SUGAR MAPLE AND ITS USE FOR SAP PRODUCTION IN MICHIGAN'S LOWER PENINSULA

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Ralph D. Nyland

1966

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in Michigan's Lower Peninsula

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Ralph D. Nyland

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of the requirements for

Ph. D. degree in Forestry

V. J. Rudolph
Major professor

Date November 18, 1966

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ABSTRACT

SUGAR MAPLE AND ITS USE FOR SAP PRODUCTION
IN MICHIGAN'S LOWER PENINSULA

by Ralph D. Nyland

Four aspects of present and potential sap production in Michigan's Lower Peninsula were investigated: (1) the sugar maple resource, (2) characteristics of the maple syrup industry, (3) plans for future tapping, and (4) the potential for additional tapping. Data from the 1949 Michigan Forest Survey were used to appraise the northern hardwood forests, and a sample of active producers provided information about the maple syrup industry.

The study considers the location, structure, and extent of sugar maple resources within the Lower Peninsula. In addition, the economics of tapping these forests were studied by cost analysis, and the minimum taphole stocking needed for commercial tapping determined. These show that stocking is relatively unimportant if tapping is integrated with sap processing operations. However, because of transportation charges incurred when sap is sold to a central evaporator plant, taphole stocking must exceed certain well-defined limits before stands can be tapped for that purpose.

Data show that Lower Peninsula forests contain a vast resource of sugar maple suited for commerical tapping. Of the 22 million tapholes available in the Peninsula in 1950, 21 million were suited for use by integrated sap-syrup enterprises, 13 million for tapping with roadside sap sale, and 10 million for use if sap is delivered to a central evaporator plant. Studies of producer-owned lands show that the resource will grow about 1 taphole per acre per year in the southern counties and 3 tapholes per acre per year in the northern region.

Small antiquated and inefficient operations characterize the present maple syrup industry. Virtually all operators collect sap by costly hand-gathering methods, and 40 percent use less than 500 tapholes. Although producers use only 75 percent of the tapholes available on their lands, 44 percent tap neighboring properties. In 1965, tapholes installed on non-producer owned lands accounted for 30 percent of the total used. Sap from 57 percent of the total tapholes used was processed in saphouses unfit for sanitary sap processing.

In recent years, many maple syrup businesses terminated production. Yet, tapping has increased since 1960 to stop the previous declining trend. This resulted from increased tapping in the northern half of the Peninsula, offsetting continued declines in the southern counties. It is forecast that by 1975, 35 percent of present operations will terminate production. Tapping will decrease six percent in the southern region, but be offset by a 10 percent increase in the north. Expected tapping for 1975 will be 3 percent above current levels, with 37 percent of the total on non-producer owned lands.

In 1975, the industry plans to use only 381,000 of the more than 21 million tapholes available. Future production will not be limited by lack of tappable resources. Rather, the poor condition of most saphouses and the inefficient production methods now employed appear the major deterrents. Strict enforcement of Michigan health laws could reduce planned tapping by 42 percent. Also, rising costs may force closure of many inefficient enterprises. To maintain itself, the industry must revolutionize production methods.

While the Lower Peninsula contains ample forest resources to support a larger industry than is planned for 1975, scarcity of tappable stands and pressures of urbanism make certain regions unattractive as locations for new centralized plants. However, the 12 northwestern counties appear to offer good opportunities for introducing about 12 large central evaporator plants that require sap delivery.

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By

Ralph D. Nyland

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INTRODUCTION

During the past 45 years maple syrup production declined as an economic activity in Michigan's Lower Peninsula. However, the recent development of labor saving devices for use in maple sap and syrup production and the promise of profits from operating automated central evaporator plants raise some hope that syrup manufacture can be revitalized within the state. This possibility is enhanced by the emergence into tappable size of vast second-growth forests within the northern counties.

Although much basic information was available relative to the potential for maple sap production in Michigan's Lower Peninsula, it had not been assembled or appraised. Neither had the northern hardwood forest been studied relative to use by an industry composed of central evaporator plants, or to determine if these forests could adequately support commercial tapping enterprises.

In 1964, the Department of Forestry, Michigan State University, initiated this study of the northern hardwood resource and the maple syrup industry within the Lower Peninsula. The project was organized around four major objectives:

1. to appraise the sugar maple resource and its condition, nature, location, growth and suitability for tapping;
2. to determine characteristics of the maple syrup industry;
3. to learn what the industry plans for the future;
4. to study the potential for expanding production in the Lower Peninsula, and to identify geographic regions best suited to accommodate a new industry of central evaporator plants.

REVIEW OF LITERATURE

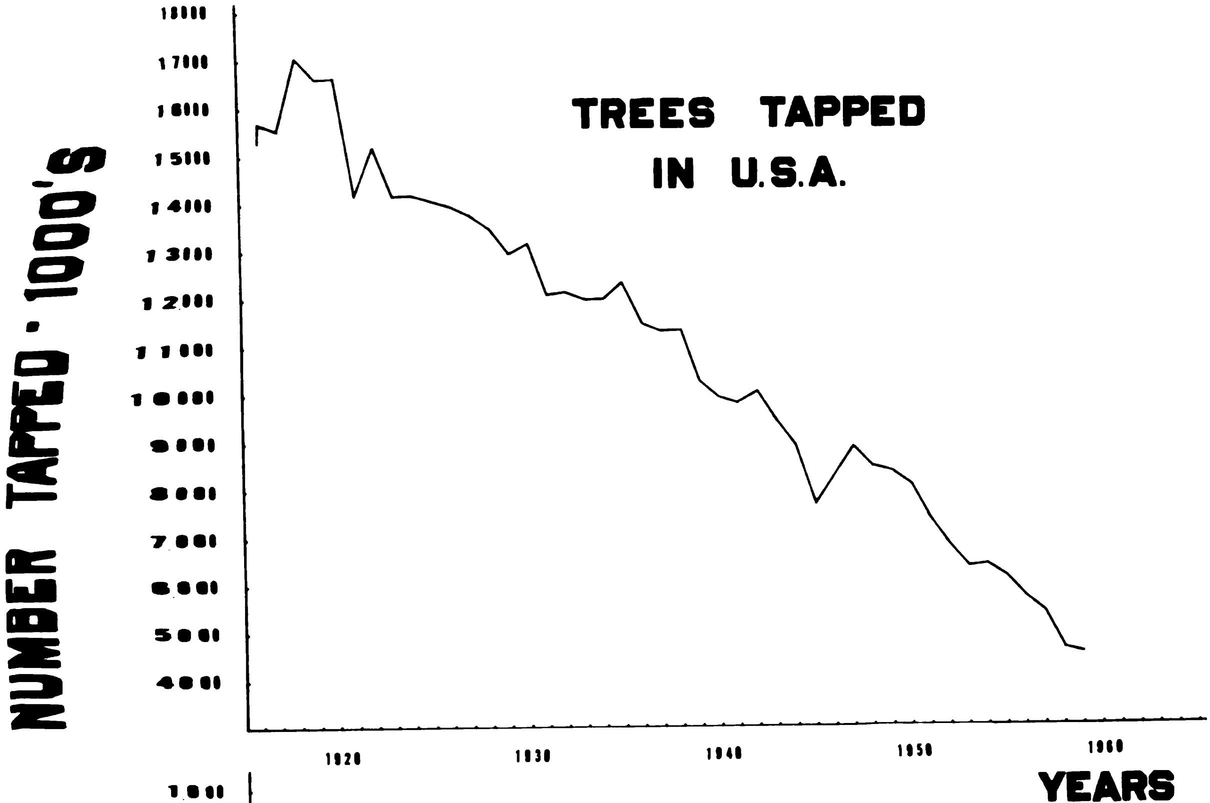
Evolution of Maple Syrup Production

History and Importance in Michigan

Maple syrup production has declined in Michigan and throughout the United States since the turn of the century (Figure 1) (Stat. Rept. Ser., 1962). In 1960, tapping was only about one-third that recorded for 1918. Today, maple syrup manufacture contributes little to the economy of the state (Table 1). Despite a 24 percent increase in tapping between 1959 and 1964 (Table 2), in 1965, the value of Michigan's maple production amounted to just 0.05 percent of the state's total agricultural cash receipts (Mich. Dept. Agr., 1966).

Writers attribute the general decline of syrup manufacture since 1918 to three major factors. First, beginning in the early 1900's timber prices rose and much of the tappable resource was cut. Then, during and after World War II, labor became increasingly scarce and costly. Lastly, production, equipment, and material costs climbed at a greater rate than syrup's sale price, reducing the profit margin (Bell, 1955; Foulds and Reed, 1962; Laing *et al.*,

Figure 1. Number of trees tapped in Michigan and the United States, 1918-1959 (Stat. Rept. Ser., 1962).


TREES TAPPED
IN U.S.A.
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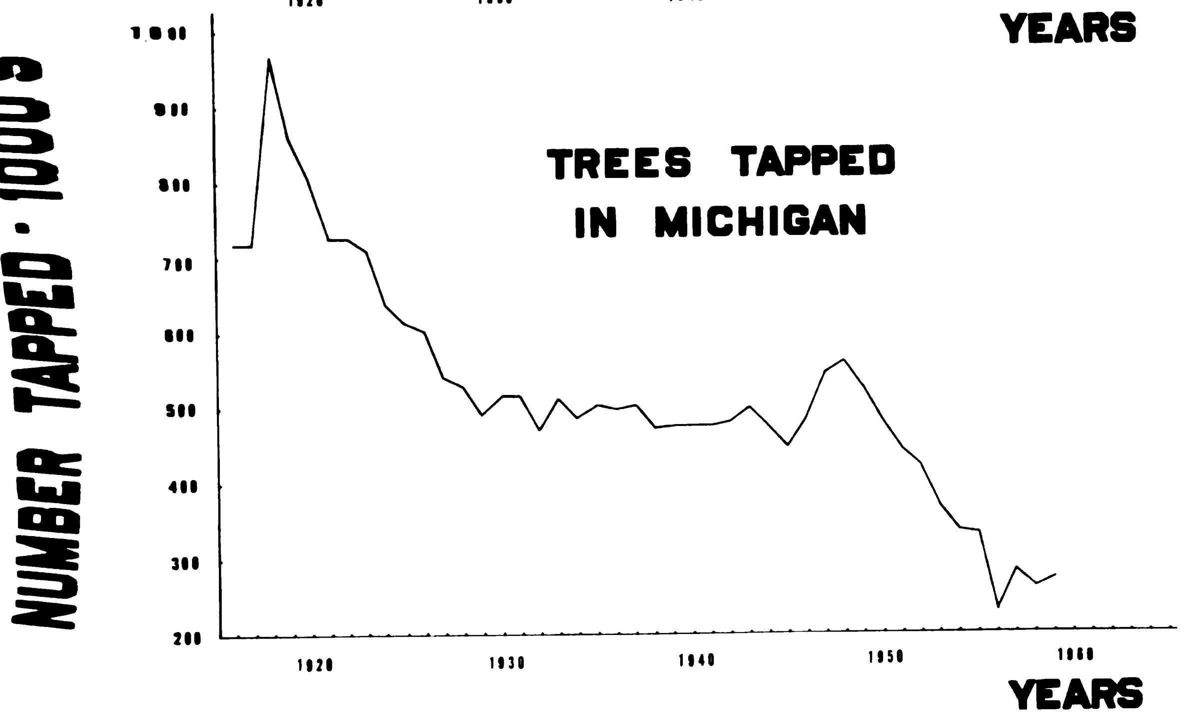
TREES TAPPED
IN MICHIGAN
NUMBER TAPPED · 1000'S
YEARS
900
800
700
600
500
400
300
200
1920
1930
1940
1950
1960

Table 1. Maple syrup production and its value in Michigan, 1955-1966[a]

Year	Syrup produced	Value of maple products
	Thousand gallons	Thousand dollars
1955	78	413
1956	79	427
1957	81	437
1958	99	538
1959	66	363
1960	65	367
1961	82	459
1962	73	405
1963	52	286
1964	96	556
1965	60	366
1966[b]	78	475[c]

[a]Source: Mich. Dept. Agr., 1965, 1966.

[b]Source: Stat. Rept. Ser., 1966.

[c]Estimated by evaluating the total production for 1966 at $6.10 per gallon, the value of syrup for 1965 reported in Michigan Agriculture Statistics (Mich. Dept. Agr., 1966).

Table 2. Tapping in Michigan's Lower Peninsula, 1949-1964[a]

Year	Number of producing farms	Tapholes used
1949	2,968	...[b]
1954	1,590	...[b]
1959	976	300,531
1964	810	372,721

[a]Source: U.S. Bur. Census, 1954, 1961, 1966.

[b]Resource used in 1949 and 1954 was recorded as the number of trees tapped. The actual number of tapholes involved is not available.

1960; Robbins, 1950; Stat. Rept. Ser., 1962; Willits, 1965; Wolfe, 1966). In addition, Wolfe (1966) alleges that changes in rural customs and practices also contributed to the decline.

Even though maple syrup production may be relatively unimportant to the economy of large regions, several analysts contend that it contributes significantly to income of many individual families and is vital to dozens of small communities (Bell, 1955; England and Tompkins, 1956; McIntyre, 1932; Moore et al., 1951; Underwood and Willits, 1963; Willits, 1965). In this respect, in 1949 nearly 3,000 farms in 68 of the Lower Peninsula counties realized some income from maple sap processing. But from 1949 to 1964, the number dropped to 810 farms in 63 counties (Table 2).

Modernization of Production Techniques

Production of maple sap and syrup by traditional methods requires much labor. However, research in recent years has provided the means to improve efficiency. For example, from this research has come the use of power drills, plastic tubing, vacuum pumps, and paraformaldehyde pellets for use in sap production, and the advent of automated equipment and better techniques for handling and processing sap in the evaporator plant. Besides helping the maple syrup industry to realize more consistent yields of high quality products, this new technology enables producers to decrease inputs of labor and, therefore, reduce operating costs (Snow, 1964; Underwood and Willits, 1963; Willits, 1962, 1965; Wolfe, 1966). As a result, some writers feel that the new technology offers the potential to help transform sap processing from a household activity to a commercial enterprise capable of competing with other businesses for capital, labor, and land (Moore et al., 1951; Willits and Sipple, 1961).

With modern equipment and techniques, producers can assemble large evaporating plants that can be operated with low inputs of labor. Based on their cost studies, Pasto and Taylor (1962) hypothesize that such large-volume production will minimize operating costs and prove economically attractive. But because of the large investment in equipment, the plants must operate at maximum capacity (Pasto and Taylor, 1962).

To devote full time to processing, some producers purchase sap from independent sapping enterprises rather than gather it themselves. Since 1955, several centralized plants have been established and operate satisfactorily with these sap purchasing arrangements (Anonymous, 1962; Mears, 1962; Peterson, 1962; Weber, 1960; Willits, 1965). While it is generally accepted that profits can be realized from selling sap to the central evaporator plants, this opinion has hitherto not been supported by cost analysis.

Sugar Maple in Michigan's Lower Peninsula

Forest Types Containing Sugar Maple

Two major forest regions converge within Michigan's Lower Peninsula. In the north half, the Northern Forest Region occupies the area overlaid with podzol soils. Within these forests, sugar maple (*Acer saccharum* Marsh.)[1] is a predominant member of two cover types of the northern hardwood-hemlock type group; namely the sugar maple-beech-yellow birch cover type and the sugar maple cover type. In the southern portion of the Peninsula where grey-brown podzolic soils predominate, the forest composition changes to that of the Central Forest Region. There sugar maple is plentiful only in the beech-sugar maple cover type[2] (Soc. Am. For., 1954).

The 1947-1949 Michigan Forest Survey combined the three distinct cover types mentioned above into one broad type group called "northern hardwood" (Table 3). This northern hardwood type[3] is stocked with 50 percent or more sugar maple, yellow birch (*Betula alleghaniensis* Brit.), American

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[1] Scientific and common names follow Little (1953).

[2] Forest classifications by Braun (1950), Hansen (1962), and DenUyl (1962) apply different terminology to the regions, but generally divide the Lower Peninsula in the manner described above.

[3] Future references to northern hardwoods in any context refer to this Forest Survey classification.

Table 3. Lower Peninsula forest cover types containing sugar maple as a chief component[a]

Cover type	Type group classification: Society of American Foresters	Type group classification: Michigan Forest Survey
Sugar maple-beech yellow birch	Northern hardwood-hemlock	Northern hardwood
Sugar maple	Northern hardwood-hemlock	Northern hardwood
Beech-sugar maple	Beech-sugar maple	Northern hardwood

[a]Source: Soc. Am. For., 1954; Chase and Horn, 1950.

beech (Fagus grandifolia Ehrh.), and American basswood (Tilia americana L.), occurring singly or in combination (Chase and Horn, 1950; Findell et al., 1960). Normally sugar maple comprises more than 25 percent of the trees in a stand (Eyre and Zillgitt, 1953).

Distribution and Stocking of Northern Hardwoods in the Lower Peninsula

The 10,290,000 acres of forest land (98 percent commercial) contained within the Lower Peninsula (Findell et al., 1960) are not uniformly distributed. Rather, in 1950 the bulk was situated in the northern 33 counties. There, northern hardwoods occupied approximately 1,049,700 acres. Pole size stands predominated, and sawtimber accounted for only 17 percent of the northern hardwood area. By contrast, in 1950 the southern portion of the Peninsula contained only 373,200 acres of northern hardwood forest. But sawtimber was about 1.5 times more plentiful there than in the northern counties, and poletimber accounted for only 13 percent of the northern hardwoods (Chase, 1953; Chase and Horn, 1950, 1955, 1956; Essex et al., 1955; Quinney et al., 1957a, 1957b; Rapp et al., 1957).

Table 4 summarizes the acreage of northern hardwoods in the Lower Peninsula. It should be noted, however, that these data are more than 15 years old. Findell et al. (1960), point out that between 1935 and 1955, significant shifts

Table 4. Distribution of northern hardwood forest lands in Michigan's Lower Peninsula by area and stand size class, 1947-1949[a]

Stand size class	Region: Northern half of Lower Peninsula	Region: Southern half of Lower Peninsula
	Acres	Acres
Large sawtimber	54,200	177,600
Small sawtimber	128,600	105,300
Poletimber	455,500	50,200
Seedling-sapling	411,400	40,100
Total area	1,049,700	373,200

[a]Source: Chase, 1953; Chase and Horn, 1950, 1955, 1956; Essex *et al*., 1955; Quinney *et al*., 1957a, 1957b; Rapp *et al*., 1957.

[b]Size classes are defined as follows (Chase and Horn, 1950):

Sawtimber--at least 1,500 bd.ft. per acre (Int.) in trees 11 inches d.b.h. or larger.

Large sawtimber--more than half the net volume in trees 15 inches and larger d.b.h.

Poletimber--10 percent or more stocked with trees 5.0 to 10.9 inches d.b.h., and at least 3 cords per acre.

Seedling-sapling--10 percent or more stocked with commercial species, at least half of which are seedling-sapling size.

occurred in the relative proportions of area in different size classes. In that period, the proportion of hardwood poletimber increased 16 percent while hardwood sawtimber decreased 10 percent. Some shifts likely continued past 1950, but the amount of change in the area by size class occurring since that time is not known.

The structure of the northern hardwood forests within Michigan's Lower Peninsula has not previously been described. However, generalized estimates of stocking by the 1947-1949 Forest Survey show that the bulk of commercial forests were poorly stocked. To illustrate, in the northern 33 counties only 10 to 20 percent qualified as well stocked, and 30 to 40 percent medium or well stocked.[4] Likewise, within the lower portion of the Peninsula, only 41 to 43 percent of forest lands were found adequately stocked and just a small portion well stocked (Chase, 1953; Chase and Horn, 1950, 1955, 1956; Essex *et al*., 1955; Quinney *et al*., 1957a, 1957b; Rapp *et al*., 1957).

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[4]Well stocked stands effectively use 70 percent or more of the available growing space, medium stocked stands use 40 to 69 percent, and poorly stocked areas only 10 to 39 percent (Chase and Horn, 1950).

Forest Ownership in the Lower Peninsula

Lower Peninsula forest lands are primarily in highly fragmented private ownerships. Within the northern 33 counties, these private individuals and corporations control 65 percent of the forest resource, and jointly hold 76 percent of the northern hardwoods. Farmer groups alone own 40 percent of the total northern hardwood resource (Table 5) (Chase and Horn, 1955, 1956; Findell *et al.*, 1960; Quinney *et al.*, 1957a, 1957b; Rapp *et al.*, 1957; Yoho, 1956; Yoho *et al.*, 1957).

Forest lands in the southern 35 counties are, by contrast, 91 percent privately owned. But these 2,428,000 acres are segmented into 127,000 different ownerships with two-thirds of them less than 25 acres each. Although farmers own the largest portion of commercial forest, their ownership of northern hardwoods is not known (Table 5) (Findell *et al.*, 1960; Schallau, 1961, 1962).

The bulk of Lower Peninsula private forest land is held by growing numbers of non-resident owners, with just 38 percent of the total forest area occupied regularly. For the northern region, only 28 percent of the owners, who control 28 percent of the forest area, live on the land. By contrast, in the southern counties, 64 percent of owners live at the site of their forest holdings. Absentee owners control just 41 percent of the forest area. Throughout the

Table [illegible]. Private forest ownerships in Michigan's Lower Peninsula[a]

Table 5. Private forest ownerships in Michigan's Lower Peninsula[a]

Owner group	Northern 33 counties: Woodland size	Owners	Forest area	Northern hardwoods	Southern 35 counties: Woodland size	Owners	Forest area
	Acres	Percent	Percent	Percent	Acres	Percent	Percent
Farmer	112	39	21	37	22	25	24
Part-time farmer	139	12	9	9	18	14	11
Businessman-professional	635	5	15	11	28	16	20
Recreation group	2,016	1	13	7	..[b]	..[b]	..[b]
Wage owner	67	32	11	8	19	19	16
Retired person	262	3	4	4	21	16	15
Undivided estate	1,097	..[c]	3	3	..[b]	..[b]	..[b]
Housewife	242	14	8	7	..[b]	..[b]	..[b]
Non-forest industry	2,019	8	5	1	..[b]	..[b]	..[b]
Real estate firms	1,254	..[b]	4	9	..[b]	..[b]	..[b]
Forest industry	1,115	3	2	2	..[b]	..[b]	..[b]
Other	..[b]	..[b]	..[b]	..[b]	31	10	14

[a]Source: Schallau, 1961, 1962, 1964; Yoho, 1956; Yoho *et al*., 1957.

[b]Unknown.

[c]Less than 0.5 percent.

Peninsula, the resident owners are primarily farmers and part-time farmers (Schallau, 1961, 1962, 1964, 1965; Yoho, 1956; Yoho et al., 1957).

Not all landowners in the Lower Peninsula maintain equal interest in forest production. Objectives like recreation, investment and speculation, and agriculture often preclude use of land for production of forest products. For example, Yoho (1956) and Yoho et al. (1957) analyzed owner objectives for the northern half of the Peninsula and found that only 41 percent of the landowners, who controlled 42 percent of the forest land, held forest production as a prime objective. Eighty-nine percent of lands held by farmers and part-time farmers were in this category. But recreation groups, real estate firms, non-forest industry, and undivided estates, holding 20 percent of the northern hardwoods, had no interest or only slight interest in forest production.

In the southern counties, some 52 percent of all owners surveyed by Schallau (1961) reported forest production as a primary objective. These persons owned 50 percent of the southern commercial forest area. Farmers and part-time farmers were 74 percent and 35 percent, respectively, concerned with forest production.

In 1960, 18 counties in the lower portion of the Peninsula supported a population of 100 or more persons per square mile, and two had 99 per square mile (Mich. State

Univ., 1962). Schallau (1962) determined that in these urban areas only 29 percent of the owners held forest land for production purposes. Harvesting operations were less frequent there than elsewhere and were carried out in a poor manner. Furthermore, he estimated that one percent of these urban fringe lands shift annually to non-forest uses.

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METHODS OF STUDY

The research was organized into three parts: (1) compilation and analysis of Forest Survey data, (2) evaluation of the maple syrup industry and of sap production in the Lower Peninsula, and (3) collation of resource and sap production information to predict future trends and potential. The first two phases actually constituted separate studies which, although related in some respects, were conducted somewhat independently of each other. These, however, were brought together in the final stages of research to create a picture of probable and potential tapping by 1975.

Collection of Data

The 1947-1949 Michigan Forest Survey used a sampling procedure which employed both aerial photo-interpretation and field plots. Individual Forest Survey reports give the details of this sampling and estimates of the accuracy for each Survey block. In general, however, systematically located points on aerial photographs were examined and classified for forest type, stand size class, and stand density. Then a sample of the photo points was selected and checked in the field. At the selected ground check-points, Forest Survey crews established a one-fifth acre plot. Within the plot they measured and classified all trees six inches d.b.h. and larger. Smaller stems and the 10-year radial increment for all size trees were subsampled on a one-fiftieth acre within the larger plot.

The North Central Forest Experiment Station made available Forest Survey plot records for the 190 northern hardwood plots taken in the northern 33 counties and the 321 plots located in the 35 southern counties (Appendix 1). From these records I copied the following information onto tally sheets like that shown in Appendix 2: (1) the county, (2) the number of trees in each two-inch diameter class, (3) the stand size class, (4) the growth measurements for individual trees, and (5) other descriptive material. In addition, I traced the location of northern hardwood forests within the Lower Peninsula from published and unpublished type maps prepared from the Forest Survey. These plot records and type maps provided the information needed to study the northern hardwood forests within the Lower Peninsula.

Data relative to the maple syrup industry were collected by sampling 48 active producers within the Lower Peninsula. To form the sample, I used a listing of 349 names furnished by the Extension Forester, Michigan Cooperative Extension Service. These names included persons known by Cooperative Extension Service personnel, producers who had attended Cooperative Extension Service training meetings, and names the Extension Forester received through correspondence.

Each person listed in the Cooperative Extension Service's maple syrup producer directory was catalogued by county and assigned a number. From the list, 12 names were selected at random from the 169 operations included for the 35 southern counties and 12 from the 180 listed for the northern 33 counties. Selections were restricted to one producer per county.

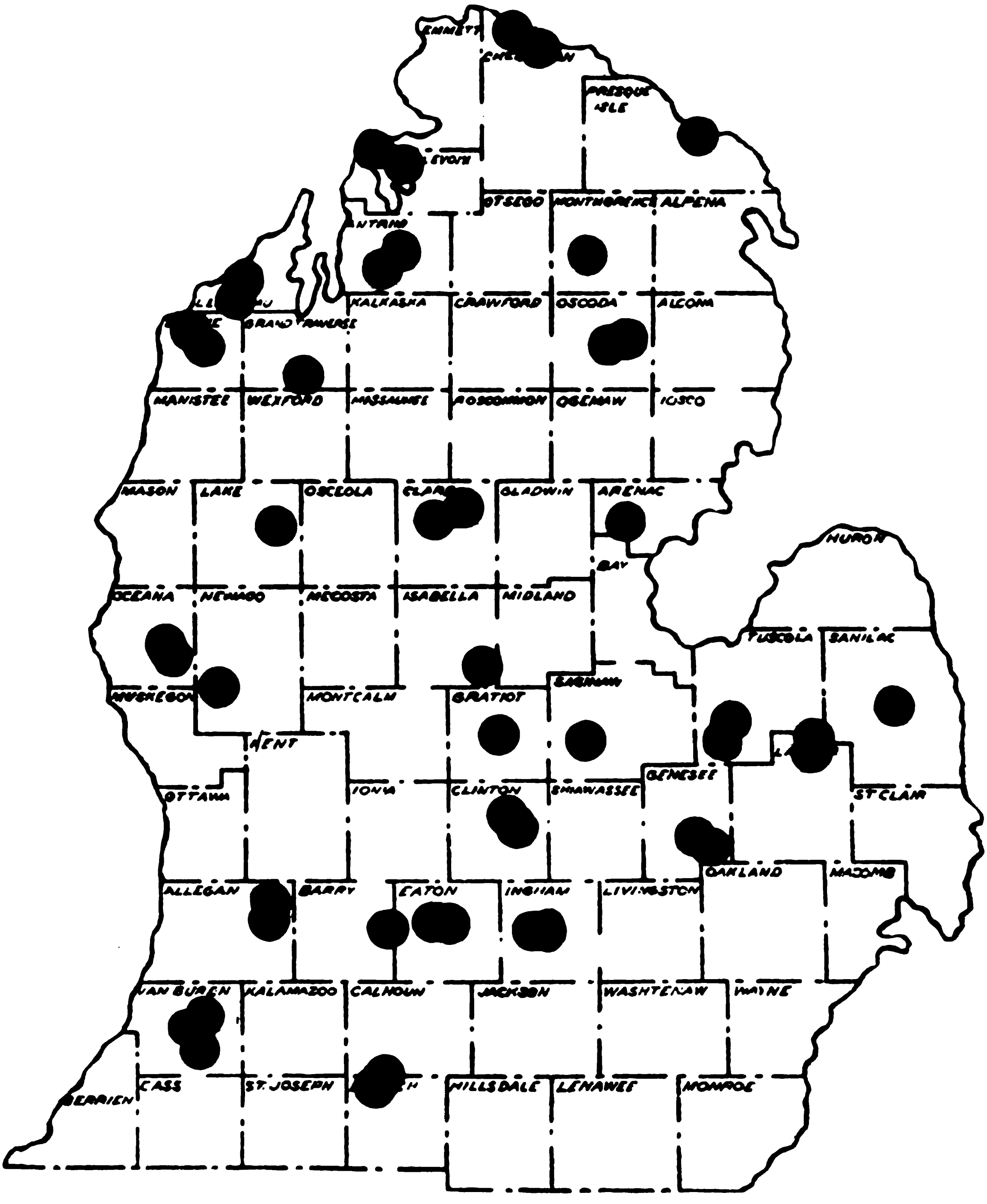
During the summer of 1965 each selected producer was visited and screened according to two criteria: (1) Did he produce maple sap or syrup in 1965? and (2) Did he sell any of his product? If the producer answered negatively to either question he was dropped from the sample, and a new name was selected. But if the operation qualified for sampling, I interviewed the producer and asked a series of questions designed to identify characteristics of his operation and his plans for the future (Appendix 3). Then I inventoried the producer's forest land to determine the size, nature, and amount of tappable resource owned, and to learn how it is used for sap production. In addition, I checked the producer's saphouse to evaluate his compliance with requirements of the Michigan health laws (Appendix 4).

Although the producer directory from which the 24 names were selected comprises the most complete listing of sap and syrup operations in Michigan, it does not include all producers in the Lower Peninsula, and may not truly represent the entire commercial industry. Therefore, I expanded the sample to include operations selected without regard to their being on the above-mentioned listing. These additional enterprises were selected by locating a second producer living near each of the 24 persons chosen from the Cooperative Extension Service's listing. The new persons were screened to insure that they had produced and sold some sap or syrup during 1965. Then they were interviewed and their forest land inventoried. Adding these 24 producers to the 24 initially selected provided the sample shown in Figure 2 and Table 6.

Variable-radius point samples were used to inventory the forest lands owned by the 48 selected producers. These points were placed at a spacing of 2- by 2-chains for properties 5 acres or less, at 4- by 4-chains for areas 5 to 25 acres in size, and spread over wider intervals for larger properties. Although the number of sample points varied with the woodland size, configuration, and homogeneity, at least six points were included for each ownership.

To identify sample trees, I used a calibrated BFA-10 factor prism in the manner recommended by Beers and Miller (1964), and by Hovind and Rieck (1961). The selected sugar

Figure 2. Location of maple sap and syrup operations sampled in Michigan's Lower Peninsula, 1965.


PRESQUE ISLE
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ALPENA
KALKASKA
CRAWFORD
OSCODA
ALCONA
GRAND TRAVERSE
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WEXFORD
MISSAUKEE
ROSCOMMON
OGEMAW
IOSCO
MASON
LAKE
OSCEOLA
GLADWIN
ARENAC
BAY
HURON
OCEANA
NEWAYGO
MECOSTA
ISABELLA
MIDLAND
TUSCOLA
SANILAC
MUSKEGON
MONTCALM
GRATIOT
SAGINAW
KENT
OTTAWA
IONIA
CLINTON
SHIAWASSEE
GENESEE
ST CLAIR
OAKLAND
MACOMB
ALLEGAN
BARRY
EATON
INGHAM
LIVINGSTON
VAN BUREN
KALAMAZOO
CALHOUN
JACKSON
WASHTENAW
WAYNE
BERRIEN
CASS
ST. JOSEPH
HILLSDALE
LENAWEE
MONROE

Table 6. Sample of maple sap and syrup producers in Michigan's Lower Peninsula, 1965.

Region	Maple sap and syrup operations in the Lower Peninsula			Tapholes used in the Lower Peninsula		
	Reported in 1964 Census[a]	Sampled		Reported in 1964 Census[a]	Sampled	
	Number	Number	Percent	Number	Number	Percent
Northern half	340	23	6.8	206,190	39,818	19.3
Southern half	470	23	4.9	166,531	13,378	8.0
Entire Peninsula	810	46	5.7	372,721	53,196	14.3

[a]Source: U.S. Bur. Census, 1966.

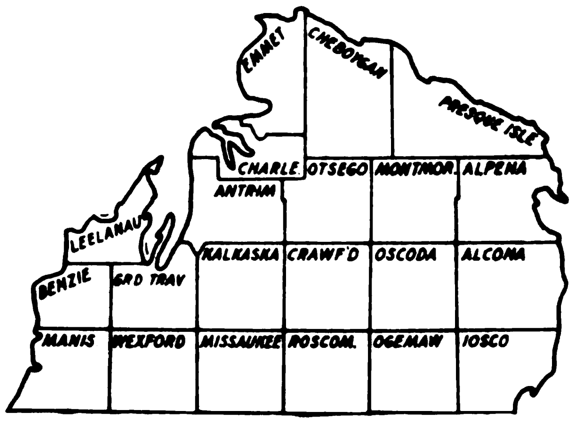
maples were measured for d.b.h. (to the nearest one-tenth inch), and the number of tapholes installed in 1965 were counted. In addition, I estimated the total basal area per acre at each point location. All data were recorded on the form shown in Appendix 5.

Analysis of Data

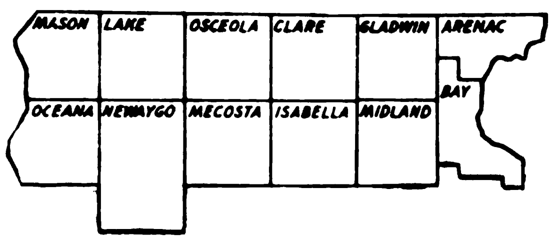
The forest type maps traced from eight original Forest Survey plottings were merged to form a generalized type map for northern hardwood forests in the Lower Peninsula. This map was used to identify patterns of forest distribution, and to help locate areas best suited to support an industry of central evaporator plants.

The structure and composition of northern hardwood forests was analyzed by using information from the Forest Survey plot records. Each record was summarized, and the plot basal area and the size of the tree of average basal area calculated. Then the records were separated by stand diameter, and grouped according to the four geographical zones shown in Figure 3. For each zone, the plot records were used to construct stand tables by conventional methods. These stand tables provided estimates of the tapholes per acre, the number of tappable sugar maple per acre, the percent of basal area in sugar maple, the number of sugar maple per acre, and the structure of the tappable segment of average northern hardwood stands.

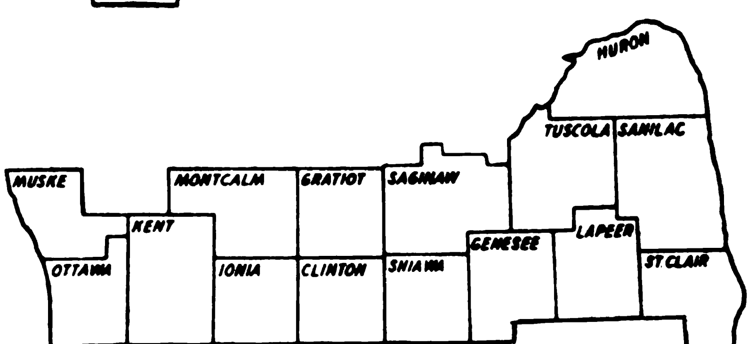
Figure 3. Selected inventory zones in Michigan's Lower Peninsula.



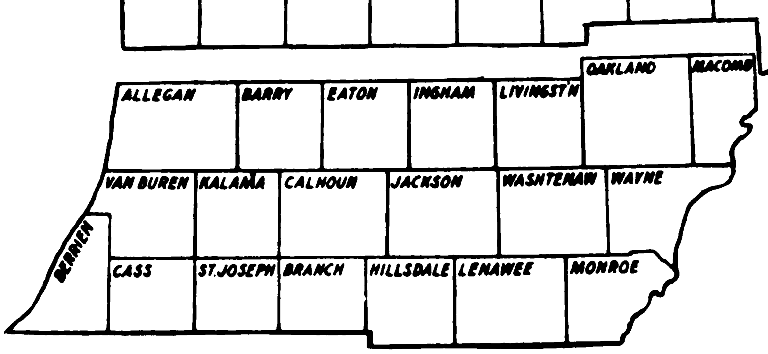
Upper northern half



Lower northern half



Upper southern half



Lower southern half

Growth estimates for sugar maple were calculated from the increment boring data taken in the Forest Survey. These data were subjected to regression analysis in the CDC-3600 computer at the Michigan State University Computer Laboratory. A multiple regression program prepared by Professor D. J. Gerrard, Department of Forestry, Michigan State University, was used. The models applied in the regressions were designed to generate growth estimates needed in other phases of the research.

Published literature gives no reference to the minimum number of tapholes needed per acre to justify commercial tapping. Therefore, I calculated the probable costs and returns that might be expected from commercial tapping within the Lower Peninsula. From the results, I estimated the minimum numbers of tapholes per acre needed for break-even operation. Later, the Forest Survey plot records and the producer forest inventory data were evaluated by these criteria to estimate the total acreage and numbers of tapholes suited for commercial tapping in the northern hardwood forests of the Lower Peninsula, and to determine the extent of tappable resources available on producer-owned lands.

Data collected from the sample of 48 maple syrup producers were summarized to show the nature, size, and use of tappable resources on individual properties. The mean values and variances were then calculated for the sample of persons selected from the Cooperative Extension Service listing and for those producers selected without regard to their being on the listing. T-tests showed that these two sets of data were not significantly different (Appendix 6). Therefore, the data collected from all the producers were combined and used jointly to analyze and describe the maple syrup industry within each half of the Lower Peninsula. The results were compared by t-tests to identify differences between the two regions.

After the northern hardwood forest resource had been appraised and characteristics of the present commercial industry studied, the findings were collated in order to predict future trends and potential. Here, I studied the characteristics of the industry and the plans of producers for future tapping to determine the probable tapping by 1975. Then, by applying growth data to the producer inventory records, I estimated the change expected in available tapholes due to growth on producer-owned forests. These estimates of the future resource were compared with the forecast of probable tapping to determine the potential for the industry to expand production within the next 10 years.

Finally, after considering the probable tapping for 1975 I studied the total forest resource of the Lower Peninsula to determine which regions appeared suited for a new industry of central evaporator plants. Forest distribution was analyzed to identify areas where the tappable resource was sufficient for this purpose. Then the resource data were examined in light of information about land ownership to separate out the areas best suited to accommodate new central evaporator plants.

RESULTS

The Northern Hardwood Forests of the Lower Peninsula

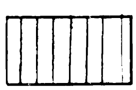
Location and Area by Size Class

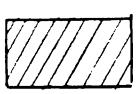
Northern hardwood forests are found throughout the Lower Peninsula (Figure 4). Although they are most heavily concentrated in the northwestern counties, sizable blocks of the type grow in the south-central region. In other portions of the Peninsula the northern hardwoods are absent, or they occur in relatively small stands scattered within other forest types.

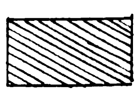
Table 7 lists the proportion and area of northern hardwood stands of differing average diameters within Michigan's Lower Peninsula. These estimates show that the bulk of northern hardwood forests occur within the northern 33 counties. However, 83 percent of the northern hardwoods in the northern region are poletimber size. Sixty-seven percent of the area with an average stand diameter of 11.0 inches or larger is found within the southern 35 counties. This apportionment of sawtimber does not change abruptly at the boundary between the two halves of the Peninsula. Rather, the abundance of sawtimber increases progressively from north to south.

Figure 4. Geographic location of the northern hardwood type group in Michigan's Lower Peninsula (adapted from original type maps of the Michigan Forest Survey, 1947-1949).

Legend:


5-24 percent forest cover


25-49 percent forest cover


50 percent or more forest cover

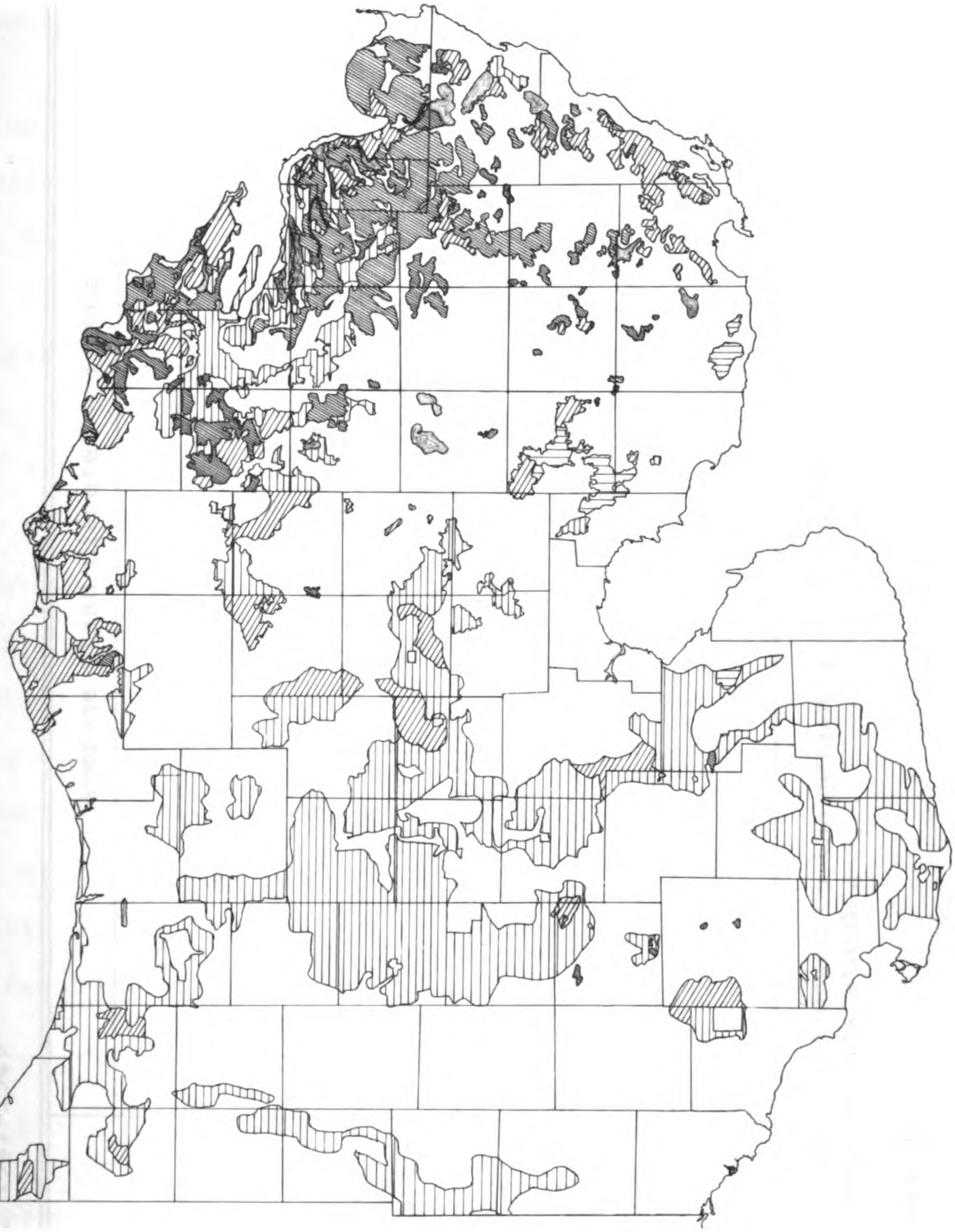


Table 7. Proportion and area of northern hardwoods in stands of differing average diameters within Michigan's Lower Peninsula (exclusive of seedling-sapling size), 1947-1949[a]

Region[b]	Average stand diameter - inches					
	5 - 11		11 - 15		15 +	
	Percent	Acres	Percent	Acres	Percent	Acres
Upper north half	85	451,435	13	69,043	2	10,622
Lower north half	66	70,752	29	31,088	5	5,360
North half of the Lower Peninsula	82	522,187	16	100,131	2	15,982
Upper south half	36	59,724	45	74,655	19	31,521
Lower south half	25	41,800	52	86,944	23	38,456
South half of the Lower Peninsula	30	101,524	49	161,599	21	69,977
Entire Lower Peninsula		623,711		261,730		85,959

[a]Area estimates are based on the proportion of Forest Survey plots located in the different diameter-class stands.

[b]See Figure 3.

Structure of Northern Hardwood Stands

The northern hardwood forests of Michigan's Lower Peninsula are primarily uneven-aged and contain a wide range of size classes.[1] Their structure, however, differs somewhat between the two halves of the Peninsula (Figure 5). This difference is due mainly to dissimilarities in the numbers of stems present in seedling-sapling classes. Otherwise, the average stands portrayed in Figure 5 are remarkably similar between the two regions.

The sugar maple component of the average northern hardwood stands also differs in several respects between the two regions (Table 8). Despite variations in the numbers of sugar maple per acre, the basal area per acre in sugar maple, and the average size of sugar maple stems, the stands with an average diameter of less than 15 inches have similar numbers of tapholes available per acre throughout the Lower Peninsula. However, for the largest-diameter sawtimber the two regions differ widely. In the northern counties, stands

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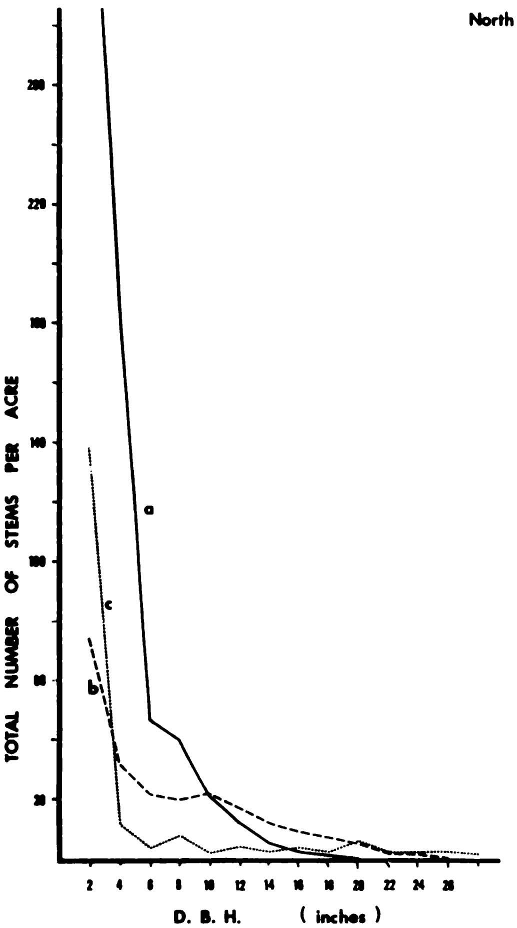
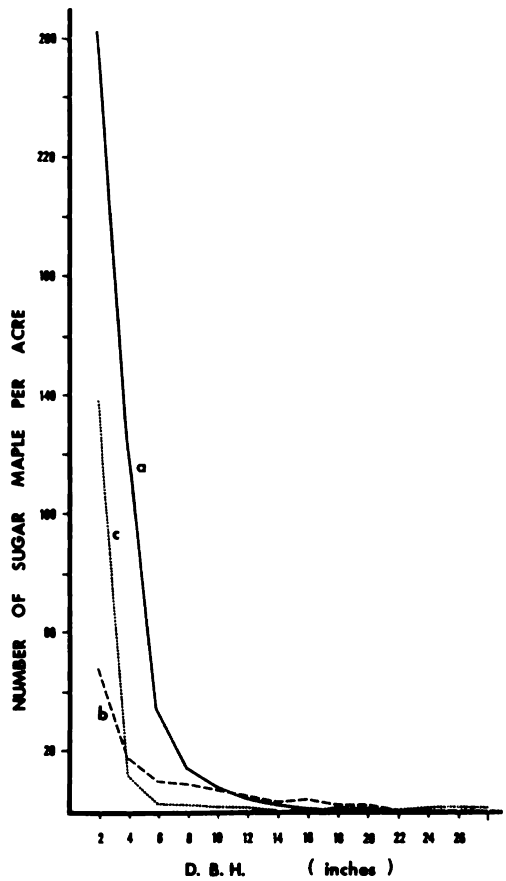
[1]The Society of American Foresters (1958) applies the term uneven-aged to stands with 3 age classes represented, and at least a 10-to 20-year range in the ages of trees present. All northern hardwood stands sampled by the Forest Survey contained at least three size classes of trees, and virtually all plot records show a wide range of size classes within the sampled stands. Regression analysis of sugar maple age and diameter indicate a good correlation between age and diameter for the species, and show a spread of about 10 years between the 2-inch size classes used by the Forest Survey.

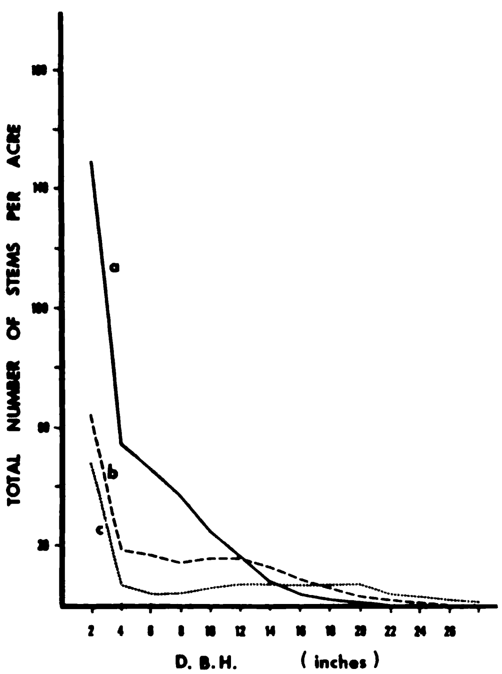
Figure 5. Structural form of average northern hardwood stands and their sugar maple component in Michigan's Lower Peninsula, 1947-1949 (a: 5-11 inches average stand diameter, b: 11-15 inches average stand diameter, c: 15 inches and larger average stand diameter).

North half of Lower Peninsula





South half of Lower Peninsula



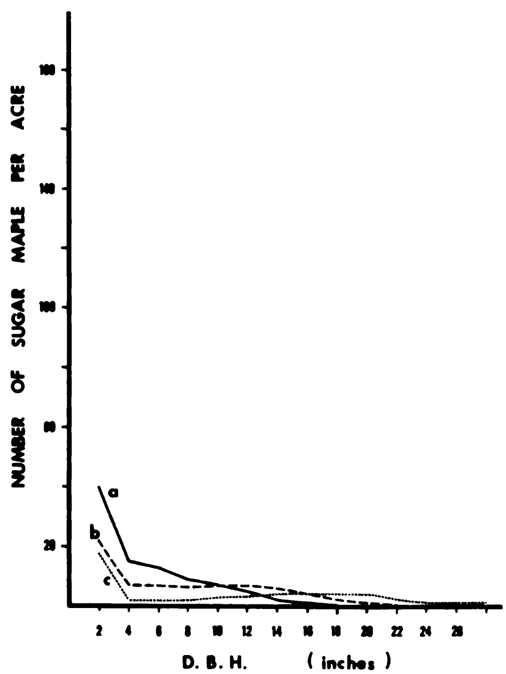


Table 8. Stand characteristics of northern hardwood forests in Michigan's Lower Peninsula, 1947-1949

Stand characteristics		Average stand diameter - inches					
		5-11	11-15	15 +	5-11	11-15	15 +
		Northern half of Peninsula			Southern half of Peninsula		
Total basal area per acre	Sq. ft.	80	97	58	80	86	88
Basal area in sugar maple	Sq. ft.	39	33	15	19	34	42
Basal area in sugar maple	Percent	49	34	26	24	39	48
Basal area in sugar maple 6.0 or more inches d.b.h.	Percent	41	32	21	24	39	48
Basal area of average sugar maple stem	Sq. ft.	.087	.303	.097	.215	.482	.868
D.b.h. of sugar maple of average basal area . . .	Inches	4.0	7.5	4.2	6.3	9.4	12.6
Total stems per acre . .	Number	677	222	189	345	179	113
Sugar maple per acre . .	Number	448	108	159	88	70	49
Stems in sugar maple . .	Percent	66	49	84	25	39	43
Sugar maple 6.0 or more inches d.b.h.	Number	63	41	10	36	41	29
Stems 6.0 or more inches d.b.h. in sugar maple .	Percent	9	18	5	10	23	26
Stems less than 6.0 inches d.b.h. in sugar maple .	Percent	57	30	79	15	16	18
Tapholes per acre	Number	15	33	11	16	37	49

with an average diameter of 15 inches or larger are poorly stocked.

While Figure 5 and Table 8 describe average stocking for the Lower Peninsula, individual plot records show that the numbers of sugar maple per acre may vary from place to place within a region. Small numbers of the species do not necessarily indicate that the stand is poorly stocked. Rather, variations in the number of sugar maple present may simply reflect differences in forest composition.

The actual numbers of tapholes associated with differing numbers of sugar maple per acre in the Lower Peninsula can vary greatly. However, typical stocking for various numbers of tappable stems per acre can be estimated by assuming that the proportion of 1-, 2-, 3-, and 4-taphole trees[2] in each stand will be identical to the proportion of tappable stems in these different tree size-classes found in the average northern hardwood stands portrayed in Figure 5. Table 9 lists these estimates of taphole stocking associated with different numbers of tappable sugar maple per acre. The estimates represent the kinds of stands that might be encountered within the northern hardwoods in Michigan's Lower Peninsula.

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[2]A 1-taphole tree is 9.5 to 14.9 inches d.b.h., a 2-taphole tree 15.0 to 19.9 inches d.b.h., a 3-taphole tree 20.0 to 24.9 inches d.b.h., and a 4-taphole tree 25.0 inches d.b.h. and larger.

Table 9. Number of tapholes in different stands of sugar maple within Michigan's Lower Peninsula, 1947-1949

Stand size class	Tappable trees per acre	Region									
		Northern half of Lower Peninsula					Southern half of Lower Peninsula				
		Tapholes per acre by tree size class					Tapholes per acre by tree size class				
		1-tap tree	2-tap tree	3-tap tree	4-tap tree	All trees	1-tap tree	2-tap tree	3-tap tree	4-tap tree	All trees
Inches	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number
5-11	10	9	1	..	..	11	9	1	..	..	11
	20	19	1	..	..	21	19	1	..	..	21
	30	28	2	..	..	32	28	2	..	..	32
	40	37	2	1	..	44	37	2	..	..	41
	50	46	3	1	..	55	46	3	1	..	55
	60	56	3	1	..	65	56	4	1	..	67
	70	65	4	1	..	76	65	4	1	..	76
11-15	10	7	2	1	..	14	7	2	1	..	14
	20	13	5	2	1	33	14	4	1	..	25
	30	20	7	2	1	44	21	7	2	..	41
	40	26	10	3	1	59	29	9	2	..	53
	50	33	12	4	2	77	36	11	3	..	67
	60	39	14	4	2	87	43	13	4	..	85
	70	46	17	5	2	103	50	15	4	1	96
15 +	10	3	1	3	3	26	4	3	3	1	23
	20	6	3	6	6	54	8	6	5	1	39
	30	9	4	9	9	80	12	8	8	2	60
	40	11	6	11	11	100	16	11	11	2	79
	50	14	7	14	14	126	20	14	13	3	99
	60	17	8	17	17	152	24	17	16	3	118
	70	20	10	20	20	180	28	20	19	4	141

Taphole Stocking Required for Commercial Tapping

The feasibility of tapping the northern hardwood stands described in the previous section depends upon the costs and returns realized from an operation. Financial yield will fluctuate according to the number of tapholes available, the volume of sap collected, and the sap sweetness. Costs arise from investment in equipment and materials, charges for ownership of equipment, and for labor.

Producers encounter conditions suitable for commercial tapping in stands where revenues from production equal or exceed the costs incurred. The following model estimates the minimum numbers of tapholes per acre required for this marginal production. It applies to newly established operations tapping producer-owned lands in Michigan's Lower Peninsula.

Assumed Operating Conditions and Costs

A realistic financial evaluation of sap production must consider use of the most efficient equipment and methods available. Therefore, costs were calculated for sap collection by non-vented plastic tube systems serviced with vacuum pumps. Morrow's (1961) estimate of eight minutes labor per taphole per year was adopted, and assessed at $1.50 per hour. A pumping cost of $0.11 per taphole, suggested by Morrow (1963), was used.

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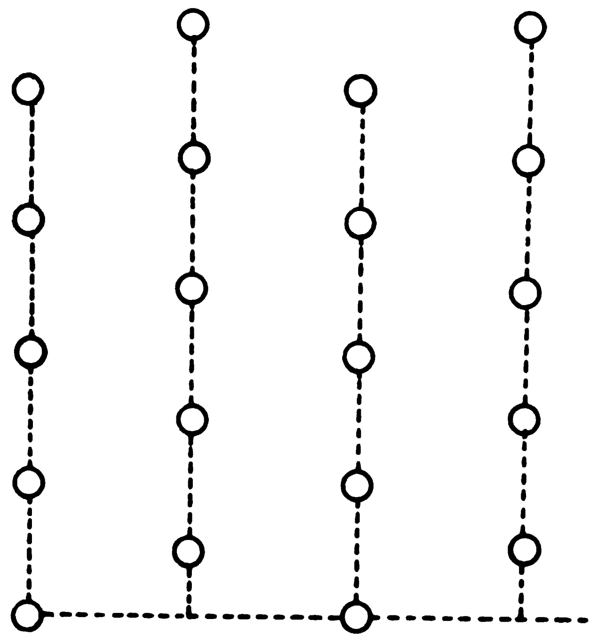
Figure 6 shows a sample tree-location diagram used to plan the tube system and equipment required for differing numbers of sugar maple distributed over an acre in a uniform diamond-shaped pattern. A separate plotting incorporating a variety of tube sizes in accord with recommendations for flat lands (Appendix 7) was prepared for all stand conditions tested, and the amount of tubing required for each situation estimated from the diagrams. Since woodlands within the Lower Peninsula are frequently located some distance from a road, extra tubing was added to permit transport of the sap through the woodlot plus one-quarter mile from the sugarbush to a roadside saphouse or collection point (Appendix 8).

Quotations obtained in the fall of 1965 set the equipment and material prices used in the analysis (Appendix 9). The model assumes a 10-year life expectancy for tube items and storage tanks, and 5 years for the power tapper and pumps. Investments have been depreciated over these time intervals at six percent per annum compound interest (Appendix 10). Where necessary, investments were prorated over 700 tapholes for operations in the south half of the Peninsula and over 2,000 tapholes per enterprise for the northern region (Appendix 11). Appendices 12 to 14 give the detailed cost calculations. Appendix 15 summarizes the estimated annual operating costs per taphole.

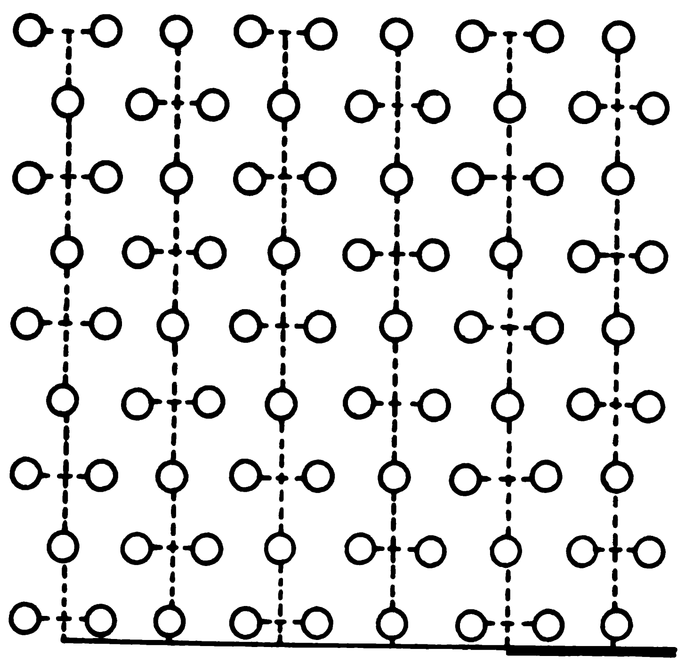
Figure 6. Assumed tree locations and tube gathering systems for 20 and 81 sugar maple trees per acre.

Legend:

══════	3/4-inch tubing
──────	1/2-inch tubing
------	5/16-inch tubing
O	Tapped tree



20 tapholes per acre



81 tapholes per acre

Stands were considered fully stocked in order to avoid concern for variations in sap sweetness and yield that might be associated with differences in stand density. In addition, tapholes were assumed treated with paraformaldehyde pellets and to yield annually 25 gallons per taphole.[3] Since sap sweetness of 2.1 $^{\circ}$Brix[4] appears representative of the Lower Peninsula (Appendix 16), each gallons of sap was evaluated at \$0.043 (delivered to the saphouse) (Appendix 17).

Tapping by Integrated Sap-syrup Enterprises

Appendix 18 illustrates the detailed analysis used for the study. The following tabulation of costs and returns for 20 tappable sugar maple trees per acre, located in a stand 5-11 inches average d.b.h. in the southern half of the Lower Peninsula, shows the general approach used to determine the practicability of tapping when the sap is processed at the site where collected:

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[3]Yield is based on estimates by Robbins (1966) for a 25 percent increase above the average of 19 gallons per taphole that might be expected in Lower Michigan (Robbins, 1949).

[4]$^{\circ}$Brix expresses sap density as the percentage of sugars plus other solids in solution.

COSTS PER ACRE:

Annual cost of equipment	$ 7.40
Other annual costs	10.92
Total	$ 18.32

REVENUE PER ACRE:

Sap value	$ 22.58

SURPLUS PER ACRE . . . . $ 4.26

Because the revenues exceed the costs, the 20 sugar maples per acre are sufficient to place production above the break-even point. Table 10 shows the results from analyzing tapping in stands with 10 to 70 tappable sugar maples per acre as depicted in Table 9. In all these cases tapping provides a surplus of revenue over costs when the sap is processed on the property where collected.

The approximate production costs for operating with plastic tube systems employed in the manner described above range from just under \$0.03 to about \$0.04 per gallon depending upon the stand conditions encountered (Table 11). For production circumstances that demand different costs, yields, or interest rates than those used above, the average cost per gallon will change. For example, a lower labor charge and interest rate will lower the cost and increase the surplus, while less sap yield and lower ^{o}Brix will correspondingly reduce the revenue. Data in Table 10 indicate that

Table 10. Costs, returns, and surpluses from sap production when the product is processed at the property where collected, 1965

Stand size class	Tappable trees per acre	Region							
		Northern half of Lower Peninsula				Southern half of Lower Peninsula			
		Tapholes per acre	Annual cost	Annual return	Surplus	Tapholes per acre	Annual cost	Annual return	Surplus
Inches	Number	Number	Dollars	Dollars	Dollars	Number	Dollars	Dollars	Dollars
5-11	10	11	10.55	11.82	+ 1.27	11	10.55	11.82	+ 1.27
	15	16	14.75	17.20	+ 2.45	16	14.75	17.20	+ 2.45
	20	21	18.32	22.58	+ 4.26	21	18.32	22.58	+ 4.26
	30	32	27.33	34.40	+ 7.17	32	27.23	34.40	+ 7.17
	40	44	36.57	47.30	+ 10.73	41	34.53	44.08	+ 9.55
	50	55	44.60	59.13	+ 14.53	55	44.60	59.13	+ 14.53
	60	65	51.42	69.88	+ 18.46	67	52.68	72.03	+ 19.35
	70	76	60.14	81.70	+ 21.56	76	60.14	81.70	+ 21.56
11-15	10	14	12.47	15.05	+ 2.58	14	12.47	15.05	+ 2.58
	15	21	18.35	22.58	+ 4.23	20	17.32	21.50	+ 4.18
	20	33	26.98	35.48	+ 8.50	25	20.76	26.88	+ 6.12
	30	44	36.20	47.30	+ 11.10	41	33.74	44.08	+ 10.34
	40	59	46.05	63.42	+ 17.37	53	42.39	56.98	+ 14.59
	50	77	60.46	82.78	+ 22.32	67	52.95	72.63	+ 19.08
	60	89	67.58	95.68	+ 28.10	85	66.06	91.16	+ 25.10
	70	103	78.43	110.72	+ 32.29	96	73.99	103.20	+ 29.21
15 +	10	26	20.40	27.95	+ 7.55	23	18.50	24.73	+ 6.23
	15	47	34.75	50.52	+ 15.77	30	23.96	32.25	+ 8.29
	20	54	40.37	58.05	+ 17.68	39	30.37	41.93	+ 11.56
	30	80	61.39	86.00	+ 24.61	60	48.02	64.50	+ 16.48
	40	100	74.66	107.50	+ 32.84	79	60.04	84.93	+ 24.89
	50	126	93.86	135.45	+ 41.59	99	74.75	106.43	+ 31.68
	60	152	111.33	163.40	+ 52.07	118	87.86	126.85	+ 38.99
	70	180	131.05	193.50	+ 62.45	141	103.64	151.58	+ 47.94

Table 11. Costs per gallon of maple sap collected from differently stocked stands and processed at the property where collected, 1965

Stand size class	Tappable trees per acre	Region: Northern half of Lower Peninsula				Region: Southern half of Lower Peninsula			
		Tapholes per acre	Sap per acre	Total cost	Cost per gallon	Tapholes per acre	Sap per acre	Total cost	Cost per gallon
Inches	Number	Number	Gallons	Dollars	Dollars	Number	Gallons	Dollars	Dollars
5-11	10	11	275	10.55	0.038	11	275	10.55	0.038
	20	21	525	18.32	0.035	21	525	18.38	0.035
	30	32	800	27.23	0.034	32	800	27.23	0.034
	40	44	1,100	36.57	0.033	41	1,025	34.53	0.034
	50	55	1,375	44.60	0.032	55	1,375	44.60	0.032
	60	65	1,625	51.42	0.032	67	1,675	52.68	0.032
	70	76	1,900	60.14	0.032	76	1,900	60.14	0.032
11-15	10	14	350	12.47	0.036	14	350	12.47	0.036
	20	33	825	26.98	0.033	25	625	20.76	0.033
	30	44	1,100	36.20	0.033	41	1,025	33.74	0.033
	40	59	1,475	46.05	0.031	53	1,325	42.39	0.032
	50	77	1,925	60.46	0.031	67	1,675	52.95	0.032
	60	89	2,225	67.58	0.030	85	2,120	66.06	0.031
	70	103	2,575	78.43	0.030	96	2,400	73.99	0.031
15 +	10	26	650	20.40	0.031	23	575	18.50	0.032
	20	54	1,350	40.37	0.030	39	975	30.37	0.031
	30	80	2,000	61.39	0.031	60	1,500	48.02	0.032
	40	100	2,500	74.66	0.030	79	1,975	60.04	0.030
	50	126	3,150	93.86	0.030	99	2,475	74.75	0.030
	60	152	3,800	111.33	0.029	118	2,950	87.86	0.030
	70	180	4,500	131.05	0.029	141	3,525	103.64	0.029

even with a lower sap sweetness, smaller yield per taphole, higher interest rate, and higher labor charge than used above, producers could operate profitably with plastic tube systems to gather sap at the site where it will be processed.

Sap Production for Sale to a Central Evaporator Plant

The advent of central evaporator plants opened prospects for sale of sap either at the production site or delivered to the processing plant. In the former case, the plant management transports the sap, and levies a charge for this service. In the latter situation, the sap producer transports the sap and directly absorbs all transportation costs.

Although the actual cost for transporting sap will vary for different production situations, a levy of $0.005 to $0.015 per gallon appears appropriate for most cases involving roadside sale (Anonymous, 1962; Willits, 1965). Accordingly, $0.01 per gallon was added to the costs in the model presented above, and the results summarized in Table 12. Under these new conditions, tapping is feasible only with taphole stockings greater than or equal to those shown in Table 13.

While many stands could support a greater transportation cost than used above, adjustment of the transportation charges up or down from $0.01 per gallon will cause the

Table 12. Costs, returns, and surpluses from sap production when the product is sold for transport away from the property where collected, 1965

Stand size class	Tappable trees per acre	Region: Northern half of Lower Peninsula — Tapholes per acre	Annual cost	Annual return	Surplus	Region: Southern half of Lower Peninsula — Tapholes per acre	Annual cost	Annual return	Surplus
Inches	Number	Number	Dollars	Dollars	Dollars	Number	Dollars	Dollars	Dollars
5-11	10	11	13.30	11.82	- 1.48	11	13.30	11.82	- 1.48
	20	21	23.57	22.58	- 0.99	21	23.57	22.58	- 0.99
	30	32	35.23	34.40	- 0.83	32	35.23	34.40	- 0.83
	40	44	47.57	47.30	- 0.27	41	44.78	44.08	- 0.70
	50	55	58.35	59.13	+ 0.78	55	58.35	59.13	+ 0.78
	60	65	67.67	69.88	+ 2.21	67	69.43	72.03	+ 2.60
	70	76	79.14	81.70	+ 2.65	76	79.14	81.70	+ 2.56
11-15	10	14	15.97	15.05	- 0.92	14	15.97	15.05	- 0.92
	20	33	35.23	35.48	+ 0.25	25	27.01	26.88	- 0.13
	30	44	47.20	47.30	+ 0.10	41	43.99	44.08	+ 0.09
	40	59	60.80	63.42	+ 2.62	53	55.68	56.98	+ 1.30
	50	77	79.21	82.78	+ 3.57	67	69.70	72.03	+ 2.33
	60	89	89.83	95.68	+ 5.85	85	87.26	91.16	+ 3.90
	70	103	104.18	110.72	+ 6.00	96	97.09	103.20	+ 6.11
15 +	10	26	26.90	27.95	+ 1.05	23	24.25	24.73	+ 0.48
	20	54	53.87	58.05	+ 4.18	39	40.12	41.93	+ 1.81
	30	80	81.39	86.00	+ 4.61	60	63.02	64.50	+ 1.48
	40	100	99.66	107.50	+ 7.84	79	79.79	84.93	+ 5.14
	50	126	125.36	135.45	+ 10.09	99	99.50	106.43	+ 6.93
	60	152	149.33	163.40	+ 14.07	118	117.36	126.85	+ 9.49
	70	180	176.50	193.50	+ 17.00	141	138.89	151.58	+ 12.69

Table 13. Minimum number of tapholes per acre required for break-even operation when sap is sold for transport away from the property where collected

	Required tapholes per acre	
Stand size class	Northern half of Lower Peninsula	Southern half of Lower Peninsula
Inches	Number	Number
5-11	46	48
11-15	31	34
15+	10	10

threshold point to fluctuate. Table 14 shows the maximum amounts available to defray transportation charges for each differently stocked stand considered above. These values are based on the surpluses listed in Table 10. Table 15 indicates the general transportation charges permitted for the average northern hardwood stands of the Lower Peninsula described in Table 8.

While roadside purchase can be used, most central evaporator plants rely upon delivered sap to satisfy production needs. For the sap producer, daily delivery to a plant 5 miles from the sugarbush costs about $0.011 per gallon (Appendix 19). Commercial tapping, then, is justified only in stands that provide revenues sufficient to offset normal tapping costs plus this transportation fee.

Table 16 clearly demonstrates the effect of adding the $0.011 transportation charge to the other operating costs. With this new expense, tapping is not justified unless stands contain at least the number of tapholes per acre shown in Table 17. These minima, then, define the general requirements for successful tapping with sap delivery to a central evaporator plant located within Michigan's Lower Peninsula. If the haul distance, trucking charges, and labor costs varied from those applied in the model, the break-even level would shift accordingly. Producers could, therefore, modify the various factors to fit their particular

Table 14. Allowable transportation charge per gallon for sap sold for transport away from the property where collected, 1965

		Region							
		Northern half of Lower Peninsula				Southern half of Lower Peninsula			
Stand size class	Tappable trees per acre	Tapholes per acre	Sap per acre	Total surplus	Allowable transport charge	Tapholes per acre	Sap per acre	Total surplus	Allowable Transport charge
Inches	Number	Number	Gallons	Dollars	Dollars	Number	Gallons	Dollars	Dollars
5-11	10	11	275	+ 1.27	0.005	11	275	+ 1.27	0.005
	20	21	525	+ 4.26	0.008	21	525	+ 4.26	0.008
	30	32	800	+ 7.17	0.009	32	800	+ 7.17	0.009
	40	44	1,100	+ 10.73	0.010	41	1,025	+ 9.55	0.009
	50	55	1,375	+ 14.53	0.011	55	1,375	+ 14.53	0.011
	60	65	1,625	+ 18.46	0.011	67	1,675	+ 19.35	0.011
	70	76	1,900	+ 21.56	0.011	76	1,900	+ 21.56	0.011
11-15	10	14	350	+ 2.58	0.007	14	350	+ 2.58	0.007
	20	33	825	+ 8.50	0.010	25	625	+ 6.12	0.010
	30	44	1,100	+ 11.10	0.010	41	1,025	+ 10.34	0.010
	40	59	1,475	+ 17.37	0.012	53	1,325	+ 14.59	0.011
	50	77	1,925	+ 22.32	0.012	67	1,675	+ 19.08	0.011
	60	89	2,225	+ 28.10	0.013	85	2,120	+ 20.10	0.009
	70	103	2,575	+ 32.29	0.013	96	2,400	+ 29.21	0.012
15 +	10	26	650	+ 7.55	0.012	23	575	+ 6.23	0.011
	20	54	1,350	+ 17.68	0.013	39	975	+ 11.65	0.012
	30	80	2,000	+ 24.61	0.012	60	1,500	+ 16.48	0.011
	40	100	2,500	+ 32.84	0.013	79	1,975	+ 24.89	0.013
	50	126	3,150	+ 41.59	0.013	99	2,475	+ 31.68	0.013
	60	152	3,800	+ 52.07	0.014	118	2,950	+ 38.99	0.013
	70	180	4,500	+ 62.45	0.014	141	3,525	+ 47.94	0.014

Table 15. Maximum permissible transportation charges for sap collected from average northern hardwood stands in Michigan's Lower Peninsula, 1965

Stand size class	Northern half of Lower Peninsula: Tapholes per acre	Northern half of Lower Peninsula: Allowable charge per gallon	Southern half of Lower Peninsula: Tapholes per acre	Southern half of Lower Peninsula: Allowable charge per gallon
Inches	Number	Dollars	Number	Dollars
5-11	15	0.006	16	0.006
11-15	33	0.010	37	0.010
15+	11	0.005[a]	49	0.012

[a]Estimated from calculations for 11 tapholes in a stand 5-11 inches average diameter, northern counties.

Table 16. Costs, returns, and surpluses from sap production when the product is transported five miles to the evaporator plant, 1965

Stand size class	Tappable trees per acre	Northern half of Lower Peninsula: Tapholes per acre	Annual cost	Annual return	Surplus	Southern half of Lower Peninsula: Tapholes per acre	Annual cost	Annual return	Surplus
Inches	Number	Number	Dollars	Dollars	Dollars	Number	Dollars	Dollars	Dollars
5-11	10	11	13.58	11.82	- 1.76	11	13.58	11.82	- 1.76
	20	21	24.10	22.58	- 1.52	21	24.10	22.58	- 1.58
	30	32	36.03	34.40	- 1.63	32	36.03	34.40	- 1.63
	40	44	48.67	47.30	- 1.37	41	45.81	44.08	- 1.73
	50	55	59.73	59.13	- 0.60	55	59.73	59.13	- 0.60
	60	65	69.30	69.88	+ 0.58	67	71.11	72.03	+ 0.92
	70	76	81.04	81.70	+ 0.66	76	81.04	81.70	+ 0.66
11-15	10	14	16.32	15.05	- 1.27	14	16.32	15.05	- 1.27
	20	33	36.06	35.48	- 0.58	25	27.64	26.88	- 0.76
	30	44	48.30	47.30	- 1.00	41	45.02	44.08	- 0.94
	40	59	62.28	63.42	+ 1.14	53	56.97	56.98	+ 0.01
	50	77	81.64	82.78	+ 1.14	67	71.38	72.03	+ 0.65
	60	89	92.06	95.68	+ 3.62	85	89.38	91.16	+ 1.78
	70	103	106.76	110.72	+ 3.96	96	100.39	103.20	+ 2.81
15 +	10	26	27.55	27.95	+ 0.40	23	24.83	24.73	- 0.10
	20	54	55.22	58.05	+ 2.73	39	41.10	41.93	+ 0.83
	30	80	83.39	86.00	+ 2.61	69	64.52	64.50	- 0.02
	40	100	102.16	107.50	+ 5.34	79	82.13	84.93	+ 2.80
	50	126	128.51	135.45	+ 6.94	99	101.98	106.43	+ 4.45
	60	152	153.13	163.40	+ 10.27	118	120.31	126,85	+ 6.54
	70	180	180.55	193.50	+ 12.95	141	142.42	151.58	+ 9.16

Table 17. Minimum number of tapholes per acre required for break-even operation when sap is delivered five miles to the evaporator plant

	Required tapholes per acre	
Stand size class	Northern half of Lower Peninsula	Southern half of Lower Peninsula
Inches	Number	Number
5-11	61	60
11-15	51	53
15 +	10	24

conditions, and evaluate the suitability of their forests to support commercial tapping.

The Prospects for Profitable Tapping Operations

The conclusions and recommendations offered above assume rational action by producers, and identify limits for profitable tapping within the Lower Peninsula. In essence, the models show that stand stocking is of minor consequence in operations that gather sap by plastic tube systems and process it into syrup at the production locality. But previous optimism about profits from selling sap to central evaporator plants deserves qualification. To insure profits, operators must limit activity to stands sufficiently stocked to provide revenue in excess of normal operating costs plus the cost of transportation. Only forests stocked as well as or more heavily than those shown in Tables 13 and 17 should be considered for this use.

If plant managers experience difficulty procuring sap due to scarcity of suitably stocked stands near the evaporator plant, they could offer roadside purchase and enhance procurement efforts. Also, efficient processors could increase the purchase price. Pasto and Taylor (1962) suggest that with a syrup value of $6.00 per gallon, efficient processors operating large automated plants could pay as much as $0.09 to $0.10 per gallon (delivered) for 2.0

^{o}Brix sap. However, cost analysis data presented above show that sap can be delivered to the evaporator plant for approximately \$0.045 to \$0.055 per gallon. For most cases in the Lower Peninsula, raising the purchase price only \$0.01 per gallon for sap of average ^{o}Brix would increase revenues sufficiently to permit tapping with plastic tube systems.

The Tappable Resource in Michigan's Lower Peninsula and Its Suitability for Commercial Tapping

Total Tapholes Available

In 1950, the northern hardwood forests of Michigan's Lower Peninsula contained approximately 22.3 million tapholes (Table 18). Within the northern 33 counties, the bulk of the tappable resource was in pole-size stands. But in the southern region, the tappable resource was mostly concentrated in sawtimber forests.

Although northern hardwood stands occupy a greater total area within the northern region than in the south, the preponderance of well stocked sawtimber stands in the southern counties compensates for the smaller acreage of northern hardwoods there. To illustrate, whereas 57 acres provided 1,000 tapholes in the northern half of the Lower Peninsula, 1,000 were found on only 30 acres in the southern counties. Despite the acreage differences between the two regions, the tappable northern hardwood resource in 1950 was almost equally divided between the northern and southern portions of the Peninsula (Table 18).

Resources Suited for Commercial Tapping

Maple sap can be commercially produced in the segment of the total northern hardwood forest that is sufficiently stocked to permit break-even operation. Tapping

Table 18. The total tappable resource within Michigan's Lower Peninsula, 1947-1949[a]

Region[b]	Average stand diameter - inches			Total
	5-11	11-15	15 +	
	Tapholes	Tapholes	Tapholes	Tapholes
Upper north half	6,771,525	2,278,419	116,842	9,166,786
Lower north half	1,061,280	1,025,904	58,960	2,146,144
Northern half of the Peninsula	7,832,805	3,304,323	175,802	11,312,930
Upper south half	955,584	2,762,235	1,544,529	5,262,348
Lower south half	668,800	3,216,928	1,884,344	5,770,072
Southern half of the Peninsula	1,624,384	5,979,163	3,428,873	11,032,420
Entire Lower Peninsula	9,457,189	9,283,486	3,604,675	22,345,350

[a]Based on taphole stocking shown in Table 8 and the acreage estimates in Table 7.

[b]See Figure 3.

must be limited to stands with a minimum taphole stocking shown in Tables 13 and 17 if the sap is sold to a central evaporator plant.

About half of the northern hardwood poletimber and three-fourths of the sawtimber within the Lower Peninsula is sufficiently stocked to permit commercial tapping if the sap is processed at the collection site. Within the northern region, pole-size stands comprise about 60 percent of these usable resources. By contrast, the bulk of forest area suited for tapping by integrated sap-syrup enterprises within the southern half of the Peninsula is in sawtimber stands (Table 19).

Approximately one-third of the 660,000 acres sufficiently stocked to support tapping by integrated sap-syrup operations are adapted to production using roadside sale to dispose of the sap. Only one-fifth of the area is suited for tapping if the sap is delivered to an evaporator plant. About 38,000 acres in the northern counties and 94,000 acres in the southern region can be profitably tapped if the sap is delivered to a central evaporator plant (Table 19 and Appendix 20). In general, sawtimber forests are best suited for this latter use. Only five to seven percent of the pole stands in the Lower Peninsula can be worked under these circumstances.

Table 19. Northern hardwood forest area suited for commercial sap production in Michigan's Lower Peninsula, 1947-1949

Region	Stand size class	Total area	Commercial area, sap processed where collected		Commercial area, sap sold roadside		Commercial area, sap delivered five miles	
		Acres	Percent	Acres	Percent	Acres	Percent	Acres
Upper north half	Poletimber	400,200	47	188,094	7	28,014	5	20,010
	Small sawtimber	94,100	77	72,457	16	15,056	6	5,646
	Large sawtimber	36,800	79	29,072	53	19,504	26	9,568
Lower north half	Poletimber	55,300	65	35,945	..	..	..	..
	Small sawtimber	34,500	57	19,665	11	3,795	6	2,070
	Large sawtimber	17,400	87	15,138	48	8,352	4	696
Northern half of Peninsula	Poletimber	455,500	49	244,039	6	28,014	4	20,010
	Small sawtimber	128,600	72	92,122	15	18,851	6	7,716
	Large sawtimber	54,200	82	44,210	51	27,856	19	10,264
Upper south half	Poletimber	27,000	62	16,740	10	2,700	10	2,700
	Small sawtimber	64,300	72	46,296	35	22,505	18	11,574
	Large sawtimber	74,600	80	59,680	54	40,284	40	29,840
Lower south half	Poletimber	23,200	24	5,568	12	2,784	6	1,392
	Small sawtimber	41,000	71	29,110	19	7,790	10	4,100
	Large sawtimber	103,000	76	78,280	57	58,710	43	44,290
Southern half of Peninsula	Poletimber	50,200	44	22,308	11	5,484	8	4,092
	Small sawtimber	105,300	72	75,406	29	30,295	15	15,674
	Large sawtimber	177,600	78	137,960	42	98,994	42	74,130
Lower Peninsula	Poletimber	505,700	49	246,347	7	33,498	5	24,102
	Small sawtimber	233,900	72	167,528	21	49,146	10	23,390
	Large sawtimber	231,800	79	182,170	55	126,850	36	84,394
Total area		971,400	61	596,045	22	209,494	14	131,886
Usable area in southern half			40		64		71	
Usable area in northern half			60		36		29	

The entire area of northern hardwoods that is sufficiently stocked to permit commercial tapping (local use) contained about 20.7 million tapholes in 1947-1949 (Table 20). Of this total, stands suited for tapping with roadside sap sale had about 12.9 million tapholes, while those adapted for use with delivery of the sap to an evaporator plant contained approximately 9.6 million.

Northern hardwood stands within the southern 35 counties provide the greatest number of tapholes suited for commercial tapping under all production situations. In 1950, they contained 53 percent of the total adapted to local use, 68 percent suited for use with roadside sap sale, and 72 percent of the resource capable of supporting profitable operations requiring sap delivery. About two-thirds of the tapholes in stands suited for this latter use within the northern region in 1950 were in pole-size forests. However, within the southern counties, the tappable resources within poletimber stands were of minor consequence.

Table 20. Total tapholes suited for commercial sap production in Michigan's Lower Peninsula, 1947-1949

Region	Size class	Sap processed where collected			Sap sold roadside			Sap delivered five miles		
		Area	Tapholes per acre	Total tapholes	Area	Tapholes per acre	Total tapholes	Area	Tapholes per acre	Total tapholes
		Acres	Number	Number	Acres	Number	Number	Acres	Number	Number
Northern half	Poletimber	224,039	27	6,049,053	28,014	75	2,101,050	20,010	85	1,700,850
	Small sawtimber	92,122	23	2,118,806	18,851	53	999,103	7,716	58	447,528
	Large sawtimber	44,210	33	1,458,930	27,856	35	974,960	10,264	51	523,464
	Total	360,371	27	9,626,789	74,721	55	4,075,113	37,990	70	2,671,842
Southern half	Poletimber	22,308	31	691,548	5,484	61	334,524	4,092	75	306,900
	Small sawtimber	75,406	42	3,167,052	30,295	68	2,060,060	15,674	86	1,347,964
	Large sawtimber	137,960	52	7,173,920	98,994	65	6,434,610	74,130	71	5,263,230
	Total	235,674	47	11,032,520	134,773	66	8,829,194	93,896	74	6,918,094
Lower Peninsula	Poletimber	246,347	27	6,740,601	33,498	73	2,435,574	24,102	84	2,007,750
	Small sawtimber	167,528	32	5,285,858	49,146	62	3,059,163	23,390	77	1,795,492
	Large sawtimber	182,170	47	8,632,850	126,850	58	7,409,570	84,394	69	5,786,694
	Total	596,045	35	20,659,309	209,494	62	12,904,307	131,886	73	9,589,936

The Maple Syrup Industry in Michigan's Lower Peninsula

The present maple syrup industry, with 810 producers, uses about 372,770 of the total tapholes available (U.S. Bur. Census, 1966). Beside being small, the industry exhibits characteristics of operation and resource use that help explain the past, present, and probable future tapping.

Characteristics of Operations

Study of producer sample data, in conjunction with information from the 1964 Census of Agriculture (U.S. Bur. Census, 1966), disclosed recent changes in the amount and distribution of tapping in the Lower Peninsula. For example, while the number of operations decreased between 1959 and 1964, total tapping increased slightly. This resulted in an apparent increase in the average number of tapholes used per operation (Table 21).

Between 1959 and 1964, tapping did not increase uniformly throughout the Lower Peninsula. Rather, it increased in some areas and decreased in others. For example, during the 5-year period, total tapping increased 18 percent in the northern counties, and the proportion of Lower Peninsula producers located in the northern region increased by 6 percent. However, during the same period tapping declined by 9 percent within the southern counties. As a result, while only 39 percent of all tapping was within the northern 33

Table 21. Changes in tapping within Michigan's Lower Peninsula, 1949-1964[a]

Region	Year	Producers	Tapholes used	Producers	Tapholes	Average tapholes per operation
		Number	Number	Percent	Percent	Number
North half	1959	350	117,674	36	39	336
	1964	340	206,190	42	55	606
South half	1959	626	182,839	64	61	292
	1964	470	166,531	58	45	354
All	1959	976	300,513	..	..	308
counties	1964	810	372,721	..	..	460

[a]Source: U.S. Bur. Census, 1961, 1966.

counties in 1959, by 1964 northern producers were using 55 percent of the tapholes installed in the Lower Peninsula.

Producer sample data shed some light upon the nature of this change in the amount and distribution of tapping in the Lower Peninsula. Between 1963 and 1965, 56 percent of operations within the northern 33 counties decreased the size of their tapping and only 11 percent increased production. Nevertheless, the northern region experienced an overall growth of 11 percent by commercial enterprises during the 3 year period. Within the southern 35 counties, only 21 percent of the producers decreased tapping, and 35 percent expanded their operations. Still, resource use within the southern region decreased by four percent (Table 22). Because the expansion in the north exceeded the decline in the southern region, tapping increased for the Lower Peninsula and continued to concentrate within the northern 33 counties. This increase within the northern region resulted from rather large-scale expansion by a relatively small proportion of the commercial industry. The tapping decline noted for the southern counties was due to drastic cutbacks or terminations, also by a small proportion of the producers.

Table 23 shows the percentage of present commercial operations in each of three arbitrary size categories and the average number of tapholes used by operations in these classes. Since few producers purchase sap to supplement their own tapping the data in Table 23 represent the size

Table 22. Change in size of tapping operations during the period 1963-1965 by producers sampled in Michigan's Lower Peninsula, 1965

Change noted	Region: Northern half	Region: Southern half	Entire Lower Peninsula[a]
Operations sampled	18	19	37
	Percent	Percent	Percent
Operations that increased tapping	11	32	23
Operations that reduced tapping	56	21	36
Operations that did not change tapping	33	47	41
Change in tapholes used in the region	+11	- 4	+ 4

[a]Weighted averages based on the proportions of producers and tapholes reported for each half of the Lower Peninsula in the 1964 Census of Agriculture (U.S. Bur. Census, 1966).

Table 23. Size of sapping operations sampled within Michigan's Lower Peninsula, 1965

Size operation	Northern 33 counties: Producers	Northern 33 counties: Average tapholes used	Southern 33 counties: Producers	Southern 33 counties: Average tapholes used
Tapholes	Percent	Number	Percent	Number
	(All operations sampled)			
0-499	10	250	61	307
500-999	33	621	30	746
1,000 +	57	2,914	9	1,425
All	100	1,896	100	538
	(Operations that do not purchase extra sap)			
0-499	11	250	59	310
500-999	39	621	32	746
1,000 +	50	2,908	9	1,425
All	100	1,723	100	550

of maple syrup enterprises within the Lower Peninsula.[5] The most striking relationship shown in Table 23 is that a majority of northern enterprises use more than 1,000 tapholes. However, most southern operations presently utilize less than 500 tapholes. Willits (1965) contends that enterprises using less than 500 tapholes are not profitable. On this basis, 40 percent of the Lower Peninsula industry appears submarginal, including 61 percent of operations now active in the southern 35 counties.

The same contrast in the size of enterprises between the two halves of the Peninsula noted in Table 23 also appears in data reported in the 1964 Census of Agriculture (U.S. Bur. Census, 1966). There, the tabulation shows that operations average 606 tapholes in the northern counties and 345 in the southern region[6] (Table 21). In Table 21 it was shown that the average size of operations increased between 1959 and 1964. Based on the data in Table 23, it appears that this regional growth in the average size of individual enterprises resulted from the termination of many small

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[5]Only 1 of the 22 syrup operations sampled in the southern region and 3 of the 20 in the northern counties reported sap purchase.

[6]The 1964 Census of Agriculture enumerated production by the commercial enterprises and the many small noncommercial operations that produce syrup for family use. Because the present study considers only the commercial enterprises, the averages shown in Table 23 are larger than the Census data.

operations rather than from expanded tapping by the remaining ones.

The bulk of these present commercial businesses within the maple syrup industry of the Lower Peninsula began operations several years ago. Within the southern 35 counties, 22 percent of operations trace their origin back 50 years or more and 45 percent have produced for at least 25 years. Of those in the northern region, 13 percent are 50 or more years old, and 25 percent were established 25 or more years ago.

These records of longevity nicely complement the shifts in production noted earlier. For example, within the southern part of the Peninsula, only 4 percent of current operations started within the past 5 years. But 17 percent of the present industry in the northern 33 counties began production since 1960. Thus, the northern region attracted more new operations recently than did the south, and gained more new tapholes to offset losses from terminating or declining operations.

These age data also help explain both the instability in numbers of operations shown in the 1964 Census of Agriculture (U.S. Bur. Census, 1966) and the shift in proportion of operations located within the two halves of the Peninsula between 1959 and 1964. While 23 percent of the present enterprises started production during that 5-year period, only 9 percent initiated their operations within the past 5 years. Furthermore, those that began tapping between 1959 and 1965 were 17 percent fewer than the number that terminated production between 1959 and 1964. This caused a reduction in the total numbers of operations within the Lower Peninsula, but at a more rapid rate in the south than in the north.

In many respects the sapping equipment used by the Lower Peninsula producers echoes the age of their operations. Seventy percent of the producers interviewed use buckets to collect sap, another 2 percent use plastic bags, and 28 percent employ a mixture of equipment, primarily buckets and bags. Only 1 of the 48 hangs any appreciable amount of plastic tubing. With this antiquated equipment, great amounts of manual labor are utilized in the sapping operations. For example, the sampled producers reported the following numbers of men required daily for sap gathering:

Northern half of Lower Peninsula	2.9 men
Southern half of Lower Peninsula	3.6 men
Lower Peninsula average	3.3 men.[7]

[7] Data for the Lower Peninsula are weighted averages based on the numbers of producers and tapholes reported for each half of the Lower Peninsula in the 1964 Census of Agriculture (U.S. Bur. Census, 1966).

Lamb (u.d.) reports that 1 man can work about 3,000 tapholes if plastic tube systems are used to gather the sap. With their antiquated bucket operations, producers in the southern counties of the Lower Peninsula require 1 man for every 149 tapholes and producers in the northern region need 1 man for every 653 tapholes.[8] On the average, the maple syrup industry in the Peninsula uses 1 man for each 240 tapholes. Willits (1965) claims that by converting from buckets to tubing for gathering, producers can reduce the cost of syrup-making by 40 percent. Thus, by clinging to the antiquated hand-gathering methods for sap collection, most Lower Peninsula producers ignore the potential to reduce operating costs.

Not all Lower Peninsula producers confine their tapping to personally-owned forest lands. Rather, 48 percent of those sampled in the southern counties and 39 percent in the northern region reported some tapping on other ownerships. For the entire Peninsula, 44 percent of the operations gather sap from neighboring properties (Table 24). But while a large proportion of producers tap on lands they do not own, only 22 percent of the tapholes installed in the southern region in 1965 and 36 percent in the northern half

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[8]These estimates are based on the size of operations reported earlier. Since the working day length varies so greatly between and within operations, the actual man-hours were not determined.

Table 24. Sap production on other than producer-owned forest lands in Michigan's Lower Peninsula, 1965[a]

Region	Producers	Proportion of total tapholes
	Percent	Percent
Northern half of Peninsula	39	36
Southern half of Peninsula	48	22
Entire Lower Peninsula	44	30

[a]See Appendix 21.

were placed off producer-owned lands. For the entire Peninsula, about 30 percent of the resource used for sap production by the commercial industry is not personally owned (Table 24 and Appendix 21).

Most of the enterprises within Michigan's Lower Peninsula integrate their tapping with sap processing. Occasionally producers get some low-grade product that can be sold only in bulk quantities as commercial-grade syrup. Frequently this inferior syrup results from processing low-grade sap at season's end. Nevertheless, by continuing operation each year as long as possible and selling the lower grade syrup in bulk quantities, producers can increase their annual production at no additional fixed costs and help minimize the annual overhead per unit of product.

Only 19 percent of the producers in the Lower Peninsula take advantage of the market for commercial-grade syrup. By regions, just 14 percent of producers interviewed in the southern counties and 27 percent in the north sell commercial-grade products. Sixty-six percent of all producers explained that pressures from more important spring farm work required terminating operations before the sap and syrup became low quality at season's end. Others believed that because of the labor involved and the lower sale price realized for the commercial-grade product, it would not pay to extend the season for this purpose. Still others did not wish to bother with handling and marketing the lower-grade syrup. These attitudes may reflect the inefficient methods commonly used throughout the industry.

While about one-fifth of the maple syrup enterprises in the Lower Peninsula sell some commercial-grade syrup, the bulk of Michigan maple products are sold for table use. To protect the consumer, Michigan health laws require that producers maintain sanitary facilities and working conditions in the saphouse (Appendix 4). However, most producers have not complied with the provisions of the laws. To illustrate, during the course of field work, saphouses used by 34 enterprises were evaluated according to the criteria given in Appendix 4. Fifty-eight percent of those examined failed to meet the minimum requirements, including 41 percent of the saphouses in the northern counties and 71 percent in the south. These sub-standard plants processed the sap collected from 57 percent of the tapholes installed in 1965 by the producers sampled. In both regions, this non-compliance occurs commonly, but not entirely, with producers who plan to terminate production soon.

The general failure to comply with Michigan Health laws reflects both a carelessness by producers and an apparent laxity or absence of State inspection. The fact that a large proportion of producers have not invested sufficient capital in past years to keep their saphouses in a condition safe for food processing may be a reflection of low profits within the industry.

The Tappable Resource on Producer-Owned Lands and Its Use for Sap Production

Maple sap and syrup producers in the northern half of the Lower Peninsula own an average of 24 tappable acres each, containing approximately 1,802 tapholes. In the southern half of the Peninsula the average usable area owned per producer is only 9 acres, and contains about 555 tapholes. The inventory of these producer-owned lands revealed great variation in the nature and condition of the producer-owned forest from one property to another, and within ownerships. Although differences in stand characteristics were noted between the northern and southern regions, the great variability encountered rendered them statistically nonsignificant (Table 25).

Producers throughout the Lower Peninsula do not completely and properly utilize the resource available on their lands. Rather, only 17 percent of the operations sampled in the southern countries, and none in the north, use their resource to best advantage. On an average, for current tapping operations producers utilize just 75 percent of the total tapholes they own (Table 26).

Within the northern 33 counties, 61 percent of the commercial industry uses less than the full capacity of its lands. The remaining 39 percent taps too heavily. Only three-fourths of the producer owned areas and 69 percent of the available tapholes were tapped in 1965. Still, 76

Table 25. The nature of producer-owned sugar maple resources in Michigan's Lower Peninsula, 1965

Resource characteristic	Region: Northern half	Region: Southern half	Difference[b]
Basal area per acre, sq.ft.[a]	102	95	ns
Basal area per acre in sugar maple, sq.ft.	76	58	ns
Sugar maple per acre, number[a]	193	61	ns
Average d.b.h. sugar maple, inches	14.5	17.9	ns
Tappable sugar maple per acre, number	55	38	ns
Area available to tap, acres[a]	24.4	9.3	*
Tapholes per acre, number	69.5	50.2	ns
Total tapholes available, number[a]	1,802	555	*

[a]Tests showed the variances to be non-homogeneous. Thus, a t-test approximation was used to test the difference in the manner recommended by Dixon and Massey (1957), p. 124.

[b]ns - non-significant difference; * - significant difference at the 95 percent level.

Table 26. Use of the available sugar maple resource on producer-owned lands in Michigan's Lower Peninsula, 1965

	Region		
	Northern half	Southern half	Entire Peninsula[a]
Area available . . . Acres	24.4	9.3	..
Area tapped. . . . . Acres	15.1	9.2	..
Tapholes used . . Percent	69	83	75
Producers making proper use of their resource . . . . . Percent	0	17	..
Producers using less than the full potential of their resouce . . Percent	61	70	66
Producers overtapping their resource . . Percent	39	13	..

[a]Weighted averages based on the proportions of tapholes and producers reported for each half of the Lower Peninsula in the 1964 Census of Agriculture (U.S. Bur. Census, 1966).

percent of the sampled producers excessively used some portion of their woodlands, primarily because they tapped trees too small for production or because they placed two tapholes in trees suited for just one. For the northern region, the incomplete resource noted above results primarily from the producers' failure to tap the entire area they own.

Producers within the southern half of the Lower Peninsula tap almost all the suitable forest area they own. However, 70 percent of the present operations do not use all of their personally-owned resource. Collectively, in 1965, southern producers installed only 83 percent of the total tapholes possible within their forests, primarily because they failed to put as many tapholes as possible in the larger trees they own. In 1965, many 4-taphole trees supported just 2 buckets.

Surprisingly, 73 percent of producers in the southern counties and 33 percent of those in the north who failed to utilize all their personally-owned resource also reported tapping on other ownerships. Although 60 percent of producers in the southern region who tapped neighboring lands claim they also exhausted the potential of their own forests, inventory data collected on their forest lands revealed they could have installed more tapholes there than they did in 1965. While on the one hand the high use of tapholes on other ownerships suggests that producers recognize a potential to expand tapping through the use of lands they do not own, the simultaneous incomplete use of their own resources suggests that many producers fail to understand the full potential of their own woodlands. By placing 30 percent of their tapping on properties owned by someone else, producers ignore a chance to reduce operating costs by confining production to a smaller area and eliminating any rental costs.

The Prospects and Potential for Tapping in Michigan's Lower Peninsula by 1975

Prospects for Future Production

Plans for future activity in the Lower Peninsula commercial industry indicate that there will be a slight increase in maple sap production by 1975. About 43 percent of all operators hope to maintain production at the present level for another 10 years, and 22 percent plan to increase tapping. But 35 percent of the present commercial enterprises will cease production by 1975. Those terminating production account for 26 percent of present commercial resource use (Table 27).

Producers who plan to terminate operations give somewhat similar reasons for their action: (1) advancing age, (2) shortage of labor at wages they can pay, and (3) lack of adequate profit from past operation. Former producers, also encountered in the course of field work, who terminated operations in recent years cited these same reasons for their action.

The three reasons producers give for terminating their operations appear interrelated, and are amplified by earlier discussions about producer characteristics. It seems that as producers grow older they become dissatisfied with the physical work involved with collecting and hauling sap. Thus, they attempt to hire laborers for the work.

Table 27. Tapping planned by the maple syrup industry in Michigan's Lower Peninsula, 1965-1975

Future activity	Region: Northern half	Region: Southern half	Entire Peninsula[a]
Increase planned:			
Producers . . . Percent	22	22	22
. . . Number	75	104	179
Tapholes . . . Percent	19	26	22
. . . Number	39,176	43,298	82,474
No change planned:			
Producers . . . Percent	48	39	43
. . . Number	163	183	346
Tapholes . . . Percent	62	40	52
. . . Number	127,838	66,612	194,450
Termination planned:			
Producers . . . Percent	30	39	35
. . . Number	102	183	285
Tapholes . . . Percent	19	34	26
. . . Number	39,176	56,621	95,797

[a]Weighted averages based on the proportions of tapholes and producers reported for each half of the Lower Peninsula in the 1964 Census of Agriculture (U.S. Bur. Census, 1966).

But because of the inefficiency in their operations, the high fixed costs associated with their methods, and their desire for profits from the work, producers offer only a low wage. The available labor refuses to work for such low pay, and appears in short supply. With a higher wage, the needed laborers would probably be available, but the profit margin would diminish to an unacceptable level. So, production becomes physically and financially unattractive, and many producers terminate operation.

That 31 percent of producers in the north and 36 percent in the south hope to increase their tapping by 1975, however, offers a bright prospect for the future. If plans materialize, the average number of tapholes used per enterprise will increase to 2,717 in the northern counties and to 896 in the south. This will spread the fixed costs over a larger volume of production and improve the chances for profits as suggested by Willits (1965).

Although the anticipated cessation by about one-third of the commercial industry promises a noticeable effect on future tapping, increases planned by remaining enterprises will offset the losses. While in the southern half of the Lower Peninsula commercial tapping by existing operations will decline six percent, a nine percent increase in the northern counties will compensate for the loss (Table 28).

Table 28. Anticipated resource use for sap production in 1975 by enterprises active in Michigan's Lower Peninsula in 1965

Region	Tapholes now used[a]	Expected change	Future tapholes	Future total by region
	Number	Percent	Number	Percent
Northern half	206,190	+ 9	224,747	59
Southern half	166,531	- 6	156,539	41
Lower Peninsula	372,721	+ 2[b]	381,286	100

[a]Source: Tables 2 and 21.

[b]A weighted average based on the number of tapholes and producers reported for each half of the Lower Peninsula in the 1964 Census of Agriculture (U.S. Bur. Census, 1966).

Some new commercial operations will start production by 1975 and add new tapping. But records indicate that the number of tapholes added annually by new businesses has diminished in recent years. For example, of the operations sampled, those established between 1955 and 1960 accounted for 26 percent of commercial use in 1960. But the operations initiated between 1960 and 1965 utilized only 17 percent of the commercial tapholes in 1965. Furthermore, 93 percent of tapping by new enterprises within the past 5 years was confined to the northern 33 counties. If these trends continue, enterprises established after 1965 will locate primarily in the northern region and account for only 7 to 10 percent of total tapping in 1975. More specifically, new operations will account for 12 percent of tapping in the northern region and 3 percent in the south by 1975.

Considering both the plans of the present industry and the additions by new enterprises, tapping by 1975 will be approximately 383,350 tapholes. Fifty-nine percent of these will be installed in the northern 33 counties. This represents a continued shift northward in the concentration of tapping within the Lower Peninsula, maintaining the 1959-1964 trend (Table 23). For the entire Lower Peninsula tapping will increase by 3 percent above the level noted for 1964 (Table 29).

Table 29. Total tapping expected in Michigan's Lower Peninsula, 1975

Region	Tapholes used, 1964	Change by existing industry	Additions by new enterprises	Total change by 1975	Future tapholes	Future tapholes by region
	Number	Percent	Percent	Percent	Number	Percent
Northern half	206,190	+ 9	+ 1	+ 10	226,809	59
Southern half	166,531	- 6	...[a]	- 6	156,539	41
Lower Peninsula	372,721	+ 2[b]	...	+ 3[b]	383,348	100

[a]Less than 0.1 percent.

[b]Percentages for the Lower Peninsula are weighted averages based on the numbers of producers and tapholes reported for each half of the Lower Peninsula in the 1964 Census of Agriculture (U.S. Bur. Census, 1966).

While these data outline the prospects for production by 1975, the plans for tapping, alone, do not portray the entire character of future activity. Thirty-five percent of the syrup operators sampled in the north half of the Peninsula and 33 percent in the south who plan to continue production to 1975 also hope to purchase some sap to supplement their own tapping. In addition, 2 producers among the 17 contacted in the north (12 percent) and 1 of the 12 in the south (8 percent) want to abandon sap processing and convert to sap selling. These facts suggest that some degree of centralization will take place within the Lower Peninsula, creating at least a small market for sap sale.

Although the forecast presented above predicts growth in the maple syrup industry, it is based on plans that may or may not come to fruition. The sub-standard condition of nearly half the saphouses within the Lower Peninsula may constitute a major deterrent to future production. These numerous sub-standard plants were able to continue operation in past years because saphouse inspection was inadequate and ineffective. But if and when health laws are enforced, production within the Lower Peninsula could be seriously curtailed.

At the present time 71 percent of the processing plants used for maple syrup production in the southern 35 counties, including 60 percent of those that will be in operation in future years, fail to meet the minimum requirements shown in Appendix 4. Likewise, 41 percent of the saphouses in the northern region, including 38 percent of the ones counted on for future production, face certain closure if the health laws are strictly enforced (Table 30). Closing these sub-standard processing plants should reduce tapping planned for 1975 by 42 percent, dropping resource use within the Lower Peninsula to 222,300 tapholes located primarily within the northern 33 counties.

At least one other factor may also strongly influence the chances for production plans to materialize. It was pointed out earlier that most enterprises within the Lower Peninsula appear to incur high operating costs because of the labor-demanding techniques used for sap production. Furthermore, nearly half of the producers probably realize low profits due to the smallness of their operation. As a result of these inefficiencies within the present industry, many producers who wish to continue production may be forced out of business in future years by rising costs and shortages of low-cost labor.

Capacity of Producer-Owned Resources to Support Future Operations

The tappable resource on producer-owned lands is dynamic. Within the next 10 years it will increase in direct proportion to the growth of the tappable stands owned.

Table 30. Proportion of Lower Peninsula maple saphouses that fail to meet minimum standards of sanitation, 1965[a]

Condition	Region: Northern half	Region: Southern half	Lower Peninsula[b]
	Percent	Percent	Percent
Unsanitary saphouses	41	71	58
Unsanitary saphouses, future production planned	38	60	48
Present tapholes supplying unsanitary saphouses	30	76	57
Planned future tapholes supplying unsanitary saphouses	13	78	42

[a]Based on observation of 34 saphouses at 45 maple syrup operations, 1965.

[b]Weighted averages based on the proportion of tapholes and producers reported for each half of the Lower Peninsula in the 1964 Census of Agriculture (U.S. Bur. Census, 1966).

Total accretion expected for each property will depend upon the present size and structure of the tappable resource owned and upon the growth of individual sugar maple trees in these forests.

Sugar maple diameter growth estimates generated by regression analysis from Forest Survey increment boring data (Figure 7 and Appendix 22) were applied to inventory records for producer-owned forests to furnish estimates of the size of each producer's resource in 1975.[9] Because of differences in the nature and structure of tappable reserves from ownership to ownership, estimates of accretion varied greatly among properties. For example, in the southern counties taphole growth will range from 5 to 24 per acre between 1965 and 1975, with a mean increment of 11.7 tapholes per acre for the 10-year period. For the northern half of the Peninsula, data indicate that there will be an increase of 6 to 24 tapholes per acre, with a mean growth of 20.6 per acre for the 10 years. These changes represent an average accretion of 1 taphole per acre per year for the southern region, and 3 tapholes per acre per year in the north. The bulk of additions will come from ingrowth or from growth of trees that now support a single taphole (Table 31). Because they contain a considerable number of small trees that will reach

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[9] All sugar maple sampled in 1965 were assumed to live for another 10 years.

Figure 7. Ten-year diameter growth for sugar maple in Michigan's Lower Peninsula (shaded areas define limits of the data).

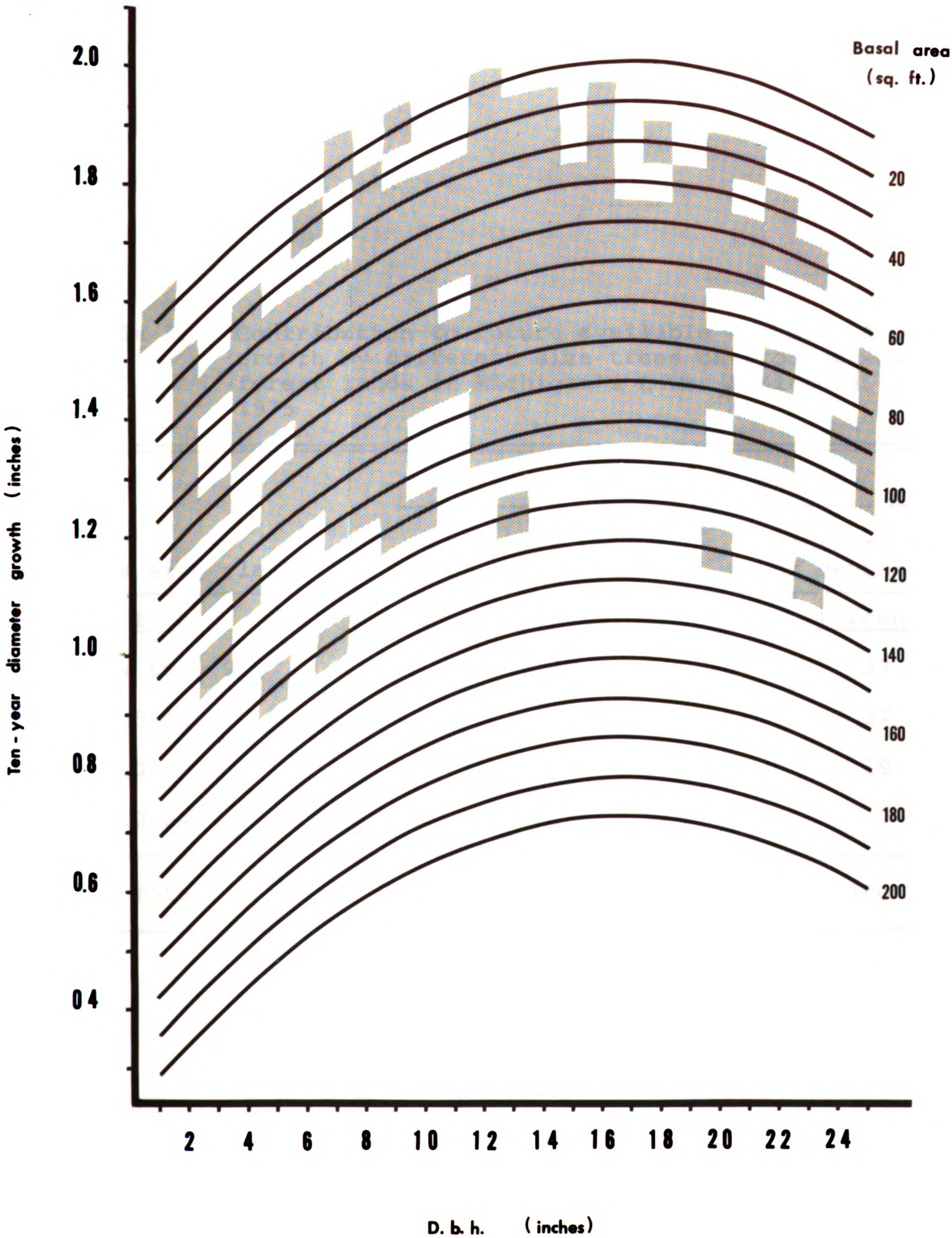

Basal area
(sq. ft.)
20
40
60
80
100
120
140
160
180
200
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
Ten-year diameter growth (inches)
2
4
6
8
10
12
14
16
18
20
22
24
D. b. h. (inches)

Table 31. Contribution to future available tapholes from growth by different size trees on producer-owned forest lands in Michigan's Lower Peninsula, 1965-1975

	Future taphole growth	
Tree size class	Northern half of Peninsula	Southern half of Peninsula
Inches	Percent	Percent
Less than 9.5	56	37
9.5-14.9	29	37
15.0-19.9	13	19
20.0-24.9	2	7
Total	100	100

tappable size within the next 10 years, producer-owned stands in the northern counties offer the greatest potential for future growth.

Table 32 summarizes the growth expected for average producer-owned resources within the Lower Peninsula. In essence, by 1975, producers can expect a 23 percent increase within the southern counties and a 33 percent growth in the north. Within the next 10 years, producer-owned resources in the southern region will increase by an average of 290 tapholes, while those in the northern half of the Peninsula will add an average of 810 new tapholes.

Despite the growth expected within the next 10 years, the tappable resources on producer-owned lands will be sufficient to accommodate tapping planned by only 44 percent of the operators in the northern counties and 43 percent of those in the south (Table 33). To satisfy their sap requirements, 56 percent of the producers planning to continue tapping in the future will need to rely upon tapholes installed on land owned by someone else. The use of non-industry owned resources will include 37 percent of tapping planned for the northern region and 27 percent of taphole use expected in the south. If these plans materialize, tapping on non-producer owned forest lands will increase by 3 percent in the next 10 years to about 125,400 tapholes.

Table 32. Ten-year increase in the commercial resources available on producer-owned lands within Michigan's Lower Peninsula, 1965-1975

Taphole growth		Region: Northern half	Region: Southern half	Lower Peninsula
Tapholes presently available	Number	1,802	555	...
Tapholes available in 1975	Number	2,613 ± 3,814	845 ± 556	...
Increase expected	Percent	33 + 18	23 ± 13	28 ± 26
Taphole growth per acre	Number	20.6 ± 3.4	11.7 ± 6.0	16.2 ± 14.8
Total accretion on average producer-owned properties	Number	810	290	...

Table 33. Capacity of producer-owned resources to support future tapping operations in Michigan's Lower Peninsula, 1975

Region	Operations that can meet needs on their own land, 1975	Planned tapholes that must be rented, 1975	
	Percent	Percent	Number
Northern half	44	37	83,156
Southern half	43	27	42,266
Lower Peninsula[a]	44	33	125,422

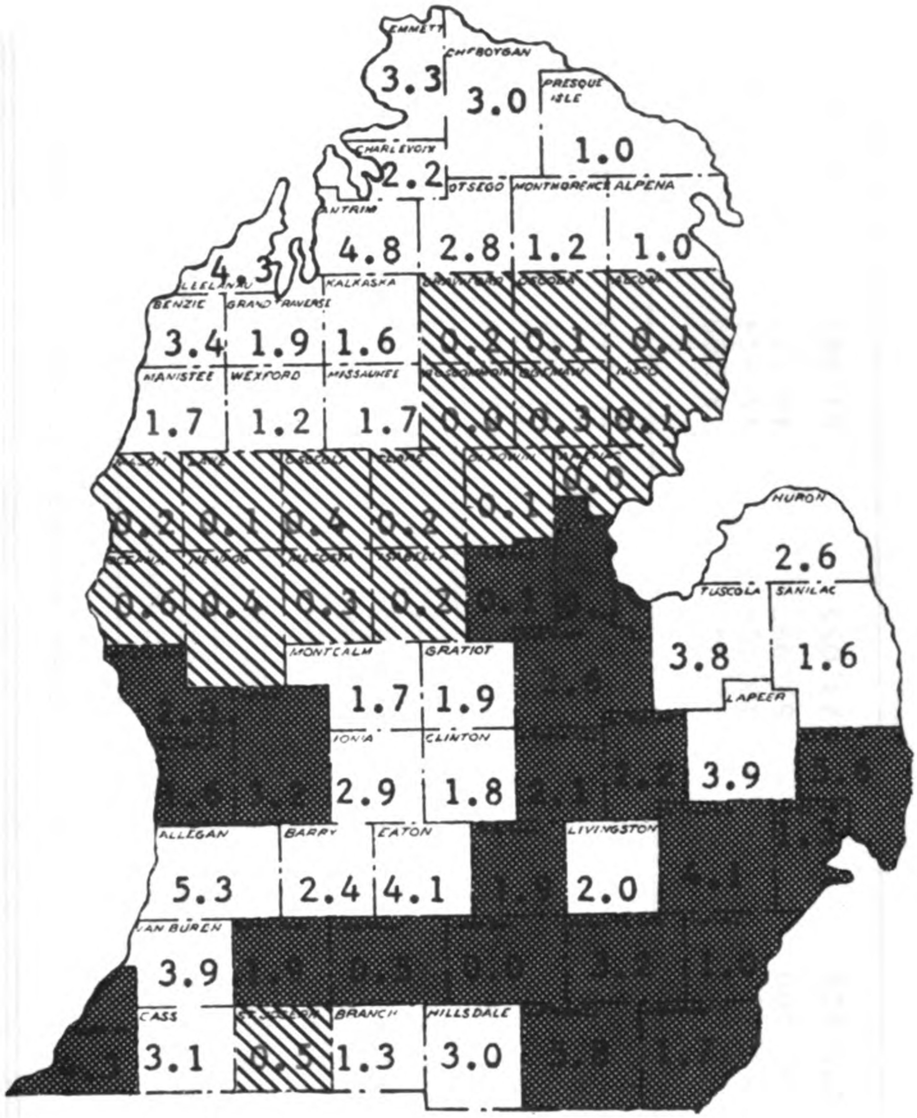
[a]Weighted averages based on the proportions of tapholes and producers reported for each half of the Lower Peninsula in the 1964 Census of Agriculture (U.S. Bur. Census, 1966).

Opportunities for Additional Tapping in the Sugar Maple Resource of Michigan's Lower Peninsula

The maple syrup industry presently uses less than 2 percent of the 22.3 million tapholes estimated for the Lower Peninsula from the 1947-1949 Forest Survey data. By 1975, tapping will increase slightly. Still, within the next 10 years the industry will continue to use less than 2 percent of the resources available.

The potential for commercial tapping in excess of production planned by the present industry may appear to be practically unlimited. However, certain factors make portions of the Peninsula poorly suited and unattractive for investment in a large, permanent central evaporating facility. Quite important in this respect is the threat of urban sprawl. While forest lands in the 18 urban fringe counties (Figure 8) could support extensive commercial tapping (Table 34), the pressures of urbanization, reversion of woodlands to non-forest uses, and purposes of ownership identified by Schallau (1962) make the urban fringe area undesirable as a site for long-term investment in a primary forest industry like maple sap processing. Even though some small, isolated maple syrup operations may continue there into the future, the urban fringe should be discounted as a locality suited for much expansion by present operations or for addition of new processing plants. Table 35 shows the tapholes available

Figure 8. Counties and regions of Michigan's Lower Peninsula suited for commercial sap production serving a central evaporator plant (excluding the urban fringe and the counties with less than 1,000 acres suited for tapping with sap delivery to an evaporator plant).



- Urban fringe

- Area with less than 1,000 acres of northern hardwoods

3.3 - Acres of northern hardwoods in the county

Table 34. Commercial sap production area of northern hardwoods located in the urban fringe of Michigan's Lower Peninsula, 1947-1949[a]

Region	Stand size class	Total northern hardwood forest	Area suited for sap production if the sap is:		
			Processed where collected	Sold roadside	Delivered 5 miles
		Acres	Acres	Acres	Acres
Northern half	Poletimber	2,600	1,600	...	...
	Small sawtimber	2,600	1,482	286	156
	Large sawtimber	1,500	1,305	720	60
	All sizes	6,700	4,477	1,006	216
Southern half	Poletimber	27,700	12,652	3,008	2,294
	Small sawtimber	54,800	39,234	15,628	8,088
	Large sawtimber	85,900	66,692	47,907	35,881
	All sizes	168,400	118,578	66,543	46,263
Lower Penin-sula	Poletimber	30,300	14,342	3,008	2,294
	Small sawtimber	57,400	40,716	15,914	8,244
	Large sawtimber	87,400	67,997	48,627	35,941
	All sizes	175,100	123,055	67,549	46,479

[a]An additional 21,400 acres of seedling-sapling forest in the urban fringe is not included in this tabulation.

Table 35. Potentially available tapholes suited for commercial sap production in Michigan's Lower Peninsula, 1947-1949

Resource	Tapholes suited for production if the sap is: Processed where collected	Sold roadside	Delivered 5 miles
	Tapholes	Tapholes	Tapholes
	(Northern half of the Lower Peninsula)		
Total	9,626,789	4,075,113	2,671,842
Less urban fringe	130,879	55,330	15,120
Outside urban fringe	9,495,910	4,019,783	2,656,722
	(Southern half of the Lower Peninsula)		
Total	11,032,520	8,829,194	6,918,094
Less urban fringe	5,537,166	4,391,285	3,423,462
Outside urban fringe	5,495,354	4,437,909	3,494,632
	(Lower Peninsula)		
Total	20,659,309	12,904,307	9,589,936
Less urban fringe	5,704,045	4,446,615	3,438,582
Outside urban fringe	14,955,264	8,457,692	6,151,354

within the Lower Peninsula after excluding the urban fringe forests.

Caution is advised relative to the usefulness of the area along the boundaries of the urban fringe within the southern half of the Lower Peninsula. Ionia, Eaton, Van-Buren and Cass Counties already support over 75 persons per square mile, and their populations will likely increase. Future encroachment by the swelling population centers should further restrict their use for forest production and tapping. Long-term investment in sap processing facilities within this region might be unwise.

Beyond the effects of urbanism, the potential of the Lower Peninsula to support an industry of central evaporator plants is restricted by other factors. In each of 18 other counties, forming an L-shaped region along the southern portion of the northern 33 counties (Figure 8), there are less than 600 acres of northern hardwood forest suited for tapping by operations that require delivery of sap to a central evaporator plant (Appendix 20). Although many woodland owners in this region may wish to tap, the resource available could not adequately support large centralized plants.

Figure 8 portrays the remaining three blocks of counties which offer some utility as locations for central evaporator enterprises. However, data discussed earlier relative to the characteristics of Lower Peninsula forest owners give grounds for skepticism about the prospects that the entire resource within these areas might be used for tapping. To be prospective sap producers, landowners should live near the site of their forest holdings and have an interest in forest production. Studies by Schallau (1961, 1962, 1964, 1965), Yoho (1956), and Yoho et al. (1957), showed that only 38 percent of the total forest area in the Peninsula is controlled by resident owners, and nearly half of the private landowners have no interest in forest production.

Farm and part-time farm owners best fill the qualifications for potential sap producers. They mostly live at the site of their forests, and they have good interest in forest production. Historically, these persons have dominated the maple syrup industry. Within the southern portion of the Peninsula farm owners who have an interest in forest production control about 30 percent of the northern hardwood area. In the northern region, they own about 41 percent of the northern hardwood forests (Table 36).

At least one other factor has some influence on the attractiveness of the different regions for the sites of new central evaporator plants. In the southern region of the Lower Peninsula, farm forests are small in size and highly fragmented (Table 5), and the northern hardwood forest cover is sparse and widely dispersed (Figure 4). This in itself does not render the region useless for large-scale sap

Table 36. Proportion of northern hardwood forests potentially available for owner-operated sap production enterprises on farm-owned lands[a]

		Region	
		Northern half	Southern half
Total forest area in farm forests	Percent	30	40
Total ownerships in farms.	Percent	51	49
Total northern hardwoods in farm ownerships	Percent	46	49[b]
Farm forest area intended for forest production	Percent	89	62[c]
Total northern hardwood area potentially available for tapping on farm forests intended for forest production .	Percent	41	30

[a]See Table 5.

[b]Computed on the assumption that farm owners hold the same proportion of northern hardwood area as they control of the total commercial forest area.

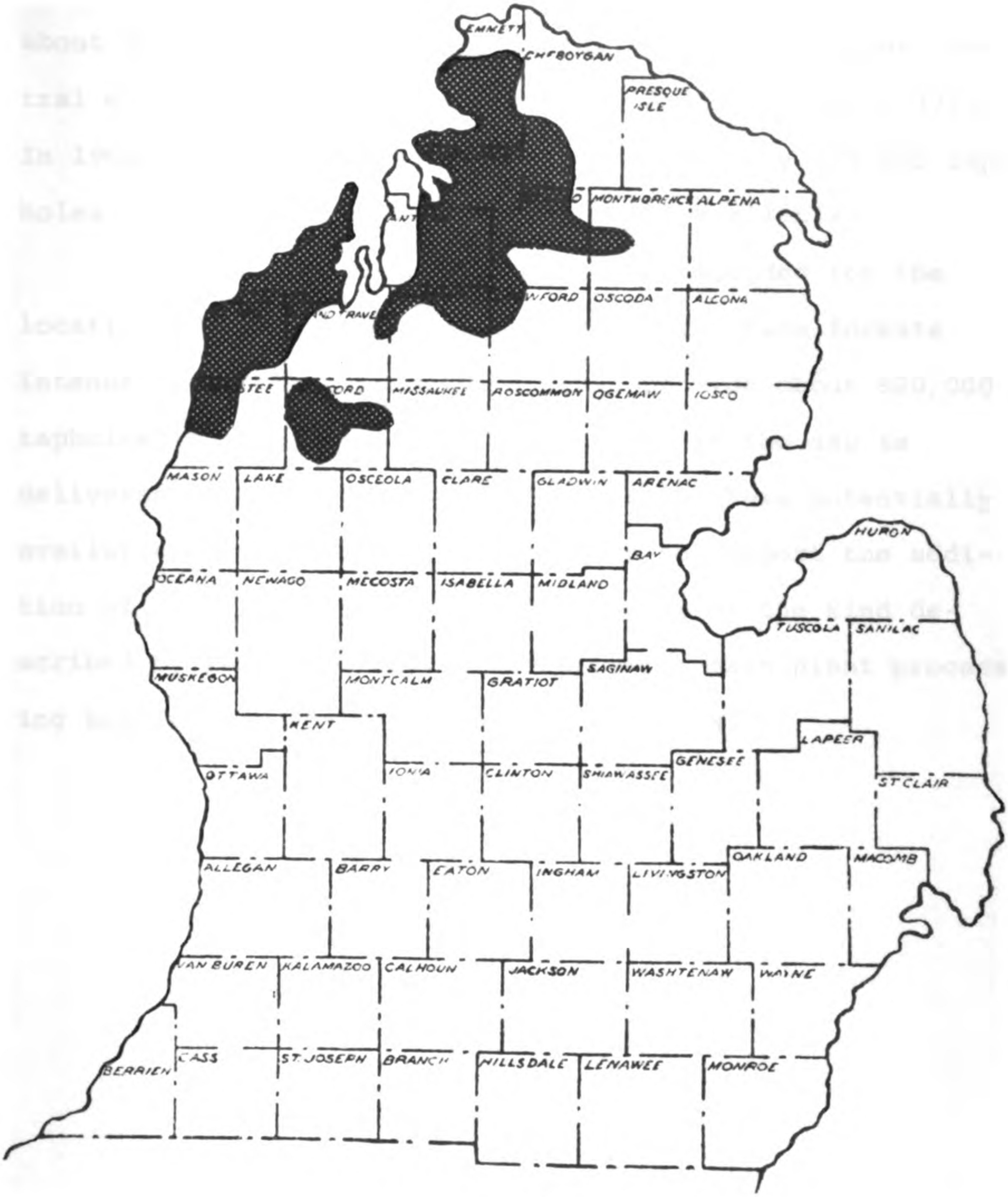
[c]A weighted average for full-time and part-time farmers combined.

production. But in order to meet their production needs, managers of large evaporator plants would need to depend upon tapping by a great number of producers scattered over a rather large hinterland. Procurement in the southern counties would be difficult. To the north, especially in the 15 northern-most counties, the northern hardwood forests are fairly contiguous, and the forest cover is reasonably dense (Figure 4). Farm ownerships average over 100 acres in size (Table 5). As a result, the supply area for a central evaporator plant would be much smaller than needed in the southern region, and procurement would be from fewer producers.

After considering the ownership patterns and purposes, the resource concentration, and the pressures of urbanism, the 15 counties in the northern-most part of the Lower Peninsula appear best suited for a new industry of central evaporator plants. Within this north-tip region, Emmet, Cheboygan, Charlevoix, Otsego, Leelanau, Antrim, Benzie, Grand Traverse, Wexford, Kalkaska, Crawford, and Manistee Counties provide areas with the greatest concentration of usable northern hardwoods. In these counties probably could be found good locations for new central evaporator plants.

Figure 9 identifies the specific region of the Lower Peninsula that appears best suited for a new industry of central evaporator plants. This 12-county area contains

Figure 9. Region of the Lower Peninsula best suited for sites of new central evaporator plants that require sap delivery.



- Area best suited to supply a central evaporator industry about 2 million tapholes suited for tapping to support central evaporator plants requiring sap delivery (Table 37). In 1964, producers within the region used only 155,655 tapholes, less than 8 percent of the total available.

Within the 12-county region recommended for the location of new central evaporator plants, farm forests intended for forest production could provide about 820,000 tapholes in stands that could be tapped if the sap is delivered to a central evaporator plant. This potentially available farm resource is sufficient to support the addition of about 12 large evaporator plants of the kind described by Pasto and Taylor (1962), with each plant processing sap from approximately 66,000 tapholes.

Table 37. Tapholes available in the 12 northwestern Lower Peninsula counties best suited to supply a central evaporator industry relying upon delivered sap[a]

County	Pole stands		Small sawtimber		Large sawtimber		Total tapholes
	Area	Tapholes	Area	Tapholes	Area	Tapholes	
	Acres	Number	Acres	Number	Acres	Number	Number
Antrim	2,800	238,000	660	38,280	780	39,780	316,060
Benzie	670	56,950	726	42,108	2,002	102,102	201,160
Charlevoix	1,255	106,675	480	27,840	468	23,868	158,383
Cheboygan	2,355	200,175	390	22,620	234	11,934	234,729
Crawford	130	11,050	42	2,436	...	...	13,486
Emmet	2,315	196,775	426	24,708	520	26,520	248,003
Grand Traverse	580	49,300	546	31,668	783	39,933	120,901
Kalkaska	580	49,300	174	10,092	806	41,106	100,498
Leelanau	1,960	166,600	930	53,940	1,378	70,278	290,818
Manistee	630	53,550	258	14,964	780	39,780	108,294
Otsego	2,300	195,500	282	16,356	208	10,608	222,464
Wexford	515	43,775	120	6,960	520	26,520	77,255
Total							2,092,051

[a]Area data based on the percentages of usable area shown in Table 19. Stocking data were obtained from Table 20.

SUMMARY AND CONCLUSIONS

The Northern Hardwood Forest Resource

Northern hardwood forests, which contain sugar maple as a chief component, are dispersed throughout Michigan's Lower Peninsula, but are mostly concentrated within the northern 33 counties. In this northern region, pole-size stands predominate, and stands with an average diameter of 11 inches or more account for only 39 percent of the northern hardwood area. Within the southern counties where northern hardwoods occur less abundantly, 70 percent of the stands are sawtimber size. These southern sawtimber forests account for about two-thirds of the total northern hardwood forest acreage with an average stand diameter of 11 inches or more.

Northern hardwood stands of the Lower Peninsula are primarily uneven-aged. Sugar maple comprises 20 to 50 percent of the total basal area per acre. In the southern region the species is of greatest importance in sawtimber stands. But in the north, sugar maple occurs most abundantly in pole-size stands. Consequently, sugar maple is most common in the types of stands that form the greatest proportion of the northern hardwood area within the different regions.

Rather low levels of taphole stocking suffice for commercial tapping by integrated sap-syrup operations. Under these conditions, the bulk of the northern hardwood area, including half of the poletimber, contains ample tapholes to justify commercial tapping. But when sap must be transported to a central evaporator plant, the minimum stocking required for break-even operation rises to a high level. Under these circumstances only 14 percent of all northern hardwood stands in the Lower Peninsula provide sufficient tapholes per acre to permit profitable tapping. Despite previous optimism relative to the ease of sap procurement by central evaporator plants, unless well stocked stands prevail near the plant location, procurement may be difficult.

While some individual areas in the Peninsula are poorly suited for large-scale commercial tapping, the northern hardwood forests on the whole provide a vast commercial resource that could easily support a maple syrup industry much larger than at present. Forest Survey data show that in 1950, the Peninsula contained about 21 million tapholes suited for tapping associated with integrated sap-syrup operations, 13 million usable for tapping and roadside sale of sap, and about 10 million tapholes suited for sap production and delivery to a central evaporator plant. The bulk of tapholes suited for each of these uses were located within stands of the southern 35 counties.

The Maple Syrup Industry

The maple syrup industry which draws upon the tappable resources of the Lower Peninsula is comprised of many old and small businesses that maintain inefficient operations hampered by their antiquated production methods. The bulk of producers invest great amounts of labor for sap gathering. In addition, 40 percent of the present commercial enterprises appear submarginal due to their small size. Throughout the industry, producers need to take drastic measures to revolutionize their equipment and methods of operation.

Little difference was noted between the sugar maple stands on producer-owned lands in the two halves of the Peninsula, except that total producer-owned resources in the northern region are about three times larger than those in the south. Neither in the north nor in the south do producers fully utilize the tapholes available in their forests. Sixty-six percent of present operations could immediately expand tapping on their own lands. Still, about 44 percent of all enterprises tap on other ownerships, placing some 30 percent of the tapholes used in 1965 on lands owned by someone else. These facts suggest additional inefficiency in many operations.

More than half the maple sap collected in the Lower Peninsula is processed in saphouses that fail to meet minimum sanitary conditions required by Michigan health laws. Apparently there has been inadequate inspection and enforcement of these requirements in past years. To remedy this situation the State could amend the health laws to require all producers to register with the State Health Department. This would provide the means to locate processing plants for inspection. Also, the law should require annual inspection of all saphouses and issuance of an annual permit as a prerequisite to the sale of products. Although these two measures might seriously curtail production of maple syrup in the Peninsula, they would quickly force adherence to acceptable sanitary standards for purity in Michigan maple syrup.

Outlook for the Future

While the number of enterprises decreased in recent years, overall tapping increased slightly between 1960 and 1964, reversing the declining trend noted for earlier years. This increase, however, occurred only because expansion in the northern counties offset production declines within the southern half of the Lower Peninsula.

These trends appear certain to continue. Data indicate that by 1975, the total number of syrup enterprises within the Lower Peninsula will decrease by 35 percent. Production will continue to decline within the southern region. However, expanded tapping by northern producers plus some additions by new enterprises there will offset the losses. For 1975, maple sap production in the Lower Peninsula is projected to increase by 3 percent and to continue concentrating within the northern region. In spite of this increase the widescale termination planned in both regions makes maple syrup manufacture seem destined to further decline as a farm enterprise within the Lower Peninsula.

In retrospect, the whole question of production potential seems a bit academic. Despite the increase noted in the past few years and the added tapping planned for the future, the level of sap production within the Lower Peninsula drifts further and further away from the potential of the resource. Producers now utilize only 75 percent of their personally owned resource and but a fraction of the total available. Taphole accretion has and will continue to add new reserves to the total resource at the rate of about one taphole per acre per year in the southern counties and three tapholes per acre per year in the northern region. Even though by 1975 the producer-owned resource will accommodate only 68 percent of planned tapping, and though 57 percent of the enterprises will collectively use about 125,000 tapholes on lands they do not own, availability of resources will not limit production. Despite the opinion offered by earlier writers who believe that insufficient forest resources contributed to past declines within the industry, Forest Survey data clearly show that the resource has been more than ample to accommodate production in recent years, and will continue to exceed production levels planned for 1975.

Although many producers wish to increase tapping within the next 10 years, two major obstacles may hinder future production and prevent plans from coming to fruition. First, at least half of the present saphouses that will continue to be used until 1975 are unsanitary. Proper enforcement of Michigan health laws would bring certain closure of these installations, and could reduce production to about 222,000 tapholes. Secondly, unless producers take advantage of the efficiency of modern, automated equipment, the rising costs of labor will likely reduce the profit margin, and diminish the financial incentive for production in many enterprises. In essence, inadequate facilities and equipment, coupled with economic factors, will limit production in future years. Only if producers improve their methods by adopting new techniques will they be able to continue their operations and occupy a competive position with other businesses for the use of capital, labor, and land.

The hope to greatly increase syrup production in Michigan's Lower Peninsula does not appear to rest with the present industry. Neither does it depend upon added forest resources or the discovery of new production techniques. Rather, the hope lies with developing an industry that will use available equipment and methods.

The best chance to stimulate sap production within the Peninsula may rest with the use of plastic tube systems for collecting the sap, and with introducing a new industry of central evaporator plants that will purchase the sap gathered by independent sapping enterprises. Within the Lower Peninsula, the concentration of northern hardwood forests, the purposes of forest ownership, and freedom from urban sprawl in the 12 northern-tip counties make that region best suited for such a new industry. Resources there are adequate to accommodate the addition of 12 central evaporator plants that require sap delivery.

Recommendations for Future Research

The smallness of the Lower Peninsula maple syrup industry and its minor effect on the state's economy raise serious question about investing much effort and resources into future maple sap and syrup investigations. On the other hand, some planners look to the maple industry as a means to actively stimulate Michigan's rural economy. Justification for future research into maple sap and syrup production depends upon weighing the relative merits of these two arguments. However, before the potential effect on Michigan's economy can be properly appraised, many factors must be evaluated to provide a more complete picture of the economics of maple sap and syrup production.

While modern techniques for sap production are generally considered to be more economical than older methods, the benefits of such new equipment and materials need to be determined by cost analysis and time studies. For example, tube systems should be compared with bucket methods to quantify the improvement in efficiency obtained by automating sap production. Furthermore, case studies and marginal analysis should be made to identify the size of operations required for profitable production and to estimate the net returns per acre that could be realized from modern sapping operations within the Lower Peninsula.

Detailed studies should also be made in the 12-county area singled out as the region best suited for locating new central evaporator plants. These investigations should be designed to: (1) determine the receptiveness of landowners to opportunities for sap sale, (2) explore purchase arrangements which would insure sufficient sap supplies for large plants, (3) evaluate specific sites where plants might locate, (4) assess the potential effect of a centralized maple syrup industry on the economy of the region, and (5) examine marketing activities including possible cooperative marketing procedures.

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APPENDICES

Appendix 1. Number of Forest Survey plots in northern hardwoods within Michigan's Lower Peninsula, Michigan Forest Survey, 1947-1949.

Region	Average stand diameter - inches 5-11	11-15	15 +	Total plots
	Number	Number	Number	Number
Northern half	155	27	8	190
Southern half	95	158	68	321
Lower Peninsula	250	185	76	511

Appendix 2. Forest Survey plot record form.

County____________________ Stand size class____________

Type______________________ Average plot d.b.h._____.___

	Sugar maple		Other species		Total		
D.b.h.	Number	Sq.ft.	Number	Sq.ft.	Number	Sq.ft.	Tapholes
2		.		.		.	
4		.		.		.	
6		.		.		.	
8		.		.		.	
10		.		.		.	
12		.		.		.	
14		.		.		.	
16		.		.		.	
18		.		.		.	
20		.		.		.	
22		.		.		.	
24		.		.		.	
26		.		.		.	
26+		.		.		.	
TOTAL		.		.		.	

Species	D.b.h.	Age	10-year growth
			.
			.
			.
			.

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Appendix 3. Producer sample questionnaire.

_____ Producer identification number

_____ Number of years in production

_____ Type of producer

1. Sap and syrup
2. Sap only
3. Syrup only

_____ Do you make commercial grade syrup from low grade sap?

1. Yes
2. No

_____ How may persons are used daily to gather sap?

_____ What type equipment is used to collect the sap?

1. Buckets only
2. Plastic bags only
3. Plastic tube systems
4. Plastic dropline and tank
5. A mixture

_____ How many tapholes were made in 1965?

_____ How many tapholes were made in 1964?

_____ How many tapholes were made in 1963?

_____ Why did you tap that number in 1965?

1. No more tapholes available on the property.
2. It does not pay to tap more.
3. There is no market for more sap or syrup.
4. No time to tap more.
5. Cannot handle more tapping with present sapping equipment.
6. Cannot handle more sap with present evaporator.
7. Do not want to tap any more than now used.

_____ How many tapholes were installed on non-owned properties in 1965?

_____ How many gallons of sap were required in 1965 to make one gallon of syrup?

______ How many gallons of sap purchased in 1965?

______ How many gallons of sap sold in 1965?

______ What are your plans for future production?

1. No change anticipated.
2. Will expand tapping.
3. Will reduce tapping.

______ Percent change in tapping anticipated.

______ Do you plan to purchase any sap by 1975?

1. Yes
2. No

______ How many gallons?

______ Do you plan to sell sap by 1975?

1. Yes
2. No

______ How many gallons?

* * * * * *

______ Accuracy of responses

1. From records
2. Sure memory
3. Guessing

Appendix 4. Criteria used to evaluate maple syrup processing plants for compliance with Michigan health laws.[a]

Saphouse:

1. Should be of tight construction, with adequate ventilation for removing steam.
2. Should have floors, walls, and ceiling made of wood, plastic, metal, cement, or other such suitable material.
3. Floors, walls, and ceiling should be kept clean.
4. Running water and electricity are desired but not mandatory.
5. A safe water supply adequate for cleaning needs should be provided.
6. Handwashing facilities should be available in the saphouse, and consist of hot water, soap, wash basin, and individual towels.
7. The saphouse must be free of rodents and insects at all times.

Storage tanks:

1. Should be kept in a cool place outside the saphouse.
2. Should be covered tightly enough to exclude contamination.
3. Should be equipped with a strainer.
4. Should be made of metal, but not of lead or be lead coated or soldered.
5. Should not be painted with lead paint on the inside.

---

[a]Criteria based on recommendations prepared by the Foods and Standards Division, Michigan Department of Agriculture, and the Forestry Department, Michigan State University (Mimeo, 1961).

Appendix 5. Producer-owned forest inventory form.

Owner number	___ ___ ___	Woodland acres	___ ___ ___
Plot number	___ ___ ___	Saphouse condition	________
B.a./ac.	___ ___ ___	Tapholes/ac.	___ ___ ___
B.a./ac., maple	___ ___ ___	Tapholes used per ac., 1965	___ ___ ___
B.a./ac., other	___ ___ ___		

Percent available tapholes used in 1965 ___ ___ ___

<u>Sugar maple stems tallied in point-sample</u>:

D.b.h.	No.per ac.	Tapholes available		Tapholes used, 1965		Future tapholes
		In tree	Per ac.	In tree	Per ac.	
TOTAL						

Nyland-65

Appendix 6. Comparison of sampled maple syrup producers included in the Extension Service producer listing with sampled producers not included on the listing, 1965.

Variable observed	Operations randomly selected from producer listing		Neighboring operations		t-test[a]
	Calculated mean	Variance	Calculated mean	Variance	
Number of tapholes used	1,159	2,194,328	1,257	1,727,345	0.04[ns]
Age of enterprises	19.6	313	28.3	608	.03[ns]
Percent of available tapholes used	90	4,383	83	1,798	.08[ns]
Tapholes available on the property	1,615	1,798[b]	848	7,011[b]	3.72**

[a]ns - non-significant test; ** - significant at the 99 percent level.

[b]Non-homogeneous variance at the 99 percent level. Therefore, a t-test approximation used as recommended by Dixon and Massey (1957), p. 124.

Appendix 7. Sap flow capacities for various size tubing used on level topography.[a]

Tube diameter	Maximum tapholes accommodated
Inches	Number
5/16	20
1/2	60
3/4	180
1	540

[a]Source: Lamb, 1962, u.d.; Willits, 1965; Willits and Sipple, 1961.

Appendix 8. Cost of transporting maple sap across producing lands to the saphouse or roadside collection point.

Northern half of Lower Peninsula--sap transportation system for 120 acres with 17 tapholes per acre, including one-quarter mile to roadside or saphouse:

Equipment costs:[a]

8,078 ft., 1/2-inch tube . .	$ 646.00
12,118 ft., 3/4-inch tube . .	1,454.00
1,795 ft., 1-inch tube . .	359.00
Total	$2,459.00

Annual cost = $333.47[b]

Cost per taphole = $\frac{\$333.47}{2,000} = \$0.17$[c]

Southern half of Lower Peninsula--sap transportation system for 20 acres with 33 tapholes per acre, including one-quarter mile to roadside or saphouse:

Equipment costs:[a]

1,346 ft., 1/2-inch tube . .	$ 108.00
1,571 ft., 3/4-inch tube . .	189.00
224 ft., 1-inch tube . .	45.00
Total	$ 342.00

Annual cost = $82.62[b]

Cost per taphole = $\frac{\$82.62}{700} = \$0.12$[c]

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[a]Lengths of tubing determined from plotted diagrams.

[b]See Appendix 10.

[c]See Appendix 11.

Appendix 9. Cost of equipment and material required in commercial sapping operations, 1965.

Part number[a]	Description	Price
33-U	5/16-inch tubing, plastic	$ 0.04 per ft.
43-U	1/2-inch tubing, plastic	0.08 per ft.
44-U	3/4-inch tubing, plastic	0.12 per ft.
45-U	1-inch tubing, plastic	0.20 per ft.
36	Nylon spile, ventless	0.10 each
34	Nylon tee, 5/16-inch	0.10 each
48	Nylon tee, 1/2-inch for 4 lines	1.00 each
111	Plastic coupling, 3/4-inch	0.35 each
106	Reducing coupling, 3/4- x 1/2-inch	0.40 each
60	Bronze gear pump, 1/4-inch[b]	75.00 each
..	Power tapper[c]	125.00 each
..	Storage tanks[d]	0.13 per gal.

[a]The part number is for Lamb Naturalflow tubing and tube equipment. These listings do not constitute an endorsement of the manufacturer's product, but are used only for illustrative purposes.

[b]See Appendix 14.

[c]See Appendix 12.

[d]See Appendix 13.

Appendix 10. Computation of the annual cost for investment in sapping equipment.

Annual cost is computed by a means that provides for return of capital annually, plus payment for interest on the remaining unpaid investment. The method is explained in detail on pages 377-378 of Chapman and Meyer (1947).

A fixed annual payment is applied to defray annual interest on the net principal, and to retire a portion of the net capital. The annual payment on the sum to be repaid over "n" years is:

$$r = \frac{(1+p)^n \ (p) \ (V)}{(1+p)^n - 1}$$

where: r = the annual payment

p = the rate of interest

V = the initial value or investment.

This formula is a recast version of the discounted annuity formula:

$$V = \frac{r \ ((1+p)^n - 1)}{p \ (1+p)^n} \quad .$$

Appendix 11. The average size of farm woodlands and their tappable resource in Michigan's Lower Peninsula.

Region	Average farm woodland[a]	Average tapholes per acre[b]	Total tapholes
	Acres	Number	Number
Northern half	120	17	2,040
Southern half	21	33	693

[a]Source: Schallau, 1961; Yoho, 1956.

[b]Weighted averages based on the stocking shown in Table 8.

Appendix 12. Annual cost of power tapping equipment, 1965.

The initial cost of a power tapper is \$125.00. With a life expectancy of five years, and depreciated at six percent per annum, the annual cost is:[a]

$$r = \frac{(1.06)^5 \ (0.06) \ (\$125.00)}{(1.06)^5 - 1}$$

$$= \$29.68.$$

Prorated over 700 tapholes for the average farm woodland in the southern half of the Lower Peninsula, the cost per taphole is:[b]

$$\frac{\$29.68}{700} = \$0.04$$

Prorated over 2,000 tapholes for the average farm woodland in the northern half of the Lower Peninsula, the cost per taphole is:[b]

$$\frac{\$29.68}{2{,}000} = \$0.01$$

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[a]See Appendix 10.

[b]See Appendix 11.

Appendix 13. Cost of storage tanks used with plastic tube gathering systems, 1965.

Tank capacity	Total cost[a]	Cost per gallon
Gallons	Dollars	Dollars
96	13.50	0.14
152	19.95	0.13
189	22.75	0.12
225	28.25	0.13
260	28.95	0.11
310	39.75	0.13
	Average	0.13

Considering two gallons per taphole (Lamb, 1962, u.d.), plus one additional gallon for temporary storage in the transport system,[b] the total cost per taphole is:

3 gallons x \$0.13 = \$0.39 per taphole.

Allowing an extra \$0.01 per taphole for covering the tank brings the total cost per taphole to \$0.40.

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[a]Prices quoted by Sears, Roebuck and Company in fall of 1965. These listings do not constitute an endorsement of the products, but are used only for illustrative purposes.

[b]See Appendix 8.

Appendix 14. Annual cost of tube cleaning equipment, 1965.

Willits *et al*. (1959), and Willits and Sipple (1961) describe methods and equipment required for cleaning plastic tube systems. Besides specific items needed for this operation, gathering tanks and tube sections used for sapping can be employed in the cleaning operation.

A pump purchased at an initial cost of $75.00 and depreciated over 5 years at a rate of 6 percent per annum costs:[a]

$$r = \frac{(1.06)^5 \ (0.06) \ (\$75.00)}{(1.06)^5 - 1}$$

$$= \$17.80.$$

Prorated over 700 tapholes for the average farm woodland in the southern half of the Lower Peninsula, the cost per taphole is:[b]

$$\frac{\$17.80}{700} = \$0.03$$

Prorated over 2,000 tapholes for the average farm woodland in the northern half of the Peninsula, the cost per taphole is:[b]

$$\frac{\$17.80}{2{,}000} = \$0.01$$

---

[a]See Appendix 10.

[b]See Appendix 11.

Appendix 15. Estimated annual operating costs per taphole for sap production in Michigan's Lower Peninsula, 1965.

Equipment and materials	Cost per taphole	
	Northern half	Southern half
	Dollars	Dollars
Paraformaldehyde pellet	0.01	0.01
Vacuum pumping[a]	0.11	0.11
Power tapper[b]	0.01	0.04
Labor[c]	0.20	0.20
Transport across the property[d]	0.17	0.12
Cleaning equipment[e]	0.01	0.03
Cleaning materials	0.01	0.01
Total	0.52	0.52

[a]Source: Morrow, 1963.

[b]See Appendix 12.

[c]Calculated at $1.50 per hour for 8 minutes according to time estimates made by Morrow (1961).

[d]See Appendix 8.

[e]See Appendix 14.

Appendix 16. Average sap sweetness reported for Michigan's Lower Peninsula, 1965.[a]

Gallons of sap required for producing one gallon of syrup

	Northern half of Peninsula	Southern half of Peninsula
	Number	Number
	45	32
	40	40
	42	37
	50	45
	40	37
	36	40
	35	37
	40	40
	25	35
	45	45
	40	45
	50	35
	50	37
	50	43
	50	45
	50	40
	50	35
	40	50
	35	45
	36	55
	40	
Total	889	736
Mean	42.3	40.9
Number	21	20
°Brix	2.03	2.14

Overall mean 2.08 = 2.1 °Brix

t-test: Observed t = 0.14[ns][b]

[a]Based on 41 averages reported by active producers for the 1965 boiling season.

[b]ns - non-significant.

Appendix 17. Proposed prices for maple sap delivered to an evaporator plant.[a]

Sap sweetness	Price per gallon[b]
^{o}Brix	Dollars
1.5	0.015
1.6	0.020
1.7	0.025
1.8	0.030
1.9	0.035
2.0	0.040
2.1	0.043
2.2	0.046
2.3	0.049
2.4	0.052
2.5	0.055
2.6	0.058
2.7	0.061
2.8	0.064
2.9	0.067
3.0	0.070

[a]Source: Anonymous, 1962

[b]Sap purchased and picked up at the sugarbush bears a haul charge of $0.005 to $0.01 per gallon.

Appendix 18. An example of the cost analysis used to determine stocking required for break-even tapping when the sap is processed at the property where collected, for 60 trees per acre in a stand 11-15 inches average d.b.h. in Michigan's Lower Peninsula.

Northern half of Lower Peninsula
(89 tapholes per acre)

COSTS:

Equipment:	
1,926 ft., 5/16-inch tubing . .	$ 77.04
208 ft., 1/2-inch tubing . .	16.64
39 ft., 3/4-inch tubing . .	4.68
89 spiles	8.90
81 tees, 5/16-inch	8.10
6 connectors, 1/2-inch . .	6.00
1 adapter, 3/4-inch	.40
Storage tanks	35.60
	$156.76
Annual charge =	$ 21.30
Other annual costs:	
89 tapholes at $0.52 each . . .	$ 46.28
TOTAL ANNUAL COST	$ 67.58

REVENUE:

2,225 gallons x $0.043	$ 95.68

BALANCE:

$95.68 - $46.28 = + $28.10

Southern half of Lower Peninsula
(85 tapholes per acre)

COSTS:

Equipment:	
1,843 ft., 5/16-inch tubing . .	$ 73.72
375 ft., 1/2-inch tubing . .	28.56
25 ft., 3/4-inch tubing . .	3.00
85 spiles	8.50
37 tees, 5/16-inch	3.70
9 connectors, 1/2-inch . .	9.00
1 adapter, 3/4-inch	.40
Storage tanks	34.00
	$160.88
Annual charge =	$ 21.86
Other annual costs:	
85 tapholes at $0.52 each . . .	$ 44.20
TOTAL ANNUAL COST	$ 66.06

REVENUE:

2,120 gallons x $0.043	$ 91.16

BALANCE:

$91.16 - $44.20 = + $25.10

Appendix 19. Cost of delivering maple sap five miles to an evaporator plant.

A 500-gallon per day operation that hauls sap 5 miles to the evaporator plant incurs the following cost per gallon:

Truck rental:

1-1/2 ton truck for 10 miles at \$0.20 per mile:

$$\frac{\$0.20 \times 10 \text{ mi.}}{500 \text{ gal.}} = \$0.004 \text{ per gallon}$$

Storage tanks:

2 tanks, 250 gallons each at \$0.13 per gallon, at 6 percent per annum:[a]

$$\frac{(1.06)^{10}\ (0.06)\ (\$65.00)}{(1.06)^{10} - 1} = \$8.83 \text{ per year}$$

\$8.83 / 15,000 gallons[b] = \$0.001 per gallon.

Labor cost:

2 hours per day at \$1.50 per hour:

$$\frac{\$3.00}{500 \text{ gal.}} = \$0.006 \text{ per gallon.}$$

When combined, these costs total \$0.011 per gallon.

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[a]See Appendix 10.

[b]500 gallons per day for a 30-day season gives 15,000 gallons per year.

Appendix 20. Northern hardwood forest land and tappable area by county for Michigan's Lower Peninsula, 1947-1949[a]

County	Northern hardwood area				Area suited for commercial tapping if the sap is[b]		
	Large sawtimber	Small sawtimber	Poletimber	Seedling-sapling	Processed where collected	Sold roadside	Delivered 5 miles
	Acres	Acres	Acres	Acres	Acres	Acres	Acres
			(Northern half of Lower Peninsula)				
Alcona	.....	200	2,400	8,000	1,330	200	132
Alpena	500	2,800	14,800	12,500	9,803	1,749	1,038
Antrim	3,000	11,000	56,000	35,200	38,280	7,270	4,800
Arenac	100	600	800	900	949	114	40
Bay	1,100	700	600	200	1,746	605	97
Benzie	7,700	12,100	13,400	16,200	21,966	6,955	3,398
Charlevoix	1,800	8,000	25,100	28,900	19,379	3,991	2,203
Cheboygan	900	6,500	47,100	36,200	27,853	4,814	2,979
Clare	400	2,400	2,000	2,200	3,016	456	160
Crawford	.....	700	2,600	7,800	1,813	294	172
Emmet	2,000	7,100	46,300	30,400	28,808	5,437	3,261
Gladwin	300	1,000	1,600	1,800	1,871	254	72
Grand Traverse	2,900	9,100	11,600	8,200	14,982	3,805	1,880
Iosco	200	500	1,200	800	1,131	270	142
Isabella	2,000	2,500	2,200	600	4,595	1,235	230
Kalkaska	3,100	2,900	11,600	39,600	10,366	2,919	1,560
Lake	500	1,800	1,500	2,700	2,436	434	128
Leelanau	5,300	15,500	39,200	14,000	35,330	8,033	4,268
Manistee	3,000	4,300	12,600	4,300	11,855	3,160	1,668
Mason	1,700	2,100	6,000	1,300	6,576	1,047	194
Mecosta	1,700	4,200	8,600	1,000	9,463	1,278	320
Midland	400	1,900	2,000	1,700	2,731	401	130
Missaukee	2,400	1,300	19,500	39,700	12,452	2,845	1,677
Montmorency	100	2,700	20,900	15,400	12,399	1,948	1,233
Newaygo	2,000	5,500	8,000	1,500	10,075	1,565	410
Oceana	3,700	7,500	11,400	800	14,904	2,601	598
Ogemaw	.....	900	4,600	9,900	2,947	466	284
Osceola	3,500	4,300	10,600	3,500	12,386	2,153	398
Oscoda	.....	200	2,200	5,700	1,232	186	122
Otsego	800	4,700	46,000	43,500	26,791	4,396	2,790
Presque Isle	1,100	1,400	12,100	15,800	7,634	1,654	975
Roscommon	.....	200	700	3,800	497	81	47
Wexford	2,000	2,000	10,300	17,500	8,167	2,101	1,155

Appendix 20.--Continued

County	Northern hardwood area				Area suited for commercial tapping if the sap is:		
	Large sawtimber	Small sawtimber	Poletimber	Seedling-sapling	Processed where collected	Sold roadside	Delivered 5 miles
	Acres	Acres	Acres	Acres	Acres	Acres	Acres
	(Southern half of the Lower Peninsula)						
Allegan	11,100	3,400	2,200	1,300	11,378	5,890	5,348
Barry	5,200	900	800	700	5,543	2,533	2,383
Berrien	9,200	2,200	1,700	800	8,962	4,689	4,330
Branch	2,200	2,200	500	400	3,354	1,617	1,294
Calhoun	1,000	600	100	500	1,210	605	518
Cass	6,700	1,200	1,200	900	6,232	3,294	3,090
Clinton	3,800	1,600	600	1,200	4,564	2,382	1,830
Eaton	8,200	3,800	700	900	9,098	4,623	4,070
Genessee	3,900	3,400	2,500	900	7,118	3,144	2,167
Gratiot	3,600	2,400	1,200	600	5,352	2,652	1,860
Hillsdale	5,900	2,700	1,300	400	6,713	3,404	2,987
Huron	4,600	4,100	2,900	2,900	8,430	3,749	2,562
Ingham	3,700	1,800	400	200	4,186	2,120	2,043
Ionia	6,100	2,000	800	2,000	6,816	3,953	2,871
Jackson	.....	.....	.....	.....	.....	.....	.....
Kalamazoo	4,200	600	700	600	3,786	2,015	1,910
Kent	5,600	6,900	1,500	3,700	10,378	4,683	3,188
Lapeer	8,400	8,000	3,000	4,300	14,340	6,638	3,872
Lenawee	12,300	3,300	1,800	600	12,123	6,321	5,805
Livingston	3,900	1,900	1,500	900	4,673	2,354	2,043
Macomb	2,100	1,900	1,300	1,300	3,257	1,576	1,271
Monroe	3,300	1,400	800	600	3,694	1,880	1,660
Montcalm	3,300	2,300	800	2,200	4,792	2,414	1,697
Muskegon	3,300	4,100	2,600	1,100	7,204	2,972	1,985
Oakland	7,000	5,900	3,300	1,800	10,301	5,014	4,089
Ottawa	3,100	1,700	2,300	1,400	5,130	2,366	1,641
Saginaw	5,300	2,500	1,600	1,100	7,032	3,688	2,625
Sanilac	3,000	3,200	200	400	4,828	2,342	1,622
Shiawasse	3,700	4,300	1,200	300	6,800	3,058	2,093
St. Clair	10,300	9,700	3,100	2,700	17,146	8,055	5,585
St. Joseph	900	600	100	100	1,134	563	476
Tuscola	6,600	8,100	2,700	1,700	12,786	5,625	3,810
Vanburen	8,200	2,100	2,000	200	11,460	4,273	3,919
Washtenaw	6,200	2,800	1,900	400	7,156	3,625	3,176
Wayne	1,700	1,700	900	1,500	2,715	1,306	1,041

[a]Source: Chase, 1953; Chase and Horn, 1950, 1955, 1956; Essex et al., 1955; Quinney et al., 1957a, 1957b; Rapp et al., 1957.

[b]Tappable area calculated by using percentage figures from Table 19.

Appendix 21. Sap production on other than producer-owned forest lands by producers sampled in Michigan's Lower Peninsula, 1965.

Region	Producers sampled	Tapholes used	Tapping on non-owned land			
			Producers	Producers	Tapholes	Tapholes
	Number	Number	Number	Percent	Number	Percent
Northern half	23	38,216	9	39	13,573	36
Southern half	23	13,375	11	48	2,902	22
Lower Peninsula	46	51,591	20	44[a]	16,475	30[a]

[a]A weighted average based on the proportions of tapholes and producers reported for each half of the Lower Peninsula in the 1964 Census of Agriculture (U.S. Bur. Census, 1966).

Appendix 22. Sugar maple diameter growth in Michigan's Lower Peninsula.

Sugar Maple Diameter Growth

Sugar maple grows slowly to moderately fast, but persistently (Eyre and Zillgitt, 1950; Gilbert and Jensen, 1958; U.S. For. Ser., 1907, 1908). Furthermore, data collected by Doppel (1927) and Zillgitt (1945) from old-growth stands show diameter growth increasing with tree size up to some maximum diameter, but thereafter decreasing or remaining somewhat constant. Other published data indicate that mean annual increment changes with tree age. On an average, stems reach tappable size after 60 to 80 years' growth (Chittenden, 1923; Doppel, 1927; Illick and Frontz, 1928).

Goodman (1957) claims that stand density influences sugar maple growth. However, past studies show this effect only for recently logged areas where diameter growth increased in proportion to the intensity of the cut (Anonymous, 1928; Downs, 1946; Jensen, 1943; Zillgitt, 1944). Although published data actually describe the magnitude of tree response to differing degrees of release, they do give some reason to suspect a cause-effect relationship between stand density and growth.

The hypothesis that diameter increment varies with tree size and is affected by stand density gets support from unpublished growth data prepared for the 1947-1949 Forest

Survey of Michigan. These show sugar maple diameter increment at approximately 1 to 2 inches in 10 years, depending upon tree diameter and stand stocking (U.S. For. Ser., 1954).[1]

Growth Estimates

Increment borings from the 1947-1949 Forest survey in the southern half of the Lower Peninsula provided data to test the hypothesis outlined above and to generate the sugar maple diameter growth estimates needed within the project. These measurements included the past 10-year radial increment, with tree diameter, tree age, and stand density pertaining to the terminus of the growth period.

Two procedures described by Davis (1954), Husch (1963), and Spurr (1952) were used. The first technique provides an estimate of the increment previously attained in different size classes by relating past increment to present values for sample tree parameters. In essence, it describes how much trees of a given diameter and condition grew in the preceding growth period. The second approach postulates that the growth of a size class will repeat the pattern and increment established by sample trees previously the same size, but which have subsequently grown larger. This latter

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[1]The Forest Survey growth estimates were not prepared for specific stand densities, but only for the very general stocking classes used in the Survey.

scheme relates diameter increment to sample tree and stand values at the beginning of the observed growth period. It estimates the increment expected in future years.

To apply the latter technique for estimating future sugar maple growth from the Forest Survey data first required adjusting the measurements to describe initial values. Beginning tree diameters were obtained by subtracting the increment as follows:

$$D_1 = D_2 - 2(Gr)$$

where D_1 = initial d.b.h.

D_2 = terminal d.b.h.

Gr = 10-year radial growth

But adjusting the stand basal area necessitated accounting for the accretion of all trees on the Forest Survey plot. This was accomplished in two stages:

1. For the 369 sugar maple sample trees and the 498 trees of species other than sugar maple,[2] past growth was estimated with the regression model:

$$G_P = b_0 + b_1(D_2) + b_2(D_2)^2 + b_3(B_2)$$

where G_P = past 10-year radial growth

D_2 = terminal d.b.h.

B_2 = terminal stand basal area per acre.

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[2]Other species include primarily American beech, American basswood, black cherry (<u>Prunus serotina</u> Ehrh.), American elm (<u>Ulmus americana</u> L.), red maple (<u>Acer rubrum</u> L.), northern red oak (<u>Quercus rubra</u> L.), and white oak (<u>Quercus alba</u> L.), plus small numbers of miscellaneous species.

Tables A and B show the past growth equations generated, and Figure A presents past diameter increment curves calculated from these equations.

2. Diameter increment (Figure A) was converted to past basal area increment, and the individual growth values for all trees on a plot accumulated to describe total plot accretion. Finally, plot basal area growth was combined with mortality data[3] and used to adjust the terminal plot basal area to describe initial stocking as follows:

$$B_1 = B_2 - S(b_i) + M$$

where B_1 = the initial plot basal area per acre

B_2 = the terminal plot basal area per acre

$S(b_i)$ = the cumulative basal area increment for all trees on the plot

M = the basal area mortality.

---

[3]For 117 continuous forest inventory plots in northern hardwood stands on lands owned by the Michigan Conservation Department, the average 10-year mortality per acre was 1.75 square feet.

Table A. Regression analysis for past sugar maple diameter growth

Variable	Partial regression coefficient	F
b_0	0.7032612	65.17**[a]
D_2	0.0358930	10.19**
D_2^2	-0.0008338	4.20**
B_2	-0.0028332	27.08**

Analysis of Variance

Source	d.f.	Sum of squares	F
Regression	3	4.33	18.03**
Residual	365	29.19	
Total	368	33.51	
R^2 = 0.129			

[a]** - Significant at the 99 percent level.

Table B. Regression analysis for past growth of species other than sugar maple

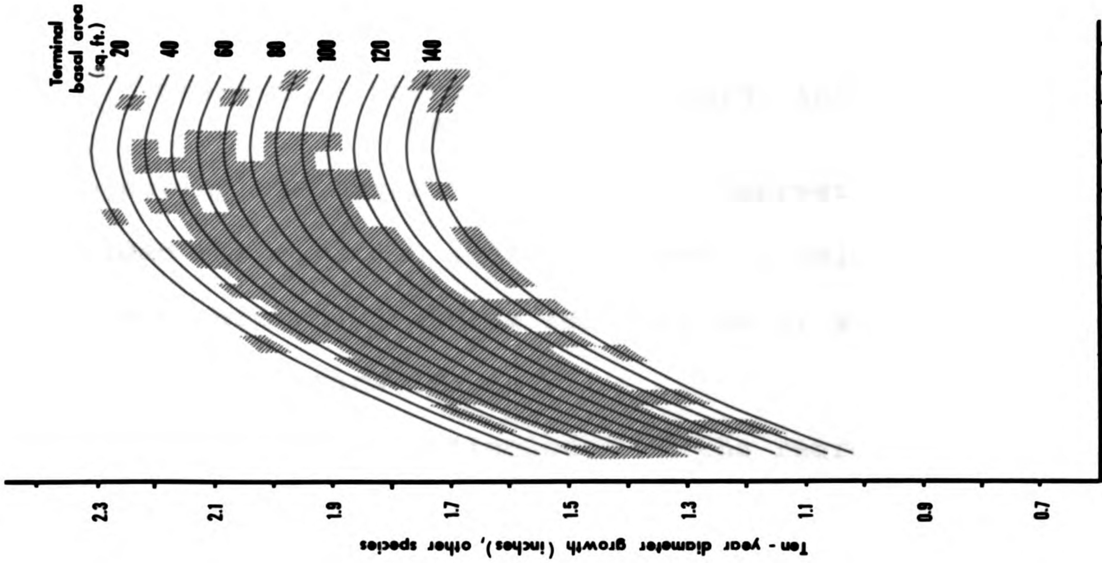
Variable	Partial regression coefficient	F
b_0	0.7634417	51.01**[a]
D_2	0.0372727	6.78**
D_2	-0.0008074	2.47*
B_2	-0.0021564	10.19**

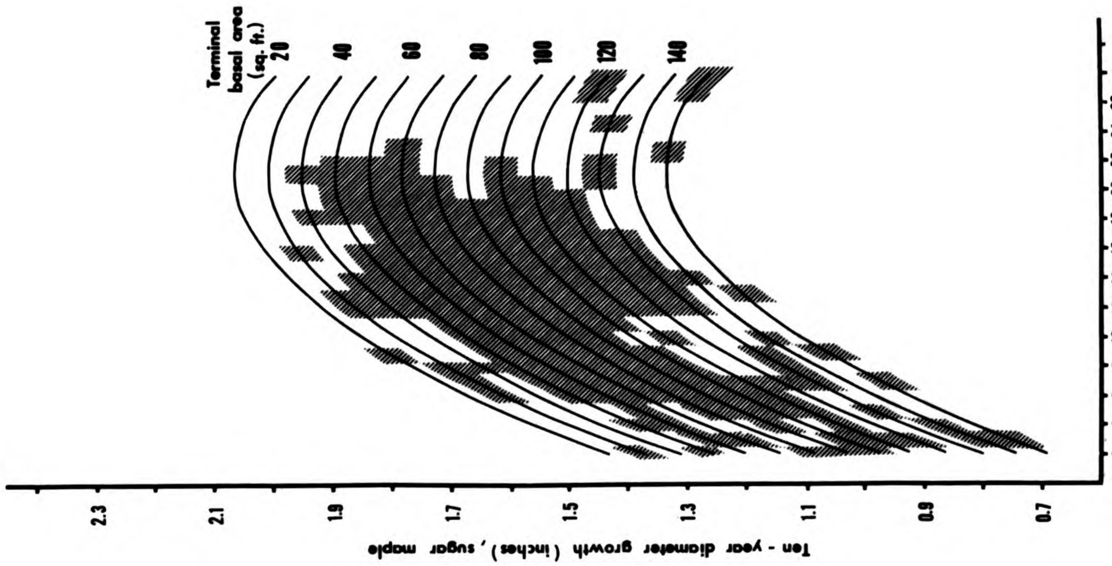
Analysis of Variance

Source	d.f.	Sum of squares	F
Regression	3	5.39	9.46**
Residual	494	93.76	
Total	497	99.14	
$R^2 = 0.054$			

[a]** - Significant at the 99 percent level; * - Significant at the 94 percent level.

Figure A. Past 10-year diameter growth for sugar maple and other species in Michigan's Lower Peninsula (shaded area defines limits of the data).


Ten - year diameter growth (inches), other species
2.3
2.1
1.9
1.7
1.5
1.3
1.1
0.9
0.7
Terminal d.b.h. (inches)
2 4 6 8 10 12 14 16 18 20 22 24 26
Terminal basal area (sq. ft.)
20
40
60
80
100
120
140


Ten - year diameter growth (inches), sugar maple
2.3
2.1
1.9
1.7
1.5
1.3
1.1
0.9
0.7
Terminal d.b.h. (inches)
2 4 6 8 10 12 14 16 18 20 22 24 26
Terminal basal area (sq. ft.)
20
40
60
80
100
120
140

After completing these adjustments the initial tree diameter was combined with initial stand density in the regression model:

$$G_f = b_0 + b_1(D_1) + b_2(D_1)^2 + b_3(B_1)$$

where G_f = future 10-year radial increment for sugar maple.

Subjecting the sugar maple growth observations to this model yielded the equation (Table C) used to calculate the 10-year diameter growth estimates for a range of stand conditions and tree diameters (Table D).

Each variable included in the regression models proved statistically significant. But addition of the average stand diameter to the equations gave only a non-significant improvement beyond the other variables. In all models, the R^2 values were low, suggesting that the selected independent variables accounted for only a small portion of the variation associated with the sample tree diameter growth.

In an attempt to improve the correlation, individual tree age was added to the model, and multiple regression analysis applied to 175 observations with age measurements.[4] Table E shows the equation obtained. Although adding tree age gave a significant improvement in the estimated growth, the R^2 only increased from 0.123 to 0.174 for the 175 observations used. Thus, the bulk of variation remains unexplained.

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[4]The restricted sample had a mean diameter of 3.8 inches less than the complete set used earlier.

Table C. Regression analysis for future growth of sugar maple

Variable	Partial regression coefficient	F
b_0	0.7812351	107.12**[a]
D_1	0.0297104	7.54**
D_1^2	-0.0008843	4.15**
B_1	-0.0033201	25.13**

Analysis of Variance

Source	d.f.	Sum of squares	F
Regression	3	3.10	12.22**
Residual	357	30.16	
Total	360	33.26	
$R^2 = 0.093$			

[a]** - Significant at the 99 percent level.

Table D. Ten-year diameter growth for sugar maple in Michigan's Lower Peninsula[a]

D.b.h.	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
	Basal area per acre--square feet																			
Inches	10-year diameter growth--inches																			
1	1.57	1.50	1.43	1.36	1.30	1.23	1.16	1.09	1.02	0.96	0.89	0.82	0.76	0.69	0.62	0.55	0.49	0.42	0.36	0.29
2	1.62	1.55	1.48	1.42	1.35	1.28	1.21	1.15	1.08	1.01	0.94	0.88	0.81	0.74	0.68	0.61	0.54	0.48	0.41	0.34
3	1.67	1.60	1.53	1.45	1.40	1.33	1.26	1.20	1.13	1.06	0.99	0.93	0.86	0.79	0.72	0.66	0.59	0.52	0.46	0.39
4	1.71	1.65	1.58	1.51	1.44	1.38	1.31	1.24	1.18	1.11	1.04	0.98	0.91	0.84	0.77	0.71	0.64	0.57	0.50	0.44
5	1.76	1.69	1.62	1.55	1.49	1.42	1.35	1.29	1.22	1.15	1.09	1.02	0.95	0.88	0.82	0.75	0.68	0.61	0.55	0.48
6	1.79	1.73	1.66	1.59	1.53	1.46	1.39	1.33	1.26	1.19	1.12	1.06	0.99	0.92	0.86	0.79	0.72	0.65	0.59	0.52
7	1.83	1.76	1.70	1.63	1.56	1.50	1.43	1.36	1.30	1.23	1.16	1.09	1.03	0.96	0.89	0.83	0.76	0.69	0.62	0.56
8	1.86	1.80	1.73	1.69	1.60	1.53	1.46	1.40	1.33	1.26	1.19	1.13	1.06	0.99	0.93	0.86	0.79	0.73	0.66	0.59
9	1.89	1.83	1.76	1.72	1.63	1.56	1.49	1.42	1.36	1.29	1.22	1.16	1.09	1.02	0.96	0.89	0.82	0.75	0.69	0.62
10	1.92	1.85	1.80	1.74	1.65	1.58	1.52	1.45	1.38	1.32	1.25	1.18	1.11	1.05	0.99	0.91	0.85	0.78	0.71	0.64
11	1.94	1.87	1.18	1.76	1.67	1.61	1.54	1.47	1.41	1.34	1.27	1.20	1.14	1.07	1.00	0.94	0.87	0.80	0.73	0.66
12	1.96	1.89	1.83	1.78	1.69	1.63	1.56	1.49	1.42	1.36	1.29	1.22	1.16	1.09	1.02	0.95	0.89	0.82	0.75	0.68
13	1.98	1.91	1.84	1.79	1.71	1.64	1.57	1.51	1.44	1.37	1.31	1.24	1.17	1.10	1.03	0.97	0.90	0.84	0.77	0.70
14	1.99	1.92	1.86	1.80	1.72	1.65	1.59	1.52	1.45	1.39	1.32	1.25	1.18	1.12	1.05	0.98	0.91	0.85	0.78	0.71
15	2.00	1.93	1.87	1.80	1.73	1.66	1.60	1.53	1.46	1.39	1.33	1.26	1.19	1.12	1.06	0.99	0.92	0.86	0.79	0.72
16	2.01	1.94	1.87	1.80	1.73	1.67	1.60	1.53	1.46	1.40	1.33	1.26	1.20	1.13	1.06	0.99	0.93	0.86	0.79	0.72
17	2.01	1.94	1.87	1.80	1.74	1.67	1.60	1.53	1.47	1.40	1.33	1.26	1.20	1.13	1.06	0.99	0.93	0.86	0.79	0.72
18	2.01	1.94	1.87	1.80	1.73	1.67	1.60	1.53	1.46	1.40	1.33	1.26	1.19	1.13	1.06	0.99	0.92	0.85	0.79	0.72
19	2.00	1.93	1.86	1.79	1.73	1.66	1.59	1.52	1.46	1.39	1.32	1.25	1.19	1.12	1.05	0.99	0.92	0.85	0.78	0.71
20	1.99	1.92	1.85	1.79	1.72	1.65	1.58	1.52	1.45	1.38	1.31	1.24	1.18	1.11	1.04	0.98	0.91	0.84	0.77	0.70
21	1.98	1.91	1.84	1.77	1.70	1.64	1.57	1.50	1.43	1.37	1.30	1.23	1.16	1.10	1.03	0.96	0.89	0.83	0.76	0.69
22	1.96	1.89	1.82	1.75	1.69	1.63	1.55	1.49	1.42	1.35	1.28	1.21	1.15	1.08	1.01	0.95	0.88	0.81	0.74	0.67
23	1.93	1.87	1.80	1.73	1.67	1.60	1.53	1.46	1.40	1.33	1.26	1.19	1.13	1.06	0.99	0.92	0.86	0.79	0.72	0.65
24	1.91	1.85	1.78	1.71	1.59	1.58	1.51	1.44	1.37	1.30	1.24	1.17	1.10	1.03	0.97	0.90	0.83	0.76	0.70	0.63
25	1.89	1.82	1.75	1.68	1.57	1.55	1.48	1.41	1.35	1.28	1.21	1.14	1.08	1.01	0.94	0.87	0.81	0.74	0.67	0.60

[a] The shaded areas define limits of the data.

Table E. Regression analysis of sugar maple growth including tree age

Variable	Partial regression coefficient	F
b_0	0.77529214	69.15**[a]
D_1	0.07442926	16.83**
D_1^2	-0.00233254	8.09**
B_1	-0.00288038	10.14**
A	-0.00430174	10.48**

Analysis of Variance

Source	d.f.	Sum of squares	F
Regression	4	2.61	8.93**
Residual	170	12.43	
Total	174	15.05	
$R^2 = 0.174$			

[a]** - Significant at the 99 percent level.

It should not be inferred that these low correlations prove the growth estimates inadequate. Forest Survey data were collected over a 33-county area, and from a range of sites and forest conditions. They exhibit great variability. Regression analysis cannot improve this feature, but only attempt to explain patterns inherent in the population. The significant F-tests provide evidence that growth patterns have been successfully detected and can be expressed as a function of the selected variables. A better correlation might be obtained by further stratifying the data according to additional unavailable parameters.

Tree Age and Diameter

Growth estimates generated above indicate rather slow rates for sugar maple, and raise question about the time intervals required to grow trees to tappable size. Therefore, the observations with tree age and diameter were subjected to regression analysis in the following model:

$$A = b_0 + b_1(D_1)$$

where A = tree age.

Table F shows the regression equation obtained, and Figure B the regression line that defines the following relationship between sugar maple diameter growth and tree age:

Table F. Regression of tree age and diameter

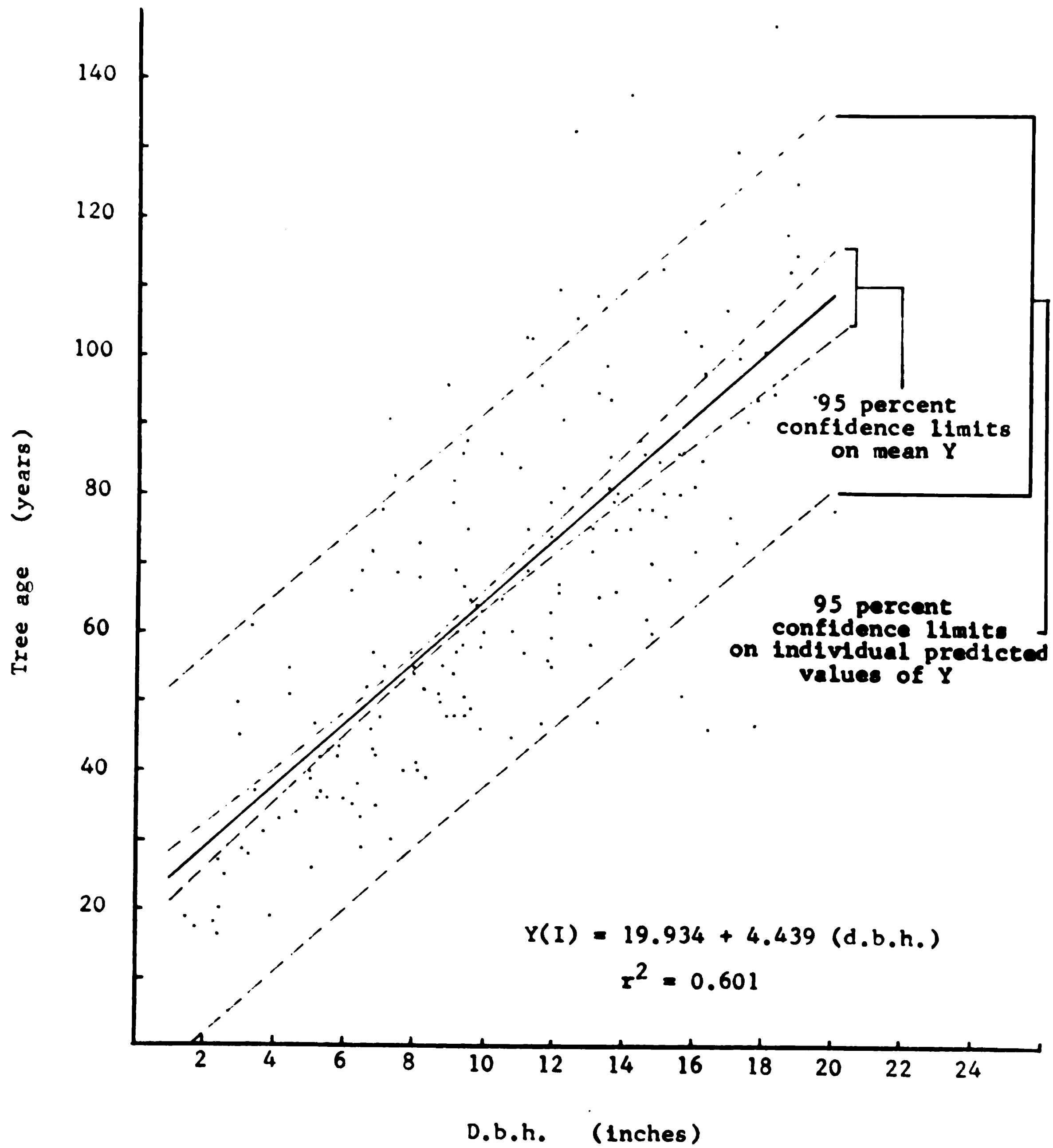
Variable	Partial regression coefficient	F
b_0	19.9340290	41.36**[a]
D_1	4.4392351	266.71**

Analysis of Variance

Source	d.f.	Sum of squares	F
Regression	1	73,226.29	266.71**
Residual	177	274.55	
Total	178	121,821.89	
$R^2 = 0.601$			

[a]** - Significant at the 99 percent level.

Figure B. Age associated with sugar maple trees of differing diameters in Michigan's Lower Peninsula.


140
120
100
80
60
40
20
Tree age (years)
2
4
6
8
10
12
14
16
18
20
22
24
D.b.h. (inches)
95 percent confidence limits on mean Y
95 percent confidence limits on individual predicted values of Y
Y(I) = 19.934 + 4.439 (d.b.h.)
r2 = 0.601

D.b.h. Inches	Age Years	D.b.h. Inches	Age Years
1	21	11	69
2	29	12	74
3	33	13	78
4	38	14	82
5	42	15	87
6	47	16	91
7	51	17	96
8	56	18	100
9	60	19	104
10	65	20	109

Adding the square of the diameter to the model gave no significant improvement beyond these estimates.

The age estimates presented above indicate that individual trees reach tappable size after 60 years' growth under average conditions in the southern half of the Lower Peninsula. Then, they move into 2-taphole size at about 85 to 90 years, and reach 3-taphole proportions at 100 years. Although the estimates vary from measurements in old-growth stands by Doppel (1927), Frothingham (1915), and Illick and Frontz (1928), they give the same general growth patterns evident in their data.

Patterns of Sugar Maple Growth

As a sugar maple in the Lower Peninsula grows older and increases its size, the diameter increment increases annually until about 100 years age when the tree reaches approximately 18 inches d.b.h. However, this increase occurs at a decreasing rate up to its maximum. Then annual increment decreases. Both tree age, if known, and diameter have utility for predicting individual tree diameter growth. For sugar maple the increment is somewhat slower than the combined average growth of associated species.

The greater the growing space available to a sugar maple tree, the more rapid its annual increment. Whereas past studies demonstrated a response to release, the present growth analysis shows a relationship between growth and stand density, and underscores the usefulness of that parameter for predicting growth.