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# Preliminary Estimates of Bark Percentages and Chemical Elements In Complete Trees of Eight Species In Maine

Harold E. Young

## Abstract

Five tables were prepared to show the relative amount of bark in each of the tree components, the concentration and range of 12 chemical elements in the bark of each tree component, the proportion of each of the chemical elements in the bark of that element in the complete tree, and the proportion of each element in the bark as compared to the wood and bark of the merchantable bole. There is an overall 4.6:1 wood to bark ratio, but due to the higher concentration of the elements in the bark, the proportion of the elements in the bark is much greater than one might expect from the wood to bark ratio. The wood and bark of the merchantable bole contains about half of each of the elements in the standing tree about equally divided between bark and wood.

*Populus tremuloides*

The author is Professor, School of Forest Resources, University of Maine, Orono, Me. The author wishes to acknowledge the assistance of J. Trafford and M. P. Young who assembled the tables. This paper was received for publication in October 1970.

Table 1. — BARK CHARACTERISTICS OF COMPLETE TREE FOR EIGHT SPECIES IN MAINE.<sup>1</sup>

Species	Component(s)	Bark as Percent of Complete Tree Bark <sup>2</sup>	Bark as Percent of Wood and Bark of Component(s) <sup>2</sup>
Red Spruce	Branches and unmerch. top	14	21
	Merch. bole	50	12
	Stump and roots	36	15
	All components	100	14
Balsam Fir	Branches and unmerch. top	29	35
	Merch. bole	41	18
	Stump and roots	30	28
	All components	100	24
Hemlock	Branches and unmerch. top	15	17
	Merch. bole	59	14
	Stump and roots	26	15
	All components	100	13
White Pine	Branches and unmerch. top	10	27
	Merch. bole	63	19
	Stump and roots	27	21
	All components	100	20
Northern White Cedar	Branches and unmerch. top	40	24
	Merch. bole	38	13
	Stump and roots	22	15
	All components	100	16
White Birch	Branches and unmerch. top	24	29
	Merch. bole	58	15
	Stump and roots	18	19
	All components	100	18
Red Maple	Branches and unmerch. top	32	26
	Merch. bole	46	13
	Stump and roots	22	15
	All components	100	16
Aspen	Branches and unmerch. top	25	36
	Merch. bole	61	21
	Stump and roots	14	27
	All components	100	25

<sup>1</sup>Exclusive of leaves or needles and branches and roots less than 1/4 inch in diameter.

<sup>2</sup>Dry weight basis.

TABLE 2. — AVERAGE AND ACTUAL RANGE OF FIVE ESSENTIAL ELEMENTS IN THE BARK AS A PERCENT FOR EIGHT TREE SPECIES IN MAINE.<sup>1</sup>

Species	Component(s)	N%		Ca%		Mg%		K%		P%	
		Ave.	Range	Ave.	Range	Ave.	Range	Ave.	Range	Ave.	Range
Red Spruce	Branches and unmerch. top	0.26	0.17-.33	1.06	0.68-1.40	0.08	0.07-.16	0.15	0.13-.17	0.06	0.05-.08
	Merch. bole	.15	.13-.17	.40	.06-.70	.04	.03-.15	.13	.12-.14	.03	.03-.04
	Stump and roots	.22	.19-.24	1.47	1.38-1.55	.06	.06-.06	.20	.16-.25	.05	.04-.06
Balsam Fir	Branches and unmerch. top	.31	.22-.36	.84	.56-1.18	.08	.06-.08	.36	.29-.46	.11	.08-.28
	Merch. bole	.28	.22-.37	.53	.46-.63	.06	.05-.07	.23	.20-.26	.06	.05-.08
	Stump and roots	.25	.23-.29	.64	.46-.78	.06	.03-.08	.19	.13-.23	.07	.04-.10
Hemlock	Branches and unmerch. top	.39	.32-.43	1.39	1.05-1.65	.08	.06-.08	.19	.17-.20	.10	.09-.10
	Merch. bole	.24	.16-.35	.83	.50-1.20	.04	.02-.05	.12	.06-.19	.05	.04-.09
	Stump and roots	.31	.29-.32	.54	.50-.58	.04	.03-.05	.11	.10-.13	.06	.06-.14
White Pine	Branches and unmerch. top	.50	.19-.85	.83	.60-.98	.11	.09-.14	.24	.19-.30	.07	.05-.10
	Merch. bole	.37	.26-.61	.35	.08-.63	.06	.04-.09	.13	.03-.24	.04	.03-.07
	Stump and roots	.24	.23-.24	.09	.06-.19	.04	.03-.04	.10	.05-.15	.05	.02-.16
Northern White Cedar	Branches and unmerch. top	.38	.33-.40	2.28	1.74-2.60	.07	.05-.09	.05	.02-.09	.04	.02-.05
	Merch. bole	.28	.22-.33	2.45	1.65-2.70	.07	.00-.10	.08	.04-.14	.02	.01-.04
	Stump and roots	.31	.24-.42	2.22	.95-2.60	.09	.06-.12	.16	.07-.24	.06	.03-.13
White Birch	Branches and unmerch. top	.67	.56-.89	1.05	.69-1.50	.05	.04-.06	.10	.09-.10	.04	.03-.09
	Merch. bole	.53	.41-.65	1.04	.86-1.35	.04	.04-.05	.10	.07-.14	.04	.03-.04
	Stump and roots	.35	.30-.39	.89	.67-1.20	.06	.05-.07	.16	.15-.17	.06	.05-.08
Red Maple	Branches and unmerch. top	.69	.35-1.05	1.38	1.30-1.50	.05	.05-.06	.24	.20-.29	.07	.06-.08
	Merch. bole	.51	.32-.88	1.23	.98-1.65	.04	.04-.04	.20	.19-.20	.06	.05-.08
	Stump and roots	.41	.39-.42	2.01	1.60-2.40	.07	.05-.09	.37	.29-.41	.11	.09-.13
Aspen	Branches and unmerch. top	.57	.34-.95	1.18	1.08-1.35	.09	.08-.10	.20	.18-.22	.04	.03-.05
	Merch. bole	.34	.24-.54	1.33	1.12-1.50	.08	.07-.09	.29	.27-.30	.03	.03-.04
	Stump and roots	.29	.27-.30	1.16	.75-1.45	.15	.10-.19	.39	.23-.47	.15	.11-.16

<sup>1</sup>For material larger than 1/4 inch in diameter.

TECHNICAL BULLETINS 12<sup>1</sup>, 17<sup>2</sup>, 20<sup>3</sup>, 27<sup>4</sup>, and 28<sup>5</sup> of the Maine Agricultural Experiment Station are devoted to the weight, chemical element content, and pulping characteristics of seedling, sapling, and mature red spruce, balsam fir, white pine, hemlock, northern white cedar, white birch, red maple, and aspen. The fresh weight tables in Bulletins 12, 27, and 28 include

<sup>1</sup>Young, H. E., L. Strand, and R. A. Altenberger. 1964. Preliminary fresh and dry weight tables for seven tree species in Maine. Maine Agri. Exp. Sta. Tech. Bul. No. 12.

<sup>2</sup>Young, H. E., and A. J. Chase. 1965. Fiber weight and pulping characteristics of the logging residue of seven tree species in Maine. Maine Agri. Exp. Sta. Tech. Bul. No. 17.

<sup>3</sup>Young, H. E., P. N. Carpenter, and R. A. Altenberger. 1965. Preliminary tables of some chemical elements in seven tree species in Maine. Maine Agri. Exp. Sta. Tech. Bul. No. 20.

<sup>4</sup>Dyer, R. F. 1967. Fresh and dry weight, nutrient elements and pulping characteristics of northern white cedar. Maine Agri. Exp. Sta. Tech. Bul. No. 27.

<sup>5</sup>Young, H. E., and P. N. Carpenter. 1967. Weight, nutrient element and productivity studies of seedlings and saplings of eight tree species in natural ecosystems. Maine Agri. Exp. Sta. Bul. No. 28.

the bark, but the dry weight tables in Bulletins 12 and 27 are for the wood only. The separate tables for twelve chemical elements in Bulletins 20, 27, and 28 are for the wood, bark, and leaves of complete trees or for the wood and bark of the merchantable bole. Information to prepare similar sets of tables for the bark of these species was available; however, they were not prepared at that time due to absence of a recognized need for such information.

In the past 5 years there has been increased interest in the amount of bark and its properties in complete trees. The bark segment of the basic data used for the five experiment station bulletins has been analyzed in order to prepare five tables of bark percentages and chemical elements which may be of interest and use until more comprehensive tables are available.

Table 1 shows the bark of each component of the tree as a percent of the bark of the complete tree and the bark as a percent of the wood and bark of each component. This is on a dry weight basis and excludes the leaves or needles and branches and roots less than 1/4 inch in diameter. There are noticeable differences

Table 3. AVERAGE AND ACTUAL RANGE OF SIX ESSENTIAL ELEMENTS AND ALUMINUM IN THE BARK AS PARTS PER

Species	Components	Mn ppm		Fe ppm		Zn ppm		Cu ppm	
		Ave.	Range	Ave.	Range	Ave.	Range	Ave.	Range
Red Spruce	Branches and unmerch. top	834	790-900	124	54-195	71	56- 88	14.	8-41
	Merch. bole	667	440-650	90	60-121	45	32- 53	8.	7- 9
	Stump and roots	762	720-820	112	12-180	72	64-159	8.	7- 9
Balsam Fir	Branches and unmerch. top	777	700-850	162	110-230	66	36- 94	9.	7-17
	Merch. bole	567	510-610	142	43-310	48	32-100	8.	5-14
	Stump and roots	340	300-370	193	110-300	36	22- 43	8.	5-12
Hemlock	Branches and unmerch. top	1223	1060-1390	146	82-185	41	16- 54	9.	7-11
	Merch. bole	705	440-960	58	34- 71	13	11- 18	9.	5-19
	Stump and roots	453	430-480	300	300-300	13	11- 17	6.	6- 7
White Pine	Branches and unmerch. top	319	290-340	111	88-130	94	82-120	7.	5-10
	Merch. bole	149	120-310	59	20-105	58	11-120	5.	4- 7
	Stump and roots	46	35- 57	229	83-300	19	10- 25	9.	5-14
Northern White Cedar	Branches and unmerch. top	19	12- 33	122	65-230	21	15- 25	1.	0- 3
	Merch. bole	24	12- 42	43	19- 81	20	14- 29	1.	0- 3
	Stump and roots	56	29-180	194	48-300	23	10- 50	1.	0- 3
White Birch	Branches and unmerch. top	235	10-310	38	27- 64	100	99-100	7.	5- 7
	Merch. bole	286	138-440	64	15-145	98	97-100	6.	4- 9
	Stump and roots	117	85-145	300	300-300	83	55-100	7.	6-13
Red Maple	Branches and unmerch. top	732	700-760	62	41- 74	70	56- 84	8.	6-11
	Merch. bole	643	520-880	51	37- 69	78	46-150	12.	11-14
	Stump and roots	577	480-700	278	230-300	73	35-120	11.	9-12
Aspen	Branches and unmerch. top	140	120-152	80	67- 93	97	87-100	12.	6-30
	Merch. bole	116	95-125	47	20- 76	98	84-120	8.	7- 9
	Stump and roots	100	84-115	300	300-300	93	66-120	8.	4-13

<sup>1</sup>For material larger than 1/4 inch in diameter.

between species, but in general the merchantable bole contains about half the bark of the complete tree and the wood to bark ratio is about 4.6:1 for the complete tree.

Tables 2 and 3 show the estimated average and range in percent for the five macro-essential elements

and in parts per million for the six micro-essential elements and for aluminum. These tables have been compared with similar tables in Bulletin 28 which are based on composite samples of wood and bark together. In almost every instance the entries in Bulletin 28 are less, indicating that the concentration of almost every

Table 4. — ESTIMATED AMOUNT OF ELEMENT IN BARK AS PERCENT OF AMOUNT OF ELEMENT IN COMPLETE TREE FOR EIGHT SPECIES.<sup>1</sup>

Species	Elements											
	Al	Mn	Mo	Ca	P	Mg	Zn	Cu	Fe	B	N	K
Red Spruce	48	25	39	40	17	24	35	20	28	25	14	25
Balsam Fir	28	23	34	34	30	25	30	13	45	31	14	30
Hemlock	34	25	50	42	18	19	37	21	34	21	14	16
White Pine	74	43	55	63	46	44	49	22	57	57	21	39
Northern White Cedar	82	29	58	54	34	33	37	26	31	18	29	31
White Birch	25	45	55	59	23	23	36	14	43	40	32	17
Red Maple	59	49	70	64	34	30	30	24	40	46	38	25
Aspen	59	39	69	67	41	43	55	28	53	53	34	40

<sup>1</sup>This table does not include elements in bark in material in the tree smaller than 1/4 inch, however, the element in such material is included in estimates of the complete tree resulting in a slight underestimate in this table.

B ppm		Mo ppm		Al ppm	
Ave.	Range	Ave.	Range	Ave.	Range
14.	12.0-15.5	6.7	4.0-10.0	89.	46-125
10.	8.0-11.0	4.2	2.8- 5.5	49.	40- 61
11.	9.5-13.0	10.0	9.6-10.4	158.	74-200
13.	12.0-14.0	5.5	3.9- 7.5	154.	105-200
12.	8.0-14.0	3.4	2.4- 5.5	87	52-170
12.	8.0-16.0	4.3	2.8- 5.4	132	76-200
18.	15.0-19.5	8.7	6.0-10.0	130	115-140
11.	9.0-13.5	5.0	3.2- 7.5	124	112-150
16.	13.0-17.0	3.1	2.5- 3.5	200	200-200
14.	13.0-16.0	5.1	3.3- 7.0	157	128-195
11.	3.0-15.0	2.0	0.6- 4.4	134	74-175
14.	7.5-25.0	.7	0.5- 1.1	200	200-200
9.	7.0-11.0	16.	13.0-17.0	85	41-151
6.	5.5-12.0	15.	9.0-17.0	37	22- 66
10.	8.0-16.0	15.	8.0-17.0	168	61-210
12.	11.0-13.0	6.3	3.9- 9.5	24	12- 54
14.	11.0-16.0	7.0	4.8- 9.8	37	10- 90
17.	14.0-19.0	5.6	4.0- 6.8	200	200-200
17.	15.0-19.5	7.5	6.5- 8.0	23	18- 27
13.	13.0-14.0	6.2	4.8- 8.6	15	8- 27
20.	15.0-28.0	12.4	9.5-14.5	172	142-400
14.	10.0-17.0	6.4	4.4- 8.5	36	16- 47
14.	13.0-15.0	7.1	5.4- 8.5	15	11- 27
27.	26.0-32.0	6.2	3.4- 8.0	....	.... ....

chemical element in every component is higher in the bark than in the wood of the same component.

Tables 4 and 5 also show the variation between species for each of the 12 elements in the bark as a percent of the merchantable bole or complete tree. Twenty of the entries in Table 4 are more than 50 percent of the complete tree and almost all of the others are greater than might be expected from a 4.6:1 wood to bark ratio

comparing the increased concentration of the elements in the bark. In Table 5, except for balsam fir, the only element that is 26 percent or less of the merchantable bole is copper. For the other 11 elements the bark contains nearly half and often more than half of the total amount of that element in the merchantable bole.

Within the past 15 years most of the pulp mills in Maine have changed their policy from requiring peeled wood to one of accepting rough wood. This eliminates dependence on the sap peeling season in the spring, permitting a year-round flow of wood to the mills which can be mechanically debarked at less expense than manual debarking in the forest. The peeled merchantable bole contains approximately 25 percent of each of the essential chemical elements of a complete tree. This relatively new policy not only doubles the amount of nutrient elements (about 50 percent removed from the felled trees), but also creates a problem in the establishment of mountainous piles of bark in the mill yard. Unless natural processes are able to replace the nutrient elements removed from the mineral cycling process of current harvesting methods, the productivity of the forest must eventually be reduced. This is equally applicable to all other uses of wood where debarking is performed in the mill yard.

Bark has never been studied to the same degree as wood. These preliminary tables of eight tree species indicate the amount of bark and the chemical elements in bark; however, more detailed work including more species is desirable. Only a few studies have been made of the organic compounds in bark and their potential use. These and other studies of bark are of basic importance within the context of the complete tree concept<sup>6</sup>, which calls for biological and technological investigations of the entire tree from the root hairs to the leaf hairs, inclusive. Such studies will lead to intelligent use of the forest in such a manner that the requirements of our society for the living forest and its products can be maintained in an ecologically sound manner.

<sup>6</sup>Young, H. E. 1964. The complete tree concept - a challenge and an opportunity. Proc. Annual Meeting 1964, Soc. Amer. Foresters.

Table 5. — ESTIMATED AMOUNT OF ELEMENT IN BARK AS PERCENT OF AMOUNT OF ELEMENT IN WOOD AND BARK OF MERCHANTABLE BOLE FOR EIGHT TREE SPECIES.<sup>1</sup>

Species	Elements											
	Al	Mn	Mo	Ca	P	Mg	Zn	Cu	Fe	B	N	K
Red Spruce	100	37	38	46	53	51	47	21	44	67	27	49
Balsam Fir	100	51	66	59	100	32	47	93	70	56	43	42
Hemlock	100	47	77	66	48	41	55	24	64	66	41	36
White Pine	100	60	65	82	100	66	57	19	61	73	37	53
Northern White Cedar	81	100	78	62	32	47	63	26	16	18	48	63
White Birch	19	58	63	69	30	30	38	20	49	69	50	39
Red Maple	62	59	78	70	76	36	29	26	43	63	47	31
Aspen	100	52	82	75	48	44	61	25	55	65	47	37

<sup>1</sup>From stump to 4 inch top diameter, inclusive.