Southern Regional Extension Forestry
A Regional Peer Reviewed Technology Bulletin
SREF-FM-001
January, 2006

Measuring Survival and Planting Quality in New Pine Plantations

Dr. Andrew J. Londo, Associate Professor, Department of Forestry, Mississippi State University
Dr. Stephen G. Dicke, Extension Professor, Department of Forestry, Mississippi State University.

Introduction

Thousands of acres of new pine plantations are established across the southern United States each year. Unfortunately, some of these plantations are considered failures for timber production once survival drops below 300 trees per acre. A question often asked is, "How do I determine the number of good seedlings per acre?" The goal of this publication is to provide landowners with an easy-to-use sampling technique to evaluate a new pine plantation. Landowners with a potential failure are encouraged to contact a forester for help.

Plantation evaluations are useful when vendors plant seedlings. Contracts with vendors specify the number of trees per acre to be planted. In addition, most contracts list what constitutes an improper planting method, including U, J, and L rooting of seedlings, loose seedlings, and excessive root pruning. Ideally, landowners or their agents (consulting or county forester) should check the number of planted trees per acre and planting quality while the planters are still on the site. Errors can then be spotted quickly and corrected. A quick evaluation also lets vendors know they have a satisfied landowner.

Plantation evaluations in early summer can detect early survival problems. Seedlings with little competition are called free-to-grow and need little additional help. But, seedlings under thick competition are under stress and are more likely to die. Once potential loss is estimated, a decision can be made concerning what additional steps need to be taken.

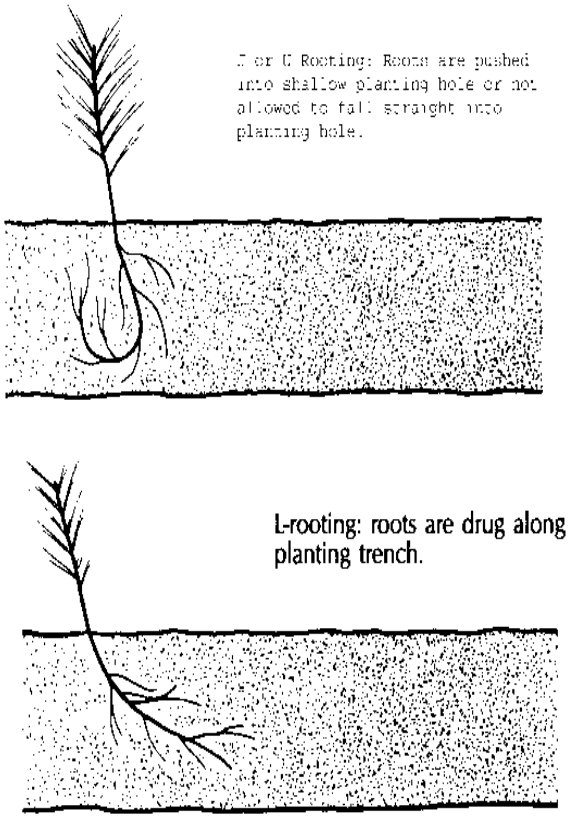
Improper planting techniques

Landowners need to be aware of several causes of seedling mortality. In many cases, the reason for seedling mortality is due to misplanting. Bareroot seedlings have about a 6-8 inch taproot, and subsequently, need a 6-8 inch deep planting hole. Failure to open a planting hole of sufficient depth results in roots being bent and forced close to the soil surface. Because of this, shallow planted seedlings have a decreased chance of survival. Machine planting too fast can result in the roots sticking out flat behind the seedling, which also results in shallow rooting. Following are a couple of examples of how planting seedlings too shallow, or too fast can result in seedling mortality:

1. J and U Rooting: "J" and "U" rooting of seedlings occur when the seedling is planted in a hole too shallow for the roots. The roots are forced to the side or upward, creating a "J" or "U" shaped root. The roots do not grow properly and will result in seedling mortality. (Fig 1.)

2. L Rooting: Machine planting often reduces the occurrence of U and J rooting, however L rooting can then occur. L rooting is the result of the planter moving too fast, with the seedlings not being planted deep enough. The roots stick out like an "L" behind the seedling (Fig. 1). Machine planting can also fail if the packing wheels do not work properly.

Figure 1: Examples of J, U, and L-rooted seedlings (Adapted from Ezell, Moorhead and Londo
2001)



Seedling roots need firm contact with the soil to live. Gently pull on a few leaves; if the seedling lifts out of the ground before the leaves break, the seedling is too loose. Unless you want to walk the plantation repacking every seedling, notify the vendor immediately.

Excessive root pruning can cause seedling mortality. Current nursery practices produce seedlings with a 6-8 inch taproot and good lateral root development. Root pruning has already occurred at the nursery, so do not allow your vendor to prune seedlings. Check seedlings for a short, freshly cut taproot to determine if additional root pruning has been done in the field.

If seedling roots are longer than the blade of the planting tool, then change to a deeper planting tool. For example, you might request a vendor that normally uses hoedads (a pickaxe with a long flat blade) to switch to planting bars and get seedling roots deeper. In return, you willingly pay the vendor a little more per acre.

Loblolly, slash, and shortleaf pine seedlings prefer to be planted deep. Ideally the root collar should be buried 1-2 inches deeper (up to 3 inches) in the field than in the nursery. In wet soils, bury the root collar less than 1 inch. Exposed root collars are not acceptable.

Longleaf pine seedlings require extra attention to depth. A frequent cause of seedling mortality is soil covering over the bud and base of the needles. Bare root seedlings should be planted at the exact same depth in the field as they were in the nursery. Container-grown seedlings should be planted with ¼ to ½ inch of the container plug exposed above ground.

Plantation Measurements

100th Acre Circular Plots

A simple method to determine trees per acre is to measure 100th acre plots throughout the plantation. A 100th acre plot has a radius of 11 feet, 9.3 inches (or 11.775 feet). A center stake and a piece of string, twine, or bamboo pole cut to this length can be used to determine a plot. All seedlings within the plot are counted. For each plot, record the number of seedlings that are free to grow, alive but growing under weeds, and those that are dead in Appendix 1. If seedlings are dead, it is important to dig them up to determine why they died. Also carefully dig out the seedling closest to the center and evaluate it for improper planting techniques (see above). Check the plot as a failure if seedlings were improperly planted and note what problem was identified.

An adequate sample is about one plot per acre, with usually no more than 30 plots evenly distributed throughout the plantation. Record each plot separately on the tally sheet (Appendix 1). Count the number of living seedlings with little weed competition (called free-to-grow), living seedlings under heavy weed competition, and dead seedlings. If the plantation has just been planted assume all seedlings are free to

grow (Note: plantings in grass pasture should not be considered free-to-grow unless scalping or adequate chemical site prep was done). From these data, calculate free-to-grow, living and total seedlings per acre. Percent survival and percent of plots failing planting quality can also be determined. Formulas are listed in Appendix 1.

10-Tree Row Plots

By early summer, seedlings can become hard to find. In dense vegetation, a preferred sampling method is measuring 10-tree row plots. One row plot requires finding a row and evaluating 10 seedlings (or planting spaces) along that row. The field data would be recorded the same as circular plots, using Appendix 1. Likewise, measure one 10-tree row plot per acre, with up to 30 plots, to get an adequate sample.

Measure also the average spacing between trees within rows (t) and average spacing between rows (r). This additional information on average tree spacing determines the critical Per Acre Conversion Factor or "PACF" (number used to convert plot data to a per acre basis). Find the appropriate PACF using your plantation's tree (t) and row (r) spacing in Table 1. Or calculate:
PACF row plot = 43560 / (10 * t * r); where tree within row and row spacing are in feet.

Table 1. Common plantation spacings (feet) with corresponding seedling density (trees per acre) and the Per Acre Conversion Factor for a 10-tree Row Plot.

Space between trees within rows	Spacing of rows	Trees per acre	Per Acre Conversion Factor for 10-tree plot
6	12	605	60.50
7	9	691	69.14
7	10	622	62.23
7	11	566	56.57
7	12	519	51.86
8	8	681	68.06
8	9	605	60.50
8	10	545	54.45
8	11	495	49.50
8	12	454	45.38
9	9	538	53.78
9	10	484	48.40
9	11	440	44.00
9	12	403	40.33
10	10	436	43.56
10	11	396	39.60
10	12	363	36.30

Use the formulas below to calculate free-to-grow, living and total seedlings per acre and percent survival. These formulas are identical to the ones in Appendix 1 except the "100" (PACF for a 100th acre plot) is replaced with the row plot "PACF".

10-Tree Row Plot Calculations

In the calculations below, the letters "A", "B", "C" and "D" are column totals as depicted in the table outlined in Appendix 1.

Total Seedlings per acre = ((A + B + C) / number of plots measured) * PACF = ____ Total Seedlings/acre

Live seedlings per acre = ((A + B) / number of plots measured) * PACF = ____ Live Seedlings/acre

Free-To-Grow Seedlings per acre = (A / number of plots measured) * PACF = ____ Free-To-Grow/acre

Percent Survival = ((A + B) / (10 * number of plots measured) * 100 = ____ % Survival

Percent of Plots Failing Quality Test = (D / number of plots measured) * 100 = ____ % Plots Failing Test

Evaluating the Data

Trees per acre: Ideal plantation density is a personal decision based on your management objectives as well any requirements associated with a cost share program. But for most plantations, density should average 400 to 700 live seedlings per acre (Table 1). If seedling count is low, you need to re-evaluate the site and decide whether to re-establish the plantation. No

1/100th acre plot should have less than three live seedlings (300 seedlings per acre).

Too many seedlings can also be a problem, especially along plantation edges near mature pines. Seedling counts over 1000 per acre indicate a need for a pre-commercial thin.

New plantings: Immediately replant if planting quality fails. Once a planting job passes inspection, the vendor should be paid.

First growing season: By late spring, the number of live free-to-grow seedlings should be well over 300 per acre. If weed competition is severe, herbicide release applications are warranted. If the number of free-to-grow seedlings drops below 300 per acre, landowners have three viable options:

1. Do nothing. Look forward to having a mixed pine-hardwood stand (monetary returns will most likely be diminished).

2. Rehabilitate the plantation
   a. Apply release herbicide over the seedlings. A viable option only if release herbicide can control weeds. (Note that many herbicide rates sufficient to control woody competition may injure slash & longleaf seedlings in the 1st growing season. Always follow current herbicide label instructions.)
   b. Reinforcement planting to increase seedling number. Unfortunately, reinforcement plantings have only been successful for longleaf pine, when container-grown seedlings were planted in the fall.
3. Start over. Apply herbicides at site preparation rates and replant. This is a viable option when weeds are too difficult to control.

Conclusions

Thousands of acres of pine plantations are established throughout the U.S. South each year. Some of these plantations will fail due to poor planting practices. To avoid a failure on your property, begin with a reforestation contract that includes a clause concerning improper planting techniques. Follow up with an evaluation of the planting. The sampling procedure described here will allow you to determine the quality of your planting job and condition of your new plantation. This determination should be made early so that corrective measures can be taken. If you suspect that you have a plantation failure, contact your local forester or tree-planting vendor.

Literature Cited

Ezell, A.W., D.J. Moorhead, and A. J. Londo. 2001. Planting southern pines: A guide to species selection and planting techniques. Mississippi State University Extension Service, Publication 1776. 15p.

Acknowledgements

The authors thank Drs. Andy Ezell and John Hodges of the Department of Forestry at Mississippi State University, Dr. George Kessler of the Department of Forest Resources at Clemson University, and Drs. David Moorhead and David Dickens from the Warnell School of Forest Resources at the University of Georgia for providing improvements to this manuscript.

This publication is part of a regional peer reviewed Extension Service publication series. Editor, William G. Hubbard, Southern Regional Extension Forester, 4-402 Forest Resources Building, The University of Georgia, Athens, GA 30602. Please visit www.sref.info for more information.

Appendix 1. Pine plantation evaluation form. Measure one plot per acre up to 30 plots.

Determine stocking – Count number of trees in plot (100^{th} Acre Plot = 11ft. 9.3in. radius)				Planting Quality: Evaluate seedling near plot center (living or dead)	
Plot	Number of Live Seedlings Free-To-Grow	Number of Live Seedlings Under Weeds	Number of Dead Seedlings	√ if Planting Quality Fails	Reason: J, U or L root, Not packed, too shallow, root pruned, Too deep-Longleaf
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
Total	**A=**	**B=**	**C=**	**D= # Plots √ Failing =**	

Calculations for 100^{th} acre circular plots (see text if using 10-tree row plots):

Total Seedlings per acre = ((A + B + C) / number of plots measured) * 100 = ____ Total Seedlings/acre
Live seedlings per acre = ((A + B) / number of plots measured) * 100 = ____ Live Seedlings/acre
Free-To-Grow Seedlings per acre = (A / number of plots measured) * 100 = ____ Free-To-Grow/acre
Percent Survival = ((A + B) / (A + B + C)) * 100 = ____ % Survival
Percent of Plots Failing Quality Test = (D / number of plots measured) * 100 = ____ % Plots Failing Test