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SPRUCE BUDWORM DAMAGE TO BALSAM FIR
IN IMMATURE STANDS, QUEBEC
(Project Q-39)

by
R.J. Hatcher

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SPRUCE BUDWORM DAMAGE TO BALSAM FIR IN IMMATURE STANDS, QUEBEC^{1/}

R.J. Hatcher^{2/}

ABSTRACT

A study was made of the effect of the 1945-1957 spruce budworm infestation on 1,800 acres of spruce-fir and spruce-fir-hardwood forest logged for pulpwood about 15 years prior to the infestation.

The number of fir trees was reduced 64 per cent between 1951 and 1961 in the main cover type representing 69 per cent of the forest; fir was reduced from a major stand component of 45 per cent by volume to a minor component of 11 per cent. The basal area reduction of fir was discovered to vary directly with the fir basal area at the time of the outbreak. Losses were very high in stands containing over 20 sq. ft. of fir per acre.

These young stands did not exhibit the degree of resistance to damage often observed in young stands elsewhere. But in spite of heavy losses through all diameter classes, the amount of spruce and fir regeneration that survived to 1961 is believed adequate to produce a pulpwood crop within 60 years.

INTRODUCTION

Forest managers in eastern Canada are keenly interested in how well their forests recover from the recent spruce budworm (Choristoneura fumiferana (Clem.) infestation and in any changes in species composition

^{1/} Contribution No. from the Forest Research Branch, Dept. of Forestry, Canada.

^{2/} Research Officer, For. Res. Br., Dept. of Forestry, Box 35, Sillery, P.Q.

that result therefrom. Failure to regenerate or substantial alteration in stand composition could be of profound economic significance.

Studies in mature balsam fir ^{3/} forests devastated by the budworm indicate that over 95 per cent fir mortality may occur but that, in general, more than enough fir seedlings survive to assure well stocked future stands (Blais 1954, Ghent et al 1957, Vincent 1962). However, there is surprisingly little information available on budworm damage in young and immature stands. This report presents the results of 1951 and 1961 measurements in stands of black spruce, spruce-fir, and spruce-fir-hardwoods that originated from a pulpwood logging in 1932-34, and which were attacked by the spruce budworm from 1945 to 1957.

FOREST DESCRIPTION

The Vermillion River Observation Area is one of 14 five-square-mile cut-over areas in Quebec which the Forest Research Branch has established since 1948. The purpose of these study areas is to provide data on regeneration, growth, and yield for use in management of second-growth stands. Plots are remeasured at ten-year intervals.

The study area occupies 1,800 acres of a north-south ridge (1,400 feet elevation), plus the lower slopes surrounding the ridge, near the junction of Creek Gagnon and the Vermillion River (47°15'N., 73°40'W.) 15 miles west of the Consolidated Paper Corporation Straw Hat Depot and 90 miles northwest of Trois-Rivières. The forest is typical of Forest Section B.7, the predominant cover type of which is a mixedwood

^{3/} Nomenclature as in "Native Trees of Canada", Bulletin 61. Canada, Department of Forestry, 6th edition, 1961.

association of fir, black spruce, white birch and scattered white spruce and aspen (Rowe 1959). As a result of the recent ravages of birch die-back and spruce budworm there are vast areas of open, snag- and blowdown-filled forest in which a proliferation of mountain maple, hazel, (Corylus cornuta Marsh.) pin cherry and raspberry (Rubus Idaeus L.) retard conifer regeneration.

The forest was classified in 1951 according to four cover types with differing species composition (Table 1). The pure softwood stands of the Black Spruce type (bS) represent 7 per cent of the area and are confined to the low flat areas where drainage is retarded. The Spruce-Fir type (SF) represents 9 per cent of the area and is found on gentle lower slopes between the SFwB and bS types. Spruce is mostly black spruce in this and the bS type. The Spruce-Fir-White Birch type (SFwB) is a mixedwood occupying the well-drained middle and upper slopes of the ridge and represents 69 per cent of the area. The remaining 15 per cent is the Spruce-Fir-Sugar Maple type (SFsM), a mixedwood confined to the drier ridge top and the only type containing sugar maple. Spruce in this and the SFwB type is mostly white spruce.

TABLE 1.

The area is a small part of the extensive forest of the St.Maurice Valley that was logged for white and red pine sawlogs about the turn of the century, and re-logged for spruce and fir pulpwood since the late twenties.

The study area was logged between 1932 and 1934 and the spruce-fir volumes removed were estimated from the 1951 stump measurements as follows:

<u>Cover Type</u>	<u>Spruce and Fir Cut, 1932-34, Cubic Feet per Acre^{h/}</u>
bs	890
sf	1,170
SFwB	600
SFwH	160

The precise structure of the stands immediately before logging is not known but the diameter class distribution of both residual trees and stumps in 1951 indicate an uneven-aged structure. Cutting was controlled in mixedwood stands by a stump diameter limit of 6 inches below which trees could not be cut; no such control was imposed in softwood stands.

The amount of fir present when the budworm arrived on the scene in about 1945 can only be estimated from the 1951 data. In the SFwB cover type (69 per cent of the area), of the 142 fir per acre larger than 3.5 inches d.b.h. (Table 2), 113 were between 3.6 and 6.5 inches. Although logging did not completely change the uneven-aged conifer structure, at the advent of the budworm attack the bulk of the insect's food was represented by fir trees below 6.5 inches d.b.h.

The recent spruce budworm infestation, reported to have first reached outbreak proportions in Quebec in 1939 (Filon and Blais 1961),

^{h/}

A report on the establishment of observation area number 7, Vermillion River, 1951, by A.F. Berg. Forest Research Branch Binder No. 836.

spread eastward and reached the study area in 1945^{5/}. The attack in this part of Quebec was marked by two waves of severe defoliation, from 1946 to 1948 and from 1953 to 1956. During the intervening years, defoliation was light to moderate and the infestation ended in 1957.

METHOD OF STUDY

In 1951, 146 permanent, square, tenth-acre line plots were systematically established on a 10-chain grid.

The following data were recorded on each plot: 1) all trees 0.6 inch d.b.h. and larger were tallied by species and one-inch diameter classes, 2) dead trees judged to have died during the preceding decade were tallied by species and one-inch diameter classes and scribed with an "X", 3) a stocked quadrat tally of regeneration was made on 20 milacre quadrats, 4) height-diameter measurements were made in order to construct local volume tables, 5) stump diameters were tallied and converted to d.b.h.

In 1961, items 1) and 2) above were repeated. Many one- and two-inch fir probably died and disappeared since 1951 so that the 1961 sapling mortality estimate would be low although the effect of these missing stems on mortality volume estimates would not be great. A stocked quadrat regeneration survey was done on 10 milacres on each plot and per cent values were converted to number of seedlings per acre using Ray's (1948) graph.

5/

Source: 1944-53 Annual Reports, Forest Insect and Disease Survey, Can. Dept. of Agriculture; 1954-57 Reports of the Forest Insect Survey in the Province of Quebec, Bureau of Entomology, Quebec Department of Lands and Forests.

RESULTS

Stand development after the 1932-34 logging was quite satisfactory until the early 1940's judging by the number of conifers estimated in 1951 (Table 2). The spruce budworm, which began feeding in about 1945, caused severe defoliation but very little mortality up to 1951 (Figure 1). Heavy losses only began after 1951 and by 1961 fir mortality ranged up to 474 cu. ft. per acre (Table 3, Figure 2). The result has been a reduction of fir from a major to a minor volume component, particularly in the mixedwood types which represent 84 per cent of the forest (Figure 3).

Spruce apparently resisted the budworm better than fir as suggested by spruce increases in both absolute and proportional values for numbers of trees and volume (Table 2, Figure 3).

The percentage changes in numbers of stems suggest that fir losses were higher in mixedwood than in softwood stands (Table 2). Attempts to explain this observation led to examination of the possible dependence of fir mortality on several stand variables. The scattergrams for individual plot values did not indicate significant relationships between mortality and the proportion of fir in the stand, or between mortality and fir basal area in the original stand. However, a significant regression line was found for the SPwB type when the fir basal area in 1961 was plotted over fir basal area in 1951. The transformation of the dependent variable into per cent change in fir basal area for the period 1951-61, changed the linear regression equation into a curvilinear equation. The relationship shows an increase in basal area for initial basal areas below about 10 sq. ft. and changing to a decrease for plots

above 10 sq. ft. and larger decreases for greater initial basal areas (Figure 4). Because of the small range in basal area covered by the bS and SF types no attempt was made to find a similar relationship but the average basal area reductions for these types were plotted as single points on the scattergram of individual SPwB plots (Figure 4). The position of these points relative to the curve for the SPwB type suggests that losses in softwood types were much greater than in the SPwB. The mixedwood apparently suffered higher losses because of larger fir basal areas and actually may be somewhat more resistant to damage than softwood stands, at least when basal areas are small.

Examination of the changes in the numbers of fir trees suggests that saplings resisted the budworm better than larger trees (Table 2). In fact, in the softwood types the numbers of one- and two-inch-fir actually increased during the 1951-61 decade, although much less than would have occurred had there been no outbreak. But in the mixedwood types (84 per cent of the area) the numbers of 1-3-inch-fir were substantially reduced. The residual spruce and fir saplings alone would not provide well-stocked future stands but with the addition of seedlings, numbers are more encouraging, varying from 1,420 to 1,850 per acre (Table 4).

DISCUSSION

Fir mortality in ^{immature} ~~25-year-old~~ stands began only after an estimated 5 to 7 years of budworm feeding, a number of years that has proved equally lethal in mature fir stands (Delyea 1952, Blais 1958, Craighead 1924, McIntock 1955). Although two short periods of high budworm population were responsible for this mortality, the fir trees

8.
apparently recovered very little if at all during the four years following the first period of attack (Figure 1). * *Insert*

In assessing the total destruction caused by the budworm the future potential of these stands must be examined. As expected, increased numbers of hardwoods are evident in both mixedwood types but these increases are not believed to be large enough to jeopardize the development of the 1,420 to 1,850 conifer stems per acre into operable pulpwood stands. Fir seedlings are shade-tolerant and are known to survive severe competition after logging (Hatcher 1960, Ray 1956), even though their development may be somewhat retarded (Vincent 1956). The discovery that, in spite of high mortality, up to 1,850 conifer seedlings and saplings managed to survive parallels the findings of Blais (1954) in mature stands and apparently represents a typical recovery in stands where seedlings and saplings are abundant when a budworm outbreak begins.

Spruce resisted the budworm attack better than fir, a finding that corroborates those of other investigators (Blais 1954, Craighead 1925, de Gryse 1944, McLintock 1947, Turner 1952). However, it remains to be seen whether spruce will maintain its newly-gained position; evidence gathered in other areas suggests that it may not (Ghent et al. 1957, Graham and Orr 1940).

A number of workers (Balch 1946, Blais 1958, Craighead 1925, Graham and Orr 1940) have come to the conclusion that immature fir stands, while not necessarily immune to attack by the spruce budworm, are usually more resistant to damage than mature or overmature stands. The immature stands at Vermillion River represent a very small portion

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Fir volume reductions were proportionally about equal to reductions observed elsewhere in mature stands. The numbers of fir saplings were greatly reduced over most of the area, in spite of an apparent greater resistance to damage exhibited by these smaller fir trees.

of the outbreak area which extended across Quebec. Therefore, the degree of damage to which these stands were subjected is not necessarily representative of what occurred in immature stands elsewhere in the province, particularly when considering the additional fact that budworm damage may vary greatly between regions and even within a given region (Craighead 1924, Ghent et al. 1957, Turner 1952). However, it is evident that at least some stands of immature fir can suffer severe losses through budworm defoliation.

Turner (1952) discovered that in mature stands, fir mortality increased with larger initial fir basal area. In the present study the results indicate the relationship is stronger between percentage change in fir basal area over a period of years and initial fir basal area (Figure 4). For studies of budworm damage to young stands, per cent change in fir basal area is perhaps a better measure of the total budworm effect than per cent mortality because the former includes the balancing effects of seedling ingrowth.

In view of the economic implications, additional research is required to establish the degree of resistance of young fir stands to budworm damage. In particular, damage in 25 to 40-year old stands should be studied because the fir seedlings which have provided the future stocking in devastated mature stands, and in the immature stands of this study, are generally absent in stands of this age range. This research also is important in view of the recommendation that the conversion of extensive areas of mature fir into patches of mature and immature stands could be used as a budworm control measure (Turner 1952 pp. 106, 107).

SUMMARY

Effects of the 1945-57 spruce budworm infestation on ^{immature} ~~15-year-~~
~~old~~ stands of black spruce, spruce-fir, and spruce-fir-hardwood were
investigated on 1,800 acres 90 miles northwest of Trois-Rivières, Québec
(Forest Section B.7). The forest was logged for conifer pulpwood in
1932-34. The 146 permanent tenth-acre line plots of the one percent
systematic sample were established in 1951 and remeasured in 1961.

Conifer regeneration evidently ~~was~~ successful after the
1932-34 logging. However, the spruce budworm caused severe fir def-
oliation which by 1961 resulted in a 64 per cent reduction in the number
of fir trees in the principal cover type representing 69 per cent of
the forest. Volume losses in these young stands were proportionally
about the same as those reported elsewhere for mature fir stands.

The per cent reduction in fir basal area between 1951 and
1961 was found to be related to fir basal area per acre in 1951 for the
principal cover type. No relation could be established between fir
losses and the proportion of fir in the stands.

At low levels of fir basal area, mixedwood stands suffered
less mortality than softwood stands. Spruce losses were less than fir
in all types and in three of four types its proportion of the total stand
increased.

Although the smaller fir resisted the budworm attack better
than the larger trees, the young stands as a whole were quite severely
damaged. In spite of heavy mortality among the small trees, from 1,420
to 1,850 spruce and fir stems per acre survived the infestation.

Although shrub competition is severe it is believed that this stocking is adequate for the formation of pulpwood stands within 60 years.

The results of the study are summarized briefly as follows:

- 1) Balsam fir throughout a 2.8 square mile immature forest was severely damaged by the spruce budworm.
- 2) Fir basal area reduction was dependent on the original fir basal area.
- 3) Smaller fir were more resistant to damage than larger trees.
- 4) Spruce was more resistant to damage than fir.
- 5) Mixedwood stands were slightly more resistant than softwood stands at low levels of original fir basal area.
- 6) Probably enough spruce and fir survived to provide a pulpwood crop within 60 years.
- 7) Additional research is needed to elucidate the relation between stand age and degree of budworm injury, particularly in the age range 25-40 years.

SOMMAIRE

Le présent travail a trait aux effets de la tordeuse des bourgeons de l'épinette (Choristoneura fumiferana) qui, entre 1945 et 1957, infesta des jeunes peuplements d'épinette noire, d'épinette-sapin et d'épinette-sapin-feuillus couvrant une superficie de 1,800 acres, à quelque 90 milles au nord-ouest de Trois-Rivières, dans le Québec (section forestière B-7). On avait exploité cette forêt pour ses bois à pâte, les résineux, entre 1932 et 1934. On procéda à un inventaire en 1951, puis en 1961. L'intensité de ce travail fut de 1 p. cent et comporta l'établissement systématique de 146 places d'étude permanentes de 1/10 d'acre échelonnées le long de virées parallèles.

Une abondante régénération de conifères suivit la coupe effectuée dans les années trente. Cependant, la tordeuse défeuilla sévèrement le sapin et en réduisit le nombre de 64 p. cent dans le principal type de peuplement qui couvrait 69 p. cent de la superficie considérée. Les pertes de volume dans ces jeunes peuplements étaient en proportion égales à celles que d'autres ont rapportées à l'endroit de peuplements mûrs de sapin.

On a trouvé pour le principal type de couvert que la réduction en surface terrière du sapin entre 1951 et 1961 était fonction de ce qu'elle était en 1951. Cependant, on n'a pu établir de relation entre les pertes et la proportion de sapin dans les peuplements.

La mortalité a été plus faible chez les peuplements mélangés que chez les résineux, quand la surface terrière en sapin était d'un bas niveau. Dans tous les types de couvert, l'épinette a été moins affectée que le sapin et sa proportion a augmenté dans trois des quatre types.

Les petits sapins ont résisté mieux que les gros, il est vrai, mais dans l'ensemble, les jeunes peuplements ont subi des dommages considérables. En dépit du taux élevé de mortalité parmi les petits arbres, de 1,420 à 1,850 tiges d'épinette et de sapin à l'acre ont survécu à l'infestation. La compétition offerte par les arbustes est considérable, mais on croit que ce nombre de tiges est suffisant pour obtenir en moins de 60 ans des peuplements de bois à pâte exploitable.

Les résultats de cette étude sont résumés brièvement comme suit:

- 1) Le sapin baumier à l'intérieur d'une superficie de 2.8 milles carrés constituée de jeunes peuplements a été sévèrement endommagé par la tordeuse.

2) La diminution en surface terrière du sapin dépendait de la surface terrière originale de l'essence.

3) Les petits sapins se sont montrés plus résistants que les gros.

4) L'épinette a subi moins de dommages que le sapin.

5) Quand la surface terrière en sapin était faible dans les peuplements originaux, les peuplements mélangés ont résisté un peu plus que les peuplements purs de résineux.

6) Il est probable qu'assez d'épinette et de sapin ont survécu pour obtenir une récolte de bois à pâte avant 60 ans.

7) Des recherches plus poussées sont nécessaires pour mettre en lumière la relation qui existe entre l'âge du peuplement et l'étendue des dégâts causés par la tordeuse des bourgeons de l'épinette, particulièrement entre 25 et 40 ans.

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TABLE 1. SPECIES PER CENT OF TOTAL BASAL AREA, BY COVER TYPES, 1951.

Cover Type	Fir	Spruce	Other Conifers	White Birch	Aspen	Yellow Birch	Sugar Maple	Red Maple
bS	17	82	1	0	0	0	0	0
SF	35	50	2	3	10	0	0	0
SFwB	56	8	2	26	6	1	0	1
SFsm	30	6	0	22	9	3	17	13

TABLE 2. NUMBER OF TREES PER ACRE BY SPECIES, COVER TYPE, YEAR AND DIAMETER;
SPECIES PER CENT OF TOTAL STAND; AND PER CENT CHANGE 1951-61.

Cover Type	Per Cent of Plots	D.B.H. Inches	Balsam Fir	Spruce	Hardwoods	Per Cent Change
			1951	1961	1951	1961
			Per Cent Change	Per Cent Change		
bs	7	1	38	402	0	1
		2	12	105	0	0
		3	9	53	0	0
		4+	13	61	0	0
		Total	72	621	0	1
			Per Cent of Total	91	0	-
SF	9	1	131	246	24	15
		2	49	77	29	34
		3	32	57	21	18
		4+	44	72	15	39
		Total	256	452	89	106
			Per Cent of Total	68	11	2
SFwb	69	1	396	28	54	40
		2	144	13	28	44
		3	107	7	19	37
		4+	142	18	49	76
		Total	789	66	150	197
			Per Cent of Total	20	15	33
SFwM	15	1	98	0	58	50
		2	51	0	10	39
		3	25	1	10	34
		4+	71	10	97	100
		Total	245	11	175	223
			Per Cent of Total	3	41	55

TABLE 3. VOLUME OF MORTALITY BY SPECIES AND COVER TYPE, ONE INCH D.B.H. AND OVER
1942-1951, and 1952-1961.

Cover type	Period	Mortality, Total Cubic Feet Per Acre					Other species
		Fir	Spruce	Birch	Maple		
bs	1942-51	1	0	0	0		0
	1952-61	26	29	0	0		0
SF	1942-51	1	1	2	0		1
	1952-61	108	35	21	0		9
SFwB	1942-51	10	1	58	0		5
	1952-61	474	49	201	5		69
SFwM	1942-51	1	0	0	0		1
	1952-61	256	16	119	71		26

TABLE 4. NUMBER OF SEEDLINGS (LESS THAN 0.6 INCH D.B.H.) AND
SAPLINGS (0.6-3.5 INCHES D.B.H.) BY SPECIES AND COVER TYPE, 1961.

Cover type	Size class	Number of Stems per Acre					Other species
		Fir	Spruce	Birch	Maple		
bs	Seedling	300	350	0	0		0
	Sapling	110	1088	1	0		18
	TOTAL	410	1438	1	0		18
SF	Seedling	500	375	0	0		250
	Sapling	264	677	17	0		65
	TOTAL	764	1052	17	0		315
SFwB	Seedling	825	225	225	125		250
	Sapling	267	100	76	12		34
	TOTAL	1092	325	301	137		284
SFsM	Seedling	1425	175	175	2575		0
	Sapling	140	5	17	106		1
	TOTAL	1565	180	192	2681		1

Figure 1 - Fir severely
defoliated by the spruce
barkworm but still living,
1951.



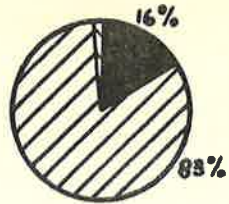
Figure 2 - Typical scene
devastation in mixedwood
stands in 1961. Surviving
conifers are hidden in
tangle of blowdown and
shrubs.



Cubic Feet
per Acre

249

1951

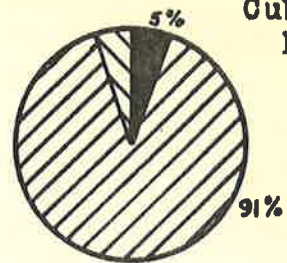


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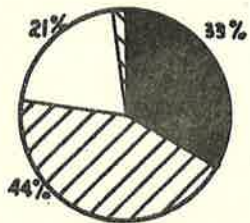
1961

Cubic Feet
per Acre

436

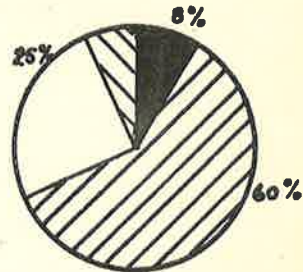


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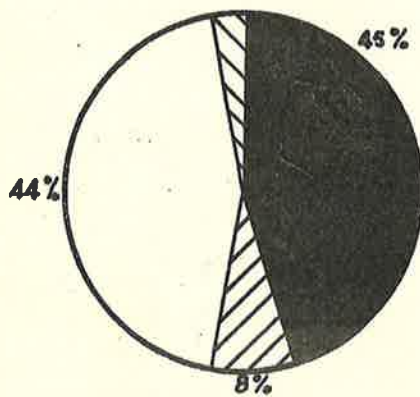


SF
Type

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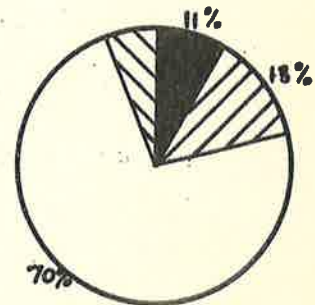


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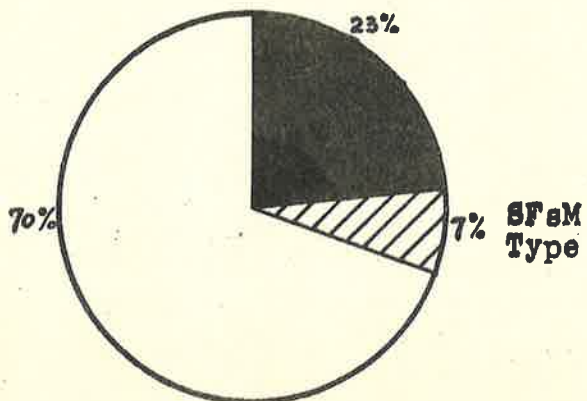


SFwB
Type

651

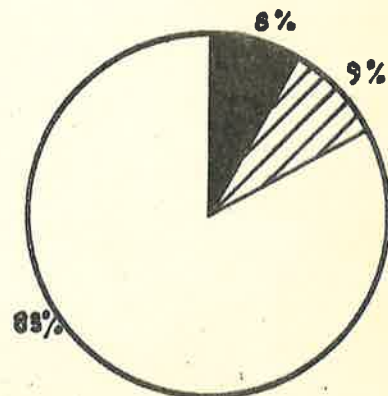


1,350



SFwM
Type

1,117



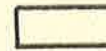
Fir



Spruce



Other



Hardwoods

Figure 3 - TOTAL VOLUME AND SPECIES PER CENT OF TOTAL VOLUME
1951 AND 1961.

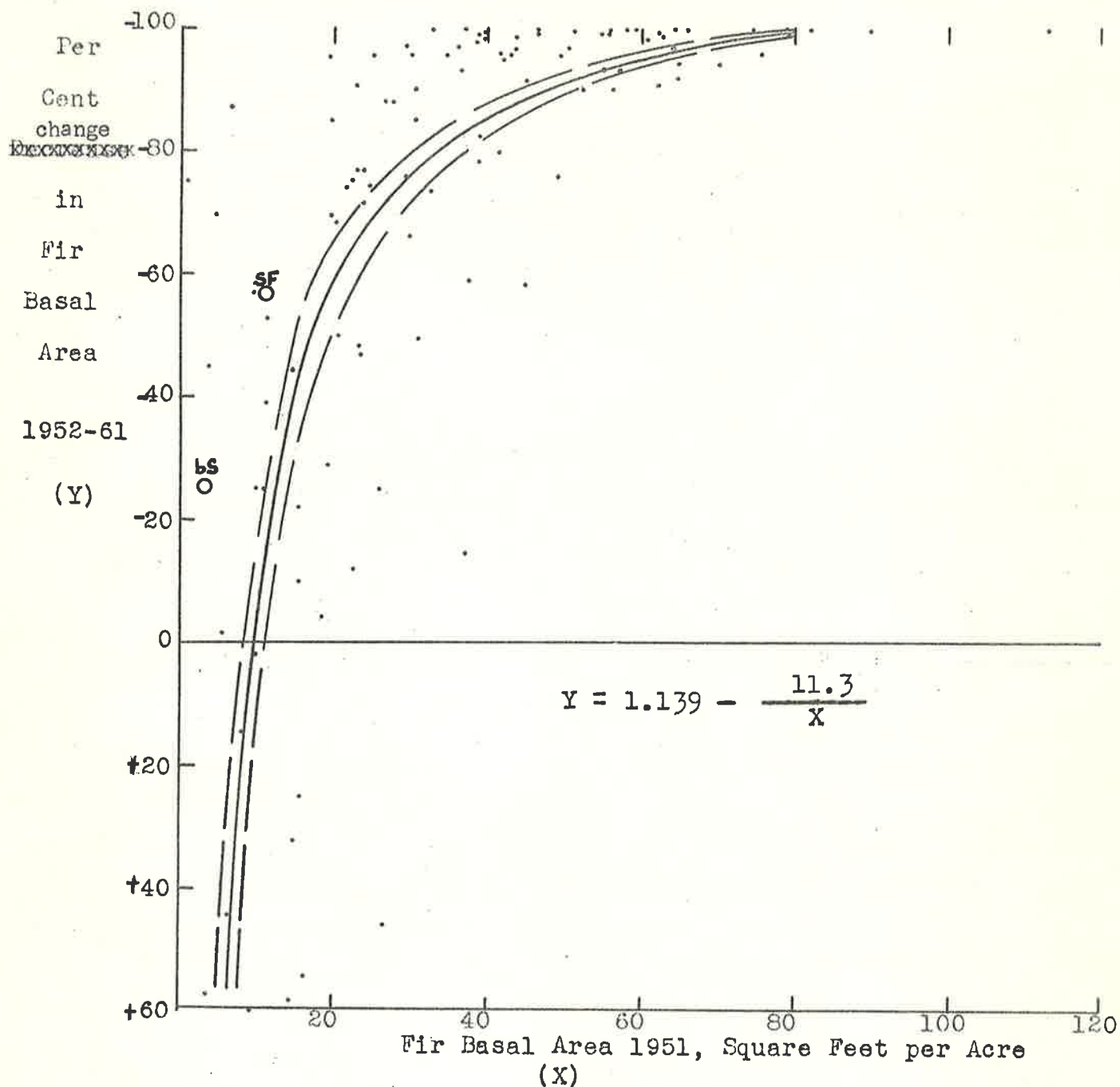


Figure 4. Relationship of per cent fir basal area change on 1951 fir basal area for a range of 0 to 80 sq.ft., for 106 SFWB plots, and a confidence band for the line at the 95 per cent limit.