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Estimating Weights of Branch Segments

Estimating the forces and loads applied in tree systems requires the weight of different parts and portions be determined. One of the most difficult measures to estimate is green xylem weight in branches. Wood weight can be precisely and accurately determined in the laboratory from small samples at oven-dry moisture contents. Within living trees, moisture content values are difficult to determine accurately. The moisture contents of living tree xylem and associated tissue can vary between 30% and 250% as compared with the weight of any associated woody material.

To estimate branch segment weight, the solid woody material weight must be added together with the moisture (water) content held within and around xylem cells. Intercellular spaces, cell wall areas, and interior cell spaces can all hold water in different forms of chemical attachments and at various hydration layer depths. Since water can account for most of the weight of a branch, moisture content values must be incorporated into estimates of wood weight.

Table 1 estimates how many cubic feet are in a given branch section based upon its average diameter (outside the bark) and length. Bark weight, cavities, included foreign materials, and atypical growths are not included in the volume estimate, and so, not included in the subsequent weight calculation. Cubic feet volumes are calculated using a geometric average diameter outside the bark at the small end and at the large end of the branch segment. The average diameter value generated can be inserted into Table 1 to estimate the number of cubic feet in a branch segment. Figure 1 graphically describes the calculations.

Table 2 provides green wood density values per cubic foot for a variety of tree species. The green wood moisture contents used in the density calculations are an average of heartwood and sapwood moisture contents cited for each species. Branch segment weight can be estimated by multiplying the number of cubic feet in a branch segment times the green wood density in pounds per cubic feet. The result is an estimate of pounds in the branch segment. Figure 1 graphically defines the calculations.

For example, a green branch segment from a mockernut hickory is seven (7) feet long and has a small end diameter of 15.5 inches and a large end diameter of 23.5 inches. Calculated average diameter for use in Table 1 would be 20 inches. This branch segment contains approximately 15 cubic feet of woody material (dotted lines in Figure 1). Multiply the number of cubic feet from Table 1 (15 cubic feet) by the species density value in pounds per cubic foot found within Table 2 (dotted lines -- 65.9 pds/cubic feet) to determine the estimated green weight of the branch segment in pounds (example answer = 989 pounds).



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Table 1: The number of cubic feet in a wooden cylinder with a given diameter or circumference (in inches), and with a length between 1 and 15 feet long. See Figure 3 for a description of measures and calculations used in this publication. (1 foot = 30.48cm)

NOTE: All values are approximations and rounded to whole numbers when appropriate.

diameter (inches)	circumference (inches)	length (feet)														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	6.3	0.02	0.04	0.07	0.09	0.11	0.13	0.15	0.17	0.2	0.2	0.2	0.3	0.3	0.3	0.3
3	9.4	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.4	0.5	0.5	0.6	0.6	0.7	0.7
4	13	0.1	0.2	0.3	0.35	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.1	1.2	1.3
5	16	0.1	0.3	0.4	0.6	0.7	0.8	1.0	1.1	1.2	1.4	1.5	1.6	1.8	1.9	2.1
6	19	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0
7	22	0.3	0.5	0.8	1.1	1.3	1.6	1.9	2.1	2.4	2.7	2.9	3.2	3.5	3.7	4.0
8	25	0.4	0.7	1.1	1.4	1.8	2.1	2.4	2.8	3.1	3.5	3.8	4.2	4.5	5	5
9	28	0.4	0.9	1.3	1.8	2.2	2.7	3.1	3.5	4.0	4.4	5	5	6	6	7
10	31	0.6	1.1	1.6	2.2	2.7	3.3	3.8	4.4	5	6	6	7	7	8	8
11	35	0.7	1.3	2.0	2.6	3.3	4.0	4.6	5	6	7	7	8	9	9	10
12	38	0.8	1.6	2.4	3.1	3.9	5	6	6	7	8	9	9	10	11	12
13	41	0.9	1.8	2.8	3.7	4.6	6	7	7	8	9	10	11	12	13	14
14	44	1.1	2.1	3.2	4.3	5	6	8	9	10	11	12	13	14	15	16
15	47	1.2	2.5	3.7	5	6	7	9	10	11	12	14	15	16	17	18
16	50	1.4	2.8	4.2	6	7	8	10	11	13	14	15	17	18	20	21
17	53	1.6	3.1	4.7	6	8	10	11	13	14	16	17	19	21	22	24
18	57	1.8	3.5	5	7	9	11	12	14	16	18	20	21	23	25	27
19	60	2.0	3.9	6	8	10	12	14	16	18	20	22	24	26	28	30
20	63	2.2	4.4	7	9	11	13	15	18	20	22	24	26	28	31	33
21	66	2.4	5	7	10	12	14	17	19	22	24	27	29	31	34	36
22	69	2.6	5	8	11	13	16	19	21	24	26	29	32	34	37	40
23	72	2.9	6	9	12	14	17	20	23	26	29	32	35	38	40	43
24	75	3.1	6	9	13	16	19	22	25	28	31	35	38	41	44	47
25	79	3.4	7	10	14	17	21	24	27	31	34	38	41	44	48	51
26	82	3.7	7	11	15	18	22	26	30	33	37	41	44	48	52	55
27	85	4.0	8	12	16	20	24	28	32	36	40	44	48	52	56	60
28	88	4.3	9	13	17	21	26	30	34	39	43	47	51	56	60	64
29	91	4.6	9	14	18	23	28	32	37	41	46	51	55	60	64	69
30	94	4.9	10	15	20	25	30	34	39	44	49	54	59	64	69	74

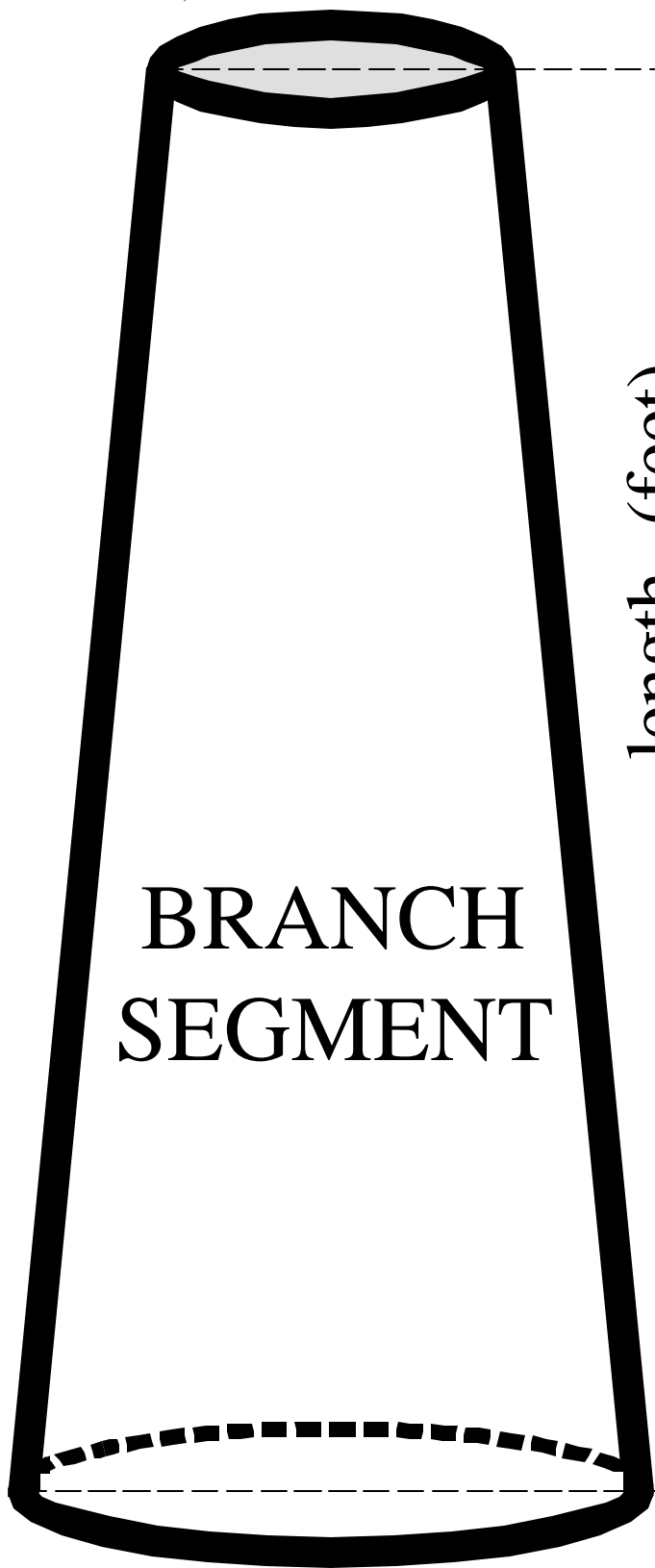
TABLE 1 CONTINUED ON PAGE 3

Table 1: (continued from page 2) Table values are in cubic feet.

diameter (inches)	circumference (inches)	length (feet)														
		1	2	3	4	5	6	7	8	9	19	11	12	13	14	15
31	97	5	11	16	21	26	32	37	42	47	52	58	63	68	73	79
32	101	6	11	17	22	28	34	39	45	50	56	62	67	73	78	84
33	104	6	12	18	24	30	36	42	48	54	59	65	71	77	83	89
34	107	6	13	19	25	32	38	44	51	57	63	69	76	82	88	95
35	110	7	13	20	27	33	40	47	54	60	67	74	80	87	94	100
36	113	7	14	21	28	35	42	50	57	64	71	78	85	92	99	106
37	116	8	15	22	30	37	45	52	60	67	75	82	90	97	105	112
38	119	8	16	24	32	39	47	55	63	71	79	87	95	102	110	118
39	123	8	17	25	33	42	50	58	66	75	83	91	100	108	116	125
40	126	9	18	26	35	44	52	61	70	79	87	96	105	114	122	131
41	129	9	18	28	37	46	55	64	73	83	92	101	110	119	128	138
42	132	10	19	29	39	48	58	67	77	87	96	106	116	125	135	144
43	135	10	20	30	40	51	61	71	81	91	101	111	121	131	141	151
44	138	11	21	32	42	53	63	74	85	95	106	116	127	137	148	159
45	141	11	22	33	44	55	66	77	88	100	111	122	133	144	155	166
46	145	12	23	35	46	58	69	81	92	104	116	127	139	150	162	173
47	148	12	24	36	48	60	72	84	96	109	121	133	145	157	169	181
48	151	13	25	38	50	63	75	88	101	113	126	138	151	164	176	189
49	154	13	26	39	52	66	79	92	104	118	131	144	157	170	183	197
50	157	14	27	41	55	68	82	96	109	123	136	150	164	177	191	205
55	173	17	33	50	66	83	99	116	132	149	165	182	198	215	231	248
60	189	20	39	59	79	98	118	138	157	177	197	216	236	255	275	295
65	204	23	46	69	92	115	138	161	184	208	231	254	277	300	323	346
70	220	27	54	80	107	134	160	187	214	241	267	294	321	348	374	401
75	236	31	61	92	123	155	184	215	246	276	307	338	368	399	430	460
80	251	35	70	105	140	175	210	245	279	314	349	384	419	454	489	524
85	267	39	79	118	158	197	237	276	315	355	394	434	473	513	552	591
90	283	44	88	133	177	221	265	309	354	398	442	486	530	575	619	663
95	299	49	99	148	197	246	296	345	394	443	493	542	591	640	690	739
100	314	55	109	164	218	273	327	382	437	491	546	600	655	709	764	819

Table 2: Average calculated green-wood density for selected species at greenwood specific gravity and average moisture contents (MC) for combined heartwood and sapwood. Average Green-Wood Moisture Content (MC) = ((average heartwood moisture content) + (average sapwood moisture content)) / 2. See Figure 3 for calculation descriptions.

species common name	wood density (lbs/ft ³)	average MC (%)	greenwood specific gravity	species common name	wood density (lbs/ft ³)	average MC (%)	greenwood specific gravity
green ash	49.6	50	0.53	chestnut oak	64.0	80	0.57
white ash	51.5	50	0.55	live oak	89.9	80	0.80
American basswood	40.9	105	0.32	overcup oak	64.0	80	0.57
American beech	57.7	65	0.56	post oak	67.4	80	0.60
black cherry	46.9	60	0.47	swamp chestnut oak	67.4	80	0.60
Eastern cottonwood	60.0	160	0.37	white oak	67.4	80	0.60
American elm	56.0	95	0.46	sassafrass	49.8	90	0.42
red elm	58.4	95	0.48	sweetgum	60.3	110	0.46
pecan	67.4	80	0.60	American sycamore	64.6	125	0.46
mockernut hickory	65.9	65	0.64	black gum	58.8	105	0.46
pignut hickory	68.0	65	0.66	black walnut	58.8	85	0.51
shagbark hickory	65.9	65	0.64	yellow-poplar	48.7	95	0.40
honeylocust	61.8	65	0.60	baldcypress	65.5	150	0.42
black locust	68.0	65	0.66	Atlantic white-cedar	35.8	85	0.31
Southern magnolia	56.0	95	0.46	Easternred-cedar	50.8	85	0.44
red maple	55.0	80	0.49	Eastern hemlock	49.8	110	0.38
silver maple	49.4	80	0.44	Eastern white pine	37.1	75	0.34
sugar maple	59.4	70	0.56	loblolly pine	51.3	75	0.47
black oak	62.9	80	0.56	longleaf pine	59.0	75	0.54
cherrybark oak	68.5	80	0.61	pitch pine	51.3	75	0.47
laurel oak	62.9	80	0.56	sand pine	50.2	75	0.46
scarlet oak	67.4	80	0.60	shortleaf pine	51.3	75	0.47
Southern red oak	58.4	80	0.52	slash pine	59.0	75	0.54
water oak	62.9	80	0.56	Virginia pine	49.1	75	0.45
willow oak	62.9	80	0.56	red spruce	42.7	85	0.37



small-end
diameter
(inches)

length (feet)

BRANCH
SEGMENT

Measure small-end diameter (d_s)
and large-end diameter (d_l).

Geometric average diameter =

$$dx = 0.71 \times \sqrt{(d_s^2 + d_l^2)}$$

$$\text{Volume in cubic feet} = (0.00182) \times (0.5 \times dx_{\text{inches}})^2 \times (\text{length}_{\text{feet}} \times 12)$$

Average moisture
content (MC) of
green wood =
 $((\text{sapwood MC} + \text{heartwood MC}) / 2)$

large-end
diameter
(inches)

$$\text{Density (lb/ft}^3\text{)} = 62.4 \times (\text{specific gravity}) \times (1 + \text{MC})$$

Moisture Content (MC) is green-wood basis by species in decimal form