GROWTH AND YIELD OF SINNISSIPPI FOREST STANDS

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INTRODUCTION

The goal of forest management is continuous production of forest products at an optimum level consistent with the related forest uses. Since the continuity and level of production rest upon the ability of the forest to grow, knowledge of the growth and yield of the various component stands of the forest is prerequisite to management. Of prime importance to foresters, this knowledge should be of considerable interest to all concerned with furthering the multiple-use concept which recognizes timber, wildlife, recreation, and watershed management as supplementary and interdependent phases of intelligent use and development of our forest resources.

Data on growth and yield are presently not available in sufficient numbers over a sufficiently broad base to enable reliable assessment of the productivity of our many and varied Illinois forest types. Furthermore, these meager growth data are based largely on increment cores. Growth data based on continuous inventory which provides for direct measurements of drain (including harvest and mortality), growth, and ingrowth, such as are presented here for Sinnissippi Forest, are almost nonexistent for Illinois forest types.

SINNISSIPPI FOREST

Sinnissippi Forest is a private enterprise of 2,313 acres (1954 inventory) operated to produce maximum, sustained, annual, net returns from growing, harvesting, utilization, and marketing of forest products. It is located in Ogle County, Illinois, a few miles south of Oregon on the Rock River, which bounds it on the north and west. The forest is favorably situated with respect to markets.

The beginning of Sinnissippi Forest management dates back to about 1905, when annual planting of some 50,000 white pine, *Pinus strobus,* was started by Frank O. Lowden. These plantings were continued until about 1917 (Dept. Forestry, Univ. Ill., 1953). Extensive fuelwood cuttings from the forest, beginning shortly after the turn of the century and extending to about 1945, removed principally dead and dying trees and those of low sawtimber value.

Reforestation activities were resumed in 1938 and have been carried on annually since that time. Livestock were excluded from the forest in 1938. A continuous inventory system was set up, and a systematic program of improvement cuttings was begun in 1949. Prior to this improvement program, almost no

commercial cuttings were made in the present sawtimber stands.

Forest Cover Types

Sinnissippi Forest is a part of the oak-hickory forest, the westernmost region of the eastern deciduous forest. Black oak, *Quercus velutina,* and white oak, *Quercus alba,* in pure or mixed stands predominate on the 1,577 acres of upland hardwood. Red oak, *Quercus rubra,* is generally found only on the better, more mesophytic sites. Pure stands of red oak, totaling 67 acres, are confined to coves and north-facing slopes. The upland oak stands are characteristically even-aged with the 71- to 90-year age-class predominant. Annual ring counts made in 1949 indicated that the majority of the trees in this age-class were then about 80 years old. Shagbark hickory, *Carya ovata,* although universally present in the forest, occurs infrequently in relatively undisturbed sawtimber stands, more frequently in more disturbed sawtimber stands, and abundantly in reproduction stands.

Mixed hardwood sawtimber stands, comprising only 54 acres of the upland forest, are composed principally, in approximate order of their occurrence, of: black and white oaks; American elm, *Ulmus americana;* black cherry, *Prunus serotina;* shagbark hickory; black walnut, *Juglans nigra;* and green ash, *Fraxinus pennsylvanica,* var. *subintegerrima.* Upland hardwoods areas, with a stocking of less than 1,200 board feet, are classed as hardwood reproduction. They total 306 acres which, for the most part, are former pasture.

The 71 acres of bottomland forest occurring as a narrow strip bordering the Rock River includes 61 acres of overmature, decadent stands of: silver maple, *Acer saccharinum;* American elm; a scattering of younger green ash; hackberry, *Celtis occidentalis;* and other bottomland tree species.

The 617 acres of forest plantations, including 74 acres of older white pine stands, are chiefly single-species plantings of white pine or red pine, *P. resinosa.*

A breakdown of the forest types by sites and 1949 age-class designations (miscellaneous stands and young plantations are excluded) is presented in Table 1A.

Field Measurements and Volume Computations

Field measurements for this study were obtained for the 1949 and 1954 forest inventories covering the 1949 through 1953 growing seasons on permanent, circular, one-fifth-acre, sample plots. Plots were laid out on a rectangular grid at the rate of 12 per 40 acres. Diameter measurements for trees 3.6 inches in diameter and over at breast height were available from both inventories. Diameters of trees over 8.5 inches were taken to the nearest one-tenth inch in such a manner that successive measurements of the same tree could be paired. Total and merchantable height measurements were available from two or more mechanically selected sample trees on each plot. Merchantability standards applied to the sample trees were in accord with sawtimber utilization practices at Sinnissippi Forest.

Merchantable lengths of hardwood trees were invariably limited by branching or deformity. Although a minimum top-diameter limit of eight inches was allowable, for hardwood sawlogs, this limit was seldom attained. Over 95% of the merchantable length determinations for hardwood trees 12 inches and larger on poor, medium, and good sites averaged 1, 1.25, and 1.5 logs, respectively, shorter than theoretical taper would allow to an eight-inch top. Merchantable length of white pine was determined entirely by taper to a six-inch top.

Stand tables were compiled, from the sample plot, field data sheets, by forest-condition classes consisting of stands of similar cover type, the same 20-year age-group, and site-quality classes. These groupings were made strictly in accordance with the forest-type map to avoid bias. Pure types were not recognized on the forest-type map unless 80% or more of the trees forming the dominant crown canopy were of the type species. Three upland, hardwood, site-quality classes—poor, medium, and good—corresponding to upland, oak, site index classes of 50, 60, and 70 (Schnur, 1937), respectively, were recognized. All pine plantings were considered to be on medium pine sites. Dominant trees in the oldest white pine planting have attained an average height of 67 feet at age 50. The silver maple-American elm type is considered to be on inherently good sites.

Basic volume computations were carried out in cubic feet by the volume-line method described by Spurr (1954). Least-squares solutions of the regression of sample-tree volume on diameter squared were computed for species within site classes. Sample-tree volumes were based on Table 3 in Gevorkiantz and Olsen (1955), giving gross, peeled volume of the entire stem in cubic feet. All hardwood volume-lines were based on measurements of sample trees in 1954 because no measurable change was observed in the diameter-height relationships during the five-year inventory period. Substantial changes in these relationships during the period were found in the case of pine, however; hence, separate volume-line solutions for 1949 and 1954 were computed and used for computing pine volumes. Good fits of the calculated regression lines with plotted data were obtained in all instances. Only slight adjustments of the hardwood regressions were required to correct for the observed curvilinearity below the ten-inch diameter class.

Gross board-foot volume estimates for trees 9.6 inches and larger were obtained from cubic-foot volumes using conversion formulae developed for Sinnissippi Forest inventory purposes. These formulae are based on the linear or essentially linear relationships existing between International one-fourth inch board-foot volumes and total cubic-foot volumes of sample trees as determined for the 1954 inventory. Sample-tree board-foot volumes were based on Table 2 of Gevorkiantz and Olsen (*op.cit.*). The influences of tree diameter and of site on this relationship were tested by co-variance methods and found not to be significant in the case of the data on upland hardwoods. Statistical differences found in the highly uniform

data on pines were small and considered of no practical significance. Consequently, pooled regressions of board-foot volume on total cubic-foot volume were computed by the least-squares method, one for upland hardwoods and one for pine. An approximate regression of board foot on cubic foot was used for the decadent bottomland, hardwood type, because gross board-foot volumes in this type are of little value since there is a large and variable amount of cull in sawtimber trees in this type.

The regression formulae used for converting total cubic-foot volumes of merchantable trees 9.6 inches and larger into board-foot volumes are the following where N is the number of trees making up the cubic-foot volume to be converted:

Upland hardwood

Bd. ft. vol. = 3.96 (cu. ft. vol.) $-18N$

White pine

Bd. ft. vol. = 6.68 (cu. ft. vol.) $-20N$

Bottomland

Bd. ft. vol. = 3.31 (cu. ft. vol.)

Results and Discussion

Inventory and growth data in cubic feet for all trees 3.6 inches in diameter and larger are presented in Table 1A, and in cubic feet and board feet for all trees 9.6 inches and larger exclusive of cull trees in Table 1B for the important condition-classes at Sinnissippi Forest. The values in Table 1B are of greatest interest in the management of even-aged stands nearing maturity, since they are most likely to contribute to yield during the current rotation. The cubic volumes of cull trees excluded from the 9.6-inch-and-over volume grouping amounted to: less than 5% for upland types on medium and good sites; up to 8% for upland types on poor sites with the exception of 18% for the 71- to 90-year-old black oak age-class; and 20% for the bottomland type of the total 1949 inventory volume in trees 9.6 inches and over. No cull white pine were recorded on the white pine sample plots.

Harvest volumes shown in Table 1A contained varying amounts of volume in cull trees girdled concurrently with the improvement cuttings. Dead trees harvested between inventories constituted less than 5% of volumes shown in Table 1B.

Mortality values are considerable, relative to growth, and must not be ignored, in a managed forest. Most of the mortality, being confined to smaller trees, might be expected as normal losses due to the suppression effects of the dominant trees. The abnormally high losses in trees 9.6 inches and larger, shown for the red oak type and the 71- to 90-year black oak and mixed oak age-classes on poor sites, reflect losses attributable to oak wilt disease. Oak wilt survey records at Sinnissippi Forest indicate that 55% of the mortality shown in Table 1A can be accounted for by the known recorded volumes of red and black oaks killed by oak wilt during a five-year period coinciding with the inventory period. The extremely heavy board-foot losses for the silver maple-American elm type are to be expected in overmature stands of this type.

Growth values appearing under the column headed "production," include ingrowth and growth on

TABLE 1A.—Volume and Growth Per Acre for Sinnissippi Forest Stands Based on 1949 and 1954 Forest Inventories. All Trees 3.6 Inches and Over in Diameter at Breast Height Included.

Condition class			1954 acreage	No. of plots	1949 inventory	Periodic annual				1954 inven.
						Harvest	Mortality	Ingrowth	Production	
Type	Age class	Site quality			Cu. ft.	Cu. ft.	Cu. ft.	Cu. ft.	Cu. ft.	Cu. ft.
Upland hardwoods										
A. Red oak	71-90	Good	67.4	19	3,248	94	24	2	62	3,088
B. Mixed oak	71-90	Good	58.6	23	3,254	60	15	5	60	3,254
C. Mixed oak	51-70	Med.	23.6	6	2,096	77	16	1	28	1,847
D. White oak	71-90	Med.	111.8	35	2,487	39	9	1	40	2,494
E. Mixed oak	71-90	Med.	355.1	105	2,508	69	6	4	51	2,418
F. White Oak	91-100	Med.	6.4	3	2,624	0	5	0	34	2,792
G. Mixed hdwd.	Uneven	Med.	12.2	4	2,174	9	8	1	33	2,259
H. Black oak	51-70	Poor	12.5	4	1,853	99	8	0	35	1,536
I. Mixed oak	51-70	Poor	159.6	37	1,678	41	6	3	40	1,677
J. White oak	71-90	Poor	49.6	14	1,724	37	2	0	29	1,686
K. Black oak	71-90	Poor	195.2	51	1,709	33	10	4	45	1,766
L. Mixed oak	71-90	Poor	142.8	43	1,814	77	6	0	29	1,575
M. Mixed oak	Uneven	Poor	34.1	8	1,683	153	1	1	47	1,152
N. Mixed hdwd.	Uneven	Poor	41.7	11	1,704	2	7	10	56	1,974
O. Reproduction	1-30	.....	306.4	68	632	17	1	13	38	737
Bottomland hardwood										
P. Maple-elm	71+	Good	61.4	13	3,135	14	31	11	66	3,395
Pine plantations										
Q. White pine	45	Med.	15.7	5	3,080	54	3	0	155	3,582
R. White pine	31-40	Med.	8.6	3	2,120	4	0	0	151	2,853

TABLE 1B.—Volume and Growth Per Acre for Sinnissippi Forest Stands Based on 1949 and 1954 Forest Inventories. All Trees, Except Cull Trees, 9.6 Inches and Over in Diameter at Breast Height Included.

Condition class	1949 inventory		Periodic annual								1954 inventory	
			Harvest		Mortality		Ingrowth		Production			
	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.
					Upland hardwoods							
A	2,941	10,278	89	322	16	49	9	25	63	255	2,811	9,943
B	2,988	10,356	60	214	6	19	6	17	61	236	2,993	10,466
C	1,382	4,303	73	242	2	6	21	56	43	150	1,234	3,843
D	2,145	7,126	38	138	4	11	12	32	48	179	2,192	7,330
E	2,079	6,901	66	230	1	3	15	41	55	200	2,023	6,751
F	2,523	8,569	0	0	0	0	0	0	37	147	2,709	9,306
G	1,280	4,079	9	34	0	0	26	72	47	154	1,468	4,679
H	956	2,796	64	215	0	0	26	63	57	185	918	2,645
I	925	2,835	35	116	2	5	28	68	50	155	1,001	3,028
J	1,292	3,946	33	111	0	0	16	40	44	151	1,351	4,144
K	1,157	3,538	21	70	7	23	14	34	37	130	1,237	3,837
L	1,390	4,388	65	223	5	15	12	28	38	136	1,257	3,952
M	1,428	4,773	151	540	0	0	9	23	37	131	856	2,724
N	1,087	3,332	2	8	3	7	21	51	49	164	1,320	4,111
O	348	1,162	16	55	0	2	7	16	16	54	351	1,156
					Bottomland hardwood							
P	2,391	7,412	13	41	29	91	9	27	34	104	2,493	7,728
					Pine plantations							
Q	2,198	12,343	40	232	0	0	60	314	152	927	2,757	15,817
R	763	3,957	0	0	0	0	113	572	166	932	1,595	8,615

cut trees prior to cutting and exclude mortality. The effects of the recent improvement cuttings on these growth values are believed to be minor because volume was small and time short. Except for these effects, the values in Table 1A are indicative of growth for unmanaged stands. Periodic annual production for even-aged, oak, condition-classes and white pine stands is above estimated mean annual increment.

The total periodic production in trees 9.6 inches or more in diameter on the entire upland hardwood area, including reproduction stands, averaged 45 cubic feet or 160 board feet per acre annually. This production amounted to 95% of the periodic annual drain. Proper interpretation of the balance between production and drain depends on what is desired in stocking and age distribution.

Comparisons of yields as of the 1954 inventory (volume of periodic harvest plus 1954 inventory) among hardwood sites and white pine stands are of interest. The contrast between pine and hardwood yields is most striking when it is realized that the pine yields were obtained on dune sand of low fertility. White pine yields for the 50-year-old stand are comparable to cubic-foot, and surpass by 50% board-foot, yields for 80-year-old native hardwoods on the very best sites. Obviously, the comparison between pine yields and those of hardwood on the poor hardwood sites is more favorable to pine.

Conclusions and Summary

Conclusions based on a single inventory period as short as five years must be tentative; however, the following appear presently justifiable:

1. The total Sinnissippi Forest upland hardwood area of 1,577 acres is currently producing 250 thousand board feet of sawtimber in trees 9.6 inches or more in diameter annually (160 board feet per acre per year).

2. Approximately 55% of the cubic volume of mortality in trees 3.6 inches or more in diameter for the upland hardwood forest during the period 1949-54 was in black and red oaks killed by oak wilt.

3. Sawtimber yields of white pine stands on sandy soils on Sinnissippi Forest are expected to be at least twice those of native hardwood stands on good sites and at least five times those on poor sites over short rotations up to 80 years.

4. Hardwood sawtimber management on poor sites is unlikely to prove profitable because of low yields and generally poor quality of sawtimber trees. Conversion of these areas to white pine or other coniferous species offers greater management opportunities The growth and management opportunities for white pine at Sinnissippi Forest have been reported (Lorenz, 1952).

Literature Cited

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