UNDERSTORY PLANTS AS INDICATORS OF GRAND FIR MORTALITY DUE TO THE FIR ENGRAVER[1]

By

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ABSTRACT

Mortality of grand fir trees, caused by the fir engraver, *Scolytus ventralis*, was monitored during 3 years on ten 0.1 acre (0.04 ha) circular plots in each of nine stands in northern Idaho. Understory vegetation was sampled on each plot on the basis of circular subplots of 0.03 acre (0.012 ha). Analyses showed four species to be strongly correlated with high and two with low tree mortality. The interaction between these groups of plant species provided a variable that increased as the proportion of high to low hazard plants increased. Various linear and nonlinear expressions were tested between the two plant groups and their interaction regressed against killed trees per acre. The plant group interaction term accounted for the most variation (r^2=0.914) and produced the lowest standard error of the estimate (1.55). The equation for this variable took the form Y=2.291 + 0.111ex, where X=plant group interaction. This equation provides an indication of the susceptibility of grand fir stands to mortality caused by the fir engraver.

Grand fir, *Abies grandis* (Dougl.) Lindl., is a major component of the grand fir - western larch - Douglas-fir type in the northwestern United States and southern British Columbia (Fowells 1965). In Idaho, this species comprises half (874 M acres) (349.6 M ha) of the total acreage occupied by the spruce-fir group of types (Wilson 1962).

Numerous insect species attack grand fir, but most of them cause little damage and are of relatively minor economic importance. The western balsam bark beetle, *Dryocetes confusus* Sw., and the fir engraver, *Scolytus ventralis* LeConte, are the principal bark beetle pests (Fowells 1965). Epidemic infestations of the fir engraver are sometimes severe, but relatively localized and may be correlated with epidemics of the Douglas-fir tussock moth, *Orygia pseudotsugata* (McD.) (Berryman 1973). As an example of their severity, Stevens (1971) reported that about 37,000 grand fir trees were killed in 1954 on 6,000 acres (4800 ha) of the Cibola National Forest in New Mexico.

Parasites and predators may help to control the fir engraver in some years (Massey 1966, Ashraf and Berryman 1970), but generally are considered ineffective in preventing outbreaks (Stevens 1971). Chemical control methods under forest conditions are considered by most workers to be limited because of the wide variation in the pattern of attack and injury to the host tree. Little or no benefit is gained by chemically destroying fir engraver broods in trees under mass attack, unless those broods in top-killed and "patch" attacked trees (having the potential to sustain or regenerate an epidemic) are also identified and destroyed (Keen 1952, Struble 1957, Stevens 1971).

Silvicultural methods probably offer the best possibility for minimizing losses. This approach requires cultural practices that remove trees predisposed to attack, and the maintenance of stand vigor and resistance through regulation of density and composition. Attainment of these objectives necessitates a stand hazard rating system that will help forest managers to assign treatment priorities. The system should be based on data easily obtained during the taking of standard timber inventories.

It has been demonstrated that, in the northern Rocky Mountains, the subordinate plant unions reflect differences in site characteristics (Daubenmire and Daubenmire 1968). Thus, it seemed likely that the presence or absence of certain understory plant species or species groups could indicate site conditions favorable or unfavorable to high mortality caused by the fir engraver. A plant species group as used here is a collection of plants with similar relationships to a specified variable.

The study was conducted in three experimental areas (replicates), each consisting of three study sites, established on lands of the

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Potlatch Corporation in northern Idaho. Two replicates (Gold Creek and Lost Creek) are located in *Abies grandis/Pachistima myrsinites* habitat types in Latah County and the third replicate (Jaype) is located in a *Thuja plicata/ Pachistima myrsinites* habitat type in Clearwater County. In each study grand fir comprises between 63% and 76% of the stems per acre of more than 3 inches dbh.

Ten circular plots each of 0.1 acre (0.04 ha) were systematically located with a random start within each of the nine study sites. Grand fir mortality attributable to the fir engraver was monitored in each plot for 3 years (1972-1974). The total mortality per acre caused by the fir engraver in each study site was then calculated.

Understory vegetation was sampled on each 0.1-acre plot during late summer of 1974, using 0.03-acre (0.012 ha) circular subplots with witnessed and staked plot centers. These vegetation plots were offset 18 feet from the 0.1-acre plot centers to avoid the disturbance resulting from frequent visits to the main plot centers. All perennial shrubs, forbs, and graminoids on each plot were recorded. An ocular estimate of percent cover with low and tall shrub species also was recorded for each plot.

Within any given study site, the subordinate plant complex was not influenced by topography. We calculated the frequency or percentage of the total number of understory vegetation plots occupied by each herbaceous and shrub species at each study site, and also the average percentage cover for each shrub species.

The frequencies or average percentage cover of about 50 plant species were evaluated by means of correlation matrices, using killed trees per acre during three years as one variable and, as the other, frequency of a herb or shrub species, or the average percentage cover of a shrub. We assumed that the composition of the subordinate plant complex and its relationship to the site would remain unchanged during the three years in the absence of outside disturbance and considering only perennial plant species. Based on this assumption, plant data collected at the end of the mortality period were used to indicate a relationship to mortality in stands where fir engraver populations were likely to be present. Those species showing direct or inverse correlation coefficients of 0.80 or more were subjectively accepted as indicating high or low mortality caused by the fir engraver. Six species were thus selected for further analyses.

Results

Four of the six plant species had frequencies that were directly correlated (group A), and two had frequencies that were inversely correlated (group B), with killed trees per acre during the three years (Table 1). Additional analysis showed a high degree of correlation between the frequency of a given plant species and the frequency of other species having a similar (direct or inverse) correlation. The frequency of each group was then calculated for each study site, based on the percentage of the total number of understory vegetation subplots within each study site in which any single member species of the plant group occurred.

The interaction between the frequencies of the two plant species groups produced a variable that increased with the proportion of group A or high hazard to group B or low hazard plants. This is expressed by:

$$PGI = fA/1 + fB$$

where:

PGI=plant group interaction
fA=frequency of occurrence of plant species in group A.
fB=frequency of occurrence of plant species in group B.

Table 1. Correlation coefficients for plant species correlated with grand fir trees killed per acre by the fir engraver during 3 years, in northern Idaho, 1974.

Plant species variable	Common name	Usual habitat1/	r
Carex deweyana Schw.	Dewey's sedge	Moist woodlands to forest openings	0.886
Arenaria macrophylla Hook.	Sandwort	Moist to dry, shaded to open woods	0.812
Satureja douglasii (Benth.) Breq.	Yerba buena	Coniferous woods	0.825
Holodiscus discolor (Pursh) Maxim.	Oceanspray	Open dry to moist woods	0.946
Clintonia uniflora (Schult.) Kunth.	Blue-bead lily	Moist coniferous woods	-0.822
Chimaphila umbellata (L.) Bart.	Pipsissewa	Under conifers in woods	-0.820

1/Scientific name, common name and usual habitat from Hitchcock and Cronquist 1973.

To develop a mathematical expression that would relate understory vegetation variables to trees killed per acre by the fir engraver during the three years, we tested various linear and non-linear expressions of plant species groups A and B, and plant group interaction, regressed against trees killed per acre. The best mathematical equations for these variables took the following form:

$$Y=1.922 - 0.809X_1^2 + 1.713X_1^4 \qquad (1)$$

$$Y=15.045 - 0.136X_2 \qquad (2)$$

$$Y=2.291 + 0.111e^{X_3} \qquad (3)$$

where:

Y=trees killed per acre by the fir engraver during 3 years (KTA)

X_1 =frequency of occurrence of plant species in group A

X_2=frequency of occurrence of plant species in group B

X_3 =plant species group interaction $(X_1/1 + X_2)$

The correlation coefficients for equations 1—3 are 0.954, -0.917 and 0.956, and their standard error of the estimates are 1.634, 1.765, and 1.550 respectively. The variable that accounted for the most variation and also produced the lowest standard error of the estimate was plant group interaction (equation 3) which accounted for 92% of the variation in KTA, and is significant at an α level of .01.

Discussion

It is noteworthy that the plant species in group A are considered seral and those in group B are considered climax species when the subordinate plant union is *Pachistima myrsinites* (Daubenmire and Daubenmire 1968). Thus, the presence of group A species indicates a site presumably less conducive, and the presence of group B species indicates a site more conducive, to the maintenance of favorable moisture conditions and vigor of grand fir.

The value of the relationship reported here is its use as a means of ranking sites supporting grand fir according to their potential susceptibility. The level of mortality is dependent upon stand variables, upon the intensity of stress imposed on the site by adverse abiotic factors, and upon the population levels of the fir engraver. Other predisposing factors include the presence of root disease (Partridge and Miller 1972), and the reduced ability of trees to produce traumatic resin canals (Berryman 1969, Berryman and Ashraf 1970).

In practice the subordinate plant union would be sampled at each plot center during the regular timber inventory, using 0.03-acre circular plots, and recording the presence of each plant species group. At each plot, a plant species group would be recorded as present if any of the member species were present. The plant group interaction term (PGI) would be calculated and used as the independent variable in equation 3 to indicate the susceptibility of the stand of grand fir to mortality caused by fir engraver.

Table 2. Correlation matrix between the frequencies of plant species in two groups, northern Idaho, 1974.

y/x	1	2	3	4	5	6
1	1.000					
2	0.796	1.000				
3	0.898	0.767	1.000			
4	0.887	0.738	0.905	1.000		
5	-0.783	-0.702	-0.701	-0.833	1.000	
6	-0.912	-0.775	-0.973	-0.885	0.613	1.000

Plant Group A
1, *Holodiscus discolor* (Pursh) Maxim.
2. *Carex deweyana* Schw.
3. *Arenaria macrophylla* Hook.
4. *Satureja douglasii* (Benth.) Briq.

Plant Group B
5. *Clintonia uniflora* (Schult.) Kunth.
6. *Chimaphila umbellata* (L.) Bart.

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