CONTINUOUS COVER FORESTRY IN THE UNITED STATES— EXPERIENCE WITH SOUTHERN PINES

James *M. Guldin* *

Abstract

*Continuous cover forestry (CCF) has not been common in the southern United States. but if does exist. The best record **of research** and practice exists for mixed loblolly-shortleaf pine (Pinus taeda L.-P. echinata Mill.) stands in the Upper West Gulf Coastal Plain west of the Mississippi River. After 60 years, the Good and Poor Furm Forestry Forties had annual yields **of merchantable** volume (trees 10 cm dbh and larger) of 6.0 und 7.4 m^3/ha, und annual yields **of** sawtimber volume (trees 30 cm and larger) **of** 5.0 and 5.5 m^3/ha, respectively. Acceptable regeneration development und volume growth can both be maintnined at basal areu levels between I4 and 17 m^2/ha. If hurvests ure not maintained regularly over time, regeneration development will become suppressed and the stand will quickly develop an even-aged character. Competing vegetation is a problem on these good sites, and the use of herbicides hus been an important element **of success.** Over time, long-term success with CCF methods in pine stands in the southern United States requires uttention IO regeneration establishment and development, basal area of the residual stand, control **of** competing vegetation. and regular cutting-cycle hurvests.*

Keywords: uneven-aged, loblolly pine, shortleaf pine, regeneration, volume.

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INTRODUCTION

To a European, 100 miles is a long distance and 100 years is a short time—whereas Americans think the opposite.

This expression is often used in the United States to illustrate the difference in the general philosophy of life between Europeans and North Americans. It certainly applies to the forest history of our respective continents. For example, Fernow (1913) dated the development of forestry methods in Germany to the period between 1500 and 1800. Hartig wrote his eight rules for the shelterwood method in 1808 (Femow, 1913), which predates the establishment of the USDA Forest Service in 1905 by 97 years. In the United States, Gifford Pinchot, generally thought as the father of the forestry profession in North America, learned forestry in Europe and brought the concepts to North America in the late 19”’ and early 20”’ century. As a result, we professional foresters in North America trace our roots primarily to Europe a mere 100 years ago. It is likely that research papers will be presented during this Congress from European studies that are older than this.

Thus, it might be considered presumptuous for a North American scientist to keynote a congress on continuous cover forestry (CCF) using examples from the southern United States. Active management of second-growth forests of southern pines did not begin in earnest until the 1930s. That history is highlighted in the early 1940s by a capstone publication on managing loblolly pines in the west Gulf region (Chapman, 1942). Research in the southern United States dates back to the late 1920s and early 1930s--a long time in North American professional circles, but not necessarily in Europe and elsewhere.

But while it is admittedly not the oldest body of forestry knowledge, CCF research and practice in southern pines of the southern United States has a number of elements of keen interest. With emphasis on pines, it parallels other long-term CCF research such as the Dauerwald with Scots pine (*Pinus sylvestris* L.) (Troup, 1952) and ponderosa pine (*P. ponderosa* Laws.) in the western United States (Pearson, 1950; Becker and Corse, 1997). Secondly, the practice evolved not as a means of converting even-aged natural or planted stands but rather as a means to recover from understocked conditions. Finally, for some of this work, the record demonstrates success in managing intolerant species using CCF methods over time on good sites with high levels of competing vegetation; thus, it differs from previous experience in pines.

In this paper, research and practical application of CCF will be reviewed for one major southern pine forest type--the Upper West Gulf Coastal Plain west of the Mississippi River, in southern Arkansas and northern Louisiana, in mixed pine stands dominated by loblolly pine (*P. taeda* L.) with a minor and varying component of shortleaf pine (*P. echinata* Mill.). Additional practical experience, though with less research support, exists with longleaf pine (*P. palustris* L.) in the lower Gulf Coastal Plain of Florida and southern Georgia, and with pure shortleaf pine stands in the Ouachita Mountains of western Arkansas and eastern Oklahoma. The objective of this paper is to summarize the available research and review practical application of CCF methods with these southern pines.

METHODS

Study Area

In the South, the best long-term uneven-aged data set in the loblolly-shortleaf pine type comes from the Good and Poor Farm Forestry Forties of the Crossett Experimental Forest (CEF) in southern Arkansas. These unreplicated demonstration stands were established in 1937 in mixed loblolly-shortleaf pine stands of the West Gulf Coastal Plain. The Good Forty is 16.2 ha, and the Poor Forty is 13.2 ha; both have a site index of 29 m (base age 50). Results from these and results have been summarized after four decades (Reynolds et al., 1984; Baker, 1986), and the demonstrations are ongoing today (fig. 1). Demonstration stands in Mississippi and southwestern Arkansas share similar results to the Crossett work (Farrar et al., 1984; Farrar et al., 1989).

Stand origin

Loblolly-shortleaf pine stands of natural origin in the west Gulf region originated after the first cut of virgin forest in the early 1900s. In 1315, the Crossett Lumber Company, which owned the virgin forest land that would later become the CEF, harvested the area using a 38-cm stump limit (roughly, a 30-cm diameter limit) cut. Between 1915 and 1934, no deliberate management was done. The area supported occasional harvest of small hardwoods for chemical distillation, and was subject to arson fires. This was partly why the Company leased the 680-ha tract to the Forest Service in 1934 for establishment of the CEF; while the company interested in research information on management of second-growth forests, they also thought the Forest Service research staff could help control the arson fires.

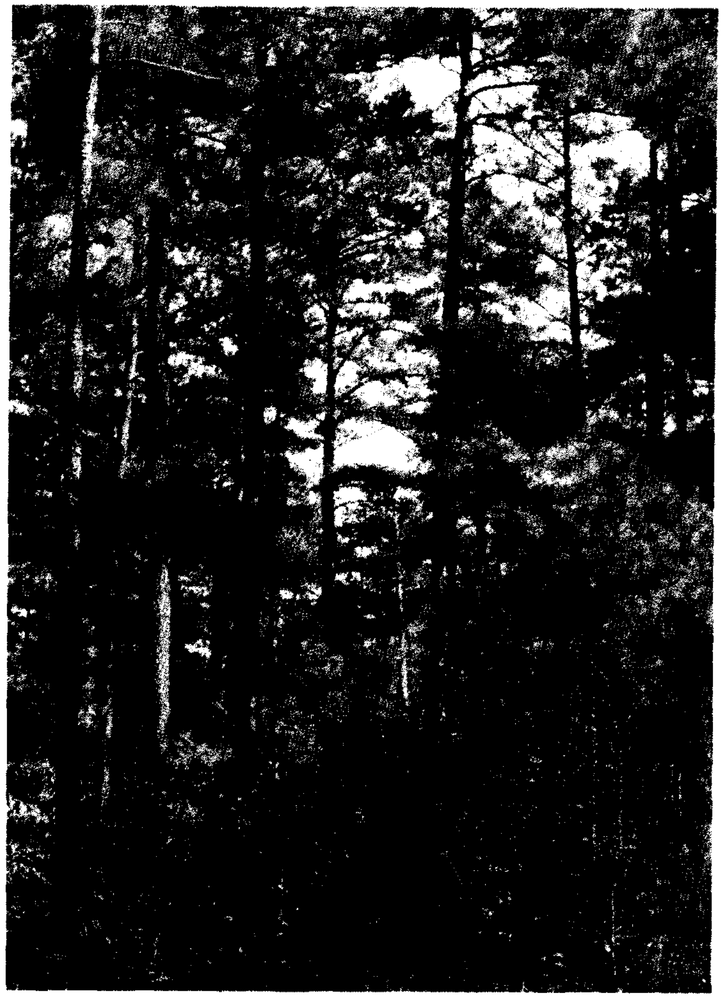

Figure I. Typical uneven-aged loblolly-shortleaf pine stand on the Crossett Experimental Forest, southern Arkansas, USA.

The Good and Poor Farm Forestry Forty demonstration stands were established in 1937, and at that time the diameter distribution of the pine component shows the reverse J-shaped curve typical of uneven-aged structure (figs. 2 and 3).

The area was stocked with pines that were smaller than the 30-cm diameter limit in 1915 but that had responded to release since then. The stands also had seedlings, saplings, and poles that seeded in after the cut and grew between 1915 and 1937. On average, the stands were 40 percent stocked in 1937 (Reynolds, 1969). This is a typical description of selective cutting in the region.

The descriptors "Good" and "Poor" refer to initial stocking, not site quality (Table I). The Good Forty had an initial basal area of 15.4 m^2/ha in the pine component (60 percent of which was sawtimber), and had a sawtimber volume of 71.4 m^3/ha.

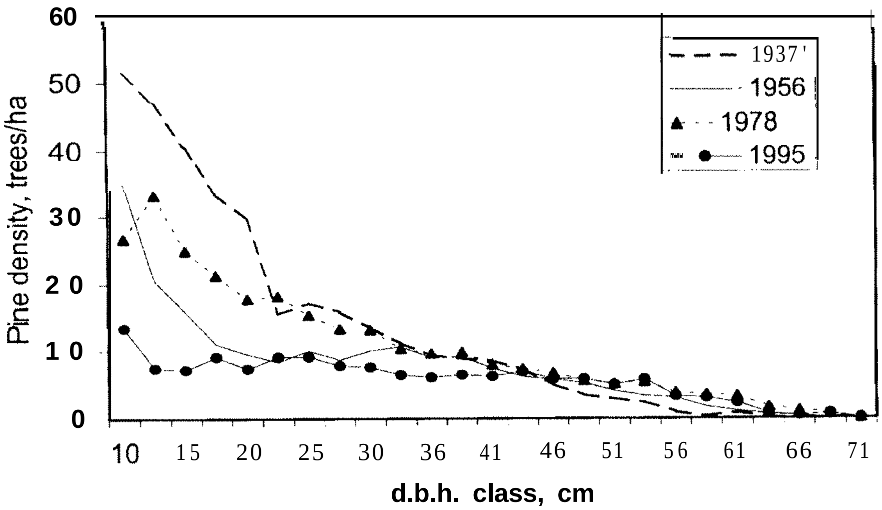

Figure 2. ***Distribution of pine stems per hectare by diameter class, Good Forty demonstration stand, 1937-1996.***

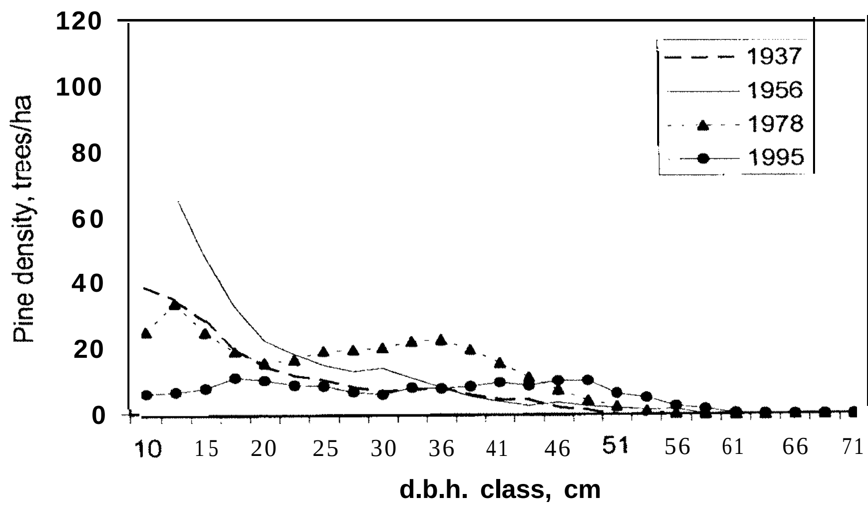

Figure 3. ***Distribution of pine stems per hectare by diameter cuss, Poor Forty demonstration stand, 1937-1996.***

Table 1. Summary of the mean properties in the Crossett Experimental Forest's Good and Poor Forties from 1936 to 1996. Cut data refers to amount harvested over the 60-year period.

	----- Poor Forty -----			----- Good Forty -----		
Property	1936	1996	Cut	1936	1996	Cut
Stems/ha						
<30 cm dbh	168.0	66.7	407.7	252.0	69.2	303.9
>30 cm dbh	42.0	86.5	222.4	74.1	74.1	185.3
Total	210.0	153.2	630.1	326.2	143.3	489.3
Basal area, m^2/ha						
<30 cm dbh	3.7	2.1	9.4	6.0	2.1	6.7
>30 cm dbh	4.8	12.6	34.4	9.2	11.5	33.1
Total	8.7	14.7	43.8	15.4	13.5	39.7
Volume, m^3/ha						
>10 cm dbh	68.3	135.3	374.3	125.4	123.8	360.2
>30 cm dbh	36.1	105.8	261.4	71.4	98.5	276.0

The Poor Forty had an initial basal area of only 8.7 m^2/ha (55 percent of which was sawtimber), and had a sawtimber volume of only 36.1 m^3/ha. After 60 years of management, standing sawtimber volume on the Good and Poor Forties had increased to 98.5 and 105.8 m^3/ha, respectively.

RESULTS

Regenera fion

Thc importance of regeneration in these demonstrations is poorly documented, for two reasons. First, there are no data on regeneration development between 1915 and 1937, from the initial high-grading prior to the establishment of the demonstrations. Secondly, the scientists involved in establishing the demonstrations in 1937 paid little attention to regeneration, for an obvious reason--its abundance.

High shade of overstory pines provides less competition for pine seedlings and saplings than the low shade of small hardwoods (Brender and Barber, 1956). Thus, control of the lower levels of shade that inhibit regeneration is most important. Reynolds (1959, 1969) reported that pine reproduction resulted from removal of poorer hardwoods of large and medium size, from continuing fire protection on the area, and from control of small hardwood stems. WC further noted that pine seedlings, saplings, and poles are regularly found growing in small openings and often directly under high-crowned larger stems. This is apparent in the diameter distributions of the Good and Poor Forties during the first 15 years of management (figs. 2 and 3). The continued ingrowth into the 10-cm class during this period is thc result of recruitment of saplings from the smaller classes.

The use of herbicides has been an element of every successful long-term demonstration of uneven-aged silviculture in southern pines, including the successful practical experience of which the author is aware. For example, periodic control of hardwoods using hcrbicides on approximately IO-year intervals has been an element of the CEF prescriptions from 1953 through 1979 (Baker, 1986). Thus, obtaining reproduction and promoting its development through the seedling and sapling classes is critical for successful uneven-aged management (Shelton and Cain, 2000).

This may be critical to the success of CCF methods with intolerant species on high-site quality stands. The previous successes using CCF methods to manage pines all occurred in situations where sites were relatively poor, and where competing vegetation was not a problem. Troup (1952) points to the Dauerwald sites near Bärenthoren, Germany, as sandy soils, annual precipitation of 22 inches, and a soil covering of moss, heath, and “a scanty growth of heather”. Isaac (1956) points to the general failure in obtaining regeneration when harvesting old-growth stands in the Pacific Northwest with CCF methods during the 1930s to 1950s, but reported success in ponderosa pine stands on semi-arid sites east of the Cascades. These demonstration studies at CEF are the first to show that CCF methods can bc applied with intolerant species on good sites, provided that competition is controlled effectively.

Residual basal area

Regeneration establishment and development are linked to the basal area of the merchantable component of the stand. Data from the CEF and elsewhere suggest that uneven-aged stands can be successfully managed within a range of residual basal area between roughly 10 and 17 m^2/ha (Baker et al., 1996; Farrar et al., 1984; Farrar et al., 1989; Farrar, 1996). At residual basal area levels less than 10 m^2/ha, the overstory is understocked and growth will not be optimal. At residual basal areas higher than 17 m^2/ha at the end of the cutting cycle, regeneration development is adversely affected.

The residual basal area target immediately after harvest must be established in conjunction with the expected length of the cutting cycle, the expected growth of the residual stand, and the upper basal area limit for the species. For example, uneven-aged loblolly-shortleaf pine stands at CEF grow between roughly 0.5 and 0.7 m^2/ha in basal area annually. If a 5-year cutting cycle is planned, the target residual basal area immediately after the cutting cycle harvest tnust therefore be roughly 13.5-14.5 m^2/ha, so that the stand does not exceed 17 m^2/ha at the end of the cutting cycle. Longer cutting cycles require lower residual basal area levels.

Volume development

Annual pine harvests were begun on both forties using the Volume-Guiding Diameter Limit (VGDL) method of stand regulation (Baker et al,. 1996; Farrar, 1996). This method is implemented as follows:

1. Construct a before-cut stand table using cruise data and local volume tables.
2. Calculate the expected future compound growth rate of the stand
3. Determine allowable cut. This is the difference between current volume and volume to which current stand must be reduced to grow back (at the expected compound growth rate) to desired volume over expected length of future cutting cycle.
4. Determine guiding diameter limit (GDL). The GDL is the diameter class in which allowable cut will be obtained, if all trees in larger classes are cut and part of guiding class is cut. This is easily done using an inverted cumulative volume table from largest to smallest classes.
5. Mark the stand both above and below the GDL, using the marking rule "cut the worst and leave the best, regardless of diameter class." If a tree larger than the GDL is growing well, note its volume, and remove an equivalent volume of poor trees smaller than the GDL .

Between 1937 and 195 1, VGDL harvests on the Poor Forty removed about half the annual growth to permit growing stock to rapidly build up. Over this same period on the Good Forty, harvests removed slightly less than annual growth to allow a gradual increase in stocking. Stocking on the Poor Forty reached an adequate level after 14 years, after which periodic harvest were about equal to growth. Both areas were cut annually for the first 32 years of management (1936-1968), but since then have been harvested about every 5 years.

Over 60 years, the total merchantable volume (trees IO cm dbh and larger) standing on the Good Forty remained constant at roughly 125 m^3/ha, but nearly three times that volume was cut in the interval (table 1). Conversely, the Poor Forty, which was poorly-stocked initially, doubled its standing over the 60-year period, and still supported harvests of 375 m^3/ha during that time. The average annual growth in total merchantable volume was 6.0 and 7.4 m^3/ha for the Good Forty and Poor Forty, respectively (fig. 4).

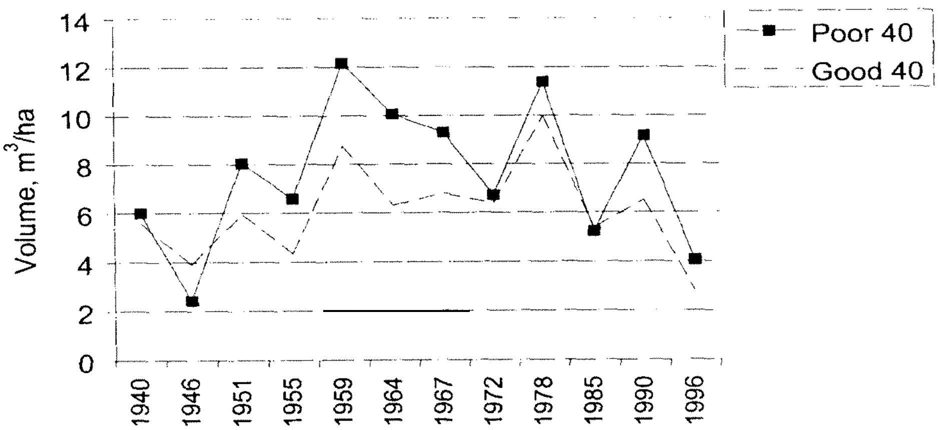

Figure 4. Total merchantable cubic volume, m^3/ha, for the Good and Poor Farm Forestry Forties at Crossett Experimental Forest, 1936-1996.

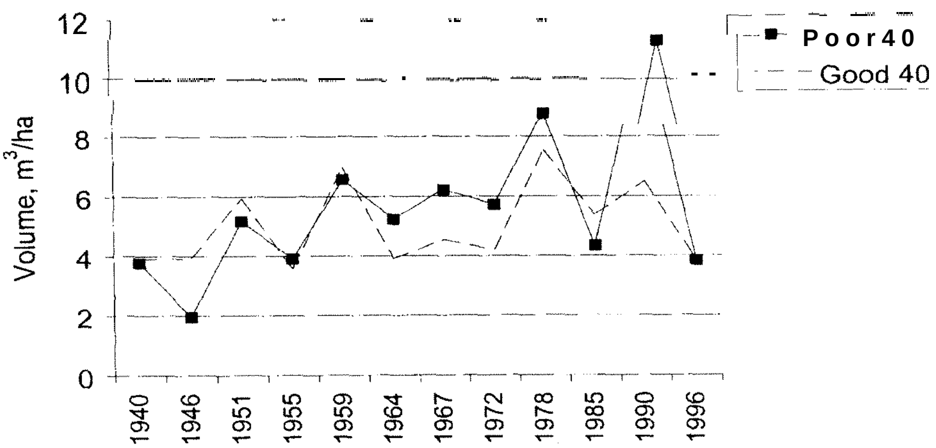

Figure 5. Sawtimber cubic volume, m^3/ha, for the Good and Poor Farm Forestry Forties at Crossett Experimental Forest, 1936-1996.

Over this same period, the sawtimber volume (trees 30 cm dbh and larger) standing on both the Good Forty and Poor Forty increased (table 1). On the Good Forty, standing sawtimber volume increased about 30 percent over 60 years; on the Poor Forty, standing sawtimber volume nearly tripled. On both Forties, harvests over the 60-year period exceeded 260 m^3/ha.

The average annual growth in sawtimber volume was 5.0 and 5.5 m^3/ha for the Good Forty and Poor Forty, respectively (fig. 5).

Developmental dynamics

Long-term management of southern pines using CCF methods requires a continued commitment to regular cutting cycle harvests. This is demonstrated by the changes in stand structure from the Crossett Good and Poor Forties through an accident of administrative history. In 1969, the retirement of the scientist in charge of the work led to a period of diminished custodial activity at the CEF. Active research was reestablished there in 1978. Between 1969 and 198.5, only two harvests occurred-a 1973 salvage cut following a severe ice storm, and a cutting cycle harvest in 1978. Neither of these harvests occurred according to classical uneven-aged guidelines. The salvage removed about 42 percent of the trees in the pulpwood component but only 12 percent of the trees in the sawtimber size classes, and the 1978 harvest was not sufficiently intensive, leaving a residual basal area of 16 m^3/ha.

This custodial management and recovery led to a loss in recruitment of reproduction into the pulpwood classes between 1978 and 1995. The Poor Forty (fig. 3) shows the results more clearly than the Good Forty (fig. 2): a decline in ingrowth and stocking in the pulpwood size classes, and a shift in the modal diameter class in the sawtimber component. Future monitoring on these demonstrations will show whether the abundant regeneration currently in the stands can grow into the 1 O-cm d.b.h. class and beyond at an acceptable rate.

Thus, a managed uneven-aged stand is not a “natural” stand structure. Without active silvicultural intervention, the defining structure is lost. If timely harvests had not been re-initiated at CEF after 1978, these stands would have reverted to fully-stocked single-stratum stands of even-aged character rather rapidly. As it is, the effect of the failure to recruit regeneration into the pulpwood component will be visible in the diameter distributions of the Good and Poor Forties for several decades.

Marking rules

Most of the long-term experience in marking uneven-aged prescriptions in southern pines fits within a simple axiom: cut the worst and leave the best (Reynolds, 1959; Reynolds, 1969; Farrar et al., 1984; Farrar et al., 1989; Farrar, 1996; Guldin, 1996; Baker et al., 1996). When stands have developed an uneven-aged structure over time, tree size becotnes correlated with age across the diameter distribution. This makes it easy to remove the poorer trees from each diameter class, leaving better trees in each class for future growth.

A practical approach to this was outlined in Baker et al. (1996), in which the before-cut stand inventory includes a three-way tree classification: the best trees ("growers"), average trees ("thinners"), and poor trees ("cutters"). This allows timber marking crew to get a feel for the proportion of cutters by diameter class, and to concentrate on removing the "cutters" when the stands are marked.

Some guidance is required that allows markers to judge whether an intermediate tree in the pulpwood size class can respond to release if it is allowed to remain in the stand. Reynolds (1959) noted that loblolly pines in the west Gulf region could respond to release even at advanced age. Baker and Shelton (1998) observed that if a loblolly pine had a 20 percent live crown ratio and good apical dominance, it should satisfactorily respond to release, even if it developed in the lower crown classes of fully-stocked uneven-aged stands for up to 40 years. Different standards would probably apply for different southern pine species, and for trees from lower crown classes in even-aged stands.

DISCUSSION

Successful management using CCF methods in mixed loblolly-shortleaf pine forest stands in the southern United States depends on a number of factors. Foremost is that the establishment and development of pine reproduction is critical. Cutting cycle harvests must be heavy enough to create conditions suitable for regeneration establishment, but also to prevent it from being suppressed before the second cutting cycle harvest occurs. Subsequent cutting cycle harvests must continue this developmental pattern. To ensure development of the pine reproduction, herbicides are needed to control competing vegetation, especially on better sites.

Maintaining the residual stand at basal areas between 14 and 17 m^2/ha allows for establishment and development of pine regeneration. The average annual growth and thus the allowable cut is from 6.0 to 7.4 m^3/ha of total merchantable volume, and 5.0 to 5.5 m^3/ha of sawtimber volume, annually. At this growth rate, operable sawtimber harvests of 25 m^3/ha are generated in five years. At current stumpage prices in Arkansas, this would be a value of approximately $ 1500/ha every five years.

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In these intolerant pine types, the stand will quickly revert to even-aged character if the scheduled cutting cycle harvests are delayed or omitted. The marking rule of “cut the worst and leave the best” allows for continuous improvement of the residual stand.

Finally, the most prominent conclusion drawn from the southern pine experience is that understocked stands can be effectively rehabilitated to full stocking using uneven-aged silviculture, where regeneration establishment is linked with effective control of competing vegetation. Starting from understocked conditions, one can quickly develop stands that can support a cutting cycle harvest equivalent to growth. A rule of thumb based on CEF stands is that three cutting cycles will be needed to go from understocked to fully-stocked conditions.

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Continuous Cover Forestry

Assessment, Analysis, Scenarios

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