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FORECASTING WESTERN SPRUCE BUDWORM DEFOLIATION IN MIXED CONIFER STANDS BY COUNTING HIBERNATING LARVAE

by

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ABSTRACT

An attempt was made in January 1971 to relate the numbers of hibernating western spruce budworm larvae on a square foot of bark surface with subsequent shoot damage on Douglas-fir and grand fir in northern Idaho. Twenty-six plots sampled in January were also sampled in April to determine if larval mortality due to breaking dormancy in midwinter occurred.

An average of 3.9 and 1.8 larvae per square foot of bark surface occurred on Douglas-fir and grand fir logs respectively in January. In April, the average was 7.7 on Douglas-fir and 3.0 on grand fir. In January there was a significant difference between numbers of larvae on Douglas-fir and grand fir logs, but no difference in April. There was no significant difference in numbers of larvae on Douglas-fir logs between January and April, but there was a significantly higher number of larvae on grand fir logs in April.

A regression analysis was made to obtain the correlation between larvae per square foot of bark surface in January and resultant foliage damage (sampled in September). There was no correlation on grand fir plots, and only a weak correlation on Douglas-fir plots.

INTRODUCTION

The western spruce budworm, *Choristoneura occidentalis* Freeman, one of the most destructive forest defoliators in the Northern Rocky Mountains, is currently epidemic over approximately 4 million acres in central and western Montana and northern Idaho. Moderate to heavy defoliation has occurred in recent years in high-value mixed conifer stands of northern Idaho on Douglas-fir, *Pseudotsuga menziesii* var. *glauca;* grand fir, *Abies grandis*; subalpine fir, *Abies lasiocarpa*; western larch, *Larix occidentalis*; and Engelmann spruce, *Picea engelmannii.* Successive defoliation causes reduction in radial increment, top dieback, and in some areas, eventual mortality. Consequently, forest land managers may consider chemical control to suppress infestations and prevent permanent injury to highly productive timber stands. Sampling techniques are needed to forecast population trends of the western spruce budworm to provide land managers with a sound basis upon which to decide for or against control.

Virtually every stage in the life cycle of the western spruce budworm has been sampled. Recently, McKnight, et al. (1970), developed a sequential sampling plan for estimating the numbers of egg masses on 24-inch branch samples taken at midcrown from Douglas-fir in western Colorado, New Mexico, and Arizona. Use of this plan in the Northern Rocky Mountains has met with moderate success in pure Douglas-fir stands east of the Continental Divide but is of little value in mixed conifer forests. Tunnock, et al. (1968) reported that egg mass density on grand fir and Douglas-fir did not differ, but in repeated studies (unpublished) were unable to detect significant numbers of egg masses on grand fir. A problem inherent in egg mass sampling is the difficulty of differentiating between old and new egg masses. It is often winter before land managers define proposed spray areas, and by this time egg masses deposited in August are in varying stages of deterioration. Considerable effort has been directed toward using the hibernating second instar larvae as an index of defoliation potential. Egg mass counts do not take into account dispersal losses which occur when the first instar larvae migrate to hibernating sites; consequently, counts of hibernating larvae may provide a more reliable index of the degree of defoliation which may be expected. McKnight (1967), working with Douglas-fir in Colorado, reported that approximately 65 percent of the overwintering larvae occurred on the branches and 35 percent occurred on the bole. Terrell (1959) reported that bole sections contained a significantly higher number of larvae per unit area than did branch sections, making them perhaps a better indicator of defoliation potential. Terrell and Fellin (1960) reported correlation between hibernating larvae and defoliation on 25 plots in Montana. Counts of hibernating larvae were obtained from bole samples 6 to 8 inches in diameter reared in 6-gallon paperboard ice cream cartons.

Terrell (1961) described a method of estimating defoliation on Douglas-fir using the inverse relationship between undamaged buds and percent of defoliation. McKnight (1967) applied the same method to Douglas-fir and white fir in Colorado.

Presently, there is no effective means to evaluate defoliation potential of the western budworm in mixed conifer stands of northern Idaho. Severe defoliation by this insect has occurred in these stands for several years, particularly on the Nezperce, Clearwater, and St. Joe National Forests. It is necessary to have reliable data upon which to predict potential defoliation and provide a valid basis for control decisions in this area. The objective of this study was to develop a means of predicting potential defoliation of grand fir and Douglas-fir in the mixed conifer type of northern Idaho based on counts of hibernating second instar larvae.

METHODS

Collection of bolt samples.--During January 1971, 40 plots were sampled for hibernating budworm on the Nezperce National Forest, Idaho. Each area either contained a young pole-sized stand of grand fir or Douglas-fir. It was desired to have 20 grand fir plots and 20 Douglas-fir plots but the Forest had a greater volume of grand fir; therefore, 16 Douglas-fir plots and 24 grand fir plots were obtained. Snowmobiles were used to get into most areas. On each plot, five trees were felled and a log, no larger than 9 inches in diameter and 16 inches long, was cut near midcrown from each tree.

Each log was placed in a 5-gallon ice cream carton with two glass vials inserted in the lid. Room temperature was maintained at 75°F. and fully illuminated 24 hours each day. Larvae began emerging from their hibernacula on the logs into the glass vials in about 10 days. A record was kept of the number of larvae that emerged from each log.

To determine if there was mortality due to breaking dormancy in winter[1/], collections from the same plots were made during the last week in April. The same procedures were used as in the January sampling. However, only 26 of the plots (15 grand fir and 11 Douglas-fir) could be resampled because of muddy roads and snow drifts.

1/ Fellin, David G. Personal communication.

Estimation of defoliation.--In September, defoliation was estimated on the plots by using the number of currently damaged shoots as a factor. At each plot, five trees were sampled by cutting four branches from midcrown from each tree. On each branch, 25 current year's shoots were inspected for budworm feeding. The number of damaged shoots per 100 was recorded for each tree, and the average number of damaged shoots per 100 was determined for each plot.

RESULTS

Numbers of larvae per square foot of bark surface varied considerably between trees on the same plot. On one grand fir plot in January there was a range of 1.04 to 26.29 larvae per square foot. A Student's T-test at the 5 percent level showed that there was a significant difference between Douglas-fir plots and grand fir plots (Table 1). There was an average of 3.9 larvae per square foot on the Douglas-fir logs in January and 1.8 on the grand fir logs (Table 2). Also in January, the mean number of larvae per square foot on a plot ranged from 0 to 11.2.

Table 1.--Student's T-values for January and April spruce budworm densities, Nezperce National Forest, Idaho--1971.

January	April	January vs. April	
DF vs. GF	DF vs. GF	DF	GF
2.206*	1.526	0.281	2.343**

* Significant difference at the .05 level where t = 2.093 with 19 DF.

** Significant difference at the .05 level where t = 2.145 with 14 DF.

Table 2.--Mean number of western spruce budworm larvae per square foot of bark surface in January and April.

Tree species	January	SE	April	SE
Douglas-fir	3.88	± .90	7.74	± 3.02
Grand fir	1.77	± .34	3.01	± .67

Results in April showed there was an average of 7.7 larvae per square foot of Douglas-fir bark on 15 plots and an average of 3.0 larvae on 19 grand fir plots (Table 2). A "t"-test at the 5 percent confidence level indicated there was no significant difference between numbers of larvae on the Douglas-fir and grand fir plots (Table 1).

The differences between numbers of larvae per square foot of bark surface on 26 paired Douglas-fir and grand fir plots in January and April are shown in Table 3. It shows that for both tree species the mean number of larvae per plot sometimes increased and sometimes decreased from January to April. However, T-tests at the 5 percent confidence level indicated (Table 1) there was no significant difference on Douglas-fir between January and April, but there was a difference on grand fir--more larvae were collected in April.

A regression analysis was made to determine the correlation between larvae per square foot of bark surface in January and resultant foliage damage. For grand fir, the correlation coefficient (r) was 0. For Douglas-fir the $r = 0.44$. Overall, there was a weak correlation between hibernating larvae on Douglas-fir plots and damaged shoots.

DISCUSSION AND CONCLUSIONS

The above data indicates that **five** bolt samples from an area are not an adequate sample due to the large between-tree variation. Analysis of these data indicate that 15 bolt samples are needed to correctly estimate western spruce budworm population with a mean of 3.9 insects/square foot within $\pm$ 2 larvae 95 out of 100 times.

The number of larvae per square foot of grand fir bark in Table 4 is not reflected in subsequent damage. On one grand fir plot, no larvae were found, but 76.6 shoots per 100 were damaged.

Predicting damage in stands of grand fir persists to be a problem. Hardly any egg masses could be found on grand fir foliage in a heavy infestation on the St. Joe National Forest in 1970 but defoliation in 1971 was heavy[2/]. Similarly, overwintering larvae on grand fir bark do not appear to be related to subsequent damage. Additional work in sampling western spruce budworm in the mixed conifer forests of Idaho is needed.

2/ Honing, Frederick W. 5230 Memorandum of October 7, 1970 to Forest Supervisor, St. Joe National Forest.

Table 3.--Differences between the numbers of western budworm larvae per square foot of bark surface on Douglas-fir and grand fir plots in January and April, 1971.

Plot number	Species of tree	January means	SE	April means	SE
3-1	GF	2.94	± 1.64	3.00	± 1.59
3-3	GF	6.35	± 2.52	12.13	± 6.30
3-5	GF	2.55	± 1.22	1.82	± .58
3-6	GF	3.61	± 1.49	2.80	± 1.52
3-8	GF	1.04	± .53	2.39	± 1.36
3-9	GF	.33	± .13	.89	± .55
3-10	GF	2.81	± 1.20	4.23	± 1.25
3-11	GF	4.51	± 2.19	8.50	± 2.27
1-2	GF	.67	± .33	1.61	± .25
1-5	GF	.12	± .12	1.72	± .80
1-13	GF	.47	± .35	.30	± .19
1-14	GF	.15	± .15	.55	± .15
4-2	GF	.88	± .18	1.56	± .23
2-1	GF	1.99	± .72	3.99	± 1.99
2-2	GF	2.14	± .83	1.42	± .70
3-2	DF	1.31	± .59	4,18	± 1.36
3-4	DF	3.52	± .92	5.48	± 1.76
3-7	DF	11.81	± 4.98	6,07	± 3.44
3-12	DF	2.24	± 1.02	8.48	± 3.73
1-1	DF	.63	± .30	,34	± .21
1-3	DF	.87	± .31	1,62	± .82
1-6	DF	1.13	± .44	.68	± .32
1-7	DF	1.31	± .67	.62	± .36
2-3	DF	2.70	± .90	1.80	± 1.19
2-4	DF	3.03	± .95	3.07	± 1.09
2-5	DF	1,90	± .69	.85	± .52

Table 4.--Comparison between number of larvae per square foot of bark surface and subsequent feeding damage on Douglas-fir and grand fir plots.

Plot no. and tree species	Av. larvae per sq. ft. of bark in January	SE	Average damaged shoots per 100	SE	Plot no. and tree species	Av. larvae per sq. ft. of bark in January	SE	Average damaged shoots per 100	SE
3-1-GF	2.94 ±	1.64	45.2 ±	5.88	3-2-DF	1.31 ±	.59	7.4 ±	.75
3-3-GF	6.35 ±	2.52	52.8 ±	12.29	3-4-DF	3.52 ±	.92	32.8 ±	5.30
3-5-GF	2.55 ±	1.22	19.6 ±	5.22	3-7-DF	11.81 ±	4.98	8.6 ±	2.23
3-6-GF	3.61 ±	1.49	33.0 ±	6.52	3-12-DF	2.24 ±	1.02	23.4 ±	8.77
3-8-GF	1.04 ±	.53	28.6 ±	3.47	3-13-DF	3.78 ±	2.32	15.6 ±	2.94
3-9-GF	.33 ±	.13	24.8 ±	6.30	3-14-DF	4.14 ±	.95	12.6 ±	3.26
3-10-GF	2.81 ±	1.20	11.0 ±	3.30	2-3-DF	2.70 ±	.90	20.8 ±	5.51
3-11-GF	4.51 ±	2.19	14.2 ±	4.55	2-4-DF	3.03 ±	.95	18.8 ±	5.13
3-15-GF	2.85 ±	2.55	61.8 ±	5.73	2-5-DF	1.90 ±	.69	16.2 ±	3.28
2-1-GF	1.99 ±	.72	83.0 ±	5.27	1-1-DF	.63 ±	.30	2.8 ±	1.50
2-2-GF	2.14 ±	.83	10.0 ±	4.74	1-3-DF	.87 ±	.31	2.8 ±	1.07
1-2-GF	.67 ±	.33	24.4 ±	5.78	1-6-DF	1.13 ±	.44	29.4 ±	8.11
1-5-GF	.12 ±	.12	27.4 ±	2.48	1-7-DF	1.31 ±	.67	31.2 ±	6.76
1-8-GF	1.86 ±	1.09	54.2 ±	3.31	1-9-DF	3.33 ±	1.45	36.2 ±	8.93
3-16-GF	.00		65.4 ±	5.99	3-20-DF	10.02 ±	3.16	86.0 ±	7.31
3-17-GF	.00		76.6 ±	2.23					
3-18-GF	1.80 ±	.70	86.2 ±	6.86					
4-1-GF	.00		15.0 ±	5.21					
1-14-GF	.15 ±	.15	21.6 ±	2.69					
[illegible]-13-GF	.47 ±	.35	29.2 ±	5.64					
4-2-GF	.88 ±	.18	19.4 ±	3.01					
3-19-GF	.68 ±	.32	78.8 ±	8.76					

LITERATURE CITED

McKnight, M. E., 1967. Ecology of the western budworm in Colorado. PhD. Thesis Colorado State University.

McKnight, M. E., Donn R. Cahill, and H. W. Flake, 1970. Sequential plans for western budworm egg mass surveys in the central and southern Rocky Mountains. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Res. Note 174, 8 pp.

Terrell T. T., 1959. Sampling populations of overwintering spruce budworm in the Northern Rocky Mountain Region. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Res. Note #61.

Terrell, T. T., 1961. Estimating defoliation caused by spruce budworm from undamaged shoots. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Res. Note #86.

Terrell, T. T., and D. G. Fellin, 1960. Study of techniques of spruce budworm surveys in the Northern Rocky Mountain Region. Intermountain Forest and Range Experiment Station. Unpublished report.

Tunnock, S., W. E. Bousfield, and H. E. Meyer, 1968. Distribution of spruce budworm egg masses on grand fir and Douglas-fir trees on the Powell Ranger District, Clearwater National Forest, Idaho. U.S. Department of Agriculture, Forest Service, Division of State and Private Forestry, Northern Region. Unpublished report.

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