Module 4 – TIMBER CRUISING

1. Inventory
    a. Read "Forest Inventory Intro"
2. Unit Boundaries
    a. Watch "Intro and Ground Truth" (1:54) https://www.youtube.com/watch?v=RGK4V7HuR04&feature=youtu.be
3. Plot establishment
    a. Read "Intro to Cruising"
    b. Watch "Timber Inventory and Plot Sampling" from the 2:34 time mark (8:17) https://www.youtube.com/watch?v=0I5h1AoKdhs
    c. Watch "Fixed Plot" (4:37) https://www.youtube.com/watch?v=iha7TQI_lV4&feature=youtu.be
    d. Watch "Variable Plot" (0:50) https://www.youtube.com/watch?v=tdr0gzm8BRc&feature=youtu.be
4. Data Collection and Interpretation
    a. Watch "DBH" (2:31) https://www.youtube.com/watch?v=Zwy8IEUVbq0&feature=youtu.be
    b. Watch "Clinometer" (2:10) https://www.youtube.com/watch?v=YPhm8gcA7dc&feature=youtu.be
    c. Read "Height Measurements on Level Ground"
    d. Read "Height Measurements on Sloping Ground"
    e. Read "Biltmore Stick Diameter"
    f. Read "Biltmore Stick Height"

g. Watch “Woodland (Biltmore) Stick Diameter” (1:04) https://youtu.be/9u9KLTVsMOM
h. Watch “Woodland (Biltmore) Stick Height” (1:12) https://youtu.be/QmmnrH-zEDw
i. Look at examples of Volume Tables for different species
j. Basal Area
    i. Watch “Keyhole Prism” (0:47) https://youtu.be/kcHsPMhfzbw
    ii. Watch “Wedge Prism” (2:11) https://youtu.be/WLeJVcBlVK4
    iii. Watch “Limiting Distance to Determine ‘In’ Trees” (1:29) https://youtu.be/eVhScW2oxKQ
    iv. Look at Limiting Distance Tables for 20 and 40 Basal Area Factors
k. Read pdf “How to Use a Densitometer”
l. Increment Borer
    i. Read “Increment Borers”
    ii. Watch “Increment Borer” (4:57) https://youtu.be/aHiC2TtzhLY
m. Site Index
    i. Read “Overview of Site Index”
    ii. Look at Site Class and Site Index graphics
n. Watch “Plot Data Collection at Usal Forest” (13:52) https://youtu.be/BYP2ApgVt8A
o. (Optional) Watch “Gino” (1:11) https://youtu.be/2xC5M4KJ5ws
p. Read “Basic Inventory Calculations”
q. Complete “Tree Measurement” worksheet

Basic Forest Inventory Techniques for Family Forest Owners

By Kevin W. Zobrist, Donald P. Hanley, Amy T. Grotta, and Chris Schnepf

Introduction

An inventory is a cornerstone of forest stewardship planning that not only ensures your forest is healthy and productive, but can meet your objectives as a landowner for years to come. After all, to assess the needs of your forest and plan for the future, you have to know what forest resources you have. A forest inventory will help you quantify what you have and identify needs and opportunities for forest health, wildlife habitat, timber production, aesthetics, and carbon storage. An inventory will give you insights into species composition, tree density, basal area, and volume, and help you document change (e.g., growth and mortality) in your forest over time.

Many landowners just walk through their forest to make a rough assessment of their forest characteristics. While this is better than a "windshield cruise," doing a more formal inventory gives you a systematic, focused feel for what is happening in your forest. Many landowners who have measured plots discover their forest is quite different than they initially thought (e.g., different species mixes). Ultimately, this hands-on, up-close contact with your forest may be one of the biggest benefits of collecting data about your forest.

This manual will teach you the basic principles of taking an inventory of your forest. You will first learn how to identify individual forest stands on your property, take a plot sample, establish an inventory plot, and measure individual trees. You will then learn how to compute basic statistics that will help you assess the condition of your forest and plan appropriate management activities.

There are many different methods of doing forest inventory, with different applications, required skill levels, and regional variations. This manual presents an approach to forest inventory that is intended to be relatively easy to implement, broadly applicable across the Northwest, and suitable for stewardship planning.

This approach will not be appropriate for all applications. For instance, this manual is not intended to teach you how to do a professional-quality timber cruise for the purposes of appraisal, preparing a timber sale, or similar applications for which much tighter sampling protocols are required. You will be able to collect useful data about your forest, but it is not a substitute for the services of your local forestry professional if you have more advanced needs. If you do need to hire a professional, this manual will help you to better understand and communicate regarding the principles that a professional forester will apply when working on your property.

Designing Your Inventory Strategy

Conducting a forest inventory takes a lot of time and effort, so doing it right the first time is important. Before you head out into the woods to begin collecting data, decide what information you need. This manual provides instructions on gathering and generating all types of information about your forest, but you may find that not all of the information is relevant to you. Your forest inventory should be tailored to your goals and objectives as a landowner. Do you expect to sell timber from your property in the future? Then having information on timber volume would be valuable. Have you had a recent timber cruise of your property? If so, you may not need to calculate volume at this time. Are you most interested in the aesthetic and recreational values of your property? In that case, you might be able to narrow your focus to just the fundamentals: species composition, tree density, and forest health indicators such as live crown ratio.

Many landowners conduct an inventory to gather information for a forest management plan. While forest management plan standards might vary from state to state, in general the following types of information are needed for a plan: a stand map for each stand that includes tree species composition, trees per acre, and average diameter or distribution of diameters. This manual will help you assemble that information, and much more. Your local Extension or state service forester can advise you on the best inventory strategy to meet your objectives for your property.

TIMBER CRUISING

FORESTRY CHALLENGE℠

WHAT IS TIMBER CRUISING?

- A more efficient way to collect information
- No need to measure every tree

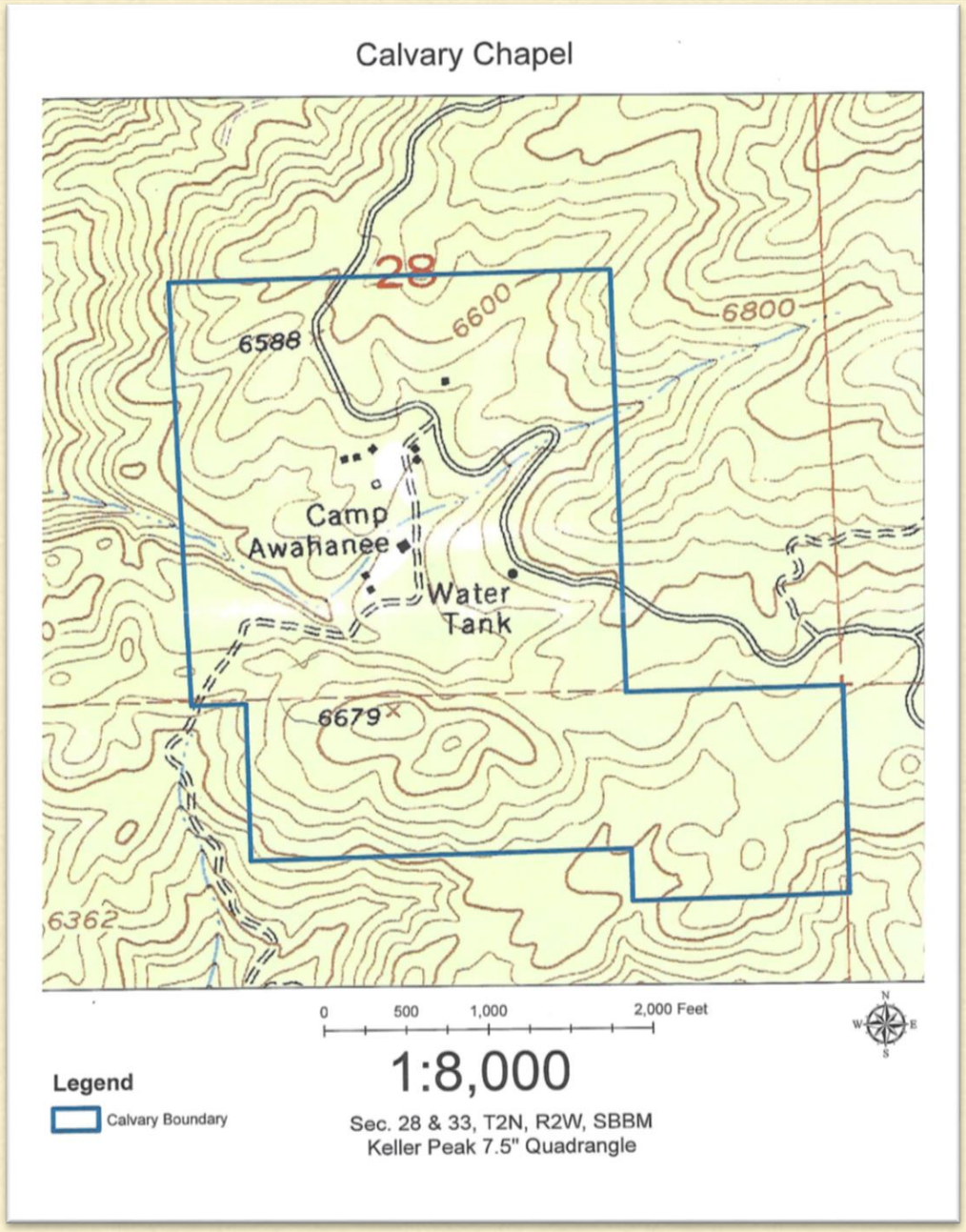
FOREST OR STAND?

- A *forest* is comprised of individual stands.
- A *stand* is a distinct, recognizable area of the forest that is likely to be managed as a unit.
- Age, tree species composition, soil types, topography, or other natural features will differentiate stands.
- Characterizing stands is a subjective process. Different people may look at the same forest and describe different stand boundaries.

DETERMINE STAND BOUNDARIES

- Aerial
- On-the-ground

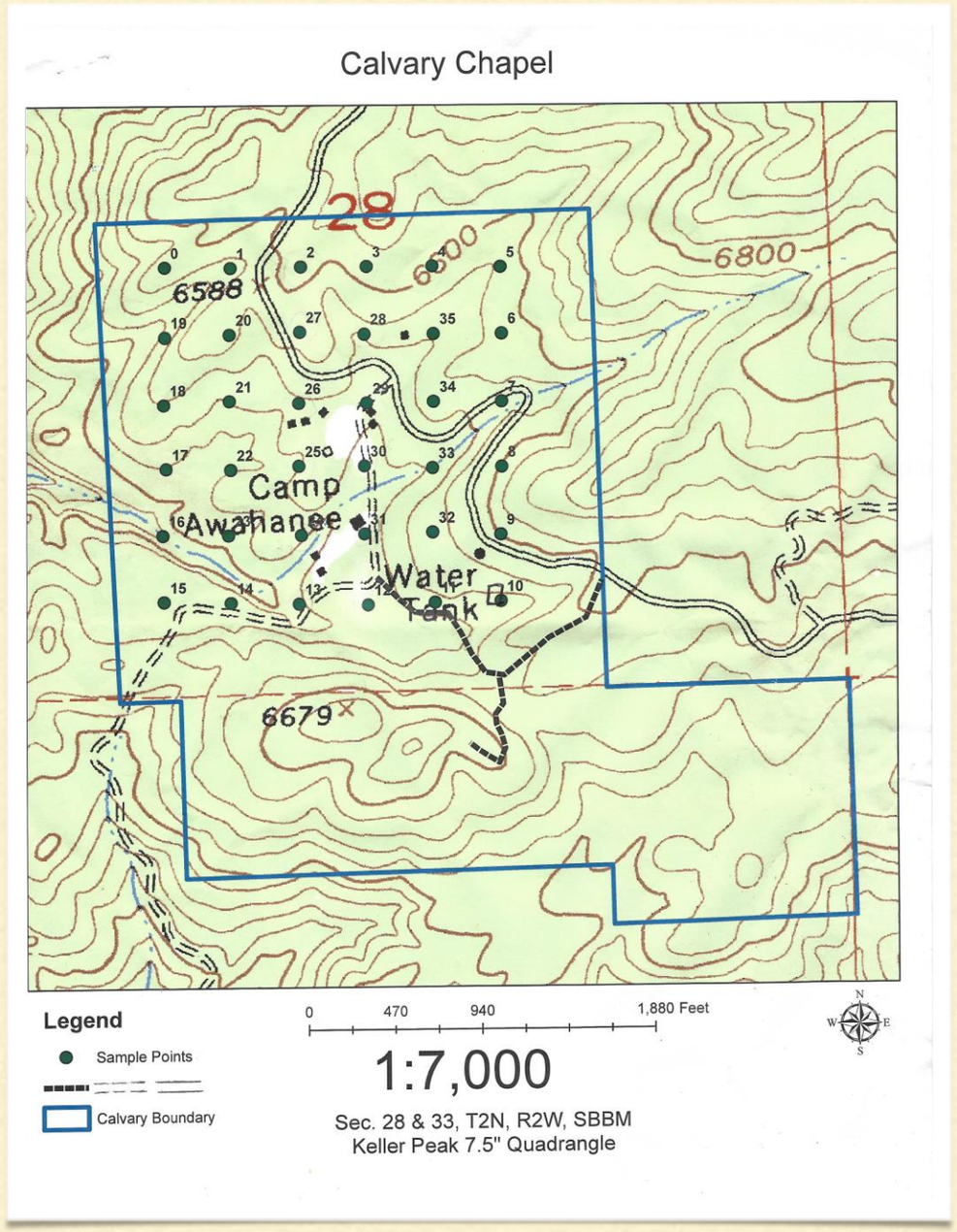
PLOT SAMPLING



QUANTITY

- How many plots per stand?
- Consider species diversity, terrain, desired accuracy, and labor you are willing to put in

PLOT SAMPLING



LOCATION

- Spread data points to evenly and accurately represent stand.
- How far apart should plots be?
- Physical reference points vs. cardinal directions.

LOCATING PLOT CENTERS

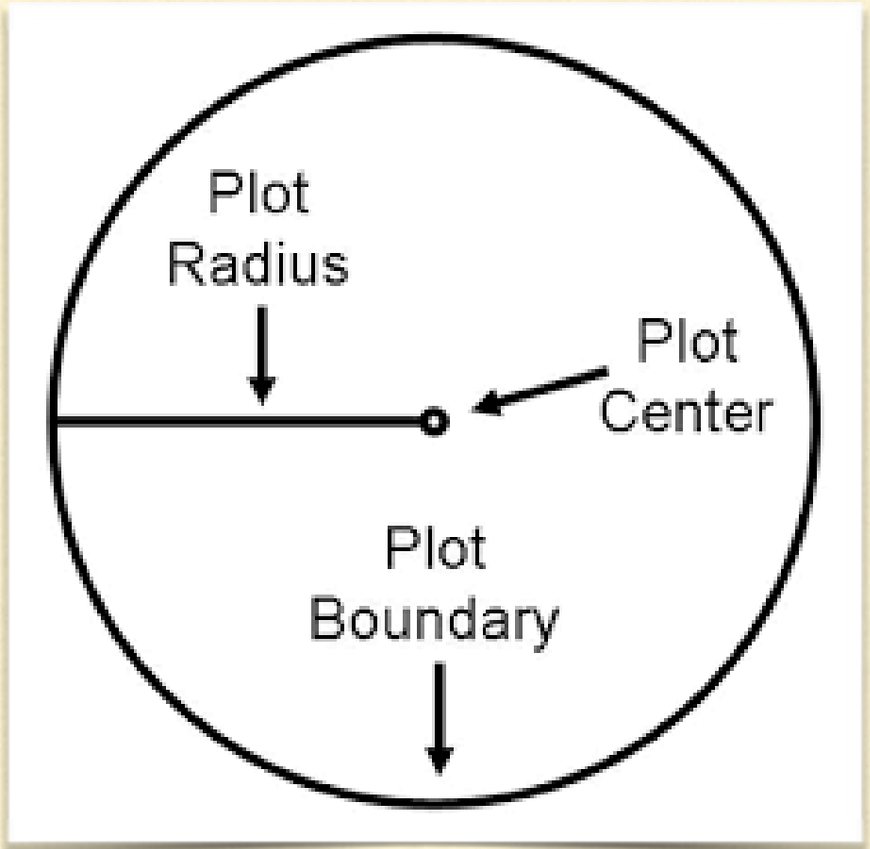
- GPS
- Compass and pacing

How to measure your pace: http://breeze.wsu.edu/inv_pacing/

ESTABLISHING PLOT SIZE

FIXED RADIUS PLOTS

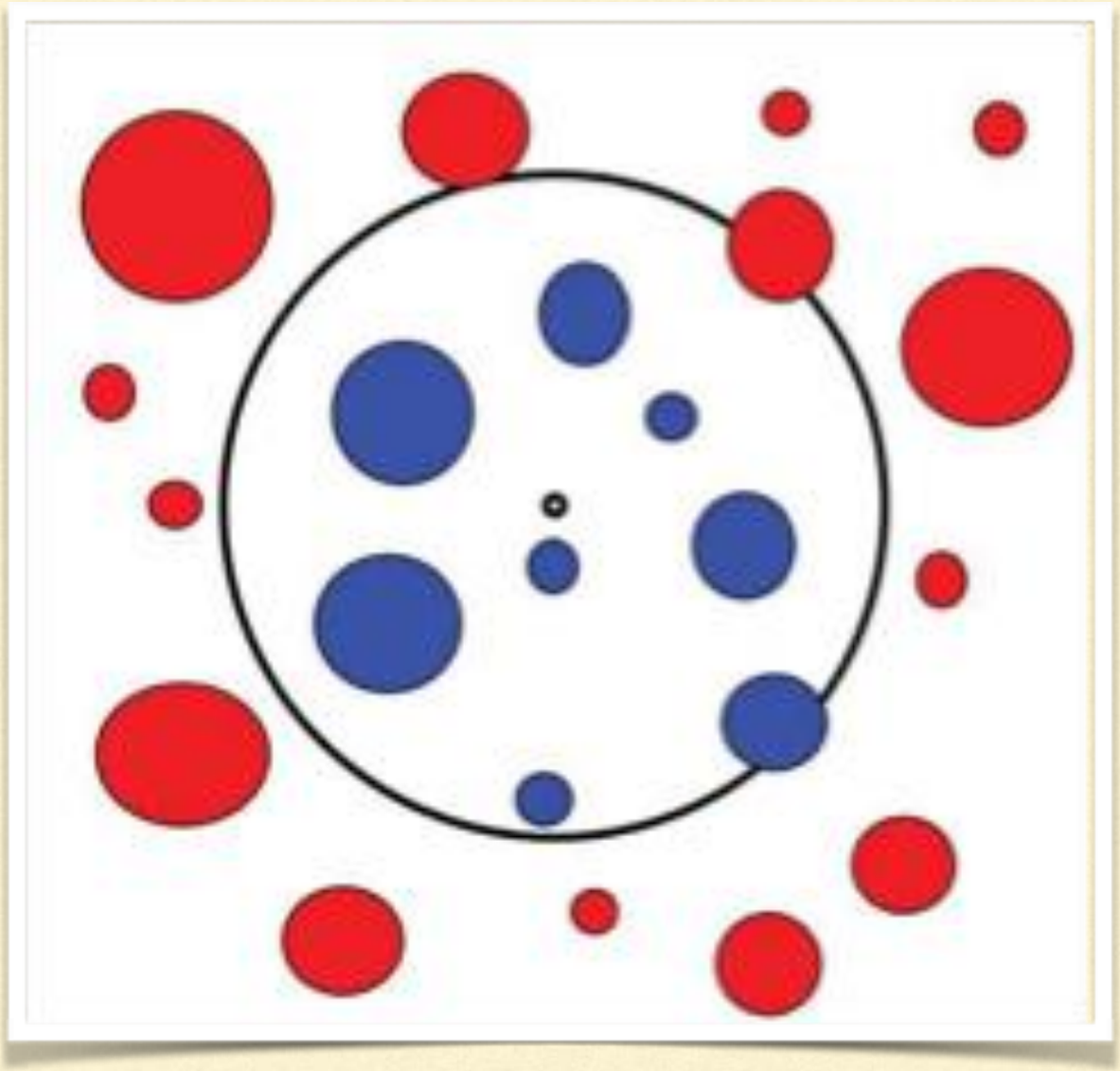
Plot Size (acres)	Radius (feet)
1/5	52.7 (≈52′8″)
1/10	37.2 (≈37′2″)
1/20	26.3 (≈26′4″)
1/30	21.5 (≈21′6″)
1/40	18.6 (≈18′7″)
1/50	16.7 (≈16′8″)
1/60	15.2 (≈15′2″)
1/100	11.8 (≈11′10″)
1/250	7.4 (≈7′5″)



DETERMINING TREES IN A FIXED PLOT

FIXED RADIUS PLOTS

Determine “in” trees.



STAND POPULATION

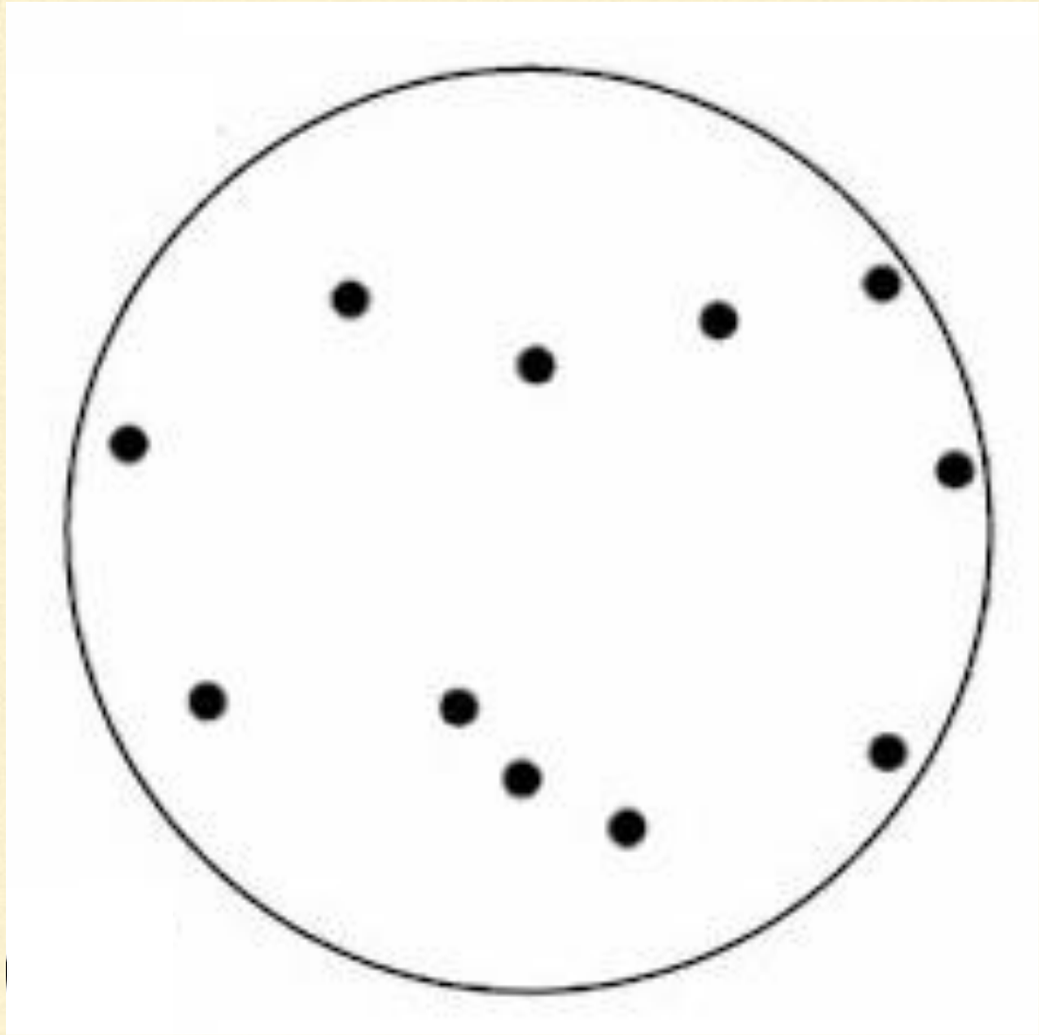
Trees per acre from a **fixed** plot

1. Determine the expansion factor for the plot trees (the number of trees per acre a given plot tree represents; e.g., 20 for a 1/20th acre plot).

2. Add up the total number of trees in a plot and multiply by the expansion factor to get the trees per acre represented by that plot.

3. Repeat this for the other plots in the stand.

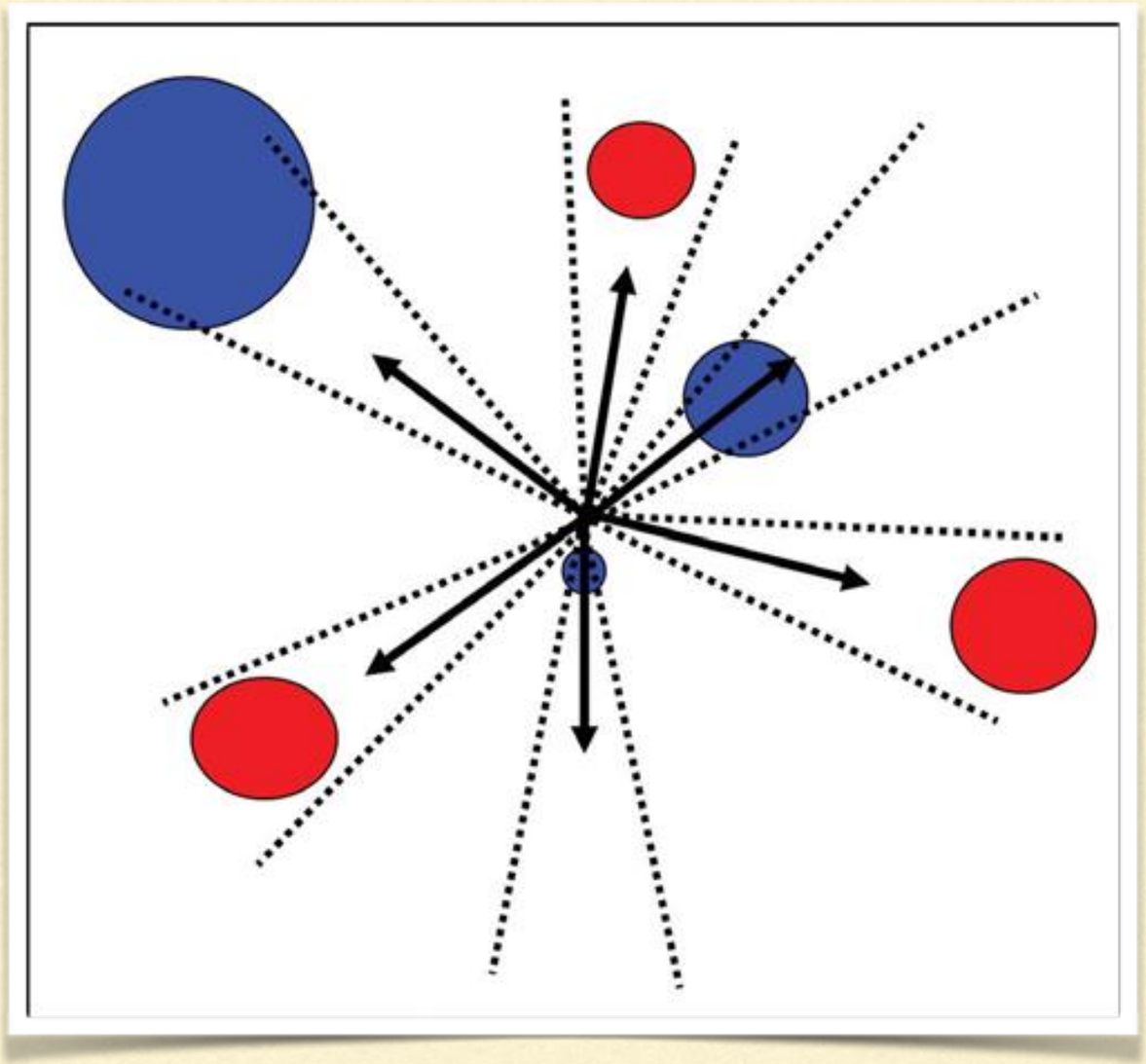
4. Add up the TPA for all plots in the stand and then divide by the number of plots to get the average TPA for the stand.



11 Trees x 20 = 220 Trees Per Acre

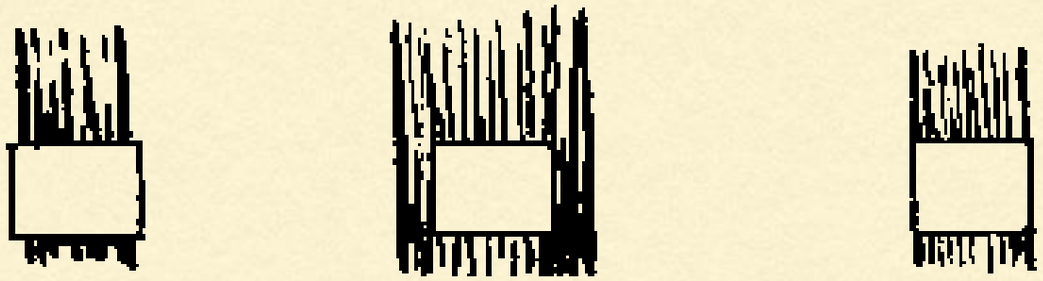
DETERMINING TREES IN A VARIABLE PLOT

VARIABLE PLOTS



- Unlike a fixed radius plot, which has a defined area, “in” trees will be determined by using an angle gauge.

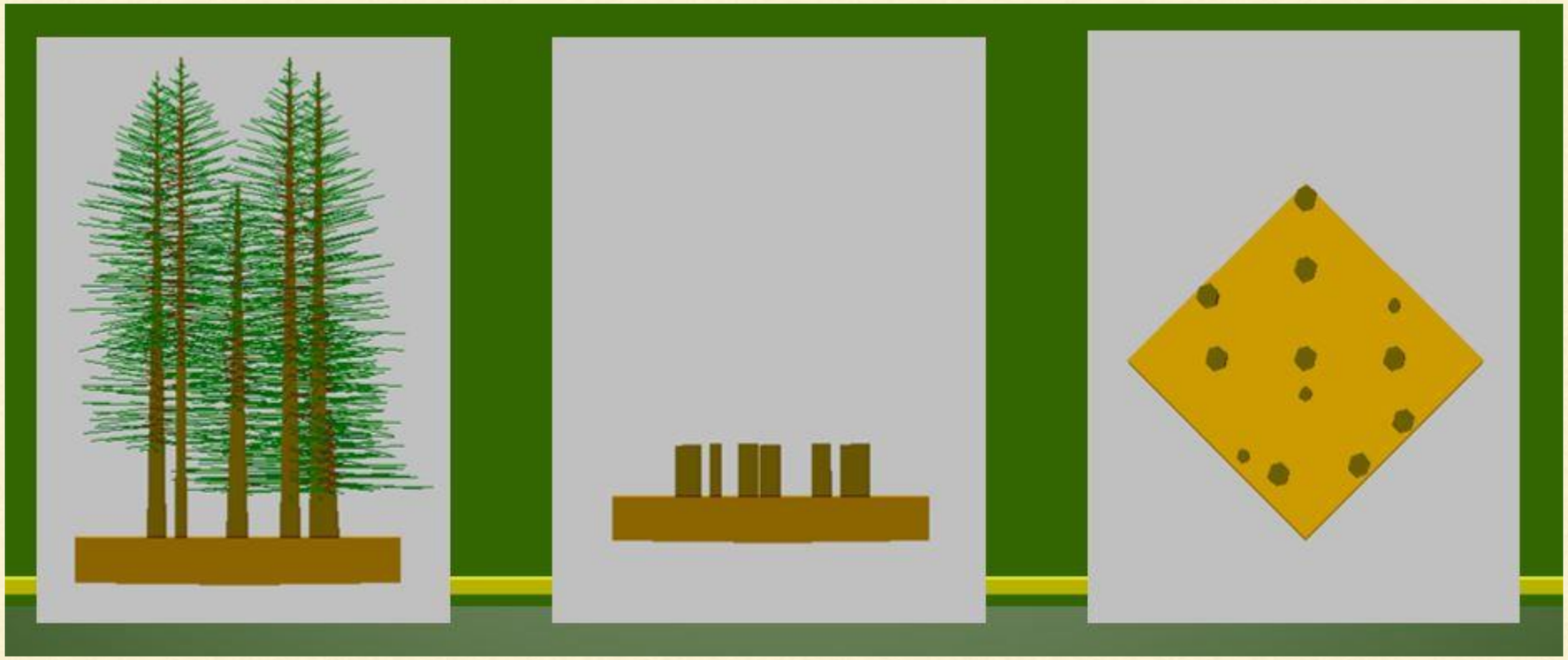
STAND DENSITY



TREES IN YOUR **VARIABLE** PLOT

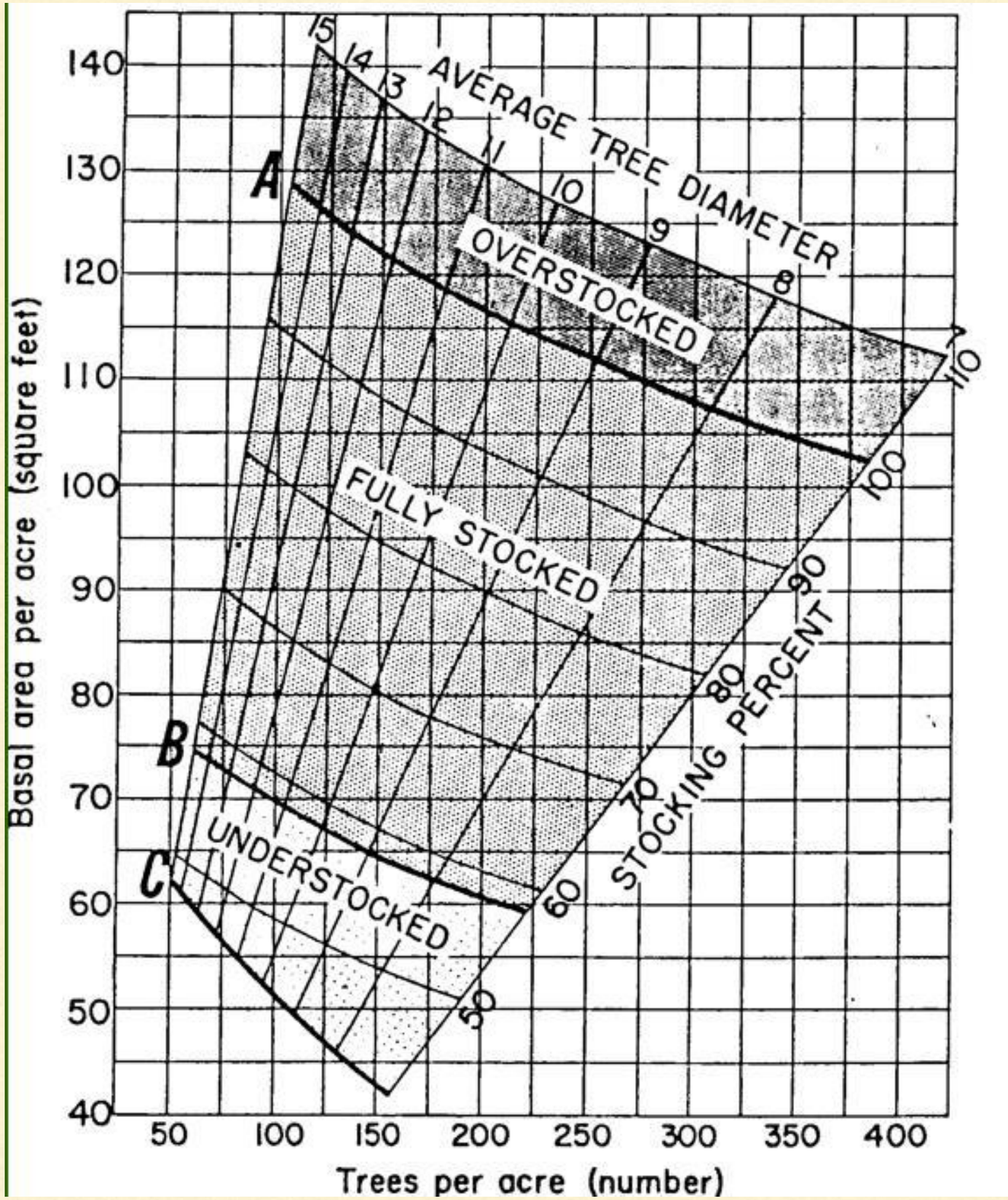
Computing Basal Area

Basal area is the cross sectional area of the trunk of a tree at breast height (i.e., 4.5 feet above the ground). For instance, if you establish a variable plot using a BAF 40 prism, every “in” tree would represent 40 square feet of basal area regardless of the actual basal area of each tree. Thus if you had three trees in a BAF 40 plot, it would represent 120 (3 x 40) square feet of basal area per acre.



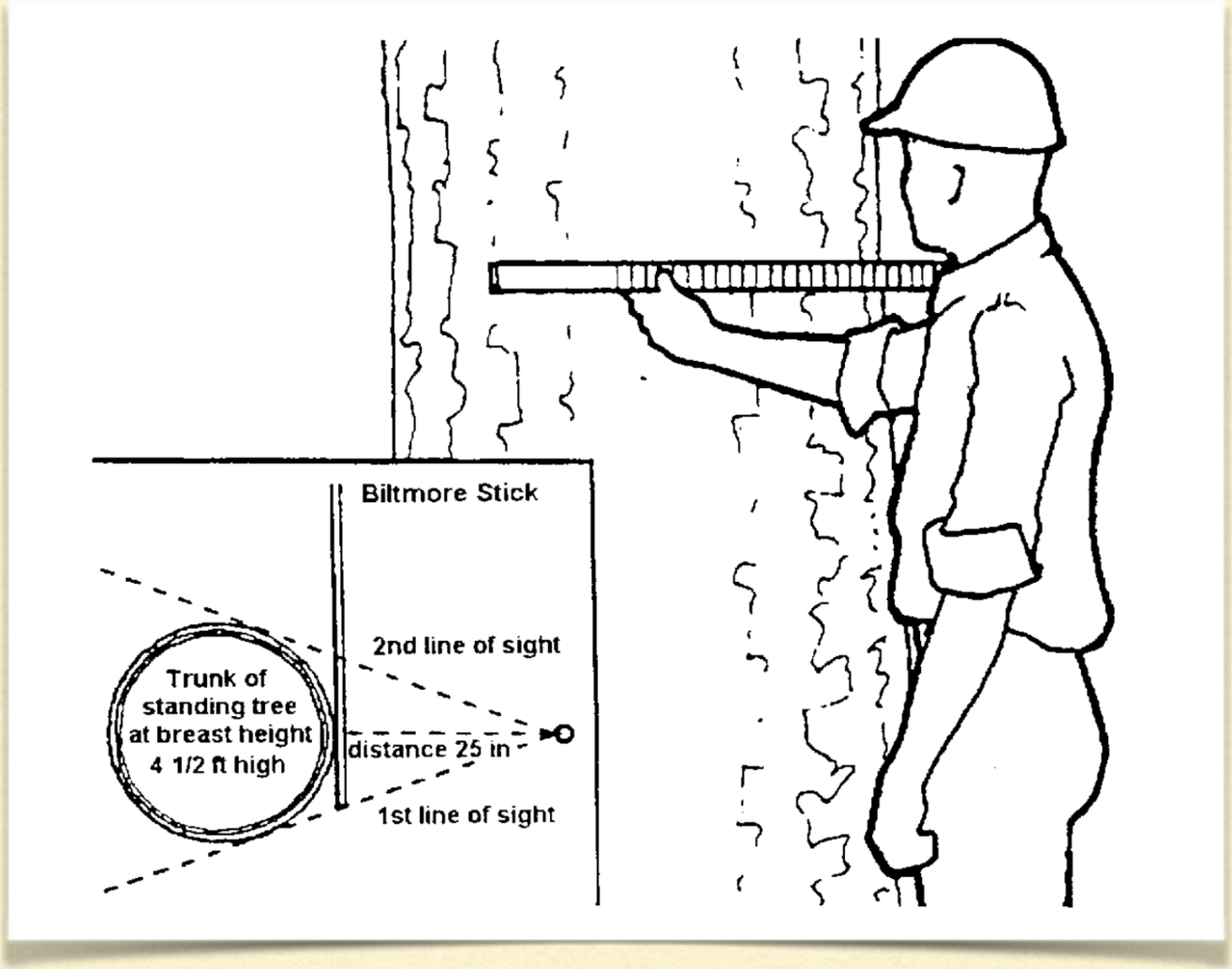
STOCKING

Once you determine the basal area and trees per acre, you can determine if the stand is under, fully, or overstocked.



DIAMETER AT BREAST HEIGHT (DBH)

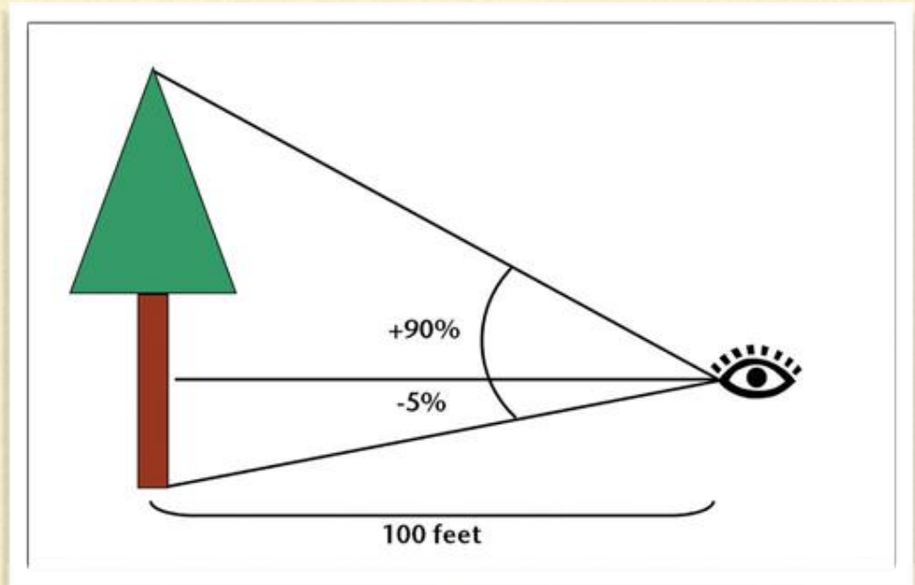
- Breast Height = 4.5 feet from the ground (on uphill side of tree)
- Find DBH using a d-tape
- Find DBH using a Biltmore stick

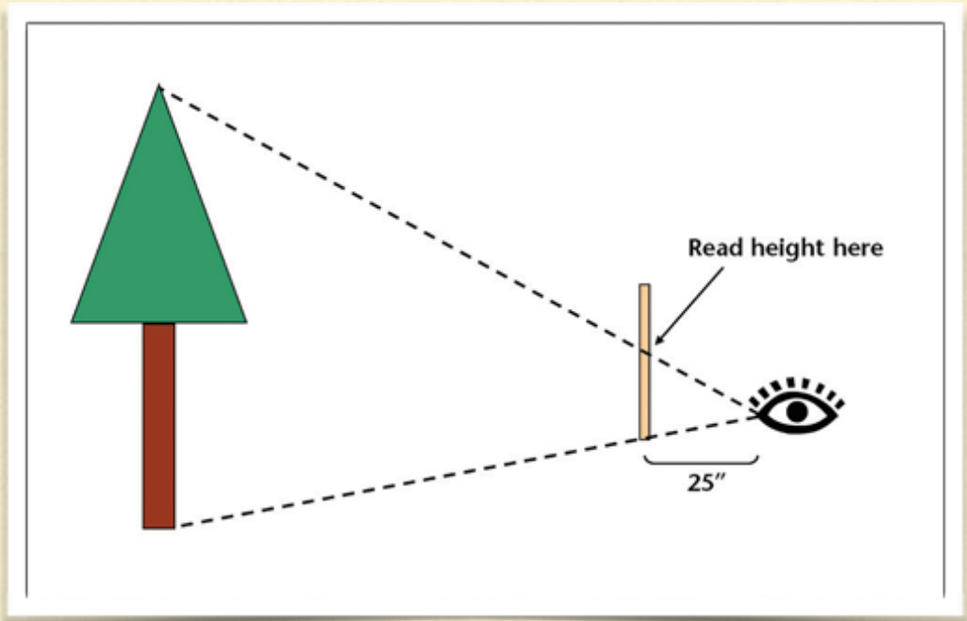


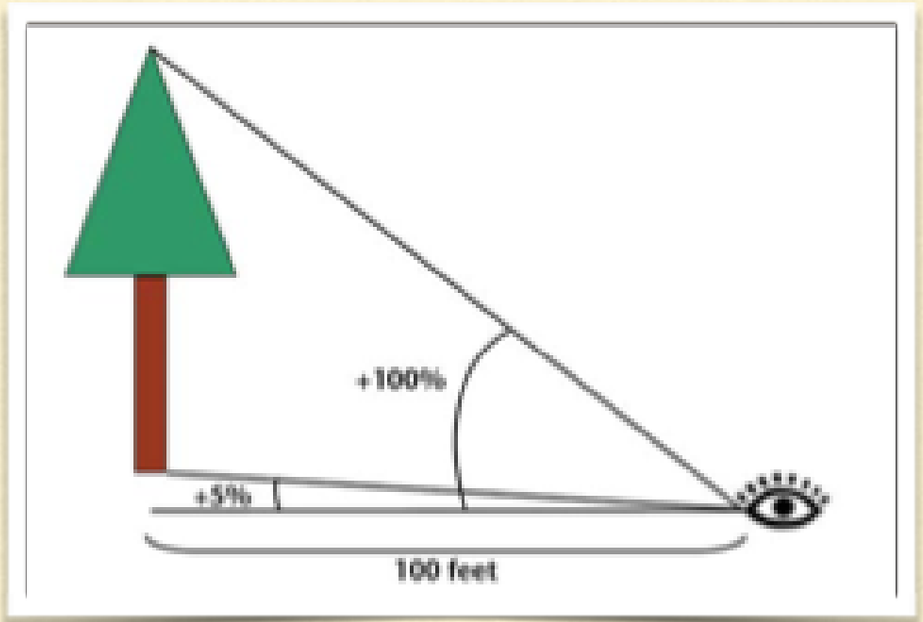
How to use a Biltmore stick: http://breeze.wsu.edu/inv_dstick/ How to use a d-tape: http://breeze.wsu.edu/inv_dtape/

DETERMINE TREE HEIGHT

- Find height using Biltmore stick
- Find height using Clinometer
- How to measure or pace away from a tree







Using a Clinometer: http://breeze.wsu.edu/inv_clinometer/

Using a Biltmore Stick: http://breeze.wsu.edu/inv_hstick/

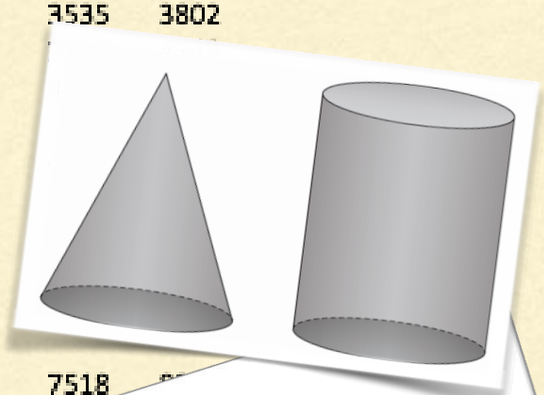
VOLUME

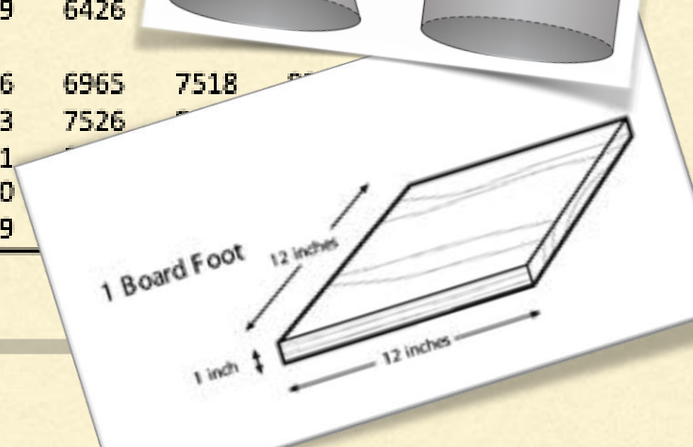
ONCE YOU KNOW THE DIAMETER AND THE HEIGHT, YOU CAN USE A VOLUME TABLE TO DETERMINE THE VOLUME OF WOOD IN A TREE, EXPRESSED IN BOARD FEET.

C.1 GROSS BOARD-FOOT VOLUME TABLE
DOUGLAS FIR

DBH	TOTAL HEIGHT (FEET)																
(INCHES)	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210
12	47	62	78	95	113	132	152	173	195	218	242	266	291	317	344	371	399
14	64	85	106	130	155	181	209	238	268	299	331	365	399	435	472	509	547
16	85	111	140	171	204	238	275	313	352	393	436	480	525	572	620	669	720
18	108	142	178	218	259	303	350	398	449	501	555	611	669	729	790	852	917
20	134	176	221	270	322	377	434	494	557	622	689	759	831	904	980	1058	1138
22	163	214	269	328	391	458	528	601	677	756	838	923	1010	1100	1192	1287	1384
24	195	256	322	393	468	547	631	718	809	904	1002	1103	1207	1315	1425	1538	1654
26	230	301	379	463	551	645	744	847	954	1065	1181	1300	1423	1549	1680	1813	1950
28	267	351	441	539	642	751	886	986	1111	1240	1375	1513	1657	1804	1955	2111	2270
30	308	404	509	621	740	865	997	1136	1280	1429	1584	1744	1909	2078	2253	2432	2615
32	352	461	581	708	844	988	1139	1256	1461	1631	1808	1991	2179	2373	2572	2776	2986
34	398	522	657	802	956	1119	1290	1468	1654	1847	2048	2254	2468	2687	2912	3144	3381
36	448	587	739	902	1075	1258	1450	1651	1860	2077	2302	2535	2775	3021	3275	3535	3802
38	500	656	826	1008	1201	1406	1620	1845	2078	2321	2573	2832	3100	3376	3659		
40	556	729	918	1120	1335	1562	1800	2049	2309	2579	2858	3147	3444	3751	4065		
42	614	806	1014	1238	1475	1726	1990	2265	2552	2850	3159	3478	3807	4146	4493		
44	676	887	1116	1362	1623	1899	2189	2492	2808	3136	3475	3826	4188	4561	4944		
46	740	972	1223	1492	1778	2080	2398	2730	3076	3435	3807	4192	4588	4996	5416		
48	808	1060	1334	1628	1940	2270	2617	2979	3357	3749	4155	4574	5007	5452	5910		
50	879	1153	1451	1770	2110	2469	2846	3240	3650	4076	4518	4974	5445	5929	6426		
52	952	1249	1572	1918	2287	2676	3084	3511	3956	4418	4897	5391	5901	6426	6965	7518	
54	1029	1350	1699	2073	2471	2891	3332	3794	4275	4774	5291	5825	6376	6943	7526		
56	1109	1455	1830	2234	2662	3115	3591	4088	4606	5144	5701	6277	6870	7481			
58	1191	1563	1967	2400	2861	3348	3859	4393	4950	5528	6127	6745	7383	8040			
60	1277	1676	2109	2573	3067	3589	4137	4710	5306	5926	6568	7231	7915	8619			

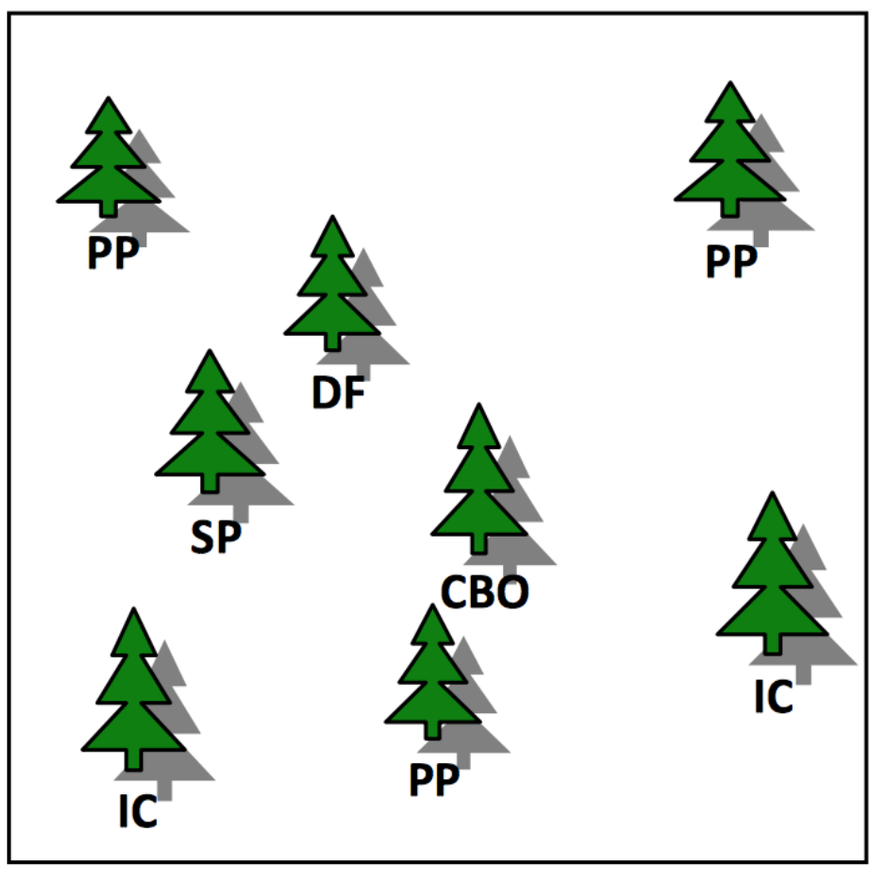
VOLUME = EXP (-7.0809 + 2.0521 LN (DBH) +1.4906 LN(HT))





SPECIES COMPOSITION

IN MIXED SPECIES STANDS, IT IS IMPORTANT TO KNOW THE RATIO OF THE VARIOUS SPECIES.

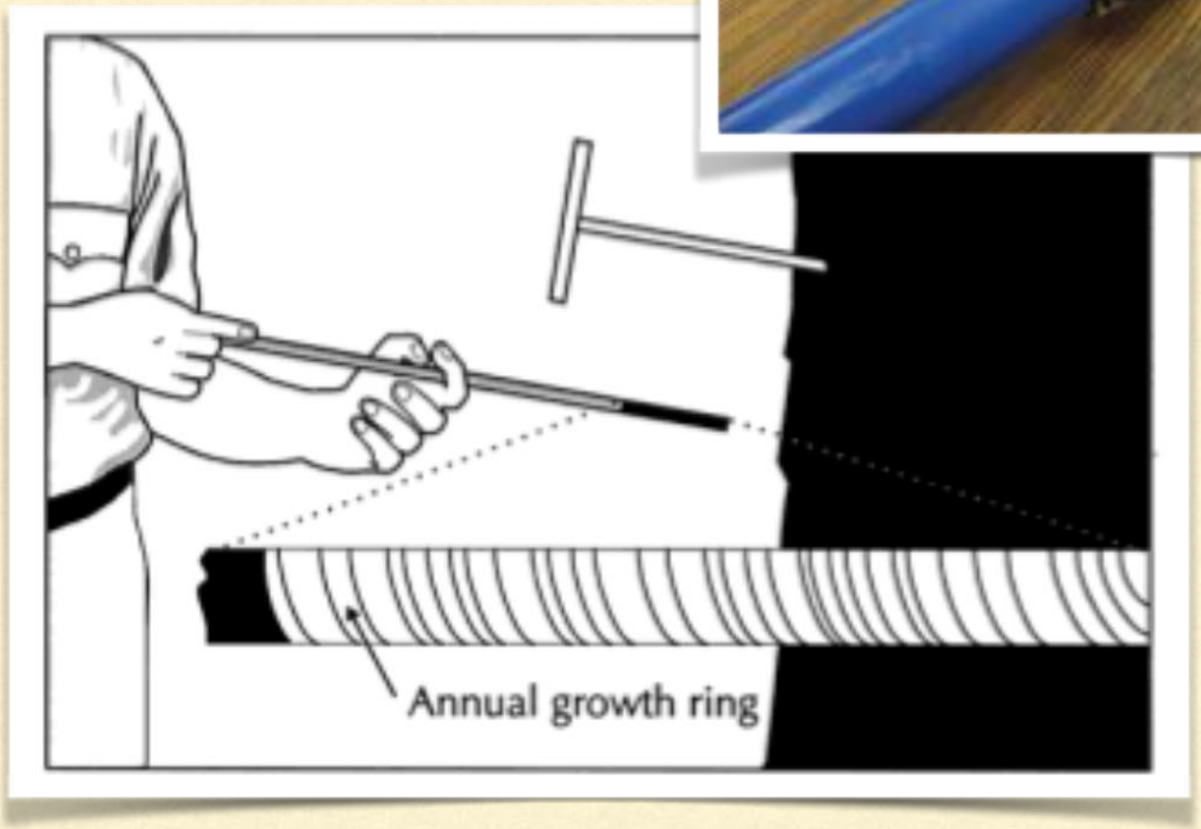


The answer for this plot would be as follows:

Species:	Ponderosa Pine	# trees:	3
Species:	Incense Cedar	# trees:	2
Species:	Sugar Pine	# trees:	1
Species:	Douglas Fir	# trees:	1
Species:	California Black Oak	# trees:	1

This site is **PINE** dominant.

OTHER TOOLS



- Densitometer
- Increment Borer

Height Measurements
On Level Ground And Above a Tree

Using the percent scale and horizontal baseline distance convenient for you to see both the top and bottom of the tree, follow these simple procedures. Back away from the tree the baseline distance. In this example, 80'. Sight the top of the tree and read the % scale (63%). Sight the bottom of the tree and read the % scale (-7%). Subtract the bottom reading from the top reading: 63% -(-7%) = 70%. To obtain tree height, simply multiply this percentage times your horizontal baseline distance. 70% x 80' = 56' tree height. (See Figure 1.)

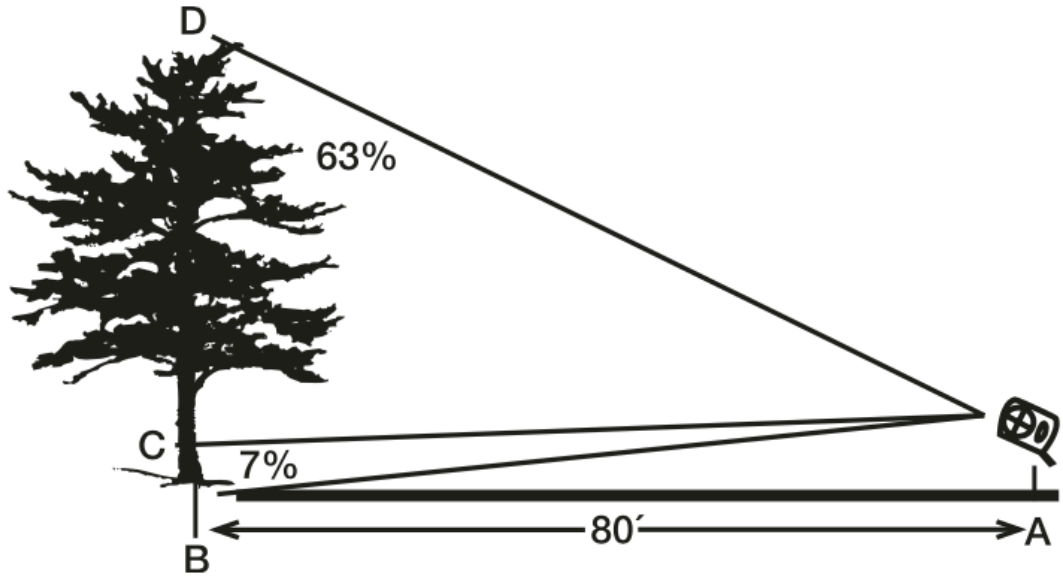


Figure 1

Height Measurements
On Sloping Ground And Below a Tree

Using the percent scale and 100' horizontal baseline (or other baseline convenient for you to see both the top and bottom of the tree), follow these simple procedures. When the base of the tree is ABOVE eye level, sight the top then sight the base. Subtract the base reading from the top reading. For example:

70% - 14% = 56%.

Then multiply 56% x 100' = 56' (tree height). (See Figure 2.)

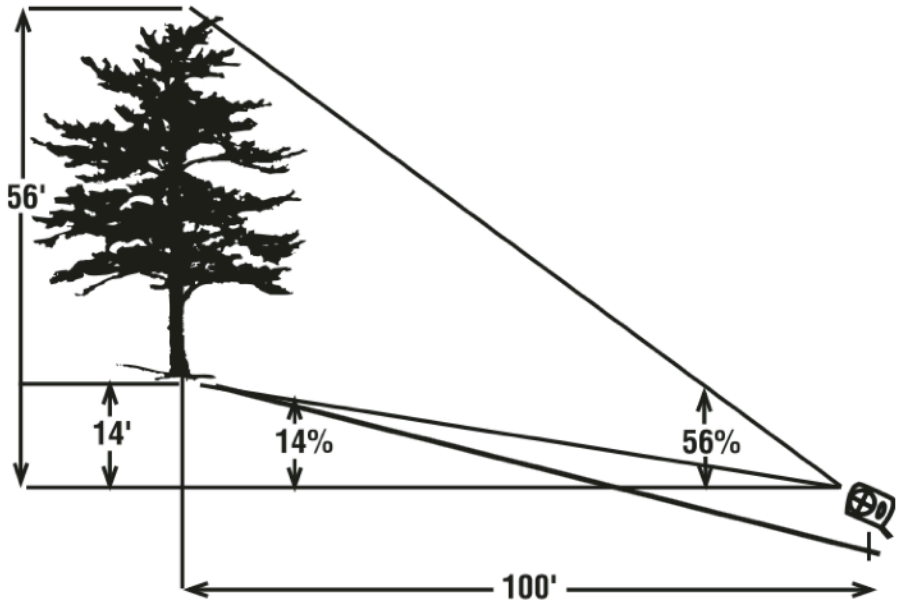


Figure 2

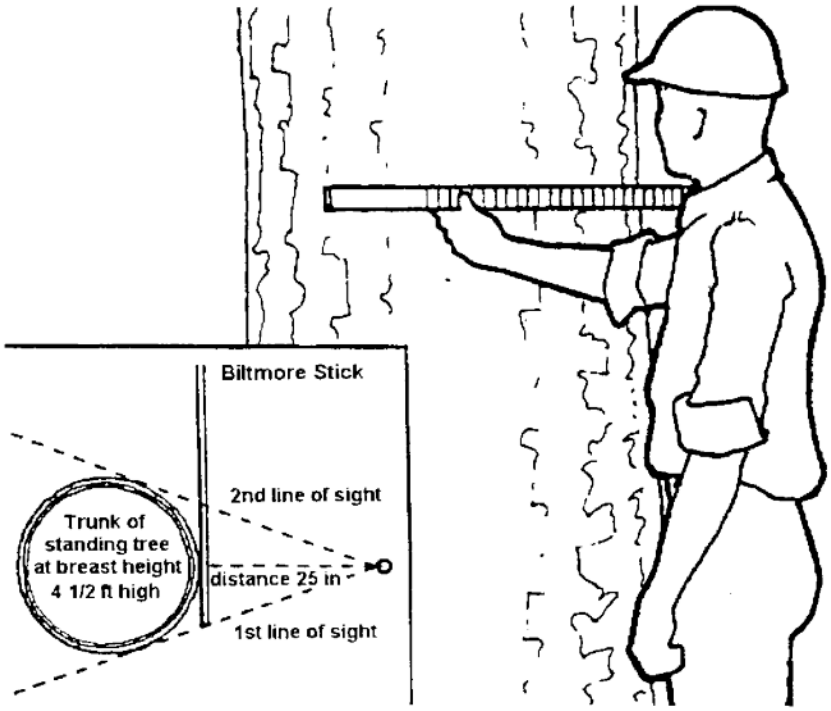
When the base of the tree is BELOW eye level, sight the top then sight the base. Subtract the bottom reading from the top reading. For example:

-10% top reading - (-66% bottom reading) = 56%

Then multiply by 100' (baseline) for a tree height of 56'.

Biltmore Stick

Measuring Diameter



To Measure Diameter

1. Diameter is measured at what is called Diameter Breast Height (DBH). This is 4.5 ft. (1.37 m) up the trunk from the ground. If the tree you are measuring is on a slope, diameter should be taken at 4.5 ft. (1.37 m) on the uphill side of the tree.

2. Hold the Biltmore stick against the tree at DBH, 25 in. (62.5 cm) from your eye. Make sure the edge of the stick that reads diameter is facing you.

3. Sight past the zero end of the stick and the edge of the tree.

4. Without moving your head, shift your eyes to other side of the tree and read the black diameter mark nearest to your line of sight.

5. Tree trunks usually are not round. If a trunk is very much out of round, you should measure both wide and narrow diameters and take the average of the two.

Biltmore Stick

Measuring Height

To Measure Height

1. Stand 66 ft. (20.12 m) from the tree so that --
   - you are about on a level with the base of the tree. Walk out across the slope instead of up or down slope from the tree.
   - the tree is not leaning away from you.
   - you can see the top up to its merchantable height. If you are measuring for sawlogs, the merchantable height is the point where the top is 6 in. (15 cm) in diameter. For pulpwood, merchantable height is to a 3.6 in. (9 cm) diameter top; and for firewood, it is an 3.2 in. (8 cm) diameter top. Practice estimating these top diameters by standing back from a tree with a known diameter of 6, 3.6, or 3.2 inches (15, 9, or 8 cm) and comparing this to the tops of other trees.

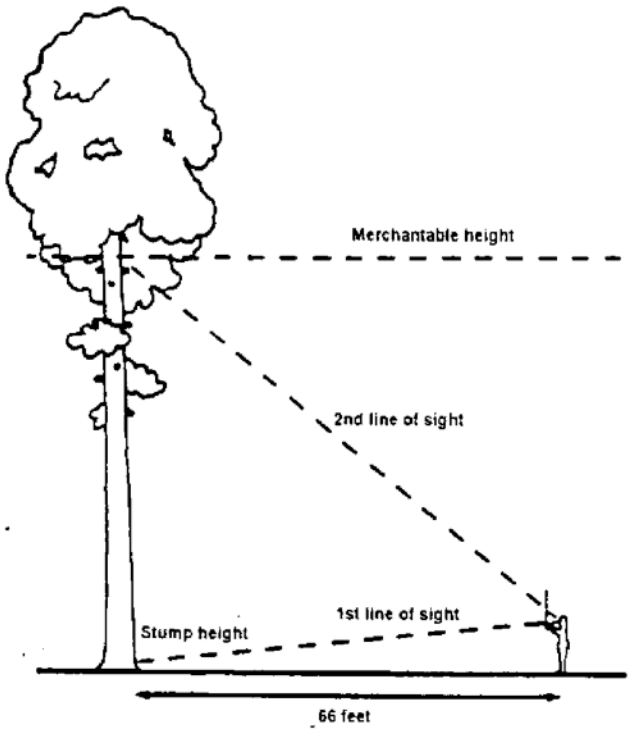
2. Hold the stick vertically 25 in. (62.5 cm) from your eye with the lower end approximately at eye level and with the scale for measuring heights facing you.

3. Line up the zero end of the stick with the stump height - the height of the stump if the tree were cut. This is usually not more than 1 ft. (.3 m) from the ground.

4. Without moving your head or the stick, raise your eyes and sight to the merchantable top.

5. The nearest log mark or meter is the merchantable height of the tree.

Practice measuring heights and diameters to develop your skill before recording actual measurements from your plots.



C.2 GROSS BOARD-FOOT VOLUME TABLE
PONDEROSA PINE

DBH	TOTAL HEIGHT (FEET)																			
(INCHES)	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
10	15	23	31	39	49	58	68	79	90	101	113	125	138	150	164	177	190	204	218	233
12	23	34	47	60	74	89	104	120	137	155	172	191	210	229	249	269	290	311	332	354
14	33	49	66	85	105	127	149	172	196	220	246	272	299	327	355	384	413	444	474	505
16	45	67	90	116	143	172	202	234	266	300	335	370	407	445	483	522	562	603	645	687
18	59	87	119	152	188	226	265	306	349	393	439	486	534	583	634	685	738	792	846	902
20	75	111	151	194	240	288	338	391	445	501	560	619	681	744	808	874	941	1009	1079	1150
22	94	139	188	242	299	359	421	487	555	625	697	771	848	926	1006	1088	1172	1257	1344	1432
24	114	170	230	296	365	438	515	595	678	763	852	943	1036	1132	1238	1330	1432	1536	1642	1750
26	138	204	277	355	439	527	619	715	815	918	1024	1134	1246	1361	1479	1599	1722	1847	1975	2105
28	163	242	328	422	521	625	734	848	967	1089	1215	1345	1478	1615	1754	1897	2043	2191	2343	2497
30	191	284	385	494	610	733	861	995	1133	1277	1425	1577	1733	1893	2057	2224	2395	2569	2747	2927
32	222	329	447	574	708	850	999	1154	1315	1481	1653	1829	2011	2196	2387	2581	2779	2981	3187	3397
34	255	379	514	660	815	978	1149	1327	1512	1704	1901	2104	2312	2526	2744	2968	3196	3428	3665	3906
36	291	432	586	752	929	1116	1311	1514	1725	1943	2168	2400	2638	2881	3131	3386	3646	3911	4181	4456
38	330	489	664	852	1053	1264	1485	1715	1954	2201	2456	2719	2988	3264	3546	3835	4130	4430	4736	5047
40	371	551	747	959	1185	1422	1671	1930	2199	2478	2765	3080	3363	3673	3991	4316	4648	4986	5330	5681
42	416	616	836	1073	1326	1591	1870	2160	2461	2772	3094	3424	3763	4111	4466	4830	5201	5579	5965	6357
44	463	686	931	1195	1476	1772	2082	2405	2740	3086	3444	3811	4189	4576	4972	5376	5789	6211	6640	7076
46	513	760	1031	1324	1635	1963	2306	2664	3035	3419	3815	4222	4641	5069	5508	5956	6414	6881	7356	7840
48	565	838	1138	1460	1803	2165	2544	2938	3348	3772	4208	4656	5119	5592	6076	6570	7075	7590	8114	8648
50	621	921	1250	1604	1981	2379	2795	3228	3678	4144	4623	5117	5624	6144	6675	7218	7773	8338	8914	9501
52	680	1008	1368	1756	2169	2604	3059	3534	4026	4536	5061	5601	6156	6725	7307	7901	8505	9127	9758	10399
54	742	1100	1492	1916	2366	2840	3337	3855	4392	4948	5521	6110	6715	7336	7971	8619	9282	9957	10645	11344
56	806	1196	1623	2083	2572	3088	3629	4192	4776	5380	6003	6644	7303	7977	8668	9373	10093	10827	11575	12336
58	874	1296	1760	2259	2789	3349	3935	4545	5178	5834	6509	7204	7918	8649	9398	10163	10943	11739	12550	13375
60	945	1402	1903	2442	3016	3621	4254	4914	5599	6308	7038	7790	8561	9352	10161	10988	11833	12693	13570	14462

VOLUME = EXP (-7.2408 + 2.3047 LN (DBH) + 1.3690 LN (HT))

C.3 GROSS BOARD-FOOT VOLUME TABLE
SUGAR PINE

DBH	TOTAL HEIGHT (FEET)																
(INCHES)	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190
10	17	24	32	41	49	58	68	77	87	97	107	118	128	139	150	161	173
12	26	37	49	62	75	89	103	117	132	147	163	179	195	211	228	245	262
14	37	53	70	88	107	126	146	167	188	210	232	255	278	301	325	349	374
16	50	72	95	120	145	172	199	227	256	285	315	346	377	409	441	474	507
18	66	94	125	157	190	225	261	297	335	374	413	453	494	536	578	621	665
20	84	120	159	200	242	286	332	379	427	476	526	577	630	683	737	791	847
22	104	149	198	248	301	356	413	471	531	592	655	719	784	850	917	985	1054
24	127	182	241	303	368	435	504	575	648	723	800	878	957	1037	1119	1203	1287
26	153	219	290	364	442	523	606	691	779	869	961	1054	1150	1247	1345	1445	1547
28	181	260	344	432	524	620	718	820	924	1030	1139	1250	1363	1478	1595	1713	1833
30	212	304	403	506	614	726	814	960	1082	1207	1334	1464	1597	1731	1868	2007	2148
32	246	353	467	587	712	842	976	1114	1255	1400	1548	1698	1852	2008	2167	2328	2491
34	283	406	537	674	818	967	1121	1280	1442	1609	1779	1952	2128	2308	2490	2675	2863
36	322	462	612	769	933	1103	1279	1459	1645	1834	2028	2225	2427	2631	2839	3050	3264
38	365	524	693	871	1056	1249	1448	1652	1862	2007	2296	2519	2747	2979	3214	3453	3695
40	411	589	779	979	1188	1405	1628	1858	2094	2336	2583	2834	3090	3351	3616	3884	4157
42	459	659	871	1095	1329	1571	1821	2079	2346	2613	2889	3170	3457	3748	4044	4345	4650
44	511	733	970	1219	1479	1748	2027	2313	2607	2907	3214	3527	3846	4170	4500	4834	5173
46	566	812	1074	1350	1638	1936	2244	2561	2887	3219	3559	3906	4259	4618	4983	5353	5729
48	624	895	1184	1488	1806	2135	2475	2824	3183	3550	3925	4307	4696	5092	5494	5903	6317
50	685	983	1300	1634	1983	2344	2718	3102	3495	3899	4310	4730	5158	5592	6034	6483	6937
52	750	1075	1423	1788	2170	2565	2974	3394	3825	4266	4716	5176	5643	6119	6603	7093	7591
54	818	1173	1551	1950	2366	2797	3243	3701	4171	4652	5143	5644	6154	6673	7200	7735	8278
56	889	1275	1687	2120	2572	3041	3525	4023	4534	5057	5591	6135	6690	7254	7827	8408	8998
58	963	1382	2298	2798	2788	3296	3821	4360	4914	5481	6060	6650	7251	7862	8483	9114	9453
60	1041	1494	1976	2484	3013	3563	4130	4713	5312	5924	6550	7188	7838	8498	9170	9851	10542

VOLUME = EXP (-6.7150 + 2.2952 LN (DBH) + 1.2542 LN (HT))

C.1 GROSS BOARD-FOOT VOLUME TABLE
DOUGLAS FIR

DBH	TOTAL HEIGHT (FEET)																
(INCHES)	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210
12	47	62	78	95	113	132	152	173	195	218	242	266	291	317	344	371	399
14	64	85	106	130	155	181	209	238	268	299	331	365	399	435	472	509	547
16	85	111	140	171	204	238	275	313	352	393	436	480	525	572	620	669	720
18	108	142	178	218	259	303	350	398	449	501	555	611	669	729	790	852	917
20	134	176	221	270	322	377	434	494	557	622	689	759	831	904	980	1058	1138
22	163	214	269	328	391	458	528	601	677	756	838	923	1010	1100	1192	1287	1384
24	195	256	322	393	468	547	631	718	809	904	1002	1103	1207	1315	1425	1538	1654
26	230	301	379	463	551	645	744	847	954	1065	1181	1300	1423	1549	1680	1813	1950
28	267	351	441	539	642	751	886	986	1111	1240	1375	1513	1657	1804	1955	2111	2270
30	308	404	509	621	740	865	997	1136	1280	1429	1584	1744	1909	2078	2253	2432	2615
32	352	461	581	708	844	988	1139	1256	1461	1631	1808	1991	2179	2373	2572	2776	2986
34	398	522	657	802	956	1119	1290	1468	1654	1847	2048	2254	2468	2687	2912	3144	3381
36	448	587	739	902	1075	1258	1450	1651	1860	2077	2302	2535	2775	3021	3275	3535	3802
38	500	656	826	1008	1201	1406	1620	1845	2078	2321	2573	2832	3100	3376	3659	3950	4248
40	556	729	918	1120	1335	1562	1800	2049	2309	2579	2858	3147	3444	3751	4065	4388	4719
42	614	806	1014	1238	1475	1726	1990	2265	2552	2850	3159	3478	3807	4146	4493	4851	5216
44	676	887	1116	1362	1623	1899	2189	2492	2808	3136	3475	3826	4188	4561	4944	5336	5739
46	740	972	1223	1492	1778	2080	2398	2730	3076	3435	3807	4192	4588	4996	5416	5846	6287
48	808	1060	1334	1628	1940	2270	2617	2979	3357	3749	4155	4574	5007	5452	5910	6380	6861
50	879	1153	1451	1770	2110	2469	2846	3240	3650	4076	4518	4974	5445	5929	6426	6937	7460
52	952	1249	1572	1918	2287	2676	3084	3511	3956	4418	4897	5391	5901	6426	6965	7518	8086
54	1029	1350	1699	2073	2471	2891	3332	3794	4275	4774	5291	5825	6376	6943	7526	8124	8737
56	1109	1455	1830	2234	2662	3115	3591	4088	4606	5144	5701	6277	6870	7481	8109	8753	9414
58	1191	1563	1967	2400	2861	3348	3859	4393	4950	5528	6127	6745	7383	8040	8715	9407	10117
60	1277	1676	2109	2573	3067	3589	4137	4710	5306	5926	6568	7231	7915	8619	9342	10085	10845

VOLUME = EXP (-7.0809 + 2.0521 LN (DBH) +1.4906 LN(HT))

C.5 GROSS BOARD-FOOT VOLUME TABLE
WHITE FIR

DBH	TOTAL HEIGHT (FEET)																			
(INCHES)	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
10	17	26	35	46	58	70	83	97	112	127	142	159	175	193	210	229	248	267	286	307
12	25	37	52	68	85	103	122	142	164	186	209	233	257	283	309	336	363	392	420	450
14	34	52	72	94	117	142	169	197	226	257	289	322	356	391	427	464	503	542	582	622
16	45	69	95	124	155	189	224	261	300	341	383	426	472	518	566	615	666	717	770	824
18	58	88	122	159	199	242	287	335	384	436	490	546	604	664	725	788	853	919	987	1056
20	72	110	152	198	248	302	358	418	480	545	612	682	754	829	905	984	1065	1147	1232	1318
22	88	134	186	242	303	369	438	510	586	666	748	834	922	1013	1106	1203	1301	1402	1506	1611
24	106	161	223	291	364	443	526	613	704	800	899	1001	1107	1216	1329	1444	1563	1684	1808	1935
26	125	191	264	344	431	524	622	725	834	946	1063	1185	1310	1440	1573	1709	1850	1993	2140	2290
28	146	223	309	403	504	612	727	848	974	1106	1243	1385	1531	1683	1838	998	2162	2330	2501	1677
30	169	258	357	465	583	708	841	980	1127	1279	1437	1601	1771	1946	2125	2310	2500	2694	2092	3096
32	194	295	409	533	668	811	963	1123	1290	1465	1646	1834	2028	2229	2435	2646	2863	3086	3313	3546
34	220	335	464	606	758	921	1094	1276	1466	1664	1871	2084	2305	2532	2766	3006	3253	3506	3764	4029
36	249	378	524	683	855	1039	1234	1439	1654	1877	2110	2350	2599	2856	3120	3391	3669	3954	4246	4544
38	279	424	587	766	958	1165	1383	1612	1853	2103	2364	2634	2912	3200	3496	3800	4111	4431	4757	5091
40	310	472	654	853	1068	1297	1540	1796	2064	2343	2633	2934	3245	3565	3894	4233	4580	4936	5300	5672
42	344	523	724	945	1183	1438	1707	1990	2287	2597	2918	3251	3595	3950	4315	4691	5075	5470	5873	6285
44	379	577	799	1042	1305	1585	1883	2195	2523	2864	3218	3586	3965	4357	4759	5173	5598	6032	6477	6932
46	416	634	877	1144	1433	1741	2067	2411	2770	3145	3534	3938	4354	4784	5226	5681	6147	6624	7112	7612
48	456	693	959	1252	1567	1904	2261	2637	3030	3440	3865	4307	4762	5232	5716	6213	6723	7245	7779	8325
50	496	755	1046	1364	1708	2075	2464	2873	3301	3748	4212	4693	5190	5702	6229	6770	7326	7895	8477	9072
52	539	820	1136	1481	1855	2254	2676	3120	3586	4071	4575	5097	5636	6193	6765	7353	7956	8574	9206	9853
54	584	888	1229	1604	2008	2440	2897	3378	3882	4407	4953	5518	6102	6705	7324	7961	8614	9283	9968	10667
56	630	959	1327	1732	2168	2634	3128	3647	4191	4758	5347	5957	6588	7238	7907	8594	9299	10022	10761	11516
58	678	1032	1429	1864	2334	2836	3367	3927	4512	5123	5757	6414	7093	7793	8513	9253	10012	10790	11586	12399

VOLUME = EXP (-6.9870 + 2.1049 LN (DBH) + 1.4583 LN (HT))

C.6 GROSS BOARD-FOOT VOLUME TABLE
INCENSE CEDAR

DBH	TOTAL HEIGHT (FEET)														
(INCHES)	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160
12	12	20	30	40	51	62	74	87	100	113	127	141	156	171	186
14	16	28	41	56	71	87	104	121	140	158	178	198	218	239	260
16	22	38	55	74	95	116	139	162	187	212	238	264	292	320	348
18	29	49	72	96	122	150	179	210	241	274	307	342	377	413	450
20	36	61	90	121	154	189	226	264	303	344	386	430	474	519	566
22	44	76	111	149	190	233	278	325	373	424	475	529	583	639	696
24	53	91	134	180	229	281	335	392	451	512	574	639	705	772	841
26	63	109	159	214	273	334	399	467	537	609	684	760	839	919	1002
28	75	128	187	251	320	393	469	549	631	716	803	893	986	1080	1177
30	87	148	217	292	372	457	545	637	733	832	934	1038	1145	1255	1367
32	100	171	250	336	428	526	627	733	844	957	1074	1195	1318	1445	1574
34	114	195	285	384	489	600	716	837	963	1092	1226	1363	1504	1648	1796
36	129	221	323	435	553	679	811	948	1090	1237	1388	1544	1703	1867	2033
38	145	248	364	489	624	764	912	1066	1226	1391	1562	1737	1916	2100	2287
40	162	278	407	547	696	854	1020	1192	1371	1556	1746	1942	2142	2348	2558
42	180	309	452	608	774	950	1134	1326	1525	1730	1942	2159	2382	2611	2844
44	199	342	500	673	857	1051	1255	1467	1687	1914	2149	2389	2636	2889	3147
46	220	376	551	741	944	1158	1382	1616	1858	2109	2367	2632	2904	3182	3467
48	241	413	605	813	1035	1270	1516	1773	2039	2313	2597	2887	3186	3491	3803
50	263	451	661	888	1131	1388	1657	1937	2228	2528	2838	3156	3482	3816	4157
52	287	491	720	967	1232	1512	1805	2110	2427	2754	3091	3437	3792	4156	4527
54	311	533	781	1050	1338	1641	1959	2291	2634	2989	3355	3731	4117	4511	4915
56	337	577	845	1137	1448	1776	2121	2479	2851	3236	3632	4039	4456	4883	5319

VOLUME = EXP (-6.9149 + 2.1764 LN (DBH) + 1.3267 LN (HT))

C.1 GROSS BOARD-FOOT VOLUME TABLE
DOUGLAS FIR

DBH	TOTAL HEIGHT (FEET)																
(INCHES)	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210
12	47	62	78	95	113	132	152	173	195	218	242	266	291	317	344	371	399
14	64	85	106	130	155	181	209	238	268	299	331	365	399	435	472	509	547
16	85	111	140	171	204	238	275	313	352	393	436	480	525	572	620	669	720
18	108	142	178	218	259	303	350	398	449	501	555	611	669	729	790	852	917
20	134	176	221	270	322	377	434	494	557	622	689	759	831	904	980	1058	1138
22	163	214	269	328	391	458	528	601	677	756	838	923	1010	1100	1192	1287	1384
24	195	256	322	393	468	547	631	718	809	904	1002	1103	1207	1315	1425	1538	1654
26	230	301	379	463	551	645	744	847	954	1065	1181	1300	1423	1549	1680	1813	1950
28	267	351	441	539	642	751	886	986	1111	1240	1375	1513	1657	1804	1955	2111	2270
30	308	404	509	621	740	865	997	1136	1280	1429	1584	1744	1909	2078	2253	2432	2615
32	352	461	581	708	844	988	1139	1256	1461	1631	1808	1991	2179	2373	2572	2776	2986
34	398	522	657	802	956	1119	1290	1468	1654	1847	2048	2254	2468	2687	2912	3144	3381
36	448	587	739	902	1075	1258	1450	1651	1860	2077	2302	2535	2775	3021	3275	3535	3802
38	500	656	826	1008	1201	1406	1620	1845	2078	2321	2573	2832	3100	3376	3659	3950	4248
40	556	729	918	1120	1335	1562	1800	2049	2309	2579	2858	3147	3444	3751	4065	4388	4719
42	614	806	1014	1238	1475	1726	1990	2265	2552	2850	3159	3478	3807	4146	4493	4851	5216
44	676	887	1116	1362	1623	1899	2189	2492	2808	3136	3475	3826	4188	4561	4944	5336	5739
46	740	972	1223	1492	1778	2080	2398	2730	3076	3435	3807	4192	4588	4996	5416	5846	6287
48	808	1060	1334	1628	1940	2270	2617	2979	3357	3749	4155	4574	5007	5452	5910	6380	6861
50	879	1153	1451	1770	2110	2469	2846	3240	3650	4076	4518	4974	5445	5929	6426	6937	7460
52	952	1249	1572	1918	2287	2676	3084	3511	3956	4418	4897	5391	5901	6426	6965	7518	8086
54	1029	1350	1699	2073	2471	2891	3332	3794	4275	4774	5291	5825	6376	6943	7526	8124	8737
56	1109	1455	1830	2234	2662	3115	3591	4088	4606	5144	5701	6277	6870	7481	8109	8753	9414
58	1191	1563	1967	2400	2861	3348	3859	4393	4950	5528	6127	6745	7383	8040	8715	9407	10117
60	1277	1676	2109	2573	3067	3589	4137	4710	5306	5926	6568	7231	7915	8619	9342	10085	10845

VOLUME = EXP (-7.0809 + 2.0521 LN (DBH) +1.4906 LN(HT))

VOLUME, YOUNG GROWTH COAST REDWOOD
COAST REDWOOD

DBH	TOTAL HEIGHT (FEET)															
(INCHES)	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190
11	20	22	25	27	29	32	34	36								
12	25	31	36	41	46	51	56	61								
13	31	39	47	55	64	72	80	88	96							
14	36	48	59	71	82	94	105	117	128							
15	42	57	72	87	102	117	132	147	162	177						
16	47	66	85	104	123	142	160	179	198	217						
17	52	75	98	121	144	167	190	213	236	259	283					
18	57	85	112	139	167	194	222	249	277	304	331					
19	62	94	126	159	191	223	255	287	319	351	383					
20	67	104	141	178	215	252	289	326	363	400	437					
21		115	157	199	241	283	325	367	409	452	494	536				
22		125	172	220	268	315	363	410	458	505	553	601				
23		136	189	242	295	349	402	455	508	562	615	668				
24		146	206	265	324	383	442	502	561	620	679	739				
25		157	223	288	354	419	485	550	616	681	746	812	877			
26			241	313	384	456	528	600	672	744	816	888	960			
27			259	337	416	495	574	652	731	810	888	967	1046			
28			277	363	449	535	620	706	792	877	963	1049	1134			
29			297	390	483	576	669	762	855	948	1040	1133	1226	1319		
30			316	417	517	618	718	819	920	1020	1121	1221	1322	1422		
31				445	553	661	770	878	986	1095	1203	1311	1420	1528	1636	1745
32				474	590	706	823	939	1056	1172	1288	1405	1521	1637	1754	1870
33				503	628	752	877	1002	1127	1251	1376	1501	1626	1750	1875	2000
34				533	666	800	933	1066	1200	1333	1465	1600	1733	1866	2000	2133
35				564	706	848	991	1133	1275	1417	1559	1702	1844	1986	2128	2270
36					747	898	1050	1201	1352	1504	1655	1806	1958	2109	2260	2412
37					789	949	1110	1271	1432	1592	1753	1914	2075	2235	2396	2557
38					832	1002	1172	1343	1513	1683	1854	2024	2195	2365	2535	2706
39					875	1056	1236	1416	1597	1777	1957	2137	2318	2498	2678	2859
40					920	1111	1301	1492	1682	1873	2063	2254	2444	2634	2825	3015
41						1167	1368	1569	1770	1971	2172	2373	2573	2774	2975	3176
42						1224	1436	1648	1859	2071	2283	2494	2706	2917	3129	3341
43						1282	1505	1728	1940	2178	2396	2618	2841	3063	3286	3509
44						1343	1577	1811	2045	2279	2513	2746	2980	3214	3448	3682
45						1405	1650	1895	2141	2386	2631	2877	3122	3367	3613	3858
46							1724	1982	2239	2496	2753	3010	3267	3524	3781	4039
47							1800	2070	2339	2608	2877	3146	3415	3684	3954	4223
48							1878	2159	2441	2722	3004	3285	3567	3848	4129	4411
49							1957	2251	2545	2839	3133	3427	3721	4015	4309	4603
50							2037	2344	2651	2958	3265	3572	3878	4185	4492	4799

Tree Volume in Board Feet based on dbh

(For Site III Santa Cruz Area)

dbh	Coastal Redwood	Douglas-fir
12	30	30
14	80	80
16	130	130
18	199	220
20	285	310
22	394	420
24	515	550
26	650	700
28	800	870
30	965	1080
32	1150	1300
34	1348	1570
36	1560	1830
38	1805	2100
40	2060	2400
42	2345	2750
44	2650	3140
46	3000	3550
48	3400	3900
50	3900	4350

LIMITING DISTANCE TABLE

BAF 20 Wedge Prism

PRF 1.944

DBH (Inches)	Distance (Feet)
0.1	0.19
0.2	0.39
0.3	0.58
0.4	0.78
0.5	0.97
0.6	1.17
0.7	1.36
0.8	1.56
0.9	1.75

(Add to dbh below for total)
(Example: 4.2" dbh is 7.78 + .39 = 8.17)

DBH (Inches)	Distance (Feet)		DBH (Inches)	Distance (Feet)
4.0	7.78		33.0	64.15
5.0	9.72		34.0	66.10
6.0	11.66		35.0	68.04
7.0	13.61		36.0	69.98
8.0	15.55		37.0	71.93
9.0	17.50		38.0	73.87
10.0	19.44		39.0	75.82
11.0	21.38		40.0	77.76
12.0	23.33		41.0	79.70
13.0	25.27		42.0	81.65
14.0	27.22		43.0	83.59
15.0	29.16		44.0	85.54
16.0	31.10		45.0	87.48
17.0	33.05		46.0	89.42
18.0	34.99		47.0	91.37
19.0	36.94		48.0	93.31
20.0	38.88		49.0	95.26
21.0	40.82		50.0	97.20
22.0	42.77		51.0	99.14
23.0	44.71		52.0	101.09
24.0	46.66		53.0	103.03
25.0	48.60		54.0	104.98
26.0	50.54		55.0	106.92
27.0	52.49		56.0	108.86
28.0	54.43		57.0	110.81
29.0	56.38		58.0	112.75
30.0	58.32		59.0	114.70
31.0	60.26		60.0	116.64
32.0	62.21			

LIMITING DISTANCE TABLE

BAF 40 Wedge Prism

PRF 1.375

DBH (Inches)	Distance (Feet)
0.1	0.14
0.2	0.28
0.3	0.41
0.4	0.55
0.5	0.69
0.6	0.83
0.7	0.96
0.8	1.10
0.9	1.24

(Add to dbh below for total)
(Example: 4.2" dbh is 5.50 + .28 = 5.78)

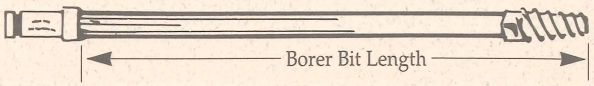
DBH (Inches)	Distance (Feet)		DBH (Inches)	Distance (Feet)
4.0	5.50		33.0	45.38
5.0	6.88		34.0	46.75
6.0	8.25		35.0	48.13
7.0	9.63		36.0	49.50
8.0	11.00		37.0	50.88
9.0	12.38		38.0	52.25
10.0	13.75		39.0	53.63
11.0	15.13		40.0	55.00
12.0	16.50		41.0	56.38
13.0	17.88		42.0	57.75
14.0	19.25		43.0	59.13
15.0	20.63		44.0	60.50
16.0	22.00		45.0	61.88
17.0	23.38		46.0	63.25
18.0	24.75		47.0	64.63
19.0	26.13		48.0	66.00
20.0	27.50		49.0	67.38
21.0	28.88		50.0	68.75
22.0	30.25		51.0	70.13
23.0	31.63		52.0	71.50
24.0	33.00		53.0	72.88
25.0	34.38		54.0	74.25
26.0	35.75		55.0	75.63
27.0	37.13		56.0	77.00
28.0	38.50		57.0	78.38
29.0	39.88		58.0	79.75
30.0	41.25		59.0	81.13
31.0	42.63		60.0	82.50
32.0	44.00			

<u>How to use a densitometer:</u>

Look through the glass with the black circle. Use the levels inside the tool to make the long section perfectly upright (level in both planes). While holding the tool still, look into the tool at the cross hatches (there are mirrors inside it so you can see around the corner) and determine whether or not the intersection of the black lines has sky or vegetation behind it. If there is sky, it is a negative for canopy cover. If there is vegetation, it is a positive for canopy cover.

Making the Right Selection

There are three things to consider when you choose an increment borer. They are length, diameter and style.



Borer bit length depends on the size of the trees you will be boring. Length is measured from the tip of the threads to the end of the round section of the borer bit. This is the maximum depth the bit will penetrate.

.169 inch (4.3mm) .200 inch (5mm) .500 inch (12 mm)

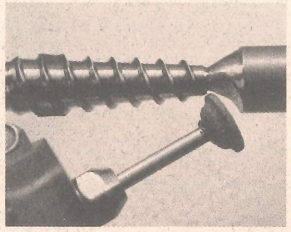
Core diameter of the wood sample is determined by the inside diameter of the opening at the threaded end of the bit. For general forestry use, .169" is commonly used, .200" is used for wood preserving testing and .500" is used for large amounts of wood for quantitative analysis.

2 or 3-Thread Style is a matter of personal preference. A 2-thread borer has two threads on the cutting edge of the bit, each originating 180° apart. A 3-thread borer has three threads, each originating 120° apart. The 3-thread borer will engage the wood faster and easier than the 2-thread borer. A 3-thread borer will also turn easier inside the tree. For each 360° turn of the handle, a 2-thread borer will penetrate deeper and come out of the tree faster than a 3-thread borer.

Increment Borer Sharpening Kit

Includes everything needed to sharpen borers: India Stone to sharpen lead cutting edge; Conical Stone to sharpen inside cutting edge, outside beveled edge; Pocket Stone to "true" cutting edge, remove chips and nicks; can of Sharpening Stone Oil to lubricate, clean stones; Cork to use as a work rest. To order, call or write at the numbers or address below. Specify stock #63399, Sharpening Kit.

Professional Increment Borer Repair Service



Extend the useful life of your increment borer. Have all cutting edges and threads machine sharpened, nicks and some minor broken threads removed — repaired. All professionally done. For more information, call and ask for Customer Service. Or send your entire increment borer (handle, extractor and bit), with a note telling what you need, to:

PHONE TOLL-FREE

1-800-647-5368

FAX Toll-Free

1-800-543-4203

Toll-Free Technical Support

1-800-430-5566

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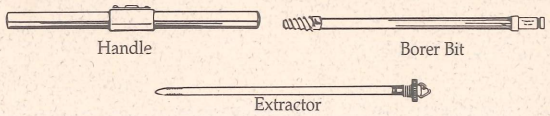
 12494 (5M)

INCREMENT BORERS

The Increment Borer is essential for extracting a core of wood from trees, logs, poles or timbers. The core extracted is used for many purposes including determination of growth rate, age, tree soundness, penetration of chemicals in the wood treating business and specific gravity studies of wood.



An increment borer consists of three parts. They are a handle, a borer bit and an extractor. When not in use the borer bit and extractor fit inside the handle and form a compact unit. Most increment borers have Teflon coated bits. This coating helps reduce friction, protects against rust and keeps the bit cleaner and extends the life of the bit.

To take an increment core, follow these simple steps

1 Remove the borer bit and extractor from inside the handle. Place the extractor in a pocket of your cruiser vest for convenience and protection of the extractor.

2 Assemble the handle and borer bit by:

a. pushing the locking latch away from the handle with your thumb,

b. inserting the square end of the borer bit into the handle, and then

c. returning the locking latch completely around the borer bit "collar." You're now ready to start boring. However we suggest you apply beeswax to the threads and shank before you begin boring.

3 Align the borer bit and the handle so that the bit will penetrate through or towards the center of the tree and at right angles to the tree. In any other alignment, the annual growth rings seen in the extracted core will be distorted and could result in erroneous growth rate analysis.


RIGHT


WRONG

4 Place the borer bit threads against the tree (Fig.1), preferably in a bark fissure where the bark is thinnest. Hold the threads in place with one hand. With your other hand push forward on the handle and simultaneously turn it clockwise until the bit threads penetrate the wood enough to hold the bit firmly in place.

5 Then place both hands, palms open, on the ends of the handle and turn the handle clockwise until the bit reaches the desired depth. (Fig. 2)

6 With the bit at the desired depth insert the full length of the extractor, concave side up like this "◠." (Fig. 3) Then turn the handle one-half turn counterclockwise to break the core from the tree and also to turn the extractor concave side down like this "◡."

7 Pull the extractor from the borer bit. (Fig. 4) The core will be resting in the channel and held in place by the small "teeth" at the tip of the extractor. **Before examining the core sample, promptly remove the borer bit from the tree.** Clean it and place it and the extractor back in the handle.


Fig. 1


Fig. 2

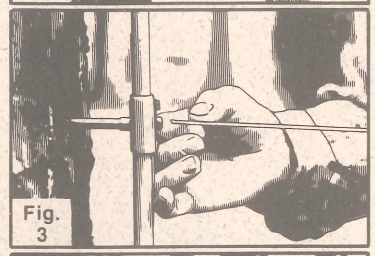


Fig. 3

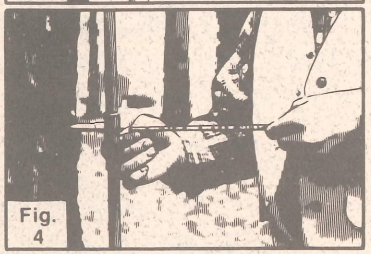


Fig. 4

Care & Maintenance of Increment Borers

Here are a few suggestions that will be helpful in maintaining the efficiency and extending the life of increment borers.

Lubricate with Beeswax

A block of beeswax is provided with every increment borer. Penetration and removal of the borer bit will be easier if beeswax is liberally applied to the threads and shank before each boring.

Clean with WD-40

WD-40 is an excellent cleaner and rust preventative for an increment borer. It will also prevent sap acid-etching of the borer. Spray it on and inside the bit and on the extractor at the end of each working day. Wipe clean.

Be Quick!

Obtain your core samples as rapidly as possible. It's best to remove the bit from the tree even before examining the core sample. This will reduce the possibility of the bit becoming stuck or locked in the tree.

Avoid Compression — Tension Wood

Never bore into suspected compression or tension wood. To explain: a tree leaning towards the North will have compression wood on the North side. If you bore into compression wood, the bit could be locked into the tree by the force of the "compressed" wood. If you bore into the South side, you are boring into "tension" wood, where the ring width may not be representative. We recommend boring on the East or West side, or if possible, select another tree.

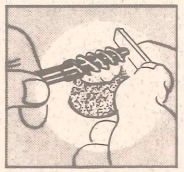
Increment Borer Sharpening

Increment borers become dull or nicked with use. A borer is dull if it does not easily engage the wood and if it will not cut a clean-edged hole when rotated on a sheet of paper.

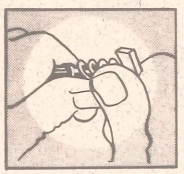
Here's How to Sharpen Borers

See Increment Borer Sharpening Kit for stones described here.

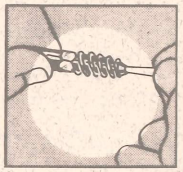
1 True Cutting Edge Using Pocket Stone - If cutting edge is uneven when placed lightly against a flat surface, it needs to be trued up. Place a few drops of oil on wide face of pocket stone. Hold borer bit steady on cork rest and pass stone back and forth across cutting edge, turning bit slightly after each pass. Repeat until true.



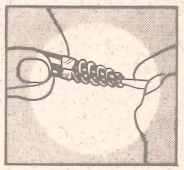
2 Sharpen Cutting Edge Using India Stone - Holding bit in left hand and India stone in right hand, slowly rotate bit away from you and against stone while holding stone parallel to and firmly on beveled edge of bit. Continue until sharp. If nicks are present, use pocket stone to work them out, then follow with the India stone.



3 Hone Inside of Cutting Edge Using Conical Stone - Put a few drops of oil on conical stone and insert tip of stone into cutting end of bit until it occupies about 3/4ths of core hole. Very lightly rotate stone against inside of cutting edge, keeping the edge of the stone parallel to the long axis of the bit.



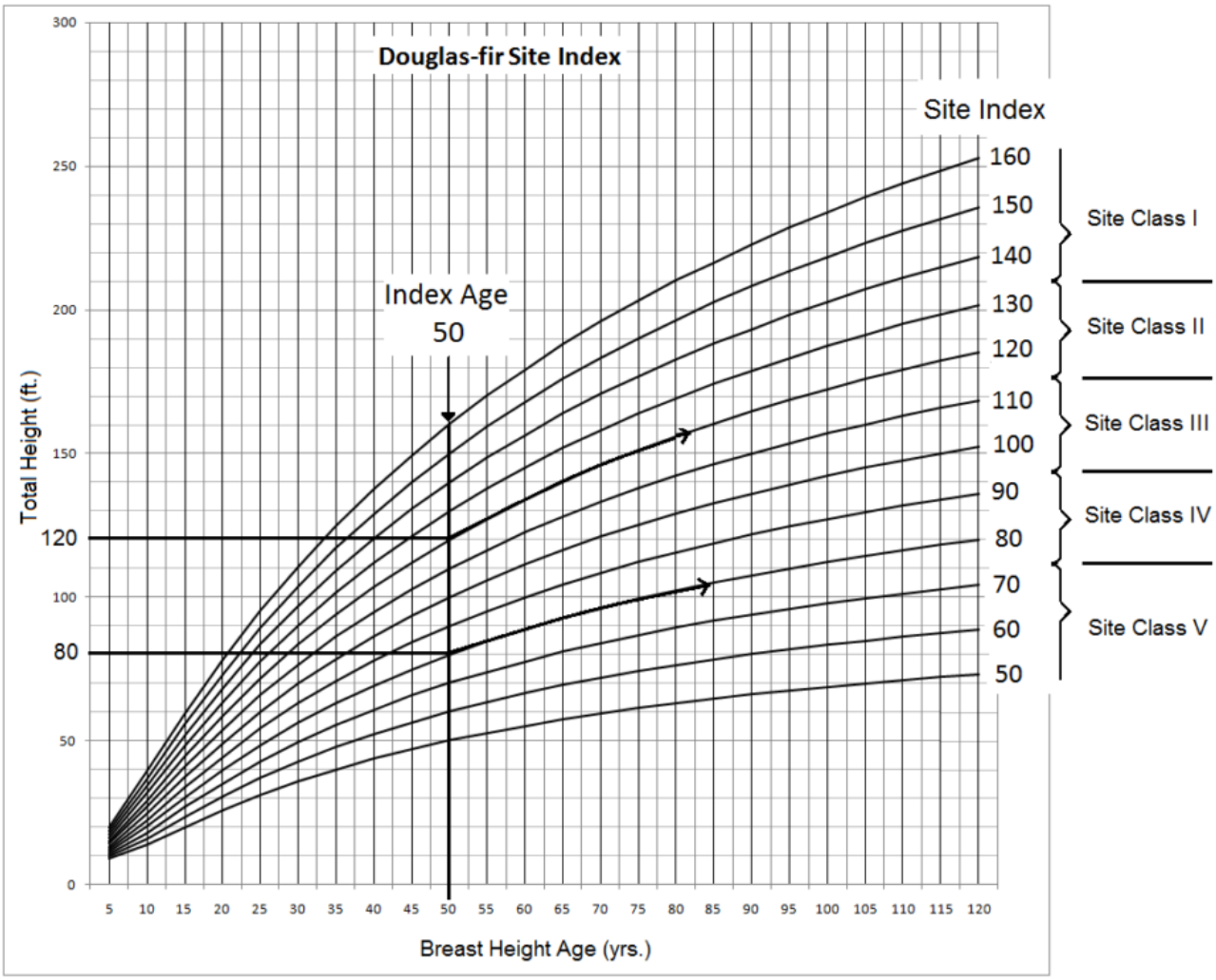
4 Hone Outside Beveled Portion of Cutting Edge Using Conical Stone - Hold borer bit with threads on cork rest and place just the tip of conical stone on and parallel to bevel. Use very light strokes back and forth over a small arc of beveled edge. Turn bit and repeat until entire edge has been honed.



When you are finished sharpening, test by cutting circular holes in a sheet of paper.

Overview of Site Index

To determine site quality using tree height as the indicator, appropriate **site trees** of each species are selected in a stand. The site trees' heights and ages are measured in the field, and then plotted or *indexed* on species-specific growth curves or tables (see Figure 6.3). These tree height-to-age relationship curves are derived from historical growth and yield field data, and show how the best trees from a variety of sites have grown over time without intensive management or site quality intervention. For a given species, a tree that is 120 feet tall at age 50 typically has better growing conditions than a tree that is only 80 feet tall at age 50. And, as indicated by the growth curves, the shorter tree will most likely continue to grow at a slower rate as it ages (Figure 6.3). There are exceptions to these generalized trends of course, but for most sites the general trends are sufficiently reliable.

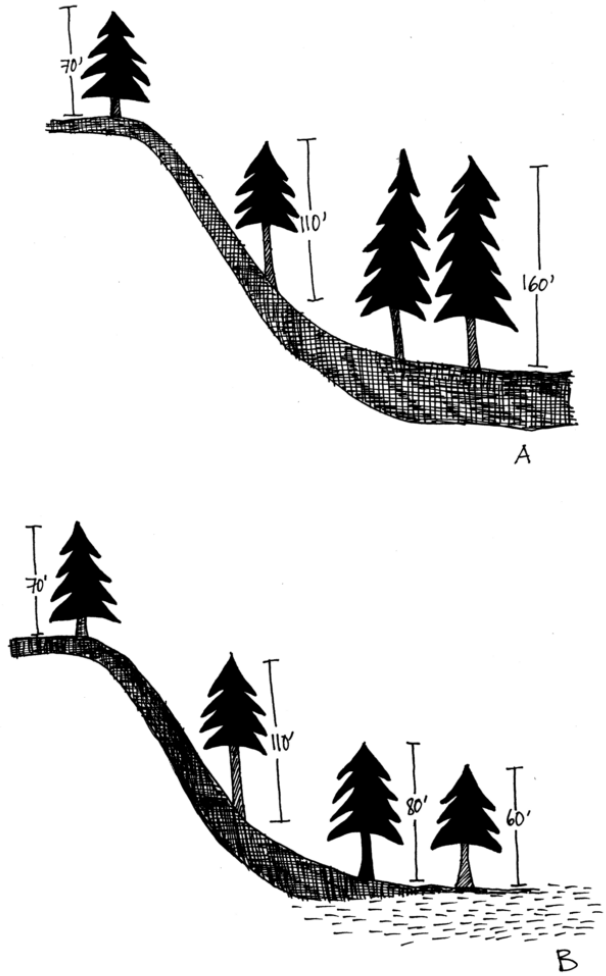


Kings' site index for Douglas-fir in western Washington. For a given age a tree 120′ tall will continue to grow at a faster rate than a tree 80′ tall. (Redrawn from King 1966.)

Site Index (SI) is defined as the height of dominant and codominant trees at some base age. Therefore, a stand with an average 50-year site index of 120 would indicate that the trees are capable of reaching a total height of 120 feet at 50 years. By establishing a base age, stands of any age can be evaluated and compared, and thus the number "120" becomes an index to the site's productivity. This can then be evaluated as a high site or low site when compared with other tree heights at this age.

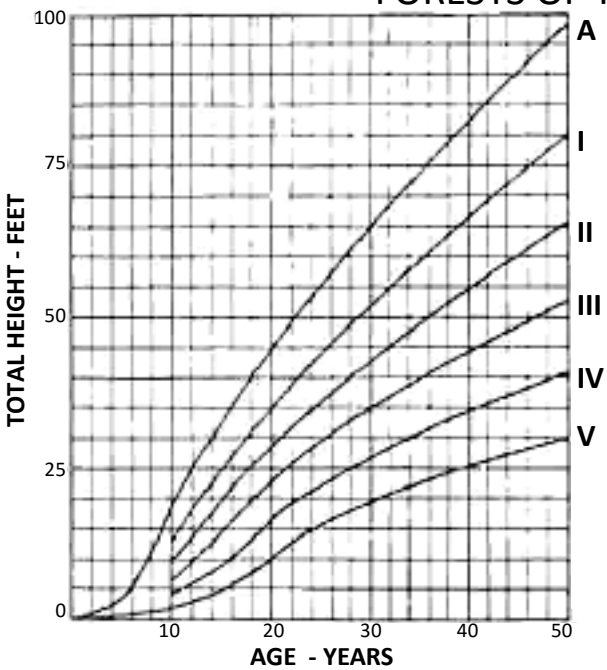
Site indexes for some species are grouped together into **site classes**, with Site Class I being the highest site, and Site Class V or VI being the lowest. In othe first example above for Douglas-fir, the tree whose 50-year site index is 80 feet is in Site Class IV, whereas the 120 foot tree is growing on Site Class II ground (Figure 6.3).

Trees growing on Site Class I lands are highly productive, typically growing on rich soil, with access to moisture and protection from the wind. Alluvial sites at low elevations often fall into this category. Conversely, Site Class V trees are generally growing on poor soils, in droughty climates, or at the upper edge of their elevational range.



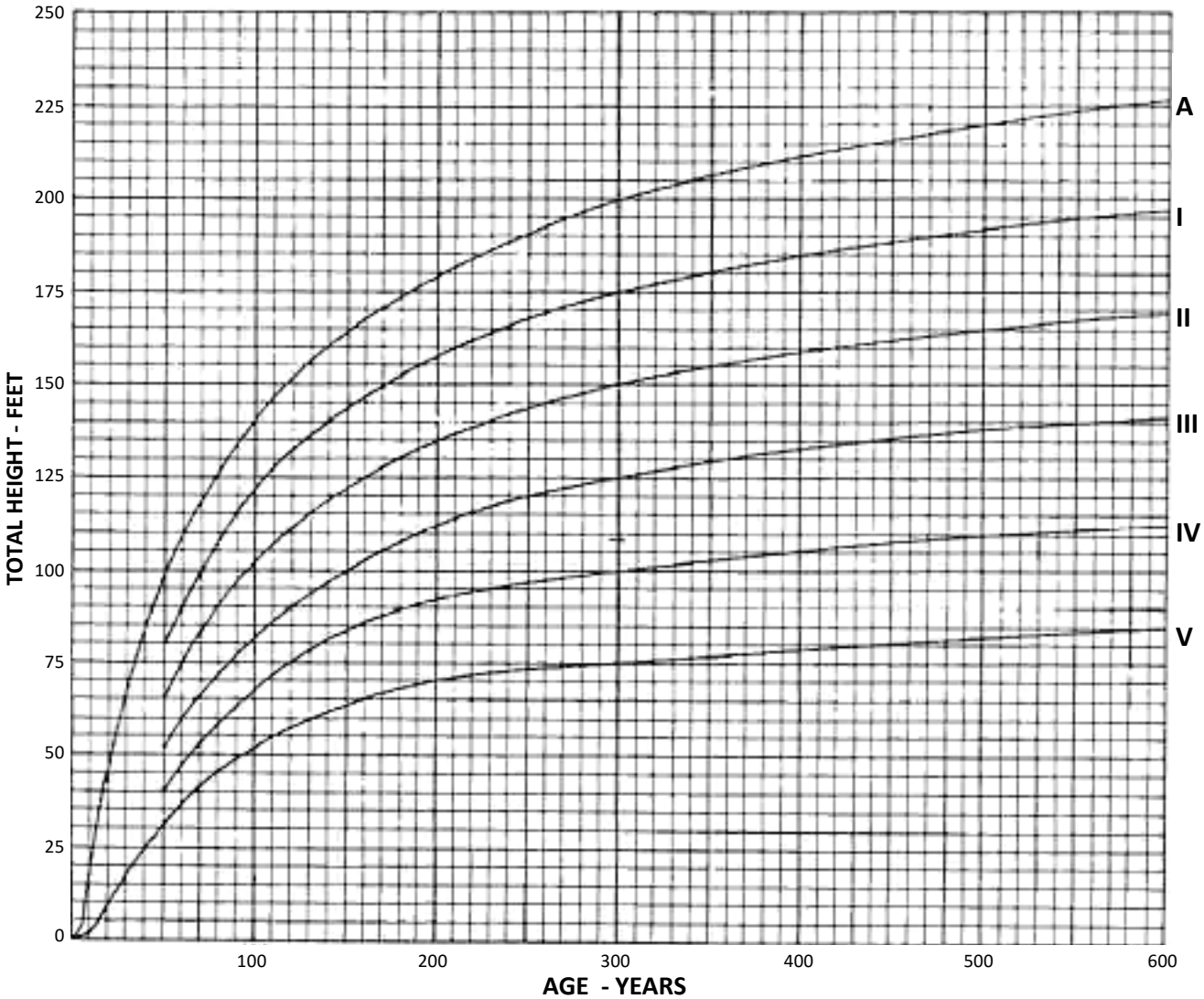
Height of dominant trees of the same age on different slope positions. Dark coloring shows depth of soil; dashed lines indicate water table. (A) Accumulation of soil and organic material at the base of the slope results in deeper soils and taller trees. (B) If the toe of the slope is subject to a high water table, restricted rooting may reduce height growth. Source: after Spurr and Barnes 1980.

A SITE CLASSIFICATION FOR THE MIXED CONIFER SELECTION FORESTS OF THE SIERRA NEVADA

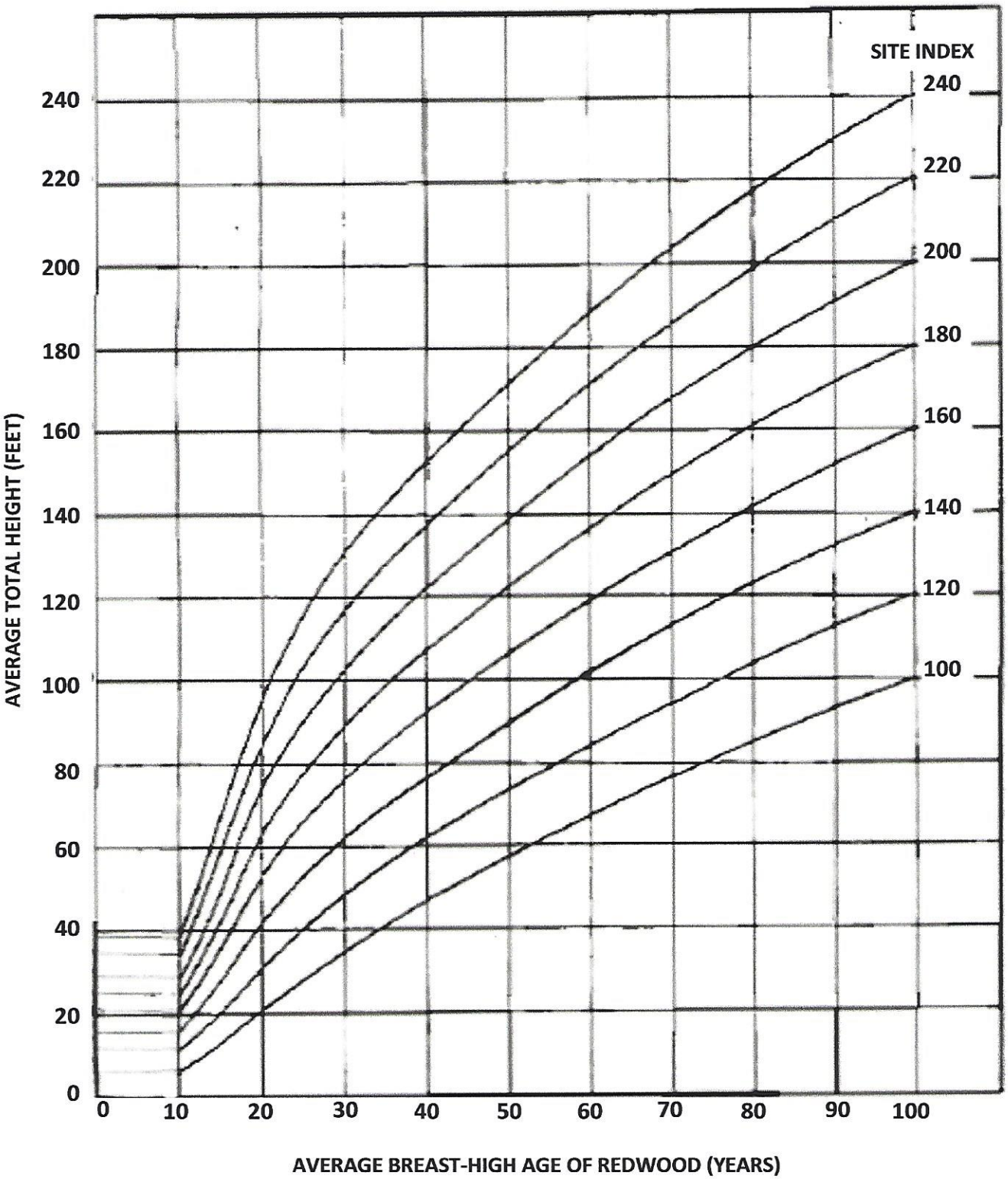


How to determine site index

To calculate the site index of a stand, use an increment borer to determine the age and a clinometer to determine the height of a dominant, undamaged tree that is growing free of competition from nearby trees. Estimate the site index by entering height and age data into the appropriate table. Use the table to the left for trees under 50 years in age, and the table below for trees older than 50.



Site Index Values of Dominant Redwood by Height and Breast-High Age Class



Basic Inventory Calculations

Once you learn how to establish and take measurements in sample plots, the next step is to make some basic calculations with your inventory data that will help you to better understand and steward your forest. It is important to decide which calculations are appropriate to the scale of the property and its management objectives. Trees per acre is an easy calculation to generate and, when combined with tree diameters and live crown ratios, can provide important information about the stocking of the stand, potential need for thinning, and forest health. Basal area is another measure of stand density or stocking, but is less intuitive. Volume data is not required for a forest management plan, but is useful when considering timber harvest options.

Determining TPA from fixed plots

1. Determine the expansion factor for the plot trees (the number of trees per acre a given plot tree represents; e.g., 20 for a 1/20th acre plot).
2. Add up the total number of trees in a plot and multiply by the expansion factor to get the trees per acre represented by that plot.
3. Repeat this for the other plots in the stand.
4. Add up the TPA for all plots in the stand and then divide by the number of plots to get the average TPA for the stand.

Example: Suppose you acquired data on two 1/20th acre plots. Suppose that there were six trees in the first plot and five in the second.
1. With 1/20th acre plots, the expansion factor would be 20.
2. The TPA represented by the first plot is 6 x 20 = 120.
3. The TPA represented by the second plot is 5 x 20 = 100.
4. Adding 120 and 100 and then dividing by 2 yields an average of 110 TPA for the whole stand.

Determining basal area from variable plots

Determining basal area is a little easier for variable plots because each “in” tree in a plot represents a given amount of basal area, as determined by the basal area

factor (BAF). For example, if you established variable plots using a BAF of 30, each tree would represent 30 square feet of basal area. Here are the steps for determining basal area per acre from variable plots:

1. Add up the total number of trees in a plot and multiply by the BAF to get the basal area per acre represented by that plot.
2. Repeat this for the other plots in the stand.
3. Add up the basal area for all plots in the stand and then divide by the number of plots to get the average basal area per acre for the stand.

Example: Suppose you did two variable plots using a BAF of 30, with eight trees in the first plot and six in the second.

1. The basal area for the first plot is 8 x 30 = 240 sq ft/ac.
2. The basal area for the second plot is 6 x 30 = 180 sq ft/ac.
3. Adding 240 and 180 and then dividing by 2 yields an average basal area for the stand of 210 sq ft/ac.

Determining tree volume

If you are managing for timber and wood products, knowing how much wood volume you have will be of particular importance. Determining the volume of wood in a tree can be challenging, as the stem of the tree is not a perfect cylinder. Rather, the stem is tapered, meaning that it starts out wide at the bottom and becomes narrower as you go up the tree, giving the tree a cone shape. Tree volume is most commonly determined using volume tables, which list volumes by tree height and DBH based on species and location. Using a volume table requires that heights be measured for all plot trees, which can be the most time-consuming part of doing a forest inventory.

Once you have determined the volume of each tree, multiply that volume by the tree's expansion factor (which you determined above when calculating TPA and basal area) to get volume on a per acre basis. Add the per acre volumes for all the trees in each plot and then take the average across all plots to get the average volume per acre in your stand. A computer spreadsheet is very helpful for doing these computations.

Once you have determined the volume per acre in your stand, you can multiply by the number of acres to find the total stand volume. If you know the current price per volume of wood in your area, you can estimate the approximate commercial value of the timber in your stand.

WORKSHEET - TREE MEASUREMENT

NAME: _____

1. In order to assess a tract of timber, foresters conduct a survey, or _____, to estimate its quantity by species, products, size, quality, or other characteristics.
2. A _____ _____ is a tool used to measure both tree diameter (girth) and height.
3. A _____ _____ is used to get a more accurate measurement of tree diameter.
4. In order to measure the diameter of a tree, the forester takes the measurement at "dbh", which stands for _____ _____ _____ _____.
5. "dbh" is _____ feet above the ground.
6. A _____ is another instrument used to measure tree height.
7. In order to measure the height of a tree, the forester must stand a certain distance from the tree. Typically, the forester will walk one "chain" from the tree, which is ____ _____ in length.
8. Once tree height is known, the forester can determine how many "logs" are in the tree. A "log" is defined as a ____ _____ long section of a tree.
9. After determining the diameter and height of a tree, the forester can use a _____ _____ to determine the volume of wood in the tree.

10. The term used to denote the volume of wood in a tree is _____ _____, and is a piece of wood 12 inches square and 1 inch thick.
11. Another important forestry tool is the _____ _____, which is an auger-like instrument with a hollow bit and an extractor. It is used to remove a small cylindrical core from the tree. Foresters determine the age of a tree by counting the growth rings in the core sample.

VOCABULARY LIST FOR WORKSHEET - TREE MEASUREMENT

biltmore stick

board foot

clinometer

cruise

diameter at breast height

diameter tape

increment borer

volume table

66 feet

16 foot

4.5