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NINE YEARS OF OBSERVATIONS ON THE CONDITION OF 241 YELLOW BIRCH

by
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CONTENTS

Ecological Studies of Forest Trees

at

Chalk River, Ontario, Canada

V. NINE YEARS OF OBSERVATIONS ON THE CONDITION OF 241 YELLOW BIRCH[1]

(Project P-375)

by

D. A. FRASER [2]

INTRODUCTION

This is the fifth contribution in a series of studies on forest trees at Chalk River. The first paper (Fraser, 1954) described site types and tree distribution on an experimental plot in a hardwood stand at the Petawawa Forest Experiment Station. The second (Fraser, 1956) presented studies of radial increment in relation to certain physical factors of the environment. The third and fourth papers (Fraser, 1957a, 1957b) described the annual and seasonal march of soil moisture and soil temperature over a number of years. The present contribution is concerned with annual changes in the condition of 241 mature yellow birch (*Betula lutea* Michx.f.) and the canopy of the stand during the 1949-1957 period.

Following the widespread deterioration of birch in New Brunswick (Balch and Prebble, 1940), foresters became concerned about the health of birch stands in Quebec and Ontario. Barter (1947) made a survey in Quebec and eastern Ontario and found mortality of yellow birch to be about 17 to 19 per cent in various parts of Quebec. In the Algonquin district of Ontario (where the Petawawa Forest Experiment Station is located), mortality was variable from stand to stand, but averaged about eight per cent of trees of merchantable size. Damage was greater in disturbed stands and was more apparent in white birch (*Betula papyrifera* Marsh.) than in yellow birch. In spite of this mortality of the larger and older trees, Barter did not find that "abnormal dieback", as exemplified in the New Brunswick birch stands, was yet established in Ontario.

In 1948 Barter continued intensive surveys of birch trees in the Algonquin district of Ontario. In analyses of individual trees, he found deterioration of small twigs and branches which could not be attributed to the bronze birch borer (*Agrilus anxius* Gory), although borer attack was very evident in trees with advanced crown injury. He indicated that the section of Ontario from Chalk River to Dorset, thence to North Bay and Lake Timiskaming showed evidence of "dieback". However, some injury to yellow birch trees was caused by fungi. Barter's statement concerning this problem was as follows:

> There was canker injury on the twigs and branchlets of most of the trees examined and it was quite prevalent in some cases. There was no correlation, however, between the prevalence of the injury and reduced tree vigour. Although some of the twig mortality may have been caused by cankers, it would be extremely difficult to explain the abnormally small, curled and yellowish foliage on this basis, especially when it was observed in the absence of canker injury.

[1] Parts I and II of this series were published in Ecology 35:406-414, 1954; and Ecology 37:777-789, 1956. Parts III and IV appeared as Forest Research Division Technical Notes No. 55 and 56, 1957.

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In this connection Barter (1948) found evidence of decreasing vigour as expressed by reduced radial increment from 1944 to 1948.

In May 1949, an 8-acre experimental plot was established at the Petawawa Forest Experiment Station so that intensive studies could be carried out throughout the entire year in a hardwood stand containing yellow birch. These studies are concerned with the physical ecology of the stand and with the physiology and growth responses of selected trees in various stages of decadence. This investigation should provide information on the early case-history of individual yellow birch trees if extensive dieback becomes established in Ontario.

MATERIALS AND METHODS

The experimental plot is located in a stand of mature yellow birch, white spruce (*Picea glauca* (Moench) Voss), hemlock (*Tsuga canadensis* (L.) Carr.), and sugar maple (*Acer saccharum* Marsh.). Topography and forest cover have already been illustrated by an aerial photograph (Fraser, 1953). The plot (Figure 1) extends ten chains in a magnetic north-south direction and eight chains in a magnetic east-west direction. The undulating ground moraine of the plot consists of loamy sand. Bedrock topography is partly responsible for the north-south ridges. However, most of the bedrock is at least ten feet below the surface. The soil shows evidence of sheet erosion on the steeper slopes. This site, classified as a "Trillium Site" by Heimburger (1936), usually consists of rounded hills and small plateaus, covered with a deep layer of slightly water-washed loamy till which supports a forest of tolerant hardwoods with a rich ground vegetation. *Trillium grandiflorum* (Michx.) Salis. is characteristic of the ground vegetation, although it is nowhere abundant; *Erythronium americanum* Ker is very conspicuous in the early spring. A dense reproduction of sugar maple and other tolerant hardwoods covers most of the ground. All other vegetation is rather scattered, but contains several species that indicate a rich soil. These include: *Acer pensylvanicum* L., *Actaea pachypoda* Ell., *Dryopteris spinulosa* var. *intermedia* (Muhl.) Underw., *Streptopus roseus* Michx., *Viburnum alnifolium* Marsh., and *Viola pubescens* Ait.

Most west to east transects (Figure 1) across the plot include the top of a dry ridge (Moisture Regimes 1-2), passing into a steep slope which shows sheet erosion. This is followed by a more gradual moist slope (Moisture Regimes 3-4) which extends across a small wet seepage area (Moisture Regimes 5-6). This transition is repeated in reverse on the opposite side of this small valley. Variations in soil moisture and soil temperature on these sites have already been described (Fraser, 1957a, 1957b).

Fifteen species of trees occur on this plot. Hemlock and sugar maple are the most abundant species and are represented by many large trees. Beech (*Fagus grandifolia* Ehrh.) is very numerous, but most of the trees are of small diameter. There were 241 yellow birch trees, many of which were of moderate to large size (12 to 30 inches d.b.h.). In 1949 four of these yellow birch had been recently uprooted. This number increased to 17 by August 1957, most of which were windthrown by a hurricane in 1954. There were approximately 225 trees per acre of all species with a basal area of 142 square feet in 1949. The stand is mostly 100 years old with a few trees exceeding 200 years. Fire scars on these older trees and charcoal in the organic layer of the soil indicate that a fire occurred shortly before the majority of the trees in the stand originated. Distribution of the trees on the plot in relation to soil moisture regimes has already been described (Fraser, 1954).

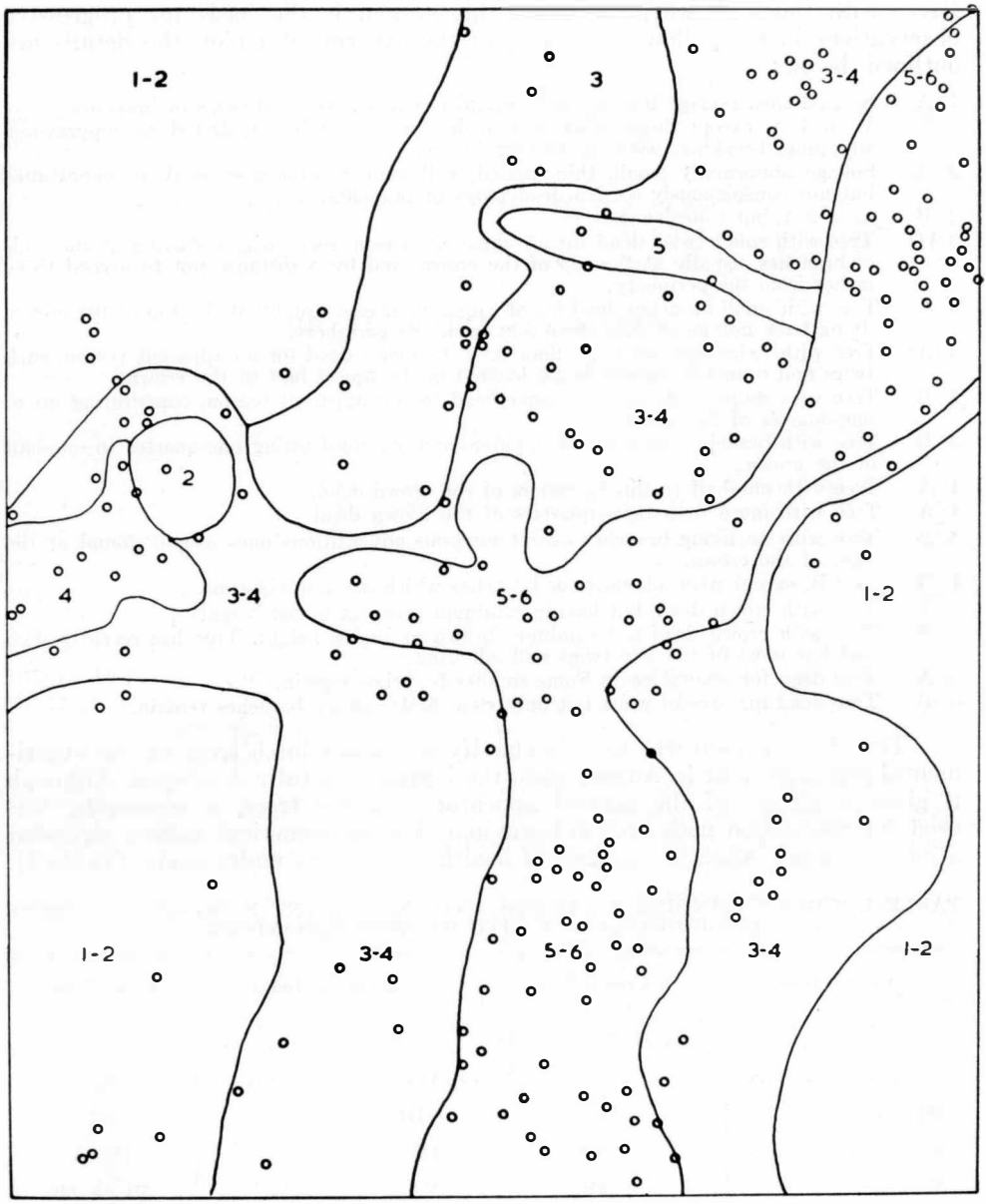

FIGURE 1. Map of an 8-acre plot (8 x 10 chains). Soil moisture regimes (shown in arabic numerals) are delimited by solid lines. Locations of yellow birch trees are indicated by open circles.

CLASSIFICATION OF VIGOUR OF YELLOW BIRCH

Hawboldt and Skolko (1948) established a crown classification system for use in their study of birch "dieback" in the Maritime Provinces of Canada. Other investigators (Greenidge, 1953; Hill and Sinclair, 1954) have also used this system in their studies of birch. The same classification was used in this investigation to permit a valid comparison of the vigour of the trees at Chalk

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River with those elsewhere. Because this system is the basis for progressive observations in the yellow birch trees of the experimental plot, the details are outlined below:

1 A Normal tree. Foliage full size and normal in colour. No dead twigs or branches.
1 B As in 1 A, except dead twigs or branches that may be attributed to suppression, whipping, breaking, wind or logging injury.
2 A Foliage abnormally small, thin, curled, yellowish or otherwise weak in appearance but not conspicuously so. No dead twigs or branches.
2 B As in 2 A, but conspicuously so.
3 AD Tree with small twigs dead for no apparent reason, such twigs occurring at the ends of branches, usually at the top of the crown, and for a distance not to exceed three inches from the periphery.
3 A Tree with small branches dead for no apparent reason usually at the top of the crown, dying back not more than three feet from the periphery.
3 (A) Tree with twigs and not more than three branches dead for no apparent reason, such twigs and branches usually being located in the apical half of the crown.
3 B Tree with more than three branches dead for no apparent reason, constituting up to one-quarter of the crown.
3 $\underline{B}$ Tree with branches dead for no apparent reason, constituting one-quarter to one-half of the crown.
4 A Tree with one-half to three-quarters of the crown dead.
4 $\underline{A}$ Tree with more than three-quarters of the crown dead.
4 $\overline{B}$ Tree with no living branches except vigorous adventitious ones usually found at the base of the crown.
4 $\underline{B}$ As 4 B, except with adventitious branches which are not vigorous.
5 $\overline{A}$ Tree with crown dead, but having cambium green at breast height.
5 B Tree with crown dead but cambium brown at breast height. Tree has recently died and has most of the fine twigs still adhering.
6 A Tree dead for several years. Some smaller branches remain.
6 B Tree dead for several years but only stem and primary branches remain.

The above system was used to classify all yellow birch trees on the experimental plot each year in August when the leaves were fully developed. Although it gives a picture of the general appearance of the trees, a regrouping was used for correlation with growth behaviour. Eleven numerical indices represent a more even gradation in the state of health of the trees under study (Table 1).

TABLE 1.—CROWN CONDITION CLASSES AND EQUIVALENT NUMERICAL INDICES FOR CORRELATION WITH GROWTH BEHAVIOUR

Numerical Index	Crown Class	Numerical Index	Crown Class
I	1A, 1B, 2A, 2B, 3AD	VI	4A
II	3A	VII	4$\underline{A}$
III	3 (A)	VIII	4B
IV	3B	IX	4$\underline{B}$, 5A
V	3$\underline{B}$	X	5B, 6A, 6B
		XI	Fallen

OBSERVATIONS AND RESULTS

Vigour of Yellow Birch

In 1949 the census of the 241 yellow birch in various health classes (Appendix, Table A) showed that 1.7 per cent (4 trees) had recently fallen over, and 5 per cent (12 trees) were dead but still standing. A relatively small number (1.2 per cent) were in the advanced stages of decadence and 66.8 per cent

(161 trees) were in a healthy condition (Classes I, II and III). There were 18.7 per cent (45 trees) in Class IV (3B) which, with at least three branches in the crown dead for no apparent reason, may be considered as a stage marking the progress of decadence. However, trees in this group occasionally may recover and be reclassified into a healthier category. This occurs when the dead branches break off and no further deterioration occurs in the crown. The 6.6 per cent (16 trees) in Class VI (4A) in which the trees have from one-half to three-quarters of the crown dead represent a group from which there is usually no return to healthier classes but rather a progressive deterioriation until death.

In 1950 there was a general improvement in the health of the yellow birch. An increase of 3 and 25 trees in Classes I and II respectively was observed. These individuals were drawn from Classes III and IV. Only 7 trees showed deterioration and appeared in the dead Class X. This brought the total percentage of dead trees up to 7.9 which represented average conditions for birch stands in the Algonquin district as found by Barter (1947) three years earlier.

In 1951 there was again a marked improvement in the health of the yellow birch when an additional 73 trees occurred in the most healthy category (Class I), which now included 132 trees or 54.9 per cent of the stand. Most of these improved trees were from the relatively healthy Classes II, III and IV. The number of trees in the stages of advanced decadence (Classes VI to XI) remained almost the same as during the previous year.

In 1952 there was a slight deterioration in Class I which showed a 14.2 per cent decrease. One additional tree died. During the 1949-1952 period none of the dead trees fell over.

In 1953 Class I marked a slight improvement. The percentage of trees in Class II decreased from that of the previous year with some trees improving to Class I and others deteriorating into Class IV.

Over-all change in the various health classes was negligible in 1954. However, six of the dead yellow birch fell over.

In 1955 there was a 24 per cent decrease in Class I, with a resultant increase of numbers in Classes II, III, and IV. Another three trees fell over, bringing Class XI up to 5.4 per cent of the original yellow birch component. A generally slow deterioration of the trees in Class I was recorded in 1956 and 1957 with reasonable stability of the Classes II, III and IV. The largest change occurred in the intermediate Class VI which increased from 0.8 per cent to 8.3 per cent in 1957.

Thus during the nine years of observations there was a gradual improvement in crown condition from 1949 to 1951, followed by a slow decline until conditions in 1957 were essentially the same as those in 1949 except for the trees which had been windthrown, and the increase in the total of dead standing trees from 5.0 per cent to 9.5 per cent, which may be considered average for this type of stand (Barter, 1947).

Although radial growth of yellow birch and the distribution and abundance of tree species have been related to the three soil moisture sites on the experimental plot (Fraser, 1954, 1956), it is important to assess the relation of crown condition of the birch trees to the various sites. Of the 241 yellow birch, 17 were located on Moisture Regimes 1-2 (usually adequate moisture), 110 on Moisture Regimes 3-4 (moist), and 114 on Moisture Regimes 5-6 (wet). The condition of the trees on these three sites are shown in the Appendix, Tables B, C, and D, for the 1949-1957 period.

Of the 17 yellow birch on Moisture Regimes 1-2, there was an increase in Health Class I from 17.6 per cent in 1949 to 52.9 per cent in 1951. Thereafter, a gradual reversion took place until only 17.6 per cent of the trees were again in Health Class I by 1957. A similar pattern existed in the other Health Classes, except for Class XI (Fallen) which increased by one windthrown tree.

The percentage of the 110 yellow birch on Soil Moisture Regimes 3-4 in Health Class I ranged from 19.1 per cent in 1949 to 51.9 per cent in 1951, thereafter decreasing to 18.3 per cent by 1957. Other classes again followed a similar trend except for Classes X (Dead) and XI (Fallen) which increased from 4.5 per cent to 10 per cent, and 0.9 per cent to 4.5 per cent respectively. Most of this increase was caused by wind damage.

The 114 yellow birch located on the wet Soil Moisture Regimes 5-6 showed essentially the same changes as those on the other sites, with an increase in the percentage of trees in Health Class I from 28.1 per cent in 1949 to a maximum of 57.9 per cent in 1951, followed by a gradual decline to 26.4 per cent by 1957, almost the same status as nine years earlier.

Thus irrespective of the sites on which the yellow birch trees were located, the over-all changes in the condition of the trees followed the same pattern.

Radial Growth

Although relations of radial increment to ecological conditions on the plot have already been reported (Fraser, 1956), it is pertinent to include here the total annual radial growth of individual yellow birch trees for which progressive changes in crown conditions have been observed.

Radial growth was measured at periodic intervals with a dial gauge dendrometer (Fraser, 1952) on the south side of 39 yellow birch trees at the 4-foot level. The maximum growth for the trees in each Health Class was averaged for every year (Table 2). Although increment for the first three Health Classes overlapped, Class I had the greatest average increment of 59.1 mils for the 1949-1957 period. Classes I and III followed with 57.1 and 54.5 mils respectively. This would indicate that photosynthetic capacity of the trees in these three classes did not appreciably differ. Except in 1949, when the equilateral triangular location of the dendrometer reference screws may have stimulated callus growth at the dendrometer measuring point (this possible error was eliminated in 1950 by a rearrangement of the reference screws in the form of a right-angled scalene triangle), the greatest average growth rate for trees of the first three classes occurred during 1951 and 1952. This is probably a reflection of the opening of the stand by defoliation of hardwood species other than yellow birch by infestation of the tent caterpillar (*Malacosoma disstria* Hubn.) at that time (Fraser, 1956). Appreciable reduction of radial increment occurred in Health Class I during 1955 and 1956. This may be attributed to the abnormally dry (1955) or wet (1956) conditions during those respective years.

Health Class IV was accompanied by a gradual decrease in radial increment, except for growth in 1952, and trees in this class are considered unhealthy and likely to continue to deteriorate. Once a tree has passed into Health Class V or higher, death will inevitably follow within a few years. Trees in Classes V to IX were dying with only a few individual branches or adventitious shoots remaining alive. Annual radial growth less than 10 mils was usually recorded in this group. When the trees died, a gradual shrinkage of radius averaging 10 mils per year occurred during the first five years after death.

The annual radial increment in selected yellow birch trees in various Health Classes is illustrated in Figure 2. The progressive changes in health conditions are shown by the open squares. A value of Class I indicates the most healthy condition, and various stages of decadence are designated with increasing orders of magnitude through to XI. Similarly the amount of radial growth for each year is designated by histograms with the annual amount of growth indicated along the vertical axis on the left side of the figure.

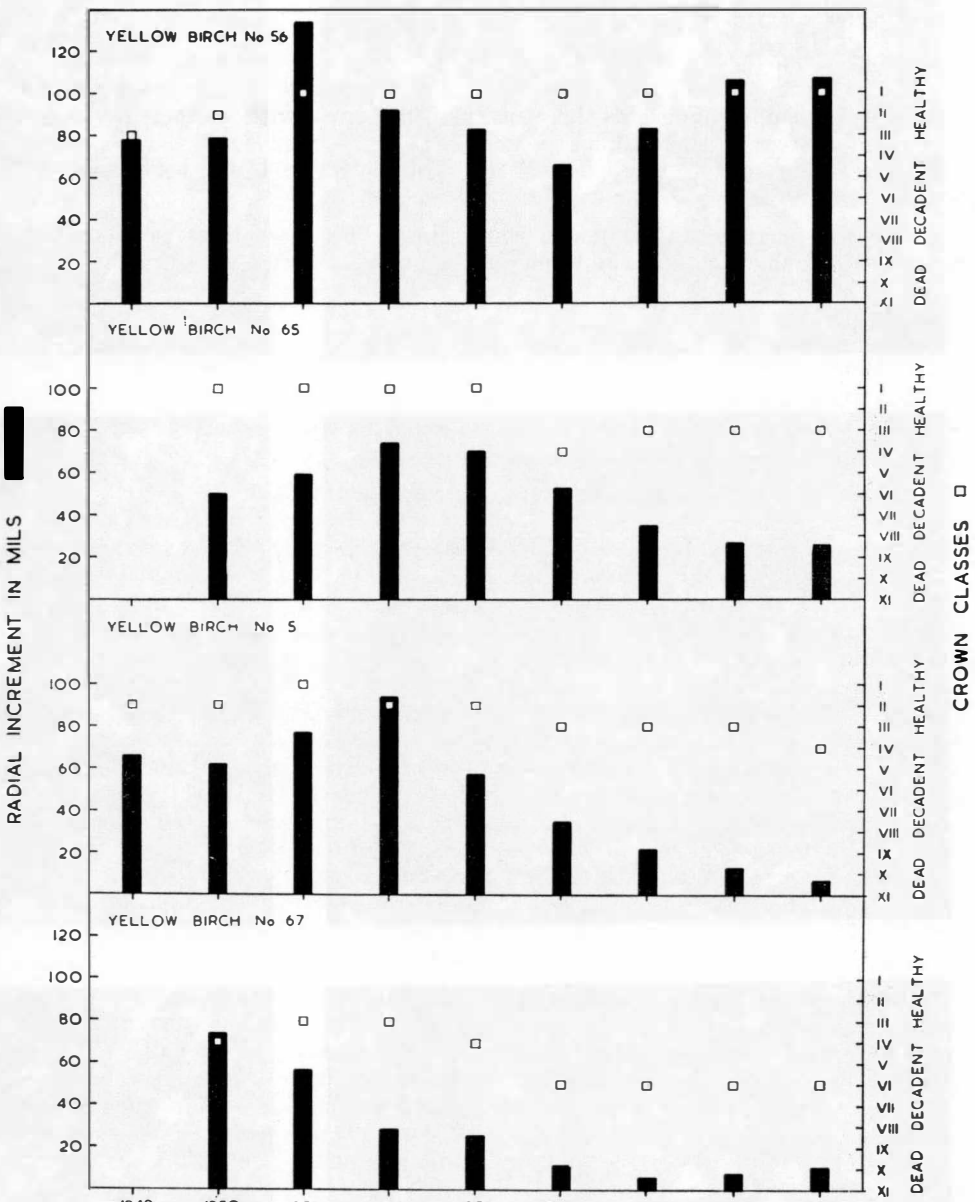
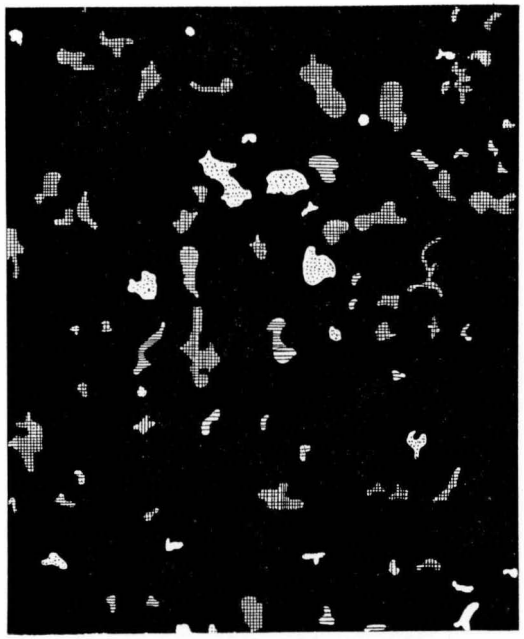
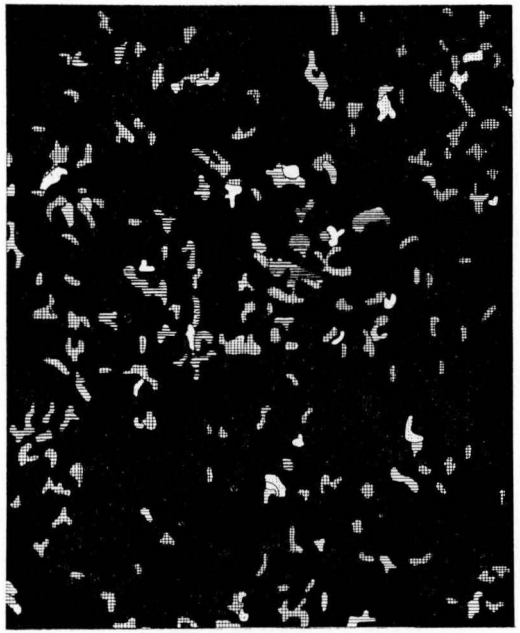


FIGURE 2. Radial increment (histograms) and health condition (open squares) of four yellow birch trees during the 1949-57 period.

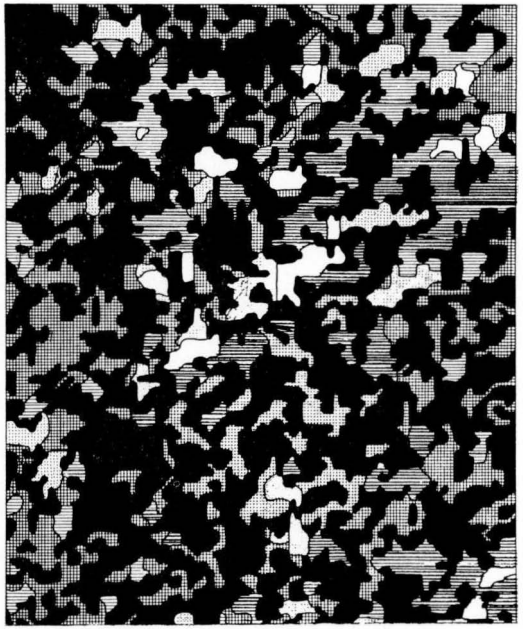
1949



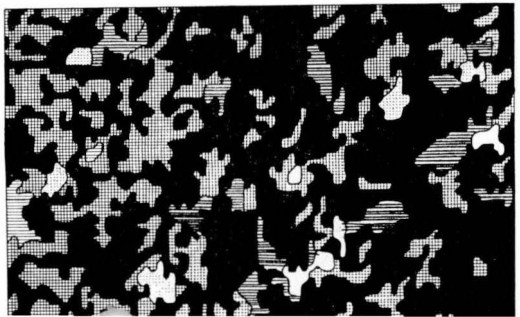
1950



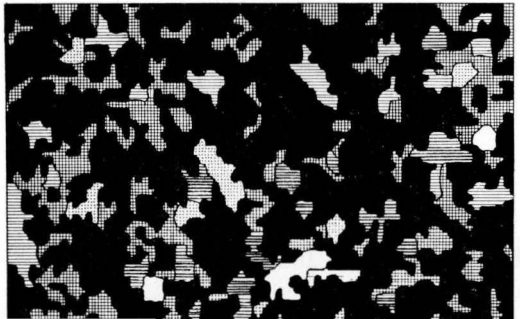
1951



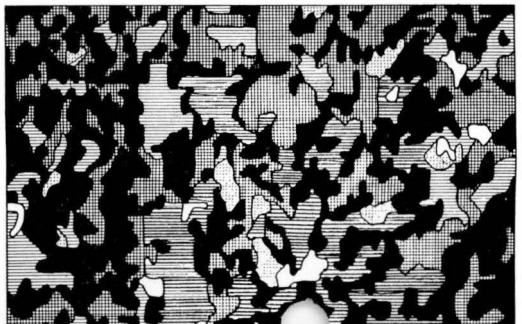
1952



1953



1954



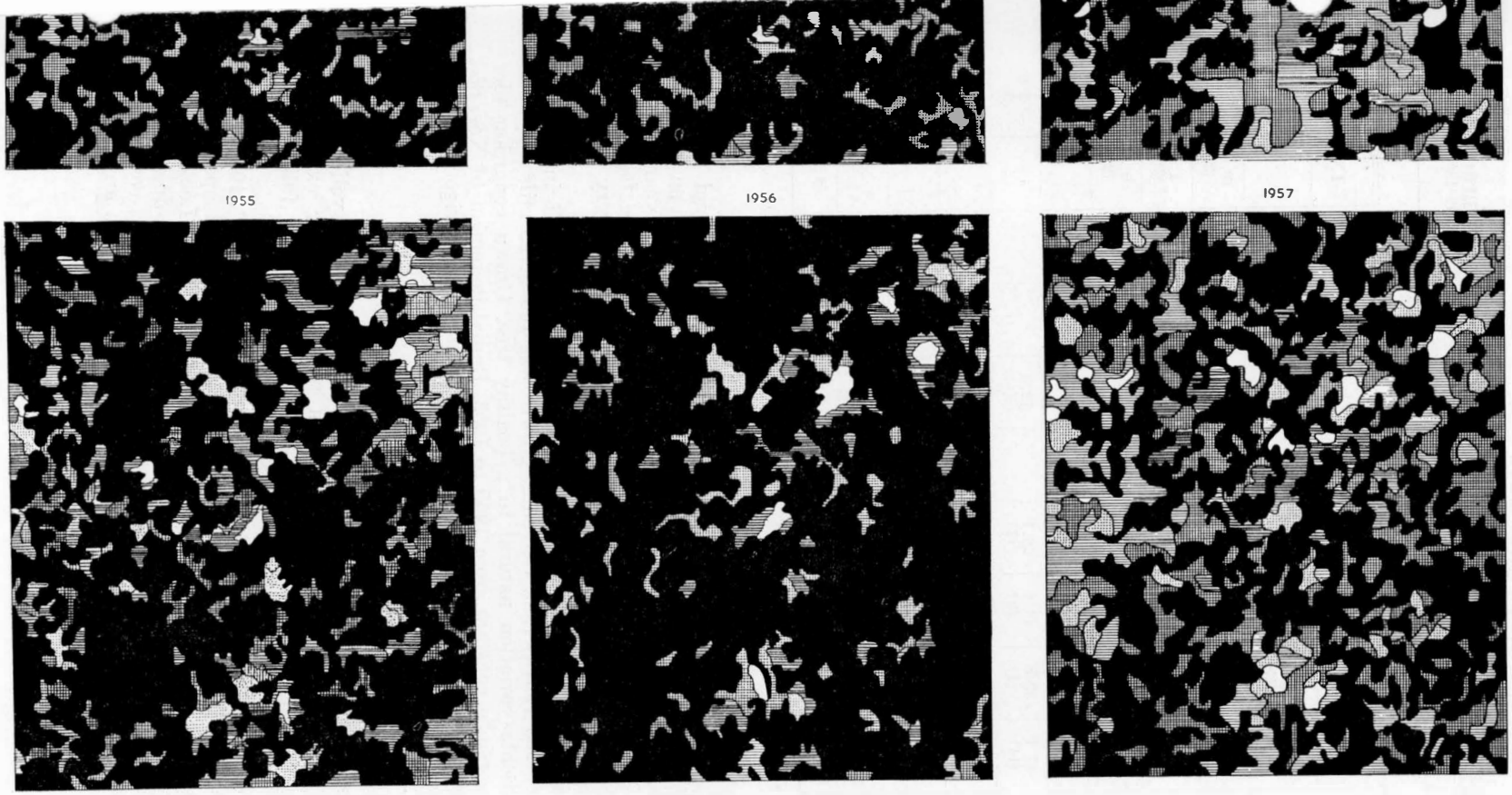


FIGURE 3. Canopy conditions on the experimental plot during the 1949-57 period.

Crown Density:		*Symbol*:	
	90-100%		black
	80-89 %		double hatched
	60-79 %		single lines
	40-59 %		stippled
	0-39 %		white

TABLE 2.—AVERAGE ANNUAL RADIAL GROWTH IN MILS OF YELLOW BIRCH ON AN 8-ACRE PLOT, IN VARIOUS HEALTH CLASSES DURING THE 1949–1957 PERIOD. (Number of trees in each group shown in brackets.)

YEAR	Crown Class I	II	III	IV	V	VI	VII	VIII	IX	X (Dead)
1949*	82.7 (3)	66.4 (5)	71.9 (19)	62.0 (5)						
1950	51.3 (6)	62.8 (11)	48.5 (14)	55.0 (5)		9.0 (1)			10.0 (2)	
1951	77.4 (18)	55.3 (7)	75.0 (9)	39.5 (2)		4.0 (1)			1.5 (2)	
1952	72.0 (12)	79.3 (12)	54.9 (8)	52.8 (4)					0.5 (2)	
1953	66.8 (14)	63.5 (8)	68.7 (7)	36.2 (6)						−14.0 (3)
1954	47.1 (14)	52.8 (4)	46.1 (9)	32.1 (7)		12.0 (1)				− 5.0 (3)
1955	34.2 (11)	58.2 (5)	32.4 (11)	23.1 (7)		6.0 (1)				− 8.7 (3)
1956	38.3 (8)	25.7 (10)	30.9 (9)	12.5 (6)		8.5 (2)				−11.3 (3)
1957	58.3 (6)	46.4 (8)	54.6 (5)	17.6 (10)	6.0 (1)	11.0 (3)		−2.0 (1)		−14.7 (3)
1949–57	59.1	57.1	54.5	33.3	6.0	9.0		−2.0	4.0	−10.7

* Based on 32 trees only.

The four yellow birch trees represented ranges in age, site and variation of crown conditions. Tree No. 56 was 86 years old in 1949 and located on Moisture Regime 2 with infrequent wilting condition. Tree No. 5 was 98 years old on a damp part of the plot with the water table usually within three feet of the surface. Trees No. 65 and 67 were both 120 years old on the very wet Soil Moisture Regime 6.

The crown condition of Tree No. 56 improved from Class III in 1949 to Class I for the 1951-1957 period. Its radial growth was 100 ± 25 mils per year and this represents variation natural to a healthy tree. Crown condition for Tree No. 65 remained constant from 1950 to 1953. Radial increment of Nos. 65 and 5 increased up to 1952. The other trees showed diminishing vigour during the study period accompanied by decreased radial increment.

Canopy

In addition to the annual tally of the condition of individual yellow birch trees, a record of crown closure was kept as part of another experiment (Fraser, 1956). Canopy conditions might reflect the amount of foliage and consequent photosynthetic capacity in a specific year.

The "moosehorn" periscope apparatus developed by Robinson (1947), and modified as described below, was used in this study. The vertical aperture of this instrument contains a glass plate graticuled into 25 squares. Looking into the eyepiece, the observer views the crown through the vertical aperture by means of a mirror set at a 45-degree angle. The number of squares covered by the foliage is recorded. When held at eye level, the grid subtends an area of one

milacre at a height of 40 feet. Canopy observations were made annually at 100 stations, 10 links apart, on each of the 80 square chains of the experimental plot during August when the leaves were fully developed. Although there were variations in the height of the canopy from the ground, this intensity of study allowed for approximately 100 per cent crown canopy sampling.

The consistency of crown closure measurements with this instrument was tested by the selection of 33 stations at each of which one observer made 10 determinations, and three other observers made a single determination. Variability in the records obtained by different observers has already been described (Fraser, 1956). Somewhat more consistent readings were obtained by one observer than by the entire group of four untrained observers. The results indicate that the "moosehorn" gives consistent readings at high crown canopy densities, but less accurate readings at moderate crown canopy cover (50 per cent crown cover). This is in agreement with work by Lemmon (1956).

In studying the canopy of the entire plot, observations were made during calm days to avoid difficulties introduced by swaying of the tree crowns. The data were grouped into five density classes. The proportion of sampling stations characterized by low crown densities was so small that broad classes of crown density were accepted in the lower ranges while much narrower classes were used in the upper ranges (Table 3).

TABLE 3.—PERCENTAGE OF PLOT AREA CORRESPONDING TO VARIOUS CROWN DENSITY CLASSES, 1949–1957.

Crown Density Class	1949	1950	1951	1952	1953	1954	1955	1956	1957
90–100%	92	90	58	70	72	41	66	81	50
80–89%	6	6	19	21	19	36	19	11	28
60–79%	1	3	16	6	6	17	9	5	15
40–59%	1	1	5	3	2	4	3	1	4
0–39%	0	0	2	0	1	2	3	2	3

In 1949 and 1950 the crown canopy classifications were similar, more than 90 per cent of the plot being in the highest density class. Six per cent of the crown canopy fell in the 80-89 per cent coverage during these two years. The distribution of these crown closure classes (Figure 3) indicates the locations of the five crown density classes for the 1949-1957 period. In 1951, an infestation of tent caterpillar caused moderate defoliation (50%) of basswood (*Tilia americana* L.), red oak (*Quercus rubra* L.), and sugar maple, and light defoliation (15%) of white birch. The resultant opening of the canopy is reflected in the measurement of crown density during 1951 when only 58 per cent of the plot was recorded in the highest density class. Less defoliation occurred in 1952 with a corresponding improvement in crown closure, 70 per cent being in the highest density class. Although there was no defoliation in 1953, the crown closure remained the same as during the previous year. This underdevelopment of the crown in 1953 is attributed to lack of photosynthetic capacity during

the previous period of defoliation. The stand opened somewhat in 1954 and 1957 when 77 and 78 per cent of the canopy were in the 80-100 per cent crown density classes. Although this still represented rather dense cover, it did portray a change from the intervening years of 1955 and 1956, when the percentages of canopy in these cover classes were 85 and 92 per cent respectively. The decreased crown cover in 1954 and 1957 was partly caused by windthrown trees. It is of interest to note that the two years of 1954 and 1957, when the canopy was opened more than usual, were years of higher than average rainfall and were relatively cool in the earlier part of the summer. This may have affected the size of leaf development, although no quantitative data are available to substantiate this assumption.

DISCUSSION

Concerning the progress of "dieback" symptoms in individual yellow birch trees, Barter (1953) stated that "affected trees usually die within two to six years after the onset of malady; surviving trees suffer variable degrees of crown damage, some of which eventually recover."

Thus the nine years of observations on the 241 yellow birch of the experimental plot at Chalk River should be sufficiently long to warrant a conclusion as to the presence of a "dieback" epidemic similar to that prevalent in certain Maritime birch stands during the past two decades.

The observations indicate that the health of the yellow birch improved from 1949 to 1951 and then gradually declined until in 1957 it was essentially the same as nine years earlier, except in those trees damaged by winds. The increase in number of dead trees from 5.0 to 9.5 per cent may be considered average for such a hardwood stand, and agrees with Barter's findings (1949) in adjacent birch stands in eastern Ontario. The improved health and growth of yellow birch in 1951 may be attributed to the temporary release of this species when other hardwood components of the stands were defoliated by an infestation of tent caterpillar.

There was no indication that changes in crown conditions were associated with sites on the experimental plot, although variations of radial growth were correlated with annual fluctuations in soil moisture (Fraser, 1956). Radial increment did not show a marked reduction until Crown Class IV was reached. This would indicate that changes in the first three Crown Classes do not represent a decline in the distribution of photosynthate to the cambium at breast height.

The canopy measurements indicated the effects of defoliation by insects in 1951, but it was surprising that similar classes of crown density were observed in 1954 and 1957 when no infestation by tent caterpillar was present. Some of the opening of the crown during these two particular years was caused by windfall, but it is of interest to note that both of these years were wetter and cooler than average. Perhaps leaf development was influenced by these environmental conditions.

SUMMARY

The crowns of 241 yellow birch trees were classified during the 1949-1957 period into Numerical Health Indices ranging from I (Healthy Crown) to X (Dead) and XI (Fallen). There was a progressive improvement in crown conditions from 1949 to 1951, followed by a gradual regression until 1957, when the health of the yellow birch was essentially the same as nine years earlier. Crown changes had no relation to site differences on the experimental plot. Radial growth of yellow birch was not reduced until the crown declined to an index of IV or higher. Defoliation of the hardwood species other than yellow birch in 1951 by a tent caterpillar infestation caused a temporary opening in the canopy and may have contributed to the improvement of yellow birch crowns at that time.

ACKNOWLEDGMENTS

The annual tally of crown conditions was carried out in co-operation with A. W. Hill, Forest Biology Division, Canada Department of Agriculture. Valuable service in the compilation of results was rendered by E. E. Gaertner, Z. Zdrazil, and D. McGuire.

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APPENDIX

Health classes of yellow birch over the 8-acre plot, and in relation to the three soil moisture sites thereon.

TABLE A—HEALTH CLASSES OF 241 YELLOW BIRCH ON AN 8-ACRE EXPERIMENTAL PLOT DURING 1949–1957

(Percentage of each class shown in brackets)

	HEALTHY			DECADENT				DYING		DEAD	
Year / Crown Class	I 1A – 3AD	II 3A	III 3(A)	IV 3B	V 3B	VI 4A	VII 4A	VIII 4B	IX 4B – 5A	X 5B – 6B	XI Fallen
1949	56 (23.3)	35 (14.5)	70 (29.0)	45 (18.7)		16 (6.6)		2 (0.8)	1 (0.4)	12 (5.0)	4 (1.7)
1950	59 (24.5)	60 (24.9)	51 (21.2)	30 (12.4)		15 (6.2)		3 (1.2)		19 (7.9)	4 (1.7)
1951	132 (54.9)	23 (9.5)	23 (9.5)	23 (9.5)		12 (5.0)	1 (0.4)			23 (9.5)	4 (1.7)
1952	98 (40.7)	57 (23.6)	25 (10.4)	20 (8.3)	1 (0.4)	9 (3.8)	2 (0.8)		1 (0.4)	24 (10.0)	4 (1.7)
1953	106 (44.0)	39 (16.2)	22 (9.1)	28 (11.6)	3 (1.2)	11 (4.6)	2 (0.8)	1 (0.4)		25 (10.4)	4 (1.7)
1954	98 (40.7)	36 (14.9)	25 (10.4)	33 (13.8)	3 (1.2)	13 (5.4)	2 (0.8)			21 (8.7)	10 (4.1)
1955	74 (30.7)	50 (20.7)	31 (12.9)	37 (15.4)	1 (0.4)	9 (3.7)	5 (2.1)			21 (8.7)	13 (5.4)
1956	62 (25.7)	62 (25.7)	26 (10.9)	38 (15.8)	2 (0.8)	8 (3.3)	4 (1.7)	1 (0.4)	1 (0.4)	23 (9.5)	14 (5.8)
1957	53 (22.1)	51 (21.2)	28 (11.6)	36 (14.9)	20 (8.3)	6 (2.5)	7 (2.9)	1 (0.4)	2 (0.8)	23 (9.5)	14 (5.8)

TABLE B—HEALTH CLASSES OF 17 YELLOW BIRCH ON MOISTURE REGIMES 1—2 ON AN 8-ACRE PLOT

(Percentage of each class shown in brackets)

	HEALTHY			DECADENT				DYING		DEAD	
Year / Crown Class	I 1A – 3AD	II 3A	III 3(A)	IV 3B	V 3B	VI 4A	VII 4A	VIII 4B	IX 4B – 5A	X 5B – 6B	XI Fallen
1949	3 (17.6)	3 (17.6)	7 (41.2)	1 (5.9)		1 (5.9)				1 (5.9)	1 (5.9)
1950	4 (23.5)	6 (35.2)	2 (11.8)	1 (5.9)		2 (11.8)				1 (5.9)	1 (5.9)
1951	9 (52.9)	1 (5.9)	2 (11.8)	1 (5.9)		2 (11.8)				1 (5.9)	1 (5.9)
1952	6 (35.2)	4 (23.5)	2 (11.8)	1 (5.9)		2 (11.8)				1 (5.9)	1 (5.9)
1953	8 (46.9)	1 (5.9)	2 (11.8)	2 (5.9)		2 (11.8)				1 (5.9)	1 (5.9)
1954	7 (41.2)	1 (5.9)	2 (11.8)	2 (11.8)		2 (11.8)				1 (5.9)	2 (11.8)
1955	6 (35.2)	2 (11.8)	2 (11.8)	2 (11.8)		2 (11.8)				1 (5.9)	2 (11.8)
1956	4 (23.5)	5 (29.3)	1 (5.9)	2 (11.8)		2 (11.8)				1 (5.9)	2 (11.8)
1957	3 (17.6)	4 (23.5)	1 (5.9)	3 (17.6)	1 (5.9)	1 (5.9)			1 (5.9)	1 (5.9)	2 (11.8)

TABLE C—HEALTH CLASSES OF 110 YELLOW BIRCH ON MOISTURE REGIMES 3—4 ON AN 8-ACRE PLOT

(Percentage of each class shown in brackets)

	HEALTHY			DECADENT				DYING		DEAD	
Year / Crown Class	I 1A – 3AD	II 3A	III 3(A)	IV 3B	V 3B	VI 4A	VII 4A	VIII 4B	IX 4B – 5A	X 5B – 6B	XI Fallen
1949	21 (19.1)	21 (19.1)	32 (29.1)	23 (20.9)		6 (5.6)			1 (0.9)	5 (4.5)	1 (0.9)
1950	21 (19.1)	31 (28.1)	28 (25.5)	14 (12.7)		6 (5.5)				9 (8.2)	1 (0.9)
1951	57 (51.9)	15 (15.6)	11 (10.0)	11 (10.0)		5 (4.5)	1 (0.9)			9 (8.2)	1 (0.9)
1952	41 (37.3)	30 (27.3)	11 (10.0)	11 (10.0)	1 (0.9)	4 (3.6)	1 (0.9)			10 (9.1)	1 (0.9)
1953	46 (41.9)	22 (20.0)	10 (9.1)	14 (12.7)	2 (1.8)	4 (3.6)	1 (0.9)			10 (9.1)	1 (0.9)
1954	43 (39.2)	20 (18.2)	12 (10.9)	16 (14.5)	2 (1.8)	5 (4.5)	1 (0.9			9 (8.2)	2 (1.8)
1955	32 (29.1)	26 (23.6)	14 (12.7)	19 (17.4)		3 (2.7)	3 (2.7)			9 (8.2)	4 (3.6)
1956	26 (23.6)	30 (27.3)	14 (12.7)	19 (17.4)	1 (0.9)	2 (1.8)	1 (0.9)		1 (0.9)	11 (10.0)	5 (4.5)
1957	20 (18.3)	27 (24.6)	15 (13.6)	16 (14.5)	11 (10.0)	2 (1.8)	2 (1.8)		1 (0.9)	11 (10.0)	5 (4.5)

TABLE D—HEALTH CLASSES OF 114 YELLOW BIRCH ON MOISTURE REGIMES 5—6 ON AN 8-ACRE PLOT

(Percentage of each class shown in brackets)

	HEALTHY			DECADENT				DYING		DEAD	
Year / Crown Class	I 1A – 3AD	II 3A	III 3(A)	IV 3B	V 3B	VI 4A	VII 4A	VIII 4B	IX 4B – 5A	X 5B – 6B	XI Fallen
1949	32 (28.1)	11 (9.6)	31 (27.1)	21 (18.4)		9 (7.9)		2 (1.8)		6 (5.3)	2 (1.8)
1950	34 (29.8)	23 (20.2)	21 (18.4)	15 (13.2)		7 (6.1)		3 (2.6)		9 (7.9)	2 (1.8)
1951	66 (57.9)	7 (6.1)	10 (8.8)	11 (9.6)		5 (4.4)				13 (11.4)	2 (1.8)
1952	51 (44.7)	23 (20.2)	12 (10.5)	8 (7.0)		3 (2.6)	1 (0.9)		1 (0.9)	13 (11.4)	2 (1.8)
1953	52 (45.5)	16 (14.0)	10 (8.8)	12 (10.5)	1 (0.9)	5 (4.4)	1 (0.9)	1 (0.8)		14 (12.3)	2 (1.8)
1954	48 (42.0)	15 (13.2)	11 (9.6)	15 (13.2)	1 (0.9)	6 (5.3)	1 (0.9)			11 (9.6)	6 (5.3)
1955	36 (31.6)	22 (19.3)	15 (13.6)	16 (14.0)	1 (0.9)	4 (3.5)	2 (1.8)			11 (9.6)	7 (6.1)
1956	32 (28.1)	27 (23.8)	11 (9.6)	17 (14.9)	1 (0.9)	4 (3.5)	3 (2.6)	1 (0.9)		11 (9.6)	7 (6.1)
1957	30 (26.4)	20 (17.6)	12 (10.5)	17 (14.9)	8 (7.0)	3 (2.6)	5 (4.4)	1 (0.9)		11 (9.6)	7 (6.1)