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FORM RECOVERY BY UNDERSTORY SUGAR MAPLE UNDER UNEVEN-AGED MANAGEMENT

Abstract.—A study of advanced sugar maple reproduction on a good site in West Virginia indicated that considerable improvement of stem form takes place after selection cutting in the overstory. The study stems were 1 to 6 inches in d.b.h. and many of them were over 50 years old. To an appreciable extent, flat tops and minor crooks were overcome after partial release.

In many unmanaged forest stands on good sites in the northern Appalachians, sugar maple (*Acer saccharum* Marsh.) is a strong component in the understory. This occurs often in the so-called cove hardwoods as well as in the northern hardwood types. Sugar maple is tolerant and aggressive: even after years of suppression it can respond to partial release with increased growth (*Godman 1957; Tubbs 1968*). Trimble (*1965*) found that this species tends to increasingly dominate the stand after the initiation of uneven-aged management and individual tree selection cuttings.

In uncut stands, small (1- to 6-inch diameter) understory stems of sugar maple are generally present, and most of them appear to have poor form. Crooks and flat tops are common among these saplings (fig. 1). It is often assumed that these stems are old and defective, and that they have no potential as crop trees. How realistic is this observation?

For a number of years the author has been observing understory sugar maples and has been impressed by the *good* form of many 6- to 10-inch trees that started as understory stems in well-stocked unmanaged stands

Figure 1. — A flat-topped understory sugar maple that grew suppressed all its life.

and have grown into the intermediate crown class after selection cutting (fig. 2). These observations led to a small study of understory sugar maple in an attempt to learn whether or not the apparently poor stems have the ability to develop into satisfactory crop trees after release.

Ten $1/5$-acre plots were established in good-site stands of 60-year-old second-growth sawtimber that had received either two or three individual tree selection cuts. Stand volumes in trees over 11.0 inches d.b.h. ranged from 8 to 12 thousand board feet per acre. Species composition of the overstory ran heavily to yellow-poplar *(Liriodendron tulipifera* L.), black cherry *(Prunus serotina* Ehrh.), red oak *(Quercus rubra* L.), and sugar maple. Site indexes determined for oak were in the 80-foot class (75 to 84 feet at 50 years of age); these are considered very good sites.

On each plot, all sugar maple stems between 1 and 6 inches d.b.h. were tallied by 1-inch classes. The form of each stem was rated as *good,* *medium, fair,* or *poor* according to a rating system we devised (appendix) for trying to determine which trees had good sawtimber potential. Some of the stems were cut to determine age: ages varied from 17 to 55 years, but all stems examined were older than the 15-year period since the first managed cut was made in the area.

Analysis of these data revealed a strong trend toward a higher portion of good stems as diameter increased (table 1). Though only 4 percent of the 1- to 2-inch stems were rated *good,* 11 percent of the 3- to 4-inch stems and 35 percent of the 5- to 6-inch stems rated *good.* This is a great increase in the proportion of good stems going from the 1- to 2-inch d.b.h. class to the 5- to 6-inch class. Conversely, the percentage of *poor* stems dropped from about 69 percent for the 1- to 2-inch class to 17 percent for the 5- to 6-inch class. Though the trend by plots was more erratic than the trend for the total, it was in the same direction in all cases.

Still another trend was evident in the data: a drastic reduction in the number of stems going from the 1-inch class to consecutively larger diameter classes (table 1). This is in accord with the usual stem distri-

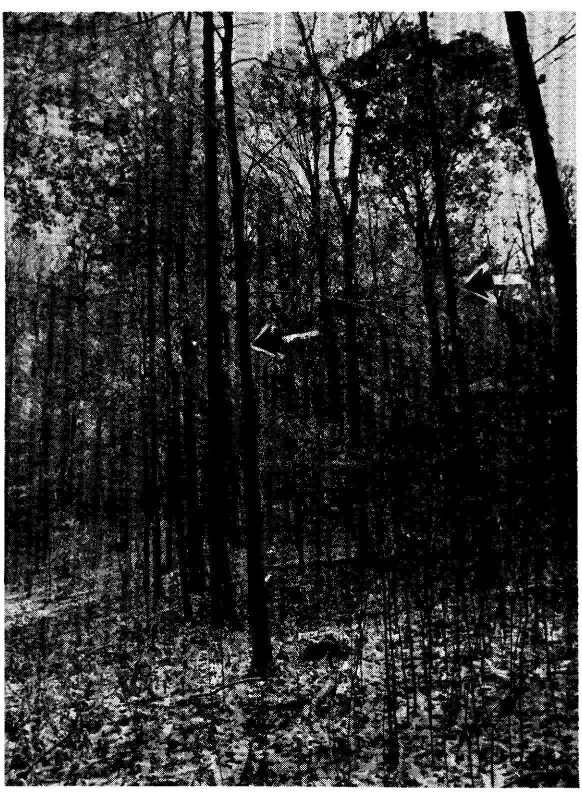

Figure 2. — Arrows mark two 7-inch understory sugar maple trees of good form. Both were suppressed until 17 years ago. Since then three individual tree selection cuts have been made in the area.

Table 1.—*Stem form rating of understory maple saplings*

Diameter class (inches)	Stem form	Portion in each class	Trees in sample
			No.
1 to 2	Good	4	201
	Medium	10	
	Fair	17	
	Poor	69	
2 to 3	Good	5	113
	Medium	13	
	Fair	30	
	Poor	52	
3 to 4	Good	11	65
	Medium	23	
	Fair	40	
	Poor	26	
4 to 5	Good	21	39
	Medium	28	
	Fair	23	
	Poor	28	
5 to 6	Good	35	23
	Medium	26	
	Fair	22	
	Poor	17	

bution in an all-aged stand as illustrated by the typical inverted J-shaped curve.

These results suggest either that: (1) form improves appreciably as the stems grow into the larger size classes; or (2) most of the small and poorly formed stems die while the well-formed small stems live and grow. Because the poorly formed small stems did not appear to be any less vigorous than the well-formed stems of the same size, the second theory seemed to be a poor one.

We decided that a comparison of growth data among form classes for small understory stems in an uncut stand would clarify this situation. If growth rates proved to be unaffected by stem-form class, then we could assume that mortality was the same for each form class and that the increasing proportion of better formed trees in the larger d.b.h. classes was due to form improvement of trees responding to openings in the crown canopy.

A 60-to-65-year-old well-stocked second-growth cove hardwood stand on an excellent site was chosen for this comparison. No cutting had disturbed this stand. A moderately heavy understory of sugar maple stems was present. Ten stems in each form class were chosen at random within the 2-to-3-inch d.b.h. class; stem wafers were cut from each of these at a 1-foot stump height and stem ages were determined (table 2).

The poor stems, slightly younger and slightly smaller in d.b.h., grew a little faster than the others. The good stems grew next fastest, with the medium and fair stems in the middle. But these growth differences were very small and unimportant. Thus it does not appear that increases in the proportion of good stems among the larger trees is due to higher survival among the stems of good form. It is more likely that some trees of poor form develop better form after release. Carvell *(1967),* working with oak in West Virginia, found that understory seedlings recovered form after a single-tree selection cutting. While these stems were smaller than the sugar maple, they developed after release in the same way: flat-topped stems developed new straight leaders and many straightened crooks in the bole.

It is interesting to speculate about how this form recovery takes place. In flat-headed trees it appears that, as release stimulates height growth, a new vigorous terminal shoots up through the flat head (fig. 3). The flat head becomes just a dense whorl of branches, which eventually are shaded out and drop off.

Table 2.—*Growth rate and related data for 2- to 3-inch understory sugar maple stems*
(Based on 10 stems in each form class)

Stem form class	D.b.h. of 2-3-inch trees		Age at 1.0-foot stump		Rings per inch at 1.0-foot stump	
	Average	Confidence interval[1]	Average	Confidence interval[1]	Average	Confidence interval[1]
	Inches	*Inches*	*Years*	*Years*	*Number*	*Number*
Good	2.68	2.43-2.93	51	45-57	19.3	16.5-22.1
Medium	2.46	2.26-2.66	51	46-56	20.7	18.7-22.7
Fair	2.51	2.35-2.67	51	48-54	20.4	18.5-22.3
Poor	2.39	2.19-2.59	44	39-49	18.5	16.4-20.6

[1] At 5-percent level.

Figure 3. — A previously flat-headed understory sugar maple that developed a new vigorous terminal after release through an individual tree selection cut. (This tree was cut and moved into an opening so this photo could be taken.)

For crooked trees the mode of recovery is less obvious. A slight to moderate crook may recover completely or to the extent that it necessitates only a small scaling deduction in the log volume; an extreme crook will persist and must be cut out when the tree is harvested. Presumably the trees outgrow the crooks gradually because a greater portion of the diameter growth that occurs in the crooked section is laid on in the concave side of the curve. Sorensen and Wilson *(1964)*, in a study of red oak on the Harvard Forest, found that maximum radial increment occurred on the lower sides of naturally leaning trees. Engler *(1918)* found that the maximum increment in S-shaped ash and birch stems was always on the concave side of the curve. On the Fernow Experimental Forest, cross-sections were cut out of curves of five sapling understory sugar maples that had been partially released, and wider growth rings were found on the concave side. Other processes may also be at work. Jacobs *(1945)* stresses the role of strain gradients found in leaning hardwood stems, which cause the leaning stem to tend to attain or regain an erect habit.

Literature Cited

Carvell, Kenneth L.
1967. THE RESPONSE OF UNDERSTORY OAK SEEDLINGS TO RELEASE AFTER PARTIAL CUTTING. W. Va. Univ. Agr. Exp. Sta. Bull. 553, 19 pp., illus.

Engler, A.
1918. TROPISMEN AND EXCENTRISCHES DICKENWACHSTUM DER BÄUME. 106 pp. Beer and Co., Zurich.

Godman, R. M.
1957. SILVICAL CHARACTERISTICS OF SUGAR MAPLE. U. S. Forest Serv., Lake States Forest Exp. Sta., Sta. Paper 50, 24 pp., illus.

Jacobs, M. R.
1945. THE GROWTH STRESSES OF WOODY STEMS. Austral. Forestry Bur. Bull. 28, 67 pp., illus.

Sorensen, Ronald W., and
Brayton, F. Wilson.
1964. THE POSITION OF ECCENTRIC STEM GROWTH AND TENSION WOOD IN LEANING RED OAK TREES. Harvard Forest Paper 12, 10 pp., illus.

Trimble, George R., Jr.
1965. SPECIES COMPOSITION CHANGES UNDER INDIVIDUAL TREE SELECTION CUTTING IN COVE HARDWOODS. U. S. Forest Serv. Res. Note NE-30, 6 pp. NE. Forest Exp. Sta., Upper Darby, Pa.

Tubbs, Carl H.
1968. THE INFLUENCE OF RESIDUAL STAND DENSITIES ON REGENERATION IN SUGAR MAPLE STANDS. U. S. Forest Serv. N. Cent. Forest Exp. Sta., St. Paul, Minn. Res. Note NC-47, 4 pp., illus.

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APPENDIX
Sampling Rating System

Good Stem

(1) No main fork in first 32 feet above a 1-foot stump or to total height, if total height, is less than 32 feet. Stem may be forked below stump height.
(2) No stag head.
(3) No flat head.
(4) Butt-log alinement (first 17 feet) no more than 10-percent from vertical.
(5) No crooks that must be cut out below 17 feet.
(6) Stem has potential of at least 32 feet in merchantable log length with no log less than 8 feet and with one log at least 12 feet.
(7) Defect none or slight. *Definition of defect:* rot, crack, canker, potential rot entry from large low limb with weak connection.
(8) Seedling or seedling sprout origin.

Medium Stem

(1) No main fork in first 24 feet above 1-foot stump height or to total height, if total height is less than 24 feet. Stem may be forked below stump height.
(2) No stag head.
(3) May have evidence of previous flat head if it has well-recovered straight tip.
(4) Butt-log alinement no more than 20-percent from the vertical.
(5) No crooks that must be cut out below 9 feet.
(6) Stem has potential of at least 24 feet in merchantable log length with no log less than 8 feet.
(7) Defect none or slight.
(8) Seedling or seedling sprout or well-anchored single-stem sprout from stump less than 8 inches in diameter. Stem shows no evidence of rot having entered from stump.

Fair Stem

(1) No main fork in first 8 feet above 1-foot stump height. Stem may be forked below stump height.
(2) No stag head.
(3) May have evidence of flat head if it has well-recovered straight tip.
(4) Butt-log alinement no more than 30 percent from the vertical.
(5) No crooks that must be cut out below 9 feet.
(6) Stem has potential of at least 16 feet in merchantable log length with no log less than 8 feet.
(7) Defect none, slight, or moderate.
(8) Seedling or seedling sprout or well-anchored single-stem sprout from stump less than 8 inches in diameter. Stem shows no evidence of rot having entered from stump.

Poor Stem

All stems that are alive and fail to meet the requirements of the above three classes.

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