305	.350	.42
14	.095	.167	.228	.273	.311	.353	.40	.47
15	.107	.193	.262	.318	.364	.41	.46	.52
16	.122	.220	.300	.367	.42	.47	.53	.59
17	.138	.250	.340	.42	.48	.54	.59	.66
18	.155	.282	.382	.47	.55	.60	.65	.73
19	.173	.318	.43	.53	.61	.68	.73	.81
20	.194	.353	.48	.59	.68	.76	.81	.89
21	.217	.395	.54	.66	.76	.84	.90	.98
22	.240	.44	.60	.73	.84	.93	1.00	1.07
23	.262	.48	.66	.80	.92	1.03	1.10	1.17
24	.288	.52	.72	.88	1.00	1.12	1.21	1.28
25	.312	.58	.78	.96	1.10	1.23	1.33	1.38
26	.340	.62	.84	1.04	1.19	1.33	1.44	1.51
27	.363	.67	.91	1.13	1.29	1.45	1.56	1.63
28	.388	.72	.97	1.20	1.38	1.55	1.67	1.76
29	.41	.76	1.03	1.29	1.49	1.66	1.80	1.90
30	.43	.80	1.10	1.37	1.59	1.70	1.93	2.04

[1] The bold figures in the upper portion of the table are to a minimum top diameter (inside bark) of 3.0 or more, but less than 4.0 inches. Other top diameters are variable but not less than 4.0 inches.

From USDA Tech. Bull. #1104, Jan. 1955

1.10 R-9 Cubic Foot Volume Table – Cordwood

DBH (inches)	Cubic Feet Inside Bark to Variable Top Diameter When the Number of 8-Foot Bolts is:							
	1	2	3	4	5	6	7	8
6	1.3	2.2	3.2					
8	2.4	3.9	5.4	6.9	8.4			
10	3.9	6.5	8.8	10.5	12.6	14.9		
12	5.5	9.6	13.0	15.6	17.8	20.5	23.7	
14	7.5	13.2	18.0	21.6	24.6	27.9	31.6	37.1
16	9.6	17.4	23.7	29.0	33.2	37.1	41.9	46.6
18	12.2	22.3	30.2	37.1	43.4	47.4	51.3	57.7
20	15.3	27.9	37.9	46.6	53.7	60.0	64.0	70.3
22	19.0	34.8	47.4	57.7	66.4	73.5	79.0	84.5
24	22.8	41.1	56.9	69.5	79.0	88.5	95.6	101.1
26	26.9	49.0	66.4	82.2	94.0	105.1	113.8	119.3
28	30.7	56.9	76.6	94.8	109.0	122.4	131.9	139.0
30	34.0	63.2	86.9	108.2	125.6	134.3	152.5	161.2

This table is based on Table 6 of LSFES Technical Bulletin 1104 and a conversion of 0.79 Cc.f. per cord (or 1.266 cord/Cc.f.). Top diameter is variable but not less than 4 inches.

1.11 R-9 Cubic Foot Volume Table - Sawtimber

DBH (inches)	Cubic Feet Inside Bark in Sawlog. Portion of Stems When Number of 8-Foot Bolts is:										Approximate Board Foot: Cubic foot ratios	
	1	2	3	4	5	6	7	8	9	10	Scribner Dec. C	Int. ¼"
8	2	4	6	7							4.3	
10	4	7	9	11	14	15					4.4	5.8
12	5	10	13	16	19	22	25				5.0	6.0
14	7	13	18	22	27	30	34	37			5.3	6.0
16	10	17	23	29	35	40	44	48	52		5.5	6.1
18	12	22	29	36	44	50	56	61	66	70	5.7	6.4
20	15	28	36	45	54	62	69	75	81	86	5.9	6.5
22	18	33	44	54	65	75	84	91	98	105	6.1	6.6
24	22	39	52	65	78	89	99	109	117	124	6.2	6.7
26	26	46	61	76	91	104	117	127	137	146	6.3	6.7
28	30	53	70	88	106	121	136	148	159	169	6.4	6.7
30	34	61	81	101	122	139	156	170	183	194	6.4	6.8
32	39	70	92	115	139	158	178	193	208	221	6.5	6.8
34	44	78	104	130	156	179	201	218	235	250	6.6	6.9
36	49	88	117	146	175	200	225	244	263	280	6.6	6.9
38	55	98	130	163	195	223	251	272	293	312	6.6	6.9
40	61	109	144	180	216	247	278	302	325	346	6.6	7.0

This table is based on data contained in LSFES Technical Note 382 and LSFES Technical Bulletin 1104 (Table 20). Merchantable height is measured above a 1-foot stump to a point on the stem where merchantability is limited by branches, defects, deformity, or a minimum top diameter of 8 inches inside the bark.

1.12 Stave Bolt and Heading Bolt Volumes in Standing Trees

Stave Bolts

DBH (inches)	Number of 39-inch Cuts						
	1	2	3	4	5	6	7
	Volume in Cord Feet						
12	1.6	3.0					
14	2.8	5.4	7.0				
16	3.3	6.3	8.4	10.0			
18	3.9	7.4	10.7	13.7	16.5	19.1	
20	4.2	8.2	12.1	15.6	18.9	21.9	24.7
22	4.9	9.4	13.6	17.6	21.5	25.0	28.3
24	5.2	10.2	15.1	19.6	23.8	27.8	31.7
26	6.0	11.6	16.8	21.8	26.7	31.2	35.4
28	6.5	12.7	18.7	24.3	29.5	34.5	39.4
30	9.3	16.0	22.5	28.7	34.7	40.3	45.2
32	11.5	21.9	31.2	37.9	44.4	50.6	56.6
34	12.2	24.1	35.6	46.0	55.3	62.0	68.5
36	14.1	27.2	39.4	51.3	62.8	73.2	82.5

Heading Bolts

DBH (in.)	Number of 24-inch Cuts									
	1	2	3	4	5	6	7	8	9	10
	Volume in Cord Feet									
18	4.6	9.2	13.7	18.1	22.3					
20	5.1	10.2	15.2	20.1	24.9	29.5	34.0	38.4	42.7	
22	5.6	11.2	16.7	22.1	27.3	32.4	37.3	42.0	46.5	50.7
24	6.1	12.0	17.6	22.9	27.9	32.6	37.0	41.0	44.9	48.5
26	6.7	13.1	19.2	25.0	30.5	35.7	40.6	45.2	49.5	53.0
28	7.2	14.1	20.7	27.0	33.0	38.7	44.1	49.2	54.0	58.5
30	7.7	15.1	22.2	29.0	35.5	41.7	47.6	53.2	58.5	63.5
32	8.2	16.1	23.7	31.0	38.0	44.7	51.1	57.2	63.0	68.5

From: University of Missouri AGR. EXT. SVC. CIR 671 and EXT. SVC. Kansas State University, 3A-574-4-500.

1.13 Number of Cords Per MBF and Number of Board Feet Per Cord by Tree Diameters for Pine Timber (International ¼" Rule)

DBH	Board Feet Per Cord	Cords Per MBF
10	288	3.5
12	342	2.9
14	378	2.6
16	405	2.5
18	423	2.4
20	432	2.3
22	441	2.3
24	450	2.2

Note: Cords are 128 cubic feet and includes all of the stem to a diameter of 4 inches outside of bark.

1.14 Composite Table: Gross Volume in Number of 16-Foot Logs (International ¼ inch Log Rule)

DBH (inches)	Number of 16-foot Logs in Tree							
	½	1	1½	2	2½	3	3½	4
	Contents in Board Feet							
12	30	60	80	100	120			
14	40	80	110	140	160	180		
16	60	100	150	180	210	250	280	310
18	70	140	190	240	280	320	360	400
20	90	170	240	300	350	400	450	500
22	110	210	290	360	430	490	560	610
24	130	250	350	430	510	590	660	740
26	160	300	410	510	600	700	790	880
28	190	350	480	600	700	810	920	1020
30	220	410	550	690	810	930	1060	1180
32	260	470	640	790	940	1080	1220	1360
34	290	530	730	900	1060	1220	1380	1540
36	330	600	820	1010	1200	1380	1560	1740
38	370	670	910	1130	1340	1540	1740	1940
40	420	740	1010	1250	1480	1700	1920	2160
42	460	820	1100	1360	1610	1870	2120	2360

1.15 Composite Table: Gross Volume in Board Feet by Number of 16-Foot Logs (Doyle Log Rule)

DBH (inches)	Number of 16-foot Logs in Tree							
	½	1	1½	2	2½	3	3½	4
	Contents in Board Feet							
12	20	30	40	50	60			
14	30	50	70	80	90	100		
16	40	70	100	120	140	160	180	190
18	60	100	130	160	200	220	240	260
20	80	130	180	220	260	300	320	360
22	100	170	230	280	340	380	420	460
24	130	220	290	360	430	490	540	600
26	160	260	360	440	520	590	660	740
28	190	320	430	520	620	710	800	880
30	230	380	510	630	740	840	940	1040
32	270	440	590	730	860	990	1120	1220
34	300	510	680	850	1000	1140	1300	1440
36	350	580	780	970	1140	1310	1480	1640
38	390	660	880	1100	1290	1480	1680	1860
40	430	740	990	1230	1450	1660	1880	2080
42	470	830	1100	1370	1620	1860	2100	2320

1.16 Composite Table: Gross Volume in Number of 16-Foot Logs (Scribner)

DBH	½	1	1½	2	2½	3	3½
	Contents in Board Feet						
12	47	61	75	85	95	100	106
14	69	92	114	130	146	156	166
16	95	127	159	185	211	229	247
18	123	166	209	244	280	306	331
20	157	214	270	317	364	398	432
22	194	266	338	398	458	504	549
24	234	322	409	484	558	611	665
26	281	388	494	585	676	745	814
28	327	452	578	686	795	877	959
30	382	530	678	806	933	1028	1124
32	440	612	784	936	1089	1206	1322
34	498	695	892	1066	1239	1373	1507
36	563	789	1015	1216	1416	1572	1728
38	629	882	1135	1366	1596	1769	1942
40	703	988	1274	1532	1791	1993	2195

1.17 Volume Distribution (Percent)

Cumulative % Volume (rounded)

Actual % Volume by 4' Bolts

									Bolt #
60-64								2-100	8
56-60								3-100	
52-56							3-100	4-90	7
48-52							3-100	4-90	
44-48						5-100	4-90	4-90	6
40-44						5-90	5-90	5-80	
36-40					7-100	6-90	6-80	6-80	5
32-36					7-90	7-80	7-80	6-70	
28-32				9-100	8-90	7-80	7-70	6-70	4
24-28				10-90	9-80	8-70	7-60	7-60	
20-24			13-100	11-80	9-70	9-60	8-60	8-50	3
16-20			14-90	11-70	10-60	9-50	9-50	8-40	
12-16		21-100	15-70	12-60	11-50	9-40	9-40	8-40	2
8-12		23-80	17-60	14-50	12-40	11-30	10-30	9-30	
4-8	39-100	26-60	19-40	16-30	13-30	12-20	11-20	10-20	1
0-4	61-60	30-30	22-20	17-20	14-10	12-10	11-10	10-10	
	8'6"	**12'6"**	**21'0"**	**29'0"**	**37'6"**	**45'6"**	**54'0"**	**62'0"**	**Min. Merch. Ht.**
	1	2	3	4	5	6	7	8	

Merchantable Height - 8' Bolts

Merchantable Height must exceed this figure to qualify (exception 1 bolt heights).

Example: A sugar maple sawtimber tree has a merchantable height of 5 bolts to 7.6" top and 8 bolts to a 4.0" top with the first and sixth bolts being cull. The sawlog defect would be 30 percent and the pulpwood defect 40 percent.

1.18 Rate of Growth (Growth Factor Table)

DBH	Rings Per Inch											
	4	5	6	7	8	9	10	11	12	13	14	15
4"	.282	.225	.188	.161	.141	.125	.113	.102	.094	.087	.080	.075
5"	.220	.177	.147	.126	.110	.098	.088	.080	.073	.068	.063	.059
6"	.181	.145	.121	.103	.091	.080	.072	.065	.060	.056	.052	.048
7"	.153	.123	.103	.088	.077	.068	.061	.056	.051	.047	.044	.041
8"	.133	.106	.089	.076	.067	.059	.053	.048	.044	.041	.038	.035
9"	.116	.093	.078	.067	.058	.052	.047	.042	.039	.036	.033	.031
10"	.105	.084	.070	.060	.053	.047	.042	.038	.035	.032	.030	.028
11"	.095	.076	.063	.054	.047	.042	.038	.034	.032	.029	.027	.025
12"	.087	.070	.058	.050	.044	.039	.035	.032	.029	.027	.025	.023
13"	.080	.064	.053	.046	.040	.035	.032	.029	.027	.025	.023	.021
14"	.074	.059	.049	.042	.037	.033	.030	.027	.025	.024	.021	.020
15"	.069	.055	.046	.039	.034	.031	.028	.025	.023	.021	.020	.018
16"	.064	.052	.043	.037	.032	.029	.026	.023	.021	.020	.018	.017
17"	.061	.048	.040	.035	.030	.027	.024	.022	.020	.019	.017	.016
18"	.057	.046	.038	.033	.029	.025	.023	.021	.019	.018	.016	.015
19"	.054	.043	.036	.031	.027	.024	.022	.020	.018	.017	.015	.014
20"	.051	.041	.034	.029	.025	.023	.020	.019	.017	.016	.015	.014
21"	.049	.039	.033	.028	.024	.022	.020	.018	.016	.015	.014	.013
22"	.046	.037	.031	.027	.023	.021	.019	.017	.015	.014	.013	.012

Procedures

1. Determine Growth Factor by applying average DBH and average rings per inch to above table.
2. Compute annual rate of growth of Basal Area, Cords, Tons, Board Feet (International), or Cubic Feet by multiplying amount of good growing stock in each category by the Growth Factor.
3. Multiply Growth Factor by 100 for growth percent.

1.19 Guide for Hardwood Tree Grading Based on Butt Log

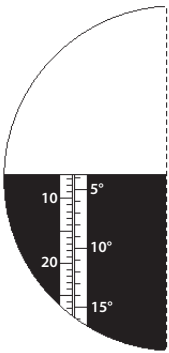
Minimum DBH Based on Form Class 80			Clearcutting in Grading Face of Best 12' Section[1]			Cull Percent in Grading Section	
Grading Section			Min. Length per Cutting	Max. # of Cuttings per Face	Min. Total Length/ Face	Max. Sweep %	Max. Total Cull %
0-12'	2-14'	4-16'					
Grade 1							
13.5[2]	14.0[2]	14.5[2]	10'	1	10'	15%	40%
14.7	15.3	15.8	10'	1	10'		
18.2	18.9	19.5	5'	2	10'		
22.5	23.5	24.5	3'	2	10'		
Grade 2			Surface must be Grade 1				
(10.8) 11.2	11.6	12.0				15%	40%
(11.5) 12.4	12.9	13.3	3'	2	8' (6')	30%	50%[4]
(12.6) 13.5	14.0	14.5	3'	3[3]	8' (6')	30%	50%[4]
Grade 3							
(8.2) 8.9	9.2	9.5	2'	Unlimited	6' (4')	50%	50%[5]
Grade 4							
(8.2) 8.9	9.2	9.5	No requirements[6]			[7]	[8]

[1]Specs in ( ) are applicable to trees with only 8' of merchantable height - 8 foot grading section.
[2]Ash and basswood only.
[3]Limited to two cuttings for trees with 8-11' of merchantable height.
[4]60% allowed if otherwise grade 1 quality.
[5]60% allowed if otherwise grade 2 quality.
[6]Sound surface defects: Any number of knots or holes admitted provided the diameter of individual knots or holes or the sum of the diameter of whorled knots does not exceed 1/3 of the log diameter at point of occurence. No holes admitted if they extend over 3" into the included timber, which is always square and dimension is judged from small end. Unsound surface defects: same requirements as for sound defects if they extend into the included timber. No limit if they do not.
[7]25% for every 8' of length.
[8]Allowance for sweep plus cull outside included timber. See footnote #6 for limitations on defect (rot, etc.) that extends into the included timber.
Note: Grade 4 applicable to construction (Tie and Timber) logs.

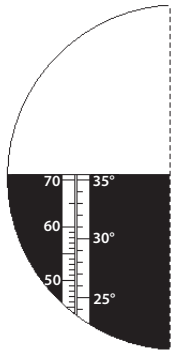
1.20a Relaskop / Spiegel Relaskop©

A sophisticated, compact and robust instrument for measuring height, diameter, basal area, and range. Has a variety of scales for the different uses.

Height Measurement



Bottom measurement



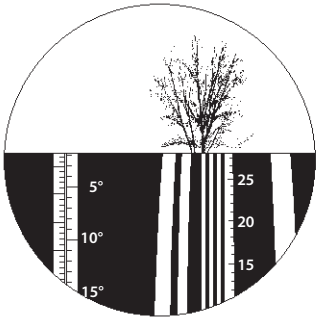
Top measurement

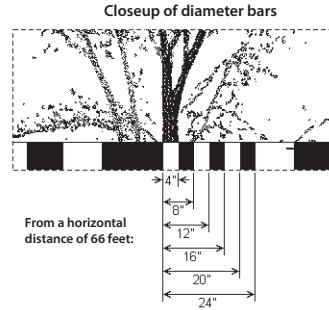
There are three height scales (20, 25, and 30 m) on the standard metric version. (The wide angle Spiegel relaskop has a larger number of height scales). All the height scales are visible when sighting but they are not identified.

General instruction for use of the Relaskop for measuring height:

1. Measure the desired horizontal distance from the base of the tree (or point directly beneath the tree tip) to a location where the required point (e.g. tree tip) can be seen;
2. Sight at the required point, while holding the break button to allow the scales to freely rotate;
3. Read the height from the appropriate scale once the scale has settled. Tapping and releasing the break button can help the scales to settle more quickly;
4. Sight to the base of the tree and repeat the above two steps; and
5. Add the heights together to get total tree height.

Diameter Measurement





General instruction for use of the Relaskop for measuring diameter:

1. Measure the desired horizontal distance (H metres) from the base of the tree (or point directly beneath the desired tree site) to a location where the required point (e.g. change in diameter) can be seen. Note that you must be at least 5 m away for every 20 cm anticipated diameter;
2. Sight at the required point, while holding the break button to allow the scales to freely rotate;
3. Read from the diameter scale once the scale has settled the number of large bands (with the number 1 printed on them) (L); the number of small bands (4 narrow bands immediately to the right of the large 1 band) (S); and an estimate of any fractional small band (s). Estimate the fractions of the small band as 0.2 (just into the band), 0.4 (almost half), 0.6 (just over half), 0.8 (amost full narrow band).
4. Diameter is calculated as d (cm) = H*(L+0.25*(S+s))*2;

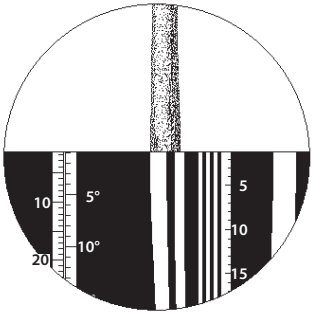
Check to ensure the diameter appears correct. Note that L will be 0 or 1, S will be 0, 1, 2, 3, 4 and s will be a fraction less than 1.0.

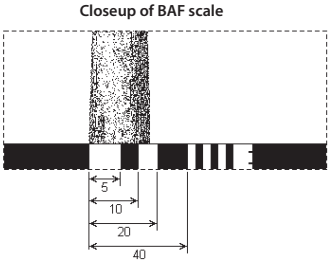
If the sample tree above was 20 m away, the diameter would be:

d (cm) = 20 * (1+0.25*(3+0.2)) * 2

= 72 cm

Measuring Basal Area with the Relaskop





The original instrument of BITTERLICH was called a RELASKOP. It comprised a 1 metre rod with a 2 cm wide opaque blade mounted at one end at right angles to the rod axis - this generated the reference angle.

Disadvantages of Relaskop

- The instrument requires a simultaneous alignment by eye of four lines, the two reference marks, and the two sides of the tree.
- Slight movement of the tree or the instrument interferes with the alignment.

These disadvantages become most apparent in use in the approximate BORDERLINE situation, i.e. the situation where the reference angle and the angle subtended by the tree are about the same.

Bitterlich, over the years, has repeatedly modified the original Relaskop. The latest model is a compact, multipurpose instrument called the SPIEGEL RELASKOP which can be used to measure tree height, stand height, tree diameter at any height from ground, stand basal area, and miscellaneous other tree/stand parameters.

The Spiegel Relaskop incorporates reflected scale images which allow a choice of as many as nine basal area factors. Through an adjustment of the calibration on the internal scale, the instrument automatically corrects for slope.

However, the disadvantages of the original Relaskop still apply to the latest Spiegel Relaskop.

Checking Doubtful Trees when Angle Counting using Bitterlich's Spiegel Relaskop

(Also see Wood, G.B. 1982. Checking borderline trees by Spiegel Relaskop. Aust. For. 45(1):57-8).

Bitterlich's Spiegel Relaskop is a most versatile instrument for forest measurement. It is particularly useful and efficient for estimating stand basal area per unit area but has the disadvantage that it cannot establish precisely whether doubtful trees are in, out, or truly borderline. Such cases occur on average in about 10% of the trees counted in an angle count sweep.

Precise estimation of stand basal area by Relaskop requires that all doubtful trees be checked by direct measurement. Checking is complicated by the fact that efficient use of the Relaskop requires the brake to be freed which corrects automatically for slope. This must be allowed for in calculating limiting or borderline slope distances.

The ready availability today of pocket calculators enables limiting slope distances for doubtful trees to be calculated quickly in the field using the formula:

Limiting slope distance (metres) = d (cm) × Sec ÿ x K

where d is DBHob, preferably measured by caliper at right angles to the line of sight from the observer.

and ÿ is the angle of slope from the observer's eye to the breast height mark.

Values of K for the nine bands or band combinations of the standard metric relaskop are presented in Table. Comparison of the calculated limiting slope distance with the measured slope distance then determines whether the doubtful tree is in, out, or truly borderline.

K values for determining limiting distances when sweeping by standard Spiegel Relaskop with the brake freed.

Band	BAF	K
1 narrow band (NB)	0.0625	2
2 NB	0.25	1
3 NB	0.5625	0.6
1	1.0	0.5
1+1 NB	1.5625	0.4
1+2 NB	2.25	0.3
1+3 NB	3.0625	0.2857
2	2.0	0.3536
4	4.0	0.25

Derivation of K:

BAF = 2500 (d/D)^2 /10 000, where d is DBHob (cm) and D is the limiting distance (m).

In the true borderline situation, d/D is constant. Hence D = d.K.

Substituting for D in the equation, we have:

K = 0.5/_BAF.

Dr. Walter Bitterlich, who pioneered this approach, sees a bright future for further enhancement of the Relaskop. See his articles:

Bitterlich, W. (1984) The Relaskop idea. Commonwealth Agricultural Bureau.

Bitterlich, W. (1990) A comprehensive concept of tree and stand measurements. Proceedings from Session S4.01 Mensuration, Growth and Yield at the world congress of the IUFRO. Montreal, Canada. August 5-11. p. 1-12.

1.21 Shortcut Formulas for Determining Volumes with a 10-Factor Prism or Gauge –Pulpwood (Cords)

1. $$\frac{\text{Average number of countable trees per sample (average number of 8-foot sticks per tree +1)}}{2} = \text{cords per acre}$$

Example: The countable trees averaged 2.5 8-foot sticks.
The average number of countable trees per sample was 6.

$$\frac{6(2.5+1)}{2} = 10.5 \text{ cords per acre}$$

2. $$\frac{\text{Number of 8-foot sticks in countable trees + number of countable trees}}{2 \times \text{number of point samples}} = \text{cords per acre}$$

Example: 48 trees were tallied. 120 8-foot sticks were tallied in countable trees. 8 samples were taken.

$$\frac{120+48}{2\times 8} = 10.5 \text{ cords per acre}$$

3. $$\frac{\text{Number of 8-foot sticks in countable trees} \times^{*}}{\text{number of point samples}} = \text{cords per acre}$$

* Use: 0.9 if trees average 1 stick; 0.7 if trees average 2 sticks; 0.65 if trees average 3 sticks; 0.6 if trees average 4 or more sticks.

Example: 10 samples were taken. 132 8-foot sticks were counted. Average number of sticks per tree - 2.

$$\frac{132 \times 0.7}{10} = 9.24 \text{ cords per acre}$$

4. Cords can be converted to tons by using the appropriate TONS PER STANDARD CORD RATIO in Section 2.10.

1.22 Rule of Thumb Shortcut Formulas for Determining Volumes with a 10-Factor Prism or Gauge – SAWTIMBER

(Board Feet – International Rule)

1. $\frac{\text{Number of 16-foot logs in countable trees} \times^{*}}{\text{number of point samples}}$ = board feet per acre

*Use: 750 if trees average 1 log
660 if trees average 1.5 logs
625 if trees average 2.0 logs
600 if trees average 2.5 logs
580 if trees average 3.0 logs

Example: 8 point samples were taken.
22.5 16-foot logs were tallied in countable trees.
Average number of logs per tree – 2.5

$$\frac{22.5 \times 600}{8} = 1{,}688 \text{ board feet per acre}$$

2. To determine approximate Doyle Rule volume, apply factor from following table to the calculated International Rule volume:

Average	DBH Factor
12"	.50
16"	.65
20"	.75
24"	.85
28"	.90
32"	.95

1.23 Ratios for Cruising by Basal Area

I. Sawtimber – Basal area / board foot ratios by various merchantable lengths:

1.0 – 16-foot log – 75 BF to 1 square foot
1.5 – 16-foot log – 100 BF to 1 square foot
2.0 – 16-foot log – 125 BF to 1 square foot
2.5 – 16-foot log – 150 BF to 1 square foot
3.0 – 16-foot log – 175 BF to 1 square foot
3.5 – 16-foot log – 200 BF to 1 square foot

Ratios for other numbers of 16-foot logs can be computed by using the following formula:

25 + (average number of logs per tree × 50) = BF / sq. ft. ratio

Example: Average number of 16-foot logs per tree is 2.72.

25 + (2.72 × 50) = 161 BF to 1 square foot

To obtain board foot volume, multiply ratio by number of square feet of basal area involved.

II. Pulpwood or Firewood – Basal area / cord ratios by various merchantable lengths:

1 – 8´ stick – .089 cords to 1 square foot
2 – 8´ stick – .143 cords to 1 square foot
3 – 8´ stick – .195 cords to 1 square foot
4 – 8´ stick – .249 cords to 1 square foot
5 – 8´ stick – .302 cords to 1 square foot

Ratios for other numbers of 8-foot sticks can be computed by using the following formula:

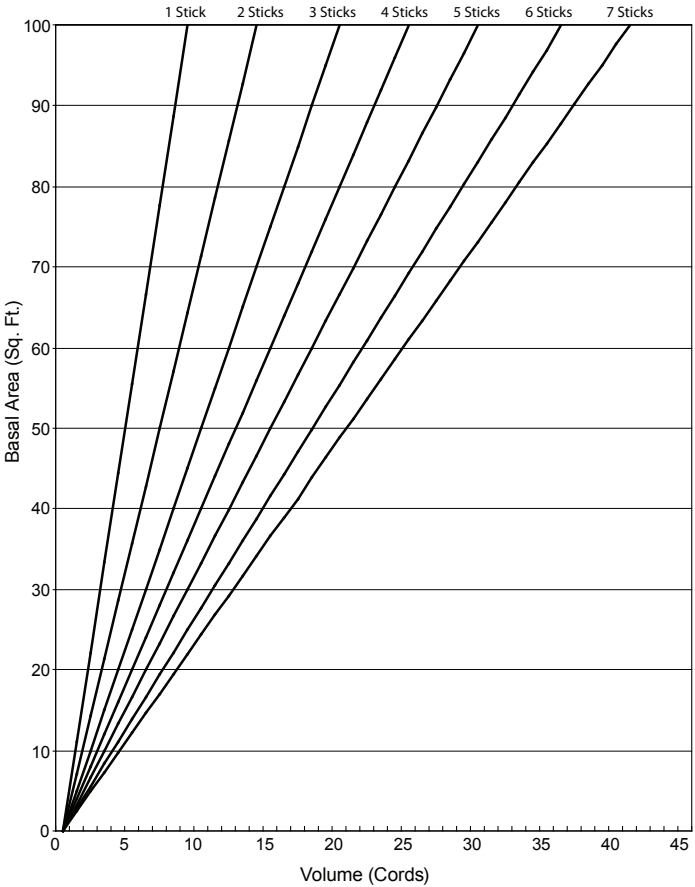
[.037 + average number of sticks per tree × .053] = cords / sq. ft. ratio

Example: Average number of 8-foot sticks per tree is 3.3.

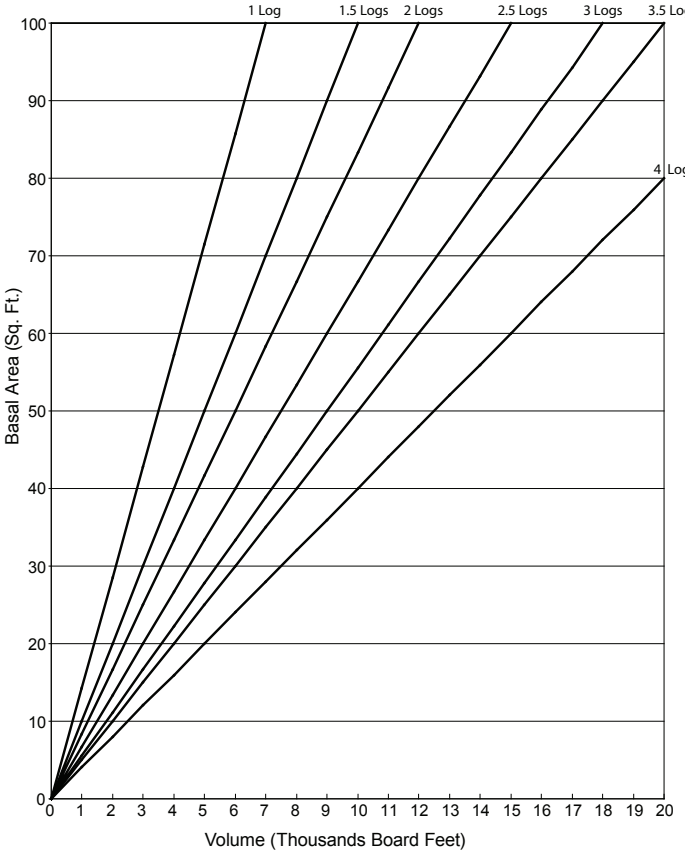
.037 + (3.3 × .053) = .2119 cords to 1 square foot

To obtain cord volume, multiply ratio by number of square feet of basal area involved.

1.24 Quick Cruise Computer Volume – Cords (1 Stick = 8 Ft.)



1.25 Quick Cruise Computer Volume – Board Feet - Int.
(1 Log = 16 Ft.)



1.26 Shortcut Calculations for Growth

1. Rule-of-thumb for Central Hardwoods:

Estimated No. of trees per acre above 9″ DBH × _*_ = Annual growth rate (board feet)

* Insert: 5 for good site
4 for average site
3 for poor site

2. Quick growth computation for an individual tree:

$$\frac{\text{Future volume after increment of 2″ DBH} - \text{present volume}}{\text{RPI}} = \text{Annual growth}$$

3. Shortcut growth formulas:

a. $\frac{4 \times \text{volume per acre}}{\text{DBH} \times \text{RPI}}$ = Growth/acre/year (volume)

b. $\frac{4 \times \text{basal area per acre}}{\text{DBH} \times \text{RPI}}$ = Growth/acre/year (basal area)

c. Ingrowth:

(1) No. of 10″ DBH trees/acre × 5 = BF ingrowth/acre/year

(2) $\frac{\text{Basal area in 10″ DBH trees} \times 91.5}{\text{RPI}}$ = Board feet/acre/year

Scaling

2.1 Pulpwood Measurements (Standing Trees) Cords

2.2 Cord Equivalents – Pulpwood Sticks

2.3 Number of 8-foot Bolts per Standard Cord

2.4 Diameter at Breast Height and Stump Diameter Relationships

2.5a Scaling Defect Deduction Table International ¼ Dec. Log Rule

2.5b Sawlog Scale Deduction for Sweep Percent of Gross Scale

2.5c Scaling Defect Deduction Table (Scribner Decimal C)

2.6 Scribner Decimal C Log Rule

2.7 Log Scale International ¼ Inch Decimal Rule

2.8 Board Foot Content of Logs (Doyle Rule)

2.9 Comparision of Log Rules

2.10 Weight Table for Various Woods

2.11 Lumber Scale

2.12 Tons Per Tree When Cut in the Following Lengths (Central Hardwoods)

2.1 Pulpwood Measurements

(Standing Trees)

CORDS

DBH (Inches)	8-Foot Sticks						
	1	2	3	4	5	6	7
5	.010	.018					
6	.018	.030	.043				
7	.025	.039	.056	.074			
8	.032	.050	.070	.092	.116		
9	.040	.061	.085	.112	.140	.168	
10	.049	.074	.101	.132	.167	.200	.239
11	.059	.087	.119	.155	.195	.233	.280
12	.070	.100	.138	.180	.225	.271	.324
14	.095	.134	.179	.233	.291	.351	.419
16	.120	.168	.222	.290	.361	.437	.521
18	.146	.208	.270	.350	.439	.531	.634
20	.186	.246	.320	.416	.522	.632	.755
22	.220	.294	.374	.494	.612	.739	.883

Source: S. R. Gevorkiantz, Lake States Forest Experiment Station Technical Note No. 241, 1945.

2.2 Cord Equivalents – Pulpwood Sticks

Top Diameter Inside Bark	Volume Per Unpeeled Stock in Cords			
	Spruce and Balsam	Jack and Red Pine	Aspen and Hardwood	Hemlock
3	.006	.006	.007	.006
4	.010	.011	.011	.011
5	.015	.016	.017	.017
6	.021	.023	.023	.024
7	.029	.029	.030	.030
8	.036	.037	.038	.038
9	.045	.045	.045	.048
10	.056	.056	.056	.059
11	.067	.067	.071	.071
12	.077	.077	.077	.083
13	.091	.091	.091	.100
14	.1	.1	.1	.111
15	.111	.111	.111	.125
16	.125	.125	.125	.143
17	.143	.143	.143	.167
18	.167	.167	.167	.2
20	.2	.2	.2	.250
22			.250	.250
24			.333	.333

2.3 Number of 8-foot Bolts per Standard Cord[1]

Average top diameter bolts inside bark (inch)	Number of unpeeled 8-foot bolts per standard cord[1]			
	Spruce and Balsam-fir	Jack and Red Pine	Aspen	Hemlock
3	165	155	150	155
4	98	91	89	90
5	65	61	60	59
6	47	44	43	42
7	35	34	33	33
8	28	27	26	26
9	22	22	22	21
10	18	18	18	17
12	13	13	13	12
14	10	10	10	9
16	7	7	7	7
18	6	6	6	5
20	5	5	5	4

[1]Table values apply to well-stocked stands. If bolts are cut from open-grown trees, smaller numbers of bolts are required, depending upon limbiness and crookedness. Example 1. Jack pine pulpwood averaging 5½ inches at the small end requires about 52 bolts per standard cord.

From L.S.F.E.S. Technical Notes

2.4 Diameter at Breast Height and Stump Diameter Relationships[1]

Stump[2] Diameter (inches)	Diameter at Breast Height		
	Softwoods	Hardwoods	Aspen
4.0	3	3	3
5.0	4	4	4
6.0	5	5	5
7.0	6	6	6
8.0	6	7	7
9.0	7	7	7
10.0	8	8	8
11.0	9	9	9
12.0	10	10	10
13.0	11	11	11
14.0	12	12	12
15.0	13	13	13
16.0	14	14	13
17.0	15	14	14
18.0	15	15	15
19.0	16	16	16
20.0	17	17	17
21.0	18	18	18
22.0	19	19	19
23.0	20	20	19
24.0	21	21	20
25.0	22	21	21
26.0	23	22	
27.0	23	23	
28.0	24	24	
29.0	25	25	
30.0	26	26	
31.0	27	27	
32.0	28	28	
33.0	29	28	
34.0	30	29	
35.0	31	30	
36.0	32	31	

[1]Data were collected in 1956 and 1957 in Minnesota.
[2]Stump diameters were measured at 12" above ground level for sawtimber and 6" above ground level for smaller trees.
Note: Broken line separates sawtimber size from poletimber and sapling sizes.
From: Lake States Forest Experiment Station Technical Note #507.

2.5a Scaling Defect Deduction Table
International ¼ Dec. Log Rule

Deduction Bd. Ft. in Tens	Defect Length in Feet							
	2	4	6	8	10	12	14	16
	Defect End Area - Minimum Sq. Inches							
1	40	20	13	10	8	7	6	5
2	120	60	40	30	24	20	17	15
3	200	100	67	50	40	33	29	25
4	280	140	93	70	56	47	40	35
5	360	180	120	90	72	60	51	45
6	440	220	147	110	88	73	63	55
7	520	260	174	130	104	87	74	65
8	600	300	200	150	120	100	86	75
9	680	340	227	170	136	113	97	85
10		380	254	190	152	127	108	95
11		420	280	210	168	140	120	105
12		460	306	230	184	153	131	115
13		500	333	250	200	167	143	125
14		540	360	270	216	180	154	135
15		580	387	290	232	193	166	145
16			414	310	248	207	177	155
17			440	330	264	220	189	165
18			467	350	280	234	200	175
19			494	370	296	247	212	185
20			520	390	312	260	223	195

Example - End of defect measures 9" ×11" (99 sq. inches). Length of defect is 12'. From defect length of 12' read down to 99 square inches or next smaller number found (in this case 87). Read across to find deduction of 7.

2.5b Sawlog Scale Deduction for Sweep Percent of Gross Scale

Absolute Sweep Inches	Scaling Diameter - Inches													
	8	9	10	11	12	13	14	15	16	17	18	19	20	22
	16- Foot Logs													
3	12	11	10	9	8	8	7	7	6	6	6	5	5	5
4	25	22	20	18	17	15	14	13	12	12	11	11	10	9
5	38	33	30	27	25	23	21	20	19	18	17	16	15	14
6	50	44	40	36	33	31	29	27	25	24	22	21	20	18
7	c	56	50	45	42	38	36	33	31	29	28	26	25	23
8	c	c	60	54	50	46	43	40	38	35	33	32	30	27
9	c	c	c	64	58	54	50	47	44	41	39	37	35	32
10	c	c	c	c	c	62	57	53	50	47	44	42	40	36
Absolute Sweep Inches	12- Foot Logs													
3	19	17	15	14	12	12	11	10	9	9	8	8	8	7
4	31	28	25	23	21	19	18	17	16	15	14	13	12	11
5	44	39	35	32	29	27	25	23	22	20	19	18	18	16
6	56	50	45	41	38	35	32	30	28	28	25	24	22	20
7	c	67	55	50	46	42	39	37	34	32	31	29	28	25
8	c	c	65	59	54	50	46	43	41	38	36	34	32	30
9	c	c	c	c	63	58	54	50	47	44	42	40	38	34
10	c	c	c	c	c	66	61	57	53	50	47	45	42	39
Absolute Sweep Inches	8-Foot Logs													
2	12	11	10	9	8	8	7	7	6	6	6	5	5	5
3	25	22	20	18	17	15	14	13	12	12	11	11	10	9
4	38	33	30	27	25	23	21	20	19	18	17	16	15	14
5	50	44	40	36	33	31	29	27	25	24	22	21	20	18
6	c	56	50	45	42	38	36	33	31	29	28	26	25	23
7	c	c	60	54	50	46	43	40	38	35	33	32	30	27
8	c	c	c	64	58	54	50	47	44	41	39	37	35	32

2.5c Scaling Defect Deduction Table
(Scribner Decimal C)

Deduction Bd. Ft. in Tens	Defect Length in Feet								Deduction Bd. Ft. in Tens
	2	4	6	8	10	12	14	16	
	Defect End Area - Minmum Sq. In.								
1	38	19	13	10	8	7	6	5	1
2	113	57	38	29	23	19	17	15	2
3	188	94	63	47	38	32	27	24	3
4	263	132	88	66	53	44	38	33	4
5	338	169	113	85	68	57	49	43	5
6	413	207	138	104	83	69	59	52	6
7	488	244	163	122	98	82	70	61	7
8	563	282	188	141	113	94	81	71	8
9	638	319	213	160	128	107	92	80	9
10		357	238	179	143	119	102	90	10
11		394	263	197	158	132	113	99	11
12		432	288	216	173	144	124	108	12
13		469	313	235	188	157	134	118	13
14		507	338	254	203	169	145	127	14
15		544	363	272	218	182	156	136	15
16		582	388	291	233	194	167	146	16
17		619	413	310	248	207	177	155	17
18		657	438	329	263	219	188	165	18
19			463	347	278	232	199	174	19
20			488	366	293	244	209	183	20

Example - End of defect measures 9" ×11" (99 sq. inches). Length of defect is 12'. From defect length of 12' read down to 99 sq. inches or next smaller number found (in this case 94). Read across to find deduction of 8.

2.6 Scribner Decimal C Log Rule

Diameter (inches)	Length of Log (feet)						
	6	8	10	12	14	16	18
	Contents in Board Feet (tens)						
6	0.5	0.5	1	1	1	2	2
7	0.5	1	1	2	2	3	3
8	1	1	2	2	2	3	3
9	1	2	3	3	3	4	4
10	2	3	3	3	4	6	5
11	2	3	4	4	5	7	8
12	3	4	5	6	7	8	9
13	4	5	6	7	8	10	11
14	4	6	7	9	10	11	13
15	5	7	9	11	12	14	16
16	6	8	10	12	14	16	18
17	7	9	12	14	16	18	21
18	8	11	13	16	19	21	24
19	9	12	15	18	21	24	27
20	11	14	17	21	24	28	31
21	12	15	19	23	27	30	34
22	13	17	21	25	29	33	38
23	14	19	23	28	33	38	42
24	15	21	25	30	35	40	45
25	17	23	29	34	40	46	52
26	19	25	31	37	44	50	56
27	21	27	34	41	48	55	62
28	22	29	36	44	51	58	65
29	23	31	38	46	53	61	68
30	25	33	41	49	57	66	74
31	27	36	44	53	62	71	80
32	28	37	46	55	64	74	83
33	29	39	49	59	69	78	88
34	30	40	50	60	70	80	90
35	33	44	55	66	77	88	98
36	35	46	58	69	81	92	104
37	39	51	64	77	90	103	116
38	40	54	67	80	93	107	120
39	42	56	70	84	98	112	126
40	45	60	75	90	105	120	135

Diameter given is for the small end of the log measured inside bark.
Ref. USDA Forest Service Misc. Publication 225

2.7 Log Scale
International ¼ Inch Decimal Rule
(Board Foot Volume)

Diameter (Inches)	Length of Log (feet)								
	4	6	8	10	12	14	16	18	20
	Contents in Board Feet								
4	0	0	0	0	0	0	10	10	10
5	0	0	0	10	10	10	10	10	20
6	0	5	10	10	15	15	20	20	30
7	10	10	10	15	20	25	30	30	40
8	10	10	15	20	25	35	40	50	50
9	10	15	20	30	35	45	50	60	70
10	10	20	30	35	45	55	65	80	90
11	20	25	35	45	55	70	80	90	110
12	20	30	45	55	70	85	95	110	130
13	30	40	55	70	85	100	115	130	150
14	30	45	65	80	100	115	135	160	180
15	40	55	75	95	115	135	160	180	200
16	40	60	85	110	130	155	180	210	230
17	50	70	95	125	150	180	205	240	270
18	50	80	110	140	170	200	230	270	300
19	60	90	125	155	190	225	260	300	330
20	70	100	135	175	210	250	290	330	370
21	70	115	155	195	235	280	320	370	410
22	80	125	170	215	260	305	355	400	450
23	90	140	185	235	285	335	390	440	500
24	100	150	205	255	310	370	425	480	540
25	110	165	220	280	340	400	460	530	590
26	120	180	240	305	370	435	500	570	640
27	130	195	260	330	400	470	540	620	690
28	140	210	280	355	430	510	585	660	740
29	150	225	305	385	465	545	630	710	800
30	160	245	325	410	495	585	675	770	860
31	170	260	350	440	530	630	720	820	920
32	180	280	370	470	570	670	770	870	980
33	200	300	400	500	610	710	820	930	1040
34	210	320	420	530	640	760	870	990	1110
35	220	340	450	570	680	810	930	1050	1180
36	230	360	480	600	730	850	980	1110	1240
37	250	380	500	640	770	900	1040	1180	1320
38	260	400	530	670	810	950	1100	1240	1390
39	280	420	560	710	860	1010	1160	1310	1460
40	290	440	590	750	900	1060	1220	1380	1540

2.8 Board Foot Content of Logs (Doyle Rule[1])

Diameter (Inches)	Length of Log (feet)					
	6	8	10	12	14	16
	Contents in Board Feet (tens)					
6	2	2	3	3	4	4
7	3	5	6	7	8	9
8	6	8	10	12	14	16
9	9	13	16	19	22	25
10	14	18	23	27	32	36
11	18	25	31	37	43	49
12	24	32	40	48	56	64
13	30	41	51	61	71	81
14	38	50	63	75	88	100
15	45	61	76	91	106	121
16	54	72	90	108	126	144
17	63	85	106	127	148	169
18	74	98	123	147	172	196
19	84	113	141	169	197	225
20	96	128	160	192	224	256
21	108	145	181	217	253	289
22	122	162	203	243	284	324
23	135	181	226	271	316	361
24	150	200	250	300	350	400
25	165	221	276	331	386	441
26	182	242	303	363	424	484
27	198	265	331	397	463	529
28	216	288	360	432	504	576
29	234	313	391	469	547	625
30	254	338	423	507	592	676

[1]The Doyle Rule is based on the formula $\frac{(D-4)^2}{16} \times L$ = Board feet, in which D is the diameter of the small end of the log, inside the bark in inches, and L is the length in feet. In spite of its inaccuracies when applied to small logs, this rule is used in some areas. It underscales average-sized logs by about 30 board feet.

2.9 Comparison of Log Rules

Top Diameter Inside Bark (inches)	Board foot values for 16-foot logs for log rules and in percentage of International (for saws cutting a ¼ inch kerf taken as a standard=100%)				
	International ¼ kerf	Scribner Decimal C		Doyle	
	Bd. Ft.	Bd. Ft.	Percent	Bd. Ft.	Percent
4	5	(10)	200	---	---
5	10	(10)	100	1	10
6	20	20	100	4	20
7	30	30	100	9	30
8	40	30	75	16	40
9	50	40	80	25	50
10	65	60	92	36	55
11	80	70	88	49	61
12	95	80	84	64	67
13	115	100	87	81	70
14	135	110	81	100	74
15	160	140	88	121	76
16	180	160	89	144	80
17	205	180	88	169	82
18	230	210	91	196	85
19	260	240	92	225	87
20	290	280	97	256	88
21	320	300	94	289	90
22	355	330	93	324	91
23	390	380	97	361	93
24	425	400	94	400	94
25	460	460	100	441	96
26	500	500	100	484	97
27	540	550	102	529	98
28	585	580	99	576	98
29	630	610	97	625	99
30	675	660	98	676	100
31	720	710	99	728	101
32	770	740	96	784	102
33	820	780	95	841	103
34	875	800	91	900	103
35	925	880	95	961	104
36	980	920	94	1,024	104
37	1,040	1,030	99	1,089	105
38	1,095	1,070	98	1,156	106
39	1,155	1,120	97	1,225	106
40	1,220	1,200	98	1,296	106

2.10 Weight Table for Various Woods

	Weight Per Standard Cord (Pounds)	Tons Per Standard Cord Ratio	Weight Per 1000 B.F. of Green Lumber (Pounds)	Weight Per Cubic Foot Green (Pounds)	Weight Per Cubic Foot Air Dry 128 Moisture Content
Ash, white	4300	2.2	4000	48	41
Aspen	3900	2.0	3600	42	27
Basswood	3800	1.9	3500	41	26
Beech	4900	2.5	4500	55	44
Birch, yellow	5100	2.6	4800	58	43
Birch, white	4500	2.3	4200	50	39
Cedar, red	3300	1.7	3100	37	33
Cedar, n. white	2500	1.3	2300	28	22
Cherry, black	4000	2.0	3800	46	35
Cottonwood	4400	2.2	4100	49	29
Elm	5000	2.5	4600	56	37
Gum, sweet/ black	4500	2.3	4200	45/50	35/34
Hackberry	4500	2.3	4200	50	37
Hemlock	4500	2.3	4200	49	28
Hickory	5700	2.9	5300	64	51
Locust, black	5200	2.6	4800	58	49
Maple, hard	5300	2.7	4600	56	44
Maple, soft	4300	2.2	3900	50	38
Oak, red	5700	2.9	5200	63	44
Oak, white	5600	2.8	5200	62	48
Pine, red	3800	1.9	3500	42	33
Pine, shortleaf	4700	2.4	4300	51	38
Pine, white	3200	1.6	3000	36	25
Poplar, yellow	3400	1.7	3200	38	28
Spruce	3000	1.5	2800	34	28
Sycamore	4700	2.4	4300	52	35
Tamarack	4200	2.1	3900	47	37
Walnut, black	5200	2.6	4800	58	39

2.11 Lumber Scale

Thickness and Width	Length of Board in Feet					
	6	8	10	12	14	16
	Contents in Board Feet					
1×3	1.5	2.0	2.5	3.0	3.5	4.0
1×4	2.0	2.6	3.3	4.0	4.6	5.3
1×5	2.5	3.3	4.0	5.0	6.0	6.6
1×6	3.0	4.0	5.0	6.0	7.0	8.0
1×7	3.5	4.6	6.0	7.0	8.0	9.3
1×8	4.0	5.3	6.6	8.0	9.3	10.6
1×10	5.0	6.6	8.3	10.0	11.6	13.3
1×12	6.0	8.0	10.0	12.0	14.0	16.0
2×4	4.0	5.3	6.6	8.0	9.3	10.6
2×6	6.0	8.0	10.0	12.0	14.0	16.0
2×8	8.0	10.6	13.3	16.0	18.6	21.3
2×10	10.0	13.3	16.6	20.0	23.3	26.6
2×12	12.0	16.0	20.0	24.0	28.0	32.0
2×14	14.0	18.6	23.3	28.0	32.6	37.3
3×6	9.0	12.0	15.0	18.0	21.0	24.0
3×8	12.0	16.0	20.0	24.0	28.0	32.0
3×10	15.0	20.0	25.0	30.0	35.0	40.0
3×12	18.0	24.0	30.0	36.0	42.0	48.0
4×4	8.0	10.6	13.3	16.0	18.6	21.3
6×6	18.0	24.0	30.0	36.0	42.0	48.0

2.12 Tons per Tree When Cut in the Following Lengths (Central Hardwoods)

DBH	8-Foot Sticks						
	1	2	3	4	5	6	7
6"	.043	.070	.100				
8"	.078	.125	.170	.218	.265		
10"	.123	.205	.278	.333	.400	.470	
12"	.175	.303	.413	.495	.563	.650	.750
14"	.238	.418	.570	.682	.778	.883	1.000
16"	.305	.550	.750	.918	1.050	1.175	1.325

DBH	6-Foot Sticks							
	1	2	3	4	5	6	7	8
6"	.033	.058	.078	.100				
8"	.058	.103	.140	.170	.205			
10"	.093	.165	.230	.278	.313	.368	.420	.470
12"	.133	.230	.343	.413	.465	.530	.590	.650
14"	.178	.328	.473	.570	.640	.730	.818	.883
16"	.230	.428	.623	.750	.863	.985	1.103	1.175

DBH	5-Foot Sticks									
	1	2	3	4	5	6	7	8	9	10
5"	.018	.035								
6"	.028	.053	.068	.085	.105					
8"	.048	.098	.115	.148	.178	.205	.235	.265		
10"	.075	.150	.188	.243	.288	.313	.358	.400	.445	.490
12"	.109	.220	.275	.358	.420	.465	.515	.563	.620	.675
14"	.150	.298	.380	.495	.593	.640	.723	.778	.848	.918
16"	.190	.380	.500	.650	.780	.863	.958	1.050	1.138	1.223

Piled Pulpwood

$$\frac{\text{Length (ft.)} \times \text{width (ft.)} \times \text{height (ft.)}}{51} = \text{tons}$$

Reforestation

3.1 Number of Trees Per Acre by Various Methods of Spacing

3.2 Dichotomous Key for Field Identification of Soil Texture

3.3 Textural Classification of Soils

3.4a-d Seeds per Pound and Bushel

3.1 Number of Trees Per Acre by Various Methods of Spacing

Spacing (Feet)	Trees (Number)	Spacing (Feet)	Trees (Number)	Spacing (Feet)	Trees (Number)
2×2	10,890	7×9	691	12×15	242
3×3	4,840	7×10	622	12×18	202
4×4	2,722	7×12	519	12×20	182
4×5	2,178	7×15	415	12×25	145
4×6	1,815	8×8	681	13×13	258
4×7	1,556	8×9	605	13×15	223
4×8	1,361	8×10	544	13×20	168
4×9	1,210	8×12	454	13×25	134
4×10	1,089	8×15	363	14×14	222
5×5	1,742	8×25	218	14×15	207
5×6	1,452	9×9	538	14×20	156
5×7	1,245	9×10	484	14×25	124
5×8	1,089	9×12	403	15×15	194
5×9	968	9×15	323	15×20	145
5×10	871	10×10	436	15×25	116
6×6	1,210	10×12	363	16×16	170
6×7	1,037	10×15	290	16×20	136
6×8	908	10×18	242	16×25	109
6×9	807	11×11	360	18×18	134
6×10	726	11×12	330	18×20	121
6×12	605	11×15	264	18×25	97
6×15	484	11×20	198	20×20	109
7×7	889	11×25	158	20×25	87
7×8	778	12×12	302	25×25	70

3.2 Dichotomous Key for Field Identification of Soil Texture

A. Soil, when pinched between the thumb and finger, crumbles, will form no "ribbon."

B. Soil squeezed in the hand when dry, falls apart readily; Squeezed when moist, forms a cast that breaks if not handled very carefully. Individual sand grains can be readily seen and felt.....**Sandy Loam**

B. Soil squeezed in hand when dry, forms a cast that bears careful handling; Squeezed when moist, forms a cast that can be handled quite freely without breaking, Soil smooth sand grains not readily evident.

C. Soil slightly plastic when moist, but not greasy. Gritty when dry, not floury. Color brown or dark grey..... .**Loam**

C. Soil greasy when moist, floury when dry. On wetting it runs together and puddles. Color light grey to nearly white.....**Silt Loam**

A. Soil, when pinched between the thumb and finger, forms a ribbon, at least barely sustaining its own weight.

D. Ribbon breaks easily, barely sustains own weight.

E. Individual sand grains can readily be seen and felt. Moist soil friable. Color usually brownish yellow to brownish red.....**Sandy Clay Loam**

E. Soil smooth, sand grains not evident. Moist soil somewhat plastic.

F. Soil heavy and greasy when moist. Color dull grey, sometimes containing iron concretions.....**Silty Clay Loam**

F. Soil mellow and loose when moist. Color usually yellowish brown to reddish brown.....**Clay Loam**

D. Ribbon is long and flexible, strong.

G. Individual sand grains can readily be seen and felt. Moist soil somewhat friable. Color usually bright red or yellow.....**Sandy Clay**

G. Sand not evident. Moist soil plastic.

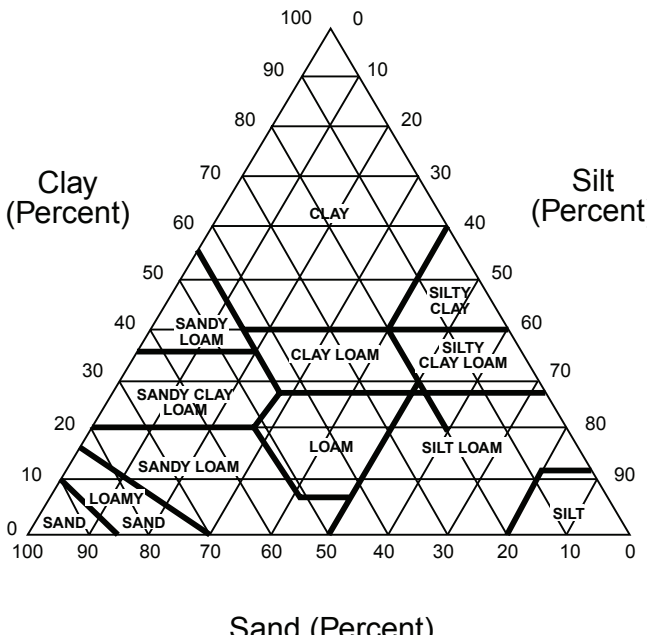
H. Color usually grey, sometimes containing iron concretions.....**Silty Clay**

H. Color usually dark red, often mottled with grey or yellow.....**Clay**

3.3 Textural Classification of Soils

Soil texture refers to the relative proportions of sand, silt, and clay particles that make up the soil mass. The chart below shows the percentage of these soil fractions in the basic textural grades.

Three classifications—sandy loam, loam, and silt loam—are common surface soils; they also may occur as subsoils. The rest of the classifications are subsoils.



3.4 Seeds per Pound and Bushel*

Species	Cleaned Seeds/lb.	Average Cleaned Seeds/lb.	Cleaned Seeds/bushel	Average Cleaned Seeds/bushel	Fruits/ Cones/ Bushel
Ash, Black	6,100–9,500	8,100			
Ash, Green	11,000–24,600	17,260			
Ash, White	5,540–18,185	13,120	68,690–225,490	162,680	
Basswood	3,000-8,000	5,000			
Beech	1,300-2,300	1,600			
Birch, Black	443,000-933,000	646,000			
Birch, Paper	610,000-4,120,000	1,380,000			
Birch, River	287,000–548,000	375,000			
Birch, Yellow	278,000-907,000	450,000			
Black Cherry	2,800-6,040	4,240			
Black Chokeberry		276,000			
Black Locust	24,000				
Black Walnut	11-100	40	484-4,400	1,760	
Blackgum	1,850-4,000	3,380			
Boxelder	8,200–20,400	13,400			
Buckeye, Ohio	48–67	58			
Butternut	15–40	30			
Buttonbush	118,000-160,000	134,000			
Chokecherry	3,010–8,400	4,790			
Cottonwood	200,000–590,000	350,000			
Dogwood, Flowering	3,300-6,200	4,500			
Dogwood, Gray	10,200–15,300	13,000			
Dogwood, Red Osier	13,800-26,700	18,500			
Dogwood, Roughleaf	8,600-21,000	15,200			

3.4 Seeds per Pound and Bushel*

Species	Cleaned Seeds/lb.	Average Cleaned Seeds/lb.	Cleaned Seeds/bushel	Average Cleaned Seeds/bushel	Fruits/ Cones/ Bushel
Dogwood, Silky	10,200-14,000	12,200			
Elderberry	175,000-324,000	232,000			
Elm, American	48,000–109,000	70,900			
Elm, Slippery	35,000–54,000	41,000			
Fir, Balsam	30,000-94,500	59,600		1,000-2,000	
Hackberry	3,500-5,400	4,300			
Hawthorn Species		4,700-20,600			49
Hawthorn, Washington		29,800			
Hazelnut, American	197–736	491			
Hemlock, Eastern	124,000-360,000	187,000			
Hickory, Bitternut	125–185	156	5,000–7,400	6,240	
Hickory, Shagbark	80–150	100	2,720–5,100	3,400	
Hickory, Shellbark	25–35	30			
Holly, American	22,000-36,350	28,430			
Holly, Mountain	31,000-66,000	45,000			
Holly, Winterberry	40,000-129,000	92,000			
Maple, Red	12,700-38,200	22,860			
Maple, Silver	900–3,200	1,780			
Maple, Sugar	3,200–9,100	7,030			
Ninebark	454,000-1,660,000	1,045,000			
Oak, Black	125–400	245	6,500–18,000	11,000	
Oak, Bur	40–135	75	1,300–4,380	2,960	
Oak, Northern Pin	205–290	245			
Oak, Northern Red	75–256	125	4,720-16,100	7,870	

3.4 Seeds per Pound and Bushel*

Species	Cleaned Seeds/lb.	Average Cleaned Seeds/lb.	Cleaned Seeds/bushel	Average Cleaned Seeds/bushel	Fruits/ Cones/ Bushel
Oak, Swamp White	90–175	120			
Oak, White	70-210	120	5,070-15,200	8,700	
Pawpaw	1,300				
Pecan	151-174	162			
Pine, Jack	71,000-250,000	131,000		2,500-3,200	
Pine, Loblolly	12,300-26,400	18,200		400-1,100	
Pine, Pitch	42,500-82,200	61,700			
Pine, Red	30,000-71,000	52,000		1,300-1,800	
Pine, Shortleaf	32,100-72,900	46,300		1,400-2,500	
Pine, White	17,500-53,000	26,500		500-700	
Plum, American	550-1,500	870			
Redbud	14,000–25,000	18,000			
Redcedar, Eastern	37,000-55,000	43,600			
Serviceberry	50,000-81,000	80,000			42
Spicebush	4,500-4,600				
Spruce, Black	335,000-510,000	404,000		7,000-16,000	
Spruce, Red	100,000-289,000	139,000		5,000	
Spruce, White	135,000-401,000	226,000		6,500-8,000	
Sweetgum	65,000-98,400	82,000	0.8		
Sycamore	133,500-267,400	193,270			
Tamarack	210,000-420,000	318,000			
Viburnum, Arrowwood	14,600-32,600	20,400			
Viburnum, Highbush Cranberry	9,400-17,800	13,600			

3.4 Seeds per Pound and Bushel*

Species	Cleaned Seeds/lb.	Average Cleaned Seeds/lb.	Cleaned Seeds/bushel	Average Cleaned Seeds/bushel	Fruits/ Cones/ Bushel
Viburnum, Nannyberry	2,200-12,400	5,900			
Willow					
Witch-hazel	8,700-10,900				
Yellow-poplar	6,880-14,050	10,630			
* Seeds of Woody Plants in the United States. USDA Forest Service Agriculture Handbook No. 450					

Stand Improvement

4.1 Basal Area Spacing Guide

4.2 Central Hardwood Spacing Table

4.1 Basal Area Spacing Guide

DBH Inches	Square feet of Basal Area per Acre									
	40	50	60	70	80	90	100	110	120	140
	Square spacing to the nearest foot									
2	5	4	4	4	3	3	3	3	3	3
3	7	7	6	6	5	5	5	4	4	4
4	10	9	8	7	7	6	6	6	6	5
5	12	11	10	9	9	8	8	7	7	7
6	15	13	12	11	10	10	9	9	8	8
7	17	15	14	13	12	11	11	10	10	9
8	19	17	16	15	14	13	12	12	11	10
9	22	20	18	17	16	15	14	13	13	11
10	24	22	20	18	17	16	15	15	14	13
12	29	26	24	21	21	19	18	18	17	16
14	34	31	28	26	24	23	22	21	20	18
16	39	35	32	29	28	26	25	24	24	21
18	44	39	36	33	31	29	28	26	25	23
20	49	44	40	37	34	32	31	29	28	26
Factor	2.4	2.2	2.0	1.8	1.7	1.6	1.55	1.45	1.4	1.3

Factor multiplied times DBH (inches) gives approximate square spacing in feet.

4.2 Central Hardwood Spacing Table

Diameter (inches)	Maximum Stocking "A" Level Spacing (feet)	Minimum Stocking "B" Level Spacing (feet)
2	4.6	6.5
3	6.1	8.2
4	7.6	9.9
5	9.0	11.6
6	10.3	13.4
7	11.6	15.0
8	13.0	17.0
9	14.3	18.7
10	15.6	20.4
11	17.0	22.1
12	18.1	23.8
13	19.4	25.6
14	20.8	27.2
15	21.9	29.0

Rule of Thumb:

For "A" Level stocking spacing, multiply diameter by 1.5
For "B" Level stocking spacing, multiply diameter by 2.0

Silvicultural Information

5.1 Synecological Requirements of Forest Species
5.2 Central States
5.3 Average Number of Years to Reach Breast Height by
5.4 Upland Central Hardwood Stocking Guide
5.5 Upland Central Hardwood Stocking Guide (cont.)
5.6 Hardwood Stocking Chart in the Northeast
5.7 Mixedwood Stocking Chart in the Northeast
5.8 Upland Hardwoods (oak-hickory) Stocking Charts
5.9 Jack Pine and Northern Hardwoods Stocking Charts
5.10 Red Pine and White Birch Stocking Charts
5.11 White Pine Stocking Chart
5.12 Elm–Ash–Cottonwood Stocking Guide

5.13 to 5.25—Site Index / Maximum Mean Annual Increment Curves

5.13 ASPEN
5.14 BALSAM FIR
5.15 BLACK SPRUCE
5.16 JACK PINE
5.17 NORTHERN WHITE-CEDAR
5.18 PAPER BIRCH
5.19 RED PINE
5.20 SUGAR MAPLE
5.21 TAMARACK
5.22 UPLAND OAKS
5.23 WHITE PINE
5.24 WHITE SPRUCE
5.25 YELLOW-POPLAR
5.26 Recommended Rings per Inch for Second Growth Timber for Quality Products

5.27 to 5.41—Site Index Curves

5.27 AMERICAN BEECH
5.28 AMERICAN ELM
5.29 BLACK CHERRY
5.30 COTTONWOOD
5.31 EASTERN HEMLOCK
5.32 GREEN ASH
5.33 LOBLOLLY PINE
5.34 RED MAPLE
5.35 RED SPRUCE
5.36 SILVER MAPLE
5.37 SWEETGUM
5.38 VIRGINIA PINE
5.39 WHITE ASH
5.40 WHITE OAKS
5.41 YELLOW BIRCH

Stocking guide direction in the U.S. Forest Service manuals, handbooks, and forest plans will be followed on National Forests.

5.1 Synecological Requirements of Forest Species

Moisture (M), nutrients (N), heat (H), and light (L)
in relative values from 1 (least) to 5 (greatest).

From Minnesota Forestry Notes No. 84 by Bakuzis and Hansen

	Relative Values					Relative Values			
Species	**M**	**N**	**H**	**L**	**Species**	**M**	**N**	**H**	**L**
TREES									
Balsam fir	3.6	2.0	1.4	2.0	White oak	2.1	5.0	4.6	1.3
White spruce	2.8	2.2	1.5	2.3	Northern pin oak	1.0	1.8	3.0	5.0
Black spruce	4.5	1.2	1.0	3.5	Bur oak	1.5	3.2	3.8	3.5
Jack pine	1.0	1.1	1.9	5.0	Northern red oak	1.5	4.2	3.5	2.8
Red pine	1.1	1.6	2.1	4.5	Basswood	2.5	5.0	3.8	1.5
White pine	1.7	2.1	2.0	2.8	American elm	3.5	5.0	3.9	2.0
N. white cedar	4.2	2.3	1.3	1.2	Rock elm	2.9	5.0	5.0	2.6
Tamarack	5.0	1.0	1.0	5.0	Quaking aspen	2.0	2.3	2.1	4.2
E. redcedar	1.0	2.6	5.0	3.0					
Boxelder	3.3	5.0	5.0	3.4	**SHRUBS**				
Red maple	1.9	2.3	2.6	3.4	Mountain maple	3.5	2.4	1.7	1.4
Sugar maple	3.2	5.0	3.5	1.0	Serviceberry	2.8	2.3	1.9	4.7
Silver maple	3.2	5.0	5.0	4.5	Bog birch	5.0	1.1	1.0	5.0
Yellow birch	3.7	5.0	2.4	1.7	Red-Osier dogwood	3.9	2.1	1.7	3.4
Paper birch	2.9	2.1	1.7	5.0	Am. hazelnut	1.3	2.5	3.1	5.0
B. hickory	2.7	5.0	4.8	1.0	Bk. hazelnut	1.9	1.4	1.9	3.1
Hackberry	3.3	5.0	5.0	1.6	*Crataegus* spp.	2.6	5.0	4.4	4.5
Black ash	3.9	3.5	2.6	1.8	Pin cherry	1.2	1.8	2.9	5.0
Green ash	3.0	5.0	4.4	3.6	Sand cherry	1.2	1.8	1.5	5.0
Black walnut	1.6	5.0	5.0	2.0	Chokecherry	1.1	3.4	3.1	3.6
Ironwood	2.4	5.0	4.3	1.1	Sweetfern	1.0	1.0	1.8	5.0
Balsam poplar	3.7	2.7	2.1	3.5	*Ribes* spp.	3.7	3.6	2.0	2.1
Cottonwood	2.9	5.0	5.0	3.9	Green alder	1.6	1.3	1.2	3.9
Bigtooth aspen	1.3	3.0	3.1	3.4	Speckled alder	4.6	1.6	1.0	3.6

5.2 Central States

Species	Major Forest Types			
	Central Mixed Hardwoods	Oak-Hickory	Shortleaf Pine and S.P.-Oak	Bottomland Hardwoods
(Years to DBH after complete overhead release)				
White oak	3	4	4	–
N. red oak	2	3	3	–
Scarlet oak	2	3	3	–
Pin oak	–	–	–	2
Black oak	2	3	3	–
White & green ash	3	–	–	1
Elm	2	–	–	1
B. walnut	2	–	–	2
Beech	4	–	–	–
Soft maple	2	–	–	1
Sugar maple	3	–	–	–
Yellow-poplar	1	–	–	1
Cottonwood	–	–	–	1
Shortleaf pine	–	5	4	–

Total Age (years)

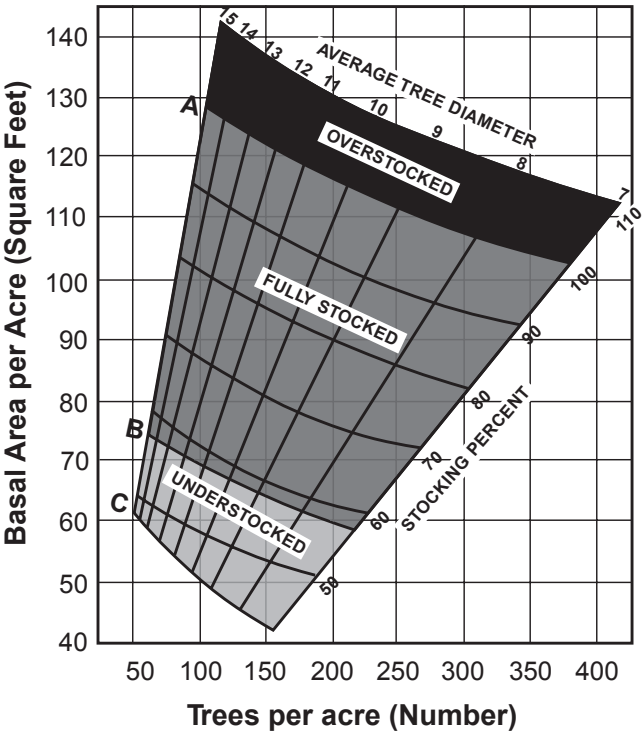
Table: Average number of years required for oak sprouts to reach breast height.

White Oak	1.8 years
Black Oak	2.0 years
Scarlet Oak	1.4 years
Chestnut Oak	1.6 years

5.3 Average Number of Years to Reach Breast Height by Species and Site Lake States

Species	Good Site	Average Site	Poor site and Suppressed Trees
Aspen	1	1	2
Ash	8	10	15
Balsam poplar	1	1	2
Balsam fir	10	10	15
Basswood	2	3	4
Birch, yellow	8	10	15
Birch, paper	2	3	4
Cedar, northern white	10	15	20
Elm	4	6	8
Maple, hard	8	10	15
Maple, soft	2	3	4
Oak	3	3	6
Pine, Jack	5	6	8
Pine, red (Norway)	6	8	10
Pine, white	8	10	12
Spruce, black	10	15	20
Spruce, white	10	12	15
Tamarack	5	7	10

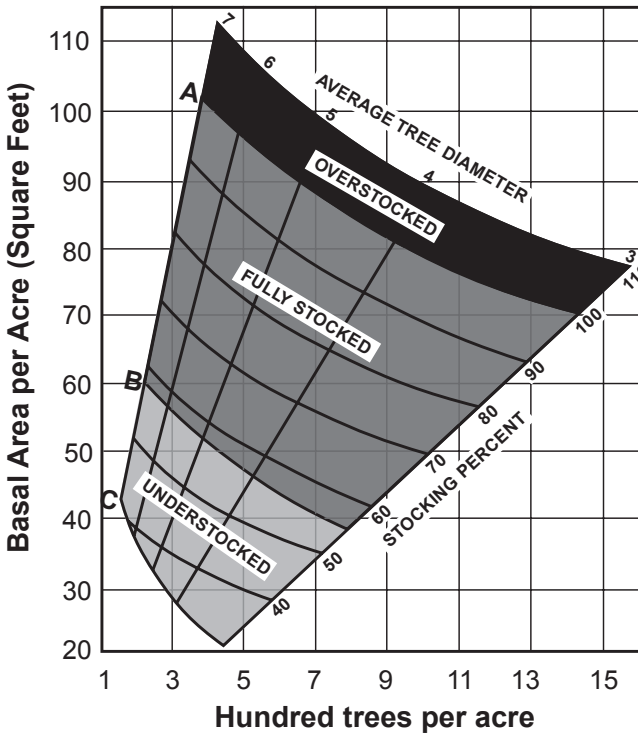
5.4 Upland Central Hardwood Stocking Guide*



Relation of basal area, number of trees, and average tree diameter to stocking percent for upland central hardwoods. Tree-diameter range 7-3 (page 5.5). The area between curves A and B indicates the range of stocking and . . .

* Even-aged Silviculture for Upland Central Hardwoods Agriculture Handbook 355.

5.5 Upland Central Hardwood Stocking Guide* (cont.)



. . . trees can fully utilize the site. Curve C shows the lower limit of stocking necessary to reach the B level in 10 years on average sites. (Average tree diameter is the diameter of the tree of average basal area.)

* Even-aged Silviculture for Upland Central Hardwoods Agriculture Handbook 355.

5.6 Hardwood Stocking Chart in the Northeast

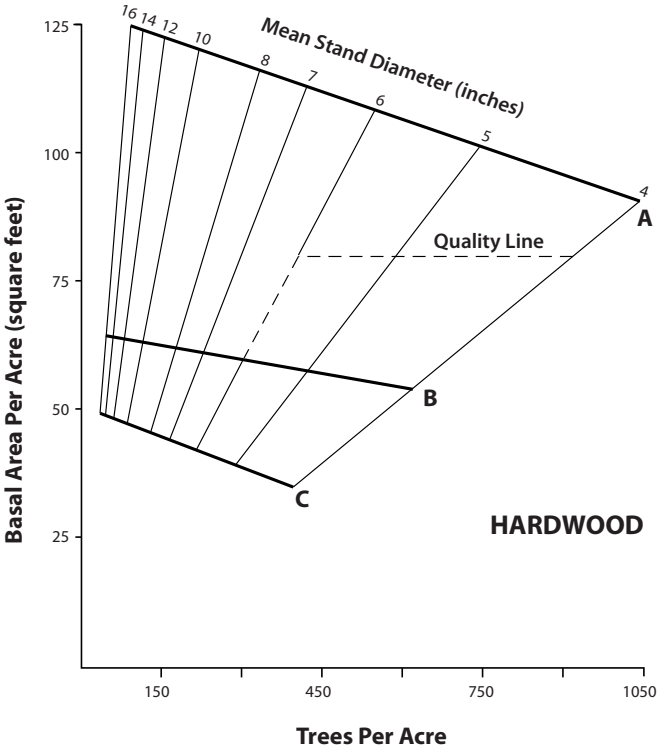


Figure 6.—Stocking chart for main crown canopy of even-aged hardwood stands (beech-red maple, beech-birch-maple) shows basal area and number of trees per acre and quadratic mean stand diameter. The A-line is fully stocked, the B-line is suggested residual stocking. The C-line is minimum stocking. The quality line is the density required to produce high quality stems of beech, sugar maple, yellow birch, and red maple.

Source: Silvicultural Guide for Northern Hardwood Types in the Northeast (revised), N.E.F.E.S. Research Paper NE-603

5.7 Mixedwood Stocking Chart in the Northeast

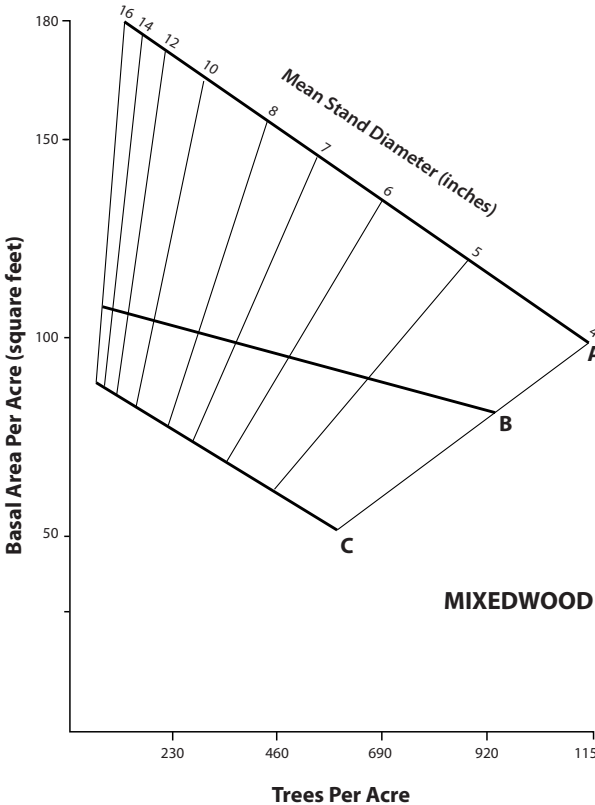
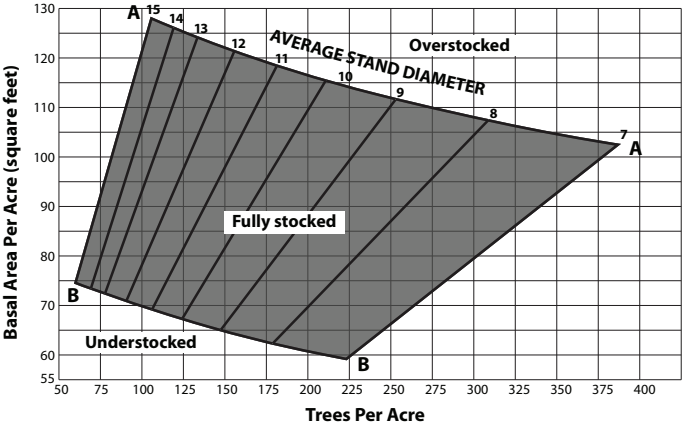


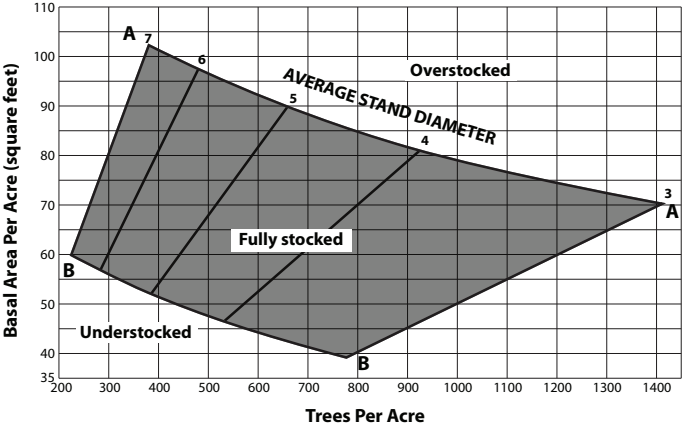
Figure 7.—Stocking chart for main crown canopy of mixedwood stands (25 to 65 percent softwoods) shows basal area and number of trees per acre and quadratic mean stand diameter. The A-line is fully stocked, the B-line is suggested residual stocking, the C-line is minimum stocking.

Source: Silvicultural Guide for Northern Hardwood Types in the Northeast (revised), N.E.F.E.S. Research Paper NE-603

5.8 Upland Hardwoods (oak-hickory) Stocking Charts

Upland hardwoods (oak-hickory) stocking charts. Use the upper chart for stands with larger diameter trees and the lower chart for stands with small diameter trees.

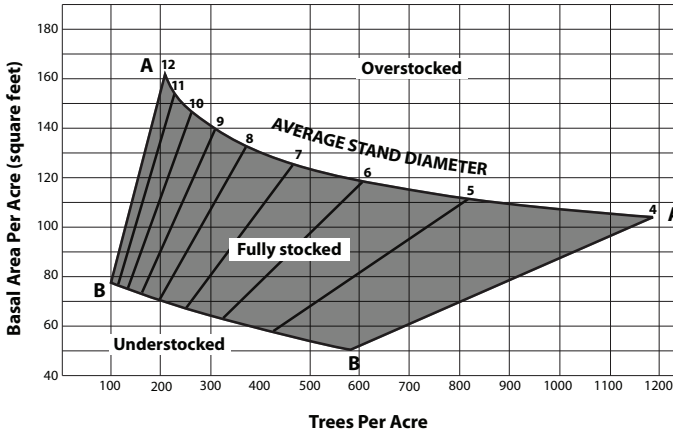




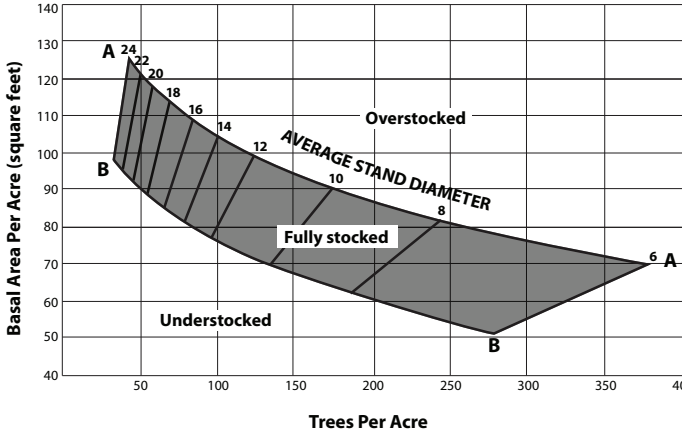
Source: Wisconsin Woodlands: Estimating Stocking Conditions in Your Timber Stand by Jeff Martin.

5.9 Jack Pine and Northern Hardwoods Stocking Charts

Jack pine stocking chart.



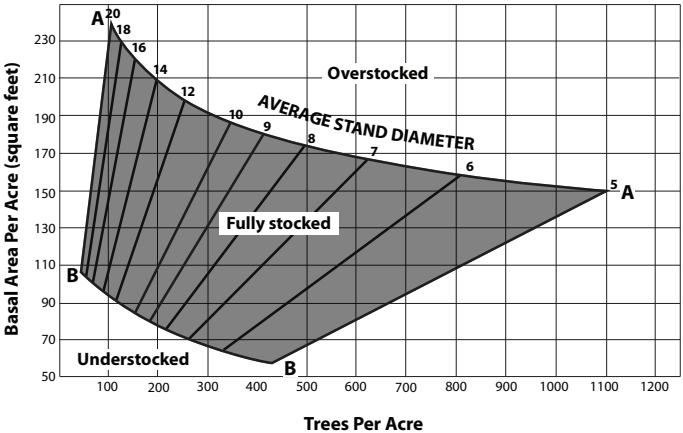
Northern hardwoods stocking chart (for even-aged stands).



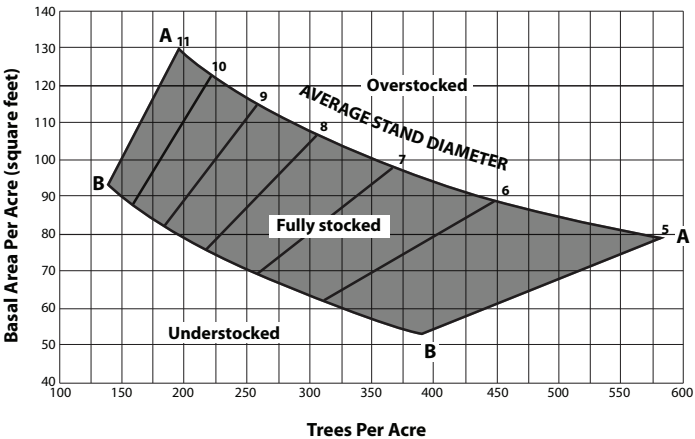
Source: Wisconsin Woodlands: Estimating Stocking Conditions in Your Timber Stand by Jeff Martin.

5.10 Red Pine and White Birch Stocking Charts

Red pine stocking chart.



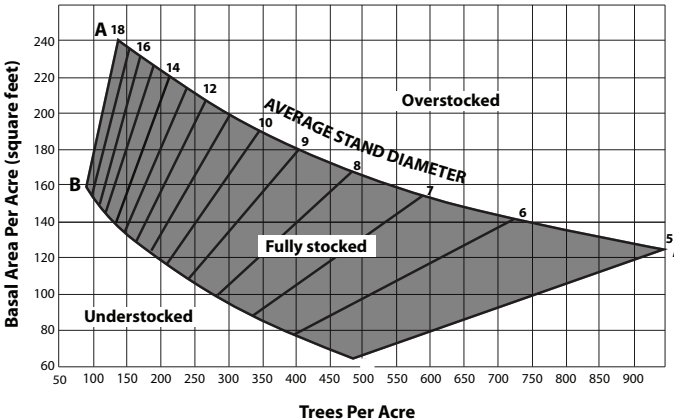
White birch stocking chart.



Source: Wisconsin Woodlands: Estimating Stocking Conditions in Your Timber Stand by Jeff Martin.

5.11 White Pine Stocking Chart

White pine stocking chart.



Source: Wisconsin Woodlands: Estimating Stocking Conditions in Your Timber Stand by Jeff Martin.

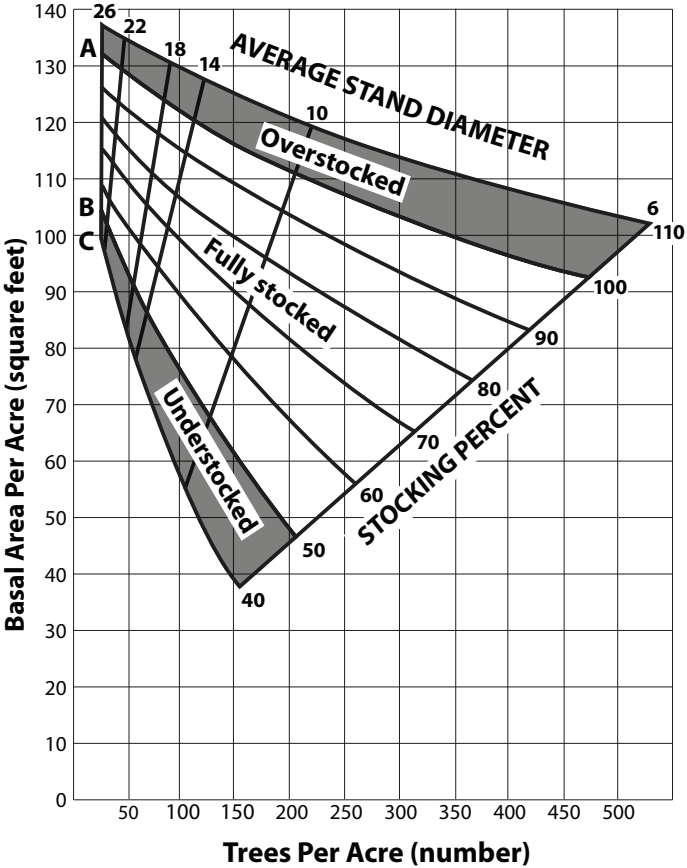
Red and White Pine[1]
Site Index – 5-Year Intercept Method

Intercept (in feet)	S.I.
0 - 3.2	30
3.3 - 4.4	40
4.5 - 5.7	50
5.8 - 7.3	60
7.4 - 10.8	70
10.9+	80

1. Select a dominant or co-dominant tree.
2. Measure the distance between the first and sixth whorl of branches above D.B.H.
3. Read site index directly from chart.
4. Stand site index should be based on measurements of at least 3 trees.

[1]For use on pine less than 25 feet tall. For pine over 25 feet tall use standard (height over age) site index curves.

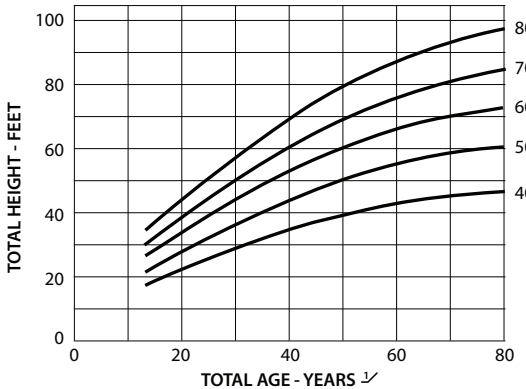
5.12 Elm–Ash–Cottonwood Stocking Guide



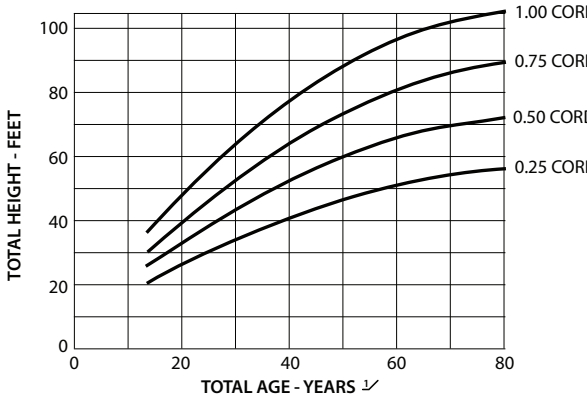
Relation of basal area, number of trees, and average tree diameter to stocking percent of elm-ash-cottonwood (based on Putnam et al. 1960) from Manager's Handbook for Elm-Ash-Cottonwood in the North Central States, GTR-NC-98.

5.13 ASPEN

SITE INDEX CURVES



MAXIMUM MEAN ANNUAL INCREMENT CURVES 2/

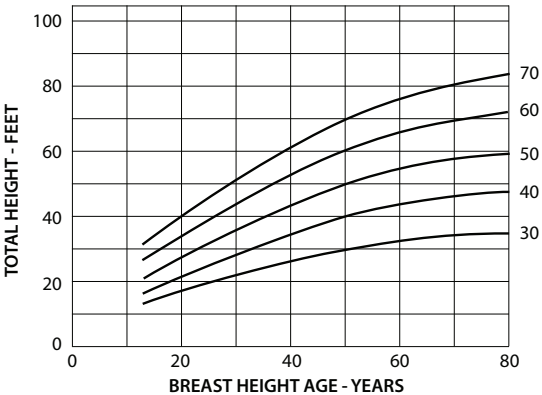


1/ Total age = Breast height age + 2 years

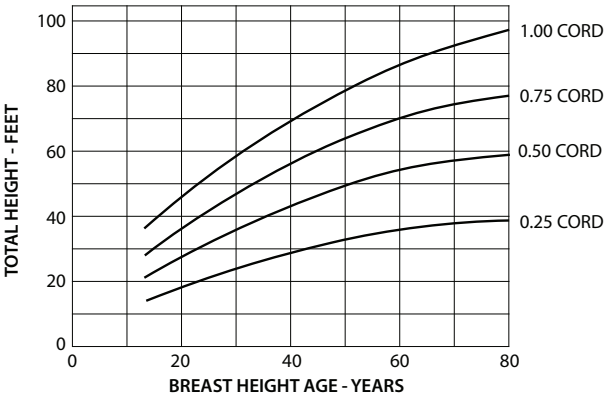
2/ Rotation = 50 years. Unmanaged stands.
Source: Econ. Note No. 9 and Tech. Note No. 464. L.S.F.E.S.

5.14 BALSAM FIR

SITE INDEX CURVES



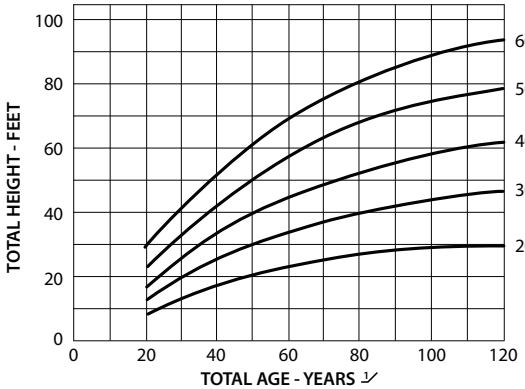
MAXIMUM MEAN ANNUAL INCREMENT CURVES 1/



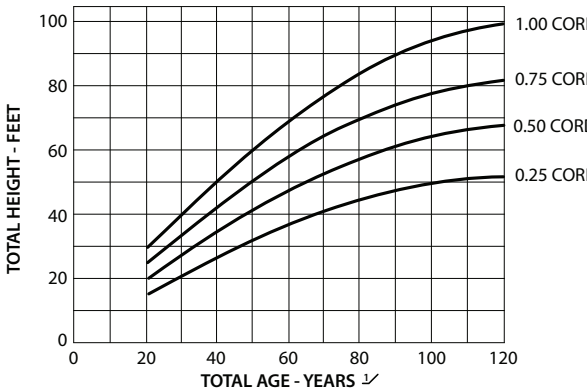
1/ Rotation = 50 years. Unmanaged stands.
Source: Yield tables for important timber species in the Lake States, unpublished, and Tech. Note No. 463. L.S.F.E.S.

5.15 BLACK SPRUCE

SITE INDEX CURVES



MAXIMUM MEAN ANNUAL INCREMENT CURVES 2/

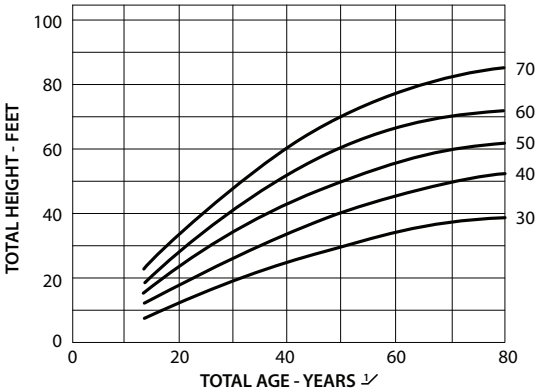


1/ Total age = Breast height age + 12 years

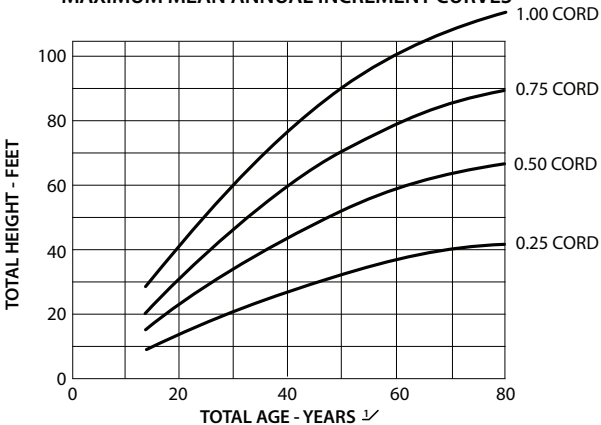
2/ Rotation = 100 years. Unmanaged stands.
Source: Yield table for important timber species in the Lake States, unpublished, and Tech. Note No. 483. L.S.F.E.S.

5.16 JACK PINE

SITE INDEX CURVES



MAXIMUM MEAN ANNUAL INCREMENT CURVES 2/

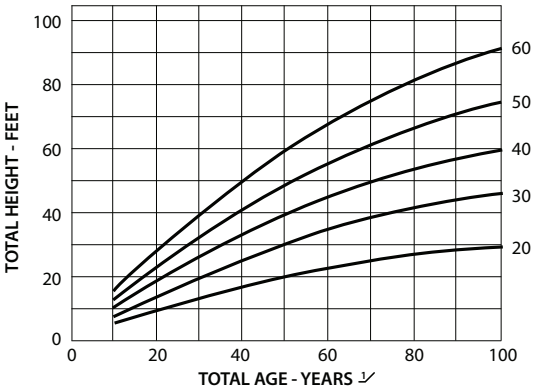


1/ Total age = Breast height age + 6 years

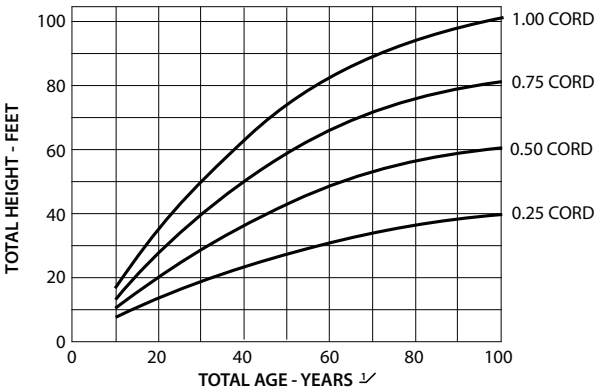
2/ Rotation = 50 years. Unmanaged stands.
Source: Econ. Note No. 9 and Tech. Note No. 463. L.S.F.E.S.

5.17 NORTHERN WHITE-CEDAR

SITE INDEX CURVES



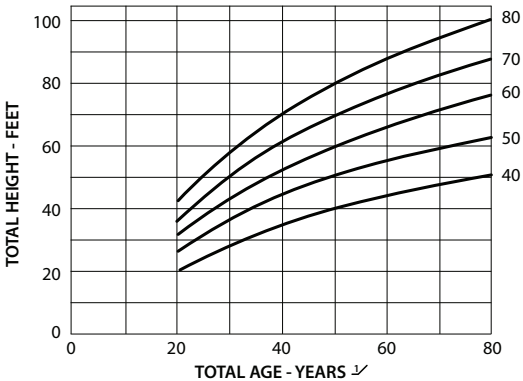
MAXIMUM MEAN ANNUAL INCREMENT CURVES 2/



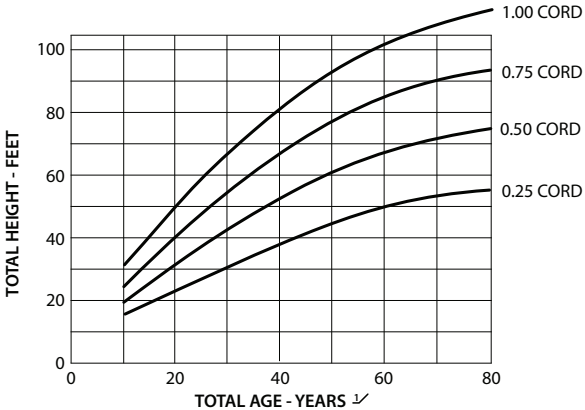
1/ Total age = Breast height age + 12 years
2/ Rotation = 100 years. Unmanaged stands.
Source: Yield tables for important timber species in the Lake States, unpublished, and Tech. Note No. 472, L.S.F.E.S.

5.18 PAPER BIRCH

SITE INDEX CURVES



MAXIMUM MEAN ANNUAL INCREMENT CURVES 2/



1/ Total age = Breast height age + 2 years

2/ Rotation = 60 years. Unmanaged stands.
Source: L.S.F.E.S. Technical Note No. 541.

5.19 RED PINE

SITE INDEX CURVES

MAXIMUM MEAN ANNUAL INCREMENT CURVES 2/

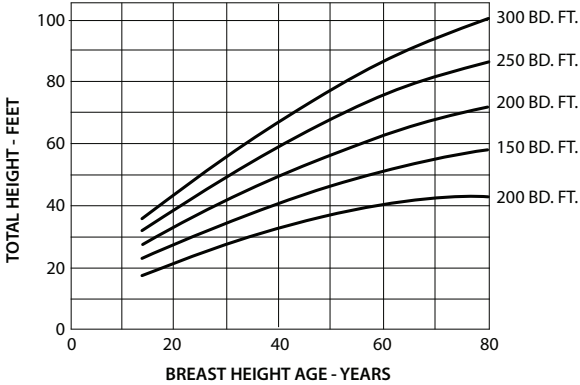
1/ Total age = Breast height age + 8 years

2/ Intensive management. Include sawtimber yields from intermediate cuttings. Residual basal area level = 90 sq. ft. Rotation = 115 years. Source: USDA Tech. Bull. No. 1272.

5.20 SUGAR MAPLE

SITE INDEX CURVES

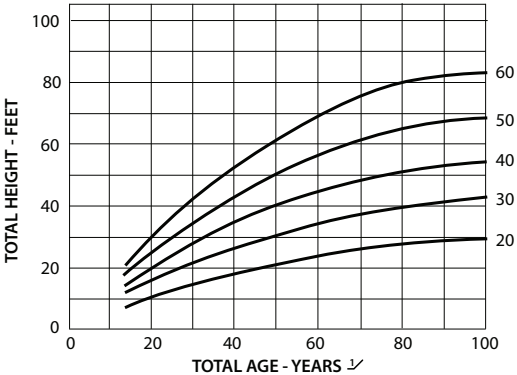
MAXIMUM MEAN ANNUAL INCREMENT CURVES 1/



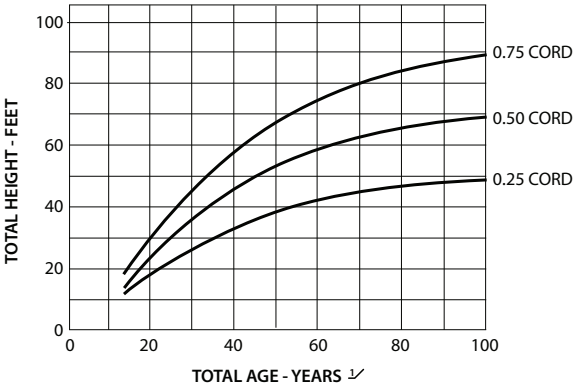
1/ Intensive all-age management of northern hardwoods using sugar maple as site indicator.
Source: Yield tables for important timber species of the Lake States, unpublished, L.S.F.E.S.; and Bulletin 629, Univ. of Vermont Agric. Station.

5.21 TAMARACK

SITE INDEX CURVES



MAXIMUM MEAN ANNUAL INCREMENT CURVES 2/

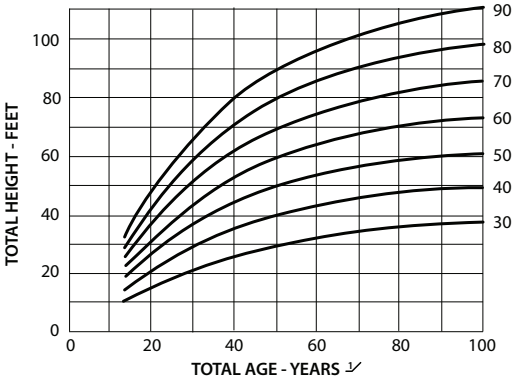


1/ Total age = Breast height age + 7 years

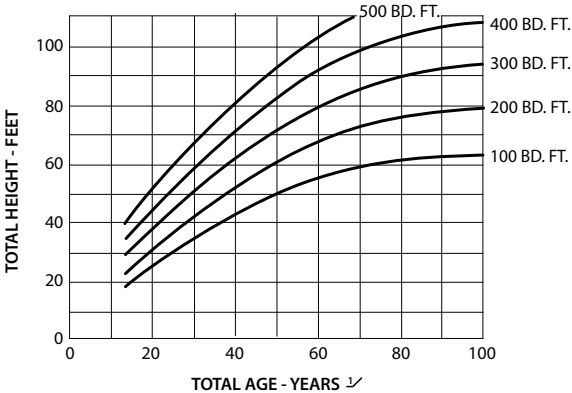
2/ Rotation = 100 years. Unmanaged stands.
Source: Yield tables for important timber species in the Lake States, unpublished, and Tech. Note No. 498. L.S.F.E.S.

5.22 UPLAND OAKS

SITE INDEX CURVES



MAXIMUM MEAN ANNUAL INCREMENT CURVES 2/



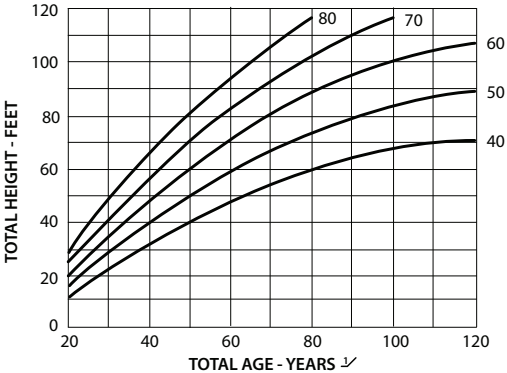
1/ Total age = Breast height age + 2 years

2/ Rotation = 100 years. Managed stands.

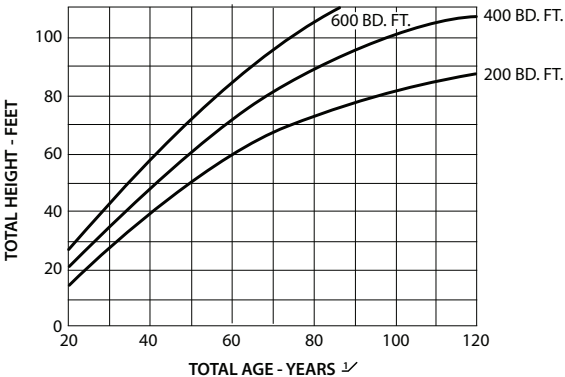
Source: Tech. Bull. No. 560, USDA, and Res. Note #125, S.E.F.E.S.

5.23 WHITE PINE

SITE INDEX CURVES



MAXIMUM MEAN ANNUAL INCREMENT CURVES 2/



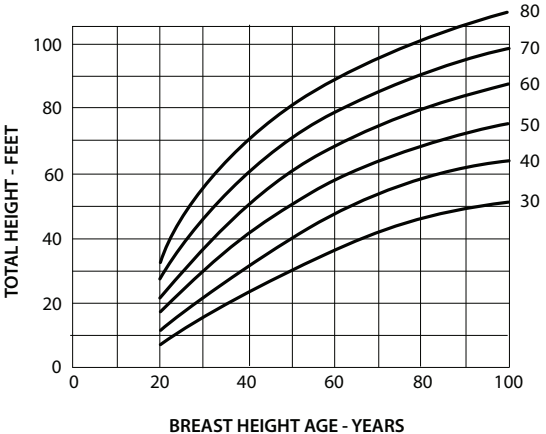
1/ Total age = Breast height age + 10 years

2/ Managed stands. Intermediate yield estimate was based on the assumption that the increase would be proportional to that realized between managed and unmanaged red pine stands. Rotation = 115 years.

Source: Yield tables for important timber species of the Lake States, unpublished, and Tech. Note 483.

5.24 WHITE SPRUCE

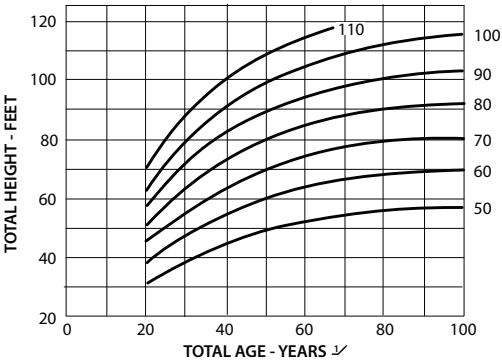
SITE INDEX CURVES 1/



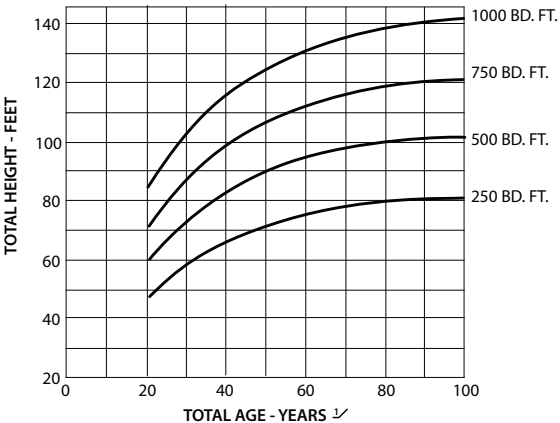
1/ Source: Tech. Note No. 474. L.S.F.E.S.

5.25 YELLOW-POPLAR

SITE INDEX CURVES



MAXIMUM MEAN ANNUAL INCREMENT CURVES 2/



1/ Total age = Breast height age + 2 years

2/ Rotation = 50 years. Unmanaged stands.

Source: Technical Bulletin No. 356, Research Note No. 1x0, S.E.F.E.S.

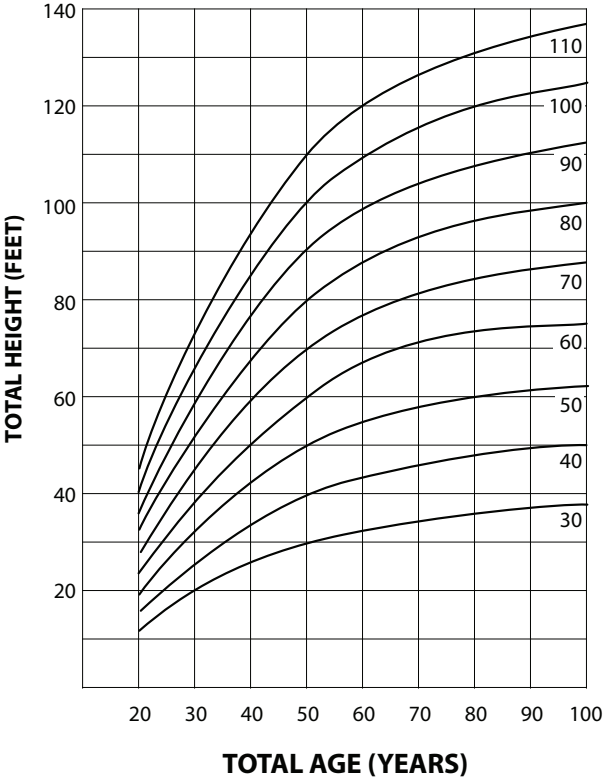
5.26 Recommended Rings per Inch for Second Growth Timber for Quality Products

FPL No. 2170, December 1959

Aspen	10
Balsam	8
Basswood	10
Beech	8
Black gum	10
Black spruce	10
Cottonwood	6
Eastern red cedar	8
Elm	8
Hickory	8
Jack pine	6
Loblolly pine	6
Northern white cedar	12
Oak	
Bur	8
Chestnut	8
Post	10
Swamp	8
White	10
Paper birch	6
Pitch pine	10
Red maple	8
Red oak	8
Red pine	8
Shortleaf pine	6
Silver maple	6
Sugar maple	8
Sweet gum	8
Sycamore	8
Tamarack	12
Virginia pine	8
Walnut	8
White ash	8
White pine	15
White spruce	10
Yellow birch	8
Yellow-poplar	8

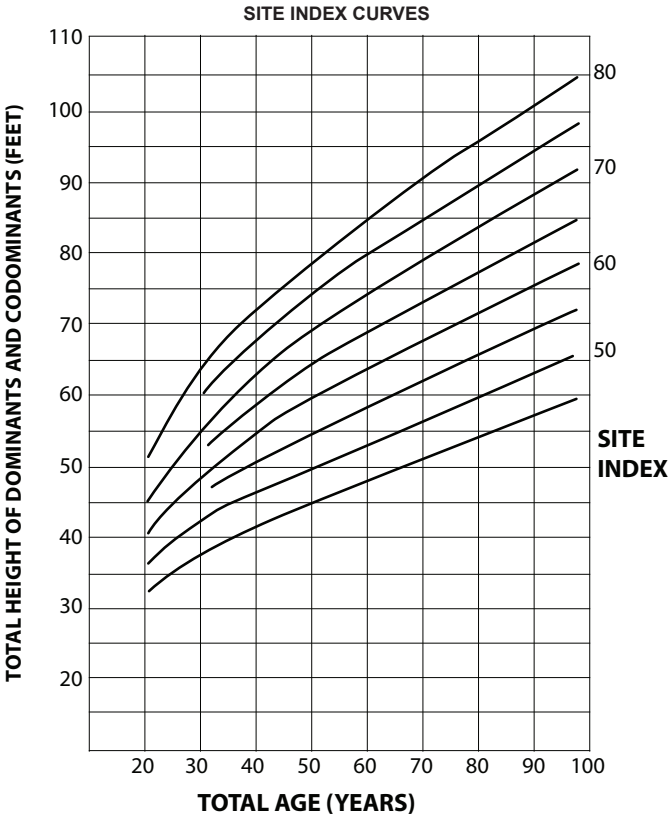
5.27 AMERICAN BEECH

HEIGHT IN FEET OF AVERAGE DOMINANT & CODOMINANT TREES, BY SITE INDEX CURVES AT 50 YEARS



Source: Constructed from Unpublished Data, N.E. Forest Exp. Station, Upper Darby, PA.

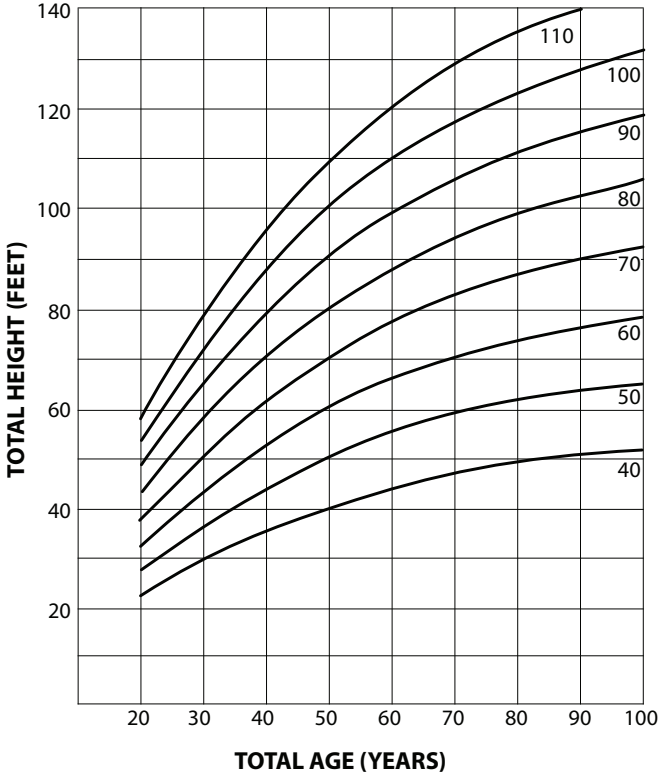
5.28 AMERICAN ELM



Site index curves for American elm (Carmean et al.) (base age 50 years) from Manager's Handbook for Elm-Ash-Cottonwood in the North Central States, GTR-NC-98.

5.29 BLACK CHERRY

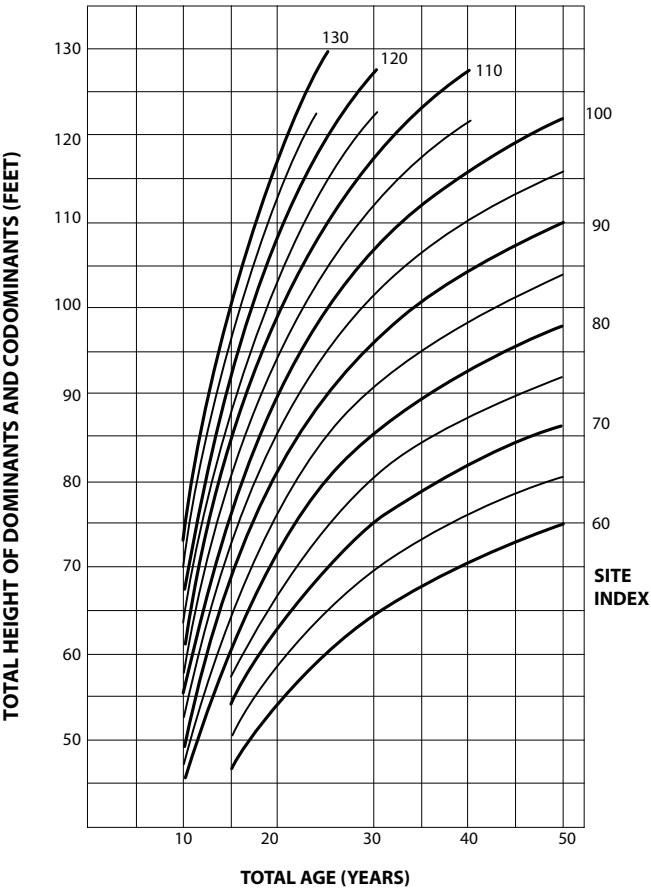
HEIGHT IN FEET OF AVERAGE DOMINANT TREES, BY SITE INDEX CURVES AT 50 YEARS



Source: Prepared from a Thesis for Graduate Degree by S.E. Defler, N.Y. State College of Forestry, 1937.

5.30 COTTONWOOD

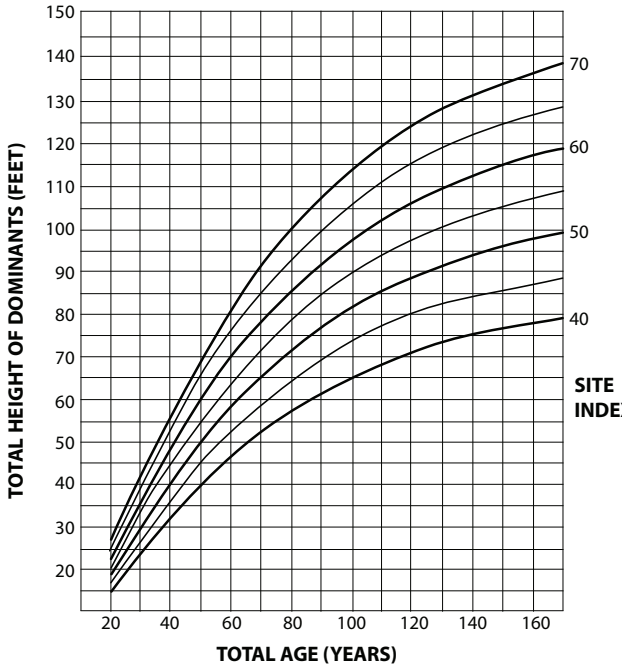
SITE INDEX CURVES



Site index curves for eastern cottonwood (Carmean et al.) (base age 25 years) from Manager's Handbook for Elm-Ash-Cottonwood in the North Central States, GTR-NC-98.

5.31 EASTERN HEMLOCK

SITE INDEX CURVES

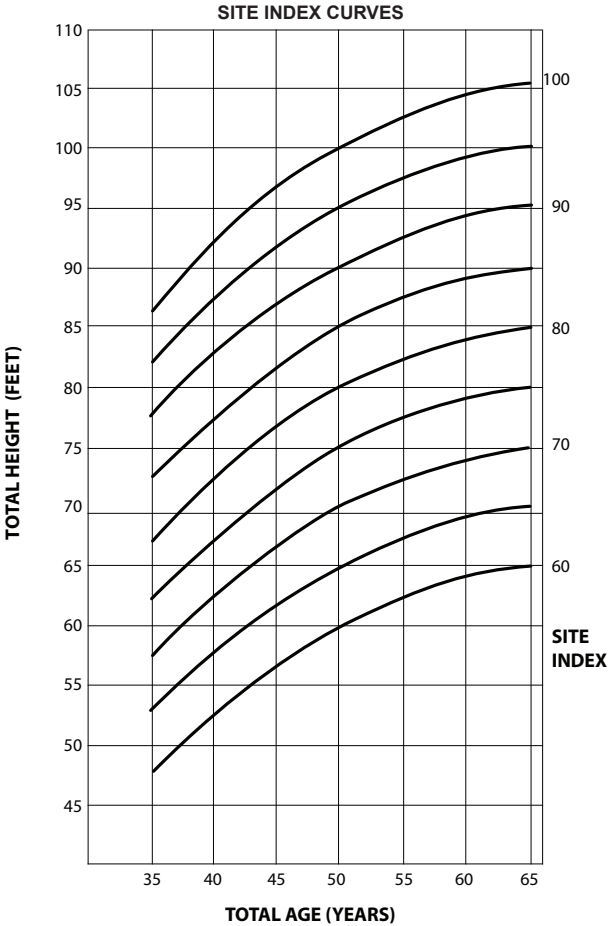


	b_1	b_2	b_3	b_4	b_5	R^2	SE	Maximum difference
H	2.1493	0.9979	-0.0175	1.4086	-0.0008	0.99	0.50	1.6
SI	0.2172	1.1309	-0.0105	-1.9120	-0.1327	0.99	1.20	3.4

Eastern hemlock (Frothingham 1915a)
Based on average of 'maximum' height growth curves from stands in New York, Michigan, and Southern Appalachian Mountains. Number of plots and number of dominant trees not given. Total height and age, anamorphic, equation not given. Add 6 years to d.b.h. age to obtain total age. Vigorous uninjured free-growing dominants in even aged stands are particularly important for estimating site index of hemlock (BH=0.0). Source: Site Index Curves for Forest Tree Species in the Eastern United States. GTR NC–128

U.S. Government Printing Office: 1989 657-204/00007

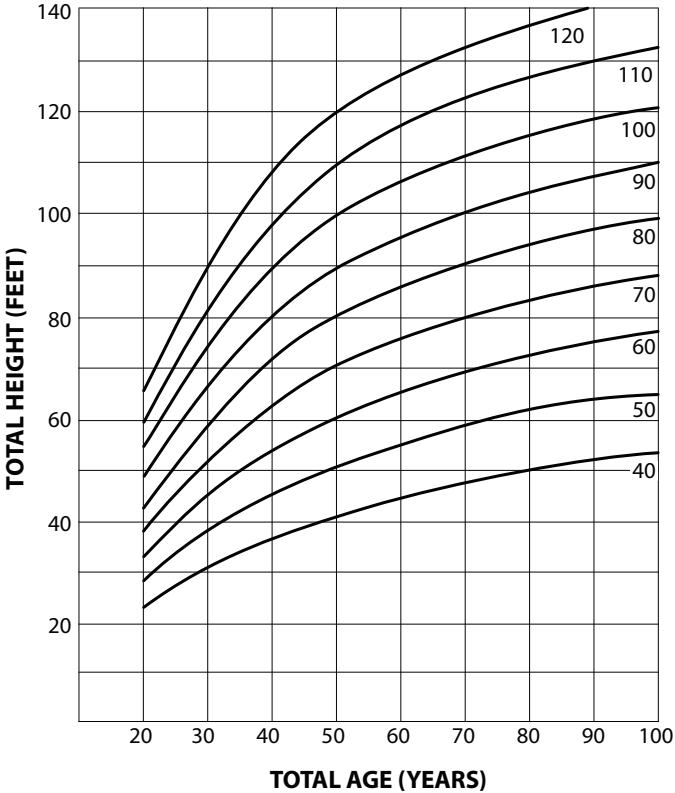
5.32 GREEN ASH



Site index curves for green ash (Carmean et al.) (base age 50 years) from Manager's Handbook for Elm-Ash-Cottonwood in the North Central States, GTR-NC-98.

5.33 LOBLOLLY PINE

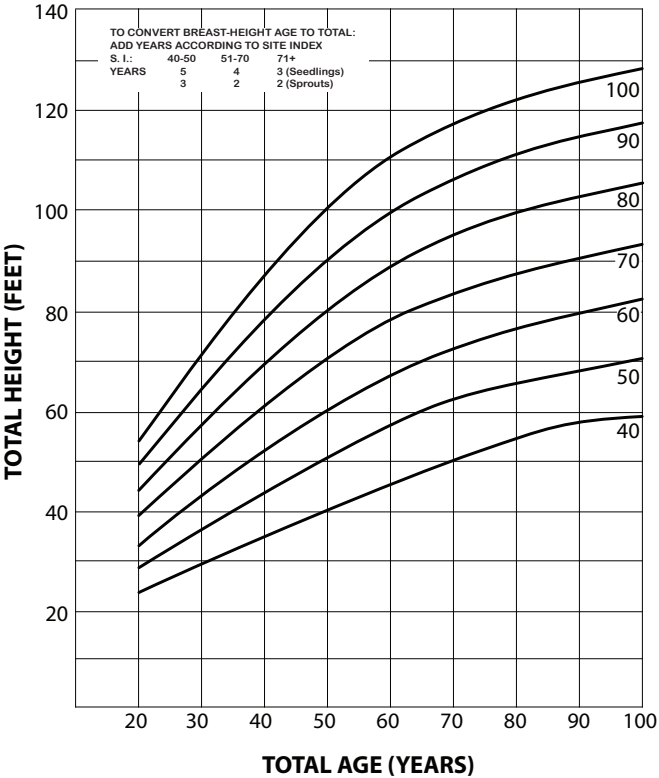
HEIGHT IN FEET OF AVERAGE DOMINANT TREES, BY SITE INDEX CURVES AT 50 YEARS



Source: Volume, Yield and Stand Tables for Second-Growth Southern Pines, U.S. Dept. Agr. Misc. Publ. No. 50 (1929).

5.34 RED MAPLE

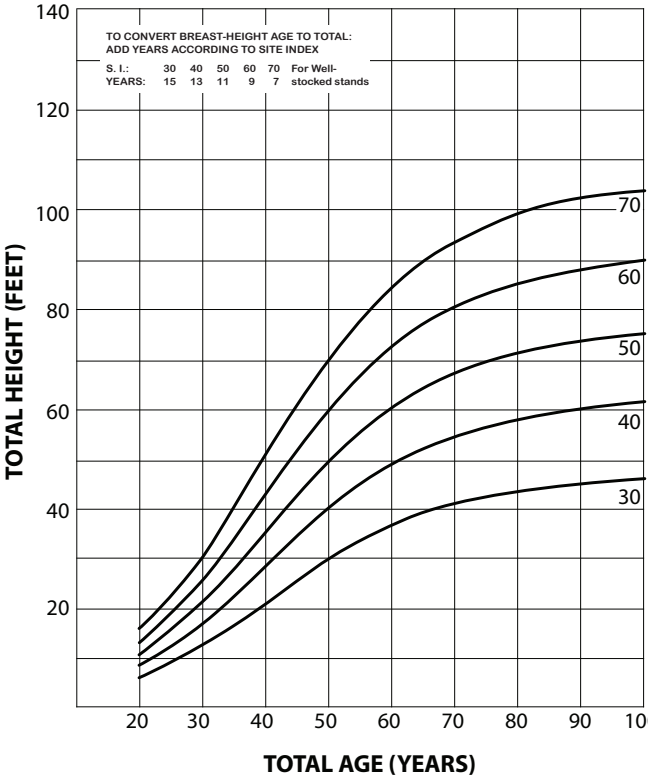
HEIGHT IN FEET OF AVERAGE DOMINANT & CODOMINANT TREES, BY SITE INDEX CURVES AT 50 YEARS IN NEW ENGLAND & N.Y.



Source: Constructed from Data Reported by R.W. Foster, Forest Science, Vol. 5, No. 3, Sept., 1959. (For Trees of Seedling Origin Only)

5.35 RED SPRUCE

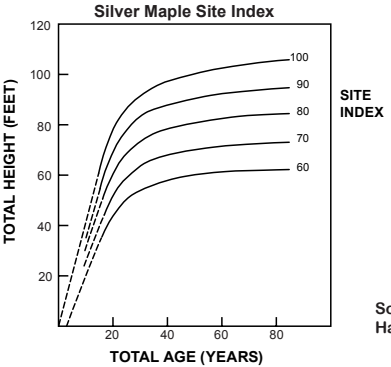
HEIGHT IN FEET OF AVERAGE DOMINANT & CODOMINANT TREES IN EVEN-AGED STANDS BY SITE INDEX CURVES AT 50 YEARS IN NATURAL RANGE



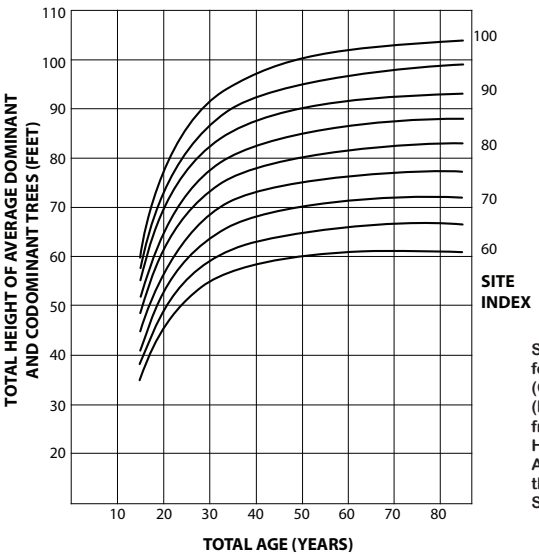
Source: Meyer, W. H., USDA Tech. Bull. No. 142, Nov. 1929. (Revised to 50-Year Age from 65 Years)

5.36 SILVER MAPLE

SITE INDEX CURVES



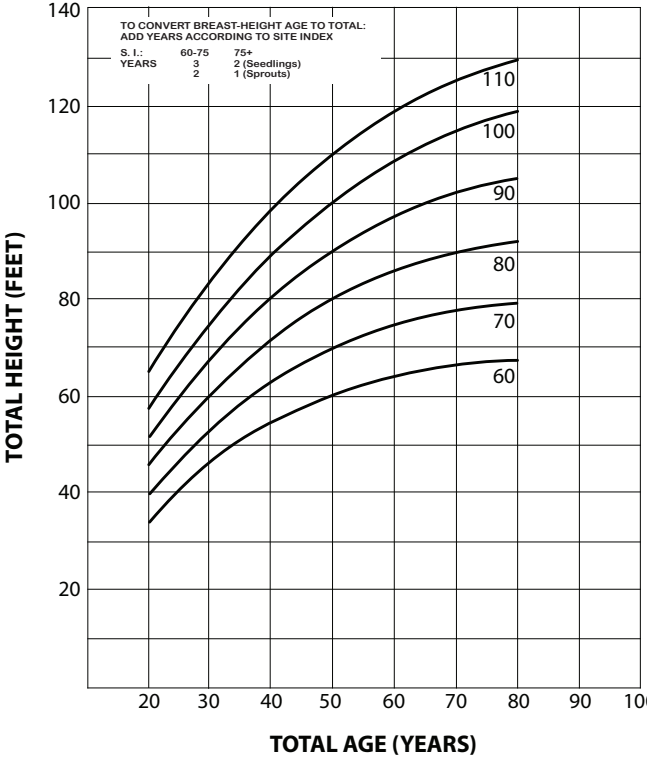
Source: Iowa Forestry Reference Handbook



Site index curves for silver maple (Carmean et al.) (base age 50 years) from Manager's Handbook for Elm-Ash-Cottonwood in the North Central States, GTR-NC-98.

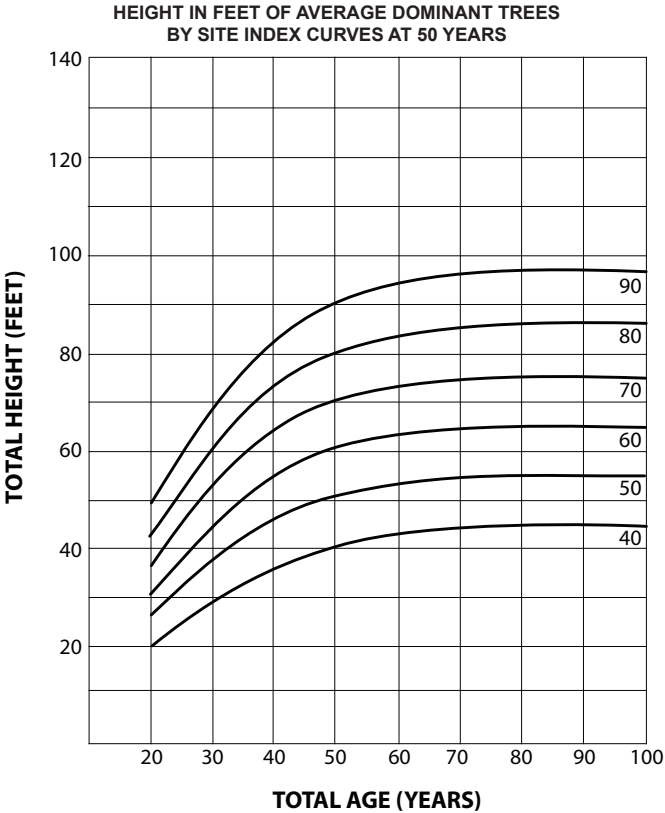
5.37 SWEETGUM

HEIGHT IN FEET OF AVERAGE DOMINANT & CODOMINANT TREES BY SITE INDEX CURVES OF 50 YEARS IN WEST VIRGINIA, IN STATES OF OHIO & MISSISSIPPI VALLEYS, AND SOUTHEASTERN STATES



Source: Broadfoot, W.M., & Krinard, R.M., Southern Forest Experiment Station. OCCAS. Paper No. 176, 1959.

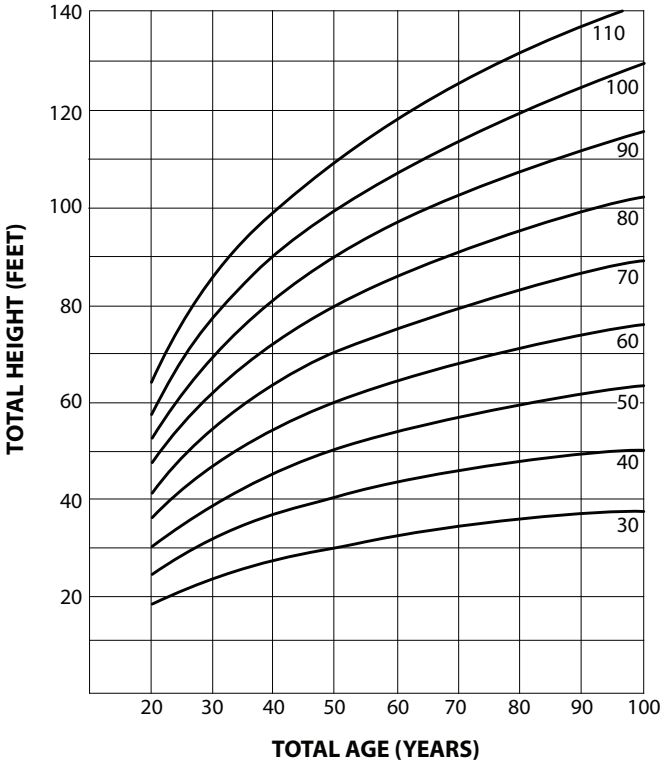
5.38 VIRGINIA PINE



Source: Chaiken, L. E., & Nelson, T.C., S.E. Forest Experiment Station. Research Notes #135, Nov. 1959.

5.39 WHITE ASH

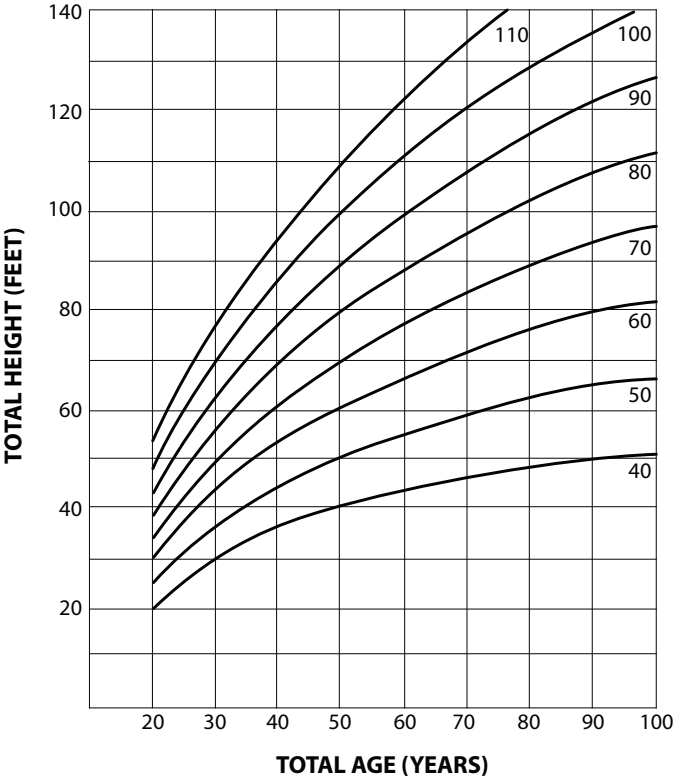
HEIGHT IN FEET OF AVERAGE DOMINANT & CODOMINANT TREES BY SITE INDEX CURVES AT 50 YEARS



Source: Constructed from Formula Developed by R.O. Curtis & B.W. Post, Bull. 629, Agr. Exp. Station University of Vermont & State Agriculture College, August 1962.

5.40 WHITE OAKS

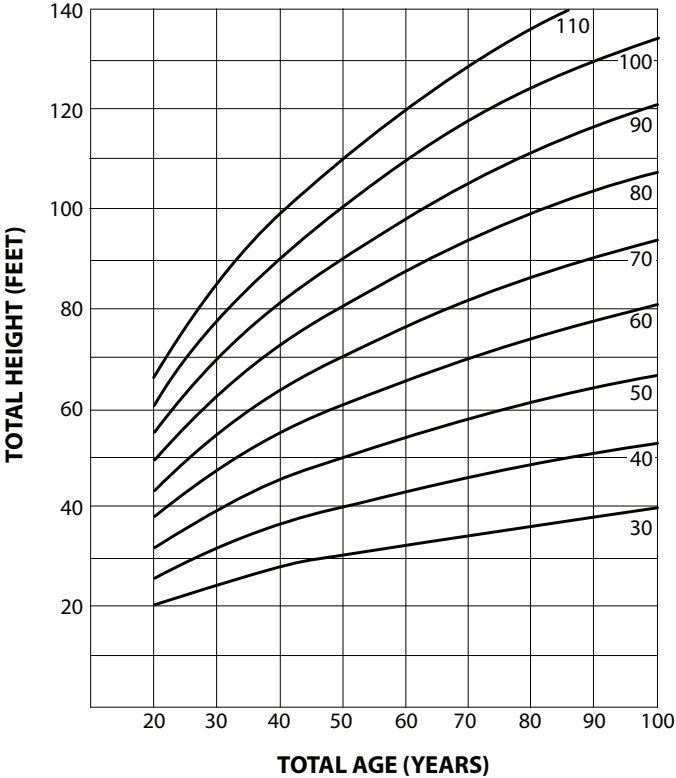
HEIGHT IN FEET OF AVERAGE DOMINANT & CODOMINANT TREES BY SITE INDEX CURVES AT 50 YEARS



Source: Doolittle, W.T., Soil Science, Vol. 22, No. 5, September to October 1958. Schur, G.L., USDA, Tech. Bull. No. 560 (1937).

5.41 YELLOW BIRCH

HEIGHT IN FEET OF AVERAGE DOMINANT & CODOMINANT TREES BY SITE INDEX CURVES AT 50 YEARS



Source: Constructed from Formula Developed by R.O. Curtis & B.W. Post, Bull. 629 Agr. Exp. Station, University of Vermont & State Agr. College, August 1962.

Economic Information

6.1 Compound Interest Table

6.2 Discount Factors (Single Payment Multiplier)

6.3 Table of Interest Rates Being Grown by Trees (6)

6.1a Compound Interest Table

Years	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%
1	1.040	1.050	1.060	1.070	1.080	1.090	1.100	1.110	1.120	1.130	1.140	1.150
2	1.082	1.103	1.124	1.145	1.166	1.188	1.210	1.232	1.254	1.277	1.300	1.323
3	1.125	1.158	1.191	1.225	1.260	1.295	1.331	1.368	1.405	1.443	1.482	1.521
4	1.170	1.216	1.262	1.311	1.360	1.412	1.464	1.518	1.574	1.630	1.689	1.749
5	1.217	1.276	1.338	1.403	1.469	1.539	1.611	1.685	1.762	1.842	1.925	2.011
6	1.265	1.340	1.419	1.501	1.587	1.677	1.772	1.870	1.974	2.082	2.195	2.313
7	1.316	1.407	1.504	1.606	1.714	1.828	1.949	2.076	2.211	2.353	2.502	2.660
8	1.369	1.477	1.594	1.718	1.851	1.993	2.144	2.305	2.476	2.658	2.853	3.059
9	1.423	1.551	1.689	1.838	1.999	2.172	2.358	2.558	2.773	3.004	3.252	3.518
10	1.480	1.629	1.791	1.967	2.159	2.367	2.594	2.839	3.106	3.395	3.707	4.046
15	1.801	2.079	2.397	2.759	3.172	3.642	4.177	4.785	5.474	6.254	7.138	8.137
20	2.191	2.653	3.207	3.870	4.661	5.604	6.728	8.062	9.646	11.523	13.743	16.367
25	2.666	3.386	4.292	5.427	6.848	8.623	10.835	13.585	17.000	21.231	26.462	32.919
30	3.243	4.322	5.743	7.612	10.063	13.268	17.449	22.892	29.960	39.116	50.950	66.212
35	3.946	5.516	7.686	10.677	14.785	20.414	28.102	38.575	52.800	72.069	98.100	133.176
40	4.801	7.040	10.286	14.974	21.725	31.409	45.259	65.001	93.051	132.782	188.884	267.864
45	5.841	8.985	13.765	21.002	31.920	48.327	72.890	109.530	163.988	244.641	363.679	538.769

6.1b Compound Interest Table cont.

Yrs.	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%
50	7.1067	11.467	18.420	29.457	46.902	74.358	117.39	184.56	289.00	450.74	700.23	1083.66
55	8.6464	14.636	24.650	41.315	68.914	114.41	189.06	311.00	509.32	830.45	1348.24	2179.62
60	10.520	18.679	32.988	57.946	101.26	176.03	304.48	524.06	897.60	1530.05	2595.92	4384.00
65	12.799	23.840	44.145	81.273	148.78	270.85	490.37	883.07	1581.87	2819.02	4998.22	8817.79
70	15.572	30.426	59.076	113.99	218.61	416.73	789.75	1488.02	2787.80	5193.87	9623.64	17735.70
75	18.945	38.833	79.057	159.88	321.20	641.19	1271.90	2507.40	4913.06	9569.37	18529.50	35672.90
80	23.050	49.561	105.80	224.23	471.95	986.55	2048.40	4225.11	8658.48	17630.90	35677.00	71750.90
85	28.044	63.254	141.58	314.50	693.46	1517.93	3298.97	7119.56	15259.2	32483.9	68693.00	144317
90	34.119	80.730	189.46	441.10	1018.92	2335.53	5313.02	11996.9	26891.9	59849.5	132262.0	290272
95	41.511	103.03	253.55	618.67	1497.12	3593.50	8556.68	20215.4	47392.8	11026.9	254660.0	583841
100	50.505	131.50	339.30	867.72	2199.76	5529.40	13780.60	34064.2	83522.3	203163.0	490326.0	1174310
110	74.760	214.20	607.64	1706.93	4749.12	13089.3	35743.40	96722.5	259407.	689650.0	1817750.	4750750
120	110.66	348.91	1088.19	3357.79	10253.0	30987.0	92709.10	274636.	805680.	2341060.	6738790.	19219400
130	163.81	568.34	1948.78	6605.28	22135.4	73357.5	240463.0	779807.	2502320	7946900.	24982200	77753400
140	242.48	925.77	3489.97	12993.6	47788.8	173664.	623700.0	2214200	7771830	26976300	92614500	314556000
150	358.92	1507.98	6250.00	25560.3	103172.	411126.	1617720.	6287050	24138100	91572800	343343000	1272550000

Agriculture Handbook 311 Compound Interest Tables for Long-term Planning in Forestry
Robert Jay Marty and David J. Neebe, 1966

6.2 Discount Factors (Single Payment Multiplier)*

Years	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%
1	.962	.952	.943	.935	.926	.917	.909	.901	.893	.885	.877	.870
2	.925	.907	.890	.873	.857	.842	.826	.812	.797	.783	.769	.756
3	.889	.864	.840	.816	.794	.772	.751	.731	.712	.693	.675	.658
4	.855	.823	.792	.763	.735	.708	.683	.659	.636	.613	.592	.572
5	.822	.784	.747	.713	.681	.650	.621	.593	.567	.543	.519	.497
6	.790	.746	.705	.666	.630	.596	.564	.535	.507	.480	.456	.432
7	.760	.711	.665	.623	.583	.547	.513	.482	.452	.425	.400	.376
8	.731	.677	.627	.582	.540	.502	.467	.434	.404	.376	.351	.327
9	.703	.645	.592	.544	.500	.460	.424	.391	.361	.333	.308	.285
10	.676	.614	.558	.508	.463	.422	.386	.352	.322	.295	.270	.247
15	.555	.481	.417	.363	.315	.275	.239	.209	.183	.160	.140	.123
20	.456	.377	.311	.258	.215	.178	.149	.124	.104	.087	.073	.061
25	.375	.295	.233	.184	.146	.116	.092	.074	.059	.047	.038	.030
30	.308	.231	.174	.131	.099	.075	.057	.044	.033	.026	.020	.015
35	.253	.181	.130	.094	.068	.049	.036	.026	.019	.014	.010	.008
40	.208	.142	.097	.067	.046	.032	.022	.015	.011	.008	.005	.004

* USDA-Forest Service Research Paper NC-51. 1971.

6.3 Table of Interest Rates Being Grown by Trees (6)

*DBH Inside Bark	Number of Annual Rings per Last Radial Inch of Growth											
	1	2	3	4	5	6	7	8	9	10	11	12
8	77.5	30.7	19.1	13.6	10.8	9.0	7.7	6.7	5.8	5.1	4.5	4.0
9	65.5	26.6	16.6	12.2	9.7	7.8	6.7	6.0	5.3	4.7	4.2	4.0
10	56.1	23.3	14.7	10.7	8.3	6.9	6.0	5.3	4.5	4.0	3.6	3.4
11	49.3	21.1	13.4	9.8	7.6	6.3	5.6	4.7	4.1	3.8	3.4	3.1
12	44.0	18.9	12.1	8.9	6.9	5.5	4.9	4.3	3.7	3.4	3.0	2.9
13	39.7	17.5	11.2	8.2	6.5	5.2	4.6	3.9	3.5	3.1	2.8	2.7
14	36.2	15.9	10.3	7.6	5.9	4.9	4.2	3.5	3.2	2.9	2.6	2.4
15	33.1	14.8	9.5	6.9	5.5	4.5	3.9	3.3	2.9	2.7	2.4	2.2
16	30.6	13.8	8.8	6.5	5.2	4.2	3.7	3.2	2.8	2.5	2.3	2.1
17	28.4	12.9	8.4	6.1	4.8	4.0	3.5	3.1	2.7	2.4	2.1	2.0
18	26.6	12.0	7.9	5.8	4.6	3.8	3.3	2.9	2.5	2.3	2.0	1.9
19	24.9	11.4	7.4	5.5	4.3	3.5	3.1	2.7	2.3	2.1	1.9	1.8
20	23.5	10.8	7.1	5.2	4.1	3.4	3.0	2.6	2.2	2.0	1.8	1.7
21	22.1	10.2	6.8	4.9	3.9	3.2	2.9	2.4	2.1	1.9	1.7	1.6
22	21.0	9.8	6.4	4.7	3.7	3.1	2.7	2.3	2.0	1.8	1.6	1.5

*2 Thicknesses of bark diameter must be deducted from increment boring. Assumed that rate growth is proportioned to the annual increase in basal area and that last inch of radial growth represents fair sample & current increment rate.

Converting Factors

7.1 Table of Measure

7.2 Conversion Factors for Rapid Approximation

7.3 Scale Conversions for Vertical Aerial Photographs

7.4 Converting Between Cubic and MBF

7.5 English-Metric Conversion Factors

7.1 Table of Measure

A. Lineal Measures
5½ yards = 16½ feet = 1 rod
320 rods = 1,760 yards = 5,280 feet = 1 mile

B. Square Measures
144 sq. inches = 1 sq. foot
9 sq. feet = 1 sq. yard
30¼ sq. yards = 272¼ sq. feet = 1 sq. rod
160 sq. rods = 4,840 sq. yards = 43,560 sq. feet = 1 acre
1 acre = 4,840 sq. yards
1 acre = 43,560 sq. feet
1 acre = 10 sq. chains
1 sq. mile = 640 acres

C. Surveyor's Measure
7.92 inches = 1 link
25 links = 1 rod
4 rods = 1 chain
100 links = 1 chain
66 feet = 1 chain
1 sq. link = 62.7 sq. inches = .436 sq. feet
10 sq. chains = 1 acre
1 sq. mile = 1 section
6 sq. miles = 36 sections = 1 township

D. Cubic Measure
1,728 cubic inches = 1 cubic foot
27 cubic feet = 1 cubic yard
1 bushel = 2,150.3 cubic inches
1 gallon = 231 cubic inches
1 cord = 128 cubic feet

E. Weight Measures (28)
1 gram = 1,000 milligrams = 15.432 grains
1 kilogram = 1,000 grams = 2.2 pounds
1 metric ton = 1,000 kilograms = 2,205 pounds
= 1.1023 net tons

7.2 Conversion Factors for Rapid Approximation

Useful Conversion Factors for Rapid (1) Approximation

Feet × .00019	= miles
Links × .66	= feet
Feet × 1.5	= links

Square inches × .007	= square feet
Square feet × .111	= square yards
Acres × 4,840	= square yards
Square yards × .0002066	= acres
Width in chains × 8	= acres per mile

Cubic feet × .04	= cubic yards (Approximate)
Cubic inches × .00058	= cubic feet

U.S. gallons × .13368	= cubic feet
U.S. gallons × 231	= cubic inches
Cubic feet × 7.48	= U.S. gallons
Cubic inches × .004329	= U.S. gallons
Cylindrical feet × 5.878	= U.S. gallons
Cylindrical inches × .0034	= U.S. gallons

Example: Given 7 acres of land. To find number of square yards, multiply 7 by 4,840

Answer: 33,880 square yards

7.3 Scale Conversions for Vertical Aerial Photographs[1]

Representative[1] Fraction (scale)	Feet per inch	Chains per inch	Inches per mile	Acres per square inch	Square miles per square inch
(1)	(2)	(3)	(4)	(5)	(6)
1: 7,920	660.00	10.00	8.00	10.00	0.0156
1: 8,000	666.67	10.10	7.92	10.20	0.0159
1: 8,400	700.00	10.61	7.54	11.25	0.0176
1: 9,000	750.00	11.36	7.04	12.91	0.0202
1: 9,600	800.00	12.12	6.60	14.69	0.0230
1:10,000	833.33	12.63	6.34	15.94	0.0249
1:10,800	900.00	13.64	5.87	18.60	0.0291
1:12,000	1,000.00	15.15	5.28	22.96	0.0359
1:13,200	1,100.00	16.67	4.80	27.78	0.0434
1:14,400	1,200.00	18.18	4.40	33.06	0.0517
1:15,000	1,250.00	18.94	4.22	35.87	0.0560
1:15,600	1,300.00	19.70	4.06	38.80	0.0606
1:15,840	1,320.00	20.00	4.00	40.00	0.0625
1:16,000	1,333.33	20.20	3.96	40.81	0.0638
1:16,800	1,400.00	21.21	3.77	45.00	0.0703
1:18,000	1,500.00	22.73	3.52	51.65	0.0807
1:19,200	1,600.00	24.24	3.30	58.77	0.0918
1:20,000	1,666.67	25.25	3.17	63.77	0.0996
1:20,400	1,700.00	25.76	3.11	66.34	0.1037
1:21,120	1,760.00	26.67	3.00	71.11	0.1111
1:21,600	1,800.00	27.27	2.93	74.38	0.1162
1:22,800	1,900.00	28.79	2.78	82.87	0.1295
1:24,000	2,000.00	30.30	2.64	91.83	0.1435
1:25,000	2,083.33	31.57	2.53	99.64	0.1557
1:31,680	2,640.00	40.00	2.00	160.00	0.2500

Method of calculation	$\frac{RFD}{12}$	$\frac{RFD}{792}$	$\frac{63,360}{RFD}$	$\frac{(RFD)^2}{6,272,640}$	$\frac{Acres/sq.in.}{640}$

[1] Conversions for scales not shown can be made from the relationships listed at the bottom of each column. Using the scale of 1:7,920 as an example (col. 1, line 1), the number of feet per inch is computed by dividing the representative fraction denominator (RFD) by 12 (no. of inches per foot). Thus, 7,920 ÷ 12 = 660 feet per inch (col. 2). By dividing the RFD by 792 (inches per chain), the number of chains per inch is derived (col.3). Other calculations can be made similarly. Under column 4, the figure 63,360 represents the number of inches in one mile; in column 5, the figure 6,272,640 is the number of square inches in one acre; and in column 6, the number 640 is acres per square mile.

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7.4 Converting Between Cubic and MBF

1. Standard Conversion Factors

   The following factors will be used to convert between units for T.M. Reports (cut & sold, etc.).

   Int. ¼" Rule: .60 MBF per Ccf (Cunit)
   Scribner Rule: .54 MBF per Ccf
   Pulpwood: .633 MBF per Ccf
   Pulpwood: 1.266 Cords per Ccf

   MBF to Ccf (or Cords)

   Sawtimber:

   $$\text{Ccf} = \frac{\text{MBF (LS-Int)}}{.6} \qquad \text{Ccf} = \frac{\text{MBF (LS-Scribner)}}{.54}$$

   Pulpwood:

   $$\text{Ccf} = \frac{\text{MBF}}{.633} \quad \text{or} \quad \text{Ccf} = (.79)\ (\text{Cord})$$

   Ccf (or Cords) to MBF

   Sawtimber:

   MBF (LS-Int) = (.6) (Ccf) MBF (LS-Scribner) = (.54) (Ccf)

   Pulpwood:

   MBF = (.633) (Ccf) or $\text{Cords} = \frac{\text{Ccf}}{.79}$

2. Conversion Formula

   $$\text{LRF} = \frac{\text{MBF(LS)} \times \text{O.R.}}{\text{Ccf}}\ ;\ \text{MBF(LS)} = \frac{\text{Ccf} \times \text{LRF}}{\text{O.R.}}\ ;\ \text{Ccf} = \frac{\text{MBF(LS)} \times \text{O.R.}}{\text{LRF}}$$

   Where:

   MBF = Thousand Board Feet
   Ccf = Cunit = 100 cubic feet
   LS = Log Scale
   O.R. = Overrun
   LRF = Lumber Recovery Factor

7.5 English-Metric Conversion Factors

MULTIPLY	BY	OR	DIVIDE	BY	TO OBTAIN
Acres	0.405		Acres	2.471	Hectares
Centimeters	0.394		Centimeters	2.540	Inches
Chains	20.12		Chains	.050	Meters
Feet	0.305		Feet	3.281	Meters
Feet ^{2}/ acre	0.230		Feet ^{2}/ acre	4.356	Meters^2/hectares
Feet ^{3}	.0283		Feet ^{3}	35.311	Meters^3
Gallons	3.785		Gallons	.264	Liters
Hectares	2.471		Hectares	0.405	Acres
Inches	2.540		Inches	0.394	Centimeters
Inches^3	.0164		Inches^3	61.013	Liters
Kilometers	.621		Kilometers	1.609	Miles
Liters	61.013		Liters	.0164	Inches^3
Liters	.264		Liters	3.785	Gallons
Meters	.199		Meters	5.03	Rods
Meters	.050		Meters	20.12	Chains
Meters	3.281		Meters	0.305	Feet
Meters^2/hectare	4.356		Meters^2/hectares	0.230	Feet ^{2}/ acre
Meters^3	35.311		Meters^3	.0283	Feet^3
Miles	1.609		Miles	.621	Kilometers
Number/acre	2.471		Number/acre	0.405	Number/hectare
Number/hectare	0.405		Number/hectare	2.471	Number/acre
Rods	5.03		Rods	.199	Meters

Miscellaneous

8.1 Sugar Maple Tap Hole Computation Sheet

Point Sample Method

8.2 Firewood

Inside Back Cover:

Discrimination Clause

8.1 Sugar Maple Tap Hole Computation Sheet Point Sample Method
(10-factor)

DBH																TOTAL
10″	18	37	55	73	92	110	128	146	165	183	201	220	238	256	275	
12″	13	25	38	51	64	76	89	102	114	127	140	152	165	178	191	
14″	9	19	28	38	47	56	66	75	85	94	103	113	122	132	141	
16″	14	29	43	58	72	86	101	115	130	144	158	173	187	202	216	
18″	11	23	34	46	57	68	80	91	103	114	125	137	148	160	171	
20″	14	28	41	55	69	83	97	110	124	138	152	166	179	193	207	
22″	11	23	34	46	57	68	80	91	103	114	125	137	148	160	171	
24″	10	19	29	38	48	58	67	77	86	96	106	115	125	134	144	
26″	11	22	32	43	54	65	76	86	97	108	119	130	140	151	162	
TOTAL																

For number of tap holes per acre – total last numbers in each diameter class – then divide this total by number of point samples taken.

(Total) _____

_____ = _____ tap holes per acre

_____

(point samples)

(Tap holes per acre) _____ × (acres) _____ = total for woodland

8.2 Firewood

I. Approximate BTU content:

1 pound of wood = 6,000-7,200 BTU
1 pound of coal = 12,000 BTU
1 pound of fuel oil = 18,000 BTU

1 cord of dry wood = 1 ton of coal = 200 gallons of fuel oil

II. Measurements:

A. 1 standard cord (4´ × 4´ × 8´) = 128 cubic feet
The solid content depends on size and straightness –
Large straight sticks – 1 cord = 90 cubic feet
Small crooked sticks – 1 cord = 70 cubic feet
Average – 1 cord = 80 cubic feet

B. For weight by species see the table on Section 2.10

C. For Cord Table, see Section 2.1

D. Formula for cubic feet per tree (works best for pine):

Divide DBH by 2, subtract 1, square remainder –

$$\left(\frac{D}{2} - 1\right)^2$$

Example: DBH = 10

$$\left(\frac{10}{2} - 1\right)^2 = 16 \text{ cubic feet}$$

E. Computing cubic feet per tree, number of trees, or acres of trees (works best on small hardwoods) –

Basal area (DBH + *) = cubic feet * Use 12 – site index 50
15 – site index 60
18 – site index 70
20 – site index 80
22 – site index 90

Example: Average DBH – 8″
Basal area – 25 sq. ft.
Site index – 60
25 (8+ 15) = 575 cubic feet
575 / 80 = 7.19 cords

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