

Birch syrup production to increase the economic sustainability of maple syrup production in the Northern Forest

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Diversifying existing maple operations to include the production of birch syrup can be a simple and ecologically sustainable way to increase the profitability, and thus the long-term economic sustainability, of some maple syrup production operations in the Northern Forest

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<http://www.nsrcforest.org>

Project Summary

Maple syrup production is a vital part of the Northern Forest's economy and working landscape, using forests sustainably to harvest and produce a natural product and provide jobs, generate income, and create business opportunities that support prosperous families, farms, communities, and businesses. However, maple producers in the region face increasing challenges to maintaining profitable operations while keeping syrup prices affordable due to rapidly rising costs of production. Adding birch syrup production could be a practical and ecologically-sustainable way for producers to help address this issue and increase the revenues, and thus the profitability, of maple operations.

Birch syrup production is very similar to maple production, uses maple equipment and tools, and the sapflow period begins as the maple sapflow season is ending. As birch trees are already abundant in or near many maple sugarbushes, many maple producers would be able to add birch production to their operations relatively simply using existing equipment that would otherwise not be in use at the time. Birch syrup currently has high economic value, and is in high demand by retail consumers and chefs who desire natural, locally-produced, sweeteners and food ingredients. The low sap sugar content and short sapflow period that have limited the yields and profitability of birch syrup production in the past should be mitigated by the use of modern equipment and practices such as reverse osmosis and tubing collection systems with vacuum. Thus, the overall goal of this study was to determine if the production of birch syrup can increase the profitability and economic sustainability of existing maple syrup production operations in the Northern Forest.

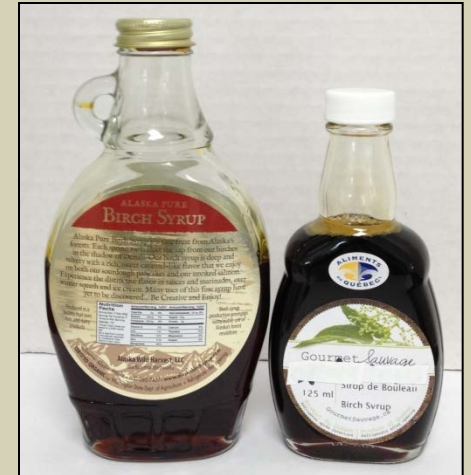


Photo: Mark Isselhardt

To accomplish this goal, we determined the average quantity of syrup that can be produced annually from birch trees in the Northern Forest using modern equipment and practices, and used these values to conduct analyses to estimate the potential profitability of adding birch syrup production to existing maple operations. Yields obtained using modern collection equipment and practices were comparable to those obtained in commercial birch syrup operations, and financial analyses indicated these yields would be sufficient for birch production to result in a net profit when added to an existing maple operation under a variety of scenarios of birch resource availability and value of the birch syrup crop. Thus, the results indicate that birch syrup can be produced profitably by maple operations in the Northern Forest and that this can be a way to increase the revenues, and thus the long-term economic sustainability, of existing maple operations in the region. Birch syrup production can be a tool to help ensure maple production remains an economically viable practice in the Northern Forest and continues to be able to provide its many economic, social, and ecological benefits to the region.

Background and Justification

The addition of birch syrup production could provide additional revenue for existing maple operations in the Northern Forest. Currently, relatively small amounts of birch syrup are produced commercially (<5,000 gallons/year), predominantly in Alaska and Canada, and the product has high economic value (e.g. \$78 per quart). Birch syrup is produced by collecting and concentrating the sap from birch trees* in a process that is very similar to maple syrup production, and that uses maple equipment and tools (spouts, evaporators, etc.). The birch sapflow season in the northeastern US begins just as the maple production season concludes, and birch trees of tappable size are already abundant in or near many sugarbushes. Thus, many maple producers would be able to add birch syrup production to their operations using almost entirely existing equipment (evaporators, sap tanks, RO units, etc.), during time when this equipment would otherwise be dormant, and using an already existing, unused forest resource.



Commercially-produced pure birch syrup from Alaska and Canada



Photo: Catherine Stevens



Photo: Ted Ortiz V Pino

Left: Tapping a maple tree for sap collection. Right: Tapping a birch tree for sap collection using maple spouts and tubing.

Background and Justification

In the past, birch syrup has not been widely produced in the Northern Forest because of the practice's limited profitability, due mainly to the low sugar content of birch sap (~1% compared to ~2% in maple). This necessitates a large quantity of evaporator fuel to concentrate the sap to syrup density, and greatly increases the cost of producing birch syrup. However, this past limitation to profitability is largely overcome by the use of reverse osmosis (RO). RO enables the sap to be concentrated to higher sugar concentrations (8% or greater) prior to processing in the evaporator, and greatly reduces the amount of evaporator fuel required to complete the concentration of the material to finished syrup density. Also, total sap yields from birch trees are somewhat limited due to a relatively short sapflow period (3-4 weeks). The use of modern maple sap collection practices and techniques, including collection in tubing systems with vacuum and current sanitation practices, should help to increase the yields able to be obtained from birch trees.



Birch tree tapped with modern sap collection practices, using vacuum collection and maple spout and tubing.

Photo: Mark Isselhardt

Thus, it is possible that using modern collection and processing practices and equipment, birch syrup could be produced profitably by existing maple operations. This could be a relatively simple and ecologically sustainable way to increase the revenues, and thus the profitability and long-term economic sustainability, of maple operations in the Northern Forest. Diversifying maple operations to include birch production would also help promote forest diversity in maple sugarbushes, and help maple producers meet increasing consumer demands for natural, locally-produced products.

Background and Justification

The overall goal of this study was to determine if the production of birch syrup can increase the profitability and economic sustainability of existing maple syrup production operations in the Northern Forest. Two primary questions must be answered to achieve this goal – 1) How much syrup can be produced from birch trees annually using modern equipment and practices?, and 2) With these yields, would adding birch syrup production generate net profits in maple operations?



Birch trees tapped using a tubing sap collection system with vacuum.



Tapping a birch tree with current maple spout and tubing.

Photo: Teal Ortiz Y Pino

Thus, the overall project goal was met by accomplishing the following objectives:

- 1) Determine the average quantity of syrup that can be produced annually from birch trees in the Northern Forest using modern equipment and practices.
- 2) Estimate the potential profitability of adding birch syrup production to existing maple syrup production operations.

Methods

Determine the quantity of syrup that can be produced annually from birch trees

Thirty-eight healthy paper birch (*Betula papyrifera*) trees in four dbh classes (8-10, 10-12, 12-14, 14-16") were selected at the University of Vermont Proctor Maple Research Center in Underhill Center, VT.[†] Each tree was connected to a large plastic chamber that enables the collection and quantification of sap from individual trees under vacuum. Vacuum was applied with a rotary-claw pump, and was maintained at standard industry level (25 "Hg) throughout the production season.

In spring 2012 and 2013, trees were tapped with a standard 5/16" maple spout. The volume of sap produced by each tree was periodically measured, and its sugar content determined with a digital refractometer. Sap collection and measurements continued until the end of the sapflow period.[‡] Trees were tapped at a location similar to the height at which a bucket would be placed for sap collection.



One of 38 Paper birch trees tapped for sap collection under vacuum in the study.



Chambers used to collect and quantify birch sap volume and sugar content under vacuum.

At the end of each season, sap yield and sugar content data were used to calculate the quantity of birch syrup (66.9 °Brix) produced annually by each tree.¹ Data were compiled and used to calculate overall average yields, and the average yields from trees in each diameter class.

Methods

Estimate the Profitability of Adding Birch Syrup Production to an Existing Maple Operation

Financial Spreadsheet Development

Once average yields were determined, the values were used to parameterize and develop a set of spreadsheet calculations that estimate the net profit or loss resulting from adding birch syrup production to an existing maple operation. The spreadsheet calculations are based on input parameters that specify the properties of the maple operation (such as the size of the evaporator and RO unit), and the size of the birch resources available (number of taps).[§] Once these values are input, the spreadsheet first calculates the total expenses of producing birch syrup in an operation with the given characteristics. These expenses include (but are not limited to) the labor and materials for all activities, such as tapping, sap collection and concentration with RO, boiling, filtering, canning, setup and cleanup, sales, marketing, transportation, woods and tubing system and equipment maintenance, overhead, and insurance. Additional details about the spreadsheet and its assumptions are included in the Notes section at the end of this report. It must be emphasized that the expenses considered are only those incurred for birch production *in addition to* the expenses of the existing maple operation.

The spreadsheet then calculates the estimated size and value of the birch syrup crop produced. It estimates the potential value of the birch syrup crop using several different sales and pricing strategies, including selling the crop in small and large containers at both wholesale and retail prices, with prices estimated using both cost-based and competition-based pricing methods. Five unit sizes are used: 40- and 100-mL glass bottles, and ½-pint, quart, and gallon-sized plastic jugs. Sizes were selected based on sizes currently commercially available for birch syrup.^{**} For cost-based pricing, prices are calculated using standard pricing formulas, with wholesale prices calculated as production costs times 2, and retail prices as wholesale prices times 1.5. For competition-based pricing, averages of the prevailing retail prices for birch syrup (in the various unit sizes) in the US and Canada in 2013 are used, and wholesale prices are calculated as retail price divided by 1.5.^{††}

Once annual expenses and revenues are calculated, for each of the unit sizes and sales/pricing strategies, the spreadsheet estimates the average cost of producing each unit, and the average annual net revenue (or loss) over 10 years for an operation with the specified birch resources and maple operation characteristics.

Operation Specifications and Calculations	
Birch Resource	
Number of taps	100
Total Production (sap volume, gallons)	1670
No. of Season days	25
Average sap sugar content (Brix)	0.74
RO	
RO flow rate (gph)	600
Concentration % (each pass)	75
RO Electrical Usage (kw)	10.4
Concentration after first pass (%)	2.96
Concentrate volume after first pass (gallons)	417.5
Concentration after second pass (%)	11.8
Concentrate volume after second pass (Total Concentrate Volume, gallons)	104.4
Total Permeate Volume (gallons)	1566.6
Concentrate flow rate (gph)	150
Total RO run time for concentration (hours)	3.5
Total RO run time (hours)	5.0
Total RO run time (wash)	1.5
Evaporator/Sugarhouse	
Evaporator burner (gal oil/hr)	8.0
Evaporator evaporation rate (gal water/hr)	100.0
Canning unit fuel use rate (gal propane/hr)	0.71
Vacuum Pump Consumption (kw/h)	3.8
Total water to evaporate (gallons)	89.7
Total evaporator hours	0.9
Total evaporator fuel required (gallons)	7.2
Percent Loss	10
Hours to setup and cleanup	20
Hours for sugarhouse work (boiling, RO, filtering)	8

Example portion of financial spreadsheet where specifications of the maple operation and birch resource are input and used to calculate parameters such as total syrup production and fuel and electricity use.

Methods

Estimate the Profitability of Adding Birch Syrup Production to an Existing Maple Operation

Assessing Profitability

To assess whether adding birch syrup production to existing maple operations is likely to be profitable, the spreadsheet was used to estimate the average annual net revenues and production costs per unit from adding birch syrup production to a hypothetical maple operation with equipment and characteristics common in the maple industry, and with several assumptions made. The hypothetical maple operation was equipped with:

- A 600 gph reverse osmosis unit (RO) using 2 sequential passes of 75% concentration (raw sap is run through the RO once to concentrate it from approximately 0.7 to 2.8 °Brix, then the concentrated material is run through the unit again to yield sap at approximately 11 °Brix).
- An oil-fired, 3 x 10' evaporator with a burner that consumes 8 gallons of oil per hour, and an evaporation rate of 100 gallons of water per hour.
- A vacuum pump with a power consumption of 3.8 kW·h.
- A propane-fueled canning unit (65,000 BTU) with a fuel consumption rate of 0.71 gallons per hour.

It was also assumed that in this operation:

- One person completes all activities (no help is hired), with a labor rate of \$20/hour.
- Syrup is finished to 66.9 °Brix.
- 10% of the overall crop is lost to sap or syrup spillage, overfill, sampling, startup/cleanup, etc.
- A new single-line tubing system with new mainlines is installed every 10 years, spouts are replaced annually, and droplines are replaced every 5 years.

The spreadsheet calculations rely on many additional important general assumptions, and likewise there are numerous factors to consider when using the tool. These are detailed in the Notes section at the end of this report. Most important to bear in mind is that this analysis is for a birch syrup operation added to an already existing maple operation. This means that the **only** expenses considered are those **in addition to** those incurred for the already existing maple operation. Thus, there are numerous expenses assumed to be already accounted for in the maple operation. These include essentially all intermediate and long-term assets not exclusively used for birch production, including:

- Principal and interest on buildings, land, and other property (sugarhouse, other buildings, etc.), and associated taxes and maintenance costs.
- All fixed equipment not exclusively used for birch operations, including: the evaporator, sap tanks, vacuum pumps, finishing pan, canning unit, RO, preheater, and filterpress, as well as associated maintenance costs.
- Vehicles (trucks, tractors, ATV's, etc.) and associated maintenance costs.

Expenses - 40-mL Nip production				
Variable Expenses				
Item	Cost per unit (\$)	No. of units	Units	Annual cost (\$)
Evaporator fuel	4.1	7.2	Gallons	29
Finishing pan fuel	4.1	2.4	Gallons	10
Canning unit fuel	5	14.2	Gallons	71
Electricity - vacuum pump	0.1434	2277	Kilowatt hours	326.5
Electricity - RO	0.1434	67	Kilowatt hours	9.6
Labor - sugarhouse	20	28.22	Hours	564.5
Labor - tapping	20	2.5	Hours	50
Labor - tubing/woods maintenance	20	13.14	Hours	262.8
Labor - RO maintenance	20	5	Hours	100
Labor - canning	20	20	Hours	399
Containers for canning	0.87	1197	Containers	1041
Other consumable supplies (\$/tap)	1	100	Dollars	100
Overhead (\$/tap)	1	100	Dollars	100
Insurance	-	-		200
Marketing	0.03	2514		75
Tapping supplies - new spouts	0.40	100	Spouts	40.0
Tapping supplies - new droplines	1.44	100	Droplines	144.0
Fixed Expenses**				
Item	Cost per tap (\$)			Total Cost
Tubing system (10-year lifespan)	14			1400

**Assumes all other equipment with fixed costs used from maple production (RO, evaporator, etc.)

Example portion of financial spreadsheet where annual expenses of adding birch production to a specified maple operation are calculated.

Methods

Estimate the Profitability of Adding Birch Syrup Production to an Existing Maple Operation

Four birch operation sizes were examined: 100, 200, 300, and 400 taps.^{##} To assess the fundamental profitability of producing birch syrup in maple operations, the production costs per unit in each operation were compared to current retail prices of birch syrup to determine whether birch syrup could be produced in maple operations and sold in the current retail market without incurring annual losses. To determine whether birch syrup production is likely to be profitable under conditions less ideal than selling syrup at current retail prices (and that may be more likely to occur), average annual revenues under a highly conservative sales/pricing strategy in which the entire birch crop is sold in quart-sized units at wholesale prices were examined to determine whether a net profit or loss was incurred. Finally, the estimated revenues under various sales and pricing scenarios were examined to explore the amount of potential additional revenue that might be gained with birch syrup production, and the activities required to achieve that level of profitability.

Crop Value		Total Annual Expenses:		
Annual Syrup Price and Value		Year	Tubing system maintenance activity	Total Annual Expenses (\$)
No. of units produced (40-mL nips)	1197	1	New tubing system	4739
Production cost per unit	3.06	2	Replace spouts	3379
Pricing method/sales type	Price per unit (\$)	3	Replace spouts	3379
Current retail price (competition-based pricing)	6.00	4	Replace spouts	3379
Competition-based Wholesale	4.00	5	Replace spouts	3379
Cost-based Retail	9.18	6	Replace droplines	3483
Cost-based Wholesale	6.12	7	Replace spouts	3379
	Total Value (\$)	8	Replace spouts	3379
Competition-based Retail	3519	9	Replace spouts	3379
Competition-based Wholesale	1125	10	New tubing system	4739
Cost-based Retail	7322	10-year Average Annual Expense:		
Cost-based Wholesale	3661			3661
Income - 40-mL Nip production				
	Pricing method/sales type	Average Annual Revenue:		
	Competition-based Retail	7179		
	Competition-based Wholesale	4786		
	Cost-based Retail	10983		
	Cost-based Wholesale	7322		

Example portion of the financial spreadsheet showing calculations of total annual expenses (depending on the maintenance activity required for the tubing system), average annual expense over 10 years, and birch crop values and production costs per unit when birch syrup production is added to a specified maple operation. (In this example, the entire crop is packaged in 40-mL units.)

Results

Determine the quantity of syrup that can be produced annually from birch trees

Yields obtained for each year of the study are presented in Table 1. The two seasons differed greatly from one another. The spring of 2012 was marked by exceptionally unusual temperatures – March 2012 was the warmest March on record,² and following warm temperatures and no nighttime freezes early in the month, there were 5 consecutive days of temperatures above 70 °F at UVM-PMRC (Figure 1). As a result, bud development in sugar maples at PMRC occurred over 2 weeks earlier than average,² and maple sap collection ended on March 21st (3-4 weeks early) due to the deterioration of sap quality caused by both bud development and warm temperatures. Following the record warm temperatures, cooler (but not freezing) temperatures returned, and birch study trees were not tapped until April 12th after temperatures warmed again. As such, the birch sap collection period was abbreviated, lasting only 13 days, and sap yields were relatively low, with an average of 15.9 gallons of sap collected per tap, or 0.14 gallons (17.3 ounces) of syrup equivalent per tap (Table 1).

In contrast, the 2013 season was actually marked by somewhat cooler temperatures than average during the birch sapflow period (Figure 1). The cooler temperatures helped to prolong the maple sap collection period (which did not end until April 18th at UVM-PMRC), and might have reduced the total yield obtained from some birch trees. Birch trees were tapped on April 8th, and sap was collected until April 29th for a total 21 season days.^{§§} Overall, yields were greater in 2013, with an average of 17.5 gallons of sap collected per tap, or 0.15 gallons (19.2 ounces) of syrup equivalent (Table 1).

Table 1. Sapflow period and average sap and syrup yields and sugar contents from 38 paper birch trees in 4 DBH classes tapped for sap collection (using vacuum) at UVM-PMRC in Underhill Ctr., VT in 2012 and 2013.

2012								
DBH class (inches)	n	Sap yield per tap (gallons)	Syrup equivalent yield per tap (gallons)	Ounces of syrup per tap	Sap sugar content (°Brix)	Season Start	Season Close	Season Days
8-10	7	10.6 ± 1.8	0.09 ± 0.01	11.3	0.73 ± 0.07	4/12/2012	4/25/2012	13
10-12	17	16.1 ± 1.9	0.14 ± 0.02	18.0	0.76 ± 0.03			
12-14	11	17.4 ± 2.5	0.14 ± 0.02	18.4	0.72 ± 0.02			
14-16	3	21.9 ± 7.7	0.18 ± 0.04	23.1	0.80 ± 0.16			
Overall	38	15.9 ± 1.3	0.14 ± 0.01	17.3	0.75 ± 0.02			
2013								
8-10	7	17.2 ± 4.3	0.15 ± 0.03	18.9	0.79 ± 0.06	4/8/2013	4/29/2013	21
10-12	17	14.8 ± 2.9	0.13 ± 0.02	16.5	0.75 ± 0.03			
12-14	11	20.3 ± 3.0	0.18 ± 0.03	22.4	0.71 ± 0.04			
14-16	3	23.3 ± 5.2	0.19 ± 0.04	23.9	0.73 ± 0.03			
Overall	38	17.5 ± 1.8	0.15 ± 0.02	19.2	0.74 ± 0.02			

Results

Determine the quantity of syrup that can be produced annually from birch trees

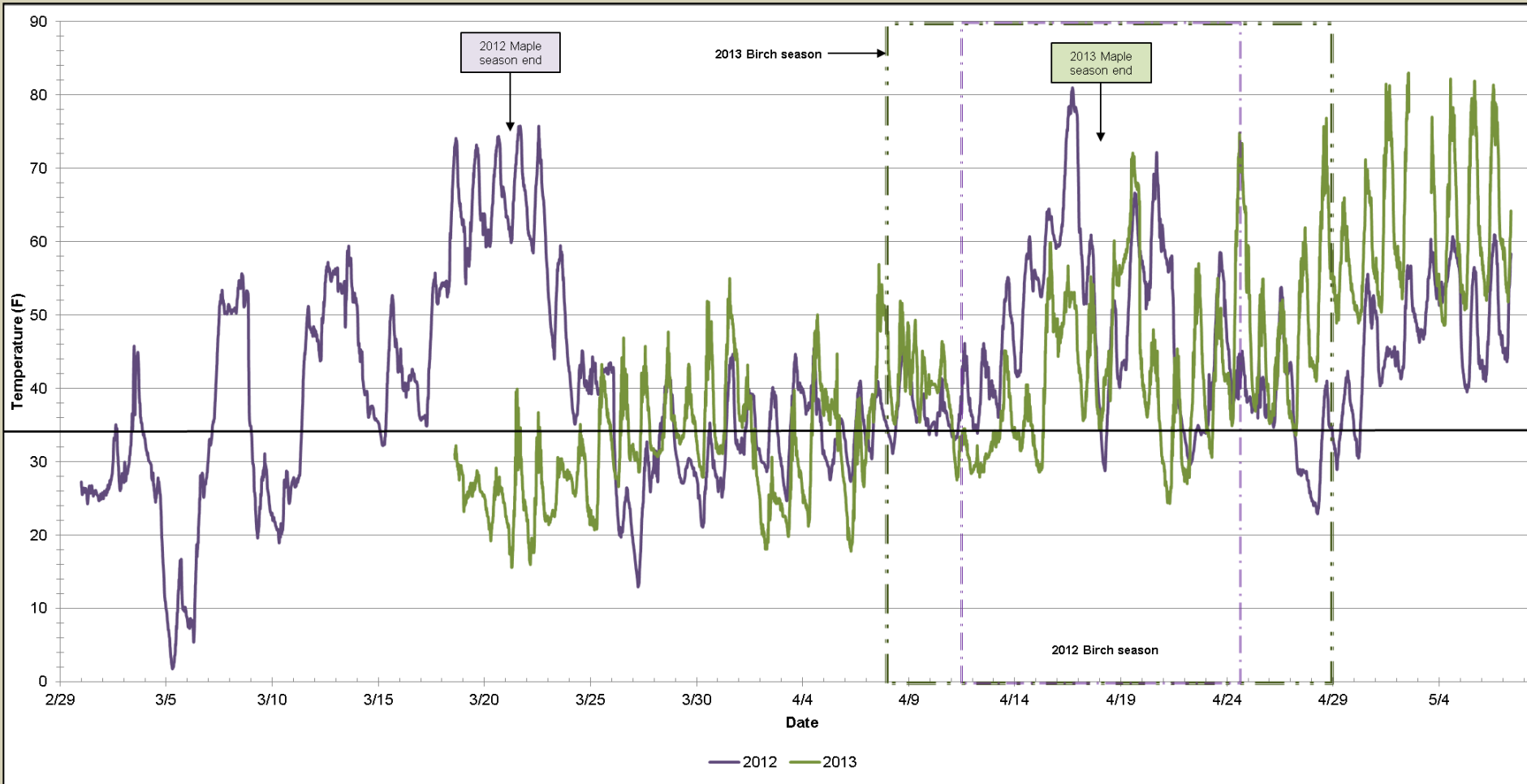


Figure 1. Air temperatures and maple and birch sapflow periods (season open and close) during the 2012 and 2013 production seasons at UVM-PMRC in Underhill Ctr., VT. (2012 air temperature data from Vermont Monitoring Cooperative Proctor Maple Research Center Monitoring Station; 2013 air temperature data collected by UVM-PMRC.)

Results

Determine the quantity of syrup that can be produced annually from birch trees

Despite the apparent difference in yields, there was not a statistically significant difference in sap or syrup yields between the two years (*data not shown*). For this reason, and since the occurrence of a periodic aberrant or low-yield year is something likely to be encountered by producers, the 2012 data were not discarded, and remaining analyses were performed using the whole dataset (Table 2). The overall average annual yield was 16.7 gallons of sap per tap with an average sugar content of 0.74 °Brix. This equates to an average of 0.14 gallons (18.3 ounces) of syrup equivalent per tap. Though there was a pattern suggesting greater sap yields with larger DBH class, there was no statistically significant difference in sap yields, syrup yields, or sugar contents between the four dbh classes (Table 2).

Table 2. Overall average DBH, sap and syrup yields, and sugar contents from 38 paper birch trees in 4 DBH classes tapped for sap collection (using vacuum) at UVM-PMRC in Underhill Ctr., VT in 2012 and 2013. *p*-values for one-way ANOVA to compare DBH class means (*n*=4). * indicates mean comparison made with nonparametric (Wilcoxon Rank Sums) test.

Overall - Both Years									
DBH class (inches)	<i>n</i>	Sap yield per tap (gallons)	<i>p</i> -value	Syrup equivalent yield per tap (gallons)	<i>p</i> -value	Ounces of syrup per tap	Sap sugar content (°Brix)	<i>p</i> -value	DBH (inches)
8-10	7	13.9 ± 3.0	0.3653	0.12 ± 0.02	0.3919*	15.1	0.76 ± 0.04	0.8018	9.3 ± 0.13
10-12	17	15.5 ± 2.0		0.13 ± 0.02		17.2	0.75 ± 0.03		11.1 ± 0.16
12-14	11	18.9 ± 2.6		0.16 ± 0.03		20.4	0.72 ± 0.04		12.9 ± 0.21
14-16	3	22.6 ± 6.2		0.18 ± 0.04		23.5	0.76 ± 0.07		14.3 ± 0.17
Overall	38	16.7 ± 1.4		0.14 ± 0.01		18.3	0.74 ± 0.02		11.5 ± 0.26

The sap and syrup yields observed in study trees were similar to those reported for commercial birch syrup production operations in Alaska. Average yields reported by four large producers for the 2012 season ranged from 8.4 to 16.1 gallons of sap per tap tree, with an average of 13.5 gallons of sap per tap, 0.13 gallons (16.8 ounces) of syrup per tap, and an average sugar content of 1.02 °Brix.⁴ Thus, the results indicate that the quantity of syrup that can be produced from birch trees in the Northern Forest using modern equipment and practices is relatively high and, in general, comparable to yields obtained in existing commercial birch syrup operations.

Results

Determine the quantity of syrup that can be produced annually from birch trees

There were overall significant linear relationships between tree DBH and both sap and syrup yields, however the correlations were rather weak (Table 3). Sap sugar content was not correlated with DBH. Despite this, DBH has been shown to correlate with sap yields in previous work,³ and producers can likely generally expect to obtain greater yields from larger trees.

Table 3. Coefficients of determination, r^2 , and p values for linear regressions of tree diameter at breast height (DBH) versus mean overall sap and syrup yields and sugar content of 38 paper birch trees tapped for sap collection in 2012 and 2013.

	r^2	p -value
Sap yield per tap (gallons)	0.18	0.0078
Syrup equivalent yield per tap (gallons)	0.17	0.0092
Sap sugar content (°Brix)	0.002	0.7949



Photo: Mark Isselhardt

Birch sap collected in vacuum sap collection chamber.

Results

Estimate the Profitability of Adding Birch Syrup Production to an Existing Maple Operation

Prior to estimating the potential profitability of adding birch syrup production to a maple operation, an accurate assessment of the income and expenses of the existing maple operation must be established. There are several resources available to help complete this task, including the “Maple Sugaring Worksheets” by Glenn Rogers of UVM Extension, the North American Maple Producers Manual, and planning worksheets by Cornell and Ohio State University Extension.⁵⁻⁹

The spreadsheet developed estimates the average annual net revenue (or loss) and production costs per unit when birch syrup production is added to an existing maple operation. The output depends on input values for properties of the available birch resource (# of taps) and the maple operation (evaporator and RO specs, etc.), and several strategies for establishing the possible value of the birch syrup crop. It must be strongly emphasized that this analysis is for birch syrup production added to an existing maple operation, and the **only** expenses considered are those in addition to those of the maple operation.

The average annual costs of producing a unit of birch syrup in the hypothetical maple operation with varying numbers of birch taps are presented in Table 4. As would be expected, the production costs per unit generally decrease with increasing operation size. An operation with 100 taps would produce approximately 51 quarts (13 gallons) of birch syrup annually, at an estimated expense of \$44.69 per quart (\$173.46 per gallon). In contrast, an operation with 400 birch taps would produce an estimated 202 quarts (51 gallons) annually, at an expense of \$28.13 per quart (\$107.20 per gallon).

Table 4. Estimated production costs per unit and number of units produced for birch syrup produced in 5 unit sizes by an existing maple operation with 100, 200, 300, or 400 birch trees tapped.

Number of birch taps	40-mL nips	100-mL bottles	1/2-pints	Quarts	Gallons
100 Taps	Price	Price	Price	Price	Price
Cost per unit	\$3.06	\$6.21	\$12.47	\$44.69	\$173.46
Number of units	1,197	476	202	51	13
200 Taps					
Cost per unit	\$2.59	\$5.04	\$9.71	\$33.65	\$129.29
Number of units	2,393	952	405	101	25
300 Taps					
Cost per unit	\$2.44	\$4.65	\$8.79	\$29.97	\$114.56
Number of units	3,590	1,428	607	152	38
400 Taps					
Cost per unit	\$2.36	\$4.45	\$8.33	\$28.13	\$107.20
Number of units	4,786	1,904	809	202	51

Results

Estimate the Profitability of Adding Birch Syrup Production to an Existing Maple Operation

Perhaps the simplest way to assess the potential profitability of birch syrup production is to compare estimated production costs to the current retail prices of birch syrup. The production cost per unit essentially provides an estimate of the 'break-even' price - the amount of revenue that must be generated in order to cover all expenses required to produce each unit of the product.^{†††} Thus, to break even and incur no losses (or profits), an operation with 100 taps would need to take in \$44.69 per quart, and an operation with 400 taps would require \$28.13 for each quart (Table 5).^{†††} Though these costs might seem relatively high, they are substantially lower than the current retail price of pure birch syrup, which is approximately \$78 per quart (Table 5). Similar results are observed with other unit sizes (Table 5). Thus, in these operations, birch syrup could be produced and sold at retail prices without incurring a net loss. This indicates, at least broadly, that the addition of birch syrup production to maple operations is potentially profitable, and that the level of profitability is likely to increase with increasing size of the birch operation.

Number of birch taps	40-mL nips	100-mL bottles	1/2-pints	Quarts	Gallons
100 Taps	Price	Price	Price	Price	Price
Current Retail Price	\$6.00	\$10.00	\$21.00	\$78.00	\$300.00
Cost per unit	\$3.06	\$6.21	\$12.47	\$44.69	\$173.46
Number of units	1,197	476	202	51	13
200 Taps					
Current Retail Price	\$6.00	\$10.00	\$21.00	\$78.00	\$300.00
Cost per unit	\$2.59	\$5.04	\$9.71	\$33.65	\$129.29
Number of units	2,393	952	405	101	25
300 Taps					
Current Retail Price	\$6.00	\$10.00	\$21.00	\$78.00	\$300.00
Cost per unit	\$2.44	\$4.65	\$8.79	\$29.97	\$114.56
Number of units	3,590	1,428	607	152	38
400 Taps					
Current Retail Price	\$6.00	\$10.00	\$21.00	\$78.00	\$300.00
Cost per unit	\$2.36	\$4.45	\$8.33	\$28.13	\$107.20
Number of units	4,786	1,904	809	202	51

Table 5. Estimated production costs per unit and number of units produced for birch syrup produced in 5 unit sizes by an existing maple operation with 100, 200, 300, or 400 birch trees tapped, and 2013 retail prices of each unit size.

Results

Estimate the Profitability of Adding Birch Syrup Production to an Existing Maple Operation

The profitability of birch syrup production in maple operations will depend greatly on the value of the birch crop produced. The value of the birch syrup crop will depend on several factors, including the pricing method (cost- or competition-based), the unit size, and whether the crop is sold at retail or wholesale prices. Typically, the crop value is highest when small units are sold at retail using cost-based pricing. Thus, to more completely assess the potential profitability of birch production in maple operations, the annual revenues from birch syrup production in each operation under each of these different pricing and sales scenarios must be examined.

The estimated average annual net revenues under several pricing and sales scenarios – from retail and wholesale sales of 5 unit sizes in 4 sizes of birch operations using cost- and competition-based pricing – were calculated. The most conservative scenario to examine is one in which the entire crop is sold in quart-sized units at wholesale prices (Table 6). In this scenario, relatively few units are produced, and it is reasonably likely to assume that buyers (such as local chefs) could be found to purchase the entire birch crop at wholesale prices. Though this is the least profitable scenario to consider, it is also the scenario in which the entire birch crop is most likely to be sold, and thus that the predicted net revenues are able to be achieved. Thus, this scenario can be used as a conservative baseline to assess the potential profitability of adding birch syrup production to maple operations. Using wholesale prices based on production costs, estimated annual net revenues would range from \$2,260 to \$5,690, depending on operation size (Table 6). Wholesale prices calculated from current retail prices (competition-based) are lower than those based on production costs, particularly in smaller operations (Table 6). Thus, estimated annual net revenues using competition-based wholesale prices are slightly lower, and range from \$370 to \$4,830 (Table 6). These results indicate that even using the most conservative pricing/sales scenarios, birch syrup production in maple operations is likely to result in a net profit, with higher profits achievable in larger birch operations.

Pricing Method/Number of birch trees tapped	Quarts	
	Price	Net revenue
100 Taps		
Competition-based Wholesale	\$52.00	\$370
Cost-based Wholesale	\$89.38	\$2,260
Cost per unit	\$44.69	
Number of units	51	
200 Taps		
Competition-based Wholesale	\$52.00	\$1,857
Cost-based Wholesale	\$67.29	\$3,403
Cost per unit	\$33.65	
Number of units	101	
300 Taps		
Competition-based Wholesale	\$52.00	\$3,343
Cost-based Wholesale	\$59.93	\$4,547
Cost per unit	\$29.97	
Number of units	152	
400 Taps		
Competition-based Wholesale	\$52.00	\$4,830
Cost-based Wholesale	\$56.25	\$5,690
Cost per unit	\$28.13	
Number of units	202	

Table 6. Estimated average annual net revenues over 10 years for birch syrup produced by an existing maple operation with 100, 200, 300, or 400 birch trees tapped, in conservative scenarios in which the entire crop is sold in quart-sized units at current (competition-based) or cost-based wholesale prices.

Results

Estimate the Profitability of Adding Birch Syrup Production to an Existing Maple Operation

Scenarios in which the birch syrup crop is sold in smaller unit sizes, or at retail prices, result in greater annual net revenues (Table 7). However, it is more difficult to guarantee sales of a large number of small units at retail or wholesale prices. In addition, cost-based pricing may not be sufficiently competitive to enable the entire crop to be sold, particularly in smaller operations with higher per unit production costs (Table 7). Thus, the feasibility and likelihood of these other scenarios, and thus the amount of potential additional revenue, will depend on the characteristics of the operation and its crop.

Pricing Method/Number of birch trees tapped	40-mL nips		100-mL bottles		1/2-pints		Quarts		Gallons	
	Price	Net revenue	Price	Net revenue	Price	Net revenue	Price	Net revenue	Price	Net revenue
100 Taps										
Competition-based Wholesale	\$4.00	\$1,125	\$6.60	\$186	\$14.00	\$309	\$52.00	\$370	\$200.00	\$336
Competition-based Retail	\$6.00	\$3,519	\$10.00	\$1,804	\$21.00	\$1,725	\$78.00	\$1,685	\$300.00	\$1,600
Cost-based Wholesale	\$6.12	\$3,661	\$12.42	\$2,956	\$24.94	\$2,523	\$89.38	\$2,260	\$346.91	\$2,193
Cost-based Retail	\$9.18	\$7,322	\$18.63	\$5,912	\$37.41	\$5,046	\$134.06	\$4,520	\$520.37	\$4,386
Cost per unit	\$3.06		\$6.21		\$12.47		\$44.69		\$173.46	
Number of units	1,197		476		202		51		13	
200 Taps										
Competition-based Wholesale	\$4.00	\$3,368	\$6.60	\$1,488	\$14.00	\$1,735	\$52.00	\$1,857	\$200.00	\$1,788
Competition-based Retail	\$6.00	\$8,154	\$10.00	\$4,725	\$21.00	\$4,568	\$78.00	\$4,487	\$300.00	\$4,317
Cost-based Wholesale	\$5.19	\$6,205	\$10.07	\$4,795	\$19.42	\$3,929	\$67.29	\$3,403	\$258.57	\$3,269
Cost-based Retail	\$7.78	\$12,410	\$15.11	\$9,590	\$29.13	\$7,858	\$100.94	\$6,807	\$387.86	\$6,539
Cost per unit	\$2.59		\$5.04		\$9.71		\$33.65		\$129.29	
Number of units	2,393		952		405		101		25	
300 Taps										
Competition-based Wholesale	\$4.00	\$5,610	\$6.60	\$2,791	\$14.00	\$3,162	\$52.00	\$3,343	\$200.00	\$3,241
Competition-based Retail	\$6.00	\$12,789	\$10.00	\$7,646	\$21.00	\$7,410	\$78.00	\$7,288	\$300.00	\$7,034
Cost-based Wholesale	\$4.87	\$8,749	\$9.29	\$6,634	\$17.58	\$5,335	\$59.93	\$4,547	\$229.13	\$4,346
Cost-based Retail	\$7.31	\$17,498	\$13.94	\$13,268	\$26.37	\$10,671	\$89.90	\$9,093	\$343.69	\$8,691
Cost per unit	\$2.44		\$4.65		\$8.79		\$29.97		\$114.56	
Number of units	3,590		1,428		607		152		38	
400 Taps										
Competition-based Wholesale	\$4.00	\$7,852	\$6.60	\$4,094	\$14.00	\$4,588	\$52.00	\$4,830	\$200.00	\$4,693
Competition-based Retail	\$6.00	\$17,425	\$10.00	\$10,568	\$21.00	\$10,252	\$78.00	\$10,090	\$300.00	\$9,751
Cost-based Wholesale	\$4.72	\$11,293	\$8.90	\$8,473	\$16.66	\$6,741	\$56.25	\$5,690	\$214.41	\$5,422
Cost-based Retail	\$7.08	\$22,586	\$13.35	\$16,946	\$24.99	\$13,483	\$84.38	\$11,380	\$321.61	\$10,844
Cost per unit	\$2.36		\$4.45		\$8.33		\$28.13		\$107.20	
Number of units	4,786		1,904		809		202		51	

Table 7. Estimated production costs per unit and average annual net revenues over 10 years for birch syrup produced by an existing maple operation with 100, 200, 300, or 400 birch trees tapped, in scenarios in which the entire crop is sold in one of 5 unit sizes at retail or wholesale prices based on competition (based on current retail prices) or production costs.

For example, for a maple operation that has an existing retail outlet for sales and which adds 100 birch taps, it might be reasonable to expect to be able to find retail buyers for the 202 units of birch syrup produced if the entire crop were packaged in ½-pint units (Table 7). Using competition-based pricing, with a unit price of \$21.00 per ½-pint, this would result in estimated annual net revenue of \$1,725. Using cost-based pricing would result in net revenue of \$5,046; however consumers might be unwilling to pay the unit price of \$37.41 per ½-pint in this scenario. Likewise, if the entire crop of a 400-tap operation was packaged as ½-pints, it might be unreasonable to expect to find retail buyers for all 809 units. However, lower production costs would mean that even wholesale sales of this unit size at cost- or competition-based prices would generate substantial revenues, from \$4,588 to \$6,741.

Results

Estimate the Profitability of Adding Birch Syrup Production to an Existing Maple Operation

These scenarios and the estimated annual revenues presented in Tables 4-7 are presented only to provide general examples. The sales in any operation will typically be a combination of wholesale and retail sales of several different unit sizes, and the prices that an operation can charge while remaining competitive will fall on the spectrum between cost- and competition-based prices. Fundamentally, the prices charged must exceed production costs, and be sufficiently competitive to sell the entire crop. It must be emphasized that when establishing prices, in order to result in a net profit, *all* costs must be accounted for. The best price and sales strategy will be determined by the characteristics and circumstances unique to each operation.



Photo: Ted Ortiz Y Pino

Taken together, the results suggest that, in general, adding birch syrup production to existing maple operations in the Northern Forest can be profitable. The level of profitability and amount of additional revenue generated in some cases can be substantial, and will tend to increase with increasing size of the birch operation added.

Conclusions

Yields obtained from birch trees in the Northern Forest using modern collection equipment and practices are generally good, and comparable to those obtained in current, commercial birch syrup production operations.

The yields obtained would enable a maple operation with common equipment and practices to generate a net profit from producing birch syrup under a variety of sales and pricing strategies in which the value of the birch crop ranges from low to very high.

Thus, the results indicate that birch syrup can be produced profitably by maple operations in the Northern Forest, and that this can be a way to increase the revenues of existing maple operations.



It must be emphasized that the financial analysis conducted in this study represents estimated values for a hypothetical operation, is intended to provide only general examples, and is in no way intended to provide financial guidance. To assess the potential profitability of adding birch syrup production to a specific individual operation, professional financial assistance is recommended to conduct a complete financial assessment of the existing maple operation as well as the birch activities under consideration.

Implications and Applications in the Northern Forest Region

Broadly, these results suggest that it is possible to produce birch syrup profitably in maple operations in the Northern Forest. Thus, adding birch syrup production can be an ecologically-sustainable way to increase the revenues, and thus the profitability and long-term economic sustainability, of maple operations in the region.

Maple producers can use this information and the spreadsheet tool to help assess whether birch syrup production might be profitable for their operations, make a decision to initiate the practice, and ultimately increase their net revenues.

Diversifying maple operations to include birch production would also help promote forest diversity in maple sugarbushes, and help maple producers meet increasing consumer demands for natural, locally-produced products.

Increasing the net revenues of some maple operations will help maintain the long-term economic sustainability of maple production in the Northern Forest, and thus help to ensure that maple operations continue to help meet many of the social, economic, and ecological challenges of the Northern Forest, including generating jobs, income, and other economic opportunities, helping to maintain diverse and profitable family farms and woodlands, and helping to maintain the working landscape and way of life of the region through an ecologically-sustainable use of its forest resources.



Photo: Mark Isehardt

Future Directions

There are currently no tapping guidelines specifically for birch sap collection. Tapping guidelines that are based specifically on data on growth rates and internal wounding of birch trees are essential to ensure birch syrup production is sustainable and does not adversely affect tree health, and future research should address this need. This is especially critical given recent incidences of birch decline in the northeast.¹⁰ Producers should follow current Conservative Tapping Guidelines for maple until specific birch guidelines are developed.¹¹

Currently, best practices for obtaining optimum sap yields from birch trees, such as how to determine the best time to tap trees, are not known. To help ensure birch production generates maximum revenues, future work should address and determine best practices for maximizing sap yields from birch trees.

Very little is known about the physiological processes involved in the development of pressure in birch stems (which allows sap to be harvested), and how this process is affected by environmental and meteorological factors. The process is wholly different in birch than in maple, and future research should focus on expanding our knowledge of this basic aspect of plant physiology. This will be essential for establishing the best practices with which to maximize sap yields.

Conditions for processing birch sap that result in syrup with the best quality and flavor are likely not identical to those for maple. Birch sap contains a higher proportion of reducing sugars than maple sap, and this greatly impacts the nonenzymatic browning reactions that develop flavor and color during processing with heat in the evaporator. Future research should investigate optimum processing conditions and practices for birch sap.



Column of discoloration extending above the taphole (indicative of nonconductive wood) generated by the wounding response in a birch stem tapped for sap collection. (Column extends below the taphole as well, but is not pictured.)

Project Outcomes, Products and Outreach

The primary outputs of this work are data on the average sap yields of birch trees in the Northern Forest, information that these yields can enable net profits when birch production is added to an existing maple operation, and an interactive spreadsheet tool that allows producers to input specifications of their own maple operations to assess whether or not adding birch production is likely to be profitable under various scenarios. Maple producers will be able to use this information and the spreadsheet to help decide whether to initiate birch production in their operations.

Other publications and tangible products

The spreadsheet tool will be available for download at the UVM PMRC website. Results of the study, and information on the development and use of the spreadsheet tool, will also be made available through a technical bulletin that will be posted on the UVM PMRC website, and published in the *Maple Syrup Digest* (expected completion date May 2014).

Conference Presentations

These results will be presented to maple producers at meetings and conferences, including:

Birch syrup production – can it be profitable for maple operations?
University of Vermont Extension Maple Conferences, Hyde Park, VT, January 25, 2014, and Bellows Falls, VT, January 18, 2014.

Birch syrup production – can it be profitable for maple operations?
2014 Addison County Maple Seminar, Middlebury, VT, January 11, 2014.

Poster Presentation

Henkle, T. 2013 University of Vermont Student Research Conference. Wounding of *B. papyrifera* following tapping for syrup production.



Undergraduate Research Assistant Teague Henkle presenting his poster at the 2013 UVM Student Research Conference.

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Photo: Mark Isselhardt

Footnotes

* White birch, *Betula papyrifera*, is the primary species used, but other species, including yellow birch, *B. allegheniensis*, can also be used.

† Trees in the 8-10" class were included for investigative purposes, but are likely smaller than the minimum diameter that would be recommended for tapping.

‡ The end of the sapflow season was determined through a combination of anecdotal indicators, including air temperatures, the quality of sap in test buckets, and the degree of bud development.

§ The input parameters can be altered to match the characteristics of a particular operation, and a version of this planning tool will be available for producers to download.

** Birch syrup is rarely sold in gallon-sized units; however it is included in the analysis because it is a unit size in which maple syrup production is commonly expressed.

†† All values and pricing formulas are estimates and provided for illustration only; actual pricing will vary for each operation, and will likely be determined by a mixture of both cost- and competition-based methods. It must be emphasized that for any pricing strategy, *all* costs must be covered in order to achieve any level of net profit.

‡‡ Operations smaller than 100 taps were not examined, as they are unlikely to yield sufficient daily sap volumes required to use standard RO units. Because of the low sugar content of birch sap, the use of RO is considered requisite for producing birch syrup profitably.

§§ The birch sapflow season actually persisted for 30 days through May 5th, but a more conservative end-date was used out of an abundance of caution.

††† This assessment is only valid if the calculations of production costs are complete; the calculations were aimed to be as comprehensive and exhaustive assessment of the potential costs incurred when producing birch syrup in maple operations with the given characteristics as possible.

‡‡‡ Though these costs might seem high relative to those of maple production, the calculations performed in this analysis are intended to be as comprehensive as possible, and there are very few (if any) of such estimates for production costs in maple operations – particularly those that account for producer labor.



Photo: Mark Isselhardt

Notes

Other assumptions, considerations, and values used in the spreadsheet calculations

The spreadsheet used to conduct the financial analyses in the report estimates the average annual net revenue (or loss) and production costs per unit when birch syrup production is added to an existing maple operation. The output depends on input values for properties of the available birch resource (# of taps) and the maple operation (evaporator and RO specs, etc.), and several strategies for establishing the possible value of the birch syrup crop. A version of the spreadsheet will be available for producers to download and use to assess the potential outcomes of adding birch syrup production to their operations. Full details of the spreadsheet's calculations, assumptions, and how calculations were derived, will be included in a technical bulletin that will accompany the spreadsheet tool.

Most important to bear in mind is that the spreadsheet is an assessment of a birch syrup operation added to an already existing maple operation. This means that the **only** expenses considered are those **in addition to** those incurred for the already existing maple operation. Thus, there are numerous expenses assumed to be already accounted for in the maple operation, and to use the tool effectively, the income and expenses of the maple operation **must** be known.

The calculations in the spreadsheet are based on values from numerous sources, including known values (such as the retail prices for fuel and electricity), values determined in UVM-PMRC research (such as the length of time spent annually on tubing system maintenance), and estimates provided by producers and maple industry sources (such as the average cost of a tubing installation).

The spreadsheet is intended to be a planning tool for maple producers who are considering adding birch production to their operations. It is *not* a business plan or standalone financial planning tool, and is not intended to be a substitute for professional financial advice.

In addition to the assumptions and information already noted in the report, the following are additional assumptions and values used in the spreadsheet, and some important factors to consider when interpreting the analyses or using the spreadsheet:

- The sap yield data used in the spreadsheet are the average yields from our 2-year study; actual sap yields could be higher or lower annually, or due to the properties of a particular operation (location, tree size, etc.). Calculations assume each tree produces 16.7 gallons of sap per tap annually, with a sugar content of 0.74 °Brix.
- The calculations assume the same sap yield from all sizes of trees. The data used are based on sap yields from trees predominantly 10-14 inches dbh (mean 11.7" (±0.3)). Although we did not find significant differences in the sap yields between different size classes in our study, smaller trees are likely to yield less sap than larger trees, and this will be particularly important to take into account if your birch resource is comprised predominantly of smaller trees.
- The spreadsheet does not account for the minimum volumes required for each step of the production process, such as the daily volume of sap required to run the RO or flood the evaporator. This will be a critical step for any producer planning a birch operation. For example, if sufficient concentrate is not available to fill the evaporator, the concentrate must then be stored until the next sap run and will result in significant deterioration of both sap and subsequent syrup quality. This issue requires particular attention for birch sap, which because of its low sugar content yields relatively small volumes of concentrate from large volumes of sap, e.g. ~60 gallons of 11.8% concentrate from 1000 gallons of raw sap.
- The spreadsheet calculations do not account for additional equipment purchased solely for birch syrup operations, or changes a producer might make to an operation to accommodate birch production, such as purchasing a different RO or evaporator sized to accommodate both types of sap.
- The calculations assume that the RO unit is able to achieve close to 4X concentration, and has a power consumption of 10.35 kW·h. Based on data collected at UVM-PMRC, the calculations assume the RO will be run for wash cycles for a length of time equaling 43% of the total run time for concentrating sap. Start of Season and End of Season wash cycles are not included, as they are assumed to be accounted for in the maple operation.
- The additional use of equipment for birch syrup production, such as using the RO to concentrate birch sap, will inevitably result in more wear and tear, and thus faster and more extensive depreciation of equipment. The spreadsheet calculations do not include estimates of this additional depreciation. The biggest item impacted by this will be the RO unit and membranes, which will need to be used for many additional hours for concentrating birch sap.

Notes (continued)

Other assumptions, considerations, and values used in the spreadsheet calculations

- A single line-item for overhead is used to capture additional expenses incurred making or selling birch syrup that are not explicitly accounted for elsewhere, and that are *in addition to* overhead expenses for the maple operation. These expenses include:
 - Retail costs (storefront), including shelfspace, rent, real estate taxes, electricity, and other charges for retail space
 - Website costs (domain charges, website maintenance, design, etc.)
 - Packaging and shipping (labor and materials)
 - Transportation, including delivery of syrup to customers (fuel costs and time)
 - Storage costs (space and any additional containers used for this purpose)
 - Credit card charges, phonecalls, mailers, and time for management and planning
 - Utility use, e.g. electricity for lights in the sugarhouse during birch production

The spreadsheet estimates the value of this expense as \$1 per tap. Actual expenses for overhead could be higher or lower than this estimate.

- Generally, suggested marketing expenses are 5-10% of gross sales, or 3% for a well-established business.⁷ The spreadsheet estimates this value as 3% of the estimated revenue from sales of the entire crop as quarts at cost-based wholesale prices.
- A single line-item expense is used to account for consumable supplies used for birch production, including filtering supplies, cleaning supplies and chemicals, tubing system maintenance supplies, chainsaw fuel and supplies, and specialty labels and printing. The spreadsheet estimates the value of this expense as \$1 per tap; however actual expenses will vary depending on operation properties.
- Insurance costs are estimated to be approximately \$200 annually to provide both general and business liability for the birch crop as an addition to existing coverage for the maple operation. (Note that all equipment is already covered under the policy for the maple operation.)
- It is assumed that new (separate) lateral and mainline tubing is installed for birch taps, and that it is plumbed into the existing releaser, vacuum, and sap collection/storage systems. It is also assumed that the birch trees tapped are within reasonable proximity to the existing sugarbush and to each other. Trees sparsely distributed throughout the property or distant from the sugarhouse will require much higher costs (up to \$50/tap) for tubing installation than the costs assumed by the worksheet.
- The calculations are based on the assumption that the entire birch syrup crop is sold.
- 2013 prices are used for all calculations (containers, fuel, electricity prices, etc.).
- The length of the birch production season is estimated at 25 days.
- The cost of installing a new tubing system is estimated at \$13 per tap, and is based on estimates provided by maple tubing installers for a standard single-line system. An additional \$1 per tap is added in the calculations to account for the costs associated with the removal and disposal/recycling of the system components when replaced.
- The length of time required for canning is based on estimates provided by producers, and is set at 60 pieces per hour for small containers (e.g. 40-mL nips).
- The length of time required for tapping is estimated at 40 taps per hour, based on UVM-PMRC data.
- The cost of new droplines (\$1.44) includes labor and materials for both construction and installation, and is based on a labor rate of \$10/hr using Leader clear check valve spouts (\$0.40/each), using data collected at UVM-PMRC.
- The following quantities of time are allotted for activities directly related to birch activities. These are *in addition to* the same activities performed and accounted for in the maple operation:
 - RO maintenance = 5 hours
 - Cleanup and setup = 20 hours
 - Tubing system maintenance (repairs, fixing leaks, etc.) and chainsaw work, both during and off-season = 0.13 hours per tap (calculated from UVM-PMRC data)
- Sugarhouse labor is calculated as the number of hours of setup and cleanup (for the birch operation only) plus the total number of hours concentrating, boiling, and filtering.
- Electricity usage is calculated for the RO and vacuum pump by multiplying power consumption times the total number of hours used and the 2013 average commercial price for electricity in Vermont (\$0.1434/kWh). The cost of electricity for general items, such as lights in the sugarhouse, is assumed to be accounted for in the maple operation.

This is not an exhaustive list of potential expenses incurred in a birch syrup operation. Some additional expenses and important factors to consider can be found in the North American Maple Producers Manual (Chapter 11),⁷ and in business planning worksheets authored by Glenn Rogers (University of Vermont Extension), Les Ober (Ohio State University Extension), and Cornell Cooperative Extension.⁵⁻⁹ Producers are strongly encouraged to consult these resources during their planning activities.

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