

FO-2213 Forest Measurement
Topic 6: DBH and Basal Area Growth

Why is determination of dbh and basal area growth important?

Both growth procedures are used to predict future and past tree sizes for timber value appraisals.

A. Future timber value appraisals are used in financial analyses of investment opportunities. Potential investors and timberland managers want to know the future value and product distribution of timber stands.

B. Past timber value appraisals are used for computation of estate or inheritance taxes. Current timber product distributions can be “grown backwards in time” to obtain value appraisals at a specific date in the past.

What field/tree data are required to determine dbh and basal area growths?

Number of sample trees: approximately 2-3 samples per encountered dbh class per desired species and a total of at least 25 observations per desired regression relationship. The most optimum number is 25 observations per regression coefficient to be estimated. Thus for a standard height-dbh equation with 2 coefficients, the optimum is $2 \times 25 = 50$.

Required sample tree measurements:

1. dbh to nearest 0.1 inches
2. single bark thickness to 0.01 inches
3. 10 year radial growth measured to nearest 0.01 inches
4. height (total or merchantable) to nearest 1.0 ft. Height must be appropriate to the variables in the volume equation; i.e. if H is total height in the equation or if MH is merchantable height to a X-inch top diameter, then the appropriate height must be measured in the field.

How do you use dbh and basal area growth:

dbh growth : applied with growth ratio index from dbh growth-dbh relationship; dbh growth in dbh_i class = function (dbh_i); i.e. from the regression equation. thus, for a 10 inch dbh class, dbh growth is 0.72 inches in 10 years. $g.r.i. = \text{growth in dbh}_i \div \text{dbh interval} = n.f$ or $(0.72/1.0 = 0.72)$ thus $f\% = 72\%$ of the trees move up $n+1 = 1$ dbh class; 18% remain at 10 inches.

basal area growth: applied with dbh basal area growth-dbh relationship:

basal area growth in dbh_i class = function (dbh_i); from the regression equation.
future dbh = the dbh for (current basal area for dbh_i class + basal area growth)
thus, for 10 inch dbh class with a growth of $0.1002 \text{ ft}^2 = 0.5454 + 0.1002 = 0.6456 \text{ ft}^2 = \text{dbh of } 10.88 \text{ inches}$.

- a. Apply tree volume to a 10.88 inch trees, or
- b. Computer g.r.i. as 0.88 inches and move 88% of the trees in the 10 inch class up 1-dbh classes and move 12% of the trees up 0-dbh class.

Sample Tree Measurement:

1. dbh (ob) is measured with a d-tape in the field.
2. obtain single bark thickness with bark gauge.
3. obtain radial growth from core obtained with an increment borer.
4. measure total tree height with clinometer.

Tree#	dbh(ob)	Height	1x-Bark	1x-RG10		curr dib	Past dib	Past DBH	dbh gro
1	2.9	33	0.20	0.04		2.5	2.4	3.6	-0.70
2	3.9	40	0.60	0.11		2.7	2.5	3.7	0.23
3	5.0	45	0.70	0.15		3.6	3.3	4.6	0.35
4	5.9	49	0.80	0.20		4.3	3.9	5.4	0.54
5	6.9	59	0.90	0.23		5.1	4.6	6.2	0.65
6	8.0	58	1.10	0.23		5.8	5.3	7.1	0.92
7	8.8	65	1.00	0.30		6.8	6.2	8.1	0.70
8	10.0	69	1.10	0.33		7.8	7.1	9.2	0.78
9	10.9	64	1.30	0.33		8.3	7.6	9.8	1.08
10	11.9	73	1.40	0.40		9.1	8.3	10.6	1.29
11	13.1	70	1.50	0.46		10.1	9.2	11.7	1.45
12	14.0	77	1.40	0.45		11.2	10.3	13.0	1.01
13	15.0	78	1.30	0.42		12.4	11.6	14.5	0.51
14	15.8	73	1.70	0.47		12.4	11.5	14.4	1.43
15	16.7	80	1.50	0.54		13.7	12.6	15.8	0.95
16	17.9	80	1.80	0.43		14.3	13.4	16.7	1.17
17	19.0	83	1.70	0.60		15.6	14.4	17.9	1.13
18	20.1	72	2.10	0.67		15.9	14.6	18.1	2.04
19	21.8	90	2.00	0.66		17.8	16.5	20.4	1.45
20	22.4	85	2.00	0.56		18.4	17.3	21.3	1.10
	Y					X		X	Y

Sample Tree Calculations:

1. $dbh(ib) = dbh(ob) - 2*(1x-bark)$
2. fit regression of dbh (ob) as a linear function of dbh (ib) [see next worksheet]
3. $past\ dbh(ib) = current\ dbh(ib) - 2*(1x-radial\ growth)$
4. compute past dbh (ob) with the regression equation (step 2) from past dbh (ib)
5. calculate dbh growth = current dbh (ob) - past dbh (ob)
6. fit regression of dbh growth as a linear function of past dbh (ob) [see worksheet]

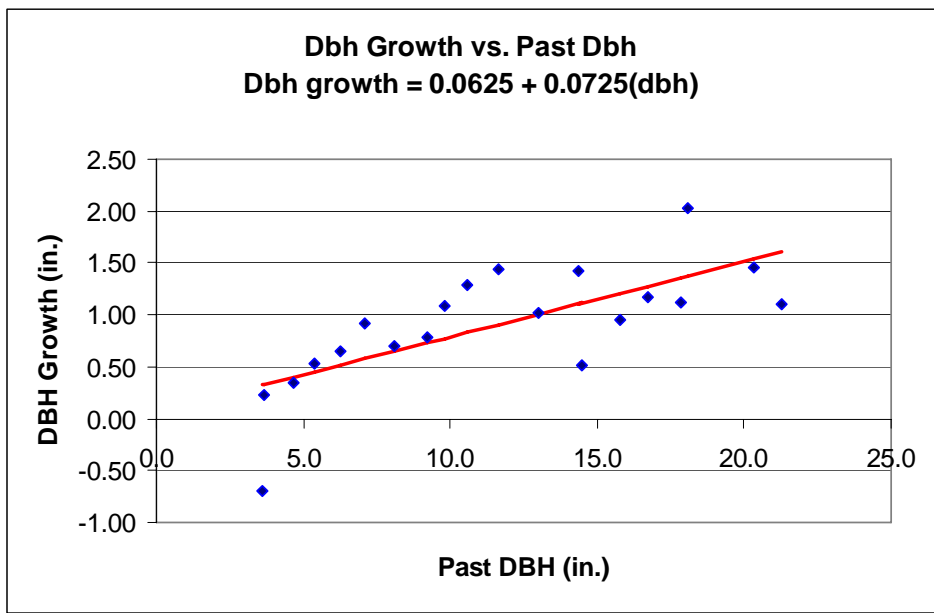
$$dbh_{ob} = b_0 + b_1(dbh_{ib})$$

7. fit regression of $\ln(\text{height})$ as a linear function of $(dbh)^{-1}$:

$$\ln(H_0) = b_0 - b_1(dbh^{-1})$$

Worksheet for: $dbh\ growth = b_0 + b_1(past\ dbh_{ob})$

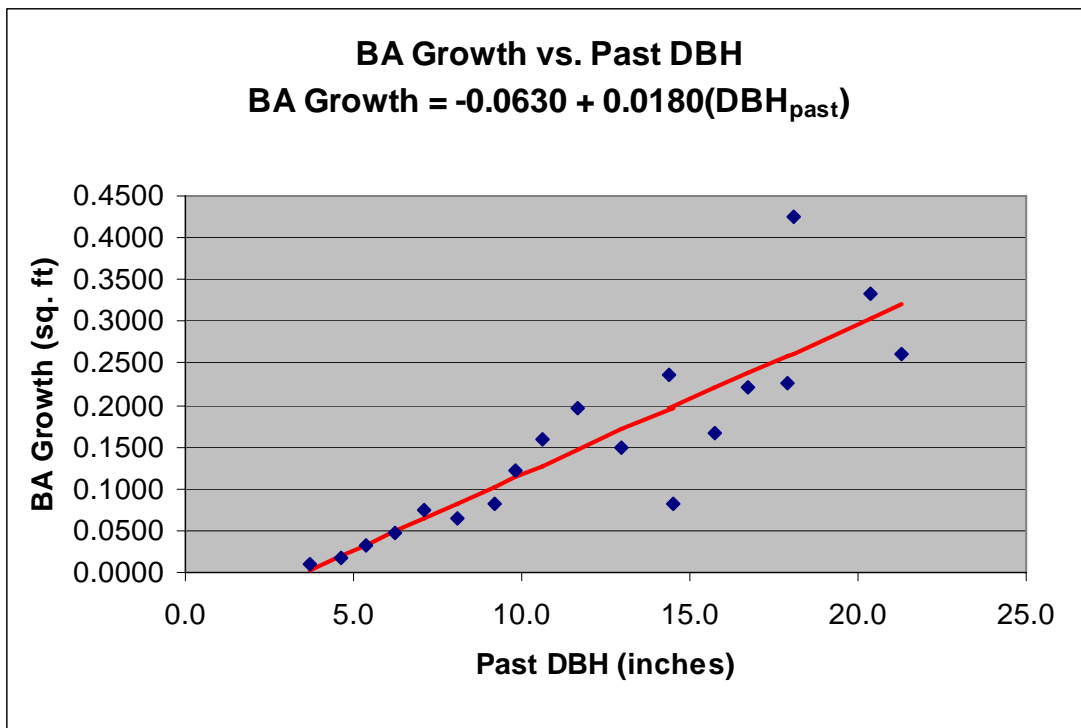
Y=dbh 10growth	X=past dbh(ob)		Y ²	X ²	XY
-0.70	3.6		0.49	12.97	-2.5263
0.23	3.7		0.05	13.49	0.8340
0.35	4.6		0.12	21.62	1.6286
0.54	5.4		0.29	28.78	2.8728
0.65	6.2		0.43	39.01	4.0849
0.92	7.1		0.85	50.12	6.5144
0.70	8.1		0.48	65.68	5.6379
0.78	9.2		0.60	85.08	7.1570
1.08	9.8		1.17	96.43	10.6081
1.29	10.6		1.67	112.49	13.7248
1.45	11.7		2.09	135.82	16.8494
1.01	13.0		1.02	168.70	13.1390
0.51	14.5		0.26	209.94	7.3988
1.43	14.4		2.04	206.50	20.5460
0.95	15.8		0.90	248.13	14.9317
1.17	16.7		1.37	279.86	19.5913
1.13	17.9		1.27	319.43	20.1515
2.04	18.1		4.15	326.27	36.7931
1.45	20.4		2.10	414.13	29.5027
1.10	21.3		1.20	453.83	23.3644
18.1	231.9	Sums	22.57	3288.28	252.8040
0.9	11.6				
		CSS	6.261903	598.4558	43.37115
		b₁	0.0725		
		b₀	0.0625		
		r²	0.501954		
		s_{y,x}	1.765989		



Worksheet for:

$$ba\ growth = b_0 + b_1(dbh_{past})$$

Tree#	CurDBH	PastDBH	BAgrow		Y ²	X ²	XY	(Y-Y [^]) ²		PastDBH	BAgrow	Y [^]
1	3.9	3.7	0.0094		0.0001	13.49	0.0344	0.0000		3.7	0.0094	0.002963
2	5.0	4.6	0.0184		0.0003	21.62	0.0857	0.0000		4.6	0.0184	0.020517
3	5.9	5.4	0.0329		0.0011	28.78	0.1765	0.0000		5.4	0.0329	0.033361
4	6.9	6.2	0.0469		0.0022	39.01	0.2929	0.0000		6.2	0.0469	0.049202
5	8.0	7.1	0.0757		0.0057	50.12	0.5358	0.0001		7.1	0.0757	0.064187
6	8.8	8.1	0.0641		0.0041	65.68	0.5198	0.0003		8.1	0.0641	0.082597
7	10.0	9.2	0.0814		0.0066	85.08	0.7504	0.0005		9.2	0.0814	0.102719
8	10.9	9.8	0.1221		0.0149	96.43	1.1988	0.0001		9.8	0.1221	0.113422
9	11.9	10.6	0.1588		0.0252	112.49	1.6847	0.0010		10.6	0.1588	0.127551
10	13.1	11.7	0.1952		0.0381	135.82	2.2748	0.0024		11.7	0.1952	0.146389
11	14.0	13.0	0.1489		0.0222	168.70	1.9340	0.0005		13.0	0.1489	0.170365
12	15.0	14.5	0.0821		0.0067	209.94	1.1900	0.0133		14.5	0.0821	0.197337
13	15.8	14.4	0.2353		0.0553	206.50	3.3808	0.0016		14.4	0.2353	0.195196
14	16.7	15.8	0.1678		0.0281	248.13	2.6428	0.0027		15.8	0.1678	0.220028
15	17.9	16.7	0.2212		0.0489	279.86	3.7001	0.0003		16.7	0.2212	0.237582
16	19.0	17.9	0.2267		0.0514	319.43	4.0525	0.0010		17.9	0.2267	0.258132
17	20.1	18.1	0.4240		0.1797	326.27	7.6582	0.0264		18.1	0.4240	0.261558
18	21.8	20.4	0.3333		0.1111	414.13	6.7823	0.0009		20.4	0.3333	0.302659
19	22.4	21.3	0.2614		0.0683	453.83	5.5691	0.0034		21.3	0.2614	0.319784
Sums	247.1	228.3	2.9055	Sums	0.6703	3275.3	44.4636	0.0545				
Means	13.0	12.0	0.1529									
				CSS	0.2260	531.162	9.5451					
				b₁	0.0180							
				b₀	-0.0630							
				R²	0.7590							
				s_{y.x}	0.0566							



Example of 10 year Stand Table Projection with Diameter and Basal Area

Equations: $Hgt = 93.9535 e^{(-3.3097/DBH)}$
 $ft^3/tree = -0.09 + 0.002618(D_2H)$
 $DBH\ growth = 0.0626 + 0.0725(DBH)$
 $BA\ growth = -0.0830 + 0.0180(DBH)$
 $PAI = (V_n - V_0)/n$ where V_0 = current volume V_n = future volume n =years
 $\% Growth = (V_n/V_0)^{1/n} - 1$ from $V_n = V_0(1 + p)^n$ and p = compound interest rate

DBH	Hgt	Trees/ac	Vol/tree	Vol/ac	DBH Gro	DBH Trees	DBH Vol	BA Gro	BA_Dbh Inc	BA Inc	BA Trees	BA Vol
6	54	100	5.0	501.1	0.50	50.0	250.5	0.0450	6.65	0.65	35.0	175.4
7	59	80	7.4	593.7	0.57	84.4	626.4	0.0630	7.78	0.78	82.6	613.0
8	62	70	10.3	722.3	0.64	71.6	738.8	0.0810	8.88	0.88	70.8	730.6
9	65	60	13.7	822.2	0.72	60.8	833.1	0.0990	9.96	0.96	64.0	877.0
10	67	50	17.6	878.8	0.79	53.7	943.8	0.1170	11.02	1.02	57.6	1012.4
11	70	40	21.9	877.6	0.86	45.1	989.5	0.1350	12.07	1.07	49.0	1075.0
12	71	0	26.8	0.0	0.93	34.4	921.6	0.1530	13.12	1.12	38.2	1023.5
13	73	0	32.1	0.0	1.01	0.0	0.0	0.1710	14.15	1.15	2.8	90.0
Totals		400		4,395.6		400.0	5,303.8				400.0	5,596.8
					PAI		90.8 cu.ft/yr					120.1
					%Growth		1.9% compound					2.4%