Biomechanics Series

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Estimating Tree Stem & Branch Weight

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Estimating forces and loads applied in tree structural systems require determining weight of different tree parts and portions. One of the most difficult measures to estimate is green xylem weight in branches and stems. 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 content alone of living tree xylem and associated tissue can vary by as much as 30% to 250% more than the weight of any woody material.

To estimate branch weight, woody material weight must be added to moisture (water) weight. Intercellular spaces, cell wall areas, and interior cell spaces all hold water in various forms and strength of chemical attachment. Moisture contents vary by wood type (heartwood / sapwood), location in cross-section (depth in wood), and by species. Green wood and living tissues at the smallest level are bathed in hydration layers of various thicknesses. Liquid water can be held within nonfunctional xylem elements. Tree life covers itself with water on an ionic, cellular, and tissue scale. In some cases, and in some species, water can make up a majority of the weight of a branch. As such, it is critical water weight (moisture content) be incorporated into estimates of living / green wood weight.

Volume

Table 1 estimates how many cubic feet are in a given branch section. The estimate is based upon the branch segment average diameter (outside periderm) and length. Periderm weight, cavities, overgrown foreign materials, and atypical growths are not included in this volume estimate and subsequent weight calculation. Cubic feet volumes are calculated using a geometric average diameter outside the periderm using the small end diameter and large end diameter of the branch segment. This geometric average diameter value is used to calculate number of cubic feet in a branch segment.

Weight

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

Table 1: Number of cubic feet in a wooden cylinder with a given diameter or circumference (in inches), and with a length between 1 and 13 feet long.

Note table values are rounded approximations.

diameter (inches)	circumference (inches)	length (feet)												
		1	2	3	4	5	6	7	8	9	10	11	12	13
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
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
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
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
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
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
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
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
10	31	0.6	1.1	1.6	2.2	2.7	3.3	3.8	4.4	5.0	6	6	7	7
11	35	0.7	1.3	2.0	2.6	3.3	4.0	4.6	5	6	7	7	8	9
12	38	0.8	1.6	2.	3.	3.9	5	6	6	7	8	9	9	10
13	41	0.9	1.8	2.8	3.7	4.6	6	7	7	8	9	10	11	12
14	44	1.1	2	3	4	5	6	8	9	10	11	12	13	14
15	47	1.2	2.5	3.7	5	6	7	9	10	11	12	14	15	16
16	50	1.4	3	4	6	7	8	10	11	13	14	15	17	18
17	53	1.6	3	5	6	8	10	11	13	14	16	17	19	21
18	57	1.8	4	5	7	9	11	12	14	16	18	20	21	23
19	60	2.0	4	6	8	10	12	14	16	18	20	22	24	26
20	63	2.2	4	7	9	11	13	15	18	20	22	24	26	28
21	66	2.4	5	7	10	12	14	17	19	22	24	27	29	31
22	69	2.6	5	8	11	13.	16	19	21	24	26	29	32	34
23	72	2.9	6	9	12	14	17	20	23	26	29	32	35	38
24	75	3.1	6	9	13	16	19	22	25	28	31	35	38	41
25	79	3.4	7	10	14	17	21	24	27	31	34	38	41	44
26	82	3.7	7	11	15	18	22	26	30	33	37	41	44	48
27	85	4.0	8	12	16	20	24	28	32	36	40	44	48	52
28	88	4.3	9	13	17	21	26	30	34	39	43	47	51	56
29	91	4.6	9	14	18	23	28	32	37	41	46	51	55	60
30	94	4.9	10	15	20	25	30	34	39	44	49	54	59	64

Table 1: Number of cubic feet in a wooden cylinder with a given diameter or circumference (in inches), and with a length between 1 and 13 feet long. (continued from page 2)

Note table values are rounded approximations.

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

Table 2: Average calculated wood density for selected species at greenwood specific gravity and average moisture contents (MC%) for combined heartwood and sapwood.

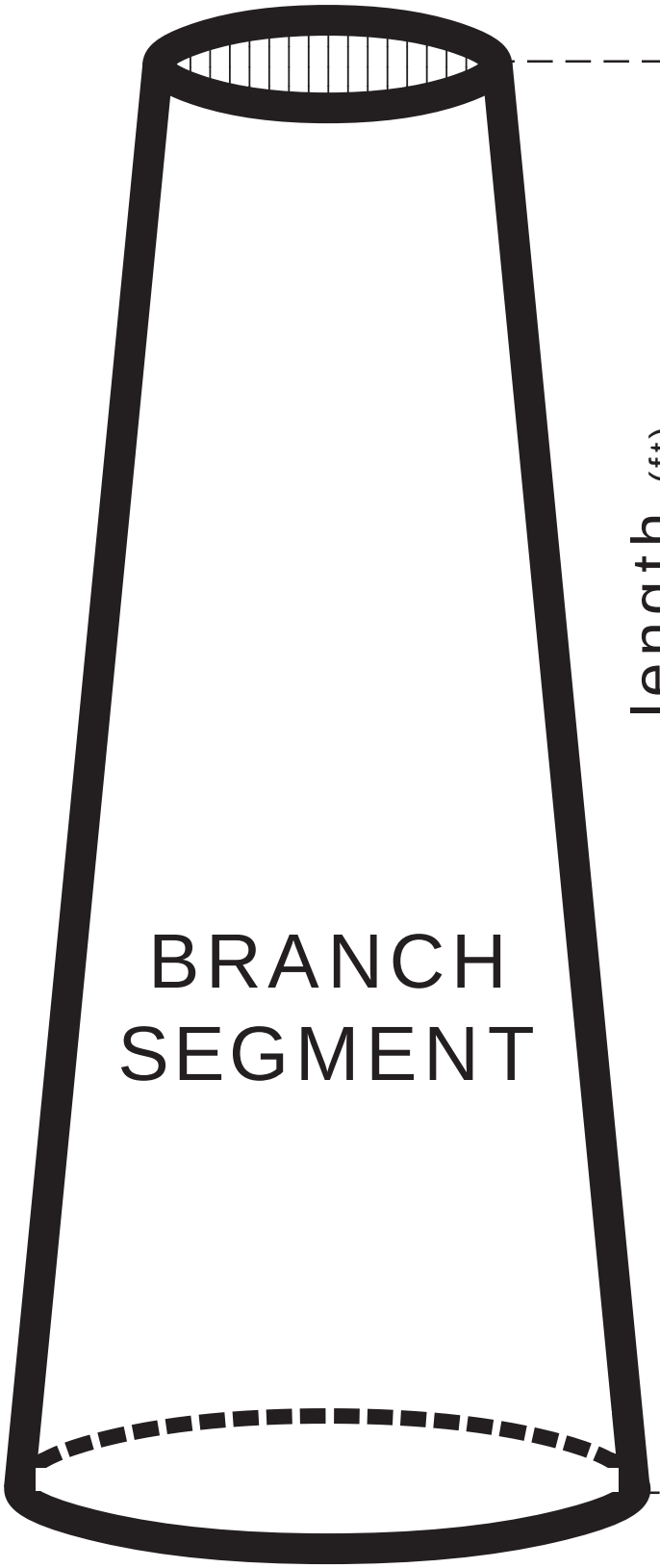
Average Moisture Content or MC% =
((average heartwood moisture content) + (average sapwood moisture content)) / 2).

species common name	wood density (lbs/ft^3)	average MC (%)	greenwood specific gravity
green ash	49.6	50	0.53
white ash	51.5	50	0.55
American basswood	40.9	11	0.32
American beech	57.7	65	0.56
black cherry	46.9	60	0.47
Eastern cottonwood	60.0	160	0.37
American elm	56.0	95	0.46
red elm	58.4	95	0.48
pecan	67.4	80	0.60
mockernut hickory	65.9	65	0.64
pignut hickory	68.0	65	0.66
shagbark hickory	65.9	65	0.64
honeylocust	61.8	65	0.60
black locust	68.0	65	0.66
Southern magnolia	56.0	95	0.46
red maple	55.0	80	0.49
silver maple	49.4	80	0.44
sugar maple	59.4	70	0.56
black oak	62.9	80	0.56
cherrybark oak	68.5	80	0.61
laurel oak	62.9	80	0.56
scarlet oak	67.4	80	0.60
Southern red oak	58.4	80	0.52
water oak	62.9	80	0.56
willow oak	62.9	80	0.56

Table 2: Average calculated wood density for selected species at greenwood specific gravity and average moisture contents (MC%) for combined heartwood and sapwood. (continued from page 4)

Average Moisture Content or MC% =
((average heartwood moisture content) + (average sapwood moisture content)) / 2).

species common name	wood density (lbs/ft^3)	average MC (%)	greenwood specific gravity
chestnut oak	64.0	80	0.57
live oak	89.9	80	0.80
overcup oak	64.0	80	0.57
post oak	67.4	80	0.60
swamp chestnut oak	67.4	80	0.60
white oak	67.4	80	0.60
sassafras	49.8	90	0.42
sweetgum	60.3	110	0.46
American sycamore	64.6	125	0.46
black gum	58.8	105	0.46
black walnut	58.8	85	0.51
yellow-poplar	48.7	95	0.40
baldcypress	65.5	150	0.42
Atlantic white-cedar	35.8	85	0.31
Eastern red-cedar	50.8	85	0.44
Eastern hemlock	49.8	110	0.38
Eastern white pine	37.1	75	0.34
loblolly pine	51.3	75	0.47
longleaf pine	59.0	75	0.54
pitch pine	51.3	75	0.47
sand pine	50.2	75	0.46
shortleaf pine	51.3	75	0.47
slash pine	59.0	75	0.54
Virginia pine	49.1	75	0.45
red spruce	42.7	85	0.37



Measure small-end diameter (ds) and large-end diameter (dl).

Geometric average diameter =

$dx = 0.71 \times \sqrt{(ds^2 + dl^2)}$

Volume in cubic feet =

$(0.00182) \times (0.5 \times dx)^2 \times (\text{length} \times 12)$

Average moisture content (MC%) of green wood =

((sapwood + heartwood) / 2)

Density (lb/ft^3) =
62.4 X (specific gravity) X (1 + MC%)
moisture content (MC%) is in decimal form