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Height growth curves and site index tables for subalpine fir, Engelmann spruce, and lodgepole pine in the ESSF zone of BC

Height growth models of coastal low- and mid-elevation Pacific silver fir, low-elevation white spruce, and low- and mid-elevation lodgepole pine have been used for predicting productivity of subalpine fir, Engelmann spruce, and lodgepole pine, respectively. These models, however, are biased in predicting height growth of high-elevation subalpine fir, Engelmann spruce, and lodgepole pine.

To improve this situation, 329 sample plots (165 for subalpine fir, 90 for Engelmann spruce, and 74 for lodgepole pine) were located throughout the Engelmann Spruce-Subalpine Fir (ESSF) zone. Stem analysis was carried out on three dominant trees in each 0.04 ha sample plot. For each study species, a height growth model was developed on the data from two-thirds of the sample plots using the conditioned Chapman-Richards' function; the model was validated using the remaining one-third of the sample plots.

The models developed were used to construct height growth curves and tables. They are recommended for estimating site index of these three major timber crop species in the ESSF zone.

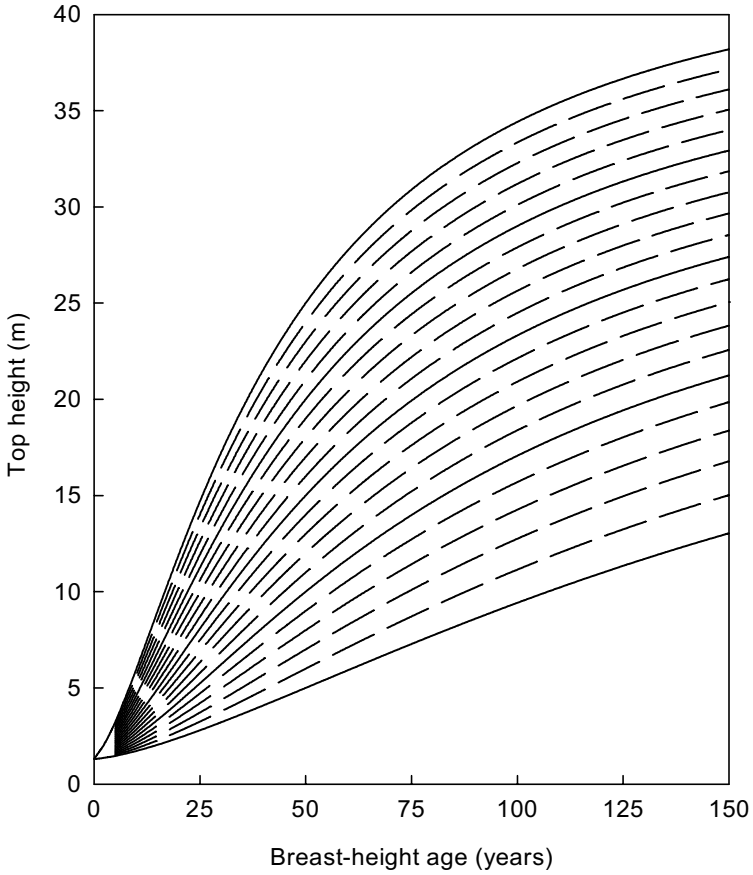
Subalpine fir

Height growth model and curves for subalpine fir in the ESSF zone

$$H = 1.3 + 5.88585\left[(S-1.3)^{0.59774}(1-e^{-0.01798A})^{p}\right]$$

where: $$p = \frac{\ln\left(\frac{(S-1.3)^{1-0.59774}}{5.88585}\right)}{\ln\left(1-e^{-0.01798\times 50}\right)}$$

where: H = top height (m); S = site index (height at 50 year breast-height age); A = breast-height age (year); e = the base of exponential function; and ln = natural logarithm.



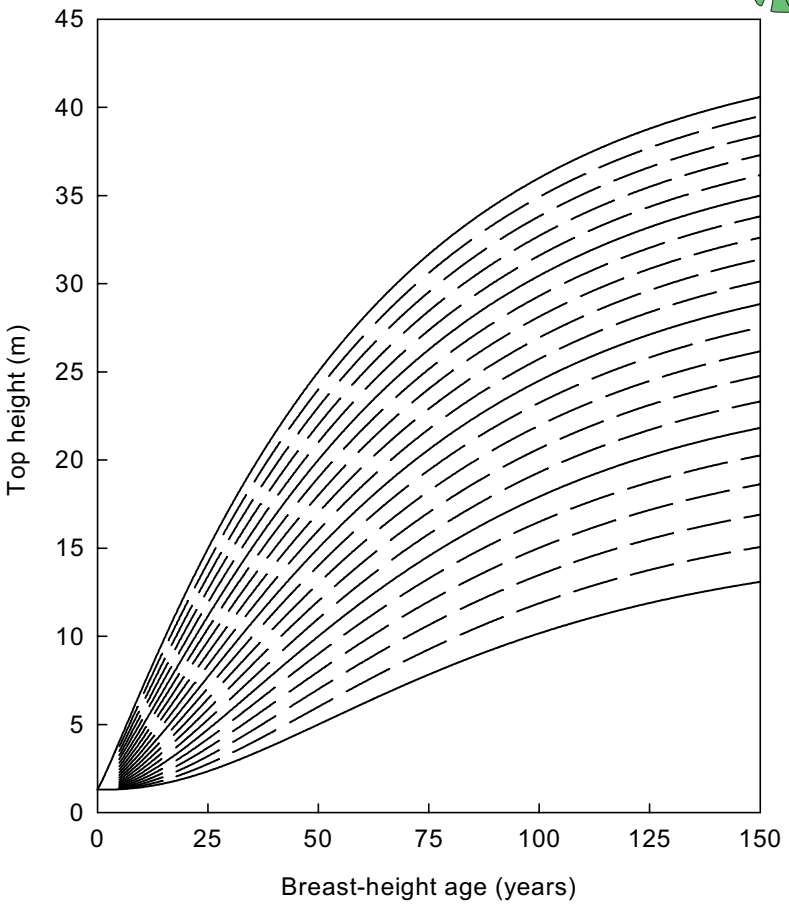
Engelmann spruce

Height growth model and curves for Engelmann spruce in the ESSF zone

$$H = 1.3 + 6.47677\left[(S-1.3)^{0.59383}(1-e^{-0.01748A})^{p}\right]$$

where: $$p = \frac{\ln\left(\frac{(S-1.3)^{1-0.59383}}{6.47677}\right)}{\ln\left(1-e^{-0.01748\times 50}\right)}$$

where: H = top height (m); S = site index (height at 50 year breast-height age); A = breast-height age (year); e = the base of exponential function; and ln = natural logarithm.



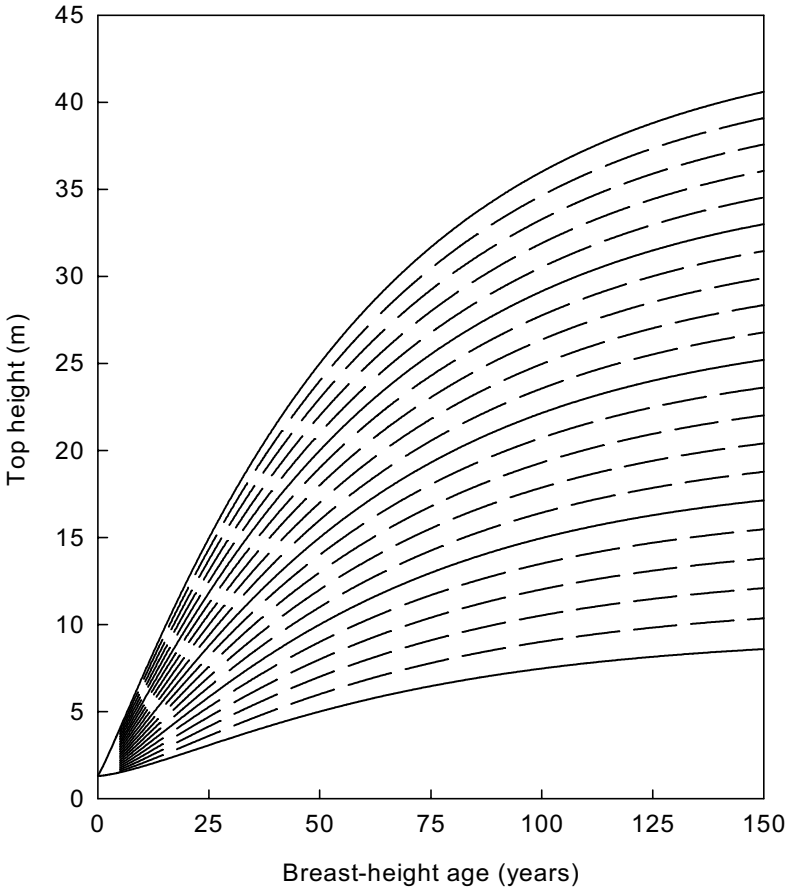
Lodgepole pine

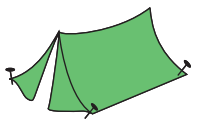
Height growth model and curves for lodgepole pine in the ESSF zone

$$H = 1.3 + 2.51526\left[(S-1.3)^{0.89265}(1-e^{-0.01759A})^{p}\right]$$

where: $$p = \frac{\ln\left(\frac{(S-1.3)^{1-0.89265}}{2.51526}\right)}{\ln\left(1-e^{-0.01759\times 50}\right)}$$

where: H = top height (m); S = site index (height at 50 year breast-height age); A = breast-height age (year); e = the base of exponential function; and ln = natural logarithm.





Site index table for subalpine fir stands in the ESSF zone

b.h.a.	Site index (m)																						
(years)	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
5	1.3	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.7	1.8	1.9	2.1	2.3	2.4	2.6	2.9	3.1	3.4	3.7	4.0	4.3	4.7	5.0
10	1.3	1.4	1.5	1.6	1.7	1.9	2.0	2.3	2.5	2.7	3.0	3.3	3.6	4.0	4.4	4.8	5.2	5.6	6.1	6.6	7.1	7.7	8.3
15	1.4	1.5	1.7	1.9	2.2	2.4	2.7	3.1	3.4	3.8	4.2	4.7	5.2	5.7	6.2	6.7	7.3	7.9	8.5	9.1	9.8	10.4	11.1
20	1.5	1.8	2.0	2.4	2.7	3.1	3.6	4.0	4.5	5.0	5.6	6.1	6.7	7.3	8.0	8.6	9.3	10.0	10.7	11.4	12.2	13.0	13.7
25	1.7	2.0	2.4	2.9	3.4	3.9	4.4	5.0	5.6	6.2	6.9	7.6	8.2	9.0	9.7	10.4	11.2	12.0	12.8	13.6	14.4	15.2	16.1
30	1.9	2.4	2.9	3.5	4.1	4.7	5.4	6.0	6.7	7.5	8.2	9.0	9.7	10.5	11.3	12.1	13.0	13.8	14.7	15.6	16.4	17.3	18.2
35	2.1	2.7	3.4	4.1	4.8	5.5	6.3	7.1	7.9	8.7	9.5	10.3	11.2	12.0	12.9	13.8	14.7	15.6	16.5	17.4	18.3	19.2	20.2
40	2.4	3.1	3.9	4.7	5.5	6.4	7.2	8.1	8.9	9.8	10.7	11.6	12.5	13.4	14.4	15.3	16.2	17.2	18.1	19.0	20.0	21.0	21.9
45	2.7	3.6	4.5	5.4	6.3	7.2	8.1	9.1	10.0	10.9	11.9	12.8	13.8	14.8	15.7	16.7	17.7	18.6	19.6	20.6	21.6	22.6	23.5
50	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	23.0	24.0	25.0
55	3.3	4.4	5.5	6.6	7.7	8.8	9.8	10.9	12.0	13.0	14.0	15.1	16.1	17.2	18.2	19.2	20.2	21.3	22.3	23.3	24.3	25.3	26.3
60	3.6	4.9	6.1	7.2	8.4	9.5	10.7	11.8	12.9	14.0	15.0	16.1	17.2	18.2	19.3	20.3	21.4	22.4	23.5	24.5	25.5	26.5	27.6
65	4.0	5.3	6.6	7.8	9.1	10.3	11.4	12.6	13.7	14.8	16.0	17.1	18.2	19.2	20.3	21.4	22.4	23.5	24.5	25.6	26.6	27.6	28.7
70	4.3	5.7	7.1	8.4	9.7	10.9	12.2	13.3	14.5	15.7	16.8	17.9	19.1	20.2	21.3	22.3	23.4	24.5	25.5	26.6	27.6	28.6	29.7
75	4.6	6.1	7.6	9.0	10.3	11.6	12.8	14.1	15.3	16.5	17.6	18.8	19.9	21.0	22.1	23.2	24.3	25.4	26.4	27.5	28.5	29.6	30.6
80	4.9	6.5	8.0	9.5	10.9	12.2	13.5	14.7	16.0	17.2	18.4	19.5	20.7	21.8	22.9	24.0	25.1	26.2	27.3	28.3	29.4	30.4	31.4
85	5.2	6.9	8.5	10.0	11.4	12.8	14.1	15.4	16.6	17.8	19.0	20.2	21.4	22.5	23.7	24.8	25.9	27.0	28.0	29.1	30.1	31.2	32.2
90	5.5	7.3	8.9	10.4	11.9	13.3	14.6	15.9	17.2	18.5	19.7	20.9	22.1	23.2	24.3	25.5	26.6	27.7	28.7	29.8	30.8	31.9	32.9
95	5.8	7.6	9.3	10.9	12.4	13.8	15.2	16.5	17.8	19.0	20.3	21.5	22.7	23.8	25.0	26.1	27.2	28.3	29.4	30.4	31.5	32.5	33.6
100	6.0	7.9	9.7	11.3	12.8	14.2	15.6	17.0	18.3	19.6	20.8	22.0	23.2	24.4	25.5	26.7	27.8	28.9	30.0	31.0	32.1	33.1	34.1
105	6.3	8.2	10.0	11.6	13.2	14.7	16.1	17.5	18.8	20.1	21.3	22.5	23.7	24.9	26.1	27.2	28.3	29.4	30.5	31.6	32.6	33.7	34.7
110	6.5	8.5	10.3	12.0	13.6	15.1	16.5	17.9	19.2	20.5	21.8	23.0	24.2	25.4	26.6	27.7	28.8	29.9	31.0	32.1	33.1	34.1	35.2
115	6.7	8.8	10.6	12.3	13.9	15.4	16.9	18.3	19.6	20.9	22.2	23.4	24.7	25.8	27.0	28.1	29.3	30.4	31.4	32.5	33.6	34.6	35.6
120	6.9	9.0	10.9	12.6	14.2	15.8	17.2	18.6	20.0	21.3	22.6	23.8	25.1	26.2	27.4	28.5	29.7	30.8	31.8	32.9	34.0	35.0	36.0
125	7.1	9.2	11.2	12.9	14.5	16.1	17.6	19.0	20.4	21.7	23.0	24.2	25.4	26.6	27.8	28.9	30.0	31.1	32.2	33.3	34.3	35.4	36.4
130	7.3	9.5	11.4	13.2	14.8	16.4	17.9	19.3	20.7	22.0	23.3	24.5	25.8	27.0	28.1	29.3	30.4	31.5	32.6	33.6	34.7	35.7	36.7
135	7.4	9.7	11.6	13.4	15.1	16.7	18.2	19.6	21.0	22.3	23.6	24.8	26.1	27.3	28.4	29.6	30.7	31.8	32.9	34.0	35.0	36.0	37.0
140	7.6	9.8	11.8	13.6	15.3	16.9	18.4	19.8	21.2	22.6	23.9	25.1	26.4	27.6	28.7	29.9	31.0	32.1	33.2	34.2	35.3	36.3	37.3
145	7.7	10.0	12.0	13.8	15.5	17.1	18.6	20.1	21.5	22.8	24.1	25.4	26.6	27.8	29.0	30.1	31.3	32.4	33.4	34.5	35.5	36.6	37.6
150	7.9	10.2	12.2	14.0	15.7	17.3	18.9	20.3	21.7	23.1	24.4	25.6	26.9	28.1	29.2	30.4	31.5	32.6	33.7	34.7	35.8	36.8	37.8

Site index table for Engelmann spruce stands in the ESSF zone

b.h.a.	Site index (m)																						
(years)	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
5	1.3	1.3	1.4	1.4	1.4	1.5	1.5	1.6	1.7	1.8	1.9	2.1	2.2	2.4	2.5	2.7	2.9	3.2	3.4	3.7	3.9	4.2	
10	1.4	1.5	1.5	1.7	1.8	1.9	2.1	2.3	2.5	2.8	3.0	3.3	3.6	3.9	4.3	4.6	5.0	5.4	5.8	6.3	6.7	7.2	
15	1.5	1.7	1.9	2.1	2.3	2.6	2.9	3.2	3.6	3.9	4.3	4.7	5.2	5.6	6.1	6.6	7.1	7.7	8.2	8.8	9.4	10.0	
20	1.7	2.0	2.3	2.6	3.0	3.4	3.8	4.2	4.7	5.2	5.7	6.3	6.8	7.4	8.0	8.6	9.2	9.9	10.6	11.3	12.0	12.7	
25	2.0	2.4	2.8	3.3	3.7	4.3	4.8	5.4	5.9	6.5	7.2	7.8	8.5	9.2	9.9	10.6	11.3	12.0	12.8	13.6	14.3	15.1	
30	2.3	2.8	3.4	3.9	4.6	5.2	5.8	6.5	7.2	7.9	8.6	9.4	10.1	10.9	11.7	12.4	13.3	14.1	14.9	15.7	16.6	17.4	
35	2.7	3.3	4.0	4.7	5.4	6.1	6.9	7.7	8.4	9.2	10.0	10.9	11.7	12.5	13.4	14.2	15.1	16.0	16.9	17.8	18.7	19.6	
40	3.1	3.9	4.7	5.5	6.3	7.1	7.9	8.8	9.7	10.5	11.4	12.3	13.2	14.1	15.0	15.9	16.8	17.8	18.7	19.6	20.6	21.5	
45	3.5	4.4	5.3	6.2	7.1	8.1	9.0	9.9	10.9	11.8	12.7	13.7	14.6	15.6	16.6	17.5	18.5	19.4	20.4	21.4	22.4	23.3	
50	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	23.0	24.0	25.0	
55	4.5	5.6	6.7	7.8	8.8	9.9	11.0	12.0	13.1	14.1	15.2	16.2	17.3	18.3	19.4	20.4	21.4	22.4	23.5	24.5	25.5	26.5	
60	4.9	6.1	7.3	8.5	9.7	10.8	11.9	13.0	14.1	15.2	16.3	17.4	18.5	19.6	20.6	21.7	22.7	23.8	24.8	25.9	26.9	27.9	
65	5.4	6.7	8.0	9.2	10.4	11.6	12.8	14.0	15.1	16.3	17.4	18.5	19.6	20.7	21.8	22.9	24.0	25.0	26.1	27.2	28.2	29.2	
70	5.8	7.2	8.6	9.9	11.2	12.4	13.7	14.9	16.1	17.2	18.4	19.5	20.7	21.8	22.9	24.0	25.1	26.2	27.3	28.3	29.4	30.4	
75	6.3	7.8	9.2	10.6	11.9	13.2	14.5	15.7	16.9	18.1	19.3	20.5	21.6	22.8	23.9	25.0	26.1	27.2	28.3	29.4	30.5	31.5	
80	6.7	8.3	9.8	11.2	12.6	13.9	15.2	16.5	17.7	19.0	20.2	21.4	22.6	23.7	24.9	26.0	27.1	28.2	29.3	30.4	31.5	32.5	
85	7.1	8.8	10.3	11.8	13.2	14.6	15.9	17.2	18.5	19.8	21.0	22.2	23.4	24.6	25.7	26.9	28.0	29.1	30.2	31.3	32.4	33.5	
90	7.5	9.2	10.8	12.3	13.8	15.2	16.6	17.9	19.2	20.5	21.7	23.0	24.2	25.4	26.5	27.7	28.8	30.0	31.1	32.2	33.2	34.3	
95	7.9	9.7	11.3	12.9	14.4	15.8	17.2	18.6	19.9	21.2	22.4	23.7	24.9	26.1	27.3	28.4	29.6	30.7	31.8	32.9	34.0	35.1	
100	8.3	10.1	11.8	13.4	14.9	16.4	17.8	19.2	20.5	21.8	23.1	24.3	25.6	26.8	28.0	29.1	30.3	31.4	32.5	33.6	34.7	35.8	
105	8.6	10.5	12.2	13.8	15.4	16.9	18.3	19.7	21.1	22.4	23.7	25.0	26.2	27.4	28.6	29.8	30.9	32.1	33.2	34.3	35.4	36.5	
110	8.9	10.8	12.6	14.3	15.8	17.4	18.8	20.2	21.6	22.9	24.2	25.5	26.8	28.0	29.2	30.4	31.5	32.7	33.8	34.9	36.0	37.1	
115	9.2	11.2	13.0	14.7	16.3	17.8	19.3	20.7	22.1	23.4	24.8	26.0	27.3	28.5	29.7	30.9	32.1	33.2	34.3	35.5	36.6	37.6	
120	9.5	11.5	13.3	15.0	16.7	18.2	19.7	21.2	22.5	23.9	25.2	26.5	27.8	29.0	30.2	31.4	32.6	33.7	34.8	36.0	37.1	38.1	
125	9.8	11.8	13.6	15.4	17.0	18.6	20.1	21.6	23.0	24.3	25.7	27.0	28.2	29.5	30.7	31.9	33.0	34.2	35.3	36.4	37.5	38.6	
130	10.0	12.1	13.9	15.7	17.4	19.0	20.5	21.9	23.4	24.7	26.1	27.4	28.6	29.9	31.1	32.3	33.5	34.6	35.7	36.9	38.0	39.0	
135	10.2	12.3	14.2	16.0	17.7	19.3	20.8	22.3	23.7	25.1	26.4	27.7	29.0	30.3	31.5	32.7	33.8	35.0	36.1	37.2	38.3	39.4	
140	10.4	12.6	14.5	16.3	18.0	19.6	21.1	22.6	24.0	25.4	26.8	28.1	29.4	30.6	31.8	33.0	34.2	35.4	36.5	37.6	38.7	39.8	
145	10.6	12.8	14.7	16.5	18.2	19.9	21.4	22.9	24.3	25.7	27.1	28.4	29.7	30.9	32.2	33.4	34.5	35.7	36.8	37.9	39.0	40.1	
150	10.8	13.0	15.0	16.8	18.5	20.1	21.7	23.2	24.6	26.0	27.4	28.7	30.0	31.2	32.5	33.7	34.8	36.0	37.1	38.2	39.3	40.4	

Site index table for lodgepole pine stands in the ESSF zone

b.h.a.	Site index (m)																			
(years)	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
5	1.6	1.7	1.8	1.9	2.0	2.1	2.3	2.4	2.5	2.6	2.8	2.9	3.1	3.2	3.4	3.5	3.7	3.9	4.0	4.2
10	2.1	2.3	2.5	2.7	3.0	3.2	3.4	3.7	4.0	4.2	4.5	4.8	5.1	5.3	5.6	5.9	6.2	6.5	6.8	7.1
15	2.6	2.9	3.2	3.6	3.9	4.3	4.7	5.1	5.4	5.8	6.2	6.6	7.0	7.4	7.8	8.3	8.7	9.1	9.5	10.0
20	3.1	3.5	4.0	4.5	4.9	5.4	5.9	6.4	6.9	7.4	7.9	8.4	8.9	9.4	10.0	10.5	11.0	11.5	12.1	12.6
25	3.6	4.2	4.7	5.3	5.9	6.5	7.1	7.7	8.3	8.9	9.5	10.1	10.7	11.3	11.9	12.6	13.2	13.8	14.5	15.1
30	4.1	4.8	5.5	6.1	6.8	7.5	8.2	8.9	9.6	10.3	11.0	11.7	12.4	13.1	13.8	14.5	15.2	16.0	16.7	17.4
35	4.6	5.4	6.2	6.9	7.7	8.4	9.2	10.0	10.8	11.6	12.4	13.1	13.9	14.7	15.5	16.3	17.1	17.9	18.7	19.5
40	5.1	6.0	6.8	7.7	8.5	9.4	10.2	11.1	11.9	12.8	13.7	14.5	15.4	16.3	17.1	18.0	18.9	19.8	20.6	21.5
45	5.6	6.5	7.4	8.3	9.3	10.2	11.1	12.1	13.0	13.9	14.9	15.8	16.7	17.7	18.6	19.6	20.5	21.4	22.4	23.3
50	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	23.0	24.0	25.0
55	6.4	7.5	8.5	9.6	10.7	11.7	12.8	13.9	14.9	16.0	17.0	18.1	19.2	20.2	21.3	22.3	23.4	24.4	25.5	26.5
60	6.8	7.9	9.0	10.2	11.3	12.4	13.5	14.7	15.8	16.9	18.0	19.1	20.2	21.3	22.4	23.6	24.7	25.8	26.9	28.0
65	7.1	8.3	9.5	10.7	11.9	13.1	14.2	15.4	16.6	17.7	18.9	20.1	21.2	22.4	23.5	24.7	25.8	27.0	28.1	29.3
70	7.5	8.7	10.0	11.2	12.4	13.7	14.9	16.1	17.3	18.5	19.7	20.9	22.1	23.3	24.5	25.7	26.9	28.1	29.3	30.5
75	7.8	9.1	10.4	11.6	12.9	14.2	15.5	16.7	18.0	19.2	20.5	21.7	23.0	24.2	25.4	26.7	27.9	29.1	30.3	31.6
80	8.0	9.4	10.7	12.1	13.4	14.7	16.0	17.3	18.6	19.9	21.2	22.5	23.7	25.0	26.3	27.5	28.8	30.1	31.3	32.6
85	8.3	9.7	11.1	12.5	13.8	15.2	16.5	17.8	19.2	20.5	21.8	23.1	24.4	25.8	27.1	28.4	29.6	30.9	32.2	33.5
90	8.5	10.0	11.4	12.8	14.2	15.6	17.0	18.3	19.7	21.1	22.4	23.8	25.1	26.4	27.8	29.1	30.4	31.7	33.0	34.4
95	8.8	10.2	11.7	13.1	14.6	16.0	17.4	18.8	20.2	21.6	23.0	24.3	25.7	27.1	28.4	29.8	31.1	32.5	33.8	35.1
100	9.0	10.5	12.0	13.4	14.9	16.4	17.8	19.2	20.6	22.1	23.5	24.9	26.3	27.6	29.0	30.4	31.8	33.1	34.5	35.9
105	9.2	10.7	12.2	13.7	15.2	16.7	18.1	19.6	21.1	22.5	23.9	25.3	26.8	28.2	29.6	31.0	32.4	33.8	35.1	36.5
110	9.3	10.9	12.4	14.0	15.5	17.0	18.5	20.0	21.4	22.9	24.3	25.8	27.2	28.7	30.1	31.5	32.9	34.3	35.7	37.1
115	9.5	11.1	12.7	14.2	15.8	17.3	18.8	20.3	21.8	23.3	24.7	26.2	27.6	29.1	30.5	32.0	33.4	34.8	36.3	37.7
120	9.6	11.3	12.9	14.4	16.0	17.5	19.1	20.6	22.1	23.6	25.1	26.6	28.0	29.5	31.0	32.4	33.9	35.3	36.8	38.2
125	9.8	11.4	13.0	14.6	16.2	17.8	19.3	20.9	22.4	23.9	25.4	26.9	28.4	29.9	31.4	32.8	34.3	35.7	37.2	38.6
130	9.9	11.6	13.2	14.8	16.4	18.0	19.6	21.1	22.7	24.2	25.7	27.2	28.7	30.2	31.7	33.2	34.7	36.1	37.6	39.1
135	10.0	11.7	13.4	15.0	16.6	18.2	19.8	21.3	22.9	24.4	26.0	27.5	29.0	30.5	32.0	33.5	35.0	36.5	38.0	39.5
140	10.1	11.8	13.5	15.1	16.8	18.4	20.0	21.6	23.1	24.7	26.2	27.8	29.3	30.8	32.3	33.9	35.4	36.9	38.3	39.8
145	10.2	11.9	13.6	15.3	16.9	18.5	20.2	21.8	23.3	24.9	26.5	28.0	29.6	31.1	32.6	34.1	35.7	37.2	38.7	40.2
150	10.3	12.0	13.7	15.4	17.1	18.7	20.3	21.9	23.5	25.1	26.7	28.2	29.8	31.3	32.9	34.4	35.9	37.4	39.0	40.5

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