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116 years of selection silviculture in upland hardwood stands

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SIXTEEN YEARS OF SELECTION SILVICULTURE IN UPLAND HARDWOOD STANDS

Richard C. Schlesinger

Although selection silviculture changes a forest gradually, the cumulative effects over a long period of time may be great. So, to evaluate such a system, we need to understand both its short-term and long-term effects on particular forest types.

A study of several management systems[1] in upland hardwood stands in southern Illinois showed some short-term changes to be fewer cull and low quality trees, fewer small trees, and indications that white oak, hickory, and yellow-poplar are replacing the red oaks as the dominant species.

BACKGROUND

Several variations of uneven-aged management were tested on upland hardwood stands in the Kaskaskia Experimental Forest in southern Illinois. Management units 10 to 30 acres in size were classified into two general productivity groups. The high productivity group (10 mixed hardwood units) was located on northerly slopes and in moist coves (fig. 1 left). The lower productivity group, (11 oak-hickory units) was confined to the drier ridgetops and southerly slopes (fig. 1 right). Oak site index ranged from 50 to 80.

Initially, the stands contained two to four separate age classes and were only moderately stocked with growing stock trees. The management variations tested included (1) cutting cycles of 4 versus 8 years on the better sites and 8 versus 16 years on the poorer sites, (2) growing the better trees to 20 inches d.b.h. (diameter at 4.5 feet above the ground) versus 25 inches on the better sites and 17 inches versus 22 inches on the poorer sites, and (3) intensive treatment of the uncut portion of the stands (killing unmerchantable trees and weeding the reproduction) versus no treatment. The planned harvest from the mixed hardwood areas was 150 board feet (1/4" International Rule) per acre per year and 75 board feet from the oak-hickory areas.

The silvicultural system applied to all units was a form of small group selection. The merchantable cut was composed of trees above the maximum size objective plus low quality and poor risk smaller

[1] *Study initiated and conducted under the general supervision of Leon S. Minckler.*

Figure 1.--*The photo at the left shows one of the mixed hardwood sites before treatment. The trees have good form and are closely spaced. The photo at the right shows one of the oak-hickory sites before treatment. The trees are generally shorter and of poorer quality.*

sawtimber trees. Cull and inoperable[2] trees were killed following each cutting on the intensive treatment units (all but two units on the mixed hardwood areas and one unit on the oak-hickory areas). Small openings (averaging 1/10 acre) were created for regeneration by cutting groups of trees. During later treatments, an attempt was made to create openings of at least 1/8 acre and to clear the openings of saplings and poles immediately. Pines were planted in the openings following the first harvest on three of the oak-hickory units but this practice was discontinued because survival was poor. Inventories of all trees larger than 4.5 inches d.b.h. were made before each treatment.

The management treatments would not be expected to differentially affect the stands during the 16-year period, and indeed we found no significant differences between treatments. Because the silvicultural system was the same for all management treatments, the data from all units within each productivity group were combined to assess the general changes in the forest.

[2] *Unacceptable growing stock between 5 and 10 inches d.b.h. These trees could have been sold for mine props or pulpwood if a market had existed.*

CHANGES AFTER 16 YEARS

The principal changes after 16 years were in the stand structure and in the overall stand quality. In addition, there were strong indications that stand composition will change in the future. The main overstory species, initially and after 16 years were white oak (*Quercus alba* L.), hickory (*Carya* sp.), and the red oaks (*Q. velutina* Lam., *Q. coccinea* Muenchh., and *Q. rubra* L.). Yellow-poplar (*Liriodendron tulipifera* L.) grew on the better sites, and post oak (*Q. stellata* Wangenh.) was found on the oak-hickory areas. The red oak group was the chief component of the stands during the 16 years.

On the mixed hardwood areas, both the number of trees and the total basal area decreased (table 1). The decrease occurred in the smaller sizes; there were 21 fewer trees per acre between 5 and 10 inches d.b.h. The red oak group accounted for almost half the decrease, all in the smaller sizes. This group appears to be essentially an even-aged component of the stands. The average d.b.h. increased from 11.5 to 14 inches, some of the smaller trees grew into sawtimber, replacing the trees that were harvested (table 2), and some mortality occurred. Little, if any, ingrowth into the 5-inch class took place.

Table 1.--*Mixed hardwood growing stock*

D.b.h. (inches)	Hickory	White oak	Red oak group	Yellow-poplar	Misc.	Total
ORIGINAL STAND (TREES PER ACRE)						
5- 7	10.0	8.7	6.1	0.9	3.3	29.0
8-10	5.2	5.6	9.1	1.5	1.9	23.3
11-17	4.5	5.9	15.3	3.1	3.6	32.4
18+	.8	1.2	3.4	.7	.2	6.3
Total	20.5	21.4	33.9	6.2	9.0	91.0
AFTER 16 YEARS (TREES PER ACRE)						
5- 7	6.6	7.6	2.2	1.2	0.8	18.4
8-10	4.1	4.3	3.2	.7	.5	12.8
11-17	4.5	7.9	13.4	2.9	1.3	30.0
18+	.3	1.5	4.8	1.3	.1	8.0
Total	15.5	21.3	23.6	6.1	2.7	69.2
BASAL AREA OF ORIGINAL STAND (SQUARE FEET PER ACRE)						
5- 7	1.9	1.7	1.4	0.2	0.6	5.8
8-10	2.2	2.5	4.1	.7	.8	10.3
11-17	4.4	5.6	15.5	3.0	3.5	32.0
18+	2.0	2.5	7.1	2.2	.6	14.4
Total	10.5	12.3	28.1	6.1	5.5	62.5
BASAL AREA AFTER 16 YEARS (SQUARE FEET PER ACRE)						
5- 7	1.3	1.4	0.5	0.2	0.1	3.5
8-10	1.8	1.9	1.4	.3	.2	5.6
11-17	4.3	8.1	14.5	3.3	1.3	31.5
18+	.5	3.3	10.6	2.8	.2	17.4
Total	7.9	14.7	27.0	6.6	1.8	58.0

Table 2.--*Trees removed between the first and last inventories*
(In number per acre)

Category	D.b.h. (inches)	Hickory	White oak	Red oak group	Yellow-poplar	Misc.	Total
MIXED HARDWOOD SITE							
Inoperable	5- 7	3.6	2.5	1.6	0.3	2.7	10.7
	8-10	1.7	1.4	1.7	.3	1.7	6.8
Merchantable	11-17	1.0	.6	2.5	0.3	1.8	6.2
	18+	.9	.8	2.7	.6	.3	5.3
Cull	5- 7	5.4	4.5	2.1	0.5	11.7	24.2
	8-10	1.0	.7	1.0	.3	2.8	5.8
	11-17	1.1	.4	1.5	.2	2.0	5.2
	18+	.2	.2	.3	.1	.1	.9
Total		14.9	11.1	13.4	2.6	23.1	65.1
OAK-HICKORY SITE							
Inoperable	5- 7	2.8	1.7	1.9	0.8	0.9	8.1
	8-10	1.7	1.0	1.7	.5	.5	5.4
Merchantable	11-17	1.2	.6	2.5	.4	.2	4.9
	18+	.4	.5	1.9	.1	.1	3.0
Cull	5- 7	4.9	2.5	3.3	1.3	4.7	16.7
	8-10	1.2	.6	1.3	.4	.9	4.4
	11-17	1.3	.6	1.7	.4	.7	4.7
	18+	.1	.2	.6	.2	.1	1.2
Total		13.6	7.7	14.9	4.1	8.1	48.4

The other half of the decrease is accounted for by the hickories and miscellaneous species. From a management standpoint, these species were considered least desirable and therefore were cut heavier than the oaks and yellow-poplar. For these species also, most of the decrease is in the number of small trees.

Both white oak and yellow-poplar had the same number of trees after 16 years as were initially present. Ingrowth was adequate to replace trees removed by cutting or mortality. Yellow-poplar is the only species to have more 5- to 7-inch trees. During logging, an attempt was made to scarify the openings created, and this practice combined with some release and weeding was sufficient to regenerate the central portion of the larger openings to yellow-poplar. Ingrowth trees of the more tolerant, persistent white oak were already present in the stands at the start of the study as saplings.

On the less frequently treated oak-hickory areas, both the number of trees and the basal area increased (table 3), but there was a slight decrease in the number of small trees. The red oak and miscellaneous groups contained fewer trees after 16 years, post oak had the same amount, and white oak and the hickories increased because of ingrowth. On these areas also, there are fewer 5- to 10-inch red oaks; the average diameter of the group increased from 10 to 11 inches.

A managed, uneven-aged stand is characterized by fewer trees in each successively larger diameter class. This structure allows for natural mortality, selection of the better trees to retain for future growth, and the generally slower growth rates of subdominant trees, while providing for the replacement of the trees that are removed by cutting or that grow into the next higher diameter class. The diameter distribution on the mixed hardwood areas, however, has deviated from this structure--(fig. 2), there are too few trees in the smaller diameter classes. The oak-hickory areas, on the other hand, have enough small trees (fig. 3), but a deficit may be developing in the middle diameter classes.

One problem in bringing a stand under management is developing a sustainable stand structure. During the long transition from unmanaged to managed conditions the diameter distribution may little resemble the usual one for the silvicultural system. In our stands a relatively even-aged red oak group is moving through the stand so the transition period will include the time necessary for this movement to be completed and for this group to be replaced. The stand structure after 16 years indicates that the transition period, particularly for the mixed hardwood areas, is not over.

Stand quality, as measured by the relative number of cull and inoperable trees, improved on both the mixed hardwood and the oak-hickory areas (table 4). Excluding the

Table 3.--*Oak-hickory growing stock*

D.b.h. (inches)	Hickory	White oak	Red oak group	Post oak	Misc.	Total
ORIGINAL STAND (TREES PER ACRE)						
5- 7	10.2	9.9	12.0	3.4	1.9	37.4
8-10	3.6	6.4	10.7	1.8	.7	23.2
11-17	3.6	5.3	12.6	1.2	.9	23.6
18+	.4	.6	2.3	.1	.2	3.6
Total	17.8	22.2	37.6	6.5	3.7	87.8
AFTER 16 YEARS (TREES PER ACRE)						
5- 7	11.5	13.2	9.7	2.8	1.4	38.6
8-10	4.3	6.7	7.6	1.8	.5	20.9
11-17	3.2	8.8	14.8	1.7	.7	29.2
18+	.0	.8	2.6	.1	.1	3.6
Total	19.0	29.5	34.7	6.4	2.7	92.3
BASAL AREA OF ORIGINAL STAND (SQUARE FEET PER ACRE)						
5- 7	1.9	2.0	2.5	0.7	0.3	7.4
8-10	1.6	2.8	4.6	.8	.3	10.1
11-17	3.6	5.0	12.4	1.1	.9	23.0
18+	.8	1.3	4.8	.3	.3	7.5
Total	7.9	11.1	24.3	2.9	1.8	48.0
BASAL AREA AFTER 16 YEARS (SQUARE FEET PER ACRE)						
5- 7	2.1	2.5	1.9	0.6	0.2	7.3
8-10	1.8	2.9	3.4	.8	.2	9.1
11-17	3.0	8.6	15.2	1.6	.7	29.1
18+	.3	1.8	5.7	.0	.4	8.2
Total	7.2	15.8	26.2	3.0	1.5	53.7

three units on which cull removal was not part of the treatment, there were only 14 percent as many cull and inoperable trees on the mixed hardwood areas and 37 percent as many on the oak-hickory areas. This improvement in stand quality obviously resulted from the removal of the poorer trees rather than an increase in the number of better trees. On the intensively treated areas, it was necessary to kill 54 trees per acre on the mixed hardwood areas and 41 on the oak-hickory areas. More than 60 percent of the trees killed were in the 5- to 7-inch d.b.h. class. On the three units that had no treatment, the number of cull and inoperable trees declined by 10 percent during the management period, indicating that many of the smaller cull and inoperable trees died naturally or developed into acceptable growing stock.

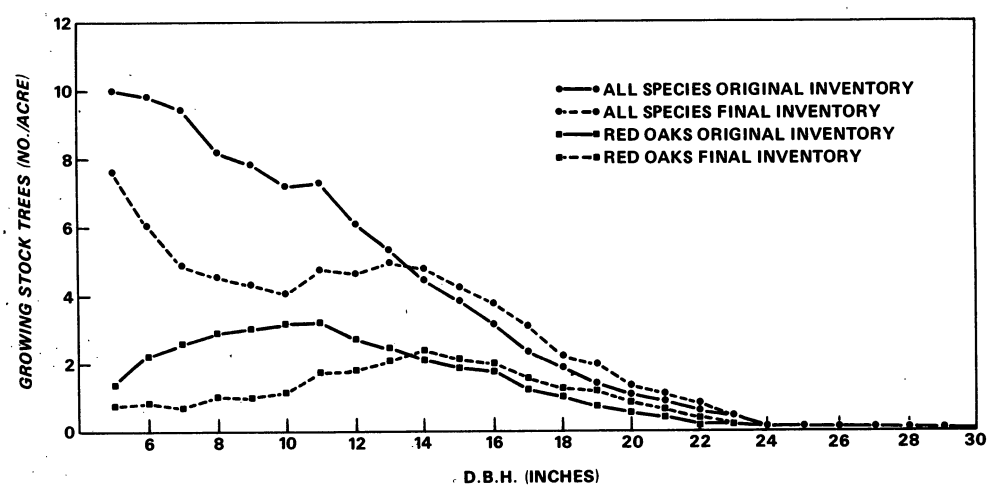

Figure 2.--*Diameter distribution on the mixed hardwood sites.*

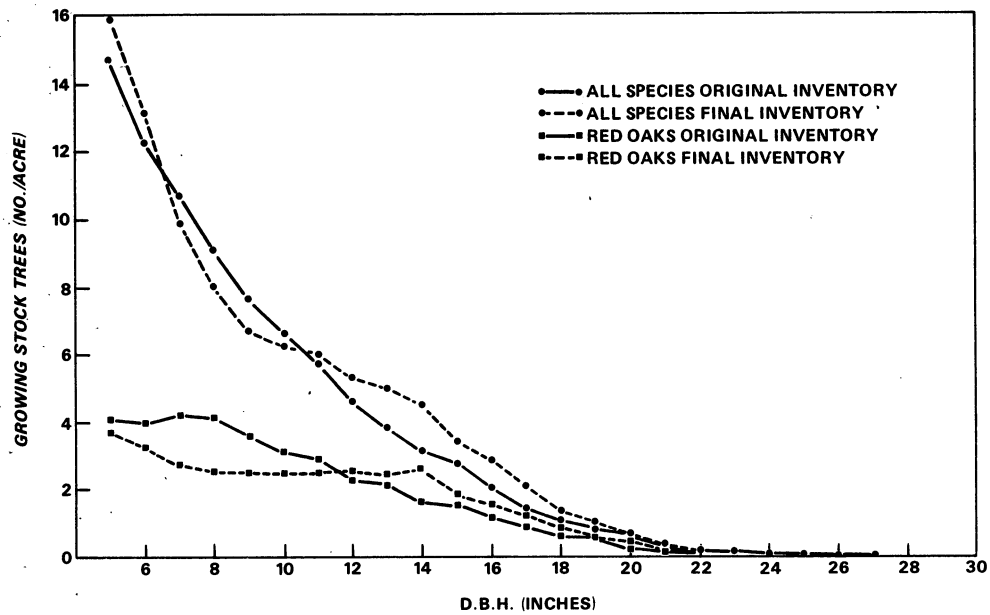

Figure 3.--*Diameter distribution on the oak-hickory sites.*

The merchantable volume increased by 1,100 board feet per acre on both the mixed hardwood and oak-hickory sites (tables 5 and 6). The increase for the red oak group alone amounted to 800 and 730 board feet, respectively. The growth per acre per year (increase in standing volume plus harvested volume) averaged 218 board feet and 133 board feet, respectively; the red oak group was the dominant factor. On both areas, the average volume per tree increased, as did the average diameter of the sawtimber, reflecting the maturing of the red oak group.

Table 4.--*Cull and inoperable trees (per acre basis, intensively treated units only)*

Category	Hickory	White oak	Red oak group	Yellow-poplar	Misc.	Total
MIXED HARDWOOD						
			Number of Trees			
Original	4.1	3.0	3.4	0.6	13.2	24.3
After 16 years	.9	.7	.4	.2	1.2	3.4
			Basal Area			
Original	1.9	1.3	2.1	0.4	4.6	10.3
After 16 years	.3	.4	.3	.1	.3	1.4
OAK-HICKORY						
			Number of Trees			
Original	6.4	3.3	5.4	1.8	4.8	21.7
After 16 years	2.5	1.5	1.9	.6	1.6	8.1
			Basal Area			
Original	2.6	1.7	3.2	1.0	1.6	10.1
After 16 years	.7	.4	1.0	.2	.3	2.6

CONCLUSIONS

Because the stands were not fully stocked initially, changes in stand characteristics would have been expected during the 16-year period even without management as the stands continued their recovery from past disturbances. The timber volumes harvested during the period were 149 board feet per year on the mixed hardwood areas (almost exactly as planned) and 64 board feet per year on the oak-hickory areas, about 15 percent below the desired harvest. Growth added 69 board feet per year to the standing volume on both areas. However, because a large portion of this growth and yield was derived from the red oak group, and this group does not appear to be replacing itself, these figures may not be good indicators of future growth and yield.

If the management is continued, the most likely species to replace the red oak group are white oak, hickory, and, on the better sites, yellow-poplar. The yellow-poplar regeneration, where present, provides ample opportunity for normal crop tree selection. Just what proportion of the white oak and hickory saplings, some of which may be as old as the overstory, will respond to management and develop into acceptable crop trees is yet an open question. And contined cultural treatments

Table 5.--*Mixed hardwood volume*
(In board feet per acre)

D.b.h. (inches)	Hickory	White oak	Red oak group	Yellow-poplar	Misc.	Total
ORIGINAL STAND						
11-17	446	430	1,423	330	294	2,923
18+	291	250	852	341	74	1,808
Total	737	680	2,275	671	368	4,731
AFTER 16 YEARS						
11-17	485	763	1,603	422	132	3,405
18+	99	383	1,474	460	19	2,435
Total	584	1,146	3,077	882	151	5,840
GROWTH AND YIELD						
Total harvested	365	242	1,183	368	221	2,379
Total growth	212	708	1,986	579	4	3,488
Growth/ year	13	44	124	36	1	218

Table 6.--*Oak-hickory volume*
(In board feet per acre)

D.b.h. (inches)	Hickory	White oak	Red oak group	Post oak	Misc.	Total
ORIGINAL STAND						
11-17	279	361	1,095	61	77	1,873
18+	86	125	534	23	47	815
Total	365	486	1,629	84	124	2,688
AFTER 16 YEARS						
11-17	242	727	1,577	95	74	2,715
18+	33	191	781	10	66	1,081
Total	275	918	2,358	105	140	3,796
GROWTH AND YIELD						
Total harvested	170	126	645	33	49	1,023
Total growth	80	558	1,374	54	65	2,131
Growth/ year	5	35	86	3	4	133

may be necessary to restrain the more tolerant but less desirable species such as American hornbeam (*Carpinus caroliniana* Walt.) and Florida maple (*Acer barbatum* Michx.).

Any conclusions based on a portion of the transitional period from unmanaged to managed conditions must be considered tentative. Nevertheless, many stands are being placed under management for the first time. Although the specific reaction to group-selection silviculture will be influenced by the initial stand structure and condition, the types of changes that have occurred in these upland hardwood stands can be expected to occur in other upland hardwood stands.

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Schlesinger, Richard C.
1976. Sixteen years of selection silviculture in upland hardwood stands. USDA For. Serv. Res. Pap. NC-125, 6 p., illus. North Cent. For. Exp. Stn., St. Paul, Minn.

Describes the changes in the structure and quality of two upland central hardwood areas and discusses an anticipated change in species composition.

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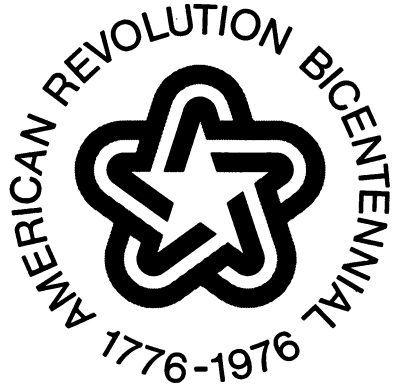
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