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Forest Regeneration Methods: Natural Regeneration, Direct Seeding and Planting [1]

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Planning for regeneration begins with the landowner examining the land and then defining the objectives for regeneration and management. Some questions to ask concerning a partial of land include:

- Do trees on the land need to be harvested first or has the land already been harvested?
- Has the land been examined to see if the site has been regenerated naturally?
- Will the present vegetation on the site be detrimental to small trees, by competing for water, sunlight, or nutrients? (If the answer is yes, some control of the vegetation may be desirable.)
- What is the soil like? Is the site: wet? dry? shallow? deep? (This will help in the selection of species as well as determine whether the site will be difficult to regenerate.)

In order to select specific practices for your particular site and answer many of these questions, it is helpful to consult a professional forester, experienced in regeneration.

Setting objectives for a partial of land means making decisions about the present and future management schemes. What are the reasons for wanting a forest on the site? Would planting trees be for: 1) aesthetic reasons, 2) providing future income in 20, 30, or 40 years, 3) restoring marginal or unused cropland, or 4) promoting wildlife? Many more reasons for planting trees exist; many are compatible with each other, such as wanting an income and aesthetics.

Finally, some of the most important questions may be:

- How much will regeneration of this partial of land cost?
- Am I eligible for one of the cost sharing programs such as the Forestry Incentives Program (FIP)? Information on these programs can be obtained from your county extension agent or county forester, the Farm Service Agency (FSA), or the Natural Resources Conservation Servive (NRCS) offices.
- What will my rate of return on the forestry investment be? For ways to assess your forestry investment see IFAS Circular 836, Estimating the

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Profitability of Your Forest Land Enterprise, Hubbard et al 1989.

This circular assumes that the landowner wants to have trees on a partial of land. It then provides three major alternatives for getting the trees on the land: natural regeneration and two kinds of artificial regeneration: direct seeding and planting seedlings. The landowner can then select the method that best fits the specific site, objectives, and economic resources.

Natural Regeneration

Definition

Natural regeneration relies on older pine trees left on the land to provide seed to regenerate the site. This practice can only be employed if the site has not yet been harvested. Plans are then made for harvesting the present forest stand and leaving some trees to provide the seed.

Mostly pine stands grow best where all trees are of the same age and receive the same amount of sunlight. Therefore, once the seedlings are established the large seed trees must be removed. For more information, some excellent articles describe the process of natural regeneration (Williston and Balmer 1974, Boyer 1978, Lohrey and Jones 1983).

Steps

1. **Selecting the seed trees.** Before the site is logged, seed trees must be selected and marked with paint. Selection means choosing the best-looking trees for seed trees -- trees which are the straightest and tallest and have large crowns (lots of green needles) and no disease. The number to leave on the site will vary according to species (Table 1). More seed trees are required for longleaf pine because it is not a prolific seed producer and its large seeds are often eaten by animals (Williston and Balmer 1974). Trees should be well-spaced over the site to allow even distribution of seed.

2. **Planning for a good seed crop.** The frequency of good seed crops varies from year to year and species to species (Table 1). To insure successful natural regeneration, the site should be logged just prior to a good seed crop. You can observe the seed crop by looking through binoculars in the spring or early summer and counting cones to determine the crop for the fall or looking at conelets to predict next year's crop (Figure 1). Conelets resemble small pink or light green cones and are located near the ends of the branches; cones are green and are located further in on the branches. Both conelets and cones are in the top 2/3 of the tree crown.

3. **Logging.** The landowner should supervise the logging operation especially to insure that the seed trees are not damaged by the logging. Damaged trees may die or not produce a good seed crop.

4. **Preparing the site.** The site must be prepared to first incorporate the forest litter (organic matter) and then expose mineral soil -- seeds need soil to germinate and grow. Some site preparation options are to burn, mechanically scarify, and/or spray with herbicides (see Fact Sheet FOR-37, Site Preparation: Alternatives for Plantation Establishment, Jack et al 1984 and Special Series FOR-10, Vegetation Management in Florida's Private Non-industrial Forests, Campbell and Long 1995). The soil needs to be exposed prior to October, when most seeds fall from the trees. Sometimes the logging operation is enough of a disturbance to expose the soil. However, the completeness and intensity of the site preparation may improve seedling establishment especially during periods of poor seed crop or drought (Lohrey and Jones 1983).

5. **Logging the remaining trees.** When an adequate seedling stand is established and about 1-2 years old, the seed trees should be harvested (Boyer 1979). If you wait too long, seed trees may affect the growth of the seedlings and logging may damage the seedlings. For Longleaf pine the seed trees may be left.

6. **Controlling unwanted vegetation.** Shrubs, small trees, and herbaceous vegetation will compete with small seedlings for nutrients, water, and sunlight causing mortality or slower growth. For the first few years, the planting site should be observed to see if this unwanted vegetation is affecting seedling growth and survival and measures should be taken to control the weeds.

Chemical control, hand-cutting, and mowing are three possible methods of control.

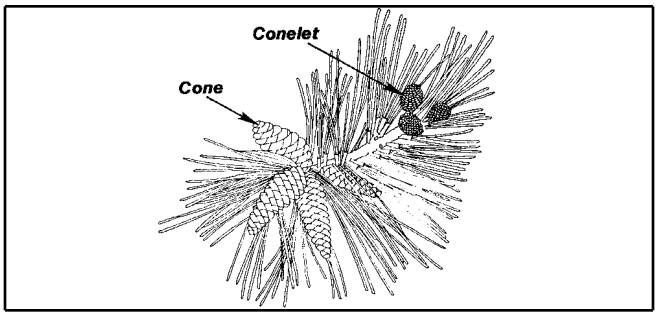

Figure 1.

Advantages

- The initial costs of establishing a forest stand may be lower especially if site preparation is not necessary.
- Less heavy equipment and labor is required.
- The seedling has a naturally shaped root system unlike seedlings which have been grown in a nursery.
- Chance of tip moth damage is reduced (Beaufait and others 1984).
- For aesthetic reasons, the landowner may prefer to see a forest stand which is unevenly and naturally spaced versus a stand which is in rows.

Disadvantages

- A seed crop must be available and seed dispersal must be timed correctly with site preparation so that a suitable seedbed is available for the seed germination.
- Moisture in the soil is necessary for the seeds to germinate; exceptionally dry years or sites may result in poor germination or seedling mortality.
- Insects and other small seed-eating animals may consume all or most of the seed.
- Competing vegetation may be a problem for survival and growth for a longer time period than with planting because seedlings are smaller or seed may not be disseminated in the first year.
- If the seed is abundant and a dense stand results, a pre-commercial thinning may be necessary to decrease the number of trees per acre. For example, if there are more than 2000 slash pine seedlings at age three, growth may be inhibited and the site will require pre-commercial thinning
- 700-1000 trees per acre. This thinning may be accomplished by hand-cutting or plowing up rows of seedlings and leaving the remaining rows about 10-12 feet apart.
- Because the site is planted with seed versus 1-year-old seedlings, the rotation length (time until harvest) may be increased by one or more years.
- The seed coming from the seed trees is not genetically improved as when the seed comes from a seed orchard.
- Natural regeneration may be less expensive initially but more costly in the long run if it is necessary to prepare the site or precommercially thin.
- Open sites without trees such as clearcuts, abandoned fields, and stands after a wildfire or windstorm cannot be naturally regenerated.
- The landowner does not have any control over spacing between trees or stocking levels and so often these can be very uneven.
- A successfully regenerated site may take longer to reach harvest than with direct seeding or planting.

Direct Seeding

Definition

Direct seeding means that the landowner applies seeds directly to the land; these seeds then germinate and a forest stand results. A lot of the principles for site conditions and site preparation are the same as with natural regeneration but, in addition, a known amount of seed is used. Direct seeding is often employed on poor or inaccessible sites or where little initial involvement is possible or desirable. Sites which are droughty or have high erosion potential

should be avoided. Three reviews give detailed information on direct seeding (Lohrey and Jones 1983, Williston and Balmer 1983, Beaufait and others 1984).

Steps

1. **Harvesting and preparing the site.** First, the present stand must be harvested and the site prepared to create a mineral soil seedbed. Again, as in natural regeneration, the options for site preparation are burning, mechanically scarifying, and/or spraying with herbicides (Jack et al. 1984).

2. **Obtaining seed.** Seed with greater than 85% viability and with a minimum of 95% sound seed should be used. After receiving seed, it should be stored immediately in a refrigerator at 34-36°F (Williston and Balmer 1983).

3. **Sowing rates.** The amount of seed required will vary according to species, method of sowing, degree of site preparation, and general ease of regeneration of the site. For instance, in an area where summer showers are frequent and survival is good, 0.6 lb/acre is adequate for slash pine. However, in drier areas I lb/acre for broadcast sowing, 0.75 lb/acre for row seeding on a disked bed, and 0.5 lb/acre for spot seeding may be required for adequate regeneration (Lohrey and Jones 1983). In general for each species there is an average amount of seed which is needed (Table 2).

4. **Treating seed.** Seed is often treated with a repellent for seed-eating insects, birds, and mammals which will otherwise consume the entire seed crop. The most common repellent for birds is Thiram. Endrin, which has been used to repel rodents is no longer available as a repellent. If a substitute cannot be found, predation will be an even bigger problem for direct seeding. Loblolly and sand pine seed also needs to be stratified, a process which subjects water-soaked seed to cold temperatures for 20-60 days according to species and improves its chance of germinating. Stratified and repellent-treated seed can be purchased from most commercial seed companies. The repellent and stratification treatments each increase the weight of seed by about 10% and 25% (Williston and Balmer 1983).

5. **Date of sowing.** Longleaf and sand pine seed should be sown in the fall when soil moisture is high from rains. Longleaf pine appears to naturally regenerate better in the panhandle than the peninsula of Florida, perhaps due to the wetter climate in the fall and winter. Loblolly and slash seed should be sown in the spring when freezing temperatures have past, soil moisture is adequate, and daily temperatures are warm enough for germination (Williston and Balmer 1983). Seeds most often germinate in 2-4 weeks and begin growth before the hot dry summer months.

6. **Methods of Sowing.** There are many methods used to sow seed (Figure 2). Large tracts of land (>500 acres) are often broadcast sown aerially by airplanes or helicopters. This method is fastest and has the most accurate and complete coverage. Another method for large tracts of land uses row-seeding machines, which 1) plow a narrow furrow or strip, 2) meter out a specified amount of seed, and 3) pack the seed into the soil with packing wheels (Lohrey and Jones 1983; Williston and Balmer 1983). Two methods for small tracts of land include hand-sowing and spot-seeding. To hand sow, hand-cranked seeders, with a metering device, are most useful. One person can sow 15 acres in a day (Lohrey and Jones 1983; Williston and Balmer 1983). Seed can also be sown on hand-raked spots, approximately 2 feet in diameter and spaced about 8 x 8 feet . Six to eight seeds are pressed 1/2" into the soil at each spot (Lohrey and Jones 1983); 2-4 acres can be sown in one day using this method. A small group of landowners can also share the cost of a helicopter or airplane if aerial seeding is preferred.

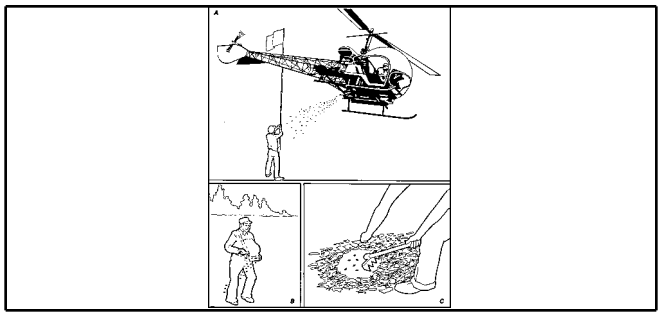

Figure 2.

Where to direct seed

Direct seeding is often not successful on dry, upland sands or coarse sandy soils where the soil dries out too rapidly and moisture is unavailable for the seeds to germinate. On these sites, germination is enhanced if the seed is covered with soil (about 1/2") (Williston and Balmer 1983). In contrast, on poorly drained sites where seeds or seedlings may be flooded for more than 1-2 weeks, direct seeding may not be successful. Also, on sites where heavy grazing is present, survival may not be good because animals will trample small seedlings. On sloped sites, direct seeding followed by heavy rains may result in seed being washed away (Williston and Balmer 1983). Sites with heavy grass may have to be disked or harrowed before direct seeding (Derr and Mann 1971; Lohrey and Jones 1983). Sites with frost problems or intense radiation should also be avoided (Wenger 1984).

Direct seeding may be used on small or large land areas where natural regeneration or planting cannot be applied. Natural regeneration may be impossible because of the lack of trees as a seed source. Planting may be difficult or expensive where terrain is inaccessible or soil conditions make planting difficult (Lohrey and Jones 1983).

Advantages

- Compared to natural regeneration, direct seeding allows the introduction of new species or seed sources.
- Compared to natural regeneration, direct seeding enables better control over seed quantity, quality, and distribution over the site (Lohrey and Jones 1983).
- Direct seeding has a lower initial cost than planting (1/3 to 1/2 the cost of planting).
- Direct seeding can be employed on sites with difficult access, or sometimes poor drainage (Williston and Balmer 1983).
- Direct seeding may be more flexible than planting-- for instance, when a forest fire or other natural disaster occurs, it is often easier to obtain seed rather than seedlings (Williston and Balmer 1983).
- Sometimes with improper planting, a "J" or "L" shaped root system will result on the planted seedling but with seeding a more natural, undisturbed root system develops.
- For aesthetic reasons, some people might prefer seeing trees randomly spaced on a site instead of in rows.

Disadvantages

- Because of bird and mammal problems, it is necessary to treat the seed with repellents and these repellents may not be available.
- Sometimes site preparation is more necessary than with planting because of the requirements for exposed mineral soil.
- Direct seeding requires more skill than planting to do it right; the landowner is advised to seek help from a forester experienced in direct seeding (Williston and Balmer 1983).
- There are many sites where direct seeding is not suitable (see section on where to direct seed).
- Relative to planting, there is less control over spacing and stocking; thus, pre-commercial thinning may be necessary to reduce the number of trees per acre and establish even spacing between trees.
- Because the forest stand is started with seed instead of one-year-old seedlings, rotations may be at least one or more years longer because of the loss in growth.
- Also, because the direct-seeded seedlings are one year younger, it may be necessary to control competing vegetation for a longer period of time to insure successful survival and growth.
- The irregularly spaced stands which often result from direct seeding are not well suited for access by mechanical harvesting and fire equipment (Williston and Balmer 1983).
- And finally, compared to planting, direct seeding generally results in lower yields of timber (Williston and Balmer 1983).

Planting

Definition

The majority of sites which are regenerated with pine in the South are planted with seedlings. Seedlings are grown at and purchased from forest tree nurseries. Although mainly bareroot seedlings are planted, each year there is a slightly increased number of containerized seedlings available for planting, especially longleaf pine seedlings.

Seedlings are lifted at the nursery and planted during the late fall and winter months. Care and handling of lifted bareroot seedlings are extremely important to planting success. If seedlings are stored, they should be stored at cool temperatures (33-35°F). Otherwise, they should be planted immediately. Planting is accomplished either by hand or mechanically. Two excellent publications on planting are "A Guide to the Care and Planting of Southern Pine Seedlings" by the USDA Forest Service and "Planting Southern Pines" by Duryea and Edwards 1997.

Steps

1. **Species and stock selection.** Selecting the species to be planted can be a complex process but a good rule of thumb for Florida is 1) on poorly drained sites, plant slash pine, 2) on moderately drained sites, plant slash or loblolly pine, and 3) on dry sites, plant longleaf or sand pine. Using genetically improved stock will insure better growth and improved disease resistance. A professional forester familiar with local conditions could assist in choosing the proper species.

2. **Site preparation.** The purposes of site preparation are: 1) to clear away logging slash and vegetation and create enough spots to plant seedlings if they are to be hand-planted; 2) to clear away logging slash and vegetation which will be obstacles for machine planting; 3) to incorporate organic matter into the soil; and 4) to reduce the levels of unwanted weeds which will compete with tree seedlings for water, light, and nutrients. The three major site preparation methods include the use of 1) fire or prescribed burning, 2) mechanical methods such as chopping, disking, shearing, and bedding, and 3) chemical herbicides. For detailed information on these site preparation methods see IFAS Fact Sheet FOR-37, Site Preparation: Alternatives for Plantation Establishment, Jack et al 1984 and Special Series FOR-10, Vegetation Management in Florida Private Non-industrial Forests, Campbell and Long 1995.

3. **Care and handling before planting.** *SEEDLINGS ARE PERISHABLE* . Realizing that seedlings require special care when they are out of their natural environment, will insure success in regenerating your site. Successful survival and growth depend on the care taken during storage, transportation, and planting. Seedlings should be picked up immediately after they are lifted at the nursery. If necessary, they can be stored at cool temperatures (33-35°F) for 1-2 weeks. If cold storage facilities are not available, seedlings should be stored in the shade (with good air circulation), kept moist, and planted as soon as possible. Sand pine and longleaf pine seedlings should not be stored but should be planted immediately (within a week) after lifting. The best way to transport seedlings is in a cooler or refrigerated vehicle. If this is not possible, they should be transported in covered vehicles and arranged so that air circulates among the bales or bags. Transporting in open trucks can cause excessive drying. Also, when seedlings get too warm they may dry Out or use up their food reserves and die. If possible transport seedlings at night in canopy-covered trucks.

4. **Care during and after planting.** The main consideration during planting is protection of the seedlings, especially the root systems. Seedling roots should not be allowed to dry; putting seedlings in buckets of water or covering them with wet burlap will protect them until they are in the ground. For large acreage a planting bag to hold seedlings is efficient and will protect the roots if the seedlings are planted quickly and not left in the bag for a long period. When planting, it may be helpful to leave a depression around the seedling to catch water. Of course, if feasible, watering after planting will aid survival.

5. **Spacing.** Usually about 500-800 seedlings are planted per acre for a pulpwood plantation. The rows on the planting site are most often 10 to 12 feet apart and seedlings are planted 5 to 8 feet apart within the row. A 6 x 10 foot spacing will have 726 trees per acre (43,560 ft /acre : 60 ft/tree = 726 trees per acre).

6. **Planting.** Seedlings are either hand-planted or machine-planted. A two person hand planting crew can plant 1000-2000 seedlings per day. When machine planting, two people can plant about 8000-10,000 seedlings per day. Various tools are commonly used for hand planting (Figure 3). The hole is made and the tree is inserted with the root collar slightly below the ground line (Figure 4). The soil is then firmly packed around the seedling to avoid air pockets. A small tractor and a mechanical planter are used for machine planting (Figure 5). Before planting begins, the following should be checked: 1) the planter must make a furrow deep enough for the entire root system, 2) spacing should be checked and regulated to insure desired spacing between each planted seedling, and 3) depth of planting should be checked; seedlings should be planted at or just below the root collar. During planting seedlings should be checked to make sure: 1) that they are planted at the proper depth, 2) that they are planted straight up and that the roots are straight in the hole, and 3) that the seedlings are firmly packed in the hole. To check the latter, grab the top needles of the seedling and firmly pull upward; if the seedling is too loosely planted, it will come out of the soil.

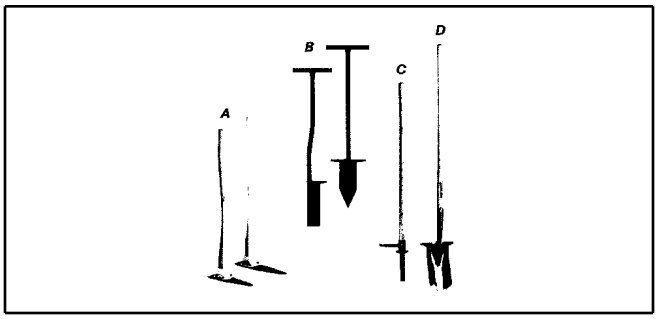

Figure 3.

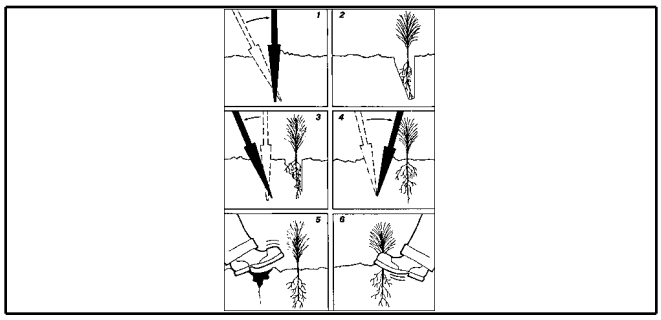

Figure 4.

Figure 5.

Advantages

- Successful survival is more likely with planting compared to natural regeneration and direct seeding.

- An evenly spaced plantation is more likely to result from planting, and therefore a plantation established from planted seedlings has better growth and is easier for future harvesting operations.

- Planted seedlings will grow faster initially than seedlings from seed. Thus, planted seedlings will more effectively compete with unwanted grasses, herbs, and shrubs for moisture, nutrients, and light.

- With planting, wood yields are generally better than with seeded stands and the length of the rotation is shorter (meaning an earlier harvest).

Disadvantages

- Initial costs may be higher than for natural regeneration and direct seeding.

- The planting site may be inaccessible to planting machines or crews.

- Distortions of the root system such as "L" or "J" shaped roots may result if care is not taken.

- Close attention to seedling care and handling is critical; poor survival and growth may result if seedlings are mistreated.

Assessing Success of Your Plantation

To assess the success of your regeneration efforts, it is necessary to check survival of the seedlings. One year after planting, seeding, or natural regeneration has occurred, is a good time for assessment. A number of plots should be taken over the entire planting site to get an idea of success over the entire site (Table 3). Establish 1/100th acre circular plots on each acre by randomly selecting a spot within the acre and then anchoring an 11.78-foot rope down at this spot. Next walk in a circle counting the number of live seedlings in the plot. Calculate the average number of seedlings on these plots and then multiply times 100 to determine the number per acre. If there are 300 or more surviving seedlings per acre on the site and these seedlings are well distributed, a replant is not necessary. If there are fewer than 300 per acre, then a decision must be made whether to replant or not. If the surviving seedlings are not well-distributed on the planting site, then a replant may be necessary in the understocked areas (Williston and Balmer 1983). For direct seeding and natural regeneration, success should be assessed for at least two years because the seedlings are so small that they are hard to see and also because mortality of these small seedlings is more likely.

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Table 1.

Table 1. Minimum number of seed trees to leave for natural regeneration and the frequency of seed crops for each pine species (seed tree numbers adapted from Williston and Balmer 1974)

Pinespecies	Number of seed trees to leave per acre by diameter of trees				Frequency of seed crop (yrs)
	Diameter (inches)				
	10	12	14	16+	
Slash	12	9	6	4	Every 3 years
Loblolly	12	9	6	4	Every 1-3 years
Longleaf	55	38	28	21	Every 3-5 years

Table 2.

Table 2. Amount of seed needed to direct seed an acre of land and the approximate number of seeds per pound.

Pine Species	Lbs. of seed needed per acre *	Approximate number of seeds per lb.**
Loblolly	0.5	18,200
Slash	0.6	13,500
Longleaf	2.5	4,900
Sand	0.6	75,000

* (Williston and Balmer 1983)**(Schoprneyer 1974)

Table 3.

Table 3. Calculations for determining the number of live seedlings per acre and survival percentage on a partial of land which has been regenerated. A) This is an example of the data collected from a 21-acre partial of land; one 1/100 acre plot was sampled on each acre for a total of 21 plots. B) Using the data collected and these formulas, we can then estimate the number of live seedlings per acre. C) Using the estimated number of live seedlings per acre and the number of seedlings planted, we can estimate survival.

A) Example of data collected from 21 plots on a 21-acre partial of land.

Plot #	Liveseedlings	Plot #	Liveseedlings	Plot #	Liveseedlings
1	6	8	0	15	8
2	3	9	5	16	4
3	5	10	7	17	7
4	5	11	3	18	2
5	7	12	9	19	10
6	8	13	6	20	5
7	4	14	5	21	5
Subtotal:	38	Subtotal:	35	Subtotal:	41

Total: 38 + 35 + 41 = 114 live seedlings on the 21 plots

B) Formulas for calculating the number of seedlings per acre.

(1) Total number of live seedlings on the 21 plots	+	Number of plots	=	Average numberof live seedlings per plot

Example: 114 + 21 = 5.43

(2) Average number of seedlings per plot	X	100 plots per acre	=	Estimated number of live seedlings per acre

Example: 5.43 X 100 = 543

C) Formula for calculating the survival percentage of planted seedlings on the site:

(1) Estimated number of live seedlings per acre	Ö	Number of seedlings planted per acre	X 100 =	Estimated percent survival for site

Table 3.

Example. 543 Ö 700 X 100 = 78%