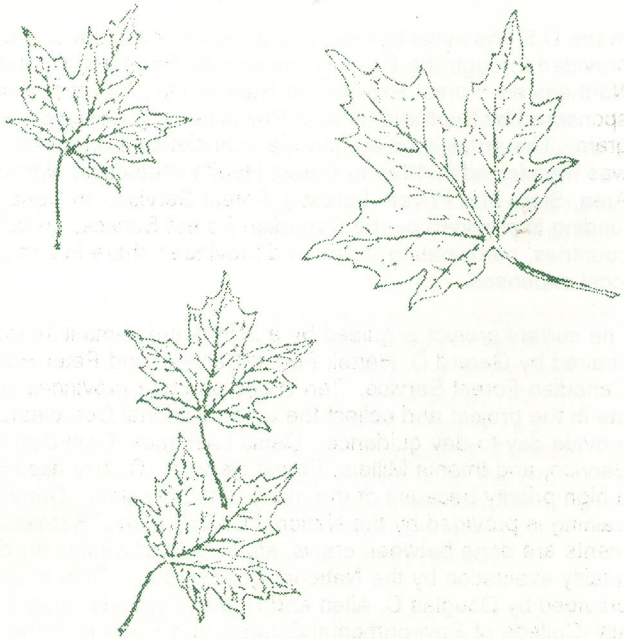
United States
Department of
Agriculture

Forest Service

Northeastern Area
State & Private Forestry

Canadian Forest Service
Service Canadian de Forêts

Sugar Maple Crowns in Good Condition in 1993



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Imants Millers[1], Douglas C. Allen[2], Denis Lachance[3], and Robert Cymbala[2]

[1]USDA Forest Service, Northeastern Area, State and Private Forestry, Forest Health Protection, Durham, New Hampshire.

[2]State University, College of Environmental Science and Forestry, Syracuse, New York.

[3]Canadian Forest Service, Forest Insect and Disease Survey, Sainte Foy, Quebec.

INTRODUCTION

During the late 1970's and throughout the 1980's, sugarbush managers and foresters who managed northern hardwood stands and the general public became concerned about maple decline. The problem was most severe in Quebec. A group of scientists recommended that a special project be designed to monitor and evaluate sugar maple condition, particularly in relation to air pollution and management for maple syrup production. In response to these concerns, the North American Sugar Maple Decline Project (NAMP) was formed in 1987 between Canada and the United States and authorized by a Memorandum Of Understanding and Special Project Agreement.

In the U.S. the initial funding and project administration was provided through the Eastern Hardwoods Research Cooperative, Northeastern Forest Experiment Station, USDA Forest Service, sponsored by the National Acid Precipitation Assessment Program. The administration and the financial support for the project was transferred in 1991 to Forest Health Protection, Northeastern Area, State and Private Forestry, Forest Service. In Canada, funding is provided by the Canadian Forest Service. In both countries, participating states and provinces share in some of the local expenses.

The current project is guided by a Joint Management Team co-chaired by Gerard D. Hertel, Forest Service, and Peter Hall, Canadian Forest Service. Ten states and four provinces cooperate in the project and collect the data. National Coordinators provide day-to-day guidance: Denis Lachance, Canadian Forest Service, and Imants Millers, Forest Service. Quality assurance is a high priority because of the many data collectors. Common training is provided by the National Coordinators. Remeasurements are done between crews, states and provinces for data quality evaluation by the National Coordinators. Data analysis is provided by Douglas C. Allen and Robert Cymbala, State University, College of Environmental Science and Forestry, Syracuse, New York.

OBJECTIVES

The objectives of the project are to determine:

1. the rate of change in sugar maple tree condition ratings.

2. if the rate of change in sugar maple tree condition ratings is different among:

   a. various levels of sulfate and nitrate wet deposition.
   b. sugarbush and non-sugarbush forests.
   c. various levels of initial stand decline conditions.

3. the possible causes of sugar maple decline and the geographical relationships between potential causes and extent of decline.

PLOT ESTABLISHMENT

The total number of plot-clusters has increased from 171 to 233 and three more states joined in 1992: Minnesota, Ohio, and Pennsylvania (Table 1). The monitoring area now extends from Minnesota and Ontario, south to Ohio and Pennsylvania, and east to Nova Scotia (Fig. 1).

Table 1. Distribution of plot-clusters in the North American Maple Project by state and province.

United States				Canada	
Maine	18	New York	27	New Brunswick	12
Massachusetts	10	Ohio	6	Nova Scotia	2
Michigan	24	Pennsylvania	10	Ontario	24
Minnesota	8	Vermont	40	Quebec	24
New Hampshire	10	Wisconsin	18		

Each plot-cluster consists of five 66 by 66 ft plots (20 by 20 m) located in a sugar maple stand estimated to be 50 to 150 years old. In most states and all the provinces, one-half of the plot-clusters are active sugarbushes and one-half are in non-sugarbush stands. Non-sugarbush stands selected in 1988 did not have any disturbance caused by management activity since 1983. Local regions selected the stands at various initial stand decline conditions. The region includes a variety of site conditions and covers most of the prime sugar maple growing areas. In 1988, annual sulfate wet deposition ranged from 9 to 31 lbs/ac (10 to 35 kg/ha), and annual nitrate wet deposition ranged from about 7 to 13 lbs/ac (8 to 15 kg/ha). Indications are that deposition has remained about the same through 1993, but more current information will be presented in the 5-year report in 1994.

The average sugarbush has 157 trees per acre (389 trees/ha), 77% of which are sugar maple, and the average tree diameter at

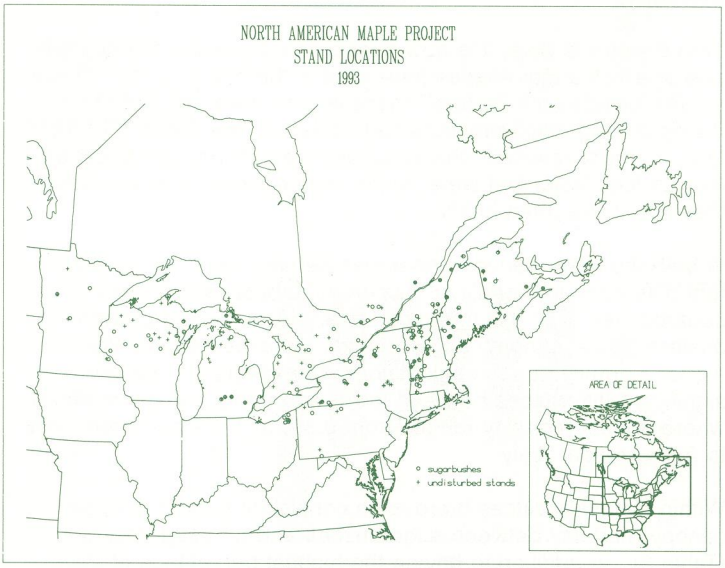


Figure 1.--Distribution of plot-clusters in the North American Sugar Maple Project.

breast height (dbh) is 10.4 in (26.4 cm). The non-sugarbush stands have an average of 194 trees per acre (479 trees/ha), 69% of which are sugar maples, with a slightly smaller average dbh of 9.6 in (24.4 cm). Average basal areas are 117.6 ft^2/ac (27.2 m^2/ha) and 119.5 ft^2 (27.3 m^2/ha) in sugarbush and non-sugarbush stands, respectively.

Observations in 1993 were made on about 20,200 live trees, of which approximately 66% or 14,600 are sugar maples. Sixty-six percent of the live sugar maples are in the dominant or codominant crown positions. The other more common species are American beech, yellow birch, red maple, and ash.

Sugar maple crowns are evaluated annually for dieback, foliage transparency, and insect defoliation. Annual visits are required, since the incidence of dieback and transparency are expected to fluctuate from year to year, probably as a result of individual tree response to changes in weather and site conditions. Insect defoliation is likely to occur in the spring and therefore two annual visits are required. Continued monitoring will reveal long-term trends in forest health and possibly identify changes due to many interacting factors such as, air pollution, defoliation, drought, or a combination of these.

Quality and consistency of data are assured through annual training and certification of field crews. At least 5% of crown ratings are remeasured to assess data quality. About 90% of remeasurements in 1988 fell within the prescribed standards. This improved to about 95% in 1989 and has remained at this level through 1993.

ANALYSIS

Even though 233 plot-clusters were examined in 1993 and are used to describe the condition of sugar maple, the evaluated change reported below is based on comparison of sugar maples in 165 plot-clusters only, which were established in 1988 and remeasured yearly through 1993. The plot-clusters established in 1988 had 14,679 live trees, of which 10,444 or 71% were sugar maple.

The results presented here are mostly based on the analyses of crown conditions for about 7,026 upper canopy sugar maples (dominant and codominant trees). Branch dieback in the upper crown is a disease condition caused by various stresses. For our purposes, up to 5% dieback is considered normal; 6% to 15% percent indicates moderate damage; and more than 15% dieback indicates severe damage. The abundance of foliage is another measure of tree vigor. It is measured as transparency; the amount of light coming through the crown. A transparency of 25% or less is normal and 26% to 55% indicates a moderately thin crown, and greater than 55% transparency indicates severe crown damage.

Pollution effects were analyzed by comparing 1990 averages of sulfate wet deposition from stands in high, moderate, and low zones (the analyses were not repeated for the 1993 data). These zones were identified from computer-generated maps based on annual sulfate wet deposition during the last decade. An analysis of pollution effects will be presented in the 5-year report. Foliage discoloration is also rated, but because the incidence was low, no analyses of this variable are presented.

SUGAR MAPLE CONDITIONS IN 1993 AND CHANGES SINCE 1988

Dieback

Dieback reflects general, long-term health of individual trees. The average plot-cluster dieback of upper canopy sugar maples in 1993 was 7% in sugarbushes and 6% in non-sugarbushes. Over 6 years this average changed by 3% or less for both sugarbushes and non-sugarbushes. An analysis of trees with high dieback provides a more sensitive indication of change.

The proportion of upper canopy sugar maples rated with severe dieback (more than 15%) in 1993 was 5.8% in sugarbushes and 3.5% in undisturbed stands (Fig. 2). This was a decrease from the 10.7% in sugarbushes and the 7.3% in non-sugarbushes recorded in 1988. The proportion with severe dieback is higher in sugarbushes each year, although there are no statistical differences between the two stand types.

Figures 3a-b compare the incidence of severe dieback between regions using all upper canopy sugar maples in 1993 (10,130 in all 233 plot-clusters). Vermont has the greatest percentage with significant dieback in both management categories.

With 6 years of data, it is possible to determine the long-term fate of trees with various initial conditions in 1988. Of 536 trees with moderately severe dieback (16-35%) in 1988, representing 8% of all upper canopy sugar maples, 72% improved (had less than 16% dieback) and 9% were dead in 1993 (Fig. 4). Of 140 trees with severe dieback (greater than 35%) in 1988, 28% improved and 49% were dead in 1993 (Fig. 5). Most of these trees were in Quebec and Vermont, where 41% and 53%, respectively, of trees rated with severe dieback died (Table 2). Other regions had a greater percentage of trees from this category dead in 1993, but sample sizes were 10 trees or less. For example, all 10 trees in the severe dieback class in New York died.

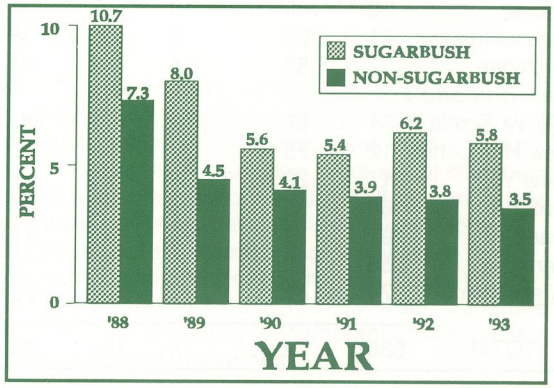
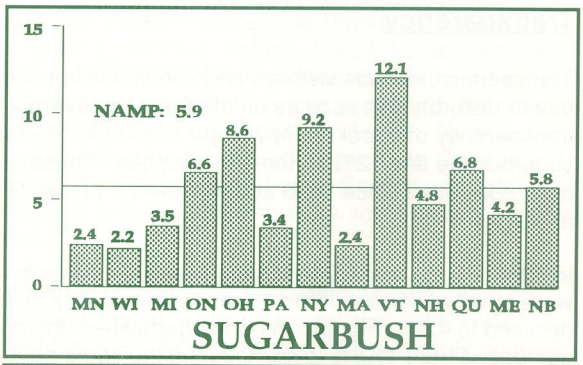


Figure 2.-- Percentage of sugar maples with severe dieback (>15%) in sugarbushes and non-sugarbushes (1988-1993).



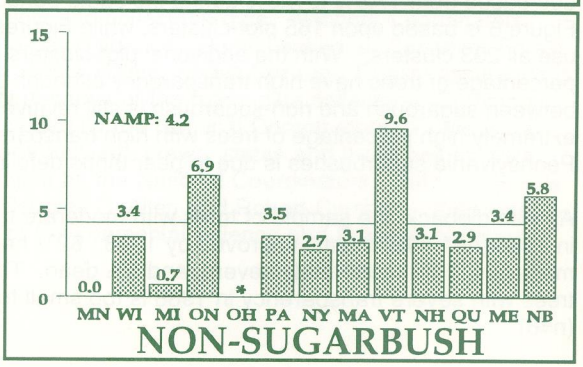


Figure 3.-- Percentage of sugar maples with severe dieback (>15%) by sugarbush (a) and non-sugarbush (b) stands for state/province in 1993. (*Note*: Ohio has only plot-clusters in sugarbush stands)

Table 2. Fate of upper canopy (dominant/codominant) sugar maples with moderately severe (16-35%) and severe (36%+) dieback in 1988 and their condition (healthy and dead only) 5 years later by state/province.

State/ Province	Condition in 1993 (based on dieback)					
	Moderately Severe (16-35%)			Severe (>35%)		
	n	Healthy%	Dead%	n	Healthy%	Dead%
Maine	26	69	19	7	0	71
Massachusetts	41	88	5		3	66
Michigan	17	82	6	2	50	50
New Brunswick/ Nova Scotia	34	82	12	5	40	20
New Hampshire	12	75	17	8	12	50
New York	17	29	29	10	0	100
Ontario	60	55	5	5	20	60
Quebec	97	75	10	59	41	41
Vermont	158	72	8	38	18	53
Wisconsin	74	81	7	3	66	33
TOTAL	536	72	9	140	28	49

Transparency

Transparency reflects visible stand conditions from year-to-year due to disturbances such as defoliation. The average plot-cluster transparency of upper canopy sugar maples in 1993 was 13% in sugarbushes and 12% in non-sugarbushes. These averages have been consistent since 1990 and are lower than the 1988 and 1989 averages.

In 1988, 21.3% of the upper canopy sugar maples in sugarbushes were rated with more than 25% transparency, but in 1993 this declined to 4.9% (Fig. 6). In non-sugarbushes, the percentage decreased from 17.8% to 4.9% during the same period (Fig. 6). Figure 6 is based upon 165 plot-clusters, while Figures 7a-b use all 233 clusters. With the additional plot-clusters, a greater percentage of trees have high transparency although the difference between sugarbush and non-sugarbush is still relatively small. The extremely high percentage of trees with high transparency in Pennsylvania sugarbushes is due to pear thrips defoliation.

As with dieback, the sample of trees with moderate transparency in 1988 (n=1,448) mostly improved by 1993: 82% healthy to moderate, 10% moderately severe, and 5% dead. The sample of trees with severe transparency in 1988 is too small to analyze (n=6).

Figure 4.-- Condition of upper canopy sugar maples in 1993 that had moderately severe dieback (16-35%) in 1988.

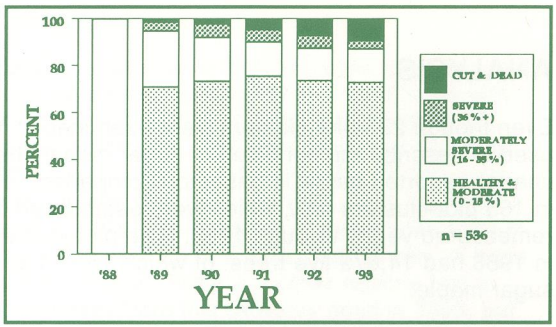


Figure 5.-- Condition of upper canopy sugar maples in 1993 that had severe dieback (>35%) in 1988.

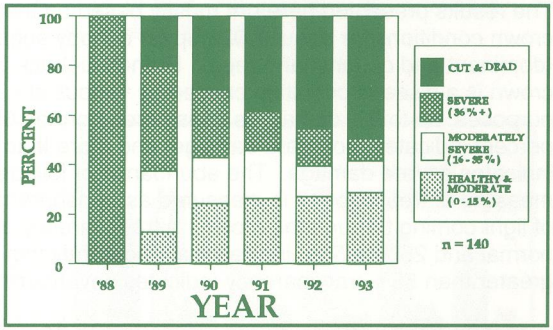


Figure 6.-- Percentage of sugar maples with high transparency (>25%) in sugarbushes and non-sugarbushes (1988 -1993).

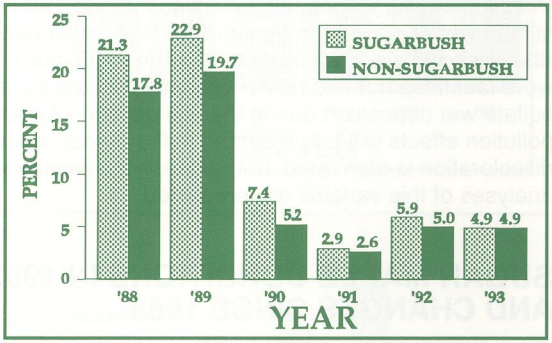
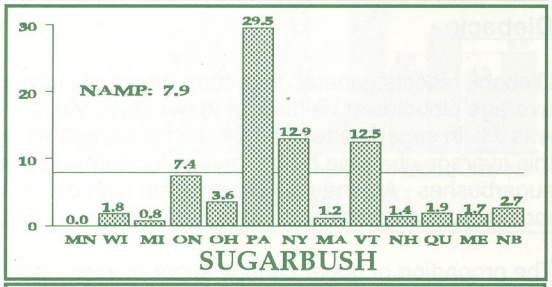
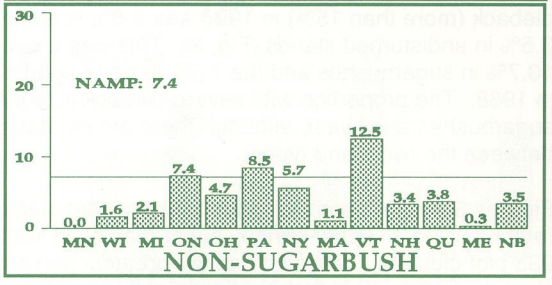


Figure 7.-- Percentage of sugar maples with high transparency (>25%) by sugarbush (a) and non-sugarbush (b) stands for state/province in 1993. (*Note:* Ohio has only plot-clusters in sugarbush stands)





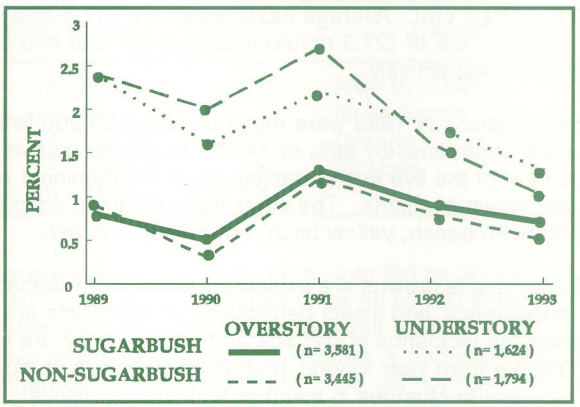
Mortality

With 6 years of data, it is now possible to determine the average rate at which sugar maples have died in the plot-clusters. These results include both "natural" mortality and trees cut or girdled during management practices regardless of tree health. Therefore, mortality results in this brochure are conservative because they include trees that were cut for management reasons though they may have been healthy.

In both the lower canopy and upper canopy, there is no consistent difference in mortality between sugarbushes and non-sugarbushes (Fig. 8). Intermediate and over-topped crown position (lower canopy) sugar maples are expected to have higher mortality due to competition. As expected, there are significant differences between lower and upper canopy mortality, where annual mortality ranges from 0.3% to 1.3% and from 1.0% to 2.7%, respectively.

Within states/provinces there is no consistent pattern in upper canopy mortality between sugarbushes and non-sugarbushes (Table 3). In addition to having the highest percentage of trees with high dieback (Fig. 3), Vermont plots had above average mortality. The high mortality in New York sugarbushes is partially explained by an ice storm in one plot-cluster. Otherwise, no significant pattern in average annual mortality appears between states and provinces.

Figure 8.-- Average annual mortality of upper canopy sugar maples by stand management class and all sugar maples (1989-1993).



DISCUSSION

More than 90% of the sugar maples on all of the plot-clusters are considered healthy. Approximately 86% of the sugar maples with more than 50% dieback had major trunk and root damage.

The condition of sugar maples in stands managed for sap production was virtually identical to the condition observed in non-sugarbushes. There are more sugar maples with high dieback in sugarbushes.

Table 3. Average annual mortality of upper canopy sugar maples and all sugar maples in the North American Maple Project by state/province and management type from 1988 to 1993.

State/ Province	No. trees live in 1988	Upper canopy annual mortality		No. trees live in 1993	Average annual mortality (all trees)
		sugarbush %	non-sugarbush %		%
Maine	1,179	0.8	0.5	1,120	1.0
Massachusetts	627	0.7	1.0	587	1.3
Michigan	276	1.1	0.6	261	1.1
New Brunswick/ Nova Scotia	960	0.3	0.4	939	0.4
New Hampshire	379	0.7	1.1	349	2.0
New York	1,083	1.8	0.2	1,014	1.3
Ontario	1,359	0.5	1.0	1,286	1.1
Quebec	1,879	1.0	0.6	1,772	1.2
Vermont	1,641	1.3	1.5	1,497	1.8
Wisconsin	1,061	0.5	0.2	1,033	0.5
TOTAL	10,444	0.8	0.7	9,858	1.2

Most of the crown condition improvements between 1988 and 1993 are associated with decreased damage from pear thrips in Vermont and Massachusetts, forest tent caterpillar and maple webworm in New York, forest tent caterpillar in northern Ontario, and recovery from severe drought in 1987 through 1989 (with 1988 as the worst year) in Michigan and Wisconsin.

Although crown conditions improved in Massachusetts and Vermont between 1988 and 1992, an increase in pear thrips damage in 1992 caused a slight decrease in crown vigor between 1992 and 1993.

CONCLUSIONS

The following conclusions are based on the results from the North American Maple Project plot-cluster data collected since 1988:

- Overall, sugar maple in the NAMP sites is in good condition.
- Sugar maple health is similar between sugarbush and non-sugarbush stands.
- Insect defoliation and drought adversely affected sugar maple crown condition in some local areas.
- Sugar maple mortality is 1.2% per year and this rate can be explained by "natural" mortality and healthy trees removed for management purposes.

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