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MAPLE SAP PRODUCTION ECONOMICS IN MICHIGAN

By

John E. Gunter

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ABSTRACT

MAPLE SAP PRODUCTION ECONOMICS IN MICHIGAN

By

John E. Gunter

Five aspects of the maple syrup industry in Michigan were studied: (1) the characteristics of Michigan's maple syrup producers, (2) the relative cost advantages and profitability of the two basic types of sap collection system (buckets and vacuum pumped plastic tubing networks), (3) the type, amount, cost, and utilization of equipment required for various sizes of operations, (4) the utilization of labor, time and duration of peak labor periods, and labor input for specific tasks involved in maple sap collection operations, and (5) the size of operation that is most profitable.

Data were gathered by mailing a questionnaire in 1972 to all maple syrup producers in the State of Michigan for which a mailing address could be obtained, and by selectively recruiting cooperators over the 500 to 3,000-taphole range, to keep time and cost records for their maple sap production operations for the 1972 and 1973 seasons.

Analytical techniques employed on the data included T-tests, linear correlation analysis, multiple regression analysis, analysis of covariance, break-even analysis, and marginal analysis.

The survey findings indicated that the majority (56 percent) of the Michigan maple syrup producers list some kind of agricultural endeavor as their principal occupation. A significant number (10 percent) of the producers were retired, and a disproportionate number were of an advanced age. The majority (58 percent) of the producers had operations of less than 1,000 tapholes in 1972. The average producer had been making syrup at the same location for 23 years.

Ten and 7 percent of the producers, respectively--primarily those with the larger operations--bought sap and syrup from other producers in 1972. It was also the larger producers who planned to increase their production of sap and syrup between 1972 and 1977.

Although a minority (45 percent) of producers had tried plastic tubing before 1972, those who had used it believed its advantages outweighed the disadvantages. Also, one-fourth of the producers reported plans to shift to more tubing and less buckets.

While most syrup is sold at the retail level, a majority (51 percent) of Michigan producers sell at least part of their syrup on the wholesale market. Eighty-nine

percent of the producers "usually" or "almost always" received a "fair" price for their syrup.

Obtaining an adequate labor supply at wage rates they can afford was a problem for most of the State's maple producers. Yet 95 percent of the producers reported they did not have to guarantee their seasonal workers a specific number of hours on the job to have an available labor force. Some producers suggested more extensive use of tubing in place of buckets as a possible solution to the "labor problem."

In the cost and returns portion of the study, equations to predict total equipment investment from the number of tapholes for both bucket and tubing operations were generated via least squares computational procedures. These equations are presented as are prediction equations for total cost of sap production by size of operation for both collection systems.

Differences in equipment investment between bucket and tubing collection systems were significant, with bucket systems requiring the larger expenditures. Bucket systems also required an average of 5 minutes per taphole more labor input than tubing. Furthermore, the bulk of the labor inputs occurred during the sap collection phase of the production process for bucket operations, whereas tubing operations required the most labor during the initial set-up of the system. Because of the heavy reliance on

labor with the bucket system, labor costs were higher for this method than for tubing operations of the same size.

Since the two largest cost items, annual equipment cost and labor cost, were higher for bucket operations, total cost was also higher for buckets. This difference was found to be statistically significant from tubing total cost values. Minimum cost per taphole (minimum average total cost) was found to vary from \$.96 to \$1.07 per taphole for bucket operations depending on whether or not workmen's compensation was included. These minimum cost values were \$.70 and \$.82 for tubing operations, or 25 to 26 cents lower than bucket operations.

Break-even and marginal analyses for a range of sap yields, sugar concentrations and associated prices, were used to define the minimum number of tapholes needed to break even and the number required to maximize net returns. Naturally, the higher the yield and sugar concentration values, the lower the break-even size and the larger the marginal size regardless of collection system employed.

ACKNOWLEDGMENTS

For providing the financial support so necessary to this research effort, the author extends sincere appreciation to the Northeastern Forest Experiment Station, United States Forest Service, and to the Department of Forestry, Michigan State University.

The author is grateful to the following for the assistance rendered during the course of the study: to Dr. Melvin R. Koelling for project direction and considerable expenditures of time and effort; to Dr. Victor J. Rudolph, his major professor, for time, counsel, advice, and suggestions; to Dr. Robert S. Manthy for manuscript review and constructive suggestions; and to Dr. Wayne L. Myers for invaluable assistance in computer programming and statistical methods.

Deserving special recognition are those members of Michigan's maple syrup industry whose willingness to cooperate made the study possible.

Above all, the author is grateful for the patience, endurance, understanding, and encouragement of his wife, Bonnie.

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INTRODUCTION

The production of maple syrup and other maple products has declined in Michigan and the other maple producing states since the mid to late 1800s when production was at a peak. Today, the industry continues to decline, in spite of a large, literally untapped, physical sugar maple resource, the highest retail prices on record, and a demand which far exceeds the available supply. Unfortunately, this steady, general decline will probably not be reversed if the traditional, highly inefficient, very labor intensive sap and syrup production methods and technology are not improved upon.

There is a problem, also, in that what is thought by experts to be improved technology is not always adopted by the maple producers themselves, because the latter remain unconvinced that the benefits to be gained will exceed the costs incurred. This appears to be the case in the very slow general acceptance of plastic tubing networks as a viable alternative to the traditional bucket collection system, despite the fact that tubing has been available for nearly 20 years. Among others, it may very well be that

one of the reasons producers do not adopt tubing systems more readily is that the information available to them concerning the relative labor and cost efficiencies of the two systems is sketchy.

Some general beliefs about the two systems do exist, however. The conventional wisdom has it that tubing systems are the more efficient in terms of labor utilization. But is also felt that tubing systems have a higher initial cost, and it is questioned if this alledgedly higher cost is justified by the additional benefits to be expected in increased yield, speed, and ease of collection.

The importance of minimizing sap production costs is emphasized by Morrow (1968), who found that 60 percent of labor costs and 40 percent of total costs (marketing included) were attributable to the production of maple sap. Any procedure for reducing sap production costs would have a significant effect on lowering overall costs and would, consequently, add to the total profit picture.

In view of the above, this present research endeavor focused on determining which of the two systems is the more cost efficient in terms of labor usage and equipment utilization, and, conversely, which of the two is more profitable. Also, as very little is known about the characteristics, attitudes, plans, problems, and opinions of Michigan's current maple syrup producers, an attempt was made to collect and disseminate information in this area as well.

The specific objectives of this study, were as follows:

1. To determine characteristics of Michigan's maple syrup producers.
2. To determine over a range of different sized operations, the relative cost advantages and profitability of the two basic types of sap collection systems.
3. To determine the type, amount, cost, and utilization of equipment required for various sizes of operations.
4. To determine the utilization of labor, time and duration of peak labor periods, and labor input for specific tasks involved in maple sap collection operations.
5. To identify within each of the two basic sap collection systems, the size of operation that is most profitable.

REVIEW OF LITERATURE

Producer Surveys

In a 1963-64 survey of the recipients of the National Maple Syrup Digest, Taylor et al. (1967) found that in 14 maple syrup producing states, 87 percent of the producers were engaged in farming either full- or part-time. The other 13 percent were of course, non-farmers. On the average, the producers in his study had been producing maple products for 23 years. As might be anticipated, it was those with the larger operations who most often reported increasing their total number of taps. And, although only 4 percent of the producers reported buying sap, it was the larger producers again who were doing the bulk of the buying.

The percentage of producers buying sap as reported in a 1968 New York survey (Smith, 1969) was somewhat higher than that of the 14 maple producing states as a whole. In this study 23 percent of the total reported purchasing sap. On the other hand, only 6 percent of the producers reported selling any sap. Twenty-eight percent of those interviewed were buying additional syrup, and quite surprisingly, 48 percent of the producers were using some tubing. This

48 percent portion is probably biased upward as the author notes that the sample was not a random one. A very significant finding of this survey revealed that the biggest problem most producers had was in getting an adequate supply of labor during the maple season.

Labor problems are not confined solely to New York. Producers in a 1965 Michigan survey cited a shortage of labor at wage rates they can afford as one of the reasons for terminating their maple syrup operations (Nyland and Rudolph, 1970). Other reasons included advancing age and a lack of adequate profit from past endeavors.

Thirty-five percent of these Michigan producers planned to discontinue their maple operation during the ten year period, 1965-1975. Another 43 percent planned to maintain their present level of production, and the remaining 22 percent planned to increase tapping. As it was the larger operations which planned to increase tapping, a net increase in maple syrup production was anticipated in the state during this period.

Another interesting finding of this survey was that in 1965 30 percent of the taps in the state's lower peninsula were installed on lands not owned by the producers themselves. This percentage was expected to increase to 33 percent by 1975.

Maple Sap Production Techniques

The traditional method of collecting sap from sugar maple trees (Acer saccharum Marsh)¹--tapping the tree, hanging the buckets, emptying the buckets into gathering pails, hand carrying the pails to the collection tank, dumping the sap from the pails into the collection tank, and hauling the tank of sap to the sugar house for processing into maple syrup and other maple products--is a very labor intensive, expensive undertaking involving much hard work. Willits (1965) is of the opinion that this method of collecting sap is the most expensive and laborous of all operations in syrup production and accounts for at least one-third of the cost of the final product. It is not surprising then, that considerable attention has been focused on more efficient, less costly, less labor intensive methods of getting the sap from the tree to the evaporator.

An alternative to the bucket system came into being in the mid-1950s (Foulds, 1973). At that time plastic tubing networks that carried the sap from the tapholes to a central storage tank were tested and found to be promising (Griggs, 1955; Morrow, 1958; Winch, 1959). As with any new system, efforts were made to improve it. Around 1960, some of these efforts lead to the addition of vacuum pumping to

¹Little (1953).

encourage sap flow (Flouds, 1973; Laing et al., 1960, 1962, 1964; Morrow, 1963).

However, tubing did not receive immediate widespread acceptance in Michigan. Nyland and Rudolph (1970) reported that in 1965 only 2 percent of the producers in the lower peninsula used tubing, and vacuum pumping remained untried in the state until 1968 (Koelling, 1970).

Nevertheless, tubing certainly has its proponents. Willits and Sipple (1968) stated that

The use of plastic tubing has practically eliminated the hard, unattractive labor of collecting sap that had to be performed under adverse weather and ground conditions. It has also eliminated as much as 40 percent of the cost of sirup-making. No longer is it necessary to construct expensive roadways through the woods to support heavy tanks of sap, nor to open these roads for the maple season following heavy snows. Tapping need not be delayed until the sap season has arrived. Large crews do not have to be hurriedly assembled to tap and hang buckets. Instead, the light-weight plastic tubing can be carried by hand through the woods, whether snow-covered or not.

One distinct advantage that tubing systems hold over buckets is potential increases in sap yields. These increases can come about when a natural vacuum is generated or artificial vacuum induced into a closed tubing system (Blum, 1967; Blum and Koelling, 1968; Laing et al., 1962; Morrow, 1963). Increases of several fold have been reported under these conditions, occurring even on level or almost level terrain (Morrow and Gibbs, 1969).

In addition to increasing yields, the presence of vacuum is also said to aid in the flow of sap by helping to overcome friction, eliminating airlocks, and reducing

losses due to freezing, leaks, and reabsorption back into the taphole (Morrow and Gibbs, 1969).

There has, however, been some controversy over whether to vent the tubing system or keep it closed. Another controversy has been whether to lay the tubing lines on the ground or suspend them in the air. On a gravity system, Smith and Gibbs (1971) found no significant difference between sap yields from aerial and ground line tubing when the lines were closed. Smith (1969) also found that if vented spouts are used, either ground or aerial lines could be used with no appreciable difference in sap yields. These same authors recognize the advantage of extra yields produced in closed tubing systems by the development of natural vacuum, and, therefore, recommend the use of closed systems where the topography is sloped.

Koelling et al. (1968) report higher yields from closed over vented systems, and suspended over ground systems. They also point out that suspended systems are more cost efficient since they require less tubing, and do not require large expenditures of time pulling lines out of the snow as is common with ground installations. The findings of Morrow (1969, 1972) corroborate those of Koelling et al.

Studies have also shown that vacuum pumping can increase sap yields over those obtained with the natural vacuum that is generated by gravity flow alone (Blum and Koelling, 1968; Laing et al., 1971). Furthermore, high

vacuums are associated with high yields, while low vacuums are associated with somewhat lower yields (Morrow, 1969). Laing et al. (1971) report that not only are higher yields the result of high-vacuum pumping (more than 15 inches of mercury), but the syrup produced from sap so obtained is comparable to that made from gravity-flow sap, and with the exception of manganese, high vacuum pumping apparently does not alter the sap's chemical composition.

The conclusion to be drawn from these studies seems to be that when plastic tubing networks are employed for maple sap production, lines should be closed (unvented), and suspended, with a high-vacuum pump attached.

Based solely on the results of the research reported above, one might very well conclude that tubing is always more efficient, and that higher yields can always be realized with tubing in comparison to those obtained with buckets. In actual practice this is not necessarily the case. In some of the earliest work with tubing systems, yields from buckets exceeded those from tubing. To illustrate, Morrow (1958) reported the following yields:

	<u>Quarts Per Tap</u>
Buckets	97
Hillside Tubing	81
Flat-Ground Tubing	62

And in a recent study by Kearl (1970), under actual field conditions, 31 producers with buckets averaged 9.5 gallons of sap per tap, while 12 producers with tubing averaged a somewhat lower 8.9 gallons per tap.

From the foregoing discussion, it is obvious that considerable differences of opinion exist concerning the relative merits of plastic tubing systems. Many of these involve personal preferences. However, as with any production process, some advantages and disadvantages are inherent in the system. For tubing systems these have been summarized in part by Willits (1965) and Foulds (1973). Included are the following:

Advantages

1. Potentially higher yields than buckets.
2. Cleaner sap.
3. Great reduction in gathering time.
4. Avoidance of sap losses from over-flowing buckets.
5. Elimination of spillage losses occurring in transferring sap from buckets to gathering pails and from gathering pails to collection tanks.

Disadvantages

1. Difficulty with hanging during cold weather.
2. Longer time required for set-up.
3. Loss of sap storage capacity available in hanging buckets.

4. Susceptibility to rodent damage.
5. Washing problems.

Costs of Maple Sap Production

In contrast to the considerable research effort into technology and methodology of maple sap production, studies to determine the specific costs of sap collection for the two basic collection systems have been limited. In the few studies that have been completed, costs have generally been separated, if at all, by size of operation, rather than distinguishing between the type of collection system used.

Sap production costs are important as they may account for up to 60 percent of labor cost and 40 percent of total costs in syrup production (Morrow, 1968). And it has been stated that plastic tubing in some instances may lower the cost of making maple syrup by as much as 40 percent (Willits, 1965).

In a Wisconsin study (Acker et al., 1970), various costs of sap production were reported for five small (average size--710 taps) and ten medium to large (average size--2,611 taps) operations. Variable costs for sap production were found to be 28¢ per taphole for the small operations, which averaged 10.7 gallons of sap per tap, and 29¢ per taphole for the medium to large operations, which averaged 8.2 gallons of sap per tap. Fixed costs were not included in this analysis, so the reported data do not

reflect the average total cost per taphole of sap production. Also, no distinction was made between bucket and tubing collection systems. The authors did report that two out of the 15 operators collected part of their sap with tubing.

In some of his early work with tubing, Morrow (1961) estimated that to install, maintain, take down, and clean plastic tubing and equipment approximately eight minutes of labor was required per taphole per year. At the \$1.50 per hour cost he used, this comes to a 20¢ per taphole annual labor charge. If the wage rate for labor is increased to \$2.00 per hour, the annual labor cost becomes 27¢ per tap, with this cost increasing to 33¢ per tap when \$2.50 per hour is used. In 1963, he estimated similarly equipped plastic tubing systems could be vacuum-pumped for an additional 11¢ per taphole per year.

A feasibility study prepared by the Northeast Kingdom Area Rural Development Committee (Elliott et al., undated) estimates that a 16,000-tap, unvented, 18-inch drop, suspended tubing installation would have a tubing cost of \$1.01 per taphole. Total cost of equipment for this installation was estimated at \$17,460 or \$1.09 per tap. Annual costs to deliver the sap to roadside pickup points were estimated by the group to be:

Taphole rent	\$1,739.00
Depreciation (10 yr., straight line)	1,746.00
Interest on capital @ 7 percent	1,222.00
Tapping labor--60 man days @ \$2.50 per hour	<u>1,200.00</u>
	\$5,907.00 or
	\$.37 per tap

These costs are considerably lower than those estimated by Nyland and Rudolph (1969) for sap production in Michigan's lower peninsula. Their study, although based on a specific localized model, estimated that a producer using tubing can deliver sap to his own saphouse at a cost per tap of \$.73 to \$.96. These estimates do not include a taphole rental value. With an average yield of 15 gallons per tap, a producer using tubing and vacuum can, according to these researchers, deliver sap to his own saphouse for \$.05 to \$.06 per gallon. If yields are 20 gallons per tap, then costs are expected to be reduced to \$.04 to \$.05 per gallon.

A recent report by Morrow (1972) on tubing cost studies covering seven years (1966-1972) at Cornell's two fields stations, Arnot Forest and Heaven Hill, reported costs in agreement with those of Nyland and Rudolph. Morrow's study appears to show economies of scale, as the 1400-tap tubing operation on the Arnot Forest exhibited an average cost per tap of \$1.17, while the 3,800-tap operation at Heaven Hill averaged \$.89 per tap. These data

include capital costs, labor costs (@ \$3.60 per hour), operating costs, sap delivery costs, and land and tree value.

Kearl (1970) also reports economies of scale. His findings showed that as the size of the operation was increased up through the 5,000 + size class (6,544 taps per producer on the average), average total cost decreased. This is for bucket and tubing collection systems combined.

Kearl's study is also significant in that it does differentiate between bucket and tubing systems, while most others do not. Costs for the 31 farmers in the study who used only buckets averaged \$1.00 per tap, while for the 12 who used only tubing average costs per tap were \$1.02. Although labor cost was decreased for the tubing operations, equipment cost was sufficiently higher to offset the savings, resulting in no significant cost advantage for either system. It should be noted, however, that this comparison was only incidental to the main study and was not intended to be an indepth comparison of the two systems.

METHODS OF STUDY

The research was divided into two distinct parts:

(1) a survey of Michigan's maple syrup producers to identify their characteristics, attitudes, plans, and problems, and (2) an analysis of costs and returns for maple sap production in Michigan. Although seemingly unrelated, the two parts are in certain respects complementary, as the former was designed to reinforce the latter, while at the same time providing a broader base for data collection.

Collection of Data

In late 1972 and early 1973 a survey questionnaire was sent to all the maple syrup producers in the State of Michigan for which a mailing address could be obtained. The mailing list included the names of the Michigan subscribers to the National Maple Syrup Digest and a list of producers supplied by the county extension agents. A total of 630 questionnaires was mailed.

Questions asked in the survey were of a varied nature and covered many aspects of the maple industry (see Appendix A). More specifically, information of a general nature, information concerning sap and syrup production

methods and plans, management and labor information, and producer suggestions were all sought. Some of the information solicited in the survey was the same as that sought in the indepth interviews of the cooperating producers, with the survey serving to broaden the data base and allow for generalization of the results for the state as a whole.

To obtain the necessary cost and labor data, and to accomplish that portion of the study's objectives, 14 operators of 17 separate Michigan sugarbushes were recruited as cooperators in the project for the first year of data collection, 1972. This number was expanded to 19 cooperators and their 24 sugarbushes for the 1973 season. By collecting data for two consecutive seasons, it was hoped that the influence of weather on sap yields and hence, labor productivity, although impossible to control, would tend to "average out."

The cooperating sugarbush operators were separated into two groups of approximately equal size. The first group consisted of sugarbush operators employing the conventional bucket system of sap collection, while the second included those utilizing vacuum pumped plastic tubing systems. In soliciting cooperators, an effort was made to obtain for both groups a uniform distribution of sizes over the 500- to 3,000-tap range. The operations actually ranged in size from 500 to 2,685 tapholes for bucket systems and 300 to 2,850 tapholes for tubing. Roadside

bushes were excluded because of obvious yield and cost advantages over woods operations.

Invaluable assistance in locating cooperators was rendered by Dr. Melvin R. Koelling, Extension Specialist in Forestry at Michigan State University. Because of his intimate knowledge of the maple syrup industry in Michigan and his many personal contacts with the state's maple syrup producers, it was a relatively simple task to enlist co-operators in the research effort. However, to have a sufficient number and range of sugarbushes to carry out the study, the cooperators were by necessity located throughout the state in both the upper and lower peninsulas (Fig. 1).

The study's cooperators do not by any means constitute a random sample of the maple producers in Michigan. They are, instead, representative of a particular size of operation employing a particular type of sap collection system. If any bias exists in the sample, it is toward the "above average" operation rather than the "below average." A list of the cooperators by type of collection system and size of operation is presented in Appendices B and C.

After recruiting the cooperators, the next step was to conduct an indepth interview of each operator concerning his maple operation. At the time of the interview, each cooperator was provided with standardized time and cost record-keeping forms and intensively instructed in their use. Then, as time permitted, an inventory was made of the

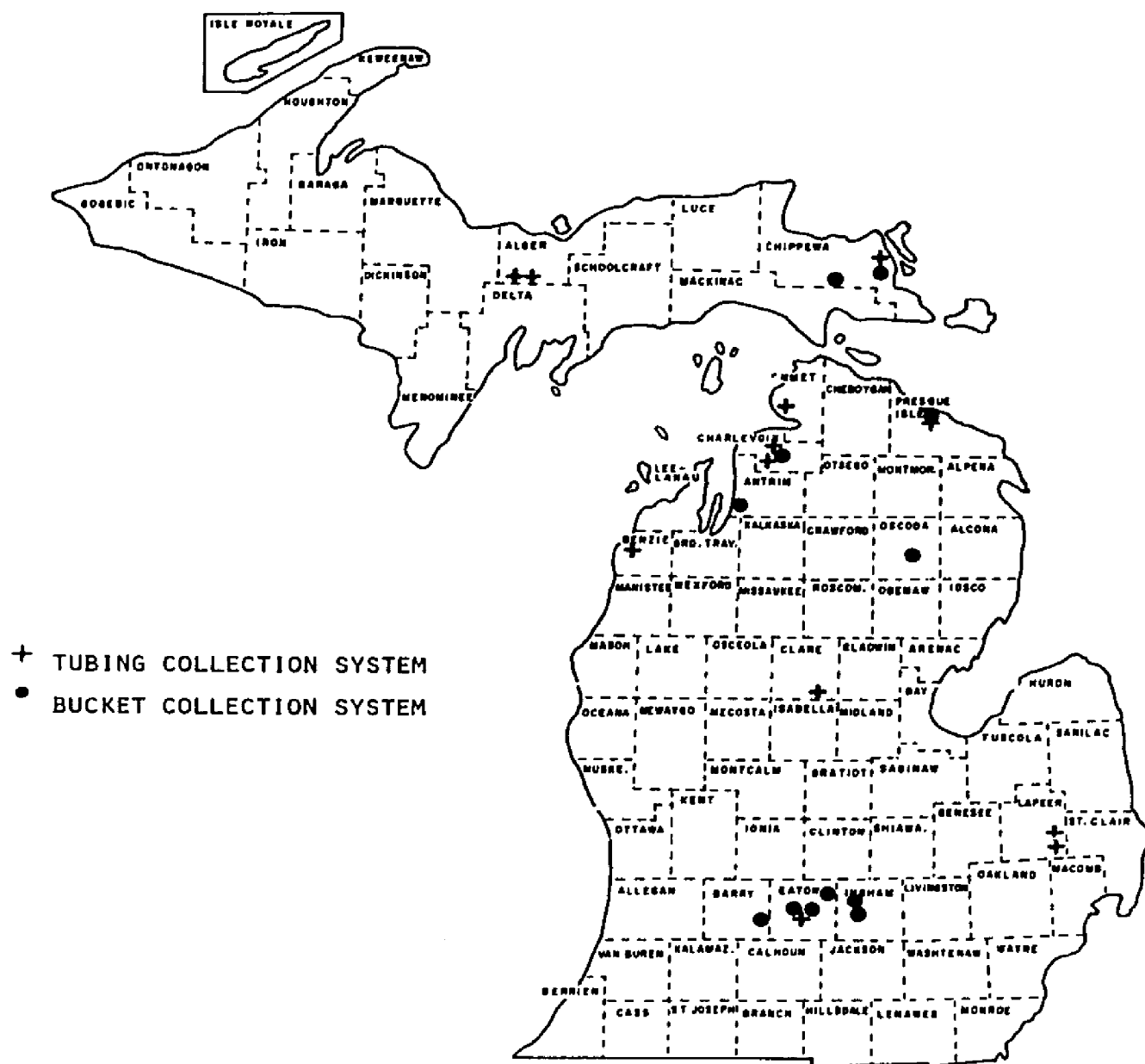


Fig. 1. Location of Cooperating Bucket and Tubing Operations, 1973.

sap production equipment and materials used at each location.

In designing the inventory, interview, and record-keeping forms, the maple syrup production and marketing record forms published by the University of Wisconsin were borrowed freely (Anonymous, undated). The original forms used in 1972 were revised for the 1973 season, with an attempt made to simplify the record-keeping task, add a greater degree of control, and yet allow for the gathering of essentially the same information as was gathered in 1972. Examples of the revised version of all the forms can be found in Appendices D through L.

As cost differences between the two sap collection systems were to be isolated, it was essential that time studies be incorporated in the procedure. These time studies would help to determine what the labor input was doing in a particular sap collection system and how long it took to do it. Labor inputs were estimated by the operators to the nearest quarter-hour and recorded on the forms provided. Work activities were separated as follows:

Preparation: Included labor time devoted to cleaning and repairing buckets or tubing, tapping equipment, snowshoes, etc. Also, where appropriate, this included the time spent in snow removal and cleaning woods roads.

Set-up: Included the labor time involved in tapping, inserting germicidal pellets, inserting spiles, laying

out and hanging buckets, layout and installation of the tubing system, installation of collection tanks or storage reservoirs, etc.

Sap gathering: Involved the labor time of all aspects of the sap collection phase including in particular, the time spent collecting sap from the individual taps and transporting it to a common collection point at roadside. Also included was the time spent dumping ice or spoiled sap as well as time required to determine if sap collection was warranted. Similarly, the time spent checking for leaks, repairing and maintaining the sap collection system and associated equipment was also included.

Take down: Included the labor time involved in disassembling the sap collection system as well as the time required for cleaning and storing equipment.

As labor inputs vary with the quantity of sap produced, especially with the bucket collection system, the gallons of sap gathered each day and its percent soluble sugar were recorded. The cooperators also recorded the amount and kind of power used each day (i.e., hours of tractor usage, hours of vacuum pumping, etc.).

Intensive checking and supervision of operators early in the season and checking at intervals throughout the season ensured that the required data were recorded in the proper manner. Without exception all operators

were very cooperative and maintained excellent records. Many expressed their willingness to expend the time and effort simply because they thought the research project to be a worthwhile endeavor.

Analysis of Data

Maple Producer Survey

Of the 630 survey forms mailed out, 367 were returned, giving a return ratio of 58.2 percent. However, out of the 367 returned questionnaires, only 140 were completed by active producers. Thus, these 140 constitute the sample.

Once the producer questionnaire was received, processing of the survey data began. Statistical analyses were completed on the data where appropriate. These included T-tests for differences between two means, linear correlation analysis, and analysis of covariance to test for differences between slope and level of two regression lines. Management and labor information obtained in the survey was used later in the cost analysis.

Sap Yields

At the close of the 1972 season it became obvious that there were differences in sap yields between the two sap collection systems. The average yield per tap for operations using the bucket system was 14.1 gallons for that year, while the tubing operations showed an average

yield of 7.2 gallons per tap. This difference was significant at the 5 percent level of testing.

Additional study showed that, generally speaking, yields were greatest in the southern-most portions of Michigan, which enjoyed what was called a "good average year," and the further north the location of the operation, the poorer the yield, with the poorest sap yields coming from the state's upper peninsula. These trends were demonstrated by the study's cooperators and were borne out by the producer survey as well. By dividing the state into north and south portions at 44° north latitude and testing for differences in yields between the two sections, it was found that there were statistical differences (significant at the 10 percent level of testing) between yields for both cooperating bucket and tubing operations.

Part, but not all, of the reason for this poor showing of tubing operations could be attributed to the fact that although cooperators using both bucket and tubing systems were located in both the northern and southern portions of the state, tubing operations tended to be weighted more heavily toward the north, and bucket operations toward the south. This was natural as tubing has enjoyed a wider acceptance in northern Michigan where the terrain is more suited to its use. Southern Michigan sugarbushes tend to be relatively level with slopes of 5 percent or less.

In an effort to achieve a better balance between bucket and tubing operations in both sections of the state and also to fill in some gaps in the distribution of operations over the 500 to 3,000-tap range, seven additional operations were added for the 1973 season.

The 1973 season proved to be different from 1972, as it was a "below average" year in southern Michigan and was considered to be "above average" in the north. Actually, for the study's cooperators, yield differences between the two sections of the state were not statistically significant, nor were the differences in yields between bucket and tubing operations for this season, although once again buckets had the higher average yield per tap. It might be concluded that the additional operations included in 1973 had the desired effect.

Differences between the 1972 and the 1973 maple seasons as determined by combining bucket and tubing operations were statistically significant at the 10 percent level of testing. When analyzed separately, differences between the two seasons were statistically significant at the 5 percent level for bucket operations, but were not significant for tubing operations.

Although there were differences in sap yields for bucket operations between the two seasons, the effect of these differences on labor time as reported by the study's cooperators was not significant. Labor inputs for bucket collection systems in 1972 were not statistically

different from those of 1973. This holds true for the tubing systems as well. In view of these findings, there is no valid reason why the two seasons of data cannot be combined, which was the procedure that was followed in all subsequent analyses. Also, by combining the two seasons, the data base is broadened to 20 operations using the bucket collection system, and 21 operations using the tubing collection system.

Costs and Returns in Maple Sap Production

Equipment investment.--Costs incurred in the production of maple sap include those for equipment and materials, labor, taphole rental or sugarbush value, and management. Of these various costs, the largest initial cost facing a producer is that of the investment in equipment.

The initial step in this analysis was to determine the amount of equipment required for each of the two sap collection systems. This was accomplished by first taking a physical inventory of each cooperator's sap production equipment. Next, the inventory lists were compared and standard equipment lists drawn up, for only by standardizing the equipment could any meaningful results be obtained. These standard lists of equipment with 1973 prices and price sources are presented in Appendices M and N.

The standard lists are self-explanatory with the exception of the standard number of feet per taphole for each size of plastic tubing. The values used here were averages for all the sugarbushes using the tubing system. This procedure was used because each sugarbush differed from the next in tapholes per acre, number of tapholes per tree, etc. The price of each vacuum pump assembly requires some further explanation as well. As it was impossible to standardize this piece of equipment, estimates of its value were obtained from each cooperator for his particular assembly, and these values were used as the price of the assembly, after making appropriate allowances.

After determining from the standard list the quantity of each item in the equipment inventory and its price, it was a simple matter to multiply price times quantity and arrive at a total equipment investment cost for each operation. This is the procedure that was used for all equipment except tractors and snowmobiles; the nature of these two pieces of equipment necessitated a different approach.

Because maple producers for the most part are farmers who use their tractors in other farm operations (e.g., plowing, mowing, towing, etc.) and their snowmobiles for recreation, it would be inequitable to charge the total investment of these pieces of equipment to the maple enterprise. For this reason the investment in each was prorated according to the hours of actual usage in the maple

operation and then added to the equipment investment total. The basis for the prorating was a useful mechanical life of 12,000 hours for tractors (Bowers, 1970), and 300 hours or four years for snowmobiles.²

Once the total equipment investment was determined for each operation, correlation analysis was completed for each of the two collection systems to determine if a linear relationship existed between the number of tapholes and equipment investment.

Annual equipment costs.--The total investment in sap production equipment is an important value, but to use it as the cost of producing sap for any one year would be erroneous as the equipment is used over a period of years. Standard procedure is to depreciate the equipment over the number of years of expected usage, and add a charge for interest on the remaining investment. A recast version of the discount annuity formula does this very nicely, and was the procedure used in this analysis (Davis, 1966):

$$a = \frac{(1 + i)^n (i) (V)}{(1 + i)^n - 1}$$

²U.S. Forest Service records.

where,

a = the annual cost

i = the rate of interest

V = the initial cost or investment

n = the number of years the equipment is depreciated.

The depreciation period used in these computations was ten years for all equipment except buckets and snowmobiles. Since buckets were expected to last twenty years, and snowmobiles four years, these time periods were used instead.

The interest rate used in the calculations was a composite rate reflecting the cost of capital as well as charges for insurance and shelter for the equipment. In the spring of 1973 the rate of interest on farm equipment loans charged by the Production Credit Association of Lansing was 8.5 percent. This rate is representative of the cost of capital to farmers in the state at that time, and since most maple producers are farmers, this rate was used.

Insurance of the equipment from losses due to fire and theft is also part of the cost of ownership, whether the owner pays an insurance premium or assumes the risk himself. The insurance premium for this type of equipment was \$.55 per hundred dollars of valuation in 1973, with the coverage extending up to 100 percent of the value of the

equipment.³ If it is assumed that the average investment is approximately one-half of the original cost, then the annual insurance charge can be expressed as a percentage of the original cost (Hunt, 1964). Using this procedure, the annual charge for insurance on sap production equipment was 0.275 percent of the original equipment investment.

Shelter for the equipment used in sap production is a must if the equipment is to be maintained in a servicable condition. It has been estimated that the annual cost of shelter for farm equipment is approximately 1 percent of the original price of this equipment (Hunt, 1964). On this basis, an annual charge of 1 percent was made for sheltering of the equipment used in sap production.

Summation of these charges leads to an interest rate of 9.775 percent ($8.5 + 0.275 + 1.0$), which is the rate used to arrive at the annual cost of the equipment. This annual equipment cost can be regarded as a fixed cost.

Equipment operation and maintenance costs.--In addition to the fixed costs chargeable to equipment ownership, there are variable costs encountered as well. Variable equipment costs are those costs associated with the operation and maintenance of the energy consuming equipment including fuel and lubricant costs, repairs, and maintenance. A listing of operation and maintenance cost by

³Farm Bureau Insurance Group quotation.

piece of equipment is presented in Table 1, while the manner in which these costs were computed is explained in Appendix O. Since each cooperator kept a record of the number of hours each piece of equipment was in use, this time was multiplied by the cost per hour from Table 1 to arrive at the annual cost of operating and maintaining that equipment.

Table 1.--Operation and Maintenance Costs--Powered Equipment.

Item	Cost Per Hour Dollars
Tractor	1.51
Snowmobile	2.16
Vacuum Pump	.0068-.1575 ^a
Bucket Washer	.0090 ^a
Tubing Washer	.0048 ^a

^aOperating cost only.

Material expenses.--Out-of-pocket expenses that occur periodically in producing maple sap, although not large in comparison to equipment or labor charges, are a definite cost of production and must be treated as such. Included are outlays for supplies and materials regardless of the type of collection system used. These include drill bits, germicidal pellets, and cleaning agents. In addition,

producers using bucket systems incur a cost when replacing worn out washer brushes, as do operators using tubing who purchase paint to remark the location of tubing lines and wire to tie the suspended mainlines to wire supports.

Although all of these expenses are not encountered each year, they do occur periodically and an annual cost can be computed. See Appendix P for a list of these material expenses, their prices, price source, and the quantity allocated.

There has been some question in recent years about the advisability of using germicidal pellets in tapholes to prolong sap flow and increase sap yields (Shigo and Laing, 1970; Smith et al., 1970). But, as most of the study's cooperators in both bucket and tubing systems continue to use them, this cost was included in the analysis.

Labor costs and labor utilization.--As has been pointed out earlier, one of the largest single costs of producing maple sap, especially when the bucket collection system is employed, is the cost of the labor inputs. Understandably, a significant portion of this analysis is devoted to labor, its usage and its cost.

One of the first tests in this analysis was for differences in labor inputs between the two sap collection systems. A significant statistical difference here might lead to a recommendation of one system over the other, all other factors being equal.

Average times were computed for each work activity, so comparisons could be made and conclusions drawn as to the relative advantages or disadvantages of each system for that specific activity. It was anticipated, for example, that there would be no appreciable difference in average tapping time between the two systems, but that there would be differences in the time spent gathering sap. Hopefully, the analysis would bring out these differences.

Arriving at a labor cost for each operation was a relatively simple matter, and involved the multiplication of the labor inputs from the operator's daily time record by the wage rate. The wage rate used in this instance was the \$2.00 per hour statewide average obtained from the producer survey. The average wage paid in 1972 was not increased in 1973 as none of the 19 cooperators increased wages paid for labor. As a matter of fact, one producer lowered his wage rate from that paid in 1972 when labor became more available to him.

In addition to the wage rate of \$2.00 per hour, there are other wage extras that accrue when labor is employed. One such wage extra is the social security tax, and the other is workmen's compensation insurance. As most of the 19 maple producers in the study pay social security tax, its cost was included in computing the cost of labor inputs in sap production. At the time of this study, employers were required under the law to withhold 5.85 percent of the employee's cash wages, plus pay an equal amount

from their own funds.⁴ The net effect of this requirement is an increase in the wage rate to \$2.12 per hour ($\$2.00 \times 1.0585 = \2.12). This latter rate was used in all labor cost computations.

Determining the effect of workmen's compensation on the cost of labor inputs was not as simple or as straightforward as that of social security. Under the Michigan Workmen's Compensation Act, employers are required to provide workmen's compensation coverage for their employees if they ". . . regularly employ 3 or more employees at 1 time" or ". . . regularly employ less than 3 employees if at least 1 of them has been regularly employed by that employer for 35 or more hours per week for 13 weeks or longer during the preceding 52 weeks."⁵ Many if not most maple sap producers meet these minimums. Those not meeting the requirements would tend to have operations of a few hundred buckets not necessitating the employment of a labor force, operations that use only family labor, or one man tubing operations of a small to medium size.

Rates for workmen's compensation coverage for maple sap production are \$6.12 per \$100 of payroll,⁶ but a

⁴U.S. Department of Treasury, Internal Revenue Service, Lansing, Michigan. Personal communication.

⁵Sec. 115 Michigan Workmen's Compensation Act as interpreted in a December 21, 1972, ruling by the Michigan Supreme Court.

⁶Farm Bureau Insurance Group quotation.

complicating factor is the minimum premium. The minimum is 25 times the rate per \$100 of payroll plus \$30 for "loss and expense constants" (Shapley, 1973). In this instance, the minimum is \$183 $[(\$6.12 \times 25) + \$30]$. This is an extremely high premium if a producer only has a \$100-\$200 payroll, as did some of the smaller producers in the study. As a matter of fact, none of the study's cooperators reach the "break-even" point on the workmen's compensation premium. The break-even point is defined here as the point above which the actual rate is \$6.12 per \$100 of payroll. Below this point the actual rate is higher. For a \$100 payroll the actual rate is \$183 per \$100 of payroll. To reach the break-even point would require a payroll of \$2,990 $(\$183 / .0612)$. The largest payroll among the study's cooperators was only \$1,560 for a 2,605-tap operation.

Because of this high minimum premium, some producers forego workmen's compensation coverage and assume the risk themselves. By not paying for this insurance coverage, the producer lowers his cost or conversely, increases his returns by \$183. But this is done at a very high risk (loss of his farm is within the realm of possibilities), and is a direct violation of the law.

In view of this seemingly inequitable high minimum premium, and considering that some of the cooperators in the study did not provide workmen's compensation coverage while others did, the approach used in this analysis was

to calculate labor cost both with and without the \$183 minimum premium.

Maple stand costs.--Another cost involved in maple sap production is that of owning the land and trees, or if tapholes are rented, the cost of taphole rental. In New York it was estimated that the value of land and trees for sap production, when computed as the sum of timber growth loss plus taxes, was 10 cents per taphole (Kearl, 1970; Morrow, 1972). Ten cents per taphole is also the rental fee paid most often by Michigan producers who gather sap from trees they do not own.⁷ From this it seems appropriate to charge 10 cents per taphole as the cost of the maple stand in sap production. This figure was used in the analysis.

Management costs.--An important but often overlooked cost in the production of maple sap is the value of the time spent by the producer in what might be termed management activities. In this context, management activities include the following: thinking, planning, book-keeping, hiring, firing, attending meetings, ordering supplies, etc. Labor performed by the producer is not considered a management activity according to this definition.

⁷Melvin R. Koelling, 1973. Personal communication.

In an attempt to arrive at the time devoted to these activities, a question in the statewide survey asked, as was each cooperator in the cost study, for an estimate of the number of hours spent per year managing the sap production operation. An analysis was then completed on the survey data to determine if any correlation existed between the number of management hours and the size of the operation (number of tapholes) for each of the two systems. Correlation coefficients of .0621 for bucket operations and .0546 for tubing were obtained. Since neither of these was statistically significant, it was concluded that such a relationship did not exist.

However, some estimate of the cost of management had to be made. Although somewhat arbitrary, it was assumed that bucket and tubing operations require the same amount of management time as there was no real basis for any other assumption. Bucket systems no doubt require more supervision of labor, but tubing requires more planning, with the two activities appearing to offset each other.

The number of hours devoted to management activities was finally determined by empirically evaluating the data provided by the cooperators and the survey respondents. Data determined in this manner and used in the analysis ranged from a low of 13 management hours per year for a 300 taphole operation to a high of 29 hours for 2,850 tapholes.

Finally, management cost was calculated by multiplying the number of hours devoted to management activities

by the value of the producer's time spent in these activities. The average rate reported by respondents to the survey was \$3.00 per hour.

Total, average total, and marginal costs and returns.--The most important cost figure of all, total cost (TC) is the sum of all the other costs: annual equipment costs, equipment operation and maintenance costs, material costs, labor costs, maple stand costs, and management costs. Once total cost is determined, other relevant cost figures can be derived from it, i.e., average total cost (ATC) and marginal cost (MC). Furthermore, if output and price can be estimated, the break-even point, marginal size, and net return can be determined.

What was desired in this analysis was a way of expressing the relationship between total cost, an endogenous variable, and size of the operation (as measured by the number of tapholes), an exogenous variable. The following model served to accomplish this objective:

$$Y = \beta_0 + \beta_1 X + \beta_2 X^2 + \beta_3 X^3$$

where

β_0 , β_1 , β_2 , and β_3 are the regression coefficients

Y = the total cost

X = the number of tapholes.

The model applies to both bucket and tubing collection systems, and is a mathematical expression of the total cost curve.

To fit the model, the sets of observations from each of the two sap collection systems were used to obtain estimates of the regression coefficients. Least squares was the estimation procedure used. Computations were made, with the aid of the EZLS program of Dr. Wayne L. Myers, on Michigan State University's CDC 6500 computer. Once the regression coefficients have been determined the fitted equation becomes a predictive one, which can be used to predict total cost for a given number of tapholes.

After the prediction equations had been obtained for both collection systems under consideration, an analysis of covariance (ANCOVA) was run to test for a statistical difference between the two total cost curves that the equations expressed. The results of the ANCOVA are important, because they establish any real differences between bucket and tubing collection systems as to the cost of maple sap production.

Obtaining average total cost per taphole from total cost is a relatively simple procedure, and involves the division of total cost by the number of tapholes. Marginal cost is the change in total cost that accompanies a change in the number of tapholes. It is also the first derivative of the total cost function. Thus,

Since

$$\text{Total cost} = Y = \beta_0 + \beta_1 X + \beta_2 X^2 + \beta_3 X^3$$

$$\text{Marginal cost} = \frac{d(Y)}{d(X)} = \beta_1 + 2\beta_2 X + 3\beta_3 X^2$$

To arrive at break-even size, marginal size, and a maximum profit (minimum loss) estimate, outputs of 5, 10, 15, and 20 gallons of sap per tap were assumed. This covers the range of sap yields experienced by the study's cooperators over the two consecutive seasons of data collection (the low reported was 3.8 gallons of sap per tap, while the high was 19.2). As the price paid for sap is a function of its sugar content, a range of sugar concentration (°Brix) values was assumed, along with associated prices. These values are as follows:

<u>Sap Sugar Content</u> <u>°Brix⁸</u>	<u>Price Per Gallon⁹</u> <u>Dollars</u>
1.5	.05
2.0	.07
2.5	.09
3.0	.11

⁸°Brix is an expression of percent sugar concentration determined by specific gravity or optical density of the sap.

⁹1972 Basic Sap Price Schedule, Rutland County (Vermont) Maple Producers Association.

Since average °Brix values reported by the cooperators over the two years varied from a low of 1.5 to a high of 2.7, the assumed sap sugar percentages appear reasonable.

Total revenue (TR) for a given yield and sugar concentration is computed by multiplying the yield per tap in gallons times the price per gallon times the number of tapholes. For example, for 1,000 tapholes yielding an average of 10 gallons of sap per tap with an average sap sugar concentration of 2.0 °Brix, total revenue is $1,000 \times 10 \times \$0.07 = \700 .

Net return is determined by subtracting total cost from total revenue. If total cost and total revenue are equal, this is the break-even point. In this instance it is the number of tapholes required to pay for all incurred expenses, no profits are earned, but on the other hand no losses are suffered.

Marginal revenue (MR) is the change in total revenue that accompanies a change in the number of tapholes. In the above example, if the number of tapholes is increased by one to 1,001, total revenue is increased by 70 cents to \$700.70, so the marginal revenue is 70 cents. Since a constant price has been assumed, marginal revenue (also average revenue) can also be computed by multiplying the sap yield in gallons per tap by its price. Ten gallons of sap per tap at seven cents per gallon also yields 70 cents of revenue per tap.

By computing marginal revenue and marginal cost, a means has been provided for determining, via marginal analysis, maximum profits or, conversely, minimum losses. Profits are at a maximum when marginal revenue is equal to marginal cost. In this analysis the term marginal size is used to denote the size of the operation in number of tap-holes at which for a given sap yield and sugar content marginal revenue equals marginal cost.

Minimum cost per taphole (minimum ATC) is not a good indicator of maximum profit. There is only one condition under which minimum ATC denotes maximum returns. This occurs when, and only when, marginal revenue, marginal cost, and average total cost are equal.

RESULTS AND DISCUSSION

Characteristics of Michigan Maple Syrup Producers

Occupation and Years in Production

Most producers of maple products in Michigan, 56 percent, list some kind of agricultural endeavor as their principal occupation (Table 2). This is somewhat lower than the 80 percent who were classed as full-time farmers in a 1963 survey of 14 maple producing states (Taylor et al., 1967). These percentages might be expected to be in closer agreement even though the surveys were conducted nine years apart and covered two different geographical areas. It is conceivable that the differences indicate a change in farm population, with the role of the full-time farmer declining during the period between the surveys.

The next most frequently listed occupation by the producers was some type of industrial employment: 16 percent of the respondents are in this category; 10 percent of the producers are retired; and 18 percent work for the government, are employed by institutions, or have some other occupation.

Table 2.--Principal Occupation of Maple Syrup Producers in Michigan, 1972.

Size of Operation (Tapholes)	Retired Percent	Agriculture Percent	Industry Percent	Govt. Percent	Institutions Percent	Other ^a Percent
0-499	15	44	18	8	5	10
500-999	10	59	13	5	5	8
1000-1499	12	62	15	. .	. .	12
1500-1999	. .	75	. .	. .	. .	25
2000-2499	. .	46	27			27
3000-3499	20	60	20	. .	. .	. .
3500+	. .	86	14	. .	. .	. .
Average	10	56	16	4	3	11

^aKiwanis Club Official, Real Estate Broker, Housewife, Mechanic, Professional.

The data presented in Table 2 show that, time and age factors tend to force retired producers and those with other than agricultural employment, to limit the size of their operations. In the smallest size class (0-499 taps), 15 percent of the producers are retired and 41 percent have principal occupations other than agriculture, for a total of 56 percent retired or employed outside of agriculture. In contrast, for the largest size class (3500 taps and over) no producers are retired and only 14 percent are employed outside of agriculture.

Michigan producers have been producing maple products at the same location for an average of 23 years. Surprisingly, this is the same as reported by Taylor et al. (1967) for all producers in 14 maple producing states in 1963.

A tabulation of the producers in Michigan by age would be interesting, but unfortunately this information is not available, as age was inadvertently omitted from the survey questionnaire. Nonetheless, since almost one-third, 30 percent, of the producers are retired or have been producing in excess of 40 years, this would seem to indicate that a disproportionate number are of an advanced age.

The vast majority, 96 percent, of Michigan producers run an integrated maple operation, producing both maple sap and maple syrup. The remaining 4 percent of the producers produce maple sap only. None of the producers

responding to the survey reported producing maple syrup without producing sap as well.

Operation Size

Small operations are the rule and not the exception in Michigan, where 58 percent of the operations have less than 1,000 tapholes (Table 3). However, only 25 percent of the total number of tapholes are in operations of this size. The larger operations, those with 3500 or more tapholes, have 23 percent of the tapholes, but only 4 percent of the producers.

As would be anticipated from a perusal of Table 3, there is a negative correlation (statistically significant at the 1 percent level of testing) between size of the operation and number of producers. There are a large number of producers with operations of a few hundred tapholes but as the size of the operation increases, the number of producers decreases, with only a very few producers having the largest operations.

Maple syrup producers in Michigan did not find a sufficient number of tapholes on their own properties to meet their needs in 1972; rather, they also tapped trees belonging to others. Of all the tapholes installed that year, 18 percent were on non-owned properties (Table 4). This is a slight increase over the 1968-72 average, but the increase is not of a sufficient magnitude to be statistically significant.

Table 3.--Distribution of Tapholes and Producers by Size of Operation, 1972.

Size of Operation (Tapholes)	Frequency Distribution			
	Taphole Basis		Producer Basis	
	Number	Percent	Number	Percent
0-499	11,121	7	40	29
500-999	29,145	18	41	29
1000-1499	30,775	19	27	19
1500-1999	14,506	9	9	6
2000-2499	23,425	15	11	8
2500-2999	. .	. .	. .	. .
3000-3499	15,000	9	5	4
3500-3999	7,350	5	2	1
4000-4499	4,000	2	1	1
5000-5499	. .	. .	. .	. .
5500-5900	11,300	7	2	1
7000-7499	14,000	9	2	1

Table 4.--Tapholes on Owned and Non-Owned Properties, 1972.

Size of Operation (Tapholes)	Tapholes	
	Owned	Non-Owned
	Percent	Percent
0-499	83	17
500-999	87	13
1000-1499	79	21
1500-1999	69	31
2000-2499	78	22
3000-3499	70	30
3500+	91	9
Average	82	18

There is some disparity between the 18 percent reported here for tapholes on non-owned properties and the 30 percent quoted by Nyland and Rudolph (1970). It is doubtful that the tapping of non-owned properties decreased by 12 percent over the seven years from 1965 to 1972. Nyland and Rudolph anticipated an increase in tapping of non-owned properties between 1965 and 1975, and the respondents to the survey reported approximately the same proportion of tapholes on owned vs. non-owned properties for the five years, 1968-1972, as they did in 1972. The difference probably lies in the relative weights given in the two surveys to the small scattered sugarbushes of

southern Michigan. The 1965 survey of Nyland and Rudolph applied only to Michigan's lower peninsula, while the 1972 survey covered the entire state. The earlier survey gave a greater weight to the small scattered sugarbushes, and consequently showed a greater percentage of tapholes on non-owned properties. When the number of tappable trees is small, the producer often turns to sugarbushes other than his own to fulfill his needs for maple sap. In analyzing the data, it was thought that there was a tendency in the larger operations, because of their size, to have a larger proportion of their tapholes on non-owned properties than do the smaller operations. However, correlation analysis failed to bear this out. The results were statistically nonsignificant.

There was a tendency, though, for the Michigan producers to increase the size of their operation in 1972 over what it had averaged from 1968 through 1972. The average number of tapholes in 1972 for all producers was 1,144, which was up slightly from 1,139 for the 1968-72 period. This trend was true for all size classes with the exception of the smallest operations, 0-499 tapholes, which declined from a five-year average of 286 tapholes per operation to 279 tapholes per operation in 1972.

Limiting Factors in Sap and Syrup Production

Of the factors that limited the number of tapholes in 1972, the one most frequently cited--19 percent of the

time on the average--by the survey respondents was a lack of time to do more tapping (Table 5). It may come as a surprise that there is a negative correlation (statistically significant at the 10 percent level of testing) between the size of the operation and the frequency with which this factor was listed as being a limiting one. The smaller the operation, the more frequently lack of time was mentioned as limiting the number of tapholes in 1972. However, if it is recalled that producers working at occupations outside of agriculture tended to limit the size of their operations, and since these same producers constituted one-third of the sample, then this relationship is not surprising.

Labor availability was the next most frequent reason for limiting the number of tapholes in 1972 (16 percent); followed by size of the evaporator (13 percent); lack of tapholes on the property (12 percent); amount of sap gathering equipment (12 percent); experience (12 percent); and other factors (8 percent).

Although cited as a limiting factor 4 and 2 percent of the time respectively by all the respondents to the survey, only the respondents with the small to medium-sized operations stated that it does not pay to tap more or did not have a market for their sap or syrup. Evidently producers with larger operations do not experience these difficulties. The producers with the larger operations do indicate that a lack of tapholes in their area is a limiting factor more often than do the smaller operations,

Table 5.--Factors that Limited the Number of Tapholes per Operation in 1972.

Item	Size of Operation (Tapholes)							Average
	0-499	500-999	1000-1499	1500-1999	2000-2499	3000-3499	3500 +	
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	
No more taps on property	17	13	5	8	21	25	. .	12
No more taps in area	2	1	. .	. .	7	12	. .	2
Amount of sap gathering equipment	8	9	17	23	7	25	22	12
Size of evaporator	11	15	15	8	. .	12	11	13
No market for sap or syrup	3	2	3	. .	. .	. .	. .	2
No time to tap more	28	20	14	15	14	12	. .	19
Labor not available	6	19	20	23	29	12	11	16
It doesn't pay to tap more	5	2	5	8	. .	. .	. .	4
Experience	5	14	15	15	14	. .	33	12
Other ^a	16	4	5	. .	7	. .	22	8

^aAge, Hobby only, Snow conditions.

although overall this factor was found to be the least limiting of all those listed.

Production Trends

Sugar maple trees tapped in Michigan in 1972 averaged 1.73 tapholes each. There was wide variation in this number, with survey respondents reporting numbers averaging as low as 1.0 and as high as 3.5 tapholes per tree. While there are notable exceptions, it is generally true that trees in southern Michigan sugarbushes are larger than those in the north, and consequently, can be expected to have more tapholes per tree.

The weather patterns during the 1972 season caused a considerable variation in sap yields as noted earlier. The average yield for the state in that year was 11.8 gallons of sap per taphole. Reported yields ranged from a low in northern Michigan of 4 gallons per tap to 25 gallons per tap in southern Michigan near the Indiana line. Average sugar content of the maple sap also varied, with a reported low of 1.5 °Brix, a high of 4.1 °Brix, and an average for all producers of 2.1 °Brix.

Producer responses to questions concerning the purchase and sale of sap, and the purchase of syrup are presented in Table 6. Although only 10 percent of the Michigan producers reported buying sap in 1972, this is a larger proportion than the 4 percent for 14 maple producing states in 1963 (Taylor et al., 1967). On the other hand,

Table 6.--Purchase and Sale of Sap, and Purchase of Syrup by Maple Producers, 1972.

Size of Operation (Tapholes)	Purchase Sap			Sell Sap			Purchase Syrup		
	Yes	Gallons Bought ^a	No	Yes	Gallons Sold ^a	No	Yes	Gallons Bought ^a	No
	Percent	Number	Percent	Percent	Number	Percent	Percent	Number	Percent
0-499	3	?	97	15	309	85	..		100
500-999	5	32	95	5	152	95	2	1	98
1000-1499	11	41	89	..	..	100	7	3	93
1500-1999	12	?	88	12	22	88	..	..	100
2000-2499	36	1,800	64	..	..	100	9	52	91
3000-3499	40	2,240	60	..	..	100	40	230	60
3500 +	14	3,571	86	14	214	86	29	26	71
Average	10	423 +	90	7	145	93	7	15	93

^aAn average for the size class.

it is somewhat less than the 23 percent buying sap in New York (Smith, 1969). The reader will recall that the sample for the New York survey was not a random one. Also, three different geographical areas and three very different sap seasons are being compared.

The 14-state survey and the Michigan survey are in agreement on one significant point: the proportion of producers buying sap increases with the size of the operation. This relationship was tested for the Michigan survey, and was found to be statistically significant at the 1 percent level. Not only are more of the larger producers buying sap, but they are buying more of it as is evident in Table 6. Producers with operations of 3,500 or more tapholes averaged buying 3,571 gallons of sap each in 1972. The amount purchased per producer decreased directly with decreases in size down to 32 gallons of sap per producer for operations in the 500-999 size class. Although one of the producers in the smallest size class (0-499 tapholes) reported buying some sap, he did not specify the quantity purchased. Correlation analysis showed the direct relationship between size of the operation (in tapholes) and the amount of sap purchased to be statistically significant at the 5 percent level.

It is surprising to find that only 7 percent of the producers reported selling any sap in 1972, while 10 percent were purchasing sap. Smith (1969) also found that of those producers interviewed in New York in 1968, more were buying

sap (23 percent) than were selling (6 percent). Evidently in Michigan and perhaps elsewhere the producers who are selling sap are selling to more than one buyer. Or, as may also be the case, a disproportionate number of the producers selling sap did not return the Michigan survey questionnaire.

Since it was found that the proportion of producers buying sap increased with size of the operation, it was reasoned that the proportion of producers selling sap would decrease with operation size. However, correlation analysis failed to substantiate this hypothesis as the results were statistically non-significant.

Fewer producers were purchasing syrup in 1972 than were purchasing sap; 7 percent for the former as opposed to 10 percent for the latter. This 7 percent is also less than the 28 percent reported to be buying additional syrup in New York in 1968 (Smith, 1969). However, purchasers of sap and syrup tend to exhibit the same characteristics. In fact many of the producers who purchased sap also bought syrup. As was the case with sap, the proportion of producers buying syrup increased with the size of the operation. This relationship was significant at the 1 percent level of testing. And, although there appears to be a tendency for the larger producers to buy larger volumes of syrup, results of a correlation analysis proved to be statistically non-significant.

The vast majority (72 percent) of Michigan producers did not, at the end of 1972, anticipate any changes

in sap production for the next five years. Producers planning to increase production between 1972 and 1977 account for another 17 percent of the total, while 3 percent planned to decrease production, and the remaining 7 percent planned to go out of business (Table 7). In contrast, in 1965, 43 percent of the producers in Michigan's lower peninsula planned to maintain their present level of tapping for 1965-1975, 22 percent planned to increase tapping, and 35 percent planned to discontinue the operation (Nyland and Rudolph, 1970).

Although the two studies are not directly comparable, a certain amount of comparison is inevitable. And surprisingly, the two studies are in close agreement on the proportion of producers planning to increase sap production. The 1972 value of 17 percent differs by only a few percentage points from the 22 percent of 1965. The real differences in the findings of the two lie in the percentage of producers planning to discontinue their operations. If the two studies had the same data base, with the only difference being that they were made seven years apart, then it would probably be appropriate to conclude that plans made in 1965 for discontinuing operations were proceeding on schedule. The 35 percent who planned to discontinue operations by 1975 had been reduced to 7 percent in the first seven years of the ten year period. Undoubtedly, this is related to the two values, but there are other factors as well. Producers whose plans would be

Table 7.--Producer Plans Concerning Maple Sap Production for 1973-1977.

Size of Operation (Tapholes)	No Change Percent	Get Out Percent	Increase By			Decrease By	
			Less Than 50 Percent	51 to 100 Percent	More Than 100 Percent	Less Than 50 Percent	More Than 50 Percent
0-499	78	11	8	3	. .	. .	. .
500-999	72	11	11	. .	3	3	. .
1000-1499	56	4	20	8	8	4	. .
1500-1999	89	. .	11	. .	. .	. .	. .
2000-2499	63	. .	18	9	. .	. .	9
3000-3499	80	. .	20	. .	. .	. .	. .
3500 +	86	. .	14	. .	. .	. .	. .
Average	72	7	13	2	2	2	1

Note: 17 percent plan to expand.
10 percent plan to decrease production or go out of business.

reflected in the 1972 value of 7 percent and not in the 35 percent of the earlier survey have no doubt decided to go out of business since the 1965 survey. Aside from differences between the samples themselves, there is no clear explanation.

Of the 7 percent of all producers planning to go out of the maple business between 1973 and 1977, none has an operation of more than 1,500 tapholes and usually less than 1,000 taps each. Thus, it is the smaller, probably submarginal producers who are discontinuing production.

In contrast, it is the larger operations that are planning to expand. Overall, 17 percent of the producers are planning to expand, but, as can be seen in Table 7, the proportion planning expansion increases with size of the operation. This relationship was tested and proved to be statistically significant at the 10 percent level.

Although the percentages in Table 7 are based on the total number of producers rather than the total number of taps, it appears that planned expansion will more than offset the planned contraction in sap production. Seventeen percent of the producers plan to expand, while 10 percent plan to decrease production or go out of business. When these values are changed to a taphole basis, it is found that this is indeed the case, and that among current producers a net increase in sap production can be expected in Michigan between 1973 and 1977. The larger operations will take up the slack left by the smaller operations. This has

been the pattern of all agricultural production in the United States for the past thirty years or so. The more efficient get larger and the less efficient drop out of the picture. The reasons for this phenomenon should become quite clear, when the costs and returns of sap production are discussed.

Producer plans concerning syrup production were almost exactly the same as those for sap production, with 72 percent planning no change, 18 percent planning to expand, 4 percent decreasing production, and 7 percent going out of business. Again it was the smaller producers who were going out of the maple business, and the larger producers who were expanding. The relationship between size of operation and the proportion of producers planning expansion became, with the slight changes in plans between sap and syrup production, statistically significant at the 5 percent level.

The tendency of Michigan producers to continue using the conventional bucket collection system is apparent in Table 9, where it can be seen that 85 percent of the tapholes in the state were on the bucket system in 1972. Although only 15 percent of the tapholes were on tubing, almost a third (31 percent) of the producers had some tubing. Of the 15 percent of the tapholes on tubing, more were vacuum pumped (8 percent) than were on gravity flow alone (7 percent), although the difference was not great (1 percent).

Table 8.--Producer Plans Concerning Maple Syrup Production for 1973-1977.

Size of Operation (Tapholes)	No Change Percent	Get Out Percent	Increase By			Decrease By	
			Less Than 50 Percent	51 to 100 Percent	More Than 100 Percent	Less Than 50 Percent	More Than 50 Percent
0-499	85	12	. .	3	. .	. .	. .
500-999	69	11	11	. .	6	3	. .
1000-1499	56	4	20	8	8	4	. .
1500-1999	89	. .	11	. .	. .	. .	. .
2000-2499	63	. .	18	9	. .	. .	9
3000-3499	60	. .	40	. .	. .	. .	. .
3500 +	86	. .	14	. .	. .	. .	. .
Average	72	7	12	3	3	2	2

Note: 18 percent plan to expand.

11 percent plan to decrease production or go out of business.

The proportion of tapholes on tubing systems (with or without vacuum) increased with the size of the operation (Table 9). In operations of less than 500 tapholes, only 5 percent of the tapholes were on tubing, but this increased to 68 percent on tubing for operations in the 4,000 to 4,499 size class. Operations larger than 4,500 tapholes utilized the bucket collection system exclusively. However, there were only four operations of this size in the sample.

Table 9 also shows the tendency of Michigan producers to favor gravity over the vacuum pump for small tubing operations, but to shift to vacuum pumping for larger installations.

Not quite half (45 percent) of the producers in the survey had at some time used plastic tubing in their maple sap operation, including small try-it-and-see type kits (Table 10). The proportion of producers trying tubing increased with increases in the size of the operation, with only 18 percent of the producers in the smallest size class having tried tubing, while 71 percent of those in the largest size class had tried it at one time or another. Correlation analysis showed this relationship to be statistically significant at the 10 percent level of testing.

Opinion was divided among producers on whether the advantages of plastic tubing outweigh the disadvantages. A glance at Table 11 shows that of the producers who had tried tubing, most (65 percent) thought the advantages outweighed the disadvantages. Producers who had not tried

Table 9.--Distribution of Tapholes by Sap Collection System, 1972.

Size of Operation (Tapholes)	Buckets	Tubing (Gravity)	Tubing (Vacuum Pump)
	Percent	Percent	Percent
0-499	95	5	. .
500-999	88	8	4
1000-1499	88	7	5
1500-1999	76	14	10
2000-2499	76	4	20
3000-3499	88	12	. .
3500-3999	68	12	20
4000-4499	32	. .	68
5500-5999	100	. .	. .
7000-7499	100	. .	. .
Average	85	7	8

Table 10.--Percentage of Maple Producers Who Have Tried
Tubing by Size of Operation, 1972.

Size of Operation (Tapholes)	Percent
0-499	18
500-999	39
1000-1499	63
1500-1999	78
2000-2499	64
3000-3499	80
3500 +	71
Average	45

Table 11.--Do the Advantages of Plastic Tubing Outweigh the
Disadvantages?

	Yes Percent	No Percent	No Response Percent
Producers who had tried tubing	65	25	10
Producers who had not tried tubing	23	40	37
All producers	42	34	24

tubing disagreed. They were of the opinion that the disadvantages carried the greater weight. Overall, opinion favored tubing. Approximately 42 percent of all the producers thought that the advantages of tubing outweigh the disadvantages, 34 percent thought otherwise, and the remaining 24 percent did not respond to the question.

Producer responses to the question "Could tubing be profitably employed in your operation?" were essentially the same as the responses to the question concerning the advantages and disadvantages of tubing. Those who had tried tubing thought it could be profitably employed in their operation, while those who had not tried tubing were of the opposite opinion. Again, when the responses of those who had not tried tubing were combined with those who had, more of the producers thought tubing could be profitably employed in their operation (39 percent) than thought otherwise (33 percent), although 28 percent chose not to answer the question (Table 12).

Table 12.--Could Tubing be Profitably Employed in Your Operation?

	Yes	No	No Response
	Percent	Percent	Percent
Producers who had tried tubing	62	22	16
Producers who had not tried tubing	20	42	38
All producers	39	33	28

Although 39 percent of the producers think tubing could be profitably used in their operation, only 31 percent are using tubing. Evidently, 8 percent of the producers think it would be to their advantage to employ tubing in their operation, but for one reason or another have not done so.

Some producers were planning to change the relative proportion of buckets to tubing by 1977, although most were not. Twenty-seven percent indicated plans for a change, but 73 percent liked things as they were (Table 13). Of the 27 percent planning a change, 25 percent were going toward more tubing, while only 2 percent chose to favor buckets.

The Marketing of Maple Syrup

Approximately one-half (51 percent) of the maple syrup producers in Michigan normally sell at least part of their syrup on the wholesale market, but most of the syrup is retailed. The marketing mix normally used by Michigan's producers is presented in Table 14. It can be seen that 49 percent of all producers sell all of their syrup on the retail market. This proportion decreases to 13 percent at a mix of 90 percent retail--10 percent wholesale, and declines from there to 2 percent of the producers at 100 percent wholesale. This correlation proved to be statistically significant at the 10 percent level.

Table 13.--Any Plans to Change the Relative Proportion of Buckets to Tubing in the Next Five Years?

Size of Operation (Tapholes)	<u>Yes</u> Percent	<u>No</u> Percent
0-499	5	95
500-999	18	82
1000-1499	39	61
1500-1999	33	67
2000-2499	44	56
3000-3499	25	75
3500 +	33	57
Average	27	73

Not all of the producers responding to the survey produced syrup for sale on the retail and wholesale markets. Some produced maple syrup strictly for gifts and for their own use. Four percent of respondents are in this category, and virtually all have operations of less than 500 tapholes.

When asked if they were able to dispose of their syrup at what they considered to be a "fair" price, Michigan producers responded as follows:

Almost always	65 percent
Usually	24 percent
Sometimes	5 percent

Table 14.--Retail vs. Wholesale Marketing of Maple Syrup by Michigan Producers, 1972.

Marketing Mix	Producers	
	Number	Percent
100 Percent Retail	65	49
90 Percent Retail- 10 Percent Wholesale	17	13
80 Percent Retail- 20 Percent Wholesale	2	2
70 Percent Retail- 30 Percent Wholesale	6	4
60 Percent Retail- 40 Percent Wholesale	5	4
50 Percent Retail- 50 Percent Wholesale	8	6
40 Percent Retail- 60 Percent Wholesale	5	4
30 Percent Retail- 70 Percent Wholesale	6	4
20 Percent Retail- 80 Percent Wholesale	5	4
10 Percent Retail- 90 Percent Wholesale	5	2
100 Percent Wholesale	2	2
Gift and Own Use	6	4
Total	132	100

Seldom	3 percent
Practically never	2 percent

Since 89 percent of the producers are in the "usually" or "almost always" categories, it might appear that there is no problem in selling syrup and getting a "fair" price for it, at least in the mind of the producer. But the 5 percent in the "seldom" and "practically never" categories would disagree. Again, it is the smaller operations who are having these problems, as the 5 percent only included producers with less than 1,500 tapholes.

In 1972 producers received an average of \$8.10 for each gallon of syrup sold on the retail market, and \$6.90 per gallon on the wholesale market (Table 15). Retail prices ranged from a low of \$2.50 per gallon to a high of \$14.00 per gallon. The low reported wholesale price was \$4.00, while \$10.00 was the high. Note that all types of wholesale and retail methods are included in these groupings.

Although correlation analysis failed to show any correlation between size of the operation and the average wholesale price received, there is a correlation (statistically significant at the 1 percent level of testing) between operation size and the average retail price received. These results are not entirely unexpected. Size of the operation has little bearing on the price received wholesale, because the purchaser (wholesaler) usually establishes

Table 15.--The Average Price Received Per Gallon of Syrup
in 1972 and a "Fair Price."

Size of Operation (Tapholes)	Average Price Received		"Fair Price"	
	Wholesale	Retail	Wholesale	Retail
	Dollars	Dollars	Dollars	Dollars
0-499	6.86	7.71	6.94	8.56
500-999	7.14	7.97	7.68	8.69
1000-1499	7.12	8.42	7.42	8.96
1500-1999	7.06	8.44	8.05	9.47
2000-2499	6.17	7.88	6.92	8.50
3000-3499	5.07	8.65	6.10	9.17
3500 +	7.28	8.86	8.00	9.93
Average	6.90	8.10	7.48	8.85
Low	4.00	2.50	5.00	3.00
High	10.00	14.00	10.00	30.00

the price to be paid, and, as the producer has little or no bargaining power, he has to accept this price if the sale is to be completed. This situation is reversed on the retail market for here the seller sets the price and the decision to buy or not to buy at the established price is made by the consumer. In general, larger producers command a higher retail price for their syrup than do those with the small operations. Evidently, the producers with the larger operations have a better product, advertise more heavily, and/or are more profit motivated in general than the latter.

It is interesting to note that although 89 percent of the producers said they were "usually" or "almost always" able to dispose of their syrup at a "fair" price, when asked what they considered to be a "fair" price, in every instance they quoted a price above the one actually received in 1972 (Table 15). And one producer stated that considering all the work involved, \$30 per gallon was indeed "fair." Perhaps the "fair price" of Table 15 could be looked at as a "fairer" fair price.

Another point of interest is that in 1972 the producers with the larger operations were already averaging retail prices above those thought to be fair by the producers with the smallest operations. The average retail price received in 1972 by producers with operations in the 3,500 taps and over size class was \$8.86 per gallon, while \$8.56 per gallon was considered to be a "fair price" by

the average producer in the 0-499 taphole class. One may get the impression from Table 15 that a correlation exists between the retail "fair price" and the size of the operation. However, this relationship proved to be statistically nonsignificant as did the relationship between the wholesale "fair price" and operation size.

Labor and Maple Sap Production

Labor used in the production of maple sap comes from three sources: the producer and his immediate family, full-time employees, and seasonal employees. Producers, the producers' immediate families, and full-time employees comprised 59 percent of the labor force employed in 1972 in sap production with the bucket system (Table 16). In contrast, 78 percent of the labor force for tubing systems came from these sources. Seasonal employees accounted for 41 percent of the labor force when buckets were used, and 22 percent with tubing. Obviously, producers using the tubing collection system can make better use of their own, their families', and their full-time employees' time than those using the bucket system. Consequently, the former have to hire less seasonal labor than do the latter.

This conclusion is supported by Table 17, where it is shown that in 1972, producers using the tubing system hired an average of .7 seasonal workers, while those on buckets hired 1.8 seasonal workers. The difference in

Table 16.--Source of Maple Sap Production Labor Force by Collection System, 1972.

Labor Source	Bucket System		Tubing System	
	Number of Workers	Percent	Number of Workers	Percent
The producer and his immediate family	294	56	91	71
Full-time employees	16	3	9	7
Seasonal employees	215	41	28	22
Total	525	100	128	100

Table 17.--Average Number of Seasonal Workers by Collection System and Size of Operation, 1972.

Size of Operation (Tapholes)	Bucket System	Tubing System
0-499	.3	.1
500-999	1.0	1.2
1000-1499	2.5	. .
1500-1999	1.6	.3
2000-2499	3.2	1.5
2500-2999	. .	1.0
3000-3499	2.0	. .
3500 +	6.2	. .
Average	1.8	.7

these two means is statistically significant at the .1 percent level of testing.

As would be expected, the information in Table 17 indicates a positive correlation between the number of seasonal workers employed for sap production and the size of the operation. The larger the operation, the greater the number of seasonal workers. Both bucket and tubing systems exhibited this relationship, which proved to be statistically significant at the 1 percent level in both cases.

Michigan producers were divided in 1972 on whether there existed an adequate supply of labor for maple sap production at wage rates they could afford. Although the differences are not great, more (52 percent) thought the supply inadequate than thought otherwise. However, even though the majority seem to be encountering difficulty in finding labor, only 5 percent of all producers found it necessary to guarantee their workers a specific number of hours per day or per week to have sufficient labor on hand when it was needed. The other 95 percent did not find it necessary to do this.

The wage rate that producers could afford must have been approximately \$2.00 per hour in 1972, as the average hourly rate of pay for all seasonal employees in that year was \$1.97. Seasonal employees who worked with the tubing collection system received a slightly higher wage rate than did their counterparts on buckets. The former received an

average of \$2.14 for each hour of labor, while the average for the latter was \$1.94 per hour. However, this difference was not significant statistically, so the combined average of \$1.97 is probably an adequate representation of the average wage rate for seasonal sap production workers in Michigan in 1972. Also, there was no evidence of a correlation between the size of the operation and the hourly wage of the seasonal employees.

Although some maple syrup producers seem to be blessed with an adequate supply of seasonal workers and enjoy as well a mutually beneficial working relationship with their employees, many producers do not have these experiences. For this latter group, labor is definitely a problem.

A composite picture of the labor problem as it exists in Michigan is provided by the producers themselves. The problem as producers responding to the survey see it is: to find seasonal help that is willing to work under the weather conditions found during the sap season. The help must respond on short notice and be available when the sap is running, not just on Saturday afternoons. In addition, the help must be willing to take care of the equipment and accept a "fair" wage. After this has all been done the problem remains of getting them to stay on and finish out the season.

Respondents to the survey have also suggested some possible solutions to the "labor problem." These solutions are listed below.

1. Quit.
2. Do-it-all yourself.
3. Maintain as efficient an operation as possible.
4. Mechanize where practical.
5. Replace grown men with high school students.
6. Employ transient labor.
7. Utilize more tubing and less buckets.
8. Pay a bonus to workers completing the season.

In this writer's view, possible solutions 3, 4, 7, and 8 have considerable merit.

Costs and Returns for Maple Sap Production in Michigan

Predicting the Total Investment in Sap Production Equipment

Two questions that potential maple sap producers should ask are: "What will my total investment in sap production equipment be, assuming I have to start from scratch and buy all new equipment?" And, "Which requires the lesser capital investment for the same number of tapholes, buckets or tubing?"

To answer these questions the total equipment investment was computed for each operation that cooperated in the cost study under the assumptions described earlier

and in the Appendix. Then, these two sets of data, one set for buckets and one set for tubing, were fitted to the model:

$$Y = \beta_0 + \beta_1 X$$

where

Y = the total equipment investment

X = the number of tapholes.

The prediction equation obtained from fitting this model for the bucket collection system was:

$$\hat{Y} = 534.75 + 2.9033 X$$

The correlation coefficient for the equation is 0.994. Statistically speaking, the probability of this relationship occurring by chance was less than 1 percent.

For tubing, the prediction equation was:

$$\hat{Y} = 203.97 + 1.7872 X$$

with a correlation coefficient of 0.996. Again, this relationship is statistically significant at the 1 percent level of testing.

An analysis of covariance showed a significant difference (at the .1 percent level) in both slope and elevation of the two regression lines predicted by these equations.

An example will clarify the use of the prediction equations and the differences that exist between the two collection systems in the total investment in sap production equipment. Assuming an operation of 1,000 tapholes, the total equipment investment for a bucket system is $\$534.75 + \$2.9033 (1,000)$ or $\$3,438.05$. For tubing, the investment in equipment for the same number of tapholes is $\$1,991.17 (\$203.97 + \$1.7872 (1,000))$. The difference in equipment investment between the two systems is considerable ($\$1,447$) and is of statistical significance. And, as comparable differences exist for all sizes of operations within the limits of this study, it is safe to conclude that the investment in equipment for a given sap production operation is less for a tubing system than it is for a bucket system.

Labor Input and Its Cost

The detailed daily records of the study's cooperators show a considerable (39 percent) savings in labor for tubing systems over buckets. Tubing operations averaged for the two years of data collection 7.7 minutes of labor time per tap for the total sap production process from time spent in preparation through the cleaning and storage of the equipment. For bucket operations, the average labor time per tap was 12.7 minutes (Table 18). The difference between these two means is significant at the 1 percent level.

Table 18.--Average Annual Labor Time for Sap Production by Activity.

Activity	Labor Time Per Tap			
	Bucket System		Tubing System	
	Minutes	Percent	Minutes	Percent
<u>Preparation</u>	.1	1	.2	2
<u>Setup</u>				
Tapping	1.1	9	1.0	14
Layout and Installation	1.3	10	3.2	42
Collection Tank Placement	.2	2	.2	3
Subtotal	2.6	21	4.4	59
<u>Gathering</u>				
Collection	7.6	60	. .	. .
Maintenance	.1	1	.8	10
Subtotal	7.7	61	.8	10
<u>Take-Down</u>				
Collection System	1.0	8	1.3	17
Collection Tanks	.2	2	.2	3
Cleaning and Storage	1.1	8	.8	10
Subtotal	2.3	18	2.3	30
Totals	12.7	101	7.7	101
Average Cost Per Tap @ \$2.12 per Hour ^a	\$.45		\$.27	

^a\$2.00 per hour plus 5.85 percent for Social Security.

The average annual labor time per tap reported for tubing is in very close agreement with the findings of Morrow (1961, 1972). In 1961 he estimated that it took about 8 minutes of labor per taphole per year to install, maintain, take down, and clean a plastic tubing system. The average annual labor per taphole reported by him for a seven year period (1966-1972) for tubing installations at Heaven Hill and the Arnot Forest was 7 and 9 minutes, respectively.

As expected, the big difference in labor inputs between the two systems occurred during the gathering phase of the operation. For this activity, bucket operations averaged 7.7 minutes of labor time per taphole annually. This was 61 percent of the total labor input for the bucket operation and was equal to the average total labor input for the tubing operations. With the bucket system, it takes as long to gather sap as it does to complete, with an equivalent tubing system, the total sap production process from preparation through setup and gathering to cleaning and storage of the equipment.

The bucket system is favored in the setup phase of the sap production process. Where the annual average is 4.4 minutes of labor per taphole for tubing systems, bucket systems averaged 2.6 minutes. Tapping time is essentially the same for both systems (1.1 vs. 1.0 minutes), but it takes about two and one-half times as long to layout and install the tubing system (3.2 minutes) as it does to

layout and hang the buckets (1.3 minutes). Setting up the system is the most time consuming phase of sap collection with tubing, as it requires about 59 percent of the total labor inputs.

Labor time required to take down the two sap collection systems is approximately the same regardless of the system used (2.3 minutes per taphole per year in both cases), and there is very little differences in preparation time (.1 minute for buckets vs. .2 minutes for tubing). It does take longer to setup the tubing system as noted above, but this slight disadvantage is more than offset by the considerable labor savings that occur during the actual sap gathering itself. The net effect of this labor savings can be seen by comparing the total sap production labor cost for a 1,000-taphole operation on buckets and on tubing. Using the average cost per tap data from Table 18 (\$.45 for buckets and \$.27 for tubing), the average annual labor cost for the 1,000 taphole bucket operation in our example is \$450, while it is \$270 for 1,000 tapholes of tubing. The difference, \$180, represents a labor cost savings of 67 percent for the tubing operation (\$180/\$270). In terms of labor input and cost, tubing collection systems are definitely the more efficient of the two.

Bucket and Tubing Annual Costs

Since bucket collection systems require larger investments in equipment and have higher labor costs than

do tubing systems of the same size, it would not be a surprise to find that the average total annual cost of producing maple sap is greater for buckets than for tubing. This is indeed the case, as indicated by data in Table 19. For the 20 bucket operations, total annual costs without the workmen's compensation premium averaged \$1.13 per taphole, while the average for 21 tubing operations was \$.78. Both these values are increased by \$.13 per tap when the workmen's compensation premium is added, becoming \$1.26 and \$.91, respectively.

These costs are in agreement with those of other researchers. Kearl (1970) reported an average cost for sap production for 64 producers in New York in 1969 of \$.88 per taphole. This was for bucket and tubing operations combined. In the same study he found that for 31 producers who used buckets only and 12 who used tubing only, the average annual costs were \$1.00 per tap for buckets and \$1.02 for tubing. Morrow (1972) found that annual costs for the 3,800 taphole aerial tubing installation at Heaven Hill averaged \$.89 per tap over a seven-year period (1966-1972), while at the Arnot Forest during the same period, a 1,400-tap tubing operation averaged \$1.17 per taphole.

The largest cost item for the bucket system is labor at \$.45 per taphole, which--disregarding the workmen's compensation minimum premium--is 40 percent of the total cost of sap production. Adding the workmen's compensation premium increases this cost by \$.13, to \$.58 per

Table 19.--Average Total Annual Cost Per Taphole by Collection System.

Cost Items	Bucket System				Tubing System			
	Without		With		Without		With	
	Workmen's		Workmen's		Workmen's		Workmen's	
	Compensation		Compensation		Compensation		Compensation	
	Dollars	Percent	Dollars	Percent	Dollars	Percent	Dollars	Percent
Fixed Equipment	.44	39	.44	35	.33	42	.33	36
Equipment Operation and Maintenance	.08	7	.08	6	.02	3	.02	2
Labor	.45	40	.58	46	.27	35	.40	44
Material Expenses	.02	2	.02	2	.02	3	.02	2
Taphole Rental	.10	9	.10	8	.10	13	.10	11
Management	.04	4	.04	3	.04	5	.04	4
Total	1.13	101	1.26	100	.78	101	.91	99

tap or 46 percent of the total cost. The second largest cost item for buckets is the annual cost of equipment ownership, which at \$.44 per tap is 39 percent of the total cost without the workmen's compensation premium and 35 percent with it. These two major costs are followed in importance by taphole rental costs (\$.10 per tap), equipment operation and maintenance costs (\$.08 per tap), management costs (\$.04 per tap), and material expenses (\$.02 per tap).

The workmen's compensation premium takes on added significance in the cost of sap production with the tubing collection system. If the premium is not paid, the cost of owning the equipment is the largest factor in sap production, accounting at \$.33 per taphole for 42 percent of the total cost. Labor, then, is the second largest item with 35 percent of the cost at \$.27 per tap. On the other hand, if the workmen's compensation premium is paid, the situation is reversed, and labor becomes the largest cost item at \$.40 per taphole and 44 percent of the cost, while the fixed equipment cost remains at \$.33 per taphole (36 percent of the cost).

Following the fixed equipment and labor costs are taphole rental costs (\$.10 per tap), management costs (\$.04 per tap), material expenses (\$.02 per tap), and equipment operation and maintenance costs (\$.02 per tap). Note that the cost of operating and maintaining equipment is approximately \$.06 less per taphole for tubing systems (\$.02) than for bucket systems (\$.08). This cost

differential reflects the savings to be realized from operating and maintaining a vacuum pump in lieu of running a farm tractor.

Total, Average Total, and
Marginal Costs

Although the average total annual cost data in Table 19 quite adequately show where the differences lie with respect to the costs of sap production with the two basic systems, these data are only averages which do not express the relationship that exists between the cost of sap production and the number of tapholes. This relationship is an important one, to which much of this study has been devoted.

The total cost of sap production for bucket collection systems that avoid paying the minimum workmen's compensation premium is predicted by the following equation:

$$TC = 1090.41 - .351404 X + (.301954 \times 10^{-3})X^2 \\ + (.568337 \times 10^{-7})X^3$$

where

TC = total cost

X = the number of tapholes.

If the workmen's compensation premium is included, fixed costs are increased while variable costs are unchanged. This is reflected in the equation by an increase

in the constant term of \$183 with the rest of the coefficients remaining the same. Thus,

$$TC = 1273.41 - .351404X + (.301954 \times 10^{-3})X^2 + (.568337 \times 10^{-7})X^3$$

These equations were obtained by the least squares computational procedures described earlier. Both equations have multiple correlation coefficients of .947, and are statistically significant at the 1 percent level. The curves generated by these equations are presented in Figure 2 along with the observed values.

The total cost curves for tubing operations differ from those of buckets and fit their observed data somewhat better as can be seen in Figure 3. An analysis of covariance showed that the difference between the bucket and tubing total cost curves was statistically significant at the .1 percent level. And, the .981 multiple correlation coefficient for tubing betters the .947 for buckets, probably because there is less variation in total cost attributable to differences in sap yields among tubing operations than is the case with buckets.

The prediction equation for tubing systems without the workmen's compensation premium is:

$$TC = 126.446 + .624323X - (.339952 \times 10^{-3})X^2 + (.133916 \times 10^{-6})X^3$$

where

TC = total cost

X = number of tapholes.

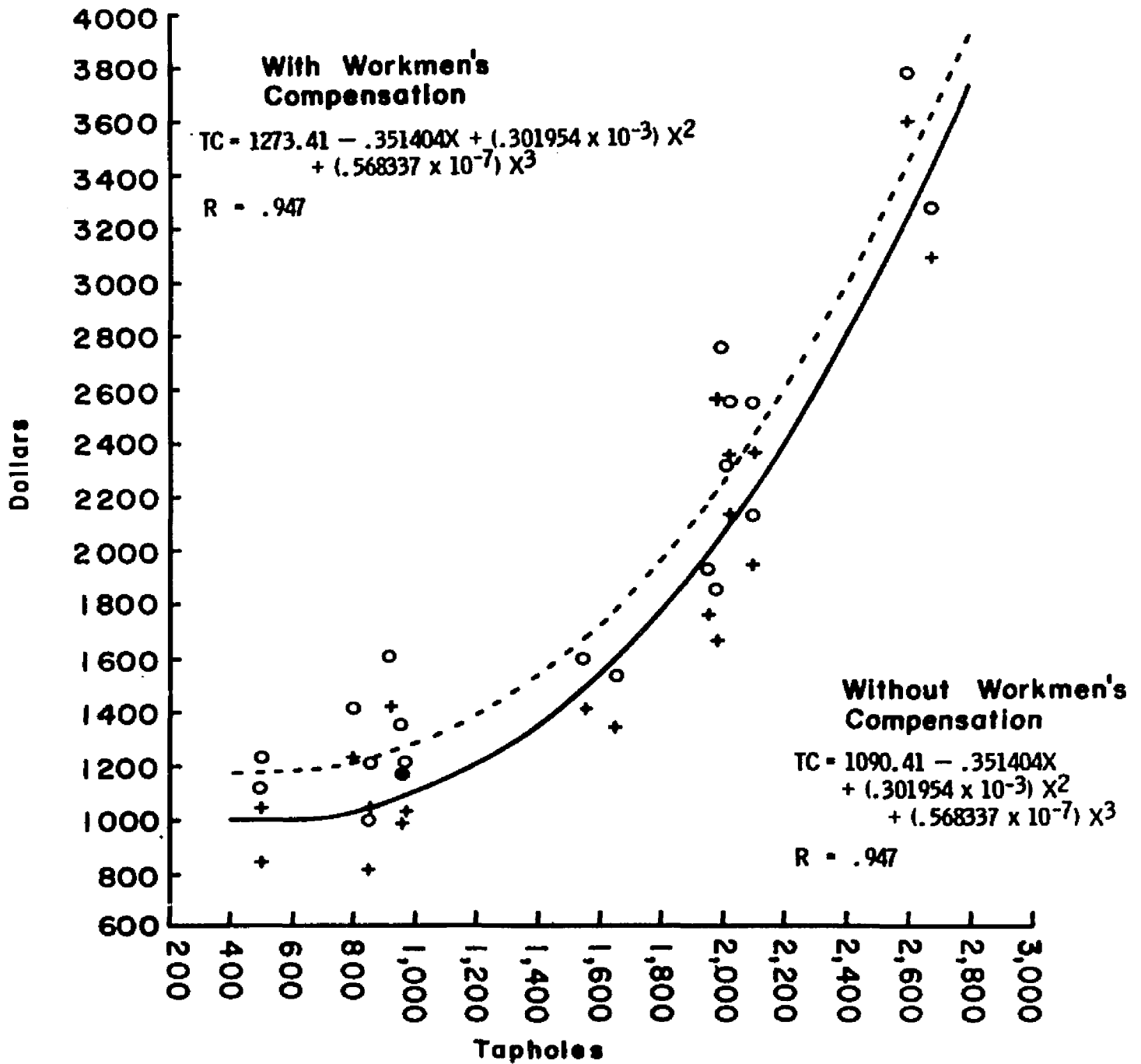


Fig. 2. Total Cost Curves for Bucket Operations.

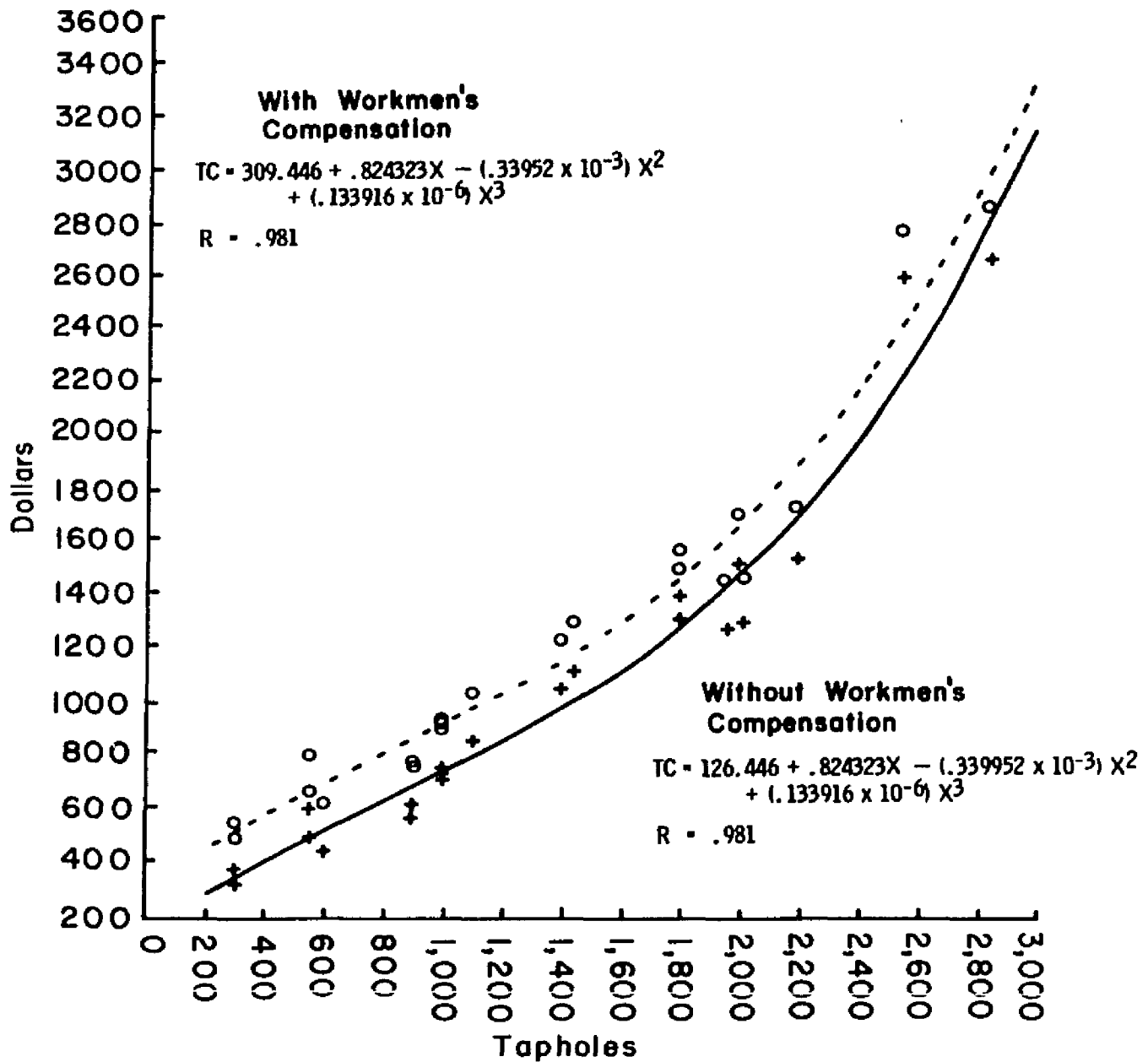


Fig. 3. Total Cost Curves for Tubing Operations.

As before, the same equation with the workmen's compensation premium is:

$$TC = 309.446 + .824323X - (.339952 \times 10^{-3})X^2 + (.133916 \times 10^{-6})X^3$$

Average total cost per taphole is obtained by dividing total cost by the number of tapholes. The cost curve so obtained is U-shaped--it decreases, reaches a minimum, and then increases. Producers are able to achieve economies of scale by spreading fixed costs over a larger number of tapholes to lower the average total cost, but only to a point. Beyond a certain number of tapholes, ATC starts rising again and diseconomies of scale are evident.

For bucket operations without the workmen's compensation premium, minimum ATC is approximately \$.96 at 1,515 tapholes (Figure 4). Adding workmen's compensation shifts the ATC curve upward and to the right so that the minimum is now \$1.07 at 1,620 tapholes.

The ATC curve for tubing operations is flatter than that for buckets, and has a lower minimum value. Without workmen's compensation, minimum ATC occurs at 1,485 tapholes and is \$.70 (Figure 5). This is \$.26 less than the comparable minimum value for buckets. If the workmen's compensation premium is paid, minimum ATC is \$.82 at 1,680 tapholes.

Marginal cost is unaffected by changes in fixed cost such as the addition of the workmen's compensation minimum premium. Rather, marginal cost is a change in

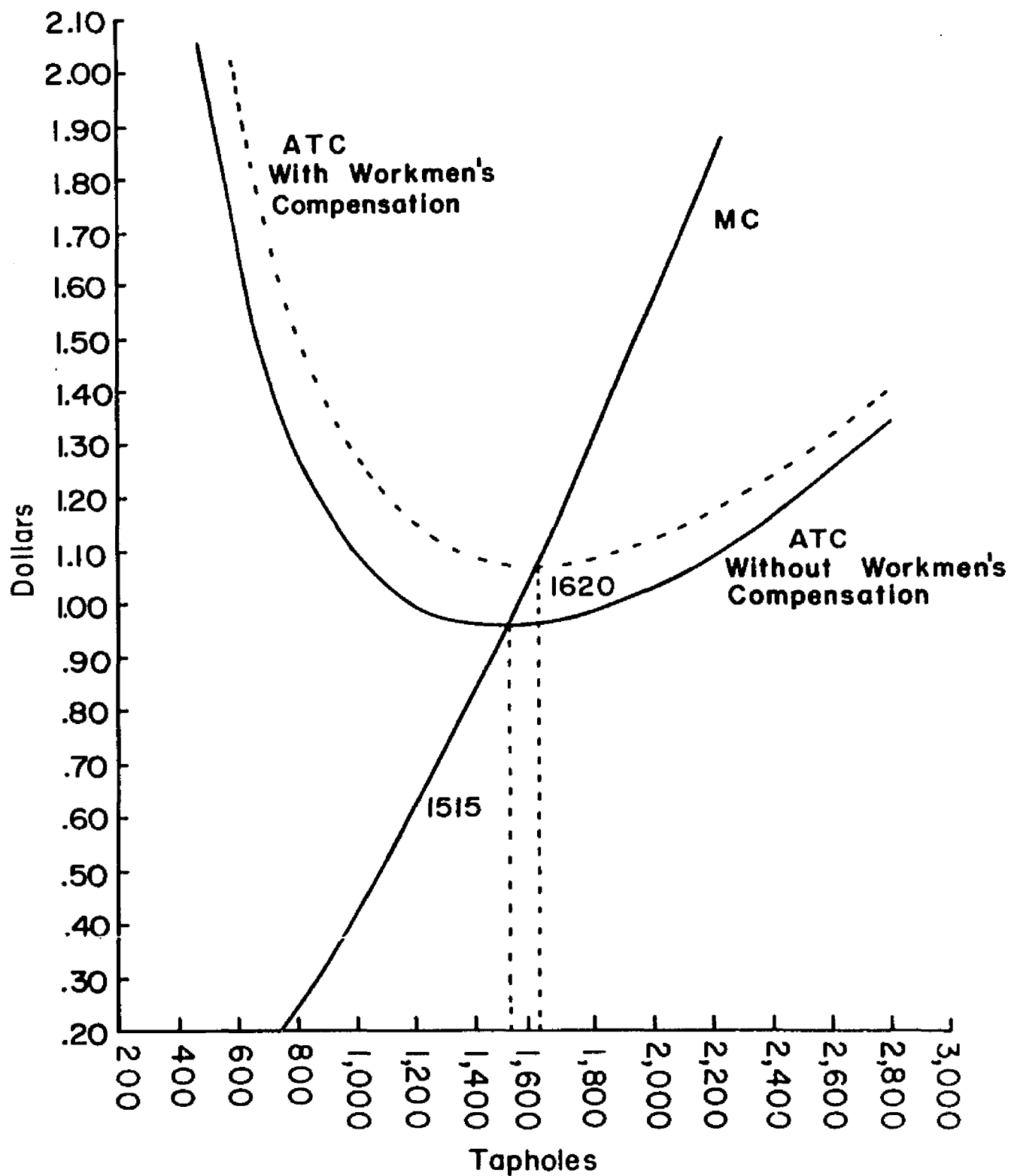


Fig. 4. Average Total Cost and Marginal Cost Curves for Bucket Operations.

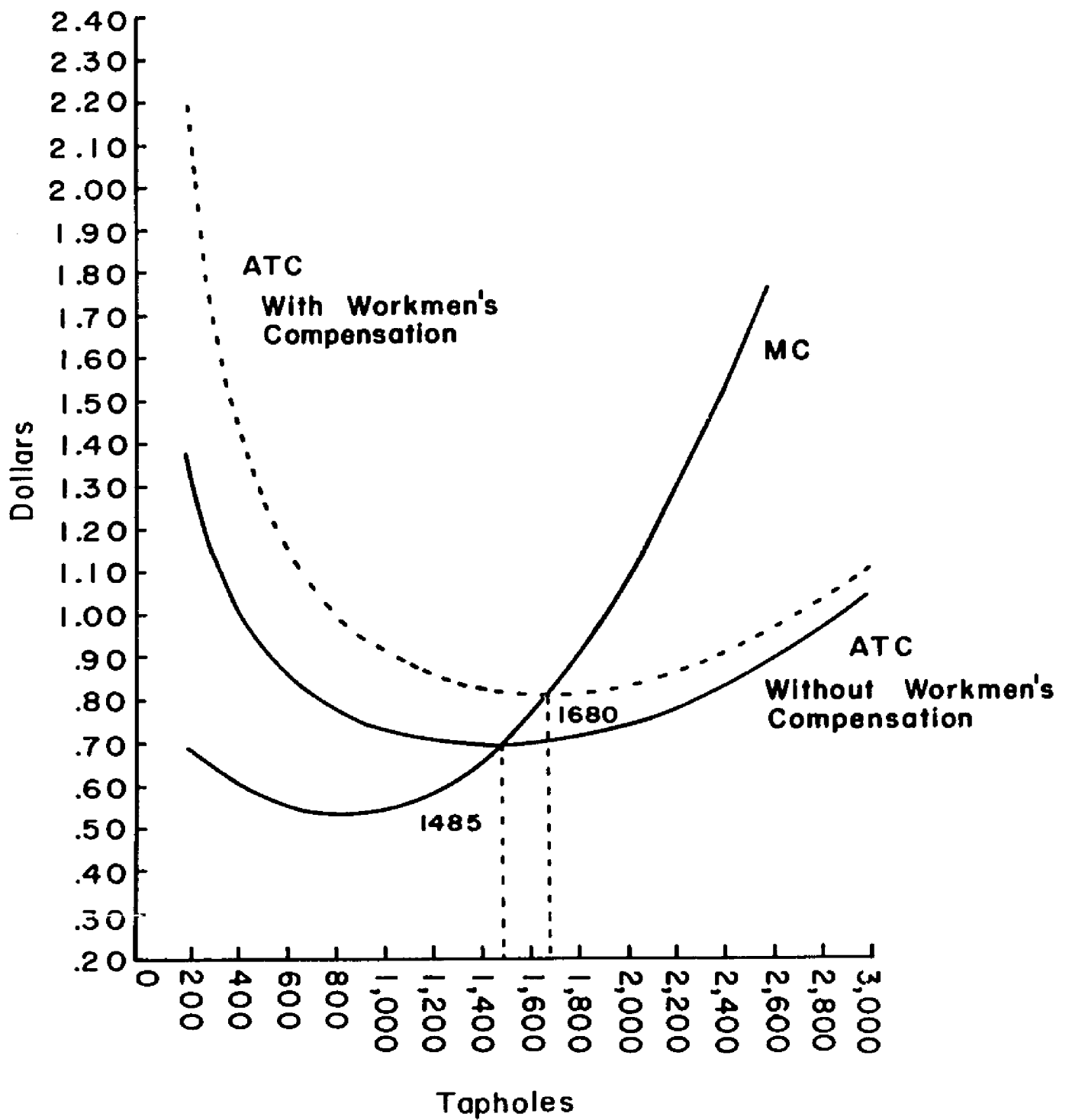


Fig. 5. Average Total Cost and Marginal Cost Curves for Tubing Operations.

total cost that accompanies a change in the number of tap-holes. Marginal cost intersects average total cost at the latter's minimum, and is found by taking the first derivative of the total cost function. Since the prediction equation for the total cost curve for bucket operations (without workmen's compensation) is

$$TC = 1090.41 - .351404X + (.301954 \times 10^{-3})X^2 + (.568337 \times 10^{-7})X^3$$

marginal cost for buckets (with and without workmen's compensation) is

$$MC = \frac{d(TC)}{d(X)} = - .351404 + (.603908 \times 10^{-3})X + (.170501 \times 10^{-6})X^2$$

For tubing operations with and without workmen's compensation, marginal cost is represented by the following equation:

$$MC = .824323 - (.679903 \times 10^{-3})X + (.401749 \times 10^{-6})X^2$$

The marginal cost curves are shown in Figures 4 and 5 along with the appropriate ATC curve.

A tabular presentation of total, average total, and marginal costs for both collection systems is given in Table 20.

Profitability of Maple Sap Production

The costs of maple sap production are important in delineating the efficiencies of the two basic sap collection systems. However, if costs alone are considered, the optimum size of operation and the profit to be made from

Table 20.--Cost Relationships in Dollars.

Number of Tapholes	Total Cost				Average Total Cost				Marginal Cost	
	Without Workmen's Compensation		With Workmen's Compensation		Without Workmen's Compensation		With Workmen's Compensation			
	Buckets	Tubing	Buckets	Tubing	Buckets	Tubing	Buckets	Tubing		
200	. .	279	. .	462	. .	1.39	. .	2.31	. .	.70
400	1,002	410	1,185	593	2.50	1.03	2.96	1.48	. .	.62
600	1,001	528	1,184	711	1.67	.88	1.97	1.18	.07	.56
800	1,032	635	1,215	818	1.29	.79	1.52	1.02	.24	.54
1,000	1,098	745	1,281	928	1.10	.74	1.28	.93	.42	.55
1,200	1,202	858	1,385	1,041	1.00	.71	1.15	.87	.62	.59
1,400	1,346	982	1,529	1,165	.96	.70	1.09	.83	.83	.66
1,600	1,534	1,124	1,717	1,307	.96	.70	1.07	.82	1.05	.76
1,800	1,768	1,290	1,951	1,473	.98	.72	1.08	.82	1.29	.90
2,000	2,050	1,487	2,233	1,670	1.03	.74	1.12	.83	1.54	1.07
2,200	2,384	1,721	2,567	1,904	1.08	.78	1.17	.87	1.80	1.27
2,400	2,772	1,998	2,955	2,181	1.15	.83	1.23	.91	2.08	1.51
2,600	3,216	2,325	3,399	2,508	1.24	.89	1.31	.96	2.37	1.77
2,800	3,721	2,709	3,904	2,892	1.33	.97	1.39	1.03	2.68	2.07
3,000	. .	3,156	. .	3,339	. .	1.05	. .	1.11	. .	2.40

producing maple sap cannot be determined. Rather, costs and returns must be considered together if profit maximization is important, and most producers would undoubtedly feel that it is.

Returns from sap production are generally dependent upon two factors: sap yield per taphole and sweetness of the sap. Assuming an average of 20 gallons of sap per taphole, an average Brix value of 1.50 and a sap value of \$.05 per gallon, the average revenue per taphole is \$1.00 ($20 \times \$.05$). Marginal revenue (the change in total revenue that accompanies a change in the number of tapholes) is also equal to \$1.00, and in this instance marginal revenue and average revenue are one and the same.

Once marginal revenue has been estimated, it is a relatively simple procedure to determine what has been termed here as marginal size. Marginal size is the size of the maple sap operation in number of tapholes at which marginal revenue is equal to marginal cost. Another term for the same phenomenon might be optimum size, because it is at this equilibrium point where profits are at a maximum or losses at a minimum.

An illustration of the graphical procedure for determining marginal size is presented in Figure 6. Although the marginal cost and average total cost curves of tubing operations (without workmen's compensation) are used in this example, the same principles apply to tubing operations with workmen's compensation and bucket operations

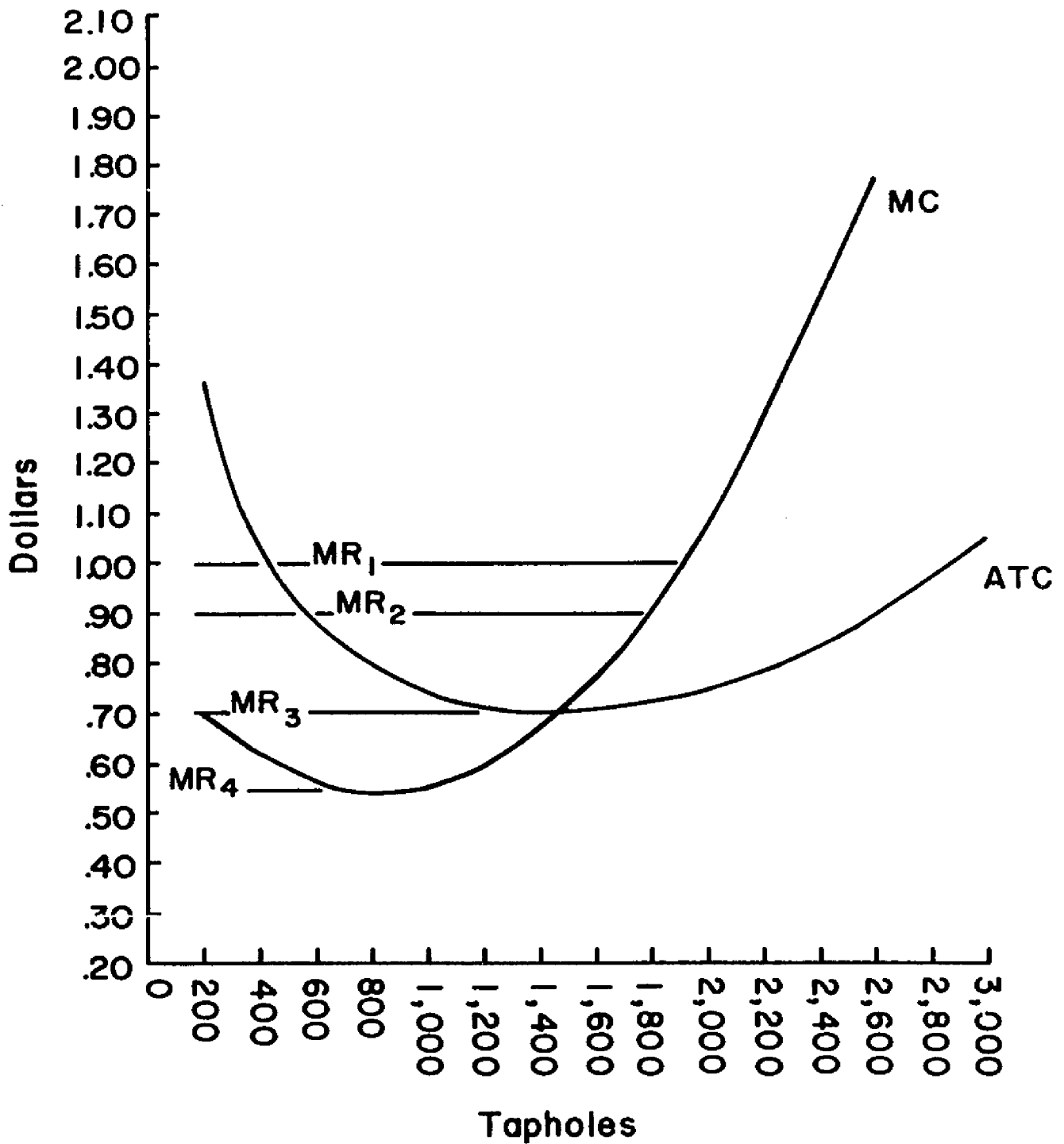


Fig. 6. Cost and Revenue Relationships, Tubing Operations (Without Workmen's Compensation).

with and without the premium. For a marginal revenue value of \$.90 (MR_2 in Figure 6), operations of 1,795 tapholes earn a larger profit than operations of any other size, as determined on the horizontal axis at the intersection of the MR_2 and MC curves.

The break-even point is normally defined as the zero profit point or the point where total cost equals total revenue. It can also be determined from average costs and revenues such as those in Figure 6. Here, the break-even point for an average revenue of \$.90 per taphole occurs at the intersection of the MR_2 and ATC curves, since marginal and average revenues are equal. Under these conditions, an operation of 565 tapholes would be required to break even.

A decrease in marginal and average revenue to \$.70 (10 gallons of sap per tap at \$.07 per gallon for 2.0 °Brix sap) brings up an interesting point. At 1,485 tapholes average revenue, marginal revenue, marginal cost, and average total cost are all in equilibrium and the break-even point and marginal size are one and the same. This is the one condition under which minimum cost per taphole (minimum ATC) indicates maximum profits which are in this case nonexistent. But, looking at the other side, no losses are suffered either.

A further decrease in average and marginal revenue to \$.55 (MR_4 in Figure 6) makes it impossible for any operation large or small to return a profit. Total costs always exceed total revenues, so there is no break-even

point. Marginal size can still be determined from the intersection of the MR_4 and the MC curves. However, marginal size is no longer an indicator of maximum profits, it is, rather, the only size short of zero tapholes at which minimum losses are incurred. In our example, marginal size is 1,025 tapholes.

An increase of only \$.10 per gallon in the price paid for maple sap has a significant effect on both break-even size and marginal size, the former is lowered, while the latter is increased. Starting with a price of \$.09 per gallon for 2.5 °Brix sap, and assuming an average yield of 10 gallons per tap, average and marginal revenue is \$.90 (MR_2 in Figure 6). The break-even size for this price and yield is 565 tapholes, and marginal size is 1,795 tapholes. If the price is increased to \$.10 per gallon for the same yield and sugar concentration, average and marginal revenue is increased to \$1.00 (MR_1). Now, break-even size is 425 tapholes and marginal size is 1,920 tapholes. With this \$.01 per gallon increase in price, the break-even size has been lowered by 140 tapholes and the marginal size increased by 125 tapholes. Producers in the 425 to 565 taphole range can now obtain a profit, where they could not before the price increase, and operators who are interested in maximizing profits are stimulated to increase the size of their operation to the larger marginal size. Theoretically at least, the result of this price increase should be a short-run increase in the supply of sap. Producers who

want to buy more sap and operators of central evaporators would do well to keep this relationship in mind.

Tables 21 and 22 have been constructed to present break-even sizes, marginal sizes, and net returns for four levels of output and four Brix values for the two sap collection systems with and without workmen's compensation insurance. Naturally, because costs are lower, the lowest break-even size, the largest marginal size, and the greatest net returns are achieved with tubing operations. And it goes without saying that the higher the yield and the sweeter the sap, the greater the return regardless of the collection system employed.

With this range of sap yield and sugar concentration values, bucket operations (without workmen's compensation) do not break-even with yields of 5 gallons of sap per tap-hole. To break-even at 10 gallons of sap per tap requires 3.0 °Brix sap, while 2.0 sap is sufficient at 15 gallons per tap. At 20 gallons per tap, a Brix value of 1.5° is adequate to break-even.

Tubing operations (without workmen's compensation) cannot break-even with 5 gallons of sap per taphole either. However, in general, tubing operations can break-even with lower yields of sap and/or lower Brix values than can bucket operations. At 10 gallons of sap per tap, tubing operations can break-even with 2.0° sap, whereas buckets require a 3.0° reading. At 1.5 °Brix, tubing operations can reach the break-even point with yields of 15 gallons

Table 21.--Break-even Size, Marginal Size, and Net Return by Sap Yields and Sugar Content, Bucket Operations.

Sap Yields and Sugar Content	Marginal Revenue ^a	Break-even Size		Marginal Size ^b	Net Return at the Margin		Net Return Per Tap at the Margin	
		Without Workmen's Compensation	With Workmen's Compensation		Without Workmen's Compensation	With Workmen's Compensation	Without Workmen's Compensation	With Workmen's Compensation
	Dollars	Tapholes	Tapholes	Tapholes	Dollars	Dollars	Dollars	Dollars
<u>5 Gallons Per Tap</u>								
1.5 °Brix (5¢)	.25	*** ^c	***	810	-832	-1,015	-1.03	-1.25
2.0 °Brix (7¢)	.35	***	***	920	-745	-928	-.81	-1.01
2.5 °Brix (9¢)	.45	***	***	1,030	-647	-830	-.63	-.81
3.0 °Brix (11¢)	.55	***	***	1,130	-539	-722	-.48	-.64
<u>10 Gallons Per Tap</u>								
1.5 °Brix	.50	***	***	1,080	-595	-778	-.35	-.72
2.0 °Brix	.70	***	***	1,280	-359	-542	-.28	-.42
2.5 °Brix	.90	***	***	1,465	-84	-267	-.06	-.18
3.0 °Brix	1.10	995	1,365	1,640	277	44	.17	.03
<u>15 Gallons Per Tap</u>								
1.5 °Brix	.75	***	***	1,325	-293	-476	-.22	-.36
2.0 °Brix	1.05	1,080	***	1,600	146	-37	.09	-.02
2.5 °Brix	1.35	755	930	1,850	664	481	.36	.26
3.0 °Brix	1.65	605	725	2,085	1,255	1,072	.60	.51
<u>20 Gallons Per Tap</u>								
1.5 °Brix	1.00	1,205	***	1,555	67	-116	.04	-.07
2.0 °Brix	1.40	725	885	1,890	757	574	.40	.30
2.5 °Brix	1.80	555	660	2,200	1,576	1,393	.72	.63
3.0 °Brix	2.20	455	535	2,485	2,513	2,330	1.01	.94

^aMarginal revenue (also average revenue) is the price per gallon times the number of gallons per tap.

^bSize at which marginal cost = marginal revenue.

^c***--indicates that the break-even point will never be reached (total cost is always greater than total revenue).

Table 22.--Break-even Size, Marginal Size, and Net Return by Sap Yields and Sugar Content, Tubing Operations.

Sap Yields and Sugar Content	Marginal Revenue ^a Dollars	Break-even Size		Marginal Size ^b Tapholes	Net Return at the Margin		Net Return Per Tap at the Margin	
		Without Workmen's Compensation	With Workmen's Compensation		Without Workmen's Compensation	With Workmen's Compensation	Without Workmen's Compensation	With Workmen's Compensation
		Tapholes	Tapholes		Dollars	Dollars	Dollars	Dollars
<u>5 Gallons Per Tap</u>								
1.5 °Brix (5¢)	.25	*** ^c	***	() ^d	..	..	..	..
2.0 °Brix (7¢)	.35	***	***	() ^d	..	..	..	..
2.5 °Brix (9¢)	.45	***	***	() ^d	..	..	..	..
3.0 °Brix (11¢)	.55	***	***	1,025	-195	-378	-.19	-.37
<u>10 Gallons Per Tap</u>								
1.5 °Brix	.50	***	***	() ^d	..	..	..	..
2.0 °Brix	.70	1,485	***	1,485	0	-183	0	-.12
2.5 °Brix	.90	565	1,080	1,795	330	147	.18	.08
3.0 °Brix	1.10	335	690	2,030	714	531	.35	.26
<u>15 Gallons Per Tap</u>								
1.5 °Brix	.75	970	***	1,575	77	-106	.05	-.07
2.0 °Brix	1.05	380	760	1,980	614	431	.31	.22
2.5 °Brix	1.35	215	470	2,270	1,252	1,069	.55	.47
3.0 °Brix	1.65	145	335	2,510	1,970	1,787	.78	.71
<u>20 Gallons Per Tap</u>								
1.5 °Brix	1.00	425	845	1,920	516	333	.27	.17
2.0 °Brix	1.40	200	445	2,310	1,367	1,184	.59	.51
2.5 °Brix	1.80	125	290	2,620	2,355	2,172	.90	.83
3.0 °Brix	2.20	90	215	2,880	3,456	3,273	1.20	1.14

^aMarginal revenue (also average revenue) is the price per gallon times the number of gallons per tap.

^bSize at which marginal cost = marginal revenue.

^c***--indicates that the break-even point will never be reached (total cost is always greater than total revenue).

^dMarginal size cannot be determined. MC always exceeds MR.

per tap, while buckets require 20 gallons per tap for sap of the same sugar content.

Adding the workmen's compensation premium has the effect of increasing the break-even point for both bucket and tubing operations. However, the insurance premium has no effect on marginal size as marginal cost and marginal revenue are unchanged. The minimum premium does reduce the amount of profit or increase the loss by \$183.

As has been point out by other researchers, greater sap yields can be achieved with a tubing system under a vacuum than can be obtained with buckets. This makes tubing look even better as the higher yields mean higher profits. However, higher yields do not always occur with tubing under field conditions, as this study has shown. While it was not the purpose of this study to compare actual sap yields between bucket and tubing systems, in that vacuum tubing systems have been reported as obtaining higher sap yields, the question may be raised as to why results of this nature were not obtained in this study. Actual sap yield differences between buckets and tubing favored buckets in 1972 and were not significantly different for the 1973 season, although we should have expected yields from tubing to be significantly higher. Some reasons for this lack of yield increase may be explored. These include:

1. Failure to properly install tubing in accordance with suggested guidelines.

2. Insufficient vacuum supply due to inadequate pump capacity.
3. Failure to regularly check and maintain the system.

Up to a point, the maple sap producer can accept lower yields with tubing should they occur, because of the lower production costs with this collection system. For example, assuming a 1,625 taphole bucket operation that pays the workmen's compensation premium and averages 12 gallons of sap per taphole valued at \$.09 per gallon (2.5 °Brix), annual profit is \$11.40. A tubing operation of the same size and under the same insurance, yield, and price assumptions shows a net return of \$387.79 per year. Reducing the yield to 10 gallons of sap per tap, with all other assumptions unchanged, results in an annual profit of \$95.29 for this tubing operation. It is obvious that even with the 2 gallon per tap lower yield, the tubing operation still earns the greater return.

SUMMARY

A study was conducted to identify characteristics, attitudes, plans, and problems of Michigan's maple syrup producers, and to delineate under Michigan conditions costs and returns for maple sap production with the two basic sap collection systems (buckets and vacuum pumped plastic tubing networks). Data for the first part of the study were obtained by mailing a questionnaire to all maple producers in the state for which a mailing address could be obtained. For the second part, 14 operators of 17 separate Michigan sugarbushes were recruited as cooperators for the 1972 maple season, with this number expanded to 19 operators and 24 sugarbushes in 1973. Approximately one-half of the cooperators utilized the bucket collection system, while the others employed tubing. The operations ranged in size from 500 to 2,685 tapholes for bucket systems and 300 to 2,850 tapholes for tubing.

After recruitment each cooperator was interviewed concerning his maple operation, and an inventory taken of each operation's sap production equipment. Labor inputs and power usage were recorded throughout each of the two

seasons by the cooperators on standardized time and cost record-keeping forms. Labor inputs were separated by work activity: preparation, set-up, sap gathering, and take down.

The equipment inventory was used to prepare a standard list of equipment for both collection systems. Then, annual equipment cost and equipment operation and maintenance costs were computed. Other sap production costs calculated included labor, materials, taphole rental, and management. The sum of all cost items was the total cost of sap production.

Analytical techniques employed in the study included T-tests, linear correlation analysis, multiple regression analysis, analysis of covariance, break-even analysis, and marginal analysis.

Producer Survey

Of the 140 active producers of maple products who constituted the 1972 survey sample, 56 percent listed agriculture as their principal occupation, 34 percent were employed outside of agriculture, and 10 percent were retired. The average producer had been making syrup at the same location for 23 years. Moreover, a disproportionate number of the producers appeared to be of an advanced age, as 30 percent were retired or had been producing for forty or more years. Ninety-six percent of the respondents

produced both sap and syrup in 1972, and operations of 1,000 tapholes or less predominated.

In 1972, 82 percent of the tapholes were drilled in trees owned by the producers. Producers favored the bucket collection system for 85 percent of their tappable resource, tubing with vacuum pump for 8 percent, and gravity flow tubing for the remaining 7 percent. The factor listed most often by the producers as limiting the number of tapholes was a lack of time to do more tapping. Lack of labor was the second most frequently mentioned factor.

Only 10 percent of the producers reported buying any sap in 1972, while 7 percent sold sap, and 7 percent purchased syrup. Most purchasing of sap and syrup was done by the larger producers. It was also the larger producers who planned to increase their production of sap and syrup between 1972 and 1977, although only 17 and 18 percent, respectively, of all producers planned to do this. Ten percent of the producers planned to decrease production or go out of business over this five-year period, but the vast majority, 72 percent, anticipated no production changes.

Producers who had tried plastic tubing networks by 1972 were in the minority (45 percent of total). But the majority of those who had tried tubing thought its advantages outweighed the disadvantages and that tubing could be profitably employed in their own operation. Opinion among producers who had not tried tubing ran counter to that of those who had. Nevertheless, 25 percent of the producers

were planning to shift their bucket to tubing ratio toward more tubing and less buckets.

The majority (51 percent) of the producers reported that they normally sell at least part of their syrup on the wholesale market, however the greatest amounts are retailed. Although some of the smaller producers were having trouble marketing their maple syrup, 89 percent reported "usually" or "almost always" getting a fair price for this product.

The majority of Michigan's maple syrup producers believed the supply of labor at wage rates they could afford is inadequate to meet their needs. Yet 95 percent of the producers reported that they did not have to guarantee their workers a specific number of hours on the job to have them available when needed. Some producers did suggest that one possible solution to the labor problem was more tubing and less buckets.

Costs and Returns

The prediction equations generated in this study, and the analysis of covariance that followed, indicated that over the 500 to 3,000-taphole range studied, the investment in sap production equipment was less for any size of tubing operation than it was for a comparable bucket system. For a 1,000-taphole operation, the investment in a tubing collection system was \$1,447 less than for a bucket system of the same size.

Tubing was also favored over buckets as far as labor inputs and labor cost were concerned. The average labor time per taphole recorded by the study's cooperators for the complete sap production process was 12.7 minutes for buckets, but only 7.7 minutes for tubing. In terms of cost per taphole, these values became, at \$2.12 per hour, \$.45 for buckets and \$.27 for tubing. Furthermore, 61 percent of the labor inputs came during the sap gathering phase of the production process when the bucket collection system was employed, but only 10 percent of tubing labor occurred here. With tubing, most (59 percent) of the labor was needed in the initial set-up.

Total annual costs, which are the sum of annual equipment costs, operation, and maintenance costs, labor costs, material expenses, taphole rental costs, and management costs, averaged, over the two years of the study, \$1.13 per taphole for the 20 bucket operations without workmen's compensation insurance, and \$1.26 for the same operations with workmen's compensation. Labor costs were computed with and without workmen's compensation insurance required under Michigan law because some producers do not qualify, and others fail to provide the coverage. For the 21 tubing operations, average total annual cost for the two years was \$.78 per taphole without workmen's compensation and \$.91 with it.

Labor was the largest cost item for bucket operations, accounting for 40 or 46 percent of the total cost

depending on whether the workmen's compensation premium was included or not. The largest cost item for tubing operations without workmen's compensation was the annual cost of owning the equipment. When workmen's compensation was included, annual equipment cost became secondary to labor inputs.

As expected, the total cost curves generated by least squares computational procedures to express the relationship between total cost of sap production and the number of tapholes differed significantly between bucket and tubing operations. The total cost curves for buckets were above those of tubing.

Minimum cost per taphole (minimum average total cost) occurred for bucket operations (without workmen's compensation) at 1,515 tapholes and was \$.96 per taphole. With the workmen's compensation premium, the minimum for buckets was increased to \$1.07 per taphole at 1,620 tapholes. Tubing operations exhibited a minimum cost per taphole of \$.70 at 1,485 tapholes without workmen's compensation, and \$.82 per taphole at 1,680 tapholes with this insurance coverage.

Break-even and marginal analysis have shown for a range of sap yields, sugar concentrations and associated prices, the minimum number of tapholes needed to break even and the number needed to realize maximum net returns. Naturally, the higher the yield and sugar content values,

the lower the break-even size and the larger the marginal size regardless of collection system employed.

IMPLICATIONS

Results of this study indicate a net increase in maple sap production can be expected among current Michigan producers between 1973 and 1977. Achieving this objective will be no easy matter, however, as the majority of producers believe the supply of labor at wage rates they can afford is inadequate. Furthermore, it is doubtful that seasonal agricultural labor will become more plentiful in the state. To resolve the labor problem, some producers have suggested increased use of tubing in sap production operations. One-fourth of the producers surveyed plan on converting portions of their tappable resource from buckets to a tubing collection system. The wisdom of these planned shifts has been borne out by the cost and returns portion of this study.

For maple sap production in Michigan, and perhaps elsewhere as well, within the approximate range of 500 to 3,000 tapholes, vacuum pumped tubing collection systems are to be preferred over bucket collection systems. Total cost of sap production is lower with tubing than with buckets, and, consequently, net returns are greater for the former.

Reasons for the lower total cost are obvious. The two largest single cost items, equipment investment and labor, are less for tubing operations than for bucket operations of the same number of tapholes.

The timing of labor inputs is another factor favoring tubing. With a tubing collection system, the largest inputs of labor come during the initial setup and not during the gathering phase as is the case with the bucket system. Thus, when the sap is flowing heavily, the producer is freed of most of the worries of sap collection, and can devote more of his energies to the very demanding task of boiling the sap. This is not true with the bucket system. Also, by spreading the set-up and take-down activities over a longer period of time than might normally be the case, a producer and his immediate family can handle, without any extra seasonal labor, a larger number of tapholes than would be possible with a bucket system. By doing it all themselves, they can avoid labor problems, eliminate the cost for outside labor, and legally forego the minimum workmen's compensation premium of \$183.

Costs and returns notwithstanding, plastic tubing networks are not a panacea. Tubing requires more technological know-how than do buckets. And, although it is possible to get increased yields with tubing, if proper techniques are not employed, yields may be lower.

Although tubing does appear to be the method to use, producers having large investments in bucket collection

systems would be ill advised to dispose of their buckets and invest in tubing. But as the buckets wear out and need to be replaced, the producer should give strong consideration to replacing buckets with tubing. In this way, the producer can ease into tubing gradually, and in so doing, allow himself time to experiment and discover what works best under his particular set of conditions.

New sap producers would do well to start out with a few hundred tapholes on tubing for the first season, and add to this number as they gain in experience. Although profits may be low or nonexistent at first, catastrophic losses will be avoided if events do not transpire as anticipated.

Before installing any tubing, producers should gather and study as much information about this sap collection system as possible. Other producers are an excellent source of information. Learning from their mistakes is always easier than making the mistakes yourself. Besides, most maple producers are only too happy to impress the novice with their knowledge of the subject.

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APPENDICES

APPENDIX A

MAPLE SYRUP PRODUCER SURVEY

QUESTIONNAIRE FORM

6. What limited the number of tapholes in 1972? (Check one or more.)

☐ No more tapholes available on the property.
☐ No more tapholes available in the area.
☐ Cannot handle more taps with present sap gathering equipment.
☐ Cannot handle more sap with present evaporator.
☐ There is no market for more sap or syrup.
☐ Do not have time to tap more.
☐ Additional labor required to handle more taps is not available in the area.
☐ It doesn't pay to tap more.
☐ Experience has shown this to be a satisfactory number.
☐ Other (Please specify). _____

7. How many tapholes did your average tree have in 1972? _____
8. How many gallons of sap did you average per taphole in 1972? _____
9. How many gallons of sap were required in 1972 to make one gallon of syrup? _____
10. Did you purchase any sap in 1972? ____ Yes. ____ No.
If yes, how many gallons? _____
11. Did you sell any sap in 1972? ____ Yes. ____ No.
If yes, how many gallons? _____
12. Did you purchase any syrup in 1972? ____ Yes. ____ No.
If yes, how many gallons? _____

II. MARKETING

1. How do you normally market your syrup?

☐ 100% retail.
☐ 90% retail - 10% wholesale.
☐ 80% retail - 20% wholesale.
☐ 70% retail - 30% wholesale.
☐ 60% retail - 40% wholesale.
☐ 50% retail - 50% wholesale.
☐ 40% retail - 60% wholesale.
☐ 30% retail - 70% wholesale.
☐ 20% retail - 80% wholesale.
☐ 10% retail - 90% wholesale.
☐ 100% wholesale.

2. Are you able to dispose of your syrup at what you consider a "fair" price?

☐ Almost always. ☐ Seldom.
☐ Usually. ☐ Practically never.
☐ Sometimes.

3. What was the average price that you received in 1972 for a gallon of syrup?
 At wholesale.
 At retail.
4. What would you consider a "fair" price to be?
 At wholesale.
 At retail.

III. PRODUCTION

1. What are your plans concerning production for the next 5 years? Sap production (Check one).
 No change anticipated (less than 10%).
 Will get out of the business.
 Will expand tapping by 11 - 50%.
 Will expand tapping by 51 - 100%.
 Will expand tapping by more than 100%.
 Will reduce tapping by 11 - 50%.
 Will reduce tapping by 51 - 100%.

Syrup production (Check one).
 No change anticipated (less than 10%).
 Will get out of the business.
 Will expand boiling by 11 - 50%.
 Will expand boiling by 51 - 100%.
 Will expand boiling by more than 100%.
 Will reduce boiling by 11 - 50%.
 Will reduce boiling by 51 - 100%.
2. Are you currently or have you at any time used plastic tubing in your maple sap operation, including any try-it-and-see type tests? Yes. No.
3. In 1972, how many taps did you have on each of the following sap collection systems?
 Buckets (including plastic bags).
 Plastic tubing (gravity only).
 Plastic tubing (with vacuum pump).
4. Do you plan to change this relative proportion of buckets to tubing in the next five years? Yes. No.

 If yes, please indicate the anticipated relative proportions.
 100% buckets.
 90% buckets - 10% tubing.
 80% buckets - 20% tubing.
 70% buckets - 30% tubing.
 60% buckets - 40% tubing.
 50% buckets - 50% tubing.
 40% buckets - 60% tubing.
 30% buckets - 70% tubing.

☐ 20% buckets - 80% tubing.
☐ 10% buckets - 90% tubing.
☐ 100% tubing.

5. In your opinion do the advantages of plastic tubing outweigh its disadvantages? ☐ Yes. ☐ No.
6. Do you think tubing could profitably be employed in your operation? ☐ Yes. ☐ No.

IV. MANAGEMENT & LABOR

The next seven questions refer only to maple sap production, which for our purposes here will include all the processes involved in getting the sap from the tree into the storage tank at the sugar-house. Any processes beyond this point (e.g., boiling, marketing, etc.) should be ignored. In addition, each question has space allotted for responses pertaining to each of the two basic sap collection systems, i.e., buckets and tubing (tubing either with or without vacuum pump). Therefore, a producer utilizing both buckets and tubing in his operation would enter two responses for each question, while a producer with either buckets alone or tubing alone will only have an entry under the one appropriate category.

1. How many hours per year do you normally expect to spend on management for the number of taps you had in 1972?

By management we mean activities such as, but not limited to the following: thinking, planning, bookkeeping, hiring, attending meetings, ordering supplies, etc. Labor performed by the producer (e.g., hanging buckets) is not considered a management activity according to our definition.

Time spent on management chargeable to:

Buckets hours per year.
 Tubing hours per year.

2. What value do you place on your time spent in these management activities? For buckets: \$ /hour. For tubing: \$ /hour.

Is this the same value that you place on labor that you perform? ☐ Yes. ☐ No.

If no, what is the value?

For buckets: \$ /hour. For tubing: \$ /hour.

3. How many workers (including yourself) were engaged in producing maple sap in 1972?
With buckets _____. With tubing _____.
 4. How many of these were members of your immediate family (again including yourself)?
Buckets _____. Tubing _____.
 5. How many of the total are full-time employees?
Buckets _____. Tubing _____.
- Their average rate of pay?
Buckets \$_____/hr.
Tubing \$_____/hr.
6. How many are seasonal employees?
Buckets _____. Tubing _____.
- Their average rate of pay?
Buckets \$_____/hr.
Tubing \$_____/hr.
- How often are they paid?
Buckets _____.
Tubing _____.
7. For bucket operations only, what is the average size of your gathering crews, including tractor drivers (i.e., number of workers per gathering tank)? _____
 8. Would you say that for maple sap production there is an adequate supply of labor in your area at a wage rate you can afford? ____Yes. ____No.
 9. Do you find it necessary to guarantee your workers a specific number of hours/day or per week in order to have sufficient labor on hand when it is needed? ____Yes. ____No.
 10. What is the biggest problem you encounter as far as hired help is concerned? _____

Your solution if any: _____

V. PRODUCER SUGGESTIONS

1. Into what area(s) of Michigan's maple syrup industry do you think future research efforts should be channeled? _____

2. Any comments, criticisms, or suggestions concerning this questionnaire in particular or the maple industry in general: _____

APPENDIX B

COOPERATORS USING BUCKET COLLECTION SYSTEM

Table B-1.--Cooperators Using Bucket Collection System.

ID Code	Name and Location	Number of Tapholes	
		1972	1973
B-1	Mrs. Amos Haigh Charlotte, Michigan	500	500
B-8	Mr. R. W. Sibbald Barbeau, Michigan	NIS ^a	800
B-2a	Mr. George Fogle Mason, Michigan	850	850
B-2b	Mr. Wayne Pennock Nashville, Michigan	920	960
B-4	Mr. Ralph Snow Mason, Michigan	960	970
B-9	Mr. Floyd Moore Ocqueoc, Michigan	NIS	1,550
B-4a	Mr. Ellsworth Handrich Fairview, Michigan	NIS	1,950
B-5b	Mr. Terry Healey Charlevoix, Michigan	1,650	1,978
B-4b	Mr. Raymond Postma Rudyard, Michigan	NIS	2,000
B-6	Mr. Robert Shaw Grand Ledge, Michigan	2,025	2,025
B-5a	Mr. Lyle Luchenbill Kewadin, Michigan	2,100	2,100
B-7	Mrs. Carl Gearhart Charlotte, Michigan	2,605	2,685

^aNot in the study in 1972.

APPENDIX C

COOPERATORS USING TUBING COLLECTION SYSTEM

Table C-1.--Cooperators Using Tubing Collection System.

ID Code	Name and Location	Number of Tapholes	
		1972	1973
T-1b	Mr. R. W. Sibbald Barbeau, Michigan	300	300
T-1a	Mr. Robert Currey Almont, Michigan	550	550
T-3	Mr. Ivan Parsons East Jordan, Michigan	NIS ^a	600
T-2a	Mr. Joe Ostanek Trenary, Michigan	900	900
T-2b	Mr. Robert Currey Almont, Michigan	1,000	1,000
T-5	Mr. Floyd Moore Ocqueoc, Michigan	1,100	1,000
T-8	Mr. Lawrence Carncross Clare, Michigan	NIS	1,400
T-3a	Mr. Leroy Warden Beulah, Michigan	NIS	1,445
T-4a	Mr. Joe Ostanek Trenary, Michigan	900	1,800
T-4b	Mr. Rowland Wehr Charlotte, Michigan	2,200	2,000
T-6	Mr. Terry Healey Charlevoix, Michigan	1,960	2,011
T-7	Mr. Leonard Carpenter Harbor Springs, Michigan	2,550	2,850

^aNot in the study in 1972.

APPENDIX D

GENERAL INFORMATION FORM

APPENDIX D

GENERAL INFORMATION FORM

CONFIDENTIAL

Producer Identification Code _____

Operator: _____

Address: _____

Operator's primary business or occupation: _____

Bush Location: County _____

Township _____ School District _____

Slope: _____

Aspect: _____

No. of taps this year (Study)

Operator owned _____

Rented _____

Total _____

No. of taps not in study _____

Grand Total _____

Tap rental fee: _____

Total No. trees tapped this year: _____

Average No. taps per tree: _____

APPENDIX E

LABOR INFORMATION FORM

APPENDIX E

LABOR INFORMATION FORM

CONFIDENTIAL

Producer Identification Code _____

Total No. of workers (excluding operator) engaged in maple
sap production: _____

No. of total that are members of the operator's immediate
family: _____

No. of total that are full-time employees of the
operator: _____

Their rate of pay:

Average _____

Range _____

No. of total that are seasonal employees: _____

Their rate of pay:

Average _____

Range _____

Frequency of payment:

Daily or on demand _____

Weekly _____

Monthly _____

End of season _____

No. of years experience of employees in maple sap production:

Average _____

Range _____

Source(s) of employees:

Town or city _____

Rural _____

Friends and neighbors _____

High school or college students _____

Migrant workers _____

Advertise (want ads) _____

State employment agency _____

Other _____

Employees (were/were not) observed to be flexible enough
to interchange jobs if need be.

There (appears/does not appear) to be an adequate supply of
labor in the operator's area.

The operator (does/does not) find it necessary to guarantee
his workers a specific number of hours/day or per week
in order to have sufficient labor on hand when it is
needed.

Seasonal employees were observed to spend _____% of their
time on activities other than sap production.

% of time on sap production _____

%

Sugarbush acreage: _____ acres

Estimated value per acre of sugarbush: \$ _____ /acre

Basis: _____

Sugarbush taxes:

Assessed value \$ _____

Assessment rate _____

Equilization factor _____

Millage rate _____

Tax \$ _____

Distance from sugarbush to sugarhouse: _____

Distance from home to sugarbush: _____

No. of years bush has been tapped: _____

No. of years by present operator: _____

Average No. taps last 5 years: _____

Average sap production last 5 years: _____ gal.

Average °Brix last 5 years: _____

Average syrup production last 5 years: _____

Future sap production: _____

Future production methods: _____

No. of hours per year spent by operator on management activities: _____

Value of operator's time for:

Management \$ _____ /hr.

Labor \$ _____ /hr.

% of time spent on other activities (e.g., splitting wood, boiling sap, milking cows, etc.)

Activity

_____	_____%
_____	_____%
_____	_____%
_____	_____%
Total 100%	

The biggest problem the operator seems to have as far as hired help is concerned is: _____

His solution: _____

Comments:

APPENDIX F

DAILY TIME AND POWER RECORD FORMS--
BUCKET SYSTEM

APPENDIX F

DAILY TIME AND POWER RECORD FORMS--BUCKET SYSTEM

CONFIDENTIAL

Daily Time & Power Record (Preparation)

DATE ¹	TOTAL # HELPERS ²	SPECIFIC ACTIVITY ³	PREPARATION ⁴			POWER USED ⁵		
			Opr. Man- Hrs.	#	Help Man- Hrs.	WASHER (BKT. OR TUB.)	SNOWMOBILE	TRACTOR
***	***	***				NO. HOURS	NO. HOURS	NO. HOURS
Page Totals								

Record Hours to Nearest .25 Hour

Daily Time & Power Record
(Set-Up, Buckets)

CONFIDENTIAL

DATE ¹	TOT. ² # HELP- ERS	SPECIFIC ³ ACTIVITY	TAPPING 6A			BUCKET 6B LAY. & HANG.			COLLECTION 6C TANK PLACEMENT			OTHER 6D			TRAVEL 6E (TO & FROM)			POWER USED 5		
																		POWER TAPPER	SNOW- MOBILE	TRACTOR
***	***	****	Opr.	Help		Opr.	Help		Opr.	Help		Opr.	Help		Opr.	Help		# Hrs	# Hrs	# Hrs
			Man Hrs	# Man Hrs		Man Hrs	# Man Hrs		Man Hrs	# Man Hrs		Man Hrs	# Man Hrs		Man Hrs	# Man Hrs		Man Hrs	# Man Hrs	

Record Hours to Nearest .25 Hour

Daily Time & Power Record
(Gathering, Buckets)

CONFIDENTIAL

DATE ¹	TOT. ² HELP- ERS	SPECIFIC ³	COLLECTION ^{7A}			MAINTEN- ANCE ^{7B}			OTHER ^{7C}			TRAVEL ^{7D} (TO & FROM)			SAP ⁸ GATH- ERED (GAL.)	°BRIX ⁹	POWER USED ⁵	
			Opr. Man Hrs	# Hrs	Help Man Hrs	Opr. Man Hrs	# Hrs	Help Man Hrs	Opr. Man Hrs	# Hrs	Help Man Hrs	Opr. Man Hrs	# Hrs	Help Man Hrs			SNOW- MOBILE	TRACTOR
***	***	****															# Hrs	# Hrs

Record Hours to Nearest .25 Hour

CONFIDENTIAL

[illegible]

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APPENDIX G

INSTRUCTIONS FOR DAILY TIME AND
POWER RECORD--BUCKET SYSTEM

APPENDIX G

INSTRUCTIONS FOR DAILY TIME AND POWER RECORD--BUCKET SYSTEM

1. Date--Maintain a daily record of the various sap production activities and power used.
2. Number of Helpers--A daily tabulation of the total number of persons engaged in maple sap production--excluding the operator, but including his immediate family.
3. Specific Activity--Use a short phrase to identify the work performed (e.g., hanging buckets).
4. Preparation--Includes labor time devoted to cleaning and repairing buckets, tapping equipment, snowshoes, etc. Also includes where appropriate the time spent in the clearing of woods roads.
5. Power Used--The amount of time the following pieces of equipment are in operation:
 - a. Washer (bucket or tubing).
 - b. Power Tapper.
 - c. Snowmobile.
 - d. Tractor.
 - e. Vacuum Pump.
6. Set-up--Includes the labor time involved in setting-up the collection system. This time will be recorded appropriately as follows:
 - a. Tapping--Time for boring the taphole, inserting germicidal pellets, and inserting spiles.
 - b. Bucket Layout and Hanging--Time used to layout, hang, and fit covers to the buckets in the sugarbush.

- c. Collection Tank Placement--Time used to install any collection tanks or storage reservoirs in the sugarbush.
 - d. Other--Time used in any other set-up activity not specifically covered in a thru d above.
 - e. Travel (To and From)--Transportation of equipment to the sugarbush will be included here, as will travel time of crews to and from the sugarbush.
- 7. Sap Gathering--Includes the labor time of all aspects of the sap collection phase recorded appropriately as follows:
 - a. Collection--In the bucket system, time spent collecting the sap from the individual taps. Also includes time spent dumping ice or spoiled sap as well as time required to determine if sap collection is warranted.
 - b. Maintenance--Time spent checking for leaks, repairing, and maintaining the collection system and associated equipment.
 - c. Other--Time used in any other sap gathering activity not specifically covered in a thru c.
 - d. Travel (To and From)--Transportation time to and from the sugarbush.
- 8. Sap Gathered--The number of gallons of sap gathered each day.
- 9. °Brix--The daily average of the percent sugar in the sap.
- 10. Take-down--Includes the labor time involved in disassembling the bucket system as well as the time for cleaning and storing equipment. Time for this activity will be recorded according to the following subdivision:
 - a. Buckets and Covers--Time spent removing spiles, buckets, and covers from individual trees and bunching them at an assembly point for transport to the area where they will be cleaned and stored.
 - b. Collection Tanks--Time used to take down any collection tanks or storage reservoirs.
 - c. Cleaning and Storage--Includes the labor time involved in washing and drying of buckets, etc., as well as the time used in checking and storing equipment. A midseason tank or bucket washing will be included in this category.

- d. Other--Will include the labor time involved in any take-down activity not specifically covered in a thru c above.
- e. Travel (To and From)--Transportation of the equipment from the sugarbush to the cleaning and storage area will be included here as will travel time of crews to and from the sugarbush.

APPENDIX H

DAILY TIME AND POWER RECORD FORMS--
TUBING SYSTEM

APPENDIX H

DAILY TIME AND POWER RECORD FORMS--TUBING SYSTEM

CONFIDENTIAL

Daily Time & Power Record (Preparation)

DATE ¹	TOTAL # HELPERS ²	SPECIFIC ACTIVITY ³	PREPARATION ⁴			POWER USED ⁵		
						WASHER (BKT. OR TUB.)	SNOWMOBILE	TRACTOR
***	***	***	Opr. Man- Hrs.	#	Help Man- Hrs.	NO. HOURS	NO. HOURS	NO. HOURS
Page Totals								

Record Hours to Nearest .25 Hour

Daily Time & Power Record
(Set-Up, Tubing)

CONFIDENTIAL

DATE ¹	TOT. ² # HELP- ERS	SPECIFIC ³ ACTIVITY	TAPPING 6A		TUBING 6B LAY. & HANG.		COLLECTION 6C TANK PLACEMENT			OTHER 6D			TRAVEL 6E (TO & FROM)			POWER USED 5		
			Opr.	Help	Opr.	Help	Opr.	Help	Opr.	Help	Opr.	Help	Opr.	Help	# Hrs	# Hrs	# Hrs	
			Man Hrs	# Man Hrs	Man Hrs	# Man Hrs	Man Hrs	# Man Hrs	Man Hrs	# Man Hrs	Man Hrs	# Man Hrs	Man Hrs	# Man Hrs	Man Hrs	# Man Hrs		
***	***	****																

Record Hours to Nearest .25 Hour

CONFIDENTIAL

Record Hours to Nearest .25 Hour

Daily Time & Power Record
(Take-Down, Tubing)

CONFIDENTIAL

[illegible]

Record Hours to Nearest .25 Hour

APPENDIX I

INSTRUCTIONS FOR DAILY TIME AND POWER
RECORD--TUBING SYSTEM

APPENDIX I

INSTRUCTIONS FOR DAILY TIME AND POWER

RECORD--TUBING SYSTEM

1. Date--Maintain a daily record of the various sap production activities and power used.
2. Number of Helpers--A daily tabulation of the total number of persons engaged in maple sap production--excluding the operator, but including his immediate family.
3. Specific Activity--Use a short phrase to identify the work performed (e.g., washing tubing).
4. Preparation--Includes labor time devoted to cleaning and repairing tubing, tapping equipment, snowshoes, etc. Also includes where appropriate the time spent in the clearing of woods roads.
5. Power Used--The amount of time the following pieces of equipment are in operation:
 - a. Washer (bucket or tubing).
 - b. Power Tapper.
 - c. Snowmobile.
 - d. Tractor.
 - e. Vacuum Pump.
6. Set-up--Includes the labor time involved in setting-up the collection system. This time will be recorded appropriately as follows:
 - a. Tapping--Time for boring the taphole, inserting germidical pellets, and inserting spiles.
 - b. Tubing Layout and Installation--Time used to layout and install the tubing system including the vacuum pump in the sugarbush.

- c. Collection Tank Placement--Time used to install any collection tanks or storage reservoirs in the sugarbush.
 - d. Other--Time used in any other set-up activity not specifically covered in a thru d above.
 - e. Travel (To and From)--Transportation of equipment to the sugarbush will be included here, as will travel time of crews to and from the sugarbush.
7. Sap Gathering--Includes the labor time of the sap collection phase recorded appropriately as follows:
- a. Maintenance--Time spent checking for leaks, repairing, and maintaining the collection system and associated equipment.
 - b. Other--Time used in any other sap gathering activity not specifically covered under maintenance.
 - c. Travel (To and From)--Transportation time to and from the sugarbush.
8. Sap Gathered--The number of gallons of sap gathered each day.
9. °Brix--The daily average of the percent sugar in the sap.
10. Take-down--Includes the labor time involved in disassembling the tubing system as well as the time for cleaning and storing equipment. Time for this activity will be recorded according to the following subdivision:
- a. Tubing System--Time spent disassembling the tubing system and bunching the equipment for transport to the cleaning and storage area.
 - b. Collection Tanks--Time used to take down any collection tanks or storage reservoirs.
 - c. Cleaning and Storage--Includes the labor time involved in washing and drying of tubing, etc., as well as the time used in checking and storing equipment. A midseason tank washing will be included in this category.
 - d. Other--Will include the labor time involved in any take-down activity not specifically covered in a thru c above.
 - e. Travel (To and From)--Transportation of the equipment from the sugarbush to the cleaning and storage area will be included here as will travel time of crews to and from the sugarbush.

APPENDIX J

MAPLE SAP EQUIPMENT INVENTORY FORM

--BUCKET SYSTEM

APPENDIX J

MAPLE SAP EQUIPMENT INVENTORY FORM--BUCKET SYSTEM

FORM #4
CONFIDENTIAL

1	2	3	4	5	6	7
Item	Units	Type	Quantity	Date Acquired	Cost or Value	Life Length
Bucket washer						
Bucket washer power source	horsepower					
Bucket paint	gals.					
Clorox	gals.					
Detergent	ozs.					
Power tapper(s)						
Hand drill(s)						
Drill bits						
Hammers						
Spouts & spiles						
Buckets						
Bucket covers						

MAPLE SAP EQUIPMENT INVENTORY FORM--BUCKET SYSTEM

FORM #4

CONFIDENTIAL

1	2	3	4	5	6	7
Item	Units	Type	Quantity	Date Acquired	Cost or Value	Life Length
Plastic collection bags						
Gathering pails						
Collection tanks						
Storage tanks - Intermed.						
Sap sled(s) or trailer(s)						
Tractor(s)						
Sap pump(s)						
Snowshoes						
Snowmobile(s)						
Snowmobile sled(s)						

APPENDIX K

MAPLE SAP EQUIPMENT INVENTORY FORM

--TUBING SYSTEM

APPENDIX K

MAPLE SAP EQUIPMENT INVENTORY FROM--TUBING SYSTEM

FORM #5

CONFIDENTIAL

1	2	3	4	5	6	7
Item	Units	Type	Quantity	Date Acquired	Cost or Value	Life Length
Tubing washer						
Tubing washer power source	Horsepower					
Clorox	Gals.					
Detergent	Ozs.					
Hand drill(s)						
Power tapper(s)						
Drill bits						
Hammer (Hatchet)						
Spouts & spiles						
5/16" Tubing	Feet					
1/2" Tubing	Feet					
3/4" Tubing	Feet					

MAPLE SAP EQUIPMENT INVENTORY FORM--TUBING SYSTEM

FORM #5

CONFIDENTIAL

1	2	3	4	5	6	7
Item	Units	Type	Quantity	Date Acquired	Cost or Value	Life Length
1" Tubing	Feet					
1-1/2" Tubing	Feet					
2" Tubing	Feet					
5/16" End caps						
5/16" T's						
1/2" Wyes						
3/4" Wyes						
1" Wyes						
5/16" Connectors						
1/2" Connectors						
3/4" Connectors						
1" Connectors						
1-1/4" Connectors						
1-1/2" Connectors						

MAPLE SAP EQUIPMENT INVENTORY FORM--TUBING SYSTEM

FORM #5

CONFIDENTIAL

1	2	3	4	5	6	7
Item	Units	Type	Quantity	Date Acquired	Cost or Value	Life Length
1/2" Clamps						
3/4" Clamps						
1" Clamps						
1" x 3/4" Reducers						
3/4" x 1/2" Reducers						
Pruning Shears						
Brake Pliers						
Clamp Pliers						
Spile Puller (Tubing)						
Screwdriver						
Other Tubing Accessories						
No. 9 wire	Feet					

MAPLE SAP EQUIPMENT INVENTORY FORM--TUBING SYSTEM

FORM #5

CONFIDENTIAL

1	2	3	4	5	6	7
Item	Units	Type	Quantity	Date Acquired	Cost or Value	Life Length
Wire ties						
Fence posts						
Marking tags (Avg. Ann.)						
Marking paint (Avg. Ann.)	Quarts					
Other marking equipment						
Vacuum pump & accessories ¹						
Sap pump(s)						
Storage (dumping) tank(s)						
Tractor						
Trailer (wagon)						

¹ Gauges, vacuum gauge (trouble shooting).

MAPLE SAP EQUIPMENT INVENTORY FORM--TUBING SYSTEM

FORM #5

CONFIDENTIAL

1	2	3	4	5	6	7
Item	Units	Type	Quantity	Date Acquired	Cost or Value	Life Length
Snowshoes						
Snowmobile(s)						
Snowmobile sled(s)						

APPENDIX L

ANNUAL OPERATING EXPENSES RECORD FORM

APPENDIX L

ANNUAL OPERATING EXPENSES RECORD FORM

CONFIDENTIAL

1 Item	2 Quantity	3 Unit Price	4 Total Cost
Custom work & machine rental	*****	*****	
Insurance--workmen's compensation	*****	*****	
Unemployment insurance	*****	*****	
Social Security	*****	*****	
Interest on borrowed money	*****	*****	
Real estate taxes	*****	*****	
Insurance--fire & theft	*****	*****	
Taphole pellets	*****	*****	
Repairs on equipment	*****	*****	

APPENDIX M

STANDARD EQUIPMENT LIST--BUCKET SYSTEMS

Table M-1.--Standard Equipment List--Bucket Systems.

Item	Price (1973)	Price Source	Quantity
Bucket Washer	\$ 130.00 ea.	a	1 per operation
Power Tapper	193.85 ea.	b	1 per operation
Hatchet	9.89 ea.	c	1 per operation
Spile	.17 ea.	a	1 per taphole
Bucket	1.30 ea.	a	1 per taphole
Cover	.40 ea.	a	1 per taphole
Gathering Pails	6.50 ea.	a	2 per crew member plus one spare
Tractors	6,185.00 ea.	d	Prorated according to usage
Collection Tank	220.00 ea.	a	1 each--1,000 tapholes or less 2 each--1,000 to 2,500 tapholes 3 each--more than 2,500 tapholes
Wagon	266.00 ea.	c	1 per collection tank
Sap Storage Tanks	.165 per gal.	c	2 gal. of storage capa- city per taphole
Snowmobile and Sled	1,000.00 ea.	e	Prorated according to usage

^aReynolds Sugar Bush, Aniwa, Wisconsin.

^bH & H Sales, Mason, Michigan.

^cSears, Roebuck and Co., Lansing, Michigan.

^dInternational Harvester Co., Lansing, Michigan.

^eAlleva's Sports and Marine Sales and Service, Lansing,
Michigan.

APPENDIX N

STANDARD EQUIPMENT LIST--TUBING SYSTEMS

Table N-1.--Standard Equipment List--Tubing Systems.

Item	Price (1973)	Price Source	Quantity
Tubing Washer	\$ 75.00 ea.	a	1 per operation
Power Tapper	193.85 ea.	b	1 per operation
Hatchet	9.89 ea.	c	1 per operation
Pruning Shears	2.88 ea.	c	1 per operation
Brake Pliers	2.47 ea.	c	1 per operation
Clamp Pliers	2.79 ea.	c	1 per operation
Screwdriver	1.60 ea.	c	1 per operation
Slip-Joint Pliers	1.88 ea.	c	1 per operation
Spile Puller	4.50 ea.	d	1 per operation
Tying Tool	1.50 ea.	d	1 per operation
Spile	.20 ea.	d	1 per taphole
5/16" Tubing	.045/ft.	d	13.62 ft. per taphole
1/2" Tubing	.035/ft.	c	1.17 ft. per taphole
3/4" Tubing	.06/ft.	c	.81 ft. per taphole
1" Tubing	.10/ft.	c	.15 ft. per taphole
5/16" T	.10 ea.	d	1.13 per taphole
3/4" Wye	1.00 ea.	d	.02 per taphole
1/2" Connector	.17 ea.	c	1 per 100' of 1/2" tubing
3/4" Connector	.20 ea.	c	1 per 100' of 3/4" tubing
1" Connector	.25 ea.	c	1 per 100' of 1" tubing
5/16" End Cap	.03 ea.	d	1 per 3/4" wye
1" x 3/4" Reducer	.65 ea.	d	1 per 500' of 3/4" tubing

Item	Price (1973)	Price Source	Quantity
3/4" x 1/2" Reducer	\$.40 ea.	d	3 per 1,000' of 1/2" tubing
1/2" Clamps	.05 ea.	d	2 per 1/2" connector, one per 3/4" x 1/2" reducer
3/4" clamps	.05 ea.	d	2 per 3/4" wye, 2 per 3/4" connector, one per reducer
#9 Aerial Wire	.012/ft.	c	1 foot per foot of 3/4" and 1" tubing
Post (Steel)	1.11 ea.	c	1 per 25' of #9 wire
Marking Tags	.05 ea.	d	8 per 3/4" wye
Sap Storage Tanks	.165/gal.	c	2 gal. of storage capa- city per taphole
Vacuum Pump Assembly	\$58-\$518 ea.	e	1 per operation
Tractor	6,185.00 ea.	f	Prorated according to usage
Snowmobile and Sled	1,000.00 ea.	g	Prorated according to usage

^aReynolds Sugar Bush, Aniwa, Wisconsin.

^bH & H Sales, Mason, Michigan.

^cSears, Roebuck and Co., Lansing, Michigan.

^dSugarbush Supplies, Lansing, Michigan.

^eCooperators using tubing system.

^fInternational Harvester Co., Lansing, Michigan.

^gAlleva's Sports and Marine Sales and Service, Lansing,
Michigan.

APPENDIX O

COMPUTATION OF OPERATION AND MAINTENANCE
COSTS--POWERED EQUIPMENT

APPENDIX O

COMPUTATION OF OPERATION AND MAINTENANCE

COSTS--POWERED EQUIPMENT

Tractors

Fuel and lubricant as well as repair costs for tractors were computed according to a procedure described in Bowers (1970).

Fuel and lubricant

$$\text{cost per hour} = \frac{\text{cost multiplier} \times \text{list price} \times \text{price/gallon}}{\$1,000}$$

$$\text{cost per hour} = \frac{.79 \times \$6,185 \times \$.183^1}{\$1,000} = \$.89$$

Repairs and maintenance

Repairs over the total life of a tractor average 120 percent of the list price.

$$\$6,185 \times 1.20 = \$7,422$$

$$\text{cost per hour} = \frac{\$7,422}{12,000} = \$.62$$

Total operation and maintenance cost per hour = \$.89 + \$.62 = \$1.51.

¹Quotation from Swans Fuel Service, Dansville, Michigan.

Snowmobiles

Operating and maintenance costs were based on cost data supplied by the Eastern Region of the U.S. Forest Service.² According to Forest Service records, 67 snowmobiles generated the following average costs:

Operating cost: \$.30 per hour

Maintenance Cost: 1.86 per hour

Total \$2.16

Vacuum Pumps

Operating costs for vacuum pumps were based on the size of the motor used to power the pump. At a cost per kilowatt hour of \$.0225,³ this worked out to be:

<u>Motor Horsepower</u>	<u>Operating Cost Per Hour</u>
1/4	\$.0068
1/3	.0090
1/2	.0129
3/4	.0188
1	.0225
1 1/2	.0338
2.0	.0450
3.0	.0675
5	.1012
7 1/2	.1575

Vacuum pump maintenance costs were based on cooperators' experience for the two seasons of data collection. Their average cost each year for repairs and maintenance was 2.5 percent of the value of the vacuum pump assembly.

²Breon, Duane G., 1972. Personal Communications.

³Quotation from Consumers Power Company, Lansing, Michigan.

Bucket and Tubing Washers

Operating costs for bucket and tubing washers were computed in the same manner as those for vacuum pumps. The charges for each were:

Bucket Washer--1/3 H.P. \$.0090 per hour

Tubing Washer--1/6 H.P. .0048 per hour

Maintenance on these two pieces of equipment is practically nil. As there was no basis for any charges, none were made.

APPENDIX P

MATERIAL EXPENSES--ANNUAL BASIS

Table P-1.--Material Expenses--Annual Basis.

Item	Price	Price Source	Quantity
Germicidal Pellet	\$.01 each	a	one per taphole
Drill Bit	\$2.25 each	a	one per 500 tapholes
Clorox			
Buckets	\$.54/gal.	b	1.6 + .0008 (number tapholes) ^d
Tubing	\$.54/gal.	b	3.1 + .005 (number tapholes) ^d
Detergent			
Buckets	\$2.59/oz.	b	34.4 + .009 (number tapholes) ^d
Tubing	\$2.59/oz.	b	not used
Wire Ties	\$.004 each	c	one per 3' of #9 wire
Washer Brush	\$16.00 each	a	one per 6,000 washings
Spray Paint	\$.99/13 oz. can	b	4.3 + .025 (number tapholes) ^d

^aReynolds Sugar Bush, Aniwa, Wisconsin.

^bMeijer's Thrifty Acres, Lansing, Michigan.

^cSugarbush Supplies, Lansing, Michigan.

^dBasis: correlation analysis of actual quantities used by the study's cooperators.

APPENDIX Q

COST OF MAPLE SAP PRODUCTION BY OPERATION

Table Q-1.--Cost of Maple Sap Production, Operation B-1,
Bucket System.

Item	Season	
	1972	1973
Number of tapholes	500	500
Gallons of sap	8,365	4,005
Gallons sap per taphole	16.73	8.01
	Dollars	
Management	45.00	45.00
Fixed equipment	327.88	306.88
Equipment operation and maintenance	104.42	66.26
Material expenses	10.70	10.70
Taphole rental	50.00	50.00
Labor (without workmen's compensation)	508.27	358.28
Subtotal	1,046.27	837.12
Workmen's compensation premium	183.00	183.00
Total cost	1,229.27	1,020.12

Table Q-2.--Cost of Maple Sap Production, Operation B-8,
Bucket System.

Item	Season	
	1972 ^a	1973
Number of tapholes	. .	800
Gallons of sap	. .	7,700
Gallons sap per taphole	. .	9.62
Dollars		
Management	. .	51.00
Fixed equipment	. .	409.75
Equipment operation and maintenance	. .	106.44
Material expenses	. .	17.00
Taphole rental	. .	80.00
Labor (without workmen's compensation)	. .	566.04
Subtotal	. .	1,230.23
Workmen's compensation premium	. .	183.00
Total Cost	. .	1,413.23

^aNot in the study in 1972.

Table Q-3.--Cost of Maple Sap Production, Operation B-2a,
Bucket System.

Item	Season	
	1972	1973
Number of tapholes	850	850
Gallons of sap	14,055	5,285
Gallons sap per taphole	16.54	6.22
Dollars		
Management	51.00	51.00
Fixed equipment	418.21	398.29
Equipment operation and maintenance	90.51	54.27
Material expenses	17.60	17.60
Taphole rental	85.00	85.00
Labor (without workmen's compensation)	380.54	208.82
Subtotal	1,042.86	814.98
Workmen's compensation premium	183.00	183.00
Total cost	1,225.86	997.98

Table Q-4.--Cost of Maple Sap Production, Operation B-2b,
Bucket System.

Item	Season	
	1972	1973
Number of tapholes	920	960
Gallons of sap	15,030	9,256
Gallons sap per taphole	16.34	9.64
Dollars		
Management	51.00	54.00
Fixed equipment	446.22	443.25
Equipment operation and maintenance	113.84	92.80
Material expenses	18.55	19.05
Taphole rental	92.00	96.00
Labor (without workmen's compensation)	699.07	465.34
Subtotal	1,420.68	1,170.44
Workmen's compensation premium	183.00	183.00
Total cost	1,603.68	1,353.44

Table Q-5.--Cost of Maple Sap Production, Operation B-4,
Bucket System.

Item	Season	
	1972	1973
Number of tapholes	960	970
Gallons of sap	15,980	8,400
Gallons sap per taphole	16.65	8.66
Dollars		
Management	54.00	54.00
Fixed equipment	434.33	426.29
Equipment operation and maintenance	76.47	51.17
Material expenses	19.05	19.20
Taphole rental	96.00	97.00
Labor (without workmen's compensation)	305.81	378.78
Subtotal	985.66	1,026.44
Workmen's compensation premium	183.00	183.00
Total cost	1,168.66	1,209.44

Table Q-6.--Cost of Maple Sap Production, Operation B-9,
Bucket System.

Item	Season	
	1972 ^a	1973
Number of tapholes	. .	1,550
Gallons of sap	. .	9,030
Gallons sap per taphole	. .	5.83
Dollars		
Management	. .	63.00
Fixed equipment	. .	668.54
Equipment operation and maintenance	. .	62.45
Material expenses	. .	29.20
Taphole rental	. .	155.00
Labor (without workmen's compensation)	. .	433.54
Subtotal	. .	1,411.73
Workmen's compensation premium	. .	183.00
Total cost	. .	1,594.73

^aNot in the study in 1972.

Table Q-7.--Cost of Maple Sap Production, Operation B-4a,
Bucket System.

Item	Season	
	1972 ^a	1973
Number of tapholes	. .	1,950
Gallons of sap	. .	14,670
Gallons sap per taphole	. .	7.52
	Dollars	
Management	. .	72.00
Fixed equipment	. .	793.14
Equipment operation and maintenance	. .	88.88
Material expenses	. .	36.80
Taphole rental	. .	195.00
Labor (without workmen's compensation)	. .	563.39
Subtotal	. .	1,749.21
Workmen's compensation premium	. .	183.00
Total cost	. .	1,932.21

^aNot in the study in 1972.

Table Q-8.--Cost of Maple Sap Production, Operation B-5b,
Bucket System.

Item	Season	
	1972	1973
Number of tapholes	1,650	1,978
Gallons of sap	6,900	12,275
Gallons sap per taphole	4.18	6.21
Dollars		
Management	66.00	72.00
Fixed equipment	553.83	786.78
Equipment operation and maintenance	56.28	63.26
Material expenses	32.75	37.18
Taphole rental	165.00	197.80
Labor (without workmen's compensation)	473.82	514.10
Subtotal	1,347.68	1,671.12
Workmen's compensation premium	183.00	183.00
Total cost	1,530.68	1,854.12

Table Q-9.--Cost of Maple Sap Production, Operation B-4b,
Bucket System.

Item	Season	
	1972 ^a	1973
Number of tapholes	. .	2,000
Gallons of sap	. .	22,350
Gallons sap per taphole	. .	11.18
Dollars		
Management	. .	72.00
Fixed equipment	. .	883.84
Equipment operation and maintenance	. .	231.02
Material expenses	. .	37.45
Taphole rental	. .	200.00
Labor (without workmen's compensation)	. .	1,141.62
Subtotal	. .	2,565.93
Workmen's compensation premium	. .	183.00
Total cost	. .	2,748.93

^aNot in the study in 1972.

Table Q-10.--Cost of Maple Sap Production, Operation B-6,
Bucket System.

Item	Season	
	1972	1973
Number of tapholes	2,025	2,025
Gallons of sap	32,170	15,730
Gallons sap per taphole	15.89	7.77
Dollars		
Management	72.00	72.00
Fixed equipment	881.16	852.11
Equipment operation and maintenance	201.68	148.99
Material expenses	37.75	37.75
Taphole rental	202.50	202.50
Labor (without workmen's compensation)	969.37	817.79
Subtotal	2,364.46	2,131.14
Workmen's compensation premium	183.00	183.00
Total cost	2,547.46	2,314.14

Table Q-11.--Cost of Maple Sap Production, Operation B-5a,
Bucket System.

Item	Season	
	1972	1973
Number of tapholes	2,100	2,100
Gallons of sap	14,780	12,215
Gallons sap per taphole	7.04	5.82
	Dollars	
Management	75.00	75.00
Fixed equipment	924.52	851.72
Equipment operation and maintenance	149.14	125.88
Material expenses	41.05	41.05
Taphole rental	210.00	210.00
Labor (without workmen's compensation)	959.30	639.71
Subtotal	2,359.01	1,943.36
Workmen's compensation premium	183.00	183.00
Total cost	2,542.01	2,126.36

Table Q-12.--Cost of Maple Sap Production, Operation B-7,
Bucket System.

Item	Season	
	1972	1973
Number of tapholes	2,605	2,685
Gallons of sap	49,975	29,897
Gallons sap per taphole	19.18	11.13
Dollars		
Management	84.00	84.00
Fixed equipment	1,194.51	1,114.49
Equipment operation and maintenance	346.45	166.22
Material expenses	50.00	51.05
Taphole rental	260.50	268.50
Labor (without workmen's compensation)	1,654.13	1,402.91
Subtotal	3,589.59	3,087.17
Workmen's compensation premium	183.00	183.00
Total cost	3,772.59	3,270.17

Table Q-13.--Cost of Maple Sap Production, Operation T-1b,
Tubing System.

Item	Season	
	1972	1973
Number of tapholes	300	300
Gallons of sap	1,400	1,150
Gallons sap per taphole	4.67	3.83
Dollars		
Management	39.00	39.00
Fixed equipment	129.80	126.76
Equipment operation and maintenance	7.87	2.11
Material expenses	8.97	8.97
Taphole rental	30.00	30.00
Labor (without workmen's compensation)	154.76	114.48
Subtotal	370.40	321.32
Workmen's compensation premium	183.00	183.00
Total cost	553.40	504.32

Table Q-14.--Cost of Maple Sap Production, Operation T-1a,
Tubing System.

Item	Season	
	1972	1973
Number of tapholes	550	550
Gallons of sap	5,960	1,640
Gallons sap per taphole	10.84	2.98
	Dollars	
Management	45.00	45.00
Fixed equipment	197.35	201.48
Equipment operation and maintenance	7.51	13.95
Material expenses	15.16	15.16
Taphole rental	55.00	55.00
Labor (without workmen's compensation)	300.65	163.24
Subtotal	620.67	493.83
Workmen's compensation premium	183.00	183.00
Total cost	803.67	676.83

Table Q-15.--Cost of Maple Sap Production, Operation T-3,
Tubing System.

Item	Season	
	1972 ^a	1973
Number of tapholes	. .	600
Gallons of sap	. .	2,854
Gallons sap per taphole	. .	4.76
Dollars		
Management	. .	45.00
Fixed equipment	. .	209.21
Equipment operation and maintenance	. .	9.14
Material expenses	. .	15.92
Taphole rental	. .	60.00
Labor (without workmen's compensation)	. .	109.18
Subtotal	. .	448.45
Workmen's compensation premium	. .	183.00
Total cost	. .	631.45

^aNot in the study in 1972.

Table Q-16.--Cost of Maple Sap Production, Operation T-2a,
Tubing System.

Item	Season	
	1972	1973
Number of tapholes	900	900
Gallons of sap	7,370	7,972
Gallons sap per taphole	8.19	8.86
Dollars		
Management	51.00	51.00
Fixed equipment	285.43	285.43
Equipment operation and maintenance	6.92	7.69
Material expenses	20.65	20.65
Taphole rental	90.00	90.00
Labor (without workmen's compensation)	152.64	146.81
Subtotal	606.64	601.58
Workmen's compensation premium	183.00	183.00
Total cost	789.64	784.58

Table Q-17.--Cost of Maple Sap Production, Operation T-2b,
Tubing System.

Item	Season	
	1972	1973
Number of tapholes	1,000	1,000
Gallons of sap	9,835	6,040
Gallons sap per taphole	9.84	6.04
Dollars		
Management	54.00	54.00
Fixed equipment	312.40	317.98
Equipment operation and maintenance	12.67	18.80
Material expenses	22.18	22.18
Taphole rental	100.00	100.00
Labor (without workmen's compensation)	265.00	204.05
Subtotal	766.25	717.01
Workmen's compensation premium	183.00	183.00
Total cost	949.25	900.01

Table Q-18.--Cost of Maple Sap Production, Operation T-5,
Tubing System.

Item	Season	
	1972	1973
Number of tapholes	1,100	1,000
Gallons of sap	5,950	4,550
Gallons sap per taphole	5.41	4.55
Dollars		
Management	54.00	54.00
Fixed equipment	439.37	312.83
Equipment operation and maintenance	61.90	11.63
Material expenses	26.11	22.18
Taphole rental	110.00	100.00
Labor (without workmen's compensation)	167.48	251.22
Subtotal	858.86	751.86
Workmen's compensation premium	183.00	183.00
Total cost	1,041.86	934.86

Table Q-19.--Cost of Maple Sap Production, Operation T-8,
Tubing System.

Item	Season	
	1972 ^a	1973
Number of tapholes	. .	1,400
Gallons of sap	. .	17,710
Gallons sap per taphole	. .	12.65
Dollars		
Management	. .	60.00
Fixed equipment	. .	417.40
Equipment operation and maintenance	. .	21.17
Material expenses	. .	30.79
Taphole rental	. .	140.00
Labor (without workmen's compensation)	. .	390.08
Subtotal	. .	1,059.44
Workmen's compensation premium	. .	183.00
Total cost	. .	1,242.44

^aNot in the study in 1972.

Table Q-20.--Cost of Maple Sap Production, Operation T-3a,
Tubing System.

Item	Season	
	1972 ^a	1973
Number of tapholes	. .	1,445
Gallons of sap	. .	27,775
Gallons sap per taphole	. .	19.22
Dollars		
Management	. .	63.00
Fixed equipment	. .	440.01
Equipment operation and maintenance	. .	29.52
Material expenses	. .	31.45
Taphole rental	. .	144.50
Labor (without workmen's compensation)	. .	418.70
Subtotal	. .	1,127.18
Workmen's compensation premium	. .	183.00
Total cost	. .	1,310.18

^aNot in the study in 1972.

Table Q-21.--Cost of Maple Sap Production, Operation T-4a,
Tubing System.

Item	Season	
	1972	1973
Number of tapholes	1,800	1,800
Gallons of sap	14,735	15,944
Gallons sap per taphole	8.19	8.86
Dollars		
Management	69.00	69.00
Fixed equipment	530.35	521.97
Equipment operation and maintenance	17.54	14.67
Material expenses	39.31	39.31
Taphole rental	180.00	180.00
Labor (without workmen's compensation)	563.92	499.79
Subtotal	1,400.12	1,324.74
Workmen's compensation premium	183.00	183.00
Total cost	1,583.12	1,507.74

Table Q-22.--Cost of Maple Sap Production, Operation T-4b,
Tubing System.

Item	Season	
	1972	1973
Number of tapholes	2,200	2,000
Gallons of sap	17,700	5,651
Gallons sap per taphole	8.05	2.83
Dollars		
Management	75.00	72.00
Fixed equipment	697.81	689.02
Equipment operation and maintenance	61.67	80.36
Material expenses	47.86	42.41
Taphole rental	220.00	200.00
Labor (without workmen's compensation)	443.08	448.38
Subtotal	1,545.42	1,532.17
Workmen's compensation premium	183.00	183.00
Total cost	1,728.42	1,715.17

Tabld Q-23.--Cost of Maple Sap Production, Operation T-6,
Tubing System.

Item	Season	
	1972	1973
Number of tapholes	1,960	2,011
Gallons of sap	9,075	15,200
Gallons sap per taphole	4.63	7.56
	Dollars	
Management	72.00	72.00
Fixed equipment	610.29	624.77
Equipment operation and maintenance	44.07	51.14
Material expenses	41.81	42.68
Taphole rental	196.00	201.10
Labor (without workmen's compensation)	316.94	307.93
Subtotal	1,281.11	1,299.62
Workmen's compensation premium	183.00	183.00
Total cost	1,464.11	1,482.62

Table Q-24.--Cost of Maple Sap Production, Operation T-7,
Tubing System.

Item	Season	
	1972	1973
Number of tapholes	2,550	2,850
Gallons of sap	13,100	17,950
Gallons sap per taphole	5.14	6.30
Dollars		
Management	81.00	87.00
Fixed equipment	904.05	923.14
Equipment operation and maintenance	121.95	95.77
Material expenses	55.62	60.35
Taphole rental	255.00	285.00
Labor (without workmen's compensation)	1,182.96	1,232.78
Subtotal	2,600.58	2,684.04
Workmen's compensation premium	183.00	183.00
Total cost	2,783.58	2,867.04