Maple Syrup Digest

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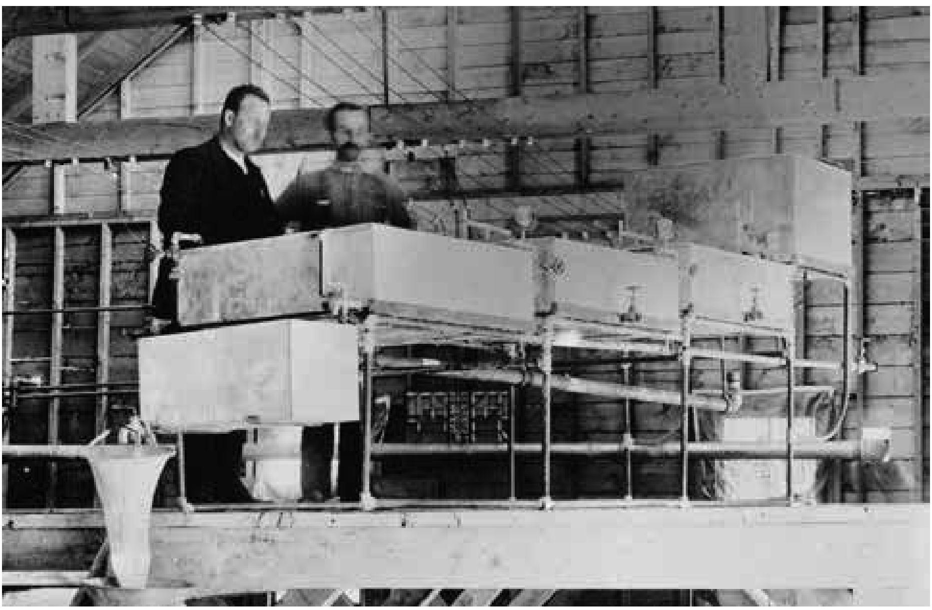

New Producers Manual
1/4" Tubing Research
Foresters and Maple

The Newsletter of the North American Maple Syrup Council


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MAPLE SYRUP DIGEST

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NAMSC's Mission is to be a leading advocate and resource for maple associations and their members, working to ensure that sugarmakers have the tools and support needed to sustainably produce high quality products.

NAMSC's Vision is for all sugarmakers to consistently and sustainably produce high quality maple products.

President's Note

Greetings, maple folks.

I started my day, in the sugarhouse at 5:30 AM. Like for many of you, my full-time job really gets in the way on those days when you need to package syrup for an order that just came in. By 7:45 I had hot-packed 15 gallons of dark amber in various sizes to round out the inventory so Jeanne could pull the order and deliver it. Also cooked down two gallons for maple cream and set it to cool so that I could process and pack it at lunch time. I have the good fortune to live close to work so I get lunches at home or at the sugarhouse.

I am not bragging about my efficient set up, as much as recognizing that "necessity is truly the mother of invention!"

I use an electric water jacketed canner to reheat my syrup. That way I can turn it on just before bed and it's ready to go at 5:30. A 50,000 BTU gas burner brings two gallons of syrup to cream temperature in 57 minutes.

For me this time of the year is for planning and contemplating future investments or improvements. It is too hot to be thrashing around in the woods and, for us, sales take a slight dip in July, then climb back in August.

Maple, like most agricultural businesses, needs careful planning where new equipment is concerned.

How much can I expand my tap numbers before it stresses my production capabilities?

How much can I enhance my production, before it stresses my ability to filter and package the product?

How much can I grow my production overall before it outpaces my market?

This is a great topic for a roundtable discussion sometime! We all have pushed over that domino only to watch the rest fall.

My message here is: take a few minutes to stop and ask yourself a few tough questions now and then.

Such as: Is this a hobby, an obsession or a business? Do I want to grow this business? How should I go about it? What is the succession plan? Will I pass it on in the family, sell it, or just fold the tent and call it quits someday?

This is what I think about when it is too hot, dry, and otherwise miserable out there.

As far as NAMSC goes: I wish to thank the Bylaw Review Subcommittee for their participation in helping us to present an updated version of our bylaws for a vote by the executive committee and then full board of directors in October. I am hoping for strong del-

President: continued on page 7


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In this issue...

President: continued from page 5

egate participation going forward.

NAMSC represents an industry of all sized producers pulling together for a common goal. To produce a high quality, consistent product to sweeten the lives of appreciating consumers. We need all of your ideas and concerns! Please participate to the fullest of your capacity.

And remember: Make maple a staple!

See you in Lacrosse in October, or somewhere along the way.

Respectfully,

Howard Boyden, President, NAMSC

Cover: James H. Hill and John Rivett, employees of A.A. Low, standing in front of a prototype of the steam evaporator they patented in 1901. Image Courtesy of the Library of Congress. See page 27.

Seeking Photos and Articles

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

Digest Online

The online archives of the *Maple Syrup Digest* at www.maplesyrupdigest.org are now accessable on your smartphone and tablet devices, as well as on your computers.

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More information at wismaple.org/2022

Hope to see you all in La Crosse!

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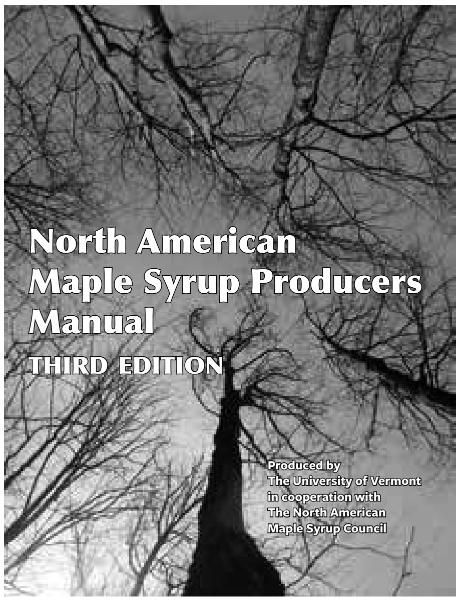
Visit wismaple.org/2022 for hotel options and updated hotel registration and information.

Now Available for Free Download: 3rd Edition

North American Maple Syrup Producers Manual

The Third edition of the *North American Maple Syrup Producers Manual* is now available for free download! This fully revised edition has a new chapter on food safety, as well as updated chapters on sap, syrup, and value-added product production based on the most current research. The remaining chapters have had modest updates. Along with chapters on sugarbush management, economics of maple businesses, marketing, and more, the Maple Manual is the most comprehensive, accurate resource for sugarmakers of all sizes. A joint project of the University of Vermont, the North American Maple Syrup Council, and dozens of the industry's researchers, scientists, and educators, the Manual is available for free download, however note that it is copyrighted, and all materials should be cited if used elsewhere (newsletters, presentations, etc.).



Since 1958 the *North American Maple Syrup Producers Manual* has served as a basic reference source for the production of pure maple products. This 2022 edition provides up-to-date, science-based information and recommendations relating to all aspects of the industry. The guidelines presented will help users ranging from the hobby and beginning producer level to those well-established in the industry. In addition, the information herein will benefit foresters, land managers, Extension and outreach personnel, and others aiming to provide assistance to those in the maple industry. Numerous photographs, tables, a glossary and hyperlinks to selected source materials are included.

To get access to the download, send a blank email to mapleproducersmanual@gmail.com and you will receive a link to view and download the 434-page *Manual*. Print versions will be available for sale in the next few months.

Quarter-Inch Tubing: Is it a Better Option for Gravity Sap Collection?

Adam Wild, Dir., Uihlein Maple Research Forest, Co-Dir,. Cornell Maple Program
Keith Otto, Technician, Cornell University Uihlein Maple Research Forest

The industry standard for maple tubing has long been 5/16″ internal diameter with sufficient capacity to allow sap flow along with air being pulled from the vacuum pump to be evacuated from the tubing. Although vacuum pumps increase yields, elaborate vacuum systems are expensive, require additional mainline tubing, and require a significant amount of energy to run. When 5/16″ diameter tubing is applied in a gravity system (no vacuum pump), sap can easily be collected from maple trees, but yields are typically diminished.

Ten years ago, 3/16″ diameter tubing was introduced to the marketplace as an alternative tubing to 5/16″ diameter tubing. The smaller inner diameter of 3/16″ tubing easily allows a full column of sap to form through capillary action. When the weight of the full column of sap drops in elevation, natural vacuum is achieved if the tubing is airtight. With every foot of drop this type of system can achieve 0.88 inHg (Wilmot 2018). When applied in a natural gravity system, under appropriate topographical conditions, 3/16″ tubing can achieve maximum potential vacuum (often better than a vacuum pump) and even has capability to pull sap over a hill. This maximum yield is achieved without the need for high-priced vacuum pumps or the energy needed to run them, and 3/16″ diameter tubing is cheaper to install.

However, recent research shows that sap production in 3/16″ tubing drops off as soon as the second year after installation due to microbial growth. With a small inner diameter, bacteria and yeast grow within the tubing and over time cause clogging, especially within any fittings where the inner diameter is less than 3/16″ (Childs, 2019). This plugging restricts sap flow and diminishes potential yield. Despite the initial gains from 3/16″ diameter tubing, by year three of using the tubing, production diminishes to significantly less than using 5/16″ tubing without vacuum unless the tubing is sanitized.

A replacement for 3/16″ diameter tubing in gravity systems could be 1/4″ tubing. With almost twice the aperture of 3/16″ tubing (0.049 sq inches compared to 0.0275 sq inches), 1/4" inch tubing is less likely to plug from microbes yet is still able to create a full column of sap for gravity vacuum. Quarter-inch tubing is currently not available for maple producers but can be procured from other industries and, with modifications, will work for maple production.

Methods

Thanks to funding from the Northern NY Agriculture Development Program, we were able to test the effectiveness of 1/4″ tubing at the Cornell University Uihlein Maple Research Forest in Lake Placid, NY during the

2020, 2021, and 2022 maple seasons. Four replicate blocks were established on a slope of at least 50 feet drop in elevation. Each replicate block contained a 3/16″ lateral line, 1/4″ lateral line, and 5/16″ lateral line with the same length, number of taps, and elevation drop. Trees were matched in elevation across the three lateral lines per block. Each tree had only one tap. Block one had eight taps per lateral, block two had ten taps per lateral line, block three had 18 taps per lateral line (added in 2021), and block four had 30 taps per lateral line (added in 2021). Each lateral line flowed into its own tank where sap volume could be measured. All lines were on gravity without the use of a vacuum pump. Vacuum gauges were attached to the top of the lateral line at the highest elevation point.

Additionally, a fifth replicate block was established to compare production yields of 3/16″, 1/4″, and 5/16″ tubing when vacuum is applied with the use of a vacuum pump. There was minimal elevation drop from the end of the lateral to the collection vessels. In this scenario, the minimal gravity vacuum could help boost the vacuum at the tap hole (especially the distance of the dropline), but most of the vacuum was initiated by the vacuum pump. Two lateral lines of the same diameter flowed into one vacuum chamber with three taps per lateral line. Each tubing replication was never cleaned. New spouts were used each year.

Volume of sap per replicate was measured from each collection vessel during each sap flow event. Vacuum levels were read from the top of each lateral during sap flow events. All sap production data was normalized to show an increase or decrease in yield over 5/16″ tubing with the 5/16″ tubing set at 100% of the yield. This allowed for equal comparison across years and removed the noise of season-to-season variability.

Results

<u>Gravity Tubing Results</u>. In the first year of testing with just 8 and 10 taps per lateral, 3/16″ tubing achieved consistently high vacuum at the top of the lateral and produced over three times the amount of sap per tap than 5/16″ tubing (figure 1, panel A & B). Quarter-inch tubing did achieve vacuum at the top of the lateral (as high as 25 in/Hg) but the vacuum was not consistent throughout the season (figure 2), yet still produced more than twice the amount of sap per tap than 5/16″ tubing (figure 1, panel A & B). The 5/16″ tubing produced little to no vacuum at the top of the lateral line. In the second season spouts were replaced but droplines and laterals were not cleaned. Similar results were observed during the second season with no significant plugging on 3/16″ tubing (figure 1, panel A & B). Production in the 3/16″ tubing was significantly lower by year three but still held the highest production (figure 1, panel A & B). Quarter-inch tubing saw a slight drop in production in year two and three but still maintained higher production than 5/16″ tubing. Fittings that we were able to acquire for the 1/4″ tubing had minimal barbs and did not fit as tightly on the tubing. These fittings most likely created micro vacuum leaks in the tubing system which

Tubing: continued on page 12

Tubing: continued from page 11

is most likely the cause of the drop in production over time. This can be seen throughout the experiment. By year two and three, some of the 1/4″ tubing replicates even pulled off the fittings, creating challenges in data collection.

With more trees per lateral, the results were extremely different. With 18 taps per lateral, all three tubing types produced essentially equal amounts of sap in year one but 5/16″ outperformed 3/16″ and 1/4″ tubing by over 20% in year two (figure 1, panel C). In 30 taps per lateral, 1/4″ tubing had significantly higher sap production in year one but in year two 5/16″ tubing outperformed the 3/16″ and 1/4″ tubing (figure 1, panel D). The large drop in production in year two is most likely a result of the previously mentioned microleaks within the tubing. The 30 taps per lateral 1/4″ line separated multiple times throughout the 2022 season. Data from the 3/16″ and 5/16″ comparison replicate was thrown out on these days to keep equal production but the loose fittings most likely impacted production. However, with more taps per lateral, 5/16″ tubing (and 1/4″ tubing if in a tight system) can create vacuum and higher yields than 3/16″ tubing (figure 2). With 18 or more trees per lateral, the 3/16″ tubing is restricted in volume space and production drops. This confirms previous research that when more trees are added to larger diameter tubing, vacuum can be created (Morrow, 1972). However, it can be challenging to find this many trees unless a very large slope is available.

Vacuum Tubing Results. In the small trial of all three tubing sizes on

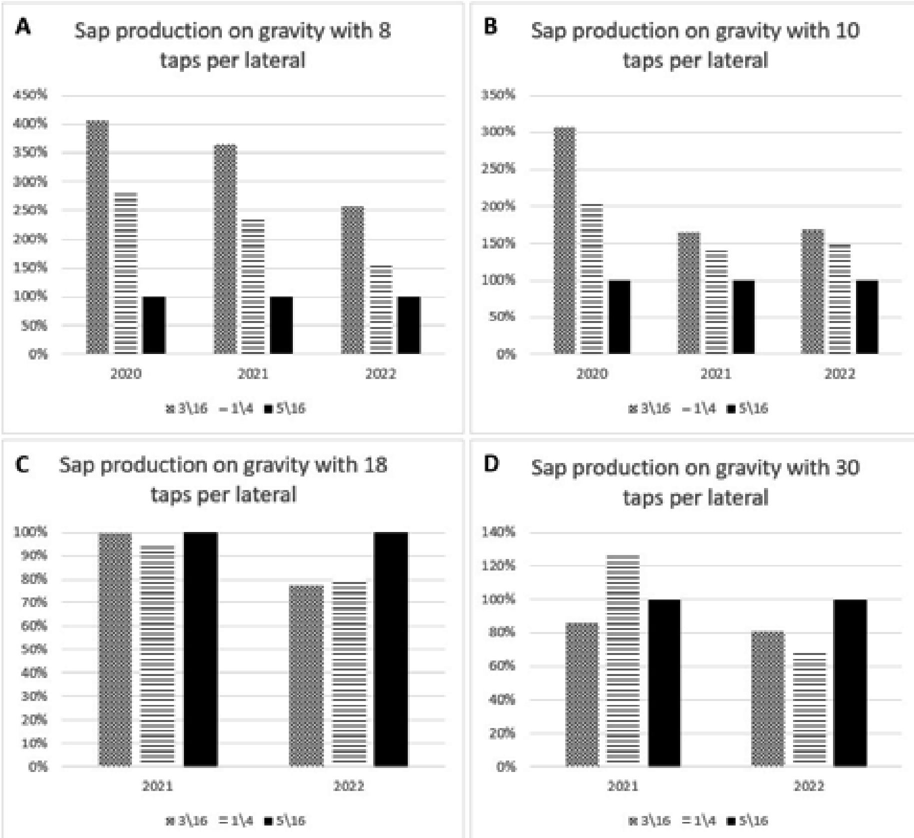


Figure 1: Sap yields on gravity tubing of three different diameters: 3/16”, 1/4”, and 5/16”. Each replication had at least 50 feet in elevation drop. Within each replication, 5/16” tubing was considered 100% of production while 3/16” and 1/4” tubing is shown to be a percentage above or below of 5/16” tubing. Panel A shows gravity production with 8 taps per lateral and panel B represents 10 taps per lateral across three seasons. In all three years, 3/16” tubing yielded higher production, but production dropped in year 2 and 3. Quarter-inch tubing did create vacuum and increased yield over 5/16” tubing but did not have as high of yields as 3/16” tubing. Quarter inch tubing did drop in production in years 2 and 3 but did not drop as much as 3/16” tubing. When more taps were added to a lateral (18 taps per lateral – panel C, and 30 taps per lateral – panel D) the highest yielding tubing size is completely different. With enough taps per lateral, 5/16” tubing does create vacuum and yields comparable or greater than 3/16” and 1/4” tubing. With more taps, the smaller 3/16” diameter tubing is not able to handle the volume of sap. With 30 taps per lateral 1/4” tubing showed the highest production in 2021 but the lowest in 2022. This is most likely a result of fittings, not made for maple production, having minimal barbs and thus creating microleaks.

Tubing: continued on page 14

Tubing: continued from page 13

a commercial vacuum pump, 1/4″ tubing performed equal to 5/16″ in year one and slightly less in years 2 and 3 (figure 2). The drop in production was most likely a result of poor fittings that created microleaks in the lateral lines. Testing production of 1/4″ tubing on a vacuum pump was not replicated nor were different numbers of taps per lateral. Not surprisingly, 5/16″ tubing still appears to be the ideal tubing when a vacuum pump is used. More testing is necessary although resources would be better focused on the effectiveness of 1/4″ tubing in a gravity system.

Conclusions

Quarter-inch tubing was shown to be an effective option for sap collection, especially when at least 18 taps per lateral were used. On laterals with more taps, 1/4″ tubing had the higher yields per tap, while with fewer taps per lateral, vacuum was not as high and 3/16″ tubing had higher yields. However, 1/4″ tubing produced significantly more sap than 5/16″ tubing and after three years of comparing yields on 3/16″, 1/4″, and 5/16″ tubing, significant plugging was not observed in either of the sizes of tubing. It is expected that the 3/16″ tubing will continue to plug and 1/4″ tubing will outperform all the tubing. We will be repeating the study during the 2023 sap season for a fourth year on 8 and 10 taps per lateral, and the third season on 18 and 30 taps per lateral.

A lot of research is still needed to determine the effectiveness of 1/4″ tubing but it is showing promising results. However, with larger hillsides with a greater number of trees, 5/16″ tubing may be a better option for gravity tubing systems. The smaller volume of the 3/16″ tubing is not recommended for laterals with more than 18 trees. We don't want to rush into promoting 1/4″

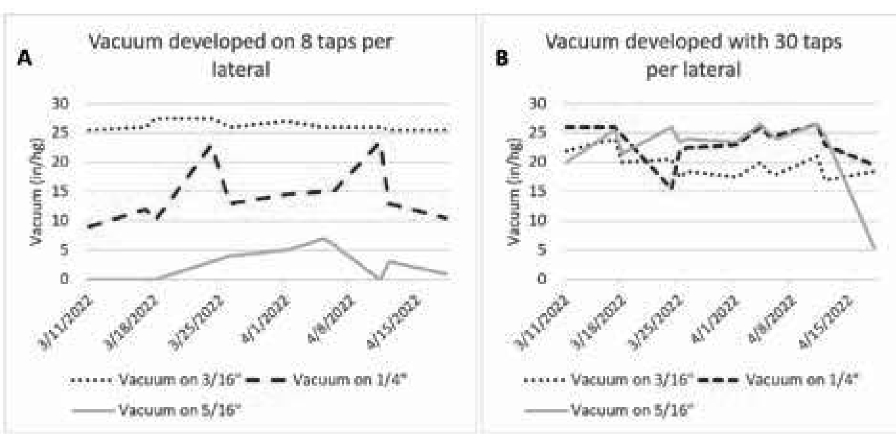


Figure 2: Vacuum created at the top of lateral lines in a gravity tubing system with 8 taps per lateral (A) and 30 taps per lateral (B) across the 2022 maple season. With only 8 taps per lateral, little to no vacuum is created on 5/16" tubing while higher vacuum is created when enough taps create enough volume of sap to create a full column of sap. With only 8 trees per lateral 1/4" tubing can create moderate vacuum that reached higher levels on bigger sap flow events.

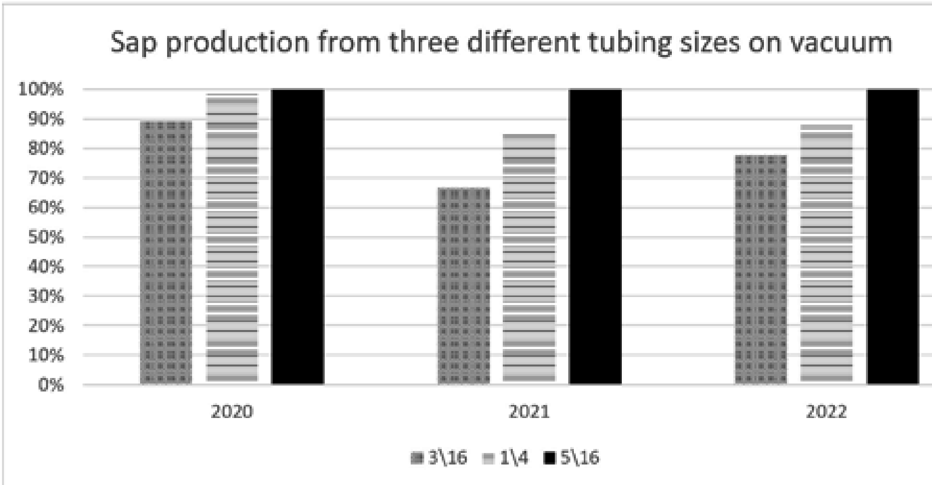


Figure 3: Sap yields on 3/16”, 1/4”, and 5/16” tubing across three maple seasons using a vacuum pump. Each lateral line had 3 taps per lateral and high vacuum was maintained throughout the season. Droplines were not replaced or sanitized. Yields were normalized to 5/16” tubing production at 100%. New spouts were used each year. Not surprising, 5/16” tubing had the highest production. The drop in production of quarter inch tubing in year two and three is likely due to poor fittings causing microleaks.

Taps per lateral	Gallons of sap per tap: 3/16” tubing			Gallons of sap per tap: 1/4” tubing			Gallons of sap per tap: 5/16” tubing		
	2020	2021	2022	2020	2021	2022	2020	2021	2022
8 taps, gravity	26.5	16.9	27.8	18.6	10.9	16.6	6.5	4.6	10.8
10 taps, gravity	27.9	9.7	15.4	18.4	8.2	13.5	9.1	5.8	9.1
18 taps, gravity		12.2	18.5		11.5	19.2		12.2	24.0
30 taps, gravity		10.6	22.9		15.5	X		12.3	26.4
Vacuum pump	18.5	14.1	19.2	20.5	18.0	21.6	20.7	21.2	24.7

Table 1: Sap yields from three years on three different tubing diameters in a gravity system with different number of taps per lateral along with production on the three different tubing sizes when a vacuum pump is incorporated. When the vacuum pump was incorporated, each lateral had three taps. Data is not shown for the 1/4” tubing with 30 taps per lateral in 2022 because the lateral line separated compromising the data. Comparison data was able to be created but not realistic yield data.

Tubing: continued on page 16

Tubing: continued from page 15

tubing until we are confident plugging will not be an issue, but it's anticipated not to be an issue as it can be with older 3/16" tubing that has not been sanitized. Finding tubing with fittings that do not create vacuum leaks and hold tight to the tubing is key. If so, 1/4" tubing may be an alternative tubing option for gravity sap collection systems.

For More Information

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Acknowledgment

This project was made possible thanks to funding from the Northern NY Agriculture Development Program.

Foresters' Approach to Sugarbush Management in the Northeast U.S.

Mark Isselhardt, University of Vermont Extension Maple Specialist
Mark Cannella, University of Vermont Extension Associate Professor
Dr. Abby van den Berg, University of Vermont Assistant Director, Proctor Maple Research Center/Research Associate Professor
Dr. Anthony D'Amato, University of Vermont Professor

Maple sap is a non-timber forest product since it is the sap and not the tree itself being harvested. The harvesting of maple sap occurred for many centuries in North America beginning with Indigenous peoples in the region, although the methods with which sap is harvested has changed greatly over time.

The production of pure maple syrup relies on access to a "sugarbush" which is defined as "woodland or other group of maple trees tapped for maple sap" (Perkins et al. 2022). Sugarbush management (SBM) therefore represents the approaches (formal or informal) to maintaining a source of tapable maple trees and includes "manipulation of maple-dominated woodlands and the culturing of maple trees to ensure they remain vigorous and resilient to stress, produce abundant sap high in sugar content, and regenerate as needed." (Perkins et al. 2022).

The primary technique foresters use to satisfy objectives related to management of forest products is silviculture. The Society of American Foresters definition of silviculture states that it is the "art and science of controlling the establishment, growth, composition, health and quality of forests and woodlands to meet landowner/stakeholder goals." Silvicultural approaches generally fall into two categories; those that will tend to develop a single cohort of trees (even-aged management) and those that result in a stand of trees that include trees of many different ages (uneven-aged management). Silvicultural prescriptions relate to the number, size and distribution certain trees retained to reach certain goals and are related to the life history of the species being managed and the products desired.

The energy-intensive process of boiling sap requires an abundant source of fuel to feed maple evaporators. Wood was the primary source of fuel most of the history of maple production since sugarmakers have access to trees and will typically generate enough firewood during the process of tending to the sugarbush. Concerns have been raised that over time this process has tended to push a given sugarbush towards monoculture when only maples are retained during each harvest activity. Work by Parker et al. (2008) has identified the benefits to sugarbushes by retaining ≥25% non-sugar maple in reducing the amount of sugar maple-specific insect damage. This work has been widely adopted by most organic certifying organizations as well as some governmental agencies tasked with

Foresters: continued on page 18

Foresters: continued from page 17

overseeing forest land use programs (FPR 2015).

Sap harvesting techniques have changed dramatically over time. For generations of sugarmakers and up until the early 1960's the only method for collecting sap relied on attaching a bucket to individual trees and gathering sap from each tree as needed. The strong positive relationship between tree size and sap yield (Isselhardt et al. 2018) combined with the high labor demand for collecting sap from individual trees encouraged producers to cultivate fewer but larger, widely-spaced crop trees. Early published recommendations support this point as the stocking recommendations (the area in a given stand covered in crop trees) was significantly lower and focused on maximizing crown size compared to similar stands managed for timber production (USDA 1922). Given that currently 98-99% of all maple taps use plastic tubing (UVM Extension *unpublished*) it stands to reason that management approaches for what constitutes an ideal sugarbush would differ depending on how sap is collected. It makes sense to better understand if forestry approaches to SBM have undergone similar changes or if new, more modern approaches are needed.

Professional foresters are licensed in many states to ensure the work they do on behalf of landowners meets industry standards and will not result in violations of state or federal environmental regulations. One document that has helped guide foresters and logging professionals in Vermont is titled

"Acceptable Management Practices (AMPs) for Maintaining Water Quality on Logging Jobs in Vermont." This publication was first adopted in 1987 and includes "the proper method for the control and dispersal of water collecting on logging roads, skid trails and log landings to minimize erosion and reduce sediment and temperature changes in streams." Harvesting sap is different than harvesting logs in many ways but both activities require a road system suitable to meet the demand. Regardless of the forest product being harvested, any activity that negatively impacts water quality can be subject to enforcement actions and penalties and for that reason many foresters employ AMPs in sugarbushes to ensure regulatory compliance.

This research is focused on a first of its kind survey of professional foresters with the goal of not only understanding the technical approaches foresters use when working in sugarbushes, but also how the surveyed foresters view SBM compared to managing stands for other forest products.

Methods

A twenty-one question, convenience survey was taken of professional foresters in the northeast United States between April and June 2020. The online-only survey consisted of twenty-one questions related to foresters' experience with SBM. The survey was shared within networks of professional foresters including the New England Chapter of the Society of American Foresters, various consulting forester networks, and foresters working on public land. The University of Vermont Institutional Review Board reviewed and approved the survey. Responses were received between April 13 and July 13, 2020.

Questions were designed to elicit responses from foresters that would characterize their perspective of how sugarbush management fits with management for other forest products and required a variety of answers from simple yes/no to more open ended. When possible, answers that were not quantitative or binary were grouped together into broad categories.

Results

A total of sixty-six (66) professional foresters from around New England and New York responded to the survey. Not all respondents answered every question which resulted in slightly different numbers of responses for each question. Ninety-one percent of respondents reported working with landowners on SBM whereas 9% said they did not. Of the foresters who did report working on SBM, 53 % reported working with landowners in Vermont, 16% in New York, 12% in NH and 10% in Maine. Additional states/provinces reported included Connecticut, Massachusetts and Québec. Nearly 92% of respondents reported working with SBM on private land, compared to 5% of those who work on both private and public land or exclusively on public land (3%).

Collectively, the respondents reported working on a total of 184,834 acres of sugarbush. The mean number of total acres was 3,186, compared to the medi-

Foresters: continued on page 20

Foresters: continued from page 19

an number of total acres of sugarbush each respondent worked on, which was 210. Figure 1 shows the distribution of total number of acres of sugarbush managed. The mean property size was 121 acres and the median was 75 acres (Figure 2).

Foresters were asked what type of land use maple sap production was. Sixty-five percent (39/60) responded that it was a mix of both an agricultural and forestry land use, 32% (19/60) said it was a purely forestry land use and only 3% (2/60) said it was purely an agricultural land use.

When asked what silvicultural technique best describes SBM strategy, foresters tended to favor approaches that would develop uneven age distribution of trees or a high proportion of large diameter trees. Fifty-eight percent of foresters use single-tree selection (34/59), 29% (17/59) use the "crop tree release" approach. The remaining responses were evenly spilt between small group selection (~7% or 4/59) and shelterwood (~7% or 4/59).

Respondents were asked if they view SBM as a short-term (<20 years) intermediate term (20-100 years) or long-term (+100 year) goal. 52% (31/60) of foresters' view SBM as a long-term goal and 47% (28/60) view it as an intermediate goal. Just one individual considered it as a short-term goal.

When asked which published guidelines for SBM are used when writing silvicultural proscriptions, the most common response from foresters, or 37% of those who answered, was "none." The next most common responses were not specifically silvicultural guides, such as the *North American Maple Syrup Producers Manual* (27%), followed by several with less than 10% including those authored by Houston (1990), Lancaster (1974) and documents such as the State of Vermont Guidelines for sugarbushes enrolled in the Use Value Appraisal program (2015).

Foresters were asked when doing an inventory for a stand's potential as a sugarbush, what they consider to be the minimum diameter a tree can be to be tapped for sap collection. The most common response was 10″ (58% of respondents, 35/60) followed by 9″ (18%, 11/30) and 12″ (15%, 9/60). Just over 8% of foresters indicated that 8″ diameter trees would be considered as tappable when doing an inventory.

Survey recipients were asked if they incorporate an anticipated annual sap yield per tap or sap yield per acre in SBM planning. Of those who responded, 81% (41/51) answered "no" whereas 19% said "yes."

Ninety-eight percent of respondents answered "yes" to the question if they viewed SBM as a sustainable land use. Only one out of fifty-nine respondents answered "no" to this question.

The next section of the survey included the open ended question: "What are the greatest challenges to successfully implementing sugarbush management?" Foresters' most common responses related to communication with sugarmakers or landowners concerned the importance of a diverse forest, and the need to cut some maples to improve growth and regeneration of remaining crop trees. Another common response related to the impediments for implementing forestry activities once sap collection tubing was in place.

Foresters: continued on page 22

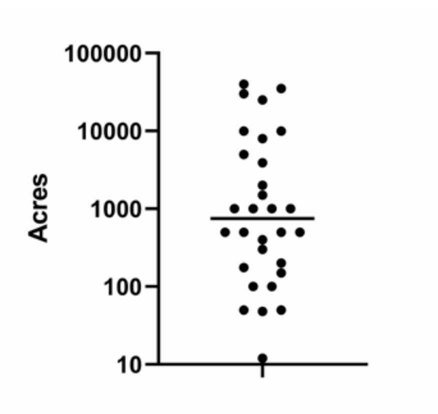

Figure 1: Individual responses from foresters to the question: "In total, how many acres of sugarbush do you assist with?" Black line represents the median value. n=29

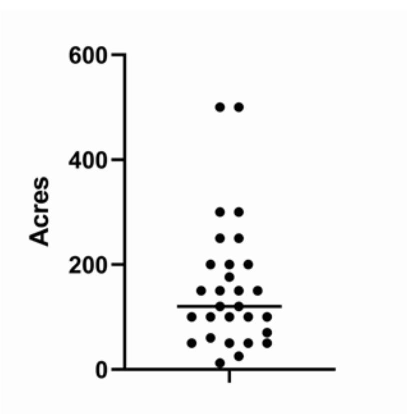

Figure 2: Individual responses from foresters to the question: "What is the average size property that you help manage for maple production?" Black line represents the median. n=30

Foresters: continued from page 21

Foresters were asked if there were differences in how AMP's were implemented in sugarbushes compared to properties managed for other forest products. The response was almost an even split with 52% indicating "yes" there were differences and 48% saying "no." Responses from those foresters who said "yes" generally stated that road system design and the need to preserve access to the woods at all times of the year (especially during the sugaring season) made management more like managing a recreation area than a typical logging job that might only need access every 10-20 years. The number and durability of water bars was pointed to more than once as a difference, as well as quality of stream crossings, culverts and bridges.

Sixty-six percent of foresters recommend a 10-20 year interval between harvest entries in a managed sugarbush. This compared with 29% recommending intervals greater than 20 years. Just over 5% of respondents (3 individuals) recommended intervals of less than 10 years. Foresters were also asked how the harvest intervals in stands with installed tubing compared to properties managed for other forest products. Just under 52% responded that the interval was longer, compared to 42% who that said the interval was no different. Just under 7% (4 individuals) said that the interval was shorter.

Seventy percent of foresters indicated that they adjust their SBM approach on stands with below average site quality. Some foresters suggested that retaining more trees that would not make quality saw timber, others would retain species more well-suited to the site and others talked about reducing the number of taps or increasing minimum diameter for a tapable tree.

When asked if silvicultural prescriptions for dealing with invasive species differed for stands managed for sap production compared to those managed for other objectives, 70% of respondents answered "no." Of the remaining 30% who said "yes" the most common answer suggested that differences depended on if the sugarbush was certified organic or not (herbicides are prohibited in certified organic sugarbushes).

The final survey questions asked foresters about their primary concerns and what they view as the positive aspects or benefits of stands managed for maple production.

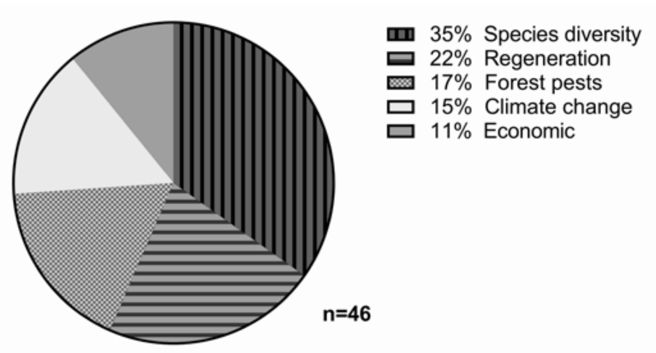

Figure 3: Answers from foresters to survey question: "What are your primary concerns with respect to forest lands managed for maple production?" (Individual responses grouped to summarize data). n=46

These open-ended questions elicited many detailed responses. Responses were coded into categories with similar themes. In response to the question "What are your primary concerns with respect to forest lands managed for maple production?" foresters' responses were grouped into five broad categories (Species Diversity/Forest Health, Regeneration/Forest Management, Forest Pests, Climate Change, and Economic). Thirty-five percent of those who expressed concerns about stands managed for maple production responded that their primary concern was related to species diversity or a general concern that sugarbushes tend to promote the development of monocultures (Figure 3). Concerns about regeneration (maple regeneration specifically) represented 22% of the responses. The remaining answers were roughly split between concerns about "Forest Pests" (17%), "Climate Change" and "Economic" (five individuals or 11%). Concerns about economic impacts of stands managed for maple production appear to be concerned with a perceived "bubble" in the growth of maple production. Some suggested that the relatively strong price for maple products will collapse if market demand does not keep pace with supply.

When asked to describe the primary benefits of stands managed for maple production (Figure 4), responses were coded into four broad categories (Economic/Financial, Forest Retention, Carbon Sequestration/Carbon Storage, and None), 45% of respondents (23/51) cited economic benefits including the annual income generated from maple products or the payments from sugarmakers who lease the trees. The next highest-ranked benefit was "Forest Retention" (43% or 22/51). A smaller group of responses referenced "Carbon Sequestration/Storage" as a benefit (8% or 4/51). 2 out of 51 respondents answered "None" and

Foresters: continued on page 25

Foresters: continued from page 23

suggested that there are no positives or benefits to forest lands managed for maple production).

Discussion

The technology and practices for harvesting maple sap have changed dramatically over time. Academic research and industry innovation have effectively doubled potential sap yields over the past 25-50 years. Far fewer innovations been made to update the instruction and practice of growing crop trees over the same period. Foresters are often hired to help forest landowners achieve specific goals including developing and maintaining productive and healthy sugarbushes, despite the fact that few if any college-level forestry courses expose students to the concept of sugarbush management. Professional foresters must therefore modify practices developed for other forest products such as timber production.

Concerns expressed by foresters about potential negative impacts of stands managed for maple production focused on loss of biodiversity, regeneration and forest health including invasive plants and insects. Few expressed concern about the direct impact of tapping on maple tree health and all but one of those responding (or 98% of foresters surveyed) consider maple sugarbush management a sustainable land use. Recent work by van den Berg et al. (2016) has highlighted the importance of growth rates, crown position and vigor in assessing the sustainability of sugarbush management. Whereas timber forest products management requires foresters to inventory stands and produce estimates for yield ahead of harvest activity, only 19% of foresters considered sap yield when assessing a stand for maple production. This is despite the strong relationship between tree size and yield (Isselhardt et al. 2018). Concepts that integrate this knowledge will provide an important foundation for future sugarbush management guidelines and help solidify foresters' perceptions of the sustainability of maple production long-term. Moreover, integrating regeneration and forest health goals more directly with sugarbush management guidelines will ensure the long-term sustainability of sugarbush management in an increasingly uncertain future.

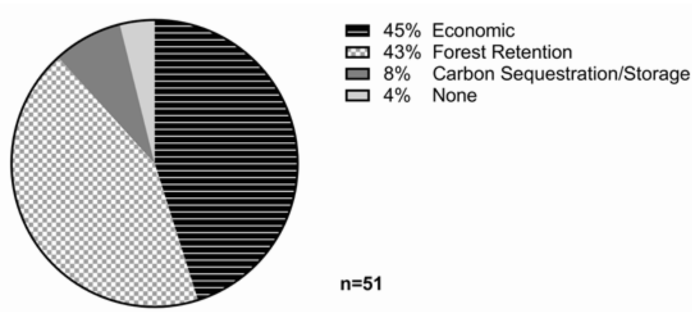

Figure 4: Answers from foresters to survey question: "What do you view as the positive aspects or benefits of forest lands managed for maple production?" (Individual responses grouped to summarize data). n=51

Foresters: continued on page 26

Foresters: continued from page 25

Conclusion

The production of pure maple syrup requires harvesting a non-timber forest product (maple sap). While harvesting practices have changed dramatically over the history of maple production in North America, published guides to the management of maple trees for sap collection have not kept pace. Foresters are largely left to lean on practices used in cultivating other northern hardwoods forest products such as timber despite fundamental differences in the two products. Respondents overwhelmingly view SBM as a sustainable land use. Those responding to the survey expressed concerns about impacts on diversity (species and forest structure), regeneration, forest pests and climate change in relation to stands managed for maple production. Foresters focused on the economic (annual income) and ecological (forest retention) implications when asked about benefits of stands managed for maple. New recommendations for sugarbush management should seek to integrate sustainable, high yield practices and while addressing foresters near and long-term concerns.

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Railroads, Syrup Plants, and Pipelines: Large Scale Syrup Production Over a Century Ago with The Horse Shoe Forestry Company

Matthew M. Thomas

In the current world of maple syrup production, it is common to find industrial scale maple operations tapping tens of thousands, even hundreds of thousands of trees. In contrast, 125 years ago most maple operations were less than one thousand taps and a sugarbush with more than five thousand taps was rare. However, the Horse Shoe Forestry Company's maple sugar and syrup operation at the turn of the last century with its 50,000 taps, defied convention and was built on a scale and model unlike anything before or for years after.

The Horse Shoe Forestry Company maple operation was the creation of Abbot Augustus Low, Sr., a multi-millionaire from Brooklyn, New York who, in the late 1890s, purchased 45,000 contiguous acres of forested land and lakes on both sides of the Bog River in the Adirondacks of northern New York. Low was a wealthy man who was known to not spare expenses, and when he settled on the idea of using his forest for making maple syrup he started big and grew even bigger. In 1897, his first year of syrup making, he started with two moderate-sized sugarhouses containing two evaporators each, and about 10,000 taps. The operation continued to expand, and by 1900 A.A. Low had replaced the two sugarhouses with four enormous syrup plants housing at least sixteen of G.H. Grimm's largest-sized Champion evaporators.

The sprawling Wake Robin syrup plant on the southeast shore of Horseshoe Lake in 1901. Image Courtesy of the Library of Congress.

To operate these plants and gather this much sap, Low employed a small seasonal army of more than

History: continued on page 30


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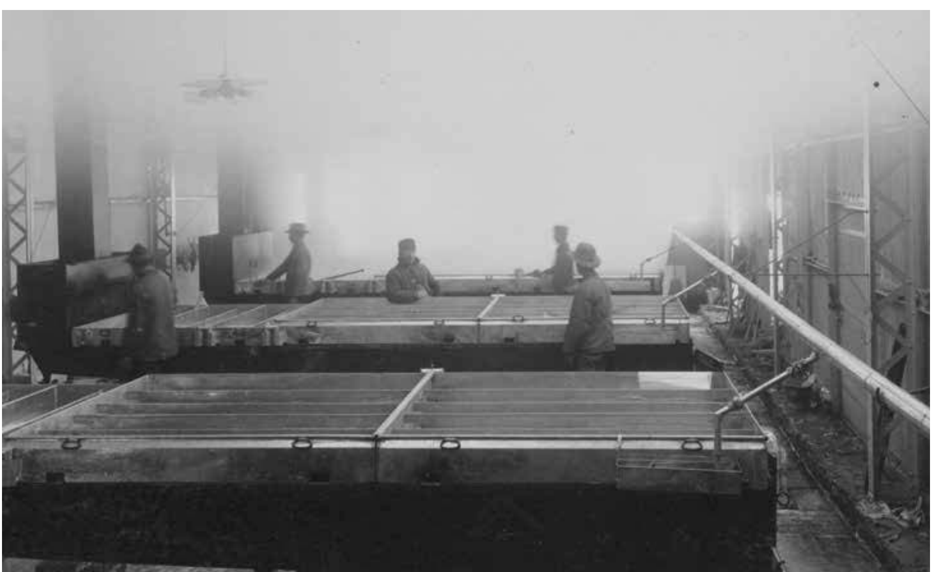
History: continued from page 28

one hundred workers, at times hiring knowledgeable maple producers from Vermont and New York. Growing up in the home of a wealthy shipping family, Low had no background or experience with maple production. Sap was gathered by hand from covered metal sap pails and hauled in tanks pulled by teams of horses. The Horse Shoe Forestry Company sugarbush spread across a large landscape and to facilitate the movement of sap, men, and supplies, A.A. Low constructed his own private railroad. Initially built using narrow gauge tracks but later upgraded to standard gauge, Low's railroad maintained at least four locomotives and spread out from the center point at the Horseshoe townsite on three lines like spokes on a wheel. In hillier sections sap was gathered and moved through two-inch diameter metal pipelines with dump stations running sap downhill to tanks placed alongside the rail lines, or directly to the syrup plant.

The three primary syrup plants, with their individual names (Maple Valley, Wake Robin, and Grasse River) were connected to their own respective rail lines over which the sap was brought in large tanks placed on flat bed rail cars. The 75-foot by 90-foot Maple Valley syrup plant was Low's showpiece building boasting a metal frame and metal walls, wood and sap storage, a finishing and settling room, and a boiling room floor covered in marble slabs on top of which stood five 6 x 18-foot wood-fired Grimm evaporators.

Low's use of the lands on his estate was not only limited to making maple syrup on a grand scale. In addition to the syrup plants and railroads, he built mills at four locations for sawing logs, cutting lathe, and planing lum-



View of the group of five large Grimm evaporators inside the Maple Valley syrup plant. Image Courtesy of the Library of Congress.

ber; provided boarding houses and family housing for his workers; and maintained a farm and stock to help feed his employees in the wilds of the Adirondacks. He personally saw to the construction of a formal railroad station for the New York Central rail line at Horseshoe Station since the shack that had originally been built by the railroad was not up to his taste or standards. In the early years, A.A. Low's buildings were electrified and lit by a network of power lines and steam powered generators which were replaced with Low's construction of two private hydro-electric dams in 1903 and 1907. Like many wealthy New Yorkers who bought large estates in the Adirondacks to establish recreational camps, Low's estate also included a twenty-building private retreat known as Camp Marian (today Camp Otterbrook) for family and friends.

Low is sometimes credited with having the second most patents to his name, after Thomas Edison. While it is true that Low both invented and patented a wide variety of items and also used his wealth to develop the ideas of engineers and craftsmen he employed, his mythical rank as a patentee is not true. Interestingly, he did help develop and patent an early version of a steam-heated maple syrup evaporator, complete with a scale prototype. However, it was never put into operation in his syrup plants.

Combined with a certain vanity and an understanding of the value of branding and advertising, Low went as far as having his own embossed glassware made for bottling syrup and packaging maple sugar and individually wrapped maple candies that he called maple kisses. A.A. Low purchased all his ma-

History: continued on page 32

One of the Horse Shoe Forestry Company steam locomotives on their private rail line loading sap for transport to a syrup plant. Image Courtesy of the Library of Congress.

History: continued from page 31

ple sugaring equipment from G.H. Grimm out of Rutland, Vermont and even worked with Grimm to develop and manufacture two unique sap pail covers, also embossed with the Horse Shoe Forestry Company name. G.H. Grimm in turn highlighted its connection with the Horse Shoe Forestry Company in its advertising, proudly noting the largest maple sugar camp in the world used Grimm equipment.

Three examples of the special embossed bottles and jars used by the Horse Shoe Forestry Company for packaging maple syrup and maple sugar. Image courtesy of the author.

Despite the enormity and sophistication of the Horse Shoe Forestry Company maple sugaring operation, it lasted only twelve sugaring seasons. In September 1908, a wildfire started by embers and sparks from a passing locomotive coupled with a severe drought in the forest of the Adirondacks, led to the destruction of A.A. Low's maple forest. Amazingly, all of Low's syrup plants, mills, great camp, and worker housing were saved. However, with the loss of the maple forest, it was impossible to continue to produce maple syrup, and the operation came to an end. Valuable infrastructure and equipment were sold, and in time the remaining buildings not put to new uses were salvaged or left to rot and return to the forest. Low himself passed away four years later. Over the ensuing years the family sold the estate to other private owners with the majority of the property eventually being sold to the State of New York and added to the lands of the Adirondack Forest Preserve. While short in lifespan, the grandeur of A.A. Low's maple operation is a story that still fascinates and amazes and has left its mark in the annals of maple industry history.

You can a read a more detailed account of the story of the Horse Shoe Forestry Company in Matthew Thomas's book A Sugarbush Like None Other: Adirondack Maple Syrup and the Horse Shoe Forestry Company, *available for purchase online at eBay and in various locations in New York and Vermont.*

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