A Prescription for Old-Growth-Like Characteristics in Southern Pines

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Abstract—*Recent interest in adding old-growth reserves conflicts with a projected increase in the demand for forest commodities. However, managing for old-growth-like characteristics may permit timber production from stands designed to be similar to primeval forests. A silvicultural strategy based on presettlement forest conditions is being tested on 120 ac of mature loblolly (*Pinus taeda*) and shortleaf (*Pinus echinata*) pine on the Crossett Experimental Forest in Arkansas. Reference conditions from historical photographs, surveyor notes, old explorer journals, early research papers, and technical reports guided the prescription's design. A combination of harvesting, prescribed burns, and competition control should gradually produce structure similar to pine-dominated presettlement forests. Timber yield and natural attributes will be monitored and compared to traditional silvicultural practices to develop flexible prescriptions that can be modified later, if appropriate.*

Introduction

Old-growth forests have garnered considerable attention in public land management because they are often associated with higher levels of biodiversity, ecological complexity, aesthetics, and unique recreational opportunities. However, the desire for additional old-growth preserves conflicts with a projected increase in the demand for wood products. For instance, by 2040 the need for softwood fiber in the southeastern United States is forecast to increase more than 50 percent over current levels (Prestemon and Abt 2002). This level of consumption does not favor new areas being made available for unmanaged old forests, especially when almost 90 percent of the timberland in the southeast is privately or industrially owned (Wear and Greis 2002).

Public land managers are under increasing pressure to reduce their commercial timber production and alter their harvesting methodologies (Murphy and others 1993). In part, this is a response to widespread displeasure with clearcutting and monoculture plantations and a perceived timber bias in public land management. It also reflects a growing interest in matching anthropogenic disturbances with natural disturbance regimes (Aber and others 2000; Palik and others 2002; Seymour and others 2002). Furthermore, our value systems have shifted to include non-timber attributes like biodiversity, aesthetics, and water quality that may be compromised under intensive, short rotation monocultures.

We are just becoming aware of many of the complex patterns and processes involved in the formation and maintenance of old-growth (Aber and others 2000; Franklin and others 2002). Silviculture for old-growth-like characteristics permits harvesting in mature stands structured to better

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Figure 1—A perspective of contemporary forest conditions typical of Compartments 1, 2, and 12. Photo by D.C. Bragg in 2003.

resemble primeval forests. Note that artificially creating old-growth-like environments does *not* result in conditions identical to those from unaltered natural events. However, many old forest attributes can be encouraged in managed landscapes (Deal and others 2002; Guldin 1991; Morton and others 1991). For example, Lennartz and Lancia (1989) proposed the use of "creative" silviculture to enhance second-growth habitat for red-cockaded woodpeckers (*Picoides borealis*) by retaining larger trees and reducing midstory density.

A strategy for managing for old-growth-like conditions is being implemented on the Crossett Experimental Forest (CEF) in southern Arkansas. One hundred and twenty acres of mature loblolly (*Pinus taeda*) and shortleaf (*Pinus echinata*) pine will be transformed from an even-aged, relatively homogeneous stand (figure 1) into a multi-aged complex using a combination of group selection, competition control, and ecosystem management principles. This paper will outline the basic principles of a managing for old-growth-like upland pine forests, including the monitoring of project progress to determine the success of the effort.

Methods

Study Area

The study area is located in the Upper West Gulf Coastal Plain of southern Arkansas, on three 40 ac parcels on the CEF (figure 2). Compartments 1, 2, and 12 are relatively level, with slopes less than 3 percent. The soils adjacent to the drainage are Arkabutla silt loams, midslopes (comprising most of the area) are Bude silt loams, and Providence silt loams cap the low ridgetops (Gill and others 1979). A small, ephemeral stream runs down the west side of the study area. The CEF receives about 54 inches of precipitation annually, with average winter and summer temperatures of 47°F and 80°F, respectively (Gill and others 1979).

Currently, Compartments 1, 2, and 12 are dominated by loblolly pine, with a lesser component of shortleaf pine and hardwoods (table 1, figure 3). The woody understory consists primarily of hardwoods like sweetgum

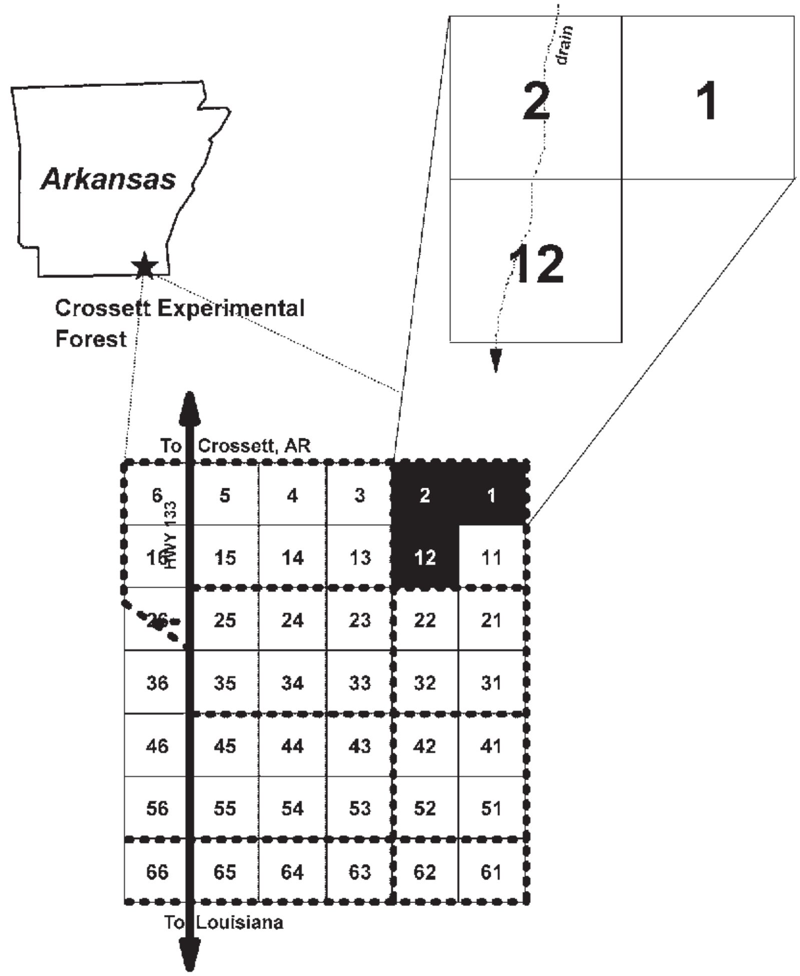

Figure 2—Location of the study compartments and the Crossett Experimental Forest in Arkansas.

Table 1—Merchantable (DBH >3.5 inches) species composition of Compartments 2 and 12 only, sampled in the summer of 2000.

Species	Min. DBH	Mean DBH	Max. DBH	Live trees	Basal area (ft²)
	------------------	inches	------------------	--------- per acre	---------
loblolly pine (*Pinus taeda*)	3.9	15.2	28.5	40.49	57.69
shortleaf pine (*Pinus echinata*)	4.4	17.5	26.1	11.34	20.80
water oak (*Quercus nigra*)	4.1	8.6	16.2	7.56	3.48
sweetgum (*Liquidambar styraciflua*)	4.0	6.8	21.7	10.80	3.31
white oak (*Quercus alba*)	3.6	7.5	14.9	8.10	2.85
winged elm (*Ulmus alata*)	3.8	5.6	9.7	9.18	1.73
cherrybark oak (*Quercus pagoda*)	4.3	6.7	8.7	2.97	0.76
red maple (*Acer rubrum*)	3.8	6.3	10.0	3.24	0.75
flowering dogwood (*Cornus florida*)	3.8	4.8	6.3	3.51	0.45
southern red oak (*Quercus falcata*)	5.8	7.9	13.6	1.08	0.43
blackgum (*Nyssa sylvatica*)	4.0	6.3	8.3	1.35	0.32
black cherry (*Prunus serotina*)	3.8	6.5	8.3	1.08	0.27
post oak (*Quercus stellata*)	4.4	5.5	6.8	0.81	0.14
green ash (*Fraxinus pennsylvanica*)	3.9	4.7	5.5	1.08	0.13
red mulberry (*Morus rubra*)	4.6	5.2	5.6	0.81	0.12
blackjack oak (*Quercus marilandica*)	9.0	9.0	9.0	0.27	0.12
sassafras (*Sassafras albidum*)	5.3	6.4	7.4	0.54	0.12
American holly (*Ilex opaca*)	3.8	4.8	6.7	0.81	0.11
black oak (*Quercus velutina*)	7.7	7.7	7.7	0.27	0.09
eastern redcedar (*Juniperus virginiana*)	6.4	6.4	6.4	0.27	0.06
mockernut hickory (*Carya tomentosa*)	3.6	4.4	5.2	0.54	0.06
willow oak (*Quercus phellos*)	3.9	3.9	3.9	0.27	0.02
			TOTALS:	**106.37**	**93.81**

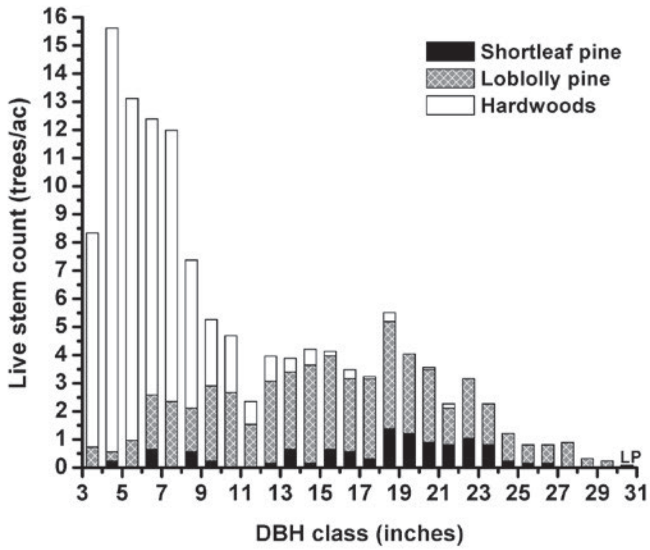

Figure 3—The 2000 inventory of Compartments 2 and 12, featuring hardwoods and pines by size class.

(*Liquidambar styraciflua*), red maple (*Acer rubrum*), and white oak (*Quercus alba*), with a large component of briars (for example, *Rubus* spp., *Smilax* spp.), vines (for example, *Vitis* spp., *Toxicodendron radicans*), and shrubs (for example, *Callicarpa americana*). There is virtually no pine in the understory and very little midcanopy except for some scattered hardwoods.

Reference Condition Acquisition

Reference conditions for presettlement pine forests in the Upper West Gulf Coastal Plain were developed from a number of historical sources, including photographs, surveyor notes, old explorer journals, and early research and technical reports. This work helped guide the old-growth-like prescription's design and implementation by quantifying key attributes of stand structure and composition to use as silvicultural targets (table 2).

Table 2—Proposed reference targets for restoring old-growth-like upland pine stands on the Crossett Experimental Forest in southeastern Arkansas.

Attribute	Reference target	Implementation strategy
Species composition	50 to 60 percent loblolly 35 to 45 percent shortleaf up to 10 percent hardwoods	Preferentially cut loblolly and hardwoods
Basal area	50 to 70 ft^2/ac	Group selection and periodic thinnings
Maximum tree DBH/age	unlimited	Avoid cutting trees >25 inches DBH
Number of big trees	5 to 15 pines >30 inches/ac	Cut no pines >30 inches DBH
Reserved timber volume	5000 to 10,000 board feet/ac	Volume reserved solely in "keepers"
Spatial pattern	patchy	Group selection with reserves
Under/midstory	open	Fire and herbicide
Red heart	10 to 50 percent cull in retained trees	Old trees, fungal inoculation(?)
Large woody debris	5 to 10 snags/ac 285 to 715 ft^3/ac	No salvage, girdling, hot fires

Historical information used to define reference conditions was preferred to contemporary studies of old-growth pine remnants (for example, Cain and Shelton 1994; Fountain and Sweeney 1987; and Murphy and Nowacki 1997) because of the impact of decades of fire exclusion, exotic species introduction, and other alterations to the original structural, compositional, and functional behavior of these reserves. For instance, evidence suggests that presettlement upland forests had a much greater proportion of shortleaf pine than modern examples (Bragg 2002). Other traits common to the presettlement pine forests of southern Arkansas included open, relatively poorly stocked stands with an abundance of grasses and forbs and fewer woody stems and vines, substantially higher levels of old, very large, and frequently decadent canopy pines, and sporadic but locally considerable volumes of coarse woody debris (Bragg 2002, 2003).

Treatment Implementation

Using a combination of harvesting, competition control, and adaptive management, the study compartments will be gradually converted into a stand similar in composition, structure, and dynamics to the pine-dominated presettlement forests once common to the region. Adaptability is key to this silvicultural prescription: there is no absolute, immutable recipe for producing an old-growth-like forest. For instance, we believe that we must incorporate the ability to adjust, modify, or even redesign some aspects of its implementation if suggested by monitoring.

Flexibility…flexibility…flexibility. Adaptive management strategies based on effective monitoring and the response to unforeseen change will help achieve the desired prescription. Given the duration of this effort, it is inevitable that unanticipated events (droughts, excessive rain, beetle outbreaks, windthrow, wildfire) will complicate the restoration. Such disturbances are not necessarily a problem unless the merchantable timber is completely lost. After all, presettlement forests were characterized by their large volume of dying and dead trees (biological legacies that contributed to ecosystem complexity). However, since a major objective of this prescription is to produce some timber products, limited salvage or preemptive thinning to avoid catastrophic loss may be required. Delays in harvesting due to bad weather, unexpected slow growth, or weak timber markets are also inconvenient but not crippling.

In this region, an operable cut typically contains 1500 to 2000 board feet (Doyle log rule)/ac in sawtimber, with pulpwood usually supplementing the sawlog yield. If a typical stand grows 300 to 400 board feet per acre per year, this results in 5-year cutting cycles. Longer cutting cycles than traditionally applied (for instance, 10-year versus 5-year) will probably be needed to provide the desired structural and compositional control. Prolonged cutting cycles are important because it may take longer to grow sapling- and pole-sized pine to sufficiently large size under these conditions, particularly when fewer large pines are available for harvesting. Extended harvest return intervals should also help avoid unnecessary logging damage, especially to the smallest merchantable size classes.

Anticipated Competition Control

Long treatment cycles should also allow most of the advanced pine regeneration to survive periodic controlled burns (Cain 1993). Prescribed fire will be an important component of this study for several reasons. First, it consumes the litter and duff and improves pine establishment. Second,

Figure 4—A "decadent" 54-inch DBH loblolly pine from Ashley County (circa 1937). If sound, this tree would have scaled 7,000 board feet (International rule), but note the prominent cankers and scars. Photo #350916 in CEF (USFS) archives.

it provides some degree of competition control. As an example, efforts to control woody vines may especially benefit from the return of fire. Third, controlled burning encourages the return of native fire-dependent grasses, forbs, and shrubs that have largely disappeared under traditional forest management. Finally, the fire-related wounding and subsequent decay of large trees helps to reintroduce decadence absent in most managed stands (figure 4). This is significant because punky, hollow, or dead trees provide critical habitat for cavity-dependent species.

However, there is only so much that can be achieved with controlled fire in the fragmented forests of southern Arkansas. Issues of smoke management, liability, and the ecological timing of the burns represent major challenges. In addition, excessive burning can drastically understock pine stands and introduce too much decay (Bruner 1930), reducing the potential of timber harvesting to support the overall restoration effort. Hence, some chemical competition control will almost certainly be needed to achieve management objectives. Hardwood and woody shrub rootstocks are often so well established that most controlled burns do little more than topkill. Given their ability to resprout, these competitors have a distinct edge over seed-origin pines. Experience has shown that an appropriate mixture and timing of herbicides and controlled burning can effectively reduce hardwood and brush competition (Cain 1993; Zedaker 2000).

Hardwood Management

As can be seen in figure 3, many small hardwoods are found in the study compartments. Hardwoods were a minor component of the presettlement pine forests of the region, usually constituting less than 25 percent of the stand (Bragg 2002; Chapman 1913; Reynolds 1980). The hardwood-filled drain in Compartments 2 and 12 will be treated as a riparian management zone, with very few of the hardwoods removed. Small hardwoods in the upland forest zone are available for cutting, girdling, or spraying, but a handful of large oak will be retained to preserve some mast.

Monitoring

As mentioned in the preceding paragraphs, monitoring is an important component of any long-term strategy because it tells the manager if the treatment has been implemented as designed, and if not, what needs modification. Close supervision should also help alert the manager to growing pest or competition problems that may require unscheduled intermediate treatment(s). Furthermore, monitoring can facilitate the prediction of future conditions.

If overall structural or compositional targets are not consistently reached, either the targets or the thinning strategies must change to meet the desired objectives. However, we must manage for a historical range of a suite of acceptable stand features, not a narrowly defined and singular density or compositional target (Trombulak 1996). Irregularity and heterogeneity are key attributes of old-growth forests. For this reason, table 2 identifies ranges of a number of characteristics expected in old-growth stands. As an example, the spatial distribution of stems in the presettlement forests of southern Arkansas (figure 5) lacked the consistency of most managed forests (Bragg 2002; Chapman 1912). Hence, some locations would match the "average" stocking range, while others are denser or more open.

Timber production and natural attributes will be compared to traditional alternatives (intensive timber yield and no harvest reserve) to help identify the economic trade-offs of managing for old-growth-like attributes. For example, it is expected that the relatively understocked, lightly cut old-growth-like prescription will produce noticeably less fiber. Other non-timber attributes will also be tracked to more fully evaluate the success of the system.

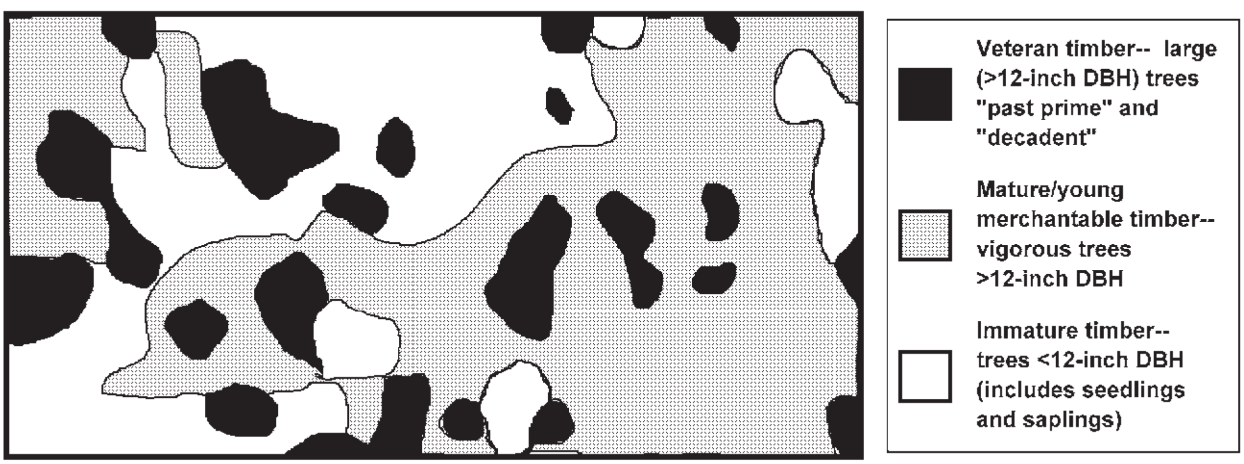

Figure 5—Example of a possible spatial pattern of the original pine stands of southern Arkansas circa 1910 (adapted from Bragg (2002) and Chapman (1912)). The dark areas represent individuals or small clusters of old, declining pine, the stippled area is large, vigorous pine, and the white areas are young timber.

Anticipated Results

Compartments 2 and 12 have been marked using thinning from below to reduce stand basal area to approximately 65 to 70 ft^2/ac. No trees greater than 21 inches in DBH were selected, and all shortleaf pine will be spared in this harvest. Compartment 1 was only recently added to this study, and since it was harvested about 3 years ago, it was not remarked for treatment. Structurally and compositionally, Compartment 1 differs little from 2 and 12, although it will be a few cutting cycles before the compartments are fully integrated. The desired stand structure (encapsulated in figure 6) is the critical result, not the starting condition or developmental path of any given compartment. Using group selection and thinning from below, the first treatment cut (scheduled for 2008) will reduce average stand density to approximately 60 ft^2/ac.

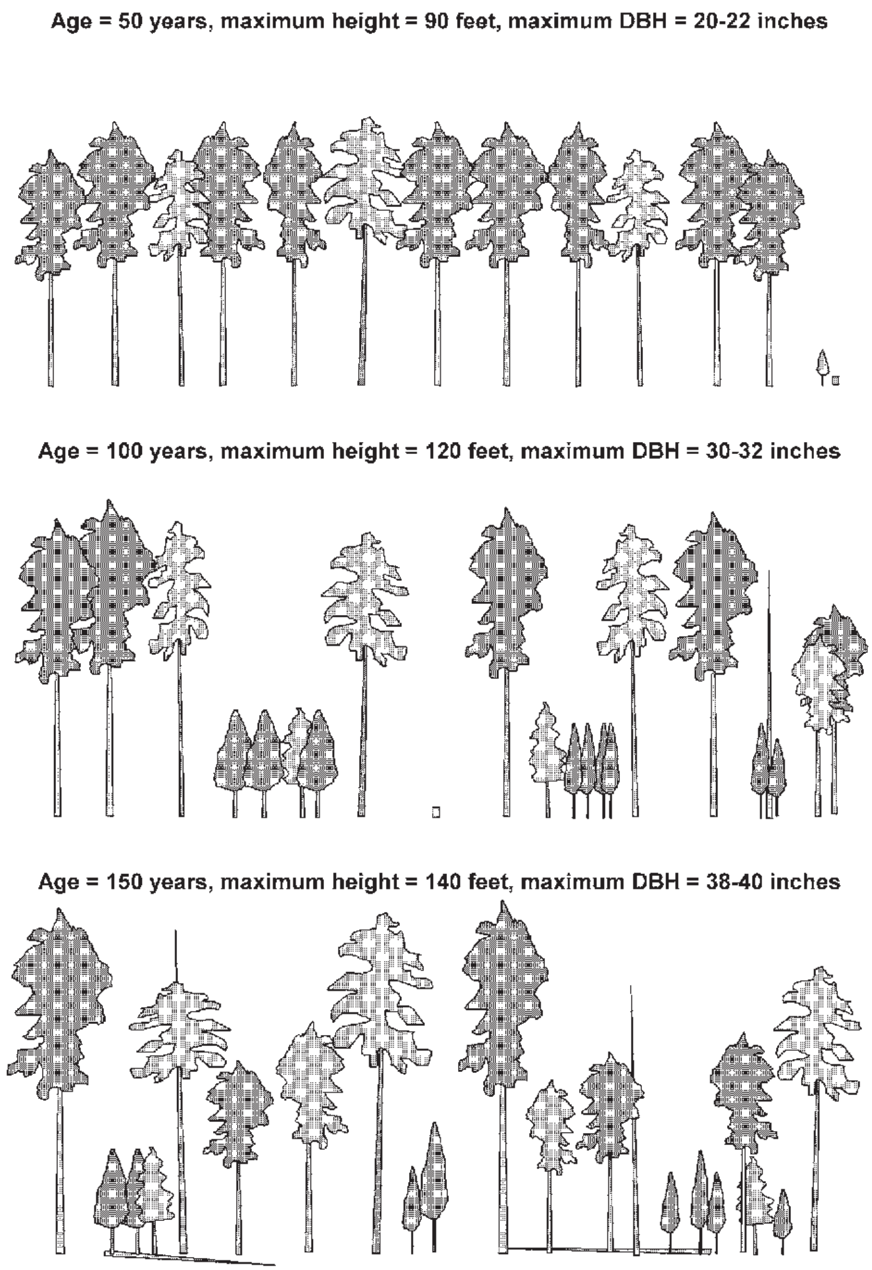

Figure 6—Temporal sequence showing the idealized developmental trajectory of the old-growth-like study compartments. Starting from a relatively even-aged, 50-year-old stand, repeated harvests and natural mortality gradually open the stand, which by year 100 has numerous regenerating gaps, and contains a relatively small number of large "keeper" pines with multiple patches of varying age by year 150.

Keepers, Groomers, Thinners, and Regeneration

Rather than following a predetermined and fixed rotation length (for example, 150 years in loblolly/shortleaf pine), certain individual trees ("keepers") will be identified and permanently excluded from regular timber marking. This will allow them to reach their biological lifespan, perish of natural causes, and eventually fall to the earth and decompose (unless specifically identified as an unacceptable hazard). Keepers will exceed 30 inches DBH and may range from poorly formed culls to prime crop trees. Keepers may be found individually or in clumps, but rarely in patches larger than a fraction of an acre. The residual volume held in keepers will eventually range from 5000 to 10000 board feet (Doyle)/ac, comparable to presettlement forests (Bragg 2002) (a single 30 inch DBH pine contributes about 5 ft^2 of basal area and scales approximately 1400 board feet).

Pines from 20 to 30 inches DBH will be treated as "groomers" in which the most "eligible" individuals are destined for a future as keepers. Groomers will be continually evaluated to ensure they contribute to long-term stand goals. Groomers that show promise as long-term keepers will be preferentially retained, while others will be harvested as appropriate. Most large groomers that perish will also be left to supplement the large dead wood pool.

The merchantable-sized pines less than 20 inches DBH are called "thinners." Thinners may range from saplings barely making pulpwood (3.6 inches DBH) to prime sawtimber 17 to 20 inches DBH During the years a pine grows from saplings to sawlogs, good forestry practices should be encouraged. Hence, cut the worst to favor the best. Remove the poles bent by glaze accumulation or afflicted with fusiform rust (*Cronartium fusiforme*). Aggressively thin the maturing groups to encourage rapid growth, but protect the residual stand from unnecessary logging damage by encouraging the loggers to leave tops and defective logs in the woods.

Regeneration will be achieved via variable-sized group selection openings. These gaps should range from 0.25 to 1 ac, often with keepers scattered amongst them. Since loblolly and shortleaf pine are shade intolerant species, most gaps will cover at least 0.5 ac. Once established, it is critical that the regeneration be protected to ensure that the gap maintains adequate stocking.

Treatment Timeframe

The objective of this effort is to gradually convert a relatively even-aged, mature forest into a patchy mixture of immature, mature, and old timber similar to the presettlement upland pine forests of southeastern Arkansas (figure 7). Thinnings may vary depending on access, markets, and growth. Competition control treatments will be scheduled to ensure that pine regeneration benefits the most from overstory and understory release. However, an extended period between seedbed preparation and controlled burns is needed so that enough pine saplings get large enough to survive the fire. Chapman (1952) recommended an 8- to 10-year burn interval for loblolly pine-dominated ecosystems.

Figure 8 provides a framework for treatment applications, including the long-term application of group selection with reserves. Since one of the goals of this prescription is to maintain an average stand basal area of 50 to 70 ft^2/ac, this means that locally some areas will average less than 30 ft^2/ac, while others will exceed 90 ft^2/ac. If a well-stocked stand on the CEF adds 3 ft^2/ac of basal area annually (Baker and others 1996), then it is capable of growing 30 ft^2/ac in 10 years. This longer cutting cycle should allow for low

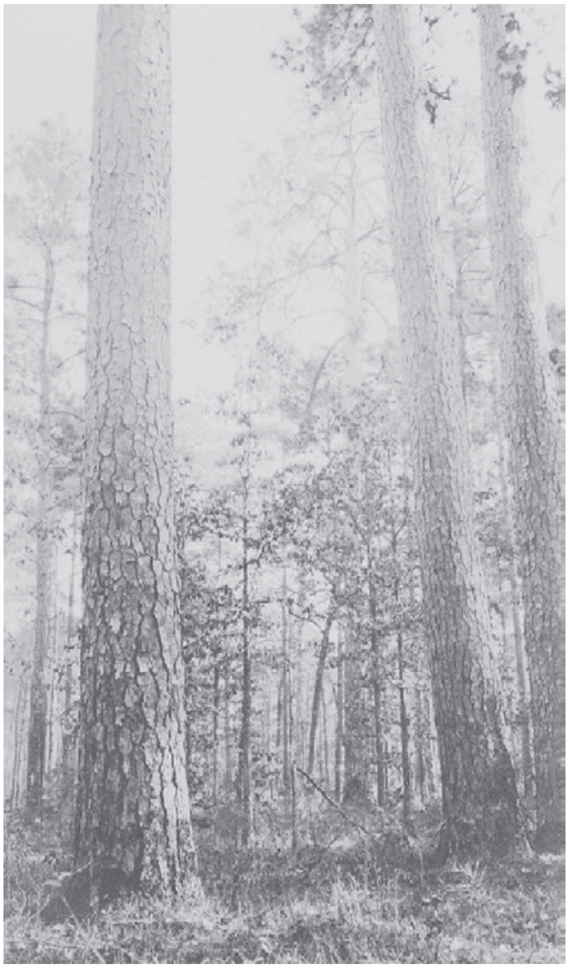

Figure 7—An image of presettlement pine forest stand structure in southern Arkansas. Photo by Russ Reynolds, circa 1935.

YR	ACTION
0	Harvest treatment
1	Herbicide/burn
2	
3	
4	Regeneration check
5	Mid-rotation thin(?)
6	
7	
8	Controlled burn
9	Pre-harvest cruise

Figure 8—A possible schedule of treatment actions under regulated management for old-growth-like stand characteristics in loblolly and shortleaf pine-dominated stands in southern Arkansas.

density areas to recover to the desired level. The denser areas will be more heavily cut when conditions are suitable. Mid-cycle thinnings may occur if an operational harvest volume is available.

Conclusions

A prescription that focuses on old-growth-like forests requires a dedicated, flexible, and long-term commitment to the treatment. Unlike many other timber operations, the desired outcome of this strategy may not become apparent for many years. Close monitoring of key stand attributes like species composition or big tree numbers is vital to help adjust treatments over time, with the sustainable achievement of structural and composition complexity (figure 6) being the true measure of success.

In principle, managing for old-growth-like characteristics appears to be a workable compromise between sustainable timber yield and functional old forests. This type of silviculture may seem inefficient, but since the primary objective is old-growth-like structure rather than commodity production, some irregularity is desirable. The effort involved in this project, the extension of the rotation period, and the reduction in timber yield are not likely to make this strategy widespread on the Gulf Coastal Plain, but when implemented, many other non-timber benefits should be realized.

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