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Sugar Bush Management

by Robert R. Morrow

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Maple sirup and sugar are important products in several northeastern states and much of southeastern Canada. New York is a leading producer with an annual crop valued at approximately $5 million.[1] Though maple sap may be obtained from roadside or ornamental trees or trees on the edges of fields, it more commonly comes from a wooded area—a sugar bush or sugar grove. Continued and improved production depends on the proper development and management of the sugar bush.

Although maple sap can be obtained from all the native maples, sugar maple *Acer saccharum,* also known as hard or rock maple, is best. It may yield 50 percent more sap, with a higher sugar content, than red or silver maples. Since the latter also bud early, the sap, when mixed with the sap of sugar maples, can degrade or ruin late-season sirup. On the other hand, black maple produces a sap similar to that of sugar maple. Where it occurs, it can be retained in the sugar bush along with sugar maple; but other maples should be removed.

1. Refer to *Production of Maple Sirup and Other Maple Products* by F.E. Winch, Jr., and R.R. Morrow, N.Y.S. College of Agriculture and Life Sciences, Information Bulletin 95, 1975.

Sugar maple

Sugar maple is now the most common tree in New York. It produces seed in abundance and is tolerant of shade. Given enough light, it grows vigorously on a wide variety of soils. Thus it is well suited to succeed in many places following harvest or windthrow of conifers and other trees. Pure stands of sugar maple are not uncommon.

Because of its high tolerance of shade, sugar maple can persist for long periods of time with little growth. Seedlings may remain in heavy shade for decades with little apparent growth (figs. 1 and 2). Crowded young trees remain as poles too small to tap. Close-spaced tapped trees have small crowns with too little leaf area to produce sweet sap. Young sugar maples, however, have remarkable recuperative powers. Trees released from overhead shade and side competition can double or quadruple their growth if the crown of leaves is still vigorous. Thus *thinning* of *young maple trees* to allow more space and growth is the *most rewarding activity* in managing the sugar bush.

Though sugar maple grows in many places, it grows best and produces more sap where there is ample moisture. Deep, moist, well-drained soils with medium or fine texture are best since they normally have plenty of nutrients as well as moisture. Glacial tills and benches are good sites. Sandy soils that hold moisture and fine, shallow soils with sufficient drainage can have moderate to good maple growth. Swamps, dry sands, and thin rocky soils should ordinarily be excluded from sugar bushes.

Figure 1. Ten- to 20-year-old sugar maples persist for years in heavy shade.

Figure 2. Overhead view of unthinned trees (same location as fig. 1).

Figure 3. Young sugar maples grow rapidly following heavy thinning and reduction of overhead shade.

Good soils are important for a good response to thinning as well as for natural growth.

Sap production is often more influenced by topography than soil. North facing slopes have maximum moisture but receive little sunlight and may be too cold. Southwest facing slopes may be too dry. Southeast facing slopes are usually best. Also low-elevation bushes are usually moister and more protected from cold winds, and can be expected to flow earlier and sometimes more. High, exposed bushes may be drier and usually flow later; and seasonal production may be lowered.

Seed production is so commonplace and prolific that new sugar bushes are easy to establish. New maple forests develop in old fields. To renew an old sugar bush, it is necessary only to exclude livestock from the area and reduce overhead shade (fig. 3). The latter can be accomplished by harvesting merchantable trees or deadening cull trees with chemicals. Although selection thinning may result in a scattering or small groups of young maples, it is usually preferable to make larger openings by removing a quarter to a half acre of overhead shade at one time. Such openings favor maple over beech (fig. 4) and provide larger groups of maple seedlings which are more easily managed. However, excessive light may encourage too many intolerant species such as cherry and birch (fig. 5). Large deer populations may delay or reduce maple reproduction as well as deform young stems. Where too many deer are present, early and sizable crown openings are needed to encourage seeding and rapid growth of saplings above deer browse level (fig. 3).

Sugar maple is a valuable tree. It often commands the highest of prices for logs to be made into furniture or flooring. Its density and weight account for good pulp yields and a high fuel value. It is a prized ornamental and shade tree and, of course, the best sugar producer. Direct *conflict exists between* growing trees for quality *timber* and growing them for *sirup.* The former is enhanced by *tall, straight stems with no branching* below the growing crown, whereas efficient sugar production is promoted by *wide crowns with leaves near the ground* (Appendix 1). Sugar bush management may involve a compromise between the two types of growth or, perhaps better, concentration on development of the younger trees near the sugar house that are best suited for crown growth, sugar production, and ease of sap collection. On the other hand, wood for pulp or fuel can be obtained without conflict from the thinning needed to promote growth in the sugar bush. Valuable ornamental or shade trees are usually not tapped since wood decay organisms, ordinarily of little consequence, can enter taphole wounds and endanger the tree.

Ideal sugar bush

The ideal sugar tree produces a large amount of sweet sap that can be gathered and evaporated efficiently. Both sap flow and sweetness are influenced by heredity and environmental factors. Chief among these is a large crown with many leaves exposed to sunlight for maximum sap and sugar production (fig. 6). Wide, deep crowns on open-grown trees are best. Sap flow is further increased by large stem diameters which develop from big crowns. It is also influenced by temperature which is related, in turn, to openness, slope direction, elevation, exposure, and taphole location. Thus the ideal sugar bush needs both superior trees and a good location.

Sirup production per acre varies little with tree or crown size, probably because the amount of solar energy falling on the leaves is the same. In dense forest stands, however, most of the annual sugar production is required for stem development and other aspects of tree growth. In open-grown trees there is relatively more sugar left for the spring maple-sap crop. The superiority of the vigorous, more

Figure 4. Beech and hop hornbeam are favored in dense, unthinned stands.

Figure 5. Excessive cutting may encourage intolerants such as cherry and birch.

Figure 6. The ideal sugar tree has a wide, deep, and open crown for high sugar production.

open trees is found in more efficient collection and evaporation of sweeter sap as well as possible higher yields per acre. Also trees reach tappable size much sooner, tapholes heal more quickly, and new tappable wood is grown at a faster rate.

Most sugar bushes fully stocked with sugar maple have about 100 tapholes per acre, each yielding a yearly average of a quart of sirup. This amounts to 25 gallons of sirup per acre per year. More open bushes with large trees usually have fewer taps (60-80) but more and sweeter sap per taphole. They may yield 1½-2 quarts of sirup per tap, or 25-40 gallons of sirup per acre. Sugar bushes that contain numerous other species produce much less. Minimum levels for profit are estimated at 30 taps per acre and 200 gallons of sirup overall.

The technical aspects of sap collection and transport can be as important to the ideal sugar bush as high-producing trees. For tubing, land with suitable slope (10 percent optimal) and facing toward a few central collection points is best for maximum vacuum and sap flow as well as ease of collection. Collection points should be accessible to roads and near the sugar house.

Thinning the Sugar Bush

The amount of sunlight reaching any particular acre of forest changes little from year to year. Except when there are extreme droughts or fertilizer is applied, the same holds true for moisture and nutrients. Thus the land supports a certain amount of woody growth. Consequently, thinning or removal of unwanted trees does not ordinarily increase or decrease growth or sugar production per acre. The purpose of thinning is to select and keep the better trees to benefit from the available light, water, and nutrients. However, thinning does greatly influence the distribution of growth. Thinning to create an open stand allows sunlight to reach the sides as well as the tops of tree crowns; deeper crowns, sugar production nearer the base of the tree, larger stem diameters, and more available sugar near the taphole result.

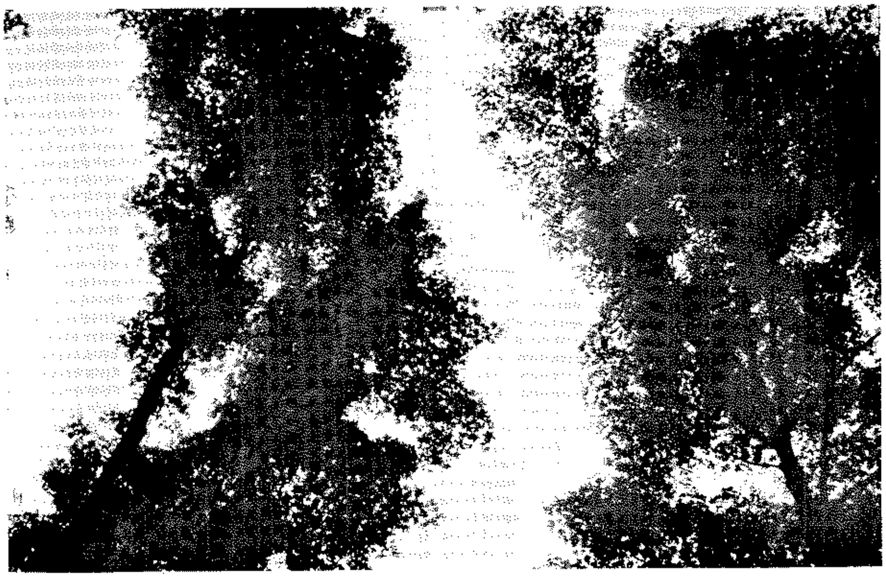

Figure 7. Crowded pole trees can sway in the wind, becoming "whip" trees, and wear away portions of the crown (see parallel edges on adjacent crowns). Thinning response is also reduced with age.

Figure 8. These crowns are still rounded and will respond to thinning even though the trees are middle-aged.

Tree response to thinning depends on a healthy, vigorous crown and the amount of release (figs. 7 and 8). Heavy thinning of young maples with good crowns causes rapid branch extension and can readily double stem diameter growth. Typical middle-aged, forest-grown trees have small crowns that show little response. Crowns of old trees have too little vigor. Therefore, thinning is best started when the trees are young and should be repeated at 5–10-year intervals to keep the crowns vigorous. Failure to continue thinning after the first time results in shading and eventual death of lower branches and loss of crowns.

Thinning objectives

Thinning prescriptions vary with the age, vigor, and condition of the sugar bush. Young sapling stands

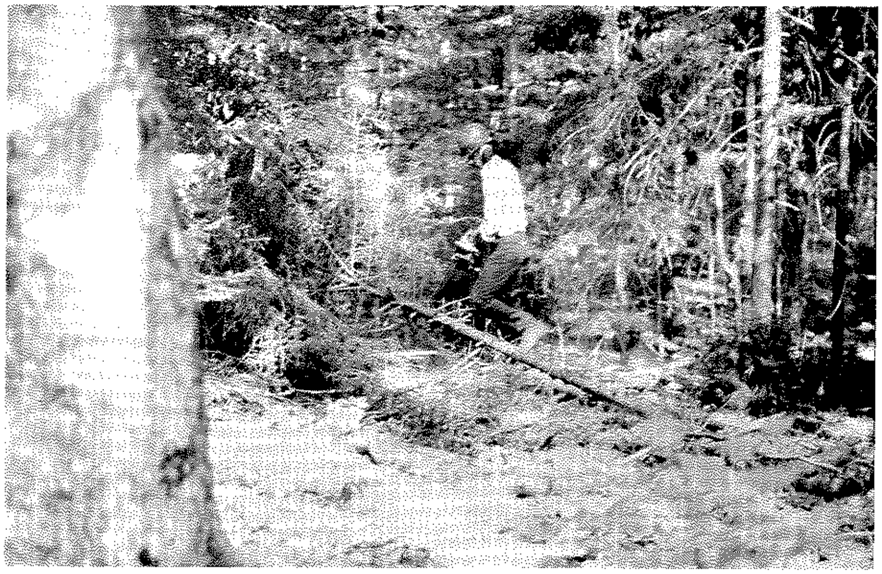

Figure 9. Cutting balsam fir to prevent shading of tube and pipe lines.

Figure 10. Fuel wood obtained from thinning is often sufficient to evaporate the sap from the sugar bush.

are treated differently than old, grazed bushes. However, thinning objectives may include the following:

- Convert area entirely to sugar trees — eliminate red or silver maples and non-sap-producing species from the sugar bush. More tapholes per acre reduce the fixed costs of tubing and roads as well as increase production.
- Develop the best sugar producers — select and grow healthy sugar maples with the best crowns and stem diameters or those trees already known to be good sugar producers.
- Hasten diameter growth so that trees reach tappable size (10″ in diameter at 4.5′ above ground) sooner; more sap is obtained from larger trees; tapholes heal more quickly; and more fresh wood is grown over old tapholes.
- Remove conifers that shade tube lines or tapholes and thus delay thawing and diminish sap runs (fig. 9).
- Hasten seedling growth to renew old stands. Heavy thinning may be needed before the harvest of old trees to encourage seedlings to grow into young saplings with terminal buds above deer browse level (fig. 3).
- Obtain usable wood products, especially fuel wood for evaporation (fig. 10).

Selection of crop trees

The crop trees are those trees selected to be favored for future growth and sugar production. More crop trees are selected in young stands to insure against losses and assure good trees for the future. By middle age the crop trees may simply be the tapped trees unless the stand is greatly overstocked. Young crop trees can be identified with a paint mark for future reference.

Thinned trees are those selected to be removed so that crop trees will grow better. They are usually those trees that most crowd the crop trees. Filler trees are those that remain and fill the spaces between the crop trees. Filler trees, predominant at very young ages, are often too small to be valuable but help to preserve a forest atmosphere. They reduce the danger of overexposure, especially to sunscald, maple borer, or wind damage, of crop trees. In succeeding thinnings, filler trees, as well as excessive crop trees, become thinned trees. Eventually, under ideal conditions, only some 25–40 large crop trees per acre, spaced 35–40 feet apart, may remain.

The first and most important step in thinning is the selection of the crop trees; only after that can you properly pick the trees to be thinned (fig. 11). Remember that selection of crop trees will influence current *and* future thinnings and is the *key to sugar bush quality* for the remainder of its lifetime.

Thinning guidelines

Thinning recommendations are best made in the individual sugar bush. However, guidelines suggest the amount or degree of thinning. These guidelines are based on average stem diameters at 4.5 feet above the ground and are applicable to

Figure 11. Crop trees (either side of the man) are first selected. Then competitors are marked (X) for removal. Small trees may remain as fillers. Only crop trees would remain if this stand had received continuous thinning from an early age.

groups of trees or to stands that are nearly the same age and height.

Table 1 shows the minimum stocking (number of trees per acre and average spacing between trees) for a sugar bush, based on the assumptions that sugar maple is the only species present and that tree crowns almost touch each other. It is equivalent to having open-grown trees placed next to one another in a forest grove. To have fewer trees is to fail to make full use of the site and to prematurely encourage maple reproduction as well as weed growth.

Middle and maximum stocking levels in table 1 are arbitrary standards. Even though many sugar bushes are more dense, maximum stocking is set at the same level as the minimum stocking prescribed for full sawlog growth.

Middle stocking, on the other hand, is considered too light for sawlogs and too heavy for optimal sugar production. Where thinning has been delayed but trees remain vigorous, it may be a desirable level for the sugar bush.

Table 1. Number of trees per acre and average spacing

Average stem diameter	*Minimum stocking		Middle stocking		Maximum stocking	
	Trees per acre	Average spacing	Trees per acre	Average spacing	Trees per acre	Average spacing
Inches	Number	Feet	Number	Feet	Number	Feet
3–4	260	13				
5–6	150	17	210	14	335	11
7–8	100	21	145	17	205	14
9–10	75	24	110	20	145	17
11–12	60	27	85	23	110	20
13–14	50	30	70	25	85	23
15–16	40	33	60	27	70	25
17–18	35	35	50	30	60	27
19–20	30	38	40	33	50	29

*Minimum stocking data derived from studies of stem-diameter and crown-width relationships on open-grown trees by the Northeastern Forest Experiment Station and further studies by the author in central New York. Middle and maximum stocking data are approximately the C and B levels determined by Northeastern Forest Experiment Station (Research paper NE-286 by Lancaster, Walters, Laing, and Foulds, 1974).

Sugar bushes with full-crowned trees, at the minimum level of stocking, are rare. A possible schedule of growth and development is shown in table 2. Three intensive thinnings are needed by age 20, nearby trees being removed on the basis of expected crown growth. Successive thinnings free the crown area for *average* distances of 6, 8, and 10 feet in each direction from the center of the crop tree crown (thinning radii) to provide sufficient growing space.

By the time the stand averages 8-inches in diameter, only 80 crop trees per acre remain. One could stop thinning at this point but at the expense of slower future growth and loss of much of the lower crown. The schedule shows a gradual reduction to only the best 40 trees which will temporarily reduce the number of taps for a period of 25–30 years. This is offset by retention of most of the crown, resulting in faster tree growth to 2- or 3-tap size as well as a likely increase in production per tap hole. At age 75, growth will be quite slow, but the trees can continue to produce well for another half century or more.

More commonly, the problem is what to do with an untended sugar bush. A simple thinning guideline is

Figure 12. Crowns of two 10-inch maples of middle age have grown together 8 years after the first thinning. The trees have an average crown radius of 10 feet, which fits the prescription in table 3.

to reduce the stocking to the maximum level (table 1) or the middle level or below. The latter is dangerous however, except in young and vigorous stands, since it would likely result in too large openings with considerable risk of sunscald, maple borer, and possibly wind damage or other "shock" factors.

A more sophisticated guideline, which may be applicable to many unthinned stands, appears in table 3. It indicates the *average* area to be released (thinning radius) around the center of the crown of each selected crop tree. It also illustrates a possible application of a D-plus rule. This rule calculates the needed growing space from the stem diameter. For example, a 6-inch tree needs freeing for an average distance of 8 feet (D + 2 = 6 + 2 = 8) in each direction to make room for crown development to a total width of 16 feet before the second thinning. The rule assumes that the crown is sufficiently vigorous to grow well following thinning. Bigger trees have usually been crowded longer and respond more poorly to thinnings. Therefore a single D-plus rule is inadequate—it changes with tree diameter and crown vigor[2] (fig. 12).

2. A simpler but less useful D-plus rule is also applicable. Growing space can be expressed in terms of average crown diameter (CD), in which CD = D + 10 (approximately). For example, 6-inch trees should be thinned to obtain crown diameters of 16 feet (6 + 10 = 16), the equivalent of a thinning radius of 8 feet.

Initial thinning at different stages

The initial thinning is briefly described for several stages in the life of a sugar bush. Groups of healthy trees or stands of similar age are assumed.

1. Bigger trees are *1-2 inches in diameter,* 10–25 feet tall. Stands are often greatly overstocked with 5–10 thousand or more trees per acre. Maximum crown development is possible by starting a thinning program now, but costs are high. Select about 200 crop trees per acre. Include the biggest and most dominant sugar maples—the tallest with widest crowns and large diameters. Selected trees should be healthy, vigorous, and free of large cankers, rot, or borer damage. Stems of seedling origin are preferred over stump or

Table 2. Schedule of growth and development with full crowns

Age	*Average diameter*	*Crop trees per acre*	*Tapholes per acre*	*Thinning radius*	*Remarks*
Years	Inches	Number	Number	Feet	
9	2	200	0	6	Machete or chemi-thin
14	4	120	0	8	Chemi-thin or fuel wood
20	6	100	0	10	Fuel wood or utility wood
26	8	80	0		Crop trees only remain
33	10	65	65		
40	12	50	50		
50	15	40	60		
60	17	40	80		
75	20	40	100		

Table 3. Thinning radius around crop trees for initial thinnings

Average stem diameter	*Crop trees per acre*	*Thinning radius*	*D-plus rule*
Inches	Number	Feet	
3–4	150	6–7	D + 3
5–6	130	7–8	D + 2
7–8	110	8–9	D + 1
9–10	100	9–10	D
11–12	100	10–11	D - 1
13–14	90	11–12	D - 2
15–16	80	12–13	D - 3

other sprouts; avoid forked or bent stems that may be too weak. Spacing can vary from 10–20 feet apart with an average of 15 × 15 feet.

For each crop tree, thin out competing trees to release the crown for an average of 5–6 feet from its center. Include all trees that touch the crown of the crop tree. Small, over-topped stems can remain, but pay special attention to nearby trees of other species that grow exceptionally fast and could soon overtop the crop tree.

The released crop trees can be expected to grow between 5 and 8 rings per inch or about 2.5–4 inches per decade. The crowns will expand rapidly, as much as 4–6 inches in each direction each year, and the stand will need thinning again in about 5 years (fig. 13).

2. Trees 3-8 inches in diameter. Unthinned stands are usually overstocked but decrease from several thousand to several hundred trees per acre as natural crown dominance increases. Potential crop trees are more apparent, thinning costs are lower, and wood from thinned trees is more usable than it was earlier. Therefore most people delay thinning until this polewood stage. However, much of the lower stem (15–30 or more feet), is already devoid of branches. Successive thinnings can develop wider crowns, with increasing depth, provided the trees continue to grow in height (fig. 14).

Select 100–150 crop trees per acre. They should include the most dominant trees—those with the largest crowns and bigger diameters. They should be healthy, vigorous, and relatively free of major defect such as canker, rot, borer damage, or weak stems. Selected trees should be 15–25 feet apart.

In addition you can select for sweetness among prospective crop trees. With a sharp awl, make a hole through the bark. Press a hypodermic needle firmly into the hole to collect at least a drop of sap. The sugar content can then be measured with a sap refractometer. A 13-gage needle with a 1-inch stem is a good choice, but an ordinary toothpick can also be used to obtain sap. Wash the hypodermic needle and wipe the refractometer clean before testing a new tree. Test all the trees on an acre within a 2-hour period to minimize the effect of normal changes in sugar content during the day. Avoid windy or rainy days which could influence the size or sugar content of drops of sap.

Release each crop tree by thinning out trees on all sides, using the thinning radius guideline in table 3. All trees touching the upper crowns of crop trees should be removed in young stands. Larger trees (6″–8″) in older stands may receive some "shock" from such a rigorous treatment; thinning should be somewhat lighter with an occasional competitor allowed to remain for the time being. All narrow-crowned, adjacent "whip" trees (fig. 7), however, must be removed.

Trees with vigorous crowns respond quickly and will need thinning

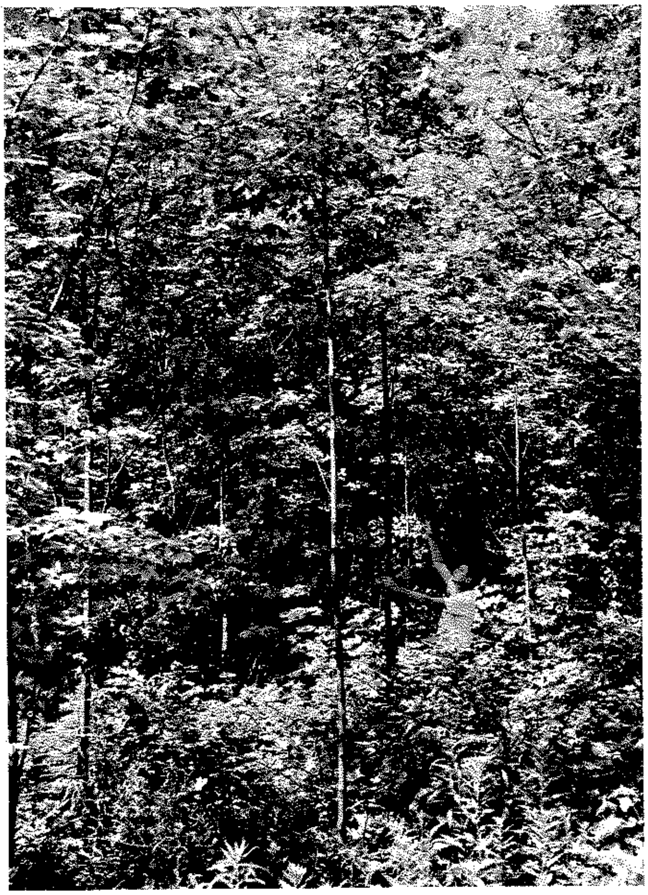

Figure 13. Young seedling sugar maple stand 2 years after thinning. Unthinned trees in background. Early thinning will permit growth of deep and wide crowns. Ample site protection following early, heavy thinning is provided by scattered brush and growth of weeds and sprouts.

Figure 14. Selected crop trees in thinned polewood stand. Untended woods in background. The lower branches are gone from the thinned trees, and depth of crown is limited at this stage.

again in 5–8 years. Light thinning as well as vigorous growth may shorten the period between thinnings. Inevitably some very good trees must be thinned out along with poor trees.

3. Trees *9–15 inches in diameter.* If thinning is delayed until trees reach tappable size, less can be accomplished. Trees are older, less vigorous, have lost much of the lower crown (30–40 or more feet), and are less capable of responding quickly to release. Nevertheless, thinning is of continued importance to encourage wider crowns and faster growth of stems. Even where trees are no longer sufficiently vigorous to respond well, thinning is needed to retain current crown size and growth rates (fig. 3).

Stem diameter growth in still vigorous stands can reach 10 rings per inch or 2 inches per decade. This is of particular importance both for increasing the number of taps per tree and for increasing the flow per taphole. The amount of sap per taphole per year increases about 10 percent with an increase of 2–3 inches in diameter for trees of this size.

For the first thinning, use the guideline in table 3. Select 80–100 crop trees per acre, including the known best producers—high sugar content and (or) good sap flow. Where necessary, emphasize elimination of other species to encourage more sugar production per acre. Strive for good distribution—crop trees spaced 20–25 feet apart. Some tappable sugar maples may need to be thinned out, the number of taps per acre being temporarily reduced. Larger thinned trees can be harvested for timber, and others will make excellent fuel wood.

Older crop trees should not have their crowns completely freed of competition in a first thinning. Remove the chief competitors, usually the nearest trees with the biggest crowns and stems, on three or four sides (fig. 15). A few competitors must usually remain until a second thinning. When unwanted trees are chemi-thinned or girdled, thinning can be somewhat heavier and more complete since treated trees die slowly and thinning "shock" is reduced (fig. 20). On the other hand, thinning should be lighter for the older trees on poorly drained soils.

In harvesting large trees, take care to prevent damage to the crowns of crop trees from felling and to the lower stem or roots from skidding.

4. Trees *over 15 inches.* Mature trees receive little benefit from thinning (fig. 16). Heavy thinning may even have adverse effects, including dieback in the crown. Little response can be expected from old trees, middle-aged trees with small crowns, or trees growing on poorly drained or dry soils. Growth rates are often 12–20 rings per inch or slower.

Removal of decayed sugar maple, mature trees of other species, diseased or defective trees, and trees susceptible to wind breakage on a tree-by-tree basis will improve the general health of the sugar bush as well as continue current growth rates for a longer period. All tapped maples that are fairly healthy should be kept since added growth from thinning is unlikely to compensate for the loss of tapholes.

Openings made by removal of individual trees are usually sufficient to encourage maple reproduction. Eventually larger openings of a quarter acre or more should be made to obtain good seedling growth as well as larger and more manageable units of regrowth.

Successive thinnings

Too often sugar bushes are thinned once and then neglected. Since the effects of normal thinnings are short-lived and since one or two excessive thinnings may be harmful, there should be numerous thinnings during the life time of a sugar bush (fig. 17). Young, vigorous trees quickly extend their branches into openings and need thinning again in about 5 years. Thinning should continue periodically as long as the trees respond well in diameter and crown growth.

Figure 15. Thinning in older stands must be lighter, yet adequate.

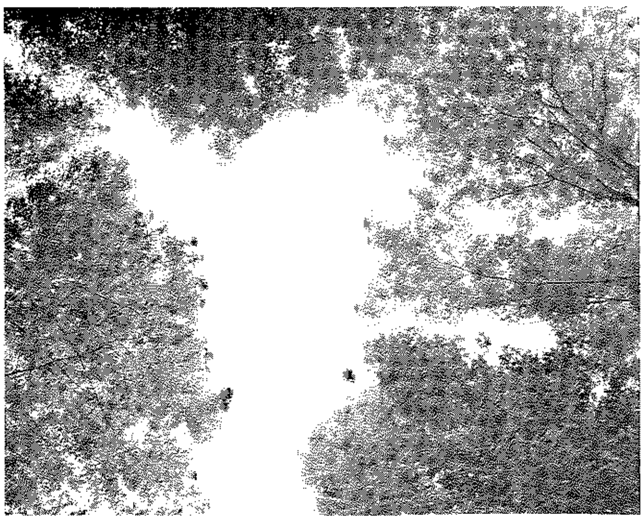

Figure 16. This sugar bush is too mature to benefit much from thinning.

Figure 17. This sugar bush (foreground) has been thinned successively for 2 decades to obtain fuel wood and promote sap production. Trees in the middle have been thinned lightly, and those in the background are untended.

Succeeding thinnings are easier since most crop trees have already been selected and marked. Thinnings usually become less severe with time and declining vigor. There may be more time between thinnings—5 years at first, then 6–8, and eventually 10–12 or more years. Best results, of course, occur on good soils. Failure to continue thinning results in interlacing and whipping of branches, followed by death of successive layers of lower branches and less growth and available sugar at the taphole.

A thinning schedule begun early enough can hold stocking at a minimum level and produce full-crowned trees, as shown in table 2. Successive thinnings begun too late can only approach this ideal condition.

Tree and site conditions govern growth response from successive thinnings. For vigorous trees first thinned at 3–6 inches in diameter, the second thinning may approach the minimum stocking level (table 1). Larger pole trees can be thinned to the middle stocking level or below, but this may be impractical for trees of tappable size. The third and later thinnings can further reduce the level of stocking, provided the trees continue to have vigorous crowns.

Most thinnings remove from a third to a half of the volume of standing trees at one time. Over a long period of time the amount of thinning is nearly equal to the amount of growth. A standard cord of dry hardwood can evaporate about 1100 gallons of sap or make 25 gallons of sirup (based on 2% sap). Since many sugar bushes average about a cord per acre per year in growth, the amount of wood to be thinned is often nearly the same as the amount needed for evaporation (figs. 10 and 17).

Stands with trees of many ages

Sugar maple, because of the history of land use and forest cutting as well as natural seeding and growth habit, often occurs in New York in stands of trees of nearly equal age. Even where several ages occur, there are usually groups of trees of nearly the same age and height. This has been considered the norm for sugar bushes and thinning recommendations.

Where there is a wide variety of ages and heights from tree to tree, the larger trees are normally preferred for crop trees since they already have bigger crowns and faster growth. An exception may occur if the larger trees are unhealthy or decadent. Since thinning usually favors the larger trees, the many-age character tends to disappear with time.

Thinning techniques

For small saplings, less than 1 inch in diameter, a sharp machete can be used for thinning. With your free hand, bend the sapling over. Then strike a solid blow with the machete. This will eliminate the crown competition, but strong sprouts are likely to grow from the remaining live stem. If the crop tree is 15–20 feet tall and vigorous, it probably will outgrow and eventually shade out the sprouts. An alternative is to chemically deaden the lower stem after cutting with the machete.

The chainsaw and ax will suffice to cut larger stems for fuel wood or other products. Cutting should be a year in advance of burning for proper seasoning. When wood is not used for fuel, small stems (1″–6″ or larger) may have little utility value. The cost of cutting and limbing, even with a chainsaw, may considerably exceed their value. Girdling or chemi-thinning are alternatives.

Girdling is accomplished by making 2 continuous rows of ax cuts around the stem, some 4–6 inches or more apart (fig. 18). The bark in between is stripped down to the cambium. Trees often remain alive for 5 or more years, living on the root system. However, the latter is eventually starved because the bark phloem, the pathway for carbohydrates moving from the crown to the roots, has been severed. Occasionally a tree may survive because of root grafts to surrounding trees or growth of callous tissue over a poor or too narrow girdle.

Figure 18. Girdling slowly deadens trees that are too expensive to cut; sprouting is greatly reduced.

Figure 19. Chemi-thinning is even cheaper. Kerosene or oil can be applied with a plastic squeeze bottle.

Figure 20. Deadened crowns of trees 4 years following chemi-thinning. Chemi-thinning can be somewhat heavier than cutting because the trees die slowly and thinning "shock" is reduced.

Figure 21. Chemi-thinning deadens spreading wolf trees such as this 40-inch giant. It could not be felled without smashing valuable trees.

Figure 22. This good forest floor has lots of humus which acts as a sponge to help hold moisture.

Chemi-thinning is the application of chemicals (herbicides) to deaden trees (figs. 19, 20, and 21). It is cheaper than girdling because only a single row of ax cuts (frill) is needed around the stem. A few chemicals translocate well in woody tissue and penetrate live wood between ax cuts. Chemi-thinning kills by deadening the wood and making a chemical girdle. Such girdles are usually wider than ax girdles, and trees generally die from 1 to 3 years sooner.

Although there are several potentially useful chemicals, most have strict restrictions concerning use. Some are prohibited or difficult to obtain. There are licensing and application regulations. *Consult your State Department of Environmental Conservation forester* before attempting to purchase or use manufactured herbicides.

Fortunately there remains one chemical that any landowner can use—kerosene or fuel oil, even used oil. Simply make a *complete* (all cuts overlapping) *frill* around the stem and apply enough kerosene for it to start to run out. This method can be used any time of the year except when sap flows. Fall and winter treatments are especially good. Trees so treated die slightly faster than girdled trees but not as fast as trees treated with chemicals with better translocation properties.

Larger trees (about 10″ or more) can be harvested for timber. Even tapped trees can be used after cutting off the tapped section. If you want to cut and sell timber to improve your sugar bush, consult your State Department of Environmental Conservation forester. You can obtain advice on prices, markets, loggers, tree marking, safe logging with minimum damage, and timber sale contracts, as well as other aspects of forest management. If a sizable sale is involved, you can ask about a timber agent or consulting forester who will supervise the timber sale for a standard fee.

Tree-marking paint is almost universally used on timber sales. Trees are marked with a spot of paint both at breast height and near the roots. The upper mark tells the logger to cut the tree; the lower mark allows the owner to check on removal of unmarked trees. Paint spots, usually orange or yellow, should be located on the same side of all trees to facilitate viewing and management decisions.

Other uses of paint in the sugar bush include identification of crop trees (blue paint), boundary marking (red), number of taps (1 dot for each tap), and tubing layout (tree numbers, arrows, color coding, etc.). Make certain that timber buyers know which paint marks are meant for them.

Organization for Management

Most sugar producers have more than enough to do. Moreover the sugar bush may stretch over a wide area. The needed woods work can appear endless, and work in the sugar house and elsewhere may be pressing. An organized schedule is necessary.

The best means of organizing sugar bush managment is by use of *compartments.* A compartment is a *management unit,* a small section of the sugar bush identified for management purposes. Ordinarily trees of similar age, size, and health, growing on the same kind of soil, are included in the same compartment so that they can receive the same management. Compartments should be kept small, about 1–5 or possibly 10 acres in size. They can be separated and identified by natural boundaries such as streams, ridges, fences, roads, or fields. If necessary, boundaries can be marked by painting trees.

The principal advantage of compartments is the feasibility of establishing priorities. Rather than thin haphazardly over 30 or 40 acres, you can select perhaps your 12 best acres in 6 compartments and do a

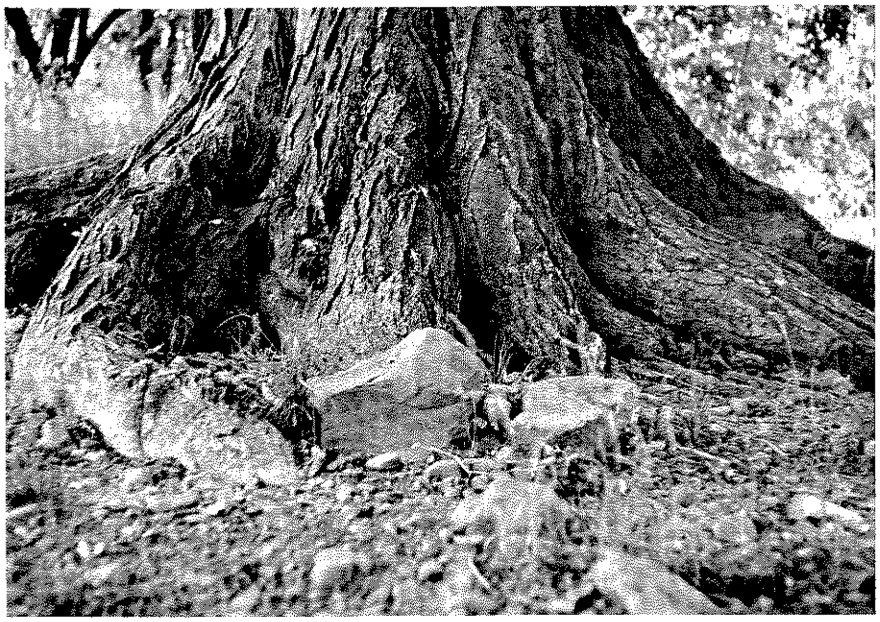

Figure 23. Severe grazing reduces soil moisture and sap flow.

top-notch job on them. There are always some compartments in which thinning is more worthwhile than in others. These include compartments on the best slopes (10%, southerly facing), those with the best or potentially the best sugar trees on good soils, those that are predominantly maple, or simply those nearest the sugar house. By giving priority to the better compartments, you can make your work more effective. You may develop different objectives for different parts of the sugar bush. For example, large-crowned sugar trees can be the objective on the best compartments, and a combination of sawlog and sugar trees can be grown on less favorable compartments.

The second advantage of compartments is their use in scheduling woods work. They provide practical and psychological incentives for sugar bush management. For example, if the 12 best acres are in 6 compartments, you can thin 1 compartment each year. After 6 years the first thinning will be complete on all 6 compartments, just about the time the second thinning is needed on the first compartment. Psychologically the job is easier to start, since 2 acres in 1 year appears much smaller than the vision of a 30-acre, or larger, bush. Once started, it is also easier to schedule and complete the work each year. Of course, as more time and resources are available, you can extend management to less favorable compartments.

Other Management Activities

Protection

Protection is sometimes as necessary as thinning in the sugar bush. Good climate, weather, and soils favor large sap flows as well as growth. Deep soils that hold adequate moisture and support good root systems are best. Leaves and humus add to the forest floor and increase water infiltration and storage (fig. 22). They also encourage an abundance of earthworms and other fauna that annually digest and mix new leaves with the soil to further enhance soil quality and moisture-holding capacity. These are the characteristics of deep natural forest soils protected from grazing by livestock and excess wind.

Although very light forest use by cattle causes little detectable injury, the effects of continuous heavy grazing are soon visible—deformed or killed maple seedlings, more growth of less palatable and unwanted species such as beech and ironwood, compacted and worn soil that absorbs and holds much less water (fig. 23), trampled roots, and eventually dying branches and butt rot. Sap loss may result from decreased moisture and tree growth or deep freezing of unprotected soils. Inasmuch as forest forage is inefficient in producing milk or meat, protection of the sugar bush from livestock is doubly important.

Wind protection is also needed for exposed sugar bushes, including those on high hills, those excessively exposed to prevailing winds, and those with reduced soil and plant protection following heavy grazing. Suitably located wind mantles or windbreaks are helpful. A wind mantle can be simply a border of unthinned trees or a conifer planting outside the bush.

Agents of forest destruction are insects, disease, fire, animals, and weather. Fire is usually caused by man; the best protection is afforded by good neighbors, a good road or access for fire fighting, and a backpack water pump. The latter is useful for spraying the fire front and cooling it. Shovels, rakes, and brooms can then be used to extinguish the fire.

The other destructive agents are inherent to forests and ordinarily require no special protection. Healthy, vigorous trees are generally least susceptible; thus the importance of thinning is reemphasized. However, insects occasionally become epidemic, or cyclic animal populations become too high; and special action may be needed. Advice should be sought from your State Department of Environmental Conservation forester.

Forest tent caterpillars, sugar maple borer, and maple dieback are discussed briefly in *Production of Maple Sirup and Other Maple Products,* Information Bulletin 95. For a broader view of maple pests, refer to *Sugar Bush Management for Maple Sirup Producers* by C. F. Coons, Division of Forests, Ministry of Natural Resources, Toronto, Ontario, 1975. Included are forest tent caterpillar, saddled prominent, sugar maple borer, heart rots, eutypella canker, nectria canker, maple dieback, porcupine, squirrel, and mice.

Fertilization

The use of commercial fertilizers to increase sugar production has been of considerable interest, but results of experiments have been inconsistent. A recent Canadian experiment, in which 250 pounds of ammonium nitrate were applied per acre for 4 successive years, yielded some 30–50 percent more sap with little change in sweetness. Earlier studies have been less convincing. Sugar content has sometimes been increased; in one case, it was decreased.

The likelihood of increased tree growth and sugar production following fertilization probably depends on a careful analysis of soil deficiencies and a suitable prescription to correct these. Otherwise, gains may be no more than can be obtained by needed thinning. The high energy costs of manufacturing fertilizer are likely to make fertilization a poor investment for many sugar bushes.

Establishing a sugar bush

The wide distribution of sugar maple throughout the state and the ease with which seedlings develop under natural conditions and following harvest have made planting generally unnecessary. High planting costs are unattractive. A maple plantation is similar to an orchard (fig. 24). The site should be plowed and harrowed, and continuous weed control practiced for several years following planting. Special protection of seedlings from rabbits, mice, deer, and other animals is needed.

With the future development of superior maple plants having the potential to yield more sugar and (or) sap, planting sugar orchards may become popular. They will be costly and so will merit excellent soils with sufficient protection from frost, wind, and sun as well as good management. A growth and development schedule similar to that in table 2 can be followed. A first consideration is the initial spacing. If 40 trees per acre are wanted for the final stand, they will be spaced an average of 33 feet apart. This final spacing can be obtained by planting trees at 16–17 feet apart and eventually keeping only the best 1 of every 4 trees planted. Much more choice in the selection of crop trees, at considerably more expense, will be available from an 11- × 11-foot spacing, with only the best tree of every 9 being kept. With wide initial spacings you may wish to interplant some fast growing nurse trees, such as larch or black locust, to provide early protection, more weed control, and improved growing conditions for the young maples. Of course, you must remove the nurse trees before they interfere with the growth of the maple crop.

The Northeastern Forest Experiment Station[3] is currently working on genetically superior maples as well as trying to solve the many problems encountered in large-scale nursery practice and growth of outplantings.

3. P.O. Box 968, 705 Spear Street, Burlington, VT 05401.

Figure 24. A 45-year-old sugar plantation. Spacing was exceptionally wide, at 40×40 feet, and crowns are just closing. The trees average over 15 inches in diameter.

Appendix

Important results of research on tree and sap characteristics

1940. Stevenson and Bartoo. Pennsylvania.

	Sugar percent
Forest-grown trees (crown length less than ½ tree height)	2.25
Open-grown trees (crown length about ¾ tree height)	3.34
Roadside trees (exceptionally wide and deep crowns)	3.72

1951. Moore, Anderson, and Baker. Ohio.
Much more sap was obtained from big, fast growing, open trees with deep and wide crowns. Smaller, but significant, gains in sugar percent were noted.

1955. Morrow. New York and Vermont.

a) Small differences in sugar percent were related to crown size (8–38% of the variation in sugar percentage was related to crown size) and openness in 3 sugar bushes. Crown diameter was important in all bushes, whereas crown depth gained importance with increasing openness. The following average sugar contents were obtained from sampling in 8 additional bushes:
Closed trees (5) - 2.0—3.0%, mean 2.4%
Open trees (2) - 2.9—3.4%, mean 3.1%
Roadside trees (1) - 4.2%

b) For 30 sugar bushes, sirup production per taphole was proportional to the mean crown diameter. Both sugar percentage and the amount of sap per tap increased with bigger crowns. However, total production per acre varied little with crown size.

1961. Toma. Michigan.
Sap flow and total sugar production were strongly related (r = .42–.50)[4] to stem diameter (4.5′ above ground) in a closed sugar bush. Sugar production was also related to crown diameter (r = .31). There were no significant correlations with either crown depth or tree height.

1971. Blum. Vermont.
Relationships between sugar production and tree characteristics varied from one sugar bush to another. Two of the 3 bushes had large trees over 150 years old whereas the other bush was about 75 years old.
Sap flow and total sugar yield were strongly related to stem diameter, crown diameter, and crown depth in all 3 sugar bushes (r = .46–.68). They were also related to tree height, especially in the younger bush (r = .36–.70). However, sugar percentage was significantly correlated only with crown diameter and only in the younger bush (r = .36).

4. r is the correlation coefficient.

1973. ———
From 50–85 percent of the variation in total sugar production was explained by tree crown and growth characteristics, but their predictive value varied from one bush to another and from season to season.

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