CORNELL UNIVERSITY
FOREST RESOURCES CONSERVATION EXTENSION PROGRAM
THEME AREA – MAPLE

FIELD ACTIVITY GUIDE
Sugarbush Thinning:
Evaluating Tree Vigor & Allocating Growing Space to Sugar Maple

Peter J. Smallidge, Cornell University; J. Rebecca Hargrave CCE – Chenango; and Jim Ochterski CCE – Schuyler. November 2004

Educator Guide

Objective:
The objective of this field activity is to help participants, especially maple producers,
1. develop the skills to assess trees for symptoms of health and vigor
2. apply different decision rules to the selection of trees to leave or cut when thinning a sugarbush.

This field activity guide provides a conceptual and practical approach to tree selection, but mathematical computations are simplified relative to a process used for actual thinning decisions. The activity takes place entirely within a sugarbush. Ideally the activity occurs in the summer or early fall when foliage is present to help practitioners evaluate tree health. However, in the spring prior to the session, the CCE educator should visit the site to measure sap sugar concentrations and tag/number trees at multiple sample points[1]. This data is ultimately provided to teams for activities 2 and 3 below.

Field Equipment List:
- Angle gauge or prism (10 factor)
- 50 ft. distance measuring tape
- clipboard
- plastic flagging ribbon, two colors with one each per group
- refractometer for sap (0 – 10 brix) [used during the sap season preceding the field exercise]
- scale sticks

Potential Partners:
- DEC Public Service Foresters
- Private Sector Foresters
- Maple equipment dealers
- SWCD and NRCS

Activity 1 – Assessing Tree Vigor (est. 45 - 60 minutes)

- Discuss why tree vigor is important to sugar maples used for sap production. Specifically address
  - The effect of site condition on growth and susceptibility to stress (Table 1).
  - The relationship among crown vigor, sap quality and sap quantity.
  - The dependence of diameter growth on new wood for future tapping, and how diameter growth depends on healthy trees.
  - How healthy trees can withstand stresses (e.g., tapping, environment, climate, pathogen) and that trees which are healthy also have good growth.
  - Reproduce the sugarbush with genetically advantaged stock.

---

[1] This would make a good 4-H youth activity.

- Using pre-selected trees, discuss several stems with different defects. Look for trees that have fungal infection, stem decay, sugar maple borer, weak forks, excluded bark, tip-up roots, thin crowns, etc. After the show-n-tell, quiz the groups on a couple of trees with defects to confirm they understand how to look at symptoms.

- Have participants learn to use the angle gauge or prism to select trees that they inspect for poor health symptoms and defects. Provide the exact sample point you used during the preceding sap season so participants will select the same trees for which you have sap sugar data. Use the attached data sheet to record observations on health, or develop a new data sheet. [note – learning to use the angle gauge can alternatively be postponed until activity #3]

- Gather the participants and discuss what they found. Inspect any new trees that have new defects to show the group.

Activity 2 – Assessing stem crowding in the sugarbush (est. 45 minutes)

- Have the participants verbally describe the current sugarbush. How does it compare to other sugarbushes? Are there more or fewer trees? Tree diameter? How do other sugarbush trees compare in crown shape, live crown ratio (% of stem in foliage), and proximity to other crowns? How is tree vigor? What is the degree of canopy fullness or openness (not the understory openness)? From the host producer, what is the production per tap? Discuss what affects health and productivity of a sugarbush.

- Discuss how thinning affects a forest. Relate tree spacing and stems/acre to other plant growth models (e.g., corn, tomatoes, etc.). Forests start with tens of thousands of stems per acre and the final mature sugarbush may have 60 to 80 tapable trees per acre. Thinning happens naturally through mortality, but the trees lost are not under our control. Thinning also happens deliberately when humans pick retention versus cut trees.

- Guide participants through a discussion about how to evaluate if it's time to thin and what the associated trade-offs. Decisions to thin are influenced by need and "cost". Need is assessed by (1) looking at crowding in the canopy and whether crowns are generally touching; (2) presence of lower dead branches on sugar maple; (3) measured reductions in sap/syrup production that can't be attributed to other factors; (4) high incidence of crown thinning, crown distortion from competition, or crown dieback; and (5) increment boring to look at growth rate. Cost of thinning includes: (1) actual financial cost if the stems are non-commercial because of tree size, low quality, or low numbers of stems; (2) cost in time or personnel (e.g., forester) to supervise the harvest; and (3) potential damage to residual stems or disruption of tubing system.

Activity 3 – Selecting trees for retention in the sugarbush (est. 25 - 40 minutes)

- Have participants discuss what information would be useful to guide decisions on which trees to retain. They will likely mention variables such as: tree spacing, tree vigor, sap sugar concentration, and tree age. All these factors are important, but their value depends on the age of the sugarbush (or the cohort being managed), the size of the sugarbush, the resources available to the producer as labor and finances, and the technical skill of the producer.

- Have the participants work as two- or three-person teams to sample trees using an angle gauge or prism from previously established points. These points should have been visited during sap flow and sugar concentrations measured on tagged and numbered trees. Have the participants select trees using the angle gauge or prism and mark them with flagging. Have the participants collect data on the trees for species, dbh, vigor rating, stem quality (mechanical stability), and the number of crown sides (quadrants) with at least 3 feet of lateral freedom to grow. After the participants have evaluated each tree, provide them the sap sugar concentration data. (prior sharing of the data could bias the health evaluation) Calculate average diameter based on an arithmetic average of dbh, but reduce the estimate for average tree diameter by two to four inches if there are a significant number of trees less than 10 inches dbh[2]. Finally, identify as crop trees any stems that are especially desirable based on the variables recorded.

---

[2] When using a prism or angle gauge, each tree represents 10 sq. ft. of basal area regardless of tree diameter, but the number of trees per acre the tree represents is inversely proportion to diameter. For example a 4" diameter tree represents 115 trees per acre, an 8" diameter tree represents 29 trees per acre and a 12" tree represents 13 trees per acre. A precise estimate of average dbh for actual management decisions would require weighting diameter by numbers of trees per acre, but for the purposes of this exercise use a rough rounding down approach to estimate the average diameter. Inventory analysis software is available through USFS at http://www.fs.fed.us/ne/burlington/ned/

- After teams have scored all trees on the plot, they should use a second piece of colored flagging to denote trees they would recommend for cutting. Note that cutting in a young sugarbush (average diameter less than 10") may remove 25 to 50% of the *number of stems*. In more mature sugarbushes, cutting should be increasingly conservative and remove less than 15% of the *volume* at a time. Thin regularly over the years as long as tree growth continues to respond. Participants should consult with the residual basal area chart (Table 2) to provide a <u>guide</u> to the average residual basal area and the tree spacing <u>guide</u> (Table 3). Focus on retaining the crop trees and removing defective or high risk trees. The distance table provides only a rough structure to use in mature stands and slightly better guidance in young sugarbushes with average diameter of 8" – 10" or less. Live crown ratio and crown diameter are more important than inter-tree spacing.

- After teams have made their cutting decisions, have the group visit several points and allow teams to defend their selections. Have teams describe the trees they had in their sample (size, quality, vigor, etc.) and the thought process they used to select individual trees.

- To use the residual basal area guide:
  - Calculate average diameter of the sample trees. Adjust diameter estimate downward if the sample includes several trees with dbh less than 10" (see footnote #2),
  - Compare calculated average diameter to the corresponding diameter on the RBA guide,
  - Round the residual BA of the average diameter to the nearest decadal increment (e.g, 43 to 40)
  - Divide the decadal increment by 10 to estimate the residual number of trees to retain from those sampled.

- At some points the participants sample, or for application of these techniques in a production sugarbush, there may be a low percentage of acceptable sugar trees. Consider cutting harder in these areas to initiate advance reproduction of sugar maple. Cutting a tree should benefit a desirable neighbor tree (current goal) or provide growing space for regeneration (future goal). This shift in goal signals a "regeneration cut" and should be based on deliberate considerations and consistent with the management plan for the sugarbush.

- Discussion questions after teams defend their selection process:
  - Would the basal area, tree spacing, or crop tree method ever by useful by itself?
  - What are the really important (or practical) variables to assess on a tree before deciding its fate? Does the method of selecting which trees to cut depend on age of the sugarbush? How does the skill and energy of the workers affect which method to emphasize?

FIELD ACTIVITY GUIDE
Sugarbush Thinning:
Evaluating Tree Vigor & Allocating Growing Space to Sugar Maple
Peter J. Smallidge, Cornell University; J. Rebecca Hargrave CCE – Chenango; and Jim Ochterski CCE – Schuyler.
September 2004
Participant Worksheets

Objective:
The objective of this field activity is to help participants, especially maple producers, develop the skills to assess trees for symptoms of health and vigor and apply different decision rules to the selection of trees to leave or cut when thinning a sugarbush. This process provides a conceptual and practical approach to tree selection, but mathematical computations are simplified relative to a process used for actual thinning decisions.

Background:
Technology has allowed syrup makers to improve production by investing in equipment. Sustainable production, though, depends on investments that ensure a healthy and vigorously growing sugarbush. Thinning can improve the growth of residual trees and shift the mix of species to emphasize growth to the most desired trees.

Trees in a sugarbush need adequate space to grow. Trees require sunlight, water, and mineral nutrients for survival. Sugar maples typically grow in areas with adequate water and soil minerals. More often, light is the limiting resource for improved growth. Without adequate growing space around tree crowns, competition for light reduces tree growth.

Adequate growth ensures good tree vigor and the accumulation of new wood. Specifically, improved tree growth produces: larger xylem vessels that favor sucrose storage; larger xylem vessels that facilitate pressure differential during sap flow; larger xylem vessels that improve the release of sugars; trees that reach tapable size at a younger age; more volume of sap producing wood; and more wood for deeper future tapping.

Low vigor trees and those not producing sufficient new wood are not able to provide clear wood for tapping in subsequent years. Tap holes should not penetrate into wood that is stained. Tapping into stained wood increases the incidence of decay. Symptoms of inadequate growing space include: a closed canopy, the death of lower canopy branches of sugar maple, or reduced radial growth increment determined via increment borer. Sometimes understory patterns showing a lack of species able to tolerate moderate shade suggests a dense canopy overstory.

Acquired Skills:
1. Recognize, differentiate, and prioritize defects and low-vigor symptoms in sugar maple that signal poor production and a decrease in the probability of survival of the tree.
2. Assess a sugarbush to determine if stem crowding warrants thinning.
3. Select sugar maple trees for retention versus cutting based on a method appropriate for the age of the sugarbush, size of the treatment area, economic profile of the production system, and skill of the practitioner.

Suggested Readings:
Guay, S. 1999. Guide to sugarbush management. Syndicat des producteurs de bois de la beauce. 35 pp. 3500, 6e Ave. Ouest, Ville de Saint-Georges, Que. G5Y 3Y9 (in English)

Heiligmann, RB. C Coons, RR Morrow, L Staats, and FE Winch, Jr. 1996. Chapter 5 - Managing maple trees for sap production. Page25-47 *in* North American Maple Syrup Producers Manual. Ohio State University Extension. MR Koelling and RB Heiligmann, eds. Ohio State University Extension Bull. 856. [not on reserve go to http://ohioline.osu.edu/b856

Morrow, R. R. 1955. Influence of tree crowns on maple sap production. Cornell Agricultural Experiment Station Bulletin No. 916.

Morrow, R.R. 1976. Sugar Bush Management. Cornell University Plant Sciences / Natural Resources 8, Information Bulletin #110. 19 pages

Activity One:
Evaluating the Sugarbush and Individual Trees

Evaluating a Sugarbush –

A healthy and productive sugarbush provides the foundation to justify investments in improved tree productivity, access, and sap collection and processing equipment. An unproductive sugarbush or one with limited opportunity for improvement may not warrant significant investment.

Several attributes of a sugarbush should be assessed (Table 1). They overlap somewhat and most sugarbushes will have some deficiencies in a couple areas. Soil conditions are the only factor that truly impacts maple production. The other issues can be overcome with design and fortitude.

- Soils should be well drained and fertile. Poorly drained soils limit the growth of sugar maple. Poorly drained soils make placement and maintenance of roads difficult. High fertility soils allow for rapid growth when trees are free to grow. Low fertility soils will require more conservative tapping, perhaps a larger initial diameter, and greater care to ensure the tap holes only access clear wood.
- Aspect reflects the coolness and dryness of a site. In warmer portions of sugar maple's range, a sugarbush is typically best on cooler and moister north and east aspects. In cooler portions of the range, grow may be better on the warmer and drier south and west aspects. This factor has a great deal of latitude and many exceptions to these guidelines exist. Soil moisture patterns and elevation can modify how strictly the guide is applied. Further, the aspect may influence the onset of sap runs each season, with north and east aspects starting later and running later than south and east aspects.
- Percent slope doesn't really affect tree performance but rather producer and tubing performance. Most maple producers work more slowly and less efficiently on slopes that exceed 20%. Tubing systems on flat sugarbushes don't drain well and require extra design features for optimum flow.
- Access controls whether the producer can enter the sugarbush in most seasons, what vehicles can be used, and the amount of road work required to allow entry of the available equipment. Roads help with production, but require great care in their design and installation.

Evaluating a Tree -

Producers should consider each tree in their sugarbush a mini factory. The tree accumulates the resources and produces the product. An efficient factory will have ready access to resources and ample equipment to make the desired product. As a tree, this means a healthy root system; a strong, stable and supportive main stem; and a healthy vigorous crown.

- The root system often receives little attention and too much abuse. Each tree has fine roots that acquire most of the moisture and nutrients needed to make starch and sugar. These fine roots are near the soil surface and extend at least to the edge of the tree. Damage to fine roots may not create major problems in otherwise healthy sugarbushes or during years of normal rainfall, but a damaged root system will seriously limit tree growth and predispose the tree to healthy problems when any growing condition becomes stressful. Thus, the need for caution with vehicles and trails. Other roots are for stability and located deeper and more centrally to the tree stem. Defects in the roots may be evidenced by obvious sources of abuse like trails or roads, damage to the butt of the tree, or fungi on the lower section of the tree.
- The main stem connects the roots to the crown. This is the portion of the tree the producers spend the most time working with during tapping. The function of the stem is to support the crown and to accumulate new wood that allows tapping in future years. Support of the main crown requires a stem with minimal evidence of defects that would weaken the tree. Nectria and Eutypella cankers and maple borers are examples of defects that weaken the tree. Their effect on sap sugar is unknown. These defects do increase the chance the stem breaks under snow or ice loading.
- The crown is the most visible and potentially most important part of a sugarbush maple tree. Sap quantity and sugar concentration are closely linked with the width of the crown, the depth of the crown, and generally the size and fullness of the crown. The crown receives sunlight through the leaves and produces starch that is converted to sugar. Reduced leaf area will result in reduce sap quality and

quantity. Look to avoid mis-shapen crowns that evidence competition, thin crowns, dead branches in the upper portions of the crown, and low leaf abundance (called transparency).

Example of a butt scar on a tree. The original wound allowed stain and decay microorganisms to enter the tree and infect the root system.

Example of canker (right) and maple borer (left). Trees with these characteristics should be cut during thinning activity in the sugar bush.

Example of compressed crowns on tapped maple trees. These trees have less than 40% of the crown they might have as a result of competition with neighboring tree. Try to avoid letting this condition develop.

The tree in the center has a full crown, both width and depth. A bit compressed on the left side. Note the amount of growing space provided to this crown.

Table 1. Sugarbush Evaluation

Feature	Desired	Comments on Current
Soil	Deep, well drained, moist, moderately coarse textured.	
Aspect	Northeast to Southeast, moderated by availability of soil moisture on drier aspects	
Slope	Minimum 5% for sap drainage in tubes, upper limit based on accessibility.	
Access	Existing or good potential for effective road network.	

Activity Two:
Assessing Crowding in a Sugarbush

Before thinning, determine if the need for thinning exists. A variety of approaches will help you decide what if any action to take. If you need to thin, consider how to manage the potential costs.

Describe the current sugarbush compared to your sugarbush:
- Are there more or fewer trees?
- How healthy do the crowns look?
- Are the crowns touching or free to grow?
- Are upper canopy crowns full?
- How much syrup per tap?
- Average sap sugar concentration? Has this changed in the last 5 – 10 years?

If this sugarbush were a garden, and the trees were tomato plants, would you expect good production? Why or why not?
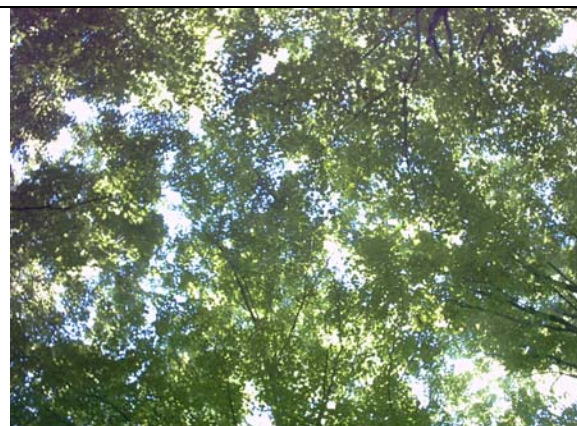
Evaluate symptoms of over crowding:
- What percentages of the crowns are touching other crowns?
- Is there evidence of lower dead branches?
- Has sap sugar concentration changed in recent years?
- Is there evidence of crown thinning, crown distortion, or crown dieback?
- Use an increment borer, how many rings per inch are there? More than 10 per inch is a problem.
- How many open tap holes exist on a tree?

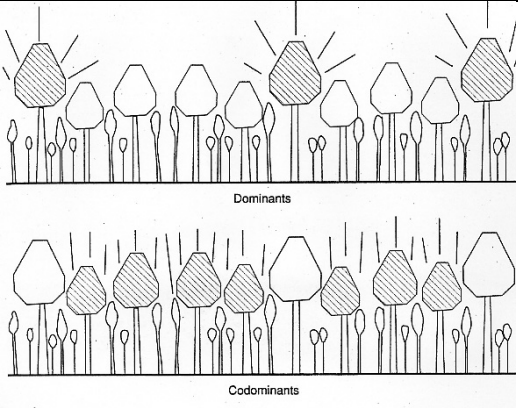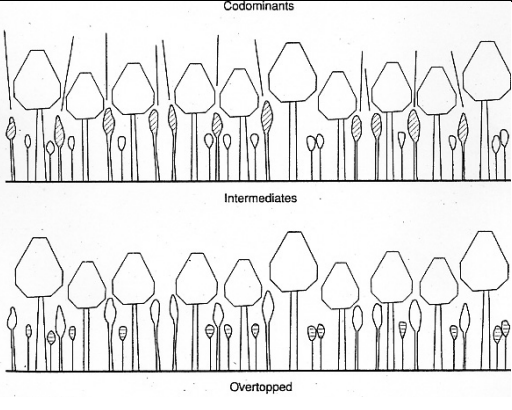*Evaluate what it would take to thin – the costs:*
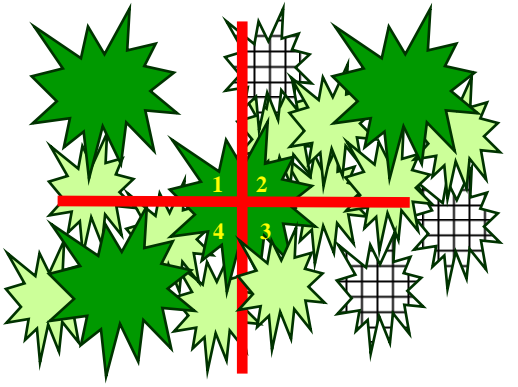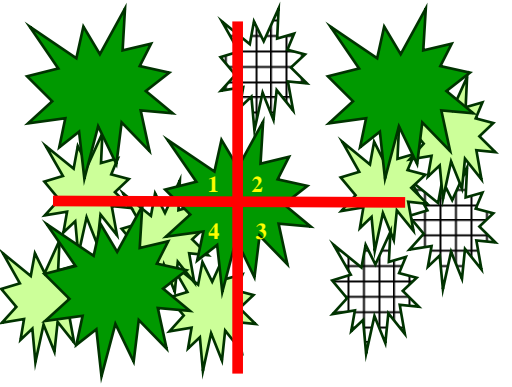- Are stems too small to be sold? Could they be used for firewood?
- Is there someone available to supervise cutting? Do they have adequate experience? Do they charge for services or if a family member could they be doing something else?
- How will you assure to minimize damage to the residual trees and tubing system?

Canopy is full, but encroached upon by neighbors. Should be thinned.

A full and dense canopy

Upper crown classes receive direct overhead and lateral light. These are the best sugar producers. (From Nyland 1996)

Lower crown classes receive little or no direct overhead light. (From Nyland 1996)

One side free to grow

Three sides free to grow

Activity Three:
Factors Influencing Thinning Decisions

Decisions on which tree to harvest and leave are not easy. Use a systematic process to evaluate trees and record those which should be left versus those to cut. Decisions to cut should include many factors, but ultimately based on crown health and vigor. As described below, residual basal area and distance between trees provide a guide to indicate the need to thin, but actual thinning should focus on maintaining healthy crowns. These tools are only guides and are not definitive. Follow through this exercise to gain experience with different approaches. You will likely become most comfortable with one. Use the guides judiciously. When in doubt, cut conservatively.

Tree Evaluation:
Measure a point using a prism/angle gauge and flag each tree with a number. Each tree contributes 10 sq. ft of basal area regardless of diameter. For each tree record the following variables. Definitions for the variables are on the following page.

Table 2. Tree evaluation

Tree No.	1	2	3	4	5	6	7	8	9	10	11
Spp											
DBH											
Health											
Stem Quality											
Crown Class											
SSC (%)											
# FTG											

Table 2 Worksheet:

trees sampled = _____

Basal Area per acre = _____ (# trees x 10 = basal area in sq. ft. per acre)

Average Diameter (DBH) = _____

% of trees that are crowded = _____ (# trees with 1 or 2 FTG divided by total # trees)

<u>Note which trees you would remove due to the Evaluation Method in Table 4 below and mark them with an additional ribbon.</u>

<u>Health</u> –   rate as 1 to 5 with 1 being poor and 5 being good. Evaluate insect, fungal, mechanical damage. Consider the ability of the tree to respond to release (crown fullness) and live for 10 years.

<u>Stem Quality</u> –   Rate as 1 to 5 with 1 being poor and 5 being good relative to strength not timber quality. Evaluate based on strength of crotches and crown symmetry.

<u>Crown Class</u> -   1 = open grown, 2 = dominant, 3= codominant, 4 = intermediate, 5 = suppressed.

<u>SSC (%)</u> -   Percent sap sugar concentration measured with a refractometer.

<u># FTG</u> -   Record the number of quadrants (0 to 4) that are at least 3' from the neighboring crown (free to grow).

Basal Area

Basal Area is the area of the cross-section of all the trees in a stand at DBH (4.5" above ground level). In a full stand, if basal area increases and stems per acre do not decrease, trees start to compete for nutrients, water and light, reducing growth rates and potential reduced sap production. For sugarbushes there is an ideal basal area for an average DBH to help ensure adequate sap production.

Compare your Average DBH and Basal Area per Acre from the Table 2 worksheet to guide what might be acceptable as the residual number of trees per acre you should have. The approximate number of trees per acre gives you a sense of what to expect. The calculations from the data you collected are beyond the scope of this exercise. You can't directly translate the number of trees in your sample to a number per acre.

Note which trees you would cut using the Basal Area method in Table 5 and mark them with a ribbon (or if already chosen for another method, mark both methods on the same ribbon).

Table 3. Residual Basal Area for Sugarbush. Adapted from Lancaster et al.1974 and Morrow 1976.

Average DBH of overstory trees	Residual Basal Area (sq. ft.) per Acre	Approximate # Trees Per Acre based on average diameter and residual basal area
6	25	127
8	34	97
10	43	79
12	50	64
14	59	55
16	64	46
18	69	39
20	74	34
22	79	30

To use the residual basal area guide:
- o Calculate the average diameter of the sample trees. Adjust diameter estimate downward if the sample includes several trees with dbh less than 10" (see footnote #2),
- o Compare calculated average diameter to the corresponding diameter on the RBA guide (Table 3),
- o Round the residual BA of the average diameter to the nearest decadal increment (e.g, 43 to 40)

Divide the decadal increment by 10 to estimate the residual number of trees to retain from those sampled.

Your current basal area = _____

Your ideal basal area = _____

Number of trees to remove = _____ (current BA – target BA) / 10

Crop Tree Selection

Crop Trees are future or current best performers. Often with large crowns, free from defects and competition, and with good health and structure. Crop Tree Management is the selection of crop trees and potential crops trees and providing them with the most room to grow, by removing trees interfering with their growth.

Select crop trees based on desired features, such as sap sweetness, absence of defect, crown fullness. Adjacent trees with touching crowns should be cut.

Note which trees you would cut using the Crop Tree Selection method in Table 5 and mark them with a ribbon (or if already chosen for another method, mark both methods on the same ribbon).

Tree Spacing

Tree spacing is important as it relates to competition. Trees too close together will compete for nutrients, water and sunlight. Too much competition can cause reduced growth rates and lead to stress, which can lead to other insect and disease problems.

Table 4. Sugarbush Tree Spacing Guide – Numbers are the minimum distance allowed between trees of two diameters to allow optimal growth for sap quality and volume. Adapted from Lancaster et al. 1974. USDA Forest Service Research Paper NE-286, North American Maple Syrup Producers Manual – Chapter 5, and Morrow 1976

Tree Diameter	4	6	8	10	12	14	16
4	13						
6	18	19					
8	19	20	21				
10	20	21	22	23			
12	21	22	23	24	26		
14	23	24	25	27	28	28	
16	24	25	26	27	28	29	31

Using the Table 4 determine which trees would need to be removed. Note your choices in Table 5 and mark them with a ribbon (or if already chosen for another method, mark both methods on the same ribbon).

Table 5. Summary of Thinning Methods

Thinning Method	Tree Number(s) you would remove
Tree Evaluation	
Basal Area	
Tree Spacing	
Crop Tree Selection	

Which method do you like best? Why? Are there some circumstances where one method would be better than another? What is the key information to have to make decisions on cut versus leave trees?

Other Management Issues

Low quality sap tree management options

For trees that are vigorous and part of the long-term production of the sugarbush, sap value will override sawtimber value. For trees that are of low vigor, poor form, or substandard sap sugar concentrations, they might be more valuable as timber and provide growing space to their neighboring trees. Note that sawtimber value continues to increase as the tree diameter increases. <u>Decreasing sawtimber value will occur when decay in the tree occurs.</u>

For each diameter, compare the value of the tree for syrup production under one of the marketing scenarios and against the estimated stumpage value of the tree for sawtimber.

Table 4. Syrup Net Present Value at 4% Over Ten Years.

DBH (inches)	Est. Prod / tap (gallons)	Potential Gross Revenue / tap/year with good marketing($)	[*Aggressive marketing = $55/gallon*] NPV / tap at 4% with net profit of $8.25 per quart over 10 years	[*Passive Marketing = $35 / gallon*] NPV / tap at 4% with net profit of $3.25 per quart over 10 years	Estimated Sawtimber Value (assume 1 log and $0.60 / bf, International ¼ " scale)
10.0	0.15	$7.50	$40.15	$15.82	$21
12.0	0.18	$8.75	$46.84	$18.45	$33
14.0	0.20	$10.00	$53.53	$21.09	$48
16.0	0.25	$12.50	$66.91	$26.36	$63
18.0	0.33	$16.50	$88.33	$34.80	$81
20.0	0.33	$16.50	$88.33	$34.80	$102

Insert your plot trees

DBH	Profit over 10 years (choose your preferred strategy)	Estimated Sawtimber Value (from above)	Potential Decay? Yes/No	Remove Or Retain?

Regeneration Concerns

Sometimes in your sample, there may be a low percentage of acceptable sugar trees. Consider cutting harder in these areas to initiate advance reproduction of sugar maple. Cutting a tree should benefit another desired tree or provide growing space for regeneration. This shift in goal signals a "regeneration cut" and should be based on deliberate considerations and consistent with the management plan for the sugarbush.