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POSITION OF TAPPING AND OTHER
FACTORS AFFECTING THE FLOW
OF MAPLE SAP

Thesis for the Degree of M. S.
MICHIGAN STATE COLLEGE
Putnam William Robbins
1948

THESIS

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*Position of Tapping and Other
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M. S. degree in *Forestry*

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Major professor

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by

Putnam William Robbins

A THESIS

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Position of Tapping and Other Factors
Affecting The Flow of Maple Sap
Putnam William Robbins

INTRODUCTION

Tapping the farm sugar bush was an important activity in colonial days for little sugar, other than maple sugar, was available. Tapping the sugar bush is still an important and facinating spring activity on thousands of farms. All over the maple sugar area of northern United States farmers who have not used their equipment for a long time, have put their maple sirup equipment in order and produced sirup during the war years due to the very favorable price of maple sirup and sugar. This increase in the activity of maple sirup production in Michigan has resulted in many inquiries concerning the most satisfactory method of tapping the sugar bush. This study has been an endeavor to solve some of the questions confronting the producer regarding the proper position on the tree to tap and the flow that may be expected from individual tap holes.

The art of making maple sirup and sugar was first discovered by the Indians of North America. Indian legend relates that a squaw was boiling venison in a clay pot and needed more water to keep the meat from burning. Instead of running to the nearest stream she dipped what she thought was water from a hole in a large maple tree where a limb had recently been broken off; when her brave returned and the meat was eaten it was found to be sweet and very appetizing, so was discovered the fact that sap from the sugar maple in the spring is sweet and that boiling yields sirup and sugar.

Brown (1) states, "The making of sirup and sugar from the sap

of the maple trees was discovered and developed in a crude way by the Indians long before the first white settlers came to this country. The earliest extant written records seems to be in 1673."

The Indians tapped the maple tree with sharp incisions in the bark with their tomohawks, and used a piece of bark for a spout to carry the sap into bark containers.

The early settlers in the regions occupied by the maple tree improved on the crude Indian methods of tapping and concentrating the sap to sirup. Since Colonial days much attention has been directed toward improving the boiling process of concentrating sap to sirup and the best silvicultural methods for handling the farm woods operated as a sugar bush.

Although increasing interest has been given during recent years in securing better production in the farm sugar bush, the range of conditions under which sap flow records have been made are so great that most results have only general application. It is therefore necessary to determine the role of importance of each factor for a given set of conditions for a locality or region in which conditions are essentially uniform. With such information applicable to Michigan, it should be possible to give reasonable sound recommendations to guide the farmer in tapping his woodland for maple sap production.

The Sanford woodland, owned and managed as a sugar bush by the Department of Forestry Michigan State College, provided an excellent opportunity to carry on studies which effect the flow of maple sap. The tract is typical of the farm woodlands in southern Michigan and results should be applicable to ninety percent of the sap and sirup production areas in the southern peninsula of the state.

REVIEW OF THE LITERATURE

The position of tapping maple trees for the production of sap was recognized by the maple sirup producers from Indian and Colonial times down to the present, but few investigators have considered this factor in their maple sirup research problems.

Chittenden (3) stated, "In tapping the greatest flow of sap is obtained on the side of the tree having the heaviest branches, and on the side exposed to the sun." He did not recommend concentrating tap holes on the sunny or south side, but recognized this side as the best producer.

Gilson(6) in his experiments on the flow of sap per season and per tree and on maple sirup and sugar making found that slightly larger amounts of sap are obtained from trees tapped on the east and south sides, but that the amount gained was so small that tapping on these sides of the tree are of little importance. He also stated that it is best to tap on the side of the heaviest branches, and to select a spot on the trunk exposed to the sun, to increase the yield of sap from a tree.

Dambach (4) in his investigations on the productiveness of adjacent grazed and ungrazed sugar maple woods, stated that trees in the two woods studied were tapped mainly on the south and west sides.

Dansereau (5) stated that apparently it is the trees notched or tapped on the south side which give the best flow of sap, at least in Quebec.

In their experiments on the flow of maple sap, Jones, Edson and Morse (7) found that maple sap flow is erratic and governed by a multitude of conditions. They found considerable difficulty in determining the relationship of various factors affecting sap flow.

They concluded that location of the tap hole in relation to sap flow did effect the yield. Their work was based on very small samples. Tap holes four feet high produced more sap than exposed tapped roots or tap holes fourteen feet above the ground. Roots produced 7,335 grams, four foot high tap holes 11,405 grams and tap holes fourteen feet off the ground 5,295 grams. They also stated, "It is quite generally held that southern or eastern exposures for tap holes are more favorable to a larger sugar yield than those on north or west sides."

Jones, et al, tapped six trees on the north and south sides in 1899, four on the north and south sides in 1900 and four on the north, south, east and west sides in 1901. In these compass positions of tapping the north had a gain over the south of 5.15 percent in 1899. In 1900 the south gained 6.28 percent over the north side. From the results of their additional experiments in 1901 their conclusions were that the variation in the amount of sugar obtained from different sides of the trees is not constant in any one direction.

The outcome of several trials in which trees were tapped on different sides of the tree is slightly in favor of the south exposure.

In 1904 Jones, Edson and Morse (8) stated, "On typical sap days a tap hole on the south side of a tree yielded the most sugar, but on cloudy days when all sides of the tree warmed more equally, the sap flow was more uniform on all sides of the tree."

Brown (1) suggested that tapping should be done in the thrifty part of the maple tree where the bark looks best to avoid old tap scars. "Tapping is commonly done on the southern side of the trees because that side warms up the earliest in the season and the first sap flow

is considered best, but experiments show that under average weather conditions, the flow of sap is equal on all sides."

Vaillancourt (11) in his experiments carried on over a period of four years found an average production of 2.4 pounds of sugar for trees tapped on the north, 4.1 pounds on the south, 2.2 pounds on the west and 2.6 pounds on the east.

In his bulletin on production of maple sirup and sugar Bryan (2) recommends in general, that the south side of a tree is best for early runs of sap, with the east side next best.

McIntyre (9) in his extensive experiments on sap flow did not consider the position of tapping as such, but states it is common practice in Pennsylvania to tap on the south side of the tree first, moving to the north side as the season progresses. At the beginning of the season the sap flow is more pronounced on the south or sunny side of the tree. The season can be prolonged a few days by putting a new tap on the north side of the tree, but this does not pay when the increased injury to the tree is considered. McIntyre noted the problem of striking good sap wood when the tapping was concentrated on the south side of the tree.

Tressler, and Zimmerman (10) while operating an experimental sugar bush for three years, 1939, 1940 and 1941, studied among other factors the relation between volume of sap, influence of tree size, and direction of tapping on sap flow. They kept complete records of each tap hole not only in regard to the compass direction of the hole but also as to the number of holes per tree and volume of sap produced. They found a correlation between the volume of sap and weight of sugar produced. When the volume is large, the sugar content was high; and this correlation held throughout the season with minor differences. The

most notable of these was the fact that in the totals the north side buckets are the lowest volume producers, but that the sap from the north side of the tree evidently contained a slightly higher percentage of sugar so that there was more weight of sugar produced by these north buckets than by the west buckets.

DESCRIPTION OF THE SUGAR BEESH STUDIED

The Sanford Woodlot, formerly known as the River Woodlot was acquired when Michigan State College was a young institution. The Woodlot has been under management for the production of wood and other products for the past sixty years, and has served as a laboratory area for the students majoring in forestry since the inception of the Forestry Department in 1902. The Woodland has been under the management for the production of maple syrup since 1913 and maple syrup has been produced each year since that date with the exception of the years 1925 to 1928 inclusive and the year 1936.

Forest products have been cut from the area in small amounts annually with extensive operations being conducted periodically which produced saw logs from the main portions of the tree and wood from the tops of branches.

The area has been used intensively as a field laboratory for the study of forest mensuration, silviculture and utilization and for specimen collection and observation by the students in Botany and Zoology.

The Sanford Woodland is located in the southeast corner of section 18, of town four north, range one east, Ingham county, Michigan. The area is bounded on the north by the Red Cedar River and on the east by a township road. A truck trail traverses the woodland on the north following the general winding of the river. The second truck trail crosses the area from the northwest to the southeast and the area is divided by additional sap trails and one bridal path.

The area is predominately occupied by a beech-sugar maple forest with variations in size from pole wood size to mature timber. Black ash, American elm, and red maple comprise the second major timber type

Plate 1. Timber types and their boundaries.

found on the area. The timber type areas and their boundaries are illustrated in Plate 1.

Soil types on the woodlot area are Carlisle Muck, Hillsdale Sandy Loam, Berrian Sandy Loam, Macomb Loam, Granby Sand, Genessee Fine Sandy Loam, Griffin and Washtenaw Loam. The soil map, Plate 2, illustrates the soil types and their boundaries.

The topography of the area is gently rolling with a constant and increasing degree of slope from the south boundary to the river on the north boundary. The highest elevation is twenty feet above the river level. The area is drained in the west portion by an intermittent creek flowing from the south boundary to the Red Cedar River and by an intermittent creek on the east portion from the south boundary to the river.

SOIL MAP
SANFORD WOODLOT
 SCALE 1"=4 CHAINS

- 4. CARLISLE MUCK
- 8. HILLSDALE SANDY LOAM
- 10. BERRIEN SAND
- 30. BERRIEN LOAMY SAND
- 31. MACOMB LOAM
- 42. GRANBY SAND
- 45. GENESSEE F. S. L.
- 51. GRIFFIN
- 85. WASHTENAW LOAM

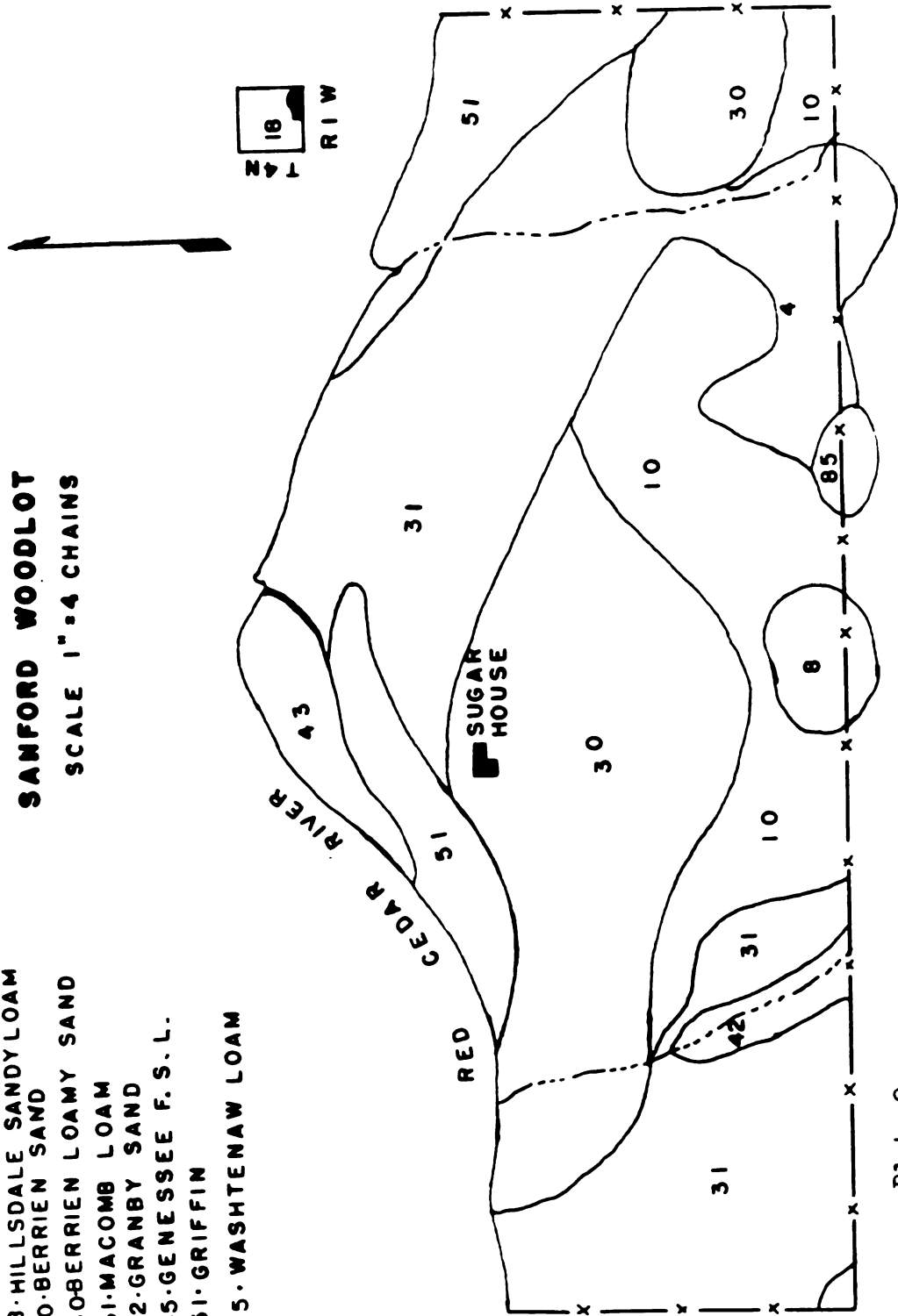


Plate 2.

EXPERIMENTAL PROCEDURE

The Sanford Woodlot, being an actively operated sugar bush producing maple sirup annually, afforded an ideal opportunity for the study of maple sap flow in relation to the position of tapping and other factors affecting the flow of maple sap. The tract is typical of much of the farm woodland areas found in the central part of Michigan and similar to many of the woodlands operated for the production of maple sirup and sugar in this portion of Michigan. Therefore, the results should be generally applicable to this region and to the entire state and to other maple sirup and sugar producing areas.

This study of the flow of sap according to the compass position of tapping, was started in the early winter of 1934. Trees of tapable size scattered throughout the regular sugar bush were numbered with metal tags and classified according to their diameter, breast high, percent of normal crown area and to crown class. The total number tagged for the study included 173 trees ranging in diameter from 10.7 to 33.1 inches, breast high, and also a sample acre containing 42 trees ranging from 9.9 to 25.9 inches in diameter. The trees on the sample acre were numbered and classified in a similar manner to the larger number of trees scattered throughout the woods. Prior to the tapping season the numbered trees received additional numbers to designate the south, west, north or east tap holes. Trees 10 to 16 inches received one tap hole, trees 16 to 24 inches received two tap holes and trees above 24 inches three tap holes. The tapping aimed to place an even number of buckets on the south, west, north and east sides of each diameter class to be tapped.

When the sugar bush was tapped early in February 1934 the 173 numbered trees in the general sugar bush area had a tap hole made at

each of the 344 spile or bucket numbers. In like manner the sample acre was tapped at each number location for a spile.

The picture (Plate 3) of two large maples in the Sanford Woodlot illustrates positions of buckets. The tree on the left has been tapped to hole one bucket on the south, one on the west and one on the east side. The tree on the right holds two buckets on the south, one on the west, and one on the east. It was observed that when tap holes have been concentrated on the south and west sides of the tree year after year as was done for the 20 years previous to this study, it is difficult to find a good scarfree tapable spot for a new tap hole. A tap hole made through new cambium into dead tissue resulting from previous tap holes, produces little or no sap.

The holes were bored with a regular three-eighths inch tapping bit and spiles and buckets of the type used throughout the sugar bush were standard equipment. All buckets were covered. The sap was gathered during the regular collection for all 780 buckets hung, and all sap from the sample acre was weighed with a standard dairy spring scales and recorded to the nearest one-fourth pound. All sap was poured from the buckets into a standard gathering pail to which the scale was strapped, weighed and recorded. The sap was then emptied into a second gathering pail or directly into the eled gathering tank. The first year, 1934, collections were made on February 14, 16, 20, 21, 30 and 31. These were days of good sap runs when the buckets contained sufficient sap from a normal operation standpoint, to make it practical to collect. All sap collected was added to the sap in the general storage tank and evaporated to maple sirup. The sample acre was handled in the same manner as the other experimental trees scattered over the entire sugar bush.



Plate 3. A Michigan sugar bush showing concentration of tap holes on the sunny side of maple trees.

The operations in 1935, 1937 and 1938 were conducted in the same manner as in 1934. The sugar bush was not tapped in 1936 due to lack of personnel.

In 1937 the metal identification tags were replaced by stenciling the tree number and spile number on each tree. This method of marking became necessary because a few metal tags disappeared each year.

In the graphs illustrating the flow of sap by position of the tap holes, the bars are in groups of four. The first black bar represents the flow of sap from the south side of the tree, the next bar represents the flow from the west, the next black bar the flow from the north and the last white bar the flow from the east side of the tree.

DATA AND DISCUSSION

Regular Sugar Bush

The average daily flow of sap for 1934 from the south, west, north and east tap holes is presented in Table 1 and Fig. 1. The first run occurred on March 14 with the heaviest flow of the entire season. The breaks in the graph between March 16 and 20 and between March 21 and 30 were periods of small flow and it was more practical to allow the sap to accumulate for collection on the dates shown. The south side lead, or nearly equalled the maximum runs for all days. The trend in sap flow for the west side was similar to that of the east side. The north side was consistently the lowest producer.

The season ended with two days of low sap flow. The weather turned warm on March 31 and continued warm for eight days, with no freezing night temperatures, and with four days of rain. Continued warm weather during the day and night, especially when accompanied by rain, stops the flow of sap. Warm days without freezing temperatures at night increase the activity of bacteria in sap and results in sap which is unfit for high quality sirup production. It has been the policy at this sugar bush to stop sap collections when the sap becomes milky in color, a characteristic of sap containing a high bacteria count.

The average daily sap flows for 1935 from the four positions are presented in Table 2 and Fig. 2. The first run occurred on March 2 and produced the lightest flow of sap of the eight runs that season. The sap runs were fairly continuous with the exception of two periods between March 5 and 11 and 11 and 15. The average flow from south tap holes was less than the west and east sides and was not consistently greater than the flow from the north side; in fact, the north position

Table 1. Average daily and seasonal flow of sap in pounds, number of tap holes and number of weighings of sap for the south, west, north and east sides of maple trees for the regular sugar bush during March 1934.

Date	Position of tap hole				Daily average
	South lbs.	West lbs.	North lbs.	East lbs.	
March					
14	10.0	9.1	7.7	8.9	8.9
16	5.6	3.3	2.1	3.6	3.8
20	6.0	6.1	4.3	6.8	5.8
21	7.5	5.5	4.0	6.3	5.8
30	4.1	2.7	2.0	2.6	2.8
31	2.8	3.0	2.6	3.0	2.8
Seasonal daily average	6.0	4.9	3.8	5.2	5.0
Maximum minimum difference	7.2	6.4	5.7	6.3	
Number tap holes	72	68	63	80	
Number weighings	432	408	378	480	

FIGURE 2 - SAP FLOW BY POSITION OF
TAP HOLE - 1935

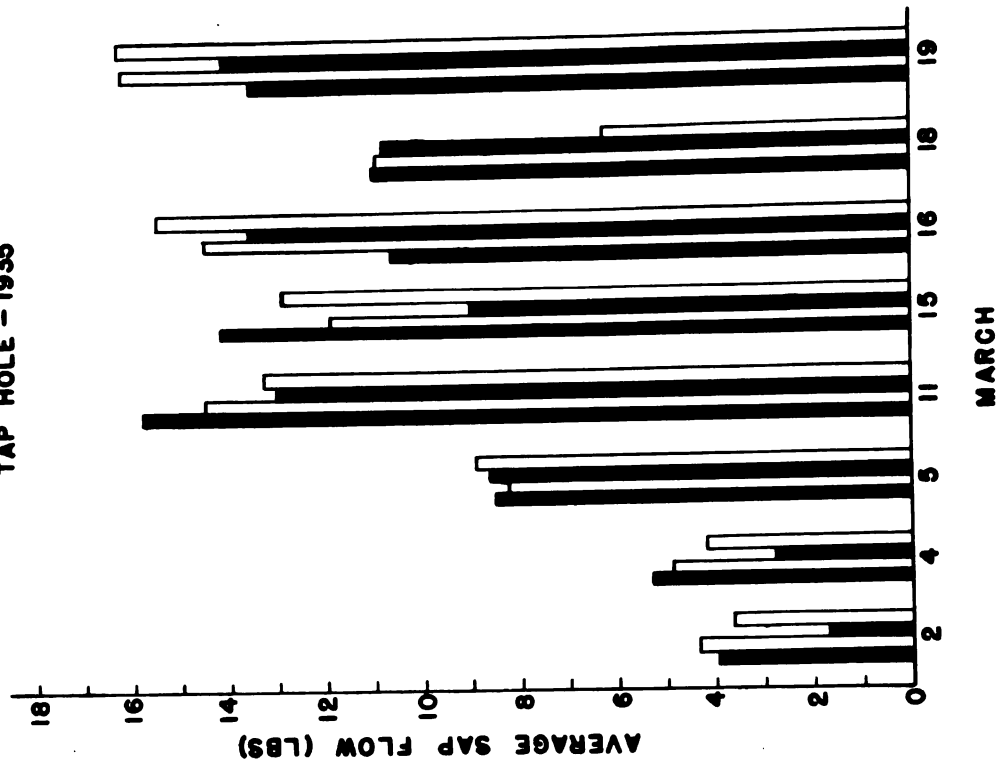
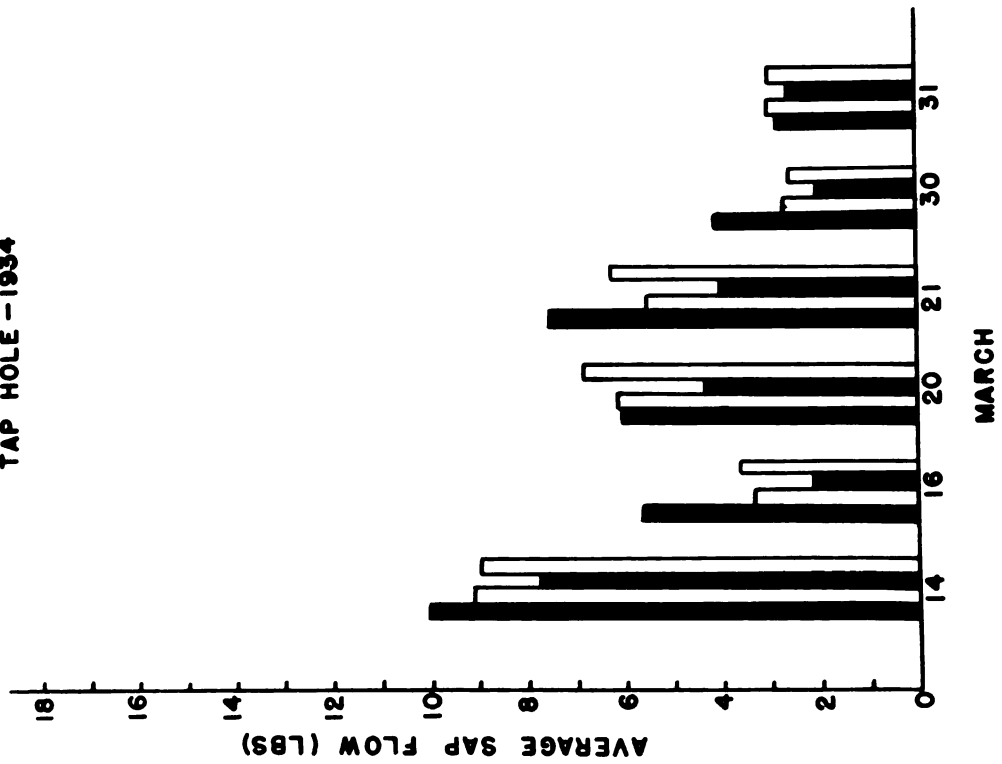


FIGURE 1 - SAP FLOW BY POSITION OF
TAP HOLE - 1934



equalled or exceeded the south flow in three runs. The west and east positions showed little variation between each other except on March 18 when the east flow was unexplainably low. The east, west, and south were similar in sap production, with less than a pound difference between their averages. The production from the north was lowest. The season ended with heavy flows from all positions. On inspection of Fig. 2, it would appear that the sap flow should have continued for additional runs and tapered off from the high flow of March 19. The abrupt cessation of flow can be attributed to the lack of freezing temperatures at night, beginning March 19 and continuing for five nights, with rain during four of the days.

The average daily flow of sap for 1937 from the four positions is presented in Table 3 and Fig. 3. The first run occurred on March 5 and was almost identical to the last run in average flow, it was neither the heaviest nor the lightest run. It exceeded five of the ten runs and was surpassed by four. The runs were broken between March 7 and 20 and between March 23 and 29. The season was thus broken into three distinct periods. The first started on March 5 and continued for three days with a drop in average daily production from the first to the third day. The second period started with the largest flow of the season and continued for two days with reduced flow. The last period started on March 29 with next to the smallest flow of the season, increased for two days and ended with a flow larger than the terminal flows of each of the two earlier periods.

The south side produced the greatest flow for any one day, consistently produced a greater flow of sap than the north side, except the last day and in seasonal average was between the west and east sectors. The west and east tap holes were in the same relative

Table 2. Average daily and seasonal flow of sap in pounds, number of tap holes and number of weighings of sap for the south, west, north and east sides of maple trees for the regular sugar bush during March 1935.

Date	Position of tap hole				
March	South lbs.	West lbs.	North lbs.	East lbs.	Daily average
2	3.9	4.3	1.7	3.6	3.4
4	5.3	4.8	2.8	4.2	4.3
5	8.5	8.2	8.6	8.8	8.5
11	15.7	14.5	13.0	13.3	14.1
15	14.1	11.9	9.0	12.8	11.9
16	10.6	14.5	13.6	15.5	13.5
18	11.0	11.0	10.8	6.2	9.7
19	13.5	16.2	14.1	16.3	15.0
Seasonal daily average	10.3	10.7	9.2	10.9	10.1
Maximum minimum difference	11.8	11.9	12.4	12.7	
Number tap holes	76	69	82	66	
Number weighings	468	552	656	528	

Table 3. Average daily and seasonal flow of sap in pounds, number of tap holes and number of weighings of sap for the south, west, north and east sides of maple trees for the regular sugar bush during March and April 1937.

Date	Position of tap hole				Daily average
	South lbs.	West lbs.	North lbs.	East lbs.	
March					
5	8.5	9.7	7.5	8.9	8.4
6	7.8	10.2	7.4	7.5	8.2
7	6.9	7.1	6.0	5.8	6.4
20	14.4	11.6	9.8	13.3	12.5
22	7.8	9.0	5.6	7.7	7.5
23	9.4	9.1	5.7	8.7	8.2
29	7.6	7.9	3.3	8.0	6.7
31	10.0	12.2	4.5	11.0	9.4
April					
1	12.6	10.7	9.7	12.1	11.3
3	7.7	9.1	8.8	8.4	8.5
Seasonal daily average	9.3	9.7	6.8	9.1	8.7
Maximum minimum difference	7.5	5.1	6.5	7.4	
Number tap holes	78	69	78	67	
Number weighings	780	690	780	670	

FIGURE 3 - SAP FLOW BY POSITION OF TAP HOLE - 1937

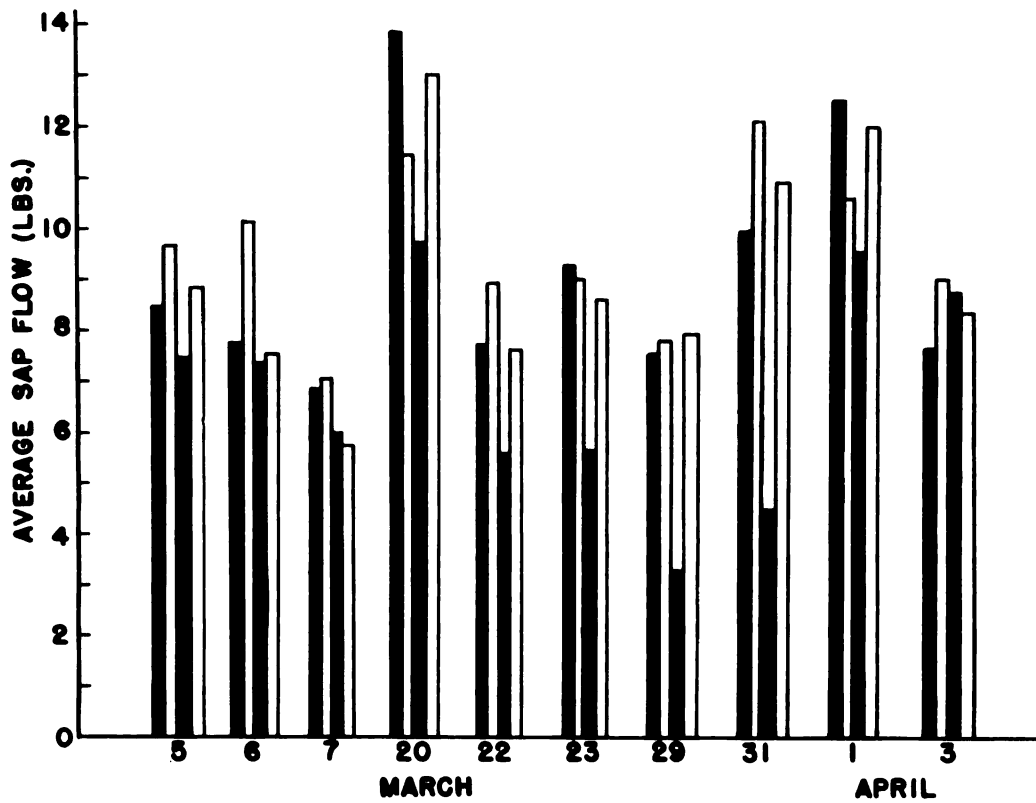
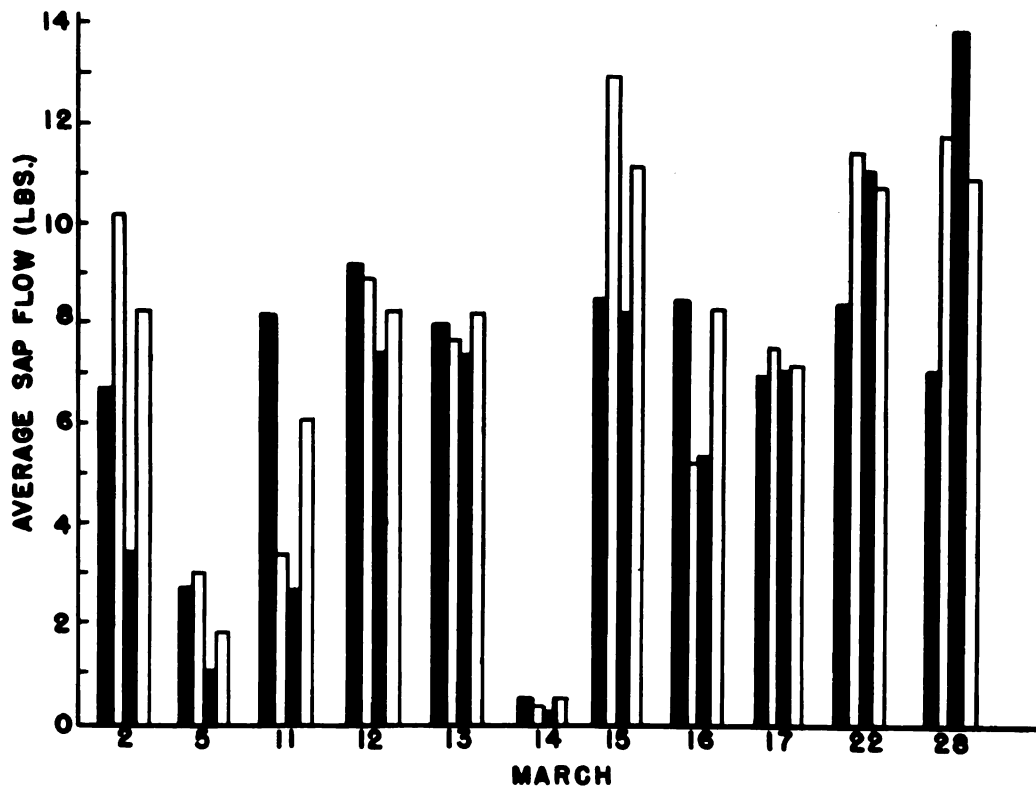


FIGURE 4 - SAP FLOW BY POSITION OF TAP HOLE 1938



position to each other for seven of the ten runs, with the west producing more sap than the east. The north side produced the smallest flow during any one day and the lowest average flow for the season.

The season ended sharply on April 3, due to the lack of freezing temperatures for three nights and rain or traces of rain for eight consecutive days, with a heavy rain of 0.83 inches on April 5.

The average daily flow of sap for 1938 is presented in Table 4 and Fig. 4. The season started with good runs on the west and east sides but below the seasonal average runs on the south and north sides. The sap flow for this season was continuous from March 11 through the 17 with good runs every day except March 14. There were three breaks in the sap flow of four days or more, one near the beginning and two near the end of the season.

The north side produced the greatest flow of any one run, with the west next highest. The season average production was greatest for the west, with the east, south and north following in the order named. No position consistently produced lowest flows. The north produced the smallest flow during the first seven runs, but surpassed the south on three runs.

The season ended with the heaviest flow of sap for all eleven runs. One would expect from the reading of Fig. 4 that the flow would taper off gradually before stopping on March 28, the day of the largest flow. Sugar bush operations were terminated on March 28 due to the arrival of three days with rain, and day temperatures approaching the seventies and night temperatures well above freezing.

The average daily sap flow for the four years studied is presented in Tables 1 to 4 and in Fig. 5. The latest starting date for

Table 4. Average daily and seasonal flow of sap in pounds, number of tap holes and number of weighings of sap for the south, west, north, and east sides of maple trees for the regular sugar bush during March 1938.

Date	Position of tap hole				
March	South lbs.	West lbs.	North lbs.	East lbs.	Daily average
2	6.7	10.2	3.4	8.3	7.1
5	2.7	3.0	1.0	1.8	2.1
11	8.2	3.4	2.6	6.1	5.1
12	9.2	8.9	4.4	8.1	7.6
13	8.0	7.7	7.4	8.2	7.7
14	.5	.3	.2	.5	.4
15	8.5	13.0	8.2	11.2	10.2
16	8.5	5.0	5.3	8.3	6.8
17	6.8	7.6	7.1	7.2	7.2
22	8.4	11.4	11.1	10.8	10.4
28	7.1	11.8	14.3	10.9	11.0
Seasonal daily average	7.4	8.2	6.5	8.1	7.5
Maximum minimum difference*	6.5	10.0	13.3	9.4	

* Data for March 14 omitted from these averages.

Number tap holes	87	69	93	74
Number weighings	957	759	1023	814

a first sap run was March 14 in 1934, this was 12 days later than the first run in 1935 and 1938 and 9 days later than in 1937. Weather conditions determine when the first sap run will occur, so consequently there is variation between the first good sap day from year to year.

The 1934 season produced 6 sap flows which is the smallest number for the four years studied. Eight runs occurred in 1935, ten in 1937 and ten good and one very small run in 1938. The average number of runs per year for the four year period was 8.7.

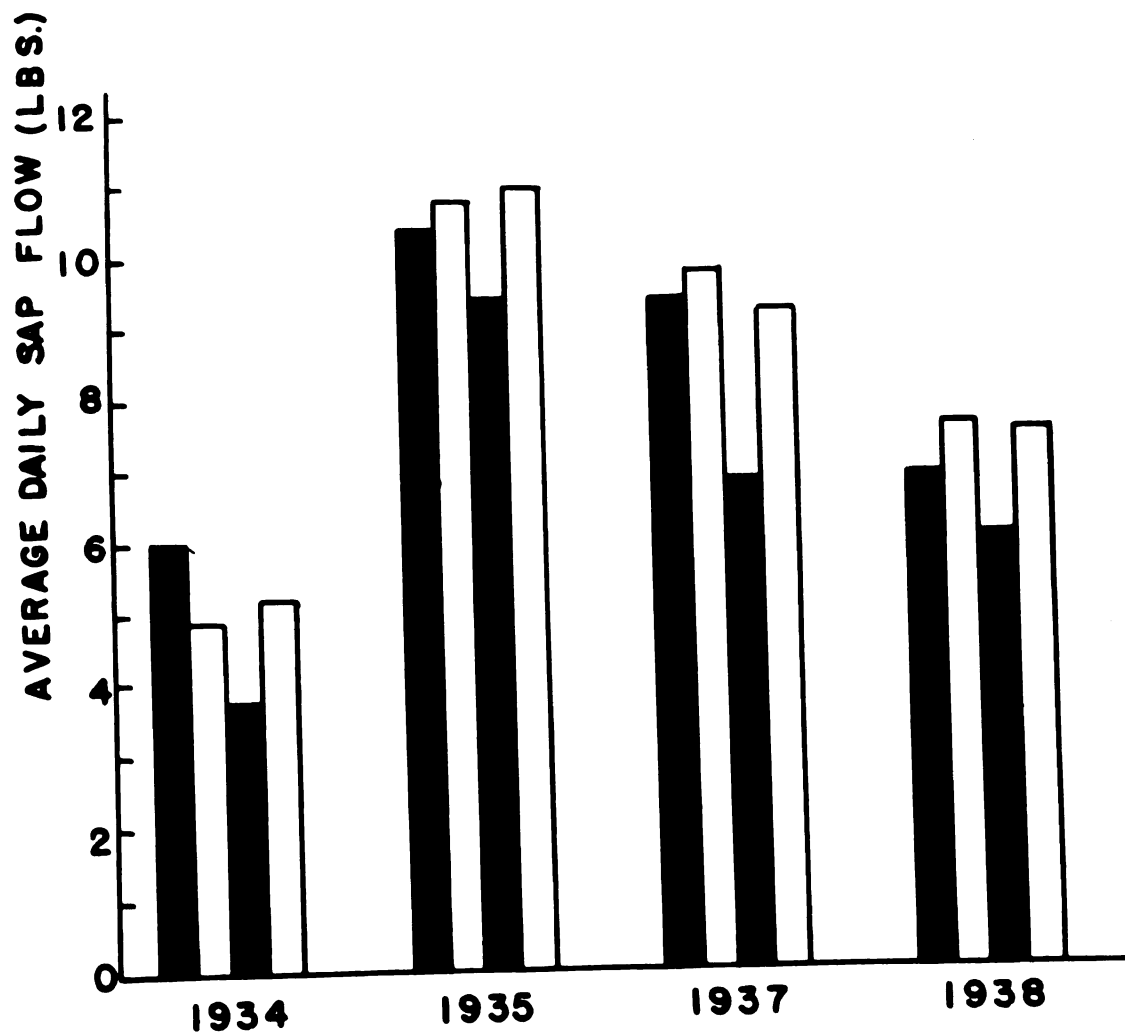
The south position produced the heaviest sap flow four times in 1934, four in 1935, three in 1937, and three in 1938, or 14 times out of a possible 34, omitting the very small run on March 14, 1938. The west position was next with a total of 13 high runs out of a possible 34. The east tap holes were third with six top runs, and the north last with one top run. Thus the south had 41 percent, the west 38 percent, the east 18 and the north 3 percent of the high runs for the four years.

The trend of the flow was from high to low in 1934, but just the reverse in 1935. The first three runs and the fourth through the seventh run of 1937 followed the general trend, from high to low production such as occurred in the 1934 season.

There was no general trend in 1938. The west and east positions gave less variation between one another, day to day and season to season, than any other pair of positions.

In 1935, larger daily flows were produced by the south, west and east positions than during any of the other three years. The highest flow for the north side was in 1938. Although the 1935 season had three days of greater than average production, considering all four

**FIGURE 5 - SEASONAL FLOW BY POSITION
OF TAP HOLE**



positions, than any of the years studied, it did not produce the largest volume of total sap. The ten runs of 1937 produced the largest volume of sap per tap hole per season.

The preferred tap hole positions over the four years as shown by Fig. 5, were the east with an average of 8.5 pounds, the west, with an average of 8.4 pounds and the south with an average of 8.3 pounds. The north position of tap holes gave the lowest average production, 6.6 pounds for the entire four year period.

The data only partially confirm the generally held idea that the tap holes on the south side will out flow those on the other sectors of the tree at the beginning of the season, while those on the north side will be the higher producers toward the later part of the season. The sums of the average daily flows for the first three runs were obtained for each season for each tap position, Table 4a. In three years the south position produced the largest average daily flow. In the other year, 1937, the west position had the lead. Considering the four-year averages the south position was the highest producer the early part of the season with the west, east and north following in productivity in that order. In each year the north sector gave the lowest average daily flow for the first three runs. The sums of the average daily flows for the last three runs were likewise obtained for each season for each tap position, Table 4a. In 1935 and 1937, the west sector produced the largest flows. In 1938 the north position gave the largest flow. Considering the four-year averages the west produced the best, late in the season, with the east, north and south positions following in that order. The south and north positions were lowest two years.

Table 4a. Sums of the daily average flows of sap for the first three runs and the last three runs of each season.

First three runs				
Season	South lbs.	West lbs.	North lbs.	East lbs.
1934	21.6	18.5	14.1	19.3
1935	17.7	17.3	13.1	16.6
1937	23.2	27.0	20.9	22.2
1938	17.6	16.6	7.0	16.2
	80.1	79.4	55.1	74.3
Last three runs				
1934	17.4	11.2	8.6	11.9
1935	35.1	41.7	38.5	38.0
1937	30.3	32.0	23.0	31.5
1938	22.3	30.8	32.5	28.9
	102.1	115.7	102.6	110.3

Table 5 Average daily and seasonal flow of sap in pounds,
number of tap holes and number of weighings of sap for the south,
west, north and east sides of maple trees for the sample acre
during March 1934.

Date	Position of tap hole				Daily average
	South lbs.	West lbs.	North lbs.	East lbs.	
March 14	15.5	10.2	9.3	9.2	11.0
16	5.4	4.9	4.6	3.7	4.4
20	5.0	3.4	5.0	3.8	4.3
21	5.8	4.7	3.8	4.8	4.8
30	4.1	2.0	2.8	2.6	3.1
31	2.7	2.4	2.5	2.3	2.5
Seasonal daily average	6.4	4.7	4.6	4.4	5.0
Maximum minimum difference	12.8	8.2	6.8	6.9	
Number tap holes	20	17	6	24	
Number weighings	120	102	36	144	

Sample Acre

The average daily flow of sap for the sample acre for 1934 is presented in Table 5 and Fig. 6. The first run occurred on March 14 and was the heaviest flow of the season. There was little variation between the different positions tapped except on the first day, when the south side produced 5.3 pounds more than the positions with the next largest flow.

The records of daily flow of sap for the sample acre during the 1935 season are presented in Table 6 and Fig. 7. The first run on March 2 and the second run on March 4 were the two smallest flows of the season. There were three periods when the sap flow started low and ended high; March 2 to 5, March 15 to 16, and March 18 to 19. The season ended sharply on March 19, due to warm weather and rain.

The trend of the 1934 sap flow was from a high flow in the early part of the season to a low flow at the end of the season, while in 1935 the flow was just reversed.

The comparison of the 1934 and 1935 seasonal flow by position of tap hole for the one acre plot is given in Fig. 8. The west, north and east positions produced approximately equal sap flows during 1934 and the south, west and east positions near equal average daily flows for 1935. The east was the low producer in 1934 and the north position of tap holes the low producer in 1935.

A comparison of the seasonal flows from the sample acre with the seasonal flows from the general sugar bush trees shows that the two areas tended to react the same to weather conditions and to give similar relative flows of sap for the four positions. In 1934, the sample acre averages for the south and east were very similar to the averages for the larger number of samples from the general sugar bush.

FIGURE 7 - SAP FLOW BY POSITION OF
TAP HOLE FOR ONE ACRE - 1935

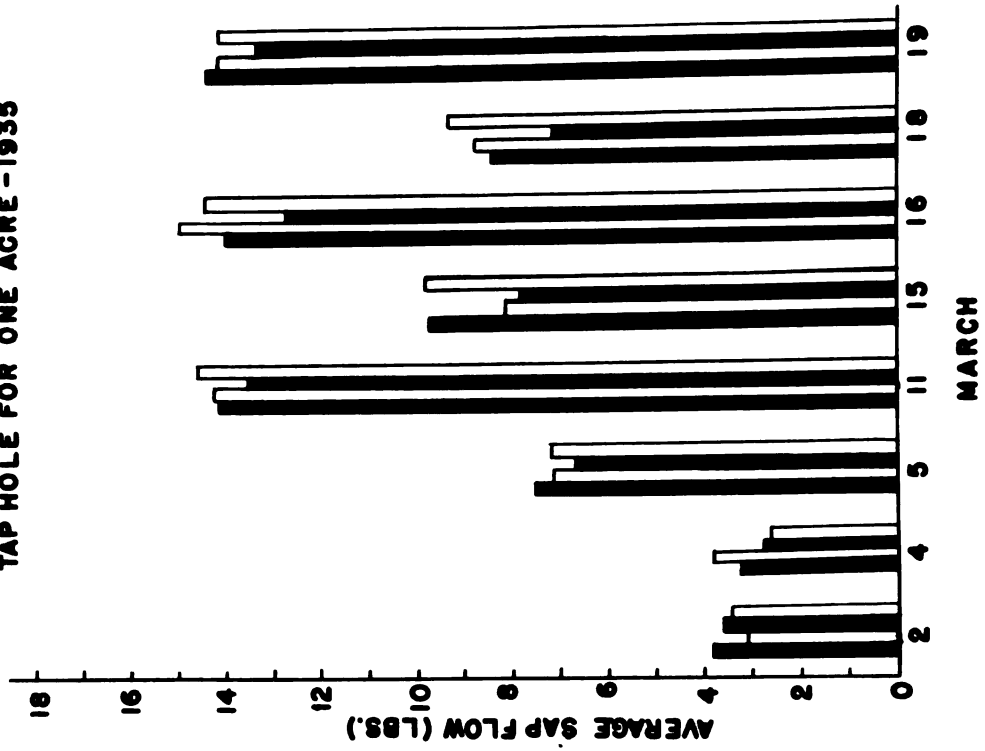


FIGURE 6 - SAP FLOW BY POSITION OF
TAP HOLE FOR ONE ACRE - 1934

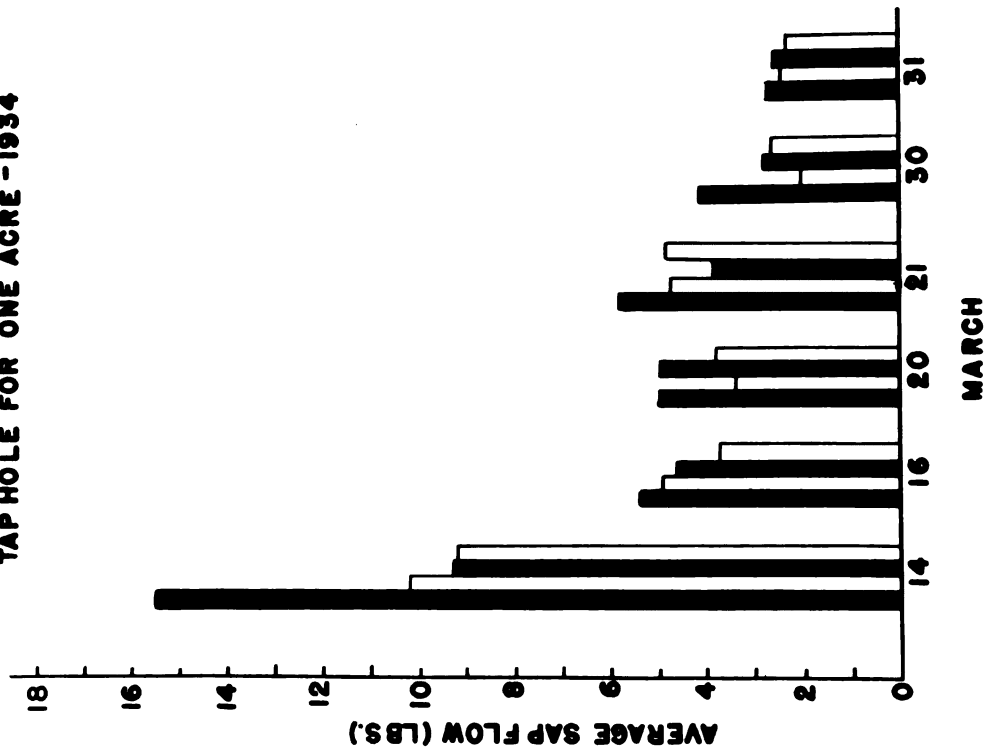
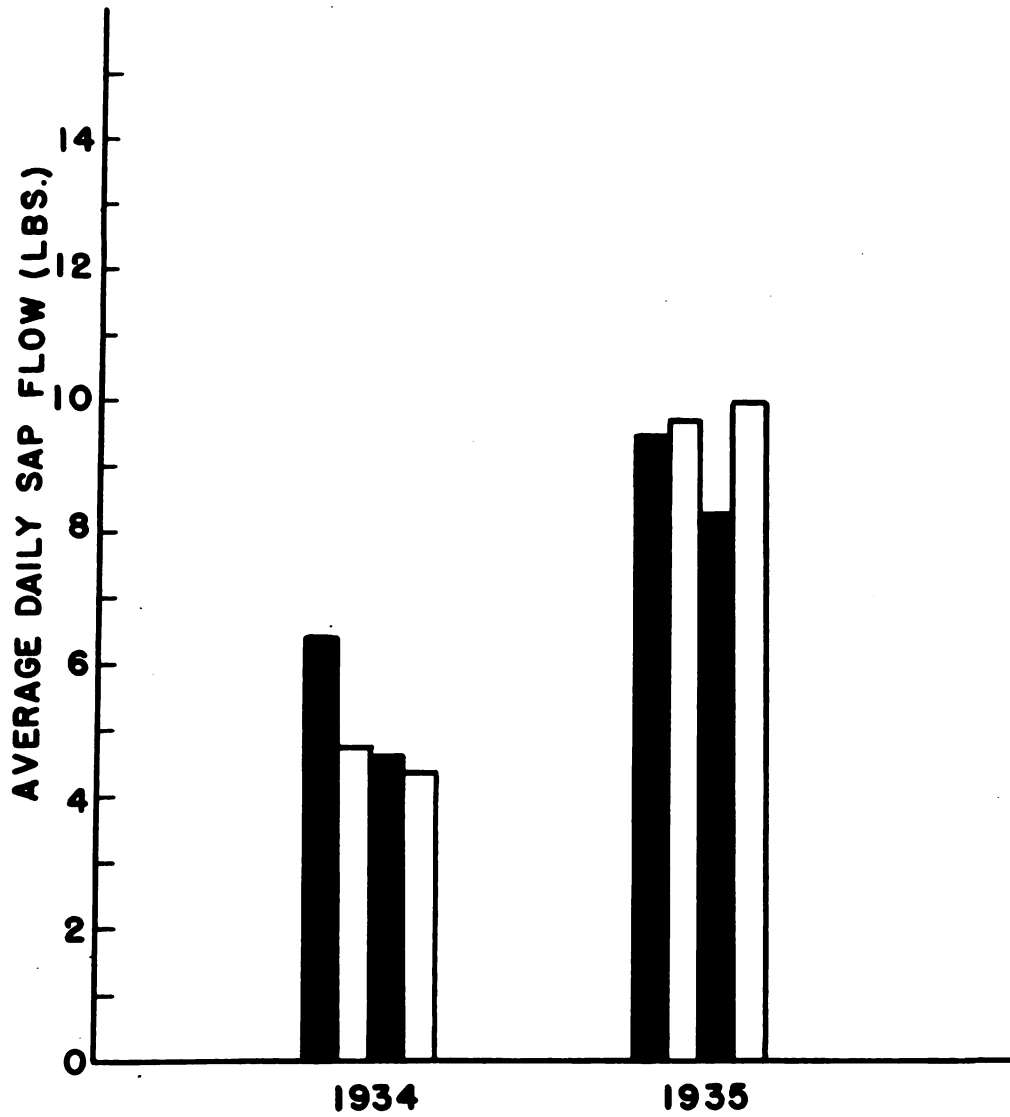


Table 6. Average daily and seasonal flow of sap in pounds, number of tap holes and number of weighings of sap for the south, west, north and east sides of maple trees for the sample acre during March 1935.

Date	Position of tap hole				
March	South lbs.	West lbs.	North lbs.	East lbs.	Daily average
2	3.8	3.1	3.6	3.4	3.5
4	3.2	3.8	2.8	2.6	3.1
5	7.5	7.1	6.6	7.2	7.1
11	14.1	14.2	13.5	14.6	14.1
15	9.7	8.1	7.8	9.8	8.8
16	14.0	15.0	12.7	14.4	14.0
18	8.4	8.7	7.1	9.3	8.4
19	14.4	14.1	13.3	14.1	13.9
Seasonal daily average	9.4	9.5	8.2	9.8	9.2
Maximum minimum difference	11.2	11.2	10.7	12.0	
Number tap holes	31	20	8	26	
Number weighings	248	160	64	208	

**FIGURE 8 - SEASONAL FLOW BY POSITION
OF TAP HOLE FOR ONE ACRE**



The variation in the flow for the north position is attributed to the small number of samples of sap from the north positions on the sample acre.

The 1935 sample acre seasonal average daily flow of sap in pounds follows very closely the results of the flow for the four tapped positions on the larger area.

SUMMARY

The purpose of this study, which analysed the flow of sap from 215 trees and over 400 tap holes each year for four years, in a sugar bush representative of the sugar maple woods of Michigan, were to show the relation of maple sap flow to the compass position at which a tree is tapped, and to make recommendations to producers of maple sirup and sugar as to the best tapping positions.

1. The positions customarily tapped by sugar bush operators (south and west) are not the only high production areas.

2. The variations of the average daily sap flow between the south, west and east are not great enough to warrant concentrating tap holes on any one of the three positions.

3. The east side is as large a producer as the south. The east produced an average daily flow for all four years of 8.5 pounds and the south 8.3 pounds of sap.

4. The east tap holes gave the greatest average number of pounds of sap for the four-year period.

5. The flow of sap from the north side of a maple tree is sufficient, in comparison to the production from the other compass directions, to warrant recommending tapping the north side of maple trees in the sugar bush.

6. The four-year daily averages were east 8.5 pounds, west 8.4 and south 8.3 pounds per tap hole. The north produced 6.6 pounds.

LITERATURE CITED

1. Brown, N. C. 1919 Forest products their manufacture and use.
John Wiley & Sons., New York.
2. Bryan, A. Hugh. 1937. Production of maple sirup and sugar.
U. S. Dept. Agric. Farmers Bul. 1366.
3. Chittenden, A. K. 1919. Notes on maple syrup making.
Mich. Agric. Expt. Sta. Quar. Bul. Vol. 1, No. 3.
4. Dambach, Charles A. 1944. Comparative productiveness of adjacent grazed and ungrazed sugar-maple woods. Jour.
Forestry 42: 164-168.
5. Dansereau, Pierre. 1944. L'INDUSTRIE de L' E'RABLE.
Institut de Biologie, Universite' de Montre'al.
6. Gilson, W. Irving. 1917. The maple sugar industry in Michigan.
Mich. Agric. College, Forestry Club Annual 2: 29-30
7. Jones, C. H., Edson, A. W. and Morse, W. J. 1903. The maple sap flow. Vt. Agric. Expt. Sta. Bul. 103.
8. Jones, C. W. Edson, A. W. and Morse, W. J. 1904. The maple sap flow Vt. Agric. Expt. Sta. Bul. 105.
9. McIntyre, A. C. 1932. The maple products industry of Pennsylvania. Pa. State College, Agric. Expt. Sta.
10. Tressler, C. J. and Zimmerman, W. I. 1942. Three years operation of an experimental sugar bush. New York State Agric. Expt. Sta. Bul. 699.
11. Vaillancourt, Cyrille. 1928. 1930 and 1931. Rapport du Service de l'Apiculture et de l'Industrie du Sucre d'Erable. Rapp. Min. Agric. P. Quebec. 108-111.

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