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Aboveground Tree Biomass on Productive Forest Land in Alaska

John Yarie and Delbert R. Mead

Authors

JOHN YARIE is a research associate with the Forest Soils Laboratory, 905 Koyukuk Avenue North, University of Alaska, Fairbanks 99701. DELBERT R. MEAD is a forester with the Renewable Resources Evaluation Unit of the Pacific Northwest Forest and Range Experiment Station, 2221 East Northern Lights, Anchorage, Alaska 99508.

Abstract

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Total aboveground woody biomass of trees on forest land that can produce 1.4 cubic meters per hectare per year of industrial wood in Alaska is 1.33 billion metric tons green weight. The estimated energy value of the standing woody biomass is 11.9 x 10'5 Btu's. Statewide tables of biomass and energy values for softwoods, hardwoods, and species groups are presented.

Keywords: Biomass, energy, wood utilization, Alaska.

Summary

Compilation of tree biomass in Alaska was part of a nationwide state-of-the-art project undertaken in 1980. This project was conceived because economic interest in forest biomass has risen dramatically in recent years concurrent with interest in alternative fuels and development of new technologies that could use total tree biomass. The project pulled together much existing information on the subject and enabled us to make estimates of biomass supply; it also provided an opportunity to assess existing knowledge and identify species for which additional research is needed.

Biomass values were developed by applying biomass equations for individual species to stand tables compiled from existing inventory data. Stand tables used in this compilation were built with data gathered from many years of aerial photo interpretation and ground sampling by Alaska's Renewable Resources Evaluation project. Biomass equations were developed by many researchers over a period of years. Sources of the equations are listed in appendix table 8.

All biomass values were calculated in pounds of green weight for two tree categories, bole and top. Data are presented by coastal and interior geographic units. Coastal forest areas are typically high biomass (176 tons/acre) Sitka spruce-hemlock-cedar stands and account for 85 percent of total biomass in the State. Interior areas have lower biomass (55 tons/acre) and account for only 15 percent of the total. White spruce, black spruce, birch, and aspen are the predominant species.

Information in this report is a best estimate based on current data. Only areas previously inventoried were included, and inventory data represents the more densely forested areas of the State judged to be capable of producing 20 cubic feet of bole wood per acre per year. Obviously, large areas of the State and substantial biomass were excluded; however, areas of highest biomass density and greatest economic potential are included. No estimate of sample error is provided because of the large number of equations and inventory units used for the final estimates. Caution is urged in applying these estimates except as a general planning tool.

Introduction

The portion of alternative energy sources being used to satisfy total energy demand is increasing in many countries throughout the world. As with oil and coal, the availability of these resources is important to know.

Wood is one renewable source of energy that is often considered for alternative energy. As a first step in determining the potential energy in the Nation's forest trees, traditional, product-oriented forest inventories have to be reanalyzed to estimate total forest biomass. This report is the result of such an effort for the State of Alaska. The information should be considered within the restrictions specified; it represents a preliminary best estimate, compiled from available data.

' See "Glossary" for definitions of terms used in this paper.

Methods

Standing tree biomass (appendix tables 5, 6, and 7) was estimated from stand-table data 2 using biomass equations (appendix table 8) for each major species found in the State. The stand-tables were constructed for both of the State's major resource areas: coastal and interior (fig. 1).

All biomass values were calculated in pounds of green weight from the equations shown in appendix tables 8 and 9. Standing tree biomass was calculated for two categories, bole and top. Bole was defined as the main stem of the tree including wood and bark from a 1-foot (30.5-cm) stump to a 4-inch-(10.2-cm-) diameter outside bark (d.o.b.) top. Top was defined as the main stem above a 4-inch d.o.b. top and all live branches, excluding foliage but including bark. A 3-inch (7.6-cm) top diameter was used for black cottonwood. Total biomass was the bole plus the top.

Some adjustments had to be made in applying these equations:

- Sometimes, predicted values derived from bole-biomass equations were greater than predicted values from total-stem equations (from a 1-foot stump to a 0 d.o.b. top, excluding branches). This occurred only in extrapolating beyond the range of the data used to develop the regression equation. This extrapolation was necessary because the true range of inventoried tree sizes was greater than the range in data used to develop the regression equation (table 5). A top-to-stem weight ratio (table 9) was used to proportion total stem weight into that above and below the 4-inch top diameter. The top-to-stem weight ratio was calculated using a ratio computed from a sample of actual bole weights or volumes to total stem weights or volumes for each diameter class. Above a certain diameter class, the species-specific, top-to-stem weight ratio was assumed to be constant (table 9).

- No biomass equations were available for Sitka spruce, so a volume equation had to be used. The factor used to convert from stem volume to green weight is presented in table 9.

- The equation for red alder branches predicts negative values within the range of stand-table diameters, so a constant value of 143.3 pounds (65 kg) was assumed above a d.b.h. of 16 inches (40.6 cm). This assumption probably results in a 10-percent or less underestimate of red alder biomass.

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[2] Stand-table data were taken from published reports for the Susitna, Fairbanks, Upper Koyukuk, Copper River, Tuxedni, Kuskokwim, and Haines-Skagway units (Hegg 1974a, b, c, 1975, 1979; Hegg and Sievering 1979; LaBau and Hutchinson 1976. Data were also taken from unpublished reports compiled by the Renewable Resources Evaluation Unit, Forestry Sciences Laboratory, Suite 106, 2221 East Northern Lights Blvd., Anchorage, Alaska 99508, for the following inventory units: Juneau, 1970; Sitka, 1971; Petersburg, 1972; Kantishna, 1973; Prince of Wales, 1973; Ketchikan, 1974; Upper Tanana, 1974; Wood-Salcha, 1975; Yakatat, 1975; Afognak, 1976; Cordova-Whittier, 1977; and Kenai, 1978. These reports are on file at the Forestry Sciences Laboratory.

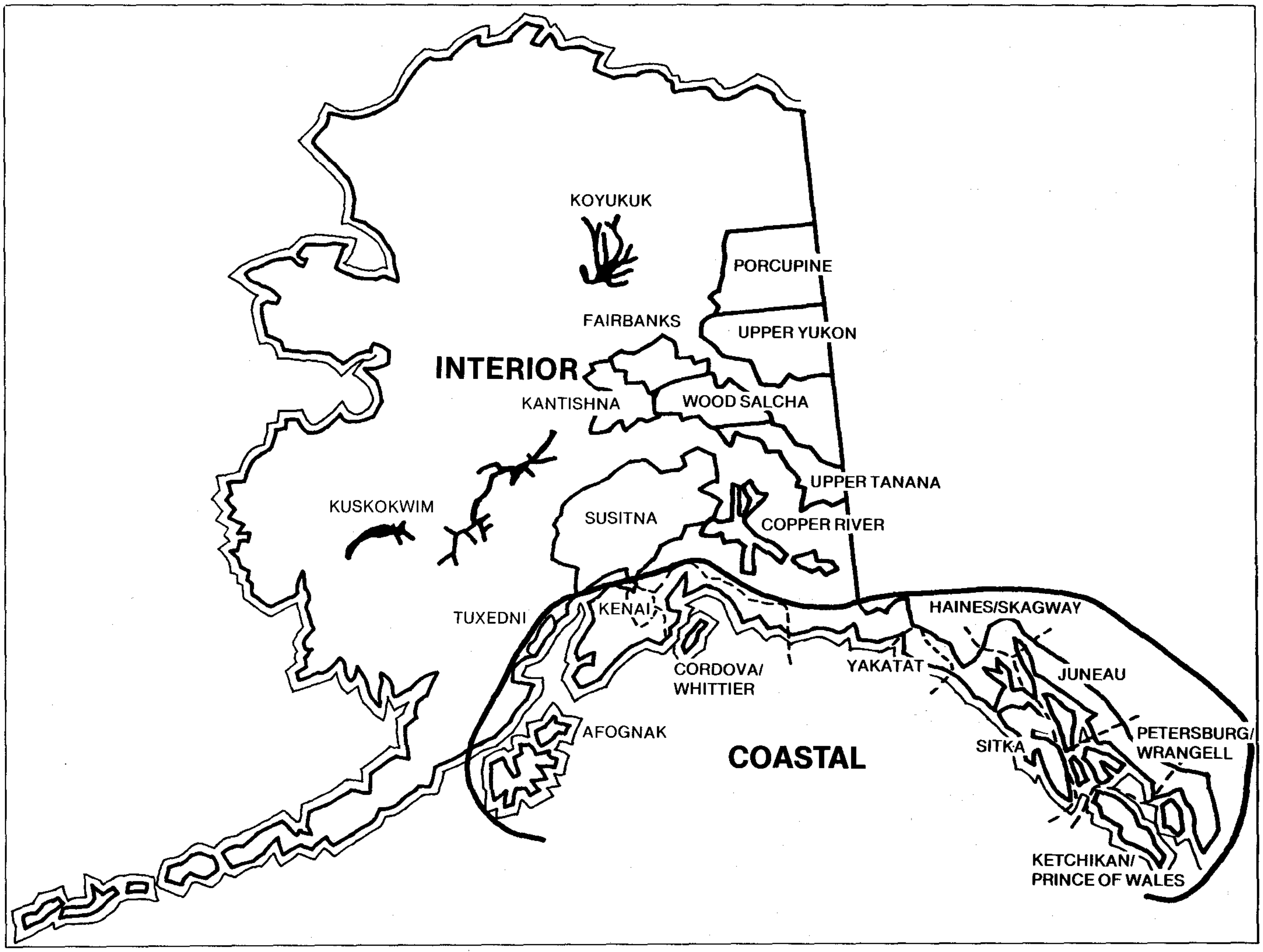

Figure 1.-Inventory units included in the aboveground tree biomass study.

Indirect methods were used to estimate biomass of rough and rotten trees because stand tables were unavailable. The ratio of rough and rotten trees to growing stock was obtained from the review draft of a USDA Forest Service paper.[3] The ratio was calculated separately for softwoods and hardwoods in interior and coastal Alaska. Totals were then added into the tables, based on the proportion of the individual species weight to total weight.

[3] Appendix table 8 in "An analysis of the timber situation in the United States, 1952-2030," Washington, DC; U.S. Department of Agriculture, Forest Service. Paper in review.

Total biomass of rough and rotten trees for coastal Alaska was only 7 percent of the growing-stock volume, so the error is probably less than 5 percent for individual species. The percentage of rough and rotten trees found in interior Alaska was even less.

Energy content was calculated using conversion factors given in Cheremisinoff (1980) for wood. The energy values listed in our tables are slight underestimates because bark and wood were considered together. Bark usually has a higher energy value than wood.

Discussion

Statewide estimates of aboveground forest biomass were compiled for Alaska in late 1980 as part of a nationwide assessment of forest biomass. The estimates were compiled from existing forest-inventory data of productive forest lands in the State. Units that had previously been inventoried (fig. 1) include:

Coastal	Afognak, 1976
	Cordova/Whittier, 1977
	Haines/Skagway, 1965
	Juneau,1970
	Kenai, 1978
	Ketchikan/Prince of Wales, 1974
	Petersburg/Wrangell, 1972
	Sitka, 1971
	Yakatat, 1975
Interior	Copper River, 1968
	Fairbanks, 1970
	Kantishna, 1973
	Koyukuk, 1971
	Kuskokwim,1967
	Susitna, 1964-65
	Tuxedni, 1971
	Upper Tanana, 1974
	Wood-Salcha, 1975

These units include most of southeast Alaska and substantial portions of the southcentral coast. Early interior inventories, such as the Kuskokwim and Koyukuk units, were centered along river bottoms and used available aerial photographs; later inventories included entire river basins (Susitna and Tanana).

The forest-land area and biomass listed in the following tables reflect only the amount of productive forest land inventoried in the above units. These units represent major forest areas of the State, but substantial, marginally productive forest areas remain uninventoried. We estimate that, if all forest lands in Alaska were included, the total biomass estimate would be at least double. A preliminary estimate of 100 million green tons of aboveground tree biomass (Yarie, unpub. data) for an inventory unit completed too late for inclusion in this report is about 38 percent of the total estimate presented in table 1 for interior Alaska. This unit represents only 9,000,000 acres in the upper Yukon drainage. In addition, several other units in the interior still remain uninventoried.

At the time stand-table data were compiled, patterns of forest ownership in Alaska were undergoing changes because of the Alaska Lands Bill. Large amounts of land are changing ownership as the Federal Government relinquishes title to the State of Alaska and Native corporations. Also, when passage of the bill was pending, large amounts of land tentatively selected by the State were readied for conveyance to the State's boroughs, municipalities, and private citizens via land sales and homesite programs. Therefore, identifying biomass by ownership class is impossible, and no biomass data are presented by class of ownership.

We can expect substantial changes in the amount and size-class distribution of the State's forest biomass as landuse changes occur along with changing ownership. The State has already undertaken several large land-clearing operations as it attempts to establish agricultural projects; also, more land is available for private use and development. Some of the State's more heavily forested areas, formerly administered by the USDA Forest Service, have been selected by Native corporations. As a result, we could expect changes in timber-sale patterns and subsequent biomass distribution.

Total biomass for the inventoried units is estimated at 1.47 billion tons green weight (1.33 billion metric tons (m.t.)). A conservative dry-weight estimate would be 0.7 billion tons (0.63 billion m.t.) (table 1). Coastal Alaska (fig. 1) accounts for 85 percent of the total biomass (1.12 billion m.t.); only 15 percent of the State's total is found in interior Alaska (table 1). Ninety-two percent of the total can be accounted for by growing-stock trees (1.22 billion m.t.), and only a small portion is rough and rotten material (4 percent or 53 million m.t.). The remaining 4 percent (54 million m.t.) are classed as saplings (table 1).

The vast differences in forest structure between coastal and interior forests (figs. 1, 2, and 3) are shown in tables 2, 3, and 4. Productive forest land in coastal Alaska averages 176 green tons/acre (395 m.t./ha); interior lands average only 55 green tons/acre (124 m.t./ha) (table 2). Total sapling biomass in the interior is about 3 times greater per acre than on the coast. The difference in sapling biomass results from large differences in fire frequency and response of species to fire between interior and coastal Alaska.

Most (95 percent) of total biomass found in interior Alaska is in trees less than 20 inches (51 cm) in diameter at breast height (d.b.h.); in coastal Alaska, 63 percent of the total biomass is in trees larger than 20 inches d.b.h. (tables 3 and 4).

Softwoods accounted for 99 percent of the total coastal biomass, but only 43 percent of the total interior biomass (tables 3 and 4). Western hemlock and spruce species accounted for 75 percent of the total aboveground woody biomass on productive forest lands in Alaska (tables 3 and 4). Mountain hemlock ("Other softwoods," table 3) and paper birch were next, accounting for only 8 and 6 percent of the total aboveground woody biomass, respectively (tables 3 and 4).

Table 1—Total green weight of aboveground tree biomass on commercial forest land in Alaska by class of timber, species group, and region

Region, species group	Total biomass			Growing stock			Rough and rotten			Saplings		
	Total	Bole	Top	Total	Bole	Top	Total	Bole	Top	Total	Bole	Top
						Million green tons						
Coastal:												
Softwoods	1232.7	927.8	304.9	1160.0	880.9	279.1	51.6	39.2	12.4	21.1	7.7	13.4
Hardwoods	9.5	6.6	2.9	8.5	6.1	2.4	0.4	0.3	0.1	0.6	0.2	0.4
Total	1242.2	934.4	307.8	1168.5	887.0	281.5	52.0	39.5	12.5	21.7	7.9	13.8
Interior:												
Softwoods	97.0	69.2	27.8	90.0	66.9	23.1	0.8	0.6	0.2	6.2	1.7	4.5
Hardwoods	129.0	67.5	61.5	94.3	57.9	36.4	3.9	2.4	1.5	30.8	7.2	23.6
Total	226.0	136.7	89.3	184.3	124.8	59.5	4.7	3.0	1.7	37.0	8.9	28.1
Alaska total	1468.2	1071.1	397.1	1352.8	1011.8	341.0	56.7	42.5	14.2	58.7	16.8	41.9

Table 1A—Total energy value of aboveground tree biomass on commercial forest land in Alaska by class of timber, species group, and region

Region, species group	Total biomass			Growing stock			Rough and rotten			Saplings		
	Total	Bole	Top	Total	Bole	Top	Total	Bole	Top	Total	Bole	Top
						Quads 1/						
Coastal:												
Softwoods	9.991	7.520	2.471	9.402	7.140	2.262	0.418	0.318	0.100	0.171	0.062	0.109
Hardwoods	0.074	0.051	0.023	0.066	0.047	0.019	0.003	0.002	0.001	0.005	0.002	0.003
Total	10.065	7.571	2.494	9.468	7.187	2.281	0.421	0.320	0.101	0.176	0.064	0.112
Interior:												
Softwoods	0.758	0.541	0.217	0.703	0.523	0.180	0.007	0.005	0.002	0.048	0.013	0.035
Hardwoods	1.090	0.570	0.520	0.797	0.489	0.308	0.033	0.020	0.013	0.260	0.061	0.199
Total	1.848	1.111	0.737	1.500	1.012	0.488	0.040	0.025	0.015	0.308	0.074	0.234
Alaska total	11.913	8.682	3.231	10.968	8.199	2.769	0.461	0.345	0.116	0.484	0.138	0.346

1/ Quads = (10^{15} Btu's). Btu's in quads (10^{15} Btu's) for air-dry material (moisture content = 12 percent).

Figure 2.-A coastal Sitka spruce stand illustrating high biomass per acre in trees of large diameter.

Table 2—Green weight of aboveground biomass on productive forest land in Alaska by class of timber, species group, and region

Region, species group	Total biomass			Growing stock			Rough and rotten			Saplings		
	Total	Bole	Top	Total	Bole	Top	Total	Bole	Top	Total	Bole	Top
					Green tons per acre							
Coastal:												
Softwoods	175.08	131.78	43.30	164.76	125.12	39.64	7.33	5.57	1.76	2.99	1.09	1.90
Hardwoods	1.35	0.94	0.41	1.21	0.87	0.34	0.05	0.04	0.01	0.09	0.03	0.06
Total	176.43	132.72	43.71	165.97	125.99	39.98	7.38	5.61	1.77	3.08	1.12	1.96
Interior:												
Softwoods	23.60	16.84	6.76	21.90	16.28	5.62	0.20	0.15	0.05	1.50	0.41	1.09
Hardwoods	31.38	16.42	14.96	22.95	14.09	8.86	0.94	0.58	0.36	7.49	1.75	5.74
Total	54.98	33.26	21.72	44.85	30.37	14.48	1.14	0.73	0.41	8.99	2.16	6.83
Alaska total	131.68	96.06	35.62	121.33	90.74	30.58	5.09	3.81	1.28	5.26	1.51	3.75

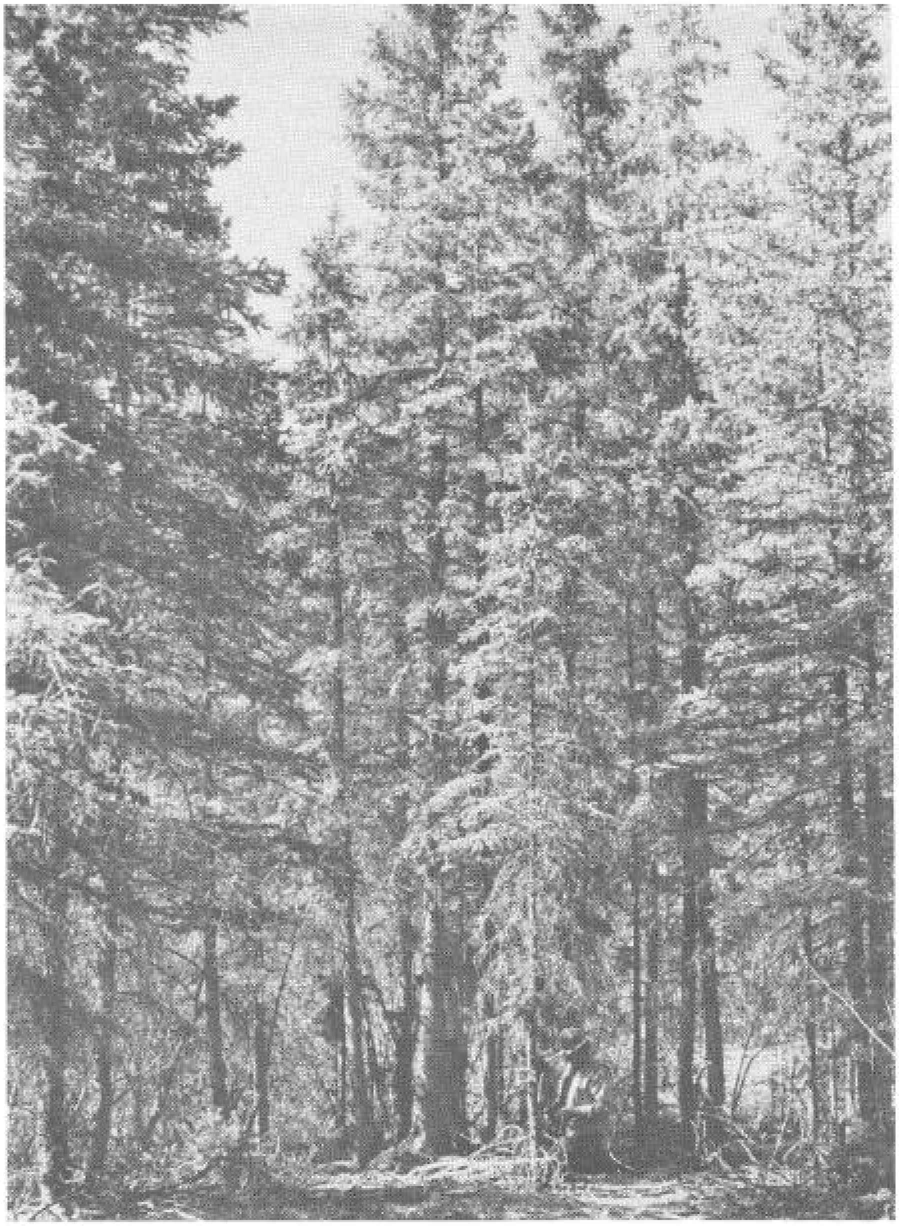

Figure 3.-An interior white spruce stand illustrating lower biomass per acre with most of the biomass in sapling-sized trees.

Table 3—Total green weight of aboveground softwood tree biomass on commercial forest land in Alaska by species, diameter class, and region

Region and diameter class	Total softwoods	True firs	Spruces	Western hemlock	Western red cedar	Other cedars	Lodgepole pine	Other softwoods
Inches				Million green tons				
Coastal:								
1.0-5.0	21.8	0.01	2.8	14.1	0.4	1.1	0.0	3.4
5.0-9.0	74.8	0.02	11.3	45.1	1.3	5.0	0.05	12.0
9.0-19.0	359.3	0.05	79.0	191.0	11.5	30.7	0.5	46.5
19.0-29.0	412.2	0.01	104.4	226.1	15.4	23.8	0.3	42.2
29.0+	364.6	0.01	135.4	194.6	12.4	6.3		15.9
Total	1232.7	0.1	332.9	670.9	41.0	66.9	0.85	120.0
Interior:								
1.0-5.0	6.2		6.2					
5.0-9.0	27.6		27.6					
9.0-19.0	60.8		60.8					
19.0-29.0	2.2		2.2					
29.0+	0.2		0.2					
Total	97.0		97.0					
Alaska total	1329.7	0.1	429.9	670.9	41.0	66.9	0.85	120.0

Table 3A—Total energy value of aboveground softwood tree biomass on commercial forest land in Alaska by species, diameter class, and region

Region and diameter class	Total softwoods	True firs	Spruces	Western hemlock	Western red cedar	Other cedars	Lodgepole pine	Other softwoods
Inches				Quads 1/				
Coastal:								
1.0-5.0	0.178	0.0001	0.022	0.117	0.003	0.008		0.028
5.0-9.0	0.610	0.0002	0.088	0.373	0.010	0.039	0.0005	0.099
9.0-19.0	2.915	0.0005	0.617	1.581	0.089	0.237	0.005	0.385
19.0-29.0	3.342	0.0001	0.816	1.871	0.119	0.184	0.003	0.349
29.0+	2.946	0.0001	1.058	1.611	0.096	0.049		0.132
Total	9.991	0.001	2.601	5.553	0.317	0.517	0.009	0.993
Interior:								
1.0-5.0	0.048		0.048					
5.0-9.0	0.216		0.216					
9.0-19.0	0.475		0.475					
19.0-29.0	0.017		0.017					
29.0+	0.002		0.002					
Total	0.758		0.758					
Alaska total	10.749	0.001	3.359	5.553	0.317	0.517	0.009	0.993

1/Quad = (10^{15} Btu's) for air-dry material.

Table 4—Total green weight of aboveground hardwood tree biomass on commercial forest land in Alaska by species, diameter class, and region

Region and diameter class	Total all hardwoods	Cottonwood and aspen	Red alder	Other hardwoods
Inches		Million green tons		
Coastal:				
1.0-5.0	0.5	0.1	0.2	0.2
5.0-9.0	1.5	0.4	0.9	0.2
9.0-19.0	4.5	2.3	2.0	0.2
19.0-29.0	1.8	1.7	0.1	0.02
29.0+	1.0	1.0	0.02	
Total	9.3	5.5	3.22	0.62
Interior:				
1.0-5.0	31.7	5.6		26.1
5.0-9.0	45.9	13.6		32.3
9.0-19.0	41.4	13.5		27.9
19.0-29.0	7.6	7.3		0.3
29.0+	2.4	2.4		
Total	129.0	42.4		86.6
Alaska total	138.3	47.9	3.22	87.22

Table 4A—Total energy value of aboveground hardwood tree biomass on commercial forest land in Alaska by species, diameter class, and region

Region and diameter class	Total all hardwoods	Cottonwood and aspen	Red alder	Other hardwoods
Inches		Quads[1]		
Coastal:				
1.0-5.0	0.005	0.001	0.002	0.002
5.0-9.0	0.012	0.003	0.007	0.002
9.0-19.0	0.036	0.018	0.016	0.002
19.0-29.0	0.014	0.013	0.0008	0.0001
29.0+	0.007	0.007	0.0002	
Total	0.074	0.042	0.026	0.006
Interior:				
1.0-5.0	0.273	0.042		0.231
5.0-9.0	0.390	0.104		0.286
9.0-19.0	0.350	0.103		0.247
19.0-29.0	0.059	0.056		0.003
29.0+	0.018	0.018		
Total	1.090	0.323		0.767
Alaska total	1.164	0.365	0.026	0.773

1/Quad = (10^{15} Btu's) for air-dry material.

The total proportion of biomass of bole to top was 3 to 1 for coastal Alaska and 1.5 to 1 for interior. The difference is because the ratio of bole to top is 1 to 1 for interior hardwoods and 2 to 1 for all interior growing stock. Although utilization could be increased by a higher percentage in interior forests if the complete tree were used, coastal Alaskan forests contain about 3.5 times more top biomass than the interior forests.

Total energy content in aboveground tree biomass minus foliage is estimated as 11.913 quads (10'5 Btu's) (table 1A). Coastal Alaska again accounts for the highest portion or 10.065 quads; only 1.848 quads were found in productive interior forests. Total energy content in aboveground tree biomass per hectare is 3.54 billion Btu's in coastal forests and 1.11 billion Btu's in interior forests. The same general trends found in biomass are also found when the data are converted to energy content.

Based on data collected by Goldsmith and Lane (1978) for 1976, the estimated aboveground biomass could meet all of Alaska's energy demands (at 1976 levels) for 55 years. Eliminating energy required by transportation and petroleum processing, the current biomass reserves could supply energy for electricity conversions, heating, and miscellaneous uses for 123 years at the rate of energy consumption in 1976. This latter figure is close to the suggested rotation age for many of Alaska's forest types.

Glossary

Bole biomass-Green weight of the wood and bark of the main stem of a tree from a 1-foot stump to a 4-inch top diameter outside bark (d.o.b.). (A 3-inch d.o.b. top was used for cottonwood.)

Diameter class-A classification of trees based on diameter outside bark, measured at breast height (4 1/2 feet (1.37 m) above the ground).

Forest trees-Woody plants having a well-developed stem and usually more than 12 feet (3.65 m) in height at maturity.

Growing stock trees-Live trees of commercial species that are capable of producing at least one 12-foot sawlog, have no serious defect in quality limiting present or prospective use for timber products, are of relatively high vigor, and contain no pathogens that may result in death or serious deterioration before rotation age.

Productive forest land-Land at least 16.7-percent stocked by forest trees of any size, or formerly having had such tree cover and not currently developed for nonforest use. This land must also be capable of producing 20 cubic feet/acre per year of industrial wood.

Quads-An energy value equivalent at 10'5 British thermal units (Btu's).

Saplings-Live trees 1.0-4.9 inches (2.54-12.5 cm) in diameter at breast height.

Seedlings-Live trees less than 1.0 inch (2.54 cm) in diameter at breast height.

Stand table-A table of tree numbers by species and diameter class.

Top biomass-Green weight of the wood and bark of the main tree stem above a 4-inch top diameter outside bark plus all live branches minus foliage.

Total biomass-Green weight of wood and bark above a 1-foot stump (bole + top).

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Table 5—Total green weight of aboveground softwood tree biomass on productive forest land in coastal Alaska [1/]

	Alaska yellow cedar		Lodgepole pine		Mountain hemlock		Sitka spruce		True firs		Western red cedar		Western hemlock		White spruce	
Diameter class	Bole	Top	Bole	Top	Bole	Top	Bole	Top	Bole	Top	Bole	Top	Bole	Top	Bole	Top
Inches	Thousands of tons of growing stock															
1.0 - 2.9	0	70	0	1	0	108	0	29	0	0	0	20	0	533	0	0
3.0 - 4.9	340	700	0	0	1118	2101	1568	1080	3	6	122	251	4491	8438	0	0
5.0 - 6.9	1652	710	27	18	3847	1656	3184	761	17	5	409	176	13101	5639	0	0
7.0 - 8.9	1741	708	2	0	4507	1523	5810	1018	1	0	419	170	18251	6167	0	0
9.0 - 10.9	3398	1204	46	13	5595	1733	8276	1169	37	9	1134	402	22353	6925	17	6
11.0 - 12.9	4065	1133	2	0	7207	2417	11480	1521	1	0	1205	336	25226	8461	8	2
13.0 - 14.9	4925	1357	2	0	7044	2529	14514	1965	2	0	1519	419	25778	9256	19	5
15.0 - 16.9	5212	1423	161	30	6828	2314	15083	2081	1	0	2116	578	29750	10081	16	4
17.0 - 18.9	5243	1420	218	43	6549	2351	17131	2403	1	0	2576	698	33269	11944	11	2
19.0 - 20.9	5305	1355	116	18	6790	2567	18674	2659	1	0	2709	692	32613	12331	5	1
21.0 - 22.9	4003	1015	74	12	6966	2761	18273	2637	2	0	2448	621	31390	12440	6	1
23.0 - 24.9	3374	850	29	5	5486	2270	17674	2582	1	0	1856	468	33747	13962	0	0
25.0 26.9	3059	767	28	4	5027	2164	16119	2382	3	1	2279	571	28024	12064	0	0
27.0 - 28.9	2492	621	0	0	4426	1977	16500	2464	4	1	2487	620	27656	12352	0	0
29.0 - 30.9	1671	415	0	0	2837	1311	13661	2060	3	1	1969	488	21117	9761	0	0
31.0 - 32.9	1274	315	0	0	2341	1118	14414	2194	2	0	1238	306	22518	10748	0	0
33.0 - 34.9	711	175	0	0	1488	732	11728	1801	2	0	1874	460	17699	8708	0	0
35.0 - 36.9	409	100	0	0	999	506	12676	1962	2	0	1133	277	14976	7581	0	0
37.0 - 38.9	165	40	0	0	1006	523	9191	1434	1	0	751	183	11521	5992	0	0
39.0 - 40.9	140	34	0	0	461	246	7723	1214	1	0	564	137	9397	5015	0	0
41.0 - 42.9	103	25	0	0	538	294	7224	1143	1	0	423	102	8653	4732	0	0
43.0 - 44.9	111	27	0	0	44	25	6119	975	0	0	354	85	5745	3216	0	0
45.0 - 46.9	0	0	0	0	217	124	5780	926	0	0	352	85	3900	2232	0	0
47.0 - 48.9	174	42	0	0	146	86	3538	571	0	0	266	64	3302	1931	0	0
49.0 - 50.9	36	9	0	0	0	0	3047	494	0	0	238	57	1720	1026	0	0
51.0 - 52.9	0	0	0	0	124	75	2770	452	0	0	176	42	456	277	0	0
53.0 - 54.9	0	0	0	0	0	0	2870	471	0	0	0	0	1127	699	0	0
55.0 - 56.9	0	0	0	0	0	0	1756	290	0	0	0	0	583	368	0	0
57.0 - 58.9	0	0	0	0	0	0	1051	174	0	0	0	0	160	103	0	0
59.0 - 60.9	0	0	0	0	0	0	2889	481	0	0	184	43	391	256	0	0
61.0 - 62.9	0	0	0	0	0	0	5659	947	0	0	0	0	284	189	0	0
Total	49605	14513	705	144	81592	33511	276380	42337	85	26	30803	8352	449196	193430	81	21

[1/] Totals may be off because of rounding.

Table 8—Documentation of methodology, equations, and moisture content values

Species or species group	Equation used	Diameter ranges: Equation	Diameter ranges: Stand table	Source
		-------- Inches --------		
White spruce	Bole green wt (kg) = $24.042 - 8.974D + 0.76D^2$ Top green wt (kg) = $(1-CF)(14.9754 - 4.313D + 0.667D^2)$ Branch dry wt (kg) = $2.59 - 7.56D + 0.07D^2$ Branch moisture content = 95.65 percent	1.5-19.7	1.0-30.0	Yarie and Van Cleve, personal communication
Black spruce	Bole green wt (kg) = $CF(1.7144 - 1.023D + 0.353D^2)$ Top green wt (kg) = $(1-CF)(1.7144 - 1.023D + 0.353D^2)$ Branch dry wt (kg) = $-0.1261 + 0.128D + 0.003D^2$ Branch moisture content = 62.26 percent	1.0-5.0	1.0-14.0	Yarie and Van Cleve, personal communication
Aspen	Bole dry wt (kg) = $CF(10^{(-1.893 + 2.3564 \log D)})$ Top dry wt (kg) = $(1-CF)(10^{(-1.1893 + 2.3564 \log D)})$ Branch dry wt (kg) = $10^{(-2.0987 + 2.3708 \log D)}$ Bole, top, and branch moisture content = 62.58 percent	1.0-14.0	1.0-18.0	Peterson et al. 1970 Van Cleve, personal communication
Paper birch	Bole green wt (kg) = $-13.18 + 0.355D^2$ Top green wt (kg) = $-4.768 + 3.609D + 0.02D^2$ Branch dry wt (kg) = $-0.8166 + 0.013D + 0.056D^2$ Branch moisture content = 72.77 percent	1.7-14.2	1.0-28.0	Yarie and Van Cleve, personal communication
Balsam poplar	Bole green wt (kg) = $8.8429 - 9.383D + 0.92D^2$ Top green wt (kg) = $(1-CF)(-7.6691 - 0.952D + 0.646D^2)$ Branch dry wt (kg) = $-0.026D + 0.041D^2$ Branch moisture content = 80.87 percent	1.6-18.3	1.0-31.0	Yarie and Van Cleve, personal communication
Black cottonwood	Bole green wt (lb) = $4.237D + 1.253D^2$ Top and branch green wt (lb) = $0.503D^2$	8.4-25.3	1.0-46.0	Yarie from State of Alaska data
Hemlock	ln STEMWOOD dry wt (kg) = $-2.172 + 2.257 (\ln D)$ ln STEMBARK dry wt (kg) = $-4.373 + 2.258 (\ln D)$ ln BRANCH dry wt (kg) = $-5.149 + 2.778 (\ln D)$ Wood moisture content = 83.2 percent Branch moisture content = 84.73 percent Bark moisture content = 121.4 percent	6.0-30.7	1.0-62.0	Gholz et al. 1979 Kurucz 1969
Cedar	ln STEMWOOD dry wt (kg) = $-2.0927 + 2.1863 (\ln D)$ ln STEMBARK dry wt (kg) = $-4.1934 + 2.1101 (\ln D)$ ln BRANCH dry wt (kg) = $-3.2661 + 2.0877 (\ln D)$ Wood moisture content = 96.3 percent Bark moisture content = 115.73 percent Branch moisture content = 98.05 percent	6.1-23.7	1.0-62.0	Gholz et al. 1979 Kurucz 1969

Inches	Thousand green tons of growing stock										
1.0 - 2.9	0	109	0	78	0	16	0	8010	0	19	0	339
3.0 - 4.9	534	2970	197	1114	265	80	6159	11226	65	114	1584	4056
5.0 - 6.9	2198	1789	1365	1113	450	148	7677	8454	611	285	5882	4203
7.0 - 8.9	2103	771	1592	574	818	282	8132	7060	395	94	11109	4862
9.0 - 10.9	1152	223	1696	314	522	185	7196	5380	76	11	15048	5033
11.0 - 12.9	435	82	1579	262	742	268	4521	3041	41	4	12481	3526
13.0 - 14.9	117	22	1040	162	954	350	2828	1756	4	0	9973	2505
15.0 - 16.9	76	14	453	68	811	301	1072	625	0	0	6273	1445
17.0 - 18.9	35	7	200	29	720	269	378	210	0	0	3137	679
19.0 - 20.9	0	0	169	24	1345	506	161	86	0	0	1658	340
21.0 - 22.9	0	0	0	0	1052	398	51	26	0	0	64	13
23.0 - 24.9	0	0	0	0	749	285	0	0	0	0	12	3
25.0 - 26.9	0	0	358	48	755	288	0	0	0	0	0	0
27.0 - 28.9	0	0	0	0	833	319	0	0	0	0	11	2
29.0 - 30.9	0	0	69	9	471	181	0	0	0	0	141	29
31.0 - 32.9	0	0	0	0	526	203	0	0	0	0	0	0
33.0 - 34.9	0	0	0	0	257	99	0	0	0	0	0	0
35.0 - 36.9	0	0	0	0	0	0	0	0	0	0	0	0
37.0 - 38.9	0	0	0	0	151	59	0	0	0	0	0	0
39.0 - 40.9	0	0	0	0	100	39	0	0	0	0	0	0
41.0 - 42.9	0	0	0	0	66	26	0	0	0	0	0	0
43.0 - 44.9	0	0	0	0	0	0	0	0	0	0	0	0
45.0 - 46.9	0	0	0	0	0	0	0	0	0	0	0	0
47.0 - 48.9	0	0	0	0	0	0	0	0	0	0	0	0
49.0 - 50.9	0	0	0	0	0	0	0	0	0	0	0	0
Total	6650	5988	8718	3794	11590	4302	38175	45874	1191	528	67375	27034

1/Totals may be off because of rounding.

Table 8—Documentation of methodology, equations, and moisture content values (continued)

Species or species group	Equation used	Diameter ranges Equation	Stand table	Source
		-------- Inches -------		
Lodgepole pine	Bole dry wt (kg) = $CF(e^{(-2.9848 + 2.4287(\ln D))})$	1.0-11.3	1.0-26.0	Gholz et al. 1979
	Top dry wt (kg) = $(1-CF)(e^{(-2.9848 + 2.4287(\ln D))})$			
	Branch dry wt (kg) = $e^{(-4.6004 + 2.3533(\ln D))}$ Bole, top, and branch moisture content = 66 percent			Markwardt and Wilson 1935 Smith and Kozak 1971
Red alder	Bole dry wt (kg) = $CF(0.02 + 1.60(\frac{D^2H}{100}) - 0.0005(\frac{D^2H}{100})^2)$	5.0-300 [1/]	10-30.0	Zavitkovski and Stevens 1972
	Top dry wt (kg) = $(1-CF)(0.02 + 1.60(\frac{D^2H}{100}) - 0.0005(\frac{D^2H}{100})^2)$			
	Branch dry wt (kg) = $0.01 + 0.48(\frac{D^2H}{100})$			
	Bole, top, and branch moisture content = 90 percent			Smith and Kozak 1971 Markwardt and Wilson 1935
True firs	ln STEMWOOD dry wt (kg) = $-3.5057 + 2.5744 (\ln D)$ ln STEMBARK dry wt (kg) = $-6.1166 + 2.8421 (\ln D)$ ln BRANCH dry wt (kg) = $-5.2370 + 2.6261 (\ln D)$ Wood moisture content = 49.2 percent	3.4-44.0	1.0-42.0	Gholz et al. 1979 Markwardt and Wilson 1935
	Bark moisture content = 63.98 percent Branch moisture content = 51.77 percent			Smith and Kozak 1971
Sitka spruce	log wood volume = $0.9495(\log (\frac{D^2}{(0.5/D)+0.0132}))-1.2069$	-------	1.0-62.0	Fujimori et al. 1976
	Bark volume = .06 (wood volume) Stem green wt (kg) = (wood volume + bark volume) (0.5872)			
	log branch dry wt (kg) = $1.0554(\log (\frac{D^2}{(0.5/D)+0.0132}))-3.2569$			
	Branch moisture content = 42 percent			Markwardt and Wilson 1935

[1/] This is the range of the independent variable $(\frac{D^2H}{100})$ and not an actual diameter range.

For all equations:

- D = diameter at breast height in centimeters.
- H = tree height in meters.
- CF = Top to stem weight ratio conversion factor to be applied to stemwood equation to determine top and/or bole weight (table 9).
- log = common logarithm.
- ln = natural logarithm.

Bole is the main stem (wood and bark) to a 4-inch (10.1-cm) top, except for black cottonwood, which was taken to a 3-inch (7.6-cm) top.
Top is the main stem (wood and bark) above the bole.
Branch is all live branches (wood and bark).
Stem is the sum of bole and top for either wood or bark (that is, stemwood).

Table 9—Documentation on methodology, conversion factors

Species or species group	Top to stem weight ratio conversion factor (CF)	Source
White spruce	CF = bole weight/stem weight at each diameter class midpoint until 22 inches. At 22 inches and above CF = 0.98.	Yarie and Van Cleve, personal communication
Black spruce	Used white spruce CF.	
Balsam poplar	CF = bole weight/stem weight at each diameter class midpoint until 12 inches. At 12 inches and above CF = 0.95.	Yarie and Van Cleve, personal communication
Aspen, red alder	Used balsam poplar CF.	
True firs, hemlock, and cedar	CF = bole volume/stem volume at each diameter class midpoint until the following diameters were reached: True firs, d.b.h. = 16-in CF = 0.98 Hemlock, d.b.h. = 16-in CF = 0.98 Cedar, d.b.h. = 20-in CF = 0.95	Johnson 1955
Sitka spruce	CF = bole volume/stem volume at each diameter class midpoint until 12 inches. At 12 inches and above, CF = 0.94. The value of 0.5872 was calculated as: $(lbs/ft^3)(ft^3/dm^3)\ (kg/lb)$ for both wood and bark to convert stem volume into green-stem weight.	Johnson 1955
Lodgepole pine	CF = bole weight/stem weight at each diameter class midpoint until 20 inches. At 20 inches, CF = 0.99.	Adamovich 1975

Yarie, John; Mead, Delbert. Aboveground tree biomass on productive forest land in Alaska. Res. Pap. PNW-298. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1982. 16 p.

Total aboveground woody biomass of trees on forest land that can produce 1.4 cubic meters per hectare per year of industrial wood in Alaska is 1.33 billion metric tons green weight. The estimated energy value of the standing woody biomass is 11.9 x 10^{15} Btu's. Statewide tables of biomass and energy values for softwoods, hardwoods, and species groups are presented.

Keywords: Biomass, energy, wood utilization, Alaska.

Pacific Northwest Forest and Range
Experiment Station
809 NE Sixth Avenue
Portland, Oregon 97232

GPO 996-111