DETERIORATION AND REPLACEMENT IN TWO OVERMATURE FOREST STANDS

by

G. L. BASKERVILLE

Résumé en français

DEPARTMENT OF FORESTRY PUBLICATION NO. 1125

1965

ABSTRACT

The early progress of stand deterioration and replacement in two overmature stands, a softwood and a mixedwood, is described on the basis of data recorded on two 0.6-acre study plots. The major developmental difference is the vigorous invasion of the mixedwood stand by mountain maple in contrast to the formation of an evenly distributed softwood advance growth under the softwood stand.

RÉSUMÉ

L'auteur décrit les constatations faites dans deux peuplements surannées, l'un résineux et l'autre mixte, des premiers signes de dépérissement et de remplacement par de nouveaux peuplements. Ces constatations s'appuient sur des données recueillies au cours d'une étude de deux placeaux d'une superficie de 0.6 acre chacun. La caractéristique la plus frappante est l'invasion vigoureuse du peuplement mixte par l'érable à épis, par contraste avec l'établissement et la répartition uniforme des semis préexistants dans le peuplement de conifères.

Published under the authority of

The Honourable Maurice Sauvé P.C., M.P.,

Minister of Forestry

Ottawa, 1965

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1965

Catalogue No. Fo 47-1125

Table of Contents

Deterioration and Replacement in Two Overmature Forest Stands

by

G. L. Baskerville[1]

INTRODUCTION

Francis Bacon once wrote that "Nature to be commanded must be obeyed . . .". This apparently paradoxical philosophy has played an important role in silvicultural research, for we recognize that silvicultural practices which make use of natural trends are generally the simplest and least costly to implement. Observation of stand development in undisturbed areas helps to reveal these natural trends.

At the Green River Project in northwestern New Brunswick a study of stand development in a natural area was begun by A. B. Vincent in 1952. Two stand types, overmature softwood and overmature mixedwood, which together occupy a major portion of the operable sites in the watershed, are being studied. The objective of the study is to establish a record of the deterioration of old stands and their replacement by new stands. The net effect of ecological interactions uninfluenced by human action are being recorded and analyzed for some insight into the dynamics of stand development. This study is intended to complement the large amount of data of rather generalized nature accumulated from line-plots in the same area (Vincent, 1955 and Hughes, 1963).

The study consists of two 0.6-acre plots (132 feet by 198 feet) set up in 1952 and upon which detailed data are recorded for every tree over 0.5 inches d.b.h. The data include species, stem position and crown projection on a large scale map, diameter at breast height, total height, crown length, and crown class. These data are supplemented by total counts of all stems less than 0.5 inches d.b.h. by species and height class on 60 randomly distributed milliacre quadrats on each plot. A record is made of the position of all windfalls. Contour maps with a 6-inch interval were prepared for each plot.

This paper reports some trends that can be illustrated by data from a first remeasurement made in 1963.

THE AREA

The study area is near the northern end of the Green River Watershed in some 300 acres reserved from cutting. The forest is classified by Rowe (1959) as boreal (Section B.2). The climate is characterized by long cold winters and short cool summers. Annual precipitation is 42 inches of which about 18 inches fall during the frost free period. The climate and soil are near optimum for balsam fir which is the major species in what is essentially a fir-spruce-birch forest (*Abies balsamea* (L.) Mill., *Picea glauca* (Moench.) *Betula papyrifera* Marsh.

The plots lie on a broad gently sloping hill top. The elevation is 1,780 feet above sea level, the relative elevation about 450 feet, and the aspect northwest. The mixedwood plot lies on level ground and the softwood plot lies on the northwest side of a small knoll with a 10 per cent slope. The soil is a strongly podzolized,

[1]Research Officer, Department of Forestry of Canada, Fredericton, N.B.

slightly stony silt loam. The parent material is a till derived from the steeply dipping, highly fractured soft shale bedrock. Drainage is unimpeded and the site would be described as fresh.

PREVIOUS HISTORY

The stands are in every respect virgin. There has never been any disturbance by man except for plot establishment and remeasurement. The stands probably originated as advance growth under similar overmature stands in the period 1850-80. The spruce budworm (*Choristoneura fumiferana* (Clem.)) epidemic of the 1880's obliterated most of the overstorey and released the advance growth. When this study was established in 1952 the softwoods were about seventy years from release and about ninety years old in total age. The birch appears to have entered the stand as defoliation by the spruce budworm proceeded in the 1880's and is slightly younger than the softwoods. In terms of age from release the stands were even-aged in 1952.

The spruce budworm infestation of 1913-19 occurred when these stands were about forty years old and growing vigorously. Softwood mortality as a result of defoliation apparently was not excessive as a substantial stand survived. In addition to this "thinning", defoliation had two other important effects. First the loss of a portion of the softwood stand allowed more rapid development of the birch which were falling behind the fir and spruce; many birch utilized openings in the stand to become wolf trees with large spreading crowns. A second more limited effect was the introduction of a minor understorey of fir advance growth. In the forests of this area an advance growth of fir and to a lesser extent of spruce is characteristic of all stands over 50- to 60-years old containing fir and spruce in the overstorey.

Beginning about 1940 there was heavy mortality of white and yellow birch as a result of birch dieback. Dieback, which results in the loss of foliage on successively lower branches until only a fringe at the base of the lower branches remains or until the tree is totally defoliated and dies, affected all of the larger birch trees in the study area. Loss of the wolf trees created large openings in the stand and had considerable ecological importance.

STAND DEVELOPMENT 1952-1963

In 1952 the stands exhibited all the characteristics of overmaturity and were relatively open. The large birch were nearly all dead having left sizeable holes in the canopy. In the 11 years between measurements there were no exceptional wind or ice storms. Defoliation of fir by the spruce budworm in its recent infestation (1951–58) was never more than light because the stand was isolated by large areas clearcut for pulpwood. The most characteristic feature has been a steady unspectacular attrition of the older trees.

Softwood

In 1952 the softwood stand contained 363 stems per acre larger than 0.5 inches d.b.h. (Table 1). The stand was made up of fir, spruce, white birch, and a small amount of mountain ash (*Sorbus decora* (Sarg.) Schneid.). The basal area was 118 square feet per acre (Table 2). By 1963 the number of stems per acre had increased to 657 and the basal area to 137 square feet with yellow birch and pin cherry entering the stand. Mortality amounted to 61 trees per acre (56 of them fir) with a basal area of 6 square feet. The net interaction of tree size and number involved in these changes is depicted in Figure 1 where number of stems per acre

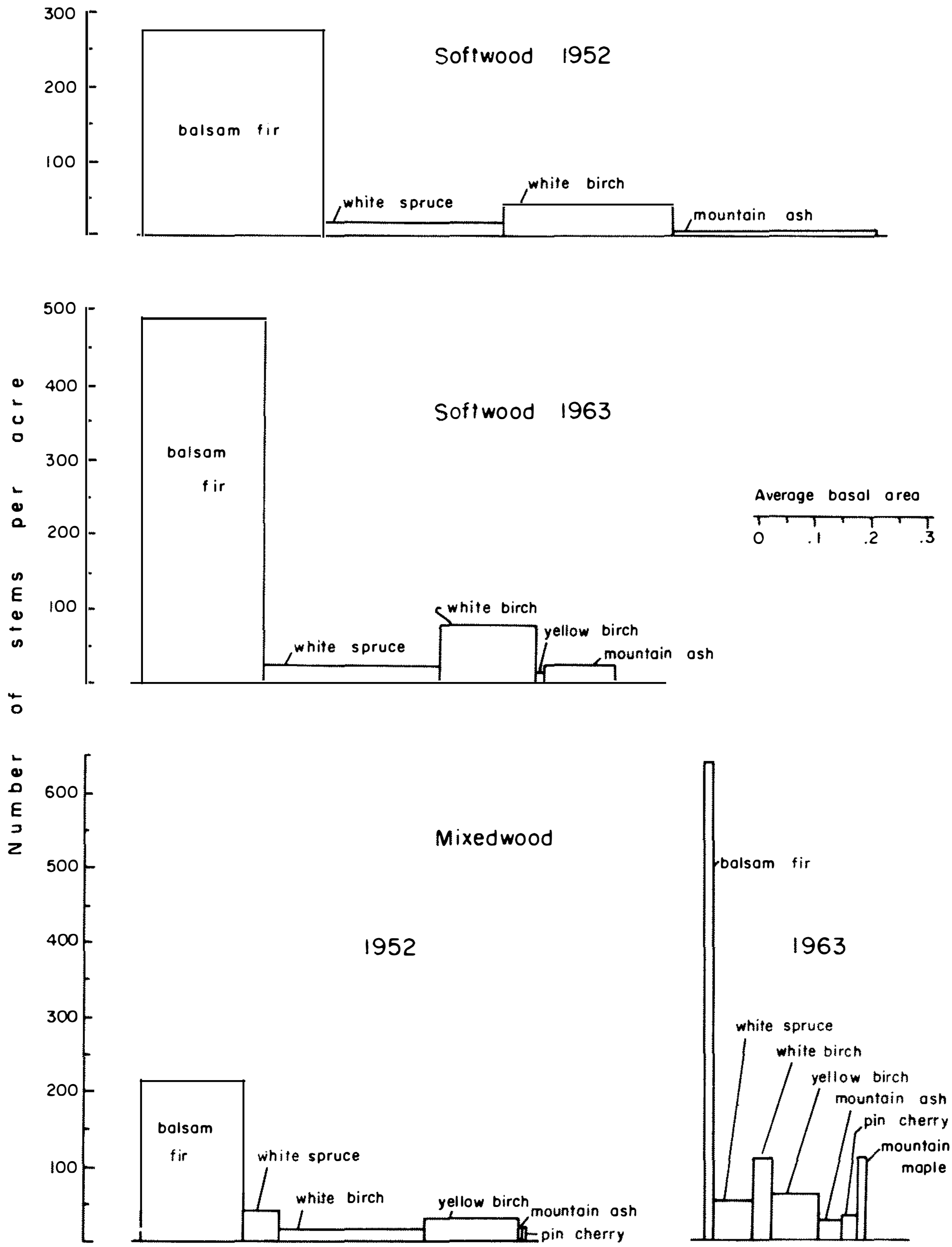

FIGURE 1. Structure histogram showing number of stems per acre (height of bar) and basal area of average stem (width of bar) for each species in the two stands for 1952 and 1963.

TABLE 1. SUMMARY OF STAND TABLES FOR 1952 AND 1963

Dia.	Balsam Fir	White Spruce	White Birch	Yellow Birch	Mountain Ash	Pin Cherry	Mountain Maple	Total
Softwood Stand				(number of stems per acre)				
1952 1-4	68	8	6	—	—	—	—	82
5-10	182	5	36	—	5	—	—	228
11 +	42	3	5	—	2	—	—	52
Total:	292	16	47	—	7	—	—	362
1963 1-4	310	13	48	12	17	2	—	402
5-10	132	5	35	—	3	—	—	175
11 +	72	3	3	—	2	—	—	80
Total:	514	21	86	12	22	2	—	657
Mixedwood Stand								
1952 1-4	266	25	10	13	12	12	—	338
5-10	126	3	2	5	—	—	—	136
11 +	30	2	3	2	—	—	—	37
Total:	422	30	15	20	12	12	—	511
1963 1 -4	517	45	113	55	27	30	167	954
5-10	93	5	2	8	2	—	—	110
11 +	63	2	2	2	—	—	—	69
Total:	673	52	117	65	29	30	167	1,113

TABLE 2. STANDING BASAL AREA AND INCREMENT

	Balsam Fir	White Spruce	White Birch	Yellow Birch	Mountain Ash	Pin Cherry	Mountain Maple	Total
Softwood Stand				(square feet per acre)				
1952	95.5	5.3	15.0	—	2.4	—	—	118.2
1963	111.8	6.9	15.1	0.1	2.8	—	—	136.7
Net change	16.3	1.6	0.1	0.1	0.4	—	—	18.5
Mortality	5.2	—	0.7	—	0.1	—	—	6.0
Gross increment	21.5	1.6	0.8	0.1	0.5	0.01	—	24.5
Mixedwood Stand								
1952	77.3	1.9	3.9	3.3	—	0.1	—	86.5
1963	92.1	3.8	3.4	5.6	1.2	0.8	1.7	108.6
Net change	14.8	1.9	−0.5	2.3	1.2	0.7	1.7	22.1
Mortality	7.7	—	0.7	—	—	—	—	8.4
Gross increment	22.5	1.9	0.2	2.3	1.2	0.7	1.7	30.5

for each species is represented by the height of the bar and average basal area per tree for each species by bar width. The area of a block in the histogram therefore represents basal area per acre.

The most significant features of the period were high softwood mortality and influx of the more intolerant species. Most of the fir mortality was in trees between 4 and 12 inches d.b.h.: there was therefore a considerable increase in the number of smaller trees, a sharp reduction of trees in the mid-range of diameter and a slight reduction in the largest diameter class (13 to 18 inches d.b.h.). All fir mortality in trees larger than 4 inches d.b.h. resulted from wind throw and wind breakage. The loss of white birch was slight, apparently because there were few trees susceptible to dieback still living in 1952.

The entry into the stand of yellow birch (*Betula alleghaniensis* Britt.) and pin cherry (*Prunus pensylvanica* L.f.), both relatively intolerant species, is indicative of the breakup of the canopy. Most seedlings of these species were found on the root mounds of windthrown fir.

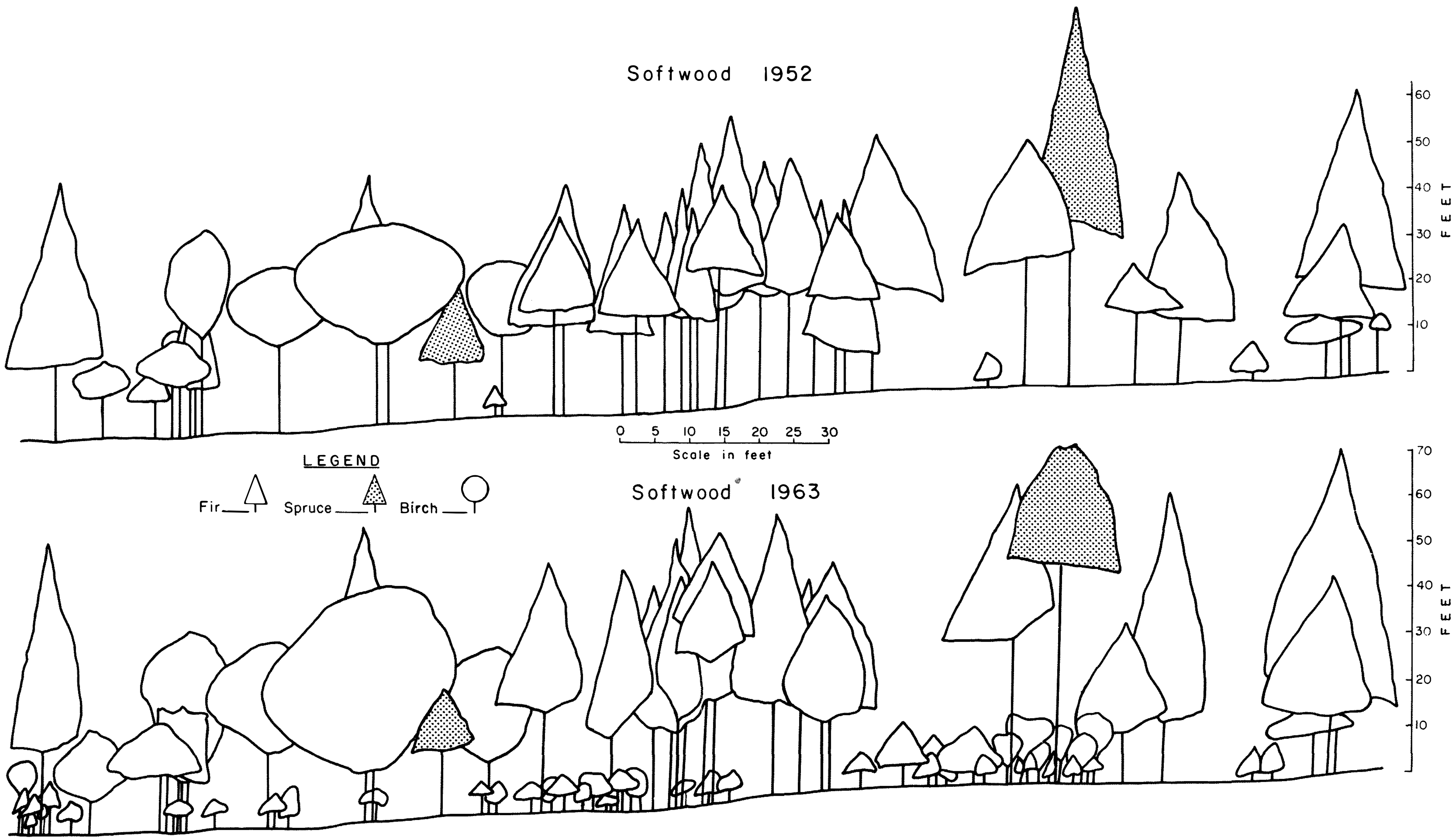

FIGURE 2. Profiles of the softwood stand in 1952 and 1963. Constructed from a transect 26 ft. x 198 ft.

TABLE 3. NUMBER OF STEMS OF ADVANCE GROWTH IN 1952 AND 1963

Height	Balsam Fir	White Spruce	White Birch	Yellow Birch	Mountain Ash	Pin Cherry	Mountain Maple	Total
	(number of stems per acre)							
(ft.)								
Softwood Stand								
1952 0–0.5	6,400	200	1,200	—	80	—	—	7,880
0.6–4.0	4,520	180	670	—	540	30	—	5,940
4.1+	230	—	30	—	30	20	—	310
Total	11,150	380	1,900	—	650	50	—	14,130
1963 0–0.5	32,650	30	1,730	370	150	—	—	34,930
0.6–4.0	3,850	280	150	100	430	—	70	4,880
4.1+	550	40	200	—	250	—	10	1,050
Total	37,050	350	2,080	470	830	—	80	40,860
Mixedwood Stand								
1952 0–0.5	3,350	50	—	20	—	—	—	3,420
0.6–4.0	1,690	30	110	90	20	50	—	1,990
4.1+	170	—	20	70	—	—	—	260
Total	5,210	80	130	180	20	50	—	5,670
1963 0–0.5	118,500	—	370	150	—	—	330	119,550
0.6–4.0	1,320	30	—	70	20	80	620	2,140
4.1+	330	—	—	130	10	—	180	650
Total	120,150	30	370	350	30	80	1,130	122,140

The number of stems per acre in sizes below 0.5 inches d.b.h. increased from 14,130 in 1952 to 40,860 in 1963 (Table 3). Most of this increase resulted from heavy fir seed crops in 1956 and 1962. By contrast 1951 was a very poor fir seed year. Yellow birch reproduction became more common while pin cherry dropped out of the reproduction stand. Probably the most interesting feature is the entry of mountain maple (*Acer spicatum* Lamb.). However these shrubs were poorly developed and if the stand continues to fall apart gradually they will not likely proliferate and take over any large portion of the site.

To illustrate the changes in stand structure during the eleven year period a profile has been constructed for a strip 26 feet wide and 198 feet long across the middle of the 0.6-acre study area (Figure 2). The transect shows only those stems 0.5 inches d.b.h. and larger. Development has been unspectacular. Trees lost to wind fall have been uniformly distributed and the response of the advance growth has been similarly uniform. Indeed the most characteristic feature of the stand today is the uniform distribution and development of the softwood advance growth (Figure 4).

Mixedwood

On the basis of the 1952 stand the mixedwood appears somewhat misnamed. It did in fact contain a sizeable hardwood component before the coming of the birch dieback and shows the chief characteristics of post-dieback mixedwood development. Hughes (1960) reported net decrements of birch basal area as great as 4.0 square feet per acre per year in stands near this study area for the period 1947–1956. It appears that this high rate of loss of white birch was concentrated in the late 1940's for by 1952 the birch component had stabilized at about eight per cent of the total basal area. Compilation on the basis of the standing dead birch in 1952 plus the then living birch indicates that the pre-dieback stand was at least 42 per cent birch. The standing dead birch in 1952 ranged from 4 to 22 inches d.b.h.

The 1952 stand contained 511 trees per acre (Table 1) with a basal area of 86 square feet per acre (Table 2). The species represented were fir, spruce, white and yellow birch, mountain ash and pin cherry. By 1963 there were 1,132 trees per acre with a basal area of 109 square feet. Mountain maple was the only new species.

Total mortality amounted to 8.4 square feet of basal area comprised of 65 trees (63 of them balsam fir). White birch had a small net decrement in basal area during the period (Table 2). Fir mortality was concentrated in the 1- and 2-inch trees as a result of crowding in dense patches and in trees larger than 9 inches as a result of wind throw and wind breakage.

The net effect of the changes on stand form and structure are shown in Figures 1 and 3. The magnitude of the changes are much greater than are apparent in the softwood stand. The mixedwood stand was more open than the softwood and the balsam in it were more subject to wind damage.

The reproduction stand increased from 5,670 stems per acre to 122,140 stems per acre during the study period (Table 3). Most of this increase was small fir resulting from the 1956 and 1962 seed crops. These small seedlings, especially the most recent, are transitory and few are expected to survive another 10-year period. The most obvious and important developmental feature of the stand is the increase of mountain maple from nil to 1,130 stems per acre.

The mixedwood transect (Figure 3) indicates rapid development of the softwood advance growth wherever it was established in 1952 and the tendency of mountain maple to fill in holes under dead birch. There is rarely, if ever, mountain maple present among the fir in the patches of thicket. There is often, indeed usually, fir present under the mountain maple but it is below the mountain maple crown level and severely suppressed. Thus where fir was well established in 1952 fir predominates to the exclusion of mountain maple, but where fir advance growth was poorly developed mountain maple has grown rapidly and now controls the site.

DISCUSSION AND CONCLUSIONS

Both trend and rate of development have been different in the two areas. The large birch have gone from both plots but the greater initial abundance of birch in the mixedwood resulted in a generally more open stand. In the mixedwood stand the loss of birch left many of the softwoods exposed to wind stress with a consequent loss of the larger fir and spruce. By contrast in the softwood stand the largest fir and spruce are still standing and the wind loss has been evenly spread throughout the stand. The rate and nature of deterioration of the overstorey has naturally influenced development of the advance growth. There is a sharp contrast between the relatively clean uniformly stocked and evenly developed softwood reproduction under the softwood stand and the intermittent patches of dense shrub and dense softwood growth found under the mixedwood (Figure 4 and 5). In this respect it is of interest to compare the percentage of crown cover of the two areas.

	Softwood	Mixedwood
	(% crown cover all species)	
1952	73	62
1963 (overstorey only)	77	69
(overstorey and understorey)	83	81

It is evident that despite the loss of a considerable number of stems in the overstorey both stands actually increased the area covered by tree crowns during the eleven year period. Most of the increases are associated with expanding crowns of the surviving white and yellow birch which are recovering from dieback. The

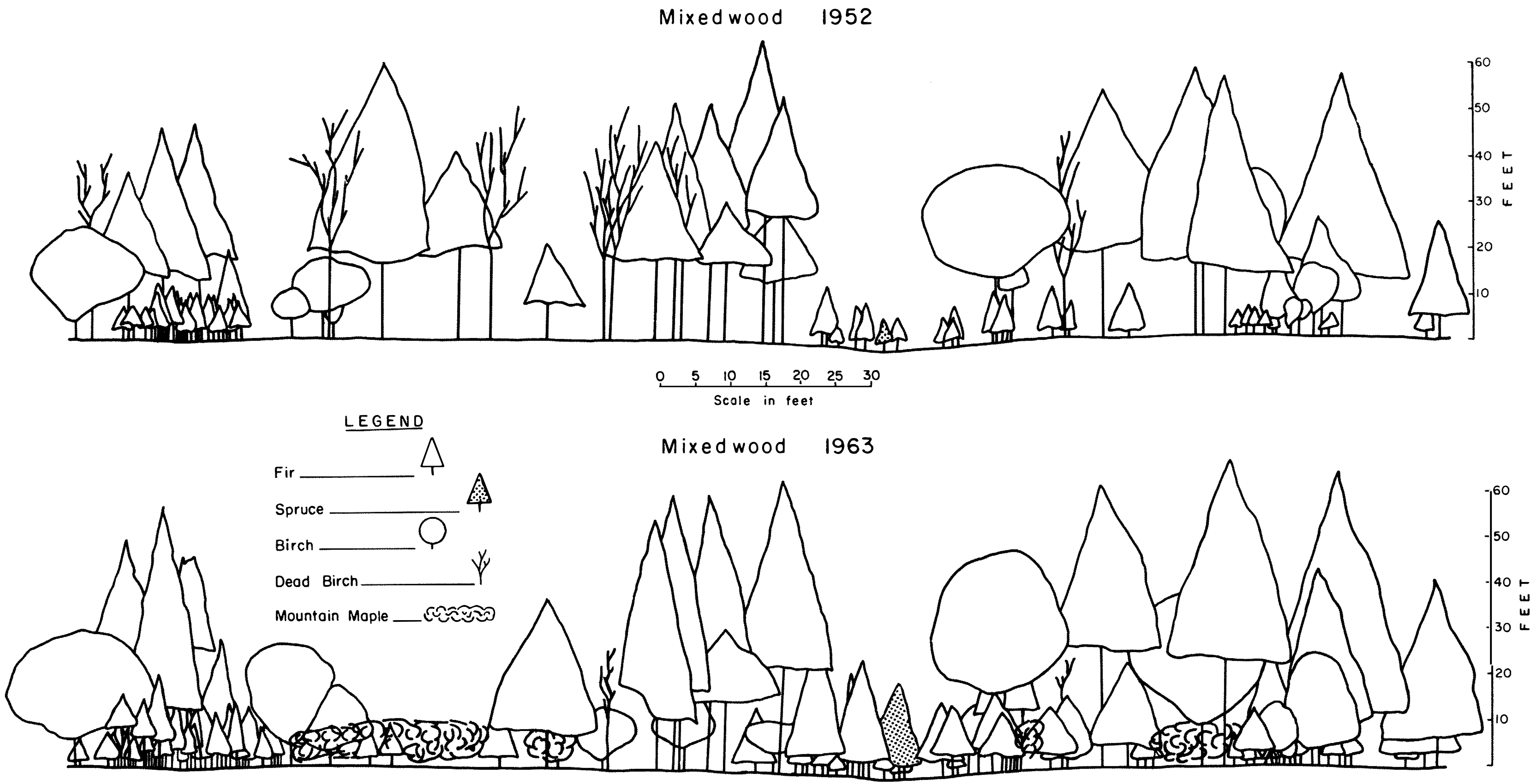

FIGURE 3. Profiles of the mixedwood stand in 1952 and 1963. Constructed from a transect 26 ft. x 198 ft.

Neg. No. 64-277

FIGURE 4. Interior of the softwood stand in 1963.

Neg. No. 64-278

FIGURE 5. Interior of the mixedwood stand in 1963.

branching habit of these species enables them to expand into unoccupied crown space much more readily than the softwoods can.

The principle shrub, mountain maple grows rapidly once established, and forms a closed canopy at a height of about ten feet in ten years (Vincent, 1953). In the mixedwood stand it followed the typical pattern of development in dense clumps which virtually exclude growth of other species. In 1963 these clumps occupied 16 per cent of the mixedwood study area with a canopy about 10 feet in height. The striking development of this shrub is apparent in Figures 3 and 5. Softwood advance growth which is still beneath the mountain maple may be suppressed for as long as forty years.

It is also evident from the tabulation of crown closure that the holes in the mixedwood, which are larger, are being more rapidly filled in than those in the softwood. Although the softwood advance growth that was established and had reached 0.5-inches d.b.h. by 1952 developed very rapidly in the study period it did not increase in aerial extent (Figure 3). Areas unstocked to softwoods in 1952 now support a dense shrub cover. In the softwood stand there was practically no understorey in 1952 but by 1963 a fairly evenly distributed advance growth had established itself throughout the area.

There is a marked difference in the size distribution of softwood advance growth in the two stands. Of the 14,130 stems of advance growth present under the softwood stand in 1952, 4,830 were fir and spruce taller than 0.5 feet and thus well established. In the same stand in 1963 there were 40,860 stems of which 4,720 were fir and spruce taller than 0.5 feet. By contrast the mixedwood contained 5,670 stems of advance growth in 1952 of which 1,890 stems were established fir and spruce and 122,140 stems in 1963 of which only 1,680 stems were fir and spruce in excess of 0.5 feet in height. This situation is explainable in terms of the invasion of mountain maple. Mountain maple developed so rapidly in the larger holes in the mixedwood stand that it quickly overtopped any softwoods. The maple cover is now so dense and competition so severe that relatively few of the fir and spruce have been able to grow to more than 0.5 feet in height. Mountain maple is spreading rapidly in the mixedwood stand and the only limiting factor will be the dense thickets of well-established softwood advance growth. In contrast the well established uniformly distributed coniferous reproduction on the softwood area will preclude any significant development of mountain maple even if the overstorey begins to deteriorate rapidly.

REFERENCES

HUGHES, E. L. 1960. Nine years of developments in a mature mixedwood stand, Green River, New Brunswick. For. Chron. 36: 6–9.

__________ 1963. Report on the remeasurement of Research Block No. 1. Dept. of Forestry Canada, Forest Research Branch, Maritimes District mimeo 63–M–22.

ROWE, J. S. 1959. Forest regions of Canada. Canada Dept. of N.A. and N.R., Forestry Branch, Bull. 123, 71 pp.

VINCENT, A. B. 1953. Mountain maple. Canada, Dept. R. and D., Forestry Branch, Silvicultural Leaflet 80, 3 pp.

__________ 1955. Development of a balsam fir and white spruce forest in northeastern New Brunswick. Dept. of N.A. and N.R., Forestry Branch. Tech. Note 6, 27 pp.