Maple Syrup Production Beginner's Notebook

Cornell Maple Program

U.S. DEPARTMENT OF AGRICULTURE
Cornell University
College of Agriculture and Life Sciences
Department of Natural Resources

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Chapter 1: Getting Started

Maple Syrup Production for the Beginner

Background

Maple syrup is among the oldest natural food products produced in North America. Folklore credits the Native Americans with the discovery of this flavorful natural sweetener. Although modern day commercial operations differ greatly from those of our ancestors, the basic process of converting maple sap to syrup still requires the removal of water from the raw sap to form the finished product. Most novice producers find the experience of producing maple syrup rewarding far beyond the sweet product of their labor. After a few years of experience, many beginners develop a level of enthusiasm that advances them to commercial-size maple production. This leaflet provides instruction for those producing maple syrup for the first time, primarily for home or family use. **Remember,** although you may want to innovate to minimize production costs, maple syrup is a food product and should be produced only with equipment and materials that are approved for food application.

Species to tap

Although several types of maples grow in the Northeast, sugar maple (*Acer saccharum*) is the traditional species tapped for maple syrup production. The sap of the sugar maple generally contains a higher level of sugar than the other maples. Identify sugar maple by its bark, its dark, brownish-colored, sharp buds, and its five-lobed leaves. Red maple (*Acer rubrum*) can be tapped also, but its sap is less sweet and the tree breaks bud before sugar maple. When buds break, or expand in late spring, the sap becomes off flavored and is not desirable for processing. The red maple has red colored, rounded buds and its three-lobed leaf is known for its vivid brilliant red color in autumn. Another species, black maple, varies slightly in the visual characteristics of sugar maple, but otherwise yields sap of similar quality to the sugar maple. Most syrup producers treat the black and sugar maple as one species (**Figure 1**).

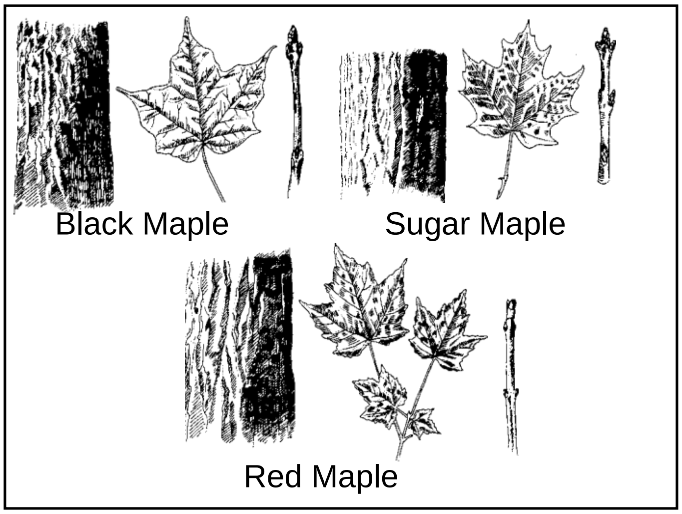

Figure 1

Trees growing along roadsides, in lawns, or in open settings, where their crowns have grown large without competition from other trees, generally produce more and sweeter sap than forest-grown trees. Open grown trees are capable of producing one half gallon of syrup in one season (15 to 20 gallons of sap), whereas trees growing in a forest setting generally produce about one quart of syrup (about 10 gallons of sap). In addition to greater sap volume and sweetness, open grown trees generally offer greater accessibility for sap collection.

Equipment

Most of the equipment required for tapping may be available in the home workshop or purchased with minimal investment. Buckets, covers, and spiles (also called spouts) are available from maple equipment dealers and many hardware stores. Other possible sap containers include clean plastic milk jugs or plastic containers with covers. The equipment for processing sap will require greater investment, but will last for many years if maintained properly. Used equipment may be purchased but use judgement and acquire only equipment free of rust and fabricated of food-grade materials. Following is a suggested list of equipment and materials for making maple syrup for home-use.

- carpenter’s hand brace or breast drill with 5/16 inch diameter drill bit
- spile (or spout), either metal or plastic for each taphole
- bucket with cover, plastic sap collection bag, or plastic tubing (food grade materials)

- collection or storage containers, such as plastic or metal trash cans (several gallons in capacity and leakfree) for sap storage before processing. Storage capacity of 1 to 2 gallons for each tap (ex. 25 taps = 25 to 50 gallons storage) should be adequate.
- pan with high sides and a heat source for boiling sap. The pan size will vary with the number of taps. Heat source can be wood fire, propane or camp stove. Stainless steel pans fabricated with lead-free solder or welded seams are strongly suggested.
- thermometer calibrated to at least 30 degrees F above the boiling point of water. Kitchen or candy thermometers may be adequate but must be easily readable above 200 degrees F.
- food approved filter for filtering hot finished syrup
- containers for storage of the finished product (canning jars, syrup jugs, etc.)

Procedures

Tapping **-** Tap maple trees in early spring when daytime temperatures go above freezing while nighttime temperatures fall below freezing. The exact time depends on the elevation and location of your trees and your region. In Pennsylvania and southern regions of New York, first sap flow traditionally takes place in mid to late - February. In northern regions and at higher elevations, the season often begins in early to mid-March. Sap usually flows for 4 to 6 weeks or as long as the freezing nights and warm days continue. If you are uncertain about when to tap, consult with a nearby maple producer or contact your Cooperative Extension Office.

The minimum suggested tree diameter for tapping is 10 inches in diameter (*Note: not circumference*) measured at 4 1/2 feet above ground (see **Other sources of information** for making a diameter measurement stick). A quick and easy way to determine the diameter of the tree is by using a household measuring tape. This will give the circumference of the tree, which can be converted to diameter from Table I.

Table I. Guideline for number of taps per tree

Diameter (inches)	Circumference (inches)	Number of taps
10-17 inches	31-53 inches	1
18-24	57-75	2
25 +	79	3

Tapholes should be drilled when temperatures are above freezing to reduce the risk of damage to the tree. Use a 7/16 inch diameter drill (available from hardware stores or maple equipment dealers) in a hand brace or breast drill. Drill into the trunk of the tree in an area that contains sound wood (free of scars, wounds, or older tapholes). If sap will be collected in buckets, a height of two to three feet above ground level allows for easy collection. However, the height can vary depending on preferences, age, and size of the individual tapping the tree. If the tree has been tapped in previous years, locate the new taphole at least 6 inches laterally and 24 inches vertically from the old taphole to insure tapping into good, productive sapwood. For trees with more than one tap, distribute the tapholes around the circumference of the tree. Drill 2 to 2 1/2 inches into the tree at a *slight* upward angle to facilitate flow of sap from the hole (**Figure 2**).

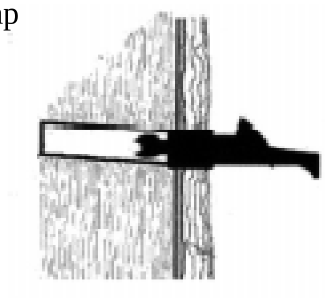

Figure 2

Notice the color of the shavings from the drill as you bore. Shavings should be light or cream colored, indicating live healthy sapwood. Shavings that are dark brown indicate wood undesirable for sap production, and another taphole should be drilled at a new location.

After making sure that the new taphole is free of shavings, insert the spile and seat it with a light hammer. Tap, *not pound*, the spile in the taphole. Seat the spile properly so it can support the bucket. Driving the spile with force can split the bark delaying taphole closure and causing a substantial wound on the tree for many years (**Figure 3**) . Do not treat the taphole with disinfectants or other materials at the time of tapping. After removing spiles from the tapholes at the end of the maple season, do not plug the taphole. Tapping done properly will allow tapholes to close naturally (covered by bark) in about two years and will allow the tree to remain healthy and productive for generations.

Plastic tubing may be used in place of buckets, but its use will not be discussed here. For more information on using maple tubing, consult your maple equipment dealer, local maple producer, or Cooperative Extension Office.

Figure 3

Collection **-** The volume of sap collected during a flow period will vary from less than a quart to several gallons per tap, depending on the tree, weather conditions, and duration of the flow or run. The sugar content of sap varies between trees, will fluctuate between runs within a season, and from year to year.

Collect sap daily if possible. It can be filtered through a clean cloth or paper filter to remove debris if desired. Sap can be stored in a clean tank (a 30 gallon storage can works fine) for more convenient processing. The storage vessel should be placed in the shade to keep the sap as fresh and cool as possible. Because sap is a mixture of sugar and water, it is a perfect medium for bacterial growth. Therefore, it should be collected and processed as quickly as possible to ensure a higher quality product. Clean pails, one for each hand to offer better balance, may be used for collecting sap from the trees for transfer to the collection tank. When using buckets, make sure each bucket has a cover to keep rain water and other debris from contaminating the fresh sap (**Figure 4**).

Figure 4

Processing **-** Usually about 40 gallons of sap are required to produce one gallon of finished syrup. Actually this figure can vary from 20 to 60 gallons or more depending primarily on sap sugar content. A large amount of water must be evaporated from the sap to produce the finished syrup of 66 to 67 percent sugar. Because the large amount of steam caused by evaporation of the sap could be damaging to interior wall surfaces, the bulk of the boiling should be done outside of the home.

For individuals with 50 or more taps, hobby-size continuous feed evaporators are commercially available. However, most hobbyists boil sap continuously in one pan over an open fire, camp stove, or discarded gas range. Multiple pans (sap is added to the first, concentrated sap from the first pan is added to the next, and so on) offer more capacity with more efficiency and are often used by producers with more experience. If wood fuel is used, a support (called an “arch”) can be constructed with concrete blocks to support the boiling pan and provide a firebox. Dry good quality firewood is most desirable for a hot fire (**Figure 5**).

Figure 5

Before the fuel is ignited, fill the pan with several inches of sap. Throughout the boiling process, make certain the liquid level is deep enough (about 1 1/2 inches) so the sap will not scorch and damage the pan. As sap is evaporated (liquid level reduced), add more sap. The faster the sap boils, the greater the potential for producing a higher quality product. This “batch” method allows the sap to be processed to a point near the final stage of evaporation. The more concentrated sap can then be finished with more controlled heat on the kitchen range.

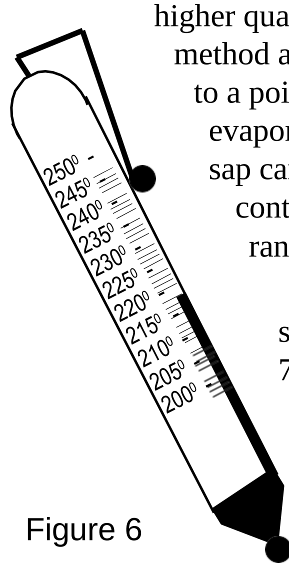

Figure 6

Temperature increments are used for illustration.

Sap becomes syrup (66-67 % sugar content) at approximately 7 1/4 degrees F above the boiling point of water (ex. if water boils at 212 degrees F, proper density for syrup would be slightly over 219 degrees F). (**Figure 6**). Concentrations below 66%

sugar content can sour over time. If boiled above the 67% density of syrup, sugar crystals can form in the bottom of storage containers. The boiling point of water, which varies with elevation and daily changes in barometric pressure, is easily determined by noting the temperature in the raw sap when it is boiling vigorously. Finished syrup will often "apron" or create a wide sheet or drip on the edge of a spoon when dipped in and quickly withdrawn above the boiling liquid. To maintain the experience of boiling sap an enjoyable one, **always practice safety**.

Throughout the process, excess foam may be skimmed off the surface of the boiling sap and discarded. Many types of materials, such as butter or vegetable oil, have been used to reduce foaming. However, a commercial defoaming agent available in small containers from maple equipment dealers is recommended. The defoamer should be fresh, and only a drop or two is needed. When used in small quantities, defoamers will evaporate without a noticeable trace in the syrup.

Filtering - When syrup has reached its proper temperature and density, it should be filtered to remove a gritty material called "sugar sand" or "niter" before hot packing in containers. The syrup should be filtered while hot through clean filter material such as wool or orlon available from maple equipment dealers. Syrup should be canned hot (180 degrees F) and stored in a cool dry location or under refrigeration. After a container has been opened for use, it must be refrigerated. Should mold form on syrup that has been stored for several months, simply bring the syrup to near boiling (190 degrees F), remove the mold by skimming, and repack the syrup in a clean container (**Figure 7**).

The procedure above is intended for home manufacture of maple syrup. If syrup is to be marketed, grading and labeling standards are required for retail sale in most maple producing states. Contact your Cooperative Extension Office or state Department of Agriculture for regulations covering maple products.

Cleanliness and quality control - After a period of warm weather, cloudy sap may appear in buckets or gathering equipment. This is caused by bacterial growth and can have a negative affect on syrup color and taste. A mixture of 1 part unscented household bleach to 20 parts clean water can be used with a cloth or brush to clean the inside surfaces of sap collection equipment. Follow the cleaning with a triple rinse of clean water to remove any hint of the bleach application. Sap boiling equipment can be cleaned with hot water, or the product recommended by the equipment manufacturer. Do not use any other cleaning substances in any maple equipment. Household detergents cannot be completely rinsed from equipment and will contaminate sap and syrup with undersirable tastes and odors. When washing sap or syrup filters, use hot water only. At the end of the season after cleaning in the manner described above, store equipment and supplies in a dry place.

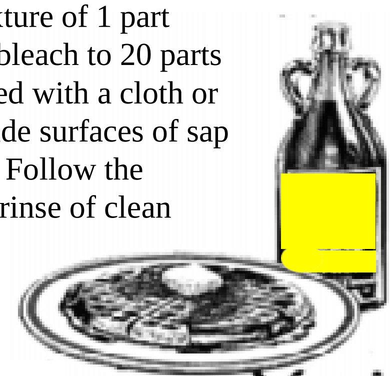

Figure 7

Equipment and supplies

Production supplies and materials are available from maple equipment dealers throughout the maple producing regions. Many local hardware stores carry a small line of equipment such as buckets and spiles. Used equipment is often offered for sale in classified sections of local newspapers and agricultural circulars. A maple equipment dealer or distributor nearest you can be located by contacting your local Cooperative Extension Office, maple producers in your area, or through your county, regional, or state maple organization.

Other sources of information

Tapping guidelines and determining tree diameter. L.J. Staats and J.W. Kelley, Dept. of Natural Resources, Cornell University, Ithaca, NY 14853.

North American Maple Syrup Producers Manual. Single copies are available from county, regional, and state maple producer organizations or from; Ohio State University Extension, Publications Office, 385 Kottman Hall, 2021 Coffey Road, Columbus, Ohio 43210-1044. Phone: (614) 292-1607.

Educational videos for maple producers; *Sugarbush Management, Maple Sap Production, Maple Sap Processing,* produced by Cornell Cooperative Extension. Each video is about 25 minutes and can be ordered from: Cornell University Resource Center, 7 Business & Tech. Park, Ithaca, NY 14850. Phone (607) 255-2090.

AGRICULTURAL ALTERNATIVES

agalternatives.aers.psu.edu

Maple Syrup Production

Making maple syrup is one of the oldest food-processing traditions in upper North America. Native Americans began boiling maple sap into sugar long before European habitation of the continent. Production in the United States is mainly in the Northeast and the northern Midwest. According to the National Agricultural Statistics Service (NASS), national production averages more than 1.3 million gallons a year with an average income of slightly over $37.5 million. Pennsylvania ranks from fifth to seventh in production with around 60,000 gallons per year and an average crop value of over $1.9 million. Vermont consistently produces the most maple syrup in the United States, producing more than half a million gallons each year. Quebec is by far the largest producer of syrup in North America with production exceeding 6.5 million gallons.

The production of maple syrup requires access to suitable woodland and many hours of labor within a short season. The distance of the maple trees (or “sugar bush”) from the storage and production facilities and the collection method you use will determine the time required for you to collect sap. Then, depending on the size of your evaporator, it will take many hours to boil the sap down to syrup. The sugar maple has the highest sugar content of all the maple species and it still takes approximately 43 gallons of sap to make 1 gallon of syrup. It is recommended that you begin production by tapping a few trees and making a small amount of syrup to see if the enterprise is suited for you. Beginning this enterprise requires extensive planning and may include a considerable capital investment depending on the size of the operation.

Marketing

There are two options for marketing. The first option is to sell the raw sap to a neighboring producer who will produce the syrup. This will reduce your initial investment and give you the opportunity to learn proper tapping techniques without the pressure of syrup production. Marketing sap will yield lower returns because syrup production is where most of the value is generated. The selling price of sap is determined by sugar content, cleanliness, and freshness with prices ranging from $0.10 to $0.70 per gallon.

The second option is to tap trees and make the syrup yourself. The first time you make syrup, you may not have a marketable product. With patience and practice, producing maple syrup can be very rewarding and provide additional income.

This publication was developed by the Small-scale and Part-time Farming Project at Penn State with support from the U.S. Department of Agriculture-Extension Service.

PENNSTATE

College of Agricultural Sciences
Agricultural Research and Cooperative Extension

The syrup you produce must conform to United States Department of Agriculture (USDA) grade and classification standards. U.S. Grade A has three classifications: U.S. Grade A light amber, U.S. Grade A medium amber, and U.S. Grade A dark amber. U.S. Grade B is used for processing and is often used in cooking and baking because of its stronger maple flavor. The third grade is labeled as Substandard and fails to meet the requirements of U.S. Grade B. There are many different tools available to determine grade. Some are somewhat expensive, while others are less expensive but may only be accurate for a short time period. Check with a maple syrup equipment dealer, cooperative extension, or a local producer to see which tools are used locally. Syrup taste is generally reflective of the color. Light amber syrup has a more delicate maple flavor, while medium amber has a slightly stronger maple flavor and is most often used as table-grade syrup. Dark amber has a stronger maple flavor and is also used as table syrup, depending on individual preferences. In order to meet the legal definition, maple syrup must have a sugar content of at least 66 brix (this equates to 66 percent sugar content) at 60°F.

Many producers also further process the syrup into value-added products. These products include (but are not limited to) hard sugar (candy), maple cream, and crumb (appears similar to brown sugar). Making candy or other confections requires you to reheat and then cool the syrup. Temperature, cooling time, and stirring will determine the resulting confection. Value-added products will increase profits, but they do require more time, effort, and equipment than just making syrup.

If you decide to make and sell maple products, your operation and facility will need to meet standards set by the Pennsylvania Department of Agriculture and your facility will likely be examined by a department inspector. You may obtain a copy of these standards from your local Department of Agriculture office.

When selling syrup, a grade label must be visible on the bottle, can, or jug. High-quality containers can be purchased from equipment dealers, distributors, or other producers. You also need to have your farm or business name and contact information visible on the container. Nutritional information should also be included; most commercially available containers already have this information listed.

Production

Site and Tree Selection

The best species of maple for syrup production in Pennsylvania is sugar (often called hard or rock) maple (*Acer saccharum*). However, red, silver, and Norway maples may be used. Generally, the sugar content of the sap of these species is not as high, requiring more sap to produce syrup. Also, red and silver maple will break bud (swelling of the buds) sooner than will sugar maple, which shortens the sap-collection season. The best trees to tap have large crowns with no defects. Check with your local extension office or forester if you have questions about the maple species you have.

One of the most important and most often overlooked factors in maple syrup production is maintaining the sugar maple tree in a healthy and productive condition. To maximize tree health and vigor, the soil should be moist but well drained. Sugar maple is a somewhat demanding species as far as soil fertility is concerned. Thinning your sugar bush is likely going to be needed to improve the spacing among your trees. Adequately spaced trees will be healthier and produce larger crowns, which will eventually lead to higher sap production. By working with a professional forester who is familiar with maple sap and syrup production, you can develop a management plan to maximize production while protecting the sugar bush.

When selecting the site of the sugar bush you plan to use, several factors should be considered. The topography of the land is of particular concern. If you plan to use tubing to collect the sap, the ideal site for the sugar bush will be at a higher elevation than the sugar house. This will allow you to move the sap by gravity and eliminate the need to haul the sap from the trees to the sugar house. If this type of site is not available to you, then ease of moving the sap should be considered.

Your annual sap crop will depend to some extent on environmental factors from the previous growing season. Two other factors play major roles in sap production and the amount of sugar found in the sap. Healthy trees with large crowns will normally produce more sap during a season and the sap will have a higher sugar percentage. As you gain experience with making maple syrup, you will likely discover trees that consistently produce more sap and are sweeter. Much of this is genetically determined. The other major factor is the weather conditions at the time the season begins.

Tapping Trees

In the Northeast, sap begins to flow in late January or early February. However, the most productive runs (times when sap flows) will be from mid-February through March (and occasionally into early April). Warm days (temperatures above 40°F) and cold nights (temperatures below 32°F) will normally start the flow of sap. The sap will often quit flowing if night temperatures exceed 32°F and will begin again when nights drop below freezing. Generally, early runs produce lighter syrups. The further you go into the season, the darker the syrup becomes. Light syrups are preferred for value-added products such as maple sugar and maple cream. You should stop collecting sap before the buds begin to swell because such sap produces off-flavored (called “buddy”) and less valuable syrup. Useable sap may flow for four to six weeks depending on weather conditions.

Trees may be tapped when they are between 10 to 12 inches in diameter (measured 4.5 feet diameter breast height [DBH] above the ground). Trees up to 18 inches in diameter should have no more than one tap. Trees greater than 18 inches in diameter may receive two taps. Using more than two taps per tree is discouraged. Unhealthy trees or trees of low vigor should not be tapped.

You should move the tap hole at least two inches to the side and twelve inches above or below the hole from previous years. Taps placed close to previous holes are likely not to produce sap. Tap holes will usually close within three years. Careful tapping will not damage trees as there are reports of trees being tapped for 100 years.

You will need a rechargeable drill or brace to begin the tapping process. Use a 5/16 inch bit to drill a hole 1 ½ to 2 inch deep into the white wood at a slightly upward angle. The upward angle will help facilitate sap flow. Take care not to oval the tap hole so the tap (spile) will fit snugly and close quickly. Tap holes should not be drilled into frozen wood.

While drilling the tap hole, check the color of the wood being removed. Cream, as opposed to brown, is the desired wood color. Brown-colored wood shavings indicate rotten or unhealthy wood, and you should move the hole to another location. Clean all shavings from the hole (do not blow, place any sort of sanitizing pellet, or spray into the hole) and insert the spile into the hole and tap it gently to secure it snugly in the hole. Keep in mind that the spile will hold the weight of the bucket and sap during collection. Your spiles should be sanitized before using with a 20:1 unscented household chlorine bleach solution. Make sure they are thoroughly rinsed with hot water after sanitizing. If using plastic tubing, any remaining chlorine bleach solution on the spile is likely to attract squirrels. They will damage the spile and make it unusable.

Commercial spiles are available from suppliers in many styles. The style you choose will depend on your collection method. If you use buckets for collection, you will require a different spile than if you plan to use plastic tubing.

Spiles should be carefully removed at the end of the syrup season. Do not leave the spile in the tree. Tap holes do not need to be plugged; this can interfere with hole closure.

Collection and Storage

If you choose to use buckets for sap collection, purchase new or undamaged, clean, used buckets. Make sure that the buckets you purchased are made of a lead-free material. You will need a lid or covering to prevent dirt, rain, snow, twigs, and other debris from getting into the sap. Before collection begins, you should clean all buckets with a 20:1 chlorine bleach solution and rinse the buckets thoroughly several times with hot water. Capped gallon jugs may also be used. Whatever you use, make sure it is of food-grade material and has not previously contained any hazardous or toxic materials.

Sap should not be left in the collection container for more than two days. After two days microbial action will result in a lower grade of syrup. If the days are warm the sap may spoil. This sap is no longer useful and must be discarded. You will need to plan accordingly to transport, store, and boil the sap as quickly as your evaporation system will allow.

Figure 1. Drilling the tree in preparation for tap insertion.

Figure 2. Maple sap collection using the bucket method.

Figure 3. Maple sap collection using the tubing method.

If your site and conditions allow, plastic tubing may be used to collect and transport the sap to the storage facility. Steep slopes are not required as tubing may be used on slopes as low as 2 to 5 percent. It should be noted that wildlife can affect the use of tubing. Squirrels often chew the tubing and deer occasionally knock the tubing from the spile. Because of these possibilities, you need to check tubing regularly during sap flow. Using hot water for several rinses instead of chlorine bleach to clean the tubing at the end of the season will reduce the amount of squirrel damage. If you wish to expand your operation, consider investing in a vacuum system. Vacuum systems increase sap production over gravity systems.

If not using tubing, you will need to consider transportation to your storage tank. Roads or paths will need to be constructed and maintained to transport the sap in all types of weather. Depending on the quality of the road or path, you may use a truck, ATV, or horses and a sled or wagon fitted with a collection tank to haul sap.

The size of the storage tank will be dictated by the size of the operation. You will need to have enough storage capacity to accommodate two days of sap collection for your operation. Allowing for two gallons of sap storage per tap is a good standard to follow. Storage tanks must be of a food grade material and nonporous. Tanks with lead solder are not acceptable. The tanks should be cleaned regularly during the evaporation season using a 20:1 chlorine bleach solution and then triple-rinsed with hot potable water. It is recommended that you have two tanks so sap can still be stored while the other tank is being cleaned.

Evaporation and Boiling

Once you have collected and transported the sap to a central location, you can begin the process of evaporating and producing syrup. Sap should be filtered to remove debris and other foreign material before boiling. Sap is best boiled in a well-ventilated building to allow steam to escape.

You will need several pieces of equipment: a heating source, evaporating pans or continuous-flow evaporator, thermometer, filtering material, and bottles or barrels for storing the syrup. You may be able to make the evaporator yourself, or you may choose to purchase an evaporator from an equipment dealer. You may be able to find good-quality used equipment from a producer who is expanding his or her operation. You should make sure that any used evaporator was constructed of lead-free materials. A hydrometer and hydrometer cup or refractometer is a must. This will help you determine the sugar content of your syrup. Syrup must have a minimum of 66 brix (this equates to 66 percent sugar content) to be considered syrup. Syrup at a lower concentration is more likely to mold or go sour. There is legally no upper limit for syrup, but syrup with sugar content greater than 68 percent is more likely to form sugar crystals in the container.

The heating source is called an “arch” in maple syrup production. For very small producers, this may be an old stove or constructed from concrete blocks and a smoke stack. If you plan to construct your arch from concrete blocks, it should match the size of your evaporating pans. It should be at least two blocks high and be fitted with a smoke stack to remove the smoke and increase heat efficiency. Wood is the most widely used fuel source, so a smokestack will help move the smoke above head level. The evaporation process may be completed by either a batch process or continuous-flow system. The batch process uses flat pans at least 2 inches deep because the sap should be at least 1.5 inches deep in the pan to prevent scorching and at least 12 inches square. The larger the pans you use, the quicker the entire process. Whatever you use as an evaporator, it must be lead free. If you have more than 50 taps, small continuous-flow systems may be purchased from a supplier.

Sap will boil at the same temperature as water and depends on elevation and barometric pressure. On any operating day, determine the boiling point of water and add about 7.5°F for the finishing temperature of syrup. Barometric pressure varies daily and affects the boiling point by a few degrees. A candy thermometer calibrated to the nearest degree should be used to determine the boiling point. While boiling, the sap will roll and foam. A defoaming agent may be purchased from a supplier to decrease the amount of foam. One to two drops per batch should be sufficient.

You should take care during the evaporation process so that your syrup is as close to 66 percent sugar content as possible. Overboiling will cause the syrup to be darker than desired and may cause the syrup to taste scorched or burned. This will greatly reduce the value of the finished syrup. Faster boiling will yield higher quality syrup, so controlling the heat during the finishing process is critical. Many producers do not finish the syrup in the large evaporator. They will draw it off at a lower concentration and then finish the syrup in a smaller pan where the temperature can be better controlled.

When you have finished syrup, you will need to filter it before filling your containers. Commercially available clean wool or orlon is commonly used to filter hot syrup. Paper filters should be used ahead of the wool or orlon filter to extend their useful life. Filtering the syrup is required to remove any “sugar sand,” small mineral particles that have precipitated out during the evaporation process. Removing the gritty sugar sand will make your syrup clearer and results in a finished product that looks and tastes good. If you increase in size, you may consider purchasing a filter press designed for filtering syrup. This will make the filtration process much easier and quicker.

Bottling

After filtering the syrup, you are now ready to begin the bottling process. Syrup should be bottled at a temperature between 180 and 190°F. You may use bottles, canning jars, or commercially available containers to store and sell the syrup. An attractive container will do a lot to help you successfully market your product. To prevent breakage, containers receiving hot syrup should be at room temperature. Separate the filled containers slightly while the syrup is cooling. As mentioned earlier, when selling syrup the containers must be labeled as to grade, net contents by volume, and have your farm or business name and address on the container. You can also store syrup in food-grade drums for future bottling.

Safety

Safety should be of utmost concern throughout the entire maple-syrup-making process. You begin the season in the woods with sharp drills and tools and end by filling bottles with very hot syrup. Care should be used during transportation of the sap, especially if the ground is soft or uneven. You will be using an open flame to boil the sap into syrup and be working with boiling sap. During all phases of the maple syrup production, worker safety should be a primary concern.

Sample Budget

Included in this publication is a template highlighting many costs associated with maple syrup production. The template summarizes these costs but does not provide net returns of a maple syrup enterprise. This template should help ensure that all costs are included in your calculations. Labor and fuel costs vary considerably depending on the size of the enterprise and the fuel source used. The cost of other syrup-making equipment can also change rapidly; check with an equipment dealer for the most current prices of equipment. If possible, discuss your potential operation with an existing producer; their input will be extremely helpful to you.

Costs and returns are often difficult to estimate in budget preparation because they are numerous, variable, and greatly depend on the volume and quality of the sap and syrup produced. Therefore, you should think of this template as an approximation and make appropriate adjustments in the "Your Estimate" column to reflect your specific production and resource situation. More information on the use of crop budgets can be found in *Agricultural Alternatives: Enterprise Budget Analysis*.

For More Information

Any serious producer should obtain a copy of the *North American Maple Syrup Producers Manual* (2nd ed.) from Ohio State University Extension.
Media Distribution
385 Kottman hall
2021 Coffey Road
Columbus, OH 43210

Huyler, N. K. *Cost of Maple Sap Production for Various Size Tubing Operations*. Newtown Square, Pa.: USDA Forest Service, 2000.

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Web Sites

Cornell Sugar Maple Research
maple.dnr.cornell.edu

Cost of Maple Sap Production for Various Size Tubing Operations
www.fs.fed.us/newtown_square/publications/research_papers/pdfs/2000/rpne712pdf.

Hobby Maple Syrup Production
ohioline.osu.edu/for-fact/0036.html

Maple Candy and Other Confections
ohioline.osu.edu/for-fact/0046.html

Penn State Maple Syrup Information
maplesyrup.cas.psu.edu/maple_syrup.html

1.2 Tree Identification

The first issue a beginner faces is knowing which trees can be tapped. In this section, you will learn how to identify the correct trees for tapping.

Identifying trees by trunk bark alone can be difficult, even for fairly experienced maple producers. Bark tends to vary with how fast the tree is growing and in different regions and soils. Having some good pictures can be helpful. Trees also tend to have some color variations that are helpful to know on a sunny dry day, but these are not as readily visible on cloudy days when the bark is wet.

All maples have buds that are opposite where many of the other forest species, or non-maples, have alternating buds. Ash is the other tree species with opposite buds, but ash can be easily identified by its much thicker twigs and diamond-shaped bark. Trees with bark that is often confused with maple include red oak, poplar or aspen, and basswood. These trees, however, all have alternate buds.

THE MAPLES

Maples (*Acer spp*.) are an important group of forest trees in New York State. Sugar maple is the state tree, and maples provide syrup, valuable hardwood timber, wildlife foods, beautiful fall colors, lawn trees, and watershed protection. Of the 16 or more maples east of the Rocky Mountains, 8 are found with moderate to high frequency in some parts of the state. These include sugar maple, red maple, silver maple, striped maple, Norway maple, box-elder, mountain maple, and black maple.

Maples as a group are readily distinguishable from other trees by their opposite arrangement of buds, leaves, and twigs, together with the characteristically shaped simple maple leaf (box-elder is the only exception, having compound leaves). The fruit of the maple group is also distinctive. Without exception, the fruit are winged seeds, borne in pairs and clusters of pairs, and commonly called samaras.

Pretty much any maple tree will yield sap that can be converted into maple syrup with fairly consistent maple flavor. However, not all maples are of equal value for making maple syrup. The three maple species used primarily for syrup production in New York are the Sugar Maple, Red Maple, and Black Maple. These trees tend to give both higher levels of sugar in the sap and stay dormant longer into the spring. Other maples can be used but have some drawbacks.

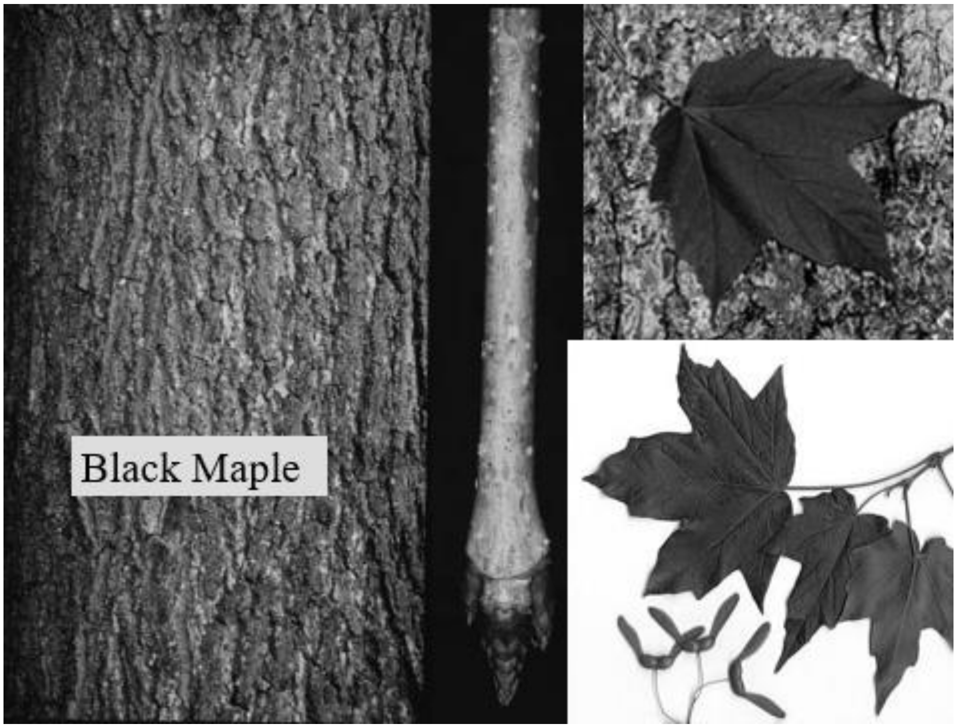
Tapping-size Maples

SUGAR MAPLE

Sugar Maple (hard maple, rock maple, *Acer saccharum*)

Sugar maple, the official state tree of New York, is a magnificent forest tree abundant everywhere in the state outside of Long Island. It provides beautiful borders to many miles of highway. It yields a wood of high grade. It is hard, strong, close-grained, and tough, with a fine, satiny surface, and is in great demand for flooring, veneer, interior finish, furniture, shoe lasts, rollers, and as a fuelwood of the best quality.

Bark: on young trees dark gray in color, close, smooth, and firm, becoming furrowed into long, irregular plates lifting along one edge. **Twigs**: slender, shining, color of maple sugar. **Winter buds**: very narrow, sharp-pointed, brown in color, terminal buds much larger than laterals. **Leaves**: simple, opposite, 3 to 5 inches long and fully as wide, 3 to 5 shallow lobes with wide-spaced coarse teeth, dark green in color above, paler below; clefts rounded at base. "U" shaped notches between leaf lobes, known as "sinuses". **Fruit**: samaras, in short clusters, ripening in September. **Seeds**: join each other in straight line. **Wings**: turn down almost at right angles. **Distinguishing features**: rounded cleft between lobes of leaves; leaf lobes lacking small teeth; sharp-pointed, brown buds; brown twig.



Black Maple (*Acer nigrum*)

Black maple can be very difficult to distinguish from sugar maple. It has pointed buds and similar bark. Secondary leaves often appear to be three lobed rather than five lobed as on sugar maple. However, there is no real need to distinguish black maple from sugar maple because their performance in producing maple syrup is identical.

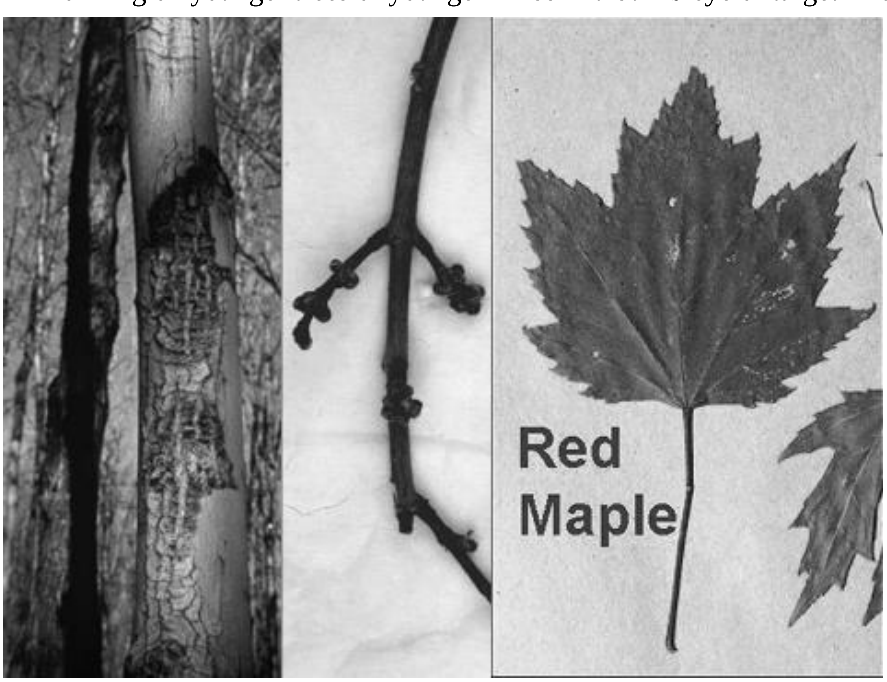
Further distinguishing features include: drooping leaf edges and tips, hairy lower surface of the leaves, and orange-brown dull twigs. Black maple's fall color is typically yellow compared to the brilliant orange to amber of sugar maple.

Red Maple (soft maple, swamp maple, *Acer rubrum*)

Red maple derives its name from its brilliant autumn foliage. Though it is common in swamps all over the state, it is also abundant on moist slopes and increasingly common in partially cut woodlots. It is an extremely rapid-growing tree, furnishing a fairly strong, close-grained wood that is extensively used for cheap furniture, baskets and crates, mine props, railroad ties, and fuelwood.

Bark: on young trunks smooth, light gray in color, often resembling beech; with age becoming darker and roughened into long ridges, often shaggy or scaly on surface; bark character extremely variable on different trees in same stand. Tends to have smaller checks or squares in the bark pattern, sometimes forming on younger trees or younger limbs in a bull's-eye or target-like pattern. **Twigs**: rather slender, bright or dark red in color, without odor when cut or broken. **Winter buds**: broad, rounded, clustered, short stalk, red in color; terminal bud slightly larger than lateral buds; numerous large, plump flower buds along twig. **Leaves**: simple, opposite, from 3 to 4 inches long, fully as wide, usually 3-lobed; clefts between lobes shallow and sharp angled ("V" shaped) as contrasted with deep clefts of silver maple; leaf edges are serrated or saw-toothed; at maturity leaves light green in color above, pale greenish-white below. **Fruit**: samaras, in clusters on long stalks, ripening in May or early June. **Seeds**: joined more or less end on end. **Wings**: diverge at wide angles. **Distinguishing features**: red buds and twigs, sharp angle between leaf lobes; leaf margin with teeth.

RED MAPLE



Red maples are commonly used in making maple syrup, but tend to have somewhat lower sugar content. Lower sugar content can be a problem for sugar makers because of the extra boiling that is required. For instance, sap at 4% sugar (a level a sugar maple standing in the open with a large full crown can attain) requires about 22 gallons of sap to make one gallon of syrup. Sap at 2% sugar (common to red maple in the open or from sugar maple in a dense woods) requires about 43 gallons of sap. Sap at 1% sugar (a level seen in silver maple, crowded red maple, or Norway maple) would require 86 gallons of sap to attain one gallon of syrup.

Many older guides to maple syrup production will include a second problem with red maples. This is that is comes out of dormancy, or the buds swell, earlier in the spring than sugar maple. The conventional wisdom is that this early bud swelling results in an off-flavor in the syrup called "buddy". However, these days, red maples are tapped right along with sugar maple with no effect on flavor. While it is true that their buds swell earlier than other maple species, it has yet to be proven that this is the cause of any off-flavor. Tapping your red maples can significantly increase your syrup yields if you have a lot of them on your property.

Here is an example of two different types of Red Maple bark. The Red Maples are flanking an example of Sugar Maple bark. Both trees have highly variable bark patterns, so it takes practice to distinguish them without leaves!

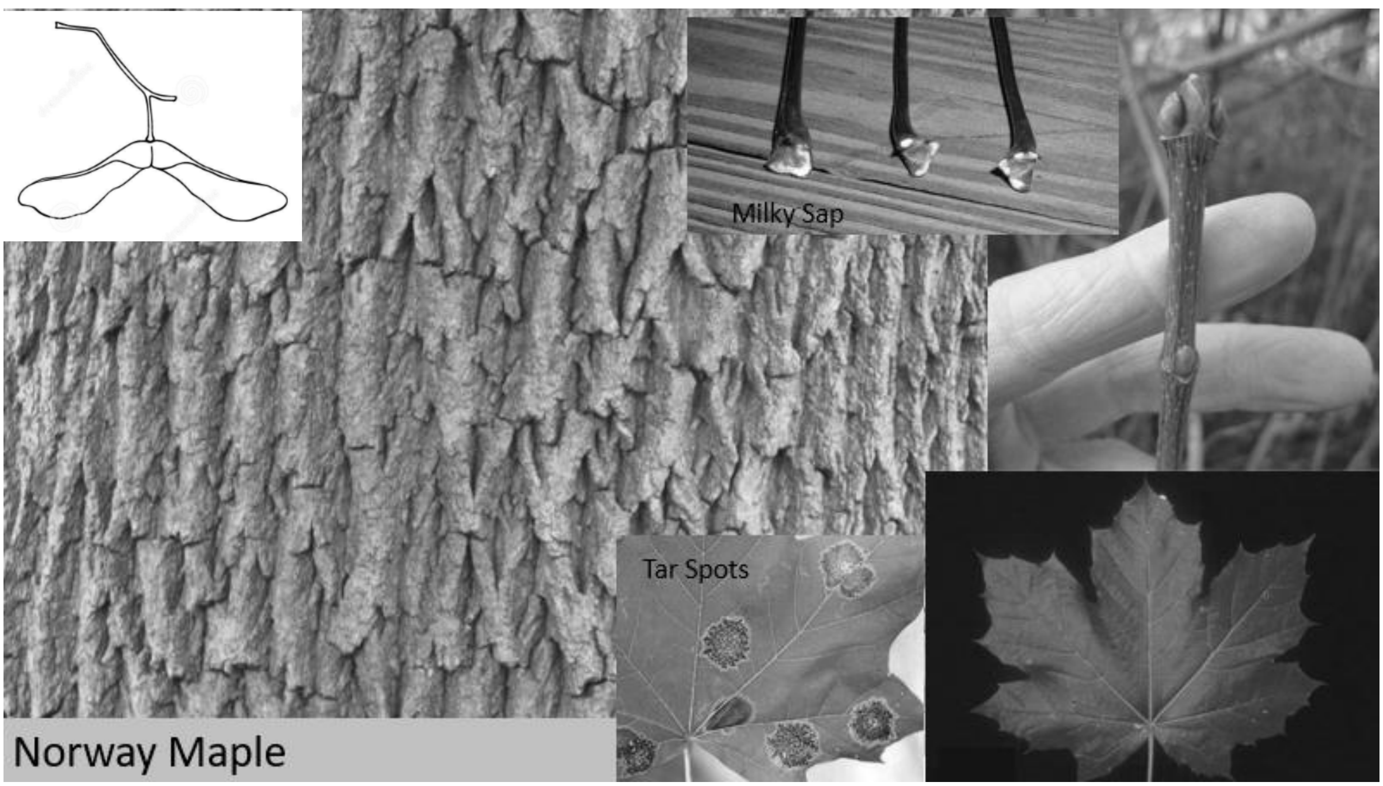
Silver Maple (white maple, *Acer saccharinum*)

SILVER MAPLE

Silver maple is generally distributed throughout the state but is not nearly as common as red maple. It prefers the same general moist soil conditions, and the wood is used for the same purposes as the red maple with which it is included under the term "soft maple" by lumbermen. Silver maple is frequently planted as a shade tree owing to its rapid growth, but because of its weak wood it shouldn't be planted near homes or cars. Silver maple tends to be even lower in sugar content than red maple. These are usually yard trees in New York, not common in woodlots or forests except very near villages or cities. The leaves have very deep cuts or grooves on each side of the center lobe, buds are rounded and the bark is much smoother than sugar, black or red maple.

Bark: on young trunks smooth, gray in color with reddish tinge; with age becoming reddish brown in color, more or less furrowed, surface separating in long, thin flakes that become free at ends and flake off. **Twigs**: similar to red maple but has distinctly rank odor when broken or crushed. **Winter buds**: similar to red maple but larger, usually very dense clusters of lateral buds. **Leaves**: simple, opposite, 3 to 5 inches long, fully as wide, 5-lobed; margins of lobes coarsely serrate; clefts between lobes, particularly middle two, very deep; at maturity leaves pale green in color above and silvery white below, hence the name "silver maple." **Fruit**: samaras, much larger than in red maple though maturing at about same time in spring. **Wings**: more widely divergent than those of red maple. Sometimes only one side of samara develops. **Distinguishing features**: silvery bark on upper limbs; deeply cut clefts between coarse-toothed lobes; rank odor from crushed twig; large-winged samaras.

Norway Maple (*Acer platanoides*)



Norway maple has been widely planted in residential areas, now overplanted, and is considered an invasive weed in some of the many areas of the state where it has naturalized. It is a common backyard tree, and it can also be used to make maple syrup. Again, it tends to have lower sugar content than sugar maple, but sugar content in these trees seems to vary significantly from tree to tree. A large, healthy, sun-grown backyard tree can have equal sugar to sugar maple. The **bark** has very fine checking and **leaves** that look much like the sugar maple only much larger. It has large, blunt terminal **buds**, and a broad leaf on a long stalk. The leaf stalk has a white, milky sap when broken. The species was removed from some sections of New York City and Long Island during an infestation of the Asian longhorned beetle, an exotic insect that feeds on and reproduces in Norway maple, other maples, and a variety of other hardwoods.

Box-Elder (Ash-Leaf Maple, *Acer negundo*)

Finally, another common backyard tree is box-elder. Although its most common name is deceptive, it, too, is a maple. In some parts of the state, it is an incredibly common weed tree. It is easy to identify because it is so different from the other maples. Box-elder is a medium-sized tree found in moist locations at lower elevations, occasionally common, and its greatest value is stream bank stabilization and shading of streams. It has a compound **leaf**, hence the name "ash-leaf maple," but its clusters of samaras give it away as a maple. The leaflets are distinctly shaped and coarsely toothed. The tree has very weak wood and the trunk is rarely straight. The gray **bark** is ridged and furrowed, more and more so with age. The **twigs** are smooth and green even in the winter. Most box-elder have low sugar content, but again, a big one in a yard can be sweet.

Understory Maples

Striped Maple (*Acer pensylvanicum*) is an increasingly abundant species in the maturing and shady forests of the state. It thrives in shade and is restricted to the subcanopy. Striped maple reproduces easily and sometimes forms a dense understory that inhibits the reproduction of other species. This species is distinguished by bright green bark with white stripes, large goose foot–shaped leaves, and its samaras with wide-reaching wings. It rarely reaches a suitable size for tapping.

Mountain Maple (*Acer spicatum*) is another shrubby maple that does not grow past the understory. You are only likely to find it at high elevations, in moist ravines and on steep slopes. Again, it rarely reaches a size sufficient for tapping. It can be recognized by its coarsely toothed leaves, down hairs on current-year twigs and bud, and in the summertime, a spike of flowers that blooms after the leaves are fully developed.

For more complete descriptions of the trees on your property, consult a regional tree ID guide.

1.3 Assessing Your Land for the Potential of a Commercial Sugarbush

Assessing the Commercial Potential of a Site for Maple Sap Collection

Steve Childs, Peter Smallidge and Mike Farrell, Cornell University Cooperative Extension, Department of Natural Resources. Ithaca, NY www.CornellMaple.com (October 18, 2016)

These 9 variables are intended to help a potential commercial maple producer evaluate the relative merits of one or more selected woods for profitable maple production. A poor or medium rating does not mean that the woods should not be tapped but that production costs in money or labor will likely be higher or greater investments will be necessary to allow the sap collection to be established relative to other sites. Some problems may be avoided if the potential producer is a creative problem solver. Small-scale producers and hobby producers have less emphasis on financial return, so these variables are relevant but perhaps not weighted as heavily.

1. Tapping Density (Number of Taps Per Acre)

Mark a center point in the sugarbush for a circular plot with a radius of 26.4'. This is a 1/20th acre plot. Measure out the circle and count 1 tap for each tree 10" diameter or more, and count each tree you will double tap (usually 18 to 20" diameter) as 2. Total this count for each plot and divide by 20. The same process could be used on a 1/10th acre plot (radius = 37.2') and multiple by 10.

Alternative

Use the third page of this guide to "point sample" trees with an angle gauge or prism. This process is faster and gives equally valid results. Video link https://www.youtube.com/watch?v=ovaHN7spfdQ

Input these estimates of tap density per acre into the cost spreadsheet to obtain a cost per tap evaluation. It can be found at www.Cornellmaple.com. The goal is to have at least 50 taps per acre.

Good 40+ taps per acre Medium 20 to
40 taps per acre Poor 1-20 taps per acre
Remediation – N.A., or thin sugarbush to increase growth and diameter of smaller maples

2. Soil types: Use your area soil maps

(http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm) Good –
well drained, moderately well drained,
Medium – excessively well drained, somewhat poorly drained Poor –
poorly drained
Remediation – N.A.

3. Health and Quality of available trees (see indicators below)

Good – healthy trees, rapid taphole closure, canopy not closed,
Medium – tree health mixed, canopy closed, few indicators of poor health
Poor – crown dieback, thin crowns, numerous trees with indications of poor health
Remediation – Thin to reduce abundance of medium and poor quality trees, favor maple on better soils

Indicators of unhealthy trees:

- Stem defects: insect scars, fungus, weak forks,
- Crown: upper crown dieback, thin crowns, live crown ratio less than 30%, recent defoliations
- Butt/root: exposed roots due to erosion, skidder damage, stem scars

4. Access:

Distance between collection site and sugarbush:

Good - sugar house or open road (normally kept open all winter) downhill and within 1000'.

Medium - sugar house or open road (normally kept open all winter) downhill and within 2000'. Seasonal road (may be seasonally maintained by the maple producer) is downhill and within 2000' of the collection site. Open road, sugar house or seasonal road level with the production woods.

Poor – No obvious access so road must be constructed by the producer. Production woods downhill from open road, sugar house or seasonal road. Greater than 3000' downhill to collection site.

Remediation – N.A., install new road, move sugar house, or lease site for collection tank

5. Access to and within the sugarbush:

Good – access roads throughout for maintaining tubing, thinning and woods to the woods and within the woods
Medium – access roads to the woods
Poor – no current access roads to the site; limited or low quality interior trails
Remediation – install roads or trails, commercial harvest with emphasis on quality well-located roads

6. Availability of electricity – important with vacuum not for buckets or gravity

Good – Electric readily available. Access to collection site is readily available if maintaining a generator

Medium – Electric within 500'. Access to collection site requires maintenance if using a generator

Poor – Access to the collection site is very limited if maintaining a generator
Remediation – Use buckets, install road for easier access to generator, or extend main line for easier generator location

7. **Steepness of site – for tubing**

Good – gradual downhill to the collection site B slopes (3 to 8% slope)

Medium – steep enough to be difficult in some places OR too flat for good tubing drop A slopes (0 to 3% slope) and C slopes (8 to 15% slope)

Poor – Access difficult due to steepness D and E slopes (>15% slope)

Remediation – N.A., or install roads on contour for easier access. Steep slopes may favor 3/16" tubing designs.

8. **Needed Management:**

Good - No canopy thinning or understory vegetation management needed

Medium - Light to medium thinning of canopy trees or understory vegetation management needed

Poor - Significant thinning or understory vegetation management needed

Remediation – thin woods by crop tree release or basal area reduction, or manage undesirable vegetation

9. **Associated vegetation:**

Good - Few evergreen trees, little or no interfering understory species, mostly deciduous, ~25% of basal other than sugar maple

Medium - Some evergreen trees, some interfering understory, 10% to 25% basal area other than sugar maple

Poor - Significant evergreen trees present, less than 10% basal area other than sugar maple, significant interfering understory: multiflora rose, honey suckle, other thorn trees, briers, beech, poison ivy

Remediation – Thin woods to enhance species composition, or control interfering species

Point Sampling for Number of Taps per Acre

Use the angle gauge or prism to count the number of trees, by diameter class, at several points. Record all your tree counts on one form. Record how many sample point you visit. Multiple the “tree count” for each diameter by the “multiplier” and record the product in the “#taps/diameter” column. You can double the “multiplier” for trees $\geq$ 18” if you plan to use two taps. Total the final column and divide the sum by the number of points you visited. This is an estimate of the number of sugar maple trees per acre available for tapping.

Number of Sample Points Visited = ______

Tree Diameter Mid-point (DBH, inches)	Tree Count	Multiplier	# Taps/Diameter
10 (9 to 11)		18.3	
12		12.7	
14		9.4	
16		7.2	
18		5.7 (x 2)	
20		4.6 (x 2)	
22		3.8 (x 2)	
24		3.2 (x 2)	
26		2.7 (x 2)	
28		2.3 (x 2)	
30		2.0 (x 2)	
		TOTAL =	

Total # taps / Total # sample points =___________/ _____________

=__________estimated number of taps per acre

Sugarbush Assessment Tally Sheet - ***Composition and Structure***

DATE

Stand Location Information	

Sample Point Summary (number of sample points)

	DBH	6"	8"	10"	12"	14"	16"	18"	20"	22"	24"+	Basal Area/ac or TPA	Basal Area or TPA (%)
Species	*TPA multplier ->*	*50.9*	*28.6*	*18.3*	*12.7*	*9.4*	*7.2*	*5.7*	*4.6*	*3.8*	*3*		
sugar maple	#stems (acceptable)												
	# stems >50% wknd crcmfnc												
	# stems >25% crown dieback												
	TPA												
	# stem												
	TPA												
	# stem												
	TPA												
	# stem												
	TPA												
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	TPA												
	# stem												
	TPA												

Basal area per acre = (# stems x 10) / number of sample points • *TPA [trees per acre]* = # stems in a DBH class x TPA multiplier/ # sample points

Quadratic mean diameter = SQRT [(average maple basal area per acre/average number maple per acre) / .005454)]

Estimating Taps Per Acre

Maple producers will need to estimate the potential number of taps per acre to assess the productive capacity of an area, and to aid in estimating the costs for installing tubing systems or buckets. Two methods allow producers to collect data that estimates the number of taps. One method uses a tape measure to establish a 1/20th acre plot. The other method uses an angle gauge to select trees from a sample point. Both methods are valid and useful, but use different mathematical principles. The data will be most easily reported using a dot-dash tally system. Use approximately one plot or point per acre.

Once you know the number of taps per acre, you can compare sites (see site comparison handout), and estimate costs using the tapping and tubing cost estimator available at www.CornellMaple.com (look at "publications" and then "tools")

Method 1. Fixed Radius Plot
Use a tape measure or rope to create a circular plot with a radius of 26.4'. Count all 10" dbh (diameter breast height, 4.5' above ground) and larger sugar or red maples within the plot. Stems larger than 26" could be counted twice. You do not need to record the dbh of the stem. Multiple the number of counted trees by 20 to obtain an estimate of taps per acre.

Plot #	1	2	3	4	5	6	7	8	9	10
# taps per plot										
Plot multiplier	20	20	20	20	20	20	20	20	20	20
# taps per acre										

Average number of taps per acre = __________________

Method 2. Variable Radius Plot

Use an angle gauge at each point to count all red or sugar maple trees greater than 10” dbh and record them as TPP or “taps per point.” Assign each tree to the appropriate dbh class. Trees should “fill the window” when inspected at 4.5’ above ground. For each point, multiple the number of taps per point (TPP) in each DBH category by the “tree per acre” multiplier (*TPA) determined for the mid-point of each diameter class. *TPP *TPA equals taps per acre for that DBH category*. Sum a row of TPA= to estimate taps/acre. Average for all points. One point/ac.

		DBH Category											
		10-11.9	12-13.9	14-15.9	16-17.9	18-19.9	20-21.9	22-23.9	24-25.9	26-27.9	28-29.9	30+	Σ
POINT	**TPA >*	*15.2*	*10.8*	*8.1*	*6.3*	*5.1*	*4.2*	*3.5*	*2.9*	*2.5*2*	*2.2*2*	*1.8*2*	
1	TPP												
	TPA =												
2	TPP												
	TPA =												
3	TPP												
	TPA =												
4	TPP												
	TPA =												
5	TPP												
	TPA =												
6	TPP												
	TPA =												
7	TPP												
	TPA =												
8	TPP												
	TPA =												
Average	TPA												

1.4 Basic Equipment Needs

Here is a brief list of equipment you should be thinking about. In subsequent sections we will go into detail on estimating costs, making decisions, and the pros and cons of different setups.

In the woods you will need:

- Spouts or “Spiles”
  - They come in different materials and with different properties... and different prices! Today, the standard size is 5/16”.
- Tubing
- Pipe
- High Tensile Wire
- OR Buckets (lead free)
  - In Section 2.1 Choosing a Collection System, we explain the costs and benefits of having a tubing vs. buckets system
- Cordless drill or impact driver – and extra batteries
- Hammer
- Other Maple Specific Tools
  - Two-Handed Tool
  - One Handed Tool
  - Tubing spools, Pipe spool & hitch
  - Spout Puller
- Warm Clothes and Good Boots

In the Sugarhouse you will need:

- Hot running water, or a stove to boil water
- Food Grade plastic buckets
- Sap Storage Tanks
  - Makeshift options
- A way to filter sap
- A way to boil syrup
- A way to filter syrup
- Grading Instruments
- Canning Equipment

1.5 Managing a Sugarbush

Cornell University
Cooperative Extension

Small-Scale Sugarbush & Woodlot Management
Tree Description and Selection Summary Table

(Peter Smallidge, NYS Extension Forester, June 2012. www.ForestConnect.info)

Thinning a woodlot can improve the growth of the residual trees by increasing their access to sunlight. During a thinning harvest, crop trees are retained for enhanced growth. Eventually, crop trees are removed as part of a regeneration harvest.

Prioritize your work in areas with the best soils and with the least amount of sky that is visible through the closed leafy canopy. Large trees may have value and you should consult a forester. Select cut vs. leave trees after understanding the impacts on the overall woodlot's growth and development. Always work safely.

1. RELEASE AND RETAIN TREES that are of a species that matches the owner's objectives, have a healthy crown located in the upper canopy, *and* are generally free of structural defects (especially root or butt damage).
2. CUT TREES if: not a species suited to the owner's objectives, have poorly formed crown and in the lower canopy, *or* have defects that may limit the longevity of the tree.

Complete this table and discuss answers with the workshop instructor.

Tree Number	Species	Approx. DBH	Upper or Lower Canopy Position	Crown, stem or root characteristics that are noteworthy for tree health or quality.	Crop Tree?	Based on adjacent trees, would you cut?
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Cornell University
Cooperative Extension

Chainsaw Safety Best Management Practices

Peter J. Smallidge, NYS Extension Forester and Director, Arnot Teaching and Research Forest. Cornell University Cooperative Extension. Ithaca, NY 14850. January 2008.

Many forest owners will use a chainsaw at some point to clear trails, collect firewood, or thin their woods for improvement and growth of the residual trees. Chainsaws are important tools, but can be especially dangerous if improperly used. Chainsaw operators should be in good physical condition, have properly functioning equipment, appropriate personal protective equipment and know which cutting techniques to use for a given situation. Following are some BMPs (Best Management Practices) to help ensure you are safe and productive with your saw.

1. **Be where you are**. Accidents with chainsaws happen in a split second, but those accidents often result from existing circumstances. Be alert to your existing circumstances of person, place and equipment. Through complete attention to your activity, that being the safe operation of the chainsaw, you can greatly reduce your potential for injury or death. Think only about what you are doing, how you are doing it, your personal ability, and the current conditions. If you mind starts to wander, stop running the saw.

2. **Participate in an approved safety and productivity course before using your saw.** Good courses will last several hours. Some courses with advanced instruction will require several days, but are worth the investment. Some chainsaw dealers provide limited instruction. Nationally, a course known as Game of Logging for Landowners provides comprehensive technical training for landowners on felling and saw maintenance. In NY, these courses are sponsored through Cornell University's ForestConnect and NYFOA.

3. **Always wear appropriate personal protective equipment**. Minimally, equipment includes: a hardhat, eye protection, hearing protection, cut-resistant chaps or pants, and sturdy boots.

4. **Identify hazards in and near the tree you plan to cut.** Look for dead branches, hanging branches, standing snags, saplings in the path of the falling tree, and other structures that might impede the falling tree. Remove hazards if possible. If hazards cannot be managed, pick a different tree to cut. Evaluate snags within one tree height of your location and cut those you deem of high risk.

5. **Determine the back or side lean of the tree relative to the direction the tree will fall.** Look into the crown of the tree you will cut and determine where the majority of weight is located. Consider branches that extend to the side which add weight. Special techniques, available in training courses, are necessary to fell a tree against the natural lean. Avoid using ropes, chains and tractors to pull a tree against the lean.

6. **Identify and clear an escape path.** When the tree starts to fall, you need to be at least 15 feet away from the stump and at a 45 degree angle from the direction of the fall. Take time before felling to clear any obstacle that might block your path. Do not stand near the stump of a falling tree. After the tree falls, look for falling branches and trees before moving to the next tree.

7. **Determine the length and thickness of the hinge.** A correctly felled tree depends on the hinge wood to determine the direction of travel. Based on what you learned in an approved felling course, measure the tree to determine the length and thickness of the hinge. Be careful not to cut your hinge.

8. **Determine the final cuts.** Know where you will stand and how you will execute your final cut. If using wedges, how many will you need and where will you place them. Make a final check on safety and others before releasing the tree to fall.

9. **Maintain your equipment.** Assess the operability of your saw and safety equipment at the beginning and end of each day. Keep your chain teeth sharp, the chain appropriately tight, and the engine running smoothly. Make adjustments to equipment as necessary during the day. Replace broken safety equipment. Improperly function equipment can cause increased fatigue and greater chances for injury.

10. **Stop before you get tired.** Know the limitations of your physical endurance. If you stop before you get tired, you will be around tomorrow to cut the tree that will be where you left it.

Chapter 2: Setting Up – Sap Collection Systems

2.1 Choosing a Collection System

Buckets

Advantages: They are simple and inexpensive. They provide the traditional aesthetic, and if you use your woods for other purposes, such as hunting or other recreation, a bucket system will eliminate the need to duck under pesky tubing and pipe. Because each tree gets its own bucket, you can get a visual for which of your trees produce the most sap and figure out why. Additionally, you can test sap sugar and find out if you have any extra sweet trees!

Disadvantages: Collecting buckets is labor intensive during poor conditions. The best runs often happen during a rain or snow, and it may be icy. Although you have to deal with poor weather conditions when maintaining tubing systems as well, at least when you slip and fall, you will not be dropping gallons of sap! You are also more likely to fall when carrying heavy buckets in treacherous conditions, than when just carrying, say, a hammer. Furthermore, you have to gather your buckets frequently – every other day, depending on conditions, so that the sap doesn't spoil. You also have to take all buckets down at the end of each season in order to remove the spouts so that the tree can heal. Finally, roads during mud season will get pretty torn up as you drive an ATV or truck through your woods to gather buckets. This will impact your soil and could require road maintenance every year. Think about access when planning your sugarbush. Buckets are a great option if your trees are located near a decent road.

Options:

The traditional galvanized buckets are no longer recommended because of the dangers associated with lead soldering. Today, metal options are stainless steel and aluminum. Stainless steel is easy to clean, however, its high value makes it a tempting target for thieves. Aluminum buckets designed for maple (coming with the spout and lid), run about $20-$30 each when bought new. Used options are a lot cheaper.

Plastic is an even cheaper option. A two-gallon plastic bucket runs about $3.90. Plastic lid: $2.55. Spout and hanger: $1.05. For a total of $7.50.

Some producers use plastic bags designed for maple. They are convenient because they are light and can be thrown out after a single season. The bags themselves are cheap, but the holders will raise the overall price. Holder $3-$5. Bags $0.30. Spout $1. For a total of $4-$7.

Another option, this bucket system style adds the minimal cost, but increased effort of drop lines, or "drops". Drops are the short pieces of tubing connecting the spouts to the buckets, or more typically, to a tubing collection system.

Tubing

It is important to understand the difference between tubing systems that are on gravity and on vacuum. A gravity system is simply convenient funnel for sap. It requires a downward slope at all times. Vacuum allows sap to overcome poor slope, and also can draw more sap out of the tree increasing yield.

Gravity

Advantages: Tubing increases yield, minimizes loss, and minimizes labor during runs. If your tubing is on vacuum, you can increase yield by up to 150%! You can read more about vacuum in Section 2.4. If you are not going to have vacuum, however, you will need a decent slope to keep all tubing at a minimum of 2% grade. This is called a Gravity System. Tubing systems are easier and cheaper to expand, and make more sense for large, dense woodlots where walking with buckets full of sap would be impractical. Furthermore, there is less ground impact with a tubing system because you avoid driving all through woods during mud season.

Vacuum

Disadvantages: Putting up a tubing system for the first time is a big investment. It is very labor and capital intensive in the first year. In the long run, however, a tubing system will save you in labor and capital, especially because that increased yield will help make up for the cost. Besides all the tubing and pipe itself, part of the investment is in the wide variety of tools you will need to set up and maintain a tubing system. Some tools are unique to maple. There is a pretty steep learning curve when it comes to efficiency when working with tubing. It takes practice.

Upon planning, you will need to consider:

- Terrain and slope
- Location of collection tanks
- Location of sugarhouse
- Density of stand

Tubing is ideal for large operations. If you have a vision of greatly expanding your maple operation in a few years, tubing is the way to go. However, buckets can be a nice way to ease into the syrup industry if you don’t quite have the capital or time for a tubing system at first.

In Summary:

Buckets	Tubing
Simple	Relatively complicated
Any Terrain	Need good slope – Gravity
Lower initial costs	Large initial investment
Lower Yield	Greater Yield – Vacuum
Great for small woodlots with road access	Great for large woods with potential to expand
No methods at hand to improve yield	Possible to add vacuum, other techniques
More labor during runs	More maintenance
All buckets removed at end of season	System stays in place year round
Better aesthetics, practical for recreation	Gets in the way of other woods use
Can determine individual trees’ outputs	All sap goes to one place
Wildlife doesn’t mess with metal	Wildlife damages plastic tubing
Easier to clean, even possible between runs	Best cleaning practices still being developed

2.2 Estimating Costs

Equipment List for Tubing System

Item	Quantity	Cost	Your Estimate
5⁄16 plastic spout (tap)	1 per tap	$0.39–0.50	______________
5⁄16-inch sap tubing	15 feet per tap	$2.40–2.60	______________
½-inch main line tubing	2 feet per tap	$0.40–0.50	______________
3/4-inch main line tubing	1.2 feet per tap	$0.38–0.45	______________
1-inch main line tubing	0.7 feet per tap	$0.33–0.40	______________
5⁄16-inch connector	0.05 per tap	$0.01–0.05	______________
½-inch connector	0.02 per tap	$0.02–0.04	______________
3/4-inch connector	0.007 per tap	$0.01–0.05	______________
1-inch connector	0.04 per tap	$0.05–0.07	______________
4-way wye	1 per tap	$1.69–1.75	______________
1-x-3/4-inch reducer	0.02 per tap	$0.04–0.06	______________
Quick clamp	0.002 per tap	$0.01–0.02	______________
Double tubing tool	1 per operation	$134.00–340.00	______________
Aluminum fence wire	0.004 per tap	$0.01–0.02	______________
Quick clamp pliers	0.082 per tap	$4.50–5.00	______________
Wire ties	0.7 foot per tap	$0.04–0.06	______________
Wire tier	1 per operation	$70.00–90.00	______________
Fence wire stretcher	1 per operation	$90.00–125.00	______________
Power tree tapper with battery pack	1 per operation	$350.00–500.00	______________
Tapping bit and bit file	1 per operation	$13.00–21.50	______________
Hand tool set	1 per operation	$25.00–50.00	______________

Table adapted from research paper NE-712 authored by Neil K. Huyler, United States Department of Agriculture Forest Service, Northeast Research Station.

Cost information estimated for Pennsylvania as of November 2009.

Worksheet for Determining Maple Syrup Production Costs and Profitability

Cost Components

Fixed Cost	Initial Cost	Life Expectancy	Yearly Cost	Your Estimate
Sugar bush				
Sugar house				
Evaporator	$1,100–3,400			
Steam Hood (optional)	$100–200			
Preheater (optional)	$750–3,000			
Forced Draft Unit (optional)	$400–2,400			
Reverse Osmosis Unit (optional)	$1,100–2,650			
Draw-off Accessories	$150–200			
Filter Press/Canning Unit	$600–750			
Storage Tanks (sap)	$200–400			
Evaporator Feed Tank	$1,200			
Miscellaneous Utensils	$200			
Sap Collection Equipment				
Bucket/Bags				
Tubing System per Tap	see equipment table			
Transfer Pumps (if necessary)	$200–400			
Tractor and Trailer	$2,500–5,000			
Gathering Tank	$150–300			
Tapping Unit	$350–500			
Miscellaneous Equipment	$20–100			
Other				
Overhead Management Costs				
Land Taxes				
Land Rental				
Insurance				
Management/Record Keeping				
Total				

Variable Cost	Quantity Used (hours)	Unit Cost	Total Cost	Your Estimate
Labor				
Managemnet	20–40			
Sugar house Operations	100–200			
Tapping and Setup	40–60			
Sap Collection	20–40			
Fuel Production Wood	30–40			
Maintenance/Cleanup	40–60			
Fuel				
Evaporator				
Finishing/Canning				
Tapping and Sap Collection				
Utilities				
Marketing				
Advertising (yearly cost)				
Sales Cost (yearly cost)				
Containers (assorted sizes)				
Total				

Expected Revenues

Amount of syrup produced (gal):	
Anticipated Sales	
Retail (gallons sold________x average sales price per gallon______):	
Wholesale (gallons sold_______x average sales price per gallon______):	
Other products (equivalent gallons sold_______x average sales price per gallon_______):	
Profit Summary	
Average fixed cost per gallon of syrup produced (total fixed yearly cost divided by gallons of syrup produced):	
Average variable cost per gallon of syrup produced (total variable yearly costs divided by gallons of syrup produced):	
Total cost per gallon of syrup produced (sum of average fixed and average annual variable costs):	
Total value of all syrup produced and sold (sum of all sales revenue):	
Total of yearly fixed and yearly variable costs:	
Total profit from production and sales of maple products (difference between total sales and total costs):	
Profit per gallon of syrup produced (total profit from production and sales divided by number of gallons of syrup produced):	

Tables reproduced from *North American Maple Syrup Producers Manual*, 2nd ed. (Ohio State University Extension).

Prepared by Robert S. Hansen, extension educator, Bradford County; Stephen L. Childs, extension maple specialist, Cornell University; Lynn F. Kime, senior extension associate; and Jayson K. Harper, professor of agricultural economics.

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Penn State College of Agricultural Sciences research, extension, and resident education programs are funded in part by Pennsylvania counties, the Commonwealth of Pennsylvania, and the U.S. Department of Agriculture.

This publication is available from the Publications Distribution Center, The Pennsylvania State University, 112 Agricultural Administration Building, University Park, PA 16802. For information telephone 814-865-6713.

Produced by Ag Communications and Marketing

Sugarbush Evaluation – The tubing system

Five aspects of a sugarbush and maple tubing system will be evaluated. Tapping density, taps per lateral line, main line sizing, vacuum sizing, and spout sanitation.

Items necessary per team: tree diameter tape, tape measure > 27', vacuum gauge, Main line guidelines, tools to measure slope, taps on main lines counted prior to workshop?, vacuum on in the sections of woods to be used, recording sheets, spout samples.

Tapping Density
Mark a center point in the sugarbush for a circle with a radius of 26'4''
Measure out the circle and count 1 tap for each tree 10" or more
Alternative
Measure out the circle and count 1 tap for each tree 10" to 20" diameter and 2 taps for each tree over 20"

For each distinct section of sugarbush do this at least three times

Sugarbush section identification ________________________________

	Site 1	Site 2	Site 3	Site 4
tap count				
x 20				
Average				

Input these averages into the cost spreadsheet for a cost per tap evaluation

Results: 1-20 taps per acre = difficult to operate commercially
21-40 taps per acre = low efficiency
41-80 taps per acre = medium efficiency
81-120 taps per acre = maximum efficiency
121+ taps per acre = over crowded, reduced sugar content of sap, slow growth

Explain: The more concentrated the taps in a woods the lower the cost per tap to install a tubing system. The negative of too many taps though could be lack of other species in the woods making it more vulnerable to insect and disease attack. Also overcrowding could lead to lower sugar content. Research from Canada has shown that with vacuum one tap for trees up to 20" is sufficient to extract available sap. Many producers will elect to put two taps in trees larger than 20" and there is no research data to indicate that this is not an acceptable practice.

Taps per lateral line estimation
Count the taps on each of 5 lateral lines in a sugarbush section and average

Sugarbush section identification _________________________________

	Lateral 1	Lateral 2	Lateral 3	Lateral 4	Lateral 5	Average
tap count						

Average of the 3 sections _____

Results: 1-3 taps per lateral = tends to increase cost with very little sap yield benefit
4-8 taps per lateral = with average maintenance this seems to work best
9-12 taps per lateral = only should be used with top notch maintenance along with steep slopes
13-20 taps per lateral = generally results in reduced yields
21+ taps per lateral = generally results in reduced yields

Explain: Research done in Vermont has shown that reducing taps per lateral increases sap yield per tap. However, too few taps per lateral increases the installation cost per tap. The recommended ideal is 5 to 6 taps. More taps per lateral does reduce installation costs but also reduces production

Main line size
For slope, measure the slope of the flattest 20' length of a main line in its lower half

Use the slope determined above for the given main line size to select the correct column to use on the tapping rate guideline sheet

Sugarbush section identification _________________________________
Main line identification _________________________________
main line diameter _____
main line length _____
number of taps _____
number of taps from the guideline _____
# of taps more than guideline _____
# of taps less than guideline _____
Difference = # of taps more or less than guideline/guideline ________

Sugarbush section identification _________________________________
Main line identification _________________________________
main line diameter _____
main line length _____
number of taps _____
number of taps from the guideline _____
# of taps more than guideline _____
# of taps less than guideline _____
Difference = # of taps more or less than guideline/guideline ________

Results: more than 25% below the guideline = good productivity but high installation costs
Less than 25% below or above the guideline = Ideal for productivity vs. installation costs
25 to 35% more taps than the guideline = reduced productivity but lower installation costs
More than 35% more than the guideline = lower cost low production system

Explain: The slope of a main line determines how rapidly sap exits the main line. However, if the slope of the line changes the flatter areas will bottleneck that flow, particularly lower in the line where the most sap is flowing in the line. Air flow needed to maintain vacuum in a main line is restricted by sap flow. The guidelines for number of taps on a main line take into account sap flow during an exceptional flow event and calculate how much capacity of the line must be free to remove the normal air leakage into the line to maintain excellent vacuum. Too many more taps and vacuum will be obstructed during good sap flow, too many less taps will be more expensive to install and can lead to sap warming as it moves through the system because of the lower flow rates.

Vacuum sizing

Sugarbush section identification ________________________________
vacuum reading in inches at the pump _____
vacuum reading in inches near the bottom of the main line _____
vacuum reading at the end of a lateral line near the top end of the main line _____
Difference between the readings _____, _____, ____

Sugarbush section identification ________________________________
vacuum reading in inches at the pump _____
vacuum reading in inches near the bottom of the main line _____
vacuum reading at the end of a lateral line near the top end of the main line _____
Difference between the readings _____, _____, _____

Results: Difference within 2” of vacuum and above 15” = highest productivity and well designed tubing system
Difference between 2” and 4” or vacuum less than 15” = lower productivity, tubing undersized or has slope change issues
Difference greater than 4” or vacuum less than 10” = lower productivity and poor tubing system design
No vacuum at the top = poor productivity, unacceptable system design

Explain: Research from various sources shows that sap flow increases with increased vacuum at the tap. Tubing systems that are undersized will obstruct the flow of leakage air through the main lines and out to the vacuum pump in turn reducing sap yield. The larger the difference between the inches of vacuum early in the system vs. at the systems most distant points shows just how undersized the main line system is. Most vacuum pumps are designed to perform well in the 12” to 18” range so we target having at least 15” available near the vacuum pump as a minimum.

Vacuum bonus points,
cfm assignment suggested by the guideline = _______
Estimated actual cfm available to the line = ______

Spout and tap sanitation evaluation

Sugarbush section identification ________________________________

	7/16"	Health spout	Check valve	Silver Spout	Tree saver
Kind of spout	____	____	____	____	____
Age of spout	____	____	____	____	____
Age of drop	____	____	____	____	____

Sugarbush section identification ________________________________

	7/16"	Health spout	Check valve	Silver Spout	Tree saver
Kind of spout	____	____	____	____	____
Age of spout	____	____	____	____	____
Age of drop	____	____	____	____	____

Results: New check valve or new silver spout or new health spout and drop line = highest productivity
2nd to 3rd season old health spout and drop line or new tree saver spout = medium productivity
7/16 spout and old drop lines = poorest productivity

Explain: Research at Cornell and Vermont has shown dramatic improvements in sap yield can be obtained when some practice of preserving taphole sanitation is used. The best results have been observed with new check valve spouts, new silver spouts, or new health spout with new drop line. Tree saver spouts or replacing the spout and drop every few years can be improving yield but less than those practices listed above. Systems still using the old 7/16 spouts and not updating drop lines in a systematic way will be creating more in tree partitioning and experiencing lower sap yield.

Estimate Cost per Tap for Installing Maple Tubing

Input Data		
Number of trees per acre	**120**	
Number of trees per lateral line	**12**	
Average distance between trees	19.1	
Average length of a lateral line	219.1	
Number of lateral lines per acre	10.0	
Main line length per acre	190.5	
Total length of lateral lines	2191.0	
Length of 5/16 lines end tree loop (3' each)	30.0	
Length of 5/16 in drop lines (30" each)	300.0	
Number of wire ties (one every 18")	127.0	
Length of side tie wire	41.0	
Costs:		
Spouts	*Price**	*Subtotal*
Spouts - use spouts or stubs not both	$ 0.39	$46.80
Stubs -use spouts or stubs not both	$ 0.29	
Stub adapter - use adapter or check valve not both	$ 0.21	
Check Valve adapter - use adapter or check valve not both	$ 0.50	
Fittings		
Saddles, all single connect	$ 2.95	$29.50
T's	$ 0.24	$26.40
Y's	$ 0.77	$7.70
Hooked connector	$ 0.33	$3.30
Lateral end tree loop (leave this blank if you use old tubing here)	$ 0.09	$2.70
Tubing/Main Line		
Drop lines	$ 0.09	$27.00
Lateral Lines	$ 0.09	$197.19
Main Lines (1") Black use black or blue not both	$ 0.38	$72.97
Main Lines (1") Blue use black or blue not both	$ 0.42	
Continued…		

An estimate of tree density can be made in a prospective wood lot by measuring out 26' 4" in a circle, count the # of tappable trees and multiply by 20. Take the average of several samples to get a more accurate assessment.

Prices are from 2009 Leader Evaporator Co. Catalog. Change these prices to reflect those available from your local supplier.

Wire/Miscellaneous		
Main Line Wire same length as main line	$ 0.06	$10.48
Wire ties	$ 0.01	$1.78
Wire grips estimated at 3 per acre	$ 1.75	$5.25
Tree hooks estimated at 2 per acre	$ 3.50	$7.00
Tensioners estimated at 1 per acre	$ 5.95	$5.95
Side tie wire	0.07	$5.33
Main line valves one on each end(1 for each 3 acres) brass plus fitting and clamp	52	$17.33
Estimated total material cost per acre		**$466.69**
Estimated cost per tap		**$3.89**

Calculating costs for a maple tubing system

Stephen Childs, NYS Maple Specialist with Cornell University

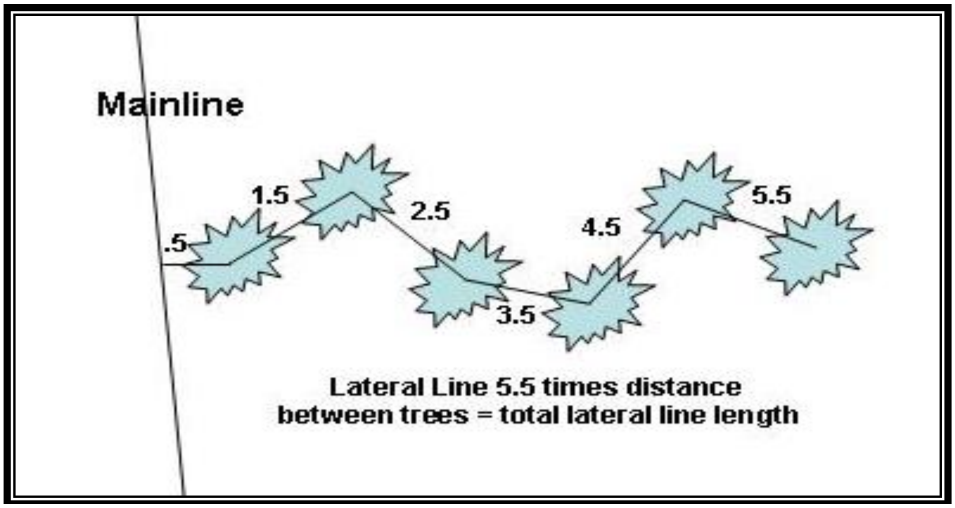
An important part of beginning or improving the tubing system in a maple enterprise is to have a good estimate of just how much the project will cost. Though there are many variables in installing a new or replacing an old system the cost of materials is predictable. Two factors allow you to make a reasonable estimate of what a sap collection system will cost in materials. The first is the number of taps per acre. The second is the density of trees.

Tree density and number of taps per acre can be calculated by measuring out 26' 4" from a center point in a circle, this distance is the radius of a 1/20th of an acre circle, count the number of tappable trees inside the circle and multiply by 20. Take several samples and then average the results to estimate the usable trees per acre. Number of taps can depend on tree size. Start with one per tree and add a tap for trees greater than 18 inches DBH. If areas of the woods differ significantly from others you would want to do separate density estimates for each area. Then estimate how big of an area the differing density samples represent. If you don't have any idea how large your sugarbush is, your county Farm Service Agency or Soil and Water Conservation Office may be able to assist you from aerial photos.

The cost calculations here are based on one tap per tree, using 5/16th spouts, and all main lines connecting the 5/16 lateral lines are 1" in diameter. This cost estimate only includes main lines used to collect sap from the lateral lines within the sugarbush. It does not include the main line conductor lines to the sugar house or collection tank. Those would need to be added based on total system size and distances. I decided not to include them in this sheet as putting in a automatic estimate of it would make the overall result much less accurate.

The average number of taps on a lateral line is an important decision. Research at the University of Vermont indicates that the fewer taps on a lateral line the more sap is yielded per tree. The recommendation for the number of taps on a lateral line tries to balance the overall system cost vs. getting good vacuum at the tree. In the early days of tubing much larger numbers were suggested. Six taps per lateral, on average seems to be a reasonable compromise.

Once you have estimates of average trees per acre and average taps per lateral line you can calculate how long lateral and main lines will be. In this example I use an average density of 120 trees per acre. From this density I calculate the average distance between trees. This is done by dividing the square footage in an acre of sugar bush by tree density, in this case 43,560 square feet per acre divided by is 363 square feet. The square root of the 363 feet gives us the average distance between two trees, in this case is 19.1 feet. Use a calculator with a square root function for this. Now to determine the average length of a lateral line I multiply the average distance between trees by 5.5. 5.5 because we chose 6 taps per lateral line. The lateral line includes the whole width for the first five trees on a lateral line but only half of the distance for the final tree on the lateral line. This makes our average lateral line 104.8 feet long.



For the number of lateral lines in one acre divide the density of 120 trees per acre by the number of trees or taps per lateral line, in this case 6 giving us 20. Now determine the total length of lateral line by multiplying 20 lateral lines by 104.8 feet each for a total of 2095.8 feet.

To calculate the total length of main line needed to connect all of the lateral lines, multiply the total number of lateral lines in the acre by the average distance between trees as the average distance between trees will also be the average distance between lateral lines were we let the distance between lateral lines fall at its most efficient distance. This calculation sets the distance between main lines as the average distance between 6 trees or 6 times 19.1 feet or 114.6 feet. If were decided we wanted the distance between main lines to be less and decided 80 feet would somehow be better. The lateral lines would stay the same 104.8 feet to capture the sap from 6 trees but the distance between lateral lines would become greater so we would be adding more main line to accomplish the same task. This would not in any way make this system more efficient. Lateral lines are the same length and we now would have more main line to add to vacuum loss due to more air friction from passing through more main line. At this given density, if we wanted main lines to be closer than 114.6 feet we should consider reducing the number of taps per lateral line. This change would reduce total lateral line length in the acre by 38 feet and increase main line length by 76 feet.

To determine the length of 5/16 tubing that will go into uses other than lateral lines we multiply the number of taps by 2 feet to total the tubing used in drop lines. In this example I am using end Y fittings to end the upper end of lateral lines which also need about 3 feet of tubing to go around each end tree. This could be one place where a maple producer could use old lateral lines rather than new since sap never enters this part of the line. However at a cost of about $4 to $5 per acre to use new tubing for this loop, the labor to handle a separate batch of tubing may not be worth the effort to get old tubing to each of the end trees. To determine the number of wire ties it will take to secure the main line to the main line wire, I assume a wire tie every 18 inches or dividing the main line length by 1.5. Side tie wires to tighten and secure the main line is estimated at placing a wire tie every 30 feet and using an average of 5 feet of wire for each side tie. Protection for the side tied trees is needed but here I assumed old materials would be used. In this example side tie wire amounted to a little over 60 feet per acre.

Number of trees per acre (one tap per tree)	120
Number of trees per lateral line	6
Average distance between trees	19.1
Average length of a lateral line	104.8
Number of lateral lines per acre	20.0
Main line length per acre	381.1
Total length of lateral lines	2095.8
Length of 5/16 lines end tree loop (3' each)	60.0
Length of 5/16 in drop lines (24" each)	240.0
Number of wire ties (one every 18")	254.0
Length of side tie wire	63.5

Next I put a price on each of the materials needed.

Costs:		
Spouts - use spouts or stubs not both	0.39	$46.80
Stubs -use spouts or stubs not both, must include one kind of adapter	0.29	
Stub adapter - use adapter or check valve not both, must also include stub	0.21	
Check Valve adapter - use adapter or check valve not both	0.5	
Saddles, all single connect	2.95	$59.00
T's	0.24	$24.00
Y's	0.77	$15.40
Hooked connector	0.33	$6.60
Lateral end tree loop (leave this blank if you use old tubing here)	0.09	$5.40
Drop lines	0.09	$21.60
Lateral Lines	0.09	$188.62
Main Lines (1") Black use black or blue not both	0.383	$145.94
Main Lines Blue (1") use black or blue not both	0.42	
Main Line Wire same length as mainline	0.055	$20.96
Wire ties	0.014	$3.56
Wire grips estimated at 3 per acre	1.75	$5.25
Tree hooks estimated at 2 per acre	3.5	$7.00
Tensioners estimated at 1 per acre	5.95	$5.95
Side tie wire	0.07	$4.45
Mainline valves one on each end(1 for each 3 acres) brass plus fitting and clamp	52	$17.33
Total material cost per acre		$577.86
Cost per tap		$4.82

All of the prices are based on a 2009 catalog and are subject to change and subject to variation depending on source. The first item is the spout. Listed first is the health or tree saver 5/16th inch spout. It would be used alone on the drop line. If you plan to use the new check valve adapter or the regular stub adapter, the stub spout would need to be purchased along with one of these adapters. A T is used to connect the drop line to the lateral line on all taps that are not end trees. To get the number subtract the number of lateral lines listed above from the total number of taps and then multiply times the cost each. There is an end Y and a hooked connector for each lateral. Next the total length of 5/16th tubing from lateral lines, drop lines and end tree lines is multiplied by the cost of 5/16th line at 9 cents per foot. The price for main line per foot was based on purchasing the largest rolls listed and calculated out to a per foot cost. The chart includes a place to calculate costs for either black or colored main lines, choose one or the other or use the chart to compare costs. The main line wire is based on purchasing a 2000' roll of 12.5 gauge wire price out on a per foot basis. I calculated the number of wire ties above. Now I multiply that times the calculated cost for each. Finally, I advise having a shut off valve where a main line connecting to the lateral lines meets the main conductor line that connects a number of main lines to the holding tank or sugar house. I also recommend a valve at the upper end of this main line. These valves can be very helpful when washing main lines and when finding and solving vacuum leaks in the line. Here I estimated that the system would need one valve for each 3 acres of installation. This is based on the tree density in this example.

Now I can sum up all of the material costs for a total per acre and divide this by the number of taps. This will give the material cost per tap for the tubing system only on that given acre. Remember this number does not include the main line needed to transfer the sap to the holding tank or the sugarhouse. It does not include the costs of a releaser, vacuum pump or other components related directly to the vacuum system. All of those costs will vary significantly depending on the size of the whole system and the distances between the woods and there rest of the collection and vacuum system. These other costs can be estimated in a fashion similar to what I have done here once the additional information is provided.

Now that you see how the calculations are done, provided below is second example of how the costs work out on a woods with fewer tappable trees per acre.

Number of trees per acre (one tap per tree)	50
Number of trees per lateral line	6
Average distance between trees	29.5
Average length of a lateral line	162.3
Number of lateral lines per acre	8.3
Main line length per acre	246.0
Total length of lateral lines	1352.8
Length of 5/16 lines end tree loop (3' each)	25.0
Length of 5/16 in drop lines (24" each)	100.0
Number of wire ties (one every 18")	164.0
Length of side tie wire	41.0

Costs:		
Spouts - use spouts or stubs not both	0.39	$19.50
Stubs -use spouts or stubs not both, must include one kind of adapter	0.29	
Stub adapter - use adapter or check valve not both, must also include stub	0.21	
Check Valve adapter - use adapter or check valve not both	0.5	
Saddles, all single connect	2.95	$24.58
T's	0.24	$10.00
Y's	0.77	$6.42
Hooked connector	0.33	$2.75
Lateral end tree loop (leave this blank if you use old tubing here)	0.09	$2.25
Drop lines	0.09	$9.00
Lateral Lines	0.09	$121.75
Main Lines (1") Black use black or blue not both	0.383	$94.21
Main Lines Blue (1") use black or blue not both	0.42	
Main Line Wire same length as mainline	0.055	$13.53
Wire ties	0.014	$2.30
Wire grips estimated at 3 per acre	1.75	$5.25
Tree hooks estimated at 2 per acre	3.5	$7.00
Tensioners estimated at 1 per acre	5.95	$5.95
Side tie wire	0.07	$2.87
Mainline valves one on each end(1 for each 3 acres) brass plus fitting and clamp	52	$17.33
Total material cost per acre		$344.69
Cost per tap		$6.89

A spread sheet is available in Excel format to actually do all of these calculations for you. You need to provide a good estimate of your forest density as described earlier in this article and the desired number of taps per lateral line. It is a great tool to compare how costs and distances change with changes in these details. It comes loaded with the 2009 material prices but you can also adjust these depending on your supplier or other ways you may choose to change your set up. It is available at no cost from the Cornell Maple Program at cornellmaple.com

Costs and Returns with Vacuum Systems

# of taps	1000	Yield of sap/tap	10	gallons		
Vacuum level			0"	15"	20"	25"
Sap yield (gallons)			10000	17500	20000	22500
cfm* required			0	10	16.7	50.0
value of syrup			$ 7,674.42	$ 13,430.23	$ 15,348.84	$ 17,267.44
Annual cost of vacuum pump			$ -	$ 480.00	$ 800.00	$ 2,400.00
Net return			$ 7,674.42	$ 12,950.23	$ 14,548.84	$ 14,867.44
Difference			$ -	$ 5,275.81	$ 6,874.42	$ 7,193.02

*cubic feet per minute

Basic rules of thumb

for each 1" increase in vacuum the cfm is reduced by 8%

for each 1" increase in vacuum sap volume is increased by 5%

1 cfm of pump capacity required for each 100 taps at the desired vacuum

vacuum cost estimated at $200 / cfm depreciated 100% over 5 years with 20% added for electric

cfm capacity of pump as rated at 15" of vacuum

sap converted to syrup at 43 gallons of sap per gallon of syrup

priced at wholesale value of $3.00 per pound

2.3 Main line sizing guidelines and worksheets for 1” line

	1 in	1 in	1 in	1 in	1 in
Distance (feet)	15cfm	30cfm	60cfm	80cfm	100cfm
0	15	30	60	80	100
3	15	29	55	62	79
5	15	28	47	59	59
25	14	26	36	48	48
50	14	23	28	28	28
100	13	19	20	20	20
200	11	14	14	14	14
300	10	12	12	12	12
400	10	11	11	11	11
500	9	10	10	10	10
600	8	9	9	9	9
700	8	8	9	9	9
800	8	8	8	8	8
900	7	8	8	8	8
1000	7	8	8	8	7
1100	7	7	7	7	7
1200	7	7	7	7	7
1300	6	7	7	7	7
1400	6	7	7	7	6
1500	6	6	6	6	6
1600	6	6	6	6	6
1700	6	6	6	6	6
1800	6	6	6	6	6
1900	6	6	6	6	6
2000	5	6	6	6	6
2100	5	5	5	5	5
2200	5	5	5	5	5
2300	5	5	5	5	5
2400	5	5	5	5	5
2500	5	5	5	5	5
2600	5	5	5	5	5
2700	5	5	5	5	5
2800	5	5	5	5	5
2900	5	5	5	5	5
3000	5	5	5	5	5
3100	4	5	5	5	5
3200	4	5	5	5	4
3300	4	4	4	4	4
3400	4	4	4	4	4
3500	4	4	4	4	4
3600	4	4	4	4	4
3700	4	4	4	4	4
3800	4	4	4	4	4
3900	4	4	4	4	4
4000	4	4	4	4	4
4100	4	4	4	4	4
4200	4	4	4	4	4
4300	4	4	4	4	4
4400	4	4	4	4	4
4500	4	4	4	4	4
4600	4	4	4	4	4
4700	4	4	4	4	4
4800	4	4	4	4	4
4900	4	4	4	4	4
5000	4	4	4	4	4
5100	4	4	4	4	4
5200	4	4	4	4	4
5300	4	4	4	4	4
5400	3	4	4	4	4
5500	3	3	4	3	3
5600	3	3	3	3	3
5700	3	3	3	3	3
5800	3	3	3	3	3
5900	3	3	3	3	3
6000	3	3	3	3	3

This table explores sap capacity of 1” main line when connected to a 15, 30, 60, 80, and 100 cubic feet per minute (**cfm**) pump. In just 800 feet, all of these one inch lines are supporting exactly the same cubic feet per minute capacity.

At 1 foot away, a 15cfm pump can pull 15cfm of sap through a 1” line, but at 25 feet, this capacity becomes 14cfm because of the distance and friction created in the line.
It may help to visualize by thinking about sap flow in gallons – 1cfm is equal to about 7.5 gallons.

“Line Loss” refers to loss of number of taps you can put on a line, for example, the farther away you get from the pump. It is essentially capacity loss. However, line loss is not only due to distance from the pump. Factors contributing to line loss include: friction in the line, length of the line, slope of the line, sap volume in the line, and vacuum capacity available to the line.

In the first 800 feet of line, most of the significant line loss due to friction has already occurred. So, no matter how big the vacuum pump connected to the line, the air flow in the line remains the same.

The following set of guideline charts for various slopes were developed using the information in this table in conjunction with sap flow calculations.

These tables are based on a balance of air and sap flow in the line. They were developed using air flow line loss charts and water flow charts for 1" line. The first two columns show the length of the tubing and the corresponding cfm from the line loss chart.

Column three shows how many taps can be on a 1" dry line of that length with the associated line loss. Column four shows the number of taps suggested for one 1" main line at the listed length and cfm for near perfect balance between sap and air flow at 2% slope, and so on.

Guidelines for 1" line at 2%, 6%, 10% and 15% slope, 15 cfm

			2% slope	6% slope	10% slope	15%slope
	1"	1"	1"	1"	1"	1"
	15cfm	15cfm	15cfm	15cfm	15cfm	15cfm
Distance (feet)	15cfm	Tap Capacity on Dry line	Max number of taps	Max number of taps	Max number of taps	Max number of taps
0	**15**	**1500**	**693**	**834**	**877**	**913**
3	**15**	**1500**	**693**	**834**	**877**	**913**
5	**15**	**1500**	**693**	**834**	**877**	**913**
25	**14**	**1400**	**693**	**834**	**877**	**913**
50	**14**	**1400**	**693**	**834**	**877**	**913**
100	**13**	**1300**	**693**	**834**	**877**	**913**
200	**11**	**1100**	**693**	**834**	**877**	**913**
300	**10.2**	**1020**	**659**	**786**	**825**	**857**
400	**9.8**	**980**	**641**	**762**	**798**	**828**
500	**9**	**900**	**604**	**712**	**744**	**770**
600	**8.5**	**850**	**580**	**680**	**709**	**733**
700	**8.1**	**810**	**560**	**654**	**681**	**703**
800	**7.7**	**770**	**539**	**627**	**652**	**672**
900	**7.4**	**740**	**524**	**607**	**631**	**649**
1000*	**7.2**	**720**	**513**	**593**	**616**	**634**
1100	**7**	**700**	**502**	**580**	**601**	**618**
1200	**6.8**	**680**	**491**	**566**	**586**	**603**
1300	**6.5**	**650**	**475**	**545**	**564**	**579**
1400	**6.3**	**630**	**464**	**530**	**549**	**563**
1500	**6.2**	**620**	**458**	**523**	**541**	**555**
1600	**6**	**600**	**447**	**509**	**526**	**539**
1700	**5.9**	**590**	**441**	**502**	**518**	**531**
1800	**5.7**	**570**	**429**	**487**	**502**	**514**
1900	**5.6**	**560**	**423**	**480**	**495**	**506**
2000	**5.5**	**550**	**418**	**472**	**487**	**498**
2100	**5.4**	**540**	**412**	**465**	**479**	**490**
2200	**5.3**	**530**	**406**	**457**	**471**	**482**
2300	**5.2**	**520**	**400**	**450**	**463**	**473**
2400	**5.1**	**510**	**394**	**442**	**455**	**465**
2500	**5**	**500**	**387**	**435**	**447**	**457**
2600	**4.9**	**490**	**381**	**427**	**439**	**448**
2700	**4.8**	**480**	**375**	**420**	**431**	**440**
2800	**4.7**	**470**	**369**	**412**	**423**	**432**
2900	**4.6**	**460**	**363**	**404**	**415**	**423**

Guidelines for 1" line continued

			2% slope	6% slope	10% slope	15%slope
	1"	1"	1"	1"	1"	1"
	15cfm	15cfm	15cfm	15cfm	15cfm	15cfm
Distance (feet)	15cfm	Capacity for taps on dry line	Max number of taps	Max number of taps	Max number of taps	Max number of taps
3000	4.6	460	363	404	415	423
3100	4.5	450	356	396	407	415
3200	4.4	440	350	389	398	406
3300	4.4	440	350	389	398	406
3400	4.3	430	343	381	390	398
3500	4.3	430	343	381	390	398
3600	4.2	420	337	373	382	389
3700	4.2	420	337	373	382	389
3800	4.1	410	330	365	374	380
3900	4.1	410	330	365	374	380
4000	4.1	410	330	365	374	380
4100	4	400	324	357	365	372
4200	4	400	324	357	365	372
4300	3.9	390	317	349	357	363
4400	3.9	390	317	349	357	363
4500	3.9	390	317	349	357	363
4600	3.8	380	310	341	349	354
4700	3.8	380	310	341	349	354
4800	3.7	370	304	333	340	346
4900	3.7	370	304	333	340	346
5000	3.7	370	304	333	340	346
5100	3.6	360	297	325	332	337
5200	3.6	360	297	325	332	337
5300	3.5	350	290	317	323	328
5400	3.5	350	290	317	323	328
5500	3.5	350	290	317	323	328
5600	3.5	350	290	317	323	328
5700	3.4	340	283	308	315	319
5800	3.4	340	283	308	315	319
5900	3.4	340	283	308	315	319
6000	3.4	340	283	308	315	319

*Note: the tap numbers listed for the first 1000 feet are not realistic simply because there is no way that many maple trees would be available within such a short distance.

The following worksheet will provide step-by-step instructions for using the chart to identify the ideal combination of pump size, line length, and number of taps for any given main line in the sugarbush.

Using the main line sizing guidelines worksheet (single main lines)
Evaluation for using a 1" main line:

Baseline information:

1. Target, how many taps on or anticipated on this line _______taps
2. Length or estimated length of this line ________
3. Slope of the shallowest 50' of this line ___%
4. cfm of vacuum assigned to this line

(see cfm assignment worksheet if necessary) ______

From the Guidelines for 1" line write the listed distance where for the first time the available CMF (in line 4 above)____cfm shows up in the second column. _____feet

Add the length of your line (from line 2 above) _____feet

Total _____feet

List the recommended number of taps from the guidelines at this distance and at your estimated slope from line 3 above _______taps

If the suggested number of taps is less than our target number then the line is too small, more cfm need to be available or have less taps on the line. If the guideline number of taps is equal to or greater than our line count then this size of main line is correct or possibly larger than necessary.

Many maple producers have decided to only use one size of main line in the Sugarbush. This reduces the number of fittings and repair parts they would need to own, let alone to carry into the woods when working on line maintenance. The extra volume in the 1" line compared to ¾" also reduces the probability that sap will obstruct the line when there are slope variations in the woods. However, the larger line does not allow for carelessness during installation or maintenance. Sagging lines with variations of little more than the thickness of the line can create sap pooling that seriously restricts the movement of air through the lines. A good, tight, well graded system will assure better vacuum to the tapholes.

Using the mainline sizing guidelines worksheet (single mainlines)
Evaluation for using a 1” main line:

Baseline information:

1. Target, how many taps on or anticipated on this line 600 taps
2. Length or estimated length of this line 1200
3. Slope of the shallowest 50' of this line 6 %
4. cfm of vacuum assigned to this line,
(see cfm assignment worksheet if necessary) 10 cfm

From the Guidelines for 1" line write the listed distance where for the first time the available CMF (in line 4 above) 10 cfm shows up in the second column. 300 feet

Add the length of your line (from line 2 above) 1200 feet

Total 1500 feet

List the recommended number of taps from the guidelines at this distance and at your estimated slope from line 3 above 523 taps

If the suggested number of taps is less than our target number then the line is too small, more cfm need to be available or have less taps on the line. If the guideline number of taps is equal to or greater than our line count then this size of main line is correct or possibly larger than necessary.

In this example there are 600 taps on the main line. It is 1200 feet long at a 6% slope and has 10 cfm of vacuum pump capacity available to the line. On the 1” Guidelines Chart, 10 cfm first shows up at about 300 feet. From here we add the 1200 feet of this main line for a total of 1500 feet where the recommended number of the taps at 6% slope is 523 taps. This main line is not of sufficient capacity to service this many taps. Sap during a good flow would obstruct the flow of leakage air from the tap to the vacuum pump and reduce the productivity of the vacuum system.

If 15 cfm of capacity were provided to this line, the distance reading would start at 0. Move down the chart to 1200 feet and the recommended number of taps at 6% slope is 566. Therefore, 15 cfm is still below the Guideline recommendations for vacuum pump capacity, indicating that this many taps should not be on this single main line. Going to more than 15 cfm on the line would represent a significant loss of vacuum pump capacity to friction loss. 15 cfm at the beginning of the line and only 6.8 available after 1200 feet in a line not obstructed by sap shows over 50% of the pump capacity lost to friction. This does, however, indicate that the line could serve as a dry line. The Guidelines take into account both the space in the line needed for sap and the space needed to conduct the flow of leakage air.

Using the mainline sizing guidelines worksheet (single mainlines)
Evaluation for using a 1” main line:

Baseline information:

1. Target, how many taps on or anticipated on this line 300 taps
2. Length or estimated length of this line 900
3. Slope of the shallowest 50' of this line 10 %
4. cfm of vacuum assigned to this line,

(see cfm assignment worksheet if necessary) 6 cfm

From the Guidelines for 1" line write the listed distance where for the first time the available CMF (in line 4 above) 6 cfm shows up in the second column. 1600 feet

Add the length of your line (from line 2 above) 900 feet

Total 2500 feet

List the recommended number of taps from the guidelines at this distance and at your estimated slope from line 3 above 447 taps

If the suggested number of taps is less than our target number then the line is too small, more cfm need to be available or have less taps on the line. If the guideline number of taps is equal to or greater than our line count then this size of main line is correct or possibly larger than necessary.

In this example, there are 300 taps on a 1” main line that is 900’ long with a consistent 10% slope. The line is connected to a vacuum pump capacity of 6 cfm. On the 1” Guidelines chart, 6 cfm first appears at about 1600’. Therefore, you would have to add the length of this main line (900’), to that first 1600’ for a total of 2500’. The chart indicates that at 2500’ and 10% slope, the recommended number of taps is 447. This number of taps is significantly more than the 300 taps available to the main line, leaving you with a few options: 1) add more taps to this line if they are available, 2) evaluate the possibility of using a 3/4" line using similar guideline charts (see the *Maple Tubing and Vacuum Notebook*), 3) direct the capacity of the vacuum pump to somewhere else in the system.

Note in the charts that more taps can be added when the slope of the main line is greater. This simply reflects the fact that sap flows quicker through a steeper line. It is important to note that in order to gain the improved performance of steeper slope, the slope must be consistent for the whole length of the line. For example, if the slope of the line is 20% for three quarters of its length, then 10% for the remaining quarter, you should consider the capacity of the line to correspond to a line at 10% slope. In fact, the slope variation itself may make the line function at an even lower capacity, because sap tends to back up and obstruct the movement of air when the pace of sap flow suddenly changes.

Using mainline sizing guidelines worksheet (wet and dry mainlines)
Evaluation for using a 1" main line:

Baseline information:

1. Target, how many taps on or anticipated on this line ________taps
2. Length or estimated length of this line _________
3. Slope of the shallowest 50' of this line ___%
4. cfm of vacuum assigned to this line,
(see cfm assignment worksheet if necessary) _______cfm

From the Guidelines for 1" line write the listed distance where for the first time the available CMF (in line 4 above)_____cfm shows up in the second column. ______feet

Add the length of your line (from line 2 above) ______feet

Total ______feet

List the recommended number of taps from the guidelines at this distance in the column capacity for taps on dry line ________taps

If the suggested number of taps is less than our target number then the line is too small, more cfm need to be available or have less taps on the line. If the guideline number of taps is equal to or greater than our line count then this size of main line is correct or possibly larger than necessary.

Wet line. Multiply the number of taps by .2 gallons per hour, (line 1 above)________taps x .2 = _________gallons of sap per hour during exceptional flow. Now check the water flow chart at your given slope (line 3 above) to see which wet line can carry that load per hour.

Water (gallons) per hour through plastic tubing at the designated slope.

Slope	2%	6%	10%	15%	20%
Gallons/hour ¾" line	195	336	444	549	640
Gallons/hour 1" line	330	630	840	1050	1215

This is the worksheet for a dry line/wet line system. Evaluating the dry line part of the system is similar to using the worksheet for single main lines, except the dry line column is used. To evaluate the wet line, multiply the number of taps by the 0.2 gallons of sap per hour per tap estimation for exceptional flow, and compare the gallons of anticipated sap flow to the pipe flow capacity estimations at the bottom of the worksheet. These estimations are based on unobstructed pipe which is unusual for a maple tubing system. Fittings, elbows, air pockets, and slope variations all act as obstructions to sap flow. You would not want to have a wet line operating near its rated full capacity. When the sap flow calculation for the wet line shows it nearly full, such as over 75%, moving to a larger line would be suggested. In a wet line, unless it is specifically oversize to add air flow capacity, its air flow is not calculated or added.

Using mainline sizing guidelines worksheet (wet and dry mainlines)
Evaluation for using a 1" main line:

Baseline information:

1. Target, how many taps on or anticipated on this line 750 taps
2. Length or estimated length of this line 800
3. Slope of the shallowest 50' of this line 2 %
4. cfm of vacuum assigned to this line,

(see cfm assignment worksheet if necessary) 15 cfm

From the Guidelines for 1" line write the listed distance where for the first time the available CMF (in line 4 above) 15 cfm shows up in the second column. 0 feet

Add the length of your line (from line 2 above) 800 feet

Total 800 feet

List the recommended number of taps from the guidelines at this distance in the column capacity for taps on dry line 770 taps

If the suggested number of taps is less than our target number then the line is too small, more cfm need to be available or have less taps on the line. If the guideline number of taps is equal to or greater than our line count then this size of main line is correct or possibly larger than necessary.

Wet line. Multiply the number of taps by .2 gallons per hour, (line 1 above) 750 taps x .2 = 150 gallons of sap per hour during exceptional flow. Now check the water flow chart at your given slope (line 3 above) to see which wet line can carry that load per hour.

Water (gallons) per hour through plastic tubing at the designated slope.

Slope	2%	6%	10%	15%	20%
Gallons/hour ¾" line	195	336	444	549	640
Gallons/hour 1" line	330	630	840	1050	1215

In this example there is a 1" dry line that is 800' long with a 2% slope, 750 taps, and a connection to 15 cfm of vacuum pump capacity. On the Guidelines chart for 1" main line, the first place 15 cfm appears is at a distance of 0. Add the 800' length of this main line to the 0' in the chart and read from the third column the capacity for taps on dry line at 770 taps. Under these conditions, 1" dry line has sufficient capacity. Then, multiply the 750 taps by the 0.2 gallons of sap per hour estimate during excellent flow. Total sap flow is 150 gallons.

The chart at the bottom of the worksheet indicates that, at 2% slope, either the 3/4" line at 195 gallons per hour or the 1 lines at 330 gallons per hour would be acceptable. During a good run the 3/4" line could be over 75% full indicating that the 1" line may be the better choice in this scenario.

For more detailed information about tubing and vacuum, see the *Maple Tubing and Vacuum Notebook* available in print or downloadable PDF from the Cornell Maple Program website.

2.4 Vacuum

Vacuum advantage

Research has shown that adding vacuum to a maple tubing system can increase sap production by 50% to 150% over a maple season. The higher the vacuum pressure at the tree, the greater the yield response. Research has also shown that vacuum does not significantly alter the level of sugar and minerals in sap. Vacuum does not cause identifiable damage to the tree. To accomplish these positive results, a vacuum and tubing system must be properly planned and installed. More information on sizing the vacuum pump and sizing and installing main lines to match the number of taps and site conditions can be found in the *Maple Tubing and Vacuum Notebook*.

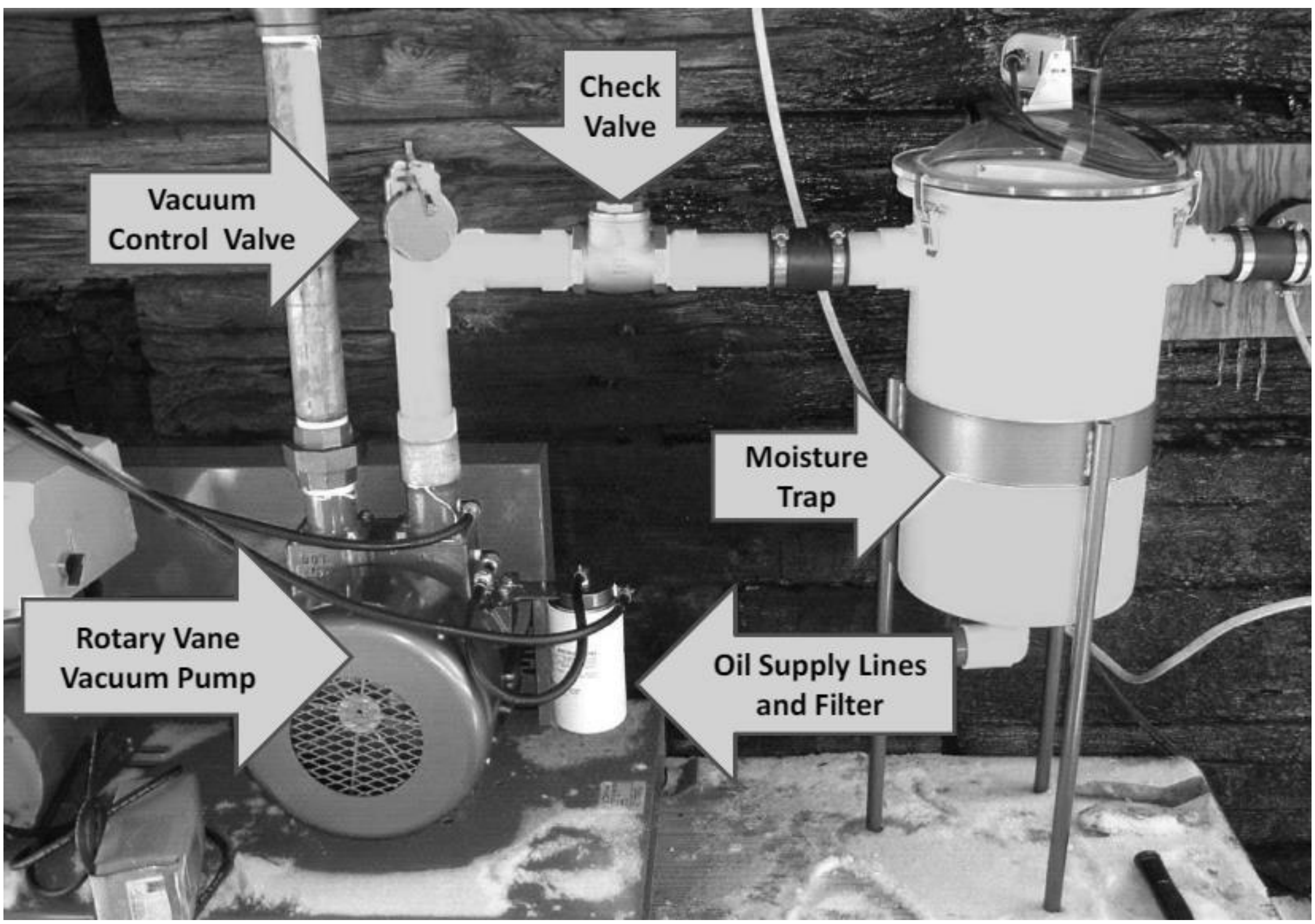
Vacuum Basics

Vacuum is simply the removal of air from a closed or nearly closed system. Maple producers have been using vacuum as a tool to increase production of sap for over 50 years. Vacuum changes the pressure gradient between the maple tree and the tubing system allowing sap to run at a lower tree pressure and temperature as well as to run faster from the tree.

There is a great variety of vacuum equipment used by maple producers, each with its own advantages and disadvantages. The *Maple Tubing and Vacuum Notebook* looks at the basics of vacuum, how vacuum level influences the pump capacity, and how vacuum is measured and calculated in the maple tubing system. It goes into much greater detail for other vacuum related topics as well.

Installing Vacuum

Adding vacuum to a maple tubing main line system requires a vacuum pump along with several additional pieces of equipment. First, you need to separate the vacuum pressure from the sap. This is commonly accomplished with a releaser or extractor or by having a sap holding tank that can tolerate vacuum pressure. Most vacuum pumps need protection from having sap enter the pump. There is a variety of equipment designed to accomplish this protection but it is most commonly done with a moisture trap installed between the vacuum pump and the extractor. Most systems would want to include a vacuum pressure control valve and one way valves to reduce back surging in the tubing system during break downs or shut down. Many vacuum systems include automated electronic systems that turn the system on or off based on weather conditions suitable for sap collection. Some kinds of vacuum pumps also need to be fitted with specific equipment to recover oil or to supply cool water. Each of these components should be considered when planning for a successful vacuum installation.



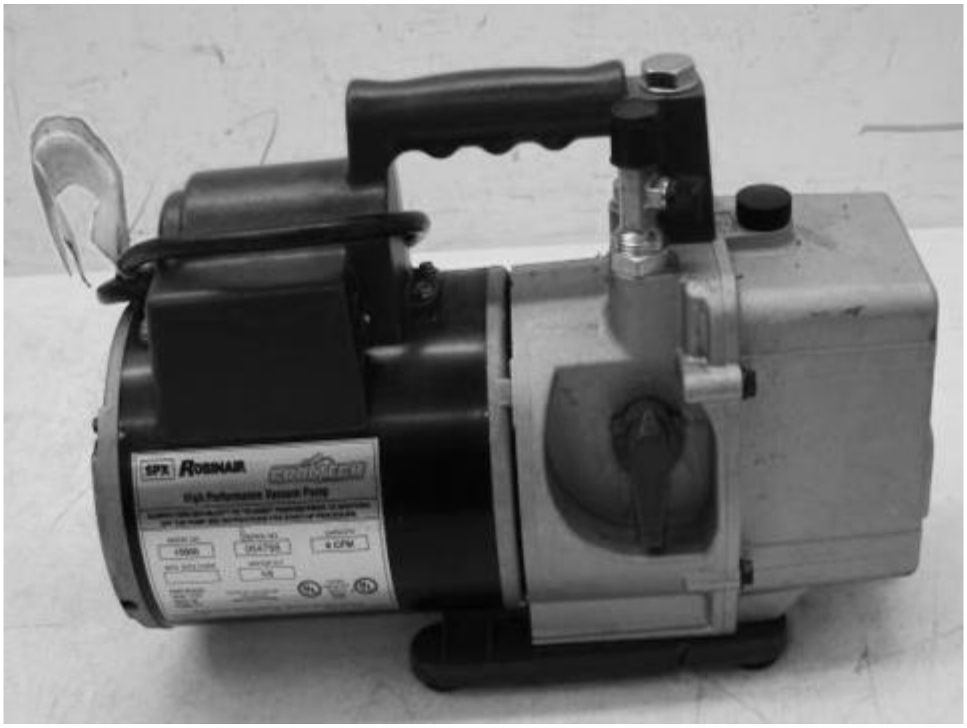
The following pages contain images of vacuum pump setups employed by small operations and backyarders.

Gallery of Small Vacuum Setups

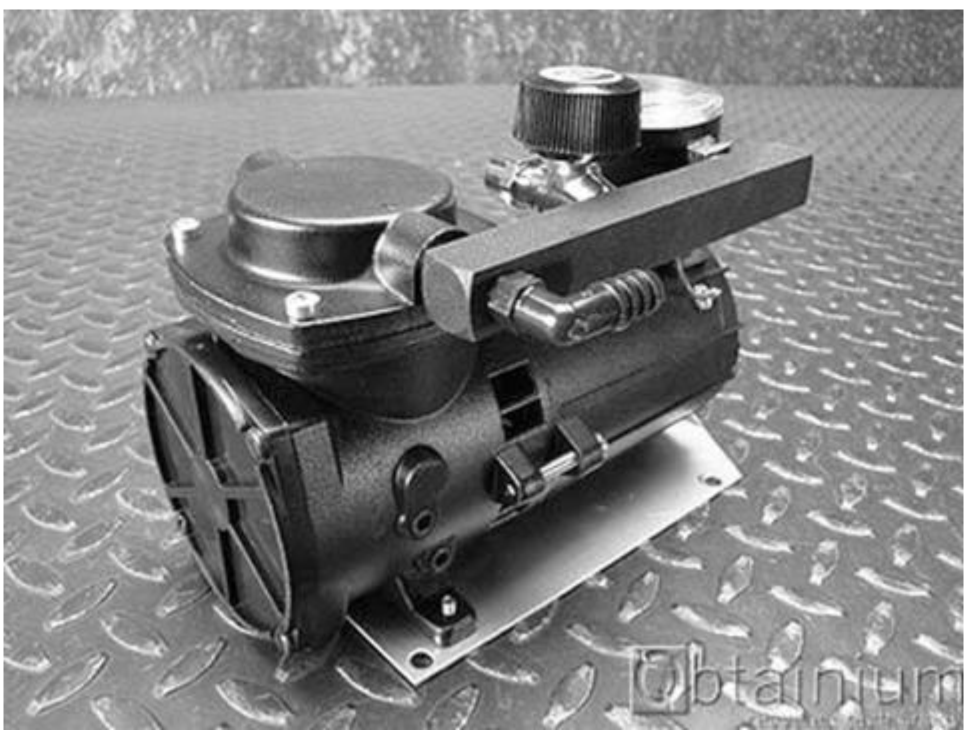
When applying vacuum to their tubing system, the two main issues for small producers are access to power and price point. The following examples find solutions for those issues.

Gas powered vacuum pump on a trailer

Old dairy vacuum pumps are available very cheap or even free



Small vacuum pumps are available (this one is 110V) that can work for just a few to as many as 500 taps



Very small 12 volt vacuum pumps give high vacuum to 1 to 30 pumps

2.5 How to Install Tubing

Tubing systems have become the most common method to collect maple sap for two reasons. The first is the significant time and labor reduction required to collect sap during the production season. The second is the significant increase in sap yield with the addition of vacuum. Under some weather conditions, sap can only be collected under vacuum. Even when sap can flow without vacuum, the addition of vacuum would boost production and increase sap yields.

Proper design of a vacuum and tubing collection system is moving from artful guessing based in experience to more of a science. However, there is still much to be learned. This section is meant to provide beginners with a better understanding of what they need to think about when designing an effective tubing collection system. For even more detailed information, consult the *Maple Tubing and Vacuum Notebook*.

Factors Affecting Tubing Systems

The rate of movement of liquids or air in tubing is affected by three factors: the diameter of the tube, the length of the tube, and the pressure difference between the ends of the tube. The volume of flow is faster in wide-diameter, short tubes under high pressure. Rate of sap flow decreases in narrower, longer tubes and with a lower pressure differential between the ends.

Under appropriate freezing and thawing temperatures, maple trees will develop reasonably high internal pressures. From the tree's perspective, the function of this internal pressure is to squeeze air out of the **xylem** tubes so that they are filled with sugary sap, ready to supply expanding leaves with energy. Under freezing and thawing conditions, vapor lock will occur in the tree. This means that air bubbles will form preventing the movement of sap up the tree.

Xylem: a plant's vascular tissue, organized into many tubes with microscopic diameter that pass water and nutrients up from the roots to the leaves, and help provide support to the plant's stem

When you drill a taphole into the tree, sap comes out on its own only when positive internal pressure has built up. In this case, the tree is pushing against air pressure. This internal pressure builds during the thawing phase and then decreases as sap leaves the tree. The mechanisms behind the pressure buildup are described in the *North American Maple Producers Manual*. The microscopic diameters of the xylem limit the flow rate of sap into the taphole so that sap flow can occur for many hours before the tree loses pressure. If you think about air loss from a tire, a big hole can produce a near instant pressure loss, while a small hole will cause a tire to lose pressure slowly over time.

The rate of pressure loss in the tree is also affected by the fact that the pressure mechanisms are internal so that the tree can increase in pressure even when sap is leaving the tree, something that a tire can't do. During periods of below freezing temperatures, the internal pressures in the tree become negative, so in effect, the tree develops its own vacuum. This is the same mechanism that allows the tree to pull water up through its roots, refilling itself with sap. This period of negative internal pressure also allows the tree to pull sap from the tubing, through the spout and taphole, and back into the stem. This is sometimes referred to as "suck back". A better understanding of this phenomenon has led to the recent development of taphole sanitation practices such as check valves, imbedded silver spouts, tap extenders, and regular replacement of spouts and drop lines. The value of these taphole sanitation techniques is discussed in great deal in the *Maple Tubing and Vacuum Notebook* in Section 8.

Putting the tubing system under vacuum decreases the external pressure the tree pushes against with its internal pressure. This increases the pressure difference causing the sap to flow much faster through the xylem and into the tubing. With vacuum, sap can be collected even with low pressures inside the tree. Additionally, a greater volume of sap can be collected in the same time period compared to a bucket or gravity tubing collection system under which the tree pushes against atmospheric pressure. Finally, this pressure difference created by vacuum allows sap to be extracted from the tree at lower temperatures. Thus, sap begins running sooner after temperatures rise and can continue running longer as the temperature drops down at night or during a weather change.

Calculations have determined that a larger volume of air and sap can move through the larger diameter tubes. The diameter of the tubing will affect the volume of sap that can be delivered to the collecting tanks. The tubing diameters typically increase from the tree to the collecting tank as more and more sap is put into the system. A main line sizing guideline for 1" line is reproduced from the *Maple Tubing and Vacuum Notebook* in Section 2.3 of this notebook, but again, there is much more information on sizing in the tubing-specific notebook.

Maple Tubing Systems Are Unique

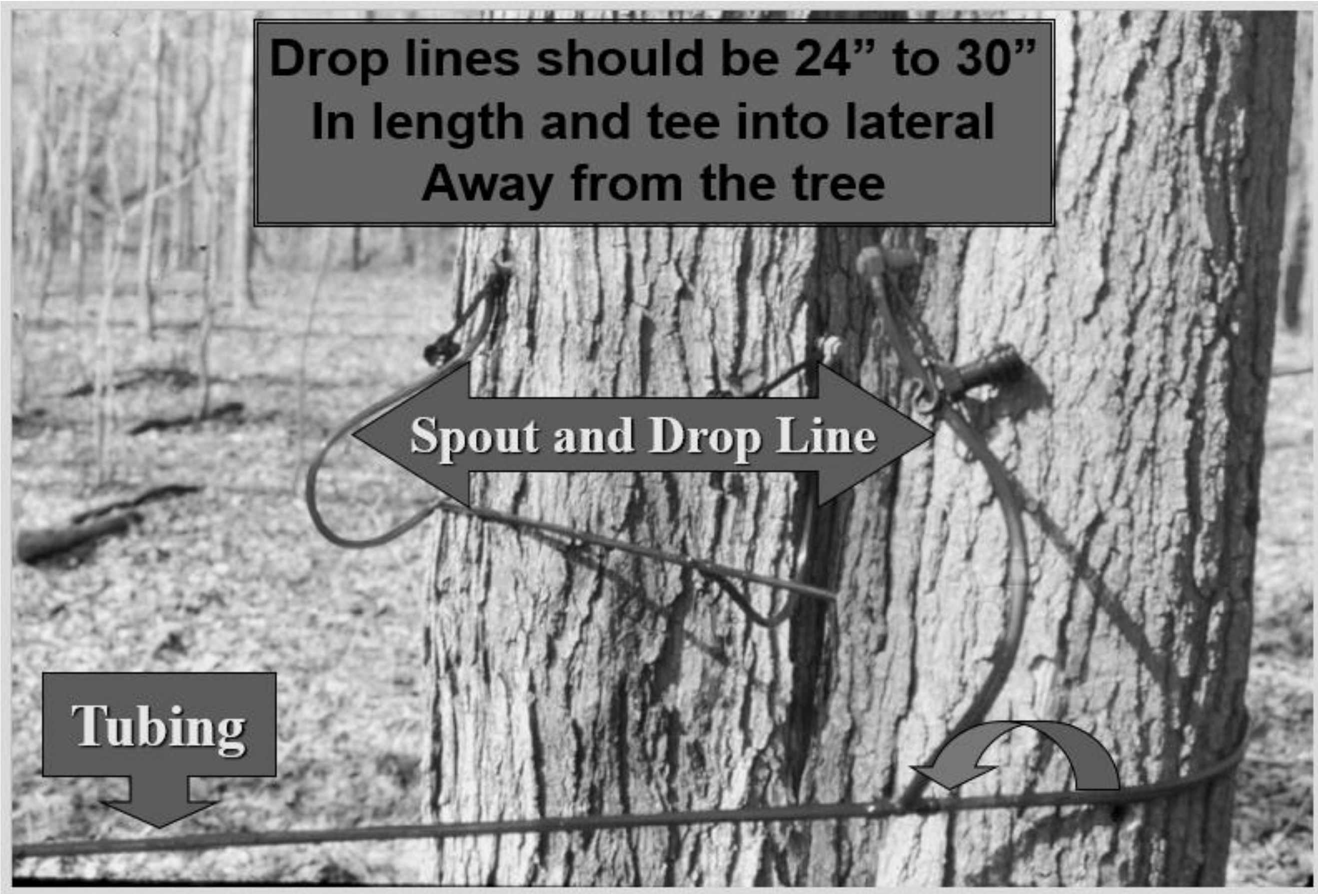
Maple tubing systems are a unique application of vacuum and collection technology. There are very few other applications where miles of main lines and lateral lines are strung out in nature. We have been learning slowly how to make such a system work to maximum productivity with the most efficient cost and return. There has been a lot of trial and error and very little system engineering applied. The vacuum systems installed in medical or dental facilities are probably the closest in design and offer maple production a wealth of information. Misconceptions about “natural” vacuum in tubing systems have caused many systems to be installed with significantly undersized capacity. Recommendations for numbers of taps per lateral line or per main line have changed dramatically over the years. Research has clearly shown the value of vacuum and closed tubing systems. The results have demonstrated that getting good vacuum levels at the tree significantly improves yields. Most recently, research has demonstrated the importance of taphole sanitation practices, namely, replacing taps and drop lines on a regular basis. Finding the most effective methods and materials for washing and sanitizing maple tubing systems remains an ongoing challenge.

Common Terms

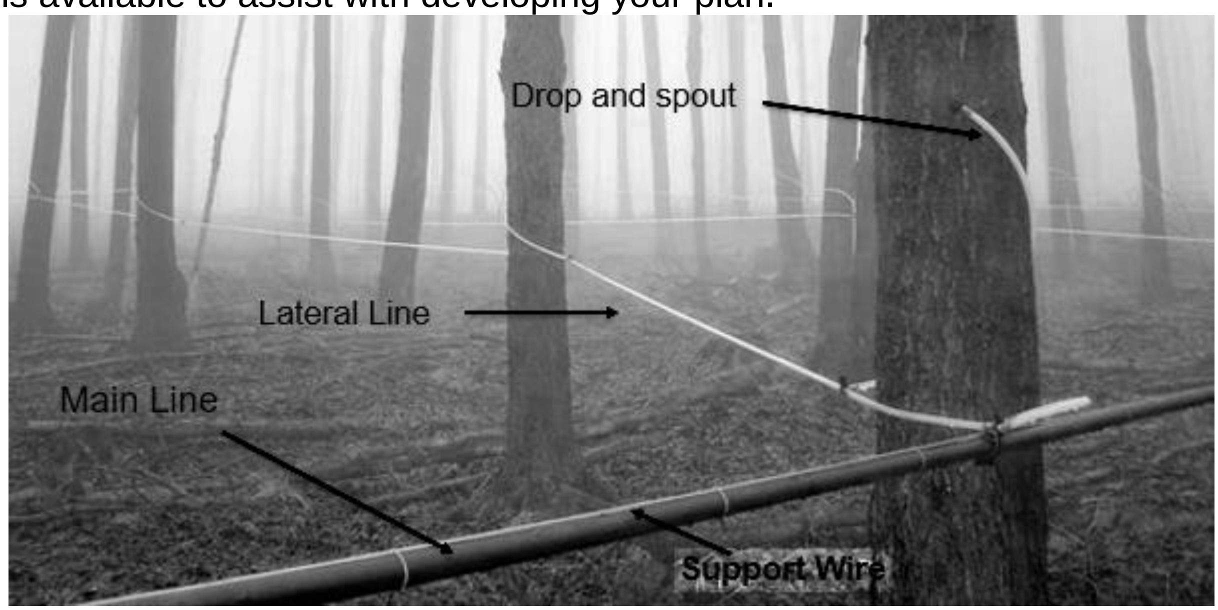
An understanding of some common terms may be helpful as the discussion progresses. The tubing that runs from tree to tree is called the **lateral line**. Lateral line can consist of plastic 5/16” or 3/16” tubing. The **drop line**, or “drop” for short, is made of the same type of tubing, but it connects the spout to the lateral line. The plastic or metal spout is driven into the taphole and is often called the **tap**, **spout**, or **spile**. The lateral line collects sap from a series of trees. In most new installations, lateral lines collect from 5 or 6 taps before emptying into a larger **main line**. Where there is just a single main line, it is commonly called a conductor line. Since these main lines carry both sap and vacuum, they are a dual purpose line. Where two lines are installed together in the tubing system, the one that primarily conducts sap is called the **wet line** and the one that primarily conducts vacuum air is called the **dry line**.

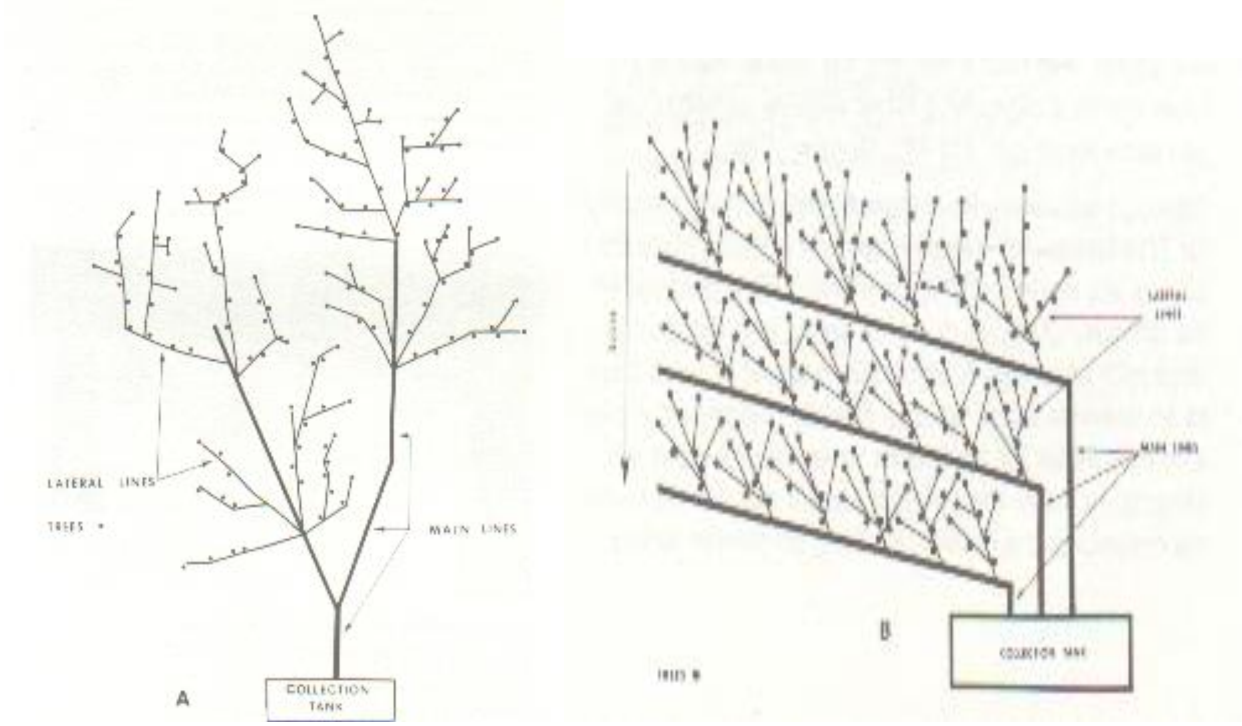
Tubing Basics

Drop lines are usually 24” to 30” long so that a taphole can be placed anywhere around the tree. Smaller trees may be fine with a shorter drop line while larger trees may need a longer drop line. The drop line connection with the lateral line should be placed 4” to 6” away from the tree as illustrated by the arrow in the picture below. This placement helps avoid rodent damage and makes replacement much easier because the connection is not pulled tight to the bark of the tree. With the exception of a sap-ladder, which is covered in section 15 of the *Maple Tubing and Vacuum Notebook*, all tubing, the drop line, the lateral line, and main lines should always be graded to flow downhill. Sap should not be allowed to sit in a dip in the line as this will lead to sap fermentation on warm days and reduced sap quality.



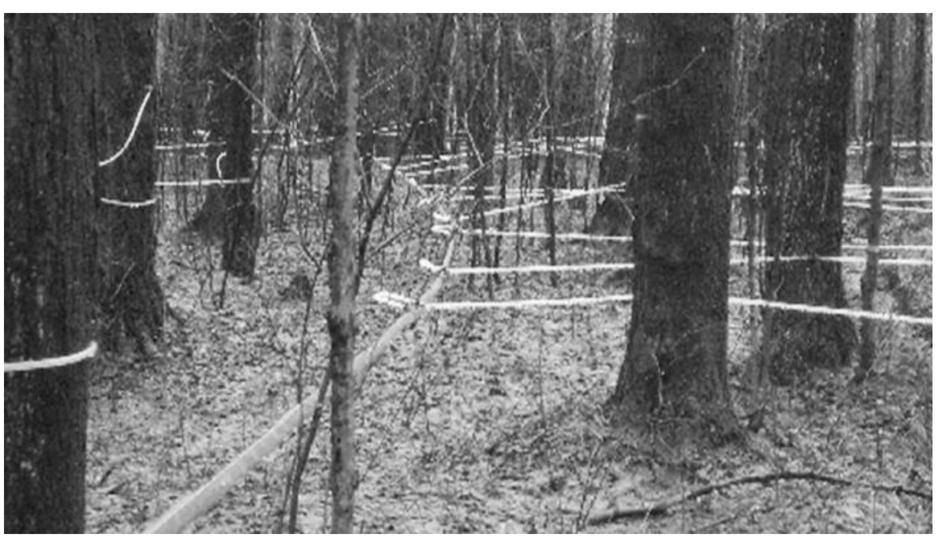
A maple tubing system is expensive and time consuming to install. Once installed, it will likely stay as constructed for the next 10 to 25 years. It is important to plan the system so that it will be efficient to maintain and easy to access, while also resulting in excellent sap yield. The location of the sugarbush and its topography dictate many of the system characteristics. Many long-term problems can be avoided with a well-thought-out plan. Here are just a few of the tools available to assist with developing your plan.





Tubing System Configurations

Tubing can be laid out in different configurations. The first example above is like a tree with the main lines following the lower ravines in the woods and lateral lines coming off on both sides. This can work well, especially in woods with distinct valleys. When checking main lines, however, the maple producer will constantly duck under or step over lines which can make for slow going and eliminates the use of a four wheeler or snow mobile. Setting main lines on a contour at even intervals of between 80’ and 150’, and then always running the 5/16” lines up hill (as in the second example above) make for a system that is convenient to walk or ride next to for maintenance or pleasure. Often a combination of these styles is adopted.



Main line set up on the contour – all lateral lines directed to the uphill side

Establish Main Collection Points

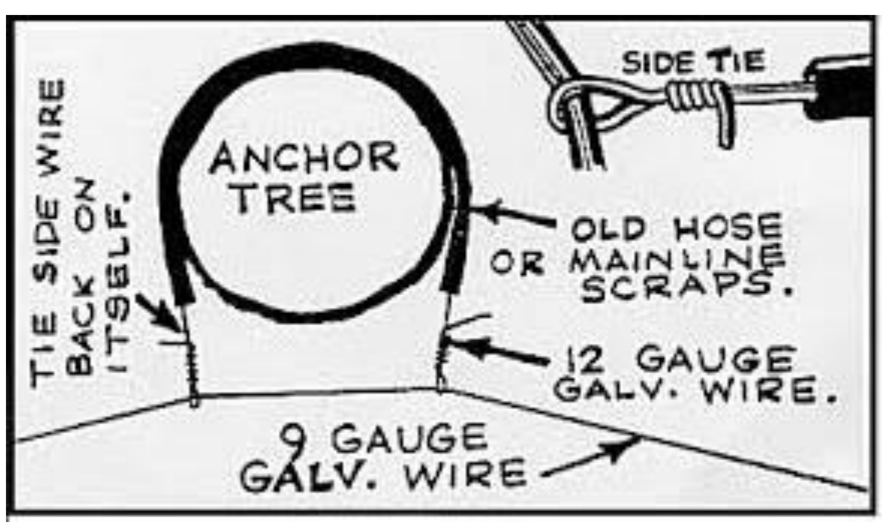
When establishing a maple tubing system there are several considerations to start with. First, channel as much sap directly to the sugar house as possible. Not having to move sap with a truck or tractor can save labor as well as investment. Second, design the system with sap ladders or remote pumping stations to move sap directly to the sugarhouse where direct flow to the sugarhouse is not feasible. Third, locate remote collection tanks where they can be easily accessed by truck or tractor. Where vacuum pumps or transfer pumps are part of the plan, site them where there is access to electricity. Finally, if none of the options listed above will make for an efficient tubing layout, placing the collection tank where it will collect the most sap the most efficiently, and then building an access road for pick up may be your best option.

Designing a Main line Network

Once the main collection points have been established, the next step is to lay out a plan for main lines to access the maple trees. Main lines can often follow the natural surface drainage pattern in the sugarbush. Where the topography of the land allows, the main lines should rise at a fairly even grade of between 2% and 6% slope. Steeper can be fine, but note that lines with changes in slope allow large slugs of sap to develop, temporarily blocking the movement of air being pulled to the vacuum pump. This makes the available vacuum at the tree inconsistent and lower than expected. It is generally considered better to have lateral lines be steep and main lines more gradual to avoid slugs of sap. Consider how to make checking and maintaining the main lines as efficient as possible when designing the system layout.

Installing Main Lines

Once the collection points and the basic configuration of the tubing have been decided, the next step is to install the main lines. Determine the distance between main lines. Using an eye level or slope gauge, you set the slope with flagging or paint marks on the trees to mark out the slope of the main lines. Install the wire that suspends the main line to the marked slope, secure the ends, and install **side ties**. Then the main line is pulled out and attached to the support wire. Hardware

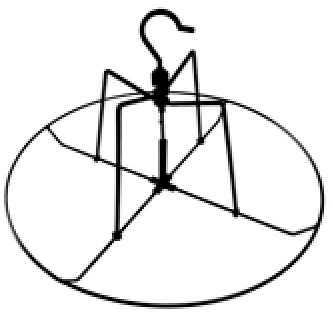


to assist with washing, draining, securing, connecting, and maintaining lines is added next. Lateral lines would then be put in place before their connections to the main line are installed.

A wire tightener and screw eye hook holding high tensile wire

If possible, side tie to a strong, healthy tree of low commercial value, such as ironwood.

Installing Lateral Lines



When stringing up lateral lines, it will make your life a lot easier to use a **tubing spool**. You can hang the spooler on the mainline while you pull tubing out to the trees. When choosing which side of the tree to rap around, try to go to the opposite side from the previous tree to get enough tension to hold up the line. For the last tree on the line, you will need an end hook to insert into the tubing and hook onto itself, creating a sort of belt around the tree trunk. Then, down the hill back at the mainline, you can add a straight connector with a small hook on the bottom for hooking onto to the high-tensile wire supporting the main line. It is important that the lateral line tubing comes into the mainline at as close to a 90 degree angle as possible so that this straight connect does not slip off the wire.

Once you have all your lateral lines in place, you can worry about attaching them to the mainline. The lateral line can be attached to the main line with what is referred to as a **saddle**. To install a saddle, a hole is drilled into the top of the mainline, and the gasket and saddle is set securely in the hole. It is then either and tied or screwed down to create a tight seal. A short loop of tubing is attached to link the end of the lateral line to the fitting on the saddle. Make sure both the free end of the straight connect and the fitting on the saddle are facing the same direction before attaching this loop.

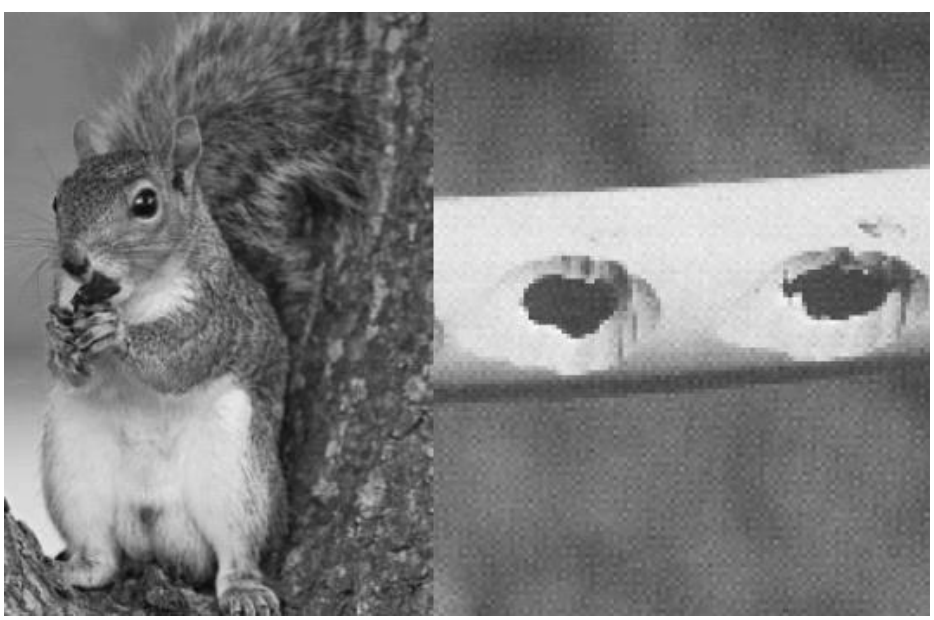
Wildlife Management

Wildlife damage to maple tubing systems impacts the maple producer in three key areas; the labor to repair damage, the cost of materials that need replacing, and the yield loss due to both direct sap leakage and vacuum loss. When sap is gathered with metal buckets, losses to wildlife are minimal. Tubing systems can be substantially damaged by wildlife, or damaged just enough to be a continual maintenance problem. Rodents, including squirrels, chipmunks, mice, voles, and porcupines are the culprit in most wildlife caused tubing damage cases. Occasional damage has also been caused by deer, moose, woodpeckers, foxes, rabbits, bears, raccoons, coyotes, bobcats, dogs, and even humans. Squirrels are particularly infamous for their ability to severely damage maple tubing systems, especially systems where tubing is left up year round and bleach is the sanitizer of choice. Specific control measures may be unavailable for the sugarbush, or techniques are very strictly regulated. A thorough understanding of the habits, life cycle, and habitat requirements for each of the potential wildlife pests can aid the maple producer in making the changes in the sugarbush that will alleviate the most persistent problems.

Because a sugarbush is considered an agricultural production area, or more specifically, a food production area, any chemicals, pesticides, repellents, or toxic baits used in the area must have been approved by the EPA and the NYSDEC for that use. Furthermore, the pesticide product label must list use in a maple sugarbush specifically, in order for such use to be legal. This severely limits the materials that can be applied in a sugarbush. Even materials available for use in a forest, woodlot, orchard, or vineyard may be excluded from use in a maple syrup production system.

Instead you can pay attention to your pests' life history and behavior and make management decisions based on that. Squirrels, for example, seem to chew more maple tubing in heavy hemlock areas of the sugarbush. Avoiding hemlock groves is a good idea to avoid both squirrels and freeze points in the line. Additionally, they feed on oak acorns, walnut, and bitternut hickory, so removing these and other nut producing trees can reduce their populations.

Capsaicin, the active ingredient in hot peppers, has been found to have repellent properties for mammals. Miller Hot Sauce Animal Repellent is the only repellent registered in New York State for use on maple sap collection equipment, including plastic tubing, lines, and fittings. This repellent can be used to prevent squirrel damage to maple sap collection equipment. If you choose to use this product, follow label instructions for preparing and applying to sap collection lines. Wear rubber gloves, goggles, and a pesticide respirator.



Squirrels love tubing almost as much as they love nuts

Chapter 3: Sugaring Season

Section 3.1: Tapping
Section 3.2: When and How Does Sap Flow?
Section 3.3: Sap Storage Basics
Section 3.4: Leak Hunting
Section 3.5: End of Season Clean-Up
Section 3.6: Safety in the Sugarbush

3.1 Tapping

Choosing trees to tap

The size of the tree should be at least 10 inches in diameter before receiving a single tap. If the tree is greater than 18 inches in diameter, or roughly, so big that your arms cannot reach fully around it, then you can give it two taps. If it is larger than 25 inches, give it three taps!

Pay attention to the vigor or health of the tree. If it has a very small canopy, it will not produce much sap. If it has only one live branch, it is not worth tapping. Look for healthy trees with large canopies that are growing fast.

How to drill the hole

Drill at a slight upward angle of 2-5% so that the sap has an easy time running down with gravity. Just the right angle:

Drill about 1 ½ - 2 ½" deep. This way, you will be sure to hit the sap wood zone, but still avoid old, deep, healed over wounds and tapholes. You can use a piece of tubing around the drill bit cut to the right length to prevent accidentally drilling too deep.

Be sure to drill straight so that the whole is a perfect circle. Ovaled holes will not make a good seal on the spout or spile. They will leak precious sap down the side of the tree and allow microbes into the taphole, potentially causing early taphole closure. To avoid an oval hole, use a sharp bit, place two hands on the drill, and take your time.

Pay attention to the color of the wood shavings that come out on the drill bit. Sometimes near an old wound, the wood will be rotten and dark. If this happens, simply drill a hole in a new spot that seems healthy. It is okay to drill a few holes until you find good, clean wood. The shavings from a good taphole will appear very light in color, almost white. If you leave a tap in dark wood, syrup flavor will be negatively impacted, and you may get very little, if any, sap.

If a tree is totally rotted and hollow, the drill bit will penetrate the wood with ease. It will be even more obvious when you begin to hammer in the spout – the spout will easily go all the way in and you will hear a hollow sound. If you suspect a tree is rotted, tapping on the bark with a hammer to listen for hollow wood can save you some time and energy.

How hard to tap

Listen to the sound the spout makes against the wood as you hammer it in to the taphole. It will sound louder and higher pitched at first as it moves a fraction of an inch into the wood. When it has made a good seal and is no longer moving deeper into the wood, it will make a low, dull thud. Once you hear that, you know you have hammered your spout in far enough.

If you hammer the spout in too far, you may get splitting wood around the taphole and leaks. This is especially likely if you are tapping frozen wood, and seems to occur more often in Red Maple. On the other hand, if you tap too gently, a freeze may push the spout out of the taphole and you will not get a good seal. This can cause loss of sap and of vacuum to your system.

Pattern Tapping

When you tap a tree, the tree creates dark partitioned wood around the taphole during the healing process. If you tap into this wood, you will get reduced sap yields and poorer quality sap. To avoid tapping into partitioned wood while also making the most of your tappable surface area, it is important to practice patterned tapping.

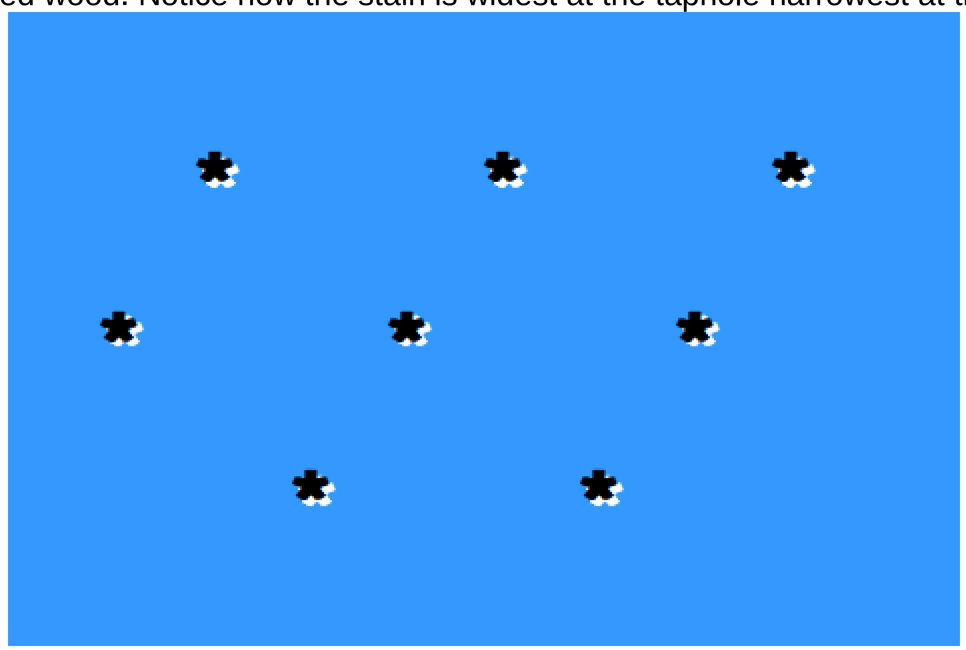
A good method is to first pick a direction to go around the tree. If you choose to have your pattern go to the right, your first taphole should be drilled as far to the left as possible so that you have room to move to the right for many years before running into a problem, such as, a V crotch you can’t fit your drill into, or a drop line too short to reach the taphole.

The next tap in your pattern should be 2 inches to the right, and 6 inches either up or down. Because partitioned wood is widest at the taphole, and narrows as it moves above and below the taphole (see image below), the 6 inches up or down helps you to get the most out of your tappable surface area.

When tapping, avoid: seams or cracks in wood, diseased or injured areas, old tapholes, hollow spots.

A common wound caused by Maple Borer.

Partitioned wood. Notice how the stain is widest at the taphole narrowest at the ends.



2” to the right and 6” up or down

Finally, at the end of the season when you are pulling taps, it can be a good idea to spray paint a small dot of bright color next to the taphole on each tree. Choose a different color each year, use paint designed for wood, and AVOID getting any paint in the taphole. The paint will help you quickly find last year’s taphole, and it will also make your tapping pattern clear to hired help.

When to Tap

Sap only runs when the temperature varies between freezing and thawing. After a good freeze the sap will run for up to two or three days and then it will stop until it freezes again. Just when to tap is a never-ending question among maple producers. Every year is different and the tapping date can be a gamble. Taps tend to heal or dry up in 6 to 10 weeks depending on the weather and the tapping date. Very early sap flows in January or early February tend to have lower sugar content. Late sap flows tend to make darker syrup. The key is to tap early enough to catch the first big runs, but not so early that the tapholes dry up before productive late season runs.

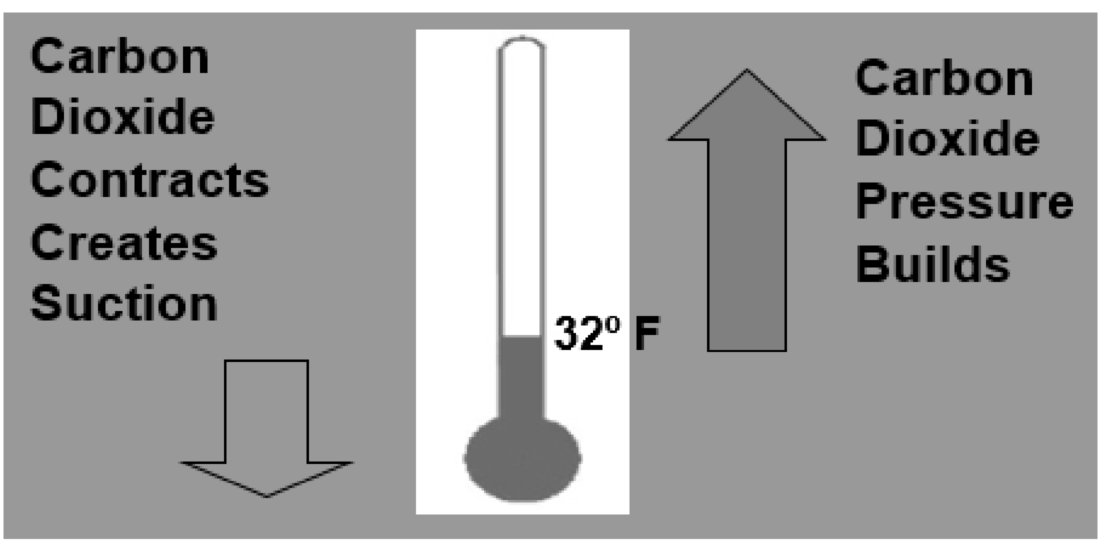
Some producers simply pick a date and begin tapping every year when that date arrives regardless of the weather or forecast. This seems to work fairly well for producers who are larger and need a number of days to get tapped. For most beginners and small producers watching the 5 day forecast is probably the most valuable. Look for a couple of days when it will be in the mid to high thirties before you tap.

3.2 When and How Does Sap Flow?

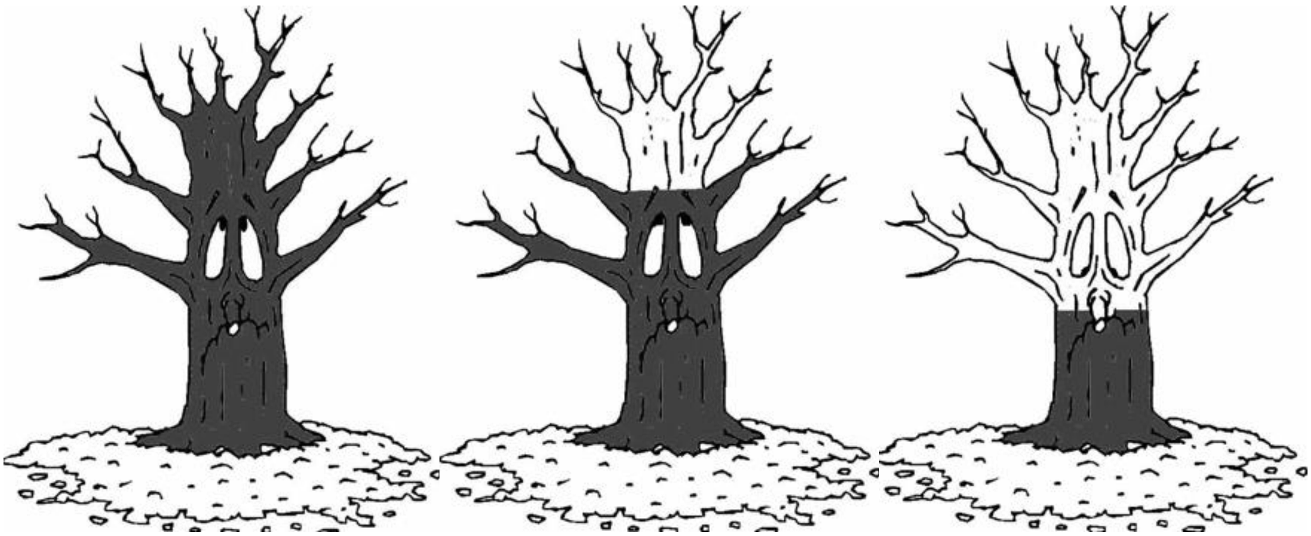
Early in the spring, when the maple trees are still dormant, temperatures rise above freezing during the day but drop back below freezing at night. This fluctuation in air temperature is vital to the flow of sap in sugar maple trees. Although sap generally flows during the day when temperatures are warm, it will also flow at night if temperatures remain above freezing. Sap will only continue to flow for 30 to 72 hours if the temperature does not fall below freezing again.

During warm periods when temperatures rise above freezing, pressure (positive pressure) develops in the tree. This pressure causes the sap to flow out of the tree through a wound or taphole. During periods below freezing, suction (negative pressure) develops, drawing water into the tree through the roots. This suction replenishes the sap in the tree, allowing it to flow again during the next warm period.

How do pressure and suction develop in the tree? Sap flows through the outer wood in the tree trunk called **sapwood**. Sapwood consists of live cells that conduct water and nutrients (sap) from the roots to the branches of the tree. During the day, activity in the cells of sapwood produces carbon dioxide. This carbon dioxide is released into the sapwood causing pressure to build up in the cells. When temperatures dip below freezing, three things happen. The carbon dioxide in the sapwood cools and therefore contracts, some of the carbon dioxide becomes dissolved in the cooled sap, and finally, some of the sap freezes. All three of these factors create suction in the tree. When temperatures rise above freezing the next day, sap flow begins again.



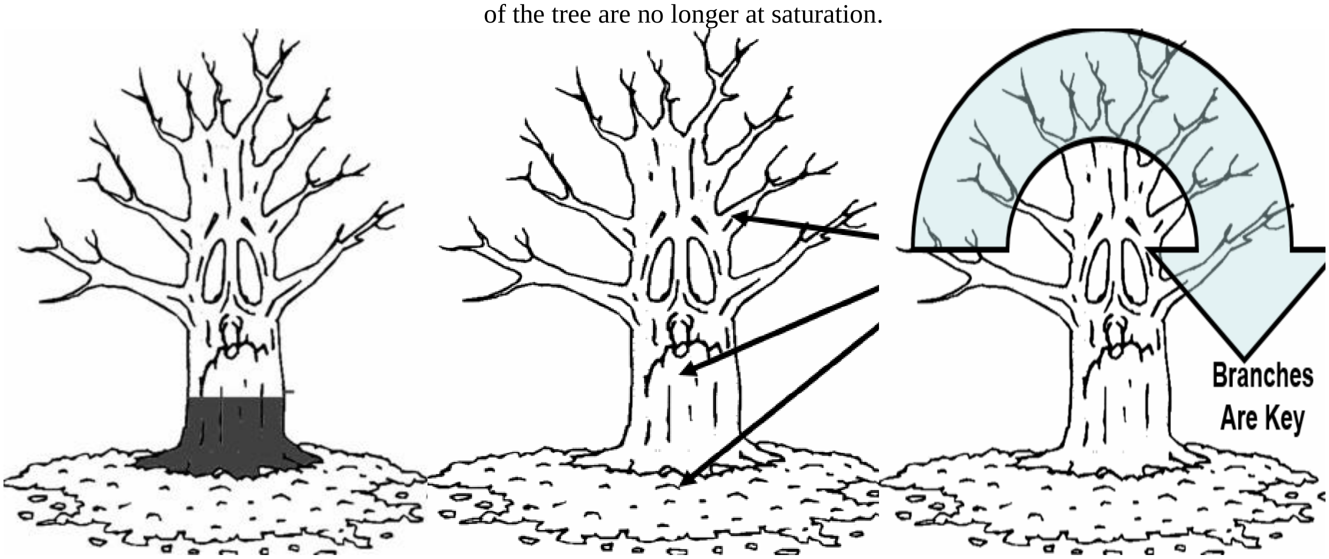
Why Does Sap Stop Running If It Does Not Freeze Again Soon?



1 Tree at sap saturation

2 Sap is still flowing well, but parts of the tree are no longer at saturation.

3 Sap flow is slowing.



4 Sap stops running. The tree has plenty of water, but is no longer at saturation.

5 Starch stored in the roots and branches converts to sugar which is added to the sap

6 The more live branches, the greater the sap yield

What can we do about it? We can’t control the weather. Controlling temperature of the tree is too difficult. We can avoid over-tapping. There is only so much sap in a tree. More taps will not get you more sap. Think about this: if you drill a hole in the bottom of a bucket, you get the same volume of liquid as if you drill 10 holes. We can also use vacuum to increase yields.

How does vacuum improve flow? Vacuum reduces the pressure at the tree. This allows more carbon dioxide to come out of the sap solution and create the internal push. Ultimately, this allows sap to run at a lower temperature and longer.

How much does vacuum improve flow? Depends on the season and the type of sap runs that occur. Research shows a 50 to 150% increase in yield.

3.3 Sap Storage Basics

It is very important that you have the storage capacity for your most productive runs. Otherwise you may forfeit some high quality product. When purchasing a sap tank, the safest estimate for capacity is 2 gallons per tap. Once you have the space to hold all your sap, there are a few basic rules to follow to ensure the best quality.

If using buckets:

- Collect often, especially as daily temperatures get warmer because the sap will spoil faster
  - Collect every other day at bare minimum
  - Collect as it arrives if temperatures exceed the mid-forties
  - Sap spoils very quickly, so if you get a run overnight, you will need to stay to boil, or else forfeit the run
- Clean buckets with plain water between runs

For a tubing system, consider letting your first run of the season go. It is likely full of wood shavings and other junk, or it might need a final rinse from whatever cleaning protocol was last used.

For both systems:

- Dump yellow sap
- Always filter sap before boiling
  - You can use something as simple as a coffee filter, or a more high tech canister filter
  - This is a necessary step to remove debris such as wood, plastic, insects, and later in the season, yeast bodies

Sap Storage Tanks:

- Locate them out of the sun to keep sap cool
- Rinse down with a hose as soon as it empties
- Scrub as frequently as possible with long handled brush

- Make sure all sap storage containers are **Food Quality**

If they are used, make sure they are clean and free of odors. The examples in these images are unacceptable.

3.4 Leak Hunting

You know you have a leak if your vacuum levels are lower than usual. Searching for leaks takes both eyes and ears, and depending on how big your system is, several helping hands.

One way to locate leaks is to walk along the main line pressing each of the loops that connect the lateral line to the saddle down with your thumb. If you see air surging through at the bottom of the loop, you know you have a leak on that lateral line. It is then time to walk the lateral line while checking the tubing for bubbles and listening for the sound of rushing air.

The leak could be caused by: a spout that has been pushed out of the taphole, large chew holes in the tubing made by rodents, tiny pinprick holes in the tubing, a pull-apart where the tubing was pulled right off the fittings, usually by a fallen tree, or a cracked or damaged T, spout, or saddle. If you cannot hear the leak because it is very small, you can look for a place in the tubing where on the uphill side, flow is normal, and on the downhill side, an unusually large amount of bubbles have formed and are moving very fast, or you see a thin stream of sap on the bottom of the tube with air surging past. The quickest way to check for these small leaks is to observe the flow pattern at each T. If you crease the drop line to cut off flow and flow in the lateral line returns to normal, you know something about that drop line is causing the leak. It may be that the spout needs a couple raps with a hammer to make a good seal with the taphole again. It could also be that the barbs on the fittings are damaged and not sealing to the tubing. And finally, you could have some miniscule holes in the drop line from wildlife that can be easily, temporarily repaired with some electrical tape.

When hunting for leaks you will want to bring with you:

- Extra Tubing
- Two-Handed Tool
- A hammer
- Straight Connects
- End hooks
- Ts
- Spouts
- At least one other person
    - To help you pull the tubing taut again

Note that there will always be a small amount of bubbles in the sap as it flows from the tree. This is normal and not a sign of a leak. The bubbles are gases formed during the process of cellular respiration within the tree. Also be aware that these bubbles expand under vacuum – the higher the vacuum, the larger the bubbles. With experience, you will quickly learn to differentiate between leaks and naturally occurring gases in sap.

Finally, if wildlife damage is extensive and happens in the same place year after year, it may be worthwhile to let a small section of woods go. You will know when you find it. Usually it will be a place high up on a steep hillside, in dense conifers, far away from the closest vehicle access point.

Happy Hunting!

3.5 End of Season Clean-Up

Untapping

Whether your sugarbush is on buckets or tubing, you will need to untap immediately at the end of each season. This means you will pull the spout or spile out of each tree using the back of a hammer or a “spout puller” tool designed for maple. It is a good idea to count aloud as you pull each tap so that you know exactly how productive your operation was that season on a per-tap basis.

A little bit of spray paint will make pattern tapping easier the following season, Buy a spray paint that is designed for wood, and be sure to get a unique color each year. Simply spray a small dot of paint beside or below each taphole, being careful not to spray into the taphole itself. Do not spray above the hole if the wood is at all wet as it may dribble down into the taphole.

As you remove taps on a tubing system, allow the drop lines to fully drain before capping the spouts. It easiest to drain a lateral line if you start with the most uphill tap and leave it hanging open while you drain and cap the others on the line. Most Ts are designed with spout holders or cups for your convenience. If the Ts you have used did not come with a holder, cap the spouts by some other means, such as a rubber stopper or spout cups from used maple supplies. Be sure to cap every spout. If you don’t, debris, water, insects, and especially mud wasps, will make a mess of your system!

If you are using a bucket system, cleaning is relatively straight forward. Simply remove all the buckets when you untap, and use the same rinse, sanitize, rinse protocol detailed below for tubing systems.

Washing Maple Tubing Systems

The Cornell Maple Program is currently conducting significant research on cleaning maple tubing systems in place. This section deals mostly with issues of various cleaners that have been used or questioned by maple producers. For additional up to date information on cleaning tubing systems, see the *North American Maple Syrup Producers Manual* beginning on page 109.

Washing all food contact surfaces is an important part of all food processing facilities, including maple tubing systems. The sooner a maple tubing system can be cleaned following the last sap flow, the less time bacteria and yeast will have to grow on sap remaining in the lines. Lines are washed to remove both any remaining sap, and the mass of bacteria and yeast that will have built up in the late-season sap.

The standard procedure for most food contact surfaces is to rinse with hot water to remove residue, wash with a cleaner, rinse out the cleaner, treat with a sanitizer, rinse again with hot water, and dry. A cleaner is a product that is good at removing microbes and debris from the tubing, but not necessarily good at actually killing the bacteria and yeast. A sanitizer is generally not good at removing microbes and debris from the tubing, but is good at killing the bacteria and yeast. Due to the fact that sap is such a weak solution of sugar water, such an extensive protocol of cleaning has been seen as un-necessary. However, a maple producer needs to be careful when deciding which parts of the washing protocol to utilize and consider the implications of their choices of cleaners and/or sanitizers. Residues of cleaners and sanitizers can be associated with off-flavors in syrup, or even with health concerns of tainted syrup. In light of this, the following treatments of maple tubing systems are suggested.

1. Tubing systems may be drained to dry either by using mechanical vacuum systems, or by removing spouts from the trees and letting them hang free to drain by gravity. All spouts should be capped or placed on holders afterwards to avoid contamination. This should be done immediately after the syrup season. Cap system afterwards to avoid insect invasion.
2. Tubing systems may be rinsed with water, then drained to dry using one of the drying methods in treatment 1. This should be done immediately after the syrup season. Cap afterwards to avoid insect invasion.
3. Tubing systems may be rinsed with either water plus bleach, or food grade peroxide, used according to label directions, then drained to dry using one of the drying methods in treatment 1. In this case, the first sap to pass through the system in the following sap season should be discarded for the first 2 to 8 hours of collection, depending on the length of the tubing system. This will flush any cleaner residue from the system and prevent contaminated sap from being used for further processing. Cap afterwards to avoid insect invasion.
4. The tubing system may have the spouts removed from the tapholes and secured on spout holders while leaving the tubing system full of sap. The sap is then allowed to ferment first to ethanol, and then to acetic acid, as a natural cleaner. In this case, the first sap to pass through the system in the following sap season should be discarded for the first 8 to 24 hours of

sap flow, depending on the length of the tubing system. This will flush all residue from the system and prevent contaminated sap from being used for further processing.

5. For small gravity tubing systems, the best cleaning method is to remove the tubing from the sugarbush, and take it to a location with running water where it can be rinsed, submersed in a solution of bleach for 20 to 30 minutes, rinsed again, and dried. The bleach solution should contain 1 tablespoon of bleach per gallon of water.

Using a cleaning chemical in ways either not mentioned on the label, forbidden on the label, or at concentrations other than listed on the label is not acceptable. The label is the legal document; even if the use is permitted by the Food and Drug Administration, the label may limit the use. Experimenting with materials without a label or with uses not listed on the label is also not acceptable.

The only sanitizers recommended for sanitizing the tubing system are sodium or calcium hypochlorite (the active ingredient in bleach), or food-grade hydrogen peroxide. Maple produces who use bleach often complain of more rodent damage to tubing. The bleach should be drained, vacuumed, or rinsed from the tubing. If left in the lines, it may not be completely purged by sap in the first run of the following season. This can lead to off flavors or saltiness of the next season’s maple syrup. The food grade hydrogen peroxide breaks down without leaving any residue and is not reported to attract rodents.

3.6 Safety in the Sugarbush

The following is basic list of things to be careful of when working in your sugarbush. Some are fairly obvious, others not so. Safety is of the utmost importance.

- On windy days, look up. Beware of dead limbs that can fall at any moment. If the wind really picks up, do not hesitate to either wear a hardhat or take your work inside for the day.
- When working with high tensile wire, always wear safety glasses. Under tension, even strong wire can break and cause injury.
- Pay attention when others are working with pipe, tubing, or wire that is under tension near you. You may be standing in harm’s way when something springs out of place.
- It almost goes without saying that steep hills can be dangerous in the snow. They can be even more dangerous in mud season. Sometimes it is not worth it to tap a tree perched precariously in the side of a ravine.
- There can be ice, but also seemingly innocuous roots under snow. A wet, exposed root can be very slick, causing injury inducing falls.
- Be careful of where in your tool belt or pockets you store things like drills, clippers, hammers, and sharp objects. Be prepared to fall.
- Pay attention when others are using chainsaws near you. Stay out of harm’s way and wear eye and ear protection.
- A unique predicament in the sugarbush, trees commonly fall on the mainline. The tree may be light enough that it ends up suspended by the line. This puts the mainline under tension and requires a good understanding of physics to avoid dangerous results.
- If you don’t feel confident with a chainsaw, Consider the Game of Logging for Landowners program offered by Cornell Cooperative Extensions

Cornell University
Cooperative Extension

If a tree falls in the forest when you cut it, do you know which direction it will fall? Peter J. Smallidge, NYS Extension Forester and Director Arnot Teaching and Research Forest, Cornell University, Ithaca, NY. March 2007.

Has this happened to you?…attired with appropriate chainsaw safety equipment you walk to a tree destined for the firewood pile. You notice an opening in the forest canopy into which you could fell the tree, but alas the tree is leaning in another direction. You hope against hope the tree might fall towards the opening, but reality strikes and you pinch your saw and hang the tree. Unfortunately, this scenario and worse happens repeatedly each year. Take heart, your luck is about to change especially if you complete a Game of Logging training. You will then know how to evaluate your ability and the lean of the tree to know if you can move the crown of the tree against gravity and into a forest canopy opening. You will learn how to work through your felling plan and execute a perfect tree fall knowing how to avoid hanging the tree and the associated headaches, risks and hazards.

Unfortunately, most forest owners and other chainsaw users have never had a safety course, much less a course in directional felling that provides safety plus productivity training. What more could you ask for in a course? Here's what…include some training on chainsaw chain and engine maintenance for the full benefit of safe and productive woods work. Add to that small classes sizes and the fact that every participant gets hands-on instruction. Through educational programs such as exist at the Cornell University's Arnot Forest the opportunity for this type of training exists. The program, Game of Logging for Landowners, teaches forest owners the skills they need to go from beginner to accomplished tree feller. Sessions are limited in class size to allow individual attention from the certified instructor. At the Arnot Forest, members of the NY Forest Owners Association and NYS Maple Producers Association receive a substantial price discount.

I know that a thorough working knowledge of directional felling is essential for safe and productive work in the woods. I have participated in three levels of the Game of Logging training. I use the skills in management and research throughout the state. My wife and I use the skills in our woodlot. The training is mandatory for people who work at the Arnot Forest. The skills you learn in saw sharpening and maintenance more than pay for the cost of the course. But don't take my word, listen to some testimonials from people who have taken and now use the skills that come with directional felling.

Testimonial 1 (Ron Pedersen)

The Game of Logging should be required at a young age, like driver training or hunter safety for a big game license. My chaps and helmet probably used to feel out of it, but now they are in use whenever there is action. I'm fortunate I am in one piece and was able to take GOL 60 years later than I should have. Directional felling is now a fun challenge, no longer a complete mystery, and when I miss, the stump usually shows me why. Safety and know how – that is sustainable. I can't imagine anyone thinking that GOL isn't a great value!

Testimonial 2 (Chuck Winship)

We, at Sugarbush Hollow, a maple syrup operation, will not let anyone use a chainsaw in our woods without first taking the Game of Logging course. We do extensive timber stand improvement even among our tubing systems. The course, with its various levels, provides each of us with the right safety procedures which enables us to have the necessary confidence and skills in handling the most dangerous tool invented by mankind. We have the ability to make the felling of trees efficient from a time and effort point of view. The trees fall where we want them without hanging up or damaging the residual trees as well as avoiding the tubing systems. The course is fun and taught by a person who can hold your interest all day. Those of us new to a chainsaw, men and women, can safely and effectively compete against those who have chainsaw for years without this training.

Testimonial 3 (Tim Levatich)

Game of Logging 1 and 2 have radically improved my felling work. I now have a quick step-by-step system and the proper techniques to get any tree down to the ground. I feel much safer and I work more efficiently, so I can get more done with my limited time. The courses I've already taken are well worth the fees paid - it's hands-on training with individual attention and real skills learned. I'm planning to take GOL 3!

Testimonial 4 (Mike Farrell)

Although I was trained as a forester, my chainsaw skills were very limited before taking GOL. Whereas I used to just mark the trees to be cut and let someone else do the felling, I now have the confidence and skills to do the actual cutting when implementing thinning operations.

These forest owners have described how they have benefited from Game of Logging for landowners course. Levels I, II, and III are offered each year through Cornell's ForestConnect program and in some offices of Cornell Cooperative Extension. Each level is required before attending the next level. For more information or to register visit the "workshop" link at www.ForestConnect.info or call 607 255 2115. Class size is limited and spaces fill quickly.

Chapter 4 Syrup Production & the Sugarhouse

4.1 Sugarhouse Design

Design Considerations

Boiling sap into syrup generates copious amounts of heat and steam. Efficient boiling at a larger scale requires specialized equipment, and the process can be messy. For these and other reasons, most sugarmakers construct a specialized building for making syrup called a sugarhouse.

Sugarhouse designs range from rustic sheds to modern industrial facilities the size of warehouses. Regardless of the size, all sugarhouses share similar design considerations and elements. These include: location, utilities, ventilation, fuel storage, and maintenance of sanitary conditions.

The location of the sugarhouse should be determined based on proximity to the sugarbush, ease of access, and the availability of essential utilities. Locating the sugarhouse close to the sugarbush minimizes transport needs. Sap is heavy and can be difficult to move during the muddy, icy conditions that prevail in the spring. Being close to the woods saves time, frustration, and limits ground impacts caused by foot and machine traffic. The sugarhouse is often located at the lowest point below the sugarbush when a tubing system is utilized. This allows the sap to flow to the processing point without any pumping or handling.

Some basic utilities are required to operate a sugarhouse safely and efficiently. At minimum, a sugarhouse should include electrical service to provide enough lighting to work safely. Other common sugarhouse equipment requiring electricity includes, but is not limited to: vacuum pumps, transfer pumps, the blower for the evaporator, filter press motors, and reverse osmosis. The correct amperage of electrical service can be calculated based on the operating wattage of each piece of equipment and the supply voltage. A qualified electrician can help perform this assessment.

Another essential utility is a supply of potable water for cleaning. For very small operations, it may be feasible to transport jugs of water to the sugarhouse for cleaning purposes. However, this soon becomes impractical with evaporators and storage tanks to keep clean. A supply of hot water is ideal. Syrup hardens when chilled, so rinsing equipment can take a large volume of cold water, whereas hot water will quickly dissolve syrup spills. If a reverse osmosis unit will be in use, it will need to be stored and operated in above freezing temperatures. A freeze will damage pumps and the osmosis membrane, resulting in costly repairs and lost production. This is also true for electric releasers. Vacuum pumps can withstand freezing temperatures while in operation, but should be heated to above freezing to thaw possible ice deposits within the pump before startup. Heat for these purposes should be considered in the sugarhouse design process. Heat can be maintained in just one insulated room for a simple and cost-effective of design.

Boiling sap is the primary activity that takes place in the sugarhouse. This generates vast amounts of heat and steam. Ventilating this excess heat and humidity is a crucial design consideration. Many larger evaporators include a stainless steel steam hood that collects the steam and ventilates it through stacks that exit through the sugarhouse roof. For an evaporator without a steam hood, the sugarhouse should include some form of roof vents to allow steam to escape. Without adequate ventilation, excess humidity begins to condense. This may damage the structure as well as electronic equipment, and form water droplets on ceiling surfaces and rafters that drip back into syrup, carrying contaminants with them. The most common design feature for steam ventilation is the iconic sugarhouse cupola. The cupola is a raised structure at the peak of the roof with doors that can be opened to vent steam. The doors are designed to be opened with pulleys when the evaporator is in use and securely closed during the off season.

Sugarhouses should be constructed to exclude bats, birds, rodents, insects, and other pests to avoid contamination of the finished product. Walls and ceiling should be made of materials that allow them to be kept free of cobwebs and dirt, and floors should be designed for hosing down. Rough interior walls and ceilings (such as unvarnished shiplap) are acceptable only if hoods are on pans and tanks have covers. LEDS are a preferable style light bulb, but if older styles are used they should be protected with shields to avoid contamination of sap/syrup if breakage occurs.

All sugarhouse equipment that comes into contact with syrup should be lead-free stainless steel or other food-grade materials. Do not use galvanized or brass plumbing materials for sap transfer. Food preparation surfaces should be of impermeable, food-safe materials that can be cleaned and sterilized as needed to eliminate microbial growth.

A final consideration in sugarhouse design is fuel storage. Many beginners choose to fire the evaporator with wood. Well dried and seasoned firewood has a much greater burn efficiency than wet, green wood. Therefore, the sugarhouse should include a covered wood storage area with protection from the weather and good air circulation. Evaporators fired with fuel oil should have spill control measures in place with a tank securely installed on a cement pad in a location accessible to fuel trucks. Keep in mind, fuel trucks may need to refill the tank during adverse weather conditions including snow and ice. A tank located at the base of a steep hill or on a poorly maintained driveway may not be accessible to heavy fuel trucks in the winter. There also needs to be proper clearance for tall fuel truck on this access road.

Incorporating these elements into your sugarhouse design will ensure the safe, efficient, and sanitary production of maple syrup.

Pest control

Squirrels can be excluded from the sugarhouse and other buildings by securely fastening hardware cloth over attic vents, which are a common entry point into buildings. Openings at joints of siding and overhanging eaves should also be sealed. Take care to also seal locations where utility cables or pipes enter buildings. Install chimney caps on all chimneys, and check for gaps in the flashing at the chimney base. Be sure not to trap squirrels inside. A squirrel excluder can be constructed by mounting an 18 inch section of 4 inch diameter plastic pipe over the building opening used by squirrels. The pipe should point down at a 45-degree angle to allow squirrels to exit but prevent them from reentering. Alternatively, if squirrels are located inside an attic, traps may be set to ensure that any squirrels left inside are removed. One way to prevent squirrels from climbing up trees to gain access to buildings is to fasten a 2-foot band of sheet metal around the trunk 6 to 8 feet above ground. Sheet metal can be fastened by wrapping wires around the trunk and attaching them together with springs. This method allows the sheet metal to spread as the tree grows. All trees that need protection, plus all trees within jumping distance (branches within 6 to 8 feet), should be protected with a sheet metal band. Tree limbs also should be trimmed to 6 to 8 feet from buildings to prevent squirrels from leaping onto buildings.

4.2 Reverse Osmosis

Working with little ROs for syrup production
Stephen Childs, New York State Maple Specialist

One of the biggest drawbacks of making maple syrup for a backyarder or small maple producer is the time it takes to boil the sap into syrup. The idea of using a small reverse osmosis (**RO**) unit to assist with syrup making is very interesting to many small maple producers. There are many little reverse osmosis systems available for water purification in households or for small commercial applications. These can be purchased from a number of big box stores, home improvement stores, or online. These RO units can be used to remove water from sap, concentrating the sugar in the sap and speeding up the boiling process.

To make a small RO unit work, you must first get the sap under pressure using a pump, typically a shallow well pump. When I began experimenting with small reverse osmosis units to try and cut down on the amount of boiling time needed to make my family maple syrup, I started with a GE Merlin that was rated to deliver 30 gallons of pure water per hour when operated at about 60 psi. That rating is for when purifying permeate from water. When you are removing water from maple sap, the permeate removal rate is 6x slower, so I was removing between 4.5 and 5 gallons of water per hour. This greatly reduced the time it took to boil. For 25 taps on a 2' x 4' wood-fired flat pan, boiling time went from about 8 hours per run to 4 hours. The little RO would sweeten the sap from about 2% up to between 4 and 5%. The investment was about $360 for the RO unit, I had to purchase a pre-filter canister, and I already owned a shallow well pump which pressurized the sap to about 55 psi.

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

The 6x reduction in capacity seems to be universal when processing sap vs. processing water with any unit setup rated for water purification. So, a home RO rated for 50 gallons per day would remove about 2 gallons per hour with plain water, or would remove about 1/3 of a gallon per hour of water from your sap. This water removal rate would be fine for someone with 2 or 3 taps. A larger unit that claims 240 gallons of water purified per day should take out about 10 gallons per hour from water, but only about 1.5 gallons of water from sap. That should work for someone with up to 5 to 12 taps. With these water purification units, you must remove the carbon filter as it will remove sugar and many other things you normally want in syrup.

Like any normal maple producer, once the small RO was working well and syrup was more efficient to make, I annually added more taps. After using the Merlin for four years, it was time to go bigger. I had a larger RO unit become available that had a higher pressure option using a small Procon pump on a half horse power electric motor and one 2.5" x 21" membrane. To this unit, I added two more 2.5" x 21" membranes to boost the capacity to handle my now 70 taps. When operated at 250 psi, this unit would remove about 15 gallons of permeate per hour and bring the sap up to 12% sugar. So, boiling for 70 taps was still taking about 4 hours of boiling time per run only with much greater yield. I continued to use the shallow well pump to feed this unit. I found that as the sap became sweeter, the water removal rate would gradually be reduced. I found the best way to keep the production high was to process the sap in 15 gallon batches, so I would hook the RO to a 15 gallon jug of sap and run the concentrate back into the sap jug until the sap reached 10 to 12% sugar, at which time the permeate removal rate would be down to about 8 gallons per hour.

The concentrated sap would then head to the boiler. As soon as we started on the next jug of 2% sap, the new sap would rinse out sugar build-up in the membrane, bringing the RO unit back to the full capacity of 15 gallons per hour. Both of the units above were used in the USDA Forest Farming YouTube videos. Unfortunately, the three-membrane RO used in the videos made the middle-sized RO look much more complicated than it need to be creating lots of inquiries. It was nice that the shorter membranes were easier to transport to maple programs for demonstrations. The 40" membranes and pressure vessels are more standard production than the 14" or 21" alternatives, so they are much more economical to purchase for the amount of output. I had the three membranes hooked up in parallel to get the most water removed per hour. If they were hooked in series, less water would be removed per hour, but the sap could be much sweeter in one pass. For the off season, I would store these membranes in holders made from PVC pipe that would be filled with permeate and sealed with a screw tight lid.

It was at this point that I began to gain friends. Friends who would show up at my garage with a 50 gallon barrel of sap or more that we would RO down to 15 gallons in about two and half hours. These visits would save them between 8 and 20 hours of boiling time each time the sap ran, but the desire for something bigger was growing. The question of how to make a simple RO that would be most useful for maple operations of 300 to 500 taps lead to the next experiment. Each year in the maple industry, some percentage of maple producers replace their 8" x 40" membranes due to loss of some percentage of capacity. This seemed like a good opportunity for a low cost source of second hand membranes for operations that don't need maximum capacity.

Breezy Maple Farm was replacing some of their membranes and provided one for our testing. An 8" x 40" Codeline fiberglass pressure vessel was purchased online along with a 330 gallon per hour Procon pump. This pump was connected using a cone connection to a standard shaft 1 horse motor that I already had on hand. This system operated at 250 psi and would remove about 300 gallons of permeate per hour. Total cost of materials was about $1150. The system performed with great efficiency but came with a couple of unexpected issues.

At first, the pump would run but nothing would happen, even when it was well primed. It turned out the motor was running backwards and needed to be rewired. The bolts in the motor were too short to connect to the cone so they had to be replaced with threaded rod, and there was enough vibration in the cone-to-pump connection that it would wear out the rubber in the motor-to-pump coupling every couple of weeks.

A clamp style connection between the motor and pump seemed like a much better system. With this new connection, I again used the feed pump in addition to the higher pressure pump. Some maple producers choose to forego the feed pump, especially if the sap is slightly elevated over the pump to help with priming. This eliminates the cost of the feed pump. I have run the system both ways, but I get less chatter in the high pressure pump when I use the feed pump. Performance seems equal either way. This system had more capacity than I needed, and sometimes I would have trouble getting enough permeate to give the 8" membrane the proper rinsing it should have following each use.

The next year, I tried a 4" x 21" membrane with the 330 gallon Procon pump. This unit did not put out as much as I had expected. I had heard that it could handle about 60 gallons per hour at 250 psi, but I was usually getting only about 45 gallons of permeate per hour. This was still great for me and my friends with our small size operations, but I noticed that the price of a 21" membrane and pressure vessel was not much cheaper than a 4" x 40" which would have twice the performance. So in my last year of making maple syrup at home, I tried a 4" x 40" with the 330 gallon per hour pump. It performed very well, delivering 80 to 100 gallons per hour of permeate.

Some of little ROs from this project are now assisting with concentration of sap at the Arnot Forest, Cornell's Teaching and Research Forest.

The reason I felt it necessary to put this information together is the overwhelming response I have had to the Little RO YouTube video series. The USDA wanted some Forest Farming Videos, so they sent a crew to tape and record some presentations to put online. There are five videos on YouTube talking about RO and covering the three different sizes I had experimented with at that time. I figured there were likely only a couple hundred of people who would be interested in making their own little RO, but to my surprise, the videos received over 60,000 views in just two years, and hundreds of people have emailed questions about some aspect of building a little RO. If you are interested, go to youtube.com and type "Cornell Reverse Osmosis" in the search bar. I hope this information will help answer many questions.

If you are not at all mechanically inclined, building your own RO is probably not the best idea. They are becoming more and more available at reasonable prices every year. Buying one can save you significant aggravation. If you are a do-it-yourselfer, this is a reasonable project. Here are a few details that should help:

- The Merlin is no longer available.
- Flush the RO filters with all the permeate you can save after every use. Do not use chlorinated water in your RO at any time. Store the membranes in pure permeate in the off season inside your pressure vessel, or make an airtight container out of PVC pipe. There are preservatives and soap available specifically for membranes if you need them. Follow suppliers' instructions and store these items where children cannot access them.
- The pressure in the RO is controlled by a valve on the exit end of the membrane on the concentrate line. Permeate comes out of the center of the membrane on both ends. You can block one end to force all the water to come out of one line. The concentrate goes in one end and out the other at the outside fittings by the rings of the membrane. Most small ROs without internal recirculation should send the concentrate back to the sap tank. Concentrate in batches.

- Flow meters can be handy, but you can get a quick measure by just putting the permeate line in a 5 gallon bucket and measuring how long it takes to fill. After a few tries, you get pretty good at seeing when you are getting a great flow and when it is slowing down. I get excellent results with my 4x40 with a 3/4 hp pump and a 330 gallon per hour pump. If you get a much smaller pump, say a 150 gph, you will get less flow over the membrane at a given pressure which allows the sugar to build up on the membrane and reduce its capacity. The membrane is like a fine screen, and the more flow pushing the sugar along, the longer it stays clean and functioning. You want a pump that has at least 50% more capacity than the rated capacity of the membrane, and more is not a problem.
- Change or clean your pre-filter often.
- Supplies are available in many places. I have used: maple dealers, amazon.com, ebay.com, americanro.com, altanticro.com, freshwatersystems.com, nextgenmaple.com, Deer Run Maple, and there are many more.
- A sap refractometer is very helpful when working with an RO as it can give you sugar content in seconds and is less breakable than a hydrometer.
- There are many membranes available. I tend to pick the ones with the highest rating for the price.
- Starting at the sap tank, here are the suggested parts in order: A foot valve, a line to either the feed pump (a valve just after the feed pump can cut down on the need to re-prime the pump so often, shut it when moving the line from one tank to another) or the pre-filter, a line from the pre-filter to the high pressure pump, a line from the high pressure pump to the outside fitting of the pressure vessel, a pressure vessel with a membrane inside, a concentrate line from the outside fitting on the exit end of the membrane that goes back to the sap tank or to a tank supplying the boiler, and a line from the center fitting on the pressure vessel to a permeate storage tank.

A special thanks to Next Generation Maple and Deer Run Maple for all the help and encouragement with this project. There are some example photos of little ROs that people have built on the following pages.

4.3 Turning Sap into Syrup

A. Boiling Process – Evaporator Basics
B. Finishing Syrup – Density
C. Filtering Syrup

A. Boiling Process

Evaporator Basics

Sap needs to be transported to a central location where the evaporation process can begin. This is how you turn sap into syrup. Sap should first be filtered to remove debris and other foreign material. It is best to then boil the sap in a well-ventilated building that allows steam to escape. Many beginners boil the sap outside until the enterprise becomes big enough to invest in a sugarhouse. You will need several pieces of equipment: a heating source, evaporating pans or continuous-flow evaporator, thermometer, filtering material, and bottles or barrels for storing the syrup. You may be able to make the evaporator yourself, or you may choose to purchase an evaporator from a maple equipment dealer. You may be able to find good quality used equipment from a producer who is expanding his or her operation. Be sure that any used evaporator you might purchase was constructed of lead-free materials.

No matter what equipment is built or selected for evaporating the sap, there are some simple rules that will help make a quality syrup. First, process sap as soon as possible. Sap is a sugar solution in a natural setting, and when temperatures get warm, it can spoil rapidly. Temperatures below mid-forties would allow sap to be gathered and processed every other day. When temperatures in the mid-forties and above, sap should be processed as it arrives every day, unless it can be refrigerated or frozen for a day or two. Holding sap until the weekend when more time is available for boiling will likely result in an off-flavored syrup commonly described as having "sour sap flavor." Second, as much as possible keep sap out of the sun and as cool as possible to slow down sap spoilage. Third, do not concentrate taste offenders. When boiling, you are concentrating the sap, and anything in the sap that has even just a little off-flavor will be concentrated into significant off-flavor in the syrup. Adding some old, spoiled sap to good, new sap can off-flavor what would have been good syrup. Any leaves or trash in buckets or sap holding tanks can dramatically flavor syrup. Keep everything clean, but if you wash sap tanks, buckets, or tubing with soap or a sanitizer, they must be very well rinsed. Otherwise, the flavors of the cleaning products will show up in the syrup much stronger than expected.

If you have really good boiling equipment, the sap may want to boil over which can be dangerous, wasteful, and irritating. To control this, maple producers use what is called **defoamer**. Most defoamers are food grade oils which can off-flavor syrup if over used. Use just what is necessary, or reduce the boiling heat in the evaporator. If exhaust or smoke from the fire or heat source for boiling is able to swirl over the boiler or over sap exposed to the air, the syrup can pick up smoky flavors.

There are many options for the boiler or evaporator. One of the simplest methods for boiling is using a propane turkey roaster, a simple burner with a pan on top commonly available in hardware or general merchandise outlets. Keep the sap just 2 to 4 inches deep. Add small amounts of sap every 10 to 20 minutes to keep the depth nearly constant. Keep adding sap until it is gone or until you need to stop for some other reason. A fine syrup can be produced with this equipment. The main drawback of this method is the cost of the propane. Because much of the heat from the burner is not captured, meaning, it is simply lost to the air, not aiding the evaporation process, the cost can approach the value of the finished syrup.

There are two main ways to approach boiling sap into maple syrup. For smaller production, most syrup makers would use the **batch method** of boiling syrup. With the batch method, sap from a whole run is gradually added to the boiler until all the sap is gone. The sap is boiled down until it is syrup or until it gets low enough in the boiling pan that you can no longer measure the temperature accurately with a thermometer. Typically, the concentrated sap would be moved to a cooking pan and finished on the kitchen stove. The best way to produce the highest quality syrup using the batch method is to keep the concentrated sap fairly low sugar, less than 50%, until you are ready to finish it to syrup. Letting the concentrated sap get close to syrup concentration (66% sugar) when still adding fresh sap will make the syrup darken and develop strong flavors. Learn more about sugar content (% sugar, or brix) in the next subsection, 4.4 B. Finishing Syrup.

The second approach to boiling sap is by **continuous flow**. This requires a larger boiler with divider walls to keep the syrup moving through the boiler as it becomes more concentrated. This kind of boiler would usually be made by a maple equipment supply company or a professional metal worker. With continuous flow, sap is continually added at the starting pocket on the boiler, and syrup is regularly taken off at the other end of the boiler. The continuous flow system is used by almost all commercial maple production facilities.

Boilers are made up of two main components, the arch and the boiling pan. The arch contains the fire and pipes the smoke away from the boiling sap. The boiling pan sits on top of the arch and holds the sap during boiling. An arch can be as simple as laid up blocks or bricks and a smoke stack, or it can have much more technology for managing temperatures and energy efficiency. One of the main questions asked by beginners is how to size a boiler for the number of taps you are planning. This is a more complex questions than most beginners realize. When purchasing a maple arch and boiling pan from a commercial supplier they usually would have a recommendation as to a range of taps that it can handle. A real question to be answered is, how much time will you have for boiling? A bigger system will get the boiling done faster or allow you to add more taps in the future without making a major equipment change. A bigger system will also cost more at startup which is a major concern for many maple producers. If you plan on using reverse osmosis, a much smaller boiler can be used. If you are tapping sweeter trees, such as most road side trees, less boiling is needed. If tapping crowded forest trees, the sap sugar is likely to be lower and a bigger boiler needed. Large trees will usually provide more sap per tap than smaller trees. If electric is available so that a small fan can be used to force air into the arch when burning wood, the boiling will happen much faster so that a smaller system can accomplish more production. Some boiling pans have flues where the hot surface on the bottom of the pan is increased by adding folds in the pan. This allows much more surface area for the fire to heat the sap. A flue pan can significantly increase the rate of boiling compared to a flat-bottomed pan of the same size.

A fairly simple calculation can be used to assist in making a decision about the volume of sap that will need to be processed. The number of taps times the likely sap yield per tap in a day will give you the number of gallons of sap you may need to deal with for a good run. Trees can range from 0.5 to 2.5 gallons of sap per tap during a good day run. So if you have 100 taps, and you expect 1.5 gallons of sap in a day, you would need to boil away about 150 gallons of water. Next question is, how many hours will you likely have to boil? If you have 10 hours available to boil, you will need a boiling system that can remove 15 gallons of water per hour with the exception of the 3 or so gallons of syrup you will have when you are done. The typical 2’ by 4’ boiling pan can remove about 15 gallons of water per hour. A 2’ by 6’ pan can remove about 25 gallons per hour. Evaporation rate estimates of small boilers of other sizes can be made from these numbers.

B. Finishing Syrup

Density

Density means solids content. The minimum density for syrup is 66% solids by weight. **Brix** means % solids by weight and is the term most commonly used to discuss maple syrup density. It is often interpreted as % sugar because sugar makes up the majority of the solids found in syrup. The new standard for density is minimum 66° Brix, maximum 68.9° Brix.

Brix can be determined three ways: by thermometer, hydrometer, or refractometer.

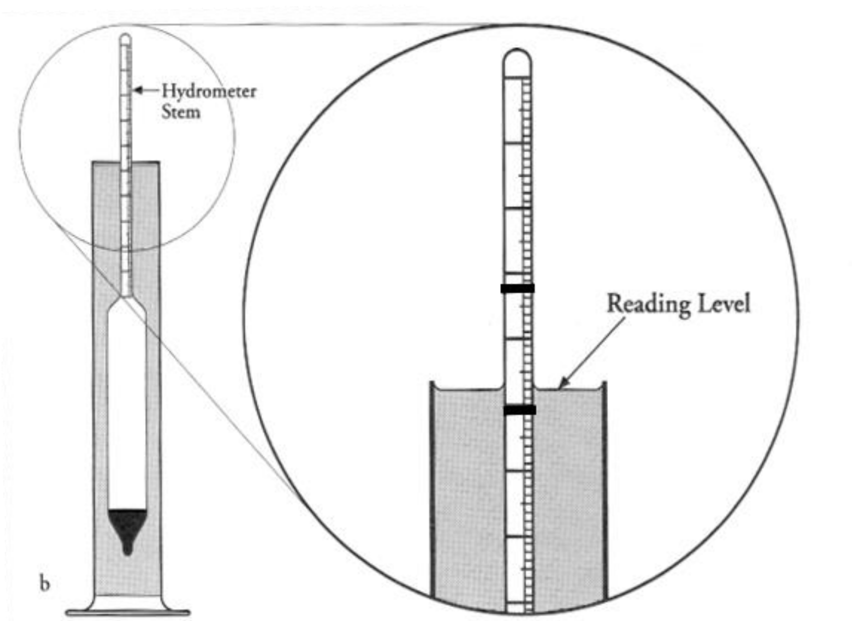
Density by Thermometer

66% sugar occurs at 7.1º F (3.94º C) above the boiling temperature of water, that is, 212º F (100º C) at the average barometric (atmospheric) pressure of 29.92 inches at sea level. So 219.1º F would be the finish temperature of syrup, if the boiling temperature that day was actually 212º F. However, the boiling temperature of water varies slightly every day, and even within the same day. Because boiling temperature depends on barometric pressure, it can change suddenly with the weather, and it also changes with elevation.

At even 1º F error up or down, you will end up with syrup that is either 63.4° Brix or 69.0° Brix. This is a problem because at 63.4° Brix and lower, syrup molds easily, and at 69.0° brix and higher, syrup will crystallize at room temperature. To avoid these issues and ensure accuracy, the maple producer must check the boiling point of water daily and adjust syrup finishing temperature accordingly.

Density by Hydrometer

The hydrometer is a simple way to test boiling sap that is getting close to being syrup. There are special hydrometers designed for maple syrup that allow maple producers to test hot syrup as it comes off the evaporator. These hydrometers also have two red indicator lines that tell the producer when they have concentrated to legal density syrup. When the hydrometer floats in a cup of hot syrup so that the upper red line is level with the flat surface of the syrup, the sugar content will be at 66.9% when the



syrup is cooled to room temperature. Why 66.9% sugar content? Because most hydrometers we use are designed for use in Vermont where 66.9° is the legal brix for syrup as opposed to the 66° brix requirement for New York. However, you may want to use a hydrometer on syrup that is not boiling hot. The following hydrometer chart makes convenient making any desired adjustments, or taking readings at temperatures other than hot right off the boiler.

Brix Corrections for Hydrometers Calibrated at 60°F and 68°F

Temperature of Syrup (°F)	Correction value to be added to observed Brix to give true Brix for Hydrometer Calibration:		Temperature of Syrup (°F)	Correction value to be added to observed Brix to give true Brix for Hydrometer Calibration:	
	60°F	68°F		60°F	68°F
215	7.3	6.9	**120**	2.8	2.4
210	7.1	6.7	**115**	2.6	2.2
205	6.8	6.4	**110**	2.4	2.0
200	6.6	6.2	**105**	2.1	1.7
195	6.3	6.0	**100**	1.9	1.5
190	6.1	5.7	**95**	1.6	1.3
185	5.9	5.5	**90**	1.4	1.0
180	5.6	5.3	**85**	1.2	0.8
175	5.4	5.0	**80**	0.9	0.6
170	5.2	4.8	**75**	0.7	0.3
165	4.9	4.6	**70**	0.5	0.1
160	4.7	4.3	**65**	0.2	-0.1
155	4.5	4.1	**60**	0.0	-0.4
150	4.2	3.9	**55**	-0.2	-0.6
145	4.0	3.6	**50**	-0.5	-0.8
140	3.8	3.4	**45**	-0.7	-1.1
135	3.5	3.1	**40**	-0.9	-1.3
130	3.3	2.9	**35**	-1.2	-1.6
125	3.1	2.7	**30**	-1.4	-1.8

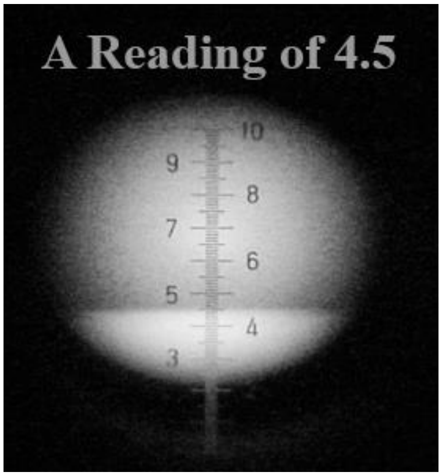
These figures are calculated from the formula on page 74 of the Maple Syrup Producers Manual, Agricultural Handbook No. 134, July 1976. True Density (° Brix) = Observed Brix + (0.047 x Temperature of Syrup - Temperature for which the hydrometer is calibrated).

Edmund E. Grote, Uihlein Sugar Maple Research Extension Field Station, Lake Placid, NY. March 1996.

Syrup density changes with temperature, so the producer must always adjust. The cost of even a 1° brix error results in 1 less gallon of syrup for each 66. This is a 1.5% loss or $0.82 retail loss per gallon per Brix.

Density by Refractometer

There are refractometers made for both sap and syrup, but each is only suited to a particular range of densities. A sap refractometer is also called a "low brix" refractometer. Be careful not to mix up your refractometers because using one designed for sap on syrup and vice versa will give you unintelligible readings. There are two kinds of refractometers: digital and visual. The visual refractometers are quick and easy to use, but not so much with hot syrup. The syrup must be cooled before use on these tools. These visual refractometers also require adequate lighting to read. They are very convenient for measuring sap sugar content, especially when quickly checking how dense sap is coming out of the RO whether when starting up for the day or shutting down. There are various other applications for sap refractometers, including checking individual trees' "sweetness." Digital refractometers are a little bit pricey, but they can be convenient for getting highly accurate density measurements before using syrup for value-added products. Measuring exact syrup density can help you achieve better consistency with your confections and other value-added products.



Reading a visual refractometer: simply look through the eye piece in an area with good lighting – sunlight works best.

C. Filtering Syrup

Clarity, Turbidity, and Sale of Syrup

If you are a backyarder planning to use your syrup only for yourself, you can get away without filtering syrup, but expect the lower parts of syrup jars to be very cloudy and contain significant sediment. This sediment, called **sugar sand** is a collection of minerals that settle out of the sugary solution of maple syrup. It is not harmful, but it is not attractive. Filtering removes the sediment making a nice, clear maple syrup.

If you intend to sell the maple syrup you produce, you must follow the USDA guidelines which are detailed in the next section, 4.5 Grading. Note that the USDA has determined that Grade A Maple Syrup is syrup that “is not turbid” and “contains no sediment”. Turbid in regards to syrup just means the opposite of clear or transparent. Filtering your syrup will allow you to maintain standards for sale of your product, while also removing any material a customer might find objectionable or questionable.

Methods

Three main methods of filtering are commonly used. A very small producer may use a filter as simple as a coffee filter. Most will use a set of cone filters, the top one of paper and the lower one of felt or similar material. A set of flat filters can also be used. Even these filters may not do a sufficient job of filtering for the syrup to be displayed in glass. For larger producers, or those wishing to sell in glass containers, a **filter press** is preferred.

Filter Maintenance

A paper filter will catch larger particles, while a felt filter will catch the finer particles. When the paper filter plugs, it can be replaced often without changing the felt. After plugging, felt and other reusable material filters should be washed as soon as possible with plain, hot water. It is a good idea to have several clean filters on hand when filtering a large amount of sap. Do not use a detergent to clean filters, as aromas from the detergent will stay locked in the fibers, and then give the syrup a detergent off-flavor. When stored, filters need to be kept dry and open to the air. They should never be stored with moth balls or other materials that could pass off a bad flavor. Filters should always be washed before their first use.

Filtration Setups

Finished syrup should be filtered while it is still hot so that it is thin enough to move quickly through the filter. The simplest setup is placing cone filters over a tall pot and clipping them in.

Whatever container is used should be clean and free of lead. Old milk cans as seen in the image to the right are no longer suggested for syrup storage, as lead solder was used to make them in the old days. Hot, finished syrup can also be filtered directly into long-term storage containers if desired, as long as a sterile temperature of at least 180 degrees Fahrenheit is maintained. Flat filters are also commonly used, but require a much wider container. The greater surface area can increase efficiency. Many maple producers use pre-filters above "cone" type or "flat type" felt filters for more effective filtration results. This setup is most effective when the double filters are not in direct contact with each other. The use of pre-filters saves a lot in labor, both because the heavy filters may be in service longer between cleanings, and due to ultimately better filtration results. Wash and dry pre-filters often in pure, hot water.

The flat filters allow for greater filtering surface area. The paper and the felt should each lay on their own grill or screen. They function better if the paper is not laying directly on the felt.

A **filter press** is the commercial standard for syrup filtration. Syrup is pumped through several filters for increased speed and clarity. The filters need to be changed when the pressure builds up. Keep a close eye on the pressure gauge.

Filter Aid

Filter aid, most commonly **diatomaceous earth**, is used to increase the life of the filter papers. Diatomaceous earth (**DE**) is a sediment composed primarily of silica thanks to the hard skeletons of ancient microscopic organisms called diatoms. DE products have an intricate, highly porous structure, and so they are commonly used in pool filters and even toothpaste. Diatoms are tiny – 15 to 30 microns in diameter – but still larger than syrup molecules. Therefore, syrup can pass through filter paper, but the DE cannot. The tiny pores in DE trap bacteria and yeast with ease. However, you must be careful of the grade of the filter aid when purchasing. Do not use garden grade DE, nor swimming pool grade for syrup, even though they are much less expensive. You are also advised not to breathe in diatomaceous earth no matter what the grade. Avoid leaning over the container as you scoop and pour the material. Experiment to find the exact amount of filter aid needed to filter the syrup. A little goes a long way.

Table 1-1: General recommendations for Diatomaceous Earth needed for various filtering batch sizes in 7" or 10" plate filter presses. (More DE may be needed for dark or late season syrup.)

Gallons=	7" Plate Press	10" Plate Press
40	5 cups	8 cups
45	6	9
50	7	10
55	8	11

Filter Paper

The purpose of filter paper is to catch the DE suspended in syrup and provide a surface for the **DE cake** to form. During filter press setup, filter paper is placed between each plate. Submerging the papers in permeate for a few seconds will help keep them in place during setup. Filter papers have two holes that match the inlet and outlet hole in the filter press plates. It is important that the correct size papers are used and that the holes are aligned between the papers and plates. Although filter paper has two distinct sides or textures, there is no detectable difference in filtering performance regardless of orientation.

Batch Vs Continuous Filtering

Sugarmakers who collect syrup into a finishing pan or some other holding container before filtering are using the **batch filtering** method. When charging the press during batch filtering, half the total DE used to filter the batch of syrup is added to the charging bucket of syrup. The remaining DE is mixed with the remaining syrup to be filtered. This insures that DE will be constantly added to the existing cake in the filter press. By adding DE continually to the filter press, more surface area is created during filtering. The impurities (niter) being filtered are spread out, and filtering capacity is increased. If more than one batch of syrup is sent through the same set of cakes and papers, care must be taken to prevent excessive cooling of the press.

An alternative to batch filtering is **continuous filtering** which involves the same steps for charging the press as batch filtering. With continuous filtering each draw-off is sent directly through the press. Sugarmakers that will only produce a gallon of syrup an hour may encounter problems with clogging or noticeable drop in temperature within the press. A press that has cooled can in turn cool filtered syrup below 180°F, too cold for canning. Gravity will naturally pull downward on the filter cakes over time. If the press is left idle for too long, gaps may be created in the DE cake allowing unfiltered syrup to pass through.

Important Notes on Operating a Filter Press

- Always use food grade grease and dispense it using a grease gun that is only used for this purpose.
- The end plate of a filter press is a waffle plate made from thicker metal than the rest of the stack. Attach this plate, and secure it using the manufacturer's hardware. Tighten down on the stack. Remember, a filter press is under pressure; if the stack is loose during filtering, hot syrup may squirt out between the plates.
- Normal operating pressure for a 10" plate press with seven plates is between 0 and 20 psi.
- Watch for spikes in the pressure. Generally, do not exceed 50 to 60 psi.
- Opening the bypass value will reduce pressure but will also reduce filtration rate.
- Filter papers should be changed often, and the pressure gauge should be monitored closely to avoid bursting of filter papers. A general rule of thumb is to clean your press if the bypass valve is used.
- If you reheat cold syrup for canning, you may want to re-filter that syrup as you may create new mineral sediment. This is especially important when canning into glass.
- Do not run the pump without fluid. This causes excessive wear and tear.

4.4 Grading Syrup

Maple syrup must be graded before it can be sold. Syrup that does not meet the standards set forth in the grading guidelines is not legal for sale. Syrup that meets the standards must be correctly graded and labeled. There is more information on correct and legal product labeling in Section 5.1 of this Notebook, titled “Laws and Labeling”. Maple syrup is a regulated food product. Below is an excerpt from the USDA maple syrup grading standards:

Grade A – Table Grade

- *Grade A maple syrup means maple syrup that is not fermented, is not turbid, and contains or has no objectionable odors, off-flavors or sediment. Grade A maple syrup must fall within one of the color and taste sub-grades of Grade A maple syrup set forth in subparagraphs (a), (b), (c), or (d) of this paragraph.*

Processing Grade (previously called Grade B)

- *Processing Grade maple syrup means maple syrup that does not meet the requirements for Grade A maple syrup set forth in paragraph (2) of this subdivision. Processing Grade Maple Syrup may not be sold, offered for sale or distributed in retail food stores or directly to consumers for household use.*

The full USDA document on Maple Syrup Standards can be found at this web address:
https://www.ams.usda.gov/sites/default/files/media/MapleSyrupStandards.pdf.
The following bullet points outline the grading standards and processes in simpler terms.

Legal Definition of Syrup

- Produced exclusively by the concentration of maple sap or by the solution or dilution of a pure maple product other than maple sap in potable water
- Minimum soluble solids of 66%
- Maximum soluble solids of 68.9%

Quality Descriptors for Grade A

No Retail Restrictions (4 Classes)

- Uniform in color
- Intensity of flavor (taste) normally associated with the color class
- Free from objectionable odors and off-flavors
- Free from turbidity and sediment

The 4 Classes

Golden Colour and Delicate Taste Light transmittance not less than 75.0% Tc	**Amber Colour and Rich Taste** Light transmittance 50.0-74.9% Tc
Dark Colour and Robust Taste Light transmittance 25.0-49.9% Tc	**Very Dark Colour and Strong Taste** Light transmittance less than 25.0% Tc

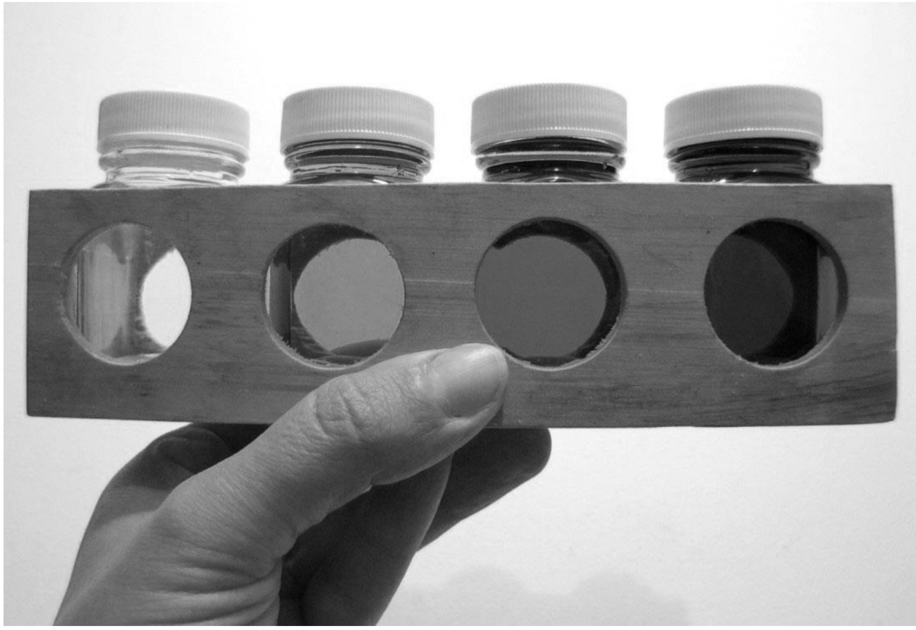
Golden Color and Delicate Taste
Pure maple syrup in this class has a light to more pronounced golden color and a delicate or mild taste. It is the product of choice for consumers preferring a lighter colored maple syrup with a delicate or mild taste. Light transmittance not less than 75% Tc.

Amber Color and Rich Taste
Pure maple syrup in this class has a light amber color and a rich or full-bodied taste. It is the product of choice for consumers preferring a full-body tasting syrup of medium taste intensity. Light transmittance 50.0-74.9% Tc.

Dark Color and Robust Taste
Pure maple syrup in this class has a dark color and a more robust or stronger taste than syrup in lighter color classes. It is the product of choice for consumers preferring a dark colored syrup with substantial or robust taste. Light transmittance 25.0-49.9% Tc.

Very Dark Color and Strong Taste
Pure maple syrup in this class has a very strong taste. It is generally recommended for cooking purposes but some consumers may prefer it for table use. Light transmittance less than 25% Tc.

Light Transmittance


Visual Grading Kit

Grading Classification Tools:

- USDA Glass Plate Grading Kit
- Vermont Grading Kit
- Lovibond
- Berliner
- New USDA plastic
- Other Grading Kits
- Background lighting
- Hanna

For Visual Grading Kits
Effects of different color background lighting on the grade groups. Background color is interacting with the color properties of the syrups and the standards to produce somewhat different results. Light Blue is the worst, green is not very good either, so don't check against the sky or against green leaves, all background colors affect the visual kits accuracy

For Hanna Meter Grading

Hanna meters are most commonly used by commercial buyers and large operations as they are fairly expensive. They read light transmittance digitally. The following table contains the light transmittance measures for each grade when using the Hanna Analyzer. Notice the old terms for Grade Classification in the left most column. The numbers in the middle columns are what the typical syrups would read when they were graded using the old system. This is before Hanna meters became a standard grading tool. The column all the way to the right contains the numbers for new official grading guidelines for accepted light transmittance.

Old Grade Classification	Canadian %T	Cornell %T	**New**
Light Amber	75	62	**75** (Golden)
Medium Amber	60.5	50	**50** (Amber)
Dark Amber	44	36	**25** (Dark)
Extra Dark	less than 44	less than 36	**<25** (Very Dark)

Processing Grade

Not for Retail Sale

- Can have any light transmittance
- May be any color class
- May contain off-flavours (i.e. caramel, woody, buddy, burnt, etc.)
- May be very strong tasting syrup
- Packed in containers of 20 litres (5 gallons) or larger
- Cannot be sold at retail
- May be used in food processing and non-food uses

Product Descriptors to Appear on the Product Label

Both Grade A and Processing Grade shall include:

- “Pure Maple Syrup”
- Grade Name
- Product Origin: Country or State
- Producer Contact Information / Packer Identification
- Batch Code

Just Grade A:

- Intensity of Flavor (Taste)
- Color Class

Just Processing Grade:

- “For Food Processing”

4.5 Off Flavors

There is a "Flavour Wheel for Maple Products" developed by the AAFC that many producers use to find the best descriptors for their syrup and to troubleshoot if need be. The wheel is organized like a color wheel. It includes flavor categories such as Herbaceous, Milky, Floral, Spicy, and for those flavors that should not be in your syrup, Foreign. The wheel can help you find the right words when you are tasting something unfamiliar in your syrup. It also unifies the way people in the industry talk about maple syrup flavors. Knowing the right terminology can also help you improve the quality of your maple products.

To view the color wheel, access the link below:
http://www.agr.gc.ca/eng/science-and-innovation/agriculture-and-agri-food-research-centres-and-collections/quebec/saint-hyacinthe-research-and-development-centre/maple-syrup-flavour/flavour-wheel-for-maple-products/?id=1231363888838

Maple Flavors and Syrup Grading
All maple syrup is not created equal. The flavors of maple syrup vary significantly from producer to producer, from various production systems, from different production areas, from year to year with a single producer, and even from specific woodlots. One only needs to serve as a maple syrup judge at a fair or maple meeting to experience the range of flavor diversity.

These flavor distinctions can be part of developing customer loyalty as they find that another producer's syrup is, "just not the same". But, sometimes flavors are less pleasing, leading to difficulty keeping customers. The causes of noticeable, and even severe flavor problems can often be identified and corrected.

The recognition of off flavors and the severity of those flavors is part of the rules and regulations for grading maple products in New York State. The New York State Agriculture and Markets Circular 947 "Manufacture, Distribution and Sale of Maple Syrup and Sugar" quite broadly describes how off flavors influence the syrup grade. The rules define several flavor related terms. First, "damage" means any defect that materially affects the appearance, edibility or shipping quality of the syrup or sugar. Second, "serious damage" means any defect that seriously affects the edibility or market value of the syrup. Badly scorched syrup, buddy syrup, fermented syrup, or syrup that has any distasteful foreign flavor or disagreeable odor shall be considered seriously damaged. Third, "buddy flavor" or "buddiness" is an unpleasant flavor characteristic of syrup or sugar made from sap collected from maple trees that are coming out of dormancy in the spring. For syrup to be labeled as Grade A for table use, it must have good flavor and odor, be practically free from damage, and be practically clear. No serious damage or buddiness is acceptable. The rule also states that the syrup shall have a good maple flavor that is characteristic of the color. For syrup to be labeled as Grade B for reprocessing or, “Extra Dark for Cooking,” it must have fairly good characteristic maple flavor, shall be fairly free from damage, fairly clear, and free from serious damage. In other words, a syrup that has a clearly identifiable off flavor would not be legally marketable as either Grade A or Grade B and could only be sold in bulk as substandard.

Henry Marckres with the Vermont Agency of Agriculture, Food and Markets has pulled together some excellent information on maple syrup off-flavors, their likely causes, and tips on how to avoid these problems. The following information has been edited from material he has written.

Chlorine (Sodium): A solution of chlorine and water is often used to clean sap tubing systems and storage tanks. When these systems are not fully rinsed afterwards, the solution leaves a residue inside the tubing. Sap running the next season "scrubs" the tubing, putting varying amounts of sodium into the finished syrup. A chlorine off-flavor often destroys maple flavor and leaves a salty flavor.

Detergents: The only detergents that should be used in syrup production are ones that are approved for food use. Producers have often used products that are designed for home use, damaging the flavor of the finished product. A detergent flavor in syrup may taste soapy, or have a perfume odor or flavor, depending on the type of detergent used and how much rinsing was done.

Paints: In the past, many producers painted the inside of galvanized sap buckets and holding tanks to prolong their useable life. Often these paints contained a fish oil base. This type of paint should never be used on any surface that is in direct contact with sap or syrup. The flavor derived from this material may have an oily taste. It is especially prevalent if the paint was not cured completely before using the bucket or tank.

Metallic: This off-flavor is usually the result of prolonged storage in metal syrup cans or storing bulk syrup in poor quality metal barrels. Always check the interior condition of galvanized and epoxy coated barrels, and do not use any with obvious rust or cracked epoxy. The recommendation for metal syrup cans is to only pack what will be sold in a three-month period. If the exposure has been prolonged, the product may have a greenish tinge to it and a “tinny” taste.

Plastic: The type of material that causes this off-flavor is most often a non-food grade plastic or a plastic not meant for exposure to hot syrup. Using the wrong type of pail to move syrup from the evaporator to the filter, or packaging syrup in containers not designed for hot filling creates a bitter flavor, or a flavor that tastes the way some plastics smell.

Filters: There are several off-flavors that can be attributed to either the way filters are manufactured, or the methods used to clean and store them.
New filters: These are the type of filters that use the weight of the syrup to filter, usually a cone type or flat filter. During the manufacturing process, these filters pick up and retain a slight chemical odor and flavor. Before use, they should be boiled in clean water and dried thoroughly. If not, they impart a chemical flavor to the syrup.
Used filters: Once used, filters should never be washed with any detergent as they may pick up detergent residue in the fibers. After the season is over, filters should be washed in water and dried thoroughly before storing in a dry location free of contaminating odors. Filters not dried thoroughly will mold, creating a musty off-flavor when hot syrup is filtered through them the next season. Never store filters with mothballs, as this will create a chemical off-flavor.

Defoamers: Many different products are used to reduce the foaming of the boiling sap during evaporation. Commercially available vegetable fat derivatives or either liquid or powdered butter, milk, or vegetable oil is often used. Only a small amount is needed to control foaming, and using too much will create an off-flavor in the syrup. A defoamer off-flavor may taste like whatever was used for a defoamer or have a rancid taste.

Chemicals: The technology used in producing syrup today often requires the use of powerful cleaners and preservatives. It is very important to follow the manufacturer's recommendations carefully and rinse thoroughly before continued use. The off-flavor usually relates to the smell of the chemical used.

Lubricants and Fuels: Care should be taken to avoid contamination of the sap or syrup from exhaust fumes or improperly operated equipment. Also, only food grade lubricants should be used in any pumps or equipment that comes in contact with sap or syrup. Off-flavors attributed to this type of contamination will taste and smell just like the contaminant smells.

Musty: This off-flavor can become present in the syrup in two ways: putting hot syrup through filters that contain mold, or into poorly sealed containers. The musty off-flavor tastes yeasty or moldy and usually has a moldy odor.

Ferment: Fermented syrup usually develops from one of two problems with the product. If syrup has not been boiled enough to concentrate the correct amount of sugar, then the syrup may work like apple cider. At times, we find correct density syrup fermented and that is usually from syrup stored in barrels that have not been properly cleaned. Even barrels that have been previously steam cleaned may have moisture in them that have revealed yeast, mold, and bacteria in great numbers. Syrup that is fermented will have a sickening sweet flavor, at times similar to honey. Depending on the type of ferment, it may have an alcoholic or fruity taste. Severe ferment may have a foamy appearance.

Sour Sap: As the weather warms near the end of the sugaring season, sap left in a tank begins to warm, basically beginning to spoil the sap. Syrup made from this sap has a ropy appearance when poured. The flavor is very sour.

Burnt Niter: When sap is boiled, minerals that are in the raw sap precipitate out of the solution and form niter that collects in the compartment in the front pan where the syrup is drawn off. To prevent this from becoming a problem, the producer switches draw-off sides as needed, or changes front pans if the evaporator construction allows. If this is not done, a build-up occurs in the pan, creating a combination off-flavor. The syrup will have a burned taste from the niter rising off the front pan and the syrup burning, and it will also have a niter flavor, which has a slightly fizzy affect, like baking soda on the tongue.

Scorch: This off-flavor is a burned flavor in the syrup. Operating the evaporator with too low level of liquid in the front pan actually burns the syrup.

Earthy flavor: Tapping into punky wood, dark-colored or stained areas in the tree, or cracked wood produces syrup with this off-flavor. The flavor tastes and smells like garden soil. Care should be taken when tapping to avoid the potential for this problem.

Metabolism: This is an off-flavor that is attributed to changes in the metabolism of the tree due to a warming of temperatures. This can be present at any time during the sugaring season, from the first run on. A metabolism off-flavor robs the product of most of its maple flavor. The resulting flavor has been described as woody, peanut butter, or popcorn. An almost cardboard like flavor may be present. A chocolaty smell may be detected.

Buddy: Buddy syrup is usually produced during the late season, depending on the weather conditions present. The tree begins to produce buds, and the sap takes on a distinctive quality that is transferred into the syrup. Buddy syrup usually tastes chocolatey, often described as a tootsie roll type flavor. If very strong, it may take on a bitter chocolate characteristic.

Learning to identify these off flavors will make catching and correcting problems in the production process much easier and quicker. Identifying off flavor early on can save your syrup and your reputation.

4.6 Syrup Handling and Canning

Canning procedures can vary widely based on equipment used, canning room setup, and other factors. In every operation, there are numerous steps necessary to creating a consistent, high quality product.

Safety
Canning involves heavy lifting and handling hot syrup. As always, use proper methods for lifting heavy objects. When in doubt, ask for assistance. Syrup is processed at 180º F for canning which can cause minor burns. Rubber gloves, a rubber apron, and work boots are recommended. Take extra precaution when pouring large, heavy containers of hot syrup from one element to another, such as from the stove or water jacket to the canner.

Batch Notes
Before canning or putting syrup into barrels, you should take careful notes on the batch of syrup. Check the light transmittance, the density, and the flavor, taking detailed notes. Keep notes organized, and write the date, grade, and batch number at minimum on the barrel. It is a good idea to set a small sample aside from each batch over the course of the season.

Pre-heating
You may can syrup straight after filtering, or store in syrup in barrels for canning at a later date. If you reheat cold syrup for canning, you may want to re-filter that syrup as you may create new mineral sediment. This is especially important when canning into glass. When reheating syrup, avoid heating to over 200ºF as excessive heat can induce significant sediment and further darken the grade. It could also change syrup density. A water jacket works well for reheating syrup.

Canning
When you have finished filtering the syrup in preparation for canning, there are a few more important steps. If using a canner, be sure it is clean and free of dust before pouring in the syrup. The syrup must be heated to at least **180º F**. This temperature effectively pasteurizes the syrup. Then pour the hot syrup into the container, leaving only a ¼ to ½ inch gap between the liquid and the lid.

Screw the lid on tightly and turn the container on its side. This ensures that all surfaces of the container are sterilized by the hot syrup. After a minute or two, return the container to the upright position. If the seal is good, the syrup should now be stable at room temperature for an unlimited length of time. However, grade may change if stored for an extended length of time. Storing syrup in a cool place reduces the amount of darkening that will occur following canning. Refrigeration is not necessary until the container is opened.

4.7 Food Processing Establishment License
NYS Department of Agriculture and Markets

Food Service Rules: 1) Use Food Grade Equipment 2) Keep it clean 3) Don't assume you cannot be inspected 4) Avoid Lead

The Food Processing Establishment License is required when Maple Syrup is *purchased* and canned, bottled, or further processed. Maple production is exempt when only canning, bottling, or further processing syrup that is produced in your own maple operation. This exemption only holds true if all of the value-added products produced only have 100% pure maple syrup in the ingredients. If non-maple components are added to products, such as in the case of a maple barbecue sauce, the Food Processing Establishment License is again required.

Exempt operations are subject to basic sanitary requirements and may be inspected to ensure compliance. **Section 276.4** states that Exempt operations must be maintained in sanitary condition by practicing the following:

1. Exclude birds, insects, rodents, and other vermin and animals from the premises of the operation.
2. Insecticides, rodenticides, and other pest control items should only be used in a way to prevent the contamination of the product.
3. Rooms, compartments, or other places where equipment and utensils used for preparing, storing, or otherwise handling the product shall be kept in a clean and sanitary condition.
4. All other parts of the operating premises shall be kept in a clean and sanitary condition.
5. No handling or storing of materials which may create unsanitary conditions in any place where product is prepared, stored or handled.
6. All equipment should be kept in good repair.
7. All finished product containers must be clean, sanitary, and properly labeled.

Section 276.1: All food processing establishments are subject to Current Good Manufacturing Practices
What qualifies as good manufacturing practices? According to the **NSF** National Sanitation Foundation:

1. Food Zone: Surface materials in the food zone shall be smooth, corrosion resistant, nontoxic, stable, and nonabsorbent under use conditions. They shall not impart odor, color, or taste, nor contribute to the adulteration of the food. Exposed surfaces in the food zone shall be finished so as to be easily cleanable. For most food zone applications, smooth is defined as surface free of pits and inclusions.

2. Splash Zones and Non-Food Zones: Splash zones shall be smooth and of an easily cleanable and corrosion-resistant material, or they shall be rendered corrosion resistant with a material that is non-cracking, non-chipping, and non-spalling.

Material Concerns: Galvanized Steel, Plastics, Solder, Paints, Cleanable Surfaces, Equipment that is not made for Food Systems

4.8 Safety in the Sugarhouse

The most common injury in the sugarhouse is burns. The syrup is hot, the steam is hot, the evaporator itself is hot, the filter press, pipe fittings, full barrels, and on and on. You get the idea. The best way to protect yourself is to use personal protective equipment (PPE), and be aware of potential hazards to do with the syrup making process.

Personal Protective Equipment

- Heat Proof Gloves
- Nonabsorbent Apron
- Safety Glasses
- Long Sleeves
- Long Pants
- Closed-Toe, Nonabsorbent, Quality Shoes

Potentially Hazardous Situations

- Steam is hot and burns; do not lean your face directly over the evaporator.
- Do not leave a fire going while you are asleep or no one is there to watch.
- Be careful when moving heavy containers or buckets full of hot syrup. Use lids where possible. Avoid spilling hot syrup on absorbent clothing, shoes, or unprotected skin. Rubber boots are a good idea.
- The foam in the evaporator pan is hot syrup, too. It can cause serious burns. A foam over is very dangerous. Keep an eye on your foam levels and add defoamer regularly. Be cautious when opening a back pan window because the foam can come flying out, burning your face.
    - Details on responding to a burn are found at the end of this section.
- Avoid small, confined spaces. Going inside a stainless steel tank is a bad idea because they can be very slippery, and often have rounded bottoms. It can be nearly impossible to get out. Long handled brushes work well, and it is much safer to clean and rinse your tanks from outside of them.
- Pay attention to the pressure gauge if using a filter press. Make sure the plates are screwed tightly together so that hot syrup does not burst out from between them. Do not exceed 60psi, and be ready to open the bypass valve to reduce pressure if necessary.
- Avoid inhaling diatomaceous earth which can irritate lungs.

Finally, some safety issues have to do with the sugarhouse design itself. There should be adequate floor drainage in unheated rooms to avoid icy floors. There should be adequate lighting everywhere. Of course, make sure there are no flammables anywhere near open flames. The building should be easy to escape from in the case of fire.

Exercise Caution when Making Maple Confections

Although maple sugar, maple cream, and any number of other maple confections taste great and offer greater income opportunities for maple producers, getting injured in the process of making them is no treat. Making maple confections involves handling very hot and very sticky sugar solutions. This combination of hot and sticky can lead to very painful and debilitating injury in the event of an accident. As we work towards having maple producers making and marketing more maple value-added products, we want to also ensure that people are not injured in the process.

This article will outline worker safety information to help maple producers avoid costly mistakes. The food service industry experiences the highest number of burns of any employment sector, about 12,000 each year. Cooks, food handlers, and kitchen workers are all listed among the top 50 occupations at risk for on-the-job burn injury.

Likely Causes of Burns

Burns in the food industry usually occur when:

- Safety rules have either not been developed, relayed to workers, or are being ignored
- Shortcuts are taken in the interest of saving time or expense
- Persons become too familiar with their job and take unnecessary risks
- Workers are ill, tired, or compromised by alcohol or drugs and are unable to concentrate

Burn injuries to maple producers can result from contact with:

- Hot syrup or liquids
- Steam from cooking or when a steam burst comes off when crystallization occurs while stirring
- Hot finished product such as syrup, molded, or granulated sugar
- Hot surfaces – stoves, grills, ovens, pans, open flame, or a hot thermometer or spoon

Clearly there are a number of ways burns can result. Fortunately, there are a number of ways to avoid these potentially dangerous situations. So what can you do to protect yourself and your workers? It is important to insist that each operator follow a safety dress code such as:

- Wear protective gloves or mitts, a non-absorbent apron, and eye protection when moving containers of hot syrup
- Wear non-slip, fully enclosed shoes or boots. Open shoes, sandals, and similar footwear are not allowed.
- Long pants that fully cover the legs are required. Shorts and skirts are not allowed.

In addition to protecting yourself and your employees, it is important to create an environment that is safe as well. There are a few things you can do to ensure that the environment and atmosphere in your work area is of the utmost safety level.

Suggestions for a Safe Environment:

- Avoid reaching over or across hot surfaces and burners. Use barriers, guards, or enclosures to prevent contact with hot surfaces.
- Read and follow directions for proper use of gas and electrical appliances.
- Keep pan handles out of walk-by areas and keep handles away from heat or flames of burners.
- Open lids away from you to let steam escape safely.
- Have a water bath handy to immediately cool any hot products spilled on skin.
- Have a phone immediately available in the event a call for help is necessary.
- Be familiar with common first aid actions to take in the event of an accident.
- Have a current first aid kit readily available as well as emergency phone numbers.

Burn injuries can result in large losses of time and money, in addition to tremendous pain and suffering. If you have employees working on maple confections, be sure to increase employee awareness of the dangers through thorough orientation and ongoing safety training. Employers have the primary responsibility for protecting the safety and health of their workers.

Precautions in Using Electrical Equipment

When using a mixer, blender, or other power equipment to make maple confections, please remember to follow these rules:

- Never put a hand or any other inappropriate object other than food into the blender, mixer, or power equipment.
- Unplug and turn off when not in use.
- No loose or floppy clothing or jewelry should be worn that has the potential to catch in any piece of equipment. Special care needs to be taken with apron strings.
- Make sure hair is tied back and out of the way.

Burns and Scalds

Whether the burn or scald is large or small, your *first priority* is to *cool the burned area quickly* by any convenient method. Immersion in cool water is ideal. The faster you remove the hot sugar and pull heat out of the affected area, the better. This will limit injury and reduce pain.

Additional treatment for the three specific types of burns is as follows:

- First-degree burn: In minor burns and scalds the skin goes red. Then apply a moist dressing, and bandage loosely.
- Second-degree burn: If blisters form, the burn is more serious. Do not break the blisters – this will compound the injury by causing an open wound. Do not apply cream, ointments, or sprays. Seek medical attention.
- Third-degree burns: In the most severe burns, the skin may be burnt away. Some flesh will be charred. If many nerve endings are damaged, there may be little pain. Do not apply creams, ointments, or sprays. Call 911 for emergency service. Call for a family member or friend who may be nearby for assistance. Wrap a clean sheet around victim and, if the weather is cool, cover them with blankets to reduce the possibility of shock. The victim should be rushed to a hospital because their life is at stake.

Chapter 5 Selling Syrup

5.1 Laws and Labelling

Laws regulating Maple Syrup

If you make syrup for personal use and do not sell it, there is no regulation.

If you sell maple syrup, there are two laws you need to follow. These are regulated by the New York State Department of Agriculture and Markets: the Label Law and the Grading Law.

The labeling law simply says you need to label the product "Maple Syrup", list your name and address on the container, and list the grade of the syrup:

Ag & Markets General Labeling Law for Containerized Ag Products

Commodity Identity: Maple Syrup

Declaration of Responsibility: Producer or Distributor Name and Address

Declaration of Quantity: Net contents in weight, measure or count printed on the bottom 30% of the label

Declaration of Grade: for example, Grade A*

The Grading Law Ag & Markets 947 is based on USDA standards for grades

Manufacture, Distribution, and Sale of Maple Syrup and Sugar – Circular 947

"Every consumer package shall be plainly marked as to the grade

- 1. Grade A, table grade
- 2. Processing grade

Density must be at least 66% solids by weight at 68º F"

*The labels Golden Color & Delicate Taste, Amber Color & Rich Taste, Dark Color & Robust Taste, and Very Dark Color & Strong Taste are classifications of Grade A. They are not required, but most consumers find them somewhat helpful when making a purchase. If you place a classification on your syrup it must be correct

The following page contains the law in full regarding maple syrup identities and label statements.

Part 270. Maple Syrup

Section 270.1 Maple Syrup: identities; label statements

(a) Definitions: For the purpose of this section, the following terms shall have the following meanings, unless the context clearly indicates otherwise:

1. Light transmittance means the fraction of incident light at a specified wavelength that passes through a representative sample of a particular sub-grade of Grade A maple syrup.

2. Soluble solids, expressed as a percentage, means the proportion of maple sap solids in the applicable solvent.

3. Tc means the percentage of light transmission through maple syrup, measurable by a spectrophotometer, using matched square optical cells having a 10-millimeter light path at a wavelength of 560 nanometers, the color values being expressed in percent of light transmission as compared to A.R. Glycerol fixed at 100% transmission.

(b) Standards of identity.

1. Maple syrup is the liquid made by the evaporation of pure sap or sweet water obtained by tapping a maple tree. Maple syrup contains minimum soluble solids of 66.0% and maximum soluble solids of 68.9%. Maple syrup includes, and is either, Grade A Maple Syrup or Processing Grade Maple Syrup, as defined in paragraphs (2) and (3) of this subdivision.

2. Grade A maple syrup means maple syrup that is not fermented, is not turbid, and contains or has no objectionable odors, off-flavors or sediment. Grade A maple syrup must fall within one of the color and taste sub-grades of Grade A maple syrup set forth in subparagraphs (a), (b), (c), or (d) of this paragraph.

a. Grade A golden color and delicate taste maple syrup has a uniform light golden color, a delicate to mild taste, and a light transmittance of 75% Tc or more.

b. Grade A amber color and rich taste maple syrup has a uniform amber color, a rich or full-bodied taste, and a light transmittance of 50% - 74.9% Tc.

c. Grade A dark color and robust taste maple syrup has a uniform dark color, a robust or strong taste, and a light transmittance of 25% - 49.9% Tc.

d. Grade A very dark and strong taste maple syrup has a uniform very dark color, a very strong taste, and a light transmittance of less than 25% Tc.

3. Processing Grade Maple Syrup means maple syrup that does not meet the requirements for Grade A maple syrup set forth in paragraph (2) of this subdivision. Processing Grade Maple Syrup may not be sold, offered for sale or distributed in retail food stores or directly to consumers for household use.

(c) Nomenclature label statement.

1. The name of the food defined in paragraph 2 of subdivision (b) of this section is “Grade A Maple Syrup”. The name “Grade A Maple Syrup” must conspicuously appear on the principal display panel of the food’s label, and the words “golden color and delicate taste”, “amber color and rich taste”, “dark color and robust taste”, or “very dark color and strong taste”, as appropriate, must also conspicuously appear on the food’s principal display panel in close proximity to the food’s name and in a size reasonably related to the size of the name of the food.

2. The name of the food defined in paragraph (3) of subdivision (b) of this section is “Processing Grade Maple Syrup”. The name “Processing Grade Maple Syrup” must conspicuously appear on the principal display panel of the food’s label, and the words “For Food Processing Only” and “Not for Retail Sale” must also conspicuously appear on the food’s principal display panel in close proximity to the food’s name and in a size reasonably related to the size of the name of the food.

FOOD LABELING

This is a brief summary of the labeling regulations governing foods offered for sale in New York State. It is not meant to be all inclusive of all of the labeling requirements. Prior to printing, it is strongly suggested that labels be submitted to this agency for review. For specific information write to:

State of New York
Department of Agriculture and Markets
Division of Food Safety and Inspection
Attn: Economic Section
10B Airline Drive
Albany, NY 12235
FSI-514 (Revised 5/01)

Five Basic Label Requirements

> Identity of Food in Package Form
> Name of Manufacturer, Packer or Distributor
> Place of Business
> Ingredient Declaration
> Net Quantity of Contents

> IDENTITY OF FOOD IN PACKAGE FORM

a. The principal display panel of a label for a food in package form shall bear as one of its principal features a statement of the identity of the commodity by its common or usual name.
b. Where a food is marketed in various forms (grated, sliced, diced, etc.) the particular form shall be considered as part of the identity statement.
c. The statement of identity shall be present in bold type on the principal display panel and shall be in a size reasonably related to the most prominent printed matter.

> NAME OF MANUFACTURER, PACKER OR DISTRIBUTOR

a. In the case of a corporation, only the actual corporate name, and this may be preceded or followed by the name of the particular division involved.
b. In the case of an individual, partnership or association, the name under which the business is conducted shall be used.
c. When the food is not manufactured by the person whose name appears on the label, a qualifying phrase such as "Manufactured for ______", "Distributed by _____", or other expression of facts, shall appear with the name.

> Place of Business

The place of business shall include the street address, city. State and ZIP code. However, the street address may be omitted if it is shown in a current city or telephone directory.

> Ingredient Declaration

a. The ingredients shall be listed by their common or usual name in descending order of predominance by weight, on a single panel of the label.
b. The name of the ingredient shall be a specific name and not a collective name.
1. If the ingredient is a designated spice, flavoring or natural color, it need only be stated as spices, artificial color or artificial flavor. Colorings subject to certification (FD&C) must be listed by their specific name, i.e. FD&C Yellow #5.
2. If an ingredient used in the product conforms to a standard of identity or is a multi-ingredient product, its ingredients are required to be listed on the label.
3. When blends of fats and/or oils are used, the common or usual name of each fat or oil used must be listed in parenthesis following the term vegetable shortening, animal fat or marine oil.
4. If an individual fat and/or oil ingredient is used, not a blend, the common name of that product must be listed in the correct order of predominance.
c. No abbreviations of an ingredient's common or usual name are permitted, unless explicitly provided for in the statutes.
d. Water used in fabricated foods shall be declared on the label in its order of predominance.

> Net Quantity of Contents

a. The principal display panel of a label for a food in packaged form shall bear a declaration of net quantity of contents.
1. The declaration shall be expressed in terms of avoirdupois pound and ounce, volume, and/or numerical count.
2. The declaration shall appear as a distinct item within the lower 30 percent of the principal display panel. The declaration shall be printed in boldface print or type in letters and numbers in a size in relationship to the total square inches of the principal display panel.
Area of PDP Minimum Type Size
5 sq. inches or less 1/16 inch (1.6 mm/6 point)
> 5 sq. inches, but < 25 sq. inches 1/8 inch (3.2mm/l4 point)
> 25 sq. inches, but < 100 sq. inches 3/16 inch (4.8mm/20 point)
3. The declaration of net quantity of contents shall be expressed in the following terms:
a. Weight (one pound, but less than four pounds) expressed in ounces and followed by the largest whole unit in parenthesis, i.e. NET WT. 24 OZ (1 LB 8 OZ).
b. Fluid measure (one pint, but less than one gallon) expressed in fluid ounces and followed by the largest whole unit in parenthesis, i.e. 20 FLOZ (1PT40Z).

4. A separate statement of the net quantity of contents in terms of the metric system is required to appear on the principal display panel as part of the required declaration, i.e. NET WT 9 OZ (255g) or 9 FL OZ (266 ml).

> GENERAL LABEL INFORMATION

a. Principal Display Panel:

The term "principal display panel" as it applies to food in packaged form means the part of the label that is mostly to be displayed, presented, shown or examined under customary conditions of display for retail sales. The principal display panel shall be large enough to accommodate all the mandatory label information required to be placed thereon with clarity and conspicuousness and without obscuring design, vignettes, or crowding.

b. Information Panel:

The term "information panel" as it applies to packaged food means that part of the label immediately contiguous and to the right of the principal display panel as observed by an individual facing the principal display panel.

c. Labeling Information Requirements:

All information appearing on the principal display panel or information panel shall appear prominently and conspicuously, but in no case may the letters/numbers be less than one-sixteenth of an inch in height, except for those requirements previously addressed.

d. Language:

1. All required label information shall appear in the English language.
2. If the labeling bears any statutory information in a foreign language, all the required labeling information shall appear in both the foreign and English language.

e. Imitation Foods:

If any food product is an imitation of another, and is nutritionally inferior to that product, it must be labeled "Imitation ___", with the space being filled in with the name of the food imitated, and with the word "imitation" in type of uniform size and prominence as used for the name of the food.

f. Packaging:

A package or commodity in packaged form means any commodity put up or packaged in any manner in advance for retail sale. This should include cellophane wrapped products kept in a closed display case, even if these products need to be weighed and priced at the time of sale.

g. Nutrition Information:

Information as to the requirements for inclusion of nutrition information on a label should be addressed to this agency.

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5.2 Wholesale and Retail Considerations

The following information is a brief overview on the aspects to consider when choosing to sell wholesale or retail. For more detailed information on how to follow through with your marketing plan, consult the *Selling Maple Wholesale Notebook*.

Introduction to Marketing Channels

Marketing channels are divided into two broad groups, direct and wholesale. These terms are often used inconsistently, however, here we provide the definitions for use in this guide.

Wholesale Marketing: Selling a product to a buyer who is not the ultimate end user.

Direct Marketing: Selling a product directly to the end user.

The size and scale of a maple operation, number of years of operator experience, the demographics of the surrounding region, and the preferences of the maple producer will determine which channels are best suited to the maple operation. A beginning producer may choose to start out using direct channels, such as a farmers' market; however, depending on a farm's business model, packing fewer product choices on a large scale for high volume buyers may be preferred. Understanding each channel, its benefits, requirements, and limitations is an important starting point for channel selection. It is also important to know the volume of production required, and average prices paid in order to assess the potential returns of a channel.

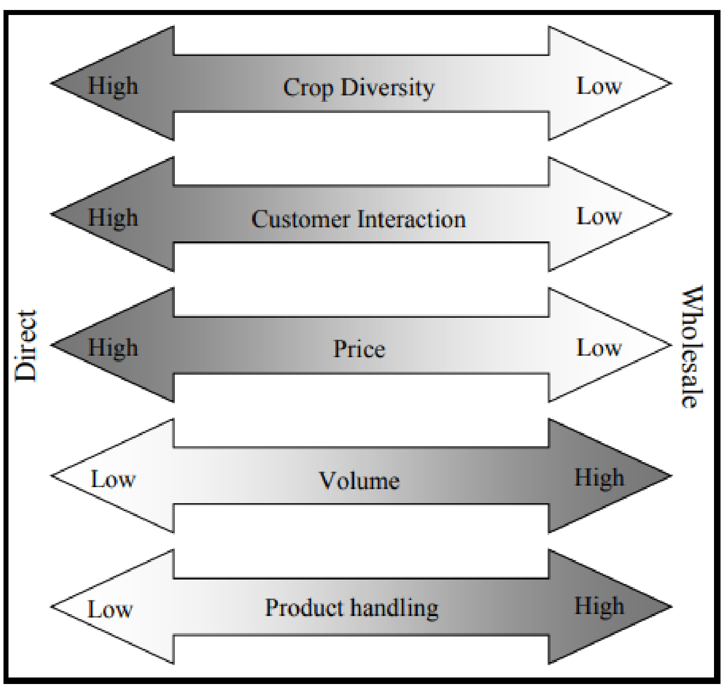

Figure 1: Generalizations about Wholesale and Direct Marketing Channels.

In marketing channel selection, producers are faced with a dilemma: they can move large volumes of product through wholesalers at relatively lower prices, or seek higher prices in direct market channels and run the risk of unsold product. Figure 1 is an illustration of the typical characteristics of these two channels.

Marketing Channel Characteristics: How to evaluate marketing channels

Choosing the right mix of marketing channels includes consideration of many factors, including sales volume, risk, lifestyle preference, stress aversion, labor requirements, and channel-specific costs. Below is a description of each of the factors that contribute to a channel's "performance." The importance assigned to each of these factors is unique to the individual farm. Additionally, the nature of short shelf-life products, along with the risks and potential sales volumes of particular channels, requires combining different channels to maximize gross sales in order to sell everything in a timely and profitable fashion. Appendix 1 of the *Selling Maple Wholesale Notebook* summarizes the major characteristics to consider when evaluating alternative marketing.

Sales Volume and Price

With maple syrup and most value-added products, there is a minimum that can be made or packaged with reasonable efficiency. The volume that can be sold through a given channel has an impact on profitability as combined with that volume in your operation. The shorter the shelf life of a product, the more important it is to have a channel that can absorb the volume produced as quickly as possible. As such, a channel's risk and potential volume are closely associated. With syrup, farmers are challenged to balance the lean years and the plenty when selling through different channels. As one farmer described, the constant challenge is finding outlets for the varying and sometimes unexpected harvest volumes, "Even though our retail markets are relatively stable year to year for volume, we will definitely produce all of the syrup we can in a given season, then find a way to sell it."

Optimizing sales requires the flexibility of combining different channels capable of absorbing unpredictable volumes. In general, wholesale distributors and retailers can be counted on to buy large quantities at once. Usually, there has been a readily available bulk market, but this does not translate into more income. The volume that can be sold through other direct channels, such as from the home, farm stands, and farmers' markets, depends on weather, location, advertising, drive-by traffic, and population size. Volume for these channels is more dependent on weather, customer numbers, and location than wholesale channels.

	Price/Pint paid producer	Pints sold	Total Gross
Farmers' Market	$12.25	9	$110.25
Grocery Store	$8.25	45	$371.25

Table 1: Comparison of price & volume for pints of syrup in direct & wholesale channels

The general tradeoff between relatively high and low-volume marketing channels is price. Table 1 gives an example of the quantities and prices paid for pints of maple syrup in both a direct and a wholesale marketing channel. Despite lower prices, high volume channels offer the benefit of increased efficiency for selling, canning, and packaging labor. For example, wholesale buyers make large purchases in as little as a five-minute phone call once a relationship has been established.

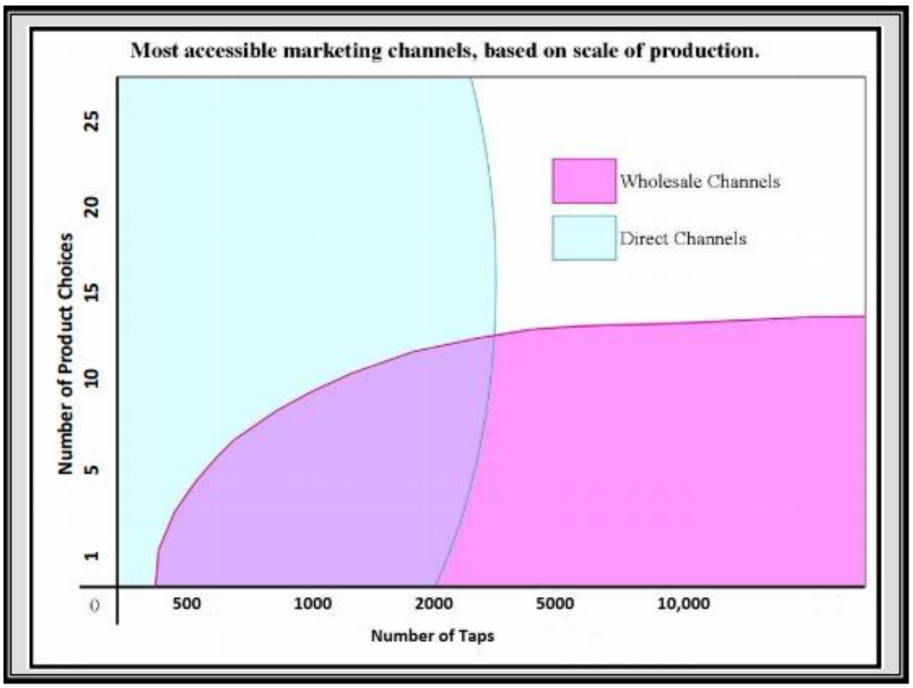

Figure 2: Direct and/or wholesale channels are the best marketing choice depending on the number of products and scale of production. (Figure is an estimation varying with each operation)

Risks and Lifestyle Preferences

In addition to regular production risks such as weather and pests, each marketing channel offers a set of risks to the producer. Marketing risk comes in many forms, including market demand for a product, price, competitors, failure to offer a diverse selection, and low volume sales. Additional risks include the possibility of low customer turnout due to weather, such as at home farmers' markets or farm stands, resulting in unsold products. Risks for any channel that allows customers on the farm are injuries, property damage, litter, and other problems.

In a survey conducted with Central New York vegetable farms (results shown in Table 2), farmers were asked what they felt were the primary risks with each channel. The responses are categorized into seven basic challenges: low volume sales, high labor and marketing costs, ability to provide product of consistent quantity and quality, buyer back-out, competition, unpredictable customer turnout, and low price risk.

Table 2: Frequency of Mentions for Risks and Challenges associated with Marketing Channels, from survey of fourteen Central New York fruit and vegetable producers.

Risk or Challenge	CSA	U-pick	Farm Stand	Farmers' Market	Restau-rant	Distrib-utor	Grocery/ Retail
Low sales volume, unsold produce	1			3	1		
High labor and other marketing costs			3	7	2	5	2
Ability to provide quality & quantity consistently	2	1		2	2	1	2
Market competition				1			1
Unpredictable customer turnout		2	2	2			
Low prices & profits						4	1
Buyer back-out, failure to fulfill commitments					1	1	1
Other	1	1	1			1	1

The two main reasons given for avoiding a particular marketing channel were lifestyle preferences and stress aversion. Wholesale channels tend to create stress because they require higher levels of preparation (e.g. grading, packing, and delivery), product specifications, and volume commitments. Distributors were also perceived to be very demanding, where producers must accept dictated prices, deadlines, and delivery logistics. Alternatively, direct marketing channels were perceived as ones that imposed relatively low levels of stress on producers. This was particularly mentioned with the CSA (Consumer Supported Agriculture) channel where customers share the risks and may have lower expectations in terms of washing, sorting, and packaging. Currently, very few maple producers use a CSA approach to marketing.

As expected, questions about direct marketing channels, except for CSA, provoked concerns over customer turnout. Factors such as weather, location, and the availability of parking are all risks when direct marketing.

The most frequently cited concern regarding all marketing channels was high labor and marketing costs. Among the direct channels, “high marketing costs” was most frequently mentioned for farmers’ markets because they tend to be labor intensive and carry additional marketing costs, such as market fees, advertising, and travel. Sales to distributors were cited as having the highest marketing costs. Respondents mentioned a high level of labor needed to solve the logistical headaches of delivery and the high level of quality control work.

Labor Requirements

In general, wholesale channels require more labor devoted to canning, packaging, and packing due to the high volume of product marketed. In comparison, direct channels tend to require higher levels of sales time and customer interaction.

While many farmers enjoy customer interaction and feedback, some prefer not to deal with customers. Farmers' market, farm stands, and home sales generally require a high degree of customer interaction and are channels that reward a tidy appearance and welcoming display. Of course, farm stands and home sales can be conducted using honor system payment, but some minimal level of customer interaction is inevitable. CSAs require customer interaction during weekly pick-up times, however, CSAs also may have newsletters or email updates for their members. CSA sales are conducted in the off-season, requiring customer interaction then as well.

Wholesale customers require less customer interaction, except when discussing orders or making deliveries. Once a relationship is established with a wholesale buyer, sales calls take less time. Wholesale accounts allow more anonymity; however, promotion in the form of cases of free sample product is common.

Other Channel-Specific Costs

While some operational costs are common among all marketing channels (utilities, equipment, insurance, licenses, certifications, vehicles, buildings, etc.), each channel has costs and requirements that are specific to that channel. Associated costs should be considered when individual operations decide on their optimal marketing channel mix. A list of associated costs by marketing channel is summarized in Table 3.

Table 3: A sample of the costs commonly associated with different marketing channels.

	Farmers' Market	CSA	U-Pick	Farm Stand	Wholesale: Restaurant, Grocery, & Distributor
Reusable plastic crates	R	X	O	R	R
Single use boxes	O	O	O	O	X
Packaging Materials	X	O	NA	R	X
Customer shopping bags	X	O	X	X	NA
Farm sign (s)	X	X	X	X	NA
Building/Tents, tables, tablecloth, chairs	X	X	X	X	X
Cash register/box, scale, calculator	X	NA	X	X	NA
Pricing signs	X	NA	X	X	NA
Market fees	X	NA	NA	NA	NA
Brochures & flyers	O	R	R	O	O
Advertising	NA	R	R	O	NA
Transport/Delivery	X	NA	NA	NA	X
Washing & sorting equipment	O	O	NA	O	R

KEY: X = Necessary R = Recommended O = Optional NA = Not applicable

Regardless of market channel, maple syrup should be stored in stainless steel barrels until packaged into the consumer sized containers. Storing in galvanized or plastic containers often results in loss of grade and off-flavors.

In a retail setting, boxes used to transport syrup and other maple products can be used over and over again, or even be wood or plastic which become part of the retail display. In contrast, with wholesale channels, the container is lost into the supply chain, so cardboard boxes are used, adding cost. In addition to boxes, an assortment of other marketing supplies are purchased, including quart and pint containers, plastic bags, twist ties, and rubber bands. These supplies are usually purchased in large quantities once or twice per year.

Some costs specific to farmers' markets are membership fees and daily market fees. In addition, a tent, along with tables, a scale, shopping bags, and signage with the farm's name and prices are common needs for most markets. Also, brochures, business cards, and other point-of-purchase materials may be used to promote sales. A benefit of membership in a farmers' market is that the advertising is done by the market. Individual farms can still advertise, but maintaining a high level of product quality and variety to attract customers to their booth is a must.

CSAs require advertising, generally through a combination of brochures, print ads, websites, and signage. Presence at a farmers' market and word of mouth are also useful ways to sell memberships. CSAs require a high level of organization and administration to sell memberships, as well as a suitable location for member share pick-up.

The home and farm stand channels have varying levels of associated costs depending on the scale of the operation and the marketing skills of the operator. Some stands involve a simple, inexpensive tent and table set-up, with one roadside sign at the location, and a cashbox for money. Larger operations may include specialized buildings, walk-in storage coolers, refrigerated display cases and tables, a cash register, bags, boxes and staff. The choice of whether or not to staff a farm stand or home sale will have a large impact on the operation's profitability.

Wholesale channels involve significantly fewer associated costs. While the number of these costs may be fewer, the level of these costs can be high. Fuel costs for delivery, refrigerated equipment, training and certifications for food safety, packaging, bar coding, boxing and equipment for making value added products are all anticipated costs for the producer selling wholesale.

5 Keys to Marketing Channel Decision Making

Value Your Time	As a farmer & business owner, you should place a value on your own time when evaluating marketing channel opportunities.
Keep Records!	Take the time to keep records, even if only for "snapshot" periods, so you can make informed decisions about your business.
Use the 6 Factors of Performance	Evaluate a channel for its: Weekly sales volume, profit, labor requirement, risk, associated costs, and lifestyle compatibility.
Rank & Compare	Rank each channel for each performance factor (give a "1" to the best), add them up, & the channel with the lowest total is the best!
Multiple Channel Strategies	Combine channels to maximize sales. Have at least one "steady" channel and one that is flexible in its volume demand.

Marketing Channel Combination

Channel combination strategies allow a farm to maximize sales and help to reduce some risks. Figure 3 illustrates some marketing channel strategies used by real farms. These strategies allow them to diversify their sources of income, as well as optimize sales with unpredictable harvest yields. Each farm has a "steady" marketing channel with a relatively consistent demand. This channel represents the farm's first priority for weekly production and delivery. Once that channel is satisfied, the farm's other channels can be supplied with additional product. For example, Farm #3's priority is its weekly CSA distribution. Once sufficient produce is available for CSA members, the farm can market extra product to its farmers' market and wholesale customers. In contrast, Farm #1 first satisfies wholesale orders, then brings surplus product to the direct channels of farm stand and farmers' market.

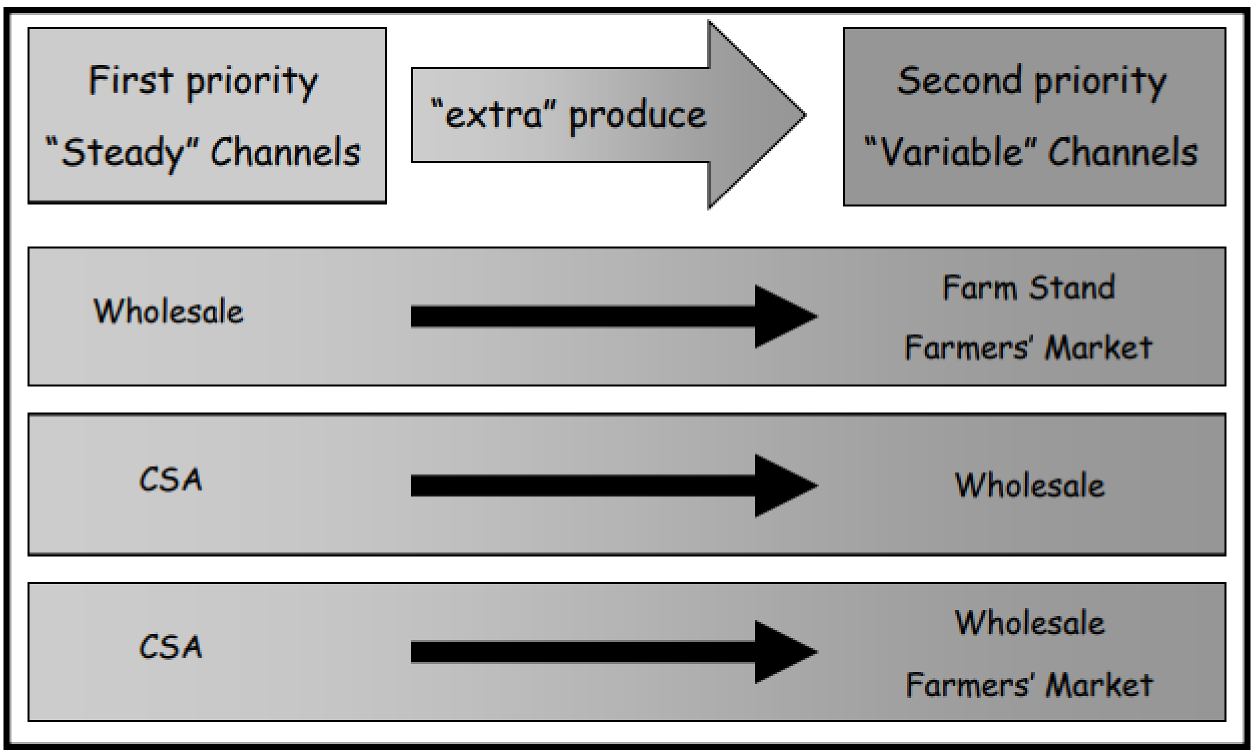

Figure 3: Examples of marketing channel combination strategies.

5.3 Confections

A. Maple Cream
B. Granulated Maple Syrup
C. Molded Maple Sugar

The following are the three most traditional maple confections on the market: Maple cream, Maple Candy (Molded Maple Sugar), and Granulated Maple Sugar. For more about quality control, the chemistry of maple, and all the ins and outs of confection making, as well as many more recipes and ideas for value-added maple products, consult the *Maple Confections Notebook*.

A. Maple Cream

Maple cream is a value-added product that is made from pure maple syrup. The name maple cream is almost a misnomer, implying that the ingredients include dairy products. This is not so. Maple cream is made by additional concentration via evaporation, quick cooling, stirring, and then packaging at room temperature. Maple spread is an alternative name that does not confuse customers about the inclusion of dairy products, but maple cream is the traditional name and will be used here.

The finished maple cream should be light in color with a smooth, creamy texture suited for use on toast, bagels, muffins, pancakes, doughnuts, and combined with other bakery or confection products. From a marketing point of view, it is an all-natural product comprised mainly of sugars, but it also has other important nutrients such as amino acids, proteins, organic acids, minerals (calcium and potassium being the most prevalent), and trace levels of some vitamins. It also has excellent levels of antioxidants.

Traditional Maple Cream ■ Generally, maple cream is made from light or medium colored maple syrup, however, guessing which syrups to use by color can result in poor quality maple cream or whole batch failures. For details on measuring and adjusting invert sugars in maple syrup, see the Cornell Maple Bulletin titled "Measuring and Adjusting Invert Sugar in Maple Syrup." The levels of invert sugar recommended for making traditional maple cream are between 0.5 and 3% with 1.5% being ideal. When the invert sugar level is between 3 and 4%, use the higher boiling temperatures to finish. See the chart on the following pages for the ideal reading on a glucose meter when using a 1 in 10 syrup dilution.

To prepare traditional maple cream, heat syrup to 22°–24°F (12°–13°C) above the boiling point of water. Boil to the higher temperature on rainy or humid days or when your invert sugar level is between 3 and 4%. Remember to establish the exact boiling temperature of water at the time the maple cream will be prepared because the boiling point of water depends on elevation and weather conditions (barometric pressure).

Watch the boiling syrup carefully as the temperature climbs. It can get too hot very quickly near the end. A good digital thermometer, especially one that shows temperatures to one tenth of a degree, can be very helpful in more precisely determining the temperature to finish. Many modern digital thermometers also have alarm functions that can help alert you when the finishing temperature is getting close. See the *Maple Confections Notebook* for more information on thermometers. As soon as the syrup reaches the desired temperature, it should be removed from the heat and rapidly cooled. The longer it takes to cool the finished syrup, the more likely large crystals will form on the surface or bottom of the pan. Using an infrared thermometer to follow the temperature drop prevents the formation of crystals on a thermometer stem.

» **Glucose Meter Reading**

(US) mg/dL	1 - 10 invert invert %
20	0.4
30	0.6
40	0.8
50	1
60	1.2
70	1.4
80	1.6
90	1.8
100	2
110	2.2
120	2.4
130	2.6
140	2.8
150	3
160	3.2
170	3.4
180	3.6
190	3.8
200	4
210	4.2
220	4.4
230	4.6
240	4.8
250	5

In the table to the left, the light gray indicates the range of invert levels in syrup useable for traditional maple cream. The darker gray indicates the most ideal range.

If you are using a paddle and turntable machine for stirring and you are only making a single batch, cool the syrup in the pan that will be used for stirring. If you plan to stir the cream by hand, the syrup can be chilled and stirred in the boiling pan. Rapid cooling reduces premature crystallization. Cooling the cooked syrup in large shallow pans will a quick cooling. Place the pans in a refrigerator or in troughs with circulating cold water and elevate the pans off the bottom so cool water surrounds all sides. Small batches can be efficiently cooled in a sink of cold water. Ice can be added to the water to speed the process. Heat is removed faster by cool water than by cool air. Be sure that the cooling syrup solution is kept absolutely still. Do not move or stir it, because crystals will begin to form and result in a grainy maple spread. The cooler the syrup becomes before stirring, the smaller the sugar crystals will be that form, and the longer the crystals will stay small while the maple cream is stored. Cooling to between 45 and 55ºF will tend to make the finest cream that will maintain quality the longest.

The problem with these cooler temperatures is that the syrup can be difficult to remove from the pan used for chilling into the equipment used for stirring. This can be overcome by dipping the bottom of the pan into hot water for a few seconds. This breaks the chilled syrup from the pan, allowing it to slide out into the stirring pan. Cold syrup can be so thick that stirring by hand is very difficult. This thicker, cooler syrup has also been known to stall the various machines used to stir it. For good results, the syrup should be cooled to at least 75°F (24° C) or below before stirring with any method. Stirring the chilled syrup at warmer temperatures tends to make a cream that will separate sooner and have a grainy texture.

In the case where the cream will be consumed immediately, this temperature is not as critical. If crystals begin to form on the surface of the cooling solution, mist the surface lightly with clean water. This creates a very thin layer of low-density syrup on the surface and tends to dissolve the surface crystals while dispersing any bubbles or foam.

When you begin stirring the chilled syrup, expect to see the syrup warm up and become more fluid. This warming always happens when crystallization occurs. It is called the heat of crystallization and is not due to the room being too warm or the stirring being too vigorous. Crystallization, similar to ice formation, involves sugar molecules moving from a higher energy state to a lower energy structure releasing energy as heat in the process.

Stirring Methods

Turn Table Cream Machine ■ If using a paddle and turntable type stirring machine, adjust the paddles so that one gently scrapes the side of the revolving pan while the other is positioned about a third of the way from the edge of the pan. When the cream reaches the proper consistency, it can be scooped out as the pan turns by using a thumb operated 2-oz. portion control scoop. If you are using a mechanical cream machine and the syrup solution starts to get too stiff, it is possible to soften it by applying a gentle heat source to the outside of the revolving pan. An electric heat gun works well for this purpose. Never heat maple cream above 120°F, and recognize that this type of reheating can cause the finished product to be grainy and to separate more quickly.

Hand Stirring ■ Stirring by hand must be done slowly – do not beat or whip the syrup. The objective is to slowly stir the solution until crystals start to form. This will require some time and strength, especially if the syrup is cooled below room temperature. This is usually a two-person operation – one person to hold the bowl and one to stir. While being stirred, the cooled syrup first tends to become more fluid (less stiff). Later it will gradually become thicker, lighter in color, and most importantly, will lose its glossy appearance becoming opaque. Eventually, it will become a smooth paste-like consistency. When this occurs, the crystallization process is complete, and the spread can be transferred to appropriate containers. If stirring is stopped too soon, the final product may become somewhat grainy due to the formation of larger crystals. Likewise, if the cooking process did not reach the correct temperature, some separation (presence of liquid syrup on top of the crystallized cream) may occur while in storage. If the cream separates, stirring will bring it back together. Stirring the mixture too long may cause it to start to harden in the pan. If this occurs, add a small amount of hot water as a mist and stir it in to soften it a bit. If the syrup solution does harden in the pan, it can be heated with a pan of hot water, a heat gun, or a warm oven until it can be easily stirred again.

Candy Machine Method ■ An advantage of making cream with a candy machine is that you can conveniently fill the finished jars directly from the machine; hand scooping will not be necessary. This machine also will allow you to run multiple batches without stopping by simply continuing to add syrup to the trough. Further, you can produce two products with one machine.

When making maple cream with the candy machine, start the worm drive and then slowly fill the trough about half full with the chilled syrup. Allow it to stir until the syrup in the trough forms crystals and loses that glossy appearance. This may take anywhere from just a few minutes to 20 – 40 minutes depending on many factors. There will be a few minutes before the syrup warms from the heat of crystallization when it will tend to bunch up at the far end of the trough. If you have filled the trough with too much syrup, it can easily flow over the side walls near the far end. When the cream loses that glossy appearance and looks finished, begin gradually adding more syrup to the trough from the pan or pig, and gradually fill jars or containers with finished cream by opening the end of the trough.

Gear Pump Cream Machine ■ This is the fastest and easiest way to make large amounts of cream. Machines from equipment manufacturers are expensive, but it is the way to go for larger producers of maple cream.

When making maple cream with the gear pump maple cream machine, start the pump before you fill the top cone with syrup. Lightly mist the cone and pump with warm water. Then, gradually add the chilled syrup to the cone until the syrup begins to circulate. Too much chilled syrup at once has been known to stall the pump or increase current draw causing circuit breakers to open.

This method of stirring causes the syrup to crystallize rapidly so that the loss of the glossy appearance takes just a few minutes. Canning can begin soon after starting the process, so have your containers ready before you begin. Continually scrape the interior of the cone while you are filling containers so that it will completely empty. The gear pump cream machine allows for continuous operation with multiple batches. When switching to an additional batch, be sure that all the syrup gets into circulation as it is possible for some to stick in the cone and get pumped directly into a jar without proper stirring. Also do not try to rinse the cone between batches as water will be trapped and upset the density of the next batch.

With this machine, containers can be quickly and easily filled without any scooping or extra handling. Be sure that all of the syrup has moved through the pump and crystallized before you begin filling jars. It is easy for pockets of syrup to remain in the cone that have not yet been stirred. The ability to control the speed of the gear pump can give better control to the stirring and filling processes, as well as significantly reduce the introduction of air into the cream in the final containers filled. Controlling gear pump speed can be accomplished by using three phase electric, single phase electronic controls, or a transmission between the motor and gear pump.

Packaging

Maple cream can be packaged in food grade glass or plastic. Containers with wide mouths are best for easy filling. Care must be taken to prevent air bubbles from forming during stirring or filling, especially when the maple spread is packaged in glass. Air bubbles are not only unpleasing in appearance, but also create the impression that the package is short in weight. Also, separated syrup can collect in these air pockets, further worsening appearance.

During cream production, the maple syrup is heated to high temperatures which eliminates all pathogenic microorganisms. However, the subsequent steps of rapid cooling and filling at room temperature occur in an open environment where the maple cream is re-contaminated. At the high levels of sugar concentration of cream, pathogens cannot grow, but the spoilage microorganisms, reportedly molds and yeast, can slowly grow and spoil the product. That is why the traditional cream is sold under refrigeration. If the spread is packaged in glass or other moisture-proof containers, it can be stored in the refrigerator for a month or two with little likelihood of the saturated syrup in the spread separating. Because traditional maple cream, like maple syrup, contains no preservatives, it is susceptible to mold forming on the surface. For long term storage (up to a year), it should be stored in a freezer where it will not mold and will show little or no separation.

All cooking utensils, thermometers and especially the stirring equipment should be thoroughly washed in hot water and completely cleaned after each use to avoid contamination of future batches with bacteria and molds that can destroy the product quality. Always make cream in a clean environment with easily sanitized surfaces.

Shelf-Stable Maple Cream ■ Over time, at room temperature, separation in traditional maple cream is likely to occur, and mold growth on the surface is a possibility. Research at the Cornell Food Venture Center found a way to make maple cream stable for a longer period of time when stored at room temperature. The Food Venture Center staff discovered that having a higher amount of invert sugar in the syrup used to make the cream could prevent separation during storage. For a complete review of the research conducted, see the section titled “Shelf Life Extension of Maple Cream” in the *Maple Confections Notebook.*

B. Granulated Maple Sugar

Granulated Maple Sugar is the most versatile product that is made from maple syrup. Because it has no available water, this product is totally shelf stable, meaning, it will not separate or mold. It can be stored indefinitely at room temperature, and with proper packaging and moisture control, will not lose its granular nature. It can be used in recipes as a replacement for brown or white sugar at a one to one conversion by volume or by weight. It can be reconstituted into maple syrup of any density, and from there, converted into any of the other maple confections. It can be shipped more easily and cheaply because of the removal of water weight, and then reconstituted into syrup at its final destination if desired. It can be an easier product for chefs or restaurants to use because of its storability and versatility. It can also be used as a topping on cereal, placed in sugar straws, or used anywhere other sugar would be used to add flavor or texture.

A quart (one liter) of syrup will yield about 2 pounds (one Kg) of granulated sugar.

Temperature and Invert Sugar Level

Granulated maple sugar is prepared by heating maple syrup until the temperature is between 45 and 50° F (25° – 28° C) above the boiling point of water. When selecting syrups to be made into granulated sugar, select or blend the syrup to be less than 2% invert sugar. Use the higher finishing temperature for syrups closer to 2% invert sugar, while the lower temperature can be used with syrups with low invert sugar content. Syrups with invert sugar levels above 2% are likely to make partially granulated batches that will not finish properly. For details on measuring and adjusting the invert sugar levels in syrup, see the section titled "Measuring and Adjusting Invert Sugar in Maple Syrup" in the *Maple Confections Notebook*. A chart of the glucose meter readings preferred when making granulated maple sugar is provided.

The gray area indicates acceptable invert sugar levels for syrup to be made into granulated maple sugar.

» Glucose Meter Readings

Reading mg/dL	1 - 10 invert invert %
20	0.4
30	0.6
40	0.8
50	1
60	1.2
70	1.4
80	1.6
90	1.8
100	2
110	2.2
120	2.4
130	2.6
140	2.8
150	3

Cooling and Safety

After cooking, the syrup can then be stirred immediately or allowed to cool to about 200°F (93°C), and stirred, either in the cooking vessel or in an appropriately sized container, until granulation is achieved. Due to the high temperature of the syrup when it is being handled and stirred, several precautions should be observed. The producer should have protective gloves, apron, long pants, closed shoes, and eye wear. For further suggestions on protecting producers and employees working with hot maple products, see Section 4.9, Safety in the Sugarhouse.

Stirring ■ Stirring can be done by hand or by using a mechanical stirring machine. There are a couple of mechanical stirring machines used by maple producers. The most common is a commercial mixer. The mixer must have a slow speed, and a beater with few cross bars will generally work best. Using a home quality mixer is not recommended as the pressure on the engine and drive is high after crystallization begins, often burning out kitchen quality machines with just a few uses. Some producers make maple sugar on the turntable and paddle machine commonly used to make maple cream. Unlike maple cream where the turntable machine stirs chilled syrup, with granulated sugar, the syrup is removed directly from cooking and poured into the turntable pan hot, stirring immediately. Over filling some turntable machines can cause them to stall when the sugar begins to crystallize and become very thick. Some producers have created a mixing impeller that they place into an electric drill and use this to stir the syrup with good success. Granulated sugar will pile up high around the edge of the pan as it is stirred. A pause in stirring will cause it to drop back down again, after which stirring can be resumed. Your mixing bowl should have sufficient depth to contain the granulated sugar. The depth of most commercial cream machine pans limits the amount of sugar that can be made at one time.

As the syrup crystallizes, the heat of crystallization given off can be significant, releasing a burst of hot steam that can catch the person stirring the mix by surprise and cause burns if protective equipment is not worn. Stirring continues until all moisture is essentially removed from the cooked syrup, and crumbly, granulated sugar remains. Stirring aggressively tends to make a finer more powdery sugar while slow even stirring tends to make a grainier sugar that is very similar to common brown sugar. Granulated maple sugar made with syrup higher in invert sugar tends to make a finer powdery sugar while syrup low in invert sugar tends to make a grainier sugar. Light low invert syrup tends to make a “drier” finished product than if darker higher invert syrup is used.

Screening ■ At this point the sugar is sifted through a coarse screen to make a uniformly sized product. 1/8” or 3mm hardware cloth is commonly used, but stainless steel is recommended for durability and ability to clean. Stainless steel sieves with handles are available at restaurant supply stores. Various sizes of commercial sifters are available. Allowing the sugar to stand exposed to air in a humidity controlled room, and sifting a second time before packaging, can reduce the chances of the sugar clumping within its packaging. Some producers save out the pebble sized clumps that do not go through the sieve and sell the as a specialty sugar to be used in hot drinks such as coffee or hot chocolate, like sugar cubes.

Packaging and Moisture Content

Granular sugar absorbs moisture and should be stored in dry, air-tight containers. Glass or see-through packaging is ideal in that the consumer can see the product being purchased. Packaging maple sugar when the moisture content is still too high is the primary reason for the sugar to harden later. Maple granulated sugar also hardens when water content is too low, usually when water evaporates from the sugar when the packaging is not properly closed or has allowed moisture to escape. Storing maple sugar in a way that allows the product to retain its natural moisture – in its original airtight container – helps maple sugar stay moist. If maple sugar hardens, let it stand overnight in a sealed jar with a damp paper towel. For a quick fix, heat the needed amount in a 250°F oven for a few minutes or in a microwave oven on low for 1-2 minutes per cup. The softened maple sugar should be used immediately. The clumps of sugar can also be broken up in a blender.

C. Molded Maple Sugar

To make molded maple sugar (maple candy), heat the syrup to 32° to 34° F (18° to 19° C) above the boiling point of water. Then cool the pan of cooked syrup to the temperature required for the hardness of candy that you want before stirring. The following chart roughly outlines the candy hardness obtained when you begin stirring the syrup at different temperatures.

Candy Hardness

- >200ºF at agitation = a harder candy more suitable for crystal coating
- 190ºF to 175ºF at agitation = a medium hard candy
- <170ºF at agitation = a softer candy but may be too soft to coat

Harder Candy ■ Where the candy will be crystal coated or handled in bulk packages you may find a harder piece of molded sugar candy works better. The harder molded sugar is made by beginning to stir the cooling syrup at around 200°F. Crystal coating then softens and protects the candy making I more desirable to the consumer. Filling the molds with the hotter syrup usually is easier as the syrup should flow readily.

Medium Hard Candy ■ A medium hardness molded sugar candy can be made by beginning the stirring when the syrup temperature has cooled to between 190°F to 175°F. This medium hardness makes the molded sugar durable for handling yet suitable for crystal coating and a nice level of hardness for the consumer.

Soft Candy ■ Allowing the syrup to cool to less than 170° F before stirring makes a fairly soft molded sugar candy. This softer candy is by far the favorite texture for with consumers. The softer candy is recommended when doing demonstrations where the candy will be consumed soon, such as at fairs or farmers markets.

However, the softer candy can be soft enough to be squashed or broken with handling and can be more easily dissolved if you attempt to crystal coat. It may need to have the crystal coating syrup cooler to coat it successfully. For more on crystal coating, see the *Maple Confections Notebook*. Filling the molds to make the softer candy is also the most difficult. The syrup can be very thick and come out in globs that may need to be pressed into the molds with a table knife or putty knife. Candy stirred cooler may also lack some of the mold detail compared to pieces that were put into the mold at a hotter temperature.

Stirring and Crystal Development

Once the syrup has been properly heated then cooled to the temperature to make the desired hardness of candy, it must be stirred, either by hand with a large spoon or with a commercial maple sugar machine. The lower the temperature to which the syrup is cooled before stirring, the finer (smaller) will be the sugar crystals formed in the candy. However, large batches of candy are commonly cooled only to approximately 200°F (93° C) or higher, because when cooled to lower temperatures it becomes almost impossible to mold the entire batch before it becomes too stiff. Rapidly filling the molds will result in greater consistency of product.

When stirring, the syrup solution muct be watched carefully as it becomes lighter in color, somewhat thicker, and has a creamy opaque appearance. This is the result of the many tiny sugar crystals that form and increase in size response to the agitation of the syrup. Stirring will tke only a few minutes, usually less than five. With experience you will learn the exact moment to pour the syrup into the molds. If the micture is stirred too long, the thickened syrup will "set up" (harden) in the pan. It's best to err on the early side. It can be very helpful to have a bottle of warm water with a mist pump to lightly mist sugar that becomes too hard in the trough of the candy machine or mixing pot. This will re-liquefy the hard sugar and allow it to fill the molds. Be careful not to use too much misting as this may risk the quality of the molded sugar.

Molding ■ While the sugar is still soft and plastic, pour or pack it into rubber or metal molds. Molds with avariety of shapes are available from all equipment dealers and cooking suppliers. If packing the molds by hand is necessary, use a wide-blade putty knife or spatula. When using a maple candy machine, the semi-liquid sugar can be run directly into the molds without packing or leveling. Use a rigid support under rubber molds to prevent them from flexing during handling. Place molds on a rack to cool. It sets up in 10 to 30 minutes. Then the individual pieces can be removed from the mold. Sugars formed by pouring rather than packing have an attractive glazed surface. Fresh maple candies can be stored in cool dry conditions for a few weeks.

Making Molded Sugar Candy with a Candy Machine

A candy machine is a good investment if large batches of candy are made on a regular basis. Most commercial candy machines can make up to 18 pounds (8.2 kg) of candy at one time. The metal pan the holds the boiled syrup on a candy maker is called a "pig" because of its shape and the pouring snout at the front Immediately after the boiling syrup has reached the proper temperature the syrup is poured into the pig. The syrup can also be boiled directly in the pig. Place the pig on the candy machine shelf and tip it up into the locked position, first making certain the nose valve is completely shut. It is not necessary to let the syrup cool much when using a candy machine; experiment to see what works best. Make sure the trough valve is closed before adding any syrup to the trough. Open the pig nose valve slightly and allow a half-inch or less of syrup to flow into the trough. Close the valve, turn on the motor and the stirring coil will slowly rotate. Watch carefully at the front of the trough by the valve. After a few minutes the syrup will become lighter in color, somewhat thicker and have a creamy, paste-like opaque appearance. At this critical stage the syrup has lost some of its gloss because many tiny sugar crystals have formed to cause this change in appearance. Stirring will only take a few minutes, usually less than three.

Open the trough valve and allow the opaque, partially crystallized syrup to flow out into your mold. Don't wait too long to complete this step because the sugar may harden in the nose of the trough. It's better to open the trough valve a bit too soon and have only semi-crystallized sugar flow out for the first few molds. They will harden in time. At the same time, slightly open the nose valve of the pig to allow more syrup to flow into the trough. The goal here is to have a small continuous flow of fresh hot syrup from the pig into the trough, while at the same time the stirring coil is crystallizing the syrup, but is still allowing liquid crystallized syrup to flow out from the trough into the molds. An extra set of hands is helpful at this stage when this equipment is being used for the first time. Try to balance the flow of liquid into the trough with the flow out into the molds keeping the syrup being stirred only a quarter inch to one half inch deep. This will reduce the chances of having the sugar harden into a solid mass in the trough.

If the syrup crystallizes n the trough valve and stops the flow, a small knife can be used to reach into the valve and clear out the clog. Be careful of the turning coil. Misting the trough with a fine spray of warm water can also cure a temporary clogging from sugar that has hardened there. Usually very little is needed. After a little experience it will be possible to make perfect candy in a continuous operation.

Removing and Drying Candies ■ Candies may be removed from the molds after 30 minutes to one hour. Do this over a coarse wire rack that allows sugar that has run beyond the mold to be removed and collected for other uses. The candies should be placed on wire racks that allow for good air circulation. Candies need to completely cool and air dry for 24 hours before packaging or crystal coating.

5.4 New Products and Potential

New Opportunities for Maple Products

As the maple industry continues to grow, many producers are diversifying their businesses with the development of new value-added maple products. Maple is a versatile food additive with many potential uses as a sweetener, flavor additive, fermentation substrate, and health supplement.

The average American consumes about 150 pounds of sugar per year. However, less than 2 ounces of that typically comes in the form of maple sugar. This points to vast untapped potential for the use of maple sugar in many food products. One sector of particular interest is the soft drink industry. Sodas sweetened with maple can have excellent flavor and also appeal to consumers as a healthier alternative to soft drinks sweetened with cane sugar or corn syrup. A maple ginger soda was recently introduced by a maple producer in upstate NY and has been a very successful product at the marketplace. Recipes for orange maple soda, and orange maple cream soda have been developed and are currently being market tested.

Another opportunity for maple is the sports supplement business sector. Maple is an excellent fit for the target consumers of these products who are typically interested in sustainably sourced ingredients. The anti-inflammatory properties as well as nutrient profile of maple also appeal to these customers. Several maple sports gels have already successfully tapped into this market. These gels typically consist of 30mL single serve foil packs of maple syrup enhanced with electrolytes. They typically sell for $2 to $3 each. Sports drinks similar to Gatorade, but with maple as the carbohydrate source, are also in development.

Maple also has potential for use in both alcoholic and non-alcoholic fermented beverages. Maple sugar works well as a fermentation substrate, meaning it can be inoculated with yeasts that convert the sugar into alcohol. Research from the Cornell Maple Program and the Cornell Department of Food Science has shown that maple syrup can be used to produce a well-balanced wine with excellent structure and great maple flavor. This wine can be inoculated with acetic acid bacteria and converted into a gourmet vinegar.

Kombucha is a fermented tea product with a rapidly expanding market. It is made by fermenting a sweetened tea with a combination of yeast and bacteria. Recent research has shown that a high-quality kombucha with excellent flavor can be produced by substituting maple syrup for cane sugar in the kombucha recipe. With sales projected in the billions of dollars annually, this is yet another opportunity for the expanded use of maple.

This is just a small selection of the market opportunities for adding value and profit to the maple industry. The possibilities are nearly limitless and extend into baked goods, cosmetics and perhaps even the pharmaceutical industry. Continued product diversification and the expansion into new markets will help keep the maple industry profitable for years to come.

Chapter 6 Financing Your Operation

6.1 Keeping Financial Records

There is a great publication available for download as PDF on the Cornell Maple Program website. It is called *Beginning or Expanding Maple Syrup Operations as a Profitable Business*. And is listed under “Maple Business Planning FarmNet”. There are quite a few other documents about marketing on the website, but here are some excerpts from the above mentioned publication which includes a sample income statement and balance sheet for a Maple Farm. It is important to keep track of your financial records, with records going back at least 7 years.

Purpose of this guide:

There are a variety of resources for business owners to use in developing a business plan. Consultants can be hired, books purchased, the internet utilized, yet at the end of the day, many of the maple producers we meet in our travels are not sure about compiling records to look at profitability or how to begin to assemble a business plan. The primary use for this guide is to assist maple operations in developing a basic plan used to secure funding for start-up, expansion, and operating loans as well as a basic framework to begin considering the income and expenses incurred as the operation develops. The business plan does not need to be a complicated document. One designed for lenders should be relatively short (six or seven pages) and give the user an understanding of your business, the direction you are going and the short and intermediate goals you expect to achieve. When using the plan for borrowing purposes, the document is a chance to give the lending institution confidence in the management of the business requesting financial assistance. The financial records can range from basic to complex. The more data collected, the more refined the answers will be, but only if the data that is put into the records is accurate and consistent.

Where to begin?

This publication expects the business operator to have a solid idea on which to develop the financial and strategic plans that will increase the likelihood of success. The options range from preparing to purchase a maple processing system or even a sugar bush to having a small operation as a hobby and considering a ramping it up profit. The point to start developing a written plan consistently falls in the realm of mission and goals in the literature. The reality is that quite often the kernel of interest spurs into "on the back of a napkin" financials and rough projections of market demand. As a clear business plan is developed, focus on the end product - where you want the company to be in 10 years, then work backward to assemble the information that explains how you achieve that level of success.

Business Planning and the Strategic Planning Process

There are several interconnected pieces of planning that businesses complete. Firms may do this in a very systematic way, or develop a plan by default. The **business plan** is interconnected to a **strategic plan**, a **marketing plan**, and a **succession plan** to name a few. All are related and integral to a business that is performing well and showing growth. However, they do not have to be daunting, or long. A **strategic plan** has been historically called a "long range" plan and can be a one page summary, or road map of the direction the business is heading. Another analogy is that the strategic plan is the umbrella that covers all of the other plan components. A well-known team builder and speaker, Steven Covey specifies: "We may be very busy, we may be very efficient, but we will be truly effective only when we begin with the end in mind." (Covey, 2004) Clearly identify the business goals for five years from now. Write them down and let them stew for a bit. Bring your team members into the discussion -- middle management, fellow owners, and trusted employees. A **mission statement** is a concise sentence or two that sums up the characteristics and goals of a company. Clear, short and to the point is the preferred format, without limiting the potential for growth in areas important to the business. Your mission statement can also guide developing specific goals and strategies to move your operation forward in a controlled, coordinated effort. Growth is always positive, but it can work against you if not monitored and fit into the overall plan you have for the business.

FINAL NOTES

A business plan is a perpetual work in motion. Provide yourself as much information as needed to help the business progress forward with you at the helm. The lender for a loan wants the stripped down, less than 10 page version. It may be advantageous to you to incorporate your Business Plan into your Strategic Plan, Marketing Plan, Succession Plan, and Production Plan. Each one is a piece of the overall management of a business. Not all pieces are needed every day, but every piece in needed on at least one day in the life of the business. More information on individual topics and resources to help develop all components of a comprehensive business plan are available through NY FarmNet.

The following page contains a sample income statement and 4 year cash projection. It is a good idea to project your finances for a few years to be sure you will be able to pay your labor at the going rate, make the payments to cover equipment costs, etc. The subsequent page contains an example balance sheet of assets and liabilities. This may seem intimidating at first, but it all comes back to simply keeping good financial records.

SAMPLE "Amber Gold Farm" Income Statement & 4 year Cash Flow Projection

.		per tap	Year 2011	2012	2013	2014
Number of taps			400	400	600	800
Gallons produced			100	120	156	200
Gallons per tap			0.25	0.30	0.26	0.25
REVENUE						
	Retail syrup sale	8.01	3,204.00	3,376.26	4,806.00	6,408.00
	Wholesale syrup sales	2.57	1,028.00	1,401.84	1,542.00`	2,056.00
	Bulk syrup sales	1.19	476.00	1,107.54	714.00	952.00
	Bulk sap sales	0.00	0.00	0.00	0.00	0.00
	Retail confections sales	1.24	496.00	553.33	744.00	992.00
	Wholesale confections sales	0.82	328.00	410.28	492.00	656.00
	Other maple sales (equipment)	3.36	1,344.00	186.32	2,016.00	2,688.00
	Other products sales	1.00	400.00	678.21	600.00	800.00
	Other income	0.18	72.00	68.52	108.00	144.00
	Internet sales	0.21	84.00	92.69	126.00	168.00
	Mail order sales	0.19	76.00	0.00	114.00	152.00
TOTAL GROSS SALES		**18.78**	**7,508.00**	**7,874.99**	**11,262.00**	**15,016.00**
EXPENSES (maple related only)						
	Fuel – gasoline & oil	0.34	136.00	193.83	204.00	272.00
	Fuel – evaporate and finish	0.95	380.00	933.89	570.00	760.00
	Utilities – electric	0.37	148.00	138.34	222.00	296.00
	Utilities – gas & other	0.10	40.00	28.90	60.00	80.00
	Maintenance	0.62	248.00	384.94	372.00	496.00
	Repairs	0.55	220.00	161.68	330.00	440.00
	Supplies	1.23	492.00	361.78	738.00	984.00
	Purchased sap	0.08	32.00	128.70	48.00	64.00
	Purchased syrup or confections	2.53	1,012.00	675.67	1,518.00	2,024.00
	Other products purchased for resale	2.86	1,144.00	138.94	1,716.00	2,288.00
	Insurance	0.49	196.00	203.39	294.00	392.00
	Interest	0.15	60.00	46.94	90.00	120.00
	Taxes	0.91	364.00	292.85	546.00	728.00
	Rent & leases	0.00	0.00	0.00	0.00	0.00
	Bank charges	0.00	0.00	28.70	0.00	0.00
	Tap or woods rental	0.24	96.00	97.76	144.00	192.00
	Advertising	0.76	304.00	189.29	456.00	608.00
	Special containers	0.70	280.00	578.61	420.00	560.00
	Booth rental	0.10	40.00	31.89	60.00	80.00
	Other marketing	0.11	44.00	0.00	66.00	88.00
	Internet	0.07	28.00	3.69	42.00	56.00
	Wages	0.54	216.00	559.43	324.00	432.00
	Payroll taxes	0.01	4.00	7.03	6.00	8.00
	Contract labor	1.02	408.00	186.69	612.00	816.00
	Charitable contributions	0.09	36.00	69.14	54.00	72.00
	Delivery expenses	0.23	92.00	133.03	138.00	184.00
	Dues and subscriptions	0.13	52.00	17.23	78.00	104.00
	Office expenses	0.24	96.00	112.28	144.00	192.00
	Permits and licenses	0.01	4.00	81.46	6.00	8.00
	Postage	0.13	52.00	35.24	78.00	104.00
	Telephone	0.09	36.00	69.64	54.00	72.00
	Travel	0.25	100.00	6.20	150.00	200.00
	Vehicle	0.08	32.00	149.36	48.00	64.00
	Misc	0.02	8.00	265.02	12.00	16.00
	Other	0.00	0.00	0.00	0.00	0.00
TOTAL EXPENSES		16.00	6,400.00	6,311.53	9,600.00	12,800.00
NET OPERATING INCOME (Gross Sales – Total Expenses)		**2.78**	**1,108.00**	**1,563.46**	**1,662.00**	**2,216.00**

*There are 11 pounds of syrup per gallon

SAMPLE “Amber Gold Farm” Balance Sheet as of January 1, 2011

Assets		**Liabilities**	
Current Assets	**Value**	**Current Liabilities**	**Value**
Cash, checking, savings	6,587	Accounts payable	0
Accounts Receivable	327	Sales tax payable	0
Syrup Inventory	1,265	Payroll taxes	
Other maple inventory	755	Accrued wages payable	
Containers	450	Short-term note payable	3,000
Fuel oil	1,188	Short term banknote payable	0
Wood/energy source		Other	1,571
Other			
Total Current Assets	**10,885**	**Total current liabilities**	**4,571**
Intermediate Assets	**Current (depreciated) value**		
Evaporator	7,500		
Steam Hood	855		
Preheater	0		
Forced Draft Unit	0		
Reverse Osmosis unit	9,056		
Draw off accessories	0		
Barrels	1,000		
Evaporator feed tanks	100		
Blower	0		
Other sap process equip.	0		
Buckets	1,200		
Tubing system/ main line	100		
Tubing tools	350		
Tubing washer	300		
Tapping units	100		
Sap pumps	50		
Transfer pumps	0		
Vacuum pumps	2,500		
Releasers	850		
Gathering tanks	100		
Sap storage tanks	0		
Chainsaws	100		
Tractor			
Truck & trailers	4,000		
Filter press	100		
Finishing pan	0		
Canner	100		
Stove	40		
Table	50		
Confection machinery	650		
Molds	40		
Scale	50		
Packaging machinery	0		
Misc equipment	500		
Total Intermediate Assets	**29,691**		
Long Term Assets	**Current (depreciated) value**	**Long-term Liabilities**	**Value**
Sugarbush real estate	165,000	Long-term note payable	3,350
Sugarhouse	14,000	Mortgage payable	
Other depreciable real estate		Other	
Total Long term Assets	**179,000**	**Total Long term Liabilities**	**3,350**
Total Assets	**219,576**	**Total Liabilities**	**7,921**
	Total Net Worth		**211,655**

6.2 Maple Summary Chart of Accounts Worksheet

Maple Enterprise Business Summary Chart of Accounts

Number of taps ____________ Gallons of syrup produced ____________

Syrup purchased for resale or processing _____ gallons, or _______ pounds

<u>Revenue</u>	**Value**
Retail syrup sales	____________
Wholesale syrup sales	____________
Bulk syrup sales	____________
Bulk sap sales	____________
Retail confections sales	____________
Wholesale confections sales	____________
Other maple products	____________
Other income(maple related only)	____________
Maple equipment sold	____________
________________________	____________

<u>Expenses (reminder - maple related only - not other enterprise, business or personal)</u>

Fuel – gasoline & oil	____________
Fuel – evaporate & finish	____________
Utilities – electric	____________
Utilities – gas & other	____________
Fuel pre-purchased for use in 2008	____________
Maintenance	____________
Repairs	____________
Supplies	____________
Purchased sap	____________
Purchased syrup	____________
Purchased pre-made confections	____________
Other products purchased for resale	____________
Insurance	____________
Interest	____________
Taxes	____________

Rent & leases	____________
Bank charges	____________
Tap or woods rental	____________
Advertising	____________
Special containers	____________
Booth rental	____________
Other marketing	____________
Wages	____________
Payroll taxes	____________
Contract labor	____________
Charitable contributions	____________
Delivery expenses	____________
Dues and subscriptions	____________
Office expenses	____________
Permits and licenses	____________
Postage	____________
Telephone	____________
Travel	____________
Vehicle expenses	____________
Other	____________

Value of operator's unpaid labor (estimated) ____________

Value of operator's other family members unpaid labor _______________

Value of non-family members unpaid labor ______________

6.3 Maple Marketing Ideas

In general, there are three ways to increase profit: reduce costs, increase productivity and sales volumes, increase prices. Most importantly, in order to do any of things you need to keep good financial records. Section **6.1** explains how to do that. To increase your profits, you need to know the numbers involved with 1) sap and syrup production, 2) labor allocation, 3) revenues and expenses. The following is a simple idea list for marketing maple.

It is obvious that expanding your operation will make it more profitable. The larger the scale of production, the more efficient production becomes. There are a few simple, quick ways to expand your operation:

- Add taps to your operation
- Tap all of your red maples
- Consider purchasing sap to augment your own syrup production

Decrease Costs

- Don't buy all of your equipment from one company
- Don't necessarily buy everything from maple equipment suppliers
- Use wine or soda bags - less than $1/tap for new sterile collection system

Manage Your Sugarbush for Optimum Health

You will want to start thinking about managing your forest for health, longevity, and productivity.

Increase Sales

- Look for markets and opportunities where pure maple is not yet being sold
- Promote the health benefits of pure maple
  - The all-natural, local, healthiest sweetener in eastern North America. There is a great brochure on the International Maple Syrup Institute Website about the health benefits of maple compared to other sugars. Additionally, at the end of this list, there is an example of marketing using maple's unique qualities amongst sweeteners. S
- Buy in Bulk Syrup and Repackage
- Sell Value-Added Maple Products


- Be Strategic in Setting Your Prices
  - Excel file for determining profit based on pricing of various maple products available at www.chelseagreen.com/mapleguide
- Participate in Regional Open House Events
  - Maple Weekend
  - Attend fairs, festivals, local food events

Develop Relationships

- Develop relationships with the chefs in your community
- Get Connected with Families/Youth in Your Community
- Go to the local schools during sugaring season
- Paint your logo or farm name on all sap buckets visible to the public
- Put your logo/farm name on your truck

Finally, always look for opportunities to further your maple education. The opportunities are endless. There are ways to make money off your land that are compatible with your sugaring business. Agroforestry is a hot term. Think outside the box. Differentiate your business from others.

Five Reasons to Buy Pure Maple Syrup

There are a number of reasons to choose Pure Maple products in preference to other sweetener and sugar products available.

It's Natural

Maple producers collect sap from the tree and boil it to remove water to concentrate the sugars and other substances produced by maple trees. Producers who tend the maple forest rarely use pesticides and fertilizers. Sugar making from maple trees is a traditional American activity. Turning maple sap into sugar has not changed from the basic process used by Native Americans hundreds of years ago even though the equipment has. So what you consume in Pure Maple is what the tree has produced from sunlight and soil.

Great Flavor

Pure Maple syrup is a unique and complex collection of fl avors, one of which is the distinct maple fl avor. Americans have used and cherished this fl avor for more than 400 years. There are as many as 50 natural fl avor elements that only exist in the real thing. No food chemist can reproduce this. And each Pure Maple syrup is different in fl avor! This is due to the unique combination of soil, weather, tree physiology, and the craftsmanship of the maple producer. Pure Maple products provide a fl avor adventure similar to wine, coffee, tea, or chocolate. All of these products refl ect a unique combination of plant, growing location, and processing artistry. All of this is there to enjoy each time you consume a Pure Maple product.

There are Potential Health Advantages

Although Pure Maple contains mostly natural sugars, it contains other substances as well. Minerals absorbed by the tree are present, especially calcium. Sugar maples have a high calcium requirement and people do also. Phenols and antioxidants are present and can be active against cancer and free radicals. Potential health advantages of these natural compounds have been demonstrated in laboratory testing. These benefi cial substances are removed in more highly refi ned sugars. For those with diabetes, Pure Maple must be consumed with the same care used for other foods. Its effect on blood glucose is the same as other sugars, but it has advantages described here that other sweeteners don't have.

Buy Local!

The signifi cant labor involved in gathering sap in the spring means that Pure Maple has its start mostly in small, family-run businesses. This is especially true in New York. Buying local means you are supporting a New York business, a community, and maybe your neighbor. It means that you can determine the conditions of production and where ingredients come from, if you want to. Maple production in New York is subject to state and federal laws and inspections. Buying local contributes to food security and keeps your money closer to home.

Sustainable Forestry

New York is 63% forests, which is the best use for much of our landscape. Forests provide a natural fi lter for our water supply. They store carbon better than other landscape uses, thus combating global warming. They provide habitat for many plants and animals, helping to preserve biodiversity. They are a great place to enjoy the wonders of nature. Pure Maple is a renewable sustainable resource. Maple sugaring allows you to appreciate a small part of the value of the forest as part of your daily meals while helping to sustain this natural resource.

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Chapter 7 Additional Resources

Cornell Maple Program Publications

- Maple Confections Notebook
- Maple Tubing and Vacuum Notebook
- Selling Maple Wholesale Notebook
- Maple Wine Guide

Other Publications

- Maple News
- The Pipeline
- The North American Maple Syrup Producers Manual
- The Sugarmaker's Companion: An Integrated Approach to Producing Syrup from Maple, Birch, and Walnut Trees, by Michael Farrell

Websites

- Cornell Maple Program: http://cornellmaple.com
- Cornell ForestConnect: https://www.youtube.com/user/ForestConnect
- New York State Maple Producers Association: www.nysmaple.com
- IMSI: www.internationalmaplesyrupinstitute.com
- www.sugarbush.info
- www.mapletrader.com

News Sources

Other Offerings

- Cornell Maple Camp

You can find a calendar of maple schools, conferences, and training sessions at cornellmaple.com

Funding for Project or Publication was made possible by a grant/cooperative agreement from the U.S. Department of Agriculture (USDA) Agricultural Marketing Service. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the USDA.