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Cone and Seed Insect Damage and Prediction of Cone Production in Grand Fir in the Potlatch Area of Northern Idaho[1]

by
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ABSTRACT

During 1971, a year of high grand fir (*Abies grandis* (Dougl.) Lindl.) cone production insect damage and cone production were evaluated on Potlatch Corporation land, Latah County, Idaho. The area was primarily an *Abies grandis/Pachistima myrsinites* habitat type. An examination of cones collected from three stands in the Gold Creek drainage revealed that 6.4 percent of the seed was destroyed by insects while 52.4 percent of the seed crop had undeveloped endosperm. The two major insect pests were *Dioryctria abietella* (Denis and Schiffermueller), a coneworm, and *Hylemya abietis* Huckett, a cone maggot. These insects destroyed 5.7 percent of the seed crop. Three binocular methods were tested to estimate the cone production from the ground. The best prediction equation was:

$$Y = -10.8 + 1.9\ WHO + 1.5\ SS\ (r^2 = 0.806),$$

where, WHO is the number of cones visible on the top two whorls and SS is the number of cones visible on the south side of the crown.

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INTRODUCTION

Grand fir, *Abies grandis* (Douglas) Lindley, is becoming increasingly important as a timber resource in northern Idaho with lumber and other products produced from grand fir accounting for 18 percent of Idaho's merchantable forest products (Wilson 1964). As stands are logged and intensity of forest management increases, artificial and natural regeneration becomes increasingly important in the silviculture of this tree species. Private industry and state and public lands no longer depend entirely on natural regeneration; long-range management policies call for the establishment of seed production areas and seed orchards to meet regeneration needs. However, cone and seed insects that are minor pests in unmanaged forests may become important economic pests in seed production areas. Coupled with the destruction of seeds by insects are the natural low viability and germination of grand fir seeds (USDA 1965) and the cyclic nature of grand fir cone crops. Years of good cone production are usually followed by years of poor cone production or crop failures (Eis et al. 1965, Franklin et al. 1974).

The objectives of this study were to evaluate the damage of cone and seed insects to the seed crop near Potlatch, Idaho on Potlatch Corporation lands during a year of high cone production (1971), and to develop a method to predict cone production.

Table 1. Location and site characteristics of grand fir study areas, northern Idaho, 1971.

Stand No.	Survey description	Average Elevation	Slope (mean %)	Aspect	Yield capacity[a] (cu.ft./ac/yr.)	Site index[b] 50 yrs.	Site class[b]	Total Basal Area/Acre ($\geq$ 3" DBH)	Volume (Gross BF/Acre $>$ 11" DBH)
Gold Creek #1	SW¼ of the SW¼ S21 T42N, R4W, Boise Meridian	2630 ft.	18	E	87.8	46	III	137	10,417
Gold Creek #2	SW¼ of the SW¼ S16 & S21, T42N, R4W, Boise Meridian	2700 ft.	20	W	77.0	41	III	138	11,434
Gold Creek #3	SE¼ of the SE¼ S8, T42N, R4W, Boise Meridian	2870 ft.	30	N	65.4	36	IV	141	14,222

[a] Brickell, J. E. 1970. Equations and computer subroutines for estimating site quality of eight Rocky Mountain species. U.S. Dep. Agr. Forest Serv. Res. Pap. INT-75. 22 p.

[b] Instructions for forest inventory of Potlatch Forests, Inc. logging units. 14 pp. & App. PFI, Lewiston, Idaho, June 17, 1957.

Table 2. Tree species composition, density, and proportion of cone-bearing grand fir in study area, northern Idaho, 1971.

Plot	WL	WWP	WRC	ES	PP	LP	DF	GF	N-C-B GF	CB GF	Total Stems/ Acre	No. GF/ Acre	No. CB-GF/ Acre	Percent CB-GF/ Acre	Mean Age CB-GF[c]	Mean No. cones/ CB-GF	Cones/ Acre
	Number stems by species per plot[a, b]																
Gold Creek 1 (plots 1, 2, 3, 4, 7)	6	0	0	2	0	1	42	119	76	43	340	238	86	36.1	72	52	4452
Gold Creek 2 (plots 2, 3, 4, 5, 8)	0	0	0	0	0	0	8	86	45	41	188	172	82	47.7	88	88	7214
Gold Creek 3 (plots 1, 4, 6, 8, 9)	2	2	11	5	1	0	14	107	79	28	284	214	56	26.2	111	64	3560

[a] WL - western larch; WWP - western white pine; GF - grand fir; WRC - western red cedar; ES - Engelmann spruce; PP - ponderosa pine; LPP - lodgepole pine; N-C-B/GF - Non-cone bearing grand fir.

[b] Diameter (breast height) $\geq$ 3"

[c] Based on 10 year age classes

REVIEW OF PREVIOUS WORK

Keen (1958) summarized the biologies and distributions of cone and seed insects of grand fir, mostly from work in Oregon and California. Pfister and Woolwine (1963) listed the insects and their damage to the grand fir cone crop at Deception Creek Experimental Forest in northern Idaho. In British Columbia, Hedlin (1966, 1967, 1974) and Ruth and Hedlin (1974) evaluated the damage by insects to grand fir cones, including a key to the damage. Kulhavy and Schenk (in press) evaluated the damage to the 1970 and 1971 seed crops in Idaho during years of moderate (1970) and high (1971) cone production. Kulhavy (1974) prepared a key to the pestiferous insects of grand fir in Idaho. Moyer and Parker (1973) and Kulhavy et al. (1975) prepared checklists of the cone and seed insects of grand fir in Idaho.

Partial cone-count estimations have been used to estimate cones within trees. These methods consist of estimating cones on a single whorl, a single branch, or other methods of partial cone counts, and comparing these to total cone counts (Eis 1973, Schenk et al. 1972, and Winjum and Johnson 1962). Franklin, (1968) used a conversion factor of 1.7 times the number of cones visible with binoculars from the ground to estimate the cone crop of grand fir.

METHODS

Cone Collections and Dissections

During June through September of 1971, 15 1/10-acre plots were used to evaluate insect-caused seed losses and cone-count techniques on Potlatch Corporation lands 6 miles northeast of Potlatch, Latah County, Idaho. The study was established in a primarily *Abies grandis*/*Pachistima myrsinites* habitat type (Daubenmire and Daubenmire 1968). In conjunction with another study,[3] five 1/10-acre plots, deployed on a 10-chain grid pattern, were used in each of the three stands designated Gold Creed (GC) stand 1, 2, 3. Location of each stand, average elevation, slope, aspect, site index, basal area and stand volume data are summarized in Table 1. Stand data, including cone-bearing grand fir and cone production are summarized in Table 2. Stands GC 1 and 2 were logged for high value Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and ponderosa pine (*Pinus ponderosa* Laws.) about 30 and 75 years ago. The resultant overstory stands consist of two age classes of released grand fir. The lower slopes of GC 3 were logged about 25 years ago for Douglas-fir and ponderosa pine, resulting in a present stand of predominantly mature grand fir. Cone production in the Gold Creek stands was mainly on the grand fir released from earlier logging.

[3] The influence of natural stand characters and management practices on fir engraver (*Scolytus ventralis* LeConte) population and damage levels and on stand regeneration and growth. Forest, Wildlife, and Range Experiment Station, University of Idaho, Moscow, Idaho.

On each 1/10-acre plot, two cone-bearing grand fir were climbed and four mature cones were picked from each of the north and south sides of the crown. Four cones from each tree were placed in single-light-source rearing cartons in the laboratory at 24°C to capture and identify emerging adults. The remaining cones from each sample tree were dissected for insect damage. External injury on each of the dissected cones was recorded and later correlated to internal infestations. The cones were cut in half lengthwise using a modified Winjum-Johnson cone cutter (1960). The seeds on the axial surface were counted and the number of seeds and location and type of damage was recorded by causal insect species. Seeds were then dissected from the cone scales, and complete counts were made of the damaged and total seeds in the cone. The data were recorded as percentage cones infested, percentage seeds destroyed and percentage of the total insect damage by each species.

Cone Production and Seed Loss

Three methods of estimating numbers of cones per tree from the ground by means of binoculars were tested using 32 trees (the 30 trees sampled previously plus two additional plot trees). On each tree, cones were counted on the branch with the most cones (LBR), all cones on the south side of the crown (SS) and all cones visible on branches of the top two whorls of the tree (WHO). These estimation counts were followed by actual counts by climbing. The data were subjected to multiple regression analysis. Prediction equations were derived from the binocular counts and used to estimate cone production and seed losses per tree and per acre.

RESULTS

Damage Evaluation

Dissection revealed that 54 percent of the cones were infested by insects (one or more seeds destroyed). Seed losses in these infested cones averaged 17.0 percent; 6.4 percent of the seeds in all collected cones was destroyed by insects. In the Gold Creek 1 area, 50 percent of the sample cones were infested, and 8.0 percent of the seeds destroyed in the sample cones; in GC 2, 57 percent of the sample cones were infested and 3.5 percent of the seeds destroyed in the sample cones; in GC 3, 60 percent of the sample cones were infested and 5.8 percent of the seeds in the sample cones were destroyed by insects. *Dioryctria abietella* (Denis and Schiffermueller), a coneworm, and *Hylemya abietis* Huckett, a cone maggot, accounted for about 90 percent of the insect damage, destroying 5.7 percent of the seeds in the sample cones. The remaining 10 percent of the damage was attributed to four other insect species or unknown causes (Fig. 1).

Prediction of Cone Production

There were no apparent differences between stands in either vegetation or elevation, thus data from the three stands were grouped for analysis. Of the three binocular methods for estimating cone production per tree, a simple linear regression model using as an independent variable (LBR) accounted for the least amount of the variation in the total cone production per tree ($r^2 = 0.299$). Simple linear regression models using counts from the top two whorls (WHO) and the south side (SS) as the independent variables had r^2 values of 0.719 and 0.769 respectively. Fitting second degree polynomials using LBR, SS and WHO failed to significantly increase r^2 over the value associated with the first degree polynomials.

Multiple regression analysis using the combined variables WHO and SS improved the fit considerably ($r^2 = 0.806$), and reduced the root error mean square (Table 3). The equation for predicting cones per tree, Y, is:

$$Y = -10.8 + 1.9\ \text{WHO} + 1.5\ \text{SS}.$$

The inclusion of variable LBR in this model failed to improve its fit. Data for all variables are summarized in Table 3.

DISCUSSION

The method for predicting cone production reported in this study was developed on the basis of one year's data. That year was one of exceptionally good cone production; the method may not be as accurate in stands of fair or average cone production. As 60 percent of the total number of cones in the crown is counted using binoculars, a conversion factor of 1.6 could be used to give a quick estimate of the cones in the crown. This conversion factor is slightly lower than the 1.7 reported by Franklin (1968).

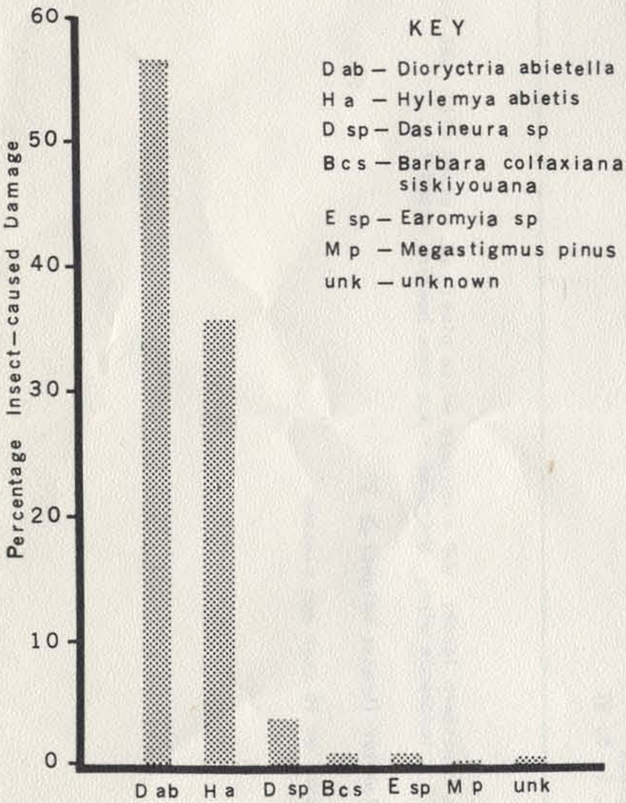

Fig. 1. Percentage of insect-caused damage by species from grand fir cones collected near Potlatch, Idaho, 1971.

Cone production in the study areas was high in 1971, exceeding the number of cones per tree classified as "good" for grand fir in the Inland Empire (USDA 1965). However, seedling-sapling stocking was below "desirable," particularly in GC 2, and tended to be aggregated.[4]

Kulhavy and Schenk (in press) found that cone and seed insects tend to increase in grand fir cones if 2 years of moderate to good cone production occur in a row. Thus, any cutting with regeneration as an objective should not be conducted during a year of poor cone production following 2 seasons of good production because of the high insect populations relative to the available cones.

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Table 3. Analysis for binocular counts of grand fir cones from the branch with the most cones (LBR), the cones on the two top whorls (WHO), cones on the south side of the tree (SS), and cones on the top whorl plus cones on the south side regressed against total cones (Y) per tree, 1971.

Independent Variables	Intercept	Regression Coefficient	Root Error Mean Square ($s_{y \cdot x}$)	Coefficient of determination (r^2)
LBR	13.9	6.42	52.2	$.299^{n \cdot s}$
SS	-5.6	2.99	28.9	.769**
WHO	-0.1	3.34	31.4	.719**
WHO,SS	-10.8	1.92, 1.50	26.9	.806**

	Mean	Standard Deviation
LBR	7.2	4.4
WHO	21.7	18.2
SS	19.6	14.6
Y	60.0	58.2

** Significantly different from zero at = 0.01 significance level; n·s = non-significant.