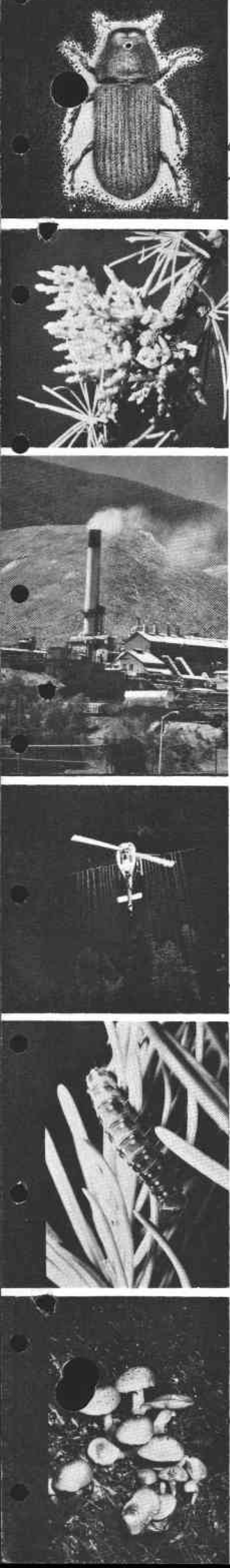

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IMPACT OF SPRUCE BUDWORM ON THE NEZPERCE NATIONAL FOREST, IDAHO, 1976

by

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SUMMARY

Western spruce budworm caused moderate to severe damage to conifers on over 138,000 acres and light damage to conifers on an additional 500,000 acres on the Nezperce National Forest from 1967 to 1974. In stands classified as being moderately to severely damaged, 54.31 percent of the trees were top killed and 19.07 percent were dead, apparently from repeated defoliation. Periodic annual growth was reduced by an estimated 17.64 percent in these stands. In stands classified as being lightly damaged, 21.79 percent of the trees were top killed, but spruce budworm-related mortality was not found. Growth was reduced by an estimated 2.66 percent in lightly damaged stands. Grand fir and subalpine fir were the most significantly damaged conifer species in the evaluation area. Slight growth reduction was found in Engelmann spruce in the more severely damaged stands, while Douglas-fir escaped serious injury as indicated by the nonsignificant reduction of periodic annual increment. Although a small increase in growth was indicated for both western larch and ponderosa pine, it was nonsignificant. Limited evaluations suggest that decay fungi do not readily infect trees with dead, unbroken tops resulting from spruce budworm defoliation.

INTRODUCTION

Western spruce budworm, *Choristoneura occidentalis* (Free.), occurred at epidemic levels on the Nezperce National Forest between 1967 and 1974. Although the infestation subsided in 1975, damage is still evident in many stands. In 1972, an aerial survey identified visible top kill and mortality of trees on approximately 138,000 acres (Ciesla *et al.*, 1972), figure 1.

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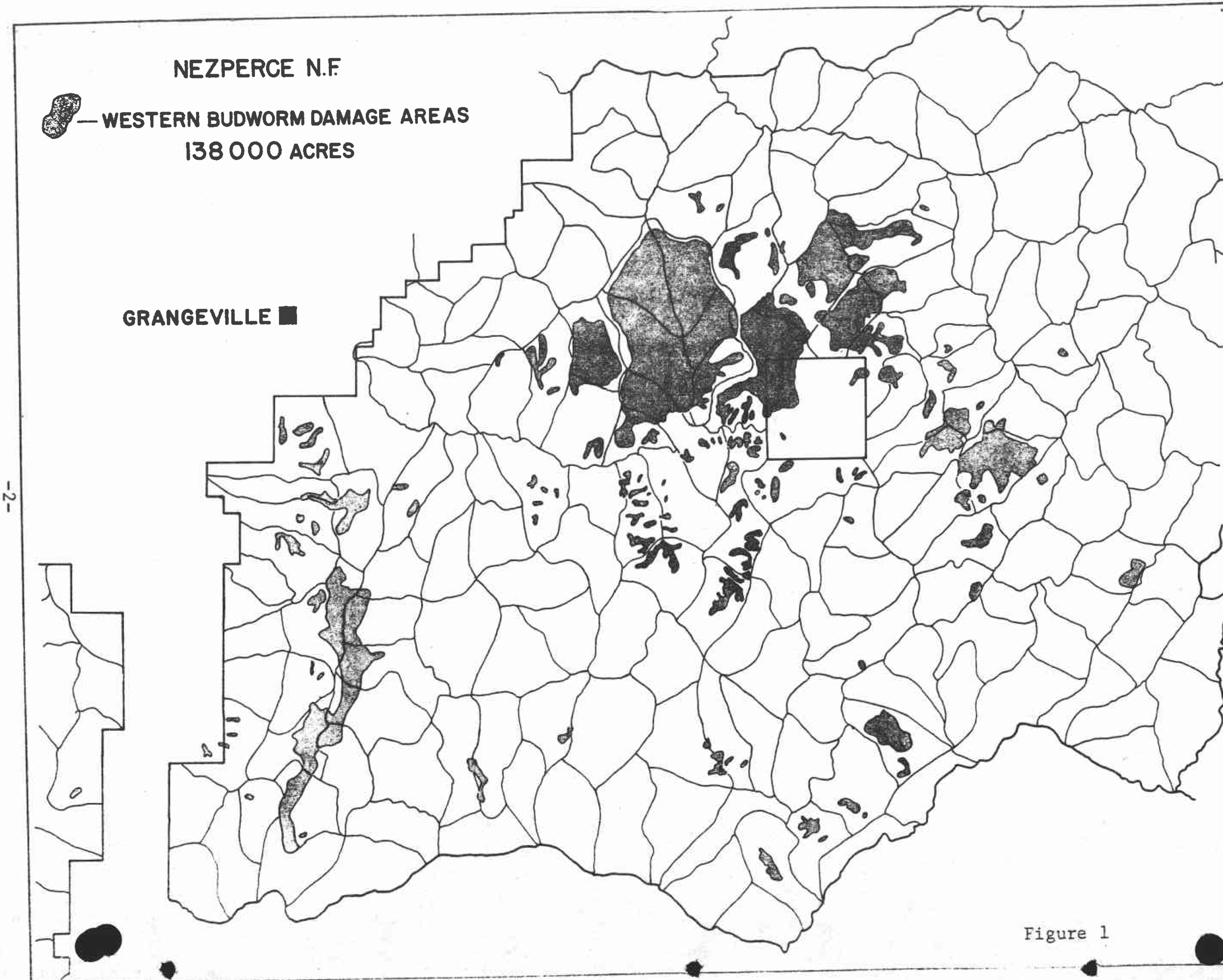

NEZPERCE N.F.
— WESTERN BUDWORM DAMAGE AREAS
138 000 ACRES
GRANGEVILLE

Figure 1

Damage caused by the western spruce budworm is well documented (Williams 1963, 1966, 1967; Fellin and Schmidt 1973) and is considered a serious threat to true firs (*Abies* spp.), Douglas-fir (*Psuedotsuga menziesii* (Mirb.) Franco), Engelmann spruce (*Picea engelmannii* Parry ex Engelm.), and western larch (*Larix occidentalis* Nutt.).

Reports concerning insect defoliator/stem decay correlations are few and results are varied. Stillwell (1956) reports that balsam fir (*Abies balsamea* (L.) Mill.) top killed by spruce budworm, *C. fumiferana* (Clem.), 30 to 40 years prior to his studies and with buried leaders 0.5 inch in diameter or larger contained some decay which had entered through the base of killed leaders. Butt and root rot of balsam fir have been shown to be associated with spruce budworm and balsam wooly aphid, *Adelges piceae* (Ratz.), defoliation (Hudak and Singh 1970; Sterner 1970). Wickman (1963) suggests that dead tops of white fir (*Abies concolor* (Gord. and Glend.) Lindl.) resulting from Douglas-fir tussock moth, *Hemerocampa pseudotsugata* McD., feeding may be entry points for decay fungi. However, Wickman and Scharpf (1972) report only minor decay in white fir defoliated by Douglas-fir tussock moth 35 years previously.

Insect-caused conifer defoliation has long been observed in the Northern Region and many stem decay fungi, including the familiar *Fomes pini* ((Brot.) Fr.) Karst. and *Echinodontium tinctorium* (Ell. & Ev.) Ell. & Ev., commonly occur here. However, reports concerning the association between insect defoliators and stem or root decay in the Northern Region have not been found.

Resource managers are concerned about managing budworm-damaged stands. First, however, information such as identification of conifer species that will tolerate damage, size class most affected, growth impact, condition of understory, and association of decay with budworm damage must be obtained. This information is also needed for valid benefit-cost analysis of pest management. Collection of these data is the subject of this report.

METHODS

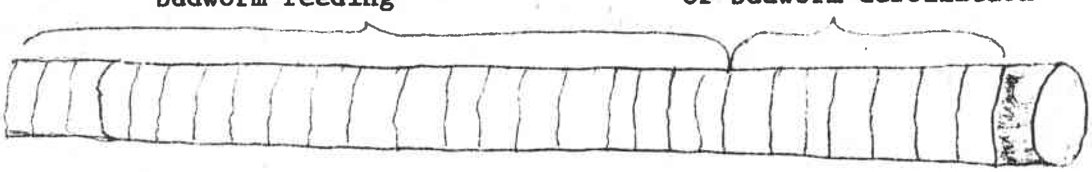
Selection of Sample Areas

Areas of aerially identified budworm damage appearing as gray areas in the forest canopy were drawn onto forest compartment maps and acreage with damage determined for each compartment. Nine-inch by nine-inch format color infrared (CIR) aerial photographs taken at a scale of 1:15,840 were obtained for 12 compartments selected on a probability proportional to number of acres of damage (size) basis. Photographs were used to stratify compartments into areas receiving moderate to severe or light budworm damage. Areas with concentrated patches of dead trees were designated as being moderately to severely damaged and areas with scattered top-killed trees were designated as being lightly damaged. Five stands from lightly damaged areas and nine stands from moderately to severely damaged areas were randomly selected for ground examination. Boundaries of these stands were based on the existing forest stand boundaries.

Sample Plot Establishment and Tree Measurement

Growth characteristics were measured for trees falling into 40 B.A.F. (Basal Area Factor) variable plots located in each stand sampled. Number of plots in each stand depended upon the number of acres in that stand, with at least 10 plots being established in stands of less than 100 acres, and a maximum of 30 plots in stands between 100 and 200 acres. Plots were placed at 5- by 10-chain intervals. Tree height and d.b.h. (diameter at 4.5 feet above ground) were measured with a Relaskop and diameter tape respectively. The former was measured to the nearest 1.0 foot and the latter to the nearest 0.1 inch. Increment cores were removed from the three trees 9 inches or greater d.b.h. nearest to plot center. Cores were placed into straws and transported to Missoula where periodic growth was measured with the aid of a variable power dissecting microscope. Measurements of growth from 0 to 7 years and from 7 to 21 years previously were made on each core (figure 2).

Figure 2.--Increment core



At the center of each variable plot, a 1/300-acre, circular, fixed plot was established to obtain an estimate of the number of 1- to 5-inch d.b.h. trees per acre. In this case tree measurements were not taken, only numbers of each species were tallied.

All trees within both the variable plot and fixed plot were visually classified into one of the following budworm damage classes:

0 Not damaged
1 Defoliated only
2 Top kill less than 10% of crown
3 Top kill 11 to 30% of crown
4 Top kill 31 to 50% of crown
5 Top kill more than 51% of crown
6 Dead (caused by severe defoliation)

Data Analyses

Volume and trees per acre by damage class were determined by subjecting field data to the Region 1 cruise computer program. This program has the capacity to stratify an individual stand into six damage classes and summarize data in trees and volume per acre for each class.

Growth loss estimates were obtained by utilizing the program "Predict" which is a modification of the stand examination (Stage II) program and is described in a previous report (Bousfield *et al.* 1975).

Decay Sampling

Trees with dead tops apparently resulting from previous budworm defoliation were sampled for decay in three widely separated areas in which spruce budworm damage was known to have occurred during different years. Seven 40- to 100-year-old trees with dead tops resulting from the current infestation (1973-1975) in the Goodwin Meadows area; ten 25- to 35-year-old trees with dead tops resulting from the 1963-65 infestation in the Bear Creek area; and five 30- to 70-year-old trees with dead tops resulting from the 1952-55 infestation in the Cow Creek area were sampled. All trees sampled were grand fir except for two Douglas-fir and one Engelmann spruce in the Bear Creek area.

That dead tops resulted from previous budworm defoliation was determined by comparing the difference between number of annual rings of the dead top and green stem immediately below the dead top to the number of years between the known infestation period and 1975. It was assumed that spruce budworm caused the top kill if these values were similar.

Samples including 1 foot of stem on either side of the dead/live interface on dead tops of each sample tree were collected and taken to the laboratory for isolation studies. Where decay was suspected, trees were cut into sections to determine extent of decay.

Laboratory procedures involved incubating on malt extract agar at 20^{o} to 25^{o} C (Nobles 1965) no fewer than eight chips aseptically obtained from unsterilized discolored wood of each sample. Cultures were periodically examined for fungi, and any possible decay fungus was worked through Nobles' keys (Nobles 1965) to determine its identity.

RESULTS

In areas classified on CIR photography as being lightly damaged, ground sampling showed that 21.77 percent of the trees over 5 inches d.b.h. (19.6 percent of the volume) and 31.0 percent of the trees from 1 to 5 inches d.b.h. sustained top kill (damage classes 2, 3, 4, 5) of varying degrees (figures 3, 4, 5). Mortality was not observed in lightly damaged areas. However, periodic annual increment (PAI) is estimated to have been reduced by 2.66 percent (table 1).

In areas classified as being moderately to severely damaged, 54.3 percent of the trees over 5 inches d.b.h. (53.7 percent of the volume) and 32 percent of the trees from 1 to 5 inches d.b.h. were top killed (figures 3, 4, 5). Nineteen percent of all trees had been killed by budworm defoliation but contained only 2.1 percent of the volume, indicating that the smaller diameter trees in the stand were killed. Periodic annual increment is estimated to have been reduced by 17.64 percent in the moderately to severely damaged stands (table 1).

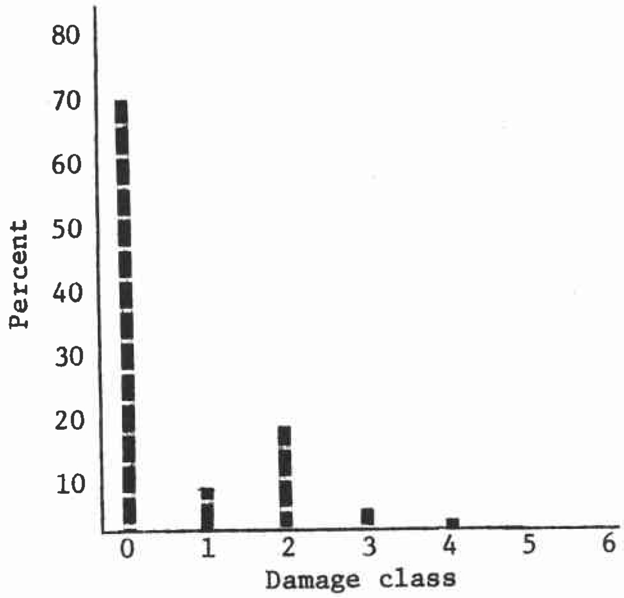
Grand fir (*Abies grandis* (Dougl.) Lindl.) and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) were conifer species most severely damaged in all stands. Periodic annual increment is estimated to have been reduced by 22.28 percent and 18.88 percent for grand fir and subalpine fir respectively for all stands measured (table 2). As determined by the PAI predictions of Douglas-fir, Engelmann spruce, and lodgepole pine (*Pinus contorta* Dougl.) growth was slightly reduced, whereas growth of western larch and ponderosa pine (*Pinus ponderosa* Dougl.) was slightly higher than expected (table 2).

Central columns of lightly discolored but sound wood approximately the same diameter as the base of the dead top and extending the entire height of the tree were observed in most trees sampled. Advanced decay columns resulting from budworm defoliation were not found.

Wood chips for isolation studies were in all cases taken from the central discolored columns. Hymenomyceteous decay fungi were not isolated from any of the columns; however, several non-hymenomyceteous fungi belonging to the Fungi Imperfectii group were isolated from six samples obtained from trees in the Bear Creek and Cow Creek areas.

Figure 3.--Trees per acre by damage class, 5 inches d.b.h. and greater

Lightly damaged areas



Moderately to severely damaged areas

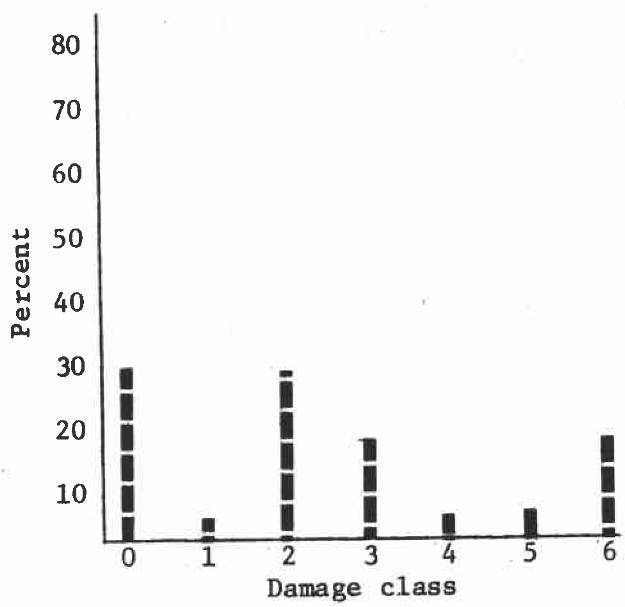
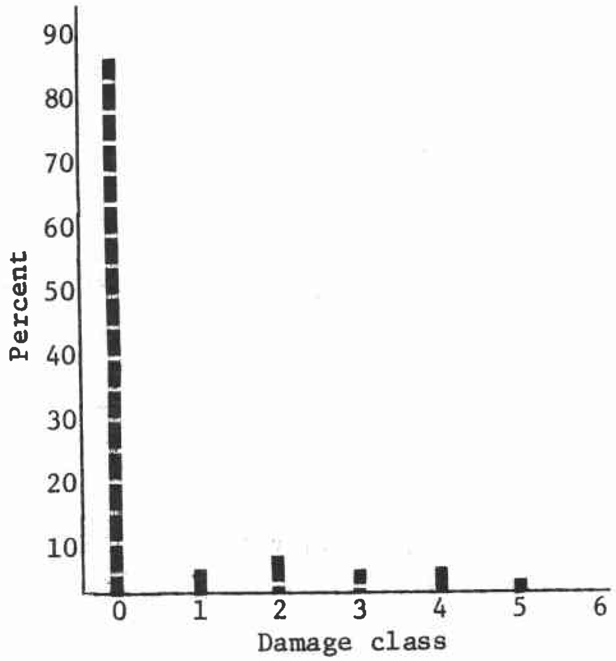


Figure 4.--Volume per acre by damage class, trees 5 inches d.b.h. and greater

Lightly damaged areas



Moderately to severely damaged areas

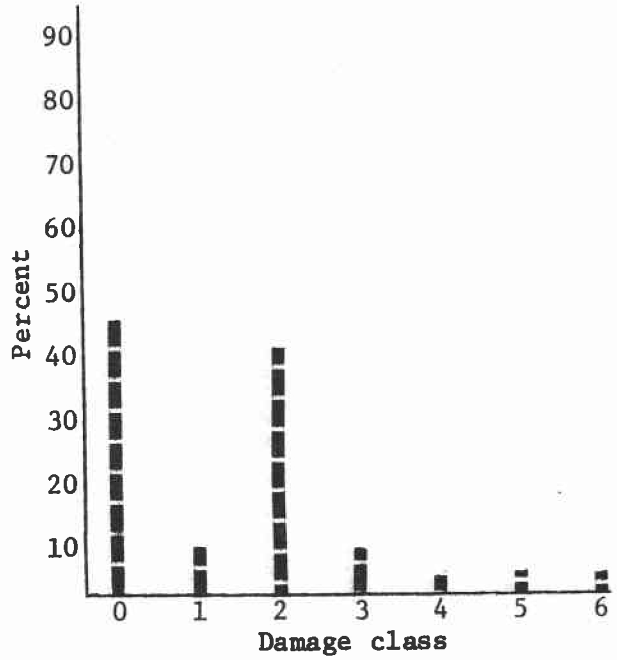
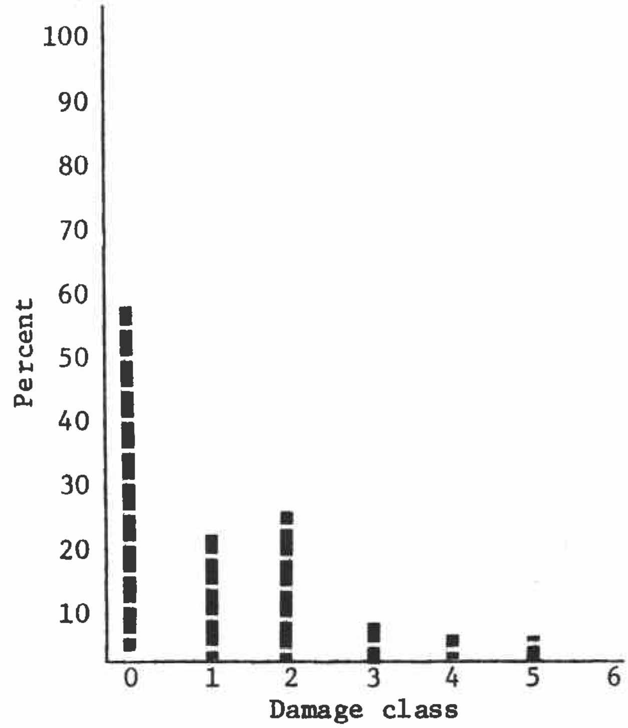


Figure 5.--Trees per acre and damage class under 5 inches d.b.h.

Lightly damaged areas



Moderately to severely damaged areas

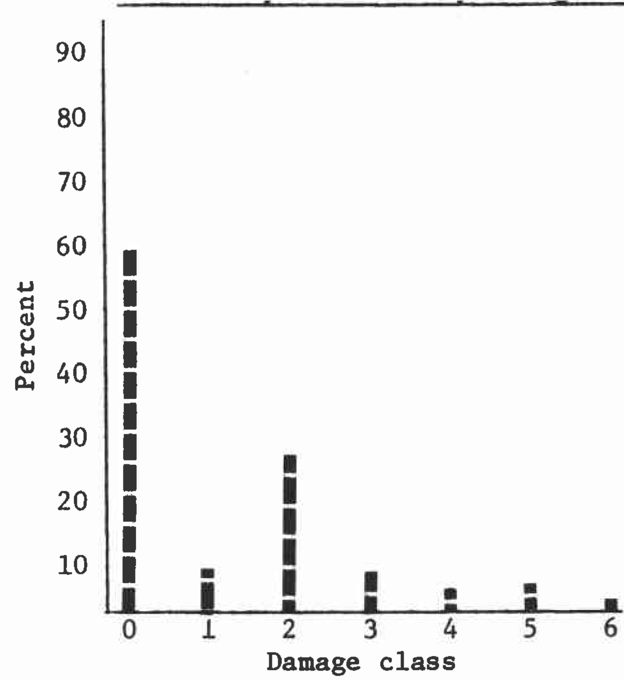


Table 1.--Periodic annual increment by stands and damage class[1/]

Lightly damaged areas

Compartment	Stand	Actual PAI	Predicted PAI	Percent of predicted
302	02	252.02	228.60	+10.24
422	02	244.18	230.72	+ 5.82
306	02	298.90	301.23	- .77
306	03	103.09	120.83	-14.68
422	01	176.51	205.02	-13.92
			Average	- 2.66

Moderately to severely damaged areas

Compartment	Stand	Actual PAI	Predicted PAI	Percent of predicted
442	03	133.61	146.09	- 9.54
801	03	87.84	102.53	-14.33
805	04	175.88	206.47	-14.82
805	02	106.53	141.87	-24.91
805	01	115.51	153.52	-24.77
810	01	140.27	201.37	-30.34
801	01	134.54	160.66	-16.26
810	02	192.91	256.07	-24.67
801	02	153.28	190.89	-19.70
			Average	-17.64

1/ Includes all tree species within the stand.

Table 2.--Differences in periodic growth by tree species

Species	Percent of expected periodic annual increment
Grand fir	-22.28*
Subalpine fir	-18.88*
Spruce	- 4.10
Larch	+ 4.09
Douglas-fir	- 8.98
Lodgepole pine	- 1.02
Ponderosa pine	+ 3.37

*Significantly different from expected PAI at the 95% level.

DISCUSSION AND CONCLUSIONS

Western spruce budworm has caused significant damage to grand fir and subalpine fir over an estimated 138,000 acres on the Nezperce National Forest. Because budworm-related mortality was associated with the smaller diameter classes, mortality does not appear to be significant to date. However, many trees have been severely damaged by top kill, and within a few years mortality rate may increase.

Engelmann spruce, Douglas-fir, and western larch have not been severely damaged in most of the stands examined. Favoring these species, where possible, during stand improvement work in stands with a history of budworm should reduce potential for damage in future western spruce budworm outbreaks. Numbers of trees necessary to provide adequate stocking do exist in a few stands. However, in most cases, understory trees have been severely damaged. Little opportunity exists for the land manager to rely on damaged understory trees for regeneration, and other regeneration procedures must be used in these areas.

Although of limited scope, our isolation studies suggest that hymenomyceteous decay fungi do not initially infect trees with dead unbroken tops resulting from spruce budworm defoliation occurring up to 25 years previously. These findings are consistent with those of Wickman and Scharpf (1972) which show little infection in white fir top killed by Douglas-fir tussock moth some 35 years earlier. These workers suggest two possible reasons for the limited amount of decay found in their studies:

1. Climate limiting infection and rate of decay.

2. Absence of suitable substrate (heartwood) in small tops.

Either or both may be of significance in the areas involved in our evaluations.

Central columns of lightly discolored wood observed in sample trees are suspected to be "wetwood," i.e., a physiological condition of unknown cause that may be associated with a bacterium (Wilcox and Oldham 1972). Wickman and Scharpf (1972) report similar findings in almost all small white fir (4 to 10 inches d.b.h.) top damaged by the Douglas-fir tussock moth.

An alternative explanation for discolored wood deals with the finding of nonhymenomyceteous fungi in tops dead for 10 to 25 years. These results may indicate that a succession of organisms thought to be involved in grand fir decay (Maloy and Robinson 1968) is currently under way. These data, however, are preliminary and further evaluations, particularly in environments more conducive to decay development and in areas of older defoliation, should be made.

Root decay resulting from spruce budworm defoliation was not evaluated in these studies.

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