

Monitoring Silvicultural Operations

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D1

***Silviculture* is the art (*experience*) and science of controlling**

- the establishment,
- growth,
- composition,
- health, and
- quality

of forests and woodlands to meet the diverse needs and values of landowners and society on a sustainable basis (Adams et al. 1994).

D2

Another definition is ...

Silviculture is the tending and regeneration of forests.

Tending

To care for or look after; give one's attention to.

Regeneration

Biology - the restoration or new growth by an organism of organs, tissues, etc., that have been lost, removed, or injured.

Theology - spiritual rebirth; religious revival

Continuous versus Discrete Variables

A continuous variable is a variable that has an infinite number of possible values. In other words, any value is possible for the variable. A continuous variable is the opposite of a discrete variable, which can only take on a certain number of values.

[Continuous Variable Definition \(Continuous Data\) - Statistics How To](#)

Measures versus counts?

Temporary versus Permanent

Temporary plots or points are

- fast and easy
- Statistically a bit inefficient

$$S_{growth_{combined}} = \sqrt{\frac{S_{y_1}^2}{n_1} + \frac{S_{y_2}^2}{n_2}}$$

For permanent plots or points

- Set up of plots takes more time
- Statistically more efficient

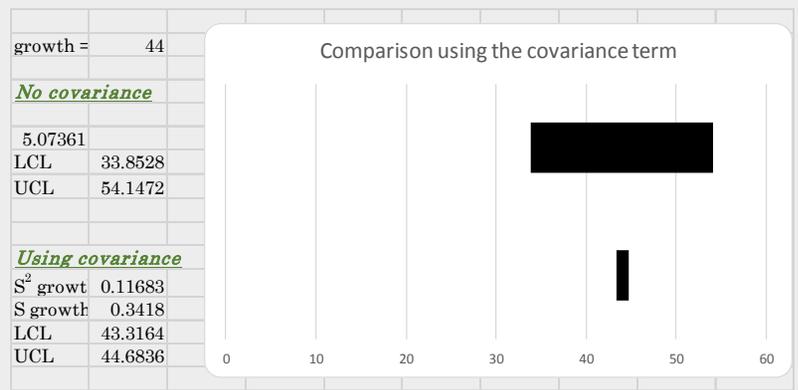
$$S_{growth_{combined}} = \sqrt{\frac{S_{y_1}^2 + S_{y_2}^2 - 2\rho S_{y_1} S_{y_2}}{n}}$$

- The covariance term can greatly reduce the standard error of the growth estimate.

Calculating Confidence Limits for Plots or Points

1999	2006	XY	X ²	Y ²		
25	33	825	625	1089		
27	37	999	729	1369		
22	29	638	484	841		
14	17	238	196	289		
30	35	1050	900	1225		
28	35	980	784	1225		
45	49	2205	2025	2401		
191	235	6935	5743	8439	Sum	
27.2857	33.5714	990.714	820.429	1205.57	Mean	
88.5714	91.619	366106	334716	407186	Var	
9.41124	9.57178				StDev	
r =	0.9956				Correlation	
859.854						
714.07						
1044.57						
863.651						

Permanent



Monitoring for Tending

Fixed Area Plots – best when principal interest is in individual trees.

Points – best when interested in per acre estimates.

Monitoring for Tending

When the focus is on the tree *example - tree height*

- It is very difficult to select individual trees randomly
- Trees are chosen in clusters (usually plots)
- Fixed area plots are a good choice because trees have equal probability of selection
- Calculate the mean as usual
- Variance is $S_E^2 = \frac{\sum_{i=1}^n y_i^2 - 2\bar{y}_{CE} \sum_{i=1}^n y_i m_i + \bar{y}_{CE}^2 \sum_{i=1}^n m_i^2}{n-1}$
- from Cochran; and Shiver and Borders
- because plots don't have the same number of trees
- This equation becomes more difficult with points because trees are not selected with equal probability on points.

Confidence Limits for Clustered Elements

Plot	DBH's				$\sum y_i$	m_i	$\sum y_i^2$	m_i^2	$y_i m_i$
1	12	13.2	15		40.2	3	1616.04	9	120.6
2	11.7	11.5	14	17	54.2	4	2937.64	16	216.8
3	12.8	13.1	12.1		38	3	1444	9	114
4	16.2	15.1			31.3	2	979.69	4	62.6
5	12.6	13.7	12.5	12.8	51.6	4	2662.56	16	206.4
					215.3	16	9639.93	54	720.4
Mean DBH	215.3	+	16	=	13.45625				
Mean Trees	16	+	5	=	3.2				
N = 7 acre stand x 10 plots/acre = 70 total possible plots									
	9639.93		7.495215		95% CL				
	19387.77				LCL	12.7			
	9777.816		0.135934		Mean	13.5			
					UCL	14.2			
			0.368693						

Confidence Limits Using the Generic Formula

12		
13.2		
15		
11.7		
11.5		
14		
17		
12.8		
13.1		
12.1		
16.2		
15.1		
12.6		12.69275
13.7		13.5
12.5		14.30725
12.8		
1.614505	SD	
0.403626	SE	

Monitoring for Tending

- Were the stand conditions what we thought they were?
- Did we do what we thought we did?
- Did we get the results that we thought we would?
- What happened that we did not anticipate?

Consider measuring ...

Basal Area

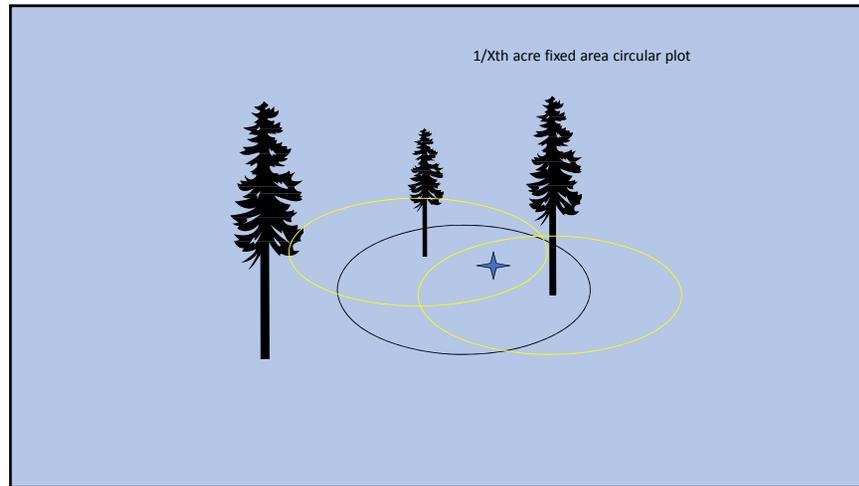
- Initial basal area
- Residual basal area
- Basal area growth

Volume growth – Dry matter, Carbon, Biomass, Board feet, Cords/Tons, \$Value?

Diameter change at breast height

Slash and Coarse Woody Material

Change in quality

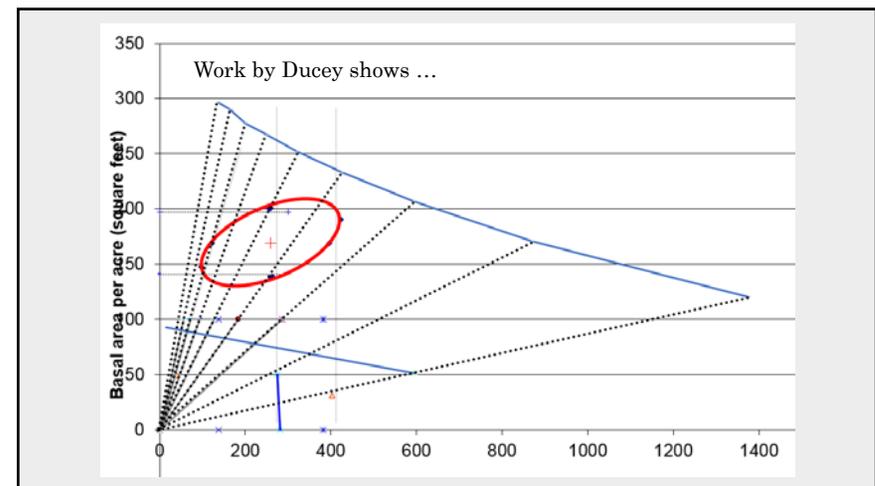


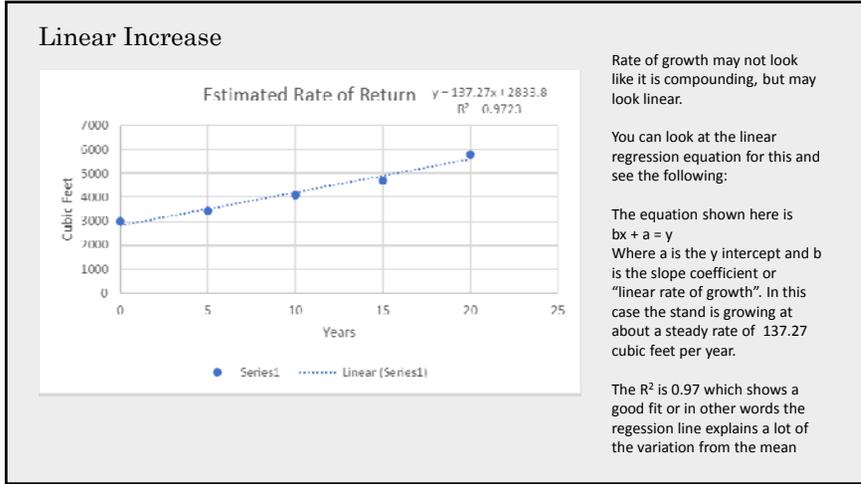
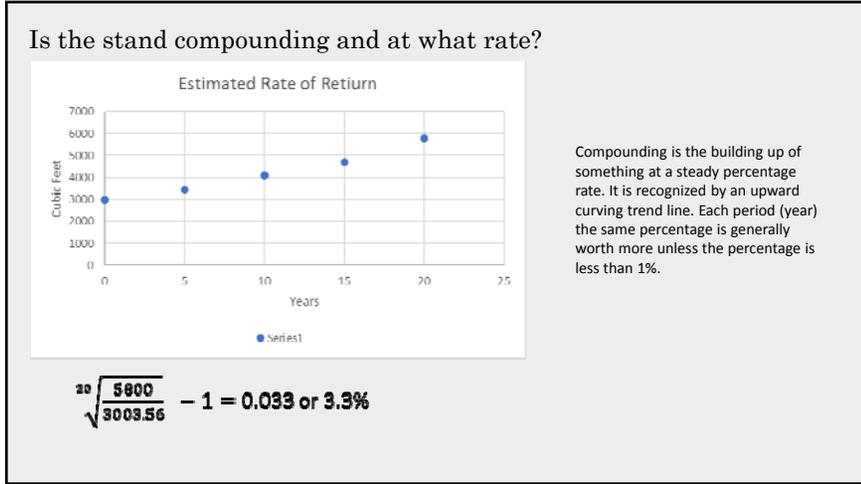
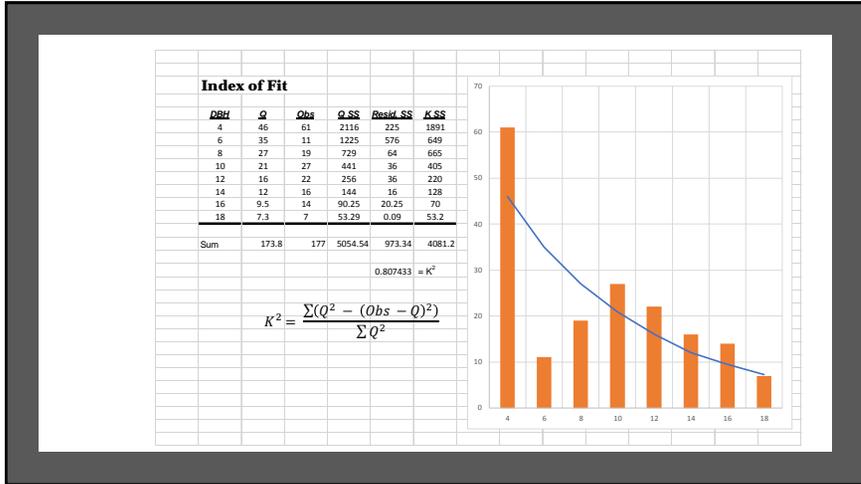
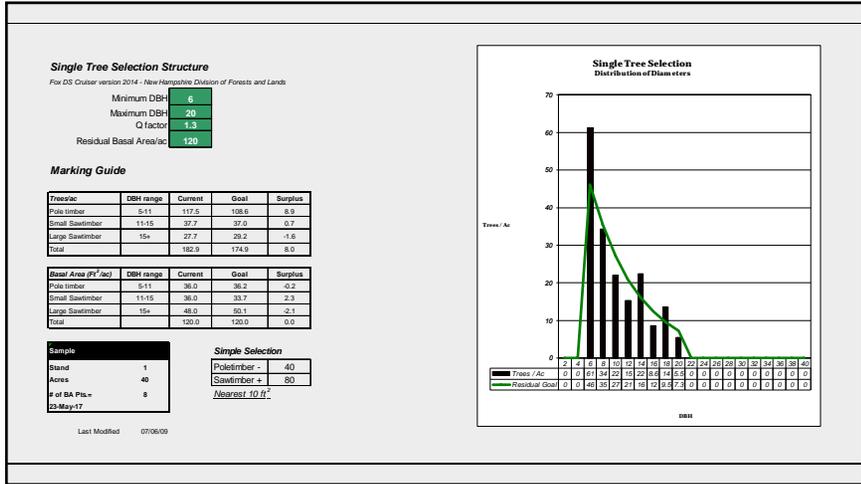
Iles Suggested Point Design

Tree	Sp	2005						2010								
		DBH	Ht	Basal Area Ft ² /ac	Cubic Feet	Blow Up	Cubic Feet per acre	BA	DBH	Ht	Basal Area Ft ² /ac	Cubic Feet	Blow Up	Cubic Feet per acre	BA	
1	WP	16	85	1.1	51.51	14.32	737.2	20	17.1	83	1.59	61.21	14.32	874.7935	22.8	
2	HO	14.5	81	1.15	37.1	17.44	647.15	20	15.4	84	1.29	42.98	17.44	749.6271	22.6	
3	RM	9.4	74	0.48	14.17	41.50	588.15	20	9.9	78	0.53	16.42	41.50	681.4474	22.2	
4	Be	11.7	76	0.75	25.52	26.79	683.56	20	11.9	79	0.77	27.25	26.79	729.9779	20.7	
5	He	5.2	37	0.15	2.56	135.62	346.8	20	5.4	40	0.16	2.96	135.62	401.4207	21.6	
6	WP															
						235.67	3003.56	100.00					235.67	3439.27	109.8	
										TPA	RA	F ³				
										T ₁₀	109.85	3439.27				
										T ₅	100.00	3003.56				
										Diff	9.85	435.71				
										Ann. Mean	1.969	87.14131				
										1.0 cords/acre						

Monitoring Stocking Levels

	Trees per acre	Basal Area
1	40	100
2	57	118
3	57	139
4	109	100
5	158	100
6	174	179
7	185	179
8	198	221
9	208	179
10	248	179
11	255	179
12	389	200
13	436	200
14	490	283
15	893	179





Monitoring for Regeneration

Continuous versus Discrete Samples

Do you really need to count seedlings?

Probably not ...

Do you care if you have 10,000 or 10,500 seedlings per acre?

What do you need to know and why?

Will a simple inspection suffice?

How about Leak's "quick plots"?

As a very last resort count seedlings – all or just enough?

What do you need to know and why?

Curiosity, Rx achievement, planning future species composition, NFMA,

Will a simple inspection suffice?

Take a walk around. Your vision is far sighted but subjective.

How about Leak's "quick plots"?

Interested in future species composition

What can be done to improve species composition

As a very last resort count seedlings – all or just enough?

Very time consuming and expensive

Often more data than is needed

Find an efficient plot size

Small size for counts, Leak's larger for quick plots

Calculating Proportions and Confidence Limits on them

$$S_p = \sqrt{\frac{P(1-P)}{n-1}} \left(\frac{N-n}{N} \right)$$

Example P=35%, n=50, N=425

$$S_p = \sqrt{\frac{0.35(0.65)}{49}} \left(\frac{425-50}{425} \right) = 0.06$$

$$LCL = 0.35 - 2(0.06) = 0.23$$

$$P = 0.35$$

$$UCL = 0.35 + 2(0.06) = 0.47$$