United States Department of Agriculture
Natural Resources Conservation Service

Arkansas Forestry Technical Note 1

Recommendations for Tree/Shrub Seedling Spacing

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Introduction

The initial planting density of trees depends upon the desired species, site condition, and objectives of the landowner.

In general, landowners planting strictly for timber production will plant Loblolly Pine at a closer spacing. Landowners that have other objectives, such as wildlife habitat, may plant shortleaf, hardwood or a mix at a wider spacing to satisfy their goals.

As different species are planted at different densities, the first decision has to be which species is to be planted. Landowner objectives are always key in this decision. If objectives require hardwoods, generally, these are planted at a wider spacing than pine. Keep in mind, no matter the objective, the desired species has to be adapted to the site. A soil's productivity (usually measured by site index and is determined by pH, drainage, and fertility) should be considered and is a major factor in determining species and spacing (carrying capacity of the site). For example, upland hardwoods should not be planted in wet areas. Shortleaf pine grows much slower than loblolly pine and may be the species of choice to be used at a wider spacing on dry sites with low fertility. Sometimes it is necessary to plant extra trees on droughty soils with a history of poor seedling survival.

Proximity to mills must also be considered. Having a market for the product (pulpwood, saw log, pole, etc.) as well as the species makes management of the stand feasible, and allows a wider range of choices for planting density. Buyers will not travel far for low value small diameter products.

Plantations outside the procurement area of mills must be managed with forest stand improvement activities (expense to landowner) rather than timber sales (income to the landowner). Too often, dense Loblolly pine plantations have been established in areas of the state with no market for pine pulpwood (true in the extreme northwest or northeast part of the State as well as Crowley's ridge). Such plantings are not commercially viable and can't be thinned in a timely manner. These stands become a forest health concern. The same can be said for cottonwood plantations since mills that use cottonwood pulpwood are limited. Cottonwood plantations in the Arkansas River Valley in western Arkansas can have problems supporting a commercial thinning.

Generally, once a tree is big enough to make a board, there is a market for that tree regardless of species or location within the state. Having a timber sale for high value large diameter (saw log size) trees is not a problem. The problem is marketing low value small diameter (pulpwood size) trees. The density of a plantation must be adjusted (thinned) as the trees get larger. The ultimate goal is to have an ideal number of good quality crop trees for the final harvest. The number of desired crop trees per acre at the final harvest depends on the carrying capacity of the site and the landowner objectives. Typically, the number of crop trees in the final harvest of a plantation managed for financial returns ranges from 150 to 200 trees per acre. Landowners with wildlife or grazing objectives may desire to have as few as 100 crop trees per acre. It is critical; trees must be allowed to be free to grow throughout their life.

Once the site has reached its carrying capacity (more productive sites can carry more trees longer), trees become stressed and stop growing. A plantation that is at the carrying capacity of the site is a place of "survival of the fittest". In this situation, some trees must die so others can live. Risk of catastrophic failure for the plantation is high. Both hardwood and pine trees under stress with poor vigor are susceptible to insects (beetles or borers) and disease. Plantations on less productive sites or with higher planting densities reach their carrying capacity sooner. Also, the size of the trees at the time of the first thinning is smaller for these plantations. Timing of the first thinning is critical once the plantation has reached the carrying capacity of the site. Keep in mind, all trees planted over the number of desired crop trees must be removed before the final harvest. It is not practical to plant only the desired number of crop trees. Extra trees are necessary to allow a culling process of the low quality trees, allow crowns to close to cause natural pruning, and have room for natural mortality of some trees.

Possessing a merchantable product and a place to market that product allows commercial thinning to be done in a timely manner to maintain the health of the plantation. Without a market for the pulpwood, the planting density has to be less to allow the trees to grow to a larger, more merchantable size before there is a need for thinning.

Some considerations:

- Relatively close spacing is encouraged by good markets for small wood.
- Economic returns are quicker with pine.
- Pine is usually managed on drier sites.
- Hardwood is usually managed on wetter sites (river bottoms and delta) or where there is a weak market for pine (uplands in the north).
- Generally hardwood is planted at wider spacing (fewer trees) than pine
- Wildlife objectives prefer hardwood, shortleaf pine, or very young loblolly pine. Plans to meet these objectives can be applied to any site with any species suited to the site.
- Wildlife objectives prefer trees at lower densities. (Fewer trees allow sunlight to reach the ground and promote ground vegetation).

Planting plans should take into consideration mechanical maintenance operations. For example, one might want to mow or disk between the planted rows. Rows should be planned to be at least 3 to 4 feet wider than the available equipment to allow such operations without damaging planted trees. It is extremely difficult to use a 6 ft mower in an 8 ft row without causing damage. Planning turn rows is extremely helpful. One consideration should be to plan alleys across the planting site to provide access and room to allow equipment to turn around. Such rows and alleys would have little effect on economic returns.

There is general agreement on the following points:

- Spacing does not influence height growth over a wide range of density.
- Wide spacing results in increased diameter growth and shorter rotations
- Wide spacing reduces total volume production only prior to stand closure, after which the site is fully utilized.
- Wide rows and alleys provide access.

There are two philosophies regarding the number of pine seedlings that should be planted per acre. One thought recommends high planting densities which usually is more than 500 seedlings per acre. The other thought recommends low stocking levels usually less than 500 seedlings per acre (formula for determining trees per acre: TPA = 43,560 ÷ (in-row spacing X between row spacing)). A typical thick planting is 622 seedlings per acre (10 ft between rows and 7 ft between trees in the row) or more.

These high density plantings increase pulpwood production and require thinning at a younger age. A typical low planting density is 453 seedlings per acre (12 ft between rows and 8 ft between trees in the row) or less. Thin planting densities provide more growing space between trees for diameter production and prevent early crown closure allowing thinning to be delayed. Thin planting densities allow trees to grow to saw log size at a younger age.

Examples of seedling spacing:

TREES PER ACRE (Plantations)							
Ft. Between Rows	Feet Within Row						
	6	7	8	9	10	11	12
10	726	622	545	484	436	396	363
12	605	519	454	403	363	330	303
14	519	444	389	346	311	283	259
16	454	389	340	303	272	248	227

Some Considerations:

- Higher density planting increases fiber production (pulpwood) (trees grow slower)
- Landowners receive little or maybe no income from the first pulpwood thinning.
- Lower density planting will grow more saw timber in the same amount of time. (diameter of trees grow faster)
- Value for saw timber is 3 to 4 times more than that for pulpwood
- Landowners receive more income if first thinning has saw log size trees.
- Establishment costs are less for thin plantings than thick plantings (fewer rows of trees in the field)
- If the planting site is far from a mill, it makes much more sense to plant seedlings at a low density
- Trees planted at a very low density do not naturally prune as well as trees planted at higher densities. Trees with many low limbs have less value as saw logs.

The trend in the past has been to plant many more seedlings as needed to avoid starting over. The plan would be to fix over-stocked stands by removing the extra trees during the first thinning. Because of seedling quality and lack of proper site preparation, seedling survival has been variable in the past. Now we know with good quality seedlings and good site preparation seedling survival is more dependable. Economically it is many times better to plant and succeed than it is to plant and fail. Only seedlings meeting specifications (see Practice 612 specifications) should be used. Larger caliper seedlings (measured at the root collar, should be 1/8 ” for pine and ¼” for hardwoods), with a good root system survive and grow better (“short and fat is where it is at”). Also, No matter the planting density, economic returns are much greater when investments are made in proper site preparation practices. Planting should be delayed until all site preparation practices are in place and weather conditions are favorable. (Even if the planting has to be delayed a year) Plan to succeed, rather than fail.

Because of multiple drought years, many forest companies now plant containerized pine seedlings. Planting containerized seedlings armor plates planting success. Plus, the planting season can be extended. Keep in mind, containerized seedlings survive better, but do not necessarily grow better. Because of cost and increased probability of success, planting densities for containerized seedlings tend to be lower. If survival is a concern, one should consider using containerized seedlings.

Some considerations:

- Only plant the number of seedlings to meet the objective (do not plant extra from fear of poor survival).
- Only plant seedlings meeting specifications
- Do good site preparation so seedlings are free to grow

- If survival is a concern, use containerized seedlings.

The amount of forage and number of years forage is available in a plantation is related to tree stocking. There will be more sunlight reaching the ground for a longer time when using lower planting densities. Such plantations have much more diversity of plant species and are much more beneficial to wildlife. Once the stand has reached crown closure the forage diminishes or is greatly reduced. If desired, pasture can be provided for livestock in plantations with lower density (silvopasture). Economic returns from livestock combined with trees are greater than either alone. It is possible to reduce the stocking of the trees to have a negative impact on the economic returns from timber (Should never plan to plant less than 200 seedlings per acre).

For hardwood plantings with wildlife objectives, a mixture of species should be planted. Ideally, no more than 60% should be hard mast species (oak, pecan, walnut, etc.) The non-hard mast part of the planting should be split evenly between soft mast (mulberry, persimmon, plum, hackberry, etc.) and light seeded (ash, cypress, maple, sweet gum, etc.) species. Diversity of species and uneven vertical structure has much more wildlife benefit than uniform plantings of same or similar species. Planting density for these stands should be between 300 and 450 seedlings per acre (preferably closer to 450). Plantings with less diversity should be closer to 300 seedlings per acre to allow room for volunteers.

Some considerations:

- Distance between rows should be at least 10 feet for both pine and hardwood.
- Objectives that include diversity and wildlife benefit should have at least 12 feet between rows for both pine and hardwood.
- Objectives that favor forage production should plant 200 to 400 pine seedlings per acre. (livestock or wildlife) (includes area in wide alleys)
- For pine, there is no significant difference in average branch size for wide or close planting spacing until the seedlings per acre goes below 150.
- Open grown trees tend to hold their branches, (degrades quality and marketability of the saw logs because of the presence of knots).
- To have a quality saw log, trees must be pruned if have live limbs lower than 18 feet.

One common fear is open grown trees are less desirable because of wide growth rings and lower specific gravity. Specific gravity for a tree is controlled by harvest age and not by growth rate. Trees of the same age have similar specific gravity no matter if they grow fast or slow. True, trees growing faster may be harvested at a younger age. Trees cut at a younger age will have a lower specific gravity. If left to grow to the same age the specific gravity will be the same. Most sawmills typically buy wood based on weight and size, not on rings per inch. There is no economic benefit to grow trees slowly.

Some considerations:

- The single most important factor controlling economic returns from planted trees is time.
- Economic returns increase as rotation age shortens.
- Operations (subsoiling, weed control, fertilizer if needed, etc.) that shorten the rotation age pay for themselves in increased returns.
- Wider spacing increases economic returns and planting density is an important consideration for those landowners doing aggressive management for maximum return.

Conclusions:

1. Pine planted with wildlife objectives should be planted less than 500 seedlings per acre.
2. Pine planted far from a mill should be planted less than 500 seedlings per acre.
3. Pine planted with forage production objectives should be planted less than 400 seedlings per acre.
4. Pine planted with only timber objectives can be planted more than 500 seedlings per acre.
5. No pine planting should be more than 700 seedlings per acre without some extraneous circumstances (soil has history of poor survival) (Would be better to plant containers than more seedlings)
6. No pine planting should be less than 200 seedlings per acre.
7. Hardwoods usually are planted between 300 and 450 seedlings per acre (diverse plantings toward the high side and non-diverse plantings toward the low side)
8. No pine planting should have rows less than 10 ft wide. (12 feet wide or more is better).
9. No hardwood planting should have rows less than 12 ft wide. (wider is better).

Forestry is an art and a science. Most technical recommendations are tempered with personal opinion. For certain, many similar practices can accomplish the same goal. In the final analysis, landowner objectives are the driving force behind choosing the correct seedling planting density.