A Silvicultural Guide for Developing A SUGARBUSH

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"When the sap begins to rise, they make a notch in the trunk of the tree, and by means of a pipe of wood inserted in it, upon which the liquor runs as in a gutter, and is received in a vessel below. That it might run in abundance, there should be much snow on the ground—that it freeze the night before and that the heavens be serene—and that it should not be too cold in the day. As the sap thickens it runs the less, and in time it stops entirely."

Comments by M. L'Abbe de la Porte
About the Huron Indians
April 8, 1749

The Authors

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Abstract

A practical guide for the management of a sugarbush. Guidelines are established for the manipulation of stand density and stocking to promote the development of healthy vigorous trees with deep, wide crowns, the necessary attributes for highest possible yield of sugar-rich sap. Specific treatments are prescribed for sapling, poletimber and small sawtimber stands and a procedure is provided for testing a sugarbush for sweetness, to select trees for thinning.

WITH A STRONG demand for maple syrup—and healthy prices—a commercial sap or syrup operation seems to be a very promising venture for a landowner. Sugarbush management is one technique for improving profit potential by increasing the yield of sweet sap. Even greater financial returns are possible by combining management with new methods of sap collection and processing.

We have established management guidelines for each size class of trees to help maximize gains from the sugarbush. These recommendations are based on silvicultural observations and experience, current research, and related literature.

In sapling stands, the crop tree selection method is recommended. In pole stands and larger, stocking should be reduced to a point that would be considered understocked for timber production. This will promote rapid crown expansion and provide an acceptable level of sap production.

Background

Maple syrup is one of this country's oldest agricultural commodities. When the first settlers arrived in this country, Indians were using maple sugar as an important food item. The settlers eagerly adopted the Indians' source of sugar, and through the years maple sugar became an important article of diet.

Maple sugar production increased rapidly in this country until about 1860, when the cheaper cane sugar gradually began to replace maple sugar. Since then, except for an increase during World War I, production has been on the decline. Presently, very little sugar is being produced. The major emphasis is on syrup production. In 1971, 962,000 gallons of syrup were made. This was the smallest amount produced in any year since yearly estimates were begun in 1916.

The production of maple syrup has always been a farm enterprise, and recently has proven to be a most profitable one. With the decline in the number of farms and in the active farm maple groves or sugarbushes, the opportunity has not diminished. In fact with modern equipment—plastic tubing, mechanical tapping tools, etc.— the opportunity has increased. The decline in production has brought record prices, so that profit potential for both the sap and syrup producer is now greater than ever before.

Sap collection accounts for 40 percent or more of the cost of syrup production. Reducing this cost would have a strong influence on the returns from a syrup operation. Using trees that produce a high volume of sap with high sugar content reduces the cost of handling the sap necessary to produce a given amount of syrup. These high-producing trees develop by good management of sugar maple stands and not by chance.

To manage a sugarbush effectively, it is essential to know the characteristics of a tree that will produce large volumes of sugar-rich sap. Research has shown that the ideal sugarbush tree is a vigorous, fast-growing tree that has a deep, wide, fully developed crown exposed as much as possible to sunlight. It has also demonstrated that sugar maples possessing these characteristics tend to produce sweeter sap and greater quantities of sap than slower-growing, smaller-crowned trees. Trees with larger crowns have greater leaf surface area and therefore have a greater capacity to carry on photosynthesis—the mechanism that produces the carbohydrates, or sugar, stored within the tree.

Sap production per tree increases with live crown ratio, width of crown, and rate of diameter growth. In a study conducted by the Ohio Agricultural Experiment Station *(Moore et al. 1951)*, the effects of these factors were identified. Trees with crowns averaging 50 to 75 percent of the total height yielded about 25 percent more sap than similar trees with a crown ratio of less than 50 percent.

Width of crown had a more dynamic effect. Trees with crowns over 30 feet wide, crowns characteristic of trees in an open stand, produced over 100 percent more sap than trees having the same stem diameter but with crowns less than 20 feet wide, a crown size typical of forest-grown trees. Growth rate, which is related to crown size, is strongly correlated with sap yields. Moore et al., found that trees with a growth rate of 5 to 10 rings per inch yielded about 30 percent more sap than trees growing at the rate of 15 to 20 rings per inch.

It has long been known by those familiar with the maple business that some sugar maple trees are "sweeter" than others. Why some trees produce sweeter sap has been a matter of study for several years. Although some of the variability among trees can be attributed to genetic differences, environmental factors such as live crown ratio, crown diameter, and crown exposure all play a significant role.

Stevenson and Bartoo *(1940)*, who reported on extensive sweetness studies in Pennsylvania, found that forest-grown trees produce sap about 30 percent lower in sugar content than open-grown trees. The sugar content of forest-grown trees averaged about 2.25 percent, in contrast to 3.34 percent for open-grown trees. Moore et al. *(1951)* and Morrow *(1955)*, substantiated this correlation. Their reports indicate that open-grown trees are about 15 to 20 percent sweeter than forest-grown trees.

These known facts about sap sweetness and sap yields can easily be incorporated into field practice by careful tree selection. Ideally, trees that are inherently sweet should be identified early, when they are small, and thinnings should be made frequently to allow them to grow and expand rapidly. Identifying the sweeter trees in young stands and favoring them by judicious thinning can greatly improve sap production.

Managing the Sugarbush

The objective of sugarbush management is to produce the highest possible yield of sugar-rich sap per acre. This is accomplished through the manipulation of stand density and stocking to foster the development of healthy, vigorous trees with deep, wide crowns.

Although much has been written on the subject, two publications "A Guide to Sugarbush Stocking", by Smith and Gibbs *(1970)* and

"Standards for Maple Sugarbush Management in Vermont", by Foulds et al. *(1956)* probably have the greatest applicability. Both papers summarize existing knowledge on the subject and both are based on maximum crown size related to tree diameter and number of trees per acre. The recommendations that follow are based essentially on the information presented in these two papers and other pertinent data, and expanded to include a technique of stand analysis not dissimilar to timber management. In fact, the method suggested uses the same stand-examination methods and prescription-writing procedures used in timber management *(Leak et al. 1969)*.

The "Diagnostic Tally Sheet for Sugarbush Stands" (Table 1) provides the means of gathering the data necessary for making sound management decisions. The tally is used to determine the number of trees and basal area per acre, the necessary ingredients of the "Stocking Chart" (fig. 1) for even-aged northern hardwoods. The chart provides the means of comparing existing stand stocking with the suggested stocking levels for increased sap yield. For example, in figure 1, the B level represents minimum stocking for timber objectives. The C level is considered as understocked for quality timber production, but in pole and larger stands not previously thinned it is an acceptable level for improving sap production. The S level is the minimum stocking for maximum crown development with full utilization of crown space. However, this ideal crown development is attainable only if management is started early in the life of the stand—at sapling or small pole size—and carried to stand maturity.

Field Procedures and Prescriptions

I. Stand Analysis

In sapling stands averaging between 2 and 4 inches in diameter, the intent of stand analysis is to determine if there are enough maple trees for management. This assessment can usually be made by a cursory observation. A stand is adequately stocked if there are 80 to 100 well distributed sugar maple trees per acre.

For stands averaging 6 inches in diameter and over, use the "Diagnostic Tally Sheet for Sugarbush Stands." Take 4 to 10 sample points with a 10-factor prism and count only trees in the main crown canopy, the intermediate to dominant trees. Record the trees by diameter class in the proper block of the cumulative tally. Summarize plot data and determine the total number of trees and basal area per acre for the stand. Use the stocking chart to determine the basal area at the C level or the level selected for management. Insert data under stand description and use it as the basis of a stand prescription.

II. Stand Prescription

1. Saplings

Thinning should start early in the life of the stand when trees average 2 to 4 inches in diameter, and should be made at 5 to 10-year intervals. Early thinning encourages the development of large side branches and increases rapid diameter growth. It is at this young age that deep crowns can be maintained or developed most successfully.

The crop tree selection method can be applied quite successfully in these stands. In writing the prescription consider the following:

a. To insure adequate stocking of about 80 to 100 trees when the stand reaches an average size of 10 inches in diameter, select 100 to 125 dominants or co-dominants with good stem and crown forms, free of defects such as acute forking.

b. Favor the sweet tree. Use a sugar refractometer (fig. 2) to measure the amount of sugar in the sap. For testing a sugarbush for sweetness, follow the field procedure suggested in the next section.

c. Free of the crowns of the selected crop trees on all sides to create openings between crowns of 6 to 7 feet.

Table 1.—*Diagnostic tally sheet for sugarbush stands*

[For the determination of the number of trees per acre, average stand diameter, stocking, and spacing for sugarbush management]

Dbh (inches)	Number of trees tallied														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	458	917	1375	1834	2292	2750	3209	3667	4125	4584	5042	5501	5959	6417	6876
4	115	229	344	458	573	688	802	917	1031	1146	1260	1375	1490	1604	1719
6	51	102	153	204	255	306	357	407	458	509	560	611	662	713	764
8	29	57	86	115	143	172	201	229	258	287	315	344	372	401	430
10	18	37	55	73	92	110	128	147	165	183	202	220	238	257	275
12	13	25	38	51	64	76	89	102	115	127	140	153	165	178	191
14	9	19	28	37	47	56	65	75	84	94	103	112			
16	7	14	21	29	36	43	50	57	64	72	79	86			
18	6	11	17	23	28	34	40	45	51	57	62	68			
20	5	9	14	18	23	27	32	37	41						
22	4	8	11	15	19	23	27	30	34						
24	3	6	10	13	16	19	22	25	29						
26	3	5	8	11	14	16	19	22	24						
28	2	5	7	9	12	14	16	19	21						
30	2	4	6	8	10	12	14	16	18						

Tally Legend

/

O

X

Number of plots ______

No. of trees/acre ______

Total Number of Trees Per Acre.—Add the last figures checked on each line and divide by the number of point samples tallied.

BA Per Acre.—Add the total number of entries in each size class, multiply by 10 and divide by the number of point samples tallied. (BA factor = 10)

STAND DESCRIPTION:

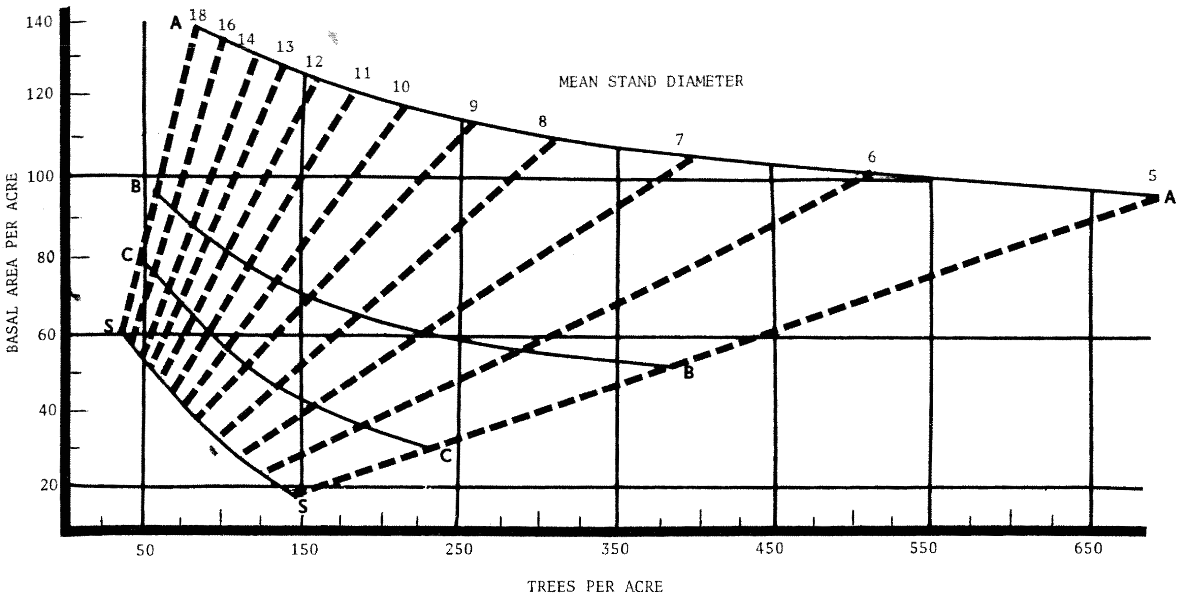
Number of trees per acre______ BA per acre ______ Average stand dbh ______

Trees per acre at C level______ (or level selected for management) BA at C level______ (or selected level)

STAND PRESCRIPTION:

Mark for cutting or girdling ______ trees = ______ BA (Total minus C or selected level) Average crop tree spacing ______ feet

Figure 1.—Stocking chart for even-aged northern hardwoods, based on number of trees in the main canopy, average diameter, and basal area per acre. *For timber objectives,* stands above the A line are overstocked. Stands between A and B lines are adequately stocked. Stands between B and C line should be adequately stocked within 10 years. Stands below the C line are definitely understocked. *For sugarbush management,* maple stands at the S line are at minimum stocking levels.



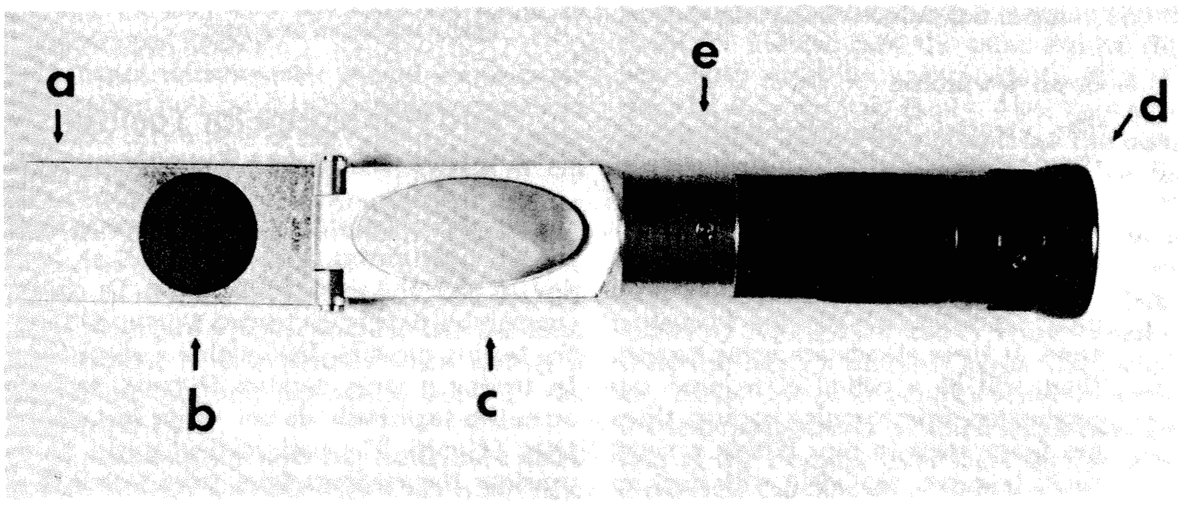


Figure 2.—The sugar refractometer: (a) cover; (b) dark circular area where drop of sap is placed; (c) glass prism; (d) eyepiece; (e) small adjustment screw is used in calibrating the instrument.

d. Select one crop tree within each spacing distance, 20 to 25 feet, and crown release it. Leave trees between the crop trees that are not competing for crown space.

2. Poletimber

The objective in stands of 6 to 10 inches diameter is to improve growing conditions for desirable crop trees by achieving good spacing between crowns. A comparison of present stocking in basal area with the recommended level will provide the basis for a sound prescription for management.

In thinning poletimber stands:

a. Favor the sweet tree as determined by the refractometer measurements made in the fall or spring.

b. In stands previously thinned for crown expansion, reduce the stocking level to bring it between the C and S lines, giving proper consideration to distribution of trees and crown development needs.

c. Stands *not* previously thinned for sap production: Reduce the stocking to the C level. The first thinning of these stands entails some danger of sunscald, insects, and windthrow, but these dangers are minimized if stocking is not reduced below the C level.

3. Small Sawtimber

The greatest immediate response in stands averaging 12 to 15 inches in diameter can be brought about by the increased diameter growth that accompanies crown expansion. Fast growing trees, free to grow, produce significantly more sap than slow-growing competing trees. If these stands are being tapped, there will be a period of reduced sap production after thinning because there are fewer trees to tap. Within a short time, however, sap yield will start to increase, and if conditions are suitable, will continue to do so until production exceeds that before thinning.

In the application of management:

a. Identify the sweetest trees for retention in the stand. Determine sweetness in the fall or during the sugaring season.

b. Reduce the stocking to the C level and strive for an even distribution of stems. If the stand was previously thinned or is sparsely stocked, reduce stocking below the C level and close to the S level to allow for continued expansion of crowns.

4. Large Sawtimber, 15 inches or more

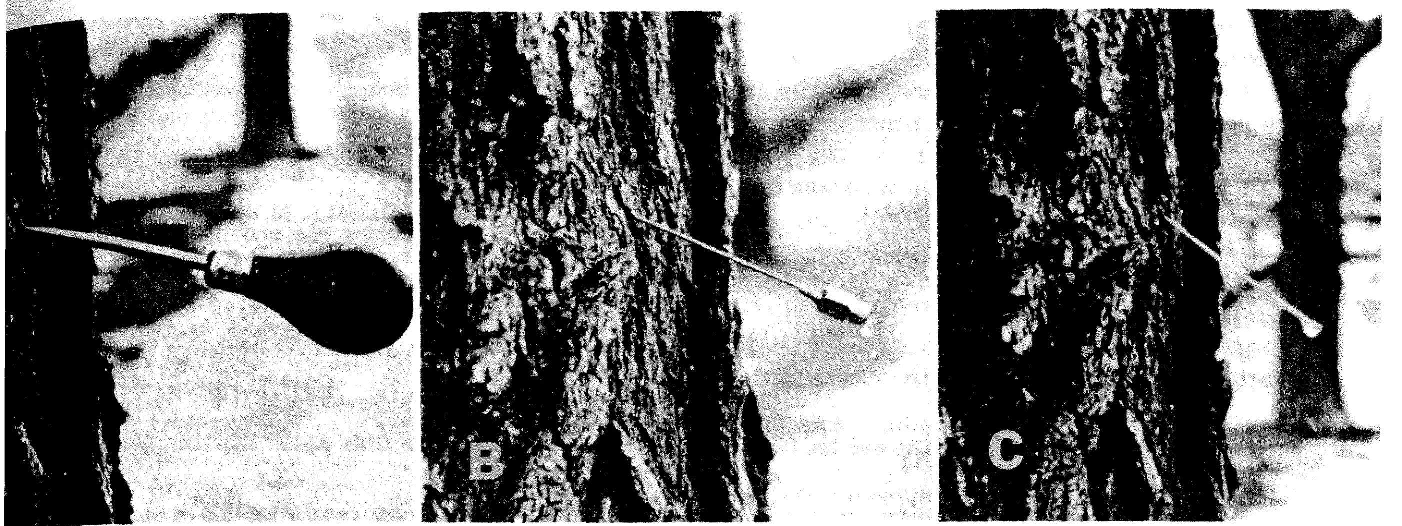
Stands of this size class, grown under forest conditions for the most part, will benefit little from thinning. Any cultural activity should aim to improve the health of the stand by removing decayed sugar maples, trees of other species, and poor-risk trees or trees susceptible to wind breakage. Removal will usually be on a tree-by-tree basis rather than by stocking or spacing.

In overmature stands or stands that need to be regenerated, clearcutting in strips, patches, or groups of ½-acre or more is recommended. The size of the patch or management unit will vary depending on topography and accessibility. In all cases, the opening must be easily identified on the ground and easily managed as a unit.

Field Procedure for Testing A Sugarbush for Sweetness

The percentage of sugar maple sap may vary considerably during the day as well as from day to day and season to season. To obtain comparable data when testing a group of trees, the testing must be done within a short time. In testing a large number of trees, such as an entire sugarbush, do not try to test all the trees at once. The best method might be to consider the readings from trees tested in a 2-hour period as one group of comparable readings, and readings taken during the next 2-hour period as a separate group. This can

Figure 3.—Testing sugar maple sap for sweetness can be accomplished by collecting a drop of sap for the sugar refractometer. Use an awl (A) to pierce the bark into the wood, insert a hypodermic needle (B) firmly into the wood, or use an ordinary toothpick (C).



be continued as long as the sap flow lasts. Sugar readings can be compared within each group, but comparisons should not be made between groups.

As a flow period begins, sap in some trees will start running before others. At the end of a flow, some trees stop before others. To avoid repeated trips to some trees to obtain a sap sample it is best to wait until the flow has well started before beginning the testing and to stop as soon as a few trees are found to have stopped flowing.

A sugar refractometer should be used for testing sap because it is fast and accurate and requires only a drop of sap to obtain a reading. The simplest way of obtaining a drop of sap is to cut a twig or small branch with pruning shears. On those trees where twigs or small branches are not within reach, a hole must be made in the trunk of the tree. Because sap from twigs give a higher reading than sap from tree trunks, it is important when testing a sugarbush that only one source be used—the twig or the trunk.

In obtaining sap from the trunk, first make a hole through the bark with a sharp awl (fig. 3a). Some sort of device must be inserted in the hole to carry sap away from the tree, and it has been found that a hypodermic needle works very well (fig. 3b). Those with large bores and short stems are the most durable. A good choice would be a 13-gage needle with a 1-inch stem. The needle should be pressed firmly or tapped into the hole. It is important that needles be washed before they are reused.

Whichever method is used, twig or trunk, you can avoid waiting for the drop of sap to appear by working several adjacent trees before testing the sap for sweetness.

With care, sharp toothpicks can be substituted for needles with the same results (fig. 3c). They must be pushed firmly into the wood so they are held firmly. Also, they must rest on the bottom of the hole at the outer edge, otherwise, the sap will run down the bark.

To find the sweetest trees as a guide to thinning a young stand, the first requirement is to establish an average. This can be determined by testing each tree or every second or third tree along a transect. Areas that include any major change in slope or exposure within the sugarbush should be tested separately. The sum of the readings from these sample trees, divided by the number of samples, establishes the working average for that particular testing period. Trees with readings below average should be identified with colored ribbon or paint spots. In thinning, remove as many of these trees of below-average sweetness as necessary to produce the desired stocking. A separate working average for sample trees should be computed for every 2- to 4-hour testing period, for best results.

Weather conditions play an important part in testing with any of the procedures mentioned above. Rain or snow may permit dilution of the sap drop and give incorrect readings. Moderate or stronger winds may blow the sap drops away or may concentrate the sugar by evaporating some of the water if the drop is exposed very long. The sap will run longer if the needles or toothpicks are inserted on the warmer side of the tree.

Conclusion

These management guidelines were developed to improve sugarbush profit potential by increasing yields of sweet sap. This is accomplished through manipulation of stand density and stocking to promote development of healthy, vigorous trees with deep, wide crowns. Best results are achieved when management is started at an early age, preferably when the trees are sapling size. Thinnings should not only favor trees with good condition and position but also those with superior sweetness or sugar content.

In sapling stands, the crop tree selection method is recommended. Thinnings in these stands should be light and frequent, no more than 5 to 10 years apart. In pole stands and larger, reducing the stocking to a point that would be considered understocked for timber production will promote rapid crown expansion and maximum sap production.

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Appendix

I

Rules of Thumb

a. An ideal sugarbush has at least 1000 or more tapholes or 70 to 90 taps per acre.
b. Sap from four tapholes will yield about 1 gallon of syrup per year.
c. The compass location of the taphole is not important.
d. Normal sap yield per tap will range from 5-20 gallons per season. This can be increased to 25 gallons or more by using a vacuum pump.
e. Trees in the 18- to 20-inch diameter class will produce over 50 percent more sap per taphole than 8- to 10-inch trees.
f. "Rule of 86" by Jones (1967). This give the amount of sap required to produce a gallon of syrup at various levels of sap sugar content. As an example, it takes about 86 gallons of sap of 1 percent sugar to produce 1 gallon of syrup. Only 43 gallons of 2 percent sap are required to produce 1 gallon of syrup. In other words, to establish the sap-syrup relationship, divide the percentage of sugar in the sap into 86.

II

Table 2.—*Number of tapholes that can safely be made in a tree*

Diameter	Tapholes per tree
Inches	*No.*
Less than 10	0
10-14	1
15-19	2
20-24	3
25 or more	4

III

Table 3.—*Comparison of average sap flow of sugar maple and soft maple, arranged by diameter classes on basis of number of buckets per tree of both species. Somerset County, Pennsylvania, 1931 (McIntyre)*

Diameter class	Average number of buckets hung	Sugar maple	Soft maple
		Average flow	Average flow
Inches	*No.*	*Quarts**	*Quarts**
9-16	1.0	8.9	5.5
17-23	1.5	15.1	7.4
24-28	2.2	17.7	12.5
29-33	2.8	22.4	13.4
34-36	3.6	27.7	20.3
37-45	3.8	31.7	18.9

Soft maple trees produce less sap that is less sweet than hard maple trees.

*Sap flow during a short period—not a seasonal flow.

IV

Table 4.—*Number of sugar maple trees per acre and spacing by average stand-diameter class for sugarbush stands at the S level, C level, and B level of stocking*

Average stand dbh class	S Level		C Level		B Level	
	Trees per acre	Tree spacing	Trees per acre	Tree spacing	Trees per acre	Tree spacing
Inches	*No.*	*Feet*	*No.*	*Feet*	*No.*	*Feet*
6	126	19	160	16	299	12
8	98	21	140	17	190	15
10	79	23	105	20	129	18
12	64	26	86	23	99	21
14	54	28	76	24	86	23
16	46	31	70	25	76	24

Table 5.—*Example of use of the diagnostic tally sheet for sugarbush stands*

[For the determination of the number of trees per acre, average stand diameter, stocking, and spacing for sugarbush management]

Dbh (inches)	Number of trees tallied														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	458	917	1375	1834	2292	2750	3209	3667	4125	4584	5042	5501	5959	6417	6876
4	115	229	344	458	573	688	802	917	1031	1146	1260	1375	1490	1604	1719
6	/51	O102	/153	/204	X255	/306	/357	/407	458	509	560	611	662	713	764
8	/29	/57	/86	/115	/143	/172	X201	/229	258	287	315	344	372	401	430
10	/18	/37	O55	/73	/92	/110	128	147	165	183	202	220	238	257	275
12	/13	/25	/38	51	64	76	89	102	115	127	140	153	165	178	191
14	9	19	28	37	47	56	65	75	84	94	103	112			
16	O7	/14	21	29	36	43	50	57	64	72	79	86			
18	6	11	17	23	28	34	40	45	51	57	62	68			
20	5	9	14	18	23	27	32	37	41						
22	4	8	11	15	19	23	27	30	34						
24	3	6	10	13	16	19	22	25	29						
26	3	5	8	11	14	16	19	22	24						
28	2	5	7	9	12	14	16	19	21						
30	2	4	6	8	10	12	14	16	18						

Tally Legend

/ Maple
O Birch
X Other species

Number of plots: ⁞ = 4

No. of trees/acre: 798/4 = 200

Total Number of Trees Per Acre.—Add the last figures checked on each line and divide by the number of point samples tallied.
407 + 229 + 110 + 38 + 14 = 798 ÷ 4 = 200

BA Per Acre.—Add the total number of entries in each size class, multiply by 10 and divide by the number of point samples tallied. (BA factor = 10)
27 × 10 = 270 ÷ 4 = 68

STAND DESCRIPTION:
Number of trees per acre 200 BA per acre 68 Average stand dbh 7.1
Trees per acre at C level 140 (or level selected for management) BA at C level 45 (or selected level)

STAND PRESCRIPTION:
Mark for cutting or girdling 60 trees = 23 BA (Total minus C or selected level)
Average crop tree spacing 18 feet