

TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE
WOOD-9 (Rev. 1)
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CULMINATION OF MEAN ANNUAL INCREMENT FOR INDICATOR TREE SPECIES IN THE STATE OF WASHINGTON

Wood fiber growth that can be attained on a particular soil map unit or soil is of considerable importance to a land manager. The most common expression of productivity is site index (total height of trees in the dominant crown canopy at the base age, usually 50 to 100 years). Many landowners are not familiar with site index, but easily comprehend productivity in terms of volume measure. The accompanying table expresses site index in such a way. It is necessary for comparative purpose, to use a method that gives one growth rate value for each site index. The method chosen is culmination of mean annual increment (CMAI).

Mean annual increment (MAI) is the average yearly volume growth per acre of a stand. This is computed by dividing the total volume by its age. As the stand increases in age, the MAI also increases until tree-to-tree competition and physiological maturity reduce the rate of increase. The point when a stand reaches its maximum MAI is called the CULMINATION OF MEAN ANNUAL INCREMENT (CMAI).

The CMAI for an indicator tree species on a particular soil is an expression of maximum productivity for unmanaged, even-aged stands. In conservation planning, it provides a means of discussing long-term productivity on an annual-equivalent basis. In soil survey reports, the CMAI is the basis of rating woodland productivity.

In the attached table, the CMAI (in cubic feet/acre/year) and AGE AT WHICH OCCURS are shown for each site index (at one-foot intervals) for the various indicator tree species in Washington State. An "indicator" tree species is the species that is common on a soil map unit and generally the most productive. Cubic feet/acre/year can be converted to cubic meters/hectare/year; board-feet/acre/year or cords/acre/year using Note #3 on page 6.

**INDICATOR SPECIES BY SCIENTIFIC PLANT NAME SYMBOL:
CULMINATION OF MEAN ANNUAL INCREMENT & AGE AT WHICH OCCURS**

Site Index	ABGR CMAI AGE		ALRU2 CMAI AGE		LAOC CMAI AGE		PICO CMAI AGE		PIEN-ABLA CMAI AGE		PIMO3 CMAI AGE		PIPO CMAI AGE		PSME 50yr CMAI AGE		PSME 100yr CMAI AGE		PSMEG CMAI AGE		TSHE CMAI AGE		POTR5 CMAI AGE	
30					31	70					67	105												
31					32	70					69	105												
32					34	70					70	105												
33					36	70					72	105												
34					37	70					74	105												
35					39	70					76	105												
36					40	70					77	105												
37					42	70					79	105												
38					43	70					81	105												
39					45	70					82	105												
40					46	70	25	100	28	150	84	105	30	60										
41					48	70	26	100	29	150	86	105	31	60										
42					50	70	27	100	30	145	87	105	32	60										
43					51	70	29	100	31	145	89	105	32	60										
44					53	70	30	100	32	140	91	105	33	60										
45					55	70	31	100	34	140	92	105	34	60										
46					56	70	32	100	35	140	94	105	35	60										
47					58	70	33	100	36	135	96	105	36	60										
48					60	70	35	100	37	135	98	105	36	60										
49					61	70	36	100	38	130	99	105	37	60										
50	57	121			63	70	37	100	39	130	101	105	38	60				29	116					
51	59	121			65	70	38	100	40	130	103	105	39	60				30	115					
52	60	121			67	70	39	100	41	130	104	105	40	60				32	115					
53	62	121			69	70	41	100	42	125	106	105	40	60				34	114					
54	64	121			70	70	42	100	43	125	108	105	41	60				35	114					
55	66	120			72	70	43	100	44	125	110	105	42	60				36	113					
56	68	120			74	70	44	100	46	125	111	105	43	55				38	112					
57	70	120			76	70	45	100	47	125	113	105	44	55				40	112					
58	72	120			78	70	47	100	48	120	115	105	44	55				41	111					
59	74	120			80	70	48	100	49	120	116	105	45	55				42	111					
60	76	120	50	35	81	70	49	100	50	120	118	105	46	55				44	110	57	70			
61	78	119	51	35	83	70	51	100	51	120	120	105	47	55				46	109	59	70			
62	79	119	53	35	85	70	53	100	53	120	121	105	48	55				47	109	60	70			
63	81	118	55	35	87	70	55	100	54	115	123	105	49	55				49	108	62	65			
64	83	117	56	40	89	70	57	100	55	115	125	105	50	55				51	107	64	65			
65	85	116	58	40	91	70	60	100	56	115	127	105	50	50				52	106	65	65			
66	87	116	60	40	93	70	62	100	58	115	128	105	51	50				54	106	67	65			
67	89	115	61	40	95	70	64	100	59	115	130	105	52	50				56	105	68	65			
68	91	114	63	40	97	70	66	100	60	110	132	105	53	50				58	104	70	60			
69	93	114	65	40	99	70	68	100	62	110	134	105	54	50				59	104	72	60			
70	95	113	66	40	101	70	70	100	63	110	135	105	55	50				61	103	73	60			
71	97	112	68	40	103	70	72	100	64	110	137	105	56	50				63	102	75	60			
72	98	112	70	40	105	70	74	100	66	110	139	105	58	50				65	102	76	60			
73	100	111	72	40	107	70	75	100	67	105	141	105	59	45				67	101	78	60			
74	102	111	73	40	109	70	77	100	68	105	143	105	61	45				69	101	79	60			
75	104	110	75	40	111	70	79	100	70	105	144	100	62	45				71	100	81	60			

Site Index	ABGR CMAI AGE		ALRU2 CMAI AGE		LAOC CMAI AGE		PICO CMAI AGE		PIEN-ABLA CMAI AGE		PIMO3 CMAI AGE		PIPO CMAI AGE		PSME 50yr CMAI AGE		PSME 100yr CMAI AGE		PSMEG CMAI AGE		TSHE CMAI AGE		POTR5 CMAI AGE	
76	106	109	77	40	113	70	81	100	71	105	146	100	63	45					73	99	82	60		
77	108	109	79	40	116	70	83	100	72	105	148	100	65	45					75	99	84	60		
78	110	108	80	40	118	70	84	100	73	100	150	100	66	40					77	98	85	60		
79	112	108	82	40	120	70	86	100	75	100	152	100	68	40					79	98	87	60		
80	114	107	84	40	122	70	88	100	76	100	154	100	69	40	98	90	58	70	81	97	88	60	48	80
81	116	106	86	40			90	100	78	100			71	40	100	90	60	70	83	96	90	60	49	80
82	118	105	87	40			92	100	79	100			72	40	102	90	61	70	86	96	92	60	50	80
83	120	104	89	40			94	100	81	95			74	40	103	90	62	70	88	95	93	60	51	70
84	122	103	91	40			96	100	82	95			75	40	105	90	63	70	90	94	95	60	52	70
85	124	102	92	40			98	100	84	95			77	40	107	90	64	70	92	94	97	60	53	70
86	125	100	94	40			100	100	85	95			79	40	109	90	66	70	95	93	98	60	54	70
87	127	99	96	40			102	100	87	95			80	40	111	90	67	70	97	92	100	60	55	70
88	129	98	97	40			104	100	88	90			82	40	113	90	68	70	99	91	102	60	56	70
89	131	97	99	40			106	100	90	90			83	40	114	90	69	70	102	91	103	60	58	70
90	133	96	101	40			108	100	91	90			85	40	116	90	70	70	104	90	105	60	59	70
91	135	95	102	40			110	100	93	90			87	40	118	90	72	70	107	89	107	60		
92	137	95	104	40			112	100	95	90			88	40	120	90	73	70	109	88	108	60		
93	139	94	106	40			114	100	96	90			90	40	122	90	74	70	112	87	110	60		
94	141	93	108	40			115	100	98	90			92	40	123	90	75	65	114	86	112	60		
95	143	92	109	40			117	100	100	90			94	40	125	90	77	60	117	84	113	60		
96	145	92	111	40			119	100	102	90			95	40	128	90	78	60	120	83	115	60		
97	147	91	113	40			121	100	104	90			97	40	130	90	79	60	122	82	117	60		
98	149	90	115	40			123	100	105	90			99	40	132	90	81	60	125	81	118	60		
99	151	90	116	40			124	100	107	90			100	40	134	90	82	60	127	80	120	60		
100	153	89	118	40			126	100	109	90			102	40	136	90	84	60	130	79	142	60		
101	155	88	120	40					111	85			104	40	138	90	85	60	133	78	144	60		
102	157	88	121	40					113	85			106	40	140	90	86	60	136	78	145	60		
103	159	87	123	40					114	85			108	40	141	90	88	60	139	77	147	60		
104	161	87	125	40					116	85			110	40	143	90	89	60	142	76	149	60		
105	163	86	127	40					118	85			112	40	145	90	91	60	145	76	151	60		
106	165	85	128	40					120	85			114	40	147	90	92	60	148	75	153	60		
107	167	85	130	40					122	85			116	40	149	90	94	60	151	74	154	60		
108	169	84	132	40					123	85			118	40	150	90	95	60	154	73	156	60		
109	171	84	133	40					125	85			120	40	152	90	97	60	157	73	158	60		
110	173	83	135	40					127	85			122	40	154	90	98	60	160	72	160	55		
111			137	40					129	80			124	40	156	90	100	60			162	50		
112			138	40					130	80			126	40	158	90	101	60			164	50		
113			140	40					132	80			128	40	160	90	103	60			166	50		
114			142	40					134	80			130	40	162	90	105	60			168	50		
115			144	40					136	80			132	40	163	90	106	60			170	50		
116			145	40					138	80			133	40	167	90	108	60			172	50		
117			147	40					140	80			135	40	169	90	110	60			174	50		
118			149	40					141	80			137	40	171	90	111	60			176	50		
119			150	40					143	80			139	40	173	90	113	60			178	50		
120			152	40					145	80			141	40	175	90	115	60			180	50		
121													144	40	176	90	116	60			182	50		
122													146	40	178	90	118	60			184	50		
123													148	40	180	90	119	60			186	50		
124													151	40	182	90	121	70			188	50		
125													154	40	184	90	122	70			190	50		

Site Index	ABGR CMAI AGE		ALRU2 CMAI AGE		LAOC CMAI AGE		PICO CMAI AGE		PIEN-ABLA CMAI AGE		PIMO3 CMAI AGE		PIPO CMAI AGE		PSME 50yr CMAI AGE		PSME 100yr CMAI AGE		PSMEG CMAI AGE		TSHE CMAI AGE		POTR5 CMAI AGE	
126													156	40	186	90	124	70			192	50		
127													159	40	188	90	125	70			194	50		
128													161	40	190	90	127	70			196	50		
129													164	40	191	90	128	70			198	50		
130													166	40	193	90	130	70			200	50		
131													168	40	195	90	132	70			202	50		
132													170	40	197	90	133	70			204	50		
133													173	40	199	90	134	70			205	50		
134													175	40	201	90	136	70			207	50		
135													177	40	203	90	138	70			209	50		
136													179	40	207	90	139	70			211	50		
137													181	40	209	90	140	70			213	50		
138													184	40	210	90	142	70			214	50		
139													186	40	212	90	144	70			216	50		
140													188	40	214	90	145	70			218	60		
141													190	40	216	90	146	65			220	60		
142													192	40	218	90	148	65			220	55		
143													195	40	220	90	149	65			224	50		
144													197	40	222	90	150	60			226	50		
145													199	40	224	90	152	60			228	50		
146													201	40	226	90	153	60			230	50		
147													203	40	227	90	154	60			232	50		
148													206	40	229	90	156	60			234	50		
149													208	40	231	90	157	60			236	50		
150													210	40	233	90	158	60			238	50		
151													212	40	235	90	159	60			240	50		
152													215	40	237	90	161	60			241	50		
153													217	40	239	90	162	60			243	50		
154													220	40	241	90	163	60			244	50		
155													222	40	243	90	164	60			246	50		
156													224	40	244	90	165	60			248	50		
157													227	40	246	90	167	60			249	50		
158													229	40	248	90	168	65			251	50		
159													232	40	250	90	169	65			252	50		
160													234	40			170	65			254	50		
161																	171	65			256	50		
162																	172	65			258	50		
163																	173	65			260	50		
164																	174	60			262	50		
165																	176	60			264	50		
166																	177	60			266	50		
167																	178	60			268	50		
168																	179	60			270	50		
169																	180	60			272	50		
170																	181	60			274	50		
171																	182	60			276	50		
172																	183	60			278	50		
173																	184	60			279	50		
174																	185	60			281	50		
175																	186	60			283	50		

Site Index	ABGR CMAI AGE		ALRU2 CMAI AGE		LAOC CMAI AGE		PICO CMAI AGE		PIEN-ABLA CMAI AGE		PIMO3 CMAI AGE		PIPO CMAI AGE		PSME 50yr CMAI AGE		PSME 100yr CMAI AGE		PSMEG CMAI AGE		TSHE CMAI AGE		POTR5 CMAI AGE	
176																	187	60			285	50		
177																	188	60			287	50		
178																	189	60			288	50		
179																	190	60			290	50		
180																	191	60			292	50		
181																	192	60			294	50		
182																	193	60			296	50		
183																	194	60			297	50		
184																	194	60			299	50		
185																	195	60			301	50		
186																	196	60			303	50		
187																	197	60			305	50		
188																	198	60			306	50		
189																	199	60			308	50		
190																	200	60			310	50		
191																	201	60			312	50		
192																	202	60			314	50		
193																	202	60			316	50		
194																	203	60			318	50		
195																	204	60			320	50		
196																	205	60			322	50		
197																	206	60			324	50		
198																	207	60			326	50		
199																	208	60			328	50		
200																	208	60			330	50		
201																	209	60			332	50		
202																	210	60			333	50		
203																	211	60			335	50		
204																	211	60			336	50		
205																	212	60			338	50		
206																	213	60			340	50		
207																	214	60			341	50		
208																	214	60			343	50		
209																	215	60			344	50		
210																	216	60			346	50		

NOTES

1. "Culmination of mean annual increment and age at which occurs" were computed for each species from the tables and publications listed below. CMAI is in cubic feet per acre per year.

- ABGR: Table 6 of Cochran, P.H. 1979. Gross Yield for Even-aged Stands of Douglas-fir and White or Grand Fir East of the Cascades in Oregon and Washington. USDA For. Serv. Res. Paper PNW-263, 17p., illus. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. Table 4 is used for the basal area adjustment to volume growth.
- ALRU2: Table 11 of Worthington, Norman P., Floyd A. Johnson, George R. Staebler, and William J. Lloyd. 1960. Normal Yield Tables for Red Alder. USDA For. Ser. Res. Paper 36, 3p., illus. Pacific Northwest Forest and Range Exp. Station, Portland, Oregon.
- LAOC: Table 33 of Schmidt, Wyman C., Raymond C. Chearer, and Arthur L. Roe. 1976. Ecology and Silviculture of Western Larch Forests. USDA For. Ser. Tech. Bul. No. 1520, 96 p., illus. Intermountain Forest and Range Exp. Station. Table 29 is used for the basal area adjustment to volume growth.
- PICO: Tables 5-9 of Myers, Clifford A. 1967. Yield Tables for Manages Stands of Lodgepole Pine in Colorado and Wyoming. USDA For. Ser. Res. Paper RM-26. 20p. Rocky Mountain Forest and Range Experiment Station.
- PIEN-ABLA: Edminster, Carleton B. 1980. Engelmann Spruce and Subalpine Fir Yield Tables. USDA Soil Conservation Service West TSC Bulletin No. W38-0-17, 4p., West Technical Service Center of SCS.
- PIMO3: Table 7 of Haig, Irvine T. 1932. Second-Growth Yield, Stand, and Volume Tables for the Western White Pine Type. USDA For. Ser. Tech. Bui. No. 323, 67p., illus. Rocky Mountain and Range Experiment Station.
- PIPO: Table 21 of Meyer, Walter H. 1961. Yield of Even-aged Stands of Ponderosa Pine. USDA For. Ser. Tech. Bul. No. 630, 59p., illus. Pac. NW Forest and Range Exp. Station. Table 4 is used for the basal area adjustment to volume growth.
- PSME: Table 2 of McArdle, Richard E. and Walter H. Meyer. 1961. The Yield of Douglas-fir in the Pacific Northwest. USDA For. Ser. Tech. Bul. No. 201, 74 p.,illus. Pac. NW For. And Range Experiment Station.
- PSME(50) Chambers, Charles. Washington State Department of Natural Resources Technical Report #20R
- PSMEG: Table 5 of Cochran, P.H. 1979. Gross Yields for Even-aged Stands of Douglas-fir and White or Grand Fir East of the Cascades in Oregon and Washington. USDA For. Ser. Res. Paper PNE-263, 17p., illus. Pac. NW For. and Range Experiment Station, Portland, Oregon. Table 3 is used for the basal area adjustment to volume growth.
- POTR5 Baker, F.S. 1925 Aspen in the Central Rocky Mountain Region USDA Bulletin #1291

TSHE: Table 12 (S.I. ≥ 100) and Table 14 (S.I. 60-99) of Barnes, George H. 1962. Yield of Even-aged Stands of Western Hemlock. USDA T.B. No. 1273, 52p., illus., Pac. NW For. and Range Exp. Station, Portland, Oregon.

2. In soil-site correlation work, the culmination of mean annual increment expressed in terms of cubic feet per acre per year of cubic meters/hectare/year is used as the basis for a timber-producing soil map unit's productivity. Productivity is expressed as a one, two or three digit number depending upon whether it is expressed as cubic feet per acre or cubic meters per acre at the designated age.
3. CMAI for a species is developed as discussed on the front page of this Technical Note. In addition, certain soils in MLRA's B6, B8, B9, E43, and E44 can have a basal area adjustment if USDA Technical Bulletins 630 or 1520, or Research Paper PNW-263 were used in computing site index and growth for the indicator species. The indicator species is normally that principal species most common on the unit and potentially the most productive. The following procedure is used to make the adjustment.
 - (1) Only ECS-005 plots are used to determine site index for the indicator species will be applicable to the adjustment.
 - (2) Each plot's basal area is divided by that normal basal area listed in Table 4 of USDA T.B. 630, Table 29 of T.B. 1520, or Tables 3 or 4 of RP-PNW 263, based on the plot's site index and average total or breast height age, as appropriate. Interpolation will be needed in most cases.
 - (3) All plot percents of normal basal area are averaged, then rounded to the nearest five percent.
 - (4) The culmination of mean annual increment (CMAI) in cubic feet/acre/year based on the assigned site index is multiplied by the average, rounded percent of normal basal area.
 - (5) The result of Step 4 is used as the CMAI in subsection (ii)(2) of Section 537.21, Vegetation and Productivity and Section 537.32(o)(1)(i), Ecological Site Interpretations. (Note: If the average rounded percent of normal basal area is 100 percent or more, do not adjust the CMAI).

4. The following chart can be used to convert volumes from one unit of measure to another.

Caution: Schribner board-feet and cords are rough approximations.

Cu. Meters/ Hectare/Yr		Cu. Ft./Ac./Yr.		Scribner Bd. Ft/Ac./Yr		Cords/Ac./Yr.
0.07	=	1	=	5	=	0.01
1.00	=	14	=	70	=	0.17
1.40	=	20	=	100	=	1.24
5.94	=	85	=	425	=	1.00