Northern NY Agricultural Development Program
2022 Project Final Report

Feasibility of American Beech Syrup Production in Northern New York

Project Leader

Adam D. Wild, Director, Uihlein Maple Research Forest; Co-Director, Cornell Maple Program; Senior Extension Associate, Cornell University, Uihlein Maple Research Station, 157 Bear Cub Lane, Lake Placid, NY 12946, 518-523-9337; adw94@cornell.edu

Collaborator

Michael Farrell, Ph.D., CEO, The Forest Farmers, 4448 RT. 374, Lyon Mountain, NY 12952, 518-637-7000; mike@theforestfarmers.com

Background

Tapping maple trees for syrup production has been an economically important agriculture crop production practice across Northern New York (NNY) for generations. Although maple sugaring can yield different products, there is a limited depth of maple-based products for producers to offer consumers. In recent years, maple producers in NNY have ventured outside of tapping solely maple trees and have started tapping birch trees for syrup production thanks to research, techniques, and promotion developed by the Uihlein Maple Research Forest, often with funding support from the Northern New York Agricultural Development Program. Adding birch trees still only taps into two species of trees among several species in the vast forest of NNY. A species yet to be tapped into for syrup production is American Beech (*Fagus grandifolia, Ehrh.*).

American beech, a dominant hardwood forest species across NNY, is abundant in maple forests and, based on preliminary trials, has the ability to be tapped and yield delicious syrup. However, little data-based information is known on tapping beech trees for syrup production. To date, there has been only one published article on the possibility to tap beech trees and produce syrup based on preliminary research conducted at the Uihlein Maple Research Forest in Lake Placid (Wild, 2020). However, this study was only preliminary and did not provide a comprehensive understanding of the yield potential and economic feasibility of tapping beech trees.

Currently, beech trees have no real economic value in NNY forests partially due to beech bark disease that slowly kills off the aboveground structure of beech trees, often before they reach maturity. Root structures remain living and send up a prolific amount of root sprouts that form into saplings. As a result, forests in the Northeast are left with a large amount of young beech that have the potential of shading out regeneration of maples and making it cumbersome for producers to move through forests.

Because of beech trees' low economic value and lack of palatability to deer, forest owners and managers have been attempting to remove beech from northern forest. Because of the prolific amount of root sprouts from beech trees in the understory of NNY forests, it would be beneficial to find a use for this high abundance of beech saplings. If value could be derived from beech trees, there would be reason to leave beech trees within the forests of NNY, thus helping to maintain the biodiversity of the forestland as well as creating a potential new revenue stream for NNY maple producers and forest owners.

Demand by consumers for beech syrup exists but extensive research is needed to determine the most economical and efficient methods for sap collection and processing to create a marketable product. Only one commercial producer of beech syrup exists in the world, i.e., The Forest Farmers, a NY-Vermont based enterprise founded by former Cornell Maple Program and NNY Maple Specialist Michael Farrell, Ph.D., who is a collaborator on this NNYADP project. The Forest Farmers has tapped beech trees the past couple of years and has successfully produced beech syrup. Beech syrup produced by The Forest Farmers has recently gained interest through articles in the New York Times (*Fabricant, 2019*) and Boston Globe (*Campbell, 2020*) allowing them to sell out of beech syrup each year. However, the best process for collecting sap and identifying the economic viability of tapping beech trees remains unknown (*Mike Farrell, personal communication, 2022*).

Due to past forest management practices and beech bark disease, many NNY forest are limited to smaller diameter beech trees. This research is a step toward determining if there is merit in tapping beech saplings (if they will yield high enough quantities of sap for profitable syrup production).

Methods

Primary research for this project took place at the Cornell University Uihlein Maple Research Forest in Lake Placid, NY, with additional data collected at The Forest Farmers commercial syrup production facility in Lyon Mountain, NY.

Sap Yields

To quantify total sap yields from different tree sizes, 17 beech trees - grouped into three sizes classes: (a) 3.0-5.5 inch diameter trees (n=7 trees), (b) 5.6-8.9 inch diameter trees (n=6 trees), and (c) 9.00 inches in diameter trees or greater (n=4 trees) - were tapped. Each tree was tapped on April 5, 2022, using traditional maple tapping techniques, such as drilling with a 5/16-inch diameter bit to a depth of 1.75 inches into each tree. A polycarbonate maple spout was tapped into the tree with a section of 5/16-inch diameter tubing connecting the maple spout to a sap collection canister. A separate tubing line was connected from the top of the canister to a vacuum system for maple sap collection, provided vacuum to the canister and at the tap hole. Vacuum was maintained around 25 in/hg throughout the sap collection period.

Sap sweetness and sap volume data were recorded daily from each canister unless there was a cold period. Sap sweetness was collected in the field using a Misco PA201 digital refractometer. Sap volume was collected through measuring the depth of sap in the vessel. Total sap volume was calculated based on the depth of sap in the canister and the volume of the canister totaled across the sap flow season.

The first day of sap was collected on April 6, 2022; data on the final sap flow event was collected on May 2, 2022. Total syrup production was calculated daily using the sap sweetness and sap volume with the assumption of reducing the sap to 66º Brix, typical practice for maple production using the rule of 87: Ratio of sap to syrup (66º Brix) = (87.1/%sap sweetness) – 0.32 (*Perkins & Isselhardt, 2013*).

At The Forest Farmers' location, approximately 4,000 beech trees, mostly ranging from 6-9 inches in diameter, were tapped with a commercial beech sap production system using standard maple tubing sap collection under high vacuum.

Tree Health and Growth Assessment

Beech bark disease is a fungal pathogen that forms quarter-size cankers in the main bole (trunk) of a tree, limiting the flow of sap within beech trees during the growing season. This could potentially limit spring sapflow for syrup production. To determine sap production levels of trees infected with beech bark disease, trees tapped at the Uihlein Research Forest and a subset of trees at The Forest Farmers' location were assessed using a visual rating scale. Severity of beech bark disease was ranked on the following scale:

0 = no beech bark disease present
1 = sparse cankers on the tree stem
2 = moderate amount of cankers covering less than 50% of the main bole
3 = heavy infestation covering more than 50% of the stem, and
4 = extreme infestation where cankers are coalescing with each other to completely cover the stem or almost completely cover the stem.

At The Forest Farmers, trees were sampled by walking 7 transects through the forested area. Transects were determined by walking along a mainline and sampling every tapped tree connected on the uphill side of the mainline. A total of 124 trees were sampled at the Forest Farmers.

Growth of the tapped beech trees was assessed by measuring the rate at which the taphole closed on the tree. This is often a measure used for determining health of maple trees that have been tapped and has been used for research to assess the health of trees (*Huggett et al., 2007*). Taphole closure was visually assessed at both locations on the following rating scale:

0 = no closure
25 = 1-40% taphole closure
50 = 41-74% taphole closure
75 = 75-99% taphole closure, and
100 = complete taphole closure.

Healthy maple trees should close a taphole within two growing seasons and it is presumed that it should be similar for beech. Taphole closure was measured in December 2022 from that season's tapholes and from the trees tapped in the 2020 and 2021 seasons to determine the rate of growth of individual trees at the end of the growing season

Syrup Processing

To produce a salable beech syrup product, optimum processing methods needed to be established.

Half of the sap collected at Uihlein was boiled down into syrup using a steam kettle and finished on a stovetop; the other half was passed through a small-scale reverse osmosis (RO) unit to concentrate the sap to 4% sugar. Syrup from both processing methods was finished to 66% sugar. After finishing the syrup, most samples were filtered using a prefilter cloth and felt filter. Some samples were not filtered to compare the difference between filtering and unfiltered syrup.

Lab Analysis
Two samples of beech syrup (one from 2021, one from 2022) and one sample of maple syrup for comparison were sent to Dairy One Laboratory, Ithaca, NY, for evaluation of mineral content, pH, and crude protein.

Results
Tapping
Preliminary testing of the tapping of beech trees prior to the project found that vacuum was necessary to harvest sap from beech trees. Trees tapped with buckets did not yield any sap. Vacuum is important to create negative pressure at the taphole to collect beech sap. Traditional maple spouts and tubing under vacuum were effective in collecting beech sap. Different levels of vacuum have not been tested on beech trees, but based on maple sap collection, the higher the vacuum, the higher the maple sap yield, which would most likely be true for beech trees as well. Testing different tapping depths and taphole diameters was not evaluated in this project, but is worthwhile to test. If tapping smaller diameter beech trees, a smaller diameter taphole would most likely be best for tree health.

Timing of Sap Flow
More research is needed on the timing of tapping to determine the optimum time for beech sap flow. For this project, beech trees were tapped in early April 2022, which was around halfway through the maple sap collection season. Sap flowed immediately if vacuum was added. Sap was collected until early May 2022, well past the maple sap flow season.

It is believed that the best time for beech sap flow is midway through the maple season and to the end of the birch sap flow season (after maple season) when the beech buds are about to open. It is important to note that beech buds open later than maples.

Freezing and thawing temperatures do not seem to dictate the flow of beech sap as they do for maples. Beech sap will flow as long as the weather is well above freezing *and* the ground is well thawed out. We are under the impression that the best time to tap beech trees is once the ground is fully thawed and a significant amount of the snowpack has melted. There needs to be significant ground moisture to be pulled in by the tree roots and pulled up through the tree through the vacuum applied to the tubing system.

More research on tapping at different intervals of the spring thaw is needed to determine the optimum time to tap a beech tree.

Sap Volume, Syrup Yield and Sweetness
Larger diameter beech trees produced significantly more sap than smaller diameter beech trees (Figure 1). Trees in the 3-5.5 inch diameter size class produced an average of 2.3 gallons of sap and 0.1 pints of syrup across the season. The medium size class of 5.6-8.9 inch diameter trees produced an average of 5.4 gallons of sap per tap and 0.25 pints of syrup. Larger diameter trees (although still not large beech trees) of 9-11.4 inches in diameter produced 12.6 gallons of sap per tap and 0.7 pints of syrup.

Production numbers from the smaller trees are very low, but to be expected. However, number of stems per acre is much higher for smaller diameter beech trees, which could make up the difference in sap production. However, with more stems per acre, spout and tubing costs would increase on a per-acre basis.

Larger class beech trees produced sap volume close to that of maple trees of similar diameter. However, the average sap sweetness was only 0.5%, much less than the 2% average sap sweetness in maple trees, which translated into significantly less syrup per tap than a maple tree.

Larger trees did tend to have slightly sweeter sap, although it was not a significant difference (Figure 2A). Sap sweetness tended to be highest early in the season with the larger trees maintaining 0.7-0.8% sugar during the first third of the sap season, dropping to as low as 0.3% at the end of the season (Figure 2B). In previous preliminary research, beech sap sweetness was as high as 1.0%.

As with sap yield, syrup yield per tap increased with tree diameter (Figure 3). One tree that was 8.6 inches in diameter was an outlier in production with poor yields. Significant beech bark disease was most likely the reason for the poor performance. If this outlier is removed, the sap yield per tap for 5.6-8.9 inch diameter trees increases to 5.9 gallons. The outlier is included in all the Figures and calculations.

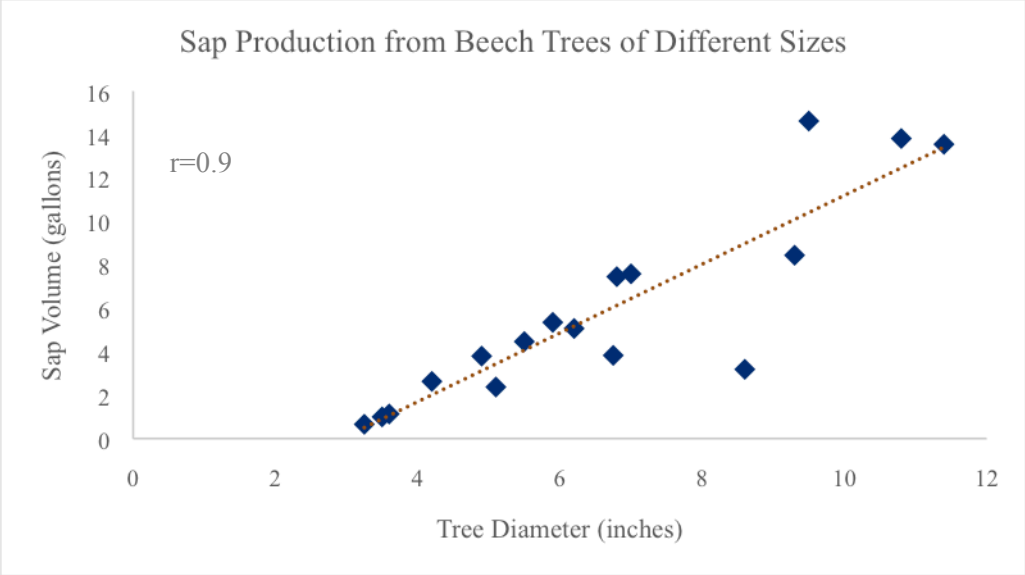

Figure 1: Trees with a greater diameter produced more sap per tap. One exception: an 8.6-inch diameter tree with severe beech bark disease that most likely reduced yields. NNYADP Feasibility of American Beech Syrup Production in Northern New York project, 2022.

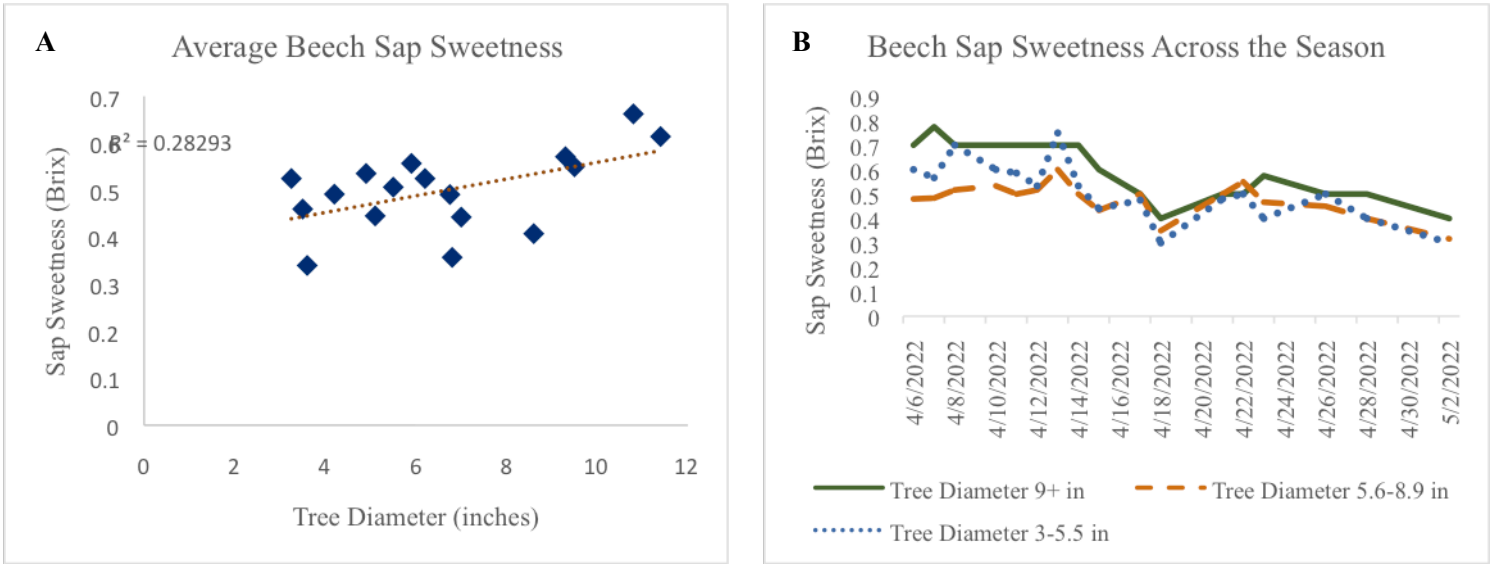

Figure 2 (A): Sap sweetness from individual beech trees of different sizes. Larger trees produced slightly sweeter sap although the difference was not significant. (B): Sap sweetness across the season for different size classes. NNYADP Feasibility of American Beech Syrup Production in Northern New York project, 2022.

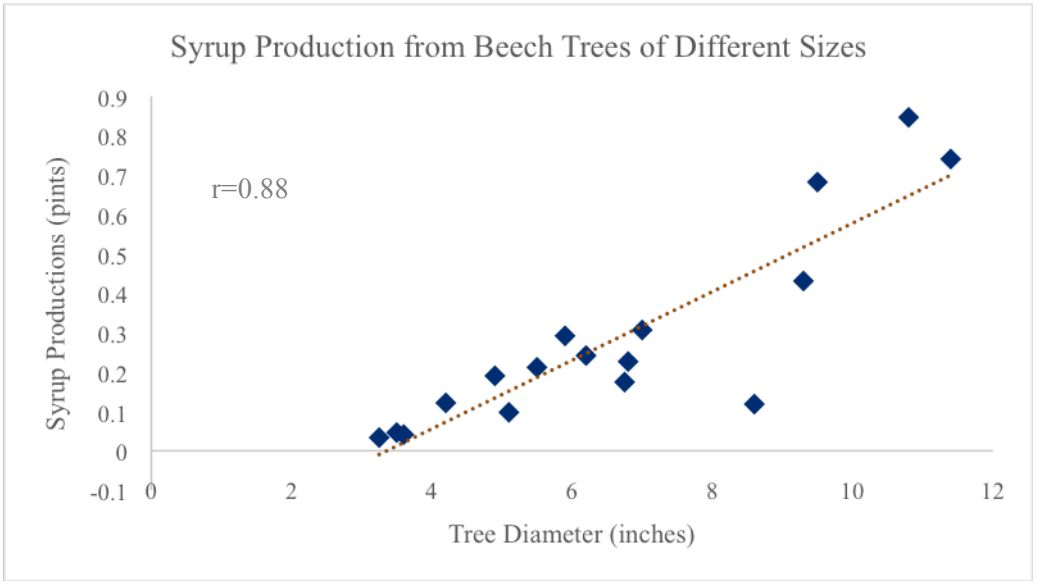

Figure 3: Trees with a greater diameter produced more syrup per tap. One exception: an 8.6-inch diameter tree with severe beech bark disease that most likely reduced yields. Due to the low sap sweetness that results in lower syrup production, syrup yields are shown in pints per tap instead of gallons per tap. NNYADP Feasibility of American Beech Syrup Production in Northern New York project, 2022.

Sap to Syrup

Cooking beech sap down into syrup produced a delicious product unique from other tree syrups. The finished product is sweet with notes of raisins, dried plums, and dried pears. We did not have enough sap at the Uihlein Forest to boil down in a traditional evaporator, so the sap was reduced in a steam kettle and finished on the stove top. The Forest Farmers process their beech sap through a steam evaporator.

Due to the significant amount of concentrating required (140 gallons of beech sap:1 gallon of syrup), a significant amount of minerals precipitate in the syrup in processing and need to be filtered before packaging. In addition, a gel-like structure can sometimes form when processing beech sap into syrup, adding difficulty in filtering the finished syrup (see section on syrup compounds).

Reverse osmosis significantly speeds up the boiling process and is highly recommend for commercial production. Even concentrating to 4% sugar can remove as much as 85% of the water. Oddly, beech sap that was pre-concentrated through an RO did not seem to form the gel-like structure in the finished syrup. The RO should not have filtered that out. Perhaps less time boiling kept the gel from forming. More research is needed to answer this question. Syrup made from beech sap that went through RO did produce syrup that was lighter in color and flavor than the same sap that boiled to evaporate all of the water.

Sap & Syrup Compounds

Sap samples are still being processed for type of sugar and mineral compounds at the time of this report. Syrup samples were sent for mineral content, pH, and protein. Not surprising, mineral content of the beech syrup was much higher than for a sample of maple syrup due to the higher ratio of sap to finished syrup. (Table 1). In particular, calcium, potassium, and manganese were much higher.

The pH of the beech syrup was on the acidic side (4.85), while maple syrup tends to be more neutral (6.6). It was initially thought that the gel-like structure that can form in the beech syrup (especially when cooked without first concentrating by RO) was thought to be pectin. Syrup made from walnut trees produces a gel-like structure that has been previously attributed to pectin; however, through this project, it was discovered that the gel structure in walnut syrup has never been tested and is only presumed to be pectin. Also, upon further research, pectin does gel up upon heating, but is destroyed if heat is applied for too long. Boiling low sugar beech sap into syrup takes an extreme amount of heat for an extended time that would presumably be too much for pectin. We are pursuing options at the time of this report to find a lab that can analyze for pectin.

The amount of protein in the beech syrup was only slightly higher than the maple syrup (Table 1).

	BEECH SYRUP	MAPLE SYRUP
PH	4.85	6.6
% CALCIUM	0.525	0.07
% PHOSPHORUS	0.00	0.00
% MAGNESIUM	0.055	0.02
% POTASSIUM	0.45	0.25
% SODIUM	0.005	0.003
% SULFUR	0.01	0.00
IRON (PPM)	6.5	2
ZINC (PPM)	16.5	5
COPPER (PPM)	2.5	<1
MANGANESE (PPM)	374	25
% EST. CARBS	69.05	74.6
% CRUDE PROTEIN	0.2	0.1

Table 1: Compounds within beech syrup in comparison to maple syrup produced at the Cornell University Uihlein Maple Research Forest. NNYADP Feasibility of American Beech Syrup Production in Northern New York project, 2022.

Tree Health

Severity of beech bark disease did not have a significant impact on sap volume based on the sample of trees at the Uihlein Forest. However, the only tree with the worst infestation rating (4) for which we have individual sap yields did yield less sap than other trees of similar size. Of the 17 trees with individual sap yield data, all had some form of beech bark disease. The majority (35%) had moderate infestation, 29% had sparse infection, 29% had heavy infestation, and 6% (one tree) had extreme infestation. Of the sampled trees at The Forest Farmers, 6% had no infestation, 27% sparse infestation, 34% moderate infestation, 23% heavy infestation, and 10% extreme infestation.

Taphole closure was better than expected for growing conditions in Northern NY. A majority of the tapholes closed within two growing seasons. However, trees with higher severity of beech bark disease were more likely to have slower taphole closure. At The Forest Farmers location, only 7% of the sampled trees had no taphole closure after one growing season, 16% were closed a quarter of the way, 13% were closed halfway, 24% were closed three-quarters of the way, and 40% were completely closed. After two growing seasons (tapped in 2021), 81% closed completely, 8% closed three-quarters of the way, 5% closed halfway, 4% closed a quarter, and only 2% had no closure. After three growing seasons (tapped in 2020), 86% of tapholes were completely closed, 3% were three-quarters of the way closed, 7% were halfway closed, and 4% were only a quarter of the way closed. All the trees that were only halfway closed or less after three growing seasons had extreme to heavy beech bark disease. Tapholes with no closure were often within a beech bark disease canker.

Economic Viability

The Forest Farmers sell beech syrup at $4.50/oz. This equates to $576 per gallon. At that value, a larger beech tree produced around $54 in beech syrup (retail value). In comparison, a similar size maple tree could produce upwards of $60 of syrup per tree if the syrup is sold in small (2 oz.) retail bottles at $1.50/oz. Most maple syrup is sold in larger bottles at less value per ounce. The medium-sized beech trees produced a value of $18.00 per tree in syrup and the small beech trees produced a value of $6.50 per tree. The Forest Farmers have been very successful in selling their syrup at the higher value and are now solely blending a small portion of beech syrup with maple syrup to create a product selling at a value higher than maple syrup alone ($3.00/oz).

Due to the low quantity of syrup per beech tap, blending or sales in very small bottles are the best options for marketing the syrup. Bottling beech sap as a beverage could be an even better option as less energy is required and have a higher economic impact. Larger size class beech trees in the project would yield 134, 12-oz bottles of beech sap, a $335 value per tree when priced at $2.50 per bottle (typical price for bottled maple sap).

Conclusions

The tapping of beech trees for syrup production in Northern NY has potential for creating a new forest product that would allow the utilization of a tree that currently has low economic value. Although the sap sweetness is very low within the sap, there is a market for the syrup with a potential for value much higher than maple, thus maximizing the difference in total syrup yields. Another option would be to sell the beech sap as a bottled beverage instead of trying to concentrate the sap into syrup. This increased the retail value 6-fold over beech syrup and energy inputs required in heat evaporation to produce syrup are not necessary. The Cornell Maple Program is currently developing methods and procedures for producers to bottle and sell maple sap as a functional beverage. Producers who tap beech trees could potentially adopt these procedures to bottle beech sap.

With a new product, extensive research is still needed to have a firmer understanding of tapping beech trees and to develop best practices. We hope to continue research into beech syrup and sap compounds. There is also a need to consider flavor changes at different parts of the season and look further into tapping at different times of the spring. At this time, tapping beech trees did not seem to impact their growth as a majority of the trees we tapped are continuing to grow and closing their old tapholes quickly.

Education and Outreach

Project leader Adam Wild presented the results of this NNYADP Feasibility of American Beech Syrup Production in Northern New York project at workshops with beech syrup samples provided as follows:

- August 2022 Upper Hudson Maple Producers Association, Greenwich, NY
- December 2022 Lewis County Maple School, Croghan, NY; attendees primarily located in Lewis & Jefferson counties; and
- January 2023 Northeastern NY Maple Conference, Brushton, NY; producers primarily located in Clinton, Essex, Saint Lawrence, and Franklin counties.

Beech syrup samples were given to the public during the 2022 New York State Maple Weekends with favorable review. Additionally, results of this project were discussed during the podcast "Sweet Talk: All Things Maple" (Episode 16) posted at https://open.spotify.com/episode/7IyBFziHy4xYN63ZxRSOVV.

Research articles summarizing this research will be submitted to the Maple News, Maple Digest, and Mapleresearch.org.

All these opportunities provided contact with maple producers across Northern New York and the broader national maple-producing market. Acknowledgement of the Northern New Yok Agriculture Development Program was identified as the funding source during each presentation, podcast, and publication.

For More Information

- Adam D. Wild, Uihlein Maple Research Forest, Cornell University, 157 Bear Cub Lane, Lake Placid, NY 12946, 518-523-9337, adw94@cornell.edu, www.cornellmaple.com

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PHOTOS

All photos for NNYADP Feasibility of American Beech Syrup Production in Northern New York project, 2022. Photos by Adam Wild.

Photos from left:
Beech trees tapped for sap collection research at UihlienMaple Research Forest, Lake Placid, NY.

Beech tree with sap collection canister attached.

Beech sap cooking down into syrup. Note the gel structures formed around the edge of the pot.

Photos from left:
Beech sap cooking down into syrup. Note the gel structures formed around the edge of the pot.

Beech syrup produced at the Uihlein Research Forest. The sample on the left was produced by first concentrating through reverse osmosis (RO) before boiling. The sample on the right was only boiled.