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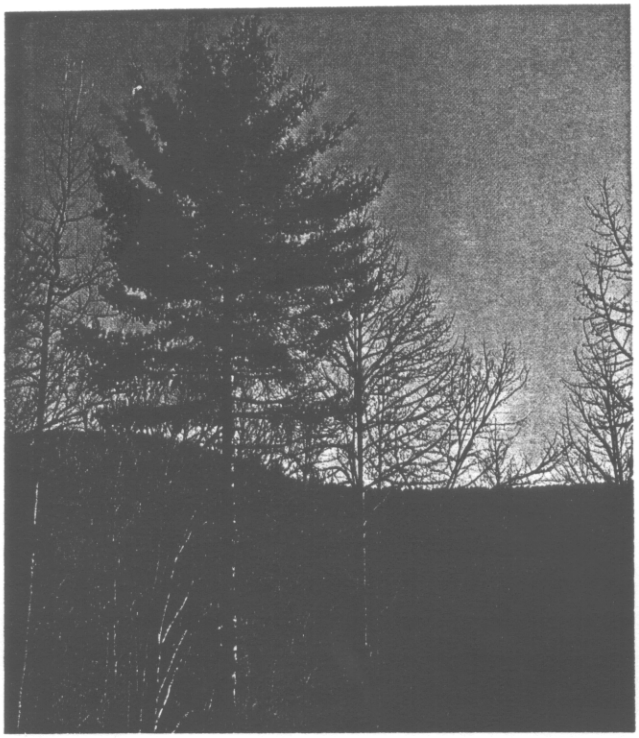

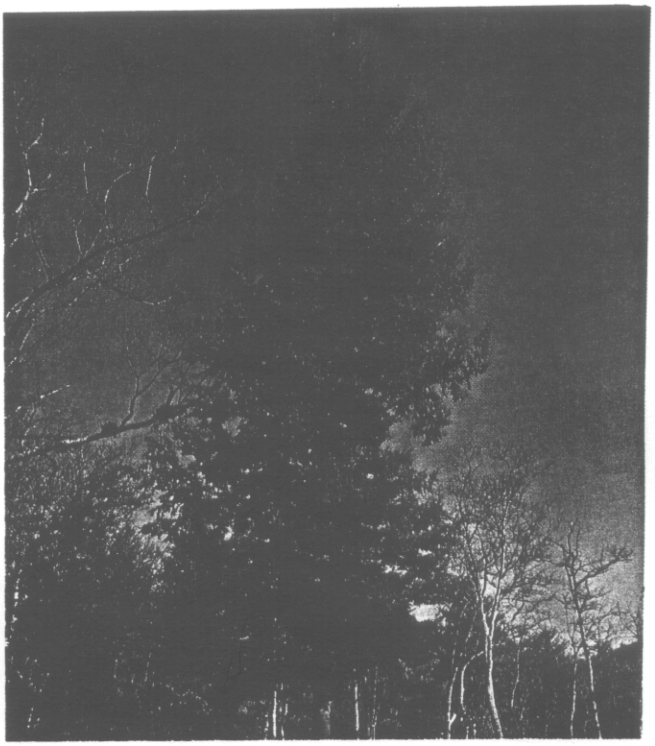

TOTAL TREE AND MAJOR COMPONENT GREEN WEIGHT OF WHITE PINE AND HEMLOCK IN NORTH GEORGIA

BY

W. HENRY McNAB AND ALEXANDER CLARK III

RESEARCH DIVISION

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INTRODUCTION

Over 30,000 acres in north Georgia are classified in the White Pine-Hemlock forest cover type, where timber stands are predominantly eastern white pine (Pinus strobus) or eastern hemlock (Tsuga canadensis) (Knight 1973). This forest type is relatively small compared with other types in Georgia and is concentrated in Gilmer, Lumpkin, Rabun, and Union Counties (Figure 1). Over a wider area in north Georgia, these species occur as scattered trees in mountain hardwood stands. The combined timber resource for these two species is about 9.5 million trees, with a volume of 170 million cubic feet as estimated from the 1972 survey (Knight 1973).

Installation of industrial wood combustion systems is causing increased demand for fuelwood in Georgia (Bulpitt and others 1980). Use of whole-tree chippers to convert unused portions of trees, such as crown wood, and unmerchantable species into fuelwood is a new means of increasing utilization of forest resources (Butts and Preston 1979). The purpose of this study was to develop biomass equations and tables for estimating green weight of the total tree and its components for hemlock and white pine. Biomass equations are available for estimating the weight of common hardwood growing in association with white pine and hemlock (Phillips and Saucier 1979).

PROCEDURES AND RESULTS

Field

A stratified sample of 28 hemlocks and 36 white pines was selected from natural, mixed pine hardwood stands in Union and Lumpkin Counties, on the Chattahoochee National Forest (Figure 1). Three to four trees were selected in each 2-inch d.b.h. class from 6 to 18 inches for hemlock and 6 to 24 inches for white pine. The average Girard form class for both species was 79 (Table 1). Site index for white pine at age 50 was about 90.

The sample trees were felled, measured for diameter, total height, and height to various merchantability limits, and cut into three major tree components: sawtimber, pulpwood, and crown. Saw logs measured to a 7-inch diameter outside bark (d.o.b.) top diameter were cut from trees more than 9 inches d.b.h. Pulpwood only was cut from trees less than 9 inches d.b.h. and from larger trees above the sawtimber top to a 4-inch d.o.b. limit. Crown wood included stem wood less than 4 inches d.o.b. and all the branches. Foliage weight was estimated from sample branches for each tree. Dead limbs were not weighed because most of these would have been broken off of the trees during logging operations. Each component was weighed separately in the field.

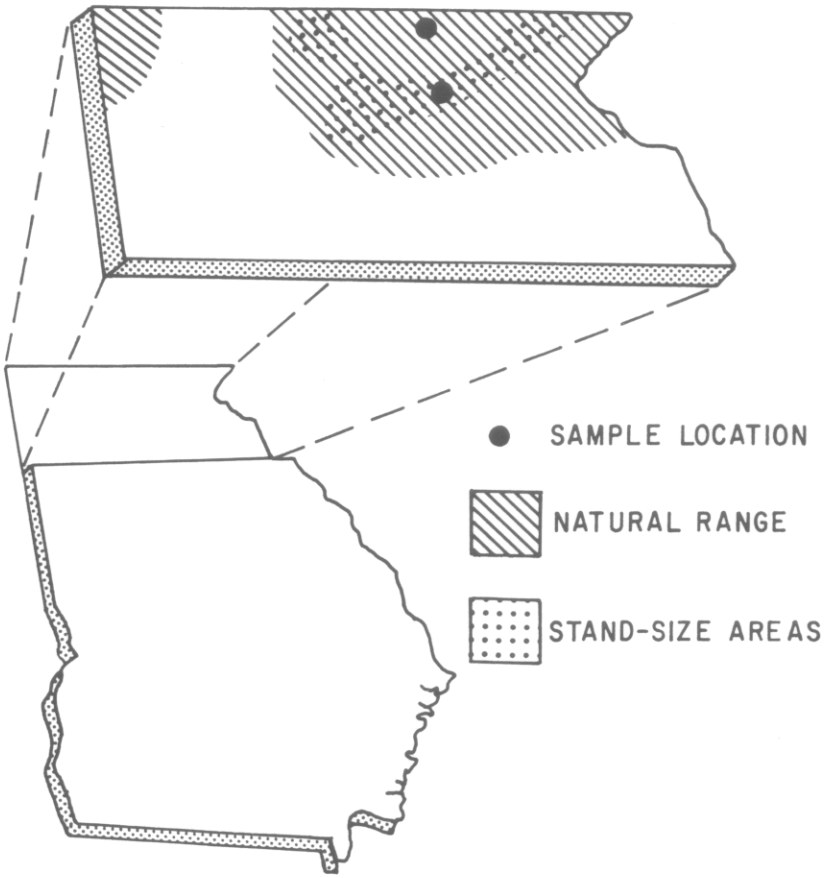

Figure 1. --Natural range of eastern white pine and eastern hemlock in Georgia. Stand-size areas of timber in the White Pine-Hemlock forest cover type are found primarily at higher elevations in the Blue Ridge Mountains.

Data Analysis

Standard regression analysis was used to develop prediction equations for estimating green weight of the total tree without foliage and green weight of the stem to a 4-inch d.o.b. top. Independent variables were tree d.b.h. in combination with stem height to a 4-inch or 7-inch top.

The green weight of sawtimber in trees more than 9 inches d.b.h. was estimated by applying a factor to the predicted stem weight to a 4-inch top. These factors were derived for each species and d.b.h. class by computing the stem green weight to a 7-inch top as a percentage of the weight to a 4-inch d.o.b. top (Figure 2). Both species had about the same percent-factor relationship, probably due to their similar form classes. The distribution of green total tree weight among the major components of sawtimber, pulpwood, and crown is shown in Figure 3.

Weight of tree crowns without foliage and topwood can be estimated by subtracting stem weight to a 4-inch top from total tree weight. Estimated foliage weights averaged about 3 percent of the total green weight of wood and bark for white pine and about 5 percent for hemlock.

Yield Tables

Yield tables based on d.b.h. and height to 4-inch d.o.b. top and on d.b.h. and saw-log merchantable height to a 7-inch d.o.b. top were produced to estimate the green weight of the total tree and its components for the two species. Tables 2-7 give the estimated green weight of wood and bark for the total tree, stem weight to a 4-inch top, and saw-log weight to a 7-inch top for white pine and hemlock. The appropriate prediction equations are included with each table. Yield tables based on other cruise measurements, such as d.b.h. alone or in combination with total height, are available from the authors.

Table 1. --Mean dimensions of sample white pine and hemlock, by d.b.h. class

D.b.h. class (inches)	Sample trees	D.b.h. mean	Height			Age	Form class
			Total	7-inch top (d.o.b.)	4-inch top (d.o.b.)		
	Number	Inches	Feet			Years	
			WHITE PINE				
6	3	6.1	42	–	24	25	–
8	5	7.8	56	–	40	34	–
10	4	10.2	73	14	56	41	76
12	4	12.0	86	34	69	52	81
14	6	14.2	86	42	71	50	77
16	3	15.9	92	50	77	57	82
18	4	17.6	106	67	90	60	79
20	3	19.9	103	68	87	49	80
22	2	22.1	104	69	90	54	77
24	2	23.6	120	95	108	72	80
Mean	36	13.9	84	50	68	48	79
			HEMLOCK				
6	4	6.3	46	–	25	57	–
8	7	7.7	48	–	31	57	–
10	3	10.2	67	17	49	56	75
12	6	12.0	68	26	52	62	77
14	4	14.3	81	43	64	85	82
16	3	16.0	89	47	69	97	82
18	4	18.2	92	58	76	79	79
Mean	31	11.6	68	39	50	68	79

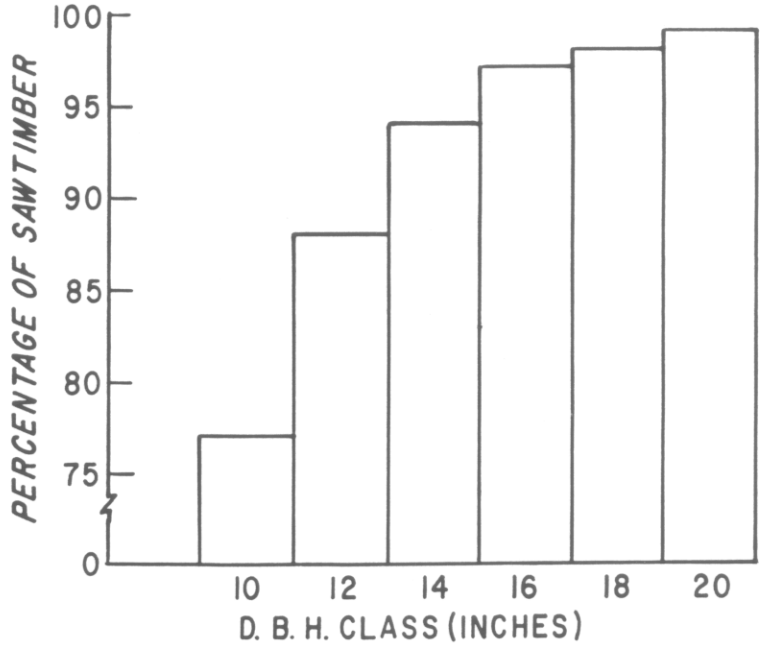

Figure 2. --Relationship between tree d.b.h. and sawtimber content for white pine and hemlock. The values are given as the percentage of total stem weight of wood and bark to a 4-inch d.o.b. top.

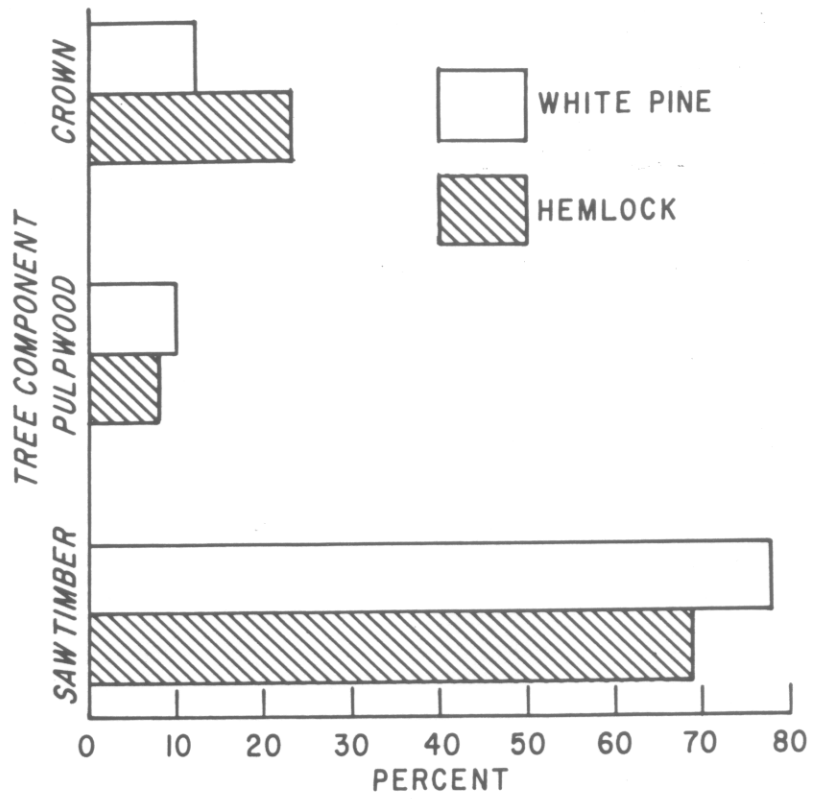

Figure 3. --Distribution of green total tree weight (without foliage) among major tree components for 14-inch d.b.h. white pine and hemlock.

Table 2. --Predicted green weight of above-stump total wood and bark without foliage for white pine and hemlock in north Georgia based on tree d.b.h. and height to a 4-inch d.o.b. top[1/].

D.b.h. (inches)	Height to 4-inch d.o.b. (feet)[2/]									
	20	30	40	50	60	70	80	90	100	110
	Pounds									
	WHITE PINE[3/]									
5	158	221	280	336	391	444	495			
6	214	298	378	454	528	599	668			
7	275	384	487	585	680	772	861	949		
8	343	479	607	729	847	961	1073	1182		
9	416	581	736	885	1028	1167	1302	1434	1564	
10	495	691	876	1052	1222	1387	1548	1706	1860	
11	579	808	1024	1230	1430	1623	1811	1995	2176	2353
12	668	933	1182	1420	1649	1872	2090	2302	2511	2715
13	762	1064	1348	1620	1882	2136	2384	2626	2864	3097
14	861	1202	1523	1829	2125	2413	2693	2967	3235	3499
15	965	1346	1706	2049	2381	2703	3016	3323	3624	3919
16		1497	1897	2279	2647	3005	3354	3695	4029	4358
17		1654	2096	2518	2925	3320	3706	4082	4452	4815
18			2302	2766	3213	3648	4071	4485	4891	5290
19			2516	3023	3512	3987	4449	4902	5346	5781
20				3284	3821	4336	4841	5333	5816	6290
21				3564	4140	4700	5248	5779	6302	6816
22					4470	5074	5663	6239	6803	7358
23					4809	5459	6092	6712	7319	7916
24						5854	6534	7198	7850	8490
	HEMLOCK[4/]									
5	183	256	325	392	456	518	579			
6	248	347	441	530	617	702	784			
7	320	448	569	685	797	906	1013	1117		
8	400	560	711	856	996	1132	1265	1395		
9	486	681	865	1041	1211	1376	1538	1696	1851	
10	579	811	1030	1240	1443	1640	1832	2021	2205	
11	678	950	1207	1453	1690	1921	2147	2367	2584	2797
12	784	1098	1395	1679	1953	2220	2481	2736	2986	3232
13	895	1254	1593	1917	2231	2536	2834	3125	3411	3692
14	1013	1419	1802	2169	2524	2868	3205	3535	3858	4176
15	1136	1591	2021	2432	2830	3217	3594	3964	4327	4683
16		1771	2249	2708	3151	3581	4001	4413	4817	5214
17		1959	2488	2995	3485	3961	4426	4881	5327	5766
18			2736	3293	3832	4355	4867	5367	5858	6341
19			2993	3603	4192	4765	5324	5871	6409	6937
20				3923	4565	5189	5798	6394	6979	7554
21				4255	4951	5627	6288	6934	7568	8192
22					5349	6079	6793	7491	8177	8851
23					5759	6546	7314	8066	8804	9529
24						7025	7850	8657	9449	10228

[1/] Blocked-in area indicates range of data.
[2/] Includes 1-foot stump allowance.
[3/] $Y=0.95548(D^2H4)^{0.82233}$
[4/] $Y=1.04832(D^2H4)^{0.83096}$

Table 3. --Predicted green weight of stem wood and bark to a 4-inch top for white pine and hemlock in north Georgia based on tree d.b.h. and height to a 4-inch d.o.b. top[1].

D.b.h. (inches)	Height to a 4-inch d.o.b. (feet)[2]									
	20	30	40	50	60	70	80	90	100	110
	Pounds									
	WHITE PINE[3]									
5	103	148	192	235	277	318	358			
6	143	206	267	326	384	441	497			
7	189	272	352	430	507	582	656	729		
8	240	345	447	547	644	740	834	927		
9	296	427	553	676	796	914	1031	1146	1260	
10	358	516	668	817	962	1105	1246	1385	1523	
11	425	612	793	969	1142	1312	1479	1644	1808	1970
12	497	716	927	1134	1336	1534	1730	1923	2114	2303
13	574	827	1071	1309	1542	1772	1998	2221	2441	2660
14	656	945	1224	1496	1762	2024	2282	2537	2789	3039
15	743	1070	1385	1693	1995	2291	2584	2872	3158	3440
16	834	1201	1556	1902	2240	2573	2902	3226	3547	3864
17		1340	1735	2121	2498	2870	3236	3598	3955	4309
18			1923	2350	2769	3181	3586	3987	4383	4775
19			2119	2590	3052	3505	3953	4394	4831	5263
20				2841	3347	3844	4335	4819	5298	5772
21				3101	3653	4197	4732	5261	5783	6301
22					3972	4563	5145	5720	6288	6851
23					4303	4943	5573	6196	6811	7421
24						5336	6016	6689	7353	8011
	HEMLOCK[4]									
5	118	169	218	266	312	358	402			
6	163	234	301	367	431	494	555			
7	214	307	395	481	565	648	729	809		
8	271	388	500	609	716	820	923	1024		
9	334	478	616	750	881	1010	1136	1260	1383	
10	402	576	742	904	1061	1216	1368	1518	1666	
11	476	681	878	1069	1256	1439	1619	1796	1971	2144
12	555	794	1024	1247	1464	1677	1887	2094	2298	2500
13	640	915	1179	1436	1686	1932	2174	2412	2647	2879
14	729	1042	1344	1636	1922	2202	2477	2749	3017	3281
15	823	1177	1518	1848	2171	2487	2798	3105	3407	3706
16		1320	1701	2071	2433	2787	3136	3480	3819	4154
17		1469	1893	2305	2708	3102	3490	3872	4250	4623
18			2094	2550	2995	3431	3861	4284	4701	5114
19			2304	2805	3295	3775	4247	4713	5172	5626
20				3071	3607	4133	4650	5159	5662	6159
21				3347	3932	4505	5068	5623	6171	6713
22					4268	4890	5502	6104	6699	7287
23					4616	5289	5951	6603	7246	7882
24						5702	6415	7118	7811	8497

[1] Blocked-in area indicates range of data.
[2] Includes 1-foot stump allowance.
[3] $Y=0.38556(D^2H4)^{0.89918}$
[4] $Y=0.49137(D^2H4)^{0.88255}$

Table 4. --Predicted green weight of stem wood and bark to a 7-inch merchantable saw-log top for white pine and hemlock in north Georgia based on tree d.b.h. and height to a 4-inch d.o.b. top[1].

D.b.h. (inches)	Height to 4-inch d.o.b. (feet)[2]									
	20	30	40	50	60	70	80	90	100	110
	Pounds									
	WHITE PINE[3]									
9	191	275	356	435	512	588	663	737		
10	275	396	513	627	739	848	957	1064		
11	358	516	668	817	962	1105	1246	1385	1523	
12	442	637	825	1008	1188	1364	1539	1710	1880	
13	528	761	986	1205	1419	1630	1838	2043	2247	
14	617	889	1152	1407	1658	1905	2148	2388	2625	
15	710	1022	1324	1618	1906	2189	2469	2744	3017	3287
16		1160	1503	1836	2164	2485	2802	3115	3425	3731
17		1304	1689	2064	2432	2793	3149	3501	3849	4194
18			1882	2300	2710	3113	3510	3902	4290	4674
19			2083	2546	3000	3446	3885	4319	4749	5173
20				2801	3300	3791	4275	4752	5224	5692
21				3066	3612	4149	4678	5201	5718	6230
22					3935	4520	5097	5666	6229	6787
23					4269	4904	5530	6147	6758	7363
24						5301	5977	6645	7305	7958
	HEMLOCK[4]									
9	215	307	396	483	567	649	731	811		
10	309	442	570	694	815	933	1050	1165		
11	401	574	740	901	1058	1212	1364	1513	1660	
12	494	706	901	1109	1302	1492	1679	1863	2044	
13	588	842	1085	1321	1552	1778	2000	2219	2436	2649
14	686	981	1264	1540	1809	2072	2331	2587	2839	3088
15	787	1125	1450	1766	2074	2376	2674	2967	3256	3541
16		1274	1643	2000	2349	2692	3029	3360	3688	4011
17		1429	1842	2243	2635	3019	3397	3769	4136	4499
18			2050	2496	2931	3359	3779	4193	4601	5005
19			2265	2757	3239	3711	4175	4632	5084	5530
20				3029	3557	4076	4586	5088	5584	6074
21				3309	3887	4454	5011	5559	6101	6637
22					4228	4844	5450	6047	6636	7219
23					4580	5248	5904	6551	7189	7820
24						5664	6373	7071	7760	8441

[1] Blocked-in area indicates range of data.
[2] Includes 1-foot stump allowance.
[3] $Y=0.38556(D^2H4)^{0.89916}(1.0-1.26920((7.0)^{3.94580}/(DBH)^{4.07207}))$
[4] $Y=0.49137(D^2H4)^{0.88255}(1.0-1.26920((7.0)^{3.94580}/(DBH)^{4.07207}))$

Table 5. --Predicted green weight of above-stump total wood and bark without foliage for white pine and hemlock in north Georgia based on tree d.b.h. and height to a 7-inch saw-log merchantable top[1].

D.b.h. (inches)	Merchantable tree height (logs)[2]									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
	Pounds									
					WHITE PINE[3]					
9	690	786	862	926	983	1033	1079	1121		
10	855	973	1067	1147	1216	1279	1335	1387		
11	1037	1180	1294	1391	1475	1551	1619	1683	1741	
12	1236	1407	1543	1659	1759	1850	1932	2007	2077	
13	1454	1655	1815	1950	2069	2175	2271	2360	2442	2519
14	1689	1922	2109	2266	2404	2527	2639	2742	2838	2927
15	1942	2211	2425	2606	2764	2906	3035	3153	3263	3366
16		2519	2764	2970	3150	3312	3458	3593	3719	3836
17		2848	3124	3358	3562	3744	3910	4063	4204	4337
18			3508	3770	3999	4204	4390	4561	4720	4869
19			3914	4206	4462	4690	4898	5089	5266	5432
20				4666	4950	5204	5434	5646	5843	6027
21				5151	5464	5744	5998	6232	6449	6652
22					6004	6311	6591	6848	7086	7310
23					6569	6906	7211	7493	7754	7998
24						7527	7861	8167	8452	8718
					HEMLOCK[4]					
9	653	795	915	1021	1117	1205	1287	1364		
10	804	979	1127	1257	1375	1484	1585	1680		
11	971	1182	1361	1518	1661	1792	1914	2028	2137	
12	1153	1404	1616	1803	1972	2128	2273	2409	2538	
13	1351	1645	1893	2112	2310	2493	2663	2822	2973	3117
14	1564	1904	2192	2445	2675	2886	3083	3267	3442	3608
15	1793	2182	2512	2803	3066	3308	3533	3745	3945	4136
16		2479	2854	3184	3483	3758	4014	4255	4482	4699
17		2795	3217	3590	3927	4237	4525	4796	5053	5297
18			3602	4019	4397	4744	5067	5370	5658	5931
19			4009	4473	4893	5279	5638	5976	6296	6600
20				4950	5415	5842	6240	6614	6968	7304
21				5451	5963	6434	6872	7284	7673	8044
22					6538	7054	7534	7986	8413	8819
23					7138	7702	8226	8719	9185	9629
24						8378	8949	9485	9992	10474

[1] Blocked-in area indicates range of data.
[2] Includes 1-foot stump allowance.
[3] $Y=3.20569(D^2)^{1.01245}(MH)^{0.32722}$
[4] $Y=2.08195(D^2)^{0.98856}(MH)^{0.49761}$

Table 6.--Predicted green weight of stem wood and bark to a 4-inch d.o.b. top for white pine and hemlock in north Georgia based on tree d.b.h. and height to a 7-inch saw-log merchantable top[1/].

D.b.h. (inches)	Merchantable tree height (logs)[2/]									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
	Pounds									
	WHITE PINE[3/]									
9	567	679	772	853	926	993	1054	1112		
10	688	823	936	1035	1124	1204	1279	1349		
11	819	981	1115	1233	1338	1435	1524	1607	1685	
12	961	1150	1308	1446	1570	1683	1788	1885	1977	
13	1113	1332	1515	1675	1818	1949	2070	2183	2290	2391
14	1275	1527	1736	1919	2083	2233	2372	2502	2624	2739
15	1447	1733	1970	2178	2364	2534	2692	2839	2978	3109
16		1950	2218	2452	2662	2853	3030	3196	3352	3500
17		2180	2479	2740	2975	3189	3387	3572	3746	3911
18			2753	3043	3304	3541	3761	3967	4161	4344
19			3040	3361	3648	3911	4145	4381	4595	4797
20				3692	4008	4297	4564	4813	5048	5270
21				4038	4384	4699	4991	5264	5521	5764
22					4774	5118	5436	5733	6013	6278
23					5180	5553	5898	6220	6524	6811
24						6004	6377	6725	7054	7364
	HEMLOCK[4/]									
9	429	570	698	816	929	1036	1139	1238		
10	521	691	846	990	1126	1256	1381	1501		
11	620	822	1006	1178	1340	1495	1643	1787	1926	
12	726	964	1180	1381	1571	1752	1926	2094	2257	
13	841	1116	1366	1598	1818	2028	2230	2424	2613	2796
14	963	1277	1564	1830	2082	2322	2553	2776	2991	3201
15	1092	1449	1774	2076	2362	2634	2896	3149	3393	3631
16		1630	1996	2336	2657	2964	3258	3543	3818	4086
17		1821	2229	2609	2968	3311	3640	3957	4265	4564
18			2475	2897	3295	3675	4041	4393	4735	5067
19			2732	3197	3637	4057	4460	4849	5226	5593
20				3511	3995	4456	4898	5325	5739	6142
21				3839	4367	4871	5355	5822	6275	6715
22					4754	5303	5830	6338	6831	7310
23					5157	5752	6323	6875	7409	7929
24						6217	6834	7430	8008	8570

[1/] Blocked-in area indicates range of data.
[2/] Includes 1-foot stump allowance.
[3/] $Y=2.78530(D^2)^{0.91744}(MH)^{0.45512}$
[4/] $Y=1.013118(D^2)^{0.91343}(MH)^{0.71519}$

Table 7. --Predicted green weight of stem sawtimber wood and bark for white pine and hemlock in north Georgia based on tree d.b.h. and merchantable height to a 7-inch d.o.b. top[1].

D.b.h. (inches)	Merchantable tree height (logs)[2]									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
	Pounds									
					WHITE PINE[3]					
9	365	437	496	549	596	639	678	715		
10	528	632	719	795	863	925	982	1036		
11	690	826	940	1039	1127	1209	1284	1354	1420	
12	855	1023	1164	1286	1396	1497	1590	1677	1759	
13	1024	1226	1394	1541	1673	1794	1905	2009	2107	2200
14	1200	1436	1634	1806	1960	2101	2232	2354	2469	2578
15	1383	1655	1883	2081	2259	2422	2572	2713	2845	2970
16		1884	2142	2368	2570	2755	2927	3087	3237	3380
17		2122	2413	2667	2895	3103	3296	3476	3646	3807
18			2695	2979	3234	3466	3682	3885	4072	4252
19			2989	3304	3586	3844	4083	4306	4516	4715
20				3641	3953	4237	4501	4747	4978	5198
21				3993	4334	4646	4935	5204	5458	5699
22					4730	5070	5385	5679	5956	6219
23					5139	5509	5852	6172	6473	6758
24						5964	6335	6681	7007	7316
					HEMLOCK[4]					
9	276	367	449	525	597	666	733	797		
10	400	530	649	760	864	964	1060	1152		
11	522	693	848	992	1129	1259	1384	1505	1622	
12	646	857	1049	1228	1397	1559	1713	1863	2008	
13	774	1027	1257	1471	1673	1866	2052	2231	2404	2573
14	906	1202	1471	1722	1959	2185	2402	2612	2815	3012
15	1043	1384	1695	1983	2256	2517	2767	3003	3242	3469
16		1574	1927	2256	2566	2862	3147	3421	3687	3946
17		1772	2170	2539	2889	3222	3543	3852	4151	4442
18			2422	2835	3225	3597	3955	4300	4634	4959
19			2685	3143	3575	3988	4384	4767	5137	5497
20				3463	3939	4394	4831	5252	5660	6057
21				3795	4318	4816	5294	5756	6204	6638
22					4710	5253	5775	6279	6767	7242
23					5116	5707	6274	6821	7351	7867
24						6176	6789	7382	7955	8513

[1] Blocked-in area indicates range of data.
[2] Includes 1-foot stump allowance.
[3] $Y=2.78530(D^2)^{0.91744}(MH)^{0.45512}(1.0-1.26920((7.0)^{3.94580}/(DBH)^{4.07207}))$
[4] $Y=1.03118(D^2)^{0.91343}(MH)^{0.71515}(1.0-1.26920((7.0)^{3.94580}/(DBH)^{4.07207}))$

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