# Maple Syrup Digest

Vol. 60, No. 1 March 2021

## Tapping Depth
## The Maple Economy
## Build Your Own Small RO

*The Newsletter of the North American Maple Syrup Council*

# *MAPLE SYRUP DIGEST*

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# Greetings from your President

As I write this, Michigan – along with most of the country - is in the deep freeze. I love winter, however this sub-zero weather is not the least bit enjoyable. We have a heat wave going here with 8 degrees at 9:30 am. Hopefully everyone is keeping warm out in the sugarbush while you finish getting ready for syrup season.

This past year has been a struggle for most. The cancellations of maple weekends and not having people visit us in the woods resulted in fewer sales on-site. Even with that, the demand for syrup has increased this past year. More people have discovered what we have known for years – that maple is the best sweetener available. Producers had to devise new marketing techniques to get our syrup to the public.

Personally, I missed not traveling to Wisconsin for the NAMSC/IMSI meetings this past fall. There is so much to gain through the in-person meetings that is just not there during the virtual meetings. I am looking forward to seeing what New York has in store for us in Niagara Falls this October. They are busy moving forward with their plans to host us this October. Watch for the information to come out.

The winter meetings that were held either via Zoom or webinars offered some great educational sessions. The advantage of these meetings is you could sit in sessions in another state or province and not have to travel. The icing on the cake was many were recorded so you watch at your convenience. At our Michigan meeting we had people from 13 states, one province, and one person from Sweden in our sessions.

We have selected Bill Corwin as the consultant to help us through our strategic plan updating process. Our first meetings have happened and Bill is emailing delegates and others for interviews. If you are contacted by Bill, please take the time to respond to him. The more information he is able to get, the better the outcome will be.

All of us need to continue to educate the public on the benefits of maple. Whether you produce syrup only or have expanded to value-added products, we need to be diligent in checking the quality of our products as we all want only the best of maple on the shelves.

I hope everyone has a great season and Mother Nature cooperates with us.

Take care, everyone.

*Debbi Thomas*
*NAMSC President*

# In this issue...



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## Seeking Photos

We're alwats looking for good maple photos for the *Digest*. Send to mapledigest@gmail.com.

**Cover photo:** Greg and Meralynne Gammon of Argyle, Guysborough County, Nova Scotia built this sugarhouse with lumber they harvested and milled from their own woodlot. They boil from about 165 taps and are members of the Nova Scotia Maple Producers Association.

# Effects of Tapping Depth on Sap Volume, Sap Sugar Content, and Syrup Yield Under High Vacuum

*Timothy D. Perkins, Abby K. van den Berg, and Wade T. Bosley, University of Vermont Proctor Maple Research Center*

Tapping depth strongly influences both sap yield and wounding. Numerous studies have focused on the amount of sap produced with different depths, the most extensive work conducted by Morrow (1963), who found a tendency for increasing sap yields with increasing taphole depth. However, this work was conducted on gravity with 7/16" tapholes, so is less informative to most producers using 5/16" spouts and vacuum.

More recently, researchers at the UVM Proctor Maple Research Center (Wilmot et al. 2007, Wilmot 2014) examined tapping depth (including bark) under vacuum (20-24"Hg) and found increasing sap yields with deeper taphole depth up to 2 ½", and suboptimal sap yields at depths of 1 ¼" or less. Taphole depths deeper than 2 ½" were not considered because of the negative consequences on sustainability.

With respect to wounding, research has demonstrated that the volume of stained wood generated by the tree in response to tapping is proportional to the size of the wound, and thus deeper tapholes result in larger volumes of wood that is nonconductive to sap (Renaud 1998, Wilmot et al. 2007, Perkins and van den Berg, unpublished data). Large accumulations of nonconductive wood are not only potentially detrimental to tree health, but also to sap yields, as tapholes drilled into stained wood produce significantly less sap (Perkins et al. 2016, Isselhardt, unpublished data).

Shallower tapholes can result in more sustainable yields and tree health over the long-term, because the reduced volume of wound created results in more conductive wood being available for tapping in general, and for growth to more rapidly bury the wound and allow shallow tapping over the same spot. Guidelines outlined in the 2006 edition of the North American Maple Syrup Producers Manual recommend tapholes extend no more than 2" into the wood (excluding bark) and be as shallow as practicable to reduce the probability of tapping into nonconductive wood and reduce its accumulation. However, because tapping depth affects yields in the current year, it is important to have quantitative information on the impact of tapping depth on sap yields so that producers can make choices to optimize all of the affected parameters – current year yields, the accumulation of nonconductive wood, and ultimately yields over the long-term.

Because vacuum enables substantial lateral and vertical movement of sap toward the taphole, the changes in technology and equipment that have occurred since the most recent research on taphole depth, including higher levels of vacuum and tightness of spout material and fittings, are likely to impact the effect of taphole depth on yields. In this study we reevaluated tapping depth to examine whether there is a point of diminishing returns in terms of syrup yield and wounding.

## Methods

All research was conducted at the UVM Proctor Center in Underhill, Vermont, during the 2018, 2019 and 2020 sap flow seasons (February-April). A total of 1,280+ trees in a single stand (approximately 60% sugar maple and 40% red maple ranging from 9″ to 44″ in diameter) were arranged across 16 mainlines. Mainlines averaged 81 trees (range 44-113) with roughly equal average diameters and were connected to an individual small hybrid releaser equipped with a counter to determine the volume of sap collected for each. Releasers were calibrated near the end of each season to determine the volume of sap released with each dump. Vacuum to all mainlines was supplied by a common Busch pump pulling 24-26″ Hg. Each mainline was assigned one of four tapping depth treatments, yielding four replicates for each treatment each year. For the 2018 season, tapping depths were 1″, 1 ½″, 2″, and 2 ½″. In 2019, depths were 1 ½″, 1 ¾″, 2″ and 2 ¼″. In 2020, tapping depths tested were 1 ½″, 2″, and 2 ½″.

Trees were typically tapped in mid late January each year by a single individual, and depth for each treatment was set using a piece of tubing as a bit stop. Clear polycarbonate 5/16″ Leader Check-valve spouts were used for all treatments. The total number of releaser dumps for each mainline was multiplied by dump volume to determine total sap volume and sap yield (gal/tap) for each mainline, and the average for each tapping depth treatment. Sap sugar content of each mainline was measured periodically with a handheld Misco refractometer, and sap sugar content calculated on a volume weighted basis. Syrup yield (gal syrup/tap) was calculated for each mainline from sap volume and sugar content using the Revised Jones Rule (Perkins and Isselhardt 2013), then averaged for each depth treatment. For each season, 1 ½″ was used as a control and set to be 100% to allow a comparison across years.

## Results

Average sap yield (gal sap/tap), sugar content (° Brix), and syrup yield (gal syrup/tap) with 1 ½″ deep tapholes as 100% are shown in Figure 1A, 1B, and 1C respectively. The trendline of sap yield (Figure 1A) with increasing depth shows a strongly curvilinear response, with 1″ tapholes producing slightly under 60% of the amount of sap as 1 ½″ tapholes, leveling out between 1 ¾″ and 2″ depth. Sap sugar content (Figure 1B) is slightly higher in 1″ tapholes than in deeper tapholes, but rapidly levels out at 1 ½″ and deeper. Taken together, sap volume and sugar content produce syrup (Figure 1C). The trendline of syrup yield with 1 ½″ tapholes set as 100% shows the dominant influence of sap yield on syrup production. Syrup yield from 1″ deep tapholes is 62% of a 1 ½″ taphole, with increasing syrup production as tapholes are drilled deeper until

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plateauing at 1 ¾″ and above. R2 values for a 2-order polynomial were significant for all three parameters (sap volume, sap sugar content, syrup yield), indicating the robustness of the model fit.

### Discussion

Although hydraulic conductivity of individual vessel elements and sap sugar content most likely decreases with increasing ring age, the ability of strong vacuum to move sap both vertically and laterally towards the taphole appears to moderate the influence of taphole depth on syrup yield once a sufficiently deep taphole is achieved that allows sap to move out of the taphole and vacuum to be transferred into the stem. Therefore, deep tapholes are not required to maximize syrup yield from maple stems. When using vacuum, a taphole of 1 ¾ - 2″ deep including bark produces a maximum syrup yield with a minimum loss in conductive wood and is therefore both the most economically advantageous and the most sustainable tapping practice. While shallow tapholes do result in far lower staining, the considerably lower syrup yield makes the practice less economically viable. Our recommendation therefore is that in most cases producers using vacuum sap collection use tapholes no deeper than 2″ for sap collection. For trees on the smaller side of the tapping range, or for individuals exhibiting slow growth, low vigor, or with a large amount of preexisting nonconductive

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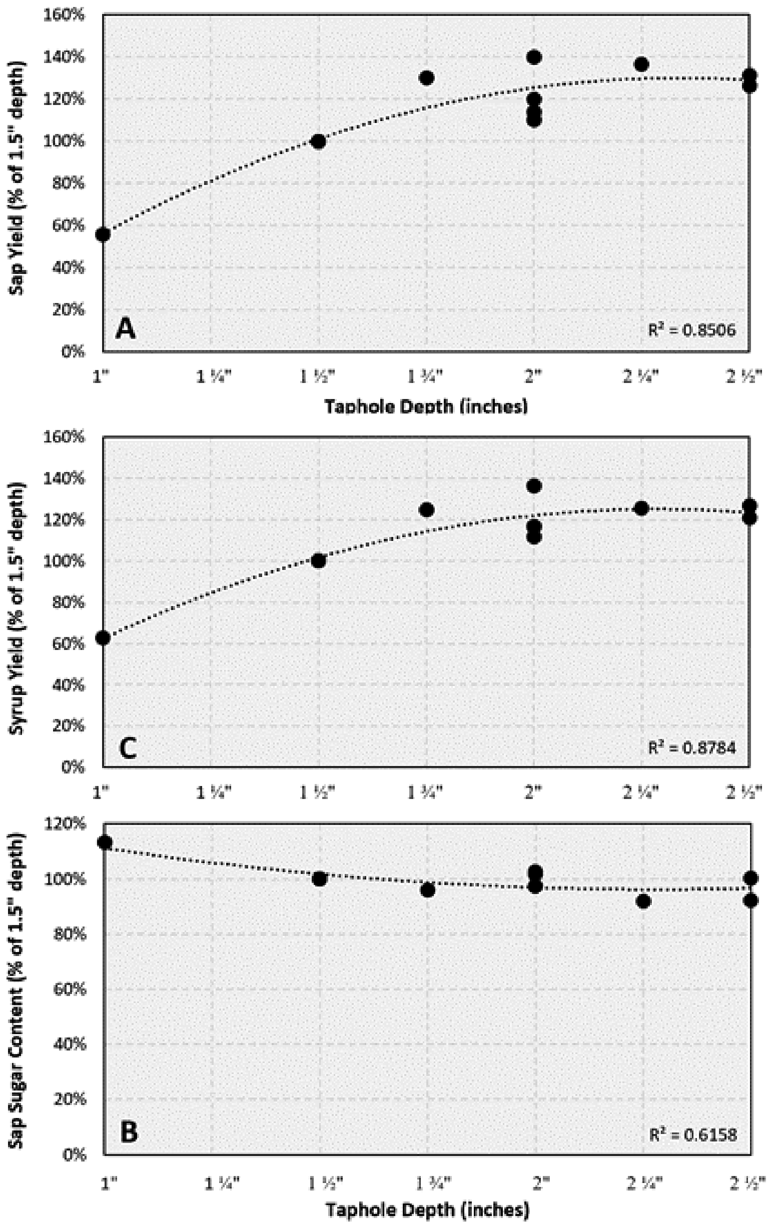


Figure 1. Sap yield (A), sap sugar content (B), and syrup yield (C) from tapholes drilled to depths from 1" to 2 ½" (including bark) in sugar maple stems expressed as a percentage of the tapholes at 1 ½" deep from 2018, 2019, and 2020. Number of independent samples (mainlines) for each depth is indicated in figure C. The R2 value for a fitted 2 order polynomial (dashed line) is shown indicating the proportion of variance explained by the model curve.

***Tapping : continued from page 11***

wood, shallower tapholes (1 ½" or less) may be more appropriate and result in higher yields over the long-term (due to reductions in the frequency nonconductive wood is tapped into), despite the lower syrup yields in the near-term. In these cases, implementing thinning and other management practices to encourage more vigorous tree growth can also help more rapidly bring about conditions where deeper tapping depths, and higher current-year yields, are possible.

### Acknowledgements

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# What Causes Buddy Syrup and What Can Be Done to Prevent it?

*J. David Miller PhD FAIHA, Distinguished Research Professor, Department of Chemistry, Carleton University*

Ontario has more than 3,000 farms where maple syrup production is more than 50% of cash receipts. The Ontario Maple Syrup Producers' Association (OMSPA) has invested in basic research in a number areas including the diversity of molds that are found in maple syrup and the factors that increase risk for post-consumer mold damage (Int J Food Microbiol 207:66). The next big problem we began to tackle was to see if a way could be found to detect the changes in maple sap that leads to "buddy syrup" before the sap was even boiled.

Buddy off-flavour is an annual, natural occurrence that has been well recognized since the dawn of commercial maple production in the late 19th century. The sap is collected and processed, consuming fuel and other resources, but is ultimately not suitable for sale due to an off flavor. For individual producers, as much as 10% of annual income can be lost in some years as a result of some stopping too early in order to avoid producing buddy syrup, and others producing unsalable syrup. Currently, producers rely on guesswork to try to determine when to stop collecting and processing sap. Common responses of producers of strategies to avoid buddy syrup range from noting the height of wild leeks in the bush, the sounds of the spring peepers, or when the maple buds have started to swell and show some green. As seasonal winter-into-spring weather patterns are changing, dealing with this problem is expected to become more challenging in the future.

Sixty years ago, USDA researchers suggested the mobilization of amino acids into sap before budding was the reason for the appearance of buddy syrup. To that end, an early USDA research used paper chromatography of maple syrup stained with ninhydrin reagent, which reacts with amino acids. This never made it into practice as testing for buddy flavours after processing does not offer an economic benefit to producers who are capable of identifying the off-flavour by palate alone.

As we began our investigation there were two basic ideas for the sudden appearance of buddy syrup. The first was that heating sap containing elevated levels of particular amino acids produced compounds (pyrazines) that contributed to buddy off flavour. A more recent idea has been that yeasts in the sap convert sulfur-containing amino acids into compounds that explain the off flavours.

The project was undertaken in two phases. First, OMSPA arranged for two maple producers in the 2018 season to collect samples of sap over a period up to the point that buddy syrup was de-

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**_Buddy: continued from page 13_**

tected. Antimicrobials were added to the samples which were stored cold. The samples were analyzed with a sophisticated liquid chromatography-mass spectrometer (Thermo Q-Exactive Orbitrap mass spectrometer coupled to an Agilent 1290 HPLC system). This was used to look for potential chemical markers in the sap that coincided with the development of buddy flavour in the syrup. The focus was on changes in the concentrations of 18 amino acids and a suite of sugars over the course of the growing season. This initial work suggested that a number of nitrogen rich amino acids and some sulfur containing amino acids showed marked increases in concentration up to the budding stage.

The second phase involved a systematic study from more stands across the 11 OMPSA districts. We knew that fundamental characteristics of the syrup vary considerably between stands in Ontario. These include the yeast mycoflora, ions and pH, all of which vary considerably according to soil chemistry and site history.

The chemical composition of maple syrup and, to a lesser extent, maple sap has been investigated for decades. In previous studies of sugar maple sap, known chemicals were targeted for analysis. The decrease of sucrose content in maple sap in late season sap has previously been observed. The causative agent of this decrease at the end of the maple production season appears to be the result of microbial activity. In 1947, Holgate reported that the sugar content diminished in the late season, conversely, when the sap was collected aseptically, the total sugar percent remained above 2% at the end of the season. Holgate found that the nitrogen content of sap increased towards the end of the season regardless of sterility.

We found that sucrose was present in much higher concentrations at the beginning of the sap run and in much lower concentrations in late spring. In addition to sucrose, and the monosaccharides fructose and glucose, two major tri-saccharides were also detected (see figure). A number of more complex sugars formed the remaining part of the picture.

In contrast, amino acids, particularly asparagine and methionine increased in late season sap. Some researchers have proposed that the small sulphur-containing compounds (similar to a skunk's spray) may be responsible for the late season, 'buddy' off-flavor. We detected a sulfur-containing amino acid in late season sap called Methionine. If the sap was heated to high temperatures, the methionine can decompose into a chemical some of which can be converted to dimethyl disulfide, which

*Buddy:*

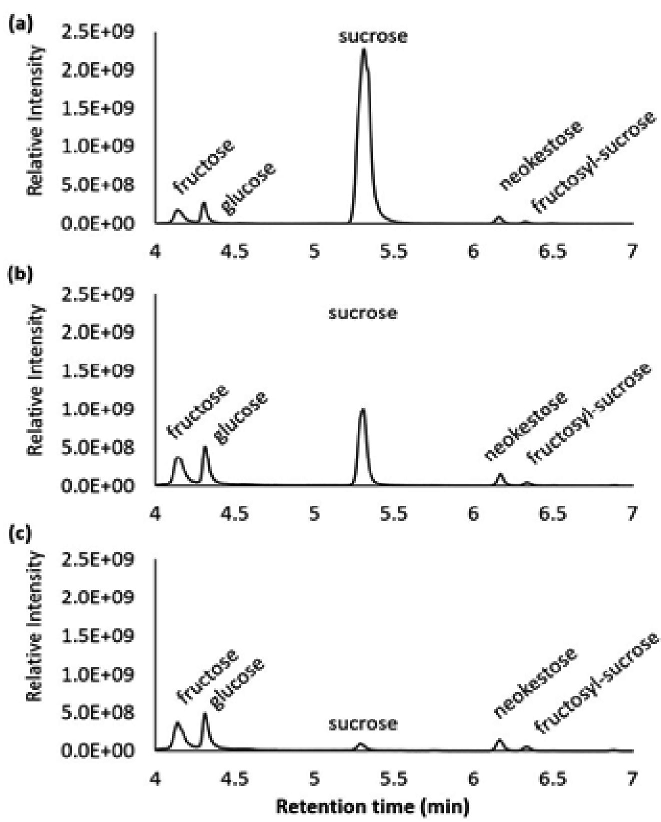


Figure 1: (a) In early season sap, sucrose was the major saccharide detected, decreased in mid season (b), and was present at low concentrations at the end of the season (c) [PLoS One

***Buddy: continued from page 15***

is volatile at room temperatures, and smells bad.

The classes of compounds which most likely contribute to the unfavorable aftertaste in maple syrup made from late season are alkyl pyrazines and sulfides. Pyrazines such as those reported in late season or buddy sap have an aftertaste characterized as 'malty' and 'astringent.' Related compounds are found in raw potatoes that have been stored for a long time. Compounds such as some of the proposed sulfur containing compounds are described as 'peppery' and 'brassica' flavours (similar to Brussels sprouts). Similar to work from Vermont researchers, this basic research supports pyrazine alkaloids as the chemistry of the off flavour. Regardless, as noted methionine and asparagine tended towards greater concentrations later in the season compared to early season values. Asparagine has been shown to be most efficiently converted to pyrazines compared to the other amino acids detected in sap. In contrast, in foods, methionine is typically most important in producing the sulfides. These two amino acids represent strong candidates for the development of poor after taste and thus targets for sap based in situ tests.

Consistent with many previous studies, the nitrogen content was higher quantities in the late season samples. The amino acids asparagine and methionine, both known precursors of off-flavours in food increased considerably in late versus early season sap. One or both of these compounds might be useful markers for sap that will not be salable.

At present we are investigating whether aptamer-based methods for the detection of these two amino acids in sap. Aptamers are like synthetic antibodies that can be used to produce tests like pregnancy test kits. However, they are much less expensive. These can be made into tests on strips of paper like a litmus test for pH. These potentially would be useful to maple producers in the field to monitor the transition to late season sap.

*This work was funded by Mitacs Ontario, the Ontario Maple Syrup Producers' Association, Fanshawe College with support from Agriculture AgriFood Canada. In addition, the project was enabled by the hard work of Ontario Maple Syrup Producers Association members who undertook the careful sample collection We thank Bob Gray who coordinated the collection and shipping of samples across the province of Ontario.*

The full study can be accessed on line:

Garcia EJ, McDowell T, Ketola C, Jennings M, Miller JD, Renaud JB (2020) Metabolomics reveals chemical changes in Acer saccharum sap over a maple syrup production season. PLoS One 15(8):e0235787

https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0235787

## International Maple Meetings
## October 17-20,2021
## Niagara Falls, NY

The New York State Maple Producers' Association is proud to host the annual meetings of the North American Syrup Council (NAMSC) and the International Maple Syrup Institute (IMSI) this year in city of Niagara Falls, NY., October 17-21.

This is a challenging year to be planning a live event, given the current uncertainly regarding travel and large gatherings. Our committee is working hard to plan a great experience for everyone, but no plans are firmly fixed yet other than the dates and the venue

Therefore we ask you to be patient. Registration will not be available until we are reasonably certain plans will not change. Check our website for updates:

https://nysmaple.com/2021-international-maple-conference/

We are working with the Niagara Falls Culinary Institute and NY food producers who are part of TASTE NY to plan some delicious eating, and the convention center will have room for a large trade show.

# The Northeast Maple Economy: Crop Distribution and Outlook

*Mark Cannella, Extension Associate Professor; Mark Isselhardt, Extension Maple Specialist; Dr. Abby van den Berg, Research Associate Professor; Dr. Anthony D'Amato, Professor; Christopher Lindgren, Forest Business Coordinator, University of Vermont*

The dramatic growth in the production of pure maple syrup from 2006 to 2016 saw total syrup production increasing from 1.67 million gallons in 2006 to 4.18 million gallons in 2016 or a roughly 249% increase over 11 years. The growth in production continued, albeit at lower rates, into 2020 (NASS 2020). The record maple syrup market prices near or over $3.00 (US dollars) per pound from 2009-2013 that fueled significant industry growth have declined to largely due to a change in the exchange rate between Canada and the U.S. and is now close to $2.00 US per pound, prompting a number of questions about the economic position of maple enterprises now and into the near future. Although the technology to produce pure maple syrup has evolved dramatically in the last 50 years and equipment costs are significant, a large number of producers who are not exclusively driven by for-profit objectives continue to operate.

As dramatic as the growth in US maple production may be, the growth in certified organic maple production has been even greater. Between 2008, when the United States Department of Agriculture's National Agricultural Statistics Service (NASS) began keeping records on organic maple production, and the most recent 2019 data, total US organic syrup production increased

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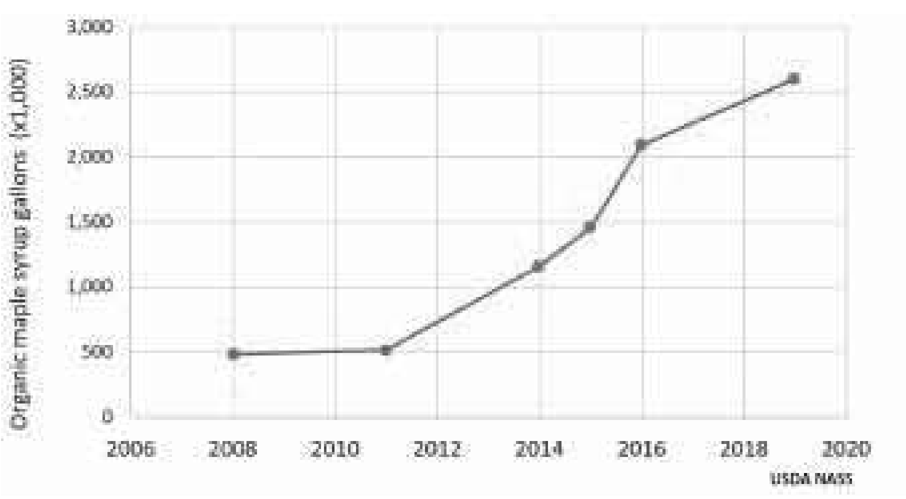


Figure 1: US organic maple syrup production 2008-2019

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from approximately 500,000 gallons to just over 2.6 million gallons (Figure 1). Consumer demand and a premium paid for organic bulk syrup are thought to be two of the leading drivers for the increase in production. Industry experts believe this demand will continue (Carbonetti et al 2020).

A survey of northeastern maple syrup producers was undertaken to explore factors of business scale, economic viability, organic production and the outlook for the maple crop in the coming years.

## Methods

To explore economic and forestry factors affecting the growing maple industry the University of Vermont conducted a regional survey of northeastern maple producers using a convenience sample procedure. The UVM Institutional Review Board reviewed the survey instrument and it was approved as an exempt social science survey. The survey was adapted into an online format using Survey Monkey™. Respondents for the convenience sample were recruited by sharing an advanced notice 7-10 days prior to survey distribution followed by the online full survey distribution. Advance notice and the active survey link were distributed via newsletters and network email lists by the following: a) Vermont Maple Sugar Makers Association, b) New Hampshire Maple Producers Association, c) New York State Maple Producers Association, and maple research specialists at University of Vermont, Cornell University and University of Maine. Survey responses were collected online from September 1, 2019 to October 30, 2019. The aggregate total of active maple producers on this list was approximately 2,500 maple producers after removing non-producing association members. Completed surveys were returned by 312 maple producers.


## Thank you to our Research Alliance Partners

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WI Maple Syrup Producers Association

**Contributors**

Haigh's Sugar House Farm, LLC
Camp Aquila
Ohio Maple Producers Association
New Hampshire Maple Producers Assoc.

## Producer Demographics

Maple producers in thirteen states responded to the survey. The majority of responses came from producers in Vermont (34%), New York (25%) and New Hampshire (11%). Additional responses were received from northeast region states of Connecticut, Maine, Massachusetts and Pennsylvania (14%). Thirteen percent of survey respondents declined to provide a location and 2% of respondents operated in states outside the northeast. Ninety-six percent of respondents identified as male, 2% identified as female and 1% identified as a male/female partnership completing the survey.

Respondents indicated the number and the age of the primary owner(s) of the business. Two-owner businesses (38%) and single-owner businesses (36%) were most common, while thirteen percent (13%) of respondents reported three active owners. The average age of primary owner 1, primary owner 2 and primary owner 3 is 55 years, 52 years and 44 years respectively. Respondents' highest level of education completed in ranked order is: Bachelor's Degree (28%), High School Diploma (22%), Associate Degree (21%), Master's Degree (16%), High School (8% ), Doctorate (3% ) and Other (3%).

| | 2018 | 2019 |
|---|---|---|
| Taps | 1,174,289 | 1,244,315 |
| Acres | 29,221 | 30,164 |
| | | |
| Syrup Gallons Produced | 408,274 | 448,019 |
| Syrup Pounds Produced | 4,547,356 | 4,990,036 |
| | | |
| Syrup Gallons Per Tap | 0.35 | 0.36 |
| Syrup Pounds Per Tap | 3.9 | 4.0 |

Table 1: Maple production factors (data from survey, n=299 respondents)

## Production Levels

Responding producers provided tap counts and syrup production for the 2018 and 2019 crop years. The survey also investigated prevailing sugarbush management practices, technology utilization and business management practices. The total tap counts, acres in production and crop size are shown in Table 1. Crop production reported in this survey for both 2018 and 2019 represents approximately 10% of the total US domestic crop reported by USDA National Agricultural Statistics Service (NASS 2019) Looking more specifically at northeast regional production in 2019, crop production in Vermont, New York, New Hampshire, Maine, Massachusetts, Connecticut, Pennsylvania and non-disclosed locations in this survey was a combined total of 434,903

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*Economy: continued from page 21*

gallons compared to USDA NASS crop reports of 3,585,000 for the same states. This survey represents approximately 12% of the 2019 northeastern state crop reported to NASS.

Syrup yield was calculated using producer reported syrup production divided by producer reported taps (gallons of syrup per tap). The average yield for 2018 was 0.35 gallons per tap and the average yield for 2019 was 0.36 gallons per tap. These values compare favorably to the overall US syrup yield per tap reported in USDA NASS crop reports in 2018 (0.244 gallons) and 2019 (0.301 gallons).

## Contribution of Crop Based on Operation Size

Further analysis of maple syrup production was conducted to explore the distribution of production (tap count per business) and contribution to the overall syrup crop produced by survey respondents. Table 2 and Table 3 below provide an overview of the percentage of respondents falling into several tap size classes based on the number of active maple taps in 2019.

| | 2019 |
|---|---|
| **1 – 4,999 taps** | 82.2% |
| **5,000 – 9,999 taps** | 10.4% |
| **10,000 – 19,999 taps** | 2.6% |
| **20,000 taps or more** | 4.9% |
| *Total respondents* | *100%* |

Table 2: Operation size (tap count) of survey respondents in four classes for 2019

When looking at the 2019 crop for the two sizes classes in Figure 3 one observes that more than three-quarters of the crop is produced by a small group of producers with 5,000 taps or more. In 2019, 81% of all syrup reported in this survey was produced by only 18% of respondents, the 53 producers in the "5,000 taps or more" size class. The remaining 19% of the 2019 crop was produced by the producers in the "1-4,999 taps" size class, making up 82% of the total count of respondents. Analysis of the same size classes for the 2018 crop produced a very similar crop distribution within 1-2%.

## Prevalence of Organic Production Based on Tap Count

In addition to overall crop distribution the survey collected additional information that measured the amount of certified organic syrup produced in

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| | | | Number of Taps | | |
|---|---|---|---|---|---|
| **Organic Status** | **n** | **Percent of 2019 Crop** | **Average Tap Count** | **Min** | **Max** |
| **Yes** | 35 | 61% | 17,834 | 200 | 105,122 |
| **No** | 247 | 37% | 1,931 | 10 | 24,000 |
| **Transitional** | 12 | 2% | 2,273 | 78 | 9,500 |

Table 3: Certified organic crop distribution and scale of business

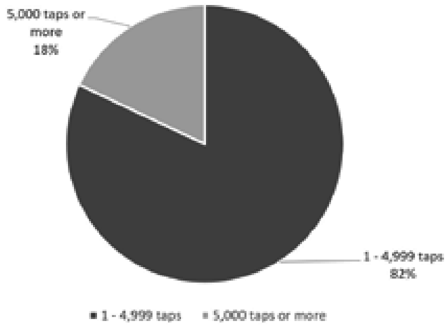

Figure 2: Distribution of operation size for all survey respondents (n= 299 survey respondents)

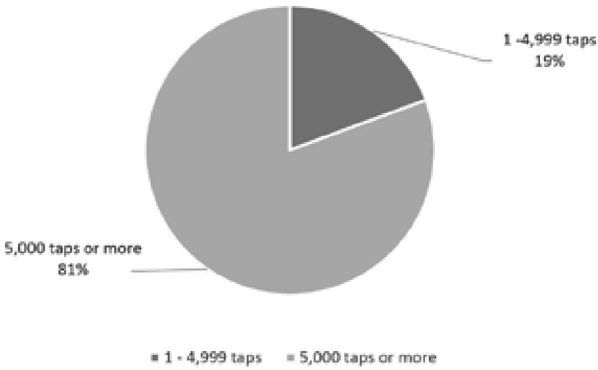

Figure 3: Distribution of reported 2019 syrup crop for survey respondents across two size classes (n=299 survey respondents)

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2018 and 2019. In 2019, 61% of the crop was certified organic with the remaining 39% either not certified or under a transitional period. This compares with the USDA NASS data that indicates 61% of the 2019 US crop was organic, up from 17% in 2011. Table 4 below demonstrates that the average tap number for organic producers is larger than the average tap numbers for producers that are not currently certified.

### Expansion Plans

Survey respondents indicated if they planned to change the scale of their maple enterprise in the next three years. We observe an equal number of respondent businesses likely to expand their scale (49%) as those likely to stay at the same scale (49%). Two percent (2%) of responding businesses plan to downsize their scale over the next three years. Given the stark contrast in scale of maple enterprises contributing to the total annual crop, a further investigation of tap number, yield or organic status could identify potential trends in production changes in the next three years. Table 4 provides this information.

| | n | Average Taps | Minimum Taps | Maximum Taps | Average Yield | % Certified Organic |
|---|---|---|---|---|---|---|
| Plan to expand in next 3 years | 139 | 5,288 | 10 | 105,122 | 0.30 | 16% |
| Plan to Stay the Same | 137 | 3,057 | 19 | 100,000 | 0.27 | 11% |
| Downsize | 7 | 1,251 | 200 | 3,500 | 0.41 | 0% |

Table 4: Characteristics of businesses based on planned changes to scale

The presence of only slight differences between the "plan to expand" group and the "plan to stay the same" group in addition to large ranges in taps size suggest there is not a functional difference in these two groups. Enterprises planning to expand are more similar to those planning to stay the same size according to the variables of tap number, average yield and organic status.

### Conclusions

As the US domestic maple syrup crop continues to grow the influence of different scales and types of business can shape local communities and national trends. Survey results presented here demonstrate the dramatic difference in the scale of maple enterprises as represented by tap count and the resulting working forest acres these businesses utilize. Survey respondent business scale ranged from 10 taps to more than 105,000 taps. Our survey findings verify that the majority of maple syrup producers in the Northeastern region operate at scales under 5,000 taps. Meanwhile, a small number of producers operate at 5,000 taps or more and this smaller group is responsible for over 80% of the maple syrup production in this survey group.

Approximately 60% of the maple crop in this survey is certified organic, produced mainly by a small group of larger enterprises. The market demand for organic syrup remains strong and has been driven to a large degree by changing consumer preferences, especially in areas beyond where maple syrup is produced. If these preferences continue as expected it is likely more producers will transition to certified production (Carbonetti et al. 2020).

These distinctions are expected to have influence in marketing trends, policy and industry organizations. As maple marketing grows to keep pace with production the presence of promotional messages the use business scale as a proxy for product quality is observed. Despite scale, however, there are existing maple quality standards that ensure uniformity and consistency of high quality syrup to consumers regardless of the production scale. The growing number of businesses seeking to differentiate their product, however, are likely to continue to adapt messaging that promotes process based attributes or other features that may appeal to consumers.

Though the barriers to entering the industry are relatively low for those who are motivated by noneconomic factors, the substantial syrup crop contribution by a small number of producers may have implications to ongoing industry organizations, policy advocacy and policy compliance. Future deci-

*Economy: continued on page 26*

***Economy: continued from page 26***

sions have the potential to impact size classes differently and there is potential for disproportionate representation of the number of businesses impacted compared to the actual crop impact in the marketplace and forested acres impacted.

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Maple Sugaring History

# The Introduction and Adoption of the First Evaporators

*Matthew M. Thomas*

For much of the modern history of the maple syrup industry evaporators have been the standard sap boiling apparatus. Prior to the introduction of the evaporator, sap boiling occurred in flat pans resting on brick and mortar or stone and earth arches. Flat pans and arches began to appear as early as the 1820s and as a more efficient boiling method, gradually replaced kettles suspended over open fires. By the 1850s flat pans were in widespread use and as reported in the Country Gentleman magazine by 1860, "the sheet iron pan is almost universally used." Beginning in the late 1850s and early 1860s significant improvements in sap boiling technology arrived with the introduction of the evaporator.

What was meant by the term evaporator at the time that this term was introduced? Flat pans were sometimes referred to as evaporators, since after all they did serve the purpose of evaporating water from maple sap. However, these new evaporators introduced a number of advancements on the simple flat pan. "Evaporators" in the more formal sense was and is a term used to refer to a more sophisticated kind of flat pan in which featured a series of baffles or partitions that facilitated the continuous flow of boiling maple sap slowly through a maze-like path of channels gradually condensing from raw sap to finished or nearly finished syrup.

*History: continued on page 28*

## MAPLE RESEARCH.ORG

NORTH AMERICAN MAPLE SYRUP COUNCIL

NAMSC has launched mapleresearch.org, a new online resource for the maple industry. The site is a curated collection of research papers, articles, videos, and tools, representing the most current and scientifically accurate information for maple production, to help all producers make the best products possible using the most current and most sustainable practices.

From *Maple Syrup Digest* articles, to producers' manuals, to how-to videos, the site includes a collection of the best resources available online about all aspects of maple syrup production, at no cost. The site is searchable, and resources can be downloaded and printed.

The site was built in collaboration with the University of Vermont's Proctor Maple Research Center, and funding was provided by the U.S. Department of Agriculture's (USDA) Agricultural Marketing Service.

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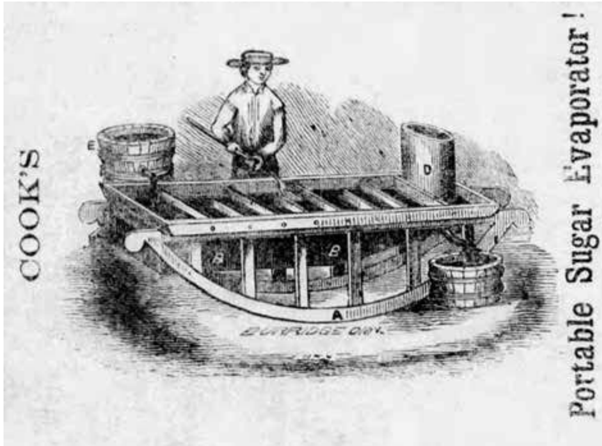
Other early features of evaporators that differed from flat pans were the introduction of flues or corrugations on the bottom of the pan to increase the surface area exposed to heat of the fire and gasses in the firebox underneath. Additional improvements unique to early evaporators were the division of the pans into multiple smaller independent pans linked by siphons and the introduction of sap level regulators or float valves. Like many of their predecessor flat pans, early evaporators were set upon on brick and mortar arches to support the weight, level the pans, and provide a tight firebox and smoke flue for a well-controlled fire underneath and behind the pans.

The earliest evaporators used by the maple industry were designed for making sugar from the sweet sap of sweet sorghum, also known as Chinese sugar cane. The first patented evaporator (US patent 20,631) came in 1858 from Daniel McFarlane Cook of Mansfield, Ohio and was essentially a flat pan with the addition of continuous flow baffles. Cook initially designed the evaporator for sorghum juice, but its utility and potential for making maple sugar was recognized and promoted from the very beginning of its commercial availability. Cook's earliest design sat on a portable arch that featured rockers on each side allowing a processor to adjust the height and make subtle shifts in the flow and level of sap and syrup in the pan. His later improved patented design (US patent 37,736) from 1863 saw the evaporator resting on a more permanent and stable brick arch.



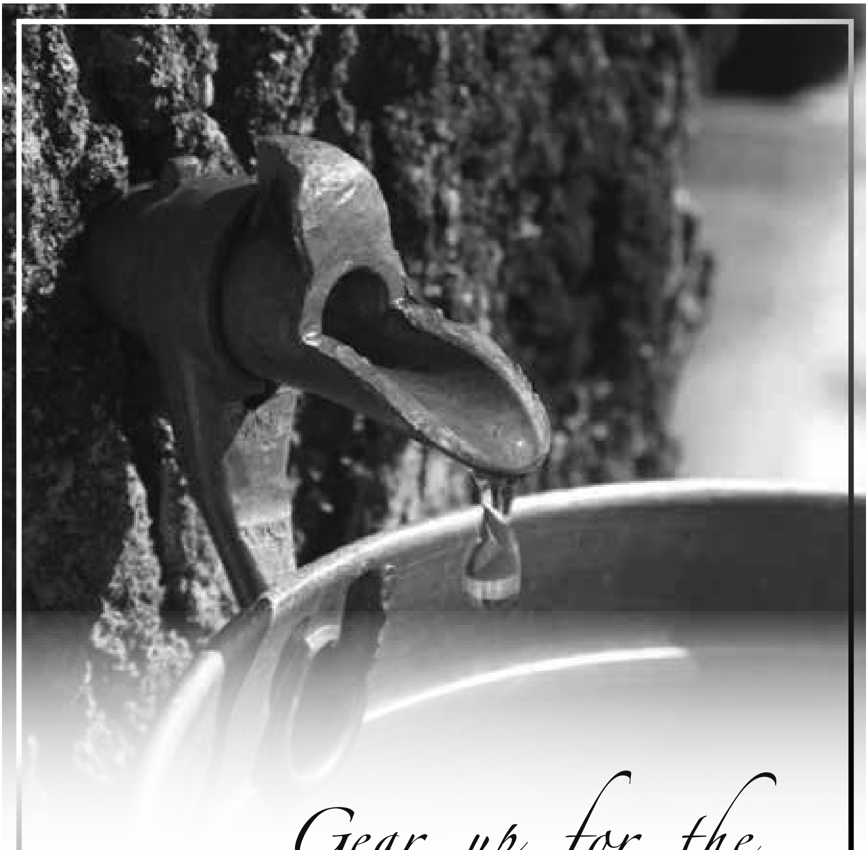
Drawing of early rocker design of Cook's evaporator from October 1859 edition of Middlebury Register newspaper.

As early as 1859, newspaper accounts began to spread the word of the improved speed and quality of maple sugar produced on Cook's evaporator. By 1860 manufacturers were advertising that they were ready to take orders. Cook was an engineer and inventor and personally never manufactured the Cook's Evaporator for sale himself, but rather sold the manufacturing and sales rights to a variety of individuals around the country. Cook's Sugar Evaporator was first available only through a number of Ohio firms like Hedges, Free & Co. of Cincinnati; Blymyers, Bates & Day Co. of Mansfield; and H.W. Wetmore from Akron, Ohio. Those outside of Ohio wishing to purchase a Cook's Evaporator had to arrange for it to be shipped to their state. C.C. Post of Hinesburg, Vermont, the inventor and seller of the Eureka sap spout, was the first Cook's Evaporator dealer in New England beginning in 1863. In one advertisement, C.C. Post boasted that there were already 6,000 of Cook's evaporators in use, and by 1868 over 20,000 sold. By about 1870 other improved evaporator designs had replaced the Cook's Evaporator and C.C. Post was no longer listing himself as sale agent.

The other notable early sap evaporator was invented by Christopher Cory, a retired Presbyterian minister from Lima, Indiana who began his involvement with evaporators when he purchased a Cook's evaporator for making sugar from sorghum. He found the Cook's evaporator to serve its purpose well but felt he could improve upon its design, arriving at what he called Cory's Improved Evaporator. Cory patented (US patent 33,328) his two-pan design in 1861 and C. Cory & Sons began manufacturing and sale to sorghum processors in 1862. Sizes offered were 45 to 48 inches wide by 6 to 15 feet in length, made in iron or copper sheeting. The top tier model in copper at 48 inches wide and 15 feet long cost $130. It is interesting that the image of an evaporator in advertisements for Cook's Evaporator from 1863 and after used the image of a Cory's Evaporator which first appeared in Cory's advertisements in 1862.

Cory's Improved Evaporator began to be promoted for maple sugaring making in 1866 when the Hartford Sorghum Machine Company formed in Hartford, Connecticut, providing an exclusive manufacturer and distributor to sugar makers in New England. In 1868 Jas. B. Williams, President and F.G. But-

*History: continued on page 31*

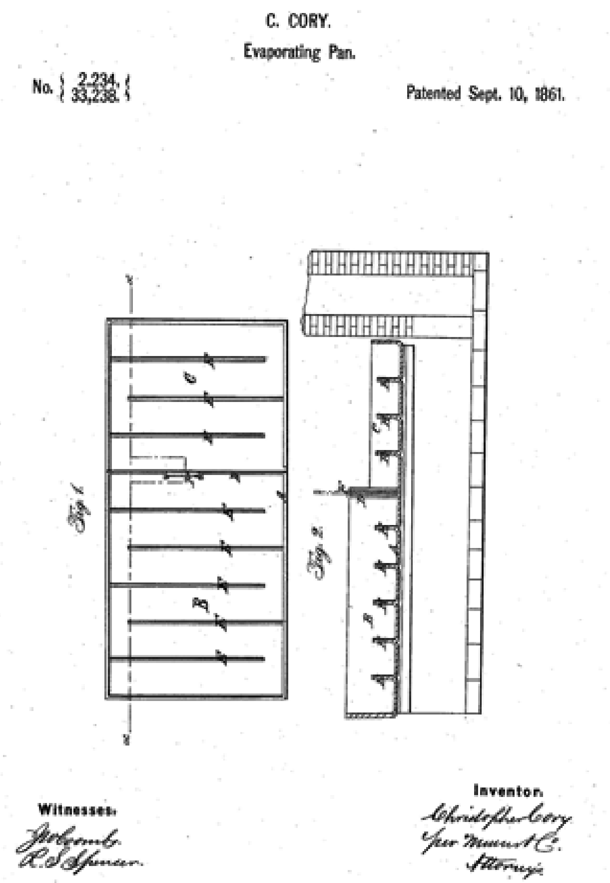


**History: continued from page 29**

ler, Secretary of the Hartford Sorghum Machine Company expanded to open a branch in Bellows Falls, Vermont for the manufacture of the Cory's Patent Evaporator and the Guild Sap Regulator for maple sugar makers. In 1870 the same founders of the Hartford Company formed the Vermont Farm Machine Company, a new larger concern to manufacture a wider range of farm equipment and implements, absorbing the production of the Cory's Evaporator. Through the 1870s Williams and Butler would develop their own improved evaporator designs, moving beyond the Cook and Cory's patent designs. The Vermont Farm Machine Company would go on to introduce the Williams Improved Evaporator and other maple supplies, becoming one of the largest and most important maple equipment dealers of the late 1800s and early 1900s.

Evaporator design improved rapidly in the 1870s and early 1880s with both well-known and lesser known inventors making their designs available for maple producers. By 1890 with the introduction of raised and drop flues, float boxes, metal full length brick arches, and even early steam hoods, producers were able to choose between a range of new and efficient evaporators with familiar names of the Champion, Williams, Eureka, Granite State, I.X.L., Lightning, Wheeler's, and Leader.

*Dr. Matthew M. Thomas is a historian of the maple industry who shares his research and writing at the website www.maplesyruphistory.com. He is the author of the recent book "A Sugarbush Like None Other: Adirondack Maple Syrup and the Horse Shoe Forestry Company," available for sale on eBay and select bookstores and gift shops. He can be reached at maplesyruphistory@gmail.com.*




Design drawing for Cory's 1861 evaporating pan patent (US patent 33,238).

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# Homemade Small Reverse Osmosis Machines

*Stephen Childs, New York State Maple Specialist*

One of the biggest drawbacks of making maple syrup for a back yarder or small maple producer is the time it takes to boil the sap into syrup. The idea of using a small reverse osmosis unit to assist with the syrup making is very appealing for many small maple producers.

There are many small RO systems available for water purification in households or for small commercial applications. These can be purchased from a number of big box stores, home improvement stores or online. These RO units can be used to remove water from sap to speed up the concentration and syrup boiling process.

To make a small RO unit work you must first get the sap under pressure using a pump, typically a shallow well pump. About nine years ago I started experimenting with small units to try and cut down on the amount of boiling time needed to make syrup for my family. I started with a GE Merlin (no longer available) that was rated to deliver 30 gallons of pure water per hour when operated at about 60 psi.

That rating is for when purifying permeate from water. When you are removing water from maple sap the permeate removal rate is reduced by 6x – I was removing only between 4.5 and 5 gallons per hour. This was still a huge benefit, as it reduced the time of boiling sap from my 25 taps on my 2′x4′ wood-fired flat pan from about 8 hours per run to 4 hours. It would sweeten the sap from about 2% up to between 4 and 5%. The investment was about $360 for the RO unit and I already had a shallow well pump that I used to pressurize the sap to about 55 psi and had to purchase a pre-filter canister.

Though this system reduced my wood use by about 50%, the primary benefit was the reduction in boiling time with no identifiable change in the taste or quality of maple syrup. In the off-season the membranes were stored in the unit with permeate created by the unit. I used this unit for 4 years and by the fourth year notice a slight reduction in performance. To keep the pump from continually turning on and off while feeding the membrane and to maximize the pressure the pressure switch on the pump had to be set at maximum.

The 6x reduction in capacity seems to be universal when processing sap vs. processing water with any unit set up and rated for water purification. So a home RO rated for 50 gallons per day would remove about 2 gallons per hour with water or would take about 1/3 of a gallon of water out of your sap per hour. That would be fine for someone with 2 or 3 taps. A larger unit that claims 240 gallons of water purified per day should take out about 10 gallons per hour from water but only about one and a half gallon of water from sap. That should be good for someone with up to 5 to 12 taps. With these water pu-

*Small RO: continued on page 34*


***Small RO: continued from page 33***

rification units you must remove the carbon filter as it will remove sugar and many other things you normally want in syrup.

Like most producers, once the small RO was working well and syrup was more efficient to make, I annually added more taps so after using the Merlin for four years it was time to go bigger. I had a larger RO unit come available that had a higher pressure option using a small Procon pump on a half horse power electric motor and one 2.5″ by 21″ membrane. To this unit I added two more 2.5 by 21″ membranes to boost the capacity to handle my now 70 taps. This unit operated at 250 psi, would remove about 15 gallons of permeate per hour and could bring the sap up to 12% sugar if given enough time. So boiling for 70 taps was still taking about 4 hours of boiling time per run only with much greater yield.

I continued to use the shallow well pump to feed this unit. I found that as the sap became sweeter the water removal rate would gradually be reduced. I found the best way to keep the production high was to process the sap in 15 gallon batches. So I would hook the RO to a 15 gallon jug of sap and run the concentrate back into the sap jug until the sap reached 10 to 12% at which time the permeate removal would be down to about 8 gallons per hour. The concentrated sap would then head to the boiler. As soon as we started on the next jug of 2% sap it would rinse out sugar build up in the membrane and go back to the full capacity of 15 gallons per hour.

Both of the units above were used in the USDA Forest Farming youtube videos. Unfortunately the three membrane RO made the middle sized RO in the videos look much more complicated than it need to be creating lots of inquiries. It was nice that the shorter membranes were easier to transport to maple programs for demonstrations. It seems the 40″ membranes and pressure vessels are more standard production than the 14″ or 21″ alternatives so they are much more economical to purchase for the amount of output. I had the three membranes hooked up in parallel to get the most water removed per hour. If they were hooked in series less water would be removed per hour but the sap could be much sweeter in one pass. For the off season I would store these membranes in holders made from PVC pipe that would be filled with permeate and a screw tight lid sealing the liquid and membrane in.

It was at this point that I began to gain friends. Friends who would show up at my garage with a 50 gallon barrel of sap or more and we would RO that down to about 15 gallons in about 2 and a half hours. These visits would save them between 8 and 20 hours of boiling time each time the sap ran. But the desire for something bigger was growing. The question of how to make a simple RO that would be most useful for maple operations of 300 to 500 taps led to the next experiment.

The fact that each year in the maple industry some percentage of maple producers are updating their 8″ by 40″ membranes that have lost some per-

*Small RO continued on page 36*

***Small RO: continued from page 35***

centage of capacity seemed like it could be a low-cost source for operations that don't need that maximum capacity. Breezy Maple Farm was updating some of their membranes and provided one for our testing. A 8″ by 40″ Codeline fiberglass pressure vessel was purchased on line along with a 330 gallon per hour Procon pump. This pump was connected using a cone connection to a standard shaft 1 horsepower motor that I already owned. This system operated at 250 psi and would remove about 300 gallons of permeate per hour. Total cost of materials was about $1,150.

This performed with great efficiency but had a couple of unexpected issues. At first the pump would run but nothing happened, even when well-primed. Turned out the motor was running backwards and needed to be rewired. The bolts in the motor were too short to connect to the cone so they had to be replaced with threaded rod and there was enough vibration in the cone to pump connection that it would wear out the rubber in the motor to pump coupling every couple of weeks. The clamp style connection between a motor and pump seem like a much better system.

Here again I used the feed pump in addition to the higher pressure pump. Some are not using the feed pump, especially if the sap is slightly elevated over the pump so that it can help with priming. This eliminates the cost of the feed pump. I've run them both ways and I get less chatter in the high pressure pump when I use the feed pump, but performance seems equal. This system had more capacity than I need and sometimes I had trouble having enough permeate to give the 8″ membrane the rinsing it should have following use.

The next year I tried a 4″ by 21″ membrane with the 330 gallon Procon pump. This unit did not put out as much as I expected. I had heard that it could do about 60 gallons per hour at 250 psi but I was usually getting about 45 gallons of permeate per hour. Still great for my 70 taps and friends but when you look at the price of the 21″ membrane and pressure vessel it is not that much less than a 4″ by 40″ which will have twice the performance. So the last year of making maple syrup at home we tried a 4″ by 40″ with the 330 gallons per hour pump and it performed very well delivering 80 to 100 gallons per hour of permeate.

Some of little ROs from this project are now assisting with concentration of sap at the Cornell Arnot Forest. If you are a do it yourselfer, this is a reasonable project to put one together. They are becoming more available at more reasonable prices than ever before. Buying one can save significant aggravation. If you are not at all mechanically inclined, making your own RO is probably not the best idea.

There are several videos of these projects available online – go to youtube.com and search for Cornell Reverse Osmosis.

**Helpful tips for building your RO**

Flush the RO filters with all the permeate you can save after every use. Do not use chlorinated water in your RO at any time. Store the membranes in pure permeate in the off season in your pressure vessel or make an air tight holder out of PVC pipe. There are preservatives and soap available for membranes if you need them. Follow suppliers' instructions and store where children cannot access.

The pressure in the RO is controlled by a valve on the exit end of the membrane on the concentrate line. Permeate comes out of the center of the membrane on both ends, you can block one end so all the water come out one line. The concentrate goes in one end and out the other at the outside fittings by the rings of the membrane. Most small ROs without internal recirculation should send the concentrate back to the sap tank. Concentrate in batches.

Flow meters can be handy but you can get a quick measure by just putting the permeate line in a 5 gallon bucket and measuring how long it takes to fill it. After a few times you get pretty good at seeing when you are getting a great flow and when it is slowing down. I get excellent results with my 4x40 with a 3/4 hp pump and a 330 gallons per hour pump. If you get a much smaller pump, say a 150 gph, you get less flow over the membrane at a given pressure which allows the sugar to build up on the membrane and reduce its capacity. The membrane is like a fine screen and the more flow pushing the sugar along the longer it stays clean and functioning. You want a pump that has at least 50% more capacity than the rated capacity of the membrane, and more is not a problem.

*Small RO continued on page 38*

***Small RO: continued from page 37***

Change or clean your pre-filter often.

Supplies are available in many places. I have used maple dealers, amazon.com, ebay.com, americanro.com, altanticro.com, freshwatersystems.com, nextgenmaple.com and Deer Run Maple, plus there are many more.

A sap refractometer is very helpful when working with an RO as it can give you sugar contents in seconds and is harder to break than a hydrometer.

There are many membranes available, I tend to pick the ones with the highest rating for the price.

Starting at the sap tank here the suggested parts in order: A foot valve; a line to either the feed pump (a valve just after the feed pump can cut down on the need to re-prime the pump so often, shut it when moving the line from one tank to another) or the pre-filter; from the pre-filter a line to the high pressure pump; a line from the high pressure pump to the outside fitting of the pressure vessel; a pressure vessel with a membrane inside; a concentrate line from the outside fitting on the exit end of the membrane that goes back to the sap tank or to a tank suppling the boiler; and a line from the center fitting on the pressure vessel to a tank for storing permeate.

End of season cleaning: For most of the years I have just run permeate water through the membrane at low pressure, lots of permeate water, and then saved the permeate from the water rinsing to store the membrane in. I made a storage chamber out of PVC pipe with a solid bottom and screw on top. Fill the PVC cylinder with the pure water and put the membrane in there completely submerged and put on the top. With our commercial membranes here at the forest we run a wash using membrane soap from one of the maple supply companies, rinse and do a second soap wash followed by lots of rinse with permeate – about 350 gallons per 8" membrane. Then store it in a PVC can, like above with membrane preservative added. I have not had trouble just rinsing and storing the membranes in the very pure water but I've heard of some who did not rinse enough or get clean enough water for the storage and it smelled bad after storing. I don't like using the preservative as it takes a lot of rinsing the following season to get the off odor and taste back out of the membrane. I've avoided using the soap wash at home as the soap is very caustic (NaOH) and I didn't want to have it around in case the grandkids happened to get into it. At the forest we have a good cabinet for storing these things.

*A special thanks to Next Generation Maple and Deer Run Maple for all the help and encouragement with this project.*

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