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WESTERN SPRUCE BUDWORM EGG MASSES FOR PREDICTING DEFOLIATION POTENTIAL IN THE NORTHERN REGION--PROGRESS REPORT

by

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ABSTRACT

An attempt was made to predict western spruce budworm defoliation using egg counts from plots in the Douglas-fir type east of the Continental Divide in Montana, the Douglas-fir type west of the Continental Divide in Montana, and the mixed grand fir Douglas-fir type of northern Idaho. The parameters used in a linear regression model for the three ecotypes were eggs per 100 buds in 1972 as the independent variable and percent defoliation in 1973 as the dependent variable. Correlation coefficients (r) were: 0.39, 0.54, and 0.66 for the data from grand fir in northern Idaho and Douglas-fir in eastern and western Montana respectively. A covariance analysis of the three regression lines showed there were differences between the three ecotypes.

INTRODUCTION

The western spruce budworm, *Choristoneura occidentalis* Freeman, is one of the most destructive insect enemies of the mixed conifer type in the Northern Region. In recent years, more than 4 million acres have been damaged in Montana, northern Idaho, and Yellowstone National Park, Wyoming.

At present, there is no reliable method of predicting budworm infestation trends west of the Continental Divide in the Northern Region. Terrell (1961) (1966) had some success with egg mass counts in the pure Douglas-fir stands of eastern Montana. Other Regions (McKnight, et al. 1970; Orr 1960) are still using egg mass counts to predict defoliation. Carolin and Coulter (1959) were the pioneers who first suggested using egg mass counts to predict damage and still advocate their use today (Carolin and Coulter 1972).

The advantages of using egg masses to estimate next season's damage are: they can be easily collected, are obvious, and are available when roads are open. Also, an early prediction helps land managers decide for or against control with ample time to organize a project if control is needed. One disadvantage is that new egg masses are hard to separate from old ones.

The objective of this study was to improve existing methods of predicting defoliation based on egg mass counts in the three major forest types susceptible to spruce budworm in the Northern Region:

1. Douglas-fir type east of the Continental Divide in Montana.

2. Douglas-fir type west of the Continental Divide in Montana.

3. Mixed grand fir/Douglas-fir type of northern Idaho.

METHODS

Egg mass sampling was initiated during late August 1972 in areas infested with western spruce budworm in the three ecotypes mentioned. The following number of plots were established in each ecotype:

1. Eastern Montana - 33 Douglas-fir plots.

2. Western Montana - 32 Douglas-fir plots.

3. Northern Idaho - 32 grand fir plots.

Five trees, open grown, from 30 to 50 feet in height, were sampled per plot. From each of the five sample trees, two 30-inch branches were cut from opposite sides at midcrown. Both branches from a sample tree were placed in a nylon bag, identified, and stored in a cooler.

In the laboratory, the total number of the following year's buds were counted on each branch and all egg masses on the needles were removed and put into plastic cups. The new from old egg masses were separated under a microscope and the length in millimeters of each new egg mass was measured. The number of rows of eggs in each new egg mass was determined by a staining technique (Jennings and Addy, 1968).

The total number of eggs per new mass could not be determined by counting individual eggs even after staining. Hatching and weathering had disfigured the egg masses too much. The length and number of rows of eggs were used to calculate total eggs per new mass by using tables developed by Washburn and Brickell (1973) and McKnight (1969). Washburn and Brickell's tables were used to determine eggs per mass for Douglas-fir in western Montana and grand fir in northern Idaho, and McKnight's tables were used for Douglas-fir from eastern Montana.

Table 1.--Average number of western spruce budworm eggs per 100 buds in 1972 and average percent defoliation in 1973 on grand fir plots in northern Idaho, and Douglas-fir plots in western and eastern Montana

Plot number	Western Montana (Douglas-fir)		Eastern Montana (Douglas-fir)		Northern Idaho (grand fir)	
	Average eggs per 100 buds	Percent defoliation	Average eggs per 100 buds	Percent defoliation	Average eggs per 100 buds	Percent defoliation
1	21.5 ± 6.8 1/	23.6 ± 3.8 1/	56.6 ± 12.1	20.6 ± 2.7	10.0 ± 3.9	42.4 ± 3.9
2	111.5 ± 21.4	41.0 ± 6.3	56.6 ± 21.6	66.5 ± 5.1	5.8 ± 3.8	83.7 ± 2.9
3	55.2 ± 16.9	23.3 ± 3.5	63.9 ± 29.1	34.3 ± 6.2	25.9 ± 7.1	74.5 ± 3.6
4	50.7 ± 28.4	17.5 ± 2.7	102.9 ± 53.3	46.3 ± 6.7	13.9 ± 2.9	65.2 ± 5.1
5	147.0 ± 34.3	24.8 ± 3.1	161.1 ± 25.6	29.2 ± 4.9	25.3 ± 10.1	39.3 ± 3.4
6	107.4 ± 29.2	9.2 ± 1.1	94.4 ± 24.6	35.2 ± 4.3	6.4 ± 3.5	28.2 ± 3.6
7	183.2 ± 25.1	9.4 ± 1.4	103.1 ± 20.8	69.3 ± 5.0	1.5 ± 1.5	8.4 ± 1.1
8	55.7 ± 16.6	7.2 ± 1.1	95.1 ± 20.0	44.8 ± 6.1	7.0 ± 3.3	35.9 ± 2.6
9	8.5 ± 8.5	2.3 ± 0.7	42.3 ± 10.0	26.0 ± 2.9	5.8 ± 2.8	-- -- 2/
10	19.3 ± 3.5	3.2 ± 0.6	23.7 ± 6.6	5.3 ± 1.3	17.2 ± 14.5	26.1 ± 2.9
11	2.2 ± 1.5	5.4 ± 0.9	72.0 ± 39.2	83.8 ± 2.6	10.8 ± 4.4	5.7 ± 1.3
12	1.1 ± 1.1	1.4 ± 0.4	7.1 ± 2.4	12.1 ± 1.6	4.1 ± 4.1	10.8 ± 2.0
13	43.7 ± 16.6	5.5 ± 0.9	53.2 ± 9.1	81.0 ± 2.7	12.2 ± 11.2	27.1 ± 3.8
14	13.5 ± 9.4	2.4 ± 0.6	70.9 ± 16.9	54.3 ± 5.6	27.3 ± 7.7	48.0 ± 4.6
15	2.3 ± 2.3	4.4 ± 1.0	30.3 ± 6.7	25.1 ± 2.9	4.5 ± 3.1	58.5 ± 3.8
16	24.1 ± 15.8	4.7 ± 0.9	12.6 ± 5.4	4.2 ± 1.1	16.3 ± 9.2	8.6 ± 2.8
17	71.1 ± 25.0	6.4 ± 0.9	52.6 ± 20.4	28.2 ± 5.1	2.4 ± 1.4	6.3 ± 1.8
18	13.4 ± 4.2	8.0 ± 1.8	43.3 ± 15.7	17.0 ± 4.1	2.2 ± 1.5	-- -- 2/
19	11.8 ± 6.7	2.6 ± 0.7	54.3 ± 12.9	61.0 ± 6.0	32.4 ± 12.2	46.9 ± 6.0
20	37.3 ± 18.8	5.5 ± 0.7	114.7 ± 30.8	88.1 ± 1.9	5.4 ± 2.2	26.9 ± 2.4
21	9.1 ± 4.7	10.5 ± 1.7	20.5 ± 7.2	6.8 ± 1.2	39.6 ± 6.3	30.4 ± 4.0
22	61.9 ± 21.1	9.0 ± 1.5	27.4 ± 6.1	13.1 ± 3.0	10.9 ± 6.6	0 0
23	9.5 ± 9.5	8.9 ± 1.3	50.4 ± 9.7	17.1 ± 3.6	34.3 ± 10.4	55.9 ± 5.2
24	41.2 ± 10.3	21.5 ± 3.9	60.3 ± 12.9	6.7 ± 1.9	0.7 ± 0.7	29.7 ± 2.9
25	28.5 ± 7.6	31.0 ± 4.8	100.8 ± 15.1	17.1 ± 2.4	21.9 ± 8.4	36.1 ± 6.5
26	137.0 ± 36.4	30.7 ± 3.6	36.8 ± 13.8	13.8 ± 3.4	27.2 ± 10.6	28.2 ± 3.9
27	37.6 ± 15.5	16.7 ± 3.0	90.4 ± 10.2	-- -- 2/	24.7 ± 13.8	76.6 ± 4.7
28	228.9 ± 53.8	81.3 ± 4.2	117.4 ± 11.5	58.5 ± 6.9	55.1 ± 16.1	90.6 ± 2.0
29	167.9 ± 43.4	68.4 ± 6.3	13.0 ± 4.3	18.6 ± 3.4	0 0	53.2 ± 5.3
30	11.8 ± 7.7	1.5 ± 0.4	42.1 ± 13.2	9.3 ± 1.7	19.4 ± 5.4	67.1 ± 4.0
31	1.6 ± 1.6	17.9 ± 3.6	16.9 ± 5.9	4.4 ± 1.2	10.7 ± 4.9	70.9 ± 5.6
32	117.8 ± 37.7	14.5 ± 4.6	1.8 ± 1.8	3.2 ± 0.6	42.3 ± 26.9	63.1 ± 3.7
33	-- --	-- --	24.3 ± 5.9	28.1 ± 4.5	-- --	-- --
Total	1,893.3	519.7	2,192.8	1,029.0	523.2	1,244.3
Average	59.2	16.2	66.4	32.1	16.3	41.5

1/ ± one standard error
2/ Could not sample

From the above data, the average number of eggs per 100 new buds was computed for each plot.

Percent defoliation on each sample plot was rated during July and August 1973. This consisted of cutting an 18-inch midcrown branch from each cardinal side of the five plot trees. The first 25 shoots on each branch were rated for percent defoliation as follows:

Percent defoliation of each shoot	Rating
0 - 25	1
25 - 50	2
51 - 75	3
76 - 100	4

For instance, if a shoot was 51 to 75 percent defoliated, a tally counter was punched three times. The total on the tally counter after 25 shoots were rated was the percent defoliation for that branch. Adding percent defoliation on all branches and dividing by 20 gave average defoliation per plot.

To determine if percent defoliation the following year could be predicted by counting eggs per 100 buds, a regression analysis was used where:

1. The independent variable X = eggs per 100 buds in 1972.

2. The dependent variable Y = percent defoliation in 1973.

Linear and curvilinear regressions were computed from the data. Linear regression gave r values of 0.39, 0.54, and 0.66 for data from northern Idaho, eastern Montana, and western Montana respectively. The R values from curvilinear regression for these areas were 0.37, 0.62 and 0.68. This showed data from eastern Montana tended to fit curvilinear regression slightly better. However, linear regression was chosen to represent the data from the three areas because there were only very slight differences between the two types of regressions, and because linear regression lines had already been plotted and their F-values and 95 percent confidence limits computed.

Arc sine transformations were made on the dependent variable Y but the resulting regression lines did not fit as well as when true percentages were used.

RESULTS

Table 1 lists average number of eggs per 100 buds in 1972 and average percent defoliation in 1973 on all plots in Montana and Idaho. Eggs per 100 buds ranged from 1.1 to 228.9 and defoliation ranged from 1.4 to 81.3 percent on Douglas-fir plots in western Montana. Eggs per 100 buds ranged from 1.8 to 161.1 and defoliation ranged from 3.2 to 88.1 percent on Douglas-fir plots in eastern Montana. Eggs per 100 buds ranged from 0 to 55.1 and defoliation ranged from 0 to 90.6 percent on grand fir plots in northern Idaho. On the average, eggs per 100 buds were more numerous (66.4) in eastern Montana but percent defoliation (41.5) was highest in northern Idaho which had the least eggs (16.3).

Linear regression lines showing the correlation between eggs per 100 buds and percent defoliation in the three ecotypes are featured in Figs. 1, 2, and 3. Correlation coefficients (r) were: 0.39, 0.54, and 0.66 for data from northern Idaho, eastern Montana, and western Montana respectively. These r values are low and indicate poor correlation between eggs per 100 buds and percent defoliation. This is also obvious because the plotted data does not fit any of the three regression lines.

The F-ratio for slope was 13.93 for eastern Montana and 25.65 for western Montana, and both F-ratios were highly significant at the 99 percent level. For northern Idaho, F=6.17 and this was significant at the 95 percent level.

Figure 4 compares the three regression lines. A covariance analysis was used to test for common regressions between northern Idaho and eastern and western Montana. The test showed no significant difference at the 95 percent level for common slopes. However, there was a significant difference between levels. Therefore, the regressions were considered different. The slopes of the regressions were not significantly different because of the low r values obtained from the regressions.

These regressions illustrate there are differences between the three ecotypes. A regression line based on western Montana data could not be used to predict what would occur in eastern Montana.

DISCUSSION

The parameter, eggs per 100 buds, does not seem to reflect degree of defoliation the following season. This was very apparent in northern Idaho where the average number of eggs per 100 buds was the lowest of the three regions but percent defoliation was the highest (Table 1). An explanation for this might be that grand fir chosen for sampling were mostly understory trees and not many were over 30 feet high. The western spruce budworm may prefer to lay its eggs in the crowns of overstory grand fir trees which are too high to sample. This should be determined because in past egg mass surveys in the grand fir type of northern Idaho, egg mass counts have been consistently low.

In the future, we should express new egg masses per 1,000 square inches of foliage on at least 50 plots in eastern and western Montana to see if this parameter would give us a better correlation. In north Idaho, grand fir studies should be initiated to determine distribution of spruce budworm egg masses by crown level and tree crown class.

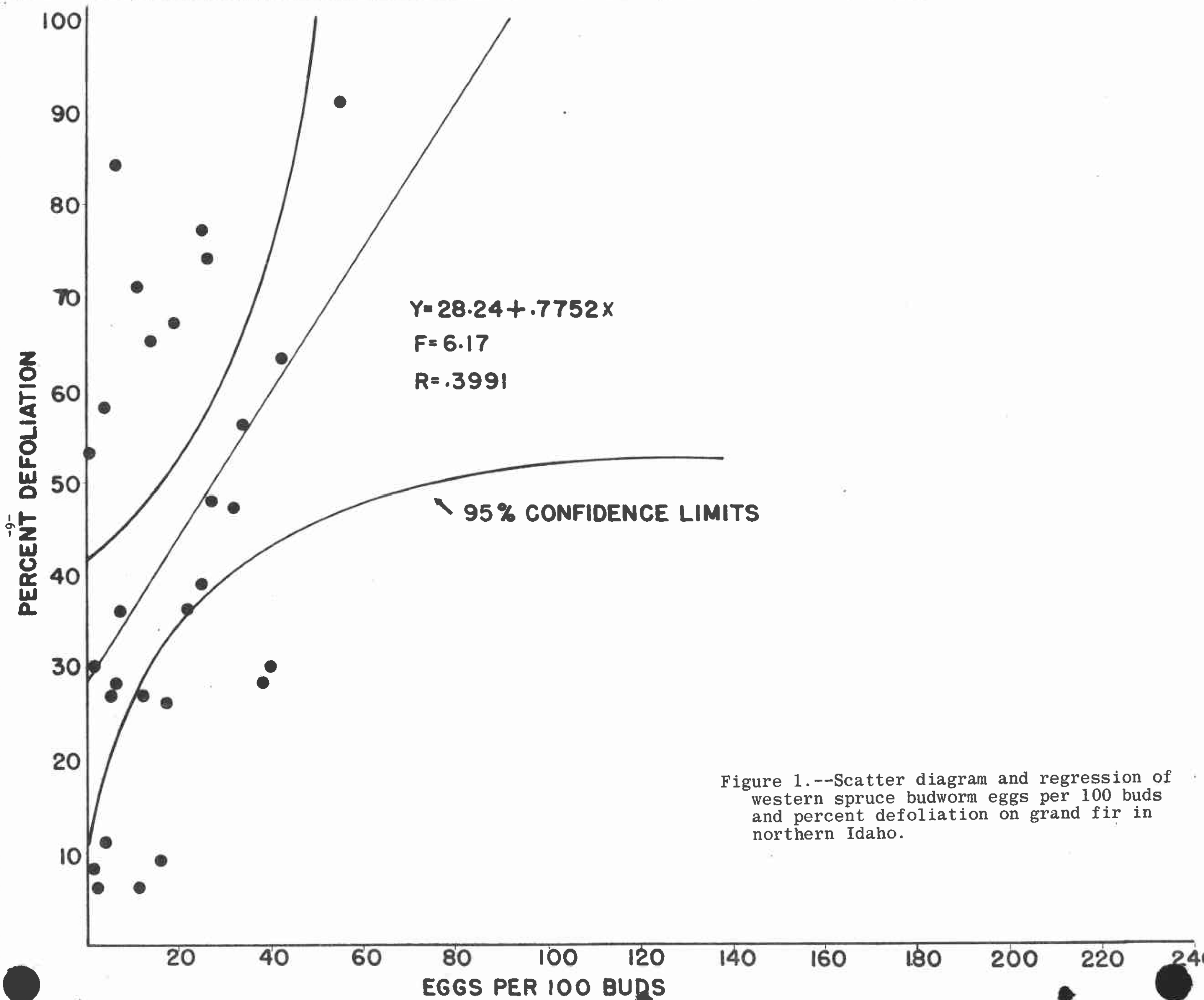


Figure 1.--Scatter diagram and regression of western spruce budworm eggs per 100 buds and percent defoliation on grand fir in northern Idaho.

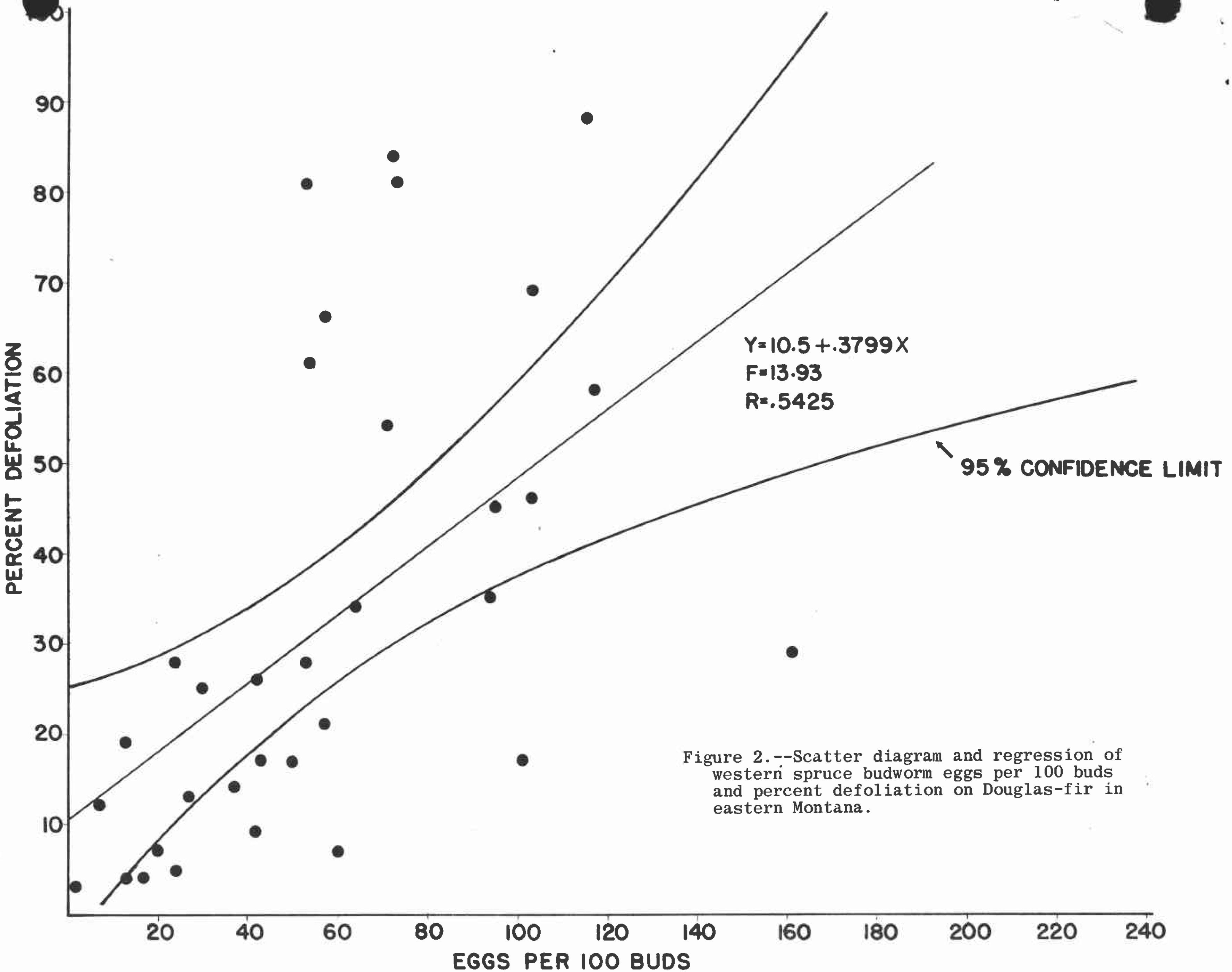


Figure 2.--Scatter diagram and regression of western spruce budworm eggs per 100 buds and percent defoliation on Douglas-fir in eastern Montana.

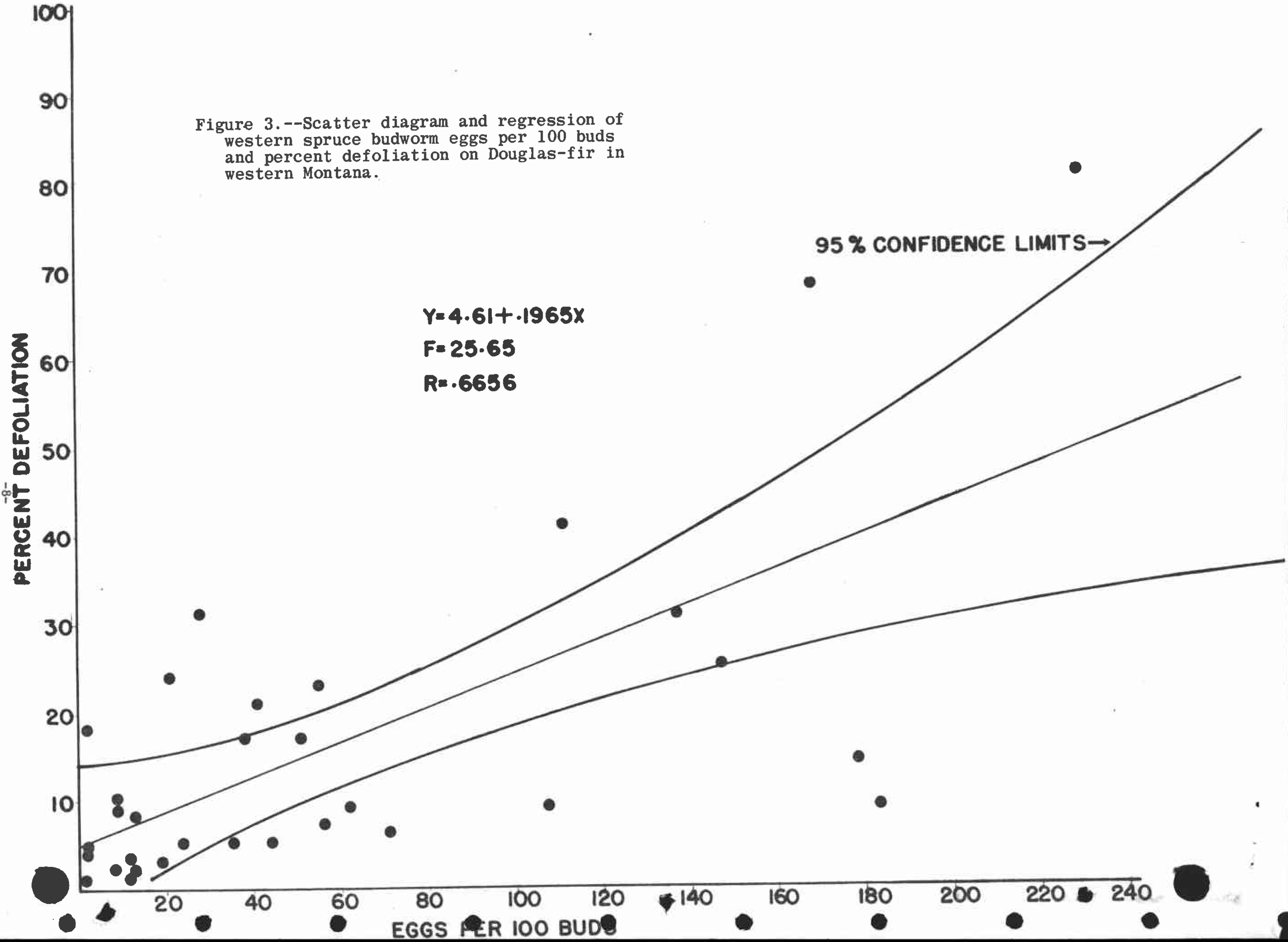
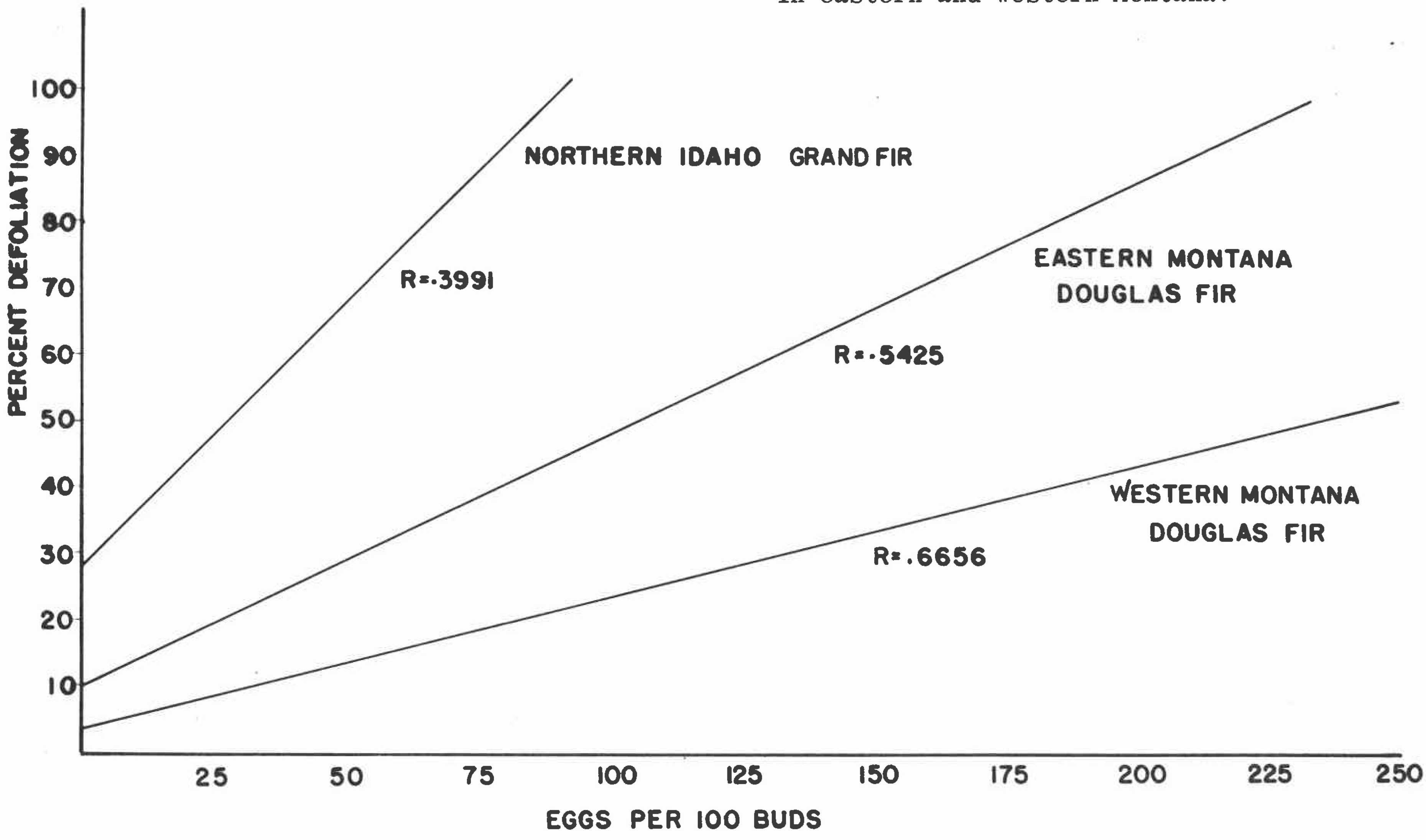


Figure 3.--Scatter diagram and regression of western spruce budworm eggs per 100 buds and percent defoliation on Douglas-fir in western Montana.

Figure 4.--Comparison of regression lines showing the correlation between western spruce budworm eggs per 100 buds and percent defoliation on grand fir plots in northern Idaho, and Douglas-fir plots in eastern and western Montana.



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