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A Southern Pine Management Guide for Tennessee Landowners

THE UNIVERSITY of TENNESSEE

Contents

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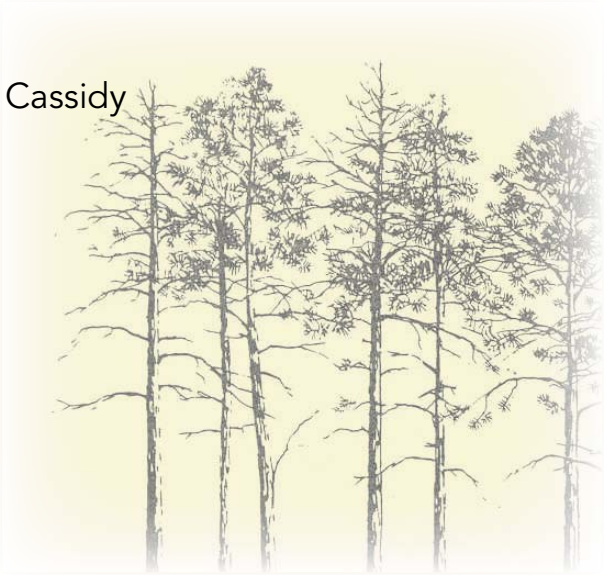


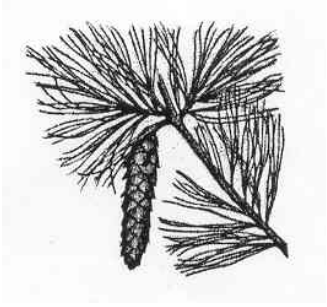
Purpose of This Handbook

Forestry's impact upon Tennessee is inescapable. The wood products industry contributes more than $21 billion annually to the state economy and employs 184,000 workers.[1] There are 14.4 million acres of forestland across the state, more than half the land base, and nearly 70 percent of these lands are owned by private, non-industrial landowners. Tennessee prides itself upon being one of the nation's largest producers of hardwood timber, but 1.2 million acres of our forests are comprised of southern yellow pines.

These pines contribute not only to a diversity of products that can be commercially marketed, but also increase the wide array of recreational and wildlife opportunities that make Tennessee a unique environment. Recent outbreaks of the southern pine beetle, as well as changing perceptions regarding intensive forestry practices, have created more interest in the limited, but valuable pine resource in Tennessee.

This handbook was written as a cooperative effort between University of Tennessee Extension, Tennessee State University Cooperative Extension and the Tennessee Department of Agriculture-Division of Forestry to assist Tennessee landowners in managing their pine resource, whether five or 500 acres. It is our hope that this resource will help landowners make sound management decisions and consider managing for pines on lands best suited for the resource. The handbook establishes guidelines in the steps to maintain a healthy pine resource and is a reference for making future decisions. However, it will not replace the expertise that can be gained from working with a local state forester or private forestry consultant.

The authors acknowledge Terry Tynes, area forester with the Tennessee Department of Agriculture, Forestry Division; Tom Cunningham with MeadWestvaco; and Tim Traugott, Extension professor with Mississippi State University; for their helpful reviews of the manuscript.



[1] English, B., J. Menard and K. Jensen. 2004. Tennessee's forest and forest products industry and associated economic impacts for 2000. The University of Tennessee, Institute of Agriculture, Agricultural Experiment Station, Dept. of Agricultural Economics, Knoxville. Research Series 01-04. 63p.

Why Plant Pine?

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Planting pine can provide many ecological and economic benefits. Pine should be considered for reforestation following pine harvest or after southern pine beetle epidemics and for afforestation of marginal agricultural lands. Outlined below are a few factors illustrating why planting pine is an attractive alternative for forestation.

1. **Site Quality** – Most pines occur on marginal sites that are better suited for pine (both ecologically and economically) than hardwood. These sites are often low in nutrients required for hardwood growth or agricultural crops. Hardwoods are more site-demanding than pines. Although various hardwoods will survive on these sites, they are not as prosperous, will not grow as fast and will not produce the "quality" hardwood sawtimber that brings the most income. Hardwoods are more sensitive to weather fluctuations, particularly the late summer droughts that frequently occur on these shallow, dry soils. Pine will produce a product on these marginal soils in a shorter time period than hardwoods. On low-productivity upland sites, those of shallow soils and south- to west-facing slopes, favoring pine over low-quality hardwood species should be considered.

   Pines will grow on the better sites too, but the cost of establishment and control of hardwood competition can be excessive. However, the shorter rotations of pine compared to the longer rotations for hardwoods may compensate for these costs. The production of pine volume on these sites may also compensate costs, where it is often twice that produced on the ridges.

2. **Ease of Planting and Seedling Cost** – Pine seedlings are cheaper and easier to plant than hardwoods. Seedling costs for pine average $40 per 1000 seedlings, while hardwoods such as yellow-poplar and oaks average $250 or more per 1,000 seedlings.

3. **Economics and Returns –** Pine is more valuable on the timber market than the red maple, low-grade oaks and sweetgum that generally occur on poorer sites. Pines are cheaper to establish and are grown at shorter rotations (20 to 30 years) than hardwoods. Establishment and management costs are recovered more quickly with the shorter rotations. Annual rate of return for pine in Tennessee averages 10 to 12 percent per year. Refer to UT Extension publications PB 1462 *(White Pine)* and PB 1466 *(Loblolly Pine)* for typical financial analyses in growing these species.

4. **Risk to Southern Pine Beetle Attack** – There is a good chance that at some time during your pine rotation you will have to deal with southern pine beetles (SPB). They are a native pest, are always present and tend to build to outbreak population levels every eight to 10 years. Our skills as pine managers will be tested to monitor, manage and capture the value of these trees before potential losses to SPB. The key is to manage these stands so that they remain healthy, vigorous and less susceptible to SPB. Consider that most of the trees killed during the 1999-2000 outbreak survived three to five earlier SPB outbreaks over the last 60 years.

   Hardwoods are also susceptible to damaging agents such as insects (defoliators, borers and piercing/sucking organisms) or diseases (cankers, wilts, root rots and other decays) as well as

unfavorable climatic variations, primarily droughts. The risk of growing hardwoods may even be greater considering their longer lifespans when compared to pine. Risk is always present when growing tree crops and managers should frequently monitor their property to minimize potential losses and promote healthy trees through their management activities.

5. **Ecology –** Most pines are shade-intolerant, requiring full sunlight to grow. They will not survive long in the shade. Pines are known as "pioneer" species, regenerating naturally on disturbed sites with their wind-blown seed. Pines have been part of the Tennessee landscape for many years, colonizing old fields and disturbed areas. Sudworth and Killebrew discussed the abundance of pine in Middle and East Tennessee during presentations at the American Forestry Association meeting in Nashville in 1897. The amount of pine in Tennessee has remained steady, ranging between 1.1 and 1.5 million acres since 1950 (USDA Forest Service, Forest Inventory Analysis (FIA) Data, 1955, 1962, 1971, 1982, 1990, 2000).

6. **Planting vs. Natural Regeneration** – Pines can readily regenerate naturally from seed, if exposed to mineral soils and full sunlight. So why the interest in planting pine seedlings?

    a. Planting pine provides more control over stand density (spacing) and arrangement. With natural seed fall, wherever a seed falls and germinates is where a new tree begins to grow. Natural stands are often too sparse or too dense, leading to added expense later (precommercial thinning) or incomplete utilization of the site. Planting gives more control of growing space and decreases the risk of establishing a pine stand that is too dense or too sparse.

    b. Pine has a shorter establishment period. Good seed crops do not occur every year, so the site could be idle for several years before adequate regeneration takes place, thus creating problems with undesirable vegetation. Also, planting may reduce the length of rotation and increase the rate of return on investment.

    c. An adjacent seed source may not be available for natural regeneration of pine. Planting is necessary to establish pines.

    d. Pines have been developed through tree improvement programs that have better form, faster growth and more resistance to insects and disease. Planting, as opposed to natural regeneration, allows using seed from improved sources.

    e. Planting does involve the costs of seedlings, planting, site preparation and control of undesirable vegetation, if needed. However, in most cases, these costs are compensated by the improved growth of planted trees at proper spacings.

7. **Species –** Several pine species are available for planting in Tennessee. Each species has its advantages and disadvantages. The species selected will depend on the site, management objectives, product objectives and costs.

    a. Shortleaf pine: Long-lived tree with dense wood and straight form. Shortleaf is less susceptible to ice damage than loblolly and white pine, but grows slowly and is susceptible to SPB. The market for shortleaf is primarily sawlogs, which requires longer rotation lengths. Seedlings are sometimes difficult to find.

b. Loblolly pine: Fast growth, widely available, inexpensive seedlings. Usually grown at shorter rotations for pulpwood or sawlogs. Loblolly pine is particularly susceptible to ice storm breakage when young and to SPB. Grows on a variety of sites – a "generalist."

c. Eastern white pine: Fast growth and less susceptible to SPB than shortleaf and loblolly. Limited markets and very site-specific. White pine will tolerate some shade as a seedling, but will eventually die unless released to full sunlight. Usually grows best at cooler temperatures at the higher elevations. White pine performs best from the Cumberland Plateau eastward in Tennessee. Will not tolerate excessive heat and droughts. Seedlings are the most expensive of the pines.

8. **Diversify Your Forest and Forest Investment –** A tremendous benefit of planting pine is that early successional habitat and winter cover are created for wildlife. Pine offers many attributes for wildlife that cannot be satisfied entirely by hardwood forests.

Pine provides more frequent income intervals than hardwoods. Considering that the rotation length for most managed hardwoods is 40 to 80 years, the income flow from pine is at a much shorter interval. Diversity of your forest and your forest investment can be provided in two ways by planting pine. First, pine plantations can be established among hardwood tracts. Second, a mixed pine-hardwood planting will provide income flows from pine in the short term, leaving hardwoods for the long term.

Pines of Tennessee

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With more than 14.4 million acres in Tennessee, the forest comprises 55 percent of the land. There are 178 native tree species in the landscape, with nearly 80 percent of the forest in hardwoods such as oaks, hickories, maples and yellow-poplar. The remainder of the forest is a mixture of hardwoods and softwoods, or pure stands of softwoods, including six species of pine. While not a large component of the resource, the pine species adds diversity to both the landscape and the economic market.

Loblolly Pine – Pinus taeda

Loblolly pine is the most important economic pine species in Tennessee and is the "King Pine" of the South, where it makes up more than half of the standing pine volume. However, loblolly pine is not native to most of Tennessee. The species has been able to adapt to the area, thanks mostly to genetic improvements.

Loblolly pine, like most southern pines, is shade-intolerant and focuses a majority of its initial growth on height accumulation. Seedling growth and development is rapid, since it is an early successional species. Over time, associated hardwoods such as oak and hickories will develop in the understory of loblolly pine stands. Loblolly pine can be established on a wide variety of soils, and under most conditions it will grow into the upper canopy on these sites unless seedlings are inhibited by vines, herbaceous plants or other shade-intolerant species. Loblolly pine is a "plastic species" capable of occupying a wide range of soils and site conditions.

Loblolly pine is very susceptible to ice damage, southern pine beetle infestation and fire. Fire should be suppressed until the trees are at least 4 inches in diameter and 20 feet tall.

Loblolly pine is intensively managed in pine plantations, where thinning, fertilization and prescribed fires have all shown improvements in the growth and volume of the stand. Pulpwood and sawtimber products can be grown in relatively short rotations, compared to other pines, under these intensive regimes. Plantation establishment is generally a process of eliminating competing vegetation through fire and herbicide treatments followed by the planting of genetically improved stock. However, natural regeneration processes are also successful in areas with a viable seed source and bare mineral soil. Naturally regenerated lands may require precommercial thinning operations to reduce the growing stock.

White-tailed deer, squirrels and bobwhite quail use loblolly pine stands. Wild turkeys do particularly well on large tracts of mature loblolly where openings have been created through thinnings and fire. The pine warbler, brown-headed nuthatch and Bachman's warbler all make their nests in natural and intensively managed stands.

Virginia Pine – *Pinus virginiana*

Once described as a "forest weed," Virginia or scrub pine is a short-lived, common pioneer species in Tennessee's landscape. Virginia pine occurs on soils with a variety of acidities ranging from pH of 4.6 to 7.9. The soils under a Virginia pine stand are generally more acidic than those under loblolly, shortleaf or white pines.

Virginia pine is an extremely shade-intolerant species, producing heavy seed crops every three years. With its rapid early seedling growth, Virginia pine is the ideal pioneer species, dominating abandoned fields quickly. It can tolerate dry, poor soils and drought conditions better than most pines in the region.

Ice storms can eliminate a Virginia pine stand. The species' susceptibility to heart rot generally makes Virginia pine a pulpwood commodity in the region. Fire is a serious threat to seedlings and young saplings and should be suppressed early on. Thinning is not suggested as a treatment in older Virginia pine stands, due to the windthrow potential resulting from a shallow root system. Recent research has also indicated that Virginia pine may be the most susceptible pine to ozone pollution.

Virginia pine is the most preferred Christmas tree species of the southern pine species, but its real value in Tennessee has been shown on mine spoils and strip-mined sites. The rapid establishment of species and its resilience with respect to the soil's acidic conditions has helped prevent erosion and returned vegetation to these highly altered sites. The species provides winter cover for many fauna. Woodpeckers favor Virginia pine for nesting cavities as individual trees mature and the wood becomes susceptible to fungal decay.

Eastern White Pine – *Pinus strobus*

Eastern white pine was once the pine sought by the British navy for use as ship masts. The species is now used in the log home building industry in Tennessee due to its remarkable durability and ease of working wood. White pine is also favored as a Christmas tree species.

The species occurs in patches and strips along the Cumberland Plateau and the ridges and mountains of the Appalachians. It is intermediately shade-tolerant, allowing it to reproduce under hardwood stands as well as replace itself. Favored as a sawtimber species, early growth is relatively slow during the first three years. Once established, height growth can be as rapid as 3 feet annually.

There are a number of diseases and insects that impact eastern white pine, such as white pine blister rust, the white pine weevil and the southern pine beetle. The species will also not tolerate prolonged heat or droughty conditions, preferring moist and cooler sites at the higher elevations. White pine plantations are not as popular as loblolly pine due to the limited markets in the area, cost of seedlings and a limited seedling supply.

The species is also a poor pruner. Dead branch whorls will remain on the bole of the tree for years after needles have fallen off. This creates difficulties when operating within the stand and as the branches shed, the amount of woody debris builds up on the stand floor. Many species of wildlife use the dense crowns and branches for protection and cover, especially in areas of heavy snowfall.

Shortleaf Pine – *Pinus echinata*

Shortleaf pine was once the dominant pine species in eastern Tennessee prior to the planting of loblolly pine and fire control programs. The species now exists only as remnant groups and individuals on the Cumberland Plateau, Appalachian Mountains and the Ridge and Valley. On the dry, better-drained ridgetops, shortleaf pine will associate better with hardwood species than loblolly pine.

A slow-growing species compared to other pines, shortleaf begins its life as a semi-shade-tolerant species capable of establishing itself under sparse competition. It has demonstrated a consistent diameter growth pattern in areas where it grows in East Tennessee. Once reaching dominant and co-dominant crown position, the species will maintain itself in the stand. Length of time between

adequate seed crops and consistently undesirable seedbed conditions have limited shortleaf pine regeneration over the last 40 years.

Shortleaf pine's slow initial growth is due to the development of a deep taproot system that allows the species to exist on poorer sites. This taproot was historically harvested as pulpwood, while the upper stem was marketed as sawtimber. Today's economic climate makes shortleaf pine a more suitable sawtimber commodity, given the rapid production of pulp by other pines in the region. The tight, dense wood and lack of taper makes it ideal for the log home industry.

Shortleaf pine is susceptible to littleleaf disease in flood-prone areas and the southern pine beetle; however, it shows the most resilience to ice with respect to the other southern pines. Fire is viewed as an asset in shortleaf pine areas, improving the seedbed conditions and eliminating competition. The species is unusual in its ability to sprout from the root collar should mortality occur to the upper stem; this ability has been seen in individuals as large as 8 inches in diameter.

As shortleaf pines reach biological maturity, they become excellent cavity trees for the endangered red-cockaded woodpecker. In mixed hardwood stands, the species also provides winter protection for many small birds and mammals. Currently, the shortleaf pine resource is in danger of disappearing in the Tennessee landscape because of the absence of regular fire occurrences and the length of time between adequate seed crop production.

Table Mountain Pine – *Pinus pungens*

Table Mountain pine occurs on xeric sites in the upper Appalachians on rocky and shale-littered soils. An Appalachian endemic, the species depends upon heat from fires to open its serotinous cones for seed distribution and ample sunlight for regeneration. These trees do not tolerate shade and establish themselves best on exposed soils after a major stand disturbance such as fire.

The suppression of fire has limited the distribution of seed from the serotinous cones, and the species is in decline. The species can be used commercially for pulpwood, but the resource is so limited in size and number that its importance lies more in stabilizing soils and minimizing erosion and runoff from the exposed rocky topographic landscape of its range.

Pitch Pine – *Pinus rigida*

Pitch pine can be found in the mid-elevations of the Appalachian Mountains in East Tennessee. The cones of the species are semi-serotinous, requiring fire or heat to open them. Because of the large amount of resin produced by the tree, the wood of pitch pine is highly resistant to decay. This dense, resinous wood makes it useful for shipbuilding, construction, mine props, railroad ties and fencing.

Pitch pine is best maintained on less fertile, sandy sites where fire is a common occurrence. The seed needs a bare mineral soil to germinate and fire to promote cone opening. Pitch pine has shown an amazing resilience to fire; sprouting after upper stem mortality much like shortleaf pine. However, in areas where severe fire is repeated pitch pine will dominate over shortleaf due to its increased seed production.

Considering that pitch pine is an intolerant, sun-loving species and requires mineral soil for germination, this pine is best managed in even-aged stands with seedbed preparation and control of competing hardwoods.

Like Table Mountain pine and shortleaf pine, pitch pine populations are in decline in Tennessee due to decades of successful fire suppression programs.

Regeneration Methods for Pine

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An important key to successful stand regeneration is to regulate the amount of exposure afforded to the developing seedlings and/or sprouts. Direct sunlight reaching the forest floor is probably the most critical component to the exposure concept. Most of the southern yellow pines that occur in Tennessee are fairly adaptable to a range of micro-site environmental conditions; therefore, several methods may be used to regenerate pine from nearly complete exposure (clearcutting) to other methods that provide more protection (shelterwood). Eastern white pine is more shade-tolerant than the southern yellow pines, but it is also flexible enough for successful regeneration with several methods.

The emphasis in this chapter is upon stand regeneration, not harvesting. The cutting of mature trees is accomplished to make room for the developing regeneration. A regeneration method is a cutting method by which a new age class is created.

Clearcutting Regeneration Method

Clearcutting is used to regenerate an even-aged stand in which a new age class develops in a fully-exposed microclimate after removal, in a single cutting, of all trees in the previous stand. Regeneration is from natural seeding, planted seedlings, sprouts and/or advanced regeneration. All the trees in the mature stand should be harvested to provide the micro-environment in which the developing regeneration will grow well. Species that regenerate clearcut stands are pioneer species, including the pines.

Those stems that are not merchantable, those that would be left standing by the logging operation, should be removed or denied growing space in some other way. These trees are usually of undesirable form and/or species, and they never constitute desirable growing stock for the next stand. Many Tennessee stands have been repeatedly harvested without regard to regeneration provisions for the next stand, and the quality of our forests has consequently deteriorated. These stands are described as high-graded. A silvicultural clearcut creates a new stand.

Advantages of Clearcutting:

1. Favors rapidly growing, high-value pioneer species like cherry, yellow-poplar and pines.

2. Management areas are easily defined and treated.

3. Cultural operations are concentrated in time and space.

4. Neither high-value seed trees nor poorly formed culls are left on site.

5. Beneficial to wildlife that depend upon early successional vegetation, particularly the plants that develop in the fully exposed understory.

6. A diversity of reproductive sources (seed, sprouts, advance regeneration) is available to regenerate the stand, including planting of seedlings to control stocking density, spacing pattern, species composition and genetic composition of the new stand.

7. Prescribed fire, to prepare the seedbed and remove logging debris, can be easily used as a cultural operation.

Disadvantages of Clearcutting:

1. A large amount of debris may be left on site, most of which will have to be treated to minimize its effect upon the developing regeneration.

2. Spacing interval and stocking density are uncontrolled, unless seedlings are planted.

3. Income is not available from the new stand for several years, usually not until the time of the first thinning.

4. Wildlife dependent upon habitat containing mature trees are displaced.

5. Visual quality for many forest users is degraded, due to the rapid change and the abundant logging debris and stumps.

6. Logging debris can present a fire hazard, plus ideal habitat for some harmful insects and diseases.

An even-aged forest is comprised of a number of even-aged stands at all stages of development from seedling stands to those within one year of the rotation age. It provides a tremendous opportunity for the landowner, the wildlife species that live there and those of us who only visit. Because of the disturbance from the total harvest, herbaceous species thrive for a period, something that is highly unlikely in other regeneration methodology. Such plants increase the diversity of habitat for wildlife species, creating niches for some animals and birds that are only duplicated in meadows and fields. The high-intensity silviculture and management operations provide greater economic values to the landowner, and even-aged stands are usually more totally productive than uneven-aged stands, partly due to stand structure and partly due to species differences.

Clearcutting is frequently judged as causing increased soil erosion. Studies have shown that such is not the case. Cutting trees, even on steep slopes, and removing them using Best Management Practices (BMPs) does not cause appreciable erosion. Carelessly constructed roads, regardless of their intended purpose, cause far more stream sedimentation than clearcutting mature stands. Understory plants and leaf litter hold the soil in place within the stands, regardless of the silvicultural operations.

Clearcutting is the preferred regeneration method when planting pine. Artificial regeneration of pine allows the use of genetically improved stock and planting at precise spacings such that each seedling has the full complement of resources to grow well.

Seed Tree Regeneration Method

Seed tree is an even-aged regeneration method in which a new age class develops from seeds that germinate in fully exposed micro-environments after removal of the entire previous stand, except for a small number of trees left to provide seed. Seed trees are removed after regeneration is established. Leaving seed trees on an area to provide the seed for regeneration is neither a new idea, nor is it unique to forestry. Seed trees were often left following natural disturbances, like wildfires. A few trees escaped serious damage and death during the wildfire and found themselves in perfect position to shed seeds upon the freshly prepared seedbed. The seed tree regeneration method is a modified clearcut, in that some trees are left on the site to provide seed, but essentially

the site is as fully exposed as that of a clearcut. The same types of plants and animals that colonize a clearcut also find the seed tree environment to their liking.

Advantages of Seed Tree:

1. Seed are available on each acre, thus the treated area is not restricted as to size or shape.

2. Delayed removal of seed trees is a safeguard against catastrophic loss of regeneration.

3. Species composition can be greatly influenced; choose only the preferred species for seed trees.

4. Regeneration is established without the high costs of planting seedlings.

Disadvantages of Seed Tree:

1. Seed trees may limit site preparation techniques and operations.

2. High-value seed trees may be lost to fire, insects, diseases, windthrow or other hazards.

3. Seed trees may restrict growth of developing seedlings, and logging the seed trees may be too destructive to the seedlings, further increasing the cost of seedling establishment.

4. Natural regeneration from even the best phenotype seed trees may not offer the growth advantages and disease resistance of genetically improved planted seedlings.

5. Precommercial thinning, at cost – not a revenue, is often necessary due to an abundance of seedlings and no control over spacing pattern.

Seed tree regeneration method is often used with pines, especially those native to the Southeast. All seed trees must be windfirm, able to stand for several years by themselves without the support of adjacent canopy. The seeds should be readily dispersed by wind currents, carrying laterally for some distance.

The seed tree regeneration method is not used often today. Most of its advantages are also addressed in the clearcutting method, and many of the disadvantages are not a part of the other regeneration methods. Most landowners would prefer to recover full economic potential from their stands, rather than leave large, high-value trees at risk for several years. Industrial owners have long been aware of the economic gains available to them through tree improvement programs and the use of genetically superior seedlings for planting.

Shelterwood Regeneration Method

A logical extension of the seed tree regeneration philosophy was to leave more trees in the overstory while the regeneration was developing in the understory. Not only would seed dissemination be more uniform, but the seedlings would have the "shelter" of the upper canopies under which to develop. The shelterwood method of regenerating an even-aged stand is where a new age class develops beneath the moderated micro-environment provided by the residual trees. The sequence of treatments can include three distinct types of cutting:

1. an optional preparatory cut to enhance conditions for seed production;
2. an establishment cut to prepare the seed bed and to create a new age class; and
3. a removal cut to release established regeneration from competition with the overwood.

This method is recommended for regenerating eastern white pine, a more shade-tolerant pine species. For the yellow pines that are more shade-intolerant, the overwood "shelter" must be removed within three or four years.

The basic premise of the shelterwood method is regeneration is established under the protection of the upper canopy while the amount of understory exposure (often interpreted to be sunlight) is regulated through a series of partial overstory removal cuts. Gradually, the regeneration is released from the influence of the upper canopies. As it forms an overstory canopy of its own, it becomes the dominant canopy on the site.

Advantages of a Shelterwood:

1. Minimal site disturbance possible or necessary so many of the aesthetical and watershed attributes of the stand remain intact. There is even minimal accumulation of logging debris.

2. The shelterwood overstory often suppresses development of competing vegetation.

3. Residual shelterwood trees continue to produce high-quality, high-dollar, diameter growth until they are removed. They must be removed to maintain the even-aged stand structure.

4. The shelterwood regeneration method is the most flexible of all methods in terms of obtaining regeneration and fulfilling a great diversity of landowner goals and objectives.

Disadvantages of a Shelterwood:

1. Large numbers of residual trees are subject to logging damage, accentuated by the repeated entries into the stand, and they impede harvesting and site preparation operations.

2. Since the overstory will grow after regeneration establishment, increasing canopy cover may hinder regeneration growth.

3. It is possible, during especially good seed years, for too much regeneration to become established, thereby requiring precommercial thinning.

4. Operational costs are high, due to repeated entries and physical limitations on operations.

5. It is not possible to gain benefits from tree improvement programs.

Selection Regeneration Method

Uneven-aged stand structure of three or more ages is maintained through the selection regeneration method. Mature trees, either as single trees or as small groups, are removed when they attain a specified size (usually expressed as maximum-diameter). Advanced regeneration is thereby released to grow into the canopy gap created by the mature tree removal. Depending upon the size of the

canopy gap, one or several of the many thousands of seedlings will eventually develop into mature trees. The stand will be visited often (once each cutting cycle) to tend the developing trees, providing stocking density control and striving to maintain the highest-quality individuals.

Stands must have three distinct age classes, and most will have more, since a new age class is released or created with each stand entry. It is not possible to regenerate and maintain an even-aged stand with the selection regeneration method.

Advantages of Selection:

1. Since the community has no regeneration period and no rotation, a less disturbed appearance is maintained.

2. The stand is less susceptible to catastrophic loss due to wildfire, insect, disease or climatic factors.

3. Habitat is maintained for those wildlife species that prefer continuous forest cover.

4. Continuous forest cover and leaf litter are maintained for site protection.

5. Seed sources are always on site, thereby assuring successful regeneration establishment.

Disadvantages of Selection:

1. The most tolerant species will dominate stand composition, whether or not they are desirable to the landowner.

2. Large volumes of high-quality timber are difficult to produce.

3. Early successional species of plants and animals are adversely affected. Usually there is less wildlife species diversity than with other regeneration methods.

4. Silvicultural operations are extended over a large area, and often repeated (once each cutting cycle).

5. More roads are necessary and they are used more often, thereby increasing erosion potential and maintenance costs.

6. Area-efficient management practices and silviculture operations are difficult to apply, e.g., prescribed burning.

Species that can be successfully regenerated with the selection regeneration method are quite shade-tolerant, forming understories of desirable seedlings while the upper canopies fully occupy the site. For the shade-intolerant pines to be regenerated successfully with the selection method, cutting cycles must be more frequent, usually every five years, pines must be regenerated during each entry and some trees must be removed in all size classes from the smallest (2 inches) to the largest during each entry to ensure that trees from each size class are progressing and growing into the next size class. This sequence of cutting generally is not cost-efficient and is rarely used to regenerate southern pines.

Planning a Planting Project

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Planning the steps to a tree-planting project should follow a sensible chronological order. Doing so will ensure success. Adequate lead time is essential, beginning at least one year prior to the anticipated planting date. It is a building process, one that begins with establishing your personal land management goals, and through a series of steps, is brought to fruition through perseverance.

The following is a checklist for planning your tree-planting project:

1. Seek professional forestry assistance.

Professional foresters from the Tennessee Department of Agriculture Forestry Division (TDA-FD) are available for technical forestry assistance. Serving as your point of initial contact, they can advise you about the steps needed for a successful planting. To locate your local area forester, contact the TDA-FD state office in Nashville at 615-837-5411.

Professionals can use their expertise to evaluate your local conditions (site productivity, competition, etc.) and prescribe several options, each with advantages and disadvantages, to best meet your management goals. Then you can choose the prescription that best fits your management objectives and finances.

Additional limited service is available through the Tennessee Wildlife Resources Agency, the county offices of University of Tennessee Extension and the Natural Resource Conservation Service. Consulting foresters or industry foresters are also worth contacting, and are often the ones who implement forestry projects.

2. Develop a forest-management/tree-planting plan.

Forest management is an involving process, one that is best simplified and organized with an action plan. A plan serves as a guide, clearly establishing your management goals, then outlining steps needed to successfully achieve those goals.

A tree planting plan can stand alone, or can be integrated into a more comprehensive plan that includes all of the forest and wildlife habitat on your property. A comprehensive plan includes components that address timber stand inventory, intermediate stand management, harvesting the forest, wildlife habitat enhancement, protection measures for water/soil resources, recreation, aesthetics and much more.

Your **tree-planting plan** should include these components:

- Ownership goals and objectives;
- Location and maps of the property and planting site;
- Site analysis (soil characteristics, natural features of the land, climatic patterns and biotic factors such as existing vegetation/wildlife/insects etc.);
- Site preparation steps;
- Planting scheme (species to plant, spacing, seedling age, planting method);
- Dates or timetable for implementation;
- Seedling care prior to and during planting;

- Control of woody and herbaceous vegetation;
- Cost-share and tax considerations

3. Secure cost-share funding.

Cost-share funds from both federal and state governments are normally available to offset expenses associated with investments in tree planting. Examples of these programs include the Conservation Reserve Program (CRP) and the Wildlife Habitat Incentive Program (WHIP).

Your professional resource manager can assist you in securing cost-share when available. In most cases, cost-share must be pre-approved in advance of implementing the project. Further, some forest industries have forest management assistance programs that can include reduced seedling cost and management assistance.

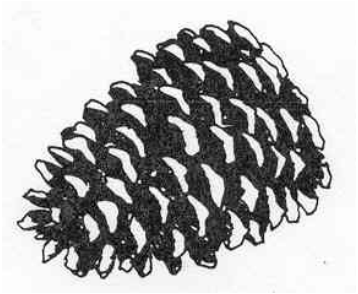
4. Order seedlings.

Demand for seedlings is normally high. To ensure your supply, order them six to nine months in advance of the anticipated planting date. Seedlings are available through TDA-FD and from private nurseries. Lists of private nurseries can be obtained by contacting either your local area forester or University of Tennessee Extension director for your county.

5. Hire a planting contractor.

Unless you intend to plant the seedlings yourself, an independent contractor will be needed to administer the project. Normally contractors are better equipped and have personnel trained to care for your seedlings and plant them properly and at the appropriate time. A separate contractor may be needed for extensive site preparation such as prescribed burning or herbicide application. Check their references, obtain copies of their insurance certificates and use a thorough contract for your and their protection.

Remember, it is better not to have planted your land than to have planted incorrectly. Having a planting plan established will help secure your investment in your land.



Planting Pines

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Tree seedlings receive foremost care while growing in a managed nursery: fertile soil, ample moisture and weed/insect/disease control. Lifting seedlings out of this comfort zone shocks them. Consider: soil is dislodged from their roots, they are handled several times, packaged, shipped, exposed to threatening wind and heat, placed in planting bags or machine buckets, roots unveiled to open air, replanted in often very harsh soil, then left to high temperatures in the hope of adequate precipitation for sustenance through the first few growing seasons.

If planting steps are not carefully followed, mortality rates rise. Seedling survival is more likely if attention is given to the following steps.

1. **Plant in late fall or early winter.**
   In Tennessee, December, January and February are ideal months for planting seedlings. Tree roots grow during cooler months. By planting well before the growing season, roots will settle into their new environment, elongate and begin preparing to supply water to the foliage when warmer temperatures arrive.

2. **Plant on cooler days.**
   Temperatures ranging from 35-55 degrees F are ideal. Higher temperatures could cause transpiration rates to increase and dry the roots. Transpiration is the process by which water vapor leaves a living plant and enters the atmosphere. Lower temperatures could freeze the roots, causing mortality.

3. **Protect seedlings during vehicular transport.**
   Transporting seedlings in an enclosed vehicle is preferred to open-air transport. If open-air must be used, cover the bags of seedlings with a tarp. High winds increase transpiration rates, rapidly drying the roots. It is best to transport on cool days or at cooler times of the day.

4. **Proper seedling storage.**
   Seedlings will remain healthier if they are stored in an enclosed cooler where temperature and moisture are regulated. Keeping the air temperature low and humidity high will slow transpiration. Maintain air temperature at 35-38 degrees F.

   Find a place to store your seedlings well ahead of their arrival from the nursery. When stacking bags of seedlings for long storage, criss-cross them, leaving large air gaps for better ventilation. Otherwise, heat will build near the center of the bags, causing seedling mortality.

   If controlled facilities are not available, or if the seedlings will quickly be planted in the field, store the seedlings in a cool, dark location, away from wind. Periodically inspect the roots and needles to determine if watering is necessary.

5. **Seedling treatment at the planting site.**
   Once on-site, seedlings can deteriorate rapidly. High air temperature and wind place

stress on seedlings. Park your transport vehicles in the shade, in lower spots, shielding the seedlings from destructive elements. Insulation tarps provide desirable protection. Avoid opening seedling bags until near time of planting. Avoid exposing roots to the open air for very long. If air temperature reaches 75 degrees F, planting should cease. Large portable coolers are ideal for field storage of seedlings.

6. **Methods of planting.**
   Two methods are used for planting tree seedlings: hand planting and machine planting. Both are acceptable.

   Hand planting is more common on steeper terrain or in forested areas that have been recently harvested. Hand tools are used to penetrate the soil and create an opening for the roots. Once the seedling is planted, the hole is resealed with the tool and foot pressure.

   A machine planter is normally pulled behind motorized equipment with a 3-point hitch. The planter has a coulter to slice through the soil, a foot to pull the machine below surface level, trencher plates for opening the soil for seedling placement, and packing wheels to re-close and compress the soil. Machine planting as compared to hand planting generally has slightly better survival rates, delivers more consistency in spacing and works best when converting old fields to forest.

   Care should be taken not to "J-root" seedlings, but rather leave the root in a natural, vertical position. Plant seedlings deep, at least to the original level planted while in the nursery, as noted by the darkened ring where the lower stem meets the roots. It is better to plant slightly too deep than too shallow. Make sure that all air pockets are sealed by applying pressure to the soil surrounding the seedling. Straighten seedlings as needed.

7. **Conduct a survival check.**
   For the first two summers after planting, conduct a survival check. If cost-share funds were used to establish the planting, it may be necessary to maintain a certain level of live seedlings. The original planting plan should have specified this minimum survival level. Your forester can assist with your survival check.

Planting Spacing

There is no magic spacing to produce the best results when planting your seedlings. Landowner objectives, markets and level of involvement will help dictate the number of trees per acre that should be planted. Planting density should be guided by the productivity capacity of the site, as well. Planting at initially high stocking levels will result in a stand that reaches canopy closure quicker than a stand with low stocking levels. The denser stand may produce taller stems as individuals compete for sunlight earlier in stand development. A wider spacing limits the competition between trees but also can result in 'bushy' or expanded crowns. Landowners should find a level of stocking that will meet their objectives. The denser the stand, the earlier a thinning will be required to promote continued growth and stand health. Otherwise, the closely planted trees will stagnate and decline, making them more susceptible to southern pine beetle attack. A stand planted on a 5' X 5' spacing would have 1,740 seedlings per acre, while stands planted on a 10' X 10' spacing would initially have 435 seedlings per acre. In areas that are susceptible to southern pine beetle, a spacing of 8' X 10' or 10' X 10' (435 to 600 trees/acre) is recommended to maintain healthy, vigorously growing trees.

Site Preparation

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The most critical time in the life of any stand is just before and during the establishment of regeneration. This period often defines the future composition and productivity of the stand. To actively mitigate conditions to favor landowner objectives, techniques classified as site preparation are often applied prior to the establishment of seedlings. Foresters use site preparation to control competition on the site, prepare the site for planting by removing brush and litter, and prepare the planting beds for seedling establishment.

There are three classifications of site preparation: chemical, mechanical and burning. All three can be used effectively in any combination given the economic constraints of the landowner. Cost-share programs may also be available to help offset the costs of these early operations.

Chemical Site Preparation

Site preparation that uses the systematic application of herbicides is classified as chemical site preparation treatment. The goal of the process is to control dense or unwanted vegetation that might interfere with the survival and development of seedlings. The application of the herbicide can also inhibit competing hardwood sprout competition. Pines are typically shade-intolerant and flourish when direct sunlight is available. The removal of overtopping vegetation increases the survival of planted seedlings. Herbicides leave a lighter footprint on the site compared to mechanical site preparations. The soil is not physically altered and the risk of erosion is minimal.

Herbicides can be applied through aerial application from a fixed-wing aircraft, from a boom sprayer attached to a helicopter or, in areas where this is not economically or physically possible, herbicides can be applied on the ground. Broadcast spraying from backpacks and tractors are common methods as are direct stem injections of the herbicide through either “hack and squirt” applications using an ax or basal sprays applied to individual stems and stumps. On-the-ground applications are often more time intensive and expensive than aerial spraying but are better suited for smaller areas, stands with sparse competition or in stands where only spot treatment is desired.

A professional forester should be contacted prior to using any herbicide to protect water quality and to make sure that all laws and regulations are followed.

Mechanical Site Preparation

Mechanical site preparation works toward removing unwanted vegetation or breaking down logging slash and debris. These techniques are accomplished by using heavy tractors and bulldozers to pile, rake, shear or disk the woody debris and vegetation. By moving the material, foresters are able to prepare a clean planting bed, reduce standing competition, and often till or mix the soil and the organic material to enrich the soils and increase productivity.

Just like many herbicides that can be used in chemical applications, there are many mechanical techniques available, ranging from simply knocking over stand vegetation to pushing the debris into organized piles or windrows.

Mechanical preparation is often used in conjunction with fire, burning the debris once it has been piled together. Mechanical operations are more common than aerial spraying and may be part of the logging contract. Care should be taken to only apply the most intensive mechanical applications on sites where the slopes are not severe nor where the soils are easily erodible. Chances of erosion are increased with mechanical site preparation, because soil is dislodged. Use of best management practices and streamside management zones is essential when applying mechanical site preparation methods. Working with a professional forester will help in deciding how intense the operation should be and the best mechanical application to use.

Fire in Site Preparation

Fire reduces the levels of slash, debris and litter, while releasing nutrients back into the soil. A properly timed fire will kill vegetation that initially invades a harvested stand and will also increase the ease of planting seedlings.

Controlled fire should be used only under ideal conditions. If the site is too wet, the application will be useless. If the site is too dry or wind and weather conditions are not ideal, the fire can burn too hot and create potential short-term nutrient and erosion problems in the area to be planted.

Smoke management should be a priority when applying fire. Considering the liability and safety issues surrounding the application of fire, landowners should always work with a professional forester and double check to ensure that all the proper permits and regulations have been filed and followed.

Research has shown that the better a site is prepared, the more likely that a release treatment will not be needed two or three years later. Investments made prior to the establishment of the stand will result in higher returns when the harvest is conducted.

Herbicides and Release Programs

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Herbicides for vegetation control in forestry are well-established. The development of more cost-effective herbicides and application equipment has led to the increased use of this forest management tool. Economic studies show that significant growth and improved survival are possible when woody and herbaceous competition is controlled.

Herbicide Use

Herbicides are used in many ways:

1. release of newly established seedlings
2. woody release of young trees
3 site preparation to establish a new stand of trees, and
4. mid-rotation hardwood control after an initial thinning.

Most cut-over areas or new sites require some type of site preparation and/or release for successful tree establishment. Vegetation control can also be of value when maintaining natural stands of pines or pine-hardwood mixtures. When pines are planted on old-field or new sites, herbaceous weeds can significantly retard growth and reduce pine survival. In many situations, control of competing vegetation can best be done with herbicides where mechanical control is not possible.

What Are Herbicides?

Herbicides are chemicals that suppress or kill certain plant growth. They affect plants by disrupting some internal growth or development function. Most herbicides do not affect humans and animals when used properly, since our growth and development is different from that of plants. Thus, forest herbicides are considered safe when specific label directions are followed.

Care must be taken when handling concentrated herbicides to protect eyes, internal tissue and skin. Many herbicides are formulated in common petroleum or alcohol type carriers that may cause severe irritation or tissue damage. At a minimum, wear a long-sleeve shirt, long pants, plastic or neoprene gloves and some type of eye protection. Follow specific label requirements for protective clothing and equipment that may be required.

Herbicides registered for forestry uses by the United States Environmental Protection Agency (EPA) and Tennessee Department of Agriculture, Pesticide Division have been well-tested. More than one herbicide and application method may be registered for use on the same site. Choose the herbicide or combination that will most effectively and economically control the targeted plants. Applying an herbicide not registered, or for uses not indicated on the label, is illegal, and may cause adverse effects to non-targeted species or the environment. Always read the label before using any herbicide. Copies of the label(s) and the "Material Safety Data Sheet(s)" (MSDS) must be read and understood before an herbicide application is made. These are available from suppliers and manufacturers. Also get information on endangered species in your area, for there may be restrictions on the use of certain materials. Then, read and carefully follow information on the label and the MSDS for a safe, effective herbicide application.

The laws require that applicators be certified before they can purchase or apply "restricted use" pesticides, but it is suggested that applicators of any pesticide be certified. The certification process will add to your knowledge about herbicide safety and attest to your competency.

Applicators for hire must be certified before they use any pesticide, and they must have a pesticide contractor's license and sufficient liability insurance. Contact the Tennessee Department of Agriculture for further information.

Forest Weeds

Forest weeds are unwanted vegetation that compete or interfere with timber and other resource management objectives. The weeds can be obstacles to regeneration, crop development and growth as they compete for moisture, nutrients and light. They may be classified as weed trees, brush, vines and herbaceous weeds (broadleaf weeds and grasses). The following section addresses weed control as it relates to specific sites.

Site Evaluation

1. **Soil Type:** Soil type influences the effective performance of a herbicide. If the soil is high in clay, a higher rate of an herbicide (within the recommended rate range) is more effective, because herbicides have a tendency to be readily adsorbed to or tied-up by clay particles, making the herbicide less available for weed kill. Herbicides applied to clay soils will not readily leach or volatilize. If the soil is high in sand, a lower rate of an herbicide (within the recommended rate range) is more effective. Because herbicides applied to sandy soils are not readily tied up, they will effectively kill the weeds. However, herbicides applied to sandy soils can be easily leached and volatilized, making long-term weed control more difficult.

2. **Weed Species:** Since susceptibility of plants to herbicides is an important factor in good weed control, the weed species must be properly identified to allow the selection and application of an effective herbicide. If the weed species is not on the herbicide label, the weeds may not be killed.

3. **Pine Species:** There are several pine species, so it is important that the herbicide you use is recommended for the pine species you have planted. Some pine species have good tolerance to an herbicide, while others will not tolerate the herbicide toxicity.

4. **Climatic Conditions:** Climatic conditions such as rainfall and temperatures are critical to the performance of an herbicide. Under normal conditions, adequate moisture and warm temperatures will allow better herbicide uptake and foliar absorption, resulting in better weed kill. If temperatures are too cool (below 50 degrees F), herbicide uptake by roots and leaves will be greatly reduced. If soil moisture is limited (<40 to 50 percent of field capacity), plants are stressed, causing poor herbicide uptake.

5. **Herbicide Selection:** A limited number of herbicides are registered for use in newly planted pines. The selection of an herbicide must be based on the weeds present or expected. If the herbicide has only pre-emergence activity, it must be applied to the soil before weeds begin to emerge. If the herbicide has both pre-emergence and post-emergence activity, it may be applied after weeds emerge but before they get too large (generally not more than 2 to 4 inches tall). If the herbicide has only post-emergence activity, it must be applied after the weeds emerge but before they get too large.

Timeline of a Pine Plantation

YEAR 0:

Harvesting of original stand

Site Preparation
Mechanical

Fire

Herbicides

YEAR 1:

Planting the site

YEARS 2 through 5:

Release (post-event pictured)

YEAR 5

Fertilization

YEARS 12 through 18

Thinning

Prescribed fire for wildlife objectives

A Mature Sawtimber Pine Stand Ready for Harvest

Images were supplied by ForestryImages.org and Dr. Wayne Clatterbuck.

Why plant pine?

1. Better suited for marginal sites than hardwoods.
2. Easier and less costly to plant than hardwoods.
3. Shorter rotations are more economically attractive than long hardwood rotations.
4. Planting gives more control over spacing and shortens the establishment period.
5. Planting allows for the use of improved genetic stock.
6. Several species of pine with varying benefits are available for planting in Tennessee.

6. Herbicide Application: If the application and equipment calibration is not completed correctly, the treatment will not achieve maximum performance. Therefore, it is important to use the correct volume and pressure and appropriate equipment. If a band treatment is used, the bandwidth should correspond to the weed species. If the weed species present are of the low-growing type, such as grasses (except Bermuda), a 3- to 4-foot band is adequate. If weed species are of the tall-growing type, a 5- to 6-foot band is recommended.

Herbicides can be applied in a variety of ways. Some applicators work on the ground, spreading the herbicide using backpack sprayers or tractor-mounted mist-blowers. Other methods are more physically demanding, using a 'hack-and-squirt' method that depends on injecting the tree using a hydro-hatchet or a spray bottle. Herbicides can also safely be applied aerially from a helicopter. New advances in technology have greatly improved this application technique. GPS units monitor exact placement of the applications and a wide range of nozzle gauges effectively govern the application rates.

Pine Release Programs

Woody vegetation control includes control of competing trees, shrubs and woody vines. This is for the release of 2- to 5-year-old stands of pine trees from competition or for site preparation of cut-over areas to permit the establishment of a new stand. In pine production areas, this usually means control of the less desirable hardwood species. Herbicides are also used for mid-rotation hardwood control after the first thinning. This application improves pine development and wildlife habitat.

Appropriate application methods are specified on herbicide labels. Currently labeled herbicides and their recommended rates are updated each year. Additional information is available at your county Extension office or chemical dealer.

This information should help you understand the requirements for an effective, economical and safe vegetation control operation. Various herbicides are registered for use in planted pines. These herbicides or herbicide combinations will not give 100 percent control of all weed species, but if treatments are properly applied and conditions are favorable, adequate control will be obtained. It is important that all herbicide treatments be made at the appropriate time. The following tables list herbicides and uses for weed control in pines.

Precautionary Statement

To protect people and the environment, herbicides should be used safely. This is everyone's responsibility, especially the user. Read and follow label directions carefully before you buy, mix, apply, store or dispose of an herbicide. According to laws regulating herbicides, they must be used only as directed by the label.

Disclaimer

Herbicides recommended in this publication were registered for the prescribed uses when printed. Herbicide registrations are continuously being reviewed. Should registration of a recommended herbicide be cancelled, it would no longer be recommended by the University of Tennessee or Tennessee State University.

Use of trade or brand names in this publication is for clarity and information; it does not imply approval of the product to the exclusion of others, which may be of similar, suitable composition, nor does it guarantee or warrant the standard of the product.

Table 1. Herbicides for Herbaceous Weed Control in Pine Plantations.

HERBICIDE FORMULATION	RATE/ACRE (BROADCAST)	REMARKS & PRECAUTIONS
Atrazine (AAtrex Nine-0 & other trade names)* or (AAtrex 4L & other rade names)*	2.2 - 4.4 lbs. Nine-0 or 4 - 8 pts. 4L	Atrazine provides both preemergence and postemergence activity. Apply in a minimum of 10 gallons of water per acre. Application may be made as a directed spray or over the top of pines, but before weeds exceed 1.5 inches. This treatment will control many annual grasses and broadleaf weeds. The addition of an oil concentrate containing 1 percent to 20 percent surfactant will improve the control of existing weeds. Use only on loblolly and slash pines.
Fluazifop-P-buytl 2.0 lb. a.i./gal. (Fusilade DX)	16-24 oz..	Apply in at least 25 gallons of water per acre. Application should be made over the top of pines and actively growing grasses. Always add 1.0 percent crop oil concentrate, or 0.25 percent of a non-ionic surfactant by volume. This treatment will give only post emergence control of grassy weeds. A split application may be necessary for perennial grasses. Fusilade will not control broadleaf weeds or sedges. Fusilade may be used on all pine species.
Glyphosate (Accord) + Sulfometuron methyl (Oust) 75 DF	16 - 24 oz. Loblolly 12 - 16 oz. Slash + 1 - 4 oz.	Apply in at least 25 gallons of water per acre. Application should be made to actively growing broadleaf weeds and grasses. Non-ionic surfactant at 0.25 percent by volume should be added to help improve control. Do not apply this mixture during rapid candle expansion when over-the-top application is contemplated. This treatment will control many grasses, broadleaves and sedges and give suppression of blackberries/brambles. Use only on loblolly and slash pines. Do not exceed 16 fl. oz. of Accord on slash pines.
Imazapyr Arsenal – 4E (Applicators Concentrate)	4-10 oz.	Apply over-the-top or as a directed spray to pines. Apply in at least 25 gallons of water/A. The addition of 0.25 percent of a non-ionic surfactant by volume will help improve control. This treatment will provide good control of most grasses and broadleaf weeds and suppression of blackberries/brambles. This treatment is a good fit in areas where Johnsongrass and Bermuda grass are serious problems. Arsenal will provide both preemergence and postemergence weed control. Use 6.0-10 fl. oz. on loblolly pines, 4-8 fl. oz on slash pines and 4-6 fl oz on long leaf pines.
Metsulfuron methyl (Escort) 60 DF	0.5 - 1 1/2 oz.	Apply over-the-top or directed in at least 25 gallons of water/A for the control of many broadleaf weeds. This treatment is especially good where blackberries and brambles are a problem. Do not use a surfactant when treating pine trees that are less than 1 year old. Use only on loblolly and slash pines.
Clethodim (Envoy) 0.94 lbs. a.i./gal.	13 to 17 ozs.	Apply over the top for control of annual and perennial grasses. Make application in enough water for good coverage (20-30 gallons per acre). The addition of a crop oil concentrate on a non-ionic surfactant will improve control. This treatment may be used on all pine species. Do not apply under drought conditions.
Sethoxydim (Vantage) 1.0 L	2 1/4 - 3 3/4 pts.	Apply in at least 25 gallons of water to actively growing grassy weeds. A split application may be necessary to help control perennial grasses. Do not add surfactant or crop oil to Vantage. This treatment will not control sedges or broadleaf weeds.
Sulfometuron methyl (Oust)	1 - 8 oz. depending on soil pH	Controls herbaceous weeds in loblolly, slash, longleaf and Virginia pine. Do not use a surfactant. Use broadcast or band application before or just after weed emergence.
Sulfometuron methyl (Oust) + Hexazinone (Velpar L)	1 - 4 oz. + 2 - 3 pts.	Apply in at least 20 gallons of water/A for the control of many broadleaf weeds, vines and small woody plants. This treatment is especially good in areas where sprouts from roots of woody plants might become a serious problem.

HERBICIDE FORMULATION	RATE/ACRE (BROADCAST)	REMARKS & PRECAUTIONS
Sulfometuron methyl + Hexazinone (Oustar) 75 DF	Rates vary by soil texture & seedling age and species. *(See Label)*	Apply Oustar to loblolly pines, slash pines or longleaf pine seedling for the control of many grasses and broadleaf weeds. Make application of 12-16 oz./A to first-year seedlings established for more than one year. Make application in 10-40 gallons per acre. Do not apply under drought-stressed conditions.
Sulfometuron methyl (Oust) 75 DF + Metsulfuron methyl (Escort) 60 DF	1 -3 oz. + 0.5 - 1.5 oz.	For control of blackberry and herbaceous weeds in loblolly pine plantations. Apply from late winter through spring after soil has settled after planting. Do not use a surfactant.

Table 2. Herbicides for Site Preparation.

HERBICIDE FORMULATION	RATE/ACRE (BROADCAST)	REMARKS & PRECAUTIONS
Picloram (Tordon K)* 2 lbs. a.i./gal.	2 qts.	Apply 5-25 gallons spray mix by air or 10 to 100 gallons mix by ground. Do not plant pines sooner than six months after treatment.
Triclopyr (Garlon 3A) 3 lb. a.i./gal.	2 - 3 gals.	Conifers planted sooner than two months after treatment may be injured.
Triclopyr (Garlon 4) 4 lb. a.i./gal.	4 - 8 qts.	Apply when target vegetation is actively growing. Apply to foliage with 5 - 25 gal. spray volume per acre by air or 10 - 100 gal. by ground.
Picloram + 2,4-D (Tordon 101M)* 2.5 lb. a.i./gal.	6 - 8 qts.	Delay planting of pines for at least six months following treatment to avoid pine seedling injury.
Imazapyr (Arsenal) 4 lbs. a.i./gal.	1 1/2 - 2 1/2 pts.	Use a minimum of ¼ percent by volume of nonionic surfactant in the spray mix.
Imazapyr (Chopper) 2 lbs. a.i./gal.	40 - 80 oz.	Enhance brownup by applying Chopper in a 12-50 percent oil:water (volume:volume) emulsion carrier. Methylated or ethylated seed oils containing at least 50 percent esterfied seed oil by volume are recommended.
2, 4-D (Various trade names)	Varies by active ingredient	Check specific product labels for rates. Provides broadleaf weed control. Typically, apply recommended rate in 10 gal. of solution by air or 20 gal. by ground. Do not apply to established plantations as injury to planted pines will occur.
Hexazinone (Velpar ULW)	2 1/2 - 8 lbs.	Controls herbaceous weeds and plants. Soluble granular formulation. Apply using DuPont ULW Applicator aerial equipment in spring when weeds and brush are actively growing. Rainfall is needed for activation. Use lower rates on coarse-texture soils and soil low in organic matter. Do not use on poorly drained or marshy sites. Maximum results will be seen in 12-24 months following treatment. Allow treated brush and trees to defoliate twice before burning.
Hexazinone (Velpar L)	1 - 3 gals.	Controls herbaceous weeds, brush and trees. Apply liquid mix in at least 5 gal./A by air or 25 gal./A by ground. Treat from bud break in late winter to early summer. Allow brush to defoliate twice before burning.
Metsulfuron methyl (Escort)	1/2 - 3 1/3 oz.	For control of blackberry and other broadleaf weeds use 1/2 - 1 1/2 ozs. Use 3 1/3 ozs. for control of cherry, locust, palmetto and honeysuckle. Loblolly and slash pine only.

HERBICIDE FORMULATION	RATE/ACRE (BROADCAST)	REMARKS & PRECAUTIONS
Sulfometuron methyl (Oust)	1 - 8 ozs. depending on soil pH	Add 0.25 percent by volume surfactant for improved control. Use lower rates on coarse-textured loamy sands, sandy loams soils and higher rates on fine-textured sandy clay loam and silty clay loam soils. Apply just before or just after weed emergence and when rainfall will activate Oust in the soil.
Glyphosate (Accord) 4 lbs. a.i./gal.	2 - 5 qts. *Directed/spot spray 3/4 - 2% by volume*	May increase Accord rate to 10 qts./A for hard-to-control trees, brush and weeds. A nonionic surfactant must be used with Accord. For surfactants with more than 50 percent a.i., mix 2 qts. surfactant per 100 gal. of spray solution. Surfactants less than 50 percent a.i. mix 4 qts. surfactant per 100 gal. spray solution. Apply to actively growing trees, brush, and weeds after full leaf expansion and before fall color and leaf drop. Aerial broadcast - apply 5-30 gal./A spray volume; ground broadcast - apply 10-60 gal./A spray volume; direct/spot spray - spray to wet foliage.
Glyphosate (Accord Site Prep) 4 lbs. a.i./gal.	2 - 10 qts. *Directed/spot spray 3/4 - 2% by volume*	This formulation contains a surfactant. Do not use this formulation as an over-the-top pine release treatment as damage to desired conifers will occur. Apply to actively growing trees, brush and weeds after full leaf expansion and before fall color and leaf drop. Aerial broadcast - apply 5-30 gal./A spray volume; ground broadcast - apply 10-60 gal./A spray volume; direct/spot spray - spray to wet foliage.

Table 3. Herbicide Tank Mixes for Site Preparation.

HERBICIDE FORMULATION	RATE/ACRE (BROADCAST)	REMARKS & PRECAUTIONS
Triclopyr (Garlon 4) + Imazapyr (Arsenal)	2 - 4 qts. + 16 - 24 ozs.	Conifers planted sooner than one month after treatment may be injured.
Picloram + 2, 4-D (Tordon 101M)* + Glyphosate (Accord)	6 - 10 qts. 3 - 5 qts.	Allow at least six months after treatment before planting pines.
Picloram + 2,4-D (Tordon 101M)* + Imazapyr (Arsenal)	6 - 10 qts. + 16 - 24 oz.	Allow at least six months after treatment before planting pines.
Triclopyr (Garlon 4) + Picloram + 2,4-D (Tordon 101M)*	2 - 4 qts. + 6 - 8 qts.	Allow at least six months after treatment before planting pines.
Triclopyr (Garlon 4) + Picloram (Tordon K)*	2 - 4 qts. + 2 - 2 1/2 qts.	Allow at least six months after treatment before planting pines.

HERBICIDE FORMULATION	RATE/ACRE (BROADCAST)	REMARKS & PRECAUTIONS
Glyphosate (Accord) 4 lbs. a.i./gal. + Picloram (Tordon K)*	3 - 5 qts. + 2 qts./A	Wood brush, trees and herbaceous weeds mix 2 or more qts. of a nonionic surfactant per 100 gal. of spray solutions. Apply tank mix solution at 10-50 gal./A with ground application, or 5-30 gal./A by aerial (helicopter only) application. Allow 6 months after treatment before planting pine seedlings.
Glyphosate (Accord) 4 lbs. a.i./gal. + Imazapyr (Arsenal)	3 - 6 qts. + 2 - 16 oz.	Use lower rates for herbaceous weed control. Higher rates for dense stands or hard-to-control brush and trees. Use a nonionic surfactant, mix 2 or more qts. nonionic surfactant per 100 gal. spray solution. Ground application - spray 10-60 gal. of tank mix per acre; aerial (helicopter) application - spray 5-30 gal. tank mix per acre. Apply after full leaf expansion until start of fall color.
Glyphosate (Accord) 4 lbs. a.i./gal. + Sulfometuron methyl (Oust)	2 - 5 qts. + 1 - 4 ozs.	Mix 2 or more qts. nonionic surfactant per 100 gal. of spray solution. Ground application - apply 10-60 gal./A tank mix; aerial (helicopter) application - apply 5-15 gal./A tank mix. Treat after full leaf expansion until start of fall color.
Glyphosate (Accord) 4 lbs. a.i./gal. + Triclopyr (Garlon 4)	3 - 5 qts. + 1 - 2 qts.	Mix 2 or more qts. of nonionic surfactant per 100 gal. of tank mix. Apply 10-60 gal. of tank mix per acre by ground application or 5-30 gal. per acre by helicopter. Treat in late spring through early summer.

Table 4. Herbicides for Injection, Directed and Spot Spray Treatments.

HERBICIDE FORMULATION	APPLICATION	REMARKS & PRECAUTIONS
2,4-D (Various trade names)	Basal spray	Spray the lower 18-24 inches of plant stem with undiluted spray.
	Stump treatment	Spray the bark and root collar area of the stump thoroughly with undiluted spray.
Glyphosate (Various trade names)	Post directed spray 0.5 - 10% solution	May be applied as a shielded or directed spray to the base of the trees. DO NOT apply over-the-top of desirable seedlings. Severe injury to trees will occur if the spray contacts the foliage. Use a 0.5 percent solution for control of annual weeds less than 6" tall (add a nonionic surfactant). A 1- 2 percent solution will control perennial weeds. Use 5 percent solution for annual & perennial weed control if spray coverage is not complete. Use a 5-10 percent solution for woody brush & trees. Refer to the label for rates and surfactant recommendations for specific perennial weeds.
Hexazinone (Velpar L)	Basal Soil Treatment 2-4 ml/inch DBH	Apply to root zone of undesirable hardwoods with a handgun application. Use 2-4 ml per inch of tree diameter at breast height on trees to be controlled. Place spots within 3 feet of root collar of trees to be controlled.
Hexazinone (Velpar L)	Injection	Inject 1 ml of undiluted Velpar L through bark of undesirable trees. Injections should be made at 4" intervals around stem. Treat in summer. Controls black cherry, oaks, red maple, sweetgum.

HERBICIDE FORMULATION	RATE/ACRE (BROADCAST)	REMARKS & PRECAUTIONS
Imazapyr (Arsenal or Chopper)	Cut stump Treatment	Use a diluted solution of 4-6 oz. Arsenal or 8-16 oz. Chopper + one gal. water and spray or brush on to cambium area inside the bark of freshly cut stump.
	Injection	Apply 1 ml of diluted solution at 1-inch interval cuts through the bark around the tree. A concentrated solution of 2 qts. Arsenal + 2 qts. water can be used for injection at 1 ml for each 4 inches of tree diameter.
	Frill or girdle	Spray or brush a diluted Arsenal solution into cuts placed at 2-inch intervals around the tree. If the concentrated solution (20 percent Arsenal or 40 percent Chopper) is used, make one cut into the stem for each 4 inches of tree diameter and spray or brush the concentrated Arsenal solution into each cut. For example a 4-inch diameter stem will receive 1 cut while an 8-inch diameter stem will receive two cuts.
Picloram + 2,4-D (Pathway, Tordon 101R)	Tree injection	Apply 1 ml of undiluted Pathway through the bark completely around the stem at 2-3 inch intervals. Treatment can be made any season. Do not treat maple during spring sap flow. Dogwood and hickory may require application to continuous overlapping cuts around the stem.
	Stump treatment	Treat the cambium layer just inside of the bark of freshly cut stumps with undiluted Pathway.
Picloram + 2,4-D (Tordon 101M)*	Tree injection	Inject 1/2 ml of undiluted Tordon 101M or 1 ml of diluted (1:1 ratio in water) through the bark of undesirable trees at 3-inch intervals around the stem.
	Stump treatment	Spray the cambium area inside the bark of freshly cut stump with undiluted or diluted (1:1) Tordon 101M.
Triclopyr (Forestry Garlon 4) + Oil	Thinline or streamline	Tank mix 20 – 30 percent Garlon 4 + 70 – 80 percent oil. Apply with a small orifice solid-stream nozzle. Make two streaks across the lower stem of smooth bark hardwoods smaller than 3 inches in diameter. Application can be made in any season. Generally most effective six weeks prior to leaf expansion, until two months after.
Triclopyr (Garlon 3A)	Tree injection Hack & squirt	Inject or spray 1/2 ml of undiluted or 1 ml of diluted (1:1 in water) through bark at 3-to 4-inch intervals around the stem.
	Stump treatment	Spray the cambium area inside the bark of freshly cut stumps with undiluted Garlon 3A.

Table 5. Herbicides for Pine Release from Hardwoods.

HERBICIDE FORMULATION	RATE/ACRE (BROADCAST)	REMARKS & PRECAUTIONS
Hexazinone (Velpar ULW)	1 - 4 lbs.	Soluble granular material. Applied using DuPont ULW applicator aerial equipment. Apply in spring when weeds and brush are actively growing. Do not apply to loblolly pine less than 4 years old when transplanting on coarse-textured soils, or less than 3 years from transplanting on fine-textured soils. Some conifer mortality may occur if applied when saplings are under stress.
Triclopyr (Garlon 4)	Directed spray only	To release conifers from red maple, sweetgum, oaks and hickory, mix 1-5 gal. Garlon 4 in water to make 100 gal. of mix. Direct spray to foliage of hardwoods using a backpack sprayer with flat fan nozzle. Hardwoods less than 6 feet tall are most effectively treated. Treatment can occur any time after hardwoods reach full leaf and before onset of fall color. Direct spray away from desirable conifer foliage.
	2 - 4 qts/A	Broadcast application for mid-rotation understory brush control in flatwoods pine stands. For control of gallberry & wax myrtle, apply 2 - 4 qts of Forestry Garlon 4 to to cover the foliage of understory competition, but DO NOT spray onto pines. Make applications from late summer (August) to fall (before leaf fall). Apply 30 gallons of water per acre. Forestry Garlon 4 may be tank mixed with Arsenal or Escort to increase control of palmetto, titi, fetterbush, etc.

HERBICIDE FORMULATION	RATE/ACRE (BROADCAST)	REMARKS & PRECAUTIONS
Hexazinone (Velpar L)	Spot Grid Treatment 2 - 8 qts.	Apply undiluted Velpar L on a grid pattern (3' x 3' to 6' x 7') to transplants 1 year old or 4 years and older. Injury may occur if pines are 2-3 years old. Use an application of 2 - 2.33 ml per spot depending on soil texture.
	2 - 8 qts.	Apply when loblolly pine is between flushes or growth spurts and from early spring to early summer when hardwoods are in 1/2 leaf to point of full leaf growth. Do not use a surfactant. Some pine mortality may occur, and some pines may show discolored foliage. 1 - 2 inches of rain are needed for soil activation.
Metsulfuron methyl (Escort)	½ to 1- ½ oz.	For the release of loblolly & slash pine from hardwoods and brush. Treat when pines are at least 3 years old on fine-textured soils, 4 years and older on coarse-textured soils. Apply from full leaf to just before leaf tissue hardens in the fall.
Metsulfuron methyl (Escort) + Imazapyr (Arsenal)	1/2 - 1 1/2 oz. + 1 pt.	In 2-year-old loblolly pine plantations controls blackberry, blackgum, elm, cherry and broadleaf weeds. Apply with 1 qt. surfactant in 100 gal. in late summer, early fall.
Metsulfuron methyl (Escort) + Sulfometuron methyl (Oust)	½ to 1- ½ oz. + 1 to 3 oz.	Release of loblolly pine from hardwoods and brush. Treat when pines are at least 3 years old on fine textured soils, 4 years and older on coarse-textured soils. Apply from full leaf to just before leaf tissue hardens in the fall.
Metsulfuron methyl (Escort) + Hexazinone (Velpar L)	1/2 - 1 1/2 oz. + 1 1/2 - 6 qts.	Brush and herbaceous weed control in 1-year-old loblolly pine plantations. Do not use a surfactant.
Glyphosate (Accord) + Imazapyr (Arsenal)	1 1/2 - 2 qts. + 1 pt.	Apply after final resting buds have formed on conifers in the fall. Actively growing conifers will be damaged. Follow Accord label recommendation for surfactant use. Will control wood brush, trees and herbaceous weeds.
Glyphosate (Accord)	1.5 - 2.5 qts.	For release from herbaceous weeds and wood sprouts in loblolly and slash pine plantations that have been established for more than one year. Mix up to 20 fluid oz. /A of Entry II or comparable nonionic surfactant. Apply in late summer to early fall after pines have hardened off.
Imazapyr (Arsenal)	1-2 pts.	Used as a broadcast to release loblolly pine from competition. Apply to loblolly plantations that have been established for two or more growing seasons in the field and after formation of final pine resting buds in the fall. Do not apply to pines under environmental stress.
	Directed spray 1/2 - 5% solution	Apply to foliage and buds of undesirable hardwoods competing with pines by a low-volume directed spray. Avoid application to foliage of desirable pines. Use a nonionic surfactant at ¼ percent by volume.
Triclopyr (Garlon 3A)	Directed spray	For the release conifers from red maple, sweetgum, oaks, ash and hickory, mix 1-5 gal. of Garlon 3A in 100 gal. water + a nonionic surfactant. Apply as a directed spray to the foliage of weed trees with a backpack sprayer. Treat after hardwoods have leafed out and before fall coloration. Hardwoods less than 6 feet tall are most economically and safely treated. Direct spray away from foliage of desired pines.
Triclopyr (Pathfinder II) 0.75 lbs. a.i./gal.	Streamline Basal Bark Treatment	Apply undiluted product in a directed, straight-stream spray to one side of stems less than 3 inches in basal diameter to treat a 6-inch-wide zone on the stem 1 to 2 feet above ground. On stems 3 to 4 inches in basal diameter, treat both sides of the stems. Apply in spring six weeks prior to hardwood leaf expansion until two months after leaf expansion is completed.

Thinning Pine Stands

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As pine stands grow and mature, individual trees compete for light, soil moisture, nutrients and space. Many trees are crowded by faster-growing neighbors and die. Thousands of pine seedlings populate a naturally seeded acre. In a plantation, usually 500 to 800 seedlings are planted. However, at maturity only 50 to 100 large-diameter, sawtimber pine trees, greater than 20 inches, remain. More than 90 percent of the trees die. This mortality is a natural progressive process in the forest. As trees grow larger and because of limited amounts of space and resources, over time the environmental constraints limit the number of survivors in the stand.

Thinning is a forestry technique that mimics this natural process of mortality under the guidance of a trained professional. By applying cuts to immature stands, material that might otherwise die before rotation age can be used and growth can be concentrated on fewer, more desirable stems left in the stand. Thinning improves the conditions within the residual stand by providing increased growing space and availability of sunlight for individual trees. The increased growth, vigor and space available to these trees produce a healthier stand. The residual or remaining trees may be selected to meet any landowner objective such as wildlife, timber or aesthetics, but the result will ultimately reduce the time required for trees to reach a target diameter class. The decreased rotation length shortens the period of return on the landowner's investment. If markets are available, some intermediate returns are possible from the thinned material removed.

When to Thin?

While there is no "magic" number of years to wait until applying a thinning, several indicators suggest when thinning should occur. As trees grow and mature, their crowns will begin to compete for available sunlight. Eventually this crown competition will result in a forest with a closed canopy, where sunlight does not reach the forest floor. This indicates that the tree crowns no longer have space to grow and expand. A thinning should be applied. A more quantifiable estimate of when to thin based on crown structure is when live crown ratios are less than 33 percent. The live crown ratio is the height of the crown divided by the height of the tree. Live crown ratios decrease because sunlight is not getting to the lower branches, decreasing the photosynthetic area of the tree, and resulting in mortality of lower branches.

Basal area per acre is another good estimate of when to thin. Basal area is a measure of stand density. Basal area is the sum of the surface area in square feet taken by an individual tree trunk at 4.5 feet for all the individuals growing on an acre. As basal area exceeds 120 square feet per acre, individual tree growth declines and the stand becomes unhealthy. For most pine stands, a thinning that results in 70 to 90 square feet of residual basal area per acre represents an ideal stocking rate. A 14-inch tree is approximately 1 square foot of basal area.

What to Thin?

Which trees to remove will depend upon landowner objectives. For timber production, undesirable species, poor-formed trees and slow-growing individuals are removed. Wildlife considerations may leave some of the poor-formed or cull trees to provide habitat. How much to thin will depend on objectives as well, but it must be enough trees for loggers to make a profit. A common mistake in thinning is to leave too many trees in the residual stand. Generally, 40 to 60 percent of the trees are

harvested during a thinning. Several thinnings may take place before the stand reaches maturity. At final harvest, when pine trees have reached sawtimber size, usually 80 to 100 trees per acre remain.

How to Thin?

Depending on when the stand is thinned, the cut can be deemed either a precommercial or commercial thin.

Precommercial thins are generally required in stands that are naturally regenerated, where thousands of seedlings per acre are established. The goal of a precommercial thin is to reduce stocking to 400 to 600 seedlings per acre. There is no merchantable material removed during this thinning; thus, it occurs at an expense. However, the removal of the excess seedlings will prevent tree stagnation and improve stand growth and development. To minimize cost, precommercial thinnings should be conducted before the stand is 4 years old. Mowing strips across the stand, leaving seedlings in 1- to 2-foot-wide rows, will quickly reduce the total number of seedlings. Row width is dependent upon seedling density.

Commercial thinnings occur typically when the stand is 12 to 18 years of age and can provide some intermediate return on long-term forest investments. There are traditionally two methods of commercial thinning: row and selection. A row thinning is the easiest thinning method to apply. With little regard to crown class, rows of pines are selected and removed, providing additional growing space for trees in the leave rows. This method is easy to mark and to implement.

A selection thinning requires a more acute eye. Selection thinnings favor only the best trees by removing the inferior individuals and producing a consistent spacing around the leave trees. This allows the favored leave trees to use the additional growing space and mature into the desired product size. The removal of the smaller, inferior trees may or may not produce an immediate economic return from the cut.

Summary of Thinning

Mortality is an inescapable function of nature. By actively managing pine stands, this mortality can be reduced by allowing select individuals to take advantage of additional space, sunlight and nutrients. The fundamental results from thinning are the improvement of stand health and growth and a reduction in the rotation length. Many of the pine stands devastated by the southern pine beetle outbreak of 1998 were over-stocked and growing poorly. A properly timed thinning will help prevent that situation from occurring in the future.

Fertilization

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Fertilization is a silvicultural practice used to increase forest productivity. Typically the process is only used in intensively managed plantations of loblolly pine. Nutrient demand is greatest in stands when the crowns of the trees are rapidly expanding. Large quantities of nitrogen, phosphorous, potassium and calcium are required to meet the growing needs of individual trees. Younger stands differ in their nutrient requirements when compared to older, established stands. This is due to the size of the root systems, as well as the changes in nutrient levels contained in the soils. As the stands age, they must seek nutrients from the more acidic and less fertile lower soil horizons or depend upon the replenishment of the nutrient pool in the upper soil horizons.

Harvesting and site preparation techniques often increase the availability of nutrients on all sites, with the exception of the most infertile soils. Specifically, harvesting and site preparation increases levels of nitrogen to limits exceeding those required by young seedlings. This increased nutrient availability is often demonstrated in rapid early growth of herbaceous and woody vegetation that may compete with planted pines.

On sites where nitrogen and phosphorus are limited, diammonium phosphate or DAP is recommended. Fertilizers containing potassium and other trace nutrients can be applied as indicated by a soil test. Where needed, these nutrients can be applied cheaply in the form of potassium chloride or "potash."

Fertilization should occur in newly established stands less than 5 years of age only when foliar analysis indicates nutrient deficiencies. Typically, fertilization is used as a mid-rotation treatment, coupled with a thinning, and is applied in the late spring or early summer. Application rates vary with soil types. Prior to any applications, the local soil scientist or Extension agent should test the soils for nutrient availability or deficiencies. The fertilizer can be applied in strips and bands or broadcast across the entire stand, but either method needs to stress the importance of uniform application. Irregular growth patterns may result from unbalanced distribution.

Fertilization should increase stand volume and value resulting from quicker stand development. Combining fertilization with proper site preparation, competition control and well-timed thins will increase the return from the investment, as will focusing rotations on the more valuable products, such as sawtimber. In areas where pulpwood values are regularly high, fertilization will assist in producing product at shorter rotations.

Fertilization is used to enhance growth of pines, especially on poorer sites. Some have portrayed fertilization as a substitute to nutrient depletion on these sites. Most operations in the region remove only stem-wood, leaving tops and root systems on the site. This remaining debris contains most of the recyclable nutrients and will maintain nutrient baseline levels. Concern of nutrient depletion should only become a factor if a whole-tree harvest removal system is used.

Pine Pests and Diseases

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A variety of insects and diseases can afflict pine stands. In most cases, active management and planning can lower the probability that your stand will succumb to any outbreaks or infestations. A key to protecting stands is to promote vigor and growth of healthy trees by protecting your stand from overcrowding, salvaging damaged trees and removing diseased or older trees.

Insects

The southern pine beetle is the most destructive forest insect in the southern United States. Because populations build rapidly to outbreak proportions and large numbers of trees are killed, this insect generates considerable concern among managers of southern pine forests. In 1750, Moravian settlers described the destruction of vast amounts of pine timber due to the "mischief" of these bark beetles. These tiny cylindrical beetles, averaging 2 to 4 mm in length or roughly the size of a grain of rice, are brownish to black with a broad head and a well-developed mouth for voracious chewing.

The beetle begins life as an egg deposited in a winding "S"-shaped gallery in the cambium layer, between the bark and the wood of the pine tree. In this gallery they mature into adults. One life cycle or generation of beetles from egg to adult may take anywhere from 26 to 54 days, depending upon the season. While development of the beetle takes place throughout the year, it slows considerably in the winter and increases in the spring and summer as temperatures warm. Several generations of southern pine beetle occur annually.

From 1999 to 2002, Tennessee experienced the worst epidemic of southern pine beetles since the 1970s. Approximately 350,000 acres of pine timber, valued at $358 million, were affected. Of 69 infested counties, infestations in 57 reached epidemic levels. The most obvious symptom of a southern pine beetle infestation is the discoloration of the needles in the tree's crown. They will fade from green to dull green, yellowish and finally reddish-brown before falling. This needle fade can be easily seen from the ground or the air.

Crown discoloration is just one sign of beetle intrusion. As the beetles enter the trunk of the tree, small light yellow to white pitch tubes usually form. These masses of pitch are about the shape and color of popcorn and similar in size. In areas where the trees are especially weak, pitch tubes may not be formed. Instead, a collection of reddish boring dust can be found in the bark crevices or along the base of a tree. Other traces of evidence that the southern pine beetle leaves behind are the winding, "S"-shaped egg galleries in the cambium, as well a blue-stain fungus that the adult beetles introduce. Along with the girdling effect of gallery excavation, the fungus contributes to the death of the tree by eventually plugging the water-conducting tissues.

Pine beetle populations are cyclic, meaning they tend to build in population over time and then decrease. In Tennessee, the peak population seems to occur every eight to 10 years. The beetles are more likely to attack pine stands and individual trees that are suffering from stress. Stress can be caused by many factors. Prolonged drought can weaken a pine's ability to defend itself from the beetle. Prolonged moisture and flood conditions have the same effect. Trees that have been damaged by ice and storms or damage to residual trees after a harvest are also more susceptible to the beetle's attack. A common stress-causing factor in many of the stands in East Tennessee is low vigor and tree growth due to overstocked and over-mature stands. The less stress a pine

stand encounters, the more likely it will be able to defend itself from the beetle outbreak. Beetle populations decline when temperatures stay below freezing for a week or more. This lack of "winter kill" has also aided the beetle in its attack on Tennessee's pine forests.

Another beetle commonly found in pine trees is the **Ips beetle.** Ips infestations generally build in fresh logging debris, weakened trees and stands where an overly hot fire has been applied. Ips is often found in association with the southern pine beetle and can be identified by the discoloration of needles and rust-colored boring dust. When young Ips beetles leave an infested tree, their passing often looks like scatter-shot had been fired at the trunk of the pine. Control of spacing through thinning, removal of damaged and salvageable timber, and active management all lower the probability of Ips outbreaks.

The **white pine weevil** can seriously impact the growth of young eastern white pine by causing the terminal leader to die back. The weevil can create stem deformation, increase the susceptibility to wood decay organisms, reduce growth and increase tree mortality. Weevil attacks can reduce tree height growth by 50 percent annually and when the dominant leader is removed, the tree will develop forks or become bushy. Early white pine weevil evidence is apparent in the spring when tiny droplets of resin are exuded from feeding punctures made by the adult insect. Larvae will girdle the leader and cause the needles of the tree to wilt. Eastern white pines infested with the weevil will appear either with brownish needle whirls or may appear completely white as pitch from the tree crystallizes along branches.

Trees grown in open spaces that receive full sunlight on the terminal shoots are vulnerable to weevil attack. The preferred method of stand protection is finding the balance between shade from crown closure and adequate light to maintain tree growth. Stands established under a hardwood canopy have shown lower susceptibility levels for weevil outbreak. Maintaining high densities of young white pines until the stand reaches 20 feet in height has also reduced the level of weevil damage. There are chemical treatments that have been used, but these should only be considered when more than 5 percent of the trees are infested and an economic evaluation warrants such a decision.

Pales weevils are attracted to freshly cutover pinelands where they breed in stumps and old root systems. Seedling mortality may approach 60 percent in areas where pales weevil is dominant. Adults will feed on the aboveground bark tissue of seedlings, causing the resin of the seedling to crystallize and giving a "sugary" appearance to damaged individuals. On older trees, the girdling of twigs and branches will produce poor form and a bushy appearance.

There are two effective measures for preventing weevil-caused mortality of seedlings – chemical spraying or delayed planting. Seedlings can be treated with an insecticide to prevent damage prior to planting. If the cost of chemical dips is high, delayed planting should be the selected option. Delaying planting one year may be costly due to the establishment of undesirable vegetation, but it allows the weevil population to build and then disperse or leave the area. Pales weevil prevention is most effective when managers take the time prior to planting to evaluate the weevil threat.

Black turpentine beetles also impact southern pines by attacking fresh stumps and the lower trunks of living pines. They produce pitch tubes similar to the southern pine beetle and feed on the cambium. **Pine sawflies**, broad-waisted wasps that resemble houseflies, can cause serious defoliation in pine stands. Several species are found in the state and all can produce several generations yearly. The young larvae feed on needles; the timing of the destruction and the needles feasted upon vary with each species of sawfly. When infestations reach unacceptable levels,

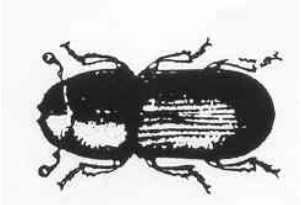
insecticide soaps and sprays may need to be applied. Sawflies are usually of minor consequence in Tennessee.

Diseases

Annosus root rot is a fungal infection that enters healthy stands by infecting freshly cut stump surfaces. This disease is particularly a problem in thinned pine plantations. Over time, the disease will produce a pinkish to violet stain on the butt log, indicating rot, and devastate the root system of individual trees. The fungus can spread from tree to tree through root contact or grafts. Annosus root rot produces conks, light gray to brown fruiting bodies along the base of the stump. These conks are often overlooked, since they may be below the litter layer or are not noticeable due to their inconspicuous color. Thinning crowns, short needles and unexplained needle fall are all secondary indicators of Annosus root rot. Summer thinning can reduce the amount of stump infection. An application of borax on infected stumps will assist in limiting the spread of the disease, but the best way to prevent infection is to have soils tested prior to plantation establishment. The application of prescribed burns at least twice before thinning will help to reduce diseases on high-hazard soils.

Littleleaf disease is an especially harsh fungal infection that afflicts mostly shortleaf pine. The first symptoms of the disease are similar to the appearance of nutrient deficiency problems, yellowish needles, reduction of shoot growth and shorter new needles. The disease normally affects trees more than 20 years of age and increases in commonality with age. The disease flourishes on sites with low soil-nitrogen levels and poor internal drainage. A wide variety of research has been conducted to establish "hazard-rankings" for shortleaf disease and these rankings should be consulted prior to stand establishment. Control of the disease can be achieved through either stand removal and replanting with different objectives and species or heavy fertilization that has slowed the disease development.

Young loblolly and slash pines are very susceptible to **fusiform rust** – a fungus that results in tapered, spindle-shaped swells on branches and stems. Mortality is highest in stands younger than 10 years of age and might account for the second greatest loss of loblolly pine timber behind the southern pine beetle. The life cycle of the rust is associated with oak species, where the fungus develops before invading the pines. Rust ratings have been established to help with placement of plantations and genetic breeding of seedlings has helped produce future generations of rust-resistant pines. Most genetically improved stock is less susceptible to fusiform rust.



Managing Pine Stands for Wildlife

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A common notion exists that pine stands are "biological deserts." Many folks believe pine stands (in particular, pine "plantations") harbor fewer wildlife species and support reduced numbers of individual animals. Furthermore, it is commonly expressed that plant species richness is drastically reduced in pine stands and understory development is often non-existent. However, not all pine stands are void of wildlife. The value of a pine stand for wildlife is strongly associated with the composition and percent cover of herbaceous vegetation. When planned accordingly and managed correctly, pine stands (including pine plantations) harbor and support incredibly diverse plant and wildlife communities.

Initial Planning and Objectives

Managing pine stands with wildlife management as an objective begins in the planning stages. Proper site preparation for pine plantings includes clearing the site of slash and debris (if the site was previously forested and subsequently harvested) and/or spraying competitive non-native grasses (if the site was previously a hayfield or pasture). The technique used to prepare the site prior to planting is critical if wildlife management is an objective. A little extra effort at this stage will pay great dividends later in terms of enhancing the area for wildlife.

On previously forested, recently harvested sites, it is important to burn the area using prescribed fire prior to planting. This helps clear the area for tree planting equipment and, more importantly for wildlife, reduces the litter layer and stimulates seed in the seedbank to germinate. A lush stand of forbs and native warm-season grasses creates favorable conditions for wildlife by providing seed and forage, as well as nesting and brooding cover for many birds. Because prescribed fire will likely be used as a management tool throughout the life of the stand, a firebreak (approximately 20 feet wide) should be planned and retained around the perimeter of the stand.

The vast majority of fields in Tennessee have been planted to tall fescue at some time in the past. Before planting pines in a field, it is imperative to spray and kill existing sod-forming grasses (e.g., tall fescue, orchardgrass and bermudagrass) if wildlife management is an objective. These grasses offer poor forage for wildlife, harbor reduced numbers of invertebrates (primary food for upland game bird poults), preclude seed in the seedbank from germinating (thereby reducing vegetative diversity and food availability in the form of forage and weed seed) and provide a structure that is too dense and thick to permit adequate travel by upland game bird poults and other small wildlife. Merely spraying a strip of herbicide where the pines are to be planted is **not** sufficient. To realize the benefits of managing a pine stand for wildlife, the entire field must be sprayed. The benefits will be evident in the short term (1–5 years) and in the long term (30+ years) as well.

Planting – Wider Is Better

Typically, pines are planted 6 – 8 feet apart in rows 6 – 8 feet apart, resulting in 680 – 1,200 trees per acre. A wider spacing should be used when wildlife management is an objective. Planting trees 10 –12 feet apart in rows 12 feet apart allows more sunlight to reach the forest floor, which stimulates increased growth of forbs and grasses, providing enhanced nesting habitat, increased forage and seed production and invertebrate availability. This wider spacing also allows a tractor to be driven into the stand later when disking and herbicide application are necessary. Where wildlife

management is the sole objective, an even wider spacing (e.g., 25 feet or more) may be used to maintain the early successional growth stage for a longer period. Planting at the wider spacing will result in lower quality timber and very little economic return from the growth of the trees.

The herbaceous vegetation stimulated by the recommended site preparation techniques and wider spacing at planting should provide attractive habitat for wildlife (e.g., bobwhite quail, rabbits, woodcock, foxes, bluebirds, wild turkeys, bobcats, pine warblers, white-tailed deer, owls, indigo buntings, bats and hawks) that frequent or require early successional habitats for approximately five years (depending on the site). At this time, the trees will have grown to the point that a considerable amount of shade is cast and vegetative growth at ground level will be reduced. The stand will appear quite "thick." From this stage until the first thinning, the stand provides excellent bedding cover for deer and thermal cover for many species of birds during winter.

Thinning and Prescribed Burning – Essential for Quality Wildlife Habitat

Most pine stands are ready for the first commercial thinning approximately 12–20 years after planting (depending on site). Thinning at this time reduces competition for sunlight, moisture and nutrients among residual trees and improves the health, vigor and growth rate of the stand. If thinning does not occur, the stand will slowly thin itself over time with a much-reduced growth rate. The increased sunlight provided through thinning also stimulates increased herbaceous growth on the forest floor, providing many of the benefits for wildlife described above.

A second commercial thinning is recommended 5–10 years later. When managing for wildlife, this thinning should remove enough trees to reduce the basal area to at least 25 square feet below the 50-year site index or to the point where 40–60 percent of the ground is open to direct sunlight. Generally, this is no more than 60–80 square feet per acre and even less (approximately 40–60 square feet) when bobwhite quail is the focal species. Often, scattered oaks (as well as other mast producers) occur within pine stands. When the second thinning is implemented, these mast producers should be identified and the ones with good form left to become established in the canopy. This will increase food availability within the stand in the future.

Thinning and burning go hand in hand. Prescribed burning in a closed-canopy stand does not stimulate the understory response desired when managing for wildlife. Likewise, thinning without burning does not produce the quality or composition of vegetation response that occurs after burning. There are many benefits in using prescribed fire throughout the life of a pine forest. Reduction of forest litter that serves as fuel for a wildfire is obviously important. Burning also stimulates vegetation wildlife use for food and cover and helps control undesirable hardwood encroachment in the stand. Perhaps most importantly (in terms of wildlife management), prescribed fire enhances the structure of understory vegetation for birds that nest on or near ground level, including wild turkeys, ruffed grouse, bobwhite quail and many songbirds. Typically, an "umbrella canopy" of forbs is the result, creating optimum brood-rearing conditions, as chicks are able to travel about with ease in search of invertebrates and seeds under the umbrella of "weeds." Most prescribed burning is completed during late winter under relatively cool, moist conditions. Burning at this time reduces available cover and forage for only a short time, as spring green-up occurs within 2–3 weeks.

Pine stands may be burned once the trees (loblolly or shortleaf) are approximately 20 feet tall with a diameter of 4 inches at breast height. Prescribed fire should be used after each thinning once the trees reach this size. Thereafter, pine stands should be burned at least every four years. When bobwhite quail is the focal species, burning should be conducted annually within some stands or sections of stands.

Sawtimber Rotation

A decision must be made once the stand reaches 30–40 years old. At that time, the stand can be clearcut for saw logs and/or chipping or the stand can be thinned and managed for long-rotation sawtimber. As mentioned earlier, the recommended basal area is priority-driven. Typically, pine stands managed for wildlife should be maintained at approximately 60–80 square feet of basal area per acre. However, if bobwhite quail is the primary species for management, basal area should be reduced to 40–60 square feet per acre. Look for oaks and other mast producers that have good form. Retain these for increased food production.

Dead trees (called snags) should be left standing. Snags provide a food source for woodpeckers and other birds, including brown creepers, nuthatches and bluebirds in search of invertebrates. Later, the cavities initially excavated by woodpeckers serve as nesting and denning cavities for many species, including other woodpeckers, bluebirds, owls, flycatchers, chickadees, wrens, titmice, nuthatches, brown creepers, wood ducks, hooded mergansers, squirrels and raccoons. Thus, it is obvious how some trees (e.g., maples, elms, sweetgum, ash, sourwood and sycamore) can provide more for wildlife when dead than alive!

As the stand reaches the age for harvest, consider management strategies that will make the next stand more attractive for wildlife. Usually, hardwoods are found along creeks and low-lying areas. Oaks and other mast producers are normally included in these areas. These trees should be retained to enhance the future stand. Streamside management zones (SMZs) left uncut along drainage areas are important not only for hard and soft mast production, but also for travel corridors connecting other forest stands adjacent to the harvested stand. Optimally, SMZs left for wildlife should be at least 100 feet wide.

Different Ages, Different Structure

Pine stands (as well as other forest types) of different ages provide habitat for different wildlife species and various life stages of those species. For example, a wild turkey hen may nest in a 3-year-old pine stand, use a 20-year-old stand for thermal cover in winter and roost in a mature stand at any time of the year. To provide habitat for a diversity of wildlife and various life stages, stands should be separated in time and space. Therefore, it is good to have stands of various ages and entire stands should not necessarily be treated (managed) all at once. For example, it may be best to thin a portion of a stand one year and wait two or three years before thinning another section or the rest of the stand. Likewise, a section(s) of a stand may be harvested at 30–40 years, while another section (or sections) is left and managed for long-rotation sawtimber. By dividing the stand into several sections (e.g., 10- to 50-acre blocks), different stages of vegetation growth (succession) can be maintained.

The same is true when using prescribed fire. Some sections should be left unburned to provide standing cover and food resources while the burned section(s) develops. The unburned section(s) can be burned the next year or two to three years later. Large stands should be broken up by establishing firebreaks throughout the stand, creating sections (e.g., 10- to 50-acre blocks) in a checkerboard fashion. Thinning and burning on a rotational cycle produces a mosaic of habitat conditions and successional stages throughout the stand. Managed as such, the area will be attractive to more wildlife species and lead to increased use of the stand.

Hardwood Control

Several hardwood species (e.g., oaks, hickories, persimmon, cherry) are desirable for wildlife; however, many of the hardwoods that encroach upon pine stands initially are of limited value. These include red maple, sweetgum, winged elm, ash and sourwood. These hardwood “weeds”

compete for sunlight and nutrients, reducing desired understory vegetation. Encroachment of these hardwoods is particularly problematic during the first five years after planting. The use of hardwood-selective herbicides (e.g., imazapyr) is recommended because legumes (the single most important herbaceous plant group for wildlife) and other preferred wildlife plants, such as blackberry, are not harmed. Depending upon the age of the stand, control of hardwoods can be achieved through three techniques: mechanical thinning, herbicides and prescribed fire.

Mechanical control is usually the least effective, unless followed by herbicides and/or burning because of the tendency of sprouting, which results in more stems per acre. The most effective hardwood control technique is an herbicide application applied over the foliage when the stand is young (2–5 years). According to stand size, this can be accomplished via helicopter, a tractor or four-wheeler with a boom sprayer or with a backpack sprayer (typically used for spot-spraying individual trees). Herbicides may be applied to the cut surface of larger trees that have been girdled with a chainsaw or frilled (hacked) with a hatchet. The herbicide is applied with a hand-held squirt bottle.

Hardwood control is often needed in older (>30 years) pine stands that have not been managed previously through thinning or burning. After thinning these older stands, an aerial application of herbicide is recommended the following growing season to control residual hardwood stems. Following the herbicide application with prescribed fire will stimulate increased herbaceous growth and improve forage and seed availability. Another approach to controlling hardwood sprouts and saplings is to use a growing-season burn. Using prescribed fire in April, just as the leaves on deciduous hardwood trees are beginning to develop, is an excellent time to control unwanted seedlings and saplings.

Managing Openings, Firebreaks And Old Logging Roads

To meet the needs for a variety of wildlife species, 25–50 percent of the property should be in early successional openings. In many cases, this is not possible; nonetheless, an effort should be made to maintain at least 15–25 percent of the property in openings if wildlife management is the primary objective. This includes forest openings as well as old logging roads (or "woods roads") and firebreaks. It is important to note that openings are not necessarily "food plots." The primary objective in creating and managing openings is to provide habitat for a number of wildlife species that require early successional vegetation. The percentage of openings that are planted is based on the wildlife species targeted for management. For many wildlife species, planting is not necessary to create favorable habitat in openings. The seed of a wide variety of forbs and grasses important to wildlife lie dormant in the top few inches of soil (the seedbank). If allowed to germinate, these plants will provide the food (forage and seed) and cover required by species that use openings. These "natural" openings are maintained and managed with prescribed fire and light disking.

If an existing opening contains a sod-forming grass (especially tall fescue, orchardgrass and bermudagrass), it is critical that it be sprayed and killed to eliminate competition and allow seed in the seedbank to germinate. Germination is then stimulated by burning the field and light disking. A firebreak is needed around the perimeter of the field and, according to field size, may be used to divide the field into sections. Various sections then can be managed differently to provide a mixture of successional stages and plant types. The perimeter firebreak around openings should not be established directly adjacent to the woods. Approximately 50 feet should be left between the woods and the firebreak for a soft edge to develop, creating a zone of escape cover (e.g., brush, brambles, briars, tall grasses and weeds) available to wildlife using the opening. This is also advantageous if the firebreak is planted because it reduces the shade effect and competition for nutrients from the adjacent trees. Additional soft edge can be created around openings by heavily thinning a zone 50 feet wide just inside the woods edge.

Some openings (or a portion of) should be burned and/or disked annually, while others are treated every two, three or four years to provide a range of successional stages from bare ground up to 4-year "rough." [Note: firebreaks surrounding and within the pine stand should be included in the rotational disking schedule.] This strategy will ensure that nesting cover, brooding cover and escape cover are always present within some of the openings. It is usually best to burn in late winter, just prior to spring green-up. Disking should be completed from November through February, depending on the response from the seedbank. Initially, it may be necessary to disk one strip per month through the winter to identify the best time to disk in a particular area. The preferred composition of plants in disked areas include ragweed, partridge pea, beggar's-lice, panicgrasses, milk pea, butterfly pea, blackberry, morningglories, wild geranium and native lespedezas. These plants provide excellent brood cover for quail and turkeys, quality forage for deer and rabbits and abundant seed production for a variety of birds. Fields containing native warm-season grasses (NWSG) provide excellent nesting habitat for ground-nesting birds. Manage openings containing NWSG on a 2- or 3-year rotation by burning half of the fields (or sections) each year. This strategy ensures some nesting cover is available each year.

Some of the firebreaks should be planted to provide a supplemental food source. For bobwhite quail, wild turkeys and other birds, at least half of the firebreaks should be planted to warm-season forage/seed mixtures (e.g., milo, millets, cowpeas, sunflowers, annual lespedeza and/or buckwheat). The other half may be left fallow if quail and songbirds are favored or planted to cool-season forages (e.g., clovers and wheat) if wild turkeys are favored.

Where white-tailed deer is the focal species, 2–5 percent of the property (including openings, firebreaks and old logging roads) may be planted in food plots containing quality forages. Ideally, half of these should be planted in warm-season mixtures (e.g., iron-clay cowpeas, lablab, reseeding soybeans, American jointvetch and alyceclover) and half in cool-season mixtures (e.g., various clovers, dwarf essex rape, Austrian winter peas, oats, wheat and rye). In areas where acorn production is limited, corn may be planted to half of the openings reserved for warm-season plantings. This strategy ensures forage is available during the two primary stress periods for deer – late summer and late winter. It is very important to match the planting to the site and to amend the soil with the recommended rate of lime and fertilizers as determined by a soil test.

Another way to enhance wildlife openings is by planting mast-bearing trees and shrubs. Recommended hard mast producers include any of the oaks (depending on site), American beech and chinquapin. Recommended soft-mast producers include apple, crabapple, persimmon, wild plum, pear, elderberry, hawthorn, cherry, dogwood and spicebush. Trees and shrubs may be planted across openings to create hedgerows, along edges where sunlight is adequate and in corners or odd areas. These trees and shrubs should be protected from prescribed fire.

Old logging roads that receive relatively little vehicular traffic should be planted to prevent soil erosion and provide additional forage and "bugging areas" for wildlife. Mixtures containing legumes (e.g., clovers and birdsfoot trefoil) and annual cool-season grains (e.g., wheat and oats) are recommended because they provide adequate soil stabilization, quality forage and harbor an abundance of insects and other invertebrates needed by turkey and quail chicks. Perennial cool-season grasses (e.g., tall fescue and orchardgrass) are not recommended because they provide virtually no benefit to wildlife.

Economic Considerations

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Woodland owners can conduct forest management as a business by becoming more proactive. With today's rising costs and taxes, owners should consider more efficient management techniques. This may mean a change in thinking for many woodland owners. Non-industrial private landowners make up more than 75 percent of the forest base in Tennessee and are the key to supplying the raw materials needed by forest industries.

Forests As Investment Instruments

Consider our forests as investments, especially as trees grow into merchantable sizes. Merchantable trees represent a value that could be obtained by selling the tree. This return or value could then be used or invested in any number of ways, depending upon each landowner's personal desires and needs. To manage our forests wisely, we must be able to compare these returns to other investments or businesses. Landowners need to know what their timber investment choices are and the return they are expecting to receive in order to make sound management choices.

Timber is a unique investment. The investment period is often extended, represented by a long period of time while the trees reach marketability. At the same time, product classifications allow landowners great flexibility in when they choose to liquidate the investment. Sometimes over-looked recreation, hunting and other non-market opportunities are associated with the investment. Risk is also unique with timber investments, for there is a real risk in a complete and unexpected loss in the value of the investment due to fire or insect damage.

Examining the Investment

By expressing tree growth in terms of compound interest, forest investments can be compared with other enterprises. The rate of compound interest of stands can be determined with a simple growth study or by comparing inventories. Divide the past volume of the stand by the present volume. The factor obtained is then applied to compound interest tables to determine the compound annual rate of interest returned.

We know that as trees age, vigor and growth tend to decline. As growth rates diminish, so does the earning power of the tree. Even if trees grow at the same rate year after year, the interest they return decreases each year. This is because as their volume increases, the same amount of wood added annually represents a smaller percent return each year. For example, $.05 added to $.50 would represent a 10 percent increase, while $.05 added to $1.00 represents only a 5 percent increase.

With this in mind, we can easily see that somewhere along the line, tree growth returns will drop below an acceptable level. At this point, trees might be considered financially mature. The time to reach this level will vary from site to site. Some individuals will demand a higher return on their investment than others and will make a final harvest before those who will accept a lower rate of interest. Three common ways tree interest rates may be used include determining when to cut stands, selecting trees to cut when removing individuals and determining whether to cut immature timber to liquidate debt.

Sometimes interest rates may be misleading. In crowded stands, low interest rates may only indicate a need to thin the stand. Often the removal of the slower-growing individuals will immediately boost the interest to acceptable rates. Sparse stands may show good growth, but due to the small number of trees, they are not paying for the use of the land. Cut and re-establish such stands so that the full site can be utilized. In determining the minimum acceptable rate of growth for trees, it is necessary to consider net return. Such factors as income taxation, handling costs, risk and flexibility of operations may make a lower rate of return more acceptable. And finally, as timber reaches large sizes, trees become more suitable for higher-valued products. Be sure to check on these markets before liquidating a stand that might appear to be financially mature.

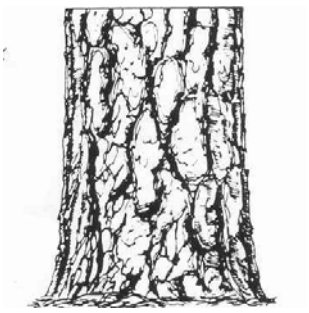
Investment Advantages and Disadvantages

Many opportunities exist to advance the quality of timber stands with active management. Timber production can be timed to provide periodic returns. This income can be a means of paying taxes on land held for future use for heirs under an estate plan. Timber income qualifies for capital gains tax treatment, which is considerably lower than taxes on ordinary income. Reforestation investments are often eligible for cost-share programs and can be amortized as well as provide immediate tax credits up to 10 percent of costs. Above all this, timber adds diversification to investment portfolios. Timber prices have historically increased at a rate of 2 to 4 percent above inflation, while the annual physical growth of timber increases 4 to 8 percent in addition to "economic growth."

Forest investments are, however, long-term propositions. The risk is real in the form of fire, insects, disease and environmental/social constraints. Often there is a heavy front-end capital investment required for stand initiation and loans for forestry investments can be difficult to acquire. Timber buyers are not attracted to small tracts and the costs of additional land purchases may be prohibitive for forestry investments. Fluctuations in price may be on a longer time-scale. Management returns are usually correlated to the intensity of management applied.

Landowners have many options as to their potential investments. The following table compares forestry and row crops and examines the differences in returns, flexibility and other considerations that should be examined before making a decision.

Forestry is a strong economic force in Tennessee. Forest investments make a sound choice in diversifying investment portfolios, as well as a financial resource that can be passed from generation to generation.



Comparing Forestry and Row Crops

ITEM	ROW CROPS	PINE STANDS
Cash flow	Annual	Peridic
Income tax	Ordinary treatment	Long-term capital gains treatment and special credits/amortization options
Supply/Demand	Variable	Favorable
Market	Must price and sell in one year	Multiple products – Multiple years
Returns	Variable	Good
Soil conservation	Poor	Good
Drought	High risk each year	Low risk once established
Management	Intensive-Active	Extensive – Passive
Investment	One year	Greater than 15 years
Flexibility	Good	Poor
Government programs	Direct payments price protection for base acres	Indirect tax effect Cost-share programs

Summary

Pines are a very versatile species, occurring in the Coastal Plain, the Highland Rim, the Cumberland Plateau, the Great Ridge and Valley, and the Smoky Mountains on a variety of soils. Under proper management, the species can be marketed for every imaginable product from pulp to construction-grade support timbers, as an important component of Tennessee's economy.

Forest management is not a 'cookie-cutter' science. Working with pines can provide landowners with an additional opportunity to achieve their management objectives. This handbook describes various species and management opportunities with the goal of encouraging pro-active management of pines. The pine resource has historically had a place in the development of Tennessee and should be treasured just as much as our hardwood stands. It is our hope that this handbook has inspired you to contact your local forester or consultant and embrace pine management as a possibility for economic diversity, recreational opportunities or adding to the beauty of Tennessee.

Visit the UT Extension Web site at
http://www.utextension.utk.edu/

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