

Learning Objective: Following this lab students will recommend appropriate site preparation treatments and planting protocols for pine plantations on typical sites in the South.

Introduction

Site preparation describes any treatment intended to 1) improve access, 2) increase early growth and survival, 3) reduce competition, or 4) ameliorate degraded sites. Most commonly site preparation treatments occur prior to planting in the establishment phase of a silvicultural system. Site preparation treatments are among the most expensive operations conducted during a typical rotation, and the costs are carried for the full length of the rotation. Thus, site prep activities should be minimized wherever possible to reduce costs. This is also why site prep treatments are much more common in artificially regenerated plantation silvicultural systems than in systems that rely on natural regeneration.

Methods to reduce mechanical site prep costs include:

1. Increase harvest utilization if possible (less slash)
2. Wider between-row spacing (fewer passes with equipment is cheaper)
3. Subsoil at shallower depths (saves fuel)
4. Use forest herbicides and fertilizer as less expensive alternative means to manipulate light, nutrient, and water availability

Effects of soil tillage on productivity vary unpredictably on different soils and often result in significantly smaller growth responses compared to chemical site prep or fertilizer application (Carlson et al. 2006). While it was previously believed that tillage resulted in improved growth, much of this effect has since been attributed to tillage's role in reducing hardwood competition, an outcome which can be accomplished more effectively with forest herbicides (Fox et al. 2007). However, there remain some situations in which mechanical site preparation is desirable to improve aeration, lower bulk density, or alter soil structure or other physical properties. The following general guidelines are supported by research conducted across the South on mechanical site prep in pine plantations (modified from Duryea and Dougherty 1991, Fox et al. 2007):

1. Bed:
 - a. Somewhat poorly to poorly drained soils
 - b. Larger beds may be required on finer textured soils (i.e. clays)
2. Subsoil or combination plow:
 - a. Clay to clay loam textured soils with poor structure
 - b. Soils being converted from agricultural production that have plow pans
 - c. Severely rutted or compacted soils requiring amelioration
3. Minimal to no soil preparation:
 - a. Clay to clay loam textured soils with good structure
 - b. Loamy to sandy textured soils
 - c. Soils that have already been in plantation for one or more rotations
 - d. Steep, highly erodible, or nutrient-poor soils that are prone to being degraded

Correct selection, handling, and planting of seedlings are critical to ensure adequate survival and cost-effective regeneration of a site. The following practical guidelines for southern pine plantations have been modified from Duryea and Dougherty (1991).

Table 1. Weather and soil condition guidelines for planting southern pine seedlings.

Planting Conditions	Temperature °F	Humidity %	Wind Speed mph	Soil Moisture % field capacity
Normal	33 – 75	> 50	< 10	75 – 100
Marginal	76 – 85	30 – 50	10 – 15	50 – 74
Critical	< 33 or > 85	< 30	> 15	< 50 or > 100

On Normal Days

1. Dip roots in water to keep them wet, but don't let them stand in water
2. Keep seedlings in planting bags; don't let planters carry in hand
3. Separate seedlings carefully but quickly
4. Carry no more than a 2-hour supply of seedlings

On Marginal Days

1. Follow all normal day guidelines stringently
2. Dip shoots and roots in water to keep them wet
3. Seedling exposure to sun and wind should be < 1 minute ideally, < 3 at most
4. Carry no more than a 1-hour supply of seedlings
5. Suspend planting on dry ridges
6. Postpone planting if frost is forecast in the 3-5 days following planting

On Critical Days

1. Postpone planting unless localized exceptions to weather and soil conditions exist
 - a. Containerized seedlings may be an exception
 - b. Can plant if weather is warming from a freeze once temp > 34°F

Planting Guidelines

1. Ensure seedlings are alive, healthy, and meet or exceed characteristics described in Table 2
2. Clear planting spots of litter or debris
3. Planting holes should be perpendicular to soil surface and wide enough so roots don't hit sides
4. Don't use planting tool to position seedlings
5. Place seedlings to maximum depth, then lift back up and shake
 - a. Avoid twisting or twirling motions; avoid balled, J, L, or U rooting
 - b. Plant bare-root loblolly 2-3 inches deeper than root collar on most sites
 - c. But, plant no more than 1 inch deeper than root collar on poorly drained sites
 - d. Never plant seedlings shallower than they were at the nursery, except
 - e. For containerized longleaf, leave the plug exposed ½ inch on a dry site or 2-3 inches on a wet site (Franklin 2008)
6. Close hole tightly to avoid any air pockets around roots; need good contact w/ mineral soil
7. When the hole is closed, no roots should be exposed, and seedling shouldn't move if tugged

Table 2. Optimum characteristics of southern pine seedlings (reproduced from USDA-FS 1996).

Characteristics	Longleaf	Loblolly or Slash	Shortleaf
Stem length (inches)	---	10	8
Root collar diameter (inches)	9/16	7/32	3/16
Tap root length (inches)	6	6	6
Laterals (number)	-----	5+ First order	-----
Winter buds	-----	Present	-----
Nature of stem	---	Stiff, woody, w/ bark	
Mycorrhizae	Present	Abundant	Abundant
Shoot/root ratio (volume)	1:1	2.5 : 1	2.5 : 1

Table 3. Costs of common site prep and establishment treatments in East Texas in 2014.*

	Treatment	Cost per Acre	Notes
Site Prep*	3-1 Plow	\$160	One Pass: Rip, Disk, Bed
	Shear	\$145	D8 V-Blade No Plow
	Shear + Bed	\$250	Two Pass
	Roller Chop	\$150	Only if slash abundant, soil erodible
	Prescribed Burn	\$50	Variable due to fire line length
	Pile Burn	\$25	Good option on erodible soils
Weed Control*	Spring Herbaceous Control	\$25	Aerial application
		\$40	Ground application
	Fall Hardwood Control	\$65	Aerial application
		\$85	Ground application
Planting*	Hand Plant	\$45	
	Machine Plant	\$80	Can sometimes also shear in one pass

*Costs are based on economies of scale realized by large landowners. Costs are often higher when managing smaller tracts.

Table 4. Seedling costs from two major vendors from 2022 (Arborgen) or 2014 (IFCO) for orders under 100,000 seedlings. Cost notation is: bare-root (containerized).

Species	Arborgen	Cost (\$/1000)	IFCO	Cost (\$/1000)
Loblolly	OP Advanced	66 (174)	OP Simple Start	N/A (120)
	OP Select	76 (187)	OP Essential	N/A (160)
	OP Elite	86 (195)		
	MCP Advanced	174 (278)	CMP Plus	N/A (230)
	MCP Select	190 (298)		
	Varietal	N/A (498)		
Slash	OP Advanced	66 (N/A)	OP Simple Start	N/A (125)
	OP Select	76 (N/A)	OP Essential	N/A (135)
	OP Elite	86 (195)	OP Plus	N/A (145)
Longleaf	OP Unimproved	N/A (210)	OP Essential	N/A (190)
	OP Improved	N/A (225)	OP Plus	N/A (215)
Shortleaf	OP Improved	60 (N/A)	OP Essential	N/A (145)

OP = open-pollinated, MCP = mass-control-pollinated, CMP = control-mass-pollinated

Procedure

Methods

Each group will survey the assigned tract for its regeneration potential, possible limitations, and current conditions. Use the attached forest regeneration plan as a guideline for what you should observe on the site.

Written Assignment:

Assume that you are taking over as the forestry consultant for this tract, and develop a forest regeneration plan following the template included on the following pages. This is a field exercise that will be completed during lab. Essentially, you will be developing a short-term prescription that covers an approximately 3-year period from the harvest of the last stand to the successful establishment of this stand. In your plan, include both activities that have already occurred on the site since the last harvest based on your observations, and activities that will be necessary to adequately regenerate the site.

Be sure to include the number of seedlings you will need to regenerate this site, and the spacing and corresponding stand density at which they will be planted. Use Table 3 and 4 to estimate costs.

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COMPARISON OF HAND VS. MACHINE PLANTING OF PINE SEEDLINGS

by SHAWN HARRISON (Auburn University)

The replanting of forests occurs on a relatively small portion of the nearly 8 million acres harvested annually in the United States. Landowners rely primarily upon natural means of regenerating their forestlands. However, a large portion of these acres would remain unproductive without artificial regeneration. Such lands include mismanaged cutovers, areas decimated by wildfire, and abandoned agricultural fields (Holland et. al., 1990). When you consider the great difficulty of naturally regenerating these stands with desirable species, it is to the landowner's advantage to use artificial methods.

The decision to use artificial regeneration as opposed to natural regeneration or direct seeding may be dependent on many factors. The lack of an adequate seed source for the desired species is the primary reason for many landowner's choice to plant seedlings manually. Secondly, the only method to grow genetically improved seedlings is to plant them. Several other advantages of artificial regeneration include:

- The landowner is assured of having a new seedling crop for the next growing season.
- The landowner can manually determine the stocking levels and row spacing.
- There is no need for precommercial thinning.
- The uniformity of the resulting stand.

However, we must also consider the downside of using artificial regeneration methods. The disadvantages include:

- Without careful and thorough planning, landowners run the risk of not having adequate seedling sources for regenerating their stands.
- Planting is normally the costliest method of regeneration.
- In order to obtain the optimum desired results, planting crews must be constantly supervised in order to maintain quality control.
- Mechanical site preparation can be detrimental to soil quality (McKee, 1987).

Seedlings can be planted by hand or by machine. Depending upon the particular site, the landowner should choose the most efficient and reliable option. Flat, open tracts that cover large acreages are best suited for machine planting, while small and/or irregularly shaped tracts, sites with little site preparation, and rocky sites are better suited for hand planting (Lantz, 1996). The table 1 shows the major restrictions and requirements of hand vs. machine planting.

The costs of planting seedlings are influenced by many variables. The intensity of site preparation, size and shape of the tract, topography, method of planting, and type of seedlings used are but a few (Schultz, 1989). Seedlings in the southeast can vary from \$0.04 to \$0.07 each depending on species and the degree of genetic improvement. Typical second-generation improved loblolly pine seedlings cost approximately \$35 per thousand, while second generation longleaf pine seedlings cost upwards of \$70 per thousand (South Carolina Forestry Commission, 2000).

Table 1. A comparison of hand and machine planting.

Characteristic	Hand	Machine
Topography	No restrictions	10% slope or less
Erosion Potential	None	Significant
Contour Planting Required	No	Yes
Rocky Sites (large rocks)	Can modify spacing	Difficult to maneuver
Logging debris	No restrictions (large amounts on site reduce production)	Must be free of large logs / stumps
Degree of site prep required	No restrictions	Must be free of large logs / stumps
Poorly drained soil	No restrictions	Difficult when wet
Average production	800-2000 / day (1 person)	7,000 to 11,000 /day (2 people)
Probability of high planting quality with large seedlings (e.g. longleaf)	Low	High

From Lantz, 1996

PLANTING PROCEEDURES

Generally, between 75 and 80 percent of properly planted seedlings will survive. Therefore, the greater the care taken in planting seedlings the greater the rate of survivability (Holland et. al., 1990). To be successful, a planting program should consist of the following:

- High quality seed from reliable sources.
- Nursery staff properly trained in the techniques of growing, lifting, pruning, packaging, and storing seedlings.
- Controlled environments during storage and transportation of seedlings.
- Adequate site preparation.
- Proper seasonal and daily scheduling of planting operations.
- Properly trained planting crews and supervisory personnel.
- When necessary, properly constructed seedling shelters.
- Monitoring and protection of the newly established plantation (Wenger, 1984).

“The art of planting is easily learned, but planting is tedious, and so it is frequently done incorrectly” (Schultz, 1997). The poor survivability of a pine crop is a direct result of incorrect planting methods. Survival in pine plantations across the Southeastern US has dramatically fallen over recent years because of “poor seedling care.” Actions that planters, nursery workers, and transporters think to be insignificant are actually “mortally wounding” the seedlings (Lantz, 1996).

Hand Planting

Before the 1940’s, all artificial regeneration of wildlands was completed with hand tools. Some of the various implements include dibbles, planting bars, hoes, shovels, and augers. This type of planting is still a common practice on smaller tracts that are impractical for machine planting and on terrain that would be difficult for the machine planters to traverse. In comparison to machine planting, hand planting provides several advantages to the landowner:

- Less expensive than machine planting.
- Survivability is comparable (and sometimes superior) to machine planting.
- Planting depth can be adjusted for each seedling.
- Hand planters can select superior microsites for planting.

We must also be aware, however of the following disadvantages that are created by hand planting:

- Spacing is not precise and can vary widely across the tract.
- Seedlings can be critically wounded during the handling and planting process.
- The physical demands on the planters are quite large.
- Fewer seedlings are planted per unit of time compared to machine planting.
- Planters must frequently stop to refill their planting bags with new seedlings (Schultz, 1996).

An experienced hand planting crew can plant an average of 1,500 seedlings per person per day. According to A Guide to the Care and Planting of Southern Pine Seedlings (1996), production rates vary from 600 seedlings per person per day on rough terrain to 2,000 seedlings on flat, open ground. It is important to remember though, that the quality of seedlings planted is more important than the quantity of seedlings planted.

Most planters in Alabama use a dibble bar or a hoedad with blades at least a 4 inch wide by 10 inches long (USDA Forest Service, 1989). Larger tools should be used for larger, high-quality seedlings. Shovels are quite well adapted for jobs requiring these larger planting holes. Regardless of the tool used, the procedures for hand planting are relatively similar. Figure A, taken from A Guide to the Care and Planting of Southern Pine Seedlings (1996), shows the correct method of planting with a dibble. Regardless of the tools used, the planting hole should be large enough that the entire root system can be inserted with ease. The seedling should then be inserted slightly deeper (~ 1-3 inches) than the root collar to further ensure the seedling is not placed too shallow. Studies show that the shallow planting of pine seedlings can lead to increased mortality, especially when exposed to low moisture levels after outplanting (Schultz, 1989).

The planting supervisor is the essential ingredient to good production in hand planting operations. Supervision is required to maintain the quantity and quality of work by the planters. One particular planting manual suggests spot-checking each worker five times per day to be sure none of the following occur:

- Tearing roots when removing seedlings from bags.
- Trimming roots or “stripping” roots before planting.
- Failing to keep seedlings moist while in planting bags.
- Carrying seedlings by hand while planting.
- Planting seedlings too shallow.
- Failing to properly close the planting hole.
- Spacing is too close or too far.
- Discarding of seedlings to conceal the planter’s lack of production (Lantz, 1996).

Machine Planting

Since the mid-1940’s, advances in design and engineering have made machine planting a practical alternative in the Southern United States (Wakeley, 1954). Today, a vast majority of loblolly plantations are planted using mechanical methods. Machine planters can place seedlings in continuous slits or intermittent holes in the mineral soil. Seedlings are then set into the holes either mechanically or

pneumatically at a predetermined spacing. For large acreages of sufficiently site prepared land, machine planting is the most effective and efficient method of artificial regeneration (Schultz, 1997). Well-trained planting crews can easily plant 7,000 to 9,000 seedlings per day on an open, flat site. Again, the key to successful regeneration lies in the task of supervision. Planting performance should be routinely checked to ensure the seedlings are planted at the correct spacing, the planters follow along the contour of the slope, and that the seedlings are planted at the appropriate depth and are upright, not leaning (South Carolina Forestry Commission, 2000).

As for the advantages of machine planting, some of these include:

- Less labor intensive than manual methods.
- Machine planting permits the precise spacing of seedlings and planting depths.
- Higher rates of productivity.
- Easier to adjust the planting depth.
- Some studies show a higher survival rate with machine planting vs. hand planting.

Disadvantages of machine planting include:

- Adequate site preparation is required before planting can begin.
- The planter cannot select specific microsites where the seedling may perform better.
- Planting spots may be overlooked.
- Seedlings may be planted incorrectly if the coulter depth and packing wheels are not inspected intermittently.

The procedure involved in machine planting is rather simple. The coulter blade (number 1 in Figure 1) should cut at least 9 inches deep into the soil while the plow point (#2) follows slightly above the coulter furrow. The seedlings are then set into the planting hole or furrow (#3) and the furrow is then closed by the packing wheels (#4).

CONCLUSION

Depending on individual site characteristics, either hand or machine planting can be the most effective and efficient option of pine regeneration. Sites with open, flat terrain are most suited for machine planting, while rocky, uneven terrain is better suited for hand planting of pine seedlings. The amount of site preparation is also key in determining the method of planting used. Machine planting requires moderate to high levels of site prep work to remove large stumps and debris before planting may begin. Hand planters can maneuver around these obstacles and plant the seedlings in the appropriate microsites. Capital outlay is another major factor in choosing the proper method. Costs for machine planting can almost double that of hand planting. However, this expense may be worth the effort since some studies show the survivability of machine planted seedlings to be greater than that of hand planted seedlings. It is the landowner and/or forest manager's job to weigh these options and choose the best alternative for the particular site.

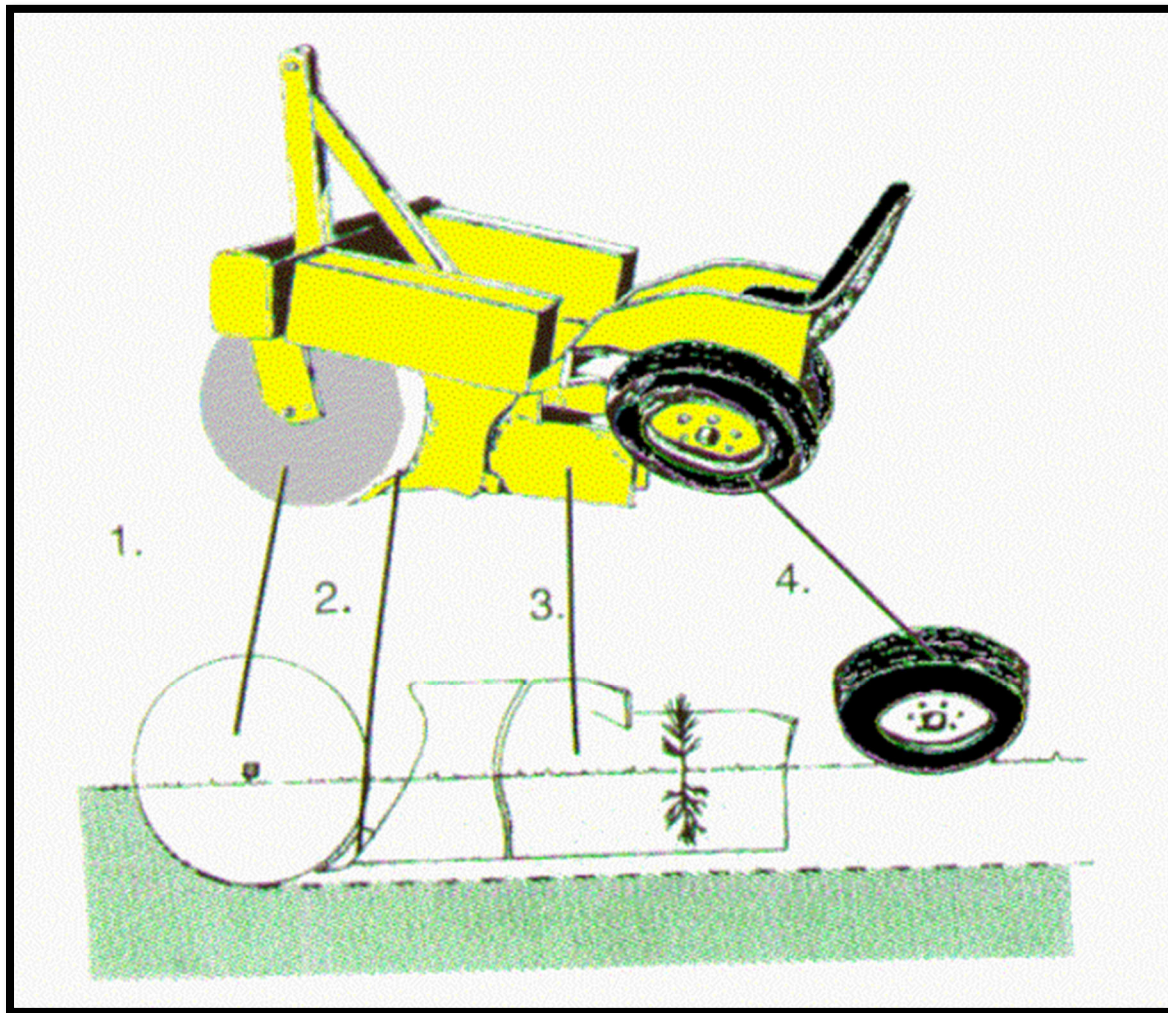


Figure 1. Diagram of a machine planter.

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FOREST REGENERATION PLAN

Modified from (Duryea and Dougherty 1991)

Tract: Tract name here

Location: General description of how to locate tract here

Acreage: XXX acres

1. Goals

List management objectives (timber, wildlife, restoration, etc.)

2. Site Description

Current stand description

Soil description

Wildlife habitat features, if relevant

3. Special Considerations

Potential issues with surrounding landowners, access, etc.

Endangered species concerns

4. Major Limiting Factors

Water, nutrients, competition, slash, insects or disease, etc.

5. Species, Seed Source, Family

Provenance, genetics, etc.

6. Regeneration Method

Machine or hand planting

7. Stock Type and Planting Procedures

Containerized or bare-root

Fungicides, insecticides, clay coatings, etc.

Where will seedlings be obtained from, and when will they be ordered and received

Transportation conditions, storage conditions

Crew description

Planting density and spacing

8. Site Needs

Harvest and site preparation description

9. Seedling –Protection Needs

Competing vegetation, insects, disease, any relevant treatments

10. Regen Survey(s)

Plan to reassess planting operation

11. Costs

Include the per acre cost of each silvicultural treatment

Add these together and multiply by acreage for an estimate of all treatments applied

Determine how many seedlings you will order, and what their cost will be (see lecture notes)

Add treatment total to seedling cost for the total cost per tract

12. Timeline

Includes harvest, mechanical and chemical site prep, planting, and regen survey activities

13. Recordkeeping

Indicate what documents (invoices, receipts, contracts) will be kept

FOREST REGENERATION PLAN

Modified from (Duryea and Dougherty 1991)

Tract (5%):

Location:

Acreage:

Consultant Name:

1. Goals (5%)

2. Site Description (10%)

3. Special Considerations (5%)

4. Major Limiting Factors (5%)

5. Species, Seed Source, Family (5%)

6. Regeneration Method (5%)

7. Stock Type and Planting Procedures (15%)

8. Site Needs (5%)

9. Seedling –Protection Needs (5%)

10. Regen Survey(s) (5%)

11. Costs (10%)

12. Timeline (15%)

13. Recordkeeping (5%)