Outreach
*Warnell School of Forestry & Natural Resources*
UNIVERSITY OF GEORGIA

# Intermediate-Aged Stand Management:
## Time Between Planting & Harvest

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Many forest stands suffer from three common problems of middle-aged forests: poor management, if any at all; no planning for regeneration; and stands which are too dense. Losses from mid-rotation management problems can offset the most careful regeneration efforts. Planting trees and then forgetting them is neither prudent nor careful management -- lost income dollars are the penalty.

There are many reasons for forest land management. Water, wildlife, aesthetics, recreation and other tree species can all be included in viable management objectives. This paper will concentrate on pine production. Professional foresters can help you set and meet goals and objectives for your land. Productive combinations using all of the land's resources can pay large rewards.

### WHAT IS INTERMEDIATE-AGED MANAGEMENT ?

Intermediate-aged stand management is cost-effective forestry practices ensuring continued productivity while minimizing risks. Intermediate-aged forests are between five years old and near rotation age. The harvest/regeneration period is critical to economic returns, but you cannot neglect the 80 percent or more of a stand's life between harvests. For example, harvest/regeneration may account for only five of 25-35 years over which a forest grows, or 14-20 percent of the life of a stand.

Intermediate-aged stand management involves manipulating tree crowns, which are the leaves and supporting branches which provide nutrients for growth. Without a healthy crown to make food, you have no tree trunk (the product you sell). Forestry is about crown management.

Trees make food by capturing sunlight in their leaves. Energy from sunlight is used along with air, soil and water to produce food. Trees which cannot capture enough sunlight decline and

die. Foresters manage tree food production to make wood. The more food produced, the more wood produced.

Every site where trees grow receives about the same amount of sunlight, but only a limited amount of the sun's energy is available for conversion into tree food. Species of tree, leaf form, soil problems, water problems, pest and damage problems, and interference (competition and allelopathy) for resources from other plants all prevent a tree from fully converting available light energy into food.

Since there is a limited amount of sunlight and other resources available for tree growth on a site, you need to decide which trees should be favored. Favoring trees with rapid growth, high-quality stems (no visible defects), few risks and a great market potential will be profitable. Allowing poor trees with no value to survive prevents good trees from using site energy to grow.

To maximize economic returns, trees must grow as big as they can in the shortest amount of time with good quality. You must concentrate any energy captured, and other site resources, onto a few "crop" trees and minimize the rest of the trees. Energy and site resources can be divided over thousands of trees, or concentrated onto a few crop trees which will make you money. Ensure crop trees fatten their trunks by keeping their crowns large and by controlling interference from other trees and plants.

## UNMANAGED STANDS

To understand effects of intermediate-aged stand treatments, observe what happens in unmanaged stands. Unmanaged stands are planted or naturally regenerated with 700 to 2500 seedlings per acre. When established, the stand is healthy, but as trees grow, problems occur. Each tree fights for its place in the sun with neighboring trees. Each tree must also compete with woody (hardwoods and shrubs) and herbaceous weeds. This interference for the limited resources of a site can be intense.

Tree crowns expand and grow, and trees with the tallest and biggest crowns collect more site resources and grow taller still. The tallest trees may be pines or hardwoods. As taller, bigger trees continue to capture more site resources, smaller trees get less resources and begin to decline and die. Successful trees have a greater chance of continuing to be successful.

Tree crowns soon deeply overlap each other and shade their own lower branches. When one branch cannot make enough food for itself, it is sealed off and dies in a process known as self-pruning. Heavy crown shading eliminates many lower branches.

The unmanaged forest becomes thick with pine and hardwood trees. As trees lose many of their lower limbs, height and volume of living crowns shrink. Live crown ratio is the length of the main trunk where all living branches are connected, divided by the total height of a tree.

For example, a tree 100 feet tall with a living crown length of 40 feet would have a live crown ratio of 40 percent. Live crown ratio is a measure used to determine interference and tree reaction potential to change and stress. The larger a living crown, the more food a tree can make and the bigger it can grow. Tree mortality accelerates when live crown ratios drop below 20 percent.

With strong interference, many trees make only enough food to grow slowly and are quickly overtopped by neighboring trees. Overtopped trees make even less food and decline further. Death of overtopped trees is the common result of site interference.

Trees which are completely overtopped and no longer growing are "suppressed" trees. Suppressed trees survive for a time, but usually die eventually. When a suppressed trees dies, all the resources used to make its food and to grow its wood are lost from harvesting. Those same resources could have been used to help a crop tree get bigger. Instead, the wasted resources become termite food with potential income dollars rotting on the forest floor.

Remaining trees in an unmanaged forest continue to grow. The forest site is now carrying its maximum amount of tree crown area. There are few places where an extra leaf could be placed. Every tree is using a lot of food to maintain itself and to interfere with its neighbors. There are many stems, each with a small crown. Each tree's potential growth is limited by the resources it can capture and control. The total resources of the site are divided to keep thousands of stems alive.

Some trees are more successful than others at competing for resources. As a few trees capture more of the limited resources, smaller trees begin to decline and die at a faster rate. This rate is the natural mortality of the stand. The remaining trees develop smaller and smaller crowns that produce less food. These poorly reacting, slow-growing trees are more prone to environmental stress and pest attacks. Pests such as Southern pine, Ips, and black turpentine beetles, remove competition-weakened trees, sometimes a whole stand at a time.

In an unmanaged stand of trees, a majority of site resources are wasted upon trees which die before their value can be harvested. This is not economically productive forestry.

### MANAGED STANDS

The preceding scenario is what can happen in unmanaged stands or in managed stands allowed to go "wild." Doing nothing in a forest stand is always an option, but often is the least cost-effective and highest risk option available. Active intermediate-aged stand management can be used to minimize problems and maximize returns.

Intermediate-aged stand management techniques or treatments include crop tree release, thinning, timber stand improvement (TSI), pruning, fertilization, pest management, and several other cultural activities. An example of a valuable cultural activity is prescribed fire, a low-cost and effective tool for controlling competition. The use of fire must be carefully designed and scheduled to prevent site resource loss. Prescribed fire is covered well elsewhere and will not be reviewed here.

Remember that any forest treatment must always meet the following criterium: "The cost of treatment must be less than its benefit at harvest, adjusted for time's effect on money." In other words, a treatment must generate product value greater than its cost, plus interest, carried over the rest of the rotation period. There are many potential treatments whose costs will not be completely recovered at harvest.

## TECHNIQUES AND TOOLS

### PINE RELEASE

Pine release propels a newly established stand of pines off to a fast start. Interference is removed by cutting or with chemicals in spots around crop trees or in strips along planted rows.

Treatments also can be broadcast over an entire forest stand. Release treatments should not be confused with herbaceous weed control used to establish a stand.

Release pines by eliminating brush, hardwood sprouts, and any tree overtopping or directly interfering with a crop pine. Try to eliminate direct competition from neighboring weeds in an area equal in diameter to half the height of the young pine. Do not allow any weeds to shade pines.

When a stand is young, competing woody weeds (trees, shrubs, and vines) prevent pines from capturing all the site resources needed for best growth. Depending upon harvest, site preparation, and establishment procedures, many pine stands under five years of age may require release from interference. All available resources can then be concentrated into rapid pine growth. Waiting too long to release pines from interference leads to increased mortality, pest problems and lost growth -- all of which costs dollars.

Herbicide treatments across a site are becoming a cost-effective method of ensuring fast, early growth in pines. Aerial, ground spray, single-tree injection and/or spot gun application procedures can be prescribed by a forester to meet your objectives and site conditions.

Mechanically cutting around crop pines is possible on small plots, but is not cost-effective over large areas. Do not treat every pine. Release only those pines which are healthy, have a large crown, and are well spaced across a site. The number of crop trees for final harvest in thining regimes ranges from 50 to 250 trees per acre, depending upon your objectives. Do not waste time with pines which will be suppressed and die in the future. Concentrate your time and efforts, as well as site resources, only on crop trees.

Pine release allows pines to grow above their competition and then control the site. Strive for 250 or fewer free-to-grow crop trees per acre. Pine release is not always needed. As a rule of thumb, release pines when one-third or more of the current stand is hardwoods. Use of prescribed fire to release very young pines is risky, so do not use fire for pine release. Also, protect young stands from wildfire with fire breaks.

## PRECOMMERCIAL THINNING

Precommercial thinning is an expensive and intensive practice to save potentially valuable stands from stagnation and pest problems. It is more rarely used to select crop trees at an early age. Precommercial thinning removes unsalable young stems to provide less competition and more site resources to remaining stems. Whole stands of young pines can be lost to overstocking and growth stagnation without treatment. Even under low-cost management, a precommercial thinning may be the only viable option in a badly overstocked stand.

With natural regeneration, it is not uncommon to have 5,000 or more seedlings per acre. If a site has more than 2,000 seedlings per acre, precommercial thinning should be considered. Precommercial thinning is most cost effective when completed within five years of establishment, because equipment such as disks, choppers or brush mowers can be used. Larger trees may require a chainsaw crew to walk the site.

When mowing or chopping, leave thin rows of seedlings standing with variable widths of cleared strips between rows. Leave 300 to 500 free-to-grow stems per acre. Establish and leave strips of trees in only one direction. Do not mow or chop in a grid to select for single trees.

## COMMERCIAL THINNING

Commercial thinning is the most widely used method of concentrating site resources onto crop trees. Thinning stands to extract pulpwood or other products can pay many benefits. Thinning brings immediate monetary returns, allows each remaining tree to grow faster, saves site resources which would have been lost through tree mortality, improves crop tree survival and reduces some types of pest risks to the stand. Finding thinning contractors and markets for harvested wood can be difficult, and must be a consideration.

Thinning allows each crop tree to develop and maintain a large crown. Thinning removes trees that are site resource wasters (declining, suppressed, deformed, cankered, crooked and limby trees). Thinning helps to increase log grade (quality) on a forest-wide basis, increase wind-firmness, and can shorten rotation (time to harvest). Thinning can improve returns and reduce risks.

The principle of thinning is to take out trees, because of their growth rate, position or quality, which will not be final crop trees. Resources released can then be utilized by crop trees. After a thinning, remaining trees will continue to grow until they again fully occupy the site.

> CAUTION: Thinning stands by removing only the best trees leads to long-term stand damage and productivity losses. This destructive process is called "highgrading". As the best trees are taken, only crooked, slow-growing and pest-infested trees survive to be harvested or reproduce. Highgrading is the worst treatment applied to a forest and recovery is difficult.

Short rotation (15 to 25 years) stands used primarily for pulpwood products should not be thinned after mid-rotation age. Fiber yield in short rotation is the objective, and proper spacing control at establishment maximizes fiber yield and eliminates the need for thinning. Sawlog or long rotation (35 years or more) stands could be thinned beginning at age 10 to 15 years.

The the common thinning methods for pine stands include: row (with either logger select or marked ahead of time) and strip. Each thinning method must be tailored to meet your objectives and characteristics of the stand and site.

Row Thinning -- Row thinning is used in pine plantations where trees are planted in rows. Thinning removes every third, fourth or fifth row. Usually no quality selections are made. Every tree in a given row is removed, and in dense stands, poor-growing trees in the remaining rows can also be cut. Originally planting trees with at least 10 feet between rows allows operation of a thinning vehicle or skidder. Row thinning is a fast way to reduce the number of stems per acre.

Strip Thinning -- Strip thinning is used in natural stands where rows are not evident or in plantations where thinning cannot follow established rows. All the trees in a strip of a certain width are removed. Strips should run along land contours and be wide enough to allow for necessary machinery.

Selective Thinning -- Selective thinning leaves the best crop trees for further growth by removing interfering trees. Selective thinning helps control spacing and crop tree growth, but can result in

extensive damage to remaining trees. Residual tree damage can more than offset any advantages of selective thinning. Also, selective thinning requires a great deal of planning, marking and supervision to ensure a proper job is done.

NOTICE: It must be noted selective thinning is rarely used due to expense, and is mentioned here only for general review. Selective thinning requires great effort in planning and expense, including high logging costs with low equipment productivity. It would be difficult to find logging contractors to perform selective thinnings.

Combo

A combination of row or strip thinning is often the best practice. A large number of stems can be quickly eliminated while the best crop trees are selected. A thinning can be applied once any trees removed can be sold (after 10 to 15 years in some markests). Once thinning has started in a stand, additional thinning could occur every 6 to 12 years depending upon tree growth rates and markets for the thinned wood.

Decisions

Basal area values, which are easily measured approximations of living crown area, can simplify thinning decisions. For example, when stands reach 100-120 square feet of basal area, thin back to 60 square feet of basal area. Keep the stand between two target basal areas.

Another important consideration in thinning is designing and building haul routes and roads. Poorly placed, marked or installed roadways can cause significant stand damage, as can thinning when the soil is wet.

When To Thin -- Tables 1 and 2 can help you visualize thinning practices using the number of crop trees per acre and the amount of space left between each crop tree. Here is an example:

> According to Table 1, if trees in your stand of pines average 11 inches in diameter and the basal area (BA) is 100 sq ft, then the ideal number of trees present is 152.
>
> According to Table 2, the distance you should allow between each crop tree is about 17 feet. This information can help you plan thinning or TSI activities. You can determine the number of trees per acre to remove in each thinning. (Table 3)
>
> If you thin the stand in the above example back to 60 sq ft BA, 91 trees per acre about 20 feet apart would remain. You would harvest 61 11-inch DBH trees (152 - 91 = 61). If 91 trees continue to grow and there is no mortality, thinning may be needed for this stand again when the average diameter reaches 14.5 inches at 100 sq ft BA. A thinning schedule can be drawn out for several cycles, if markets are available.

This is only a rough guide to help visualize a thinning process. Seek professional assistance from a forester before thinning your stand. Stand survival, productivity, stocking, stem size and site variability are held constant in these tables. Actual thinning should be planned from yield tables and stocking guides with landowner objectives in mind.

## TIMBER STAND IMPROVEMENT

Timber stand improvement (TSI) controls interference by removing unwanted species and poor quality individuals of the crop species. TSI is usually completed with a thinning treatment. TSI cleans the forest of unwanted stems that steal site resources from crop trees. TSI is essential for preventing natural stand conversion to other species and minimizing potential release problems in older or soon-to-be harvested stands. Hardwoods which sprout profusely can be cut out after pines shade the site. Crooked, damaged, suppressed and declining pines can also be eliminated. Two or three year prescribe burning cycles and/or herbicide use to control unwanted vegetation can help with TSI.

## PRUNING

Pruning is a very expensive, labor- and machinery-intensive treatment for removing lower branch stubs early in a sawtimber rotation after the living crown has receded up the stem. Consider pruning only where there is a significant dollar premium paid for high-quality, clear logs. Pruning is not an usual forest management practice, but some landowners like to prune their trees. Sometimes pruning is applied for an aesthetic or recreational value, not for finacial returns.

Cost-effective pruning requires you make only one pass through the stand. Prune only the final crop trees (70 to 100 trees per acre). Prune branches and branch stubs up to 17 to 18 feet from the ground to clear the length of one full log. Do not prune living branches that would leave trees with less than 50 percent live crown. Do not prune after mid-rotation. Do not prune when daytime temperature are warmer than 65$^{o}$F.

## FERTILIZATION

Fertilizing forests is usually not cost-effective. Fertilization should be used to offset essential element shortages on better sites with basal areas of 70 to 100 square feet. Do not fertilize poor sites (sites which are soil-water limiting like deep excessively well-drained sandy soils), sites with a high hardwood or shrub component, or overstocked stands. Soil and foliage testing are required to determine which essential elements are in short supply.

Vegetation control is required before treatment to ensure only crop pines receive benefits from fertilizer. Apply herbicides, cut, or prescribe burn interfering herbaceous and woody vegetation at least six months prior to fertilization. TSI and thinning can also be completed. Do not use prescribed fire for at least two years after fertilization. Do not fertilize under saturated or drought conditions.

Seasonally water-logged or low pH soils may lack available phosphorus. The addition of 25 to 50 pounds of phosphorus per acre, if other site problems are not limiting, may produce growth benefits. Site index at age 25 can be increased 10 feet or more by fertilizing typical poorly drained soils in the lower Coastal plain during establishment.

In many areas, nitrogen is a limiting soil factor. On highly productive sites, nitrogen fertilizer can be added at 75 - 200 pounds/acre N typically, with at least 25 pounds/acre P (to maintain proper N:P ratio), but it is relatively expensive. All other growth factors must be good

for best results. Allow seven to 10 years after application to determine the full effect on growth rates.

Alternative fertilizers such as sewage effluent, sewage sludge, and solid / liquid animal waste can be used, but transportation and application methods of these materials can be costly and water quality problems must be closely monitored. A legume nurse crop such as clover can be used to improve nitrogen levels early in a stand's life. Careful cost/benefit analysis is required before any fertilizer treatment is used.

PEST MANAGEMENT

There are several pests to be aware of when working with middle-aged stands. Depending upon your location and site conditions, different pests will be problems. Always seek the assistance of pest and stand health specialists in formulating control strategies.

Root rots can be a serious problem after thinning in some areas. Root rot infects pines on well-drained sandy soils, with some deep sandy soils having severe problems. The fungus colonizes cut stumps after thinning operations and then infects standing trees. Infected trees die over a two- to five-year period. It is possible to lose 20 percent or more of the remaining stand after a thinning. Of the three most commercially important Southern yellow pine species grown in Georgia, loblolly pine is most susceptible to root rot after thinning, slash pine is intermediate, and longleaf has low susceptibility to root rot after thinning.

Thin areas prone to root rots only in Summer. Every cut stump needs to be sprinkled with borax powder. Another treatment is a powder which contains a type of stump-infecting fungi. This applied fungi does not effect standing trees, but does prevent tree damaging root rots from colonizing the stump. Borax or fungi treatments must be put onto the cut stumps at time of cutting. Stands with root rots can be thinned and treated more frequently to salvage trees which will die without thinning.

Another severe problem in some areas is infection of young stands with fusiform rust fungi, which produces growing cankers which cause major trunk faults and degrade wood product. If a young stand has less than 25 percent of trees infected with fusiform rust, remove those trees during thinning and carry the stand to harvest.

Southern pine, Ips, and black turpentine beetles are major pests of overstocked trees on poor sites. Thinned, fast-growing stands are less susceptible to attack. Winter thinning minimizes beetle problems because the beetles are not as active. In years of beetle epidemics, you should not harvest pines or execute any forest activities causing injury.

## CONCLUSIONS

Taking care-of your forest after establishment can minimize your management risks and maximize your returns. Do not regenerate your timberland and forget it! Do not let your timber have a mid-life crisis that costs you money!

Table 1. Number of trees per acre, by average stand diameter (DBH in inches) and basal area (BA in square feet of cross-sectional area per acre).

| DBH | BA 20 | BA 30 | BA 40 | BA 50 | BA 60 | BA 70 | BA 80 | BA 90 | BA 100 | BA 110 | BA 120 | BA 130 | BA 140 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 407 | 611 | 815 | 1019 | 1222 | 1426 | 1630 | 1834 | 2037 | 2241 | 2445 | 2649 | 2852 |
| 4 | 229 | 344 | 458 | 573 | 688 | 802 | 917 | 1031 | 1146 | 1261 | 1375 | 1490 | 1604 |
| 5 | 147 | 220 | 293 | 367 | 440 | 513 | 587 | 660 | 733 | 807 | 880 | 953 | 1027 |
| 6 | 102 | 153 | 204 | 255 | 306 | 357 | 407 | 458 | 509 | 560 | 611 | 662 | 713 |
| 7 | 75 | 112 | 150 | 187 | 225 | 262 | 299 | 337 | 374 | 412 | 449 | 486 | 524 |
| 8 | 57 | 86 | 115 | 143 | 172 | 201 | 229 | 258 | 287 | 315 | 344 | 372 | 401 |
| 9 | 45 | 68 | 91 | 113 | 136 | 158 | 181 | 204 | 226 | 249 | 272 | 294 | 317 |
| 10 | 37 | 55 | 73 | 92 | 110 | 128 | 147 | 165 | 183 | 202 | 220 | 238 | 257 |
| 11 | 30 | 46 | 61 | 76 | 91 | 106 | 121 | 136 | 152 | 167 | 182 | 197 | 212 |
| 12 | 25 | 38 | 51 | 64 | 76 | 89 | 102 | 115 | 127 | 140 | 153 | 166 | 178 |
| 13 | 22 | 33 | 43 | 54 | 65 | 76 | 87 | 98 | 109 | 119 | 130 | 141 | 152 |
| 14 | 19 | 28 | 37 | 47 | 56 | 65 | 75 | 84 | 94 | 103 | 112 | 122 | 131 |
| 15 | 16 | 24 | 33 | 41 | 49 | 57 | 65 | 73 | 81 | 90 | 98 | 106 | 114 |
| 16 | 14 | 21 | 29 | 36 | 43 | 50 | 57 | 64 | 72 | 79 | 86 | 93 | 100 |
| 17 | 13 | 19 | 25 | 32 | 38 | 44 | 51 | 57 | 63 | 70 | 76 | 82 | 89 |
| 18 | 11 | 17 | 23 | 28 | 34 | 40 | 45 | 51 | 57 | 62 | 68 | 74 | 79 |
| 19 | 10 | 15 | 20 | 25 | 30 | 36 | 41 | 46 | 51 | 56 | 61 | 66 | 71 |
| 20 | 9 | 14 | 18 | 23 | 28 | 32 | 37 | 41 | 46 | 50 | 55 | 60 | 64 |
| 21 | 8 | 12 | 17 | 21 | 25 | 29 | 33 | 37 | 42 | 46 | 50 | 54 | 58 |
| 22 | 8 | 11 | 15 | 19 | 23 | 27 | 30 | 34 | 38 | 42 | 45 | 49 | 53 |
| 23 | 7 | 10 | 14 | 17 | 21 | 24 | 28 | 31 | 35 | 38 | 42 | 45 | 49 |
| 24 | 6 | 10 | 13 | 16 | 19 | 22 | 25 | 29 | 32 | 35 | 38 | 41 | 45 |
| 25 | 6 | 9 | 12 | 15 | 18 | 21 | 23 | 26 | 29 | 32 | 35 | 38 | 41 |

(CONTINUED)

Table 1 (CONTINUED). Number of trees per acre, by average stand diameter (DBH in inches) and basal area (BA in square feet of cross-sectional area per acre).

| DBH | BA 20 | BA 30 | BA 40 | BA 50 | BA 60 | BA 70 | BA 80 | BA 90 | BA 100 | BA 110 | BA 120 | BA 130 | BA 140 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | 5 | 8 | 11 | 14 | 16 | 19 | 22 | 24 | 27 | 30 | 33 | 35 | 38 |
| 27 | 5 | 8 | 10 | 13 | 15 | 18 | 20 | 23 | 25 | 28 | 30 | 33 | 35 |
| 28 | 5 | 7 | 9 | 12 | 14 | 16 | 19 | 21 | 23 | 26 | 28 | 30 | 33 |
| 29 | 4 | 7 | 9 | 11 | 13 | 15 | 17 | 20 | 22 | 24 | 26 | 28 | 31 |
| 30 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 29 |
| 31 | 4 | 6 | 8 | 10 | 11 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 27 |
| 32 | 4 | 5 | 7 | 9 | 11 | 13 | 14 | 16 | 18 | 20 | 21 | 23 | 25 |
| 33 | 3 | 5 | 7 | 8 | 10 | 12 | 13 | 15 | 17 | 19 | 20 | 22 | 24 |
| 34 | 3 | 5 | 6 | 8 | 10 | 11 | 13 | 14 | 16 | 17 | 19 | 21 | 22 |
| 35 | 3 | 4 | 6 | 7 | 9 | 10 | 12 | 13 | 15 | 16 | 18 | 19 | 21 |
| 36 | 3 | 4 | 6 | 7 | 8 | 10 | 11 | 13 | 14 | 16 | 17 | 18 | 20 |
| 37 | 3 | 4 | 5 | 7 | 8 | 9 | 11 | 12 | 13 | 15 | 16 | 17 | 19 |
| 38 | 3 | 4 | 5 | 6 | 8 | 9 | 10 | 11 | 13 | 14 | 15 | 17 | 18 |
| 39 | 2 | 4 | 5 | 6 | 7 | 8 | 10 | 11 | 12 | 13 | 14 | 16 | 17 |
| 40 | 2 | 3 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 13 | 14 | 15 | 16 |
| 41 | 2 | 3 | 4 | 5 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 42 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 14 | 15 |
| 43 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 44 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 9 | 10 | 11 | 12 | 13 |
| 45 | 2 | 3 | 4 | 5 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |

Table 2. Approximate spacing in feet between trees at different tree densities per acre.

| number of trees per acre | distance between trees (ft) | number of trees per acre | distance between trees (ft) |
|---|---|---|---|
| 10,890 | 2 | 170 | 16 |
| 4,840 | 3 | 151 | 17 |
| 2,723 | 4 | 134 | 18 |
| 1,742 | 5 | 121 | 19 |
| | | 109 | 20 |
| 1,210 | 6 | | |
| 889 | 7 | 70 | 25 |
| 681 | 8 | 48 | 30 |
| 538 | 9 | 36 | 35 |
| 436 | 10 | 27 | 40 |
| | | 22 | 45 |
| 360 | 11 | | |
| 303 | 12 | 17 | 50 |
| 258 | 13 | 14 | 55 |
| 222 | 14 | 12 | 60 |
| 194 | 15 | 10 | 65 |
| | | 8 | 75 |

## Table 3. Thinning example drawn over an sub-section of Table 1 showing the pathway a number of pines in a pine stand should follow with thinning.

This table shows the number of trees per acre, by average stand diameter (DBH in inches) and basal area (BA in square feet of cross-sectional area per acre) for BA=60 and 100 square feet.

| DBH | number of trees at BA=60 | BA=100 | DBH | number of trees at BA=60 | BA=100 |
|---|---|---|---|---|---|
| 9 | 136 | 226 | 25 | 18 | 29 |
| | | | 26 | 16 | 27 |
| 10 | 110 | 183 | 27 | 15 | 25 |
| 11 | 91 | 152 | 28 | 14 | 23 |
| 12 | 76 | 127 | 29 | 13 | 22 |
| 13 | 65 | 109 | | | |
| 14 | 56 | 94 | 30 | 12 | 20 |
| | | | 31 | 11 | 19 |
| 15 | 49 | 81 | 32 | 11 | 18 |
| 16 | 43 | 72 | 33 | 10 | 17 |
| 17 | 38 | 63 | 34 | 10 | 16 |
| 18 | 34 | 57 | | | |
| 19 | 30 | 51 | 35 | 9 | 15 |
| | | | 36 | 8 | 14 |
| 20 | 28 | 46 | 37 | 8 | 13 |
| 21 | 25 | 42 | 38 | 8 | 13 |
| 22 | 23 | 38 | 39 | 7 | 12 |
| 23 | 21 | 35 | | | |
| 24 | 19 | 32 | 40 | 7 | 11 |


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