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Above-ground Weights for Tamarack in Northeastern Minnesota

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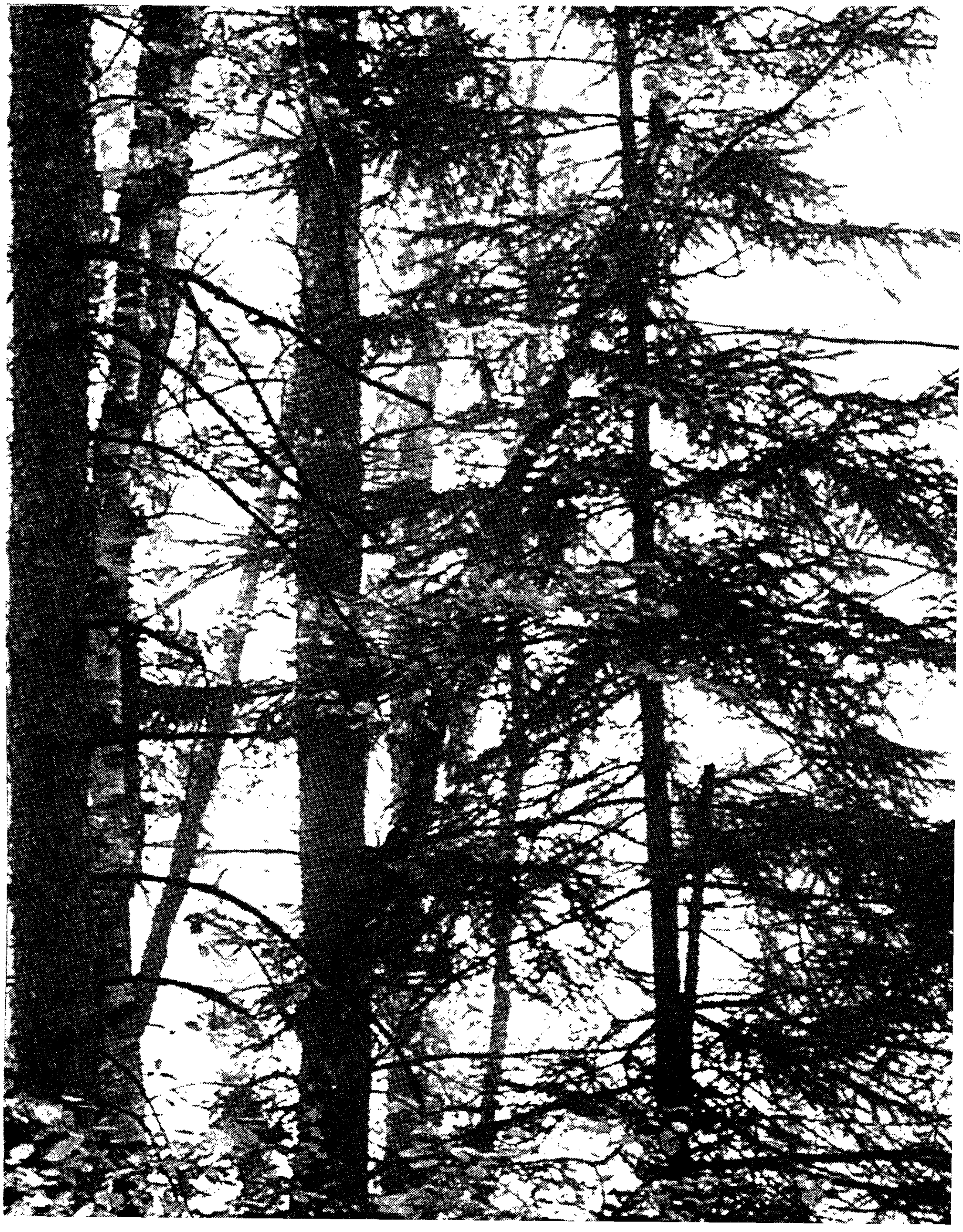

CONTENTS

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ABOVE-GROUND WEIGHTS FOR TAMARACK IN NORTHEASTERN MINNESOTA

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Timber supplies can be extended by using the tree species and more of the residue usually bypassed in harvesting. Opportunities for utilizing these materials have been enhanced by whole-tree chippers that allow the in-woods processing of the entire above-ground portion of a tree into an easily transportable product—chips.

A convenient method of estimating the amount of material in the above-ground portion of trees before harvesting is the use of weight prediction equations. From these equations we can also evaluate the yield potential, by tree component, of the entire renewable forest resource.

To promote the use of these materials, it is helpful to have information about specific gravity and seasonal moisture content by tree components. By determining the wood-bark ratio, we can judge the magnitude of the problem firms may face where processes can tolerate only a limited amount of barky chips. The intent of our study was to provide this useful information for tamarack.

PROCEDURE

Field

A stratified random sample of 53 trees was selected within four representative natural tamarack stands in the Superior National Forest in northeastern Minnesota (table 1). The distribution of sample trees over the d.b.h. range was approximately proportional to the distribution of tamarack trees in the Lake Superior Forest Survey Unit (Anonymous 1964).

Sample trees were felled leaving a 6-inch stump. Total height was measured after felling; the bole was severed at 2 inches diameter outside bark (d.o.b.) and stem length was measured. All live branches including foliage and all dead branches were cut off flush with the bole and weighed. The stem portion above 2 inches d.o.b. was included with the branches. Two 4-foot bolts were cut from the butt end, and the remaining bole was then cut into 8-foot bolts, usually ending with a random length piece at the top. Each bolt was weighed to the nearest pound in a sling attached to a crane scale that had been carefully calibrated.

For all sample trees, a 1-inch-thick disk was cut from the butt end of each bolt and from the top of the last piece. These disks were measured for d.o.b., diameter inside bark (d.i.b.), and heartwood diameter to the nearest 0.01 inch. The disks were quartered and one wedge was separated into bark, sapwood, and heartwood components. Each component was weighed immediately to the nearest 0.1 gram on a triple-beam balance and bagged for transport to the laboratory. The remaining portions of each disk were bagged and also taken to the laboratory.

Additional trees were felled near the middle of each month to determine seasonal moisture content, and with the original 53 trees, were used to determine average specific gravity of bark, sapwood, and heartwood proportions including variations based on height above stump. The bole and branch material from these additional trees was not weighed.

Laboratory

Total bolt volume, wood volume, and heartwood volume were calculated by Smalian's formula.[1] Bark and sapwood volumes were determined by subtraction. The bolt weights were combined to determine the green weight of the stem to a 2-inch d.o.b., and with the branches, the weight of the total tree.

[1]*Smalian's formula: Volume* $= \frac{A + a}{2} L$ *where A is area at the large end, a is area at the small end, L is length.*

Table 1.—*Means and ranges of selected variables of sample tamarack trees by d.b.h. class*

D.b.h. (inches)	Trees	D.b.h.		Total height		Stem length[2]		Ave.[3]	
		Ave.[1]	Range	Ave.	Range	Ave.	Range	Ave.	Range
	Number	-----*Inches*-----		--------------*Feet*--------------				----*Years*----	
3	3	3.1	3.0-3.2	25	20-31	14	11-18	39	33-49
4	7	3.9	3.5-4.3	33	25-49	22	13-38	49	30-85
5	12	5.0	4.5-5.4	39	33-50	28	23.36	45	32-62
6	10	5.9	5.5-6.3	42	33-51	31	25-40	55	44-91
7	6	6.9	6.6-7.4	48	43-56	39	33-45	50	43-56
8	2	7.8	7.6-8.0	53	52-54	41	41-43	54	53-55
9	3	8.7	8.5-9.0	58	57-59	48	48	52	46-62
10	3	9.9	9.5-10.2	52	48-56	42	36-48	54	44-71
11	3	11.1	10.8-11.4	58	52-63	48	43-53	65	56-82
12	2	11.8	11.6-11.9	64	60-69	55	50-60	55	53-57
13	1	12.8	—	70	—	63	—	70	—
14		13.7	—	66	—	59	—	71	—

[1]Quadratic mean diameter.
[2]Stem length from a 6-inch stump to 2 inches d.o.b.
[3]Age at d.b.h.

Ovendry moisture content was determined by drying the component samples at 104° C until constant weight was reached.

$$\text{Wood or bark moisture content} = \frac{\text{green weight—ovendry weight}}{\text{ovendry weight}}$$

The average moisture content for each bolt component was determined by weighting the component moisture content at each end of the bolt by a factor related to its disk basal area. These factors were derived as follows:

For total	DOB^2
For wood	DIB^2
For heartwood	$(\text{heartwood diameter})^2$
For sapwood	$DIB^2-(\text{heartwood diameter})^2$
For bark	DOB^2-DIB^2

The weighted average moisture content of each component for the total tree was calculated using component volumes in each bolt as weighting factors. The dry weight of the tree was determined by applying the average weighted bolt moisture content to the bolt green weight and summing bolt dry weights to arrive at total stem dry weight. We then added the dry weight of the top and limbs, which was determined from moisture samples taken from the live and dead branches.

From the unused portion of each disk, an additional 2-inch wedge was cut for the gravimetric determination of specific gravity by water displacement. The TAPPI standard method was used to determine the specimen volume (TAPPI 1953).

Specific gravity was determined for each component by dividing ovendry weight by green volume.

$$\text{Specific gravity} = \frac{\text{ovendry wood (bark) weight (gm)}}{\text{green wood (bark) volume (cc)}}$$

Average component specific gravity for a d.b.h. class and height point was determined by weighting the specific gravity of each disk component, as in determining moisture content.

Average green stem density was determined by dividing the total stem green weight by the Smalian stem volume; it was then converted to dry density using average stem moisture content.

For each d.b.h. class, the percents of bark, sapwood, and heartwood by green weight and height in tree were calculated using the green weight of the component moisture content samples. Each individual component weight was weighted by disk d.o.b.^{2}, and the average was determined by summing the component weighted values and dividing by the total weighted value of the component for all trees at each height point in the d.b.h. class.

To estimate stem weight to a 4-inch d.o.b., we had to proportion the bolts arbitrarily because the stem wasn't cut at this point. For bolts severed within one-tenth of an inch of 4 inches d.o.b., data were used without adjustment. For other bolts, the end d.o.b.'s of the bolt containing the 4-inch diameter were used to proportion the 8-foot length as a linear function of taper and to calculate the length of bolt from 4 inches d.o.b. to the small end diameter. Using this length and these diameters, we calculated a volume for this bolt segment and the percent of total bolt volume. This percentage applied to total bolt weight gave the weight of the bolt segment from 4 inches d.o.b. to 2 inches d.o.b. Regression analysis was then used to estimate the weight of the piece above 4 inches d.o.b. and below 2 inches d.o.b., for each d.b.h. class. This amount subtracted from the estimated stem weight to 2 inches gave the stem weight to 4 inch d.o.b. for each class.

RESULTS

Regression equations were developed to estimate green and dry weight of the total above-stump tree weight, the stem weight to 2 inches d.o.b., and the top weight above 2 inches d.o.b. plus live and dead branches. The regression coefficients were calculated using the weight determined by field weighing.

The model used to fit individual tree weights is:

$$\mathrm{Log}_{10}Y = a + b \log D$$

where: Y = the weight variable of interest
D = tree d.b.h. in inches
a and b are coefficients estimated from the data

Table 2 presents the estimates of the coefficients for predicting the variable of interest. Additional statistics presented are the coefficients, standard errors, t-statistics, the regression standard error of estimate, and the correlation coefficient.

The variance of the Y variable gets larger as d.b.h. increases; therefore, logarithmic transformations were made to satisfy the basic assumptions of the regression process for homogenity of variances (Ostle 1963).

Weight Estimates

Using individual tree d.b.h., we can estimate total tree weight, stem weight to 2 inches d.o.b., top and branch weight, weight of top and live branches, and dead branch weight.

The green and dry weights for the total tree and various tree components are shown in table 3. The crown (top plus limbs) weight above a 4-inch top, can be determined by calculating the difference between the two stem weights and adding it to the top and limb weight shown.

Seasonal Moisture Content

Stem moisture contents are presented for each week from August 22 to September 19, 1975, because a large number of trees were cut for total weight determination during that period (table 4). For the rest of the year, mid-month data are shown.

No consistent seasonal moisture content trend is indicated by the sample. The marked difference between the samples taken in July of 1975 and those taken in 1976 suggests a possible annual trend because the samples were selected from the same area. Stem heartwood moisture is the most consistent; bark and sapwood show the most variation.

Table 2.—*Regression statistics for predicting tamarack tree weight*[1]

Component	Constant a	Constant se	Constant t	D.b.h. b	D.b.h. se	D.b.h. t	Standard error of estimate	R^2
GREEN WEIGHT (POUNDS)								
Total tree	0.6837	0.039	17.46	2.271	0.048	46.84	0.059	0.977
Stem to 2 inches	.4628	.047	9.91	2.364	.058	40.89	.070	.970
Top & branch	.3080	.095	3.23	2.040	.118	17.23	.143	.853
Live branches	.2600	.115	2.26	2.010	.143	13.98	.173	.793
Dead branches	.700	.187	3.78	2.250	.231	9.54	.280	.641
DRY WEIGHT (POUNDS)								
Total tree	.4065	.039	10.45	2.298	.048	47.74	.058	.978
Stem to 2 inches	.1755	.053	3.33	2.393	.065	36.66	.079	.963
Top & branch	.0218	.091	.24	2.099	113	18.59	.137	.871
Live branches	.0646	.115	.56	2.055	.142	14.47	.172	.804
Dead branches	.700	.182	4.26	2.230	.226	9.78	.273	.652

[1] $\mathrm{Log}_{10}Y = a + b \log D$.

Table 3.—*Estimated green and dry weights of tamarack trees and components by d.b.h.*

D.b.h. (inches)	Total tree	Stem to 2 inches	Top above 2 inches, plus limbs	Live limbs and top	Dead limbs	Stem to 4 inches
GREEN WEIGHT (POUNDS)						
3	58	39	19	17	2	—
4	112	77	34	30	5	25
5	187	130	54	46	7	82
6	282	201	79	67	11	157
7	401	289	108	91	16	248
8	543	396	141	119	21	358
9	709	523	180	151	28	487
10	901	671	223	186	35	637
11	1,119	841	271	226	44	809
12	1,363	1,033	323	269	53	1,003
13	1,635	1,248	381	316	64	1,220
14	1,934	1,487	443	366	76	1,460
15	2,263	1,750	510	421	88	1,725
16	2,620	2,039	581	479	102	2,015
DRY WEIGHT (POUNDS)						
3	32	21	11	8	2	
4	62	41	19	15	4	
5	103	70	31	24	7	
6	157	109	45	34	11	
7	223	158	62	47	15	
8	303	217	83	62	21	
9	398	288	106	79	27	
10	506	370	132	98	34	
11	630	465	161	119	42	
12	770	573	194	142	51	
13	925	694	229	168	61	
14	1,097	828	268	195	72	
15	1,286	977	309	225	84	
16	1,491	1,140	354	257	97	

Weather data registered at a nearby station showed that precipitation January through May 1976 was well below normal and much below the same period in 1975. This drought may have influenced the moisture content of the sample during this period.

We analyzed the change in moisture content of wood vertically in the tree by d.b.h. class using 53 trees in the August-September sample (table 5). Moisture content generally increased as height increased except for the stump to d.b.h. section.

Thirty-nine of the trees had odd length pieces above the top of the last full bolt; in 14 cases the 2-inch d.o.b. coincided with the top of a full bolt. In all but three trees, moisture content was higher at 2 inches d.o.b., and the difference ranged up to 50 percent higher even though often only 2 or 3 feet above the next lower measurement. This could be due in part to transpirational pull after felling and the timing of severing the top from the stem. Moisture is lowest in the lower sections, increases somewhat in the upper bolts, and is usually much higher at the 2-inch d.o.b. point. As a practical matter, however, it appears that moisture content is not radically different for the bulk of the stem volume.

Density and Specific Gravity

Average weighted stem specific gravity and oven-dry density as calculated from specific gravity are

Table 4.—*Average stem and stem component moisture content, July 1975 to July 1976, for tamarack in northern Minnesota*

Date	Weather condition	Trees	Total stem	Stem wood	Stem sap	Stem heart	Stem bark
1975		*Number*	Percent				
July 23-25	Wet	10	93.9	90.8	127.9	52.0	121.7
Aug. 22-28	Dry	13	85.1	83.8	102.9	52.2	99.2
Sept. 2-5	Dry	14	91.2	90.4	115.6	58.5	98.7
Sept. 8-12	Dry	15	80.6	79.7	109.0	51.4	90.3
Sept. 15-19	Dry	11	79.3	78.3	117.1	51.2	90.9
Oct. 14-15	Very dry	8	87.6	87.4	116.8	56.0	92.1
Nov. 24-26	Very wet	8	83.4	81.7	114.8	54.4	105.1
Dec. 15-17	Normal	8	82.5	79.3	124.8	51.3	126.6
1976							
Jan. 13,14,22	Very dry	8	87.0	84.9	117.4	53.8	112.9
Feb.17,19	Very dry	8	89.1	87.7	116.2	55.2	112.9
March 17-19	Very dry	8	82.6	80.8	129.8	51.2	104.5
April 14-16	Very dry	8	74.6	73.2	113.9	51.1	93.8
May 10-12	Very dry	8	87.8	87.8	117.5	55.7	89.7
June 21-23	Wet	8	77.0	75.5	102.9	51.0	93.1
July 19,21	Normal	8	83.5	82.7	111.2	54.2	91.2
Annual average		143	84.5	83.1	115.3	53.3	100.4
Standard deviation			9.5	9.9	13.9	7.4	14.8
Standard error/mean			0.8	0.8	1.2	0.6	1.2

Table 5.—*Moisture content of tamarack stemwood by d.b.h. class*[1] *and height in feet above stump*

D.b.h. (inches)	Trees	Height above stump 0	4	8	16	24	32	40	48	56	At 2 inches d.o.b.
	Number	*Percent*									
3	3	96.7	90.3	99.0	121[1]						127
4	7	77.6	77.3	78.9	90.2[6]	78.0[2]	99.0[1]				116
5	12	82.3	81.1	78.3	87.8	106.8[10]	104.0[2]				122
6	10	78.7	75.4	79.4	85.8	103.2	104.2[4]	141.5[2]			124
7	6	75.2	71.0	69.2	84.3	89.8	100.7	113.7[3]			124
8	2	72.0	81.0	69.5	79.0	86.5	92.0	134.0			134
9	3	80.3	71.3	69.0	70.3	77.3	86.7	94.3	125.3		125
10	3	103.0	88.0	89.3	84.0	91.7	91.3	103.5[2]	121.0[1]		119
11	3	78.7	71.0	83.0	78.7	82.0	89.7	101.7	120.5[2]		131
12	2	89.0	80.0	78.0	82.5	83.0	84.5	95.0	117.5	109.0[1]	132
13	1	108.0	73.0	76.0	80.0	83.0	78.0	80.0	84.0	102.0	138
14	1	73.0	75.0	79.0	72.0	85.0	76.0	79.0	90.0	95.0	120
Total	53	82.0	77.8	78.7	85.1	94.3	94.2	107.2	114.7	102.0	124

[1]Superscripts show number of disks represented in the cell if less than number of trees in the d.b.h. class.

shown in table 6. The green density as determined by field weight and Smalian volume is shown in table 7 and compared to density calculated from specific gravity and moisture content for the same trees.

The discrepancy between the densities determined by the two methods is difficult to explain. All measurements were carefully made by trained operators. Other researchers have also experienced a similar result although this phenomena has not been reported in the literature. Although there is concern about the accuracy of the Smalian formula for determining volume, the same volume is used in both cases. Perhaps further research is needed to document the prevalence of this phenomena in developing weight estimates for tree species and, to estimate the relative accuracy of each method.

The weight/volume determined density for the stem averaged 5.4 pounds per cubic foot of wood and bark higher than that calculated from specific gravity. For individual trees, the former density ranged from 48.96 to 62.61; the latter ranged from 43.96 to 58.99. The difference held quite constant across the entire diameter range. Average green density calculated from specific gravity for the 53 sample trees in the weight study was 50.8 pounds per cubic foot of wood and bark ($Sx = 3.6$, $S\bar{x} = 0.50$). For the weight/volume green density, the average was 56.2 pounds per cubic foot of wood and bark ($Sx = 3.7$, $S\bar{x} = 0.51$).

Trends in specific gravity by d.b.h. and height in tree are shown for each component, tables 8-10. In the smaller d.b.h. classes, specific gravity generally decreased as height increased except that sapwood increased between the stump and d.b.h.

Wood and Bark Ratios

The proportion of bark decreases from stump to d.b.h. and then increases as height increases (table 11). The bark proportion decreases as d.b.h. increases. Heartwood, as expected, decreases as height in tree increases (table 12). It also increases as d.b.h. gets larger except at the 2-inch d.o.b. point where the reverse is true. Above 7 inches d.b.h., in general, heartwood proportion is constant in the lower portion of the stem and sapwood proportions are a mirror image of heartwood (table 13). The number of samples above 11 inches d.b.h. in this study are limited, and the number of disks at the higher points in each d.b.h. class are reduced because not all trees were tall enough to reach a particular height.

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Table 6.—*Average weighted stem specific gravity and ovendry density by component and d.b.h.*

D.b.h. inches	Trees	Specific gravity					Dry density				
		Sap	Heart	Wood	Bark	Stem	Sap	Heart	Wood	Bark	Stem
	Number						*Pounds/cubic foot*				
3	9	0.481 *.009	0.500 .008	0.489 .010	0.301 .006	0.459 .009	30.0	31.2	30.5	18.8	28.6
4	23	.484 .007	.493 .006	.488 .006	.282 .007	.457 .006	30.2	30.8	30.5	17.6	28.5
5	20	.460 .006	.476 .007	.466 .005	.297 .007	.441 .005	28.7	29.7	29.1	18.5	27.5
6	19	.459 .008	.482 .008	.469 .007	.292 .007	.444 .006	28.6	30.1	29.3	18.2	27.7
7	17	.451 .006	.480 .008	.465 .006	.295 .007	.443 .005	28.1	30.0	29.0	18.4	27.6
8	20	.440 .006	.463 .006	.452 .005	.294 .005	.432 .004	27.5	28.9	28.2	18.4	27.0
9	11	.452 .009	.489 .013	.470 .010	.301 .010	.448 .008	28.2	30.5	29.3	18.8	28.0
10	13	.434 .007	.463 .007	.449 .006	.301 .008	.430 .005	27.1	28.9	28.0	18.8	26.8
11	5	.422 .015	.447 .008	.436 .009	.288 .011	.417 .008	26.3	27.9	27.2	18.0	26.0
12	4	.390 .010	.430 .003	.412 .005	.299 .014	.399 .007	24.3	26.8	25.7	18.7	24.9
13	1	.421 —	.453 —	.438 —	.328 —	.427 —	26.3	28.3	27.3	20.5	26.6
14	1	.431 —	.448 —	.440 —	.314 —	.424 —	26.9	28.0	27.5	19.6	26.5
Total/Average	143	.455 .003	.477 .003	.465 .002	.294 .002	.441 .002	28.4	29.8	29.0	18.4	27.5

*Standard deviation

Table 7.—*Comparison of average weighted green density calculated from specific gravity and from green weight and volume*

D.b.h. (inches)	Trees	Green density from specific gravity	Green density from weighing	Ratio
	Number	----*Pounds/cubic foot*----		
3	3	54.6	60.2	0.906
4	7	51.9	57.2	.908
5	12	52.4	57.6	.909
6	10	51.4	57.1	.900
7	6	50.3	56.3	.893
8	2	47.9	55.8	.857
9	3	49.2	53.0	.928
10	3	51.4	53.1	.962
11	3	47.4	51.6	.919
12	2	46.3	51.6	.898
13	1	48.6	52.6	.923
14	1	47.6	51.9	.918
Average		50.8	56.2	
Sx		3.6	3.7	
Sx		0.50	0.51	

Table 8.—*Average weighted specific gravity of bark by d.b.h. and height (in feet) in tree*

D.b.h. (inches)	Trees	Height above stump									At 2 inches d.o.b.
		0	4	8	16	24	32	40	48	56	
	Number										
3	9	0.326	0.299	0.291	0.296						0.286
4	23	.307	.290	.284	.277	0.262	0.275				.278
5	20	.321	.307	.299	.296	.291	.280				.277
6	19	.324	.301	.290	.289	.279	.277				.279
7	17	.338	.300	.294	.285	.284	.287	0.273	0.263		.285
8	20	.321	.318	.294	.279	.293	.288	.284	.267		.275
9	11	.335	.309	.299	.302	.292	.300	.298	.290	0.340	.288
10	13	.337	.314	.298	.288	.302	.291	.296	.281		.283
11	5	.324	.292	.283	.281	.278	.275	.286	.273		.278
12	2	.383	.321	.297	.281	.310	.303	.302	.319	.293	.303
13	1	.370	.341	.316	.314	.308	.332	.332	.330	.349	.310
14	1	.352	.333	.306	.304	.309	.318	.314	.290	.317	.334

Table 9.—*Average weighted specific gravity of heartwood by d.b.h. and height (in feet) in tree*

D.b.h. (inches)	Trees	Height above stump 0	4	8	16	24	32	40	48	56	At 2 inches d.o.b.
	Number										
3	9	0.549	0.507	0.494	0.458						0.501
4	23	.542	.510	.494	.445	0.413	0.449				.632
5	20	.500	.482	.469	.463	.447	.458				.432
6	19	.517	.484	.476	.467	.454	.451				.449
7	17	.517	.481	.483	.463	.454	.471	0.467	0.496		.469
8	20	.492	.475	.463	.448	.442	.448	.455	.458		.455
9	11	.523	.508	.479	.477	.464	.469	.465	.474	0.515	.485
10	13	.465	.472	.463	.461	.446	.459	.462	.444		.461
11	5	.452	.438	.447	.455	.429	.438	.426	.445		.426
12	2	.441	.442	.428	.429	.424	.428	.451	.453	.557	.427
13	1	.466	.467	.446	.422	.450	.458	.518	.426	.457	.526
14	1	.435	.452	.450	.450	.438	.442	.479	.443	.524	.529

Table 10.—*Average weighted specific gravity of sapwood by d.b.h. and height (in feet) in tree*

D.b.h. (inches)	Trees	Height above stump 0	4	8	16	24	32	40	48	56	At 2 inches d.o.b.
	Number										
3	9	0.496	0.501	0.485	0.446						0.439
4	23	.507	.527	.500	.469	0.443	0.457				.437
5	20	.465	.485	.470	.455	.437	.441				.421
6	19	.472	.480	.470	.463	.445	.437				.431
7	17	.452	.480	.469	.445	.436	.446	0.420	0.419		.426
8	20	.450	.462	.452	.438	.438	.431	.422	.382		.415
9	11	.440	.462	.450	.456	.445	.456	.456	.453	0.464	.429
10	13	.408	.443	.441	.434	.430	.455	.440	.403		.437
11	5	.407	.417	.423	.446	.420	.432	.432	.426		.414
12	2	.402	.432	.388	.389	.391	.413	.415	.434	.420	.404
13	1	.409	.445	.433	.418	.420	.403	.428	.414	.422	.413
14	1	.379	.423	.458	.411	.428	.409	.477	.492	.499	.466

Table 11.—*Weighted average bark percent of green disk weight by d.b.h. and height (in feet) in tree*

D.b.h (inches)	Trees	Height above stump 0	4	8	16	24	32	40	48	56	At 2 inches d.o.b.
	Number	*Percent*									
3	9	12	10	11	[1]13^{6}						15
4	23	11	8	9	10^{22}	12^{12}	14^{3}				15
5	20	10	8	9	10	13^{19}	13^{5}				16
6	19	10	8	8	10	12	13^{9}				18
7	17	9	7	8	8	10	12	14^{10}	16^{1}		17
8	20	9	7	7	8	10	11	14^{17}	17^{1}		18
9	11	8	7	7	8	10	11	12	15^{6}	19^{1}	18
10	13	9	7	7	8	9	11	13^{11}	16^{4}		17
11	5	8	8	8	8	9	11	13	15^{2}		18
12	2	8	8	7	9	9	12	11	15	17^{1}	19
13	1	10	6	6	6	8	8	11	14	17	24
14	1	7	8	7	7	9	8	12	17	17	23

[1]Superscripts show the number of disks involved when less than the number of trees.

Table 12.—*Weighted average heartwood percent of green disk weight by d.b.h. and height (in feet) in tree*

D.b.h (inches)	Trees	Height above stump									At 2 inches d.o.b.
		0	4	8	16	24	32	40	48	56	
	Number	*Percent*									
3	9	40	32	22							19
4	23	44	47	42	34	28	12				17
5	20	45	45	40	31	21	18				10
6	19	43	45	40	34	24	17				9
7	17	50	51	49	39	32	23	14	8		7
8	20	52	50	50	42	33	24	14	8		8
9	11	52	53	50	43	36	27	18	11	7	6
10	13	49	52	48	42	33	26	18	10		8
11	5	50	50	44	41	33	24	14	15		5
12	2	50	53	51	43	39	32	25	18	7	3
13	1	35	58	52	53	46	44	34	24	13	6
14	1	59	57	52	55	40	44	28	15	3	1

Table 13.—*Weighted average sapwood percent of green disk weight by d.b.h. and height (in feet) in tree*

D.b.h (inches)	Trees	Height above stump									At 2 inches d.o.b.
		0	4	8	16	24	32	40	48	56	
	Number	*Percent*									
3	9	48	49	57	65						66
4	23	45	45	49	56	60	74				68
5	20	45	47	51	59	66	70				74
6	19	47	47	51	56	64	70				72
7	17	41	42	44	52	58	65	72	76		76
8	20	39	43	43	50	57	65	72	75		74
9	11	40	40	43	49	54	62	70	74	74	76
10	13	42	41	45	50	58	63	69	74		75
11	5	42	42	48	51	58	65	73	70		77
12	2	42	39	42	48	52	56	64	67	76	78
13	1	55	36	42	41	46	48	55	62	70	70
14	1	34	35	41	38	51	48	60	68	80	75

Carpenter, Eugene M.
Above-ground weights for tamarack in northeastern Minnesota.
Res. Pap. NC-245. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1983. 9 p.
We used trees from natural, uneven-aged stands in northeastern Minnesota to develop prediction equations to estimate total tree, stem, crown, live and dead branch weight. Presented here are specific gravity and moisture content by d.b.h. and height in tree, as well as bark, sapwood, and heartwood ratios.

KEY WORDS: Tamarack biomass, *Larix laricina* [Du Roi] K., equations, weight, component proportions, specific gravity trends, moisture content trends.

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