Profitable Tapping of Sugar Maples in Michigan's Lower Peninsula
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On the cover is an excellent woodlot densely stocked with sugar maple. Plastic tubing is being used to collect the maple sap from the tapped trees.

Profitable Tapping of Sugar Maples in Michigan's Lower Peninsula

By R. D. NYLAND and V. J. RUDOLPH[1]

INTRODUCTION

Stands tapped for maple sap may support widely varying numbers of tapholes per acre, depending upon the number and size of sugar maple trees. Within the range of sugar maple stocking levels frequently encountered, there is some minimum number of tapholes per acre where returns from gathered sap are sufficient to at least balance operating costs, including labor. Tapping in stands stocked below this threshold density would result in financial loss to the producer. By tapping stands stocked with at least the prerequisite number of tapholes per acre, maple sap and syrup producers can greatly enhance their profit opportunities.

In the past, relationships between stand stocking and the costs and returns from maple sap and syrup enterprises have not been investigated. Fragmentary information has been available on segments of the total tapping operation, but these do not form a comprehensive composite analysis of tapping economics. Guidelines to aid producers in assessing the profitability of tapping different stands have been lacking.

This report investigates the effects of stand stocking on the feasibility of commercial tapping. Available published and unpublished information bearing on the problem was collected and studied. Where factual research data relative to various costs and returns involved in commercial sap production were lacking, assumptions were made based upon available information. Estimates and assumptions were synthesized into a series of operating models to depict typical tapping enterprises in Michigan's Lower Peninsula. These models estimate costs and incomes from

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stimulated operations over a wide range of stand stocking conditions. Results show relationship between sugar-bush stocking and financial feasibility of tapping.

Although synthetic operating models are used in this analysis, they reflect typical operating conditions within Michigan's Lower Peninsula. Results offer guides to assessing the suitability of different sugar maple stands for commercial tapping under each of three operating situations: 1) where sap processing is integrated with sap production; 2) where sap is produced and sold at roadside, then transported to a central evaporator plant for processing; and 3) where the producer transports sap from his sugarbush to a central evaporator plant for sale.

CONSTRUCTING THE MODELS

Stand Stocking Conditions

The structures and densities of sugar maple stands appraised in the models resemble actual conditions found within northern hardwood forests of Michigan's Lower Peninsula. These were approximated in the following manner. First, stand tables were constructed for both the northern 33 counties and the southern 35 counties of the Lower Peninsula, using data collected in the Michigan Forest Survey by the U. S. Forest Service as part of its nationwide inventory program.[2]

Within each region, three stand size classes were recognized: stands with 5-11 in. average tree d.b.h., those with 11-15 in. average tree diameter, and those having an average tree d.b.h. 15 in. and larger. Second, it was assumed that if each size-class stand were stocked with varying numbers of sugar maple trees, the tappable trees present would range in diameter from small to large. The number of trees ocurring in each tree diameter class, however, would be proportional to the diameter-class distrubution of the sugar maple component in the average stand tables described above. Third, the percentages of 1, 2, 3 and 4 taphole trees listed in the average stand tables were determined[3] and used to estimate the probable number of sugar maples present per taphole size-class in hypothetical stands stocked with 10 to 70 tappable trees per acre. Resultant stocking tables (Table 1) formed the basis for developing the analysis which follows.

Because northern hardwood forests in the northern 33 counties of the Lower Peninsula differ in structure from those in the southern 35 counties (9), separate sets of stocking estimates were compiled for the two regions.

Equipment and Its Cost

Maple sap and syrup enterprises incur production costs for equipment, materials and labor. Published data provide only limited information about these charges. For example, Morrow (8) determined that plastic tube systems for gathering sap can be vacuum-pumped for about 11¢/taphole/yr. He also reported that to install, maintain, take down and clean plastic tubing and equipment required about 8 min. labor/taphole/yr. (7), or at $1.50/hr., about 20¢/taphole annually. But aside from these data, the literature is devoid of usable cost information. Therefore, costs for other phases of the assumed tapping and sap transport operations had to be estimated as realistically as possible for various stand conditions.

The amount of equipment required to service the stocking densities listed in Table 1 was determined

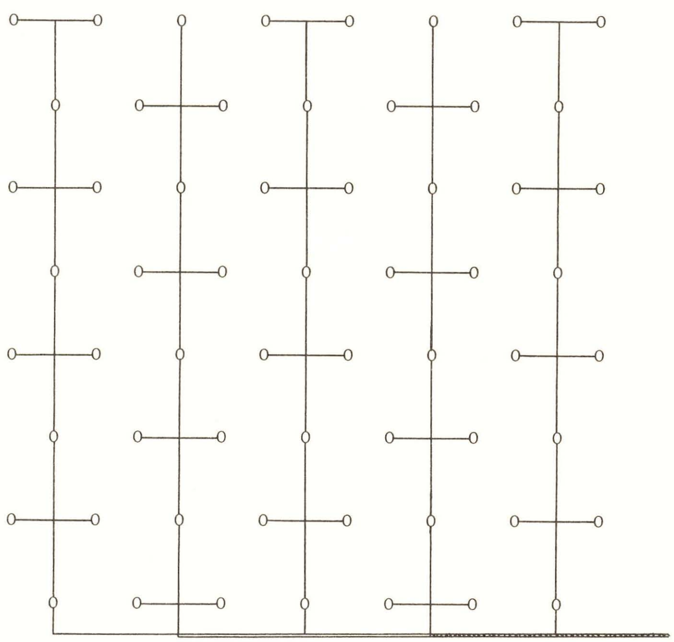
TABLE 1—Number of tapholes/A. in different stands of sugar maple within Michigan's Lower Peninsula

	Aver. stand diam.	*Tappable trees/A.*	*Tapholes/A. in:* 1 taphole trees	2 taphole trees	3 taphole trees	4 taphole trees	All trees
	In.	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
NORTHERN HALF–LOWER PENINSULA	5-11	10	9	2	–	–	11
		20	19	2	–	–	21
		30	28	4	–	–	32
		40	37	4	3	–	44
		50	46	6	3	–	55
		60	56	6	3	–	65
		70	65	8	3	–	76
	11-15	10	7	4	3	–	14
		20	13	10	6	4	33
		30	20	14	6	4	44
		40	26	20	9	4	59
		50	33	24	12	8	77
		60	39	28	12	8	87
		70	46	34	15	8	103
	15 +	10	3	2	9	12	26
		20	6	6	18	24	54
		30	9	8	27	36	80
		40	11	12	33	44	100
		50	14	14	42	56	126
		60	17	16	51	68	152
		70	20	20	60	80	180
SOUTHERN HALF–LOWER PENINSULA	5-11	10	9	2	–	–	11
		20	19	2	–	–	21
		30	28	4	–	–	32
		40	37	4	–	–	41
		50	46	6	3	–	55
		60	56	8	3	–	67
		70	65	8	3	–	76
	11-15	10	7	4	3	–	14
		20	14	8	3	–	25
		30	21	14	6	–	41
		40	29	18	6	–	53
		50	36	22	9	–	67
		60	43	26	12	–	85
		70	50	30	12	4	96
	15 +	10	4	6	9	4	23
		20	8	12	15	4	39
		30	12	16	24	8	60
		40	16	22	33	8	79
		50	20	28	39	12	99
		60	24	34	48	12	118
		70	28	40	57	16	141

[2]Stand tables were based upon records for 511 northern hardwood plots taken in the Lower Peninsula, obtained from the files of the Michigan Forest Survey in the offices of the North Central Forest Experiment Station, St. Paul, Minnesota.

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

by graphing the assumed locations of tappable trees for each different stocking density. A tube system was then designed to connect the assumed tree positions in a continuous tube network (Fig. 1). From these diagrams, the amounts of tubing, couplings and spiles required per acre for each stocking level were estimated.



LEGEND
Tappable tree
Plastic tubing, 5/16 in.
Plastic tubing, 1/2 in.
Plastic tubing, 3/4 in.

Fig. 1. Tree location and tube system for 60 tappable sugar maple trees/A.

Since Lower Peninsula woodlands frequently are located on fairly level topography, the gathering systems were designed with tube diameters commensurate with published recommendations for flat lands (3, 4). Where necessary, several sizes of tubing were included in the systems. For example, a 5/16 in. line was assumed to accomodate a maximum of 20 tapholes. Where more than 20 tapholes were available per acre, ½ in. tubing was included in the system. In turn, ½ in. lines were assumed to accommodate up to 80 tapholes, ¾ in. lines up to 180 tapholes, and, 1 in. lines up to 540 tapholes.

In addition to items required for these gathering systems (Fig. 1), equipment for transporting sap by pipeline about ¼ mile from the sugarbush to a common collection point at the roadside or saphouse was included in the models. For average farm woodlands in the northern 33 counties of Michigan's Lower Peninsula, this transport system would typically need to accommodate approximately 2,000 tapholes. For average farm forests in the sourthern 35 counties, the system would need to accommodate 700 tapholes.

These are the average sizes of farm woodlands in the two regions according to Yoho (17) and Schallau (13). Typical northern hardwood stands in the northern 33 counties contain sufficient sugar maple trees to accommodate about 17 tapholes/acre or approvimately 2,000/ownership, and stands in the southern 35 counties could accommodate about 33 tapholes/acre or approximately 700/ownership (9).

To complete production costs for the assumed operations, provisions were made for a power tapper, storage tanks and tube cleaning equipment. One power tapper was considered sufficient for the needs of an enterprise. Storage facilities were incorporated in the analysis at the rate of 2 gal. per taphole for roadside or saphouse storage tanks in accord with published recommendations (3, 4), plus 1 gal. per taphole for temporary storage within the transport system. Tube cleaning equipment was included to comply with methods recommended by Willits *et al.* (15), and Willits and Sipple (16). Prices for equipment were based on quotations shown in Table 2.

TABLE 2—Costs of tapping equipment and materials

Part No.[a]	*Description*	*Price*
33-u	5/16 in tubing, plastic	$ 0.04/ft.
34-u	1/2 in. tubing, plastic	.08/ft.
44-u	3/4 in. tubing, plastic	.12/ft.
45-u	1 in. tubing, plastic	.20/ft.
36	Nylon spile, ventless	.10 ea.
34	Nylon tee, 5/16 in.	.10 ea.
48	Nylon tee, 1/2 in. for 4 lines	1.00 ea.
111	Plastic coupling, 3/4 in.	.35 ea.
106	Reducing coupling, 3/4 x 1/2 in.	.40 ea.
60	Bronze gear pump, 1/4 in.	75.00 ea.
. .	Gasoline engine power tapper	125.00 ea.
. .	Storage tanks	.13/gal.
. .	Paraformaldehyde pellet	.01 ea.

[a]The part numbers are for Lamb Naturalflow tubing and equipment. Storage tank costs are based upon quotations by Sears, Roebuck, and Company. Other prices quoted by Sugarbush Supplies, Lansing, Michigan. These listings do not constitute an endorsement of the manufacturer's or the supplier's product, but are used only for illustrative purposes.

In calculating the annual costs, a 10 yr. life expectancy was assumed for tube items and the storage tanks, and 5 yr. for the power tapper and pumps. Investments were depreciated over these time intervals at 6% per annum compound interest using a recast version of the discount annuity formula:

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

where,

r = the annual cost
p = the rate of interest,
V = the initial cost, and
n = the number of years the equipment is depreciated.

This method provides a return to capital annually plus a yearly payment for interest on the unpaid balance (2).

The initial cost of a power tapper is $125.00. With a life expectancy of 5 yr., and depreciation at 6% per annum, the annual cost is:

$$r = \frac{(1.06)^5\ (0.06)\ (\$125.0)}{(1.06)^5 - 1}$$

$$r = \$29.68$$

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

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

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

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

For the northern half of the Lower Peninsula, the sap transporting system for the average farm woodland of 120 A., with 17 tapholes/A., including a ¼ mile pipeline to the roadside or saphouse, would require:

8,078 ft. ½ in. tubing[4]	$ 646.00
12,118 ft. ¾ in. tubing	1,454.00
1,795 ft. 1 in. tubing	359.00
Total	$2,459.00

[4]Tubing requirements are based on plotted diagrams for average size farm woodlands in each region. Taphole stocking was determined from average northern hardwood stand tables (9).

With a life expectancy of 10 years, and depreciation at 6% per annum, the annual cost would be:

$$r = \frac{(1.06)^{10}\ (0.06)\ (\$2{,}459)}{(1.06)^{10}-1}$$

$$r = \$333.47$$

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

$$\frac{\$333.47}{2{,}000} = 0.17$$

In the southern half of the Lower Peninsula, the sap transporting system for the average farm woodland of 20 A., with 33 tapholes/A., including a ¼ mile pipeline to the roadside or saphouse, would require:

1,345 ft. ½ in. tubing	$108.00
1,571 ft. ¾ in. tubing	189.00
224 ft. 1 in. tubing	45.00
Total	$342.00

Computed in the same manner as above, the annual cost would be $82.62, and the annual cost per taphole, prorated over 700 tapholes for the average farm woodland in the southern half of the Lower Peninsula, would be:

$$\frac{700}{\$82.62} = \$0.12$$

Willits *et al.* (15), and Willits and Sipple (16) described equipment required for cleaning plastic tube systems. With their procedure, gathering tanks and tube sections used for sapping can be employed in the cleaning operations. However, the method requires purchase of a pump for flushing tubing with cleaning solution.

A cleaning pump purchased at an initial cost of $75.00 and depreciated over 5 yr. at the rate of 6% per annum will cost annually:

$$r = \frac{(1.06)^5\ (\$.\$6)\ (\$75.00)}{(1.06)^5 - 1}$$

$$r = \$17.80$$

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

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

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

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

These above-mentioned items would fully equip tapping operations for an enterprise where sap is gathered and processed into syrup by the same producer. If, instead of being processed into syrup in an integrated sap-syrup enterprise, the sap is sold to a central evaporator plant, additional costs would be incurred for equipment needed in transporting the sap from the production site to a central evaporator plant. A producer using a properly fitted 1½ T. truck commonly available on most farms could haul about 500 gal. per load. With a 5 mi. haul distance, transport costs per gallon of sap would be as follows:

Truck rental: 1½ ton for 10 mi. at \$.20/mi.,

$$\text{Cost/gal.} = \frac{\$.20 \times 10 \text{ mi.}}{500 \text{ gal.}} = \ldots\ldots\ldots\ldots \$0.004$$

Storage tanks: 2 tanks, 250 gal. each, at \$.13/gal., depreciated over a 10 yr. period:

$$\text{Cost/yr.} = \frac{(1.06)^{10}\,(0.06)\,(\$65.00)}{(1.06)^{10} - 1} = \$8.83$$

With 500 gal./day, and a 30 day season, the annual production would be 15,000 gal.

$$\text{Cost/gal.} = \frac{\$8.83}{15{,}000 \text{ gal.}} = \ldots\ldots\ldots\ldots \$0.001$$

Labor: 2 hr./day at \$1.50/hr.

$$\text{Cost/gal.} = \frac{\$1.50 \times 2 \text{ hrs.}}{500 \text{ gal.}} = \ldots\ldots\ldots\ldots \$0.006$$

Total transport cost/gal. \$0.011

As an alternative to transporting sap himself, a producer might find central evaporator facilities equipped to purchase sap from him at the roadside. When sap is purchased roadside, plant management will transport the sap and levy a charge for the service, or what is more likely, transportation costs would be reflected in the roadside sale price. Although the actual cost for transporting sap will vary for each production situation, a range of \$0.005 to \$0.015/gal. has been suggested in several publications (1, 14). For an average Lower Peninsula cost at the midpoint of the above range, sap sale price would likely be reduced by \$0.01/gal. to cover transportation by the purchaser.

This transport cost, which is slightly less than that suggested for producers who transport sap themselves, is based on the assumption that large operations transporting large volumes of sap could do it more efficiently than could individual producers who handle only limited quantities of sap daily. This seems likely, since the individual producer would need to use equipment designed for other purposes but adapted for sap hauling, whereas the large central evaporator plant would probably have special equipment designed to efficiently collect and transport sap in a fashion similar to bulk milk operations.

Sap Yields and Values

Returns entered into the analysis reflect three levels of sap yield per taphole for the various levels of taphole stocking described in Table 1. In the basic calculations, each pellet-treated taphole was assumed to yield 25 gal. of sap annually, commensurate with Robbins' (12) estimate that use of paraformaldehyde pellets in tapping would increase sap yields about 25% above the average 19 gal./taphole that could be expected in Lower Michigan (11).

Morrow (8) and MacArthur (5, 6) also presented evidence that when lines are vacuum-pumped, trees yield greater volumes of sap per taphole than if lines are not pumped. However, yields applied herein were not adjusted to reflect this added potential yield from vacuum pumping. Rather, the findings have been based on the possibility of obtaining 25 gal./taphole annually from Lower Peninsula sugarbushes. Nevertheless, in some regions trees would not likely yield such high annual volumes, so the models were extended to depict operations obtaining only 15 to 20 gal. per taphole.

In all cases, stands were considered fully stocked, but containing varying numbers of tappable sugar maple stems per acre. This assumption precludes concern for variation in sap sweetness and yield that might be associated with differences in stand density. Nyland (9) found that variations in the number of sugar maple per acre in Lower Peninsula northern hardwood stands result from differences in forest composition rather than from differences in stand density.

In 1966, sap sweetness averaged about 2.1 °Brix for Lower Peninsula operations (9). According to a price schedule proposed in 1962 (1), and considered valid in 1965 (14), the sap would bring \$0.043/gal. when delivered to a saphouse or central evaporator plant. As stated above, for sap sold roadside, the purchaser would likely reduce the price by about \$0.01/gal. to compensate for transportation costs.

Operating Costs and Returns

Table 3 gives an example of the procedure followed to estimate costs and returns from tapping in an integrated sap-syrup enterprise, using all the accumulated information.

TABLE 3—An example of costs and returns computation for tapping when the sap is processed at the property where collected, for 60 trees/A. (85 tapholes) in a stand 11-15 in. average d.b.h. in the southern half of Michigan's Lower Peninsula

COSTS:	
Equipment costs for the tube system:	
1,843 ft. 5/16 in. tubing, @ 0.04	$ 73.72
375 ft. ½ in. tubing, @ 0.08	28.56
25 ft. ¾ in. tubing, @ 0.12	3.00
85 spiles, ventless, @ 0.10	8.50
37 nylon tees, 5/16 in. @ 0.10	3.70
9 nylon tees, ½ in., @ 1.00	9.00
1 reducing coupling, ¾ in. x ½ in.	.40
Storage tanks, for 85 tapholes, @ 3 gal./taphole, @ 0.13/gal.	34.00
Total	$160.88
Depreciated over a 10 yr. life expectancy, at 6%, annual cost of the tube system becomes	$ 21.86
Other annual costs:	
85 paraformaldehyde pellets, @ 0.01	$ .85
Vacuum pumping, @ 0.11/taphole	9.35
Power tapping, @ 0.04/taphole	3.40
Cleaning equipment, @ 0.03/taphole	2.55
Cleaning materials, @ 0.01/taphole	.85
Transport of sap across property to saphouse, @ 0.12/taphole	10.20
Labor, @ 0.20/taphole	17.00
Total	44.20
Total annual costs	$ 66.06
RETURNS:	
25 gal. of sap/taphole, for 85 tapholes, @ 0.043/gal.	$ 91.38
SURPLUS	$ 25.32

For roadside sap sale, and delivery for sale at an evaporator plant, the procedures were identical, except that the cost for transporting the sap was taken into account.

RESULTS AND DISCUSSION

Procedures outlined in Table 3 were applied to stands with the range of sugar maple stocking shown in Table 1. Resultant estimated costs, returns and surpluses for yields of 25 gal./taphole at each stocking level are shown in Table 4 for integrated sap-syrup operations, in Table 5 for roadside sap sale, and in Table 6 for sap delivery for sale at a central evaporator plant. Minimum numbers of tapholes per acre required for each diameter-class stand for break-even operation are summarized in Table 7.

TABLE 4—Costs, returns and surplus from sap production when the product is processed at the property where collected (integrated sap-syrup operation)

	Aver. stand diam.	*Tappable trees/A.*	*Tapholes /A.*	*Annual cost*	*Annual return*	*Surplus*
	In.	*Number*	*Number*			
NORTHERN HALF–LOWER PENINSULA	5-11	10	11	$ 10.55	$ 11.82	+$ 1.27
		15	16	14.75	17.20	+ 2.45
		20	21	18.32	22.58	+ 4.26
		30	32	27.33	34.40	+ 7.17
		40	44	36.57	47.30	+ 10.73
		50	55	44.60	59.13	+ 14.53
		60	65	51.42	69.88	+ 18.46
		70	76	60.14	81.70	+ 21.56
	11-15	10	14	12.47	15.05	+ 2.58
		15	21	18.35	22.58	+ 4.23
		20	33	26.98	35.48	+ 8.50
		30	44	36.20	47.30	+ 11.10
		40	59	46.05	63.42	+ 17.37
		50	77	60.46	82.78	+ 22.32
		60	89	67.58	95.68	+ 28.10
		70	103	78.43	110.72	+ 32.29
	15 +	10	26	20.40	27.95	+ 7.55
		15	47	34.75	50.52	+ 15.77
		20	54	40.37	58.05	+ 17.68
		30	80	61.39	86.00	+ 24.61
		40	100	74.66	107.50	+ 32.84
		50	126	93.86	135.45	+ 41.59
		60	152	111.33	163.40	+ 52.07
		70	180	131.05	193.50	+ 62.45
SOUTHERN HALF–LOWER PENINSULA	5-11	10	11	10.55	11.82	+ 1.27
		15	16	14.75	17.20	+ 2.45
		20	21	18.32	22.58	+ 4.26
		30	32	27.23	34.40	+ 7.17
		40	41	34.53	44.08	+ 9.55
		50	55	44.60	59.13	+ 14.53
		60	67	52.68	72.03	+ 19.35
		70	76	60.14	81.70	+ 21.56
	11-15	10	14	12.47	15.05	+ 2.58
		15	20	17.32	21.50	+ 4.18
		20	25	20.76	26.88	+ 6.12
		30	41	33.74	44.08	+ 10.34
		40	53	42.39	56.98	+ 14.59
		50	67	52.95	72.63	+ 19.08
		60	85	66.06	91.38	+ 25.32
		70	96	73.99	103.20	+ 29.21
	15 +	10	23	18.50	24.73	+ 6.23
		15	30	23.96	32.25	+ 8.29
		20	39	30.37	41.93	+ 11.56
		30	60	48.02	64.50	+ 16.48
		40	79	60.04	84.93	+ 24.89
		50	99	74.75	106.43	+ 31.68
		60	118	87.86	126.85	+ 38.99
		70	141	103.64	151.58	+ 47.94

Under all conditions tested, and with sap yields of 25 gal./taphole, integrated sap-syrup operations provide a surplus of returns over costs, even with only 10 tapholes available per acre. Above that minimum stocking, surplus increases quite rapidly with additional available tapholes per acre, particularly in the stands of larger average tree diameter.

For roadside sap sale, the minimum profitable stocking in large diameter sawtimber (averaging 15 in. d.b.h. and larger) remains at about the same level as noted for integrated sap-syrup operations. However, threshold stocking rises to between 30 and 35 tapholes/A. for small-sawtimber stands (11-15 in. d.b.h.) and to between 45 and 50 tapholes/A. in pole stands (5-11 in. d.b.h.).

TABLE 5—Costs, returns and surplus from sap production when the product is sold for transport away from the property where collected (roadside sap sale operation)

Region	Aver. stand diam.	Tappable trees/A.	Tapholes /A.	Annual cost	Annual return	Surplus
	In.	*Number*	*Number*			
NORTHERN HALF–LOWER PENINSULA	5-11	10	11	$ 13.30	$ 11.82	−$ 1.48
		20	21	23.57	22.58	− 0.99
		30	32	35.23	34.40	− 0.83
		40	44	47.57	47.30	− 0.27
		50	55	58.35	59.13	+ 0.78
		60	65	67.67	69.88	+ 2.21
		70	76	79.14	81.70	+ 2.65
	11-15	10	14	15.97	15.05	− 0.92
		20	33	35.23	35.48	+ 0.25
		30	44	47.20	47.30	+ 0.10
		40	59	60.80	63.42	+ 2.62
		50	77	79.21	82.78	+ 3.57
		60	89	89.83	95.68	+ 5.85
		70	103	104.18	110.72	+ 6.00
	15+	10	26	26.90	27.95	+ 1.05
		20	54	53.87	58.05	+ 4.18
		30	80	81.39	86.00	+ 4.61
		40	100	99.66	107.50	+ 7.84
		50	126	125.36	135.45	+ 10.09
		60	152	149.33	163.40	+ 14.07
		70	180	176.50	193.50	+ 17.00
SOUTHERN HALF–LOWER PENINSULA	5-11	10	11	13.30	11.82	− 1.48
		20	21	23.57	22.58	− 0.99
		30	32	35.23	34.40	− 0.83
		40	41	44.78	44.08	− 0.70
		50	55	58.35	59.13	+ 0.78
		60	67	69.43	72.03	+ 2.60
		70	76	79.14	81.70	+ 2.56
	11-15	10	14	15.97	15.05	− 0.92
		20	25	27.01	26.88	− 0.13
		30	41	43.99	44.08	+ 0.09
		40	53	55.68	56.98	+ 1.30
		50	67	69.70	72.03	+ 2.33
		60	85	87.26	91.38	+ 4.12
		70	96	97.09	103.20	+ 6.11
	15+	10	23	24.25	24.73	+ 0.48
		20	39	40.12	41.93	+ 1.81
		30	60	63.02	64.50	+ 1.48
		40	79	79.79	84.93	+ 5.14
		50	99	99.50	106.43	+ 6.93
		60	118	117.36	126.85	+ 9.49
		70	141	138.89	151.58	+ 12.69

TABLE 6—Costs, returns and surplus from sap production when the product is transported for sale 5 miles to an evaporator plant.

Region	Aver. stand diam.	Tappable trees/A.	Tapholes /A.	Annual cost	Annual return	Surplus
	In.	*Number*	*Number*			
NORTHERN HALF–LOWER PENINSULA	5-11	10	11	$ 13.58	$ 11.82	−$ 1.76
		20	21	24.10	22.58	− 1.52
		30	32	36.03	34.40	− 1.63
		40	44	48.67	47.30	− 1.37
		50	55	59.73	59.13	− 0.60
		60	65	69.30	69.88	+ 0.58
		70	76	81.04	81.70	+ 0.66
	11-15	10	14	16.32	15.05	− 1.27
		20	33	36.06	35.48	− 0.58
		30	44	48.30	47.30	− 1.00
		40	59	62.28	63.42	+ 1.14
		50	77	81.64	82.78	+ 1.14
		60	89	92.06	95.68	+ 3.62
		70	103	106.76	110.72	+ 3.96
	15+	10	26	27.55	27.95	+ 0.40
		20	54	55.22	58.05	+ 2.73
		30	80	83.39	86.00	+ 2.61
		40	100	102.16	107.50	+ 5.34
		50	126	128.51	135.45	+ 6.94
		60	152	153.13	163.40	+ 10.27
		70	180	180.55	193.50	+ 12.95
SOUTHERN HALF–LOWER PENINSULA	5-11	10	11	13.58	11.82	− 1.76
		20	21	24.10	22.58	− 1.58
		30	32	36.03	34.40	− 1.63
		40	41	45.81	44.08	− 1.73
		50	55	59.73	59.13	− 0.60
		60	67	71.11	72.03	+ 0.92
		70	76	81.04	81.70	+ 0.66
	11-15	10	14	16.32	15.05	− 1.27
		20	25	27.64	26.88	− 0.76
		30	41	45.02	44.08	− 0.94
		40	53	56.97	56.98	+ 0.01
		50	67	71.38	72.03	+ 0.65
		60	85	89.38	91.16	+ 1.78
		70	96	100.39	103.20	+ 2.81
	15+	10	23	24.83	24.73	− 0.10
		20	39	41.10	41.93	+ 0.83
		30	69	64.52	64.50	− 0.02
		40	79	82.13	84.93	+ 2.80
		50	99	101.98	106.43	+ 4.45
		60	118	120.31	126.85	+ 6.54
		70	141	142.42	151.58	+ 9.16

TABLE 7—Minimum taphole stocking per acre required for profitable tapping for maple sap in Michigan's Lower Peninsula.

Region	Yield/taphole	Aver. stand diam.	Tapholes required/A. if sap is: Processed where collected	Sold roadside	Delivered 5 miles
	Gal.	*In.*	*Tapholes*	*Tapholes*	*Tapholes*
NORTHERN HALF–LOWER PENINSULA	25	5-11	10	46	61
		11-15	10	31	51
		15+	10	10	10
	20	5-11	26	a	a
		11-15	23	a	a
		15+	10	a	a
	15	5-11	a	a	a
		11-15	a	a	a
		15+	a	a	a
SOUTHERN HALF–LOWER PENINSULA	25	5-11	10	48	60
		11-15	10	34	53
		15+	10	10	24
	20	5-11	26	a	a
		11-15	21	a	a
		15+	10	a	a
	15	5-11	a	a	a
		11-15	a	a	a
		15+	a	a	a

[a]Denotes stands where commercial tapping is not feasible under conditions considered within the analysis.

In cases where sap is transported by the producer for sale at a central evaporator plant, thereby incurring transportation costs of approximately $0.011/gal., minimum profitable taphole stocking with yields of 25 gal./taphole, rises to even higher levels, except in the large sawtimber within the northern half of Michigan's Lower Peninsula. Based on these data, it appears that when a producer delivers the sap himself, he cannot expect to break even with a yield of 25 gal./taphole unless tapping is done in pole stands having at least 60 to 65 tapholes/A., small sawtimber stands containing 50 to 55 tapholes/A., and large-diameter sawtimber stands with 10 to 20 tapholes/A. (Table 7).

The results of these analyses indicate that many producers gather sap at a rather scanty margin for profit. In fact, if sap yields drop much below 25 gal./taphole, the profitability of tapping becomes questionable, except in stands heavily stocked with large sugar maple trees. For example, with a sap yield of 20 gal./taphole, the minimum required stocking occurs between 21 and 26 tapholes/A. for integrated sap-syrup operations in pole and small-diameter sawtimber stands, and at 10 tapholes/A. in large-diameter sawtimber. With a 15 gal./taphole yield, profitable tapping by integrated enterprises would not be possible in any stands within the range of stocking covered by this study (Table 7).

For roadside sap sale or sap delivery to a central evaporator plant, a yield of either 15 or 20 gal./taphole precludes profitable operation at all stocking levels tested within this study. This occurs because expenditures remain fairly fixed even though the total volume of sap handled decreases, but revenues drop, causing a decrease in the spread between revenues and costs and elevating the threshold stocking level. Thus, producers who plan to sell sap at roadside or deliver it to a central evaporator plant must tap only in well-stocked stands. Furthermore, they must restrict tapping to stands yielding approximately 25 gal./taphole.

While these models represent typical Lower Peninsula operating conditions, some enterprises may have costs or returns deviating somewhat from those presented above. Higher or lower costs without any change in the revenues would force threshold stocking higher or lower, depending upon the direction of the net change. Likewise, higher or lower revenues without change in costs would similarly affect the threshold level for profitable tapping.

Possible cost changes may come from higher or lower prices or rates of interest for equipment purchase, longer or shorter depreciation periods for equipment, higher or lower wages, differences in prices for materials, or the spread of costs over fewer or greater numbers of tapholes.

Changes in revenues may result from greater or smaller yields per taphole, higher or lower sap sweetness, or higher or lower sap prices.

In modifying the calculations to reflect different costs and returns, care must be exercised not to overlook, exaggerate, or underemphasize factors bearing upon the economics of the operation.

While the economics of tapping proved fairly sensitive to changes in taphole stocking per acre, and while Forest Survey data showed distinct differences existing in the structure and tree size-class distribution for comparably-stocked stands between the northern half and the southern half of the Lower Peninsula, the numbers of tapholes per acre required for profitable tapping in the northern 33 counties of the Lower Peninsula is almost identical to that needed within the southern 35 counties. This leads to the inference that the level of stocking is more critical than the manner in which tapholes are distributed. The fact that stands in the northern half stocked with a given number of tapholes per acre have smaller diameter-class trees than stands in the southern region does not seem to influence the usefulness of these stands for sap production.

In general, then, the prospects for profitable tapping for roadside sap sale or sap delivery to a central evaporator plant appear dim, unless the imbalance between costs and returns can be favorably altered. Three possibilities for doing this are worthy of exploration.

First, the maple sap and syrup industry should utilize the most efficient tapping and sap gathering methods presently known. Furthermore, it could conduct or support research for ways to further reduce costs through additional mechanization of tapping and sap gathering, to improve the quality and quantity of sap yields per taphole, and to improve management practices to make operations generally more efficient. Research has already contributed significantly to these ends and further research would undoubtedly uncover additional ways to improve efficiency in sapping operations.

Second, sap producers could seek higher prices for their product. Although it is obviously highly desirable to reduce operating costs over the long run, higher sap prices offer the only feasible immediate answer to the economic problems confronting present sap producers.

Third, sugar bushes should be managed to increase the proportion of sugar maple trees in the total stand, making more tapholes available per acre and enhancing the profitability of tapping. The analyses made here are based on northern hardwood stand conditions which have not been modified by management for sugarbush objectives.

The analyses made in this study indicate that a producer using vacuum-pumped plastic tube systems can deliver sap to his own saphouse for about $0.03 to $0.04/gal., when trees yield about 25 gal./taphole. With yields of 20 gal./taphole the cost increases to $0.04 or $0.05/gal., and with a 15 gal./taphole yield the cost would be between $0.05 and $0.06/gal. A transport fee of approximately $0.01/gal. for delivery to a central evaporator plant will bring the cost per gallon of sap delivered to the plant to somewhere between $0.05 and $0.07. These amounts represent the minimum prices required for the producer just to break even, with no profit margin for labor and interest on equipment investment.

Pasto and Taylor (10) found that efficiently managed central evaporator plants, whose operators receive an average of $6.00/gal. for their syrup, could pay as much as $0.09 to $0.10/gal. for 2.0 °Brix sap delivered at the plant. Apparently, with efficient evaporator plants, delivered sap prices could be increased sufficiently to permit profitable tapping of sugar maple stands in Michigan's Lower Peninsula without raising syrup retail prices. In fact, unless sap prices are increased, tapping for roadside sap sale or for delivery to central evaporator plants offers little promise for profit, except in carefully selected stands where sap yields and taphole stocking occur at high levels. Without improved possibilities for profit, tapping cannot be recommended for other sugar maple stands in Michigan's Lower Peninsula.

SUMMARY

Minimum stand stocking required for profitable sap production in Michigan's Lower Peninsula sugar maple stands was studied by means of models designed to simulate actual sapping operations. Three operating procedures were appraised: 1) sap processing integrated with sap production; 2) sap produced and sold at roadside for transport to a central evaporator plant for processing; and 3) sap transported by the producer from sugar-bush to a central evaporator plant for sale.

Available published and unpublished data bearing on the problem were collected and used whenever possible in the analysis. Where information was lacking, estimates were prepared to simulate typical conditions within Michigan's Lower Peninsula. Data on the structures and densities of sugar maple stands were obtained from records of the Michigan Forest Survey conducted by the U. S. Forest Service.

Plastic tube gathering systems were designed to accommodate the range of stocking conditions tested, and the various equipment costs, operating costs and depreciation schedules prepared for each stand. Finally, costs, returns and surpluses were compiled from a series of operating models to define minimum stocking required for profitable tapping.

Results show that integrated sap-syrup operations appear to offer promise for profitable tapping in stands stocked with as few as 10 tapholes/A., if the yield per taphole is approximately 25 gal. of sap. Greater densities of taphole stocking enhance opportunities for profit.

Roadside sap sale operations require higher stand densities except in stands of large sawtimber. With sap yields of 25 gal./taphole, producers should have between 45 and 50 tapholes/A. for pole stands, and between 30 and 35 tapholes/A. in small sawtimber for returns to balance operating costs.

When sap is delivered for sale to a central evaporator plant, even greater numbers of tapholes are required per acre for profitable operation. With trees yielding 25 gal./taphole, break-even operation is possible only in pole size stands containing approximately 60 tapholes/A., in small sawtimber containing about 50 tapholes/A., and in large sawtimber stands containing between 10 and 25 tapholes/A.

With sap yields lower than 25 gal./taphole, opportunities for profitable tapping are more limited. At 20 gal./taphole, integrated sap-syrup operations could successfully tap stands stocked with at least 20 to 25 tapholes/A., but producers could not expect to operate profitably if they sold sap to a central evaporator plant. Furthermore, with sap yields of only 15 gal./taphole, under none of the conditions tested within the study could producers expect to break even.

The prospects for profitable tapping could likely be improved, and minimum stocking required for commercial operations lowered, by increasing sap production per tree, by adopting more efficient tapping and sap gathering methods, or by increasing sap prices either at roadside or at the central evaporator plant.

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