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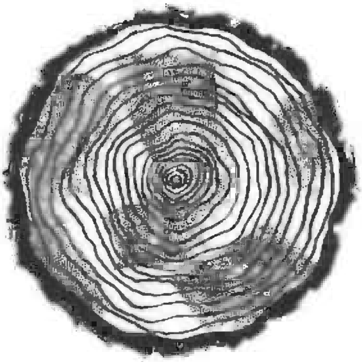
TIMBER
MANAGEMENT
ON THE CROSSETT EXPERIMENTAL FOREST

BY R. R. REYNOLDS



TECHNICAL
BULLETIN NO. 1206

NOVEMBER 1959

U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, WASHINGTON, D.C.

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FIGURE 1.—Many diametered stand of loblolly and shortleaf pine on the Crossett Experimental Forest.

EIGHTEEN YEARS OF SELECTION TIMBER MANAGEMENT ON THE CROSSETT EXPERIMENTAL FOREST [1]

By R. R. Reynolds

Southern Forest Experiment Station

INTRODUCTION

The loblolly-shortleaf pine forests of Arkansas and Louisiana are chiefly second growth (fig. 1). They consist of grown-up remnants of the virgin stands (*2*) [2] that were cut in the late 1800's and early 1900's, plus pines and hardwoods that seeded in during the last 30 to 50 years. Most stands have been cut at least once since the original timber was removed. Nearly all were repeatedly damaged by wildfire before the middle 1930's, when forest management began to be considered and fire protection became a reality.

By the time timber management appeared financially attractive, most acres were badly understocked. On the average there were less than one-fourth as many pines as were needed to utilize the sites fully.

Since pulpwood had little market in the 1930's, and since most of the pines present were below saw-log size, the diameter-limit or clear-cutting methods used in the past were infeasible. From the landowners' standpoint, expectations did not warrant spending the money required to remove the existing trees and brush and establish fully stocked stands. What was needed was an approach that would improve existing stands and also provide current and sustained income.

But would it be possible to start with understocked second-growth stands containing abundant low-grade hardwoods and develop them to full pine stocking in a reasonable time? Could this be done while timber was being harvested to provide current income? What would be the costs and returns from such management?

To answer such questions, a "pilot plant" study of 958 acres of typical unmanaged loblolly-shortleaf pine was started on the Crossett Experimental Forest [3] in 1937. From the economic as well as the silvicultural standpoint, the selection system seemed best suited to conditions both on the forest and in the region (fig. 2) at the time.

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[1] Acknowledgment is due Walter E. Bond and A. E. Wackerman, who helped plan the study that forms the main basis for this publication; Ike W. Rawls, who supervised and helped do much of the cruising, marking, and recordkeeping; and The Crossett Co., which donated the land and timber for this and other studies and has given encouragement throughout the study. Frances Walker handled most of the computations and checked all figures in the report.

[2] Italic numbers in parentheses refer to Literature Cited, p. 62.

[3] The Crossett Experimental Forest, 7 miles south of Crossett, Ark., and 1½ miles north of the Louisiana State line, was typical of the average-to-better stands in southern Arkansas and northern Louisiana.

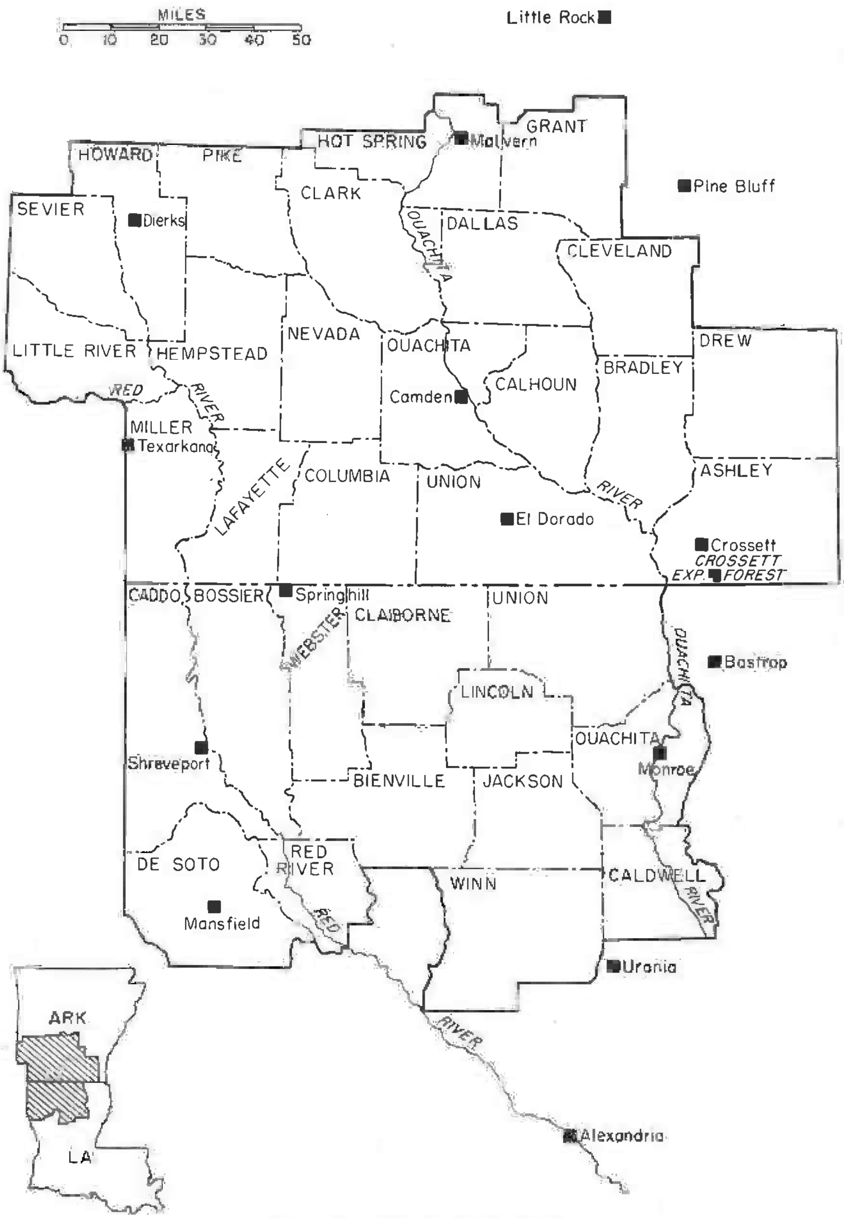

Figure 2.—The Crossett region.

Although even-aged management is a desirable system, especially for some kinds of large ownerships, the selection system has much to offer those who wish to grow a goodly percentage of large, high-quality trees. It also has much to offer farmers and others who wish to harvest trees at frequent intervals. A study of even-aged management is also now in progress at Crossett, and in a few years it will be possible to make valid comparisons of the even-aged and selection systems.

The next section pictures the region to which the study findings directly apply. The place of timber in the region's economy is also discussed, together with the market outlook and landownership patterns. A description of the study follows, beginning on page 13.

THE CROSSETT FOREST REGION

The loblolly-shortleaf pine forest type predominates in north Louisiana and south Arkansas (fig. 3). The most recent Forest Survey found 55 percent of the region's forest to be in this type (*24*, *25*). The oak-pine type is similar, usually being derived from the loblolly-shortleaf type by heavy cutting of pines with little or no cutting of hardwoods. Because pine yields a greater return than hardwoods on most of the region's upland sites, forest managers have begun to remove hardwoods (*7*, *18*) so as to increase pine stocking. As this trend continues, much of the oak-pine type will revert to loblolly-shortleaf. The oak-pine and loblolly-shortleaf types together occupy 72 percent of the forest area (table 1).

Two bottom-land hardwood types—elm-ash-cottonwood and oak-gum-cypress—are the only others occupying appreciable forest area in the region. They are found in the river and stream bottoms dissecting the pine lands. They comprise 2 million acres, or 19 percent of the region's forest area.

TABLE 1.—*Area of forest types in the Crossett region*

Forest type	Southwest Arkansas	Northwest Louisiana	Crossett region	
	Thousand acres	*Thousand acres*	*Thousand acres*	*Percent*
Softwood:				
Longleaf-slash pine		69. 3	69. 3	1
Loblolly-shortleaf pine	3, 956. 4	1, 828. 4	5, 784. 8	55
Oak-pine	943. 9	887. 7	1, 831. 6	17
Total	4, 900. 3	2, 785. 4	7, 685. 7	73
Hardwood:				
Oak-hickory (upland hardwood)	138. 2	656. 2	794. 4	8
Elm-ash-cottonwood and oak-gum-cypress (bottom-land hardwoods)	1, 300. 7	728. 2	2, 028. 9	19
Total	1, 438. 9	1, 384. 4	2, 823. 3	27
All types	6, 339. 2	4, 169. 8	10, 509. 0	100

The Loblolly-Shortleaf Pine Type

Loblolly pine (*Pinus taeda* L.) is sometimes called oldfield pine because it forms nearly pure stands on abandoned farmland. Trees in the open often grow 1 inch in diameter per year. Because such

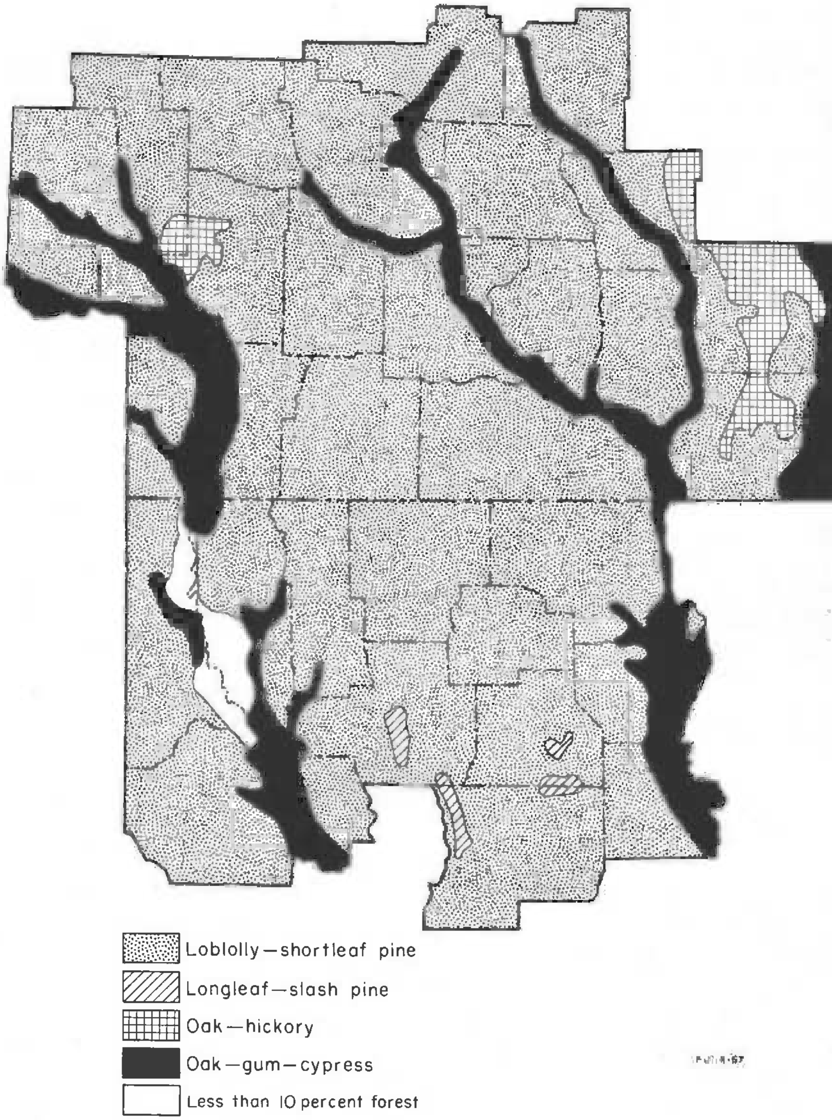

FIGURE 3.—Major forest types of south Arkansas and north Louisiana.

open-grown trees have large limbs and excessive bole taper, the species has been nicknamed bull pine. Such trees gave the species a reputation for yielding lumber that is very knotty and apt to crook and warp.

This reputation is largely undeserved. Although the species does not prune well when open grown, it produces desirable timber wherever it is forced to compete with other pines or hardwoods. Under such conditions a tree's diameter growth can be regulated almost at will by controlling competition. Until age 40 or 50, all except the hopelessly suppressed loblolly pines will quickly respond to release (*19*). This characteristic is invaluable to the forest manager, because small groups or stands of young trees can be kept dense until 20 to 40 feet of clear bole develop. These groups or stands can then be gradually opened up so that promising individuals can accumulate quality wood rapidly. Many of these trees have a knotty core of 3 to 8 inches at breast height but produce knot-free lumber outside this core on at least the first two logs. In stands reduced to 70–90 square feet of basal area per acre, many trees grow in diameter at the rate of 3 inches in 10 years, and a few grow 4 inches.

Loblolly pine grows well on a variety of sites. It is found on deep sands and heavy clays, and on fairly shallow and dry as well as deep and wet soils. It develops best on the deeper, better, and wetter soils (*34*). Very fine specimens, 30 or more inches in diameter, over 100 feet tall, and less than 100 years old, can be found in the smaller river bottoms and along the edges of the larger bottoms. Exceptional trees are also seen on deep upland soils that have an adequate water supply.

Shortleaf pine (*Pinus echinata* Mill.) usually grows in association with loblolly. In south Arkansas and north Louisiana the proportion is often half loblolly and half shortleaf. The proportion of loblolly increases toward the southern part of the region, while that of shortleaf rises in the northern extension of the type. Shortleaf endures on poorer sites than loblolly. On medium-to-good sites loblolly will grow in diameter at a faster rate than shortleaf. On good sites, growth of 3 inches in diameter in 10 years is not uncommon in managed shortleaf stands. Height growth of loblolly usually is slightly greater than that of shortleaf. For these reasons, loblolly pine is to be preferred when choice is possible.

Shortleaf, however, does possess some advantages over loblolly. Young trees will sprout after being cut or burned, whereas loblolly will not. Shortleaf also produces smaller branches and limbs, and the bole tends to clean up more easily.

Shortleaf and loblolly rarely grow in extensive pure stands. The virgin forest contained many upland hardwoods. Because few hardwoods were removed with the virgin pine, today's second-growth stands contain many holdover hardwoods plus an abundance of new seedlings. The red oaks, including southern red oak (*Quercus falcata* Michx.), cherrybark oak (*Q. falcata* var. *pagodaefolia* Ell.), black oak (Q. *velutina* Lam.), and Shumard oak (*Q. shumardii* Buckl.) (*12*), are the most common group of hardwoods found on pine sites.

Next in importance are the white oaks, including swamp chestnut oak (*Quercus michauxii* Nutt.), white oak (*Q. alba* L.), post oak (*Q. stellata* Wangenh.), and others. In some places sweetgum (*Liquidambar styraciflua* L.) is more numerous than the white oaks. Blackgum (*Nyssa sylvatica* Marsh.) is found on the uplands and water tupelo (*N. aquatica* L.) along the streams. The uplands also have some ash (*Fraxinus americana* L. and *F. pennsylvanica* Marsh.), elm (*Ulmus americana* L. and *U. rubra* Muhl.), red maple (*Acer rubrum* L.), and beech (*Fagus grandifolia* Ehrh.). Other hardwoods (table 2) account for very small percentages in these stands (*24*).

The region has a sawtimber growing stock of nearly 19 billion board-feet (International 1/4-inch rule) in pine and over 11 billion board-feet in hardwoods. Total growing stock is 4 billion cubic feet of pine and about the same volume in hardwoods.

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TABLE 2.—*Distribution of growing stock by species within each forest type, 1948–51—Southwest Arkansas Forest Survey Unit*

Species	All types	Loblolly-shortleaf pine	Loblolly-shortleaf pine-hardwood	Cedar	Bottomland hardwood	Upland hardwood	Upland hardwood-pine
Softwood:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Loblolly pine	15.9	31.0	26.7		1.3		4.1
Shortleaf pine	24.4	57.1	26.8	5.5	[1]		7.4
Cypress	1.6		[1]		6.3		
Cedar	.2	[1]	[1]	30.4	[1]	0.3	.4
Total	42.1	88.1	53.5	35.9	7.6	.3	11.9
Hardwood:							
Southern red, black, and scarlet oaks	8.0	2.6	10.1	2.2	.6	24.2	19.6
Cherrybark, Shumard, and northern red oaks	3.1	.4	1.7	2.9	2.9	10.3	4.8
Water oaks	5.6	.3	2.6		18.0	1.3	3.0
White oaks	5.9	2.0	7.8	1.5	1.3	15.1	15.5
Other white oaks	8.5	2.6	8.5	27.1	10.9	16.1	11.2
Sweetgum	7.5	1.9	6.6	2.2	14.7	5.7	13.5
Black and tupelo gums	2.9	.7	3.0	[1]	4.4	4.6	4.5
Cottonwood	.7				2.8	.1	[1]
Willow	1.2		.1		4.6	.1	
Pecan	1.5				5.9	[1]	[1]
Other hickories	4.9	1.1	4.1	11.0	3.3	14.0	10.1
Elms	2.8	.2	.9	10.6	7.3	3.5	2.0
Maples	.6	[1]	.4	.4	1.3	.7	1.1
Yellow-poplar	[1]					.1	[1]
Sycamore	.5		[1]	.7	1.5	.5	.4
Ash	1.3	[1]	.2	2.2	3.9	1.1	1.0
Beech	.2	[1]	.2		.2	.3	.7
Sweetbay and magnolia	.1		.1		.2	.1	[1]
Hackberry	1.1		[1]	.7	4.2	.1	.1
Other hardwoods	1.5	.1	.2	2.6	4.4	1.8	.6
Total	57.9	11.9	46.5	64.1	92.4	99.7	88.1
All species	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1] Negligible.

Climate and Growing Season

The region's climate is mild. Average temperatures (table 3) range from 47° F. in January to 82° in July (*29*). The growing season averages 240 days. Annual precipitation at the Crossett Experimental Forest has averaged 53 inches (table 4), much of which occurs from December through March. Rainfall during the growing season is adequate in most years, but growing-season droughts of 20 days to 2 months are not uncommon. Notable dry spells occurred in 1936, 1952, 1953, and 1954.

TABLE 3.—*Climatic summary for selected stations within the Arkansas and Louisiana loblolly pine belt*

Station	Temperature				Growing season	Normal annual precipitation
	January average	July average	Maximum	Minimum		
Arkansas:	° *F.*	° *F.*	° *F.*	° *F.*	*Days*	*Inches*
Crossett	45. 2	81. 7	113	−14	227	50. 97
Little Rock	42. 6	81. 2	110	−12	241	46. 12
Texarkana	46. 3	82. 7	117	−9	233	47. 16
Louisiana:						
Shreveport	47. 0	83. 2	110	−5	252	41. 64
Alexandria	50. 3	82. 9	109	3	254	57. 06

That droughts seriously affect farm crops is widely understood, but the effects on timber growth are not easily observed. During the summers of 1953 and 1954 soil moisture on the Crossett Experimental Forest was at or above field capacity as late as May, yet lack of appreciable rain thereafter caused soil moisture to drop to where it probably limited tree growth by July 1 (*1, 33*). It dropped to near the wilting point by August 1. Thus for dense stands, summer droughts may reduce the growing season to 150 days. Lightly stocked stands, especially those in which unwanted hardwoods have been recently girdled, and stands in which low understory brush has been removed, have sufficient soil moisture for timber growth to continue nearly to the end of the normal growing season.

Soils and Sites

The upland soils of the area are mostly red and yellow podzols (*28*). They are usually strongly leached, acid, and low in organic matter and plant nutrients. The surface soils are light colored and sandy. Subsoils contain more clay and are red, yellow, gray, or mottled. Though low in inherent fertility for row crops, the soils are easily tilled and respond to fertilization. In times past, they have been important producers of cotton, corn, peaches, pecans, and a wide variety of other crops.

The Norfolk, Ruston, and associated soils are, by far, the most extensive. They occupy parts of the Coastal Plain that lie above

TABLE 4.—*Precipitation by months for the Crossett Experimental Forest, 1937–55*

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1937	16. 03	2. 48	5. 44	1. 40	1. 28	2. 20	4. 05	2. 78	1. 46	5. 23	4. 84	9. 03	56. 22
1938	3. 84	2. 91	4. 85	8. 85	4. 38	4. 92	1. 60	2. 96	1. 81	1. 12	3. 55	1. 94	42. 73
1939	9. 03	5. 44	3. 16	2. 89	7. 09	5. 39	2. 46	2. 05	5. 17	. 46	2. 53	5. 53	51. 20
1940	2. 63	5. 64	3. 25	9. 79	2. 71	5. 70	10. 14	6. 25	. 80	3. 41	7. 59	5. 52	63. 43
1941	4. 28	3. 37	5. 91	2. 99	1. 21	3. 50	7. 45	. 64	3. 40	9. 55	3. 15	1. 60	47. 05
1942	1. 68	1. 93	5. 73	5. 23	2. 76	8. 00	1. 63	5. 20	2. 35	1. 15	1. 20	8. 86	45. 72
1943	3. 85	3. 87	6. 43	1. 06	4. 52	2. 46	1. 73	1. 74	3. 15	1. 68	2. 60	3. 48	36. 57
1944	5. 18	11. 44	10. 73	4. 71	9. 10	. 71	2. 47	6. 12	. 91	. 11	3. 93	12. 51	67. 92
1945	4. 67	7. 75	7. 21	7. 00	3. 14	4. 60	8. 26	4. 60	4. 88	3. 16	3. 39	3. 65	62. 31
1946	12. 82	6. 16	6. 60	3. 78	9. 59	5. 59	9. 21	. 66	1. 27	2. 23	8. 21	3. 94	70. 06
1947	6. 42	3. 04	5. 49	7. 26	4. 53	4. 82	. 41	2. 32	3. 74	5. 16	5. 73	4. 17	53. 09
1948	4. 74	8. 47	4. 76	4. 22	2. 41	1. 40	3. 53	7. 98	. 54	1. 06	8. 67	2. 97	50. 75
1949	9. 23	3. 28	8. 21	4. 77	5. 10	2. 00	6. 37	2. 57	1. 91	7. 47	. 20	5. 32	56. 43
1950	9. 70	6. 17	5. 03	6. 34	4. 36	5. 81	8. 66	13. 76	2. 16	2. 13	1. 72	3. 84	69. 68
1951	11. 55	2. 36	7. 21	3. 14	. 69	8. 03	7. 78	. 45	5. 51	1. 45	3. 76	8. 31	60. 24
1952	4. 41	4. 02	4. 05	4. 70	1. 89	. 47	2. 51	2. 08	3. 52	. 02	2. 85	4. 19	34. 71
1953	3. 60	5. 92	6. 57	8. 51	10. 02	. 62	5. 26	3. 35	. 44	1. 30	2. 64	7. 15	55. 38
1954	6. 01	1. 86	1. 97	6. 32	8. 80	. 23	2. 20	. 93	1. 77	2. 61	3. 69	1. 70	38. 09
1955	3. 90	5. 60	8. 36	4. 33	4. 06	2. 23	6. 56	2. 80	. 89	2. 21	2. 37	4. 35	47. 66
Total	123. 57	91. 71	110. 96	97. 29	87. 64	68. 68	92. 28	69. 24	45. 68	51. 51	72. 62	98. 06	1, 009. 24
Average	6. 50	4. 83	5. 84	5. 12	4. 61	3. 61	4. 86	3. 64	2. 40	2. 71	3. 82	5. 16	53. 12

the so-called flatwoods and range from 75 to 500 feet above sea level. They are cut by many large rivers and smaller streams. Terrain ranges from nearly flat to undulating or gently rolling. Where relief exists, the soils, if cleared and cultivated, may erode severely. Drainage usually is good except on the flat areas.

A narrow belt of silty soils, 20 to 30 miles wide, parallels the Mississippi Delta and marks the easternmost border of the region. These soils, developed from loess or similar fine material deposited by streams, may vary from a very thin covering to 15 or more feet in thickness. They are naturally low in organic material and acid in reaction. Although water moves through them slowly, they have a high water-holding capacity and are excellent for tree farming.

The alluvial soils along the numerous streams and rivers are among the most productive in the Nation. In the past, such soils supported excellent stands of hardwoods and cypress. In the smaller stream bottoms and in the higher reaches of the rivers, loblolly pines of high quality and large size were found among the hardwoods. Such areas are good second-growth pine sites, and many have pine growing in with the hardwood today.

Sites (height of dominant trees at 50 years of age) average about 85 feet for the region as a whole. The sites vary from 50 to 120 feet, depending upon the depth of surface soil, subsoil characteristics, and drainage.

Timber Industry and Market Outlook

In little more than a lifetime, the West Gulf States have gone through almost three-fourths of a forest cycle. Lumber production began in Arkansas and Louisiana about 1869. The number of mills and their output reached a historic high in 1909. During that year, Arkansas mills cut more than 2 billion board-feet from the kind of trees shown in figure 4, while Louisiana mills produced 3.5 billion.

The year 1910 marked the beginning of a long decline. During the depression years output dropped to about 600 million board-feet in Arkansas, with a corresponding shrinkage in Louisiana. More important, the virgin timber had been largely cut, and these States were apparently finished as big lumber suppliers (fig. 5). At the turn of the century it was generally agreed that most timberland would be turned into farms, and hence it was reasoned that the faster the timber was cut the quicker farming could become established.

Contrary to early expectations, most of the forest was not cleared for farms (*13, 31*). Benefiting from the favorable climate and the fast-growing pine species, the timber came back. Many of the mills did not cut the last log and quit. And the area was not to be counted out of the timber picture even though the virgin stands had vanished (*15*) (fig. 6). The value of forest products and the income derived from harvesting and processing them have been increasing each year.

The latest Forest Survey of Louisiana (*25*) and the data furnished by the Arkansas State Forestry Commission indicate that the region supports 82 large and medium sawmills, each cutting 3 million or more board-feet annually, and some cutting upwards of 60 million board-feet. There are an additional 581 small sawmills. Either in the area

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FIGURE 4.—An example of original loblolly-shortleaf pine timber in the Crossett area. This pine timber averaged about 20 inches d. b. h., but trees of 40 to 50 inches were not uncommon.

or immediately adjacent are 9 pulpmills with an average daily capacity of 525 tons per mill. The area also supplies timber for 7 treating plants, 4 veneer mills, 12 handle mills, and 29 other wood-using plants. Forest industries provide more than half the industrial jobs in the region, and pay over half the salaries and wages.

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FIGURE 5.—Five years after the virgin timber was cut, much of the loblolly-shortleaf pine area of south Arkansas and north Louisiana looked like this.

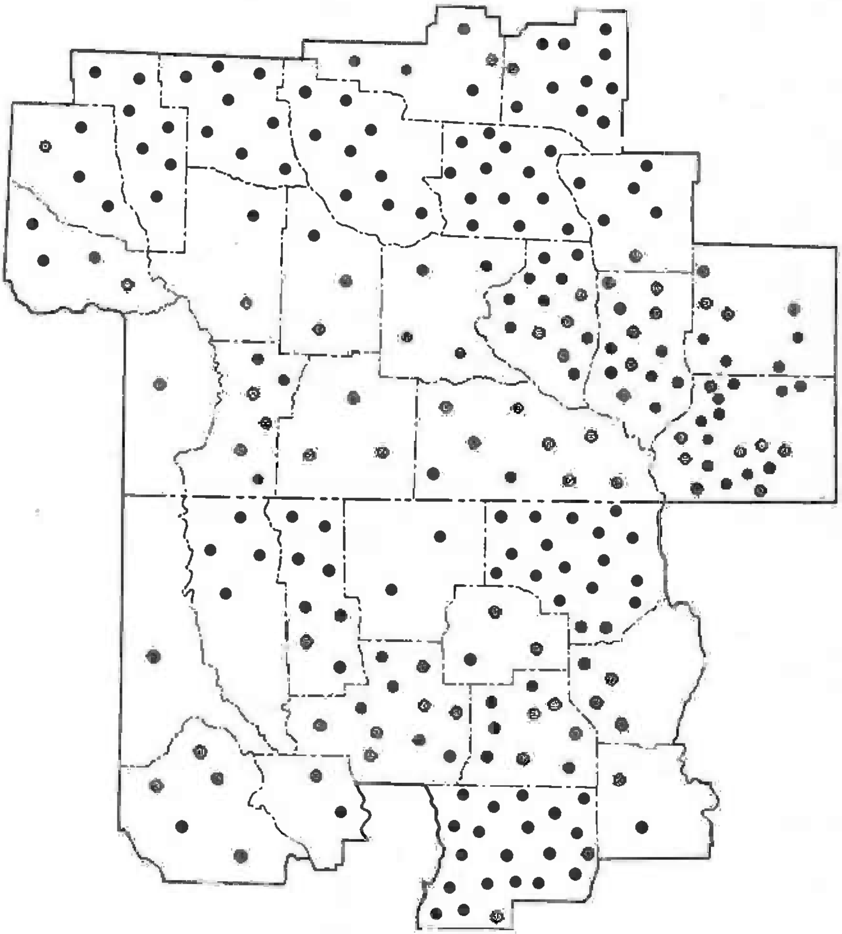

FIGURE 6.—Production of southern yellow pine in Arkansas and Louisiana, 1956. Each dot represents 2 million board-feet of lumber sawed.

An estimated 770 million board-feet of pine and 510 million board-feet of hardwood lumber has been cut in the region for each of the last 10 years. The Forest Survey estimates that pulpwood production in the area in 1955 was 1,283,000 cords of pine and 159,000 cords of hardwood (*3*). The estimated f.o.b. value of the forest products has been $282 million annually for the years 1950–55.

Even as late as 1935 there were few areas that had a pulpwood market for thinnings from pine stands (*4*, *27*). The first pulpmill in the region was built at Bastrop, La., in 1920. Another mill was built at the same place in 1924. By present-day standards these mills were very small; their wood requirements could be met from nearby lands. No one seriously considered using tops of saw-log trees, and there was little or no market for hardwood. Nor did anyone use pine slabs and edgings for pulpwood.

By 1956, there were 9 pulpmills with a yearly capacity of 2,898,000 cords. Even greater capacity is in sight. Annual pulpwood needs of the region's mills are estimated at better than 4 million cords by 1960 (fig. 7).

Today no pine tree is too far from a pulpmill. Markets for gum and red oak pulpwood are developing. Tops of pine saw-log trees, as well as thinnings, have a ready sale. Many sawmills have installed log barkers and chippers and are selling their pine slabs, edgings, and other residues as pulp chips. There is a limited market for hardwood chips.

Forest Landownership

Medium to large private ownerships predominate in the region. Lumber, pulp and paper, and a few oil or development companies own from 100,000 to 500,000 acres of timberland apiece. These ownerships hold nearly 50 percent of the region's forest area. Nearly all owners of 25,000 acres or more are well financed and have intensive forestry programs. They expect to grow timber indefinitely as a business proposition.

Federal, State, and other public forests total less than 5 percent of the area. Farm ownership of timberland varies from about 10 to 50 percent in the various counties or parishes, averaging approximately 25 percent. Generally, farm woodlands have been badly treated, so that less than one-third have reasonable stocking of good species. Examples of good farm forest management can be found, however, and are increasing in number.

Outside of the river bottoms farm abandonment is common, and the tracts are being restored to forest through natural or artificial means. Between 1936 and 1949, the forest area in southwest Arkansas increased about 300,000 acres (*24*). In the time between the two Forest Surveys of northwest Louisiana there was a 14-percent increase in forest land (*25*). The farm-to-forest trend is expected to continue.

THE EXPERIMENTAL TRACT

The experimental area is reasonably representative of the region it is intended to serve.

Topography is flat to gently rolling. Elevation above sea level is about 175 feet, and does not vary more than 20 feet. Because of the flat topography and heavy soil, drainage is poor. During the winter water remains in small depressions for weeks. Snow is rare.

The soils, laid by wind and water, are of the Memphis-Grenada series. They are uniformly heavy, silty, clay loam (Richland type). Sand content is low and stones are absent. Water percolation is very slow. Storage capacity of the upper 4 feet of soil is approximately 14 inches of water. The soil is wet and boggy during the winter and dry and hard during the summer. For this reason it is poor for agriculture. Site index for both shortleaf and loblolly pine is estimated to be 85 feet at age 50.

About 5 percent of the tract was farmed at one time or another. When the study began, these areas supported even-aged old-field pine stands ranging from 10 to 60 years of age. The rest had been cleared of virgin timber down to an approximate 14-inch stump diameter in 1915.

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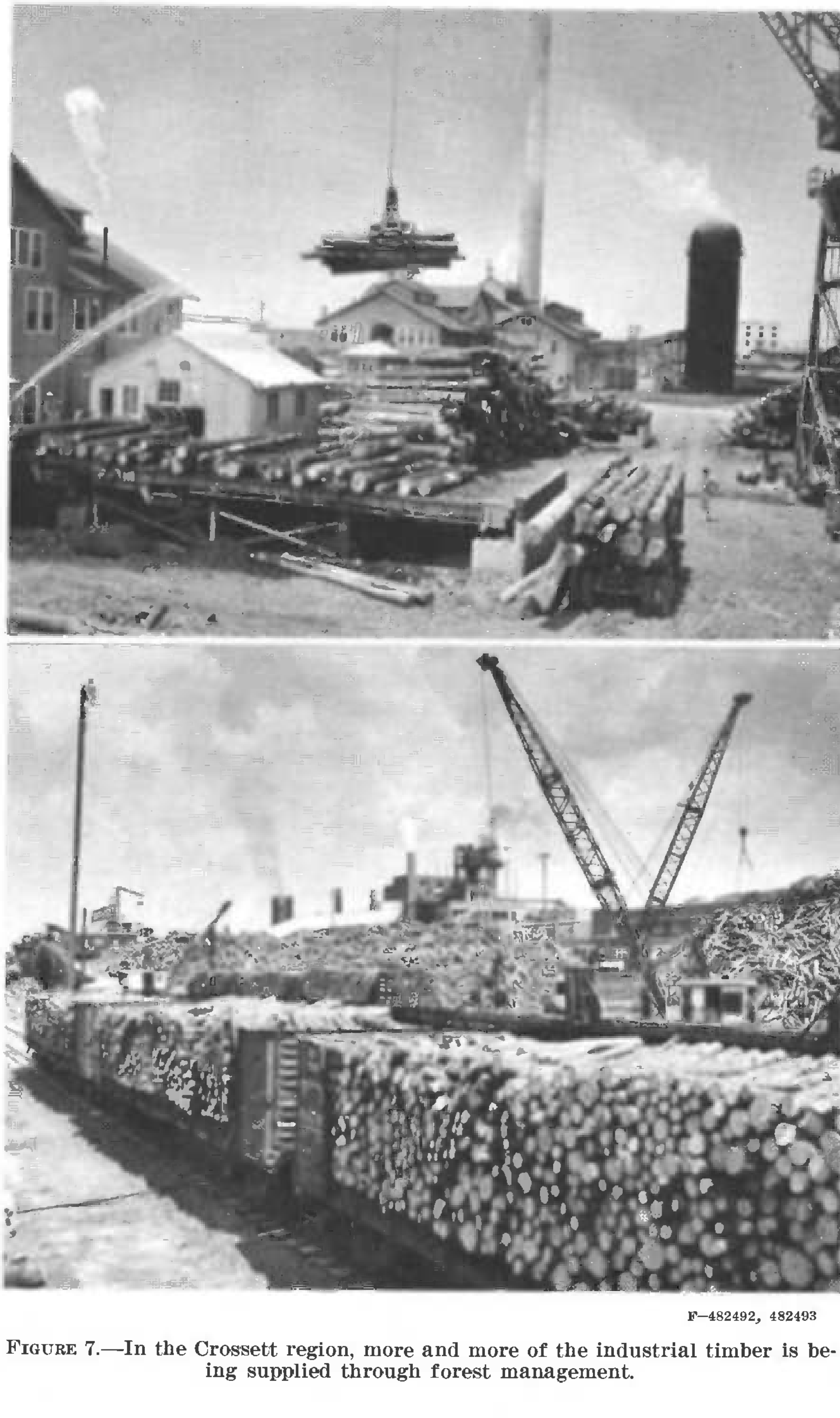

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FIGURE 7.—In the Crossett region, more and more of the industrial timber is being supplied through forest management.

Periodic and sometimes very hot fires occurred between 1916 and the time good fire protection was given the area in 1934. These fires kept pine from restocking some parts of the tract. Other spots either escaped fire or restocked quite well in spite of the fires.

Because only the very best hardwoods were cut with the virgin pine, practically all hickory, sweetgum, blackgum, post oak, water oak, and elm were left. Also left were many rotten and rough red and white oaks from 15 to 25 inches in diameter. Young hardwoods developed in many of the openings created by removal of the virgin pine.

In 1937 a 100-percent inventory was made of the 24 study compartments comprising the tract. The compartment boundaries follow old land lines, and with two exceptions the compartments contain about 40 acres apiece. For the 958 acres in the entire tract, hardwoods 4 inches in diameter and larger numbered about 88 per acre (table 5).

TABLE 5.—*Number of trees per acre before treatment, 1937*

D. b. h. (inches)	Shortleaf and loblolly pine	Red and white oak	Post oak, water oak, blackjack oak, willow oak, ash, and elm	Sweetgum, blackgum, hickory, mulberry, dogwood, and red maple	Total hardwood
	Number	*Number*	*Number*	*Number*	*Number*
4	17. 83	8. 94	8. 61	9. 61	27. 16
5	15. 75	6. 13	5. 05	6. 43	17. 61
6	12. 78	4. 38	3. 10	4. 60	12. 08
7	9. 60	2. 94	2. 01	2. 99	7. 94
8	8. 05	2. 11	1. 42	1. 98	5. 51
9	6. 30	1. 56	. 97	1. 16	3. 69
10	5. 10	1. 32	. 84	. 79	2. 95
11	4. 82	1. 06	. 65	. 58	2. 29
12	4. 40	. 93	. 51	. 37	1. 81
13	4. 06	. 71	. 45	. 34	1. 50
14	3. 39	. 58	. 39	. 21	1. 18
15	2. 97	. 44	. 36	. 17	. 97
16	2. 39	. 36	. 27	. 14	. 77
17	1. 87	. 32	. 27	. 10	. 69
18	1. 29	. 22	. 18	. 10	. 50
19	. 84	. 15	. 16	. 07	. 38
20	. 52	. 12	. 12	. 03	. 27
21	. 34	. 10	. 11	. 04	. 25
22	. 17	. 05	. 04	. 03	. 12
23	. 10	. 03	. 03	. 02	. 08
24	. 05	. 03	. 02	. 01	. 06
25	. 03	. 02	. 02	. 01	. 05
26	. 01	. 01	. 01	. 00	. 02
27+	. 02	. 08	. 02	. 01	. 11
Total	102. 68	32. 59	25. 61	29. 79	87. 99

For the 4- to 6-inch diameter group, hardwoods averaged 57 stems per acre. Thus, they were more numerous than the pines of this size. Red and white oaks made up approximately one-third of the total. Most hardwoods had no value other than for distillation wood or fuel.

Though in 1915 the pines had been cut to an approximate 12-inch d. b. h. limit, by 1937 there was an average of 103 pines per acre in all sizes from 4 inches d. b. h. on up; of these 22 per acre were 12 inches d. b. h. or larger. While the stands seemed to be of only three or four main age classes, the distribution among diameter classes was very similar to, but lower in number than, most of the suggested tables of ideal or normal stocking for all-aged pine stands. Diameter distribution for any given 40-acre tract was quite good.

The most lightly stocked 40-acre compartment contained 1,922 board-feet (International ¼-inch rule) of sawtimber per acre. (In this study the minimum d. b. h., outside bark, for pine sawtimber trees was taken as 11.5 inches and the minimum top diameter, inside bark, as 7.5 inches.) Other compartments had from 2,100 to 5,000 board-feet of pine per acre and one had 8,333 board-feet. On some acres pine stocking averaged 10,000 board-feet, with 80 or more square feet of basal area in trees 3.5 inches and larger. Other acres had only a few hundred board-feet, with 10 to 20 square feet of basal area.

Pine stocking for the tract as a whole averaged 4,669 board-feet, or 48 square feet of basal area. In addition, there were approximately 625 board-feet of merchantable hardwoods.

Treatments and Method of Assignment

Because of the rapid growth of shortleaf and loblolly pine on the average-to-better sites, the length of cutting cycle to use in timber management is important. A 10-year cycle might be too long, and a cycle of less than 5 years might be too short to yield the greatest returns.

The study was designed to include compartments managed on 3-, 6-, and 9-year cutting cycles. It is too soon, however, to expect definitive results on the cutting cycles. Most of the data presented will therefore ignore the cyclic aspect, but enough information will be given to indicate that short cycles are feasible.

The wide variation in stand structure, composition, and volume per acre required an equitable distribution of compartments to the various cycles. To achieve this end, all forties were ranked in order of their cubic volume per acre in pines more than 3.5 inches d. b. h. Next, they were grouped into clusters of three, still in order of rank. Finally, the compartments within each cluster were assigned at random to the cycles. Thus the compartments representing each cycle started with approximately the same variation in pine growing stock. Figure 8 indicates the assignment of compartments.

Method of Inventory

In the 1937 inventory three species groups were recognized: shortleaf and loblolly pine, southern red oak and white oak, and other merchantable hardwoods.

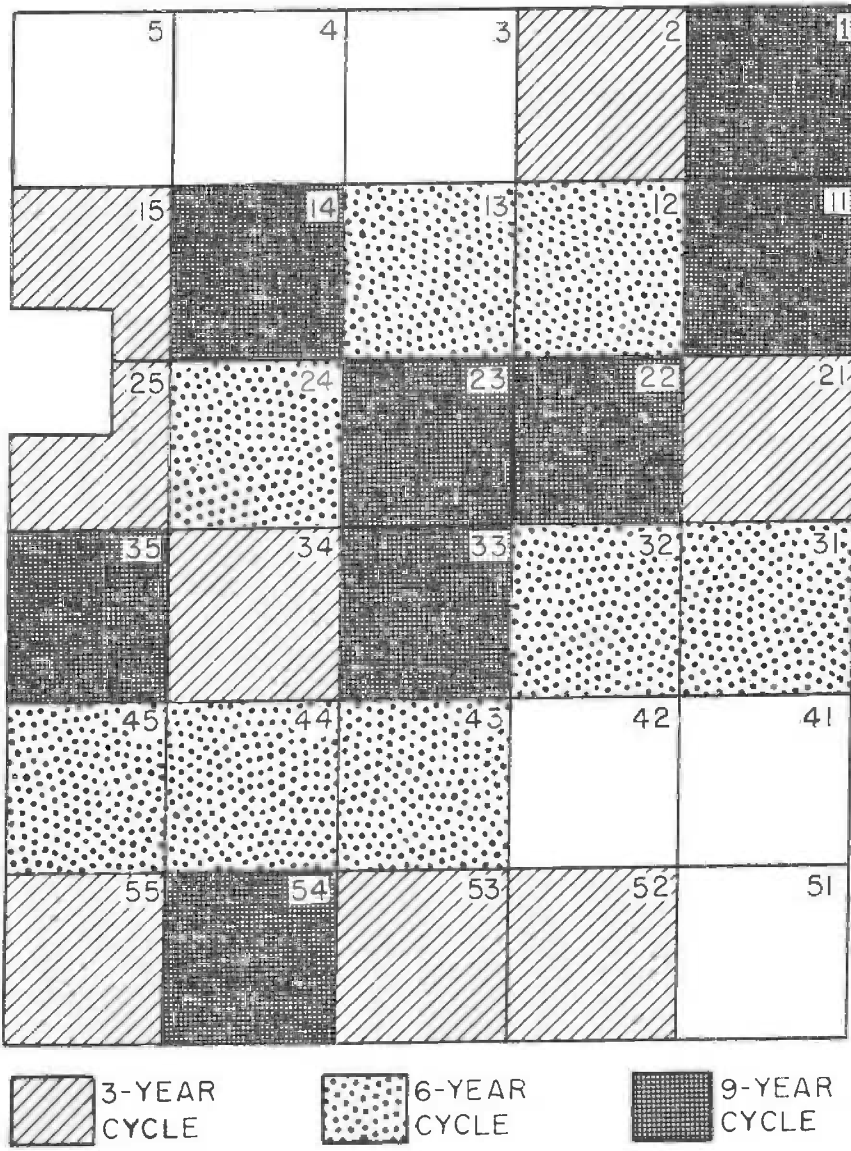

FIGURE 8.—Assignment of compartments to cycles.

"Other merchantable hardwoods" included post, water, blackjack, and willow oak, ash, elm, sweetgum, red maple, hickory, mulberry, blackgum, dogwood, cherry, and sycamore.

To measure the effect of management upon quality growth, the grades of the logs in all pine sawtimber trees were estimated and recorded at each inventory. Logs in the standing tree were estimated and graded on the basis of 16-foot lengths; when the trees were cut they were bucked into various lengths with the aim of getting maximum grade yields. The Crossett Log Grades [4] were used to estimate quality both in the standing tree and in the logs as actually cut.

To prevent year-to-year changes in utilization practice from affecting growth determinations, logs were always estimated to a minimum 7.5-inch top. If a tree was obviously not merchantable to a 7.5-inch top, only the usable portion was tallied. Volume in tops of trees above the saw-log portion was estimated from a d. b. h.-topwood volume table (table 24, p. 64).

The 1937 inventory provided the basis for setting up the records and initiating the study. Subsequent 100-percent inventories are made at the end of the designated cutting cycle for each compartment. Thus, compartments managed on a 3-year cutting cycle are inventoried every 3 years, those on a 6-year cycle every 6 years, and so on.

All inventories have been by 1-inch diameter classes and have included all merchantable growing stock. (In this study, *total pine growing stock* refers to all pine over 3.5 inches d. b. h.; *saw-log growing stock* refers to that portion of total growing stock in trees 11.5 inches d. b. h. and larger that is merchantable for saw logs.) The volume of total growing stock has been computed by the use of a local volume table (table 25, p. 64). Saw-log growing stock has been computed by use of table 26, p. 65. Board-foot volumes given in the text are by International ¼-inch rule and have been obtained by use of converting factors (*17*) given in tables 27 and 28 (pp. 66, 68). Similar conversions of cube-foot saw-log volumes to Doyle or Scribner rule can be made by use of these tables.

Complete records are also kept of the trees and grade of the logs marked for each harvest. Finally, the diameter, number of logs, grade of logs, and species group have been recorded for each tree cut or salvaged.

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[4] The Crossett Log Grades:

Grade 1.—Surface-clear logs 10.0 inches or larger in diameter inside bark (d. i. b.) at the small end, and logs over 16.0 inches in diameter at the small end containing not more than three 2- to 4-inch knots, or the equivalent (usually a maximum of about 6) in small knots. Length 10 feet or longer. Logs of this grade having 15 percent or more of volume lost because of sweep, crook, or other external defects are reduced one grade. A loss of over 40 percent reduces the log to grade 3. A loss over 50 percent of the volume culls the log.

Grade 2.—Surface-clear logs 8.0 to 9.9 inches d. i. b. at the small end, logs over 8.0 inches containing numerous small knots, or logs over 14.0 inches d. i. b. at the small end containing numerous small knots or up to six 2- to 4-inch knots. Length 10 feet or longer. Logs of this grade having 20 percent or more of the volume lost because of sweep, crook, or other external defects are reduced one grade. A loss of 40 percent or more of the volume culls the log.

Grade 3.—Knotty or crooked merchantable logs 8.0 inches d. i. b. at the small end that do not fall into grade 1 or grade 2. Length 10 feet or more. Logs of this grade with 20 percent or more of the volume lost because of sweep, crook, or other external defects are culled.

Conditions Applicable to All Grades

Small knots are defined as being formed by any live or dead branch of any size up to and including 1.9 inches in diameter. Large knots are 2.0 inches or more in diameter.

Knots that are bunched at one end or on one face of a log are not so serious as a number of knots scattered over one or more faces. Logs having such bunched knots are not usually reduced in grade as called for by the above definitions unless crook or rot is also present.

Logs showing unmistakable evidence of red heart (*Fomes pini*) or other heart rots are automatically reduced one grade below that indicated by the knot or surface characteristics. This reduction in grade is in addition to any caused by sweep or other defect.

Compartment Cutting Order

To minimize the effect of weather conditions and yearly changes in stumpage prices on returns from the various treatments, the cutting schedule was set up so that about the same number of long- and short-cycle compartments are cut each year. The cutting order is given in table 6. It has been followed without deviation throughout the study.

TABLE 6.—*Compartment cutting order*

Winter	Compartment numbers for—		
	3-year cycle	6-year cycle	9-year cycle
1937–38	-- 2 21	12 13	33
1938–39	52 53 55	-- 32	22
1939–40	34 25 15	-- 24	23
1940–41	-- 2 21	44 45	1
1941–42	52 53 55	-- 31	35
1942–43	34 25 15	-- 43	54
1943–44	-- 2 21	12 13	14
1944–45	52 53 55	-- 32	11
1945–46	34 25 15	-- 24	--
1946–47	-- 2 21	44 45	33
1947–48	52 53 55	-- 31	22
1948–49	34 25 15	-- 43	23
1949–50	-- 2 21	12 13	1
1950–51	52 53 55	-- 32	35
1951–52	34 25 15	-- 24	54
1952–53	-- 2 21	44 45	14
1953–54	52 53 55	-- 31	11
1954–55	34 25 15	-- 43	--
1955–56	-- 2 21	12 13	33

Determining the Allowable Cut

The volume of saw logs that can be removed from a given tract, without more than temporarily reducing growing stock or growth, depends upon growth rate, cutting cycle, and stand per acre. Cubic-foot growth rates for unmanaged loblolly pine stands in the area often run from 5 to 7 percent, simple interest, for all trees 3.5 inches d. b. h. and larger. Sawtimber portions of such stands frequently grow at the rate of 6 to 9 percent.

A study on the Crossett tract indicated that, prior to management, sawtimber growth had been about 7 percent for the understocked stands. This rate includes ingrowth of small trees into sawtimber sizes. Stands with very light stocking had grown at a somewhat greater rate; those stocked with about 10 M per acre at a somewhat lesser rate. In tracts being placed under management, the rate often depends more upon such circumstances as the amount of competition, the type of trees present, and the amount of reproduction than upon the volume of sawtimber. Hence, until the stands have been under management long enough to achieve some degree of uniformity in these matters, a single average growth percent can be used as a basis for determining the allowable cut without danger of serious overcutting or undercutting. Although it was expected that management would improve the rate, 7 percent was adopted as conservative for establishing the allowable cuts given in table 7.

If 17 percent of the merchantable volume is cut from a stand growing at the rate of 7 percent, the volume will return to its original level in 3 years (*22*). For stands cut on a 6-year cycle, 30 percent of the merchantable volume can be removed with confidence that it will be replaced by the end of the cycle. On a 9-year cycle, 41 percent of the stand can be harvested. These proportions hold true regardless of the volume of growing stock.

To improve the stocking, it was planned to cut less than the growth in all stands except those with 10 M board-feet at the end of the cycle. The proportion of the growth removed varies with the stocking—the lighter the stocking, the smaller the proportion of the growth cut. As table 7 indicates, the allowable cut for 2 M stands is approximately half the growth: 8 percent instead of 17 percent for compartments on a 3-year cycle, 14 percent instead of 30 percent for the 6-year cycle, and so on. In stands with 5,000 board-feet per acre, about three-fourths of the growth is harvested.

It has been assumed that stands containing 10,000 board-feet are fully stocked. This figure will doubtless change as information accumulates (*20*), but in the meantime it is a convenient guide for the study. As yet, no compartment averages 10,000 board-feet. Because one objective of management is to rebuild stand volume, the table provides that less than the growth will be harvested. This policy makes it possible to improve stocking without foregoing thinning, improvement cutting, salvage, harvesting of mature trees, and other income-producing measures.

Net returns to timberland owners are management's yardstick. In 1937 sawtimber trees yielded the greatest net return. It was therefore planned to give the main emphasis to the production of high-grade saw logs (fig. 9). Consequently, trees below saw-log size were important only as trainers, as sources for intermediate cuts of pulpwood, and to provide recruits into the sawtimber class as needed. For these reasons, the allowable cut per acre was based solely on the cubic volume of merchantable saw-log material in sawtimber trees, exclusive of the tops. Though trees below saw-log size did not figure in the allowable

TABLE 7.—*Allowable cut, by cycle and stand volume*

Present growing stock per acre		3-year cycle	6-year cycle	9-year cycle
M board-feet	*Cubic feet*	*Percent*	*Percent*	*Percent*
10	1,460	17	30	41
9	1,314	15	28	38
8	1,168	14	26	35
7	1,022	13	24	33
6	876	12	22	30
5	730	11	20	28
4	584	10	18	25
3	438	9	16	23
2	292	8	14	20

F—482479

FIGURE 9.—The production of high-quality sawtimber is the aim of management.

cut, their importance in the stand is by no means ignored. At the time of each cyclic harvest the necessary thinning and improvement cutting is done in these size classes.

Overtopped trees of good form were not marked for removal unless they had such poor crowns that mortality was imminent. If such trees are young, they usually increase their rate of growth almost immediately following release and provide a half-grown replacement for the tree removed (*19*). Because small trees have low value, little harm is done the stand or pocketbook if some are lost.

502843 O—59——4

Hardwoods not budgeted.—In 1937 the stands contained many relatively low-grade hardwoods of large and medium size. The best of these were retained during the first 5 years of cutting. With the removal of the poorer stems and with the continuing fire protection, large amounts of pine reproduction began coming in (fig. 10). This reproduction grew poorly where it was overtopped by low-crowned hardwoods.

F–482480

FIGURE 10.—An early and obvious need was to sell or deaden hardwoods that were suppressing pine seedlings.

Moreover, it became clear that on these pine sites a hardwood could be expected to produce only about one fair lumber log and that hardwoods required more growing space than pine and sold for less. In short, hardwoods could not compete with pine from the standpoint of net returns. Since 1942 no allowable cut has been set for hardwoods, though they are still tallied. The policy has been to sell all merchantable ones, girdle the culls, and prevent saw-log-size hardwoods from developing. A great many small hardwoods are still present in all compartments and will continue to be. Since hardwoods of seed-bearing size have been eliminated, however, the control job is confined to reducing the number of small stems (*21*) on areas needing pine reproduction.

Small understory hardwoods have considerable value in soil and wildlife management on pine sites, and the aim is to control but not to eradicate them. In the Crossett region, sites capable of growing good hardwoods for sawtimber are found along small stream courses and river bottoms. These hardwood areas are important in the management of wildlife species that feed on mast or require hardwood nest trees. Hence while pine management is recommended on most upland areas, it is important to maintain hardwoods on creek and bottom-land sites. Where upland pine sites are extensive and unbroken, it may also be advisable to maintain small patches of older hardwoods here and there.

Guiding Diameter Limit

Prior to marking each cut, a "guiding diameter limit" is computed for each compartment. This limit is obtained by adding the cubic volume of merchantable logs (as shown by the 100-percent tally) starting with the largest trees and continuing toward the smaller until a volume equal to the allowable cut is reached. The diameter class in which this total is achieved is the guiding diameter limit. Marking all trees in and above this class would provide the allowable cut. However, some of the smaller saw-log trees need to be removed to improve stand quality and tree spacing. Likewise, some trees above the guiding diameter limit should be saved for their superior growth and quality. In practice, the volume of small saw-log trees marked for removal has been balanced against the volume of trees that are over the guiding diameter limit but are nevertheless reserved for growth.

Experience to date indicates that when an inventory of the stand is available, the guiding diameter is a helpful tool and permits marking the tract with only minor overmarking or undermarking.

Single-Tree Selection

The type of cutting method practiced most nearly approaches what the Society of American Foresters (*23*) terms "maturity selection." This is defined as follows:

"A form of tree selection that removes trees which are biologically and financially most mature, as judged by a combination of the factors (1) mortality probability, (2) quantity and quality growth rate, and (3) carrying charge (or interest) based on current capital value. This system was devised for and is applied primarily in ponderosa pine; it ordinarily contemplates light and frequent partial cutting."

In application, trees are examined at the time of each cyclic cut to determine which individuals should be marked for cutting and which should be left to grow (fig. 11). Sometimes idealized single-tree selec-

F-482494

FIGURE 11.—To improve the future quality of the pine stands, rough stems have been removed in favor of those of potentially much higher quality. When released, the tree at the left will soon develop a good crown.

tion is approached. At other times, group selection prevails, with two to a half-dozen trees marked on a quarter acre. Within the limits of the allowable cut, trees are marked, or left for additional growth, upon their individual merits. The aim has always been to improve the value of the growing stock through removal of the lower quality stems along with the mature. Biolly's management technique (*10*) formed a background for the system that was applied.

The purpose of this study was not to test systems of management. Other tracts on the Crossett Experimental Forest are devoted to such tests, but not enough time has elapsed to permit valid comparisons.

Fire.—Much of the hardwood on the study tract in 1937 was too large to be killed by any fire short of one that would kill or damage pine overstory trees and eliminate reproduction. The silvicultural system requires that some reproduction be present on all compartments at all times, and thus precludes the use of prescribed fire (fig. 12).

Three accidental fires have occurred since 1937. Two of these, one-half acre each in size, burned shortly after a rain and did little damage. The third occurred during a drought and killed trees up to 10 inches d. b. h. on about 2 acres.

Trees cut and left.—Improvement in quality as well as in quantity of growth and growing stock is the primary consideration in marking timber. The aim is to leave those trees that have the best chance for quality growth. This means straight trees with 30 feet or more of clear bole. In general, a tree to be left must be increasing in value at the rate of at least 3 percent per year. It must also contain at least one grade 2 log or show promise of developing such a log by the time it is 15 inches in d. b. h.

Pine seedlings, saplings, and poles are regularly found growing in small openings and often directly under high-crowned larger stems. Such trees are oppressed but usually have much better crowns than the suppressed and intermediate trees of dense even-aged stands. It has been demonstrated that unless such oppressed trees are over 40 years of age and have very small crowns, they are capable of responding to release and developing into excellent dominants (*19*). Where the oppressed tree will provide a partially grown replacement for the tree that is soon to be cut, it is left regardless of present growth rate (fig. 13). The same is true for small trees that occur in dense groups. Such groups are not thinned, or are thinned only lightly, until the boles are clear for at least one log. Later cuttings gradually release the better trees, but at such a rate that they continue to clean themselves of branches for two or three or more logs. At this point the trees are given more growing space and the 3-percent rule applies.

This system of marking is consistent with current indications that pulp yield and timber strength are correlated with specific gravity, and that specific gravity is correlated with the age from the meristem (number of rings to pith) (*14*, *16*, *26*, *32*). Hence, a stand should produce more pulp and stronger lumber if the growth potential is channeled into older trees. Seedlings can be kept in close competition, accumulating age and height but little volume, until they clear their boles and are needed as recruits; then their growth can be speeded up (fig. 14). Specific gravity seems to be little affected by rate of growth, so fast growth on older trees and slow growth on young trees should prove desirable.

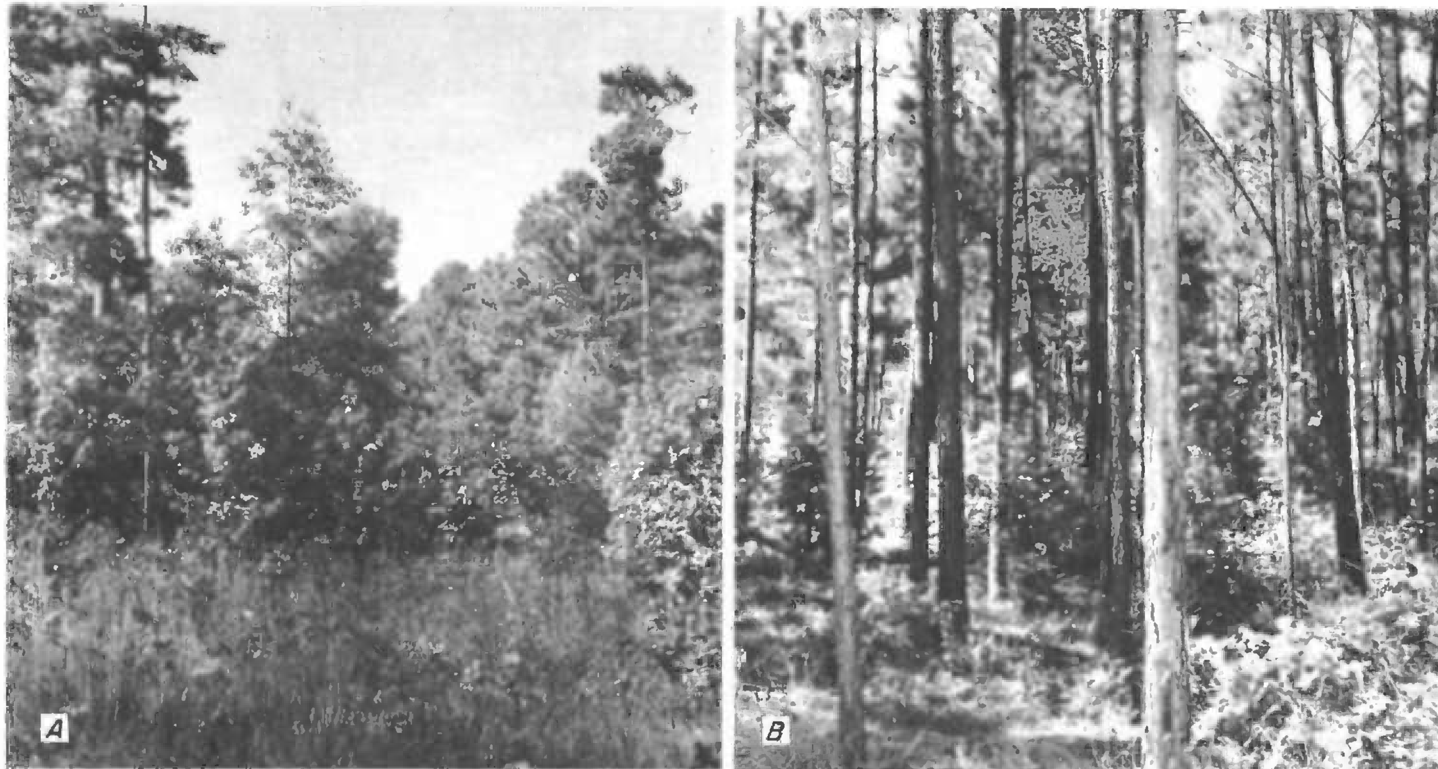

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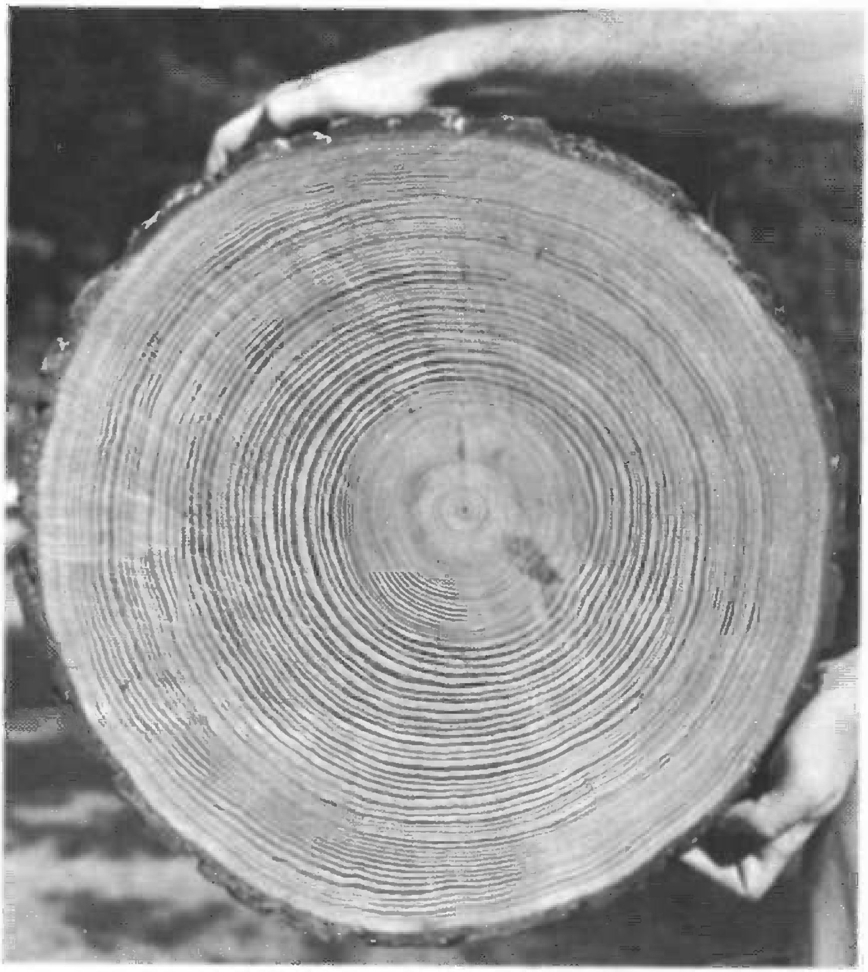
FIGURE 12.—*A*, Many of the open spots that existed in 1937 were the result of uncontrolled fires. *B*, Same spot in 1955, after a first thinning that removed about 4 cords of pulpwood per acre.

F–482488

FIGURE 13.—Loblolly pines developing under the high crowns of adjacent trees. Such young trees will provide partially grown replacements at the time the older ones are cut. These young pines are oppressed but not suppressed.

Neither size alone, nor age, is a criterion of biological or financial maturity (*5, 8*). Some trees mature at 20–30 years of age and 6 inches d. b. h. Others are 125 or more years of age and 28 inches in diameter before they become mature.



F–482483

FIGURE 14.—Many of the pines on the experimental area in 1937 were suppressed or oppressed survivors of the old-growth. They quickly developed into trees of excellent quality and size.

The cuts have been made up of mature and near-mature trees and those regarded as poor risks (fig. 15). The poor risks included trees that were—

Leaning, especially root-sprung leaners.
Fire-scarred for more than one-third of their circumference.
Open-crowned, displaying marked shortening of the needles.
Crooked.
Infected with red heart (*Fomes pini*) or other rot.
Lightning-struck.
Seriously injured in logging.
Seriously infected by fusiform rust (*Cronartium fusiforme*), i.e., having cankers on the trunk or on a branch within 15 inches of the trunk.

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F–350875, 482484, 482485

FIGURE 15.—Types of pines removed in early selection cutting included rough, limby trees, leaners, and those infected with red heart.

Perhaps 5 percent of the trees in the unmanaged stands were infected by either fusiform rust or heart rots (*9, 30*). Such trees were marked for removal in the cyclic cuts.

Only a few insects were of consequence, notably the pine engraver beetles (*Ips* spp.) and the black turpentine beetle (*Dendroctonus terebrans* (Oliv.)) (*11*). During the very dry summers of 1952, 1953, and 1954, the beetle populations built up to the point that pines were killed. Most of the dead trees were promptly salvaged.

Cutting operations.—In each regular cut, saw logs are made and removed first. Then the compartment is covered again to cut pulpwood from saw-log tops and trees seriously injured in logging, as well as from designated subsaw-log trees. Finally, unmerchantable hardwoods are girdled (fig. 16).

GRADE AND SIZE OF PRODUCTS

The First Cut

The quality of the timber removed from an understocked stand in the first managed cut will be very low. Owners of tracts that have been high graded repeatedly may have difficulty in obtaining enough salable material to pay for the first improvement cut.

The study stands had not been cut since the virgin timber harvest in 1915 and had enough good-quality pines to make the first cutting financially attractive.

The first consideration in the initial cut was to remove the defective and low-quality trees and to open up dense groups. The second objective was to harvest the mature and some of the near-mature saw-log pines. The two objectives combined provided the allowable cut.

The first cut on the 24 compartments included in the study area removed a total of 2,295 standard cords of pulpwood and 2,523 units (138 cubic feet) of chemical wood. This is equivalent to 2.4 standard cords of pulpwood per acre and 2.6 units of chemical wood per acre. These two products comprised 69 percent of the cubic volume of the first cuts (table 8). Adding these volumes to the volume of logs produced (approximately 1,300 board-feet per acre) gives a total of approximately 7.6 standard cords of wood per acre as the yield from this first cut.

TABLE 8.—*Composition of the first selection cut from the 24 compartments, based on cubic measure*

Product	Grade 1	Grade 2	Grade 3	Pulpwood and chemical wood
	Percent	*Percent*	*Percent*	*Percent*
Pine saw logs	48.1	30.1	21.8	
Hardwood saw logs	25.8	43.0	31.2	
Pine and hardwood pulpwood				100.0
Hardwood chemical wood				100.0
Percent of total production	12.7	10.8	7.9	68.6

F—482495

FIGURE 16.—Unmerchantable hardwoods were girdled.

Considering the cubic volume of all products removed, 12.7 percent was grade 1 logs, 10.8 percent was grade 2 logs, 7.9 percent was grade 3 logs, and 68.6 percent was pulpwood and chemical wood. If chemical wood is excluded (it has a limited market), grade 1 logs were equal to 19.6 percent of the total, grade 2 logs to 16.6 percent, and grade 3 logs to 12.1 percent.

Considering only the pine and hardwood logs produced in this first cut, 41 percent were grade 1.

Volume Harvested, 1938–55

All cuts from 1938 through 1955 totaled 4,708,000 board-feet of pine and hardwood saw logs. The average is equal to 4,160 board-feet of pine saw logs and 754 board-feet of hardwood saw logs per acre.

Table 9 summarizes the harvest year by year. By 1947 each compartment had received at least its first cut, and hardwoods suitable for pulpwood and chemical wood had largely been liquidated. By 1950, most of the hardwood sawtimber had been marketed. The cut of pine pulpwood, heavy during the early years when many compartments needed improvement cutting or thinning, has been fairly constant for the past decade. It is destined to rise again, as thinnings become necessary in many pine thickets that have developed since management started.

The pine sawtimber harvests have varied from year to year, chiefly because of variations in the number of compartments cut in a given year, their stocking, and the cutting cycle to which they were allocated. Thus cuts tend to be larger in years when heavily stocked 6- and 9-year compartments predominate.

TABLE 9.—*Annual volume of forest products from the cutting cycle study*

Year	Pine logs	Hardwood logs	Pine pulpwood	Gum pulpwood	Hardwood chemical wood
	Bd.-ft.	*Bd.-ft.*	*Cords* [1]	*Cords* [1]	*Units* [2]
1938	177, 897	107, 593	771		372
1939	123, 342	91, 473	572		493
1940	130, 757	29, 707	210		316
1941	151, 361	15, 707	209	2	298
1942	139, 820	41, 215	605	126	290
1943	143, 740	93, 738	176	43	316
1944	257, 911	21, 550	629	172	209
1945	146, 349	111, 172	279	239	662
1946	157, 877	18, 859	108	63	384
1947	251, 965	67, 535	105	76	82
1948	477, 428	91, 219	278	64	274
1949	423, 969	10, 072	178		
1950	327, 044	12, 113	197		
1951	342, 857	1, 658	154		
1952	117, 508	1, 260	69		
1953	222, 631		211		
1954	256, 380	7, 123	220		
1955	136, 893		45		
Total	3, 985, 729	721, 994	5, 016	785	3, 696
Per acre	4, 160	754	5. 2	0. 8	3. 9

[1] Standard cord of 128 cubic feet, or 84.7 cubic feet of bark-free wood.
[2] A unit of 138 cubic feet, or 70 cubic feet of bark-free wood.

Size and Grade of Logs

Every logging and mill-scale study made in the eastern or southern sections of the country has indicated that, given a minimum cut per acres, large logs can be produced and manufactured into lumber cheaper per M board-feet than small logs. These same studies indicate that average quality and sale value per M board-feet increase roughly in proportion to log size.

One of the objectives of this study is to produce large, high-quality logs from the understocked tract. How well has this objective been realized? The answer for the first 18 years is given in table 10. These selectively cut second-growth stands have yielded logs averaging 108 board-feet (fig. 17). Although this log volume is not equal to that obtained from the virgin timber in the locality, it is surprisingly close. Virgin timber, when cut to a 12-inch-diameter limit, averaged from 110 to 160 board-feet per log.

Net returns from timber growing are affected by the grade as well as the size of the logs. All logs have been individually measured and graded according to the Crossett Log Grades at the time and place of cutting. The grade composition of the pine and hardwood logs cut during 1938–55 is given in table 11.

TABLE 10.—*Average size of pine logs removed, 1938–55*

Compartment number	Logs	Volume per log	Compartment number	Logs	Volume per log
	Number	*Bd.-ft.*		*Number*	*Bd.-ft.*
1	1, 716	107	31	1, 591	106
2	2, 182	104	32	2, 030	112
11	730	118	33	1, 059	106
12	2, 446	107	34	1, 689	112
13	1, 599	102	35	1, 958	105
14	1, 546	119	43	664	118
15	1, 145	94	44	1, 541	113
21	1, 443	99	45	1, 508	101
22	1, 613	124	52	1, 359	106
23	1, 550	109	53	846	104
24	1, 931	113	54	2, 081	111
25	1, 291	101	55	1, 385	103
			Total	36, 903	
			Average		108

TABLE 11.—*Grade and total volume of saw logs, 1938–55*

Species	Volume	Proportion of total volume in—			
		Grade 1	Grade 2	Grade 3	Total
	Board-feet	*Percent*	*Percent*	*Percent*	*Percent*
Pine	3, 985, 729	41	28	31	100
Hardwood	721, 994	20	39	41	100

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FIGURE 17.—Type of logs produced under selection management. The volume shown—18,600 board-feet of logs and 5.8 cords of pulpwood—represents 1 year's growth on a well-stocked 40-acre compartment.

Approximately 41 percent of the pine logs have been grade 1 and 28 percent grade 2. Thus, about 70 percent of nearly 4 million board-feet of pine logs would have been profitable on almost any market. Grade 3 logs above 14 inches d. i. b. have usually been profitable, and all logs of this grade have been profitable in some years.

Because many of the larger trees in the 1937 stands had developed under the virgin pine overstory, a large percentage probably had 25 to 50 feet of clear bole by the time they were 6 to 8 inches in diameter. When they were released by the cutting of the overstory, many had little crown and were quite spindly.

These trees apparently developed a good crown in a short time. Stump cross sections show that growth rate increased almost immediately after release in 1916. By 1937 a few had become 25 inches in diameter and many had reached 20 inches (*19*). These are the trees that furnished most of the log volume (fig. 18).

Stands Not Overcut

The pine volume removed during 1938–55 equals 89 percent of the 1937 pine volume of 4,669 board-feet per acre. At first glance it would

F—482486

FIGURE 18.—The virgin timber is gone but second growth of nearly as good quality can be grown under management.

appear that the need for current income during the period resulted in overcutting the large, high-grade trees.

A summary of the guiding diameter limits to date is given in table 12. The table shows that, for all practical purposes, the diameter limit has increased in spite of heavy cutting in the larger sizes.

It is, of course, possible to maintain high flexible diameter limits by removing a large percentage of the cut from medium and small saw-log size trees. This has not been so here. The number of pine trees per acre for practically every size over 10 inches d. b. h. has increased.

Tree size has not been lowered, but what about grade? Offhand, one might expect that the grade yields obtained while the stands were being placed under management would improve with future cuts. This, of course, is a possibility, especially over the long run. In the near term, grade yields will probably decline during the period when most of the cut must be taken from trees that seeded in between 1915 and the dates that good pine stocking was obtained after management began.

The near future is to some extent portrayed in the following tabulation of the pine log grade for the average acre:

Pine:	Grade 1 (cubic feet)	Grade 2 (cubic feet)	Grade 3 (cubic feet)	Total (cubic feet)
Original volume, 1937	233	174	142	549
Cut, 1937–55	215	154	242	611
Volume, last inventory	307	341	455	1,103

As can be seen, the harvests have removed the equivalent of 92 percent of the original grade 1 pine log volume, 89 percent of the grade 2 volume, and 170 percent of the grade 3. Much of the new growth that has come into merchantable size during recent years is of a lower grade than the holdover trees that had developed in the virgin stands. Since 1937 grade 1 pine volume has risen only 32 percent, while grade 2 has doubled and grade 3 has tripled.

Some of the grade 3 volume is in old-field stands that have grown into saw-log size since 1937. Such trees have always been dominants and, while their live crowns are 30 to 60 feet from the ground, the dead branch stubs have only recently grown over. Some of these trees can

TABLE 12.—*Guiding diameter limits, in inches d. b. h.*

Compartment number	Cutting cycle	First cut	Second cut	Third cut	Fourth cut	Fifth cut	Sixth cut	Seventh cut
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
2	3 year	19	19	19	19	19	19	20
15	do	20	21	19	20	20	21	
21	do	20	20	19	20	20	20	20
25	do	19	20	19	19	20	20	
34	do	20	21	19	20	20	21	
52	do	25	23	22	20	21	21	
53	do	20	20	20	21	21	20	
55	do	20	20	20	20	21	21	
12	6 year	20	19	18	18			
13	do	18	18	19	18			
24	do	19	19	20				
31	do	20	19	19				
32	do	20	19	18				
43	do	20	21	21				
44	do	18	20	19				
45	do	18	20	19				
1	9 year	18	18					
11	do	19	19					
14	do	19	20					
22	do	19	19					
23	do	18	18					
33	do	18	19	19				
35	do	19	19					
54	do	19	18					

be used for pulpwood, but to satisfy stocking requirements some will have to be carried until they become large sawtimber.

Nevertheless, the big increase in grade 3 is certain to be temporary. Trees with the grade-yield potential of the old-growth residuals are already in the stand. Some are now grade 3 or 2 merely because they are of small diameter. Others are still too small to be graded but have already cleaned up for three logs. Trees that do not promise to produce at least one grade 1 log are removed in the early cuttings. The type of management practiced insures that the promising trees will be allowed to grow to larger sizes than their inferiors.

Despite large harvests of quality timber, the tract has not been high graded.

GROWTH

The schedule of harvest cutting has been such that two or three 3-year cutting-cycle compartments, one or two 6-year compartments, and one 9-year compartment are cut each year. Thus, some compartments of each cycle were first cut during the winter of 1937–38, while some did not receive their first cut until 1946–47. Because interest centers mainly on growth since management began, growth figures have been computed for each compartment for the years between the first cut and the last inventory prior to 1956. This means that neither the volume per acre prior to management nor the volume removed in the first cut has been considered in computing growth.

Board-foot growth plus cut by individual compartments is shown in table 13, cubic-foot growth in table 14. The volumes in these tables include trees that reached sawtimber or growing-stock size after the first cut.

To reduce estimating errors all stand and growth data were computed from local d. b. h. volume tables. Because they ignore height differences, such tables emphasize the compartments on the poor sites and understate the growth possibilities of the better sites, but site differences on the Crossett Experimental Forest are not great.

Considering the nature of the stand in 1937, the growth of 74 cubic feet or 405 board-feet per acre per year is quite gratifying. It is equal to 10 percent per year for the saw-log portion of the stand and 7 percent for all growing stock. These percentages are simple interest. They were computed by dividing the average yearly growth plus cut per acre by the volume of growing stock left after the first cut.

The figures in tables 13 and 14 are for net growth, but include the mortality that has been salvaged. Except for the occasional tree that is not found in time, all dead pine sawtimber has been cut and sold. Not all presaw-log trees have been salvaged, for many are difficult to locate and usually cost more to salvage than they are worth. The ice storm of 1944 broke many trees of sizes up to 12 inches d. b. h. Following this storm a general salvage of dead or damaged stems of all sizes was made over the entire tract. At other times, dead presaw-log stems were retrieved only when they were close to roads or could be gotten out along with a saw-log tree.

Except during the 1944 ice storm, most mortality was single scattered trees. As to value, lightning caused the greatest loss. Of lesser importance was loss by bark beetles, droughts, wind, and ice.

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Total salvage over the 18 years was 5,705 pines 3.5 inches d. b. h. and larger. Of these, 208 were of sawtimber size. This number does not include trees seriously injured during regular harvest cuttings. Such trees were removed along with the marked timber, and the volumes included in the periodic harvest.

TABLE 13.—*Sawtimber growth per acre in relation to growing stock*

Board-foot volume class and compartment number	Growing stock after first cut	Cut during growth period	Growing stock at end of growth period	Growth period	Average annual growth	
2,001 to 3,000 board-feet:	*Bd.-ft.*	*Bd.-ft.*	*Bd.-ft.*	*Years*	*Bd.-ft.*	*Percent* [1]
52	2, 391	2, 748	6, 978	15	489	20. 5
43	2, 493	3, 361	5, 358	12	292	11. 7
21	2, 564	4, 058	7, 357	18	492	19. 2
53	2, 589	1, 681	5, 376	15	298	11. 5
11	2, 699		4, 990	9	255	9. 4
33	2, 924	1, 710	7, 083	18	326	11. 2
Average	2, 610				371	14. 2
3,001 to 4,000 board-feet:						
15	3, 035	2, 212	5, 733	15	327	10. 8
31	3, 491	1, 408	8, 544	12	538	15. 4
55	3, 566	2, 699	6, 289	15	361	10. 1
13	3, 677	3, 404	7, 985	18	428	11. 6
45	3, 685	1, 528	6, 896	12	395	10. 7
Average	3, 491				406	11. 6
4,001 to 5,000 board-feet:						
44	4, 382	1, 522	6, 842	12	332	7. 6
1	4, 464		9, 483	9	558	12. 5
25	4, 473	3, 216	6, 661	15	360	8. 1
23	4, 513		7, 950	9	382	8. 5
35	4, 555		8, 829	9	475	10. 4
34	4, 699	3, 361	7, 310	15	398	8. 5
14	4, 718		7, 796	9	342	7. 2
Average	4, 543				400	8. 8
5,001 to 6,000 board-feet:						
54	5, 058		9, 336	9	475	9. 4
32	5, 061	1, 930	8, 506	12	448	8. 8
2	5, 141	5, 079	8, 014	18	442	8. 6
22	5, 166		8, 606	9	382	7. 4
24	5, 199	2, 095	8, 729	12	469	9. 0
12	5, 725	4, 952	8, 980	18	456	8. 0
Average	5, 225				447	8. 6
Overall average	4, 017	1, 829	7, 509	13	405	10. 1

[1] Simple interest.

Salvage between regular harvests has equaled 0.02 cord per acre per year for trees at all sizes. For the saw-log portion of the stand it has equaled 2.6 board-feet per acre annually.

The average annual growth, both in board-feet and cubic feet, shows considerable variation for given levels of growing stock (fig. 19). Growth much above the average for a given level of growing

TABLE 14.—*Cubic growth per acre in relation to growing stock*

Cubic-foot volume class and compartment number	Growing stock after first cut	Cut during growth period	Growing stock at end of growth period	Growth period	Average annual growth	
	Cu. ft.	*Cu. ft.*	*Cu. ft.*	*Years*	*Cu. ft.*	*Percent* [1]
601 to 800 cubic feet:						
43	630	105	1, 324	12	67	10. 6
11	727		1, 167	9	49	6. 7
33	743	293	1, 586	18	63	8. 5
52	783	610	1, 489	15	88	11. 2
Average	721				68	9. 4
801 to 1,000 cubic feet:						
53	862	399	1, 342	15	59	6. 8
15	879	489	1, 447	15	70	8. 0
55	927	568	1, 454	15	73	7. 9
45	995	291	1, 695	12	83	8. 3
Average	916				71	7. 8
1,001 to 1,200 cubic feet:						
44	1, 007	273	1, 468	12	61	6. 1
1	1, 039		2, 033	9	110	10. 6
14	1, 064		1, 657	9	66	6. 2
21	1, 069	754	1, 796	18	82	7. 7
13	1, 076	714	1, 823	18	81	7. 5
35	1, 093		1, 883	9	88	8. 0
25	1, 107	636	1, 587	15	74	6. 7
34	1, 111	596	1, 519	15	67	6. 0
Average	1, 071				78	7. 3
1,201 to 1,400 cubic feet:						
24	1, 220	382	1, 735	12	75	6. 1
31	1, 221	345	2, 116	12	103	8. 5
23	1, 230		1, 807	9	64	5. 2
54	1, 244		2, 010	9	85	6. 8
22	1, 261		1, 807	9	61	4. 8
2	1, 284	950	1, 648	18	73	5. 7
32	1, 363	365	1, 838	12	70	5. 1
Average	1, 260				76	6. 0
Over 1,400 cubic feet:						
12	1, 463	939	1, 814	18	72	4. 9
Overall average	1, 059	360	1, 672		74	7. 0

[1] Simple interest.

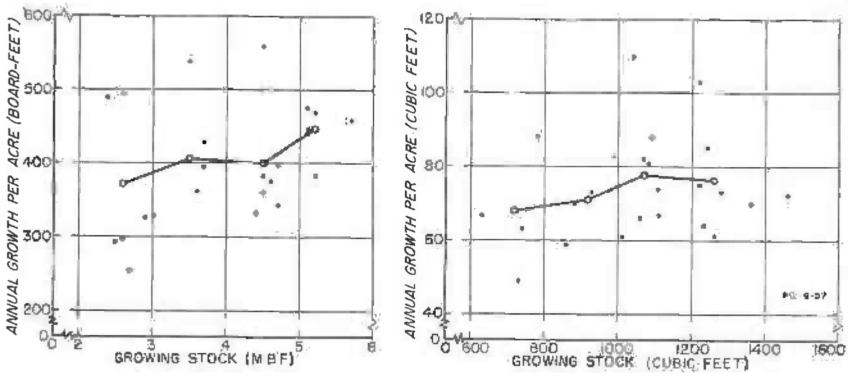

FIGURE 19.—Pine growth in respect to stocking.

stock usually is explicable in terms of ingrowth. Less-than-average growth is mostly due to poor tree distribution. Large variations in either direction should disappear as management continues.

To get some indication of the effect of management upon growth and yields, two compartments (41 and 42) were set aside as natural or check areas (fig. 20). They were inventoried to the same standards as the study plots in 1937 and again at the end of 5, 9, and 14 growing seasons. No cutting of any kind has been done on them.

Table 15 compares the growth on these compartments with that on representative managed compartments. Although the unmanaged stands originally had 95 percent more board-foot and 93 percent more cubic-foot growing stock (an advantage of 3,800 board-feet and 1,076 cubic feet per acre), the managed stands produced 12 percent more

TABLE 15.—*Comparison of net pine growth per acre in selectively managed stands vs. pine-plus-hardwood growth in unmanaged stands*

Compartment	Growth period	Sawtimber growth			Cubic growth		
		Volume in 1937	Average annual growth	Growth rate [1]	Volume in 1937	Average annual growth	Growth rate [1]
	Years	*Board-feet*	*Board-feet*	*Percent*	*Cubic feet*	*Cubic feet*	*Percent*
Unmanaged:							
41	14	7, 847	443	5. 6	2, 307	66	2. 9
42	14	7, 825	343	4. 4	2, 156	50	2. 3
Average		7, 836	393	5. 0	2, 232	58	2. 6
Managed:							
2	18	5, 141	442	8. 6	1, 284	73	5. 7
13	18	3, 677	428	11. 6	1, 076	81	7. 5
21	18	2, 564	492	19. 2	1, 069	82	7. 7
32	12	5, 061	448	8. 8	1, 363	70	5. 1
45	12	3, 685	395	10. 7	995	83	8. 3
Average		4, 028	440	10. 9	1, 156	78	6. 7

[1] Simple interest.

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FIGURE 20.—The natural or unmanaged area. Although pine stocking and pine-plus-hardwood stocking have been considerably higher here than on the managed areas, growth has been considerably less, both in volume and in rate.

sawtimber growth and 34 percent more cubic growth. The growth of the managed tracts was achieved on pine alone, while growth figures for the unmanaged compartments represent hardwood as well as pine.

When differences in growing-stock volumes and species composition are considered, it appears that management probably increased pine growth by 100 board-feet per acre annually.

Growth percents on the managed compartments will decrease as growing stock approaches the carrying capacity of the site. The rate, however, is only part of the growth story. Another is the curve of actual growth, particularly its peak. So far, the greatest growth has occurred on compartments with about 1,200 cubic feet of growing stock per acre (fig. 19 and table 14). These values are almost certain to change. Observation of individual trees in small groups makes it clear that tree distribution, diameter dispersion, and genetic quality and vigor can still be considerably improved. It also has been found that control of understory vegetation (which might include excessive pine reproduction) makes more of the limited water supply available to the pine growing stock and thus allows more growth to take place during dry summers.

Board-foot growth is still rising. If due allowance is made for continued improvements in stand structure and tree vigor, maximum sustained sawtimber growth seems capable of exceeding 600 board-feet per acre annually. A maximum sustained growth of more than 100 cubic feet per acre annually is not at all unlikely. Thus current indications are that growth in board-feet, cords, and dollars will peak at considerably higher levels of stocking than have yet been attained on any compartment.

The tentative goal of 10,000 board-feet per acre (by end of cycle), adopted arbitrarily for use in this study, was derived from observations

TABLE 16.—*Proposed well-stocked loblolly-shortleaf pine stand per acre, site index 85*

D. b. h. (inches)	Trees per acre	Basal area per tree	Volume per tree		Basal area per acre	Volume per acre	
	Number	*Sq. ft.*	*Bd.-ft.*[1]	*Cu. ft.*	*Sq. ft.*	*Bd.-ft.*	*Cu. ft.*
2	20	0. 022			0. 440		
3	18	. 049			. 882		
4	16	. 087		0. 80	1. 392		12. 80
5	14	. 136		1. 70	1. 904		23. 80
6	12	. 196		3. 10	2. 352		37. 20
7	11	. 267		5. 20	2. 937		57. 20
8	9	. 349		7. 80	3. 141		70. 20
9	8	. 442		10. 70	3. 536		85. 60
Total, presaw-log size	108				16. 584		286. 80
10	7	. 545	53	14. 10	3. 815	371	98. 70
11	7	. 660	79	18. 00	4. 620	553	126. 00
12	6	. 785	107	22. 40	4. 710	642	134. 40
13	5	. 922	137	27. 10	4. 610	685	135. 50
14	4	1. 069	168	32. 10	4. 276	672	128. 40
15	4	1. 227	202	37. 40	4. 908	808	149. 60
16	3	1. 396	239	42. 00	4. 188	717	126. 00
17	3	1. 576	280	48. 10	4. 728	840	144. 30
18	2	1. 767	325	54. 70	3. 534	650	109. 40
19	2	1. 969	375	61. 90	3. 938	750	123. 80
20	2	2. 182	431	69. 70	4. 364	862	139. 40
21	1	2. 405	492	77. 90	2. 405	492	77. 90
22	1	2. 640	561	86. 40	2. 640	561	86. 40
23	1	2. 885	631	94. 90	2. 885	631	94. 90
24	1	3. 142	706	103. 20	3. 142	706	103. 20
Total, saw-log size	49				58. 763	9, 940	1, 770. 90
Total	157				75. 347	9, 940	2, 064. 70

[1] Local tables of merchantable volume, by International ¼-inch rule.

of stands that seemed to have the best spacing, growth rate, and stocking consistent with optimum growth. The stand structure for this growing aim is given in table 16. The proposed standard for a well-stocked stand assumes that the forest is to be maintained for the production of high-quality sawtimber with pulpwood, poles, and piling as important secondary products, and that the cutting cycle will be 5 years. On these assumptions, the growing stock left after each cut would be about 7,400 board-feet; growth would exceed 500 board-feet annually. It is not yet known how length of cycle or other factors will influence growing-stock goals.

The temporary nature of this goal must be emphasized (*20*). None of the Crossett compartments have so far reached the stand structure suggested in table 16. Yet it is already possible to see that the growth attributed to this structure is likely to be proved conservative in the next decade or two. It will almost certainly have to be revised upward as soon as foresters accumulate records of a stand that has been managed from the time of seeding.

Changes in Stand Structure

Structure of the pine stand on the tract is closer to the tentative optimum today than it was in 1937.

There has been a reduction in the number of trees in the 5- to 9-inch d. b. h. classes since management started (fig. 21). In part,

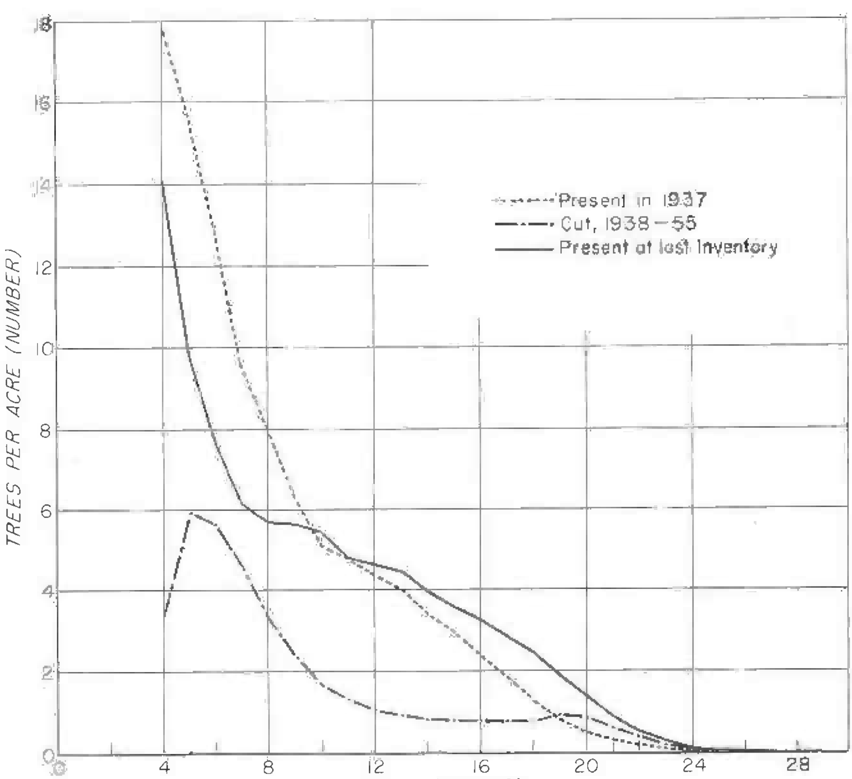

FIGURE 21.—Number of pine trees per acre by size class.

this reduction has been brought about by the thinning of dense groups of saplings and poles, by the removal of diseased and misshapen stems, and by the salvage of ice-damaged trees. Growth of many 4- to 9-inch d. b. h. stems into the 10-inch and larger classes has also been responsible.

This reduction in presaw-log size stems is not serious. More than enough stems of these sizes remain to replace any sawtimber trees cut. Moreover, the reproduction that has sprung up in openings made by cutting merchantable stems and treating culls will soon increase greatly the number of pines in sizes below 10 inches d. b. h. The number of pines in the 4-inch d. b. h. class has increased by nearly 6 per acre since 1952.

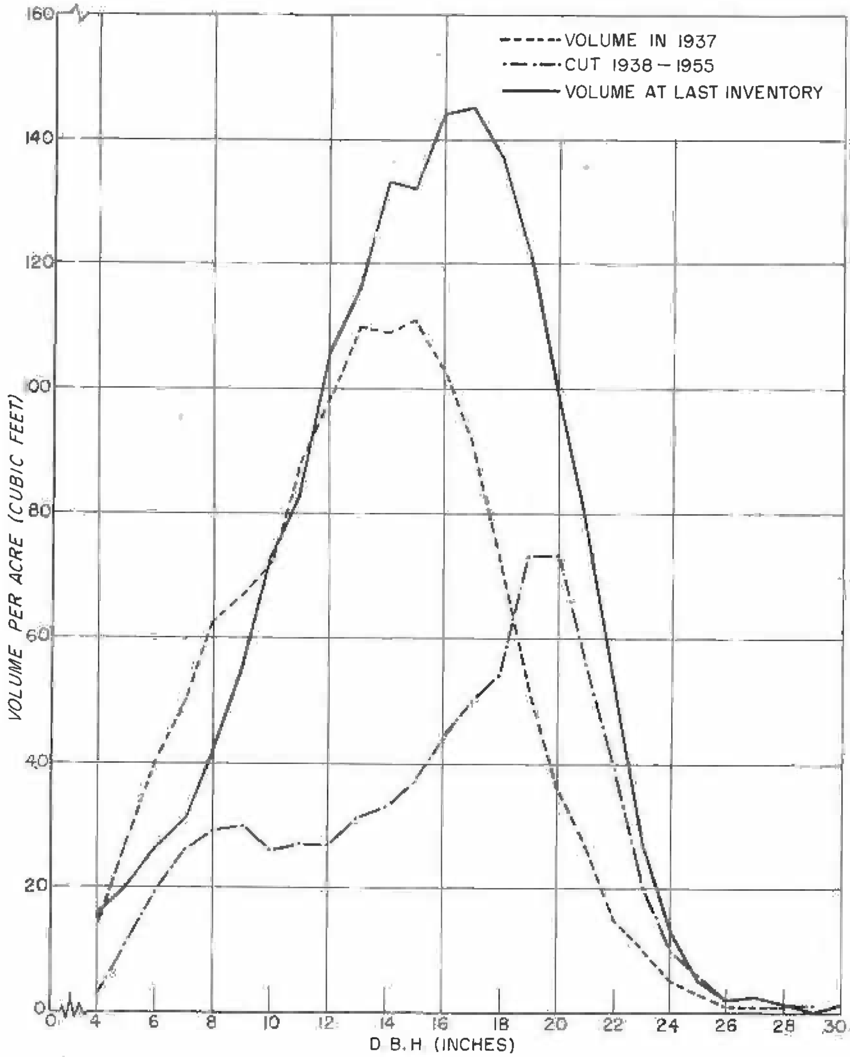

FIGURE 22.—Pine cubic volume per acre by tree size class.

The reduction in presaw-log stems may actually be desirable. Recent soil-moisture studies (*1, 33*) have shown that even in moderately stocked stands lack of soil moisture usually limits growth in the summer. Conserving the moisture for the larger, more valuable stems would probably mean more summerwood, and more volume growth. Since the presaw-log stems take much of the available water, the number on the average acre should probably be only enough to replace the larger stems as they are cut, to allow for natural mortality, and to bring about natural pruning of potential crop trees.

The cubic volume per acre for the presaw-log sizes has decreased slightly. There has been a moderate increase in cubic volume for trees of 10 to 15 inches d. b. h. and a large increase for the 16- to 26-inch trees (fig. 22). This has occurred in spite of the large volume cut from these sizes over the 18 years.

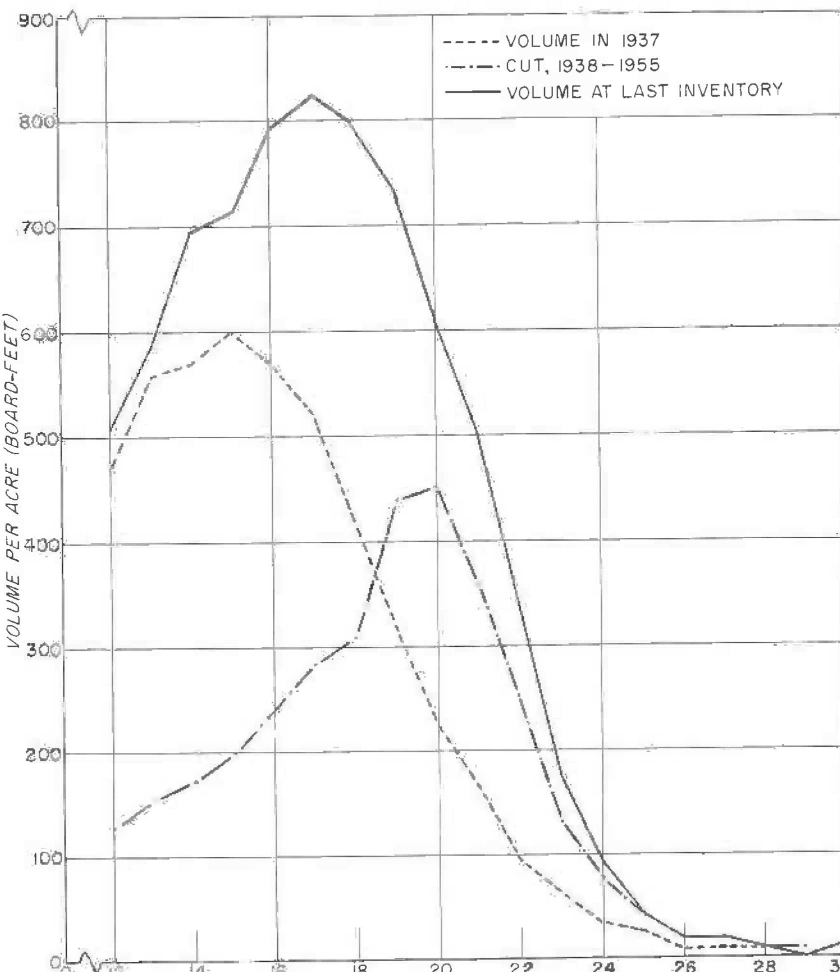

FIGURE 23.—Pine board-foot volume per acre, by tree size class.

In 1937, more of the board-foot volume was in the 15-inch d. b. h. class than in any other (fig. 23). Eighteen years later, and with only a small increase in number of trees, the peak of the board-foot volume was in the 17-inch class. Of perhaps more interest is the fact that, despite the removal of 286 of the original 524 board-feet per acre in trees of this size, the volume of the 17-inch class has increased by 302 to 826 board-feet. Similar increases are noted for the 18- to 23-inch classes, and even the board-foot volumes of 24-, 25-, and 26-inch trees have nearly doubled.

Comparing figures 21 and 23 with table 13 (p. 38) indicates that there should be no difficulty in achieving a growing stock of 10,000 board-feet per acre in the near future.

Regeneration

One of the big "if's" in regard to the selection system has always been the question of adequate pine reproduction. Will pine seed into small openings in sufficient numbers and compete with grass, weeds, and brush without expensive site preparation?

Pine seed crops of fair to large size occurred in 1935, 1939, 1942, 1947, and 1951. The 1935 and 1951 crops were excellent but were followed by severe droughts that killed many seedlings (fig. 24). The 1942 and 1947 crops were spotty. The crop of 1939 was the only bumper seedfall that was followed by good growing weather in the critical first year.

A survey was made in 1953–54 to learn how much reproduction resulted from these seedfalls. Stocking was determined on 100 mechanically spaced milacre plots per 40-acre compartment. Plots were considered stocked to pine if a pine seedling, sapling, or tree was present. The plot was also considered stocked to pine if it contained no pine but was shaded by the vertical crown projection of an overstory pine.

The survey showed that overstory pine stocking (trees 3.5 inches in diameter and larger) varied from 41 to 63 percent and averaged 47 percent. Overstory stocking of hardwood averaged 5 percent. Understory stocking of pine (seedlings and saplings under 3.5 inches d. b. h.) varied from 29 to 72 percent and averaged 53 percent.

Some plots had both overstory and understory pines. When pine reproduction was tallied on only those plots where it was needed, and when this tally was added to the amount of overstory stocking, the total effective stocking for the 24 compartments varied from 70 to 93 percent and averaged 81 percent (fig. 25).

Hardwood sprouts, saplings, and trees overtopped some pines. This hardwood competition varied from 1 to 20 percent and averaged 7 percent.

Subtracting the plots with pine overtopped by hardwoods gives a net stocking of pine free to grow equivalent to 74 percent. This must be considered excellent stocking, especially as unmerchantable hardwoods had not as yet been treated on six of the compartments (fig. 26).

Hardwood brush is, of course, present throughout most compartments. Only very rarely will it overtop pines now listed as "free to grow," but some further brush treatment is desirable.

F–396210, 482497

FIGURE 24.—An example of 1935 seedlings saved by release from hardwood competition. Inset shows seedling in 1940, large picture, in 1951.

F-482482

FIGURE 25.—After 15 years of management, pine stocking averages 81 percent.

As stocking increases and fire protection continues, the litter on the study compartments will probably deepen. A 2-inch accumulation is about as much as can be expected, however, for the high temperatures and ample rain break litter down rapidly; a natural area undisturbed for more than 15 years averaged only 1 inch of litter. Such depths would not be found uniformly, but only under dense groups or heavy-crowned trees—places where reproduction is not needed. The heaviest reproduction has occurred where litter was light, and a study by Grano shows that litter is unlikely to be a barrier to adequate loblolly pine regeneration in good seed years (*6*).

F–350886, 482489

FIGURE 26.—An area from which two large hardwoods were removed in 1934. Photos taken in 1937 and 1956.

COSTS AND RETURNS

Timber Growing Costs

Timber management costs will vary with the owner's objectives and financial situation. In the present study, it has been assumed that the owner is a private individual or company solely interested in selling stumpage.

Research costs have been excluded. Only those costs are given that would be incurred by a prudent private timberland owner.

Capital expenses.—The capital expenditures assumed necessary for managing the 958-acre tract are given in table 17. The figures are based on average costs for the 1938–55 period. The table includes only items that are to be depreciated. Cost of land is excluded because the study aims to see what return the owner would get by managing his land for timber.

Most of south Arkansas and north Louisiana is well traversed by State, county, or local roads and trails, but these roads are not always conveniently located for the timber manager, and many are not operable yearlong. To enhance stumpage values, improve fire protection, and permit salvage of dead timber, about $1,700 of road construction and improvement is needed per square mile of forest. This expense is depreciated over a 25-year period.

The cost of $1,700 per square mile for roads is based on a 1-mile spacing—about 2 miles of road per section. In practice, about a mile per section would have to be constructed or reconstructed. Of the mile of new roads, half would need to be graveled to permit yearlong operation, and the rest could be 20-foot secondary graded dirt roads.

TABLE 17.—*Timber growing costs, 958 acres*

Item	Amortization period	Total cost	Cost per acre per year	18-year cost
Capital expenses:	*Years*	*Dollars*	*Dollars*	*Dollars*
Road depreciation	25	2, 538. 70	0. 106	1, 827. 86
Cruise and management plan	10	239. 50	. 025	431. 10
Timber stand improvement	30	3, 832. 00	. 133	2, 293. 45
Car and truck depreciation [1]	3	220. 34	. 023	396. 61
Total			. 287	4, 949. 02
Current expenses:				
Taxes			. 120	2, 069. 28
Fire protection			. 050	862. 20
Timber marking			. 060	1, 034. 64
Car expense			. 016	275. 90
General supervision			. 180	3, 103. 92
Road maintenance			. 110	1, 896. 84
Total			. 823	14, 191. 80

[1] Cost of cars and trucks is based on the requirements for a typical large company that used 1 pickup full time on each 25,000 acres. Depreciation is about $0.023 per acre per year.

In the Crossett area during the 18-year period, consulting foresters have cruised tracts and prepared management plans for about 25 cents per acre. With this estimate as a guide, the original cruise and management plan were capitalized. Provision has also been made for repeat cruises and management-plan adjustments at 10-year intervals.

During the first 10 years, all compartments were covered at least once by a pulpwood operation that removed sound gum trees over 5 inches d. b. h. and by a chemical wood operation in which most sound oak trees over 6 inches in d. b. h. were cut. In the last 5 years, some sound trees of other hardwood species 3.5 inches and larger in diameter and cull trees of all hardwood species were either girdled or poisoned at a cost of about $4 per acre. Amortized over 30 years, the cost is $0.133 per acre per year.

A timberland owner with about 1,000 acres would hardly need a car or pickup truck full time on timber management. In order to arrive at a reasonable figure for car and truck expense, the cost of such equipment has been based on the requirements for a typical large company whose lands are under intensive management. The company uses one pickup truck full time for each 25,000 acres of ownership. The pickups last approximately 3 years, and the cost for depreciation is about $0.023 per acre per year. This rate is used here.

Total costs for investment-account items has been $4,949, or $0.287 per acre annually over the various amortization periods (table 17).

Current expenses.—In addition to investment costs, there have been recurrent annual charges against the property.

Taxes on timberland in 1955, averaged $0.18 per acre and varied from one county to another. They have averaged about 12 cents per acre per year for forest land in south Arkansas over the period of the study.

Most forest managers depend upon their State forestry divisions for a major portion of their protection from fire. In Arkansas the payment of 2 cents per acre per year to the State assures the owner of having the amount matched or more than matched by State and Federal funds. In addition, the owner should provide about 3 cents per acre annually for standby crews and equipment when fire risk is high. This brings the timberland owner's cost for fire protection to about 5 cents per acre.

About five compartments were marked each year on the tract, at the rate of a man-day per compartment. The total marking cost per year was $57.20, and the cost per acre per year for the tract averaged nearly 6 cents.

Running expense for automotive equipment was estimated at $0.016 per acre per year.

On large tracts in the Crossett region, the yearly cost of technical supervision is about $0.18 per acre.

From 1938 to 1955 the cost of road maintenance on the experimental tract has been $0.11 per acre per year. This figure excludes resurfacing costs but provides for keeping the roads in reasonably good condition.

Total expenses.—For the assumptions made, total investment and operating costs have averaged about $0.82 per acre per year. If this tract had been owned by a farmer or investment owner who had no other forest property and who did all or most of the supervision, cruising, and marking, the actual out-of-pocket cost would have been about $0.40 per acre per year, chiefly for taxes, fire protection, car expense, and timber stand improvement.

Returns

Returns from the tract can be considered in two parts: stumpage receipts and value added by increases in the growing stock.

Stumpage Receipts

For all products, the tract yielded $107 stumpage per acre for the 18 years. This amount equals about $6 per acre annually (table 18).

TABLE 18.—*Stumpage receipts for 18 years by product and grade*

Product	Grade 1	Grade 2	Grade 3	Total	Per acre	Per acre annually
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Pine saw logs	45, 100	22, 000	14, 400	81, 500	85. 07	4. 72
Hardwood saw logs	2, 200	3, 700	4, 100	10, 000	10. 43	. 58
Pine and gum pulpwood				10, 700	11. 12	. 62
Hardwood distillation wood				700	. 72	. 04
Total	47, 300	25, 700	18, 500	102, 900	107. 34	5. 96

Detailed returns from saw-log stumpage, by compartment, appear in tables 19 and 20. Notwithstanding that logs are seldom purchased by grade, the quality of logs produced is an important consideration in weighing the results of management. Hence the tables attempt to delineate the effects of grade on dollar returns. For this purpose the estimated log-grade prices were applied in such a way that the total stumpage return from the annual harvests approximated what would have been received had the harvests been sold at regional average stumpage prices.

For the first 10 years, the assignment of grade values relied on results of a study (*22*) of the grade-yield values and man-hour and dollar costs of producing lumber from logs of various sizes and grades. Values by log grade and size were computed each year and applied to the logs actually cut during that year.

Beginning in 1948, an annual canvass of several representative timber buyers has been used to obtain stumpage prices. These woods-run prices have then been apportioned to log size and grade as before.

To give an idea of the values applied over the 18-year period, stumpage values by log grade for 14-inch d. i. b. logs have been lifted from the yearly data and are given in table 21.

The stumpage returns for hardwood logs shown in table 20 need some explanation. In some cases the value of grade 2 saw logs, if calculated per thousand board-feet, was greater than for grade 1

TABLE 19.—*Value of pine saw logs cut, 1938–55*

Compartment number	Volume of logs cut				Total value			
	Grade 1	Grade 2	Grade 3	Total	Grade 1	Grade 2	Grade 3	Total
	Bd.-ft.	*Bd.-ft.*	*Bd.-ft.*	*Bd.-ft.*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1	78, 339	51, 993	53, 389	183, 721	2, 235. 86	1, 012. 91	669. 71	3, 918. 48
2	102, 946	70, 623	53, 456	227, 025	2, 565. 30	1, 134. 47	589. 34	4, 289. 11
11	29, 717	27, 373	28, 974	86, 064	1, 229. 80	833. 17	555. 60	2, 618. 57
12	108, 503	74, 403	80, 003	262, 909	2, 523. 83	1, 035. 34	653. 12	4, 212. 29
13	76, 928	48, 311	37, 594	162, 833	1, 677. 81	689. 54	369. 47	2, 736. 82
14	92, 574	51, 828	39, 558	183, 960	3, 455. 88	1, 286. 11	598. 22	5, 340. 21
15	32, 685	31, 987	42, 632	107, 304	1, 051. 03	701. 54	548. 31	2, 300. 88
21	56, 393	45, 608	40, 319	142, 320	1, 531. 38	778. 91	436. 19	2, 746. 48
22	45, 663	57, 439	96, 427	199, 529	911. 74	813. 22	863. 26	2, 588. 22
23	82, 797	45, 523	40, 181	168, 501	1, 598. 19	566. 21	314. 83	2, 479. 23
24	101, 136	56, 851	59, 417	217, 404	2, 743. 46	1, 105. 28	650. 29	4, 499. 03
25	51, 261	37, 751	41, 393	130, 405	1, 352. 39	831. 26	522. 46	2, 706. 11
31	53, 520	51, 044	63, 503	168, 067	1, 948. 98	1, 337. 27	1, 001. 06	4, 287. 31
32	72, 210	67, 107	87, 990	227, 307	1, 765. 56	1, 090. 55	865. 10	3, 721. 21
33	59, 718	29, 862	22, 394	111, 974	972. 29	289. 22	125. 50	1, 387. 01
34	89, 608	49, 516	50, 553	189, 677	2, 682. 63	1, 131. 56	678. 46	4, 492. 65
35	95, 971	53, 829	56, 440	206, 240	2, 510. 77	1, 062. 69	653. 02	4, 226. 48
43	35, 146	20, 300	22, 726	78, 172	1, 251. 11	557. 22	347. 46	2, 155. 79
44	78, 301	48, 861	46, 310	173, 472	2, 242. 47	1, 056. 93	583. 21	3, 882. 61
45	58, 051	44, 903	49, 622	152, 576	1, 730. 45	972. 72	656. 17	3, 359. 34
52	30, 789	39, 494	73, 830	144, 113	995. 69	972. 92	1, 052. 17	3, 020. 78
53	33, 246	25, 068	29, 660	87, 974	1, 041. 57	578. 22	389. 67	2, 009. 46
54	112, 161	57, 596	61, 181	230, 938	3, 307. 13	1, 301. 97	735. 64	5, 344. 74
55	60, 733	42, 658	39, 853	143, 244	1, 768. 91	852. 13	542. 98	3, 164. 02
Total	1, 638, 396	1, 129, 928	1, 217, 405	3, 985, 729	45, 094. 23	21, 991. 36	14, 401. 24	81, 486. 83

TABLE 20.—*Value of hardwood saw logs cut, 1938–55*

Compartment number	Volume of logs cut				Total value			
	Grade 1	Grade 2	Grade 3	Total	Grade 1	Grade 2	Grade 3	Total
	Bd.-ft.	*Bd.-ft.*	*Bd.-ft.*	*Bd.-ft.*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1	1, 286	4, 860	6, 495	12, 641	11. 50	35. 19	61. 91	108. 60
2	3, 290	9, 882	6, 232	19, 404	43. 55	155. 28	102. 59	301. 42
11	7, 614	23, 865	23, 672	55, 151	115. 27	294. 07	251. 20	660. 54
12	4, 875	7, 156	3, 041	15, 072	65. 97	104. 83	35. 02	205. 82
13	1, 208	4, 356	3, 930	9, 494	16. 30	53. 70	42. 83	112. 83
14	4, 963	6, 259	4, 760	15, 982	75. 49	84. 87	57. 91	218. 27
15	655	1, 318	1, 857	3, 830	4. 78	11. 97	19. 37	36. 12
21	13, 056	20, 318	18, 193	51, 567	175. 14	301. 32	274. 53	750. 99
22	7, 067	20, 665	29, 260	56, 992	68. 27	313. 19	574. 01	955. 47
23	4, 579	8, 936	9, 671	23, 186	79. 19	124. 31	157. 60	361. 10
24	5, 711	7, 984	8, 916	22, 611	49. 08	75. 20	95. 74	220. 02
25	---	211	925	1, 136	---	2. 42	12. 60	15. 02
31	2, 660	8, 177	11, 214	22, 051	38. 33	115. 91	150. 69	304. 93
32	6, 944	22, 013	21, 729	50, 686	59. 54	206. 81	214. 07	480. 42
33	19, 652	27, 841	23, 740	71, 233	308. 10	428. 98	410. 32	1, 147. 40
34	5, 278	5, 646	5, 388	16, 342	61. 38	65. 40	56. 49	183. 27
35	865	3, 391	3, 485	7, 741	13. 78	46. 26	56. 63	116. 67
43	24, 722	36, 806	53, 672	115, 200	580. 29	690. 00	955. 85	2, 226. 14
44	7, 312	6, 847	10, 017	24, 176	118. 76	115. 95	165. 66	400. 37
45	---	718	2, 742	3, 460	---	15. 09	55. 57	70. 66
52	8, 920	20, 919	11, 548	41, 387	85. 22	144. 71	86. 77	316. 70
53	11, 491	27, 264	24, 057	62, 812	122. 29	229. 99	197. 91	550. 19
54	3, 332	4, 481	7, 198	15, 011	56. 10	63. 64	90. 42	210. 16
55	952	2, 226	1, 651	4, 829	5. 34	15. 27	22. 57	43. 18
Total	146, 432	282, 169	293, 393	721, 994	2, 153. 67	3, 694. 36	4, 148. 26	9, 996. 29

TABLE 21.—*Stumpage value per M board-feet of 14-inch d. i. b. pine logs by log grade and year*

Year	Log grades		
	1	2	3
	Dollars	*Dollars*	*Dollars*
1938	5. 50	1. 87	−2. 32
1939	6. 33	3. 40	−. 35
1940	8. 45	5. 80	2. 55
1941	12. 15	9. 45	6. 60
1942	11. 20	7. 95	4. 35
1943	11. 25	8. 25	4. 45
1944	17. 65	14. 00	9. 85
1945	17. 60	14. 25	10. 65
1946	25. 40	23. 10	21. 20
1947	21. 92	16. 98	11. 44
1948	31. 85	24. 67	16. 62
1949	30. 30	23. 46	15. 81
1950	35. 37	27. 39	18. 46
1951	43. 42	33. 62	22. 66
1952	45. 38	35. 14	23. 68
1953	44. 84	34. 71	23. 40
1954	42. 08	32. 58	21. 96
1955	43. 25	33. 49	22. 58

logs, and some grade 3 logs were worth more than either grade 2 or grade 1. Values obtained from compartments 24 and 55 are a case in point. These seeming inconsistencies stem from the fact that in the early years of the study only grade 1 logs were generally salable. Some large grade 2 logs could be sold, but grade 3 logs had no market. Thus, in the first selection cuttings only the better hardwood logs were removed and sold, and the price received per M was low. During the middle part of the 18-year period, however, demand was good for all grades of logs, and for logs that were much smaller than anything accepted previously. Prices generally also were better. Consequently, many grade 2 and grade 3 logs marketed during 1944–47 (from compartments previously given a selection cut) were worth more than the grade 1 logs removed earlier.

The value of pulpwood (table 22) and chemical-wood (table 23) stumpage was based on the current market values of the delivered product less costs of logging and delivery to local markets. Values ranged from about 50 cents per standard cord in 1938 to about $4 in 1955.

Value Added to Growing Stock

The total gross stumpage sales value of the products over the 1938–55 period was $102,833, or $107.34 per acre. To this must be added or subtracted a value equivalent to the change in pine and hardwood growing stock.

TABLE 22.—*Value of pine and gum pulpwood stumpage cut, 1938–55*

Compartment number	Volume produced	Net stumpage value per cord [1]	Total value
	Cords	*Dollars*	*Dollars*
1	470. 49	2. 14	1, 004. 56
2	221. 79	1. 44	318. 79
11	170. 90	2. 74	468. 28
12	448. 20	1. 83	821. 18
13	175. 97	1. 39	244. 13
14	199. 69	1. 60	320. 45
15	148. 04	1. 49	220. 30
21	264. 02	1. 40	369. 47
22	281. 07	2. 53	709. 80
23	157. 21	1. 07	168. 85
24	153. 52	. 62	95. 67
25	156. 83	2. 63	413. 24
31	631. 28	1. 47	925. 24
32	475. 93	2. 55	1, 212. 92
33	61. 18	1. 28	78. 15
34	112. 59	1. 17	131. 85
35	142. 24	2. 62	372. 51
43	89. 24	. 96	86. 03
44	119. 65	1. 31	156. 59
45	197. 09	1. 87	368. 72
52	483. 34	1. 60	771. 20
53	267. 41	1. 62	434. 54
54	204. 57	2. 85	584. 03
55	168. 72	2. 25	379. 50
Total	5, 800. 97		10, 656. 00
Weighted average		1. 84	

[1] Difference between delivered value and cost of production.

As the study method provides that an average of only five compartments be inventoried every year, a current inventory for the entire tract has not been available since 1937. A figure representing 1955 stocking was arrived at by projecting each compartment's last regular inventory by its growth rate. This calculation indicated that pine growing stock has increased by approximately 3.5 million board-feet even though approximately 4.0 million board-feet was cut.

All hardwood saw-log growing stock of value was cut from all compartments prior to 1955. It amounted to approximately 722 M board-feet, about the volume present in 1937.

Most of the old-field pine stands on the tract were badly overstocked in 1937, and thinnings removed a relatively large volume from them. Necessary thinnings and salvage of badly suppressed trees in other parts of the tract also took out a good many cords of pulpwood. Pine reproduction has been heavy on many of the compartments, but most of it has not yet reached pulpwood size. In consequence, the volume of cordwood-size pines cut during the first 18 years plus outgrowth into saw-log sizes was greater than the new growth. The

TABLE 23.—*Value of hardwood chemical-wood stumpage cut, 1938–55*

Compartment number	Volume produced	Net stumpage value per unit [1]	Total value
	Units	*Dollars*	*Dollars*
1	117. 77	0. 49	57. 40
2	52. 10	. 14	7. 33
11	318. 56	3. 85	1, 226. 42
12	150. 97	. 36	53. 63
13	74. 17	. 73	53. 82
14	122. 42	. 45	55. 09
15	148. 30	−1. 87	−276. 70
21	111. 14	. 38	42. 42
22	208. 31	. 72	148. 97
23	90. 52	−. 14	−12. 74
24	168. 35	−1. 26	−211. 32
25	90. 85	−. 25	−22. 70
31	80. 40	−. 73	−58. 33
32	93. 06	. 90	83. 65
33	373. 70	. 71	264. 23
34	201. 91	−. 12	−23. 84
35	74. 37	−1. 91	−141. 76
43	180. 71	−1. 23	−222. 28
44	87. 24	. 29	25. 51
45	120. 87	. 15	17. 57
52	253. 52	−. 31	−78. 02
53	268. 64	−1. 34	−359. 21
54	135. 41	. 45	60. 93
55	173. 50	. 02	3. 99
Total	3, 696. 79		694. 06
Weighted average		. 19	

[1] Difference between delivered value and cost of production.

net result was a decrease in the pine pulpwood growing stock equivalent to 1,648 cords, approximately 1.7 cords per acre.

At average stumpage values for the period, the pine saw-log growing stock increased approximately \$55.19 per acre. The decrease in hardwood saw logs equaled \$10.44 per acre, and the decrease in pulpwood growing stock, \$3.17 per acre. The net result was a \$41.58 per-acre increase in value of growing stock. These changes can be summarized as follows:

Increase in pine saw-log growing stock inventory:		
Grade 1	225,200 bd.-ft. at \$27.52=	\$6,197
Grade 2	1,042,700 bd.-ft. at 19.46=	20,292
Grade 3	2,230,000 bd.-ft. at 11.83=	26,381
		52,870
Decrease in hardwood saw-log growing stock:	722,000 bd.-ft. at 13.85=	−10,000
Decrease in pine pulpwood growing stock:	1,648 cords at 1.84=	− 3,032
Value added to growing stock		39,838

Total Net Returns

When costs of management are subtracted from the stumpage returns plus the value of the addition to growing stock, the net return to management is $7.45 per acre annually:

Stumpage sales 1938–55	$5.96
Increase in value of growing stock	2.31
Total	8.27
Cost of producing the timber crop	.82
Net return	7.45

Starting Today

The previous sections have given a historical record of the happenings on the study area from 1937 to 1955. What are the possibilities for the company or individual who owns timberland and is thinking of starting a management program today? If the stocking and species composition are similar to that of the study area in 1937, and sites are equal, what are the cost and return possibilities over the next 20 years?

To answer such questions, the data from the study have been reappraised in terms of approximate 1957 prices. On this basis, the value of products[5] cut during the 18 years would be:

Pine saw logs:				
Grade 1	1,638,000	bd.-ft. at	$43.00=	$70,434
Grade 2	1,130,000	bd.-ft. at	33.50=	37,855
Grade 3	1,217,000	bd.-ft. at	22.50=	27,382
				135,671
Hardwood saw logs	722,000	bd.-ft. at	10.00=	7,220
Pine pulpwood	5,016	cords at	4.00=	20,064
Gum pulpwood	785	cords at	2.00=	1,570
Value of products cut				164,525

To these values must be added or subtracted the changes in growing stock that have taken place during the 18 years:

Increase in pine growing stock:				
Grade 1	225,000	bd.-ft. at	$43.00=	$9,675
Grade 2	1,043,000	bd.-ft. at	33.50=	34,940
Grade 3	2,230,000	bd.-ft. at	22.50=	50,175
				94,790
Decrease in hardwood growing stock	722,000	bd.-ft. at	10.00=	−7,220
Decrease in pine pulpwood growing stock	1,648	cords at	4.00=	−6,592
Net increase in value				80,978

Costs of growing the timber crop have also changed appreciably. Yearly costs for areas similar to those of the study might vary from $1 to $1.50 per acre depending upon the intensity of the fire protection, the local tax situation, and the amount of timber stand improvement needed. For illustrative purposes, $1.25 per acre per year will be assumed.

[5] Chemical-wood returns not projected because of uncertainty of market.

Applying 1957 values to timber growing costs, products cut, and changes in volume of growing stock gives the following net return:

	Total (dollars)	Per acre (dollars)	Per acre per year (dollars)
Stumpage return	164, 525	171. 74	9. 54
Increase in growing stock	80, 978	84. 53	4. 69
Total	245, 503	256. 27	14. 23
Cost of producing the crop	21, 555	22. 50	1. 25
Net return	223, 948	233. 77	12. 98

In 1957 dollars the timber present in 1937 would approximate $200 per acre, and the average investment in roads, timber stand improvement, and cruise and management plans about $14 per acre.

Net annual return in 1957 dollars would be $12.98 per acre. Such earnings would represent interest of approximately 6 percent on a $214 investment per acre in timber and improvements.

Acquisition today of a tract similar in site to the study area would entail an outlay of $10 to $30 per acre for the land, in addition to the value of the timber. If a land cost of $20 were added to the $214 per acre assumed for timber and improvements, the net return would be about 5.5 percent annually. Greater or smaller outlays would affect returns accordingly.

This estimate is probably conservative. Today a prudent owner would remove the inferior hardwoods during the first year or two, rather than carry them as long as was done on the study tract. In the very first years he would supplement natural pine reproduction by direct seedling and planting where necessary. These measures might increase the investment by $10 or more per acre, but in 20 years' time the cost would be more than balanced by increased growth.

Of course, sites vary considerably. An area averaging site class 70 is worth managing, but growth and yields may be 30 to 40 percent less than from class 80 sites. Taxes and all management costs are usually about the same regardless of site. Thus, net returns are likely to increase rapidly with each increase in site class.

The timber owner's investment is threatened by fire, insects, disease, wind, weather, and trespass. Through prevention and salvage, management tends to hold such losses below what could be expected in unmanaged stands. Changes in dollar values, the demand for wood, and the techniques of timber growing should also be considered in appraising the possibilities of management. Here too the outlook is good. Product markets appear promising and research should continue to yield improved silvicultural techniques. The net effect could well be a relative gain in timber receipts as against timber growing costs.

WHAT OF THE FUTURE?

The loblolly and shortleaf trees of the virgin stands, 20 to 30 or more inches in diameter and up to 100 feet tall, with 10 to 20 rings to the inch in the outer 3 to 6 inches of radius, are a thing of the past. Likewise, the larger trees in the stands today are not typical of those that will be present in the future.

Then what of the future? What can a timberland owner expect from managed stands?

There has been limited opportunity to exercise control over the form or quality of the larger trees in the Crossett study. Thinning has been done, of course, and trees with rot and those that were extremely rough have been cut. But because of the understocked stand and the fact that the saw-log-size trees were widely scattered, it was rarely possible to choose between a good tree and a poor tree competing for the same parcel of land. The average quality of the trees is and has been good, but by no means superior. Tree spacing has been far from ideal.

Today it is possible to find on the tract young trees with a considerably greater potential saw-log value and earning capacity than the average of trees managed to date (fig. 27). The form of such trees is better, the limbs smaller in proportion to the trunk, and the growth rate high in proportion to crown size. Through continuous selection, it should be possible to develop many saw-log trees that will grow at least 3 inches in diameter per decade, yield 4 logs that will be substantially clear of limbs and cut out 50 percent or more of C or better lumber, and mature at well beyond 20 inches in diameter. Figure 27 shows the protoype of such trees. It should also be possible to obtain much better spacing than is now present. The growth rate and the volume and value of the stands should be much better in the future than in the past.

A landowner cannot afford to produce lumber with 20 rings to the inch, but he can very well afford intensive management of loblolly and shortleaf pine. The future looks most promising.

SUMMARY

This bulletin presents costs, returns, and silvicultural observations from a 958-acre understocked forest of second-growth southern pine and hardwood that has been managed on a selection system for 18 years.

When management began in 1937, the stocking of shortleaf and loblolly pine of saw-log size (12 inches d. b. h. and larger) varied from 1,922 to 8,000 board-feet per acre, by the International ¼-inch rule. The average was 4,669 board-feet.

The management unit has been the 40-acre compartment. With the object of eventually determining the effect of cutting cycle on growth and returns, eight 40-acre compartments have been cut on a 3-year cycle, eight on a 6-year cycle, and eight on a 9-year cycle.

The first cutting on all compartments was essentially for improvement and sanitation, but yielded substantial proportions of high-grade logs. As the study progressed it became clear that the oaks, gums, and other hardwoods could not compete with the pine in growth rate, quality, or return per unit of area. Therefore all merchantable hardwoods 5 inches d. b. h. and larger were removed. Cull and unmerchantable hardwoods have been girdled.

During the 18 years, 4,160 board-feet of pine saw logs, 754 board-feet of hardwood saw logs, 6.0 cords of pine and gum pulpwood, and 3.9 units of hardwood chemical wood were cut per acre. Although the pine saw-log volume removed equals 89 percent of the pine growing stock present in 1937, volume in sawtimber pines has increased by 3,651 board-feet per acre.

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FIGURE 27.—Prime sawtimber in the making—today and tomorrow.

Pine growth has averaged 405 board-feet per acre per year. Based on volume of growing stock present after the initial cut on each compartment, the annual growth has been 10 percent simple interest.

Growth on pines 4 inches d. b. h. and larger has averaged 74 cubic feet, or 7 percent simple interest.

A regeneration survey in 1953–54 showed that 74 percent of all sample milacres were stocked with pine—that is, had seedlings or saplings free to grow or else were occupied or shaded by overstory pine.

If stumpage returns are based on the stumpage value of the product in the year in which it was cut, the gross 18-year return has been $107.34 per acre. This is equal to $5.96 per acre per year.

Total cost of growing the timber crop, including necessary road construction and maintenance, timber stand improvement, cruising, marking, supervision, and management planning, has averaged about $0.82 per acre per year. For farmers and other small timberland owners who could have undertaken most of their own fire protection, their own timber stand improvement, and their own timber marking and supervision, the annual timber growing cost would have been about $0.40 per acre per year.

Increase in pine growing stock has been worth the equivalent of $3.07 per acre per year. Harvests decreased the hardwood growing stock by $0.58 per acre per year and the pine poletimber by $0.18. The net increase in growing-stock volume has therefore been equal to $2.31 per acre per year.

Stumpage sales plus the value of an increase in growing stock have been $148.92 per acre, or $8.27 per acre per year. Subtracting annual timber management costs of $0.82 per acre leaves a value of $7.45 for profit, interest on the investment, and risk. Returns to the small owner would have been $7.87 per acre per year.

At 1937 values for the land and timber, the return on the investment has been equal to 37 percent annually.

If 1955 prices had been paid for the timber present in 1937, the value of the growing stock would have been about $199 per acre. If $10 per acre had been added for land value and $7 for investment in roads, timber stand improvement, cruising, and management planning, the total investment at 1955 values would have been $216 per acre. Net returns were $12.82 per acre for the 18 years. Earnings were at the rate of 5.9 percent per year for interest on the investment, risk, and profit.

The sawtimber harvested has mainly been from trees inherited from premanagement days. Growth on and returns from the stands have been very good, but many of the older trees are not of the best form. With sustained management, the future stands will contain better trees than are now present, and growth and returns will be greater still.

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APPENDIX

TABLE 24.—*Average merchantable pine pulpwood volume in tops of saw-log trees* [1]

D. b. h. (inches)	Merchantable volume per tree	D. b. h. (inches)	Merchantable volume per tree
	Cu. ft.		*Cu. ft.*
12	7. 0	21	8. 6
13	7. 2	22	8. 1
14	7. 2	23	7. 4
15	7. 2	24	6. 4
16	7. 2	25	5. 3
17	7. 2	26	4. 0
18	7. 6	27	2. 5
19	8. 2	28	. 9
20	8. 8		

[1] To a minimum top diameter of 3.5 inches, inside bark.

TABLE 25.—*Cubic volume per tree for pine and hardwood, by diameter breast high*

D. b. h. (inches)	Pine	Hardwood	D. b. h. (inches)	Pine	Hardwood
	Cu. ft.	*Cu. ft.*		*Cu. ft.*	*Cu. ft.*
4	0. 8	0. 7	19	62. 3	38. 8
5	1. 7	2. 0	20	69. 7	42. 6
6	3. 1	3. 3	21	77. 9	46. 8
7	5. 2	4. 8	22	86. 4	51. 4
8	7. 8	6. 7	23	94. 9	56. 3
9	10. 7	8. 9	24	103. 2	62. 0
10	14. 1	11. 3	25	111. 2	68. 4
11	18. 0	14. 0	26	119. 2	75. 0
12	22. 4	16. 8	27	127. 0	82. 0
13	27. 1	19. 7	28	135. 0	89. 4
14	32. 1	22. 7	29	143. 0	96. 9
15	37. 4	25. 7	30	151. 0	104. 5
16	43. 1	28. 7	31	159. 0	112. 3
17	49. 1	31. 9	32	167. 0	120. 5
18	55. 5	35. 3			

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TABLE 26.—*Estimated merchantable cubic volume per 16-foot, log-by-log position in the tree* [1]

D. b. h. (inches)	Pine				Hardwood		
	1st log	2d log	3d log	4th log	1st log	2d log	3d log
	Cubic feet	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Cubic feet*
12	8.38	6.45	4.65	3.04	7.7	5.8	2.4
13	9.80	7.71	5.59	3.46	8.9	7.0	3.4
14	11.34	9.26	6.60	3.92	10.2	8.2	4.3
15	12.99	10.95	7.88	4.65	11.3	9.4	5.0
16	14.75	12.57	9.26	5.45	12.6	10.6	5.5
17	16.62	14.30	10.56	6.31	14.0	11.7	6.2
18	18.60	16.14	11.95	7.23	15.6	12.9	6.8
19	20.70	17.84	13.42	8.38	17.5	13.9	7.4
20	22.90	19.64	14.75	9.44	19.4	15.0	8.2
21	25.22	21.79	16.38	10.56	21.4	16.0	10.1
22	27.65	23.76	18.10	11.95	23.6	17.1	11.1
23	30.19	25.82	19.64	13.20	25.8	18.2	12.1
24	32.84	27.96	21.24	14.30	28.1	19.3	13.1
25	35.61	30.19	23.19	15.44	30.4	21.2	14.1
26	38.48	32.51	25.22	16.86	32.8	23.2	15.1
27	41.47	34.91	27.03	18.10	36.2	25.2	16.1
28	44.57	37.39	29.22	19.37	38.7	27.3	17.1
29	47.48	39.95	31.23	20.64	41.4	29.5	18.1
30	51.10	42.54	33.24	21.94	44.1	31.8	19.1
31	54.53	45.31	35.25	23.30	46.9	34.2	20.1
32	58.03	48.26	37.26	24.72	49.7	36.7	21.1
33					52.5	39.2	22.1
34					55.3	41.9	23.1
35					58.1	44.6	24.1
36					60.9	47.4	25.1
37					63.7	50.3	26.1
38					66.5	53.2	27.1
39					69.3	56.3	28.1

[1] Cubic volumes computed by use of average diameter at small end times the length.

TABLE 27.—*Converting factors for 16-foot shortleaf and loblolly pine logs in southeast Arkansas*

Diameter inside bark at small end of log (inches)	Volume per log, International scale	Equivalent in—			To convert values per M board-feet International scale to values based on Doyle or Scribner scale, or cubic feet, multiply by the following figures—			Peeled volume per M board-feet when scaled by—		
		Doyle scale [1]	Scribner scale [1]	Cubic volume, inside bark	Doyle scale	Scribner scale	Cubic feet	International scale	Doyle scale	Scribner scale
	Board-feet	*Board-feet*	*Board-feet*	*Cubic feet*	*Ratio*	*Ratio*	*Ratio*	*Cubic feet*	*Cubic feet*	*Cubic feet*
6.0	19	4	12	4. 0	0. 2105	0. 6316	0. 2105	210. 5	1000. 0	333. 3
6.5	23	6	16	4. 4	. 2609	. 6956	. 1913	191. 3	733. 3	275. 0
7.0	28	9	21	5. 0	. 3214	. 7500	. 1786	178. 6	555. 6	238. 1
7.5	33	12	25	5. 6	. 3636	. 7576	. 1697	169. 7	466. 7	224. 0
8.0	39	16	31	6. 3	. 4102	. 7949	. 1615	161. 5	393. 8	203. 2
8.5	45	20	36	7. 1	. 4444	. 8000	. 1578	157. 8	355. 0	197. 2
9.0	51	25	42	7. 9	. 4902	. 8235	. 1549	154. 9	316. 0	188. 1
9.5	58	30	48	8. 8	. 5172	. 8276	. 1517	151. 7	293. 3	183. 3
10.0	65	36	55	9. 8	. 5538	. 8462	. 1508	150. 8	272. 2	178. 2
10.5	72	42	62	10. 8	. 5833	. 8611	. 1500	150. 0	257. 1	174. 2
11.0	80	49	70	11. 8	. 6125	. 8750	. 1475	147. 5	240. 8	168. 6
11.5	88	56	78	12. 9	. 6364	. 8864	. 1466	146. 6	230. 4	165. 4
12.0	97	64	86	14. 2	. 6598	. 8866	. 1464	146. 4	221. 9	165. 1
12.5	106	72	94	15. 4	. 6792	. 8868	. 1453	145. 3	213. 9	163. 8
13.0	115	81	104	16. 7	. 7043	. 9043	. 1452	145. 2	206. 2	160. 6
13.5	125	90	113	17. 9	. 7200	. 9040	. 1432	143. 2	198. 9	153. 4
14.0	136	100	123	19. 2	. 7353	. 9044	. 1412	141. 2	192. 0	156. 1
14.5	146	110	133	20. 5	. 7534	. 9110	. 1404	140. 4	186. 4	154. 1
15.0	157	121	144	22. 0	. 7707	. 9172	. 1401	140. 1	181. 8	152. 8
15.5	169	132	155	23. 5	. 7811	. 9172	. 1390	139. 0	178. 0	151. 6

16.0	181	144	166	25. 0	. 7956	. 9171	. 1381	138. 1	173. 6	150. 6
16.5	193	156	178	26. 7	. 8083	. 9223	. 1383	138. 3	171. 2	150. 0
17.0	205	169	190	28. 4	. 8244	. 9268	. 1385	138. 5	168. 0	149. 5
17.5	219	182	203	30. 2	. 8310	. 9269	. 1379	137. 9	165. 9	148. 8
18.0	232	196	216	32. 0	. 8448	. 9310	. 1379	137. 9	163. 3	148. 1
18.5	246	210	229	33. 9	. 8536	. 9309	. 1378	137. 8	161. 4	148. 0
19.0	260	225	243	35. 8	. 8654	. 9346	. 1377	137. 7	159. 1	147. 3
19.5	275	240	257	37. 8	. 8727	. 9345	. 1374	137. 4	157. 5	147. 1
20.0	290	256	272	39. 8	. 8828	. 9379	. 1372	137. 2	155. 5	146. 3
20.5	305	272	287	41. 8	. 8918	. 9410	. 1370	137. 0	153. 7	145. 6
21.0	321	289	302	43. 8	. 9003	. 9408	. 1364	136. 4	151. 6	145. 0
21.5	337	306	318	45. 8	. 9080	. 9436	. 1359	135. 9	149. 7	144. 0
22.0	354	324	334	47. 8	. 9152	. 9435	. 1350	135. 0	147. 5	143. 1

[1] Doyle scale is computed from the formula: $V=\frac{(D-4)^2\times L}{16}$.

Scribner scale is computed from the formula: $V=0.79D^2-2D-4$.

International ¼-inch scale is computed from the formula: $V=0.796D^2-1.375D-1{,}230$.

TABLE 28.—*Converting factors for shortleaf and loblolly pine trees in southeast Arkansas*

D. b. h., outside bark (inches)	Volume per tree, International scale	Equivalent in—			To convert values per M board-feet International scale to values based on Doyle or Scribner scale, or cubic feet, multiply by the following figures—			Peeled volume per M board-feet when scaled by—		
		Doyle scale	Scribner scale	Cubic volume, inside bark	Doyle scale	Scribner scale	Cubic feet	International scale	Doyle scale	Scribner scale
	Board-feet	*Board-feet*	*Board-feet*	*Cubic feet*	*Ratio*	*Ratio*	*Ratio*	*Cubic feet*	*Cubic feet*	*Cubic feet*
10	53	20	32	13. 1	0. 3774	0. 6038	0. 2472	247. 2	655. 0	409. 4
11	79	38	56	14. 7	. 4810	. 7089	. 1861	186. 1	386. 8	262. 5
12	107	58	82	17. 0	. 5421	. 7664	. 1589	158. 9	293. 1	207. 3
13	137	81	113	20. 1	. 5912	. 8248	. 1467	146. 7	248. 1	177. 9
14	168	108	146	24. 1	. 6429	. 8690	. 1435	143. 5	223. 1	165. 1
15	202	141	182	29. 3	. 6980	. 9010	. 1450	145. 0	207. 8	161. 0
16	239	176	219	34. 9	. 7364	. 9163	. 1460	146. 0	198. 3	159. 4
17	280	213	257	41. 0	. 7607	. 9179	. 1464	146. 4	192. 5	159. 5
18	325	253	298	47. 7	. 7785	. 9169	. 1468	146. 8	188. 5	160. 1
19	375	297	342	55. 1	. 7920	. 9120	. 1469	146. 9	185. 5	161. 1
20	431	344	392	62. 7	. 7981	. 9095	. 1455	145. 5	182. 3	159. 9
21	492	400	449	70. 8	. 8130	. 9126	. 1439	143. 9	177. 0	157. 7
22	561	465	513	79. 3	. 8289	. 9144	. 1414	141. 4	170. 5	154. 6
23	631	541	585	88. 1	. 8574	. 9271	. 1396	139. 6	162. 8	150. 6
24	706	621	662	97. 0	. 8796	. 9377	. 1374	137. 4	156. 2	146. 5
25	785	705	743	105. 9	. 8981	. 9465	. 1349	134. 9	150. 2	142. 5
26	867	790	827	114. 9	. 9112	. 9539	. 1325	132. 5	145. 4	138. 9
27	950	876	913	124. 0	. 9221	. 9611	. 1305	130. 5	141. 6	135. 8
28	1, 033	963	1, 000	133. 0	. 9322	. 9681	. 1288	128. 8	138. 1	133. 0
29	1, 116	1, 050	1, 090	142. 0	. 9409	. 9767	. 1272	127. 2	135. 2	130. 3
30	1, 200	1, 140	1, 182	151. 0	. 9500	. 9850	. 1259	125. 8	132. 5	127. 7

U.S. GOVERNMENT PRINTING OFFICE: 1959 O—502843