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EFFECT OF PINE BUTTERFLY DEFOLIATION ON PONDEROSA PINE IN SOUTHERN IDAHO

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ABSTRACT

The shortcut sampling technique, derived from Duff and Nolan's two-level sampling technique for the vertical growth sequence, is applicable to ponderosa pine of all ages. Growth loss due to pine butterfly defoliation is calculated and the effect of control in 1954 is compared to no control of the 1922-23 pine butterfly epidemic.

An outbreak of pine butterfly, Neophasia menapia (F. & F.), developed in 1950 on the Boise National Forest in southern Idaho. By 1953, approximately 169,000 acres of ponderosa pine type were severely defoliated. The timber loss during past epidemics shows that pine butterfly is a tree killer. In 1893-96, approximately 1,500,000 acres of ponderosa pine were affected and 20 to 90 percent of the stands were killed (Hopkins 1907); in 1922-23, on approximately 27,000 infested acres, 26 percent of the trees were killed (Evenden 1940); and an estimated 255,400 acres were ultimately affected between 1952 and 1954 (U.S. Forest Service 1954). Under ordinary conditions, butterfly larvae feed only on the older needles; but under epidemic conditions they may eat both new and old needles.

Aerial spraying in 1954, the peak year of the epidemic, reduced the infestation to an endemic level, and thus interrupted the so-called normal trend of the epidemic.

This study to determine the effects of defoliation on ponderosa pine was completed in 1959, when it was felt that sufficient time (5 years) had elapsed since the epidemic was controlled to allow for tree mortality attributable to the infestation.

OBJECTIVES

Objectives of this study were threefold: (1) to determine the effect of defoliation on increment before and after control of the epidemic; (2) to determine percent mortality of ponderosa pine caused by defoliation; and (3) to determine economic loss due to the pine butterfly.

Data from this study on tree mortality and loss of volume are compared with data from Evenden's study (1940). The important difference between these two epidemics is that the 1922-23 epidemic ran its course and was finally controlled by natural factors, primarily the ichneumonid, Theronia atalantae (Poda), while the 1952-54 epidemic was chemically controlled at its peak.

METHODS AND PROCEDURE

In the study reported here, determination of growth reduction in ponderosa pine defoliated by the pine butterfly was based on Duff and Nolan's (1953) approach to the study of growth in conifers and on a shortcut sampling technique for growth analysis by Stark and Cook (1957)--developed from Duff and Nolan's work. Mott (1957) gave brief descriptive names to Duff and Nolan's numerically designated growth sequences: oblique, radial, and vertical. The type 3, or vertical sequence, was used in the present growth analysis study. Two discs were cut from the bole of each tree felled for study. One disc shows the normal decrease in growth during several years; the other shows damage attributable to the recent epidemic.

Cole (1958) found that the shortcut sampling technique was applicable for separating external growth influences (Stark and Cook 1957) and was applicable to the growth analysis of ponderosa pine.

During 1959, 40 trees were felled and 2 discs were cut from each according to the vertical sequence technique. The trees were selected on the basis of percent defoliation; all trees selected had suffered at least 25 percent defoliation (table 1).

Table 1.--Distribution of study trees, 1959[1]

Area	Total no. of trees	D.b.h. range	Defoliation class 25-50% No.	25-50% Vol.	50-75% No.	50-75% Vol.	75-90% No.	75-90% Vol.	>90% No.	>90% Vol.	Total volume	Average volume
		Inches										
Banner	14	16-40	3	3.84	6	7.16	4	6.08	1	0.96	18.04	1.29
Beaver	14	20-42	1	0.55	5	5.66	4	6.68	4	5.30	18.19	1.30
Swanholm	12	16-40	0	0.00	5	4.29	4	4.48	3	3.37	12.14	1.01
Totals	40	16-42	4	4.39	16	17.11	12	17.24	8	9.63	48.37	
Averages		29.10		1.10		1.07		1.44		1.20		1.21

[1] Volume based on 1,000 bd. ft.

ANALYSES AND RESULTS

Two-level growth sequence curves were first plotted for the individual trees. The results appeared to conform to the basic principles of the vertical sequence technique for separating external growth influences from inherent growth characteristics (Duff and Nolan 1953).

Graphs were then plotted for all trees within each defoliation class (figs. 1-4).

The mean annual radial increment for the predefoliation period of the base discs and damage discs was almost equal (table 2). The "t" test revealed no significant difference between these means at the 99-percent confidence level.

The common growth basis of the predefoliation periods gives greater strength to the subsequent analysis of variance. It also follows that the vertical sequence using the two-level, two-disc technique is applicable for comparison when the increment is measured as years from pith.

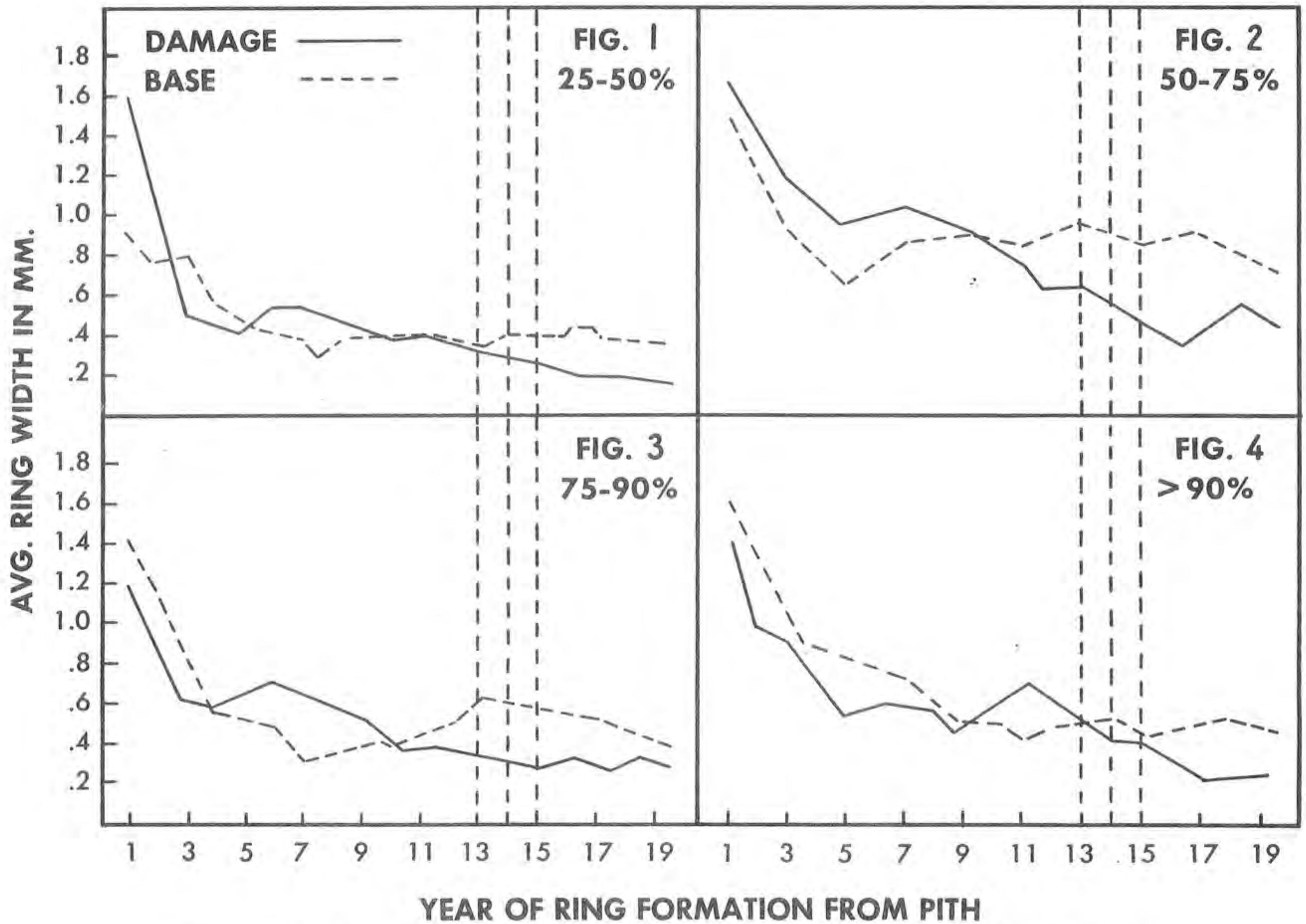
Table 2.--Comparison of means, sampling errors, and coefficients of variation of radial growth (mm) of the base discs with those of the damage discs

Discs	Defoliation periods					
	Before		During		After	
	Base	Damage	Base	Damage	Base	Damage
Sum	27.717	28.779	23.675	14.836	21.872	12.810
$\overline{x}$	[1] 0.770	0.799	0.658	0.412	0.608	0.356
SE $\overline{x}$	0.066	0.087	0.085	0.051	0.081	0.043
C. V.	8.15%	10.89%	12.92%	12.38%	13.32%	12.08%

[1] $t = 0.770 < t_{.01} = 2.724$ on 35 d.f.

The ultimate sampling unit was the average radial growth (in millimeters) per period, per disc, per tree. The variance component technique was used in determining error mean squares to test for growth differences in the analysis of variance. Because of an error in cutting, the 25-50 percent defoliation class was not represented within one plot; so only the 36 trees in the upper three defoliation classes were used in this test.

Significant differences in growth occurred between areas, defoliation classes, curves (base and damage), and between periods of defoliation. A significant growth difference in the area × defoliation interaction was of little consequence to this study. This significant difference indicated only that growth within each defoliation class varied between areas.



Figures 1-4.--Two-level growth sequence curves of ponderosa pine by defoliation class (vertical dashed lines indicate years of defoliation).

Growth differences between base and damage curves and between the periods (before, during, and after defoliation) were of chief interest. Independent comparisons revealed that rate of growth before defoliation was significantly different from the amount of growth during and following defoliation combined. Significant growth differences might possibly have been shown by the interaction, curves × periods, if a much larger sample had been taken, e.g., 100 trees instead of 36.

The magnitude of the pine butterfly's effect on tree growth was measured on the basis of a common mean of the period before defoliation for both discs, and based on the results of the independent comparison. To illustrate how this percent of growth loss could be estimated, growth data were taken from W. H. Meyers' (1934) work. The figure of 183.3 bd. ft. (site IV) was used as an example of the annual increase per acre for an area stocking 16,000 bd. ft. per acre. It was assumed that the annual increase of 183.3 bd. ft. would have continued for the period under study.

Mean annual growth (mm) before, during, and after defoliation was 0.785, 0.633, and 0.384, respectively. If this growth difference represents the normal decrease in growth over the years (base discs), the annual loss due to the pine butterfly would be 39.34 percent of the normal increment since 1952. On the basis of Meyers' figure--183.3 bd. ft.--a loss of 72.1 bd. ft. per acre per year occurred.

Loss due to tree mortality in 1952-54 was extremely small compared to that in the 1922-23 epidemic (table 3).

Table 3.--Comparison of magnitude and causes of tree mortality in the 1922-23 pine butterfly epidemic with those of the 1952-54 pine butterfly epidemic

Epidemic period	Number study years after defoliation		Study trees	Trees killed by						Volume (1,000 bd.ft.)	
				Defoliation		Bark beetles		Total			
				No.	Pct.	No.	Pct.	No.	Pct.	Amt.	Pct.
1922-23		10	100	12	12	14	14	26	26	--	36
	1st	5	100	7	7	13	13	20	20	--	28
1952-54		5	225	0	0	3	1.3	3	1.3	1.76	0.6

Comparison of the mean annual radial growth of study trees for the two epidemics is also interesting. Evenden's data (1940) are from basal measurements, whereas the data presented herein are from measurements at the internode where the disc was cut (table 4).

Table 4.--Growth of trees that recovered within the epidemics: 1922-23 and 1952-54

Epidemic period	Mean annual radial growth (mm)	
	5 years before	5 years after
	(1917-22)	(1923-28)
1922-23	0.940	0.377
	(1947-52)	(1954-59)
1952-54	0.785	0.384

SUMMARY

Defoliation by the pine butterfly can cause extensive mortality in pine stands. However, successful control of an epidemic by aerial spraying can nearly eliminate tree mortality. Even when epidemics are successfully controlled, defoliation can reduce growth to approximately 40 percent of the expected normal gain, as it did in this area.

The two-level sampling technique for the vertical growth sequence developed by Duff and Nolan is applicable to ponderosa pine for comparison of growth rates when the increment is measured by years from pith.

The shortcut sampling technique for the vertical growth sequence is applicable to ponderosa pine of all ages. The comparisons from these growth rate data are reliable on a 99-percent confidence level, provided enough samples are taken. In this study, 40 trees were adequate, but the author believes that a minimum of 100 trees should be used for maximum reliability of independent comparisons within the interactions.

The difference in radial growth during the three periods (before, during, and following defoliation) was statistically significant. There was a highly significant difference in mean annual radial growth between the 12-year period before defoliation (1940-52) and the 8-year period during and after defoliation (1952-59).

Defoliation caused reduction of growth by 39.34 percent of the estimated normal growth increment. Since the normal annual volume increase per acre for the site, age, and stocking was estimated at 183.3 bd. ft. per acre, the annual growth loss would be 72.1 bd. ft. per acre.

Tree mortality resulting from the 1952-54 epidemic equaled 1.3 percent of the stand, or 0.6 percent of the volume; comparable tree mortality losses from the 1922-23 epidemic were 26 and 36 percent.

Mean annual radial growth of the study trees of the 1922-23 epidemic was approximately equal to that of the study trees of the 1952-54 epidemic.

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