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How to Estimate Weights of Northern Red Oak Crowns in a Stand

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HOW TO ESTIMATE WEIGHTS OF NORTHERN RED OAK CROWNS IN A STAND

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Tree crowns may become a significant forest fuel, particularly after logging operations, insect epidemics, high winds, or ice storms. To appraise potential fire behavior after cutting or other disturbances, a method has been developed[1] to estimate crown fuel weights in stands of northern red oak (*Quercus rubra* L.). The estimates should also be reasonably accurate for other black oak species and other "hard" hardwoods with similar crown form (such as hickory), and be usable throughout the eastern United States. The method can also be used to estimate fiber amounts.

ESTIMATING DRY WEIGHTS OF FOLIAGE AND BRANCHWOOD

To estimate weights of foliage and branchwood (including bark),[2] the "variable radius plot" technique is used. If a 10-factor prism is used, for example, each tree tallied represents 10 square feet of basal area (BA) per acre. The d.b.h. and crown ratio (CR) of each tallied tree must also be determined. (Crown ratio is the ratio of live crown length to total tree height expressed as a percentage.) From d.b.h., crown ratio, and basal area per acre represented, you can determine the weights of the following crown components:

- Dry weight of live branchwood by diameter class (table 1).
- Total dry weight of all live branchwood (table 2).
- Dry weight of dead branchwood by diameter class and total weight (table 3).
- Dry weight of foliage (table 4).
- Dry weight of bole sections between 1 and 3 inches in diameter (table 5).

Examples

The following examples show how to determine crown component weights, both in pounds per square foot of basal area and pounds per acre for the stand, from tables 1 through 5.[3]

First collect field data and combine tallied trees into groups by d.b.h. and crown ratio. Seven tallied trees are collected this way in the sample worksheets (figs. 1-4). Since the instrument used has a basal area factor of 10, multiply the number of tallied trees in a group by 10 to get the "square feet of basal area per acre represented" (e.g., 3 trees x 10 BAF = 30 square feet BA/acre). Note that "30" has been inserted in the proper column in figures 1-4.

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[1] *Loomis, R. M.; Blank, R. W. Estimating northern red oak crown component weights in the Northeastern United States. Res. Pap. NC-194. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1981. 9 p.*

[2] *"Branchwood" and also "bolewood" as used in this report refer to both wood and bark.*

[3] *Any table value "per square foot of basal area" can be converted to "per tree" by multiplying the table value by the number of actual square feet of basal area contained by the tree. For example, a tree with a d.b.h. of 10 inches contains 0.55 square foot of basal area. Assume that the tree has a 50 percent crown ratio. Table 4 shows 27 pounds per square foot of basal area of foliage. Thus: 27 pounds per square foot of basal area x 0.55 square foot of basal area per tree = about 15 pounds of foliage per tree.*

Table 1.—*Dry weight of northern red oak live branchwood*[1] *by diameter class*

D.b.h. (inches)	Crown ratio[2] (percent) 20				30				40				50			
	0-¼	¼-1	1-3	3+[3]	0-¼	¼-1	1-3	3+	0-¼	¼-1	1-3	3+	0-¼	¼-1	1-3	3+
	Pounds per square foot of basal area															
1	18				18				18	18			18	18		
2	9	9			14	18			18	32			23	50		
3	8	16			12	33			16	53			20	65	14	
4	7	23			10	41	3		14	53	21		18	64	45	
5	7	29			10	40	17		12	51	39		16	62	69	
6	6	28	7		9	40	28		12	51	61		15	61	92	
7	6	27	12		9	37	37		12	49	75		14	60	120	
8	6	28	18		8	37	49		11	49	89		13	57	129	11
9	5	27	25		8	36	59		11	50	95	10	13	57	129	34
10	5	26	29		8	37	64	5	10	48	93	28	13	59	126	55
11	5	26	33		7	36	64	15	10	45	97	41	12	56	129	76
12	5	25	37	2	7	36	64	24	10	46	95	56	12	55	129	97
13	5	26	36	7	7	37	64	33	9	46	94	71	12	56	124	118
14	5	25	36	12	7	36	64	41	9	47	93	83	11	54	125	138
15	5	25	36	16	7	36	64	50	9	45	93	98	11	55	125	156
16	4	25	36	21	6	34	64	59	9	46	92	110	11	55	124	175
17	4	25	36	25	6	35	63	67	8	46	92	124	10	55	122	195
18	4	24	36	31	6	35	63	75	8	45	90	138	10	54	124	212
19	4	25	36	35	6	35	62	84	8	45	91	150	10	53	125	230
20	4	24	36	39	6	35	62	92	8	44	92	162	10	51	126	247
21	4	24	37	43	6	35	63	99	8	43	92	175	10	53	122	266
22	4	24	36	48	6	34	63	107	8	42	92	188	10	52	122	285
23	4	24	36	52	6	34	63	115	8	44	92	198	9	54	121	301
24	4	24	36	56	6	32	63	123	7	42	92	211	10	51	125	315
25	4	23	35	60	6	34	60	132	7	44	91	222	9	53	119	335

D.b.h. (inches)	Crown ratio[2] (percent) 60				70				80			
	0-¼	¼-1	1-3	3+	0-¼	¼-1	1-3	3+	0-¼	¼-1	1-3	3+
	Pounds per square foot of basal area											
1	37	18			37	37			37	37		
2	28	69			32	92	5		37	101	18	
3	22	75	33		26	86	55		31	94	79	
4	21	71	69		24	81	101		29	96	138	
5	20	72	110		23	81	147		26	88	191	
6	18	71	138		21	81	188		24	92	244	
7	17	71	165	3	20	79	206	23	23	90	239	49
8	16	69	163	34	19	77	198	66	22	86	241	97
9	16	68	161	66	18	77	199	104	21	86	240	143
10	15	66	161	95	18	77	198	137	20	86	233	191
11	15	65	164	120	17	76	198	171	20	83	233	233
12	14	64	163	148	17	73	199	207	19	85	232	275
13	14	65	162	174	16	73	194	242	18	86	228	319
14	14	65	157	201	16	74	195	273	18	79	234	357
15	13	66	157	227	15	73	194	306	17	84	225	399
16	13	65	155	253	15	72	192	340	16	82	229	435
17	13	63	158	275	15	69	195	370	16	79	232	472
18	12	62	160	298	14	74	190	400	17	75	234	511
19	12	60	161	323	14	71	191	432	16	80	227	550
20	12	63	156	347	14	67	191	463	16	75	227	589
21	11	61	156	372	14	70	191	490	15	79	226	622
22	11	64	156	392	14	66	190	523	16	72	235	655
23	11	59	155	419	13	69	189	550	15	76	223	699
24	11	62	153	439	13	72	186	576	15	80	219	731
25	11	58	158	460	13	66	192	603	14	72	226	765

[1]Includes bolewood less than 1 inch in diameter. Branchwood and bolewood include wood and bark.
[2]The ratio of live crown length to total tree height expressed as a percent.
[3]Due to rounding, the sum of the four diameter classes may not equal the total value given in table 2.

Table 2.—*Total dry weight of northern red oak live branchwood*[1]
(In pounds per square foot of basal area)

D.b.h. (inches)	Crown ratio[2] (percent)						
	20	30	40	50	60	70	80
1	18	18	37	37	55	73	92
2	18	32	50	73	96	124	151
3	24	45	69	100	132	169	204
4	30	56	88	126	160	206	264
5	35	67	103	147	198	249	308
6	41	76	122	168	229	290	357
7	45	86	135	191	254	326	400
8	52	95	149	212	284	361	444
9	57	104	165	233	310	396	489
10	60	114	178	253	337	429	530
11	65	123	192	273	364	462	570
12	69	131	206	292	388	495	610
13	74	140	219	310	413	526	650
14	79	148	232	329	438	557	687
15	82	156	245	347	462	588	726
16	87	164	257	365	486	619	763
17	91	172	269	382	509	649	799
18	95	179	282	400	533	678	837
19	99	187	294	418	556	708	872
20	103	195	306	434	578	736	907
21	107	203	318	451	601	765	943
22	111	210	330	468	623	793	978
23	115	218	341	485	645	821	1013
24	119	224	352	500	665	847	1045
25	122	231	364	516	687	874	1078

[1]Branchwood includes bolewood less than 1.0 inch in diameter. Branchwood and bolewood include wood and bark.
[2]Crown ratio is the ratio of live crown length to total tree height expressed as a percent.

Table 3.—*Dry weight of northern red oak dead branchwood*[1] *by diameter class and total weight*
(In pounds per square foot of basal area)

D.b.h. (inches)	Diameter class (inches)				
	0-¼	¼-1	1-3	3+	Total[2]
1	18.0	55			73
2	9.2	46			55
3	6.1	41			47
4	5.7	38			44
5	4.4	37			41
6	3.6	35	0.5		39
7	3.0	23	12		37
8	2.6	16	17		37
9	2.0	12	21	0.5	34
10	1.6	8.8	22	1.6	33
11	1.5	6.7	23	2.6	33
12	1.3	5.1	22	3.6	32
13	1.1	3.9	23	4.0	31
14	0.9	3.2	22	4.6	31
15	0.8	2.8	22	4.8	30
16	0.7	2.2	21	5.3	29
17	0.6	1.7	21	5.5	29
18	0.6	1.5	21	5.7	28
19	0.6	1.3	20	6.1	28
20	0.5	1.1	20	6.0	27
21	0.5	1.0	20	5.8	27
22	0.5	0.9	19	6.1	27
23	0.5	0.8	19	6.2	27
24	0.5	0.8	19	6.4	26
25	0.5	0.8	18	6.2	26

[1]Dead branchwood includes material from both within and below the live crown. Branchwood refers to both wood and bark.
[2]Due to mathematical rounding, the sum of the four diameter classes may not always equal the total figures.

FINDING THE DRY WEIGHT OF LIVE BRANCHWOOD BY DIAMETER CLASS

1. In table 1 use the appropriate d.b.h. and crown ratio to obtain dry weight of live branchwood by diameter class per square foot of basal area. (For example, in the worksheet in figure 1, a 12-inch d.b.h. and 50-percent crown ratio yield 12 pounds of live branchwood per square foot of basal area for the 0-1/4-inch diameter class.)
2. Multiply the pounds per square foot of basal area by the square feet of basal area per acre represented to find the pounds in each diameter class per acre (e.g., 12 pounds/square foot BA x 30 square feet BA/acre = 360 pounds per acre).
3. Repeat the process for the other diameter classes and the other tree groups from the field tally.

FINDING THE TOTAL DRY WEIGHT OF LIVE BRANCHWOOD

1. In table 2, use the appropriate d.b.h. and crown ratio to find total dry weight per square foot of basal area. The worksheet in figure 2 shows that a 12-inch d.b.h. and 50-percent CR yields 292 pounds/square foot of basal area.
2. Multiply the pounds per square foot of basal area by the square feet of basal area per acre represented to get the total dry weight per acre for each tree group. (Note in figure 2 that 292 pounds/square foot BA x 30 square feet BA/acre = 8,760 pounds/acre.)
3. Repeat the process for the other tree groups from the field tally.

Table 4.—*Dry weight of northern red oak foliage*

(In pounds per square foot of basal area)

D.B.h. (inches)	Crown ratio[1] (percent)						
	20	30	40	50	60	70	80
1	37	55	55	73	92	92	110
2	23	37	46	55	64	73	83
3	20	29	37	45	53	61	69
4	18	26	33	40	47	54	61
5	17	23	30	37	43	49	55
6	15	22	28	34	40	46	51
7	15	21	26	32	37	41	49
8	14	19	25	32	34	40	46
9	13	19	23	29	34	38	43
10	12	18	22	27	31	37	40
11	12	17	21	26	30	35	39
12	12	17	20	25	29	34	38
13	11	16	21	25	28	33	37
14	11	15	20	24	28	32	36
15	11	15	19	23	27	31	35
16	10	14	19	22	26	30	34
17	10	14	18	22	25	29	33
18	10	13	17	21	25	29	32
19	10	14	17	21	24	28	32
20	9	13	17	21	24	27	31
21	9	13	17	20	24	27	30
22	9	13	16	20	23	27	30
23	9	12	16	19	23	26	29
24	9	12	16	19	22	25	29
25	9	12	16	19	22	25	28

[1]Crown ratio is the ratio of live crown length to total tree height expressed as a percent.

Table 5.—*Dry weight of bole sections from 1 to 3 inches in diameter*

D.b.h. (inches)	Bole section
	Pounds per square foot of basal area
1	367
2	504
3	244
4	149
5	95
6	66
7	49
8	37
9	29
10	22
11	18
12	15
13	12
14	10
15	8.2
16	7.2
17	6.3
18	5.1
19	4.6
20	3.7
21	3.3
22	3.0
23	2.4
24	2.2
25	2.1

FINDING THE DRY WEIGHT OF DEAD BRANCHWOOD BY FOUR DIAMETER CLASSES AND TOTAL WEIGHT

1. To get the dry weight of dead branchwood in the various branch diameter classes, find the d.b.h. of the tallied tree groups in table 3. (In the worksheet in figure 3, 12-inch d.b.h. at 0-1/4-inch = 1.3 pounds.)
2. To get the dry weight of dead branchwood per acre for each diameter class, multiply the pounds per square foot of basal area by square feet of basal area per acre represented (e.g., 1.3 pounds/square foot BA x 30 square feet BA/acre = 39 pounds/acre).
3. Repeat the process for the other tree groups.
4. To get the total dry weight of dead branchwood for all diameter classes per square foot of basal area, consult table 3. Obtain the total dry weight per acre by multiplying the total pounds per square foot of basal area by the square feet of basal area per acre represented (e.g., using 12-inch d.b.h., 32 pounds/square foot of basal area x 30 square feet BA/acre = 960 pounds/acre).
5. Repeat the process for the other tree groups.

FINDING THE DRY WEIGHT OF FOLIAGE

1. To get the dry weight of foliage, use the d.b.h. and crown ratios in table 4. (See the worksheet in figure 4, using 12-inch d.b.h. and 50-percent CR. The pounds of foliage per square foot of basal area is 25.)
2. Multiply the pounds per square foot of basal area by the square feet of basal area per acre represented to get the total pounds of foliage per acre. (Note in figure 4 that 25 pounds/square foot BA x 30 square feet BA/acre = 750 pounds per acre.)
3. Repeat the process for the other tree groups from the field tally.

Sample plot no.	Trees	D.b.h.	Crown ratio	Basal area/acre represented	Weight of live branchwood by diameter class (inches)							
					0-1/4		1/4-1		1-3		3+	
					Per square foot of basal area	Per acre	Per square foot of basal area	Per acre	Per square foot of basal area	Per acre	Per square foot of basal area	Per acre
	No	In	Percent	Ft^2	-Pounds-							
1	3	12	50	30	12	360	55	1,650	129	3,870	97	2,910
	1	14	60	10	14	140	65	650	157	1,570	201	2,010
	3	10	40	30	10	300	48	1,440	93	2,790	28	840
Total:	7			70		800		3,740		8,230		5,760

Figure 1.—*Sample worksheet for instrument with basal area factor 10 to determine weight of live branchwood by diameter class (from table 1).*

Sample plot no.	Trees	D.b.h.	Crown ratio	Basal area/acre represented	Weight of live branchwood	
					Per square foot of basal area	Per acre
	No	In	Percent	Ft^2	-Pounds-	
1	3	12	50	30	292	8760
	1	14	60	10	438	4,380
	3	10	40	30	178	5,340
Total:	7			70		18,480

Figure 2.—*Sample worksheet for instrument with basal area factor 10 to determine total weight of live branchwood (from table 2).*

Sample plot no.	Trees	D.b.h.	Crown ratio	Basal area/acre represented	Weight of dead branchwood by diameter class (inches)									
					0-1/4		1/4-1		1-3		3+		Total	
					Per square foot of basal area	Per acre	Per square foot of basal area	Per acre	Per square foot of basal area	Per acre	Per square foot of basal area	Per acre	Per square foot of basal area	Per acre
	No	In	Percent	Ft^2	-Pounds-									
1	3	12	50	30	1.3	39	5.1	153	22	660	3.6	108	32	960
	1	14	60	10	0.9	9	3.2	32	22	220	4.6	46	31	310
	3	10	40	30	1.6	48	8.8	264	22	660	1.6	48	33	990
Total:	7			70		96		449		1,540		202		2,260

Figure 3.—*Sample worksheet for instrument with basal area factor 10 to determine dry weight of dead branchwood by four diameter classes and total weight (from table 3).*

Sample plot no.	Trees	D.b.h.	Crown ratio	Basal area/acre represented	Weight of Foliage		Weight of Bole Section 1 to 3 inches in diameter	
					Per square foot of basal area	Per acre	Per square foot of basal area	Per acre
	No	*In*	*Percent*	*Ft²*	*Pounds*			
1	3	12	50	30	25	750	15	450
	1	14	60	10	28	280	10	100
	3	10	40	30	22	660	22	660
Total:	7			70		1,690		1,210

Figure 4.—*Sample worksheet for instrument with basal area factor 10 for determining dry weight of foliage and of bole sections from 1 to 3 inches in diameter (from tables 4 and 5).*

FINDING THE DRY WEIGHT OF BOLE SECTIONS FROM 1 TO 3 INCHES IN DIAMETER

1. To get the dry weight of bole sections, use the d.b.h. of the tallied tree groups in table 5. (Again, see the worksheet in figure 4. Using 12-inch d.b.h., the weight of the bole section is about 15 pounds/square foot of BA.)
2. Multiply the weight per square foot of basal area by the square feet of basal area per acre represented to get the pounds of bole sections per acre (e.g., 15 pounds/square foot BA x 30 square feet BA/acre = 450 pounds/acre).
3. Repeat process for the other tree groups.

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How to estimate weights of northern red oak crowns in a stand.
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Describes how to estimate the weights of northern red oak and other hardwood tree crowns that could become fuels after storms, logging, or insect epidemics. Presents tables, sample worksheets, and examples.

KEY WORDS: Forest fuels, fire behavior, crown fuels, foliage weight, branchwood weight.

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