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ABSTRACT

Forest health monitoring activities carried out in the Maritimes by the Forest Insect and Disease Survey in 1993 are described and results are presented. The Acid Rain National Early Warning System (ARNEWS) is described and information is provided on the condition of and factors affecting 14 major tree species. Changes in the condition of sugar maple and the status of maples in the Maritimes relative to maple throughout the northeastern part of the continent is described through the North American Sugar Maple Decline Project (NAMP). The status of white birch along the Bay of Fundy and of white spruce near Loch Katrine, Antigonish County, Nova Scotia are described.

RÉSUMÉ

On trouvera dans ce rapport une description des activités de surveillance de l'état de santé des forêts menées dans les Maritimes par les responsables du Relevé des insectes et des maladies des arbres (RIMA) en 1993 et la présentation des résultats obtenus. Ses auteurs décrivent le Dispositif national d'alerte rapide pour les pluies acides (DNARPA) et fournissent des précisions sur la situation des 14 principales essences forestières et les facteurs qui les affectent. Le Projet canado-américain d'étude du dépérissement de l'érable porte sur les changements intervenus dans l'état de l'érable à sucre et dans la situation des érables des Maritimes par rapport aux érables de tout le nord-est du continent nord-américain. Il décrit également l'état du bouleau blanc le long de la baie de Fundy et de l'épinette blanche près de Loch Katrine, comté d'Antigonish (Nouvelle-Écosse).

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INTRODUCTION

Monitoring and regular reporting on the health of Canada's forest ecosystem is explicit in the mandate of the Canadian Forest Service (CFS) of Natural Resources Canada. Forest health assessments have been an integral part of the activities of the Forest Insect and Disease Survey (FIDS) since its establishment in 1936. Forest health monitoring was expressly mandated to FIDS only in 1984.

A Canadian network for forest health monitoring began in 1984 with the Acid Rain National Early Warning System (ARNEWS), established in response to widespread forest destruction in Europe and concern in North America (Hall and Addison, 1991). In 1988, the North American Sugar Maple Decline Project (NAMP) was implemented as an international cooperative project between Canada and the United States to monitor changes in the health of sugar maple in the northeastern part of the continent, in response to considerable tree mortality in Quebec (Allen *et al.* 1992).

In the Maritimes, predating the national networks, white birch plots were established in 1982 adjacent to the Bay of Fundy in New Brunswick and Nova Scotia to monitor changes in tree condition caused by a then unidentified air pollutant (Magasi, 1989b). An unexplained disorder of white spruce prompted the establishment of monitoring plots near Loch Katrine, Antigonish County, Nova Scotia in 1990 (Magasi, 1991).

In the past, regional forest health monitoring activities and results were reported as part of annual FIDS reports on forest pest conditions, national and international reports, or special publications. Issues such as environmental concerns, biodiversity, and forest ecosystem management have emphasized the need for detailed, regional information on the health of the Maritime forest ecosystem.

This report brings together forest health monitoring activities carried out by FIDS in the Maritimes in 1993 and describes results on a regional basis. It provides relevant information for the benefit of those concerned with the state of the forests in the Atlantic Maritime Ecozone.

ACID RAIN NATIONAL EARLY WARNING SYSTEM (ARNEWS)

The Acid Rain National Early Warning System (ARNEWS) is Canada's national forest health monitoring program. Established in 1984, ARNEWS was "to monitor the condition and changes in the condition of the forest in order to detect early signs of acid rain damage". The program has always gone beyond its original intent of an acid rain monitoring system to encompass an expanded role in forest health and biomonitoring. In recognition of this, the original network of some 100 plots across Canada was expanded to about 150 plots in 1993. Hall and Addison (1991) provide a detailed description of the ARNEWS program on the national scale.

There are 24 ARNEWS plots in the Maritimes. They are visited several times a year to determine forest insect and disease conditions; detect acid rain and other air pollution symptoms; observe seed crops, premature change in foliage coloration; and collect ground vegetation samples. In August, after a quality assurance training session for all field staff, detailed assessments of all plots are carried out following the procedures developed by the Maritimes FIDS unit for the national system (Magasi, 1988). In 1993, these procedures, in use from 1984 to 1992, were revised to support a continuing commitment to biomonitoring (D'Eon *et al.* 1994).

Maritimes ARNEWS Plots in 1993

Location and basic description — Fifteen of the 24 ARNEWS plots in the Maritimes were established in 1984, two were added in 1985, and seven more in 1993 (Fig. 1). There are 12 ARNEWS plots in New Brunswick, ten in Nova Scotia, and two in Prince Edward Island, in proportion to the total forest land in the three provinces. Some of the basic parameters of ARNEWS plots 201-215 have been described by Magasi (1986), and those of ARNEWS plots 216 and 217 by D'Eon and Power (1989). Selected parameters for ARNEWS plots 218-224, established in 1993, are presented in Table 1.

Table 1 Selected parameters of the plots established in 1993

ARNEWS Plot No.	Plot location (U.T.M. Grid)	Number of trees Living	Number of trees Dead	Species composition* %	Ecoregion**
218	Nine Mile West Road Gloucester Co., N.B. 20-27(7)-525(3)	60	5	tA - 91 bPo - 5 lA - 2 wB - 1	Southern Uplands; Jacket River District of Restigouche-Bras d'Or ecoregion (sM-H-P-zone); Northern New Brunswick Highlands.
219	Pocowogamis York Co., N.B. 19-60(7)-508(4)	49	0	sM - 51 Be - 27 bF - 14 wB - 4 yB - 4	Carleton; Carleton Distr. of St. John River ecoregion (sM-As zone); Saint John River Valley.
220	Richmond Prince Co., P.E.I. 20-42(2)-514(8)	57	9	wB - 58 Be - 17 sM - 14 bF - 5 S - 4 wS - 2	Prince Edward Island; Northumberland Shore Distr. of Prince Edward Island ecoregion (rS-H-P zone); Prince Edward Island.
221	McDonald Lake Halifax Co., N.S. 20-52(4)-500(0)	74	0	rS - 57 bF - 43	Central Lowlands; border of Musquodoboit distr. of Central Uplands and Sheet Harbour Distr. of Maritimes Lowlands ecoregion (sM-yB-F vs rS-H-P zone); South- central Nova Scotia Uplands.
222	Cape Breton Highlands National Park (Neils Harbour) 20-70(0)-518(9)	53	1	rM - 68 wB - 26 yB - 2 bF - 2 wS - 2	Cape Breton-Antigonish; Guysborough-Bras d'Or Distr. of Restigouche-Bras d'Or ecoregion (sM-H-P zone); Cape Breton Highlands. Atlantic Uplands;
223	South Range Digby Co., N.S. 20-28(2)-493(5)	32	0	rM - 34 wB - 28 yB - 19 rS - 19	Wentworth Lake Distr. of Clyde River-Halifax ecoregions (rS-H-P zone); Southwest Nova Scotia Uplands.
224	Fundy National Park (East Branch Trail) Albert Co., N.B. 20-33(3)-505(5)	37	5	rM - 54 rS - 35 sM - 5 wB - 3 yB - 3	Fundy Coast; Fundy Mountain Distr. of Maritime Uplands ecoregion (sM-yB-F zone); Fundy Coast.

* percent based on total living trees on plot; standard FIDS tree abbreviation

** first line based on Rowe (1972), second entry based on Loucks (1962), third entry based on Environment Canada ecozones and ecoregions May (1993).

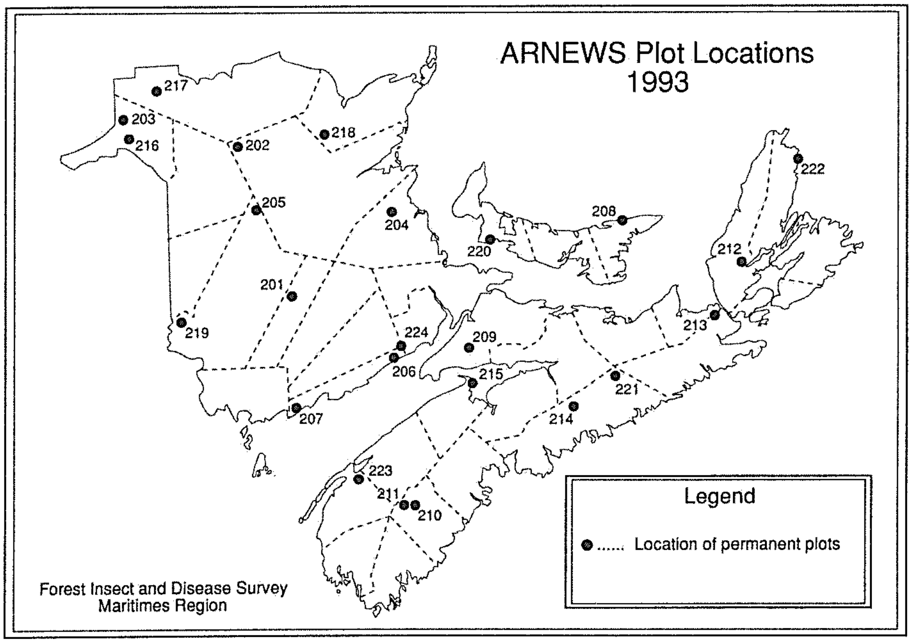


Figure 1. ARNEWS plot locations in the Maritimes

Ecoregion distribution — The entire area of the Maritimes lies within the Atlantic Maritime Ecozone, divided into 12 ecoregions (Rowe, 1972). There are plots located in all but four of these. Those ecoregions not represented by ARNEWS plots are the Cape Breton Plateau, the Cobequid Ecoregion in Nova Scotia and the coastal ecoregions South Atlantic Shore and East Atlantic Shore. The Cape Breton Plateau was purposely omitted in 1984 because a recent spruce budworm outbreak left the area devastated with no suitable ARNEWS site.

There are four plots in the Fundy Coast ecoregion, three in New Brunswick, one in Nova Scotia. The preponderance of plots there is due to the fact that this area received the highest pollution loading in the Maritimes at the time of network establishment in 1984 — one of the establishment criteria. Plot 224 ensures that the hardwood and softwood components are well represented in the Fundy Model Forest and that the Fundy National Park's ecosystem monitoring program is supported.

Stand composition — The distribution of ARNEWS plots in the four major forest stand types in 1993 is shown in Table 2. Stand dynamics played a role in changing the composition on one of the plots (216) between its establishment in 1985 and 1990. Mortality of a few conifers and in-growth of a few hardwoods changed the stand from a softwood (80%+ conifer) to a softwood-hardwood type (50-80% conifer).

Tree species in the ARNEWS system — There are 1430 trees on the 24 ARNEWS plots in the Maritimes, representing 19 species and red x black spruce hybrids (Table 3). The condition of

Table 2. Stand type distribution of ARNEWS plots in the Maritimes

Stand type	N.B.	N.S.	P.E.I.	Regional total
softwood	5	6	-	11
softwood/hardwood	2	2	1	5
hardwood/softwood	2	-	-	2
hardwood	3	2	1	6

Table 3. Tree species in the ARNEWS system and their distribution

Tree species	Number of trees	Number of plots on which present	ten or more trees
Balsam fir	368	16	9
Red spruce	236	10	8
White birch	151	15	5
Red maple	137	12	5
Trembling aspen	83	2	2
White spruce	79	8	4
Sugar maple	67	4	2
Jack pine	64	1	1
Black spruce	60	3	2
Spruce hybrid	53	3	1
White pine	37	2	1
Larch (Tamarack)	33	2	1
Beech	25	2	2
Yellow birch	22	8	-
Hemlock	4	1	-
Largetooth aspen	3	2	-
Balsam poplar	3	1	-
Ash	3	1	-
Wire birch	1	1	-
Black cherry	1	1	-

the 14 species, represented by more than ten trees in the system, is discussed in this report.

The number of species per plot varies from one to six, with nine of the plots having at least four species. The only single species plot is in a white pine stand in southwestern Nova Scotia (plot 211), established in 1984 because white pine has been reported to be sensitive to air pollutants. Two plots with six species each are both in Prince Edward Island.

Monitoring forest health requires proportional representation of tree species in relation to the total forest inventory. Table 4 shows the difference between ARNEWS tree population and forest inventory on a regional basis.

Soil and foliage chemistry — Foliage and soil samples are collected and analyzed on a 5-year cycle in accordance with standardized procedures (Morrison in Magasi, 1988). Two cycles have been completed for the original 17 ARNEWS plots in the Maritimes. The results, including comparison of the two sets of data, are to be reported (Fournier and Morrison, *in prep.*). In 1993, foliage and soil samples were collected and soil profiles were described on the seven new plots (218-224). Samples are being processed by the CFS-Maritimes Analytical Laboratory. Results will be reported.

Tree growth and age determination — Increment cores are obtained from representative trees to determine the average age and the growth pattern of the various species on plots. In 1993 (for some plots in late 1992), increment cores were collected by FIDS staff. The analysis of the results will be available later.

Tree condition — The condition of all trees is assessed on an annual basis. Data are computerized and summarized nationally at the Petawawa National Forestry Institute (PNFI) then analyzed in the region. Tree condition assessment is based on a combination of the level of defoliation and the presence and degree of twig and branch dieback, and is expressed in a numerical system (Magasi, 1988, D'Eon *et al.* 1994). Table 5 summarizes tree condition classes, codes, and the descriptions of tree conditions used in this report.

Foliar damage — The condition of the foliage is one of the major contributing factors to the health of a tree, in both the short and the long term.

Table 4. Variation between the Maritimes forest inventory and the ARNEWS tree population in 1993 for the major forest species.

Tree species group	% in inventory	% in ARNEWS
CONIFERS		
Spruces	31	30
Balsam fir	20	26
Pines	4	7
Hemlock	2	<1 (.3)
Larch (tamarack)	1	2
Other conifers	5	-
HARDWOODS		
Maples	17	14
Birches	10	12
Trembling aspen	6	6
Other hardwoods	4	3

Table 5. Tree condition classification system.

Class	Code	Description
		Coniferous species
Healthy	01	No defoliation
	02	Only current defoliation, total defoliation less than 25%
	03	Current and/or some older defoliation, total less than 25%
Weak	04	25-50% total defoliation
Poor	05	51-75% total defoliation
	06	76-90% total defoliation
Dying	07	More than 90% total defoliation
Dead	08	Dead
		Deciduous species
Healthy	10	Full complement of foliage, tree is without any visible outer crown damage
	20	Foliage thin, off-color. No dead branches present or bare twigs visible
	30	No dead branches present. Bare twigs may occur at the end of branches, usually in the top of the crown and about 0.5 to 1 m from the perimeter of the crown. Bare twigs present in up to 5% of thecrown
	35	No dead branches present. Bare twigs present in more than 6% of the crown
Weak	40	Dead branches and bare twigs present in up to 15% of the crown
	45	Dead branches and bare twigs present in 16 to 25% of the crown
Poor	50	Dead branches and bare twigs present in 26 to 37% of the crown
	55	Dead branches and bare twigs present in 38 to 50% of the crown
	60	Dead branches and bare twigs present in 51 to 75% of the crown
	65	Dead branches and bare twigs present in more than 76% of the crown
Dying	70	More than 50% of the crown dead. Only small adventitious branches present, usually at the base of the crown or stem
Dead	08	Dead

Foliage is affected by insects, diseases, air pollutants (the detection of damage by these being one of the major objectives of the program), and a wide variety of other abiotic conditions. Foliar damage is determined annually for each tree and the amount of damage is assessed for each type.

In 1993, the regional average of foliar damage was low for all tree species, although damage varied among plots. Most of the damage was nil or trace. Light damage (the highest 7.9% of foliage affected) was recorded on balsam fir, larch, sugar maple, white birch, yellow birch, and beech and all foliar damage in the light category was caused by insects. A summary of regional averages of foliar damage by the three categories of causal agents is presented in Table 6, variation among plots is discussed under the various tree species.

Table 6. Average foliar damage on the various tree species in the Maritimes in 1993

	Foliage damage by various agents (%)		
Species	**Insects**	**Diseases**	**Abiotic causes**
Conifers			
Balsam fir	7.5	0.2	4.0
Black spruce	0	1.1	0.2
Red spruce	3.5	0.2	1.0
White spruce	3.4	0.9	0.3
Spruce(hybrid)	2.2	2.2	0.4
Jack pine	3.0	0	1.0
White pine	2.5	0	0.1
Larch	5.8	0	1.8
Hardwoods			
Beech	7.9	1.8	0
Red maple	4.8	3.5	1.4
Sugar maple	6.2	3.0	0.2
Trembling aspen	4.8	1.4	0
White birch	5.5	3.8	1.5
Yellow birch	7.8	2.0	1.4

THE HEALTH OF THE FORESTS IN THE MARITIMES IN 1993

This section provides summarized information on the 14 tree species represented by more than ten trees on the 24 ARNEWS plots. For each species the description includes:

* tree condition status in 1993 with comments on variation between plots; tree mortality in 1993 and cause of death;

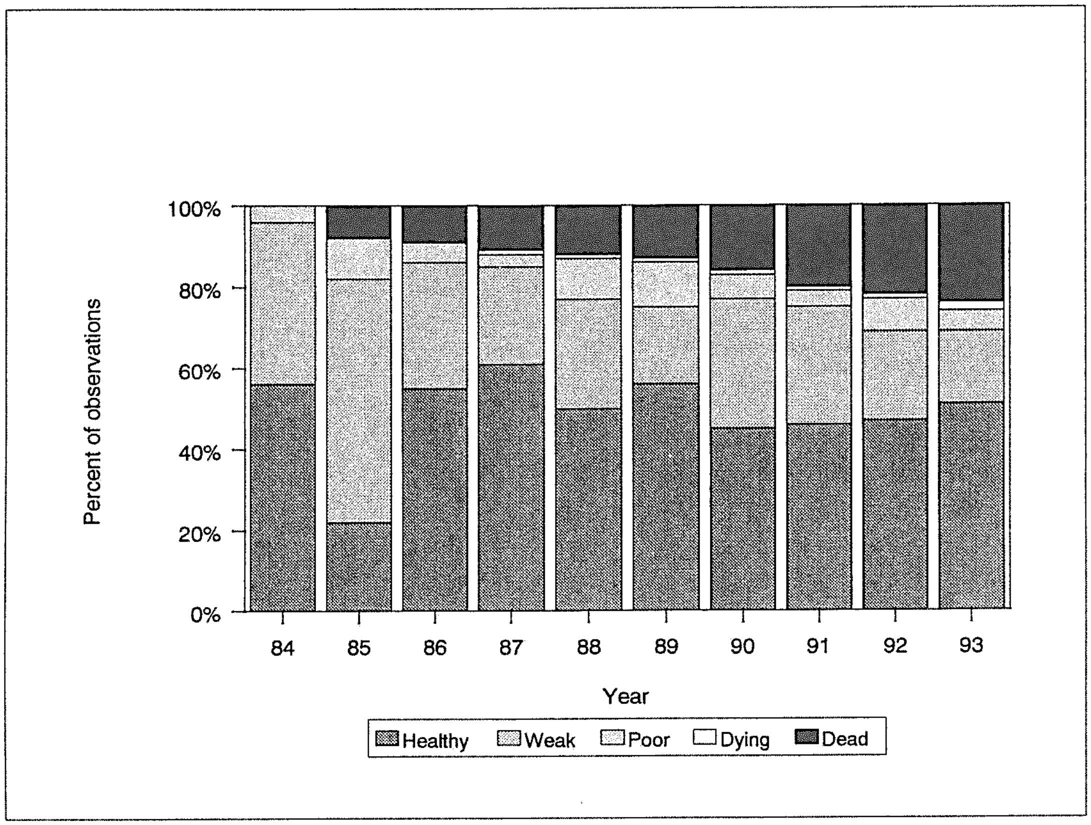
* changes in tree condition since the beginning of the program and the average annual tree mortality for the species;

* foliar damage in 1993.

Changes in tree condition since the beginning of the program are presented graphically for each species. The reader is referred to Table 5 for the description of tree condition classes and to Figure 1 for the location of the individual plots.

Average annual mortality rate figures are based only on trees on the original 17 plots at the time of plot establishment. Thus, these figures present a worst-case scenario because in-growth, determined in 1990, is not considered. Trees on the "new" plots are also not considered. As 1993 was the first year of assessment, no mortality rate can be calculated for them.

BALSAM FIR



In 1993, half of the trees (51%) were healthy, almost a fifth (18%) were weak, a few (5%) poor, and more than a quarter (26%) were dead or dying. The condition of balsam fir varied greatly among plots and ranged from very good (*e.g.*, plot 221, where almost 80% of the trees were healthy) to very poor (*e.g.*, plot 213, where more than half of the trees (58%) were dead). The variation in tree condition and the history of change on various plots is closely tied to the history of spruce budworm outbreaks.

There was a devastating spruce budworm outbreak in eastern Nova Scotia, culminating in the early 1980s. A third or more of the trees are dead on plots 212 and 213. Significant mortality occurred in the early years of the program then, although trees are still dying, the rate of mortality has slowed down. An outbreak in northern New Brunswick in the mid- to late 1980s started to affect balsam fir seriously by 1989, when mortality surpassed the 10% level on plots 202, 216, and 217 (still less than one third of the mortality already present on the Nova Scotia plots). Since then, mortality has increased gradually and by 1993 had reached 36% on plot 202, with the longest history of repeated defoliation.

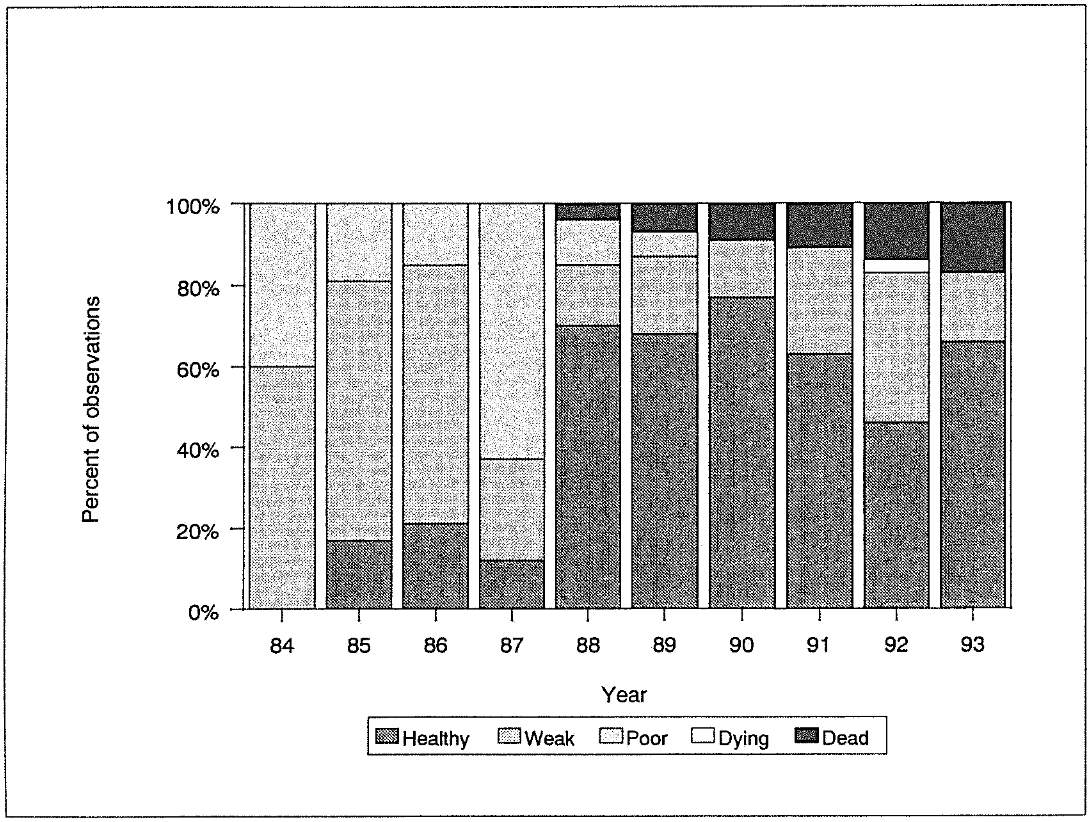
On two plots without a history of spruce budworm outbreaks (210, 221), there were no dead trees and only two of 48 trees were in poor condition in 1993. An exception to the spruce budworm scenario is present in central mainland Nova Scotia (plot 214). A third of the trees died there during the past 4 years, while the proportion of healthy trees remained unchanged at 44%. The cause of this anomaly is as yet unknown.

Eight trees died in 1993. The mortality occurred on four different plots (202, 209, 213, 214). The trees represented all four crown classes (from dominant to suppressed). Six of the trees have been deteriorating in the past 3 years and all six were attacked by either Armillaria root rot (*Armillaria mellea*) or sawyer beetle (*Monochamus* sp.) or both. The other two trees, both on plot 213, were healthy as recently as 1992 but were blown down this year. At least one of them was infected by Armillaria root rot.

The condition of balsam fir, in terms of the proportion of healthy trees, has been largely unchanged throughout the program. Healthy trees comprise about half of the balsam fir (with some fluctuation between stressed and weak trees). The big change in tree condition is in the steadily increasing tree mortality rate, as suppressed and insect-weakened trees succumb to secondary organisms or blowdown. The average annual mortality of balsam fir between 1984 and 1993 was 2.6%.

Foliar damage by insects, diseases or abiotic causes was light or only trace in 1993 (Table 6). Among insects, spruce budworm (*Choristuneura fumiferana*) caused up to 20% defoliation on the northern New Brunswick plots (202 and 217) and balsam gall midge (*Paradiplosis tumifex*) affected 5% of the needles in western Nova Scotia (plot 210). The amount of foliage browning due to abiotic causes (most likely wind damage) was more than twice that observed in 1992, most of it on the eastern Nova Scotia plots (212, 213, 214). As much as 30% of the needles were affected on plot 213. Some flecking was observed on needles on plot 212.

BLACK SPRUCE

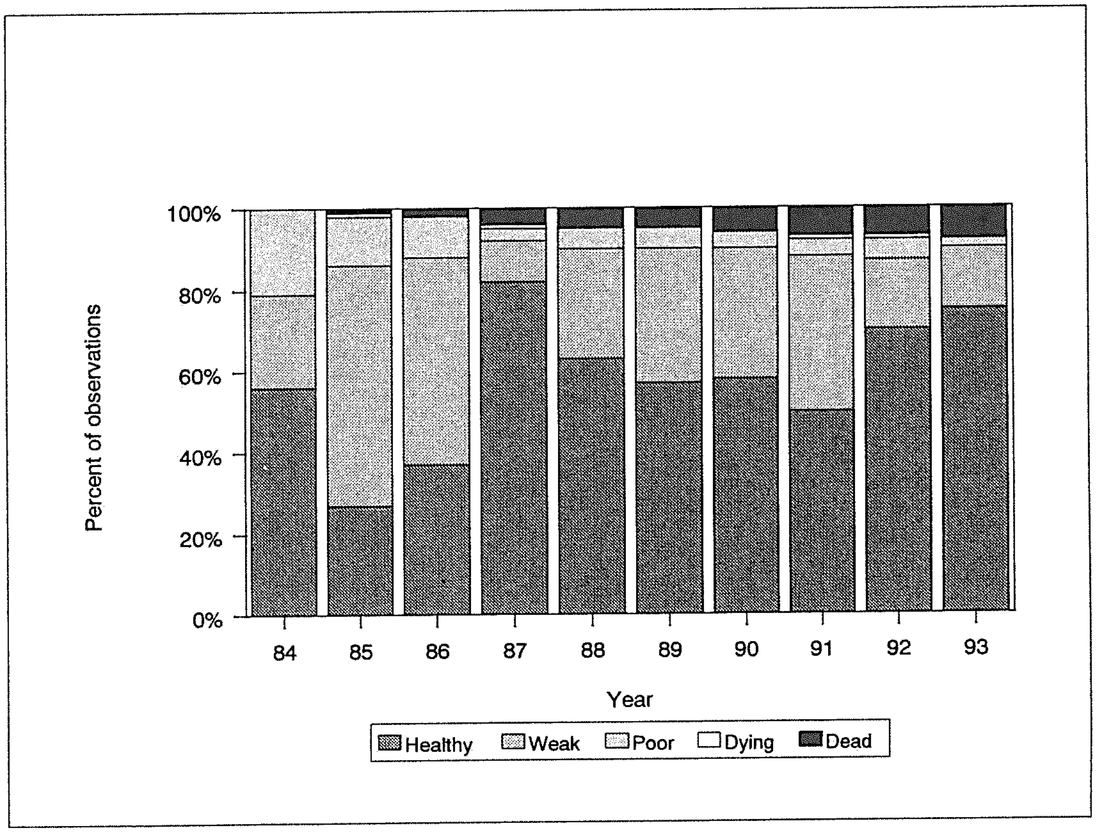


In 1993, two thirds (66%) of the trees were healthy, about a fifth (17%) were weak, and another fifth (17%) were dead, although no trees died in 1993. There has been a consistent difference in tree condition observed on the two plots in New Brunswick where black spruce is a major component. All of the living trees are healthy in the southern New Brunswick plot (207) while close to one half of the living trees are weak in the central New Brunswick plot (201). Tree mortality is the same on both plots. In 1993, there was some improvement on plot 201 as the number of weak trees decreased to about one third.

The condition of black spruce improved over 1992 conditions; however, there has been a slow, gradual, overall deterioration in the situation since 1988. Tree mortality is increasing, the number of vigorous trees is decreasing and, in spite of annual fluctuation, the trend is downward. On the other hand, the situation is still significantly better than it was prior to 1988 when trees were in very poor shape (probably as an aftermath of a spruce budworm outbreak). The average annual mortality of black spruce between 1984 and 1993 was 1.9%.

Foliar damage by insects, diseases or abiotic causes was minimal in 1993 (Table 6).

RED SPRUCE

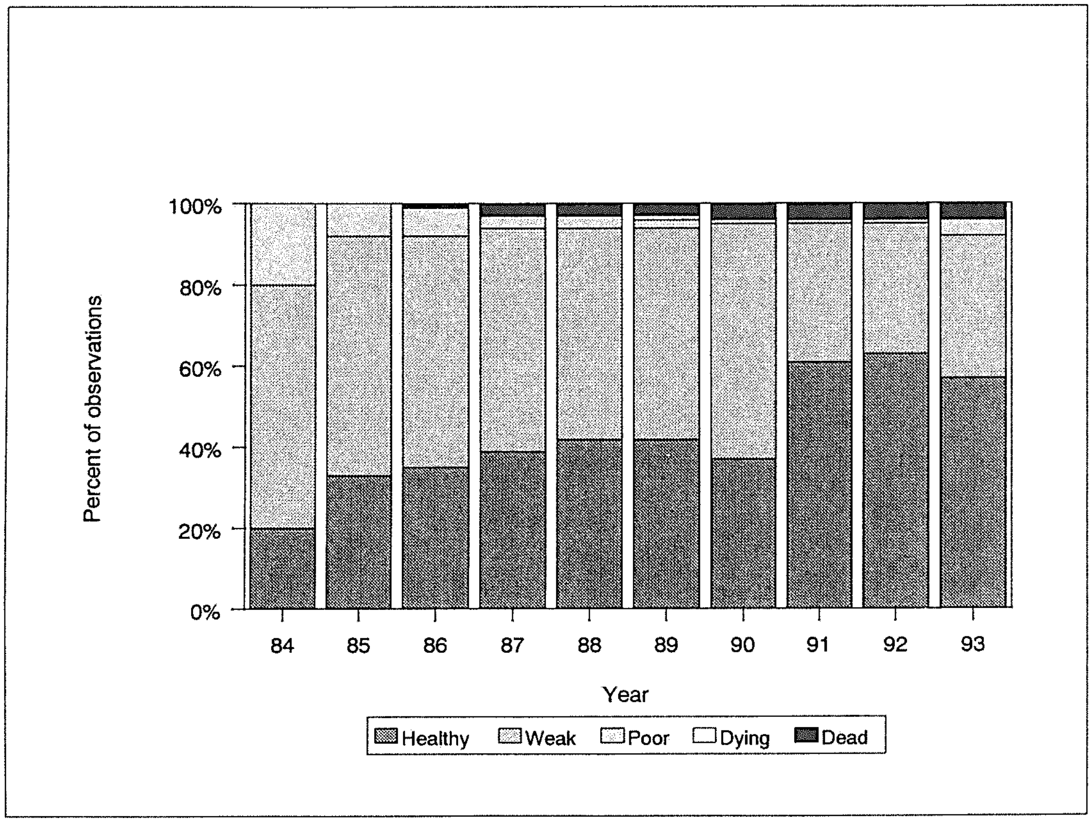


In 1993, three quarters of the trees (75%) were healthy, close to a fifth (15%) were weak, a few (2%) were poor, and about a tenth (8%) were dead. Healthy trees greatly outnumbered weak trees on five of the six original plots. The exception was a plot in western Nova Scotia (210) where healthy and weak trees were in almost equal proportions (40 vs. 35%). This was also the only plot where general tree condition was worse than in 1992. The addition of two new plots with red spruce did not alter the Maritimes situation significantly. Three trees died in 1993, two on a plot (205) in northcentral New Brunswick, the third on plot 210. All three were intermediate and showed progressive deterioration in the past 3 years. The trees in New Brunswick sustained repeated spruce budworm defoliation, the Nova Scotia tree had a broken top and was attacked by a bark weevil (*Pissodes* sp.).

The condition of red spruce has gradually improved since 1991 after a stable period of 3 years. Following a few years of wild fluctuation at the beginning of the program, there has been a slow but steady increase in the proportion of healthy trees which now constitute 75% of red spruce. The average annual mortality of red spruce between 1984 and 1993 was 0.8%.

Foliar damage by insects, diseases or abiotic causes was only trace in 1993 (Table 6) with little variation among plots. Spruce budworm caused light defoliation in northcentral New Brunswick (plot 205) and winter drying was recorded on several of the plots.

WHITE SPRUCE

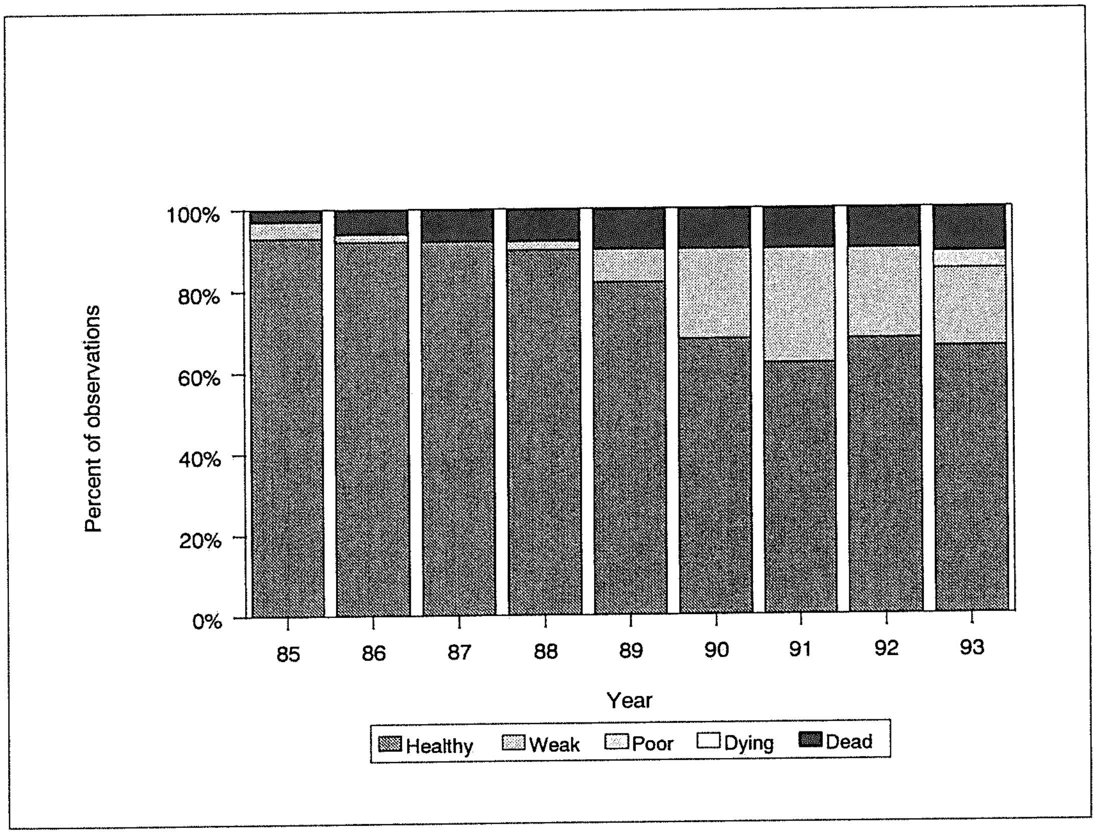


In 1993, over half of the trees (57%) were healthy, a third (35%) were weak, a few (4%) poor, and a few (4%) were dead. Tree condition on individual plots does not differ significantly from the regional average, however the plot on Cape Breton Island (212), in the former spruce budworm outbreak area, accounts for most of the early tree mortality. No trees have died on any of the 13 plots since 1989.

The condition of white spruce has been stable since 1991, and has improved gradually since the beginning of the program. There is minimal mortality or tree deterioration, weak trees are recovering and becoming healthy. The improvement has been slow but steady. The average annual mortality of white spruce between 1984 and 1993 was 0.5%.

Foliar damage by insects, diseases or abiotic causes was only trace in 1993 (Table 6). Spruce budmoth (*Zeiraphera* sp.) damaged shoots on plot 213 and needle rust (*Chrysomyxa ledicola*) was found on plot 208, both affecting less than 5% of the foliage.

SPRUCE HYBRID



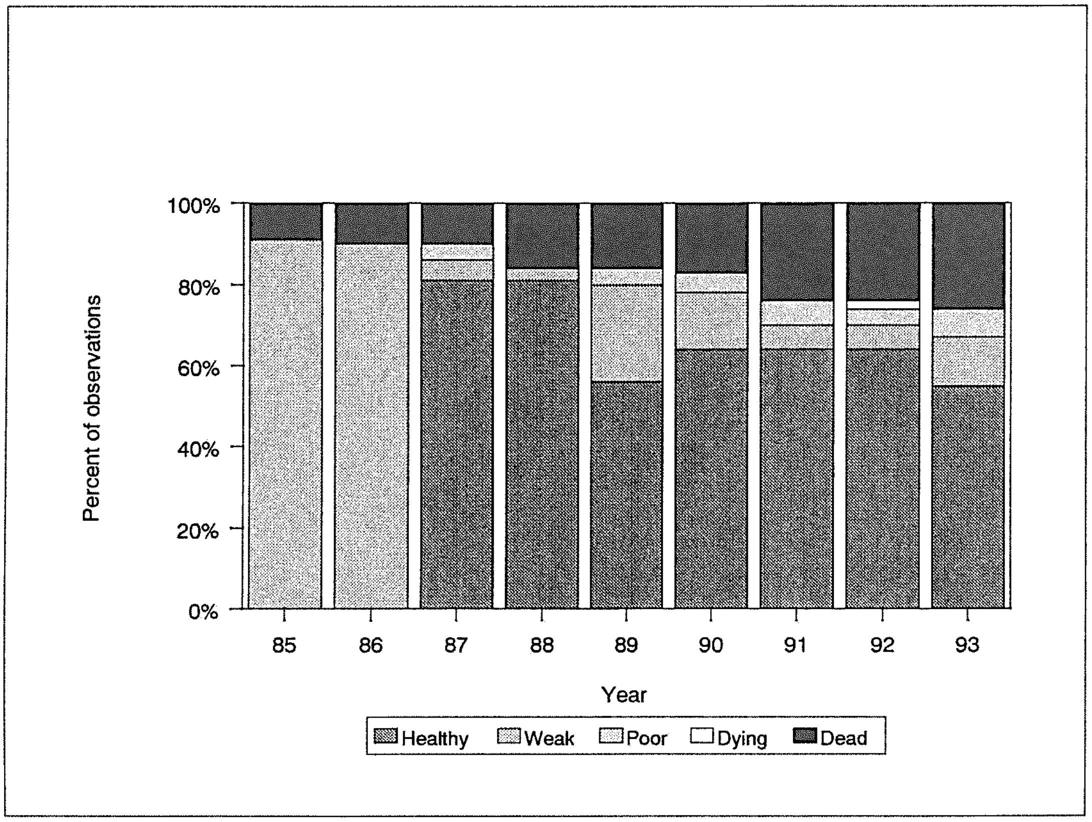
Spruce hybrid trees are introgressed spruces with various mixtures of the two parents (red spruce and black spruce) and are considered hybrids for the purposes of this report.

In 1993, two thirds (66%) of the trees were healthy, about a fifth (19%) were either weak or poor, and a tenth (11%) were dead. No trees died in 1993. The regional situation is somewhat better than tree condition on the Prince Edward Island plot (208) where almost 80% of the hybrid spruce trees are located.

The condition of spruce hybrid has been changing gradually during the past 7 years, in both directions, mostly at the expense of stressed trees. While the condition of some trees is improving, others are declining. On plot 208, the youngest of the original plots, this pattern could be the result of stand dynamics, where competition for dominance may be a factor. The average annual mortality of spruce hybrid trees between 1984 and 1993 was 0.9%.

Foliar damage by insects, diseases or abiotic causes was only trace in 1993 (Table 6).

JACK PINE

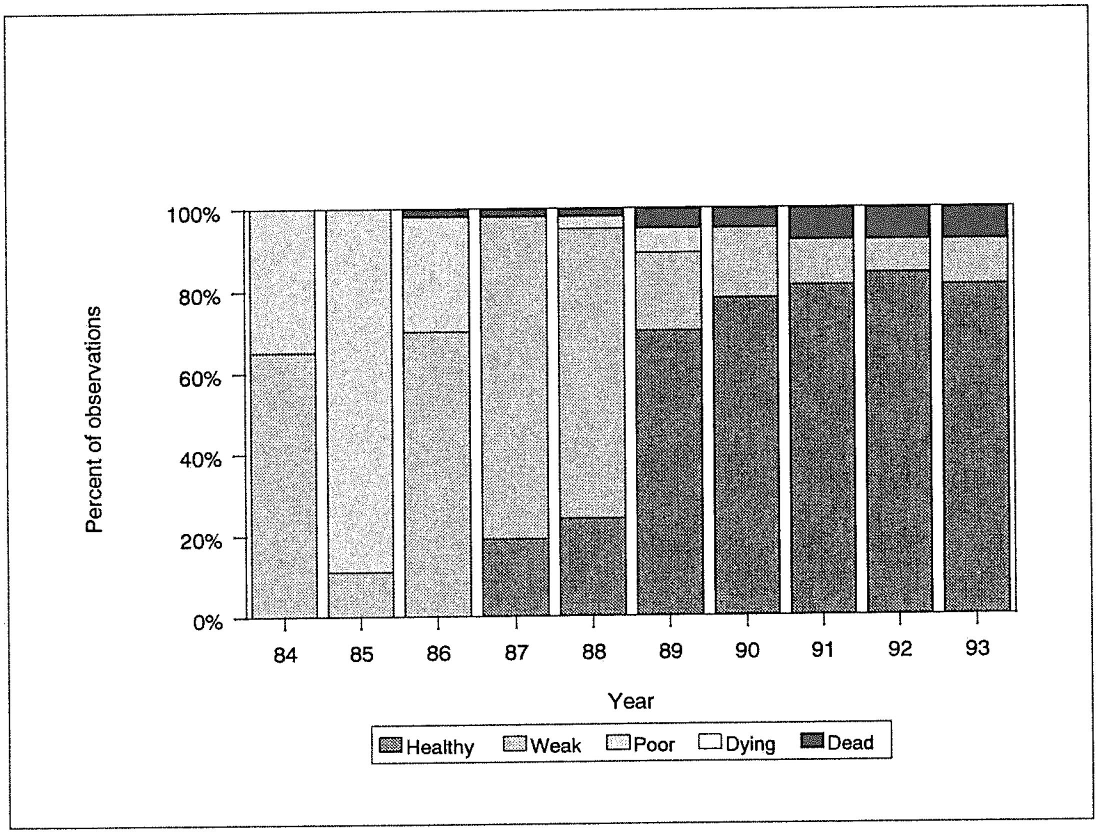


In 1993, on the only plot with jack pine content, more than half of the trees (55%) were healthy, a little over a tenth (12%) were weak, a few (7%) were poor, and over a quarter of the trees (26%) were dead. One intermediate tree that had been deteriorating since 1991 died in 1993, when it suffered a broken top. The tree was attacked by sawyer beetle (*Monochamus* sp.) that same year.

The condition of jack pine has been relatively stable in the past 5 years since many of the trees recovered from the effect of a severe storm. The most seriously damaged trees have been gradually deteriorating and many of them died. There was slight decline in the overall condition of jack pine in 1993, expressed by an increase in the number of both weak and poor trees. The average annual mortality of jack pine between 1984 and 1993 was 1.8%.

Foliar damage by insects, diseases or abiotic causes was only trace in 1993 (Table 6).

EASTERN WHITE PINE

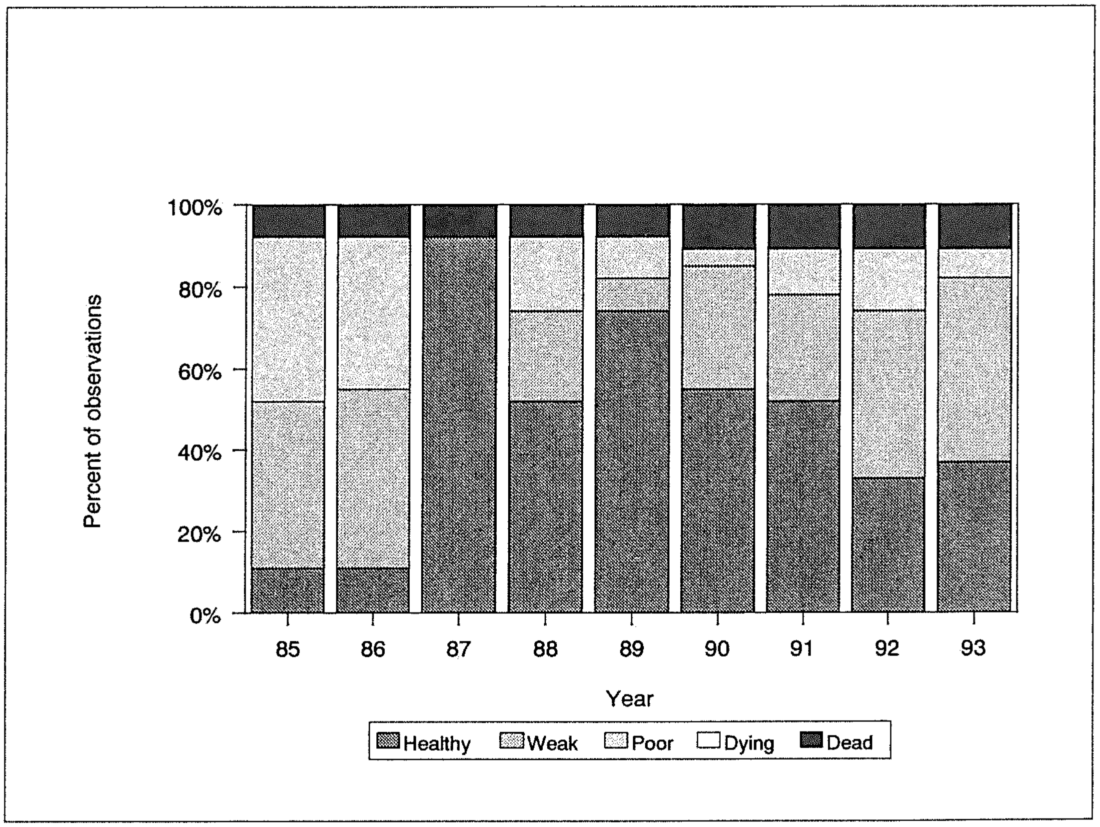


In 1993, most (81%) of the trees were healthy, a few (11%) were weak, and a few (8%) were dead. No trees have died since 1991. The condition of white pine is nearly identical on the two plots, which is to be expected as the plots are in close proximity.

The condition of white pine has been remarkably stable since 1989, following a marked improvement compared to tree condition observed in the early part of the program. All trees were weak or poor in the 1984-1986 period. Gradual improvement occurred in 1987 and 1988 and 80% or more of the trees have been classified healthy since 1990. The average annual mortality of white pine between 1984 and 1993 was 0.9%.

Foliar damage by insects, diseases or abiotic causes was minimal in 1993 (Table 6).

LARCH

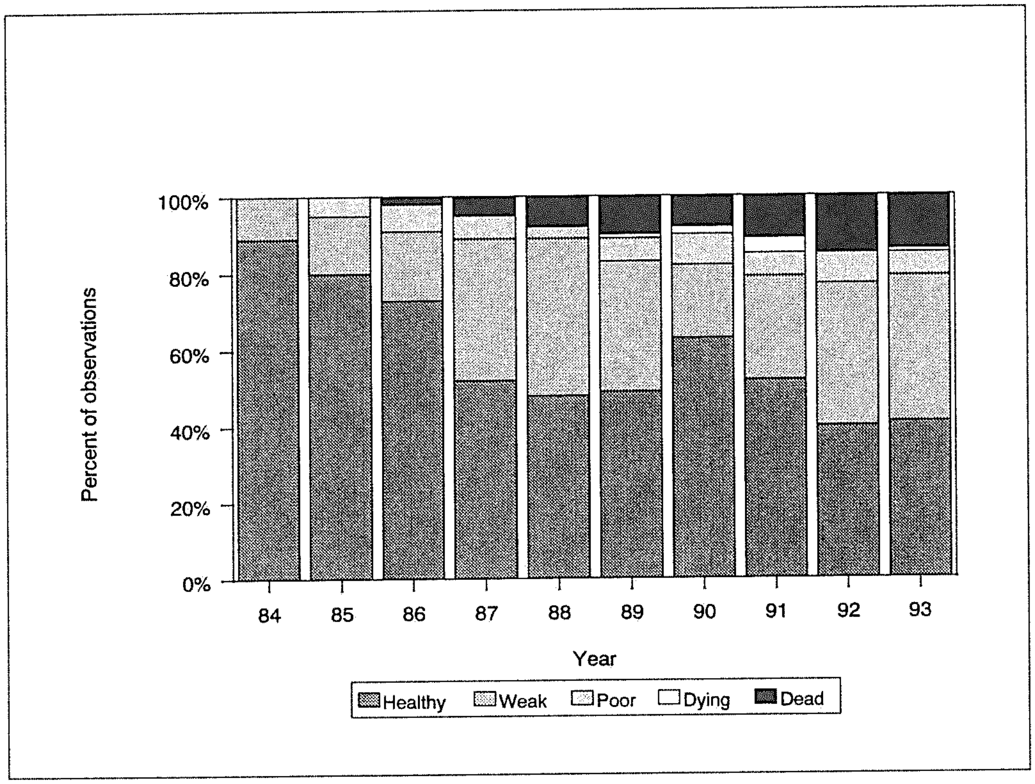


In 1993, about a third (37%) of the trees were healthy, somewhat less than half (45%) were weak, a few (7%) poor, and a few (11%) were dead. No tree has died since 1991.

The condition of larch has been deteriorating gradually over the years. Although there is little mortality, increasing numbers of trees are showing signs of decline and deterioration. The average annual mortality of larch between 1984 and 1993 was 1.0%.

Foliar damage by insects, diseases or abiotic causes was only trace in 1993 (Table 6). Larch casebearer (*Coleophora laricella*) affected less than 6% of the needles. European larch canker (*Lachnellula willkommii*) is present on many trees on the plot, mostly in the form of branch cankers.

WHITE BIRCH



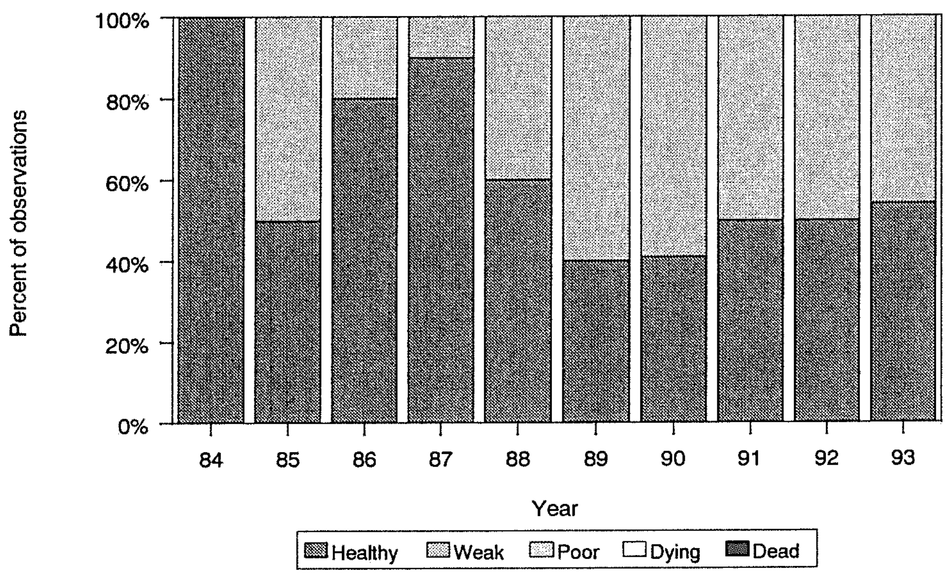
In 1993, less than half (41%) of the trees were healthy, a little over a third (38%) were weak, a few (6%) were poor, and 15% were dead or dying. There were white birch trees in all tree condition classes, indicating wide variation among the various plots. The two newly established plots were different: on one of them (plot 220) almost 90% of the trees were healthy, on the other (plot 222) 80% of the trees were weak, the rest of the trees were poor or dead. On two of the three original plots, most trees were no worse than weak, exhibiting twig or a limited amount of branch mortality. On the third plot (plot 206), however, less than a fifth of the trees (18%) were healthy, another fifth (23%) were weak, 15% were poor, and a staggering 44% were dead. Tree mortality on this plot accounts for almost 80% of total white birch mortality in the Maritimes ARNEWS plots.

Plot 206 is close to the Bay of Fundy, where a combination of acid fog and ozone appears to be responsible for repeated severe foliage browning since as early as 1979. Predating the ARNEWS program, the situation has been monitored on a series of permanent plots. The results from those plots are discussed elsewhere in this report. Three trees died in 1993, all on plot 206, all were codominant trees in poor condition during the past 4 years, and all were eventually killed by Armillaria root rot (*Armillaria mellea*).

The condition of white birch, apart from the situation along the Bay of Fundy, has been stable, with most trees exhibiting some twig and limited amounts of branch mortality. The proportion of the healthy and the weak classes fluctuates to some extent. The decline on a Maritimes basis is largely influenced by deterioration along the Bay of Fundy. The average annual mortality of white birch between 1984 and 1993 was 2.0% on a regional basis and 1.2% without the Bay of Fundy plot.

Foliar damage by insects, diseases or abiotic causes was light in 1993 (Table 6). In general, foliar damage by all three agents increased slightly over 1992 levels. There was some variation in the type and the amount of damage among plots, plot 206 having sustained most of the above average damage. Septoria leafspot (*Septoria betulina*), in association with foliage discoloration of the type observed annually in the Bay of Fundy area, was the most noteworthy agent identified but occurred on only 7% of the leaves.

YELLOW BIRCH

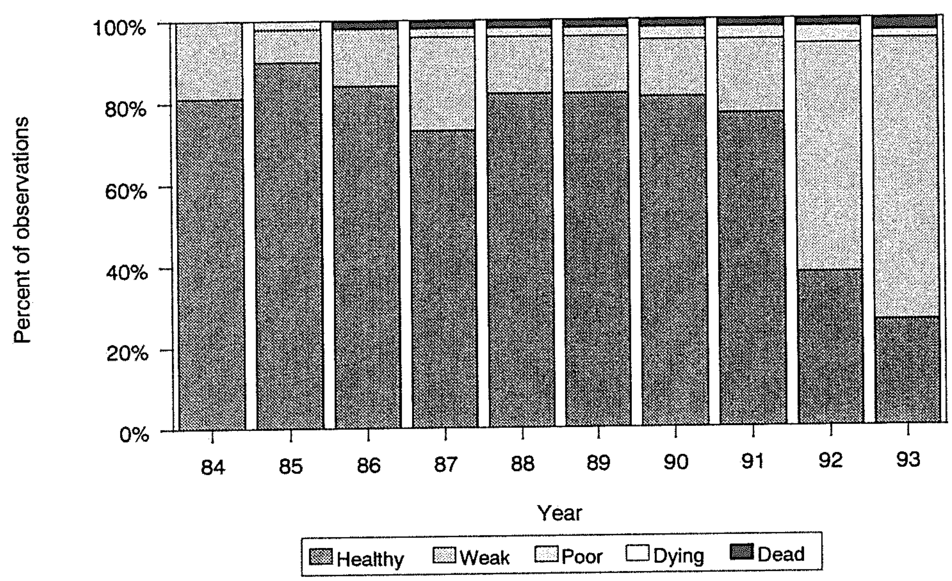


In 1993, about half of the trees were healthy (54%) the other half were weak (46%) with a limited amount of branch dieback. No yellow birch tree has died on any of the ARNEWS plots since the beginning of the program in 1984.

The condition of yellow birch has remained remarkably stable since 1991, the minor variation due to the switch of individual trees between tree condition classes. There has been a gradual decrease in the number of vigorous trees (code 10) over the years but the ratio of healthy and weak trees has stabilized at about half and half since 1988.

Foliar damage by insects, diseases or abiotic causes was trace or light in 1993 (Table 6). A variety of insects were involved on the different plots, birch leafminer (*Fenusa pusilla*) and birch casebearer (*Coleophora serratella*) two of the most notable. Wind damaged some foliage on plot 222.

RED MAPLE

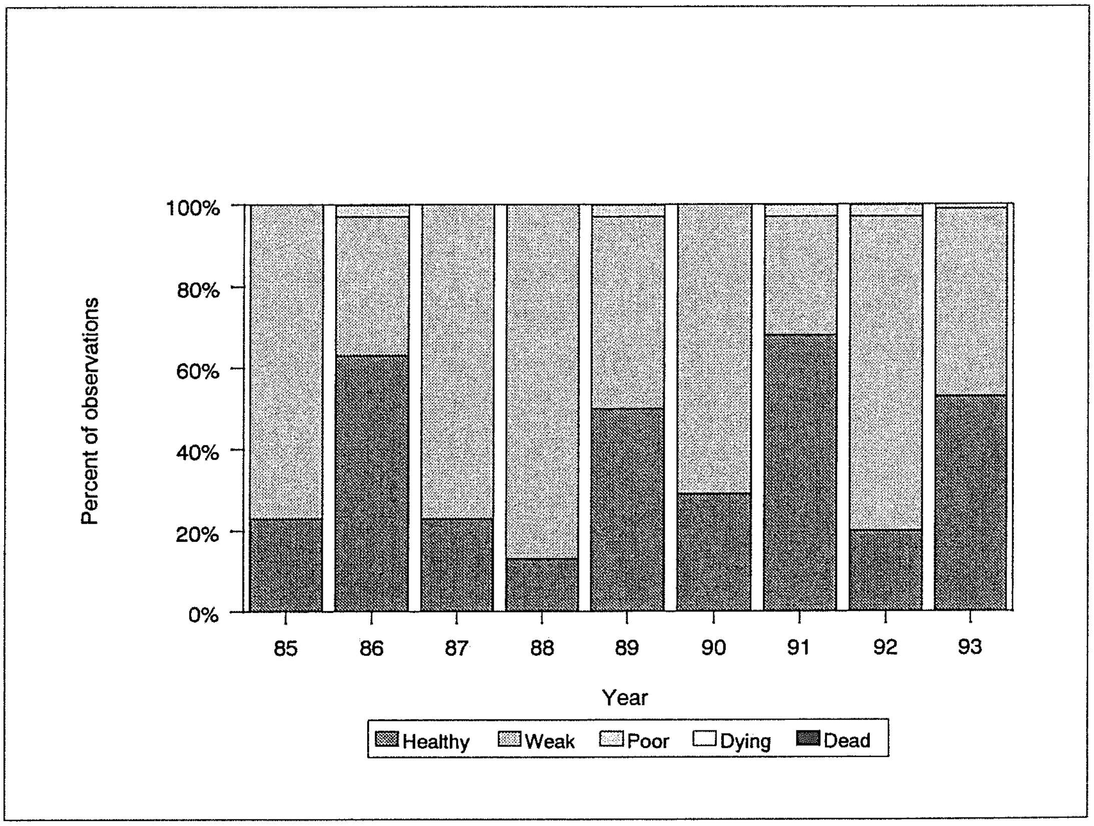


In 1993, a little over a quarter of the trees (26%) were healthy, although all exhibited limited twig mortality, two thirds (66%) were weak, a few (2%) were poor, and a few (6%) were dead. Tree condition varied little among the five plots, except that all tree mortality has been recorded on the two New Brunswick plots (201, 224). The mortality rate on these two plots is 21%. Two trees died in 1993, both on plot 201, both were suppressed trees in very poor condition during the past 3 years. One of the trees was killed by Armillaria root rot (*Armillaria mellea*), the other had several unidentified stem cankers.

The condition of red maple has been deteriorating in the last few years, expressed mostly by the increase in the proportion of weak trees with a limited amount of branch dieback. However, less than 10% of red maple in the region is in poor condition or dead. The average annual mortality of red maple between 1984 and 1992 was 0.5%.

Foliar damage by insects, diseases or abiotic causes was only trace in 1993 (Table 6). There was little variation among plots. The highest amount of insect damage (7.8% of leaves affected) was caused by gall mites on plot 224. The most common disease was the leaf spot fungus (*Phleospora aceris*), and wind caused the only noteworthy damage among abiotic agents.

SUGAR MAPLE

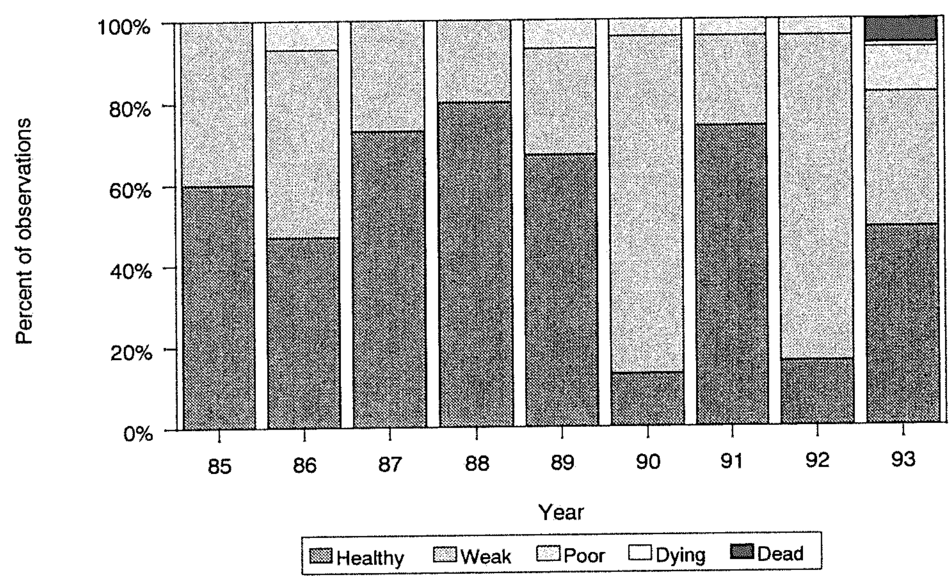


In 1993, a little over half of the trees (53%) were healthy, about half (46%) were weak with limited branch mortality, and one tree (1%) was classified as poor. There is a notable difference in tree condition between the two plots where sugar maple is a major component. While over 80% of the trees were weak on plot 203 in northwestern New Brunswick, 80% of the trees were healthy on the newly established plot in the southwestern part of the province (plot 219). No sugar maple trees have died on any of the plots since the beginning of the program in 1984.

The condition of sugar maple on the northwestern New Brunswick plot (203) has fluctuated annually since 1989 between the healthy and the weak classes, but there is no perceptible trend of either decline or improvement during these years. However, there is an improvement over the 1985-1988 period when weak trees consistently outnumbered healthy ones.

Foliar damage by insects, diseases or abiotic causes was trace or light in 1993 (Table 6).

TREMBLING ASPEN



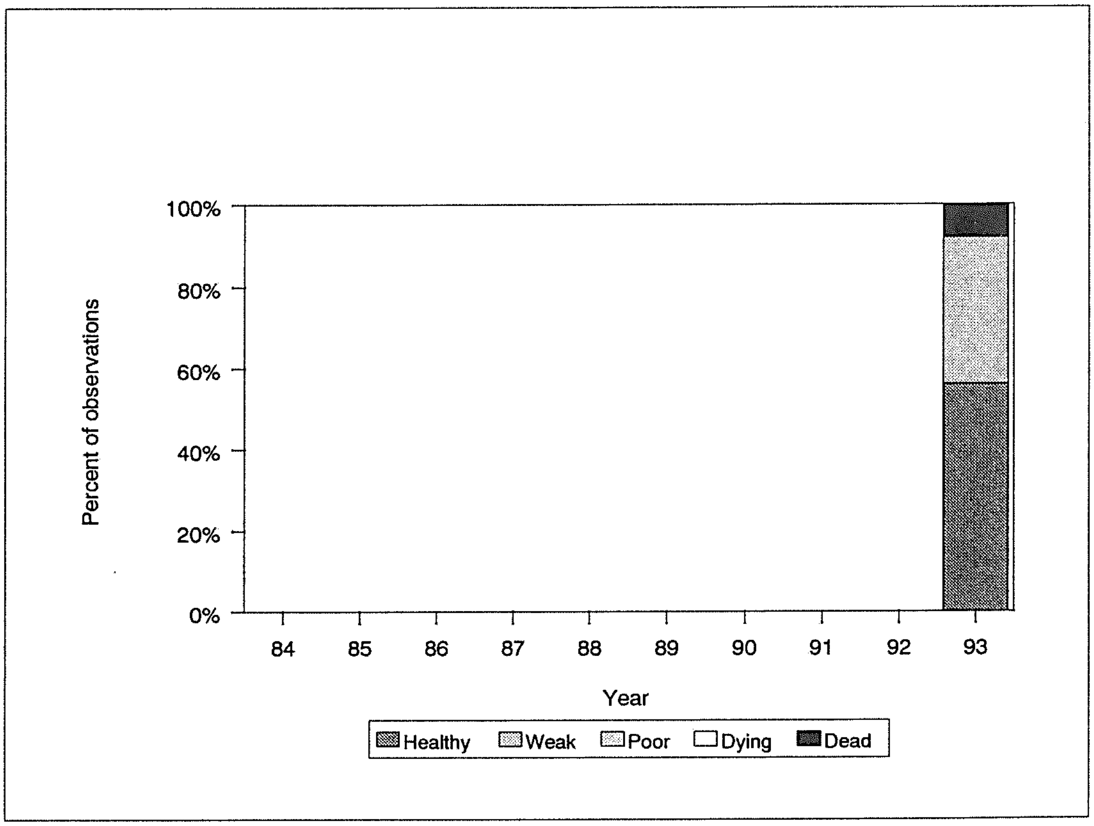
In 1993, there were trees in every tree condition category: about half (49%) were healthy, a third (33%) were weak with a limited amount of branch mortality, a few (11%) were poor, and a few (7%) were dead or dying. The overall averages in the various categories have changed drastically with the addition of a plot (218) in northeastern New Brunswick in 1993. Trembling aspen there is in a much worse shape than on the Prince Edward Island plot (208), probably as a result of a sustained outbreak of the poplar serpentine leafminer. While 15 of the 17 healthy trees are in Prince Edward Island, 32 of 37 weak and poor trees are in New Brunswick. All six dead trees are also on the New Brunswick plot.

The condition of trembling aspen has improved on the longstanding Prince Edward Island plot in 1993. Even though a few trees were degraded from weak to poor, the majority of the trees (70%) recovered and were classified as healthy. This compares to the situation in 1990 when 85% of the trees were weak and were in a state of decline. Over the years, there has been considerable annual fluctuation between the ratio of healthy and weak trees. No trembling aspen tree has died on plot 208 since the beginning of the program in 1984.

Foliar damage by insects, diseases or abiotic causes was only trace in 1993 (Table 6). Poplar serpentine leafminer (*Phyllocnistis populiella*) was present in northeastern New Brunswick (plot 218) and a leaf rust (*Melampsora abietis canadensis*) was recorded in eastern Prince Edward Island (plot 208).

Hypoxylon canker (*Hypoxylon mammatum*) is present on the newly established plot in northeastern New Brunswick (218). Some infected trees have been killed by the disease.

BEECH



Beech is a new addition to the species complement of the ARNEWS system in the Maritimes.

In 1993, more than half of the trees (56%) were healthy, a little over one third (36%) were weak, and a few (8%) were dead. There was a difference between the two plots. Even though all dead trees were on the Prince Edward Island plot (220), this plot also had a higher percentage of healthy trees (67% vs. 46% on the New Brunswick plot). Beech bark disease (*Nectria coccinea* var. *faginata*) is present on both plots and is responsible for at least some of the tree mortality in Prince Edward Island.

Foliar damage by insects, diseases or abiotic causes was trace or light in 1993 (Table 6). Eriophyd mites affected about 12% of the leaves in southwestern New Brunswick (plot 219).

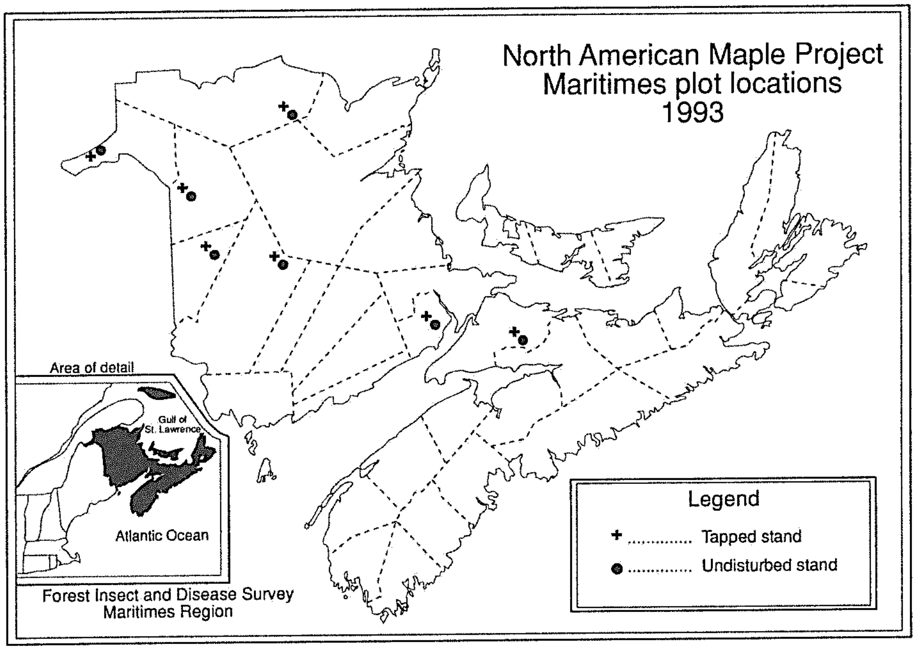


Figure 2 Distribution of plot clusters in the North American Sugar Maple Decline Project.

NORTH AMERICAN SUGAR MAPLE DECLINE PROJECT (NAMP)

Sugar maple, of all the eastern North American tree species, has possibly received the greatest attention in forest health monitoring. In the mid- to late 1970s and throughout the 1980s, sugar maple stands throughout the northeast began to show signs of deterioration. Many jurisdictions reported damage, but particular concern for tree health was expressed in Ontario, Quebec, and Vermont (Walker *et al.* 1990; McIlveen *et al.* 1986). The damage was real and significant, leading to a widespread fear that a true decline was underway — a perennial deterioration that would lead to the disappearance of sugar maple as the dominant species in its associated stand types. The fact that the maple syrup industry is based solely on this species also fueled a need for a better understanding of the phenomenon. Deteriorating stands were being aggressively thinned of dead and apparently dying stock, often making the problem worse by opening those stands to the stress of an altered micro-climate and to the possibility of enhanced insect- and disease-pest conditions. Some woodlot owners declared their stands beyond the point of redemption. They clearcut, making the losses even more real. A deteriorating condition of urban and roadside maple trees was noted that often confounded the true situation, as these environments create special problems for trees at the best of times. Initial speculation on the causes of maple decline included atmospheric pollution, insect outbreaks (especially the forest tent caterpillar), winter freezing of the soil, drought, and many other causes(Allen *et al.* 1992; Auclair and Lachance, 1991).

In the Maritimes, the extent of sugar maple deterioration was much less evident. Individual stands of trees could be found with dieback, but this condition was not widespread nor was there apparently a progressive deterioration. Most of the dieback observed was found in New Brunswick, where the majority of sugar maple are located, while in Nova Scotia and Prince Edward Island, trees were in very good condition (Magasi, 1989a).

The North American Sugar Maple Decline Project (NAMP) was devised in 1987 by Canadian and American scientists to address the threats posed by maple decline. NAMP established complementary study plots in 1988 in both countries and covering a large extent of the range of sugar maple

Table 7 Locations of Maritimes NAMP plots indicating sugarbush (SB) and non-sugarbush (NSB) types, number of sugar maple trees as of year of establishment and Rowe's (Rowe, 1972) Forest Section.

No.	Location	Type	UTM Grid	No. sM Trees	Forest Section
New Brunswick					
1	Lac Baker	SB	19 53(1) 524(4)	67	Temiscouata-Restig.
4	Lac Baker	NSB	19 50(3) 524(5)	48	
3	Gallagher	SB	19 66(1) 513(1)	64	Southern Uplands
15	Williamsburg	NSB	19 66(8) 513(8)	102	
7	Albert	SB	20 34(0) 507(0)	74	Carleton
5	Albert	NSB	20 34(1) 507(0)	79	
6	Bathurst	SB	20 70(1) 527(0)	40	Southern Uplands
17	Bathurst	NSB	20 70(4) 527(3)	46	
11	Bristol	SB	19 61(1) 515(0)	89	Carleton
12	Bristol	NSB	19 61(1) 515(0)	49	
13	New Denmark	SB	19 61(0) 519(3)	105	Temiscouata-Restig.
16	Lerwick	NSB	19 60(9) 518(8)	130	
Nova Scotia					
9	Amherst	SB	20 42(1) 504(1)	96	Cobequid
10	Amherst	NSB	20 42(1) 504(1)	169	

(Figure 2). The objectives of the program are to determine the rate of annual change in sugar maple tree condition and how the rate of change in tree condition differs among (a) the various levels of sulfate and nitrate wet deposition, (b) sugarbush and non-sugarbush forests, and (c) various levels of stand decline conditions as found in 1988.

Location and description — The Maritimes plots occupy the eastern edge of the study area, providing an important reference point for other regions in the project. Twelve plot-clusters, each composed of five 20 X 20-m plots were established in New Brunswick and two in Nova Scotia, in contrasting sugarbush and non-sugarbush stands (Table 7). The result is currently a sample of 1444 trees, of which 1102 are sugar maple. Most trees are in the 10-24 cm DBH range (Figure 3), 10 cm being set as the minimum tree size for inclusion. A smaller subset of the current total number of trees being measured is used in the following analysis, selecting only those trees originally measured in 1988. NAMP plots should have a minimum of 50% upper story sugar maple between 50 and 150 years old.

A detailed field manual was produced and has been updated annually (Millers *et al.*, 1991). In addition, a quality assurance program was put into place (Burkman *et al.*, 1990) involving joint training, documentation, field audits, and plot remeasurements.

Ecoregion distribution — NAMP plots are located in four of the 15 forest sections described by Rowe (1972) for the Maritimes, from the Temiscouata-Restigouche Section of the Great Lakes-St. Lawrence Forest Region, characterized by its sugar maple/beech/yellow birch on hill tops, through three sections of the Acadian Region: the Carleton Section, characterized additionally by

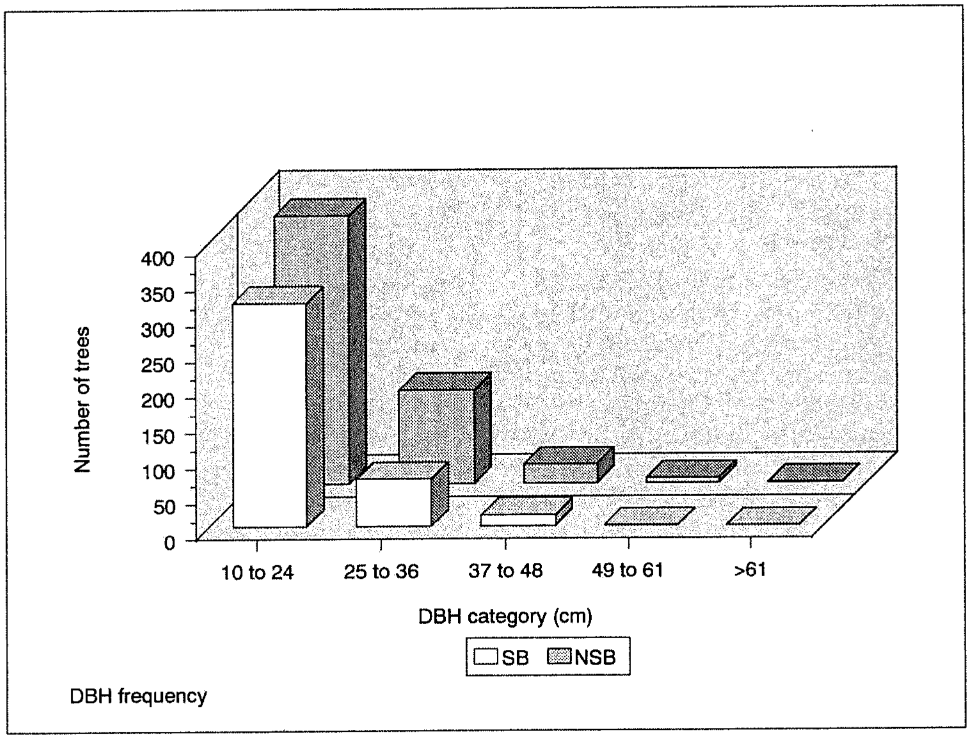


Figure 3 Diameter breast height (DBH) of sugar maple in the Maritimes plots of the North American Sugar Maple Decline Project.

amounts of red maple and white ash; the Southern Uplands Section with increasing amounts of white birch, fir and spruce, including a northern extension of this Section which reaches almost to Bathurst; and the Cobequid Section on the Nova Scotia mainland where beech and yellow birch are found with sugar and red maples and some softwoods. Sites were selected to represent a variety of field conditions and to create a geographical spread covering a range of possible levels of atmospheric pollution; however, sites that were in a significantly deteriorating condition were avoided in order to allow documentation of change in tree condition, as opposed to conducting a survey of declining sites. A concentration of sites was placed in New Brunswick so as to be continuous with the many sites to the west in Maine and Quebec.

Related investigations — In Nova Scotia, the FIDS has maintained four long-term monitoring plots for red and sugar maple in Colchester, Antigonish, and Halifax counties since 1982. An original concern was the threat of a variety of insect pests (the maple leafroller, the maple webworm, and the sugar maple borer) but these plots were also used as a check on the overall health of sugar and red maple. Since plot establishment, none of the pests have become serious and tree condition has remained relatively unchanged. All stands are now considered 'healthy', with normal levels of dieback (5-10%) and leaf density (10-20%). The one red maple plot of the four, in Halifax County, has consistently been recorded with greater amounts of dieback and reduced leaf density, as is generally the case in comparisons of these two species.

NAMP Measurements

While a large amount of information is collected from NAMP plots —vigor, dieback, transparency, leaf dwarfing, discoloration, and seed production — only dieback and transparency are considered to be critical variables (those that are repeatable within known error limits and that are fundamental to a description of tree health). Dieback and transparency describe, respectively, the amount of dead material and the amount of light intercepted/transmitted by the tree crown. They are measured by a 12-class rating system as 0%, 5%, then 10 to 100% in 10% intervals. The crown is defined by the periphery of its branch tips but excludes large stems below the foliated area, The terms 'dieback' and 'transparency' are used in forest health monitoring to describe the amount of dead twig and branch material and the relative density of leaves, respectively, when evaluating the health of a tree. Precise definitions, supported by training and rechecks, are used by observers to ensure the most standardized reporting possible. In this section of the report, 'percent dieback' or 'percent transparency' refers to the definitions developed under the NAMP program.

large openings within the crown, and areas within the crown where the remnants of dead branches remain. Thus a tree with only a few surviving branches may have a healthy transparency rating if those branches are indeed well foliated. As only recently dead branches are included in the crown definition, a tree may have much of its original crown dead, but a low dieback rating if the surviving crown has not recently suffered dieback. Thus NAMP is a sensitive measure of change and is not intended as a general survey of forest health. Measurements are also made of tapping for maple syrup, stem and root injuries, age, insect defoliation, and a number of site and stand characteristics.

NAMP Tree Condition

Six years of data collected by 1993 indicate a national trend to an improved condition of trees (Allen *et al.*, 1992; Millers *et al.*, 1993). Tree health is similar between sugarbush and non-sugarbush stands. Both insect defoliation and drought have been determined to adversely affect crown conditions in some jurisdictions.

The Maritimes plot data in 1993 indicate that 98.4% of trees in non-sugarbush stands are in a low dieback category consistent with good health and that sugarbush and non-sugarbush plots have similar levels of tree condition (Figure 4). The average dieback level for sugarbush stands was 6.4% ±1.5 and for non-sugarbush stands was 6.1% ±0.6. Similarly 95.9% of non-sugarbush trees are in a low transparency category (Figure 5), the average transparency level for sugarbush stands being 9.2% ±2.3 and for non-sugarbush stands being 9.1% ±1.1.

Minor fluctuations in average dieback from 1988 to 1993 (Figure 6) are not significant, although the slight improvement between 1988 and succeeding years in both sugarbush and non-sugarbush stands hints that maple in the Maritimes may have been recovering from slight amounts of damage earlier in the 1980s, as was observed elsewhere. Over the 6 years of the study, only 0.2 to 1.0% of trees in sugarbushes were considered unhealthy (35% or more dieback) while 0.2 to 0.7% of trees in non-sugarbushes were considered to be unhealthy. The slight differences between management types most likely represent the effects of thinning and selective harvesting on a few individual trees, rather than tapping.

The range in values recorded for transparency are often large, reflecting the normal variability among trees. A gradual improvement in transparency (decreasing light penetration through the foliage) from 1988 to 1993 is also evident in both sugarbush and non-sugarbush stands. The best condition of any year was reported in 1992, with no trees in sugarbushes and 0.2% in non-sugarbush stands exhibiting transparency greater than 35%. Values for 1993 were 0.2 and 0.4% respectively.

The NAMP program has another 4 years of data collection scheduled under its current mandate; however, with 6 years of data, the historical trends and causal relationships revealed to date under the program are now being evaluated in light of trends in atmospheric pollution and climatic disturbance. In the meantime, the determination that there is not currently a decline in our sugar maple forests is reassuring.

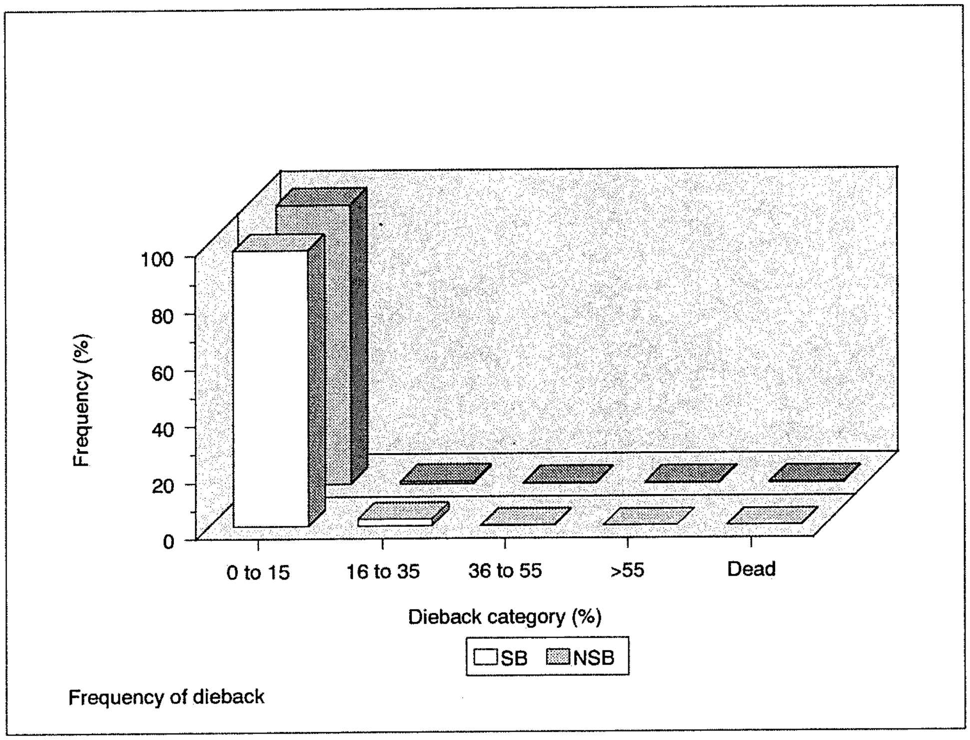


Figure 4 Crown dieback of sugar maple in sugarbushes (SB) and non-sugarbushes (NSB) in the Maritimes plots of the North American Sugar Maple Decline Project.

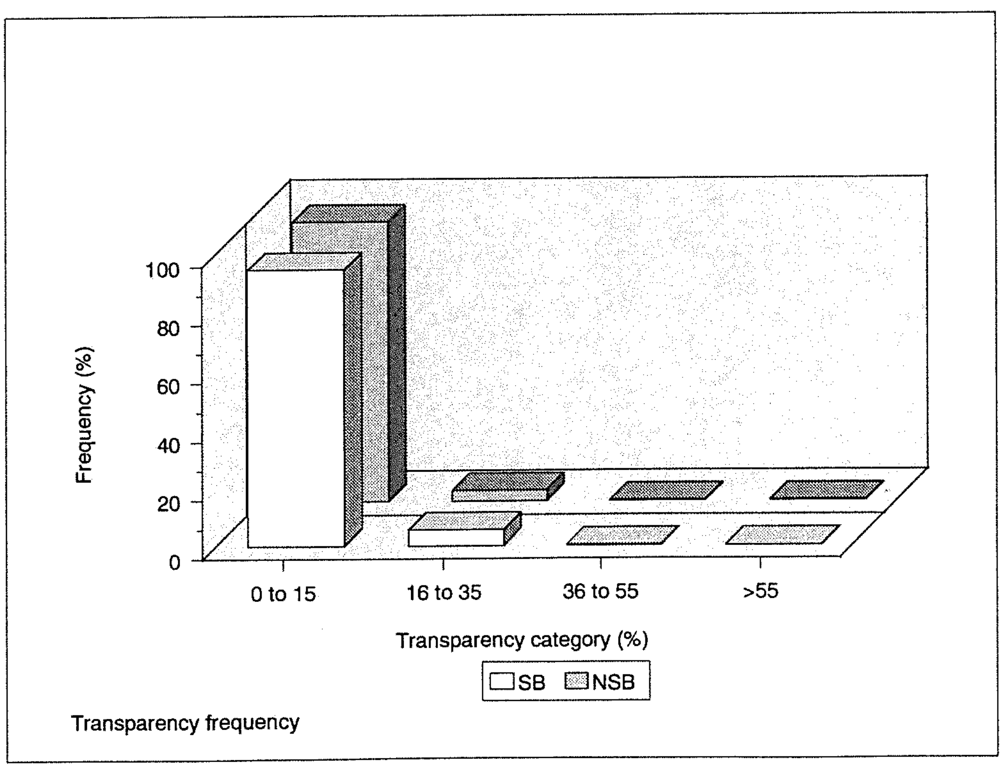


Figure 5 Crown transparency of sugar maple in sugarbushes (SB) and non-sugarbushes (NSB) in the Maritimes plots of the North American Sugar Maple Decline Project.

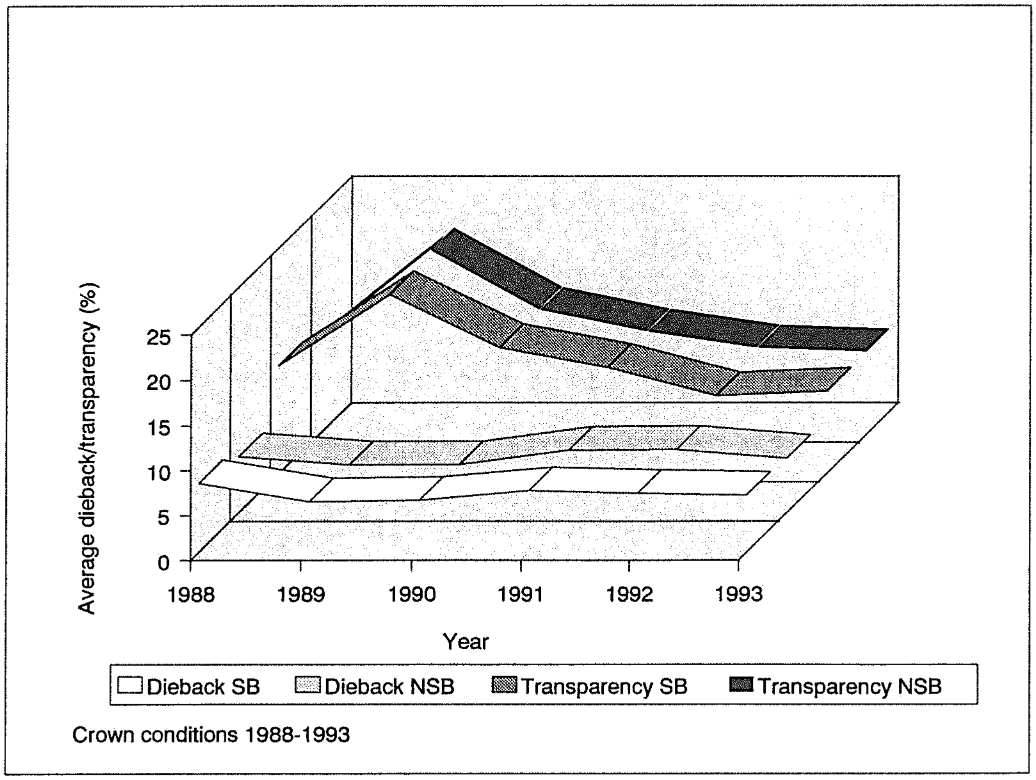


Figure 6 Fluctuations in crown dieback and transparency from 1988 to 1993, of sugar maple in sugarbushes (SB) and non-sugarbushes (NSB) in the Maritimes plots of the North American Sugar Maple Decline Project.

DETERIORATION OF WHITE BIRCH ALONG THE BAY OF FUNDY

Recurring, early, and usually severe foliage browning and premature leaf fall along the Bay of Fundy has resulted in deterioration of white birch trees in this area. The cause of the condition, first reported in 1979, is unknown, but insects and diseases have been ruled out. Multi-disciplinary research was initiated in 1986 to investigate possible causes, including acid rain, acid fog, and ozone. There are now strong indications that coastal acid fog and ozone may be major contributing factors.

As in the past 4 years, white birch condition continues to improve in 1993 along the Bay of Fundy in New Brunswick and along the Cumberland County shores of Nova Scotia. A few trees had trace browning from birch leafminers (*Fenusa pusilla* (Lep.) and *Profenusa thomsoni* (Konow)), birch skeletonizer (*Bucculatrix canadensisella* Cham.) or Septoria leaf spot (*Septoria betulina* Pass.), but most trees were green and exhibited good shoot growth. This is in sharp contrast to the condition in the early 1980s, when severe foliage browning was present by early to mid-August.

Tree condition has been assessed annually since 1982 on permanent plots. Summarized results from the plots in New Brunswick are shown in Table 8.

Leaf browning of birch, similar to symptoms usually associated with the condition just described, was mainly observed in areas of central, north-central, and eastern Nova Scotia. Foliage browning was generally moderate and was mostly associated with Septoria leaf spot. An average of 39% of the leaves were affected in 1993, compared to 48% last year. At several large areas in Pictou, Guysborough, and Inverness counties, light, moderate, and occasionally, patchy severe leaf browning was observed.

Table 8 Condition of white birch along the Bay of Fundy in New Brunswick on permanent plots, 1982-1993

	% of trees in class			
Year	**No dieback**	**Twig dieback**	**Twig & Branch dieback**	**Dead**
1982	92.9	1.5	4.7	0.9
1983	83.7	8.6	6.0	1.7
1984	64.0	24.9	7.8	3.3
1985	45.3	34.9	14.4	5.4
1986	14.5	47.3	31.3	6.9
1987	0.0	42.6	49.8	7.6
1988	0.0	38.0	54.0	8.0
1989	0.2	43.0	47.0	10.0
1990	0.2	47.0	42.0	11.0
1991	20.5	48.3	18.8	12.4
1992	6.5	58.5	19.9	15.1
1993*	1.4	60.3	23.2	15.1

Based on 540 trees in 11 plots
* Based on 484 trees in 10 plots

CONDITION OF WHITE SPRUCE NEAR LOCH KATRINE, NOVA SCOTIA

Chlorotic foliage has been observed since 1985 on white spruce trees near Loch Katrine, Antigonish Co., Nova Scotia, in an uneven-aged stand of about 20 hectares. The current foliage is green, but all older needles on affected trees exhibit various levels of yellowish discoloration. Not all trees in the stand are affected, but trees from all age classes show similar symptoms. Yellowing is more prominent on the upper surface of needles than on the underside. Needle retention of older foliage is less than normal. Some of the trees have thin crowns and a few have died. During the period 1988-1992, there has been a slight but gradual increase in the size of the affected area. The cause of this condition is unknown, but insects or diseases do not appear to be involved. Neither foliage nor soil samples, collected in 1987, showed major differences between affected and non-affected areas that might explain the chlorotic foliage. However, tree growth in the affected area was drastically reduced in 1984 and remained slow until 1987 when growth was last measured. The average annual radial increment during 1984-1987 was reduced by 35% compared to growth in the preceding 10-year period. The stands affected are on shallow soil in an area of former agriculture activity. The 'old field' spruce succession scenario is being considered as a possible cause.

Two plots were established in 1990 to obtain more detailed information on the stands and to monitor changes. In 1993, yellow green chlorosis was again present at the low levels observed last year. An overview of the plots and the site, from ground and aerial observations, indicated no significant extension in the size of the affected area. Plot trees exhibited only trace yellowing, while trees along the east bank of South River Lake at Loch Katrine displayed scattered light chlorosis.

Detailed plot work was not carried out in 1993, however, spruce beetle (*Dendroctonus rufipennis* Kby.) has continued to attack and kill white spruce trees in the area. It was also noted that spruce bud scale (*Physokermes piceae* (Schr.)) caused light damage to 60% of the spruce trees, with some branches having dozens of scales. Eastern spruce gall adelgid (*Adelges lariciatus* (Patch)) was also common, causing trace damage to 1993 white spruce shoots.

ACKNOWLEDGEMENTS

This report is the combined effort of all members of the Forest Insect and Disease Survey in the Maritimes and we wish to acknowledge this fact above all.

We wish to thank Dermot Kingston for the soil profile descriptions, soil sampling, and preparation on the six new ARNEWS plots; Steve D'Eon of the Petawawa National Forestry Institute for the ARNEWS data summaries; our summer students, staff of the Fundy National Park, Ian Millar, and Ed Kettela for providing field assistance; Caroline Simpson and Richard Morin for production of the report.

Gérard Lemieux and Art Doane, both of FIDS, provided most of the information for the sections on the condition of white birch along the Bay of Fundy and of the condition of white spruce at Loch Katrine, respectively.

NAMP studies are accomplished with the permission and support of many private landowners and an international network of forest health investigators. Analyses were assisted by the State University of New York and Anthony Hopkin and Denis Lachance of the Canadian Forest Service.

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APPENDIX I

COMMON AND SCIENTIFIC NAMES OF TREES

Common name	Scientific name
Balsam fir	*Abies balsamea* (L.) Mill.
Black spruce	*Picea mariana* (Mill.) B.S.P.
Red spruce	*Picea rubens* Sarg.
White spruce	*Picea glauca* (Moench.) Voss.
Spruce hybrid	*Picea mariana* X *Picea rubens*
Jack pine	*Pinus banksiana* Lamb.
Eastern white pine	*Pinus strobus* L.
Larch (Tamarack)	*Larix laricina* (Du Roi) K. Koch
White birch	*Betula papyrifera* Marsh.
Wire birch	*Betula populifolia* Marsh.
Yellow birch	*Betula alleghaniensis* Britton
Red maple	*Acer rubrum* L.
Sugar maple	*Acer saccharum* Marsh.
Trembling aspen	*Populus tremuloides* Michx.
Largetooth aspen	*Populus grandidentata* Michx.
Balsam poplar	*Populus balsamifera* L.
Beech	*Fagus grandifolia* Ehrh.
White ash	*Fraxinus americana* L.
Black cherry	*Prunus serotina* Ehrh.
Eastern hemlock	*Tsuga canadensis* (L.) Carr.