

B. Burns

F O R E S T P E S T M A N A G E M E N T

OFFICE REPORT
Not for Publication

VT. FOREST
& PARKS

DEC. 15 '81

N. SPRINGFIELD

PROJECT REPORT

EVALUATION OF MAPLE DECLINE
IN SUGARBUSHES OF VERMONT

1977

Imants Millers^{1/}, Brent Teillon^{2/} and
Rick Alimi^{3/}

- ^{1/} Entomologist, USDA Forest Service, Portsmouth Field Office
- ^{2/} Chief, Forest Protection, Vermont Department of Parks and Forests
- ^{3/} Statistical Technician, USDA Forest Service, now Forester, Chippewa, N.F.

USDA FOREST SERVICE, Northeastern Area, State and Private Forestry
Portsmouth Field Office, Portsmouth, NH, 03801

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EVALUATION OF MAPLE DECLINE IN SUGARBUSHES OF VERMONT

by

IMANTS MILLERS, BRENT TEILLON AND RICK ALIMI

SUMMARY

An evaluation of maple decline in sugarbushes of Vermont was made in 1977 by the Vermont Department of Agriculture, Vermont Department of Parks and Forests and USDA Forest Service. A sample was selected from a list of 1,000 maple sugar producers and 91 sugarbushes were examined in the field.

Results

This type of survey was able to find only one sugarbush that was rated in poor condition. Sugar maple mortality, or decline, may have been more severe earlier, but present tree mortality is low, and predominantly present among suppressed maples.

Some weak associations were found between declining sugarbush conditions and grazing intensity and also with shallow soils, as indicated by rock outcroppings.

The average sugarbush has about 95 trees per acre; two thirds of which are sugar maples. About one half of the maples are less than 9 inches dbh, and thus below recommended size for tapping.

Insect defoliation was recorded on most trees, with maple leafcutter as the most frequent cause. Most of the defoliation was rated light and moderate. Severe defoliation was equally common in poor and good sugarbushes.

Sugar maple borer injury was found on 22.3 percent of dominant crown class sugar maples, and more common in poor condition sugarbushes. Since stem rot was also more frequent in the poor sugarbushes, further investigation may be desirable to evaluate association of sugar maple borer injury, stem rots and their effect on tree condition.

Only one half of the sugar maples in the average sugarbush are tapped, probably because the others are too small. About one third of the trees are tapped at a higher frequency than recommended. Tap hole closures were rated poor in one fourth of the tapped trees, but because of the difficulties separating old hole with poor healing from recent hole, the observations may not be reliable.

INTRODUCTION

The problem commonly identified as sugar maple decline draws sporadic attention in the Northeastern States. About four years ago, the maple sugar producers of Vermont became particularly concerned about an apparent severe maple decline and mortality in some sugar bushes. Several meetings were held to discuss the problem and determine a course of action. A technical committee was composed of personnel from the University of Vermont, Vermont

Department of Agriculture, Vermont Department of Forest and Parks, and the USDA-Forest Service, both Northeastern Forest Experiment Station and Northeastern Area, State and Private Forestry. A questionnaire was sent to sugarbush owners in Vermont. About a third of the owners who responded indicated that their stands were not in good condition and many stated that they had observed declining trees.

As a result, a survey was designed to determine the intensity of maple decline and tree mortality in Vermont's sugarbushes and to identify clues to possible causes of the decline. The field data collection was done during the summer of 1977.

METHODS

Selection of Sugarbushes for Sampling

A sugarbush was defined as a maple stand managed for maple sap production. Roadside trees were not included in the sample. Another requirement was that the sample stands must have a record of an average of 200 taps per year during the previous 5 year period.

A list of sugarbush owners was obtained from the Maple Sugar Producers Association of Vermont. About 1,000 sugarbushes were found to meet the requirements. At random, 10 percent of sugarbushes in each county were chosen for sampling, for an initial count of 144 sugarbushes. Of these, 35 sugarbushes did not meet the requirements when examined in the field. In addition, for various reasons data were not obtained, or useable in analysis from another 18 sugarbushes. Thus, data from 91 sugarbushes was useable in the analysis. The selection process was reasonably unbiased and the results should be expandable to the 1,000 sugarbushes and, perhaps, to the state as a whole.

Sample Plots and Clusters

A cluster of five 1/5 acre (0.081 ha) circular fixed radius plots were sampled in each sugarbush. Usually, these plots were about 5 chains (100 m) apart. The first one was taken in the middle of the stand, and the others, in the four cardinal compass directions. In some of the more narrow sugarbushes, the five plots were in a line at 5 chain (100 m) intervals.

Data Collection

Most of the data collection was made by field crews from Vermont CETA programs. Field training was provided by the cooperators. The Vermont Department of Parks and Forests supervised the crews. Most of the field work was done in August and September.

The field data included location identification codes, site and stand information and tree descriptions. Data forms and definitions are shown in Exhibits A and B. The site data included slope in degrees azimuth; three categories of crown closure, four categories of grazing intensity, and seven categories

of ground cover. Rock outcrops and soil disturbances were recorded as present or absent.

The field data included stand identification codes, individual tree data, sugarbush stand descriptions and site information (Appendix exhibits A and B).

Tree Data

The individual tree data was collected for all species of trees greater than 2 inches (5 cm) in diameter at 54 inches (3.5 m) above ground (dbh). Tree species, crown class, dbh and condition class was recorded. Tree condition classes were based on the appearance of foliage and abundance of dead branches and twigs in the crown.

- Healthy - foliage of normal color and leaf size. Dead branches and twigs barely noticeable, less than 10 percent.
- Fair - foliage may be off-color and stunted. Dead branches and twigs very obvious, between 10 and 50 percent and concentrated in the periphery of the crown.
- Poor - foliage off-color, stunted and sparse. Most of the branches and twigs are dead or dying.
- Dead - green or live foliage is absent. No signs of life in the crown of the tree.

The dead trees were appraised to estimate the time of death on the basis of buds, twigs and small branches and bark condition.

- 1 year - buds and fine twigs present; bark is tight on tree.
- 2 years - buds and some small twigs have fallen; bark is beginning to loosen.
- 3 years - most of the fine twigs are gone; bark is loose and sloughing.
- 4 or more years - fine twigs and small branches are absent; most of the bark has fallen off.

The following types of injuries on the trunk were recorded as present or absent. Animal and bird damage, borers, cankers, defoliation, grazing, leaf scorch, leaf damage (other than borers), logging, root and root collar rots and stem rots. Defoliation was further broken down into three classes: 1-10 percent, 11-50 percent, and more than 50 percent. In addition, defoliation was identified as caused by maple leaf-cutter, leaf roller, tent caterpillar and gypsy moth, or other.

Tree tapping was coded as absent or present, tapped in 1977 or before, and severity of tapping in relation to the recommended tapping guides (Lancaster et al, 1974). In addition a qualitative judgment was made taphole closure rate as good or poor.

Plot and Stand Data

The degree of slope, azimuth degrees the slope was facing and site data were recorded in each plot. Crown closure was rated as open, partially closed, and closed. Rock outcroppings, surface soil disturbance and mottling were recorded as present or absent. Grazing intensity was also rated as absent, light, moderate and heavy. Stand condition was rated after all the plot data had been taken on basis of impression from all the plots and the trees visible during the travel through the stand.

- Excellent - stand vigorous, with no obvious maple decline trees.
- Good - occasional tree appears to have decline, but overall the stand appears to be healthy.
- Fair - dieback is noticeable, but none of the trees are dead or dying.
- Poor - many trees show signs of dieback and some are already dead or dying.

In a few sugarbushes the field crews had rated the individual plots instead of the stand as a whole. During the data analysis process these stands were given stand condition ratings on the basis of the majority of the plots in a stand.

Since only one sugarbush was rated poor in the field, and the distinction between healthy stands and good stands was difficult, these condition classes were combined into two for analytical purposes. The healthy and the good class was combined into good, and the fair and poor was combined into the poor.

Tree descriptions included species, diameters at breast height (dbh) to the nearest 0.1 ft. (0.5 cm), crown position and condition. Year of death up to three years was estimated for trees on basis of presence of smaller branches. Dead trees without branches under one half (1.3 cm) diameter were assumed to have been dead four or more years. Various types of injury to the tree trunk were recorded as present and absent. Defoliation was recorded in four categories and the major defoliator species identified.

Tapping of maples was recorded as current (1977), earlier, or none. Tapping severity was estimated by relating the number of tapholes and tree diameter and number of recommended taps for the size of tree (Lancaster et al, 1974). Tapping closure was rated as good or poor.

Data Analysis

Field data were transcribed to optical reader forms by the staff of Vermont Department of Parks and Forests. The analysis was made by Mr. R. Alimi at the computer center of University of New Hampshire. The data tapes are available to the research community on request from Vermont Department of Parks and Forests and from the Portsmouth Field Office, USDA Forest Service.

RESULTS

The results are presented in 3 parts:

1. The sugarbush, or stand
2. The condition of sugar maples
3. Major injuries of sugar maples

The Condition of Sugarbush or Stand

The sugarbush has had an average stocking of 95 trees per acre (Table 1). About two thirds of the trees are sugar maples. The other common species are hophornbeam, beech, red maple and yellow birch. About 1/2 of the sugar maples are less than 9 inches dbh (Table 2).

Full crown closure was found in 34 percent, partial closure in 55 percent, and open grown crown conditions in 11 percent of sample plots.

Signs of grazing were observed in 44 percent of sample plots. Light grazing was recorded in 23 percent sugarbushes, 10 percent with moderate, and 11 percent with heavy grazing.

Shallow soils, indicated by rock outcroppings, were found in 39 percent of sample plots. Soil disturbance caused by human activities, such as roads, and trails was recorded at 66 percent of sample plots.

Table 1 -- Composition of tree species (2 inches dbh and larger) in sugarbushes of Vermont, 1977 (91 sugarbushes).

Species	Average number trees/acre	Average percentage of trees
Sugar Maple	61.5	64.7
Hophornbeam	6.8	7.2
Beech	4.7	4.9
Red Maple	4.0	4.2
Yellow Birch	3.1	3.2
Hemlock	2.2	2.3
Spruce	1.9	2.0
Balsam Fir	1.0	1.1
Others (less than 1% each)	9.8	10.4
TOTAL	95.0	100.0

Table 2 -- Size of sugar maples in 91 sugarbushes of Vermont, 1977,

DBH CLASS (inches)	No. of Trees	Percentage of all trees	Accumulative Percentage
2	704	12.7	12.7
4	894	16.1	28.8
6	769	13.9	42.7
8	681	12.3	55.0
10	580	10.5	65.5
11	506	9.1	74.6
12	392	7.1	81.7
16	274	4.9	86.6
18	223	4.0	90.6
20	147	2.7	93.3
22+	376	6.8	100.0
TOTAL	5546	100.0	

Most of the sugarbushes were rated in excellent and good condition classes (29.5 and 58.5 percent, respectively). Obvious dieback, trees with one half of crown with dead branches, was found in 11 percent of bushes. These were rated in fair condition. Only one sugarbush (1.1 percent) was rated in poor condition because of abundance of dead and dying trees. For simplicity, the sugarbushes rated excellent and good were combined into a good condition class and bushes rated fair and poor were combined into poor condition class.

Table 3. Comparison of trees in various crown condition classes in good and poor rated sugarbushes of Vermont, 1977.

Crown condition class	Sugarbush condition class	
	Good	Poor
	Inches at dbh	Inches at dbh
Healthy	9.53 a	9.96 a
Fair	9.51 a	10.12 a
Poor	7.52 b	8.19 a
Dead	5.35	4.64 b
Ave. of all trees	9.34	9.67

Similar letters in a vertical column indicate no significant difference ($P = 0.05$).

The associations between stand conditions and adverse site treatments were evaluated. Increased severity in grazing appears to be associated with decreasing sugar bush vigor (Figure 1) but the association is weak statistically (Cramer's coeff. for assoc., is 0.2 on scale of 0-0.7, Chi, square signif. at 0.01).

Rock outcroppings were found in 60 percent of plots where stands were rated in poor condition but in only 40 percent of the plots in good condition stands. A weak association was found between stands in poor condition and rock outcroppings. ($\Phi = 0.15$ on scale of 0-1; Chi square significant at 0.01).

The poor condition stands tend to have lower stocking than the good condition stands (Figure 2). Again the association is weak (Cramer's coeff. of assoc. = 0.12 on scale of 0-0.7; Chi square significant at 0.05).

Many more site attributes were collected (see Exhibits A and B). However, no significant associations with poor stand conditions were found and further discussion is deleted.

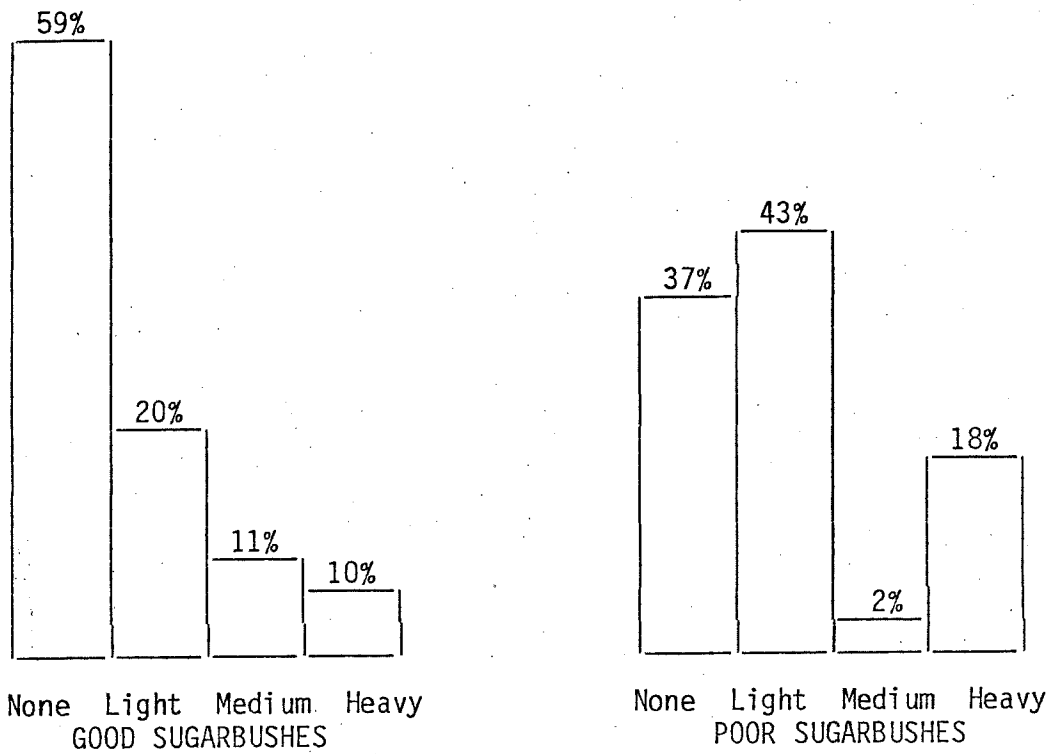


FIGURE 1. Percentages of plots with various degrees of grazing intensity in good (397 plots) and poor (54 plots) sugarbushes in Vermont, 1977

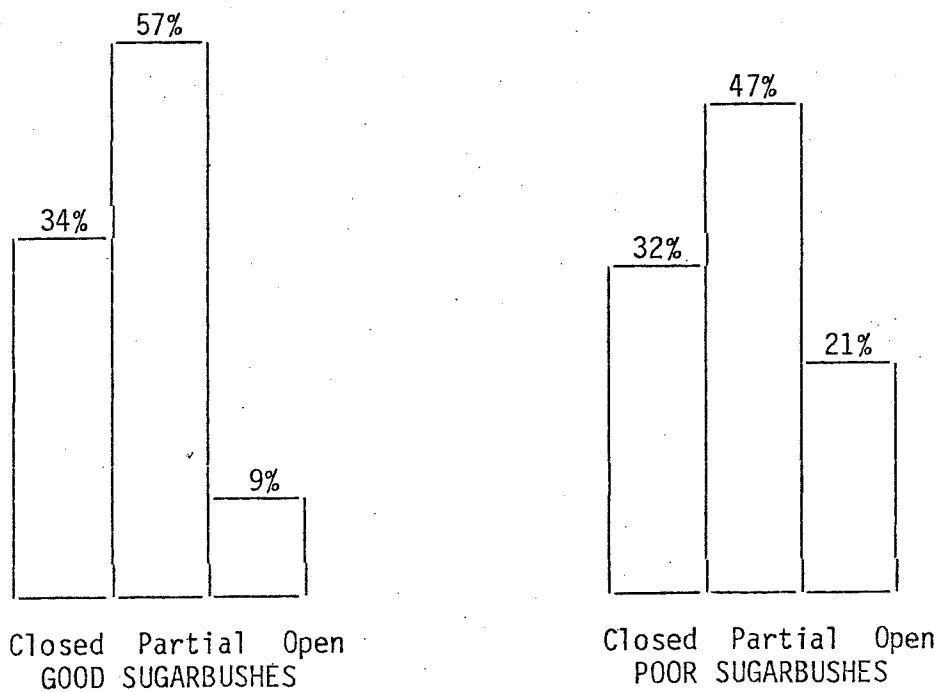


FIGURE 2 -- Distribution of crown closure classes of plots from good (395 plots) and poor (53 plots) condition rated sugarbushes in Vermont, 1977.

The Condition of Sugar Maples

The results are based on data collected from the 5546 sugar maples in 91 sugarbushes.

Most of the sugar maples, 77.2 percent, have healthy crowns. Some dieback, a few branches dead in a crown was found on 17 percent of maples. Poor crowns, more than one half of crown dead, was recorded for 2.3 percent of trees. Only 3.6 percent of maples were dead.

The proportion of small trees increases as the tree crown condition class declines (Figure 3). Forty percent of trees in the healthy and fair crowned class are under 5 inches dbh. Poor crowned tree class had 60 percent, and dead class trees had 82 percent under 5 inches dbh. However, when the average dbh of healthy sugarbushes is compared to poor bushes, the differences are not statistically significant ($P = 0.05$).

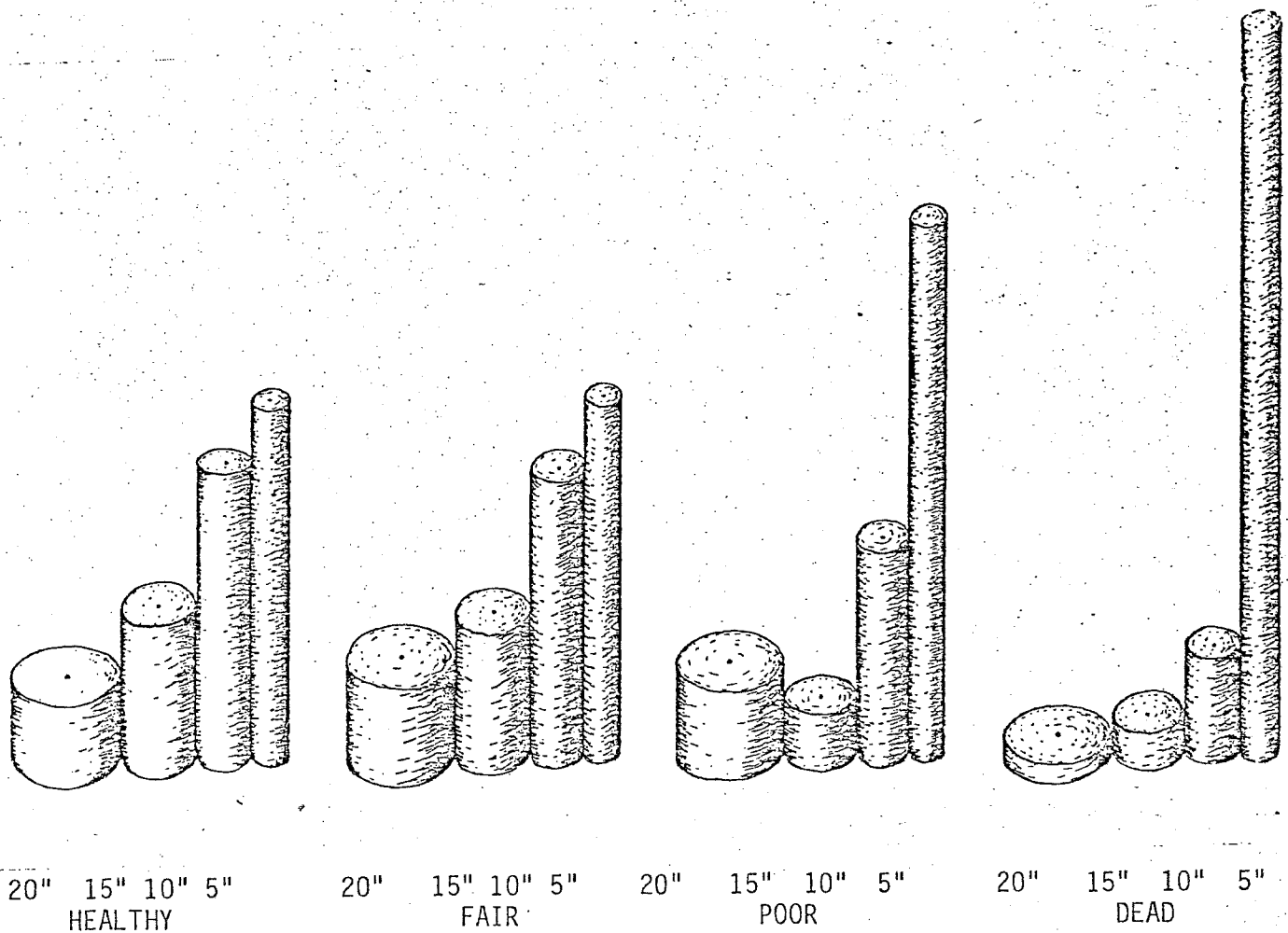


FIGURE 3. -- Distribution of tree diameters of sugar maples within 4 crown condition classes in Vermont sugarbushes (1977) (dbh classes of 5" = 2" - 6"; 10" = 8" - 12"; 15" = 14" - 18"; and 20" or larger).

The dead trees on the average were smaller at dbh than the healthy trees. Less than 1 percent of large trees, over 9 inches dbh, were dead. However, the average dbh of trees in subarbushes rated in good condition did not differ significantly from poor sugarbushes ($P = 0.05$).

About one half of the dead trees had died at least four years ago (Figure 4). Less trees had died during the previous year, than two years, or three years earlier. None of the trees dead in the poor rated sugarbushes had died during the last year. This indicates that either some sort of decline was present earlier, or the mortality evaluation scheme becomes less accurate with time after tree death.

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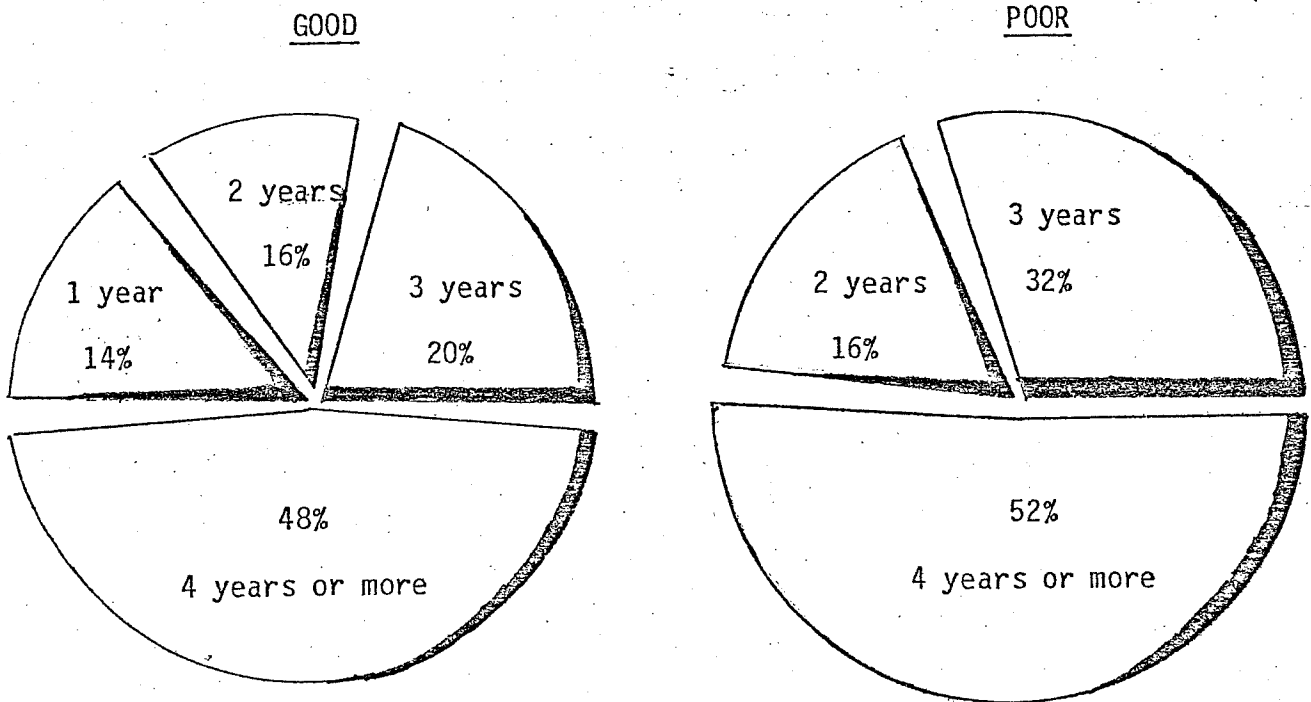


Figure 4. Comparison of sugar maple mortality classes (estimated years dead) between good and poor condition rated sugarbushes in Vermont, 1977.

Major Injury To Sugar Maples

Nearly all the sugar maples (96.1 percent) had some defoliation (Table 4). The next most common injury was stem rot, present on 29.5 percent of trees. The frequency of the following types of injury was between 10 and 20 percent: sugar maple borer, root collar rot, logging injury, and grazing damage. The frequency of injury was 10 percent or less of leaf damage (other than insect), leaf scorch, cankers, and animal damage (other than grazing). Statistical comparisons between good and poor condition sugarbushes for frequency of any one type of injury shows significant differences only for stem rot and leaf scorch (t test significant at alpha 0.05). Both were more common in bushes rated poor.

Good and poor sugarbushes had about an equal proportion of trees without defoliation (4 percent). Likewise, both groups had equal proportion of severely defoliated trees (10.7 percent and 11.2 percent, respectively). More trees had moderate defoliation in the "good" sugarbushes (19.0 percent) than in the "poor" (10.4 percent). Of course, lightly defoliated trees were in reverse order (74.4 percent in "poor" and 66.2 percent in "good"). These differences were significant statistically ($P = 0.05$).

Suppressed trees were more heavily defoliated than the trees in higher crown position (Table 5). Defoliation caused by maple leaf-cutter was the most common (Table 6). It was more abundant in good sugarbushes than in poor sugarbushes. The differences are significant statistically ($P = 0.05$).

Sugar maple borer injury was present on 22.3 percent of all dominant sugarmaples to 16.2 percent for intermediate and 7.7 percent for suppressed sugarmaples (Table 7). Sugar maple borer incidence on maples in poor sugarbushes was significantly higher than in good sugarbushes ($P = 0.05$). The differences are not great, and should be expected, because the more open stand conditions in the poor sugarbushes are more favorable for borer attack.

Table 4. Injury frequency found on sugar maples in Vermont Sugarbushes (1977).

Type of Damage	Sugarbush condition class		
	All	Good	Poor
Defoliation	96.1	96.0	96.1
Stem rot	29.5	28.4	37.8 ^{1/}
Sugar Maple borer	17.5	17.0	21.2 ^{1/}
Root collar rot	17.2	16.8	20.1
Logging	15.2	15.1	15.7
Grazing	14.1	14.2	12.8
Leaf damage	8.6	8.7	7.6
Leaf Scorch	8.2	7.4	14.6 ^{1/}
Cankers	8.2	8.0	9.7
Bird & animal	4.1	4.3	2.1

^{1/} t test shows that the difference between means in good and fair bushes is significant (alpha=0.05).

Table 5. Defoliation intensity within crown classes of sugar maples in Vermont sugarbushes, 1977.

Defoliation class	Crown class		
	Percent of trees		
	Dominant	Intermediate	Supressed
Absent (0)	3.8	4.0	3.9
Light (1-9%)	69.2	66.7	59.3
Moderate (10-50%)	19.1	19.6	17.3
Heavy (51-100%)	7.9	9.7	19.5

Table 6. Comparison of the proportion of defoliation caused by major defoliators of sugar maples in good and poor condition rated sugarbushes in Vermont, 1977.

Type of defoliators	Sugarbush condition class	
	Percent of trees	
	Good	Poor
Maple leaf-cutter	67.5	32.9
Leaf-roller	12.7	32.6
Large caterpillars	5.3	8.7
Misc. others	14.5	25.7

Table 7. Incidence of sugar maple borer injury in sugarbushes in Vermont, 1977.

Maple crown class	Sugarbush condition class		
	Percent of trees		
	All	Good	Poor
Dominant	22.3	21.3	29.7
Intermediate	16.2	16.3	14.9
Suppressed	7.7	8.0	5.3

About one half of the maples in the sugarbushes were tapped (Table 8). Current year tapping (in 1977) was 18.3 percent, of which about one third are being tapped heavier than recommended in the tapping guides. Nearly one third of maples had been tapped before, but not in 1977.

Table 8. Tapping history and wound recovery of maples in Vermont sugarbushes, 1977.

Tapping Record	Sugarbushes condition class		
	Percent of trees		
	All	Good	Poor
Not tapped	52.5	43.4	45.6
Tapped, ever	47.5	56.6	54.4
Tapped in 1977	18.3	17.7	23.0
Undertapped	13.9	14.6	9.5
Proper tapping	54.3	53.8	57.3
Overtapped	31.8	31.5	33.2
Tapped pre 1977 only	29.2	28.9	31.4
Closure rated poor	25.2	23.7	35.2

DISCUSSION

The field crews gave a poor stand condition rating to only one sugarbush out of the ninety-one examined. That sugarbush was known to have problems before the survey. Another ten sugarbushes were rated in fair condition because of the presence of some trees in the dominant crown position with symptoms similar to maple decline. These sugarbushes may represent future problems, but at the time of examination the maple decline was not severe.

The individual sugar maple data show a trend of decreasing dbh with decrease of crown condition class. This trend suggests that the crown condition is more likely affected by suppression rather than disease. Particularly, since the average dbh of fair and poor sugarbushes did not differ significantly from the average dbh of good sugarbushes.

The dead tree data show that about half of the trees died four or more years before the survey in 1977. The proportion of dead trees appears to decrease with years since death. This may be interpreted that tree mortality was more severe earlier. However, the errors in estimating year of death increases with the number of years that were rated dead four and more years include the accumulative mortality of several years.

The low correlations of site and injury factors thought to be causing decline of trees and sugarbush stands may be the result of small samples rather than lack of effects.

Tree and stand conditions found during the survey may be compared to those recommended for sugarbush management (Lancaster, et al, 1974). The average stocking of 91 trees per acre, of which only 70 trees were sugarmaples, appears to be low, particularly, since about one half of the trees are under 9 inches dbh. The number of tappable trees per acre is low and may reflect young sugarbushes or poor management. Many of the trees are tapped more severely than the guides recommend. However, since the overtapping appears to be equal between poor and good sugarbushes, it is not a likely cause for the tree decline.

REFERENCES

- Lancaster, K.F., R.S. Walters, F.M. Laing and R.T. Foulds.
1974. A silvicultural guide for developing a sugarbush. USDA
Forest Research Paper, No. NE-286, 11 p.

APPENDIX

EXHIBIT A

	Day	
	Month	
	Year	
	Plot Layout	
	County	
	Bush Number	
	Stand Condition	
	Problem Location	
	Plot Number	
	Slope	
	Aspect	
	Closure	
	Ground Cover	
	Outcropping	
	Disturbance	
	Sample	
	Mottled	

	Tree Number	
	Species	
	DBH	
	Crown Class	
	No. Years Dead	
	Logging	
	S.M. Borers	
	Cankers	
	Bird & Animal	
	Stem Rot	
	Defoliation	
	Defoliators	
	Leaf Scorch	
	Grazing	
	Root Collar Rot	
	Armillaria	
	Tapped	
	Severity	
	No Holes Open	
	No Holes Closed	
	Tap Hole Closure	
	Cored	
	Width of last 5 rings (mm)	
	Width of last 10 rings (mm)	

Exhibit B

Maple Decline Codes

PLOT LAYOUT 1 Line
 2 Group

County - Addison 1
 Bennington 2
 Caledonia 3
 Chittenden 4
 Essex 5
 Franklin 6
 Grand Isle 7
 Lamoille 8
 Orange 9
 Orleans 10
 Rutland 11
 Washington 12
 Windham 13
 Windsor 14

STAND CONDITION (Record last)
(Avoid suppressed trees)

- 1. Excellent - overall stand healthy
- 2. Good - some dieback but not alarming
- 3. Fair - obvious dieback present - a potential problem
- 4. Poor - serious dieback and death of trees

PROBLEM LOCATION

- 1. edge
- 2. pocket
- 3. scattered

PLOT DATA

SLOPE: degrees slope
 ASPECT: degrees azimuth
 CLOSURE: 0 open
 1 partially closed
 2 closed
 GRAZING 0 none
 1 light
 2 moderate
 3 heavy

SOIL - Outcrops 0 = absent
 1 = present
 Disturbance 0 = not disturbed
 1 = disturbed
 Sample 0 = not taken
 1 = taken
 Mottled 0 = not mottled
 1 = mottled

TREE DATA (2.0" DBH & up)

- Species
- 1. SM Sugar maple
 - 2. RM Red maple
 - 3. AP Striped maple
 - 4. YB Yellow birch
 - 5. WB White birch
 - 6. QA Aspen (poplar)
 - 7. WA White oak
 - 8. BE Beech
 - 9. BC Cherry
 - 10. AE Elm
 - 11. HY Hickory
 - 12. OK Oak
 - 13. IW Ironwood (Hophornbeam)
 - 14. HK Hemlock
 - 15. WP White pine
 - 16. BF Fir
 - 17. SP Spruce
 - 18. HD Hardwood
 - 19. CN Conifer

DBH: diameter at breast height to nearest 1/10 foot.

CROWN CLASS

- 1. Dominant/Codominant
- 2. Intermediate
- 3. Overtopped

Exhibit B (continued)

Maple Decline Codes

CROWN CONDITION

- 1. Healthy, foliage green, <10% dead crown branches, leaf size normal.
- 2. Fair health, foliage off-color, 10-50% dead crown branches, abnormal leaf size.
- 3. Poor health, foliage off-color, abnormal leaf size, >50% dead crown branches.
- 4. Dead, no foliage alive.

- Leaf Scorch: 0 or 1
- Leaf Damage: 0 or 1
- Grazing: 0 or 1
- Root Collar Rot: 0 or 1
- A. mellea: 0 = absent
1 = Rhizomorpha
2 = Mycelial Fans
3 = Mushrooms
4 = Combination

NUMBER OF YEARS DEAD

- 1. Fine twigs and buds present, bark tight.
- 2. Buds & some fine twigs gone, bark loosening.
- 3. Most fine twigs gone, bark loose & sloughing.
- 4. + All fine twigs gone, much or all bark sloughed.

- Tapping 0 = not tapped
1 = tapped
2 = tapped in 1977
- Severity 1 = less than recommended
2 = at recommended rate
3 = more than recommended rate

INJURIES

- 0 = absent
- 1 = present
- Logging: 0 or 1
- Sugar Maple Borer: 0 or 1
- Cankers: 0 or 1
- Birds/Animals: 0 or 1
- Stem Rot: 0 or 1
- Defoliation: 0 = absent
1 = less than 10%
2 = 10 - 50%
3 = >50%
- Defoliators: 0 = absent
1 = Maple Leaf Cutter
2 = Leaf Roller
3 = Tent Caterpillar or Gypsy Moth
4 = Other

RECOMMENDED RATES

DBH	No. of Tapholes
Less than 10"	0
10"-14"	1
15"-19"	2
20"-24"	3
25"+	4

No. Holes Open:

No. of Holes Closed:

- TAPHOLE Closure 1 - Poor closer
- 2 - Good closer

- CORED 0 - no increment core taken
- 1 - increment