2012

Increased Uniformity by Planting Clones Will Likely Have a Minimal Effect on Inventory Costs

Curtis L. Vanderschaaf
Minnesota Department of Natural Resources

Dean W. Coble
Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University, dcoble@sfasu.edu

David B. South
Auburn University

INCREASED UNIFORMITY BY PLANTING CLONES WILL LIKELY HAVE A MINIMAL EFFECT ON INVENTORY COSTS

Curtis L. VanderSchaaf, Dean W. Coble, and David B. South

ABSTRACT

When conducting inventories, reducing variability among tree diameters, heights, and ultimately volumes or biomass, can reduce the number of points/plots needed to obtain a desired level of precision. We present a simple analysis examining the potential reduction in discounted inventory costs when stand variability is decreased (via improved genetics and intensive management on a uniform soil). Sampling time might be reduced if the coefficient of variation in point volume/biomass estimates is reduced to 10% (versus 25% for genetically diverse stands). However, if this level of variability could be achieved (and depending on the desired probability and allowable percent error) discounted costs might be only reduced by $0.50 per acre for a single inventory (when a 15% error is used). When four inventories are made across a rotation (at ages 10 to 25 years) with a goal of 5% error, total discounted savings might be $20 to $30 per acre. On some very uniform sites, stands with low variability may only need one inventory plot per 25 acres. Although clones (in theory) might reduce variability, microsite conditions within a plantation will always produce variability among plots/points.

INTRODUCTION

In the early 1960's, southeastern foresters recognized that genetic modification of trees could increase yields. After years of breeding selected trees based on morphological traits, we are now able to plant third generation genetically-improved pine seedlings (Wright and Dougherty 2006) as well as mass control pollinated (MCP) seedlings. Recent technologies have been developed that eliminate variability in genotype among trees in a stand (e.g. somatic embryogenesis and varietal forestry). It is generally thought that stand uniformity can be increased by eliminating genetic variability especially when reducing variation in competing weeds (by using intensive site preparation, herbaceous weed control and perhaps release treatments). Uniformity might also be maintained by fertilization, control of pests such as Nantucket pine tip moth, *Rhyacionia frustrana* (Comstrock), and regular thinnings. When stands are uniform, fewer inventory plots will be required.

The cost of forest inventories is justified because the data help managers make decisions about future management practices. Data from inventories are used by foresters to make management prescriptions, develop silvicultural systems, and to write management plans. Rather than using rules-of-thumb to determine the number of plots to measure, foresters will often vary the sample size or number of plots to achieve a desired level of precision for a specified degree of confidence. This approach is used to better ensure that not too much time is wasted taking more plots than is required to achieve the inventory objectives. The objective of this paper is to provide a simple example of how much inventory costs of loblolly pine plantations might be reduced if stand uniformity could be greatly increased.

METHODS

When sampling stands using horizontal-angle points, the population can be assumed infinite (Shiver and Borders 1996, pg. 106) and thus the following equation can be used to estimate a required sample size:

$$n = (zCV / E)^{**}2 \quad [1]$$

Where:
n -- sample size required to obtain a desired level of precision for a specified degree of confidence,
z -- z-value corresponding to a desired degree of confidence,
CV-- percent coefficient of variation, or estimate of the amount of inherent variability among points within the population, and
E -- percent allowable error.

The CV must be estimated using either a pilot study (a reduced number of points to estimate the population CV prior to conducting the inventory) or the CV can be obtained from previous inventories of similar populations. For sample size estimation purposes, since the sample CV is assumed to equal the true CV (or the population CV), a z-value is used rather than a t-value.

To evaluate the economics, the following factors were assumed:

1. It costs $11.00 per point to obtain an estimate of tons per acre using a 10 BAF at ages 10 and 15, while at ages 20 and 25 it costs $14.00 per point. Heights and diameters will be measured on all sample trees.

Forest Modeler, Minnesota Department of Natural Resources, Grand Rapids, MN 55744, Associate Professor, Stephen F. Austin State University, Nacogdoches, TX 75962, Emeritus Professor, School of Forestry and Wildlife Sciences, 602 Duncan Drive, Auburn University, AL 36849

2. Cruises are conducted at ages 10, 15, 20, and 25 years.

3. Two CVs were used, a CV of 25% which is associated with open pollinated genotypes and a lower intensity of management and a CV of 10% which is assumed to be associated with a mono-clonal plantation on a uniform site with a higher intensity of management. Based on preliminary analyses, intensive management can reduce point sampling CVs to near 10%.

4. The allowable percent error was varied; (5%, 15%, 25%) and probability level was varied from 90% to 95%. A 6% interest rate was assumed.

RESULTS AND DISCUSSION

There has been much debate about the economic feasibility of establishing "clonal" or "varietal" plantations because of increased costs associated with the planting stock and the need for conducting intensive silviculture to achieve additive economic gains (Stanturf 2003). As of January 2010, the cost per thousand of 1.5 generation stock bareroot loblolly and slash pine seedlings was around $50 while those of bareroot mass control pollinated seedlings were around $140 and container grown clones were around $320 to $450. With rising fuel costs, fertilizer costs have increased, and intensive site preparation and conducting several herbaceous or woody vegetation control treatments can be expensive (Barlow et al. 2009). Thus, a large amount of money is invested at the beginning of the rotation that must be carried around 10 to 30 years depending on site characteristics, management preferences, and local markets.

A cost reduction that may not be generally recognized is the reduction in inventory costs resulting from stands with greater tree uniformity. When using either plots or points to sample stands, the sampling unit is the plot or point and thus the CV corresponds to the amount of variability among plots or point estimates of attributes (e.g. volume or tons), not the amount of variability among an attribute of individual trees. If greater tree uniformity is obtained from planting superior genetic stock and conducting intensive forest management, then the CV in equation [1] will be smaller resulting in a reduction of the number of required plots or points.

As the percent error decreases but the level of probability increases establishing uniform plantations will increasingly reduce the relative sampling costs across a rotation (Table 1). Assuming a 5 percent error is considered allowable at a 90% probability level, a savings of $1,046 per 50 acres might be obtained ($1248-$202; or roughly a $21 per acre savings). In contrast, a $30 per acre savings ([$1781-$294]/50 acres) might result when a 95% probability level is desired.

Of course the sample size equations are merely guidelines. For instance, for the more variable stand with a 5 percent error at a 95% probability level, the estimated sample size is 97 points (about 2 plots per acre). In a 50 acre stand, some foresters might only use one inventory plot per acre. Some prefer general rules of thumb (such as one point per acre) to taking the time to calculate an estimate of plots required. However, in cases where stands and sites are uniform, the one-per-acre rule would likely require a greater amount of time sampling than needed. Foresters need to realize their ability to reduce sample sizes because of greater uniformity, thus decreasing inventory costs. In some small sites, the coefficient of uniformity for tree diameters in a mono-clonal stand might be less than 13% (Sharma et al. 2008).

In this paper, we are not necessarily promoting the goal of increasing stand uniformity. In fact, in cases where the price-size curve (Caufield et al 1992) for logs has a positive slope, increasing uniformity might decrease stand value (Nance and Bey 1979). Although stand value would be increased when seven diameter classes (5" to 11") were reduced to one DBH class ("8"), it would be decreased if seven diameter classes (7" to 13") were reduced to one "10" class – assuming 11" and greater are sawtimber trees, trees from 8" to 11" are chip-n-saw trees, and trees smaller than 8" are pulpwood trees. The lower production of sawlogs might reduce total stand value by $100 per acre or more. This could outweigh any reduction in inventory costs.

Assuming the planting of clonal stock and intensive management would reduce the amount of variability in a stand (Sharma et al. 2008), the related reductions in inventory costs appear to be minimal. It seems likely that any savings in inventory costs might not be passed on to the landowner (except for when the landowner is conducting their own inventory). Although clonal stock will likely reduce variability among points/plots, microsite conditions within plantations will always produce some amount of variability among plots/points.

LITERATURE CITED

Avery, T.E.; Burkhart, H.E. 2002. Forest Measurements. 5th ed. New York: McGraw-Hill. 456 p.

Barlow, R.J.; Smidt, M.F.; Morse, J.Z.; Dubois, M.R. 2009. Cost and cost trends for forestry practices in the South. Forest Landowner. 68: 5-12.

Caulfield, J.P.; South, D.B.; Somers, G.L. 1992. The price-size curve and planting density decisions. Southern Journal of Applied Forestry. 16:24-29.

Nance, W.L.; Bey, C.F. 1979. Incorporating genetic information in growth and yield models. In: 15th Southern Forest Tree Improvement Conference, Mississippi State University: 481-506.

Sharma, R.K.; Mason, E.G.; Sorensson, C.T. 2008. Productivity of radiata pine (*Pinus radiata* D. Don.) clones in monoclonal and clonal mixture plots at age 12 years. Forest Ecology and Management. 255:140-148.

Shiver, B.D.; Borders, B.E. 1996. Sampling techniques for forest resource inventory. Hoboken, NJ: John Wiley & Sons. 356 p.

South, D.B.; VanderSchaaf, C.L.; Teeter, L.D. 2005. Forecasting volume and economic gains from intensive plantation management using different response curves. South African Forestry Journal. 203:41-47.

Stanturf, J.A.; Kellison, R.C.; Broerman, F.S.; Jones, S.B. 2003. Productivity of southern pine plantations: where are we and how did we get here? Journal of Forestry. 101:26-31.

Wright, J.; Dougherty, P. 2006. Varietal forestry: a giant step-up for increasing timber value on your land. Forest Landowner. 65:3-4.

Table 1—Required sample size (i.e. number of plots/points required - calculated using equation [1]), inventory costs for 50 uniform acres ($ per 50 acres), and net present value (NPV) per 50 acres estimates when the coefficient of variation (CV) is reduced from 25% to 10% (due to practices that increase stand uniformity). Each sampling point at ages 10 and 15 years is assumed to cost $11 while at ages 20 and 25 years each sampling point is assumed to cost $14. A 6% interest rate was used in calculating NPV. The numbers 5, 15, and 25 correspond to the allowable percent errors

90% probability

	Management	Sample Size			Inventory cost			NPV per 50 acres		
Age	Intensity	5%	15%	25%	5%	15%	25%	5%	15%	25%
10	Less (CV = 25%)	68	8	3	$748	$88	$33	$417.68	$49.14	$18.43
15		68	8	3	$748	$88	$33	$312.11	$36.72	$13.77
20		68	8	3	$952	$112	$42	$296.84	$34.92	$13.10
25		68	8	3	$952	$112	$42	$221.81	$26.10	$9.79
Total								$1248.45	$146.88	$55.08

	Management	Sample Size			Inventory cost			NPV per 50 acres		
Age	Intensity	5%	15%	25%	5%	15%	25%	5%	15%	25%
10	More (CV = 10%)	11	2	1	$121	$22	$11	$67.57	$12.28	$6.14
15		11	2	1	$121	$22	$11	$50.49	$9.18	$4.59
20		11	2	1	$154	$28	$14	$48.02	$8.73	$4.37
25		11	2	1	$154	$28	$14	$35.88	$6.52	$3.26
Total								$201.95	$36.72	$18.36

95% probability

	Management	Sample Size			Inventory cost			NPV per 50 acres		
Age	Intensity	5%	15%	25%	5%	15%	25%	5%	15%	25%
10	Less (CV = 25%)	97	11	4	$1067	$121	$44	$595.81	$67.57	$24.57
15		97	11	4	$1067	$121	$44	$445.22	$50.49	$18.36
20		97	11	4	$1358	$154	$56	$423.43	$48.02	$17.46
25		97	11	4	$1358	$154	$56	$316.41	$35.88	$13.05
Total								$1780.87	$201.95	$73.44

	Management	Sample Size			Inventory cost			NPV per 50 acres		
Age	Intensity	5%	15%	25%	5%	15%	25%	5%	15%	25%
10	More (CV = 10%)	16	2	1	$176	$22	$11	$98.28	$12.28	$6.14
15		16	2	1	$176	$22	$11	$73.44	$9.18	$4.59
20		16	2	1	$224	$28	$14	$69.84	$8.73	$4.37
25		16	2	1	$224	$28	$14	$52.19	$6.52	$3.26
Total								$293.75	$36.72	$18.36