Dry-Matter Production In Immature Balsam Fir Stands: Roots, Lesser Vegetation, and Total Stand

BY
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Abstract. Data are presented on the dry weight per acre of tree roots and lesser vegetation in stands of 700, 1000, 1500, 2000, 3000 and 5000 stems per acre. The dry weight of tree roots, above-ground tree stand, and total tree stand all increase with increasing stand density. The weight of lesser vegetation decreases with increasing stand density, but is insignificant in proportion to the whole stand.

IN 1962 a study of dry-matter production was intiated in 40- to 50-year-old balsam fir stands in northwestern New Brunswick. Its aim was to estimate total standing crop and increment in six natural stands of 700, 1000, 1500, 2000, 3000 and 5000 stems per acre. Data on standing crop and increment of the above-ground portion of the tree stand are presented in Baskerville 1965.[1] The present paper reports on tree roots and the vegetation of the forest floor. Summaries of data for the above-ground tree stand and for the total stand are also presented.

The stands are dense mixtures of fir, spruce and birch in the proportions .88, .03, and .09. Such stands are common in the area, having developed from a advance growth (about one foot in height) that was released in 1913-19 by spruce budworm destruction of overmature softwoods. The age from release is 43 years. The average heights and diameters are as follows:

No. stems per acre	*Ave. ht. (ft.)*	*Ave. dbh (in.)*
700	36	5.6
1000	32	4.8
1500	31	4.4
2000	32	4.4
3000	32	3.8
5000	27	3.2

For detailed stand descriptions see Baskerville 1965.[2] (See footnote 2, p. 52.)

Methods

Sampling was based on 18 plots, three in each of the six densities. Plot size was variable such that each plot contained 24 trees. For the study of above-ground tree production, 140 trees were randomly selected and analyzed in detail. However, for the study of roots it was impossible to excavate the root systems of these randomly located trees. Instead all trees were excavated on one plot in each density.

On the plots to be excavated all trees were felled and the stumps tagged. The surface litter was removed with a fire hoe and the F and H layers were removed with high water pressure directed at a low angle. The mineral soil was washed away using two hoses with high volume and low pressure while a constant lifting pressure was maintained with a

[1] Baskerville, G. L. 1965. Dry-matter production in immature balsam fir stands. Forest Science Monograph 9. 42pp.

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large tripod and block and tackle. The method resulted in the loss of most roots less than 1/16-inch diameter. Excavation with these smaller roots intact proved unfeasible. A total of 144 root systems of all species were raised. A number of these were discarded because of damage in excavation and others could not be used because they were involved in grafted unions. In the latter case it was usually impossible to determine how much of the total root mass belonged to each partner of the union. Some 89 fir, two spruce, seven birch and one pin cherry single-unit root systems, relatively free from damage, were used in the present analysis. These distributed by densities as follows:

	No. of root systems			
No. stems per acre	*Balsam fir*	*White spruce*	*White birch*	*Pin cherry*
700	18	—	—	—
1000	11	—	1	1
1500	11	—	1	—
2000	18	—	1	—
3000	16	—	3	—
5000	15	2	1	—
Total	89	2	7	1

The extracted root systems were washed and allowed to dry for several days. They were then weighed on either a dynamometer or a butcher's beam depending on their size. Immediately after weighing, samples including material from the full range of sizes were cut from each root system and weighed in the laboratory. The samples were oven-dried for 24 hours at 105° C. and reweighed. The oven-dry weight of each root system was estimated by multiplying the total green weight by the ratio of oven dry/green weight obtained for the corresponding sample.

The oven-dry weight of the root system was correlated to stem dbh as follows:

Balsam fir: $\log 10W = .618 + 2.45 \log D$ $(n = 89, r = .96)$

White birch: $\log 10W = .746 + 2.35 \log D$ $(n = 7, r = .96)$

where W was the weight in pounds and D was the diameter breast height in inches. There was no systematic variation of root weight with density, hence all values are combined for each species. The spruce data did not permit calculation of a regression. Since the two values for spruce were near the equation values for fir the equation for fir has been used for both species.

To obtain per acre estimates of oven-dry root weight the diameter of each tree not used in establishing the correlation was substituted in the above equations. This was done for the 18 plots by calculating the weight of each root system and then summing for the plot.

Because the loss of rootlets resulted in an underestimation of total root weight, an attempt was made to estimate the amount of these small roots. Two pits each 2 × 2 feet were dug in each density. All material from each pit was sifted and the roots less than 1/16-inch in diameter separated. These roots were oven-dried, and their dry weights expanded to per acre estimates.

The weight of vegetation on the forest floor was estimated from six 3 x 3-foot samples (2 from each of 3 plots) in each density. A 3 x 3-foot frame was dropped randomly and all vegetation inside the frame was collected. Sample locations were rejected if they had been disturbed by previous tree layer sampling. Vegetation from each sample was sorted and oven-dried for 24 hours at 105° C. The oven-dry weights were then expanded to per acre estimates.

Results and Discussion

The total dry weight of fir root systems increased from 11.9 tons at 700 stems per acre to 19.5 tons at 5000 stems per acre (Table 1). The proportions of spruce and birch in the stands were variable across

TABLE 1. Dry weight of the tree stand by density and tree component.

Tree Component	Number of stems per acre: 700	1000	1500	2000	3000	5000	700	1000	1500	2000	3000	5000
	(oven-dry tons per acre)						(percent)					
						Balsam Fir						
Foliage	7.07	7.07	7.49	8.03	7.77	8.23	12.8	12.5	11.6	11.0	10.2	9.8
Branch wood	4.38	4.27	4.26	4.14	3.77	3.76	8.0	7.6	6.6	5.7	4.7	4.5
Branch bark	3.12	3.06	3.19	3.18	2.98	3.03	5.7	5.4	4.9	4.4	3.9	3.6
Cones	.25	.33	.26	.30	.28	.20	.4	.6	.4	.4	.4	.2
Stem wood	24.63	24.92	29.36	35.25	37.91	43.02	44.8	44.1	45.5	48.4	49.7	51.4
Stem bark	3.65	4.22	4.31	5.05	5.76	6.04	6.6	7.5	6.7	6.9	7.5	7.2
Total above ground	43.10	43.87	48.87	55.95	58.47	64.28	78.3	77.7	75.7	76.8	76.6	76.7
Roots	11.91	12.58	15.68	16.92	17.82	19.48	21.7	22.3	24.3	23.2	23.4	23.3
Total	55.01	56.45	64.55	72.87	76.29	83.76	100	100	100	100	100	100
						White Spruce						
Foliage	.66	.08	.04	.04	.44	.42	11.9	14.8	9.8	8.7	16.3	14.9
Branch wood	.48	.04	.02	.03	.23	.16	8.7	7.4	4.9	6.5	8.5	5.7
Branch bark	.32	.03	.02	.02	.16	.12	5.8	5.6	4.9	4.3	5.9	4.2
Cones	—	—	—	—	—	—	—	—	—	—	—	—
Stem wood	2.48	.25	.22	.31	1.67	1.28	44.8	46.3	53.5	67.4	61.8	45.4
Stem bark	.28	.02	.02	.04	.17	.16	5.1	3.7	4.9	8.7	6.3	5.7
Total above ground	4.22	.42	.32	.44	2.67	2.14	76.3	77.8	78.0	95.6	98.8	75.9
Roots	1.31	.12	.09	.02	.03	.68	23.7	22.2	22.0	4.4	1.2	24.1
Total	5.53	.54	.41	.46	2.70	2.82	100	100	100	100	100	100
						White Birch						
Foliage	.02	.08	.05	.08	.09	.11	3.7	3.8	3.4	7.1	3.7	4.3
Branch wood	.06	.20	.13	.08	.14	.21	11.1	9.6	8.2	7.1	5.7	8.2
Branch bark	.02	.05	.03	.03	.04	.06	3.7	2.4	2.0	2.6	1.6	2.3
Cones	—	—	—	—	—	—	—	—	—	—	—	—
Stem wood	.28	1.14	.81	.58	1.43	1.56	51.9	54.8	55.6	51.4	58.1	60.9
Stem bark	.04	.17	.11	.10	.19	.25	7.4	8.2	7.5	8.8	7.7	9.8
Total above ground	.42	1.64	1.12	.87	1.89	2.19	77.8	78.8	76.7	77.0	76.8	85.5
Roots	.12	.44	.34	.26	.57	.37	22.2	21.2	23.3	23.0	23.2	14.5
Total	.54	2.08	1.46	1.13	2.46	2.56	100	100	100	100	100	100
						All Species						
Foliage	7.75	7.23	7.58	8.15	8.30	8.76	12.7	12.2	11.4	10.9	10.2	9.9
Branch wood	4.92	4.51	4.40	4.25	4.14	4.13	8.1	7.6	6.6	5.7	5.1	4.7
Branch bark	3.46	3.14	3.24	3.23	3.18	3.21	5.7	5.3	4.9	4.3	3.9	3.6
Cones	.25	.33	.26	.30	.28	.20	.4	.6	.4	.4	.3	.2
Stem wood	27.39	26.31	30.39	36.14	41.01	45.86	44.8	44.6	45.8	48.6	50.4	51.4
Stem bark	3.97	4.41	4.44	5.19	6.12	6.45	6.5	7.5	6.7	7.0	7.5	7.2
Total above ground	47.74	45.93	50.31	57.26	63.03	68.61	78.2	77.8	75.8	76.9	77.4	77.0
Roots	13.34	13.14	16.11	17.10	18.42	20.53	21.8	22.2	24.2	23.1	22.6	23.0
Total	61.08	59.07	66.42	74.46	81.45	89.14	100	100	100	100	100	100

the range of density, consequently there is no definable trend in the root weights of these species. When these two species are included total weight of all tree roots increased from 17.3 tons per acre at 700 stems to 20.5 tons per acre at 5000 stems per acre. Data for the above-ground portion of the tree stand are reproduced in Table 1 to indicate the proportion of the tree stand comprised of roots.

The oven-dry weights of roots less than 1/16-inch in diameter as estimated from the small pits are as follows:

No. stems per acre	*Tons per acre*		
	Sample 1	*Sample 2*	*Average*
700	2.19	1.67	1.93
1000	1.95	2.11	2.03
1500	5.76	.89	3.32
2000	1.86	1.65	1.75
3000	1.74	5.21	3.48
5000	3.63	1.63	2.63

Because of the small number of samples and the high variability, no trend is

TABLE 2. Dry weight of lesser vegetation by density (stems per acre) and genus.

Species	700	1000	1500	2000	3000	5000
			o.d. weight lbs./ac.			
Abies (seedlings)	—	.8	.2	1.4	—	.9
Oxalis	32.8	3.6	1.4	.3	2.7	.2
Coptis	—	—	.6	—	—	—
Dryopteris	65.2	117.1	—	.8	13.5	1.4
Lycopodium	343.3	—	—	—	—	—
Callierognella	—	.1	19.3	.6	9.7	29.2
Dicranum	96.7	401.2	103.6	83.2	69.8	181.6
Polytrichum	27.7	—	.1	—	.2	—
Hylocomium	2.1	2.2	1.9	.9	.6	11.7
Total	567.8	525.0	127.1	87.2	96.5	225.0

TABLE 3. Dry weight of total standing crop (including roots) by density (stems per acre) and vegetation layer.

Species	700	1000	1500	2000	3000	5000
			o.d. weight tons/ac.			
Tree layer						
Balsam fir	55.01	56.45	64.55	72.87	76.29	83.76
White spruce	5.53	.54	.41	.46	2.70	2.82
White birch	.54	2.08	1.46	1.13	2.46	2.56
All species	61.08	59.07	66.42	74.46	81.45	89.14
Shrub layer	[1]					
Forest floor	.28	.26	.06	.04	.05	.11
Total	61.36	59.33	66.48	74.50	81.50	89.25

[1] Less than .01 ton per acre.

evident. The average estimate for all 12 samples is 2.52 tons per acre. Since this value would only add a constant to the amounts given in Table 1 no correction has been made for the loss of the rootlets.

Roots accounted for 21.7 per cent of the fir stand at 700 stems per acre and 23.3 percent at 5000 stems per acre. This trend results from the fact that roots represent a slightly larger proportion of small fir trees than they do of large trees (Baskerville 1965[2]). The corresponding percentages for spruce do not indicate a trend because of the small number of trees involved and the consequent increased influence of tree size. With changing density the proportion of the birch stand comprised in roots appears to remain constant at about 23 percent. However, because of the high proportion of the total stand in fir the percentage of the total stand in roots tends to increase with increasing density.

[2] Baskerville, G. L. 1965. Estimating of dry weight of tree components and standing crop in conifer stands. Ecology (in press).

No satisfactory method of estimating current annual net and gross increments of roots was devised. As a result the only estimate of increment available is on a mean annual basis (root weight divided by age). Such a procedure would indicate increasing increment with increasing density as was found for the above ground portion of the stand.

The total shrub stand consisting of one small *Amelanchier* on a 700 stem per acre plot had a dry weight less than 0.01 tons per acre and has not been recorded.

The oven-dry weight of vegetation on the forest floor proved highly variable. However, there was a logical tendency towards decreased weight with increasing density of the tree stand (Table 2). The vegetation consisted of:

Abies balsamea (seedlings)
Oxalis montana
Coptis groenlandica
Dryopteris spinulosa
Lycopodium lucidulum
Calliergonella schreberi
Dicranum fuscesens
Polytrichum commune
Hylocomium umbratum (traces of *H. splendens*)
Hypnum crista-castrensis (traces)

The data given in Table 2 include both tops and roots. The six samples contributing to each of the averages shown were highly variable both as to weight and the presence or absence of given species.

Estimates of total standing crop including tops and roots are given by vegetation layer in Table 3. Dry weight of standing crop increases form 61.4 tons per acre at 700 stems to 98.2 tons per acre at 5000 stems per acre. The lesser vegetation forms an insignificant portion of the total stand.

Conclusion

The oven-dry weight of total standing crop in these 43-year-old fir-spruce-birch stands increases with increasing stand density.

The total weight of tree roots increases with increasing density as does the weight of the above ground tree stand. Roots form a slightly greater proportion of the total stand in the denser stands.

Shrubs were present only in the 700 stem per acre density and there in negligible amounts.

The dry weight of vegetation on the forest floor tended to decrease with increasing density but the total weight involved was insignificant in comparison to the total tree stand.