Mechanized Symmetrical Sowing

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Introduction

With hundreds of variables to investigate, and thousands of combinations, seldom is there found such appeal to the investigator as an organism's response to density. Loblolly pine (*Pinus taeda* L.) was grown at several levels of seedbed density and sowing configurations in order to display unique contrasts between consequent morphological traits, expense investments, and respective grades in revenue potential.

Seed sowing has advanced much over the past century. Only 50 years have passed since the Whitfield seeder replaced the Hazard seeder (May and others 1984), bringing precision to an already mechanized sowing process. Appropriately identified as "precision sowing" due to calibrated seed placement, greater seedling uniformity was realized. However, specifications require that the vacuum drum be restricted to 6 inches between the rows in order to satisfy cultural practices of lateral root trimming and seedling lifting. This 6-inch constraint precluded increasing seedbed density, since seedlings would have to be crowded within the row. In order to sow seedlings symmetrically, the 2- and 3-inch vacuum sowing drums were conceived. Unlike Hazard sowing, seeds were sown with precision by narrowing between-row spacing in order to extend within-row spacing.

In a 1999 nursery study (Howell 2001), symmetrical sowing was performed using a hand-sowing press to make soil impressions. The study lacked a proper comparison between 2 mechanized systems, however, because the 2- and 3-inch vacuum sowing drums were not available. Results of that study demonstrated that symmetrical sowing maintained typical seedling sizes at higher seedbed densities, and larger seedlings were produced at standard densities. The objectives of this study were (1) to demonstrate how increased seedbed densities can reduce production costs and permit nurseries to lower prices if needed, (2) to maintain seedling size (diameter and height) and uniformity by sowing in symmetry, and (3) to improve stem form.

Methods

This study involved sowing second generation loblolly pine seeds at Taylor Nursery (South Carolina Forestry Commission) in Aiken County over 4 beds at 4 by 380 ft each. Three vacuum sowing drums, drilled at 2, 3, and 6 inches between rows, were used to sow seeds at 5 seedbed densities (16, 25, 36, 49, and 64 drills/ft^2 [Table 1]). See Figure 1 for a visual configuration perspective. The 4 replicated beds (380 ft) were segmented into 2 blocks of 190 ft each; the replicated blocks held 15 individual 10-ft units for each treatment combination with 2-ft separation between units (Figure 2). The term "drills/ft^2" represents the seed sowing positions, which is synonymous with seedlings/ft^2, to be adjusted by survival.

Nursery Procedures

In early May 2003, all seedbeds were plowed, shaped, and pressed after the usual standards practiced at Taylor Nursery. Before sowing, each drum was calibrated to ensure accurate sowing density for each treatment.

Table 1—Conversion tables for area, length, and seedling densities throughout the paper.

	English	Metric
Area	1 ac	0.4 ha
	1 ft^2	0.9 m^2
Distance	1 in	2.5 cm
	1 ft	0.3 m
Seedling densities	16 seedlings/ft^2	178 seedlings/m^2
	25 seedlings/ft^2	278 seedlings/m^2
	36 seedlings/ft^2	400 seedlings/m^2
	49 seedlings/ft^2	544 seedlings/m^2
	64 seedlings/ft^2	711 seedlings/m^2

Analytical Procedures _____

Cost Estimation

Land (space), labor, and material costs were accounted (Table 2). All costs are reported in U.S. dollars ($). The workable land carries a specified cost per acre, which is unique to the region, and was set for this example at 35,000 ft^2/usable-ac or about 20% less than 43,560 ft^2. For each density, I calculated the amount of acreage required to produce 10 million stems.

For the required acreage, I calculated a labor cost in person-hours/year. Only area-specific labor costs were considered here, since overhead costs and other implicit costs have little to do with production acreage. Some examples of area-specific costs are fumigation, bed preparation, fertilization, sowing and lifting, herbicide and pesticide applications, irrigation, lateral root trimming, root undercutting, and top trimming. I based my standard on a scenario where
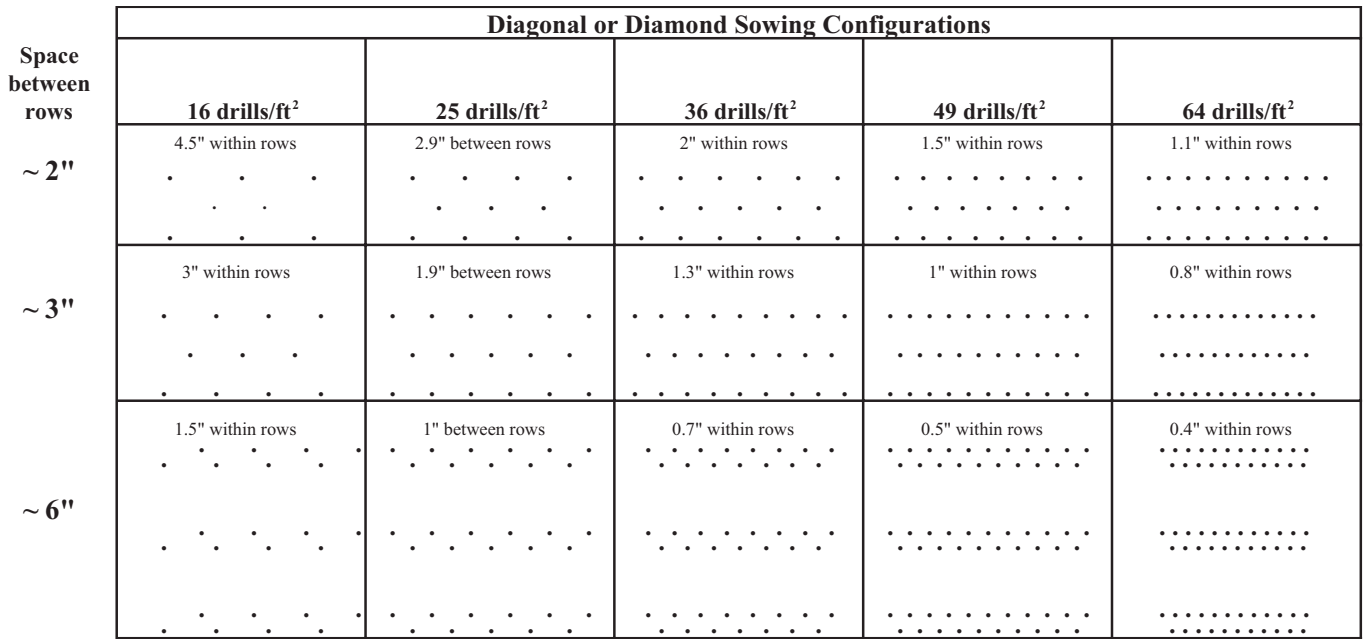

Figure 1—Sowing configurations of treatments involving 3 vacuum drums, drilled at 2, 3, and 6 inches between rows, and 5 seedbed densities of 16, 25, 36, 49, and 64 drills/ft².
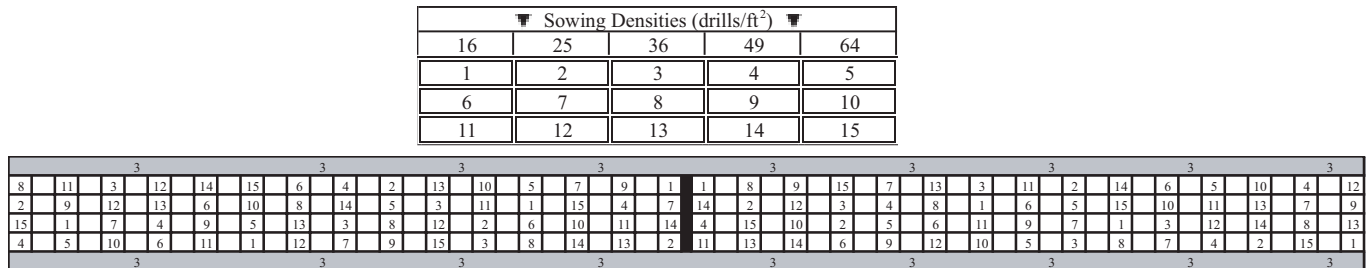

Figure 2—The treatment layout with 4 replications of 380 ft seedbed lengths as partitioned into 2 blocks. Each 10-ft treatment replication (5 densities by 3 sowing drums) was separated by 2 ft.

Table 2—Cost estimates (all in U.S. dollars [$]) as affected by area-specific trials according to the factors of Space, Labor, and Material with respect to density. Cost items were first based on calculating the numbers on 35,000 ft^2/usable-ac or about 20% less than 43,560. Then the needed acreage for 10 million seedlings produced (10M) was calculated. Next, the cost of space utilization as rent with a hypothetical per-acre rent of $100 was figured. Labor costs are first calculated by estimating person-hours (based on about 400 hours/yr for the standard of 25/ft^2) required to work respective land area, multiplied by a 4-person work force, and again multiplied by an assumed average wage of $15/hour. Material costs were based on a $20,000 cost to produce seedlings for the standard of 25/ft^2. The total combines all costs.

Cost items	16/ft^2	25/ft^2	36/ft^2	49/ft^2	64/ft^2
			density		
No. on 35,000 ft^2/ac	560,000	875,000	1,260,000	1,715,000	2,240,000
Acres for 10M stems	17.9	11.4	7.9	5.8	4.5
Spacial rent $100/ac	$1,786	$1,143	$794	$583	$446
Person-hours 400/yr	625	400	292	225	180
4 persons * hrs/person	2,500	1,600	1,168	900	720
Labor costs $15/hr	$37,500	$24,000	$17,520	$13,500	$10,800
Material costs	$31,250	$20,000	$13,889	$10,204	$7,813
Total costs	$70,536	$45,143	$32,203	$24,287	$19,059

Conversion note: 1 ac = 0.4 ha; 16 seedlings/ft^2 = 178 seedlings/m^2; 25 seedlings/ft^2 = 278 seedlings/m^2; 36 seedlings/ft^2 = 400 seedlings/m^2; 49 seedlings/ft^2 = 544 seedlings/m^2; 64 seedlings/ft^2 = 711 seedlings/m^2.

one individual is required to work 400 hours/year for the crop of 10 million seedlings at the standard density of 25 stems/ft^2. This becomes the pivotal point from which to determine the labor required to work all the other densities. To simulate a 4-person crew, hours/year were multiplied by 4, and a supposed $15/hour average wage was multiplied to get a labor cost/year for the crew for each density. Higher densities were penalized due to lags in lifting by 5, 10, and 15% with respect to 36, 49, and 64 stems/ft^2, caused by an increase in density and relative root binding. Besides any cost inflation from this hypothetical evaluation (Table 2), "real world" labor hours and costs can change with time, region, and worker experience, and must be adjusted according to nursery specifics.

Material costs, which were estimated at $20,000 to produce 10 million stems at 25 stems/ft^2, were proportionally based for other densities. The total area-specific production cost for each density was then determined by adding the estimated costs of space, labor, and material.

Seedling Measurements

To determine the effect of density and between-row configuration on seedling growth, measures of height and diameter for 10 randomly selected seedlings per treatment-replication were measured at the end of the growing season. At the time, seedling survival, uniformity, and cull percentages were also assessed for each treatment replication.

Stem form manifests its influence as the denominator of volume equation, as follows:

Volume = (* radius^2 * height) / form

where "form" approaching "2" (>1.5) is parabolic, and approaching "1" (<1.5) is cylindrical.

Data Analyses

All measurable data were analyzed using the analysis of variance (ANOVA) procedure in SAS (SAS Institute 1989), and the Tukey's mean separation procedure was employed for the comparison of main effects. Differences were significant at ≤ 0.05.

Results and Discussion _____

Evaluating Costs

Reducing seedling costs may not be just an option, but a necessity in the event of (1) a declining consumer demand, and/or (2) an increased competitive environment. Increasing seedbed density is an option for cutting production costs and lowering prices. My first objective was to demonstrate how changing seedbed density affected land, labor, and material costs, and thus a nursery's ability to lower the price of seedlings with respect to yield (that is, seedling quantity and quality).

Changing density changes land rental costs. Starting with our standard of 25 stems/ft^2, decreasing seedbed density to 16 stems/ft^2 offered a quantity of 560,000 seedlings/usable-acre, instead of the standard 875,000/usable-ac (Table 2). Increasing density to 36/ft^2, 49/ft^2, and 64/ft^2 gave quantities of 1.26, 1.72, and 2.24 million seedlings/usable-ac, respectively. Assuming a nursery production of 10 million seedlings, the acreage needed for each treatment-density ranged from 17.9 ac at 16/ft^2 to only 4.5 ac at 64/ft^2. After applying $100/ac rent, the cost of occupying respective areas would range from $1,786 to a low $446. Although dollar values must be adjusted by the specifics of a given region, proportional differences will remain as established.

This ability to produce 10 million seedlings on less land offers substantial savings in cost (rent), and releases the

unused portion for other resourceful prospects for opportunity. Because usable land seldom remains idle, less labor to work fewer acres offers the nursery additional savings. I made several assumptions to illustrate this, and these must be adjusted according to the specifics of each nursery. After assigning 400 hours/year to my 25/ft^2 standard and 1,600 hours for a 4-person crew, crew hours ranged from 2,500 hours to work 18 ac to as little as 720 hours to work 4.5 ac. In this example, higher densities were slightly penalized by 5, 10, and 15% for 36, 49, and 64/ft^2, respectfully, since higher numbers/ft^2 require more labor due to lags during the lifting process. Multiplying crew hours by \$15/hour offered a total labor cost for each density (Table 2), separating the highest and lowest density by about \$27,000 for the 10 million seedlings produced.

The cost of obtaining area-based materials (substances, items, products, and so on) involved in cultivating 10 million seedlings was the remaining factor to be estimated. Based on my estimate of \$20,000 for the standard density (25/ft^2), area-based material costs ranged from \$31,250 covering 18 ac to only \$7,813 for 4.5 ac. Because material costs depend upon the cost of products supplied and a nursery's protocol, my estimate of material costs must be tailored according to a nursery's empirical information.

Ability to Lower Price

According to my estimates, area-based operating costs from densities of 16, 25, 36, 49, and 64/ft^2 were \$7.05, \$4.51, \$3.22, \$2.43, and \$1.91/1,000 seedlings, respectively. This translates into a difference of \$5/1,000 seedlings from 16 to 64/ft^2, and about \$2/1,000 from 25 to 49/ft^2. Certainly, other fixed costs that can be cut and other costs, unaffected by area, such as overhead, interest payments, investments, and so on, need to be addressed. Additional costs may be substantially greater than area-based costs (for example, \$25/1,000 other costs versus \$7 to \$2/1,000 area-based costs). A small cost reduction of \$2/1,000 is well worth any reasonable investment, since it increases the "profit margin" built within the "asking price." The discrepancy between a nursery's asking price and the price a consumer is willing to pay may have huge implications; sometimes a mere \$2/1000 can determine whether a nursery breaks even, makes a profit, or suffers loss (Hodges and D'Ambrosio 1996).

Consumer Demand

Estimating consumer demand is an obstacle that nursery managers must consider. In my example, the supply of 10 million seedlings met demand exactly; this is not realistic. In reality, nursery managers have the difficult task of trying to predict a supply level according to past trends, where over-projections may result in plowing millions of seedlings under. Invested dollars in terms of space, labor, and material must be recovered with product sales. Suppose from 15 million seedlings cultivated only 10 million were sold, and 5 million had to be plowed under. The money (\$2.5/1,000 at 25/ft^2, \$1.3/1,000 at 49/ft^2, and so on) invested in those extra 5 million seedlings are costs to be recovered from the 10 million seedlings sold. On the other hand, to underestimate consumer demand can also be quite costly. The penalty is in terms of lost revenue and turning customers away due to a sold-out supply.

Larger Stem Size—Increased Revenue Potential

Revenue can be realized through increased seedling sales (that is, production quantity), but the potential to generate revenue is greatly increased when elevating the asking price for large seedlings. Suppose nursery "A" sells loblolly pine at \$40/1,000 for seedlings with ground-line diameters between 4 and 5 mm, and nursery "E" sets a price at \$45/1,000 for the same. Except for genetic aspects of improved quality, a nursery's ability to raise prices can be limited. However, large seedlings with average ground-line diameters of 6.5 mm (that is, improved morphological quality) can be sold for higher prices because they promise the landowner a morphological advantage. Thus, assume that nursery "I" sells high-grade seedlings for \$74/1,000, and standard-grade seedlings (like those of nurseries "A" and "E") for \$50/1,000. Certainly nursery "I" is given a tremendous incentive in charging \$24/1,000 on top of \$50/1000, which translates into an extra \$240,000 for 10 million seedlings. How does this benefit the landowner?

The Landowner's Reward

Large seedlings hold a morphological advantage; but how great is that advantage and are landowners willing to pay more for it? Figure 3 illustrates how that after 1 year in the field with a site index of 80 ft and a base age of 50 years, stems with an average height of 45 cm would have diameters ranging from 7 to 10 mm. I used a diameter-to-height ratio where diameter = height * 0.2 $\pm$ 0.03. This suggests that landowners establishing plantations with such seedlings are reducing rotation length to harvest by 1 year provided no lags in seedling growth are caused by planting shock. When planted properly, survival and growth of larger stems should increase (South 1993). A 2-year gain at establishment would require either accelerated growth or planting stems with an average height of 28 in and diameters ranging from 11 to 16 mm. This is probably unlikely. Nevertheless, reducing rotation lengths enables landowners to receive a financial return on their investment sooner (Clutter and others 1983).

Because the interest rate is quite unpredictable, it is essential for plantation costs to be held to a minimum. My example in Table 3 shows how reducing a pulpwood rotation length by 1 year (from 11 to 10 years) offers the landowner a discount of \$18/ac and \$52/ac at 4 and 8% interest, respectively. The 4% increase in interest offers the landowner even more incentive (\$34/ac) to reduce rotation length and to minimize initial costs of establishment. Now suppose the landowner typically makes a \$300/ac investment, which includes site preparation (\$175/ac), seedlings (\$50/ac), and planting (\$75/ac). An owner spending \$24/ac more for advanced seedlings from nursery "I" can harvest 1 year sooner; there is no change in future costs.
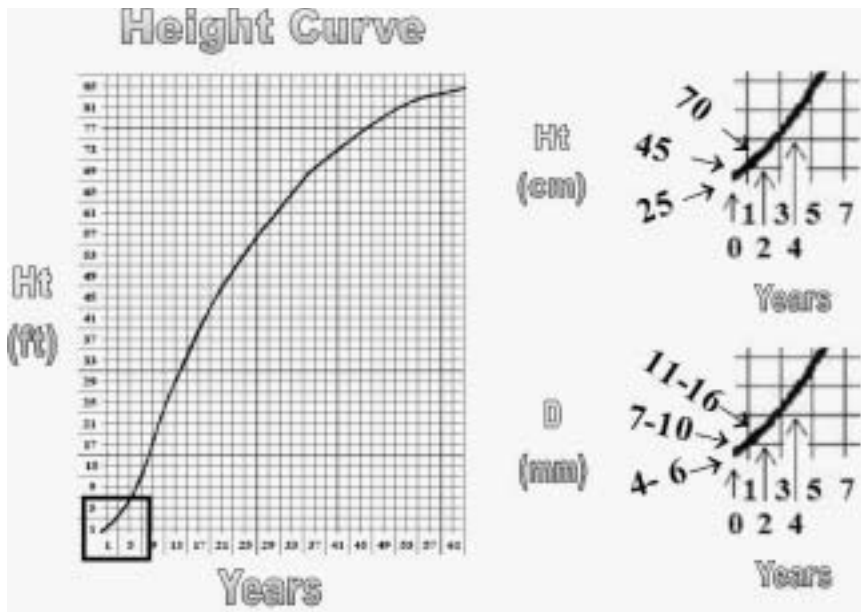
Figure 3—The first 7 years taken from a height curve, 80 ft in height and a base age of 50 years, whereby corresponding diameters measurements were determined using a diameter-to-height ratio of diameter = height * 0.2 $\pm$ 0.03.

Finding Middle Ground

The nursery/landowner relationship must be based on mutual benefit for the long-term benefit of both entities. Suppose nursery "U," by utilizing an innovative practice like symmetrical sowing, finds the ability to increase seedbed densities to produce seedlings of both grades (common and advanced). With decreased costs of production, nursery "U" realizes its ability to lower prices to absurd levels of $33/1,000 for common grades and $44/1,000 for advanced grades, and still make a profit. However, in order to maintain market stability (Tomek and Robinson 1990), nursery "U" decides to maintain price levels of advanced stems at $60/1,000 (Table 3), which is just $10/1,000 above and $14/1000

Table 3—Future cost implications (in U.S. dollars [$]) as affected by factors of initial establishment costs, interest rate, and the number of years carried. The first scenario shows the savings at 4% ($18) and 8% ($52) when harvest is realized 1 year sooner (from 11 to 10 years), due to the planting of larger seedling sizes (at least 7 mm diameter). The next scenario illustrates how much money can be saved ($34) when interest rate changes from 4 to 8%. The final scenario shows the effect of increasing the initial establishment cost by $24 (harvest 1 year sooner) instead of by only $10 (harvest 1 year sooner, and save in $30 in future costs) for larger seedling sizes.

Cost/ac ($)	Rate (%)	Yr A	Yr B	Yr A ($)	Yr B ($)	Save ($)
300	4	11	10	462	444	18
300	8	11	10	700	648	52
324	8	10		700		34
24		1		0		
310	8	10		670		
10		1		30		

below respective common grades ($50/1000) and advanced grades ($74/1,000). Therefore, the landowner spends only $10/ac instead of $24/ac more for advanced seedlings from nursery "U", enjoys a return on the investment 1 year sooner, and also realizes a future cost savings (at 8%) of $30/ac. Hence, nursery "U" becomes profitable through innovation, and shares the benefit with the landowner.

Seedling Size in Present Study

While production costs represent the investment, seedling survival and size (that is, yield) represent the payoff. The yield results (Table 4) from this study also varied distinctly with seedbed density, and symmetrical sowing served to maintain various aspects of yield at higher densities. Perhaps the most important aspect is emergence and survival (seedling presence). Final seedling presence did not vary significantly with density or sowing configuration, except for the standard (25/ft^2) where 86% was the lowest value. This seems to be an aberration, however.

Diameters differed significantly among densities (Table 4), except between those of the 2 highest densities. As expected, the largest diameters were found at the lowest density, regardless of configuration, and more than 1 mm separated diameters from the lowest density to the highest density. Diameter range illustrates how uniformity increases when seedlings are crowded, and the lowest ratio illustrates this with the highest densities. The drawback to increased uniformity is seedling suppression. Hence, without additional growth enhancements at high densities (for example, extended growing time, increased fertilization, and so on) there will be too many culls. This is illustrated with over 70% culled when the criteria is set at a 4-mm diameter limit. Had sowing been performed 1 month earlier (April rather than May) or fertilization increased, cull percentages might have been closer to those shown under the 3-mm diameter limit.

Table 4—Yield items reported include survival, diameter, range, seedling culls below 4 mm diameter (Cull$_4$) and below 3 mm diameter (Cull$_3$), and height with respect to density and between-row spacing (Drum).

Yield items	Density														
	16/ft^2			25/ft^2			36/ft^2			49/ft^2			64/ft^2		
Drum Y	2"	3"	6"	2"	3"	6"	2"	3"	6"	2"	3"	6"	2"	3"	6"
Survival (%)	94	92	92	84	85	88	90	94	84	94	90	84	94	91	94
Diameter (mm)	5.3	5.5	5.2	4.7	5.1	4.8	4.6	4.5	4.6	4.1	4.3	4.2	4.0	4.0	3.9
Range (mm)	2.2	1.9	2.7	1.6	2.1	2.0	1.8	1.8	2.1	1.7	1.8	2.2	1.8	1.7	1.4
Cull$_4$ (%)	5	6	9	19	10	11	22	31	33	54	43	53	67	72	73
Cull$_3$ (%)	0	1	2	4	3	3	4	8	13	13	6	16	17	22	21
Height (cm)	23	24	23	25	23	24	27	27	26	28	27	25	28	29	27

Conversion note: 16 seedlings/ft^2 = 178 seedlings/m^2; 25 seedlings/ft^2 = 278 seedlings/m^2; 36 seedlings/ft^2 = 400 seedlings/m^2; 49 seedlings/ft^2 = 544 seedlings/m^2; 64 seedlings/ft^2 = 711 seedlings/m^2.

High-density, symmetrically sown seedlings were significantly taller than low-density seedlings, regardless of configuration. Had top pruning been permitted, height would not have been a factor, and the interesting phenomenon caused by crowding would not have been demonstrated so thoroughly. Since top pruning is not performed in all southern pine nurseries, it is evident that some landowners and managers favor taller stems and are willing to forgo the benefits of top pruning (for example, to forgo increased root growth and the preferable root-to-shoot ratio).

Stem Form

Although not quantified statistically, differing sizes from respective densities and configurations can be depicted according to stem form. The highest densities configured with a between-row spacing of 6 inches seemed to favor lateral branching over height growth, perhaps due to the effect of more edge. The greatest benefit to crowding (Figure 4A) is expected to suppress lateral branches on 4 sides, because sowing in symmetry is designed to reduce the edge effect. In horticulture, 2 factors are required to form a bush. First, ensure that sunlight can reach the lower portions of the trunk (for example, create edge by lowering density). Second, eliminate apical dominance by repeated top trimming (Davidson and others 1994). Consequently, the impact of some current nursery practices, and their favored stem form, may maintain that form in the field for years to come, but this is my hypothetical assertion.

End Product

It is open to debate whether there are long-term consequences from specific seedling cultural practices, but short-term effects appear to be quite evident on early plantations where bushes seem to be ubiquitous (Figure 4B). How much of what we see in the field (at any stage) can be attributed to nursery training? In my opinion, when bushes are planted at relatively low plantation densities, low-lying branches tend to receive more sunlight and can remain free-to-grow with vigor; hence, they have the propensity to linger longer on the tree trunk. However, I hypothesize that when poles, having weaker lateral branches, are planted in similarly low plantation densities, the lower limbs are prone to abscise sooner

(as depicted in Figure 4B); hence, allowing vital nutrients to be allocated to basal and apical growth. Long term, it would be a more "passive" form of forest management to permit stems with excessive, low-lying branches to remain unchanged on the plantation. Not correcting this condition may actually be more expensive than manually removing unnecessary branches (creating poles) and helping increase mainstem growth, better utilizing growing space, and improving log quality (Figure 5). Again, I mention several hypotheses that need to be statistically substantiated.

Research to Come

Besides a thorough investigation of my speculation concerning the occurrence of lateral branches in plantations due to nursery practices, prospective research should also examine various plantation densities in order to find maximum stand and single-stem yield, while lowering the costs of establishment. Accelerated diameter and height growth was demonstrated for high plantation densities (1,180 trees/ac) over that of lower density plantations (120 trees/ac) of Douglas-fir trees through the fifth year after planting (Woodruff and others 2002). This indicates that there is a window of time to work within before stand closure, whether for nursery or plantation. However, upon determining the point in time when crowding begins to suppress diameter growth, a release or harvest is warranted. Typically on plantations, the only release option exercised is to thin the stand by removing trees. However, lateral branch pruning is a release that could extend a few more years to high-density plantations. More than 50 years have passed since Harold Young and Paul Kramer (1952) demonstrated that the elimination of lateral branches accelerates height growth and decreases stem taper. These principles have yet to be adequately demonstrated in the field, where the greatest benefit in pole production is anticipated by design to increase revenue potential.

Recommendations _____

In my opinion, symmetrically sowing with 2- and 3-inch sowing drums seems to advocate production of pole-shaped stems, because low-lying lateral branches appear to be more effectively impeded, but configuration's impact on stem form
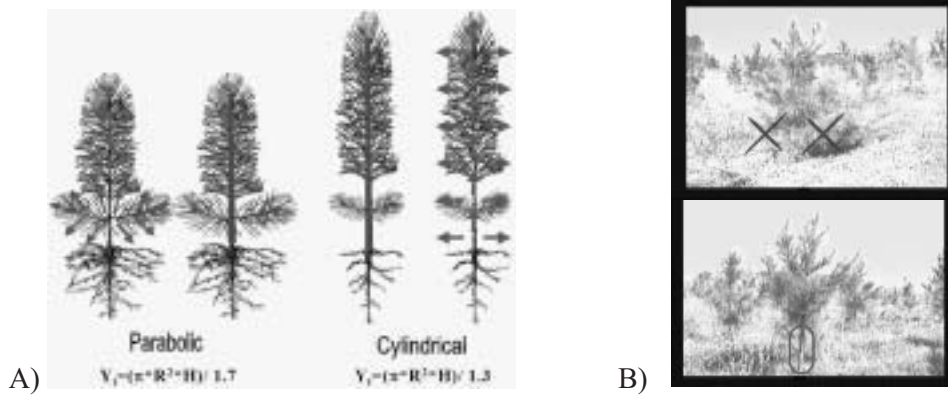
A)

B)

Figure 4—A) The parabolic stem form is shown with its allocation to increase lateral branching and stem taper and shorter spaces between branches versus decreased lateral branching and stem taper with greater spaces between branches. B) Indicates what early plantation tree form will look like when cultural practices in the nursery create bushes and retain low-lying branches (top) as opposed to the early abscission of lower branches with pole-shaped seedlings (bottom).

is presently observational. It was statistically shown, however, that desired diameters from 4 to 5 mm can be obtained with the 2-in sowing drum sown symmetrically at densities approaching 36/ft^2, and this could save tens of thousands of dollars when producing a few million stems. When diameters around 7 mm are desired, one can sow symmetrically with the 3-in sowing drum at densities approaching 25/ft^2 with minimal additional costs, but the asking price should be increased. However, what is the motive, the financial reward, for a nursery to employ innovative improvements

like symmetrical sowing? Other innovations have yet to be fully tested (for example, increased clay content in sandy soils) that may also lower costs and increase stem and stand yield. Unfortunately, these trials may not be fully advanced unless seedling prices can better reflect the important aspects of stem quality ($/unit volume or $/unit weight), rather than basing them only on stem quantity.

Acknowledgments _____

References _____

Clutter JL, Fortson JC, Pienaar LV, Brister GH, Bailey RL. 1983. Timber management: a quantitative approach. New York (NY): John Wiley and Sons. 333 p.

Davidson H, Mecklenburg R, Peterson C. 1994. Nursery management: administration and culture. 3rd ed. Englewood Cliffs (NJ): Prentice-Hall, Inc. 486 p.

Hodges SD, D'Ambrosio CA. 1996. Principles of corporate finance: study guide to accompany Brealey and Myers. 5th ed. McGraw Hill, Inc. 383 p.

Howell KD. 2001. Optimizing nursery technologies involved in the production of pine and oak planting stock [PhD dissertation]. Clemson (SC): Clemson University. 142 p.

May JT, Belcher EW, Jr, Cordell CE, Filer TH, Jr, South CB, Lantz CW. 1984. Southern pine nursery handbook. Atlanta (GA): USDA Forest Service, Southern Region.

SAS Institute Inc. 1989. SAS/STAT user's guide. Version 6. Volume 1. 4th ed. Cary (NC): SAS Institute. 943 p.

South DB. 1993. Rationale for growing southern pine seedlings at low seedbed densities. New Forests 7:63-92.

Tomek WG, Robinson KL. 1990. Agricultural product prices. 3rd ed. Ithaca (NY): Cornell University Press. 360 p.

Woodruff DR, Bond BJ, Ritchie GA, Scott W. 2002. Effects of stand density on the growth of young Douglas-fir trees. Canadian Journal of Forest Research 32:420-427.

Young HE, Kramer PJ. 1952. The effect of pruning on the height and diameter growth of loblolly pine. Journal of Forestry 50: 474-479.

A)   B)

Figure 5—Bush versus pole at a late-stage plantation age. A) The bush-like stem form is raised on "passive" plantations, where nothing is done to eliminate low-lying lateral branches, and diameter at breast height is the only measurement required. B) The pole-like stem form is raised on a hypothetical high-density plantation, where "active" procedures remove lateral branches, and diameters at various log lengths are desired.

Needs and Benefits of Nursery Accreditation

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Introduction

It appears, from observations reported by both private and public nurseries, that there are nurseries that do not have adequate quality assurance procedures. Species are being mislabeled and incorrect seed sources are being sold. It appears that some nurseries have entered the market ill prepared to provide quality seedlings. On the other hand, why should anyone listen to an established nursery instead of a new nursery that is selling a less expensive seedling? Nursery accreditation would be one way for a reputable nursery trying to follow correct practices to distinguish themselves from those that do not. Accreditation may also assist in supporting claims a nursery wishes to make concerning its products. For example, a nursery may produce seedlings with a particular strain of mycorrhizal fungus. Accreditation is one method that can be used to certify that the mycorrhizal seedlings do, in fact, possess mycorrhizae. Another nursery may wish to certify that their products are developed and grown for use within a particular state or region while another may wish to certify for superior timber production.

Benefits to Nurseries

The first benefit of accreditation would be to raise overall industry quality. While established nursery programs are not having the problems mentioned earlier in regards to seed source, new players entering the market have been found to have problems. Therefore, there is a need to have a standard. A standard would help support established programs to continue good practices (keeping them in business) and serve to educate newly organized nursery businesses.

Secondly, there are immediate benefits to a nursery that accredits its program. Accreditation would encourage tighter management. If we know someone is going to look at what we do, we will do a more thorough job. This is simply human nature. Accreditation should also help achieve recognition within our own organizations that we have a quality program. This, in turn, can reasonably justify training for personnel as well as having good facilities. Accreditation can help focus on priorities; what gets counted gets done. Finally, the records required by an accreditation process will prepare a nursery to answer challenges to its work. Every nursery manager has to face customer complaints from time to time. A completely documented program from seed source identity to sowing through pack and ship will put the manager in position to answer objectively any questions raised from outside the nursery concerning seedling quality.

Aspects and Components of an Accreditation Program

The accreditation program would be strictly voluntary and open to any nursery or seed plant wishing to participate. No one would be prevented from selling seedlings from an unaccredited nursery or seeds from an unaccredited seed plant.

A participating nursery would need to prepare a standard operating procedures manual and a quality assurance manual. These can seem overwhelming at first look, but are simply a matter of saying what you will do, doing what you say, and proving you did it. These are more than bureaucratic exercises. They are excellent ways to maintain control of the nursery or seed plant and to instill pride in quality work among employees.

A participant would need to declare a scope of accreditation. Scope refers the area of expertise for the nursery. Perhaps the nursery would seek accreditation in growing bareroot longleaf pine seedlings, while another, mycorrhizal Virginia pine.

Accreditation Body _____

The accreditation body is the organization that reviews the manuals and conducts the audits and, finally, issues the accreditation. One possible accrediting body that could work for forest and conservation nurseries and seed plants is the Livestock and Seed (LS) Program, Audit, Review, and Compliance (ARC) Branch, Quality System Verification Program (QSVP), which uses ISO Guide 65 as a standard. This program provides voluntary conformity assessment and accreditation services to approved service providers to facilitate the marketing and distribution of agricultural products. The ARC Branch is an independent third party, and strives to provide services in accordance with accepted industry practices and internationally recognized guidelines. All services are provided on a cost-recovery basis with fees as nearly equal as possible to the actual cost of providing the service. The standards used are developed by the industry or sector of the industry. The USDA would not set the standards; the role of USDA is to meet the industry needs in a way that assists it to have credibility with the public.

Basic Steps to Accreditation _____

Application materials are prepared and submitted to the Agricultural Marketing Services (AMS) for review. After the AMS reviews and accepts the materials, an onsite audit is conducted. Upon passing the audit, the nursery's accreditation status is posted on the AMS, LS Program's Internet Web site. Official USDA shields, stamps, logos, or other marks may then be used on certified products, correspondence, advertising, and promotional material to signify that the nursery has been accredited for the claims it makes for its products. The accreditation is a means of marketing a good product, not a government inspection program.

References of AMS Accreditation Programs _____

ISO Guide 65—Requirements for bodies operating product certification systems.
ISO 19011:2002—Guidelines for quality and/or environmental management systems auditing.
ARC Instruction 1001—Process Verified Program.
USDA Agricultural Marketing Service. 2004. USA Accredited Seed Laboratory Program. http://www.ams.usda.gov/lsg/arc/asl.htm (accessed July 8 2004).