D254
7127
cap. 2

OREGON STATE UNIVERSITY
AGRICULTURE EXPERIMENT STATION
FOREST RESEARCH DIVISION

Research Note No. 46 December, 1959

Forestry



Photo: U. S. Forest Service

The staggered-setting system of logging provides a natural source of seeds.

AERIAL PHOTO MENSURATION TABLES

By

J. Richard Dilworth
Professor
School of Forestry

Research leads to better forest management, and assures more adequate resources for the future.

Forest industries are the foundation of Oregon's economy. More than one billion dollars worth of products are produced annually. Two-thirds of the state's manufacturing payroll comes from these industries. Oregon ranks first in forest products manufacturing.

These industries can be maintained only through perpetuation of our basic forest resources. Current logging methods are designed to provide ample seed sources for natural seeding of cutovers.

Progressive tree-farm owners are eager to adopt more intensive management if research will lead the way. The forest research program at Oregon State College is attempting to solve some of the basic problems concerned with soils and water, insects and diseases, genetics, tree seeds, regeneration and quality of second growth timber. An expanded program will hasten development of adequate resources for the future.

JUN 1963
LIBRARY
OREGON STATE UNIVERSITY

CONTENTS

Page

INTRODUCTION 1

CONSTRUCTION OF TABLES

ACCURACY OF VOLUME TABLES

TABLE I. Relationship Between D.B.H.-V.C.D.-T.H. for Second-Growth Douglas-fir Trees in Medium and Well-Stocked Stands 3

TABLE II. Board Foot Photo-Volume Table for Second-Growth Douglas-fir Trees in Medium and Well-Stocked Stands 3

TABLE III. Cubic Foot Photo-Volume Table for Second-Growth Douglas-fir Trees in Medium and Well-Stocked Stands 4

TABLE IV. Relationship Between D.B.H.-V.C.D.-T.H. for Second-Growth Douglas-fir Trees in Well-Stocked Stands 4

TABLE V. Board Foot Photo-Volume Table for Second-Growth Douglas-fir Trees in Well-Stocked Stands 5

TABLE VI. Cubic Foot Photo-Volume Table for Second-Growth Douglas-fir Trees in Well-Stocked Stands 5

TABLE VII. Relationship Between D.B.H.-V.C.D.-T.H. for Second-Growth Douglas-fir Trees in Medium and Well-Stocked Stands 6

TABLE VIII Board Foot Photo-Volume Table for Second-Growth Douglas-fir Trees in Medium and Well-Stocked Stands 6

TABLE IX Cubic Foot Photo-Volume Table for Second-Growth Douglas-fir Trees in Medium and Well-Stocked Stands 7

TABLE X Local Photo-Volume Table for Second-Growth Douglas-fir 7

TABLE XI Regression Solution of D.B.H. on V.C.D. and T.H. for Ponderosa Pine Trees in Medium and Well-Stocked Stands on Site IV Land 8

TABLE XII Standard Tree Photo-Volume Table for Mature Ponderosa Pine in Medium and Well-Stocked Stands 8

AERIAL PHOTO-MENSURATION TABLES

J. Richard Dilworth

Aerial photo cruising that can be accomplished quickly, cheaply and with a satisfactory degree of accuracy has been the goal of many forest mensurationists throughout the world. As early as 1925, photo cruising was accomplished successfully by Professor R. Hugershoff and his associates in Germany. The development of this technique has not been rapid, particularly in America, because of the lack of adequate research and developmental efforts. Scattered reports from various parts of the United States and Canada indicate that photo cruising can be accomplished satisfactorily from both a cost and accuracy standpoint.

The purpose of this report is to make available certain aerial photo volume tables for second-growth Douglas-fir and mature Ponderosa pine stands in Oregon that may help to promote the increased use of the photo cruising technique.

CONSTRUCTION OF TABLES

The tables showing the relationship between diameter breast height (DBH), total tree height (TTH) and visible crown diameter (VCD) were derived from field measurements taken on the ground. The multiple regression method was used to correlate the three variables. The basic equation is as follows:

$$D.B.H. = b_0 + b_1 (TTH) + b_2 (VCD) + b_3 (TTH)^2 + b_4 (TTH) (VCD)$$

ACCURACY OF VOLUME TABLES

Table No.	Aggregate Difference (per cent)	Standard Error (per cent)
II	+14.40	18.5
III	+ 0.15	11.6
V	+ 0.41	13.5
VI	+ 1.60	11.5
VIII	- 0.90	6.9
IX	- 1.14	10.7
X	- 1.40	26.7
XII	+ 1.71	13.95

TABLE I

RELATIONSHIP BETWEEN D.B.H.-V.C.D.-T.H. FOR SECOND-GROWTH DOUGLAS-FIR TREES IN MEDIUM AND WELL-STOCKED STANDS

V.C.D. (feet)	TOTAL HEIGHT IN FEET											
	70	80	90	100	110	120	130	140	150	160	170	180
	D.B.H. in Inches											
8		9.3	10.4	11.4	12.5	13.5						
11	10.0	11.1	12.1	13.2	14.3	15.3	16.3					
14	11.7	12.8	13.9	15.0	16.1	17.1	18.2	19.2	20.3	21.3		
17	13.4	14.6	15.7	16.8	17.9	19.0	20.0	21.1	22.1	23.2	24.2	25.2
20		16.3	17.4	18.6	19.7	20.8	21.9	23.0	24.0	25.1	26.1	27.1
23		18.1	19.2	20.4	21.5	22.6	23.7	24.8	25.9	27.0	28.0	29.1
26			21.0	22.1	23.3	24.4	25.6	26.7	27.8	28.9	29.9	31.0
29				23.9	25.1	26.3	27.4	28.5	29.7	30.8	31.9	33.0
32						28.1	29.3	30.4	31.6	32.7	33.8	34.9
35						29.9	31.1	32.3	33.4	34.6	35.7	36.8

McDonald Forest Data. Prepared by the multiple regression method based on 1,250 trees. Site indexes 100-160. J. R. Dilworth, 1959.

TABLE II

BOARD FOOT PHOTO-VOLUME TABLE FOR SECOND-GROWTH DOUGLAS-FIR TREES IN MEDIUM AND WELL-STOCKED STANDS

V.C.D. (feet)	TOTAL HEIGHT OF TREE IN FEET											
	70	80	90	100	110	120	130	140	150	160	170	180
	Volume of Tree in Board Feet (Scribner) to 8" Top D.i.b.											
8						155	212	282				
11				114	161	218	282	359				
14			105	152	211	274	354	441	559			
17		91	142	197	259	331	418	528	659	826	1029	1248
20	73	118	180	238	309	392	494	623	766	950	1164	1426
23			215	285	363	456	570	708	872	1074	1311	1609
26			260	337	430	520	648	800	984	1208	1476	1804
29			296	380	477	589	724	882	1084	1342	1640	1999
32				437	545	657	803	980	1202	1484	1800	2180
35					613	728	885	1077	1324	1620	1964	2372

Developed from Table No. 14 U. S. D. A. Bulletin No. 201, and D.B.H. curves. Includes trees 11.6 inch D.B.H. and larger. Prepared by harmonized curve method. Based on 1,250 trees. Site indices 100-160. J. R. Dilworth, 1959.

TABLE III

CUBIC FOOT PHOTO-VOLUME TABLE FOR SECOND-GROWTH DOUGLAS-FIR TREES IN MEDIUM AND WELL-STOCKED STANDS

V.C.D. (feet)	TOTAL HEIGHT OF TREE IN FEET											
	70	80	90	100	110	120	130	140	150	160	170	180
	Volume of Tree in Cubic Feet											
8		16.2	21.7	28.2	37.3	46.8						
11	16.4	22.4	28.8	37.8	47.9	58.4	70.5					
14	21.8	29.3	38.0	48.0	59.0	70.7	85.3	102	121	141		
17	28.1	37.6	47.5	58.8	70.7	84.7	99.8	119	139	162	186	215
20		50.7	57.0	70.2	82.7	98.4	116	136	157	183	209	240
23			67.3	81.7	95.6	112	131	152	177	204	233	269
26			78.3	93.2	109	126	147	169	196	226	258	299
29				104	123	141	163	186	217	249	284	325
32						156	179	204	237	272	308	351
35						170	211	223	256	296	327	376

Developed from Table No. 12 in U. S. D. A. Tech. Bull. No. 201 by R. E. McArdle and W. H. Meyer. Considers only those trees having a D.B.H. of 9.6" or larger. Volume is the total for the stump, stem, and top. McDonald Forest data. Based on 1,250 trees. Site indices 100-160. J. R. Dilworth, 1959.

TABLE IV

RELATIONSHIP BETWEEN D.B.H.-V.C.D.-T.H. FOR SECOND-GROWTH DOUGLAS-FIR TREES IN WELL-STOCKED STANDS

V.C.D. (feet)	TOTAL HEIGHT IN FEET										
	70	80	90	100	110	120	130	140	150	160	170
	D.B.H. in Inches										
11			11.9	13.0	14.1	15.2					
14	11.6	12.2	13.8	14.9	16.0	17.1					
17	13.6	14.7	15.7	16.8	17.9	19.1	20.2	21.3	22.5	23.6	24.8
20	15.5	16.6	17.7	18.8	19.9	21.0	22.1	23.2	24.4	25.5	26.6
23	17.5	18.6	19.6	20.7	21.8	22.9	24.0	25.1	26.3	27.4	28.5
26		20.6	21.6	22.7	23.7	24.8	25.9	27.0	28.1	29.3	30.4
29				24.6	25.6	26.8	27.8	28.9	30.0	31.2	32.3
32				26.6	27.6	28.7	29.8	30.8	31.9	33.0	34.2
						30.6	31.7	32.7	33.8	34.9	36.0

McDonald Forest data. Multiple regression method. Based on 1,250 trees. Site indexes 100-160. J. R. Dilworth, 1959.

TABLE V

BOARD FOOT PHOTO-VOLUME TABLE FOR SECOND-GROWTH DOUGLAS-FIR TREES IN WELL-STOCKED STANDS

V.C.D. (feet)	TOTAL HEIGHT OF TREE IN FEET										
	70	80	90	100	110	120	130	140	150	160	170
11			102	150	204	267					
14	63	101	150	204	255	335					
17	94	142	197	257	326	407	503	623	760	923	1119
20	127	184	249	319	394	480	589	718	872	1053	1256
23	164	229	300	378	464	558	676	816	990	1187	1409
26		276	355	444	534	640	765	920	1103	1326	1570
29				510	609	721	860	1026	1228	1467	1737
32				584	691	814	962	1136	1359	1601	1897
35						904	1060	1249	1496	1742	2046
38										1892	

Developed from Table No. 14 U. S. D. A. Bulletin No. 201, and D. B. H. Curves. Includes Trees 11.6 inch D.B.H. and larger. McDonald Forest data. Site indices 100-160. J. R. Dilworth, 1959.

TABLE VI

CUBIC FOOT PHOTO-VOLUME TABLE FOR SECOND-GROWTH DOUGLAS-FIR TREES IN WELL-STOCKED STANDS

V.C.D. (feet)	TOTAL HEIGHT OF TREE IN FEET										
	70	80	90	100	110	120	130	140	150	160	170
	Volume of tree in Cubic Feet										
11			27.9	36.7	46.7	57.8					
14	21.5	28.9	37.5	47.4	58.4	70.7					
17	28.8	38.1	47.5	58.8	70.7	85.4	102	121	143	166	206
20	37.0	47.2	58.7	71.3	84.1	100	118	138	161	187	215
23	46.1	57.7	69.8	83.7	97.8	114	133	155	181	209	239
26		68.9	82.2	97.3	112	129	149	172	199	231	264
29				110	126	145	166	190	220	253	289
32				125	132	161	183	208	240	276	312
35						176	200	227	261	299	335

Developed from Table No. 12 in U. S. D. A. Tech. Bull. No. 201 by R. E. McArdle and W. H. Meyer. Considers only those trees having a D.B.H. of 9.6" or larger. Volume is the total for the stump, stem, and top. McDonald Forest data. Site indices 100-160. J. R. Dilworth, 1959.

TABLE VII

RELATIONSHIP BETWEEN D.B.H.-V.C.D.-T.H. FOR SECOND-GROWTH DOUGLAS-FIR TREES IN MEDIUM AND WELL-STOCKED STANDS

V.C.D. (feet)	TOTAL HEIGHT IN FEET											
	70	80	90	100	110	120	130	140	150	160	170	180
	D.B.H. in Inches											
8	7.8	8.8	9.9	10.9	11.9	13.0						
11	9.6	10.6	11.7	12.7	13.8	14.8	15.9	16.9				
14	11.4	12.5	13.5	14.6	15.7	16.7	17.8	18.8	19.9	21.0		
17	13.2	14.3	15.4	16.5	17.5	18.6	19.7	20.8	21.8	22.9	24.0	25.1
20		16.1	17.2	18.3	19.4	20.5	21.6	22.7	23.8	24.9	25.9	27.0
23			19.1	20.2	21.3	22.4	23.5	24.6	25.7	26.8	27.9	29.0
26			20.9	22.0	23.1	24.3	25.4	26.5	27.6	28.7	29.9	31.0
29			22.7	23.9	25.0	26.1	27.3	28.4	29.5	30.7	31.8	33.0
32				25.7	26.8	28.0	29.2	30.3	31.5	32.6	33.8	34.9
35					28.7	29.9	31.1	32.2	33.4	34.6	35.7	36.9

Combined data--O.S.C., McDonald Forest and Pope's data collected in Clackamas and Multnomah counties, Oregon. Prepared by the multiple regression method. Based on 1,554 trees. Site indexes 100-170. J. R. Dilworth, 1959.

TABLE VIII

BOARD FOOT PHOTO-VOLUME TABLE FOR SECOND-GROWTH DOUGLAS-FIR TREES IN MEDIUM AND WELL-STOCKED STANDS

V.C.D. (Feet)	TOTAL HEIGHT OF TREE IN FEET											
	70	80	90	100	110	120	130	140	150	160	170	180
	Volume of Tree, (Scribner) Board Feet to 8" Top D.i.b.											
8					137	190						
11			98	142	200	255	326	408				
14		97	142	194	255	321	402	498	613	754		
17	87	139	190	249	312	389	481	598	721	876	1058	1266
20		172	235	303	377	460	566	693	836	1011	1212	1435
23			286	362	448	537	653	790	952	1144	1370	1627
26			335	420	511	619	742	893	1071	1282	1527	1813
29			388	486	584	696	836	998	1195	1441	1693	1999
32				551	658	780	930	1106	1325	1572	1864	2171
35					737	871	1028	1219	1465	1726	2030	2363

Developed from Table No. 14 U. S. D. A. Bulletin No. 201, and D.B.H. Curves. Includes Trees 11.6 inch D.B.H. and larger. Combined data--O. S. C., McDonald Forest and Pope's data collected in Clackamas and Multnomah counties, Oregon. Based on 1,554 trees. Site indices 100-170. J. R. Dilworth, 1959.

TABLE IX

CUBIC FOOT PHOTO-VOLUME TABLE FOR SECOND-GROWTH DOUGLAS-FIR TREES IN MEDIUM AND WELL-STOCKED STANDS

V.C.D. (Feet)	TOTAL HEIGHT OF TREE IN FEET											
	70	80	90	100	110	120	130	140	150	160	170	180
	Volume of Tree in Cubic Feet											
8			19.7	25.9	34.0	43.7						
11	15.2	20.6	27.0	34.9	44.9	55.2	67.5	82.0				
14	20.8	28.0	35.9	45.7	56.5	67.9	82.1	99.1	117	138		
17	27.3	36.1	45.9	56.9	68.5	81.7	97.3	116	136	159	184	213
20		44.8	55.9	68.6	80.0	96.1	113	133	155	181	207	239
23			66.7	80.3	94.2	111	129	150	175	202	232	268
26			77.7	92.5	108	125	145	167	194	224	258	299
29			89.1	105	122	140	162	185	215	247	282	325
32				118	135	155	179	203	235	271	308	351
35					150	170	195	222	256	296	331	378

Developed from Table No. 12 in U. S. D. A. Tech. Bull. No. 201 by R. E. McArdle and W. H. Meyer. Considers only those trees having a D.B.H. of 9.6" or larger. Volume is the total for the stump, stem, and top. Combined data O. S. C.-McDonald Forest and Pope's data collected in Clackamas and Multnomah counties, Oregon. Based on 1,554 trees. Site indices 100-170. J. R. Dilworth, 1959.

TABLE X

LOCAL PHOTO-VOLUME TABLE FOR SECOND-GROWTH DOUGLAS-FIR

V.C.D. (feet)	TOTAL HEIGHT OF TREE IN FEET		
	60-110	110-140	140+
	Volume of Tree, Scribner Dec. C. to 8" Top D.i.b.		
8	9.9	17	28
11	14	26	42
14	19	34	56
17	23	43	70
20	28	52	86
23	33	62	101
26	38	72	117
29	44	84	134
32	48	95	152
35		107	173
38		120	197
41		135	225
44		152	256
47			288

Based on the volumes of 1,250 trees. Site Indices 100-160. Medium and well-stocked stands. J. R. Dilworth, 1959.

TABLE XI

REGRESSION SOLUTION OF D.B.H. ON V.C.D. AND T.H.
FOR PONDEROSA PINE TREES IN MEDIUM AND WELL STOCKED STANDS
ON SITE IV LAND

V.C.D.	TABLE HEIGHT IN FEET								
FEET	70	80	90	100	110	120	130	140	150
	D.B.H. IN INCHES								
6		11.4	13.3	15.1	16.9	18.7	20.5	22.4	
9	11.9	13.7	15.6	17.4	19.2	21.0	22.9	24.7	26.5
12	14.2	16.1	17.9	19.7	21.5	23.3	25.2	27.0	28.8
15	16.6	18.4	20.2	22.0	23.8	25.7	27.5	29.3	31.1
18	18.9	20.7	22.5	24.3	26.2	28.0	29.8	31.6	33.4
21	21.2	23.0	24.8	26.7	28.5	30.3	32.1	33.9	35.8
24	23.5	25.3	27.2	29.0	30.8	32.6	34.4	36.3	38.1
27	25.8	27.6	29.5	31.3	33.1	34.9	36.8	38.6	40.4
30			31.8	33.6	35.4	37.2	39.1	40.9	42.7
33			34.1	35.9	37.7	39.6	41.4	43.2	45.0
36				38.2	40.1	41.9	43.7	45.5	47.3
39					42.5	44.2	46.0	47.8	49.7
42					44.7	46.5	48.3	50.2	52.0

Based on 244 trees. Pringle Falls Experimental Forest Data (Oregon). David P. Paine, 1958.

TABLE XII

STANDARD TREE PHOTO VOLUME TABLE
FOR MATURE PONDEROSA PINE
IN MEDIUM AND WELL STOCKED STANDS

V.C.D.	TOTAL HEIGHT IN FEET								
FEET	70	80	90	100	110	120	130	140	150
	BOARD FEET TREE VOLUMES (SCRIBNER)								
6		65	138	226	332	469	656	888	
9	69	128	218	328	457	627	847	1100	1380
12	123	201	311	444	590	795	1050	1340	1650
15	188	281	416	573	748	986	1270	1610	1960
18	258	373	532	717	927	1190	1520	1890	2280
21	339	474	662	884	1120	1420	1780	2210	2640
24	429	589	813	1060	1320	1670	2060	2550	3020
27	530	714	979	1250	1550	1930	2390	2910	3410
30			1140	1460	1790	2210	2720	3280	3840
33			1 340	1680	2040	2539	3070	3690	4290
36				1920	2320	2850	3430	4110	4760
39					2640	3180	3830	4560	5280
42					2930	3540	4240	5040	5800

Developed from Table XI and Bruce Girard form class volume tables. David P. Paine, 1958. One foot stump. Merchantable top limit 50 per cent of the scaling diameter of the first 16-foot log or eight inches, whichever is greater.