



Maximizing Production in your sap collection system

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Hello, My name is Adam Wild. I am maple specialist with the Cornell Maple Program and Director of Cornell Universities Uihlein Maple Research Forest. During the presentation we will discuss ways to maximize production in your sap collection system. We will focus primarily on maple tubing systems as using tubing for sap collection, especially in combination with vacuum will yield more sap.



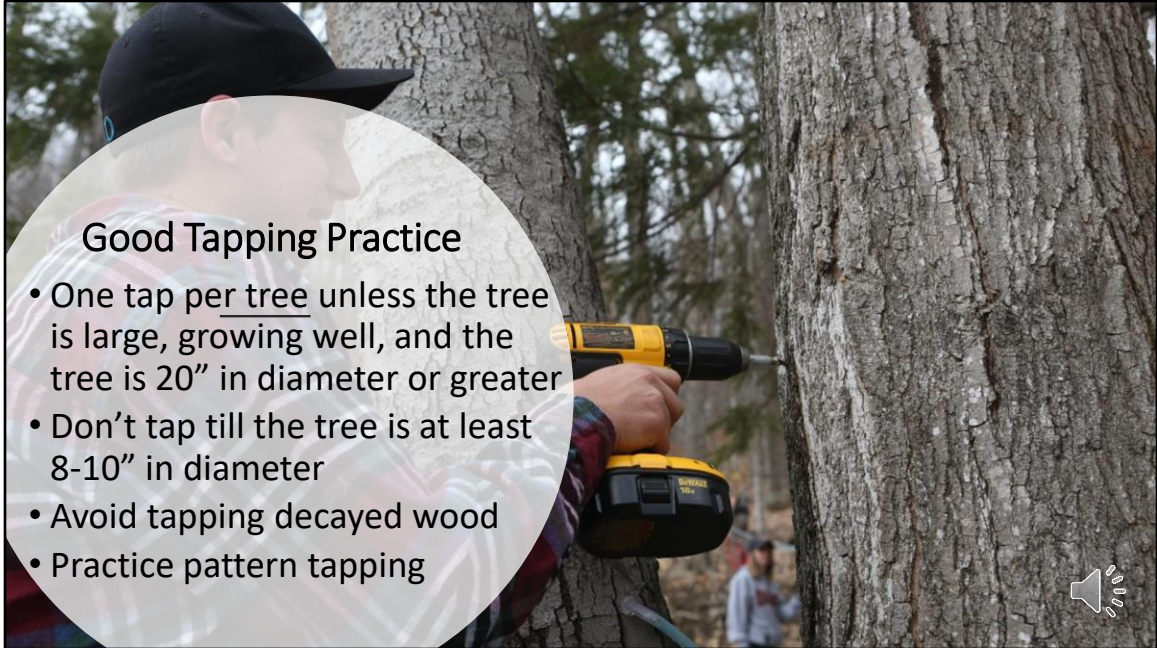
Forest factors impacting production

- Tree health and tree size
- Species composition
- Climate
- Elevation
- Aspect

Every sugarbush has different production potential!

Before we explore different components and techniques that will increase yields, it is first important to acknowledge that every tree or sugarbush has different yield potential. Just because your neighbor or someone two hundred miles away is achieving a half gallon of syrup per tap, does not always mean that you can achieve that within your forest. A sugarbush on the other side of a hill can have very different yields. Also, the amount of sap collected from a tree does not all translate into finished syrup. You will have spillage or loss of sap or syrup through priming pumps, cleaning filters, etc. There are a few factors within the forest that will impact yields. Larger trees and healthier trees will often yield more sap than smaller trees. The mix of species that you have can make a difference. Soft maple usually have a slightly lower sap sweetness which may have lower yields. If you have a lot of conifer in your forest it maybe cooler and take longer to warm up and get sap moving. Where your sugarbush is located will have a huge impact. The season for sap flow maybe longer or shorter in your climate and elevation. Whether you are on a north or south facing slope or your sugarbush is in a valley where the cold air settles and takes longer to warm up will impact when sap starts to flow during the day or season and will ultimately impact yields. Some of the forest factors such as forest health or size can be controlled although we will not get into that with this presentation. For more information on this, reference the material on sugarbush health that are a part of this

webinar series. Factors such as climate and aspect of your sugarbush can not be controlled unless you sell and move somewhere else. Those are factors we live with but let's explore techniques we can control to increase yields.



Good Tapping Practice

- One tap per tree unless the tree is large, growing well, and the tree is 20" in diameter or greater
- Don't tap till the tree is at least 8-10" in diameter
- Avoid tapping decayed wood
- Practice pattern tapping

A simple place to start is by practicing good tapping techniques. First, we want to avoid tapping into old tap columns and the dead wood that is formed. You will not get any sap from the dead wood of the tree. When you are tapping, you should be looking at the shavings that come out of the tap hole. You want to see light colored shavings. If your wood shavings are a darker tan color, then you have hit a section of dead wood. If this was more than 50% of the shavings, I would re-tap the hole. To avoid this happening, explore up and down the tree stem for old tap holes or scars within the tree.

I always recommend only one tap per tree even if it is a large tree. Only if the tree is larger, at least 20 inches, and you know it is growing well should you consider double tapping a tree. We should not just look at tree diameter to determine the number of taps. We need to look at tree growth. A quick way to determine tree growth is to look at old taps holes and see how fast they are closing. Some big, old trees grow very slowly. You need to make sure that as you move around the tree each year with your tap that there will be enough new growth to cover the area where you originally started tapping. When you double tap, you need to have enough growth in time to only go halfway around the tree. Also, adding a second tap does not equal twice the amount of sap if you are using vacuum. Without vacuum it may double your sap yield.

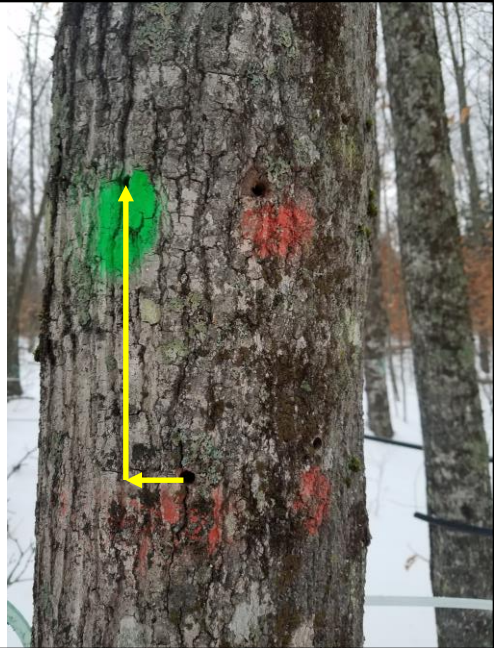
When we use vacuum for collecting sap it will draw sap from more volume within a tree which will include part of the area where a second tap would be. By adding a second tap you may only get 50% more but you are adding a second wound. Where you are located, and the length of your growing season will impact the growth rate of your trees. Smaller trees are going to produce less sap and you will go around the tree faster than a larger tree. You need to have good growth rates on small trees. Don't start tapping a tree till it is at least 8 inches in diameter or greater. **More taps does not always equal greater yield, but it always equals great work.** Focus on getting high yields from healthy trees, not just increasing the number of taps.



A way to avoid tapping into decayed wood is to practice pattern tapping which we will discuss on the next slide. First, let's look at the stain column of dead wood formed by tapping a maple tree. The stain column will travel at least 10 inches above and below a tap hole. 5/16" tap holes often have a smaller stain column.

Pattern Tapping

- Always into new, healthy sapwood
- At least 1" left or right of old tap holes and 8" up and down on the trunk
- Helps avoid hitting old tap holes
- Depth: 1.5-2"



Pattern tapping, as compared to haphazard tapping (randomly picking a spot on the tree), will help avoid tapping into old tap wounds by keeping in a system that slowly moves around the tree and allows time for the trees to put on new growth before you tap on the same side of the tree again. For pattern tapping you will move 1-2" left or right (be consistent year to year) of the previous year tap and go up or down at least 8-10" to create a staggered pattern. By going up and down you avoid straight line tapping (all taps across from each other) which has a higher chance of hitting dead wood and avoids vacuum loss from old tap holes. Old tap holes that are not healing can be a vacuum leak if you are too close to them. The top of a stain column narrows so going up from an old tap hole has less of a chance of hitting decayed wood. At both Cornell maple forests we put a dot of tree marking paint below each tap hole when we are pulling the spouts. We prefer to use a different color each year so that you know exactly how old each tap hole is and can monitor tap hole closure from year to year. In the picture the green paint was the most recent tap hole. Unfortunately, orange paint was used for three years in a row but based on the pattern, I can still know which year the tap hole was from. You can also see in this picture that this tree is not healthy as the tap holes are not closing. If you are a certified organic operation your certifying agency may not allow tree paint. You could use different color thumb tacks.

For tap hole depth, research done at the Proctor Maple Center shows little yield increase from drilling tap holes any deeper than 1.5". If you are tapping a tree for the first time, tap hole depth will not matter as you should have complete living wood. If you are tapping trees that have been tapped for 20+ years a depth of 1.5" is recommended as you will have less of a chance of hitting into dead wood.

When should you tap?

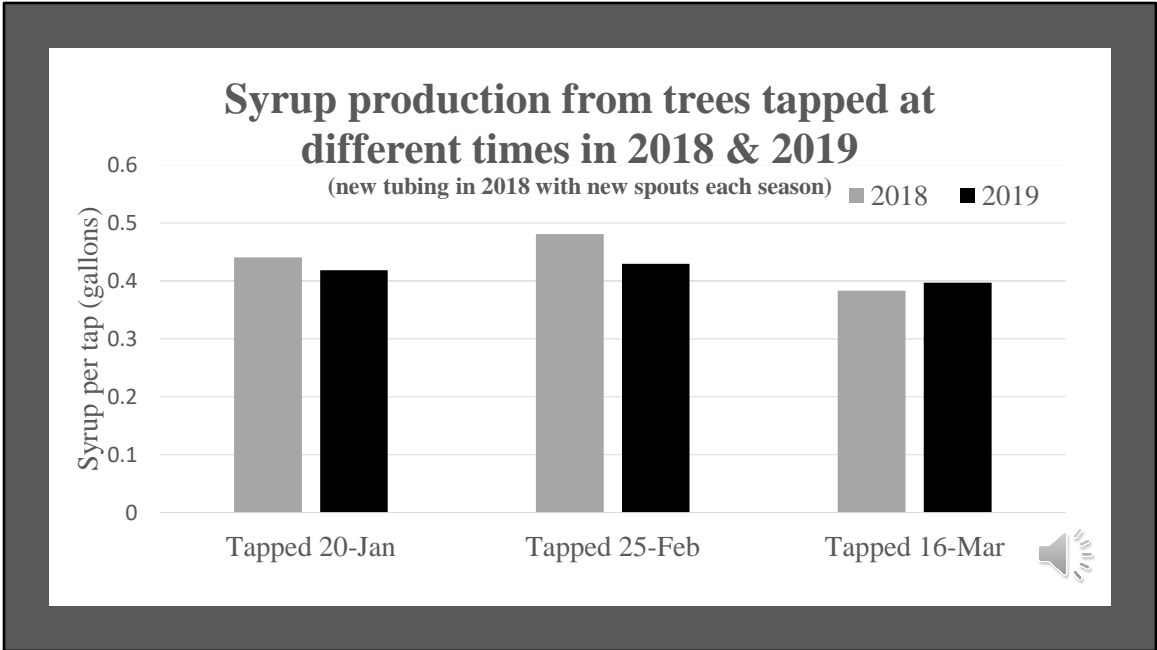


Items to consider before tapping

- How many taps? (How long will it take?)
- Buckets or tubing?
- How old is your tubing?
- What is your dropline replacement cycle?
- Do you use check valves?
- Location of your sugarbush

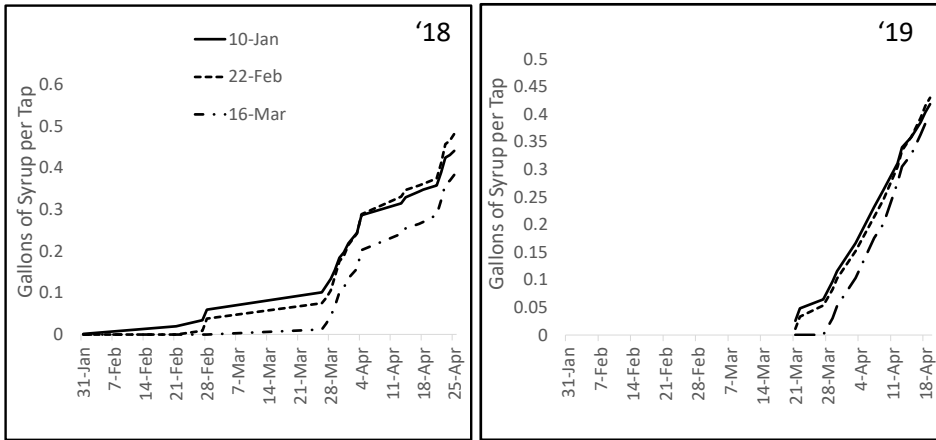


Often, we wonder when is the best time to tap our trees. Unfortunately, there is no magical date for choosing when to tap. There are a lot of factors to consider before you decide on when to start. First, how many days will it take you to tap all your trees? This will depend on the amount of labor you have and the number of taps that you have. If you can tap all your trees in one day, then have a lot of flexibility. If you have several thousand taps and it will take a couple months, then your options are limited – you must start in the early part of winter. If we tap too late you risk missing out on early runs but if you tap too early your tap holes could plug up from microbes sooner and not flow as well in the second half of the season. If you are tapping with buckets you will have an open taphole that microbes in the air can freely enter. If your tubing is old and you do not use check valve spouts you can have more microbes sucked back up into the tree limiting sapflow. The sanitation practice of your tubing and spouts will determine whether you can tap earlier or whether you should wait to tap just before major runs. The location of your sugarbush will determine tapping time as well. A maple producer in WV will tap at a different time than I maple producer in northern NY.



This graph is from a research project at the Uihlein Forest where we looked at production from tapping at three different time periods. We used 5/16" tubing that was brand-new the first year and new spouts the second year (less chance of microbe suck-back into the tree). Major sap runs in the region are typically early to mid March till the end of April. The best production when the trees were tapped in late February which allowed us to catch early runs but did not see as much drop off in sap production later in the season. By tapping at the end of January we certainly caught all early runs, but the tap holes were open for so long that production slowed from microbial plugging later in the season. By tapping in mid March we missed early sap runs and even though the tap hole was open for less time, it was not able to catch up on yields.

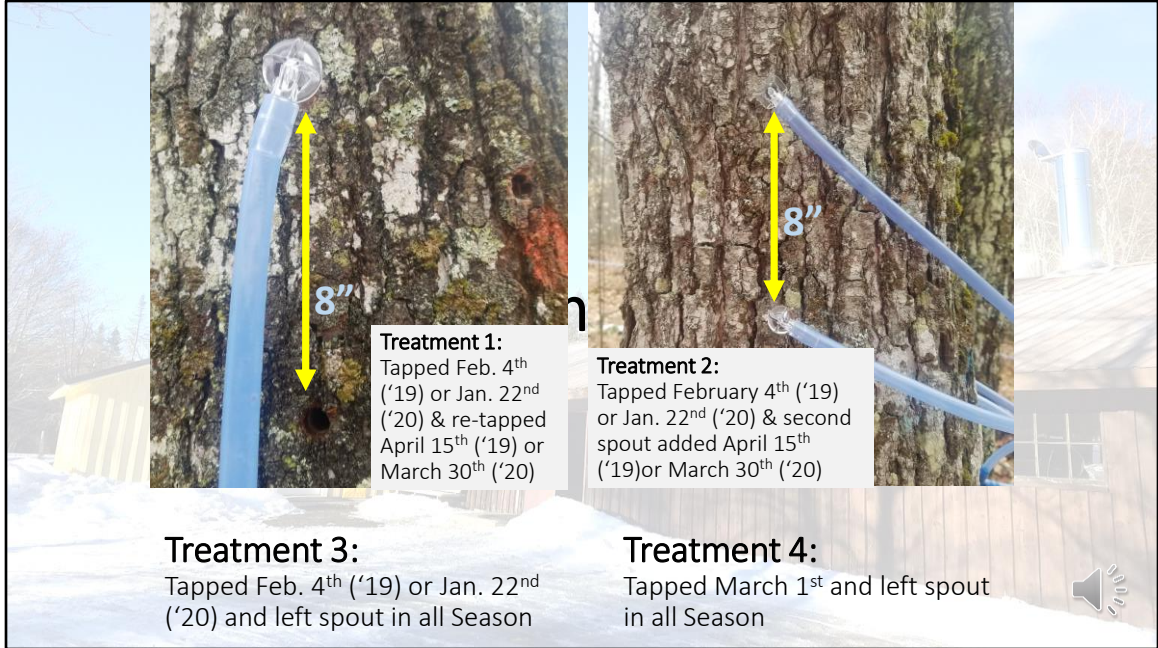
Cumulative Maple Syrup Yield Pert Tap Under Different Tapping Dates



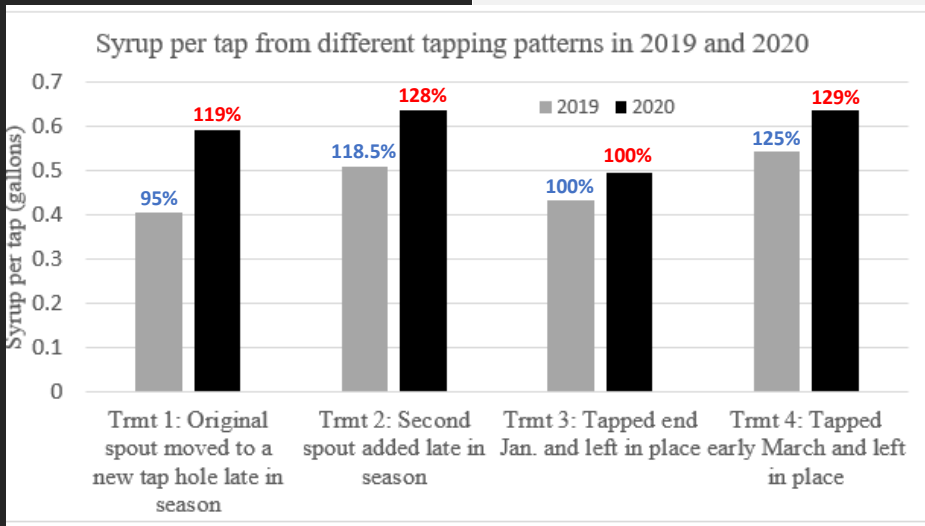
This graph is from the same data but looks across the season cumulatively. Notice that in 2019 sap flow did not begin till later March.



Another project that looked at timing of tapping and sap yields was a re-tapping project, where we looked to add a new tap hole later in the season when sap flow was just starting to slow down due to microbial plugging.



Our first treatment was tapped in early Feb. and just before sap flow slowed the tap (same spouts) was removed and inserted into a new tap hole 8 inches above the previous tap hole. In the second treatment, we tapped in early Feb. and just before sap flow slowed, we added a new dropline and a new spout 8 inches above the original taphole while leaving the original spout in the original taphole. For reference, the third treatment was also tapped in early Feb. and remained in the place the whole season. To compare with timing of tapping we did a fourth treatment where the trees were tapped in early March and left in place all year. I big note to make was that the tubing had been used for a few seasons previously so the microbe contamination potential was high. New spouts were used each season.

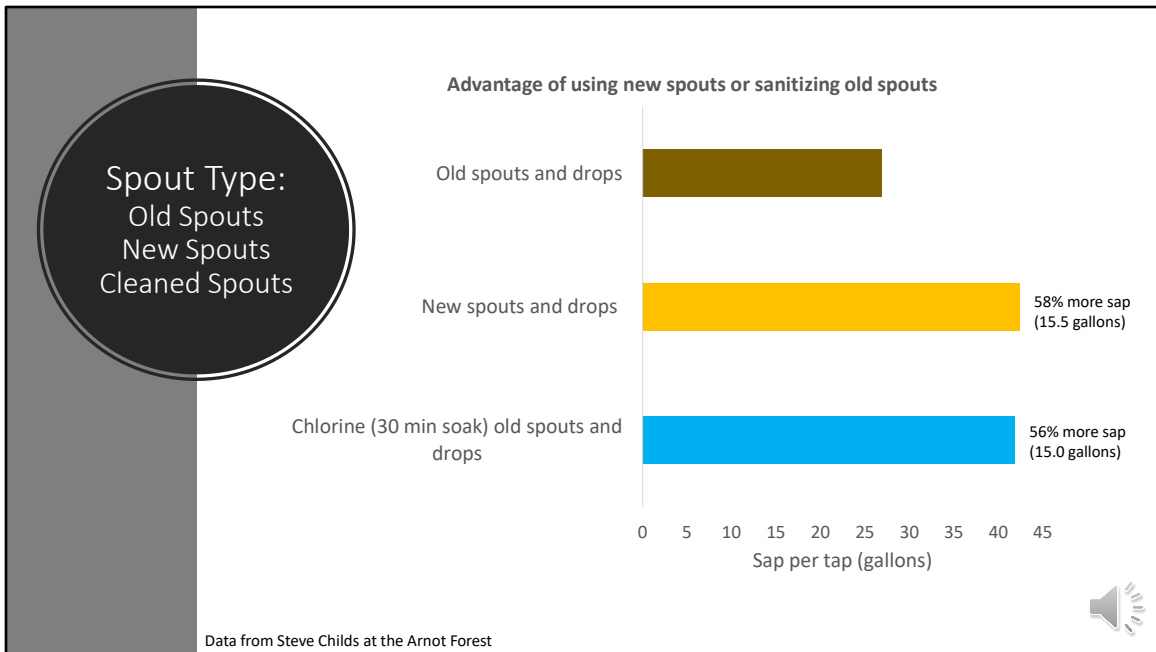


As you can see, in both years, the top performer was when we waited and just tapped in early March. We captured most of the significant sapflow events while limiting the time the tapholes were open. Remember that we were using old tubing and no check-valve spouts. By re-tapping we did gain an increase in yield but was the added time and material costs worth it?

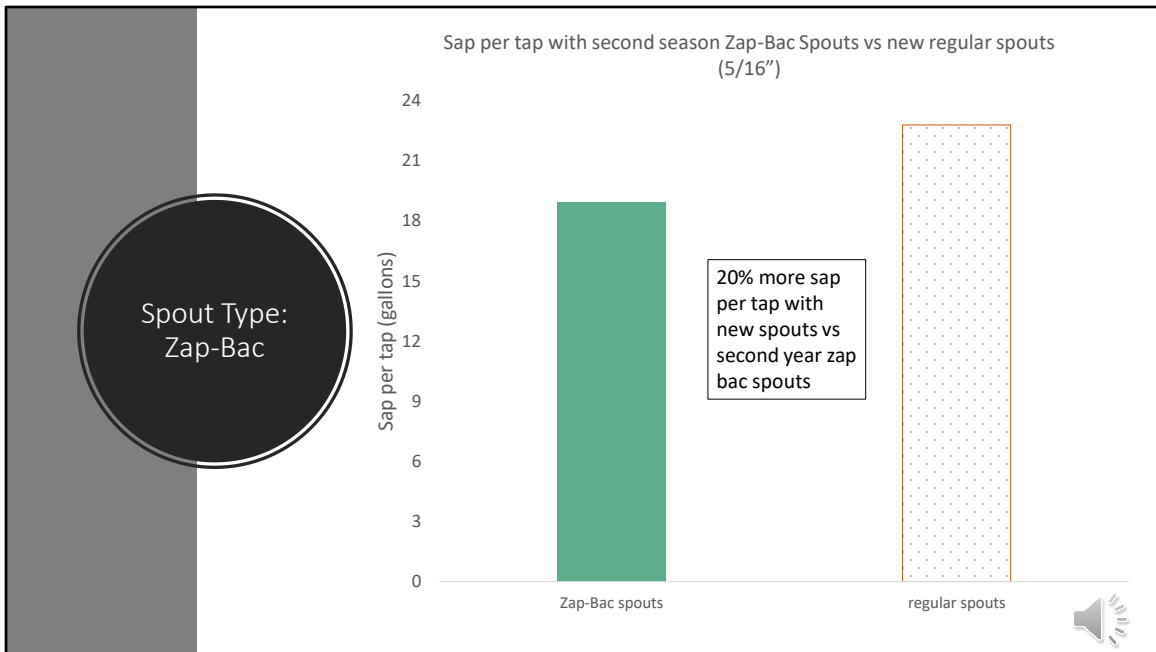


Increase in value of different tapping patterns tested				
	Trmt 1: Original spout moved to a new tap hole late in season	Trmt 2: Second spout added late in season	Trmt 3: Tapped end Jan. and left in place	Trmt 4: Tapped early March and left in place
Average gallons syrup per tap in 2019 & 2020	0.498 gal.	0.572 gal.	0.464 gal.	0.590 gal.
Additional gallons of syrup per tap than trees tapped at the end of Jan.	0.034 gal.	0.108 gal.	----	0.126 gal.
Additional pounds of syrup per tap than trees tapped at the end of Jan.	0.38 lb.	1.20 lb.	----	1.40 lb.
Value of additional syrup @ US\$2.10/lb	\$0.80	\$2.52	----	\$2.94
Estimated additional labor cost to re-tap*	\$1.50	\$2.50	\$0	\$0
Added material cost to re-tap**	\$0	\$0.75	\$0	\$0
Total added value of re-tapping after time and material	\$-0.70	\$-0.73	\$0	\$2.94

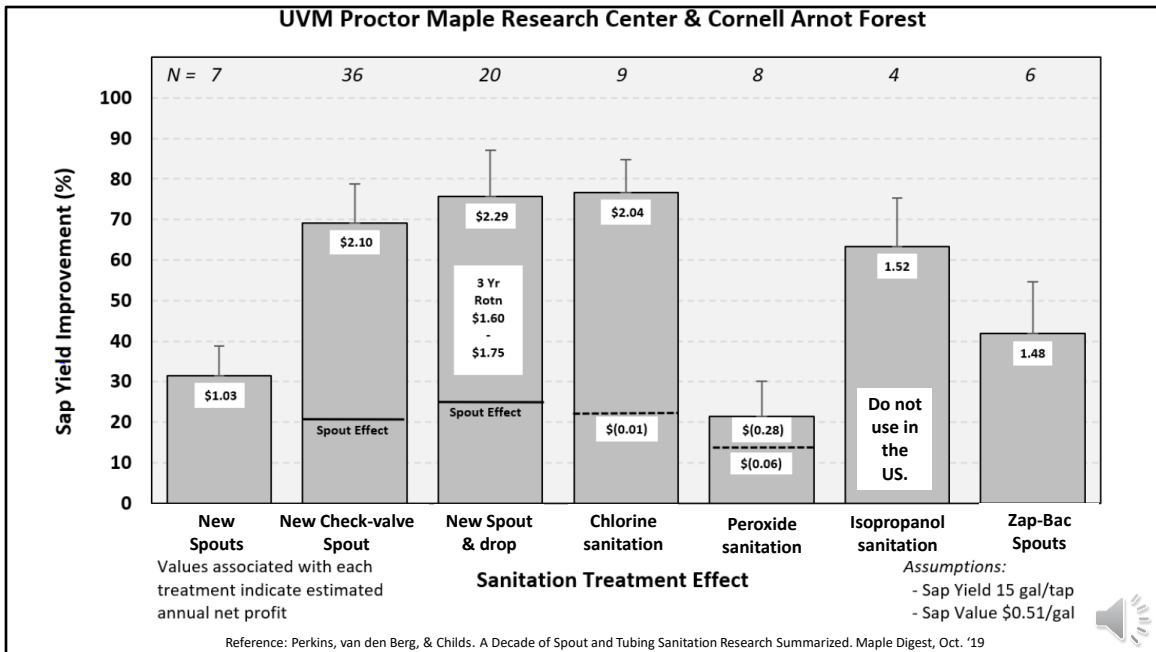
Yes, we gained an increase in sap by re-tapping but was it financially worth it? Bottom line no. As we see in this chart, the added cost in time for re-tapping and material for adding a second dropline and spout was not covered from the added yield in syrup. In addition, although we attempted to re-tap within the same stain column, we potentially created more wounding in the tree by not lining up perfectly. You would be better off tapping right before your season typically started or if not an option, replace your droplines, or use check-valve spouts and you will probably have better yield with less costs. This was in a high-elevation norther forest. In southern maple producing regions where the sap flow season could be longer, re-tapping maybe worthwhile.



Let's explore spout type. If you want to maximize production, you must use new spouts every year or sanitize the spouts. Never reuse old spouts unless you do a bleach sanitation. Under a microscope plastic looks like a mesh weaving with lots of pockets that microbes can hide out in. Water alone will not remove the microbes. As you can see in this data from the Arnot Forest, new spouts and drops produced 58% more sap than old spouts and drops. By soaking old droplines and taps in a bleach solution (200 ppm = 1 tablespoon per gallon water) brought the old spouts and drops back to almost as good as new. The chlorine needs to have at least a 30 min contact time to be effective. You also must thoroughly rinse afterward as to not contaminate your sap and you will want to remove the salts to prevent squirrel chewing. Spending 25 cents for a new spout every year will give you a return of at least \$2 in syrup at the bulk rate. Could be closer to \$6. A quick and significant return on investment.



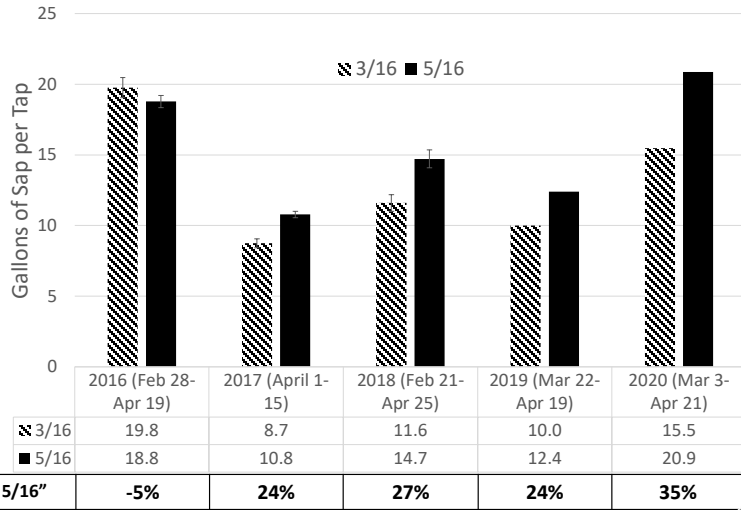
An alternative on the market to replacing spouts every year is to use Zap-Bac spouts which have antimicrobial silver in the spouts that prevent bacteria growth on the spouts and allow sap flow close to as good as new for up to three season. Although other research has shown otherwise, I found that in the first year the Zap-Bac spouts were equal with a regular, new plastic spout. As seen here in the graph, when the Zap-Bac spouts were in the second season, new regular plastic spouts produced 20% more sap per tap than the Zap-Bac spouts. Reusing the Zap-Bac the second year more than likely performed better than second season regular spout, the production was still not as good as using a new spout. There is a small labor costs to changing spouts each year but it is minimal.



This chart is from an article published by Tim Perkins, Abby van den Berg, and Steve Childs that considers 10 years of sanitation practices at both the Proctor Maple Research Center and the Arnot Forest. Starting on the left you can see that using new spouts increased sap yields by 30%, a value of \$1.03 based on their labor and syrup value. By using a check-valve spout, which prevents suck-back into the tree, yields were increased by 70%, a value of \$2.10. By replacing both the spout and the dropline increased sap yields by 75%, a \$2.29 value. By rotating out your droplines every three years instead of every year will have a benefit as well. Bleach sanitation also had a positive response by increasing yields 75% but the time costs were greater so the increase in value was \$2.04. The dashed line represents a quick sanitation rinse instead of a 30 min contact time. A quick rinse is not worth it. A hydrogen peroxide sanitation showed a slight increase in yield but nothing significant. Isopropanol alcohol sanitation did increase yields significantly however, this practice is not allowed in the US. Canada does approve of isopropanol alcohol for sanitation, but it has not been approved for use in the US. You can see here that in this data Zap-Bac spouts do show potential for an increase in yield.

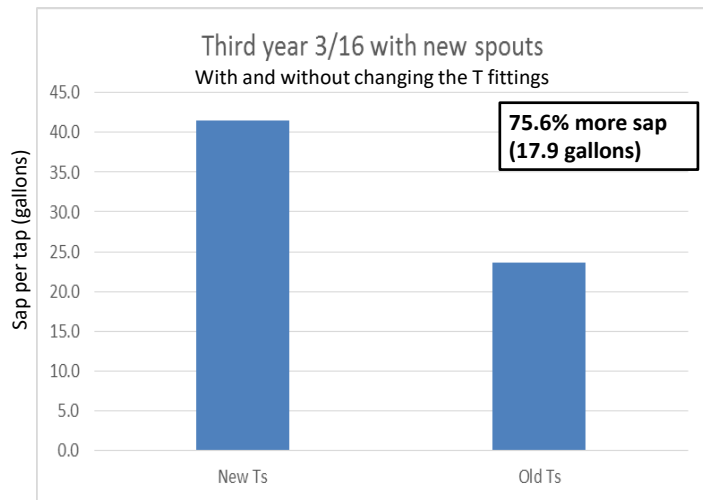
Tubing Type:
3/16" vs 5/16"

Annual sap yield per tap with 3/16" vs 5/16" tubing on vacuum
Tubing brand-new in year one. Only spouts were changed each year.



Tubing size is another factor to consider when we are looking to maximize yields. We know that 3/16" diameter tubing can have higher yields when compared with 5/16" tubing, especially on a large elevation drop where natural gravity vacuum can be created. However, this increase in yield is only for the first year or two. By year three or sooner 3/16" tubing plugs up with microbial growth restricting sap flow in the later half of the season. This happens especially right around any fittings where the diameter is even smaller. The graph shown here is from the Uihlein Forest where 3/16 and 5/16 tubing has been used for the past 5 years. Tubing was brand-new the first year but the only thing that was changed each year after was adding new spouts. The tubing was completely on a vacuum system so gravity vacuum was not as important. We can see that 3/16" had slightly higher yields in year one but every year since, 5/16" has had 24-35% higher yields. We see similar results in gravity systems.

Tubing Type:
3/16" vs 5/16"



Data from Steve Childs at the Arnot Forest

In this graph from data at the Arnot Forest, three year old 3/16" tubing was compared with three year old 3/16" tubing that had all the T fittings replaced. We can see that by replacing the T fittings, sap yields increased 75%. Tubing sanitation did help to increase yields but replacing the fittings gave the best results. 3/16" tubing has positive benefits, especially in smaller gravity systems (cheaper to install, may not need a vacuum pump). If you are using 3/16" tubing it is recommended to replace all T and union fittings every three years.

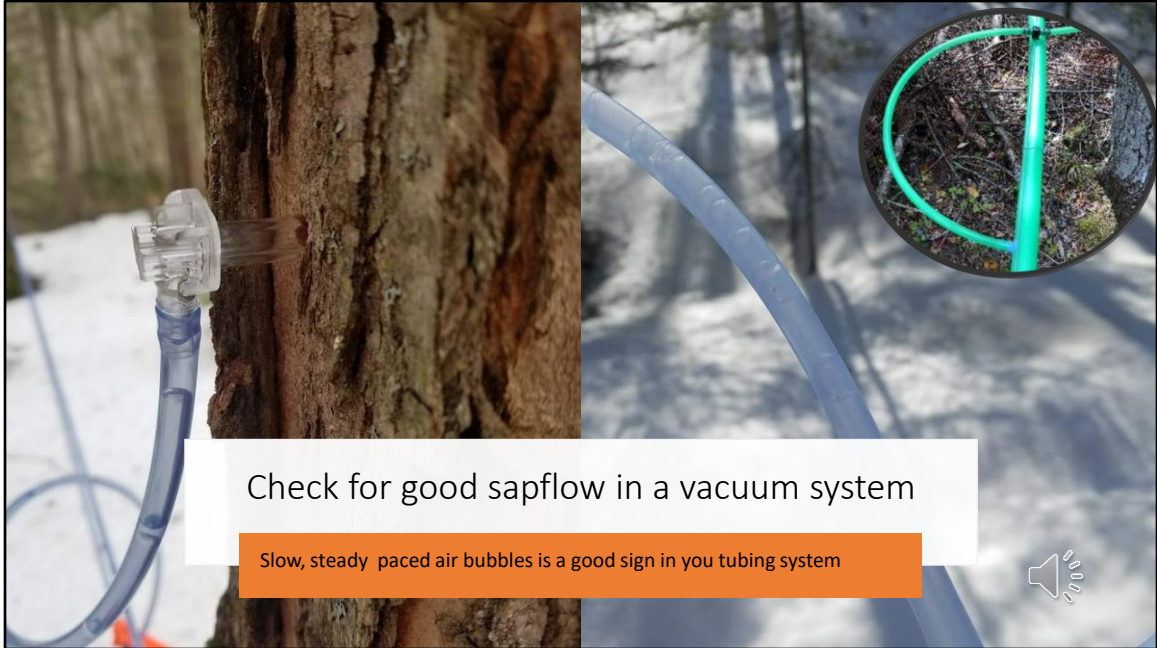
Vacuum

Higher vacuum = higher sap yields

- For every 1 in/Hg increase, gain 4-6% in production yield



One of the biggest ways to increase production is to add vacuum and maintain high vacuum in your tubing system. The higher your vacuum the higher your sap yields will be. The highest vacuum you can achieve at sea level is 29.9 in/Hg. If your elevation is higher you will not quite be able to achieve vacuum this high. Every maple producer should strive to maintain vacuum levels of at least 22-25 in/Hg. More is better. When measuring vacuum you want to look at the vacuum at the taphole, not the vacuum in your releaser at the start of your system. For every 1 in/hg you increase your vacuum you will gain 4-6% in production. Your vacuum will not be perfect on day 1 of sap flow but you should work quickly to get the vacuum level up. It is important to spend time in your woods looking for and repairing sap leaks during the season. This will have a large payback on increasing yields. Remember, **more taps does not always equal more sap, but it always equals more work**. If you don't have the time or labor, you are better off being more efficient with less taps, maintaining high vacuum, than having more taps than you can handle. Having a vacuum monitor system in your woods can help increase vacuum by finding and repairing leaks sooner.



When walking your lines during sap flow you should see slow paced air bubbles. If you see fast moving sap and air you know there is a leak somewhere in the line. The best practice is to walk your mainlines and when you come to a loop where your lateral line feeds into the mainline. Bend the loop down a little for a few seconds so sap collects at the bottom of the bend watch to see if the sap will slowly move uphill or is it racing through? If it is racing through with a lot of air then there is a leak in that lateral line. Walk up the lateral until you have found the leak. Sapflow above the leak will normally flow as usual.



This slide is a video that if you click on will show how sap should flow out of the tap hole and through the tubing. Nice and steady with a few air pockets. This was in 3/16" tubing.

Squirrel Chews



Squirrels chewing holes in your tubing are the biggest culprits for vacuum leaks. If you have a lot of conifers where the squirrels like to nest you may have more issues with squirrels. The chew marks maybe very small but it is enough to create a leak. The squirrels know the way to drive us mad is to chew the holes at the end of the lateral lines.



Woodpecker Damage



Less common, although can happen is woodpecker damage as seen in this spout.

Air leaks can create ice jams



Outside of squirrels, manifolds/saddles are often the most common issues for loss in vacuum, especially micro-leaks. A manifold not attached correctly, has a worn gasket, or is not tight enough will create a significant vacuum leak. When air is sucked into the tubing it lowers the temperature and causes sap to freeze in the line even when temperatures are above freezing. It works much like a snow gun at a ski mountain. Frost on the outside of the tubing in these pictures while the rest of the line was clear was a sure sign that the manifold was leaking, and an ice jam had created. The lower right picture shows the solid chunk of ice that was visible once the manifold was removed.



Taphole Leak

Cracks in a spout, poorly seated spouts, irregular shaped tap holes, tapping close to a cavity or unhealed tap hole can create leaks at the taphole. This will be evident by a lot of air moving through the spout and dropline. If you notice leaking on the lateral line and are not sure what tap is causing the issue, you can use a pair of vice grips to clamp off the drop line and see if the lateral line goes back to normal flow. Spouts can sometimes push out of the tree when you have heavy freezing and thawing. A simple tap with a hammer will fix this. When tapping you want to make sure that you do not let the drill move around and create an oval shaped hole that will not seal well around the spout. If the leaking is from a cavity within the tree or an old tap hole you will either need to re-tap or plug the dropline.



Tubing Design

Maintain at least 2% pitch in all mainlines



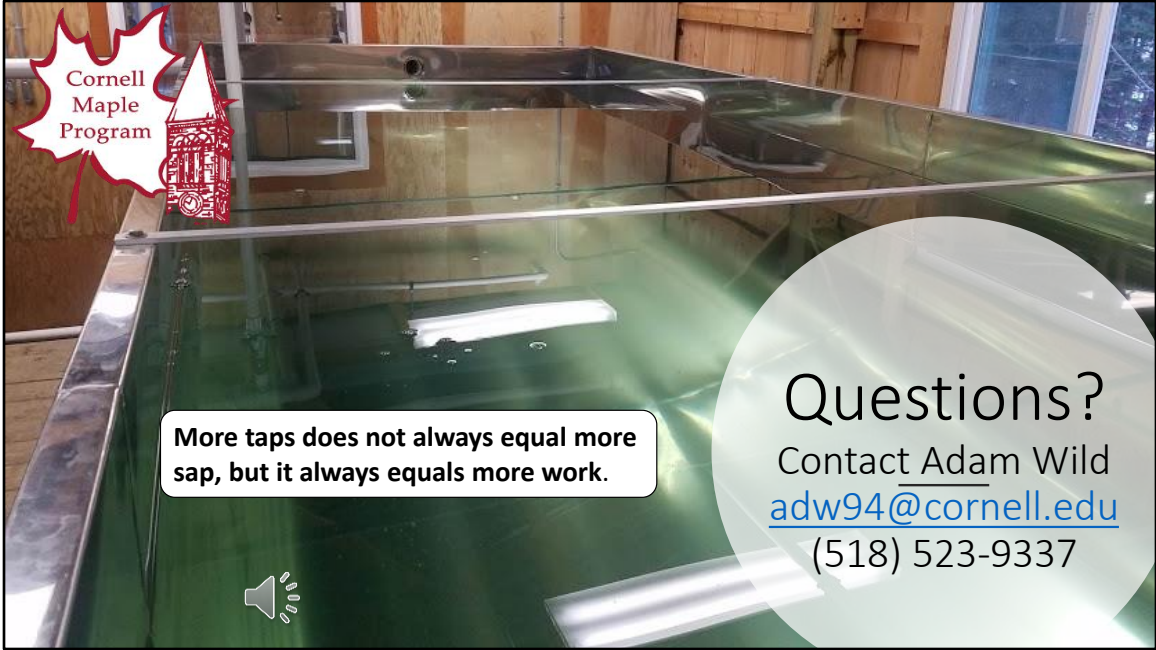
Tubing design and layout is important for maintaining high vacuum at the tap. Your mainlines should all have at least 2% pitch and be tight to prevent dips or sags where sap can collect and freeze and prevent vacuum flow.



In designing your tubing, you want to make sure that it is sized appropriately to handle the volume of sap and air removed through vacuum. You need more volume capacity to remove the air from your system than sap. The farther out you go from your vacuum pump the less effective your pump will be at evacuating all the air. If you are not getting enough vacuum at the tap and your vacuum is large enough you may need to increase your mainline tubing diameter or add an additional dry line/vacuum line as seen here with the black line. The green tubing that is arched acts as a jumper to remove air from the spur mainline into the dryline. Due to its weight, sap will stay down and drop into the sap line and will not travel up through the jumper unless there is a freeze up in the sap line.



If possible, remove conifers that maybe shading your mainline and preventing ice from melting in line.



If you have any questions, feel free to reach out to me. Remember, **more taps does not always equal more sap, but it always equals more work.**