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Effect of Thinning on Flying Insect Communities Using Window Traps in Young Douglas-Fir (*Pseudotsuga menziesii* (Mirb.) Franco) Forests in the Pacific Northwestern America

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The response of insects to four thinning intensities (control, light-thin, heavy-thin, or light-thin with gaps) was examined in 40- to 60-year-old Douglas-fir stands on the Willamette National Forest in Oregon, USA. In both 2000 and 2001, flying insect assemblages were collected from window traps placed over the forest floor in the center of each treatment block during two annual intervals: 1) June through August (early-season) and 2) August through October (late-season). The seasonal responses by these insects showed statistically significant differences in species richness (F=22.21, P <0.001) and mean abundance (F=34.87, P <0.001). The greatest numbers of taxa generated via indicator species analysis were in the early season and within the treatment of light-thin with gap (L/G). In particular, the woodborer beetle, *Buprestis* (Burprestidae), was strongly associated with L/G (Indicator Value = 52.4, P ≤0.001). Two beetle taxa, *Ampedus* (Elateridae, IV=84.7, P ≤0.001) and members of Cermabycidae (IV=58.4, P ≤0.001), were correlated significantly with early-season, whereas *Melanoplus* (Acrididae) was associated with late-season (IV=21.3, P >0.05) and L/G (IV=29.2, P ≤0.05). For all thinning treatments, the numbers of species and individuals were higher in the early season than the late season. Non-metric multidimensional scaling showed that Axis 1 (65%) and Axis 2 (27%) explained 92% of the variance. The former was strongly associated with thinning intensity, having higher coefficients of species richness (r=0.645) and species diversity (r=0.583). The multi-response permutation procedures showed a statistically significant difference for thinning intensity (T-statistics= -4.6322, A-statistics=0.0479, P <0.0001). These results suggest that heavier thinning can result in more diverse populations of flying insects, including herbivores and predators.

Keywords: biodiversity, Douglas-fir, flying insects, NMS, thinning, window trap

Since the 1930s and 1940s, the number of older forests has been steadily reduced in the landscape through selective cutting or clearcut patches of various sizes, while the amount of young, managed stands has vastly increased in the Pacific Northwest region of the United States (Hunter, 1993). Although silvicultural knowledge pertinent to the management of young ecosystems has become significant in that region, the public is voicing concern over the dramatic changes to those structures. This project is part of a multi-disciplinary research effort by the U.S. Forest Service and it is called Young Stand Thinning and Diversity Study. Its silvicultural design is predicted to provide a sustainable rate of timber harvesting and maintain an array of late-successional characteristics, which is a primary requirement of the Pacific Northwest Forest Plan (Hunter, 1993; Ribe, 1999). The goal of that study is to determine to what extent these management strategies will accelerate the return of old-growth attributes and promote more diverse stands.

Forest insects are an important component that depends upon the complexity of a particular ecosystem (Schowalter et al., 1986; Stork et al., 1997; Schowalter and Ganio, 1998; Hunter, 2001, 2002). Their role during changing environmental conditions can significantly affect forest productivity and nutrient cycling (Schowalter et al., 1986; Hunter, 2002; Williams and Liebhold, 2002; Raynolds and Hunter, 2004). Nevertheless, studies of insects are difficult to conduct because of their taxonomic complexity and the generally un-replicated nature of forest treatments. In addition, it is challenging to determine how insects respond to altered forest habitats and management practices. In some examinations, true tree-canopy arthropod communities have been compared between stands of different ages or as part of a tally of disturbance histories at the ecosystem level (Schowalter and Crossley, 1988; Schowalter, 1995, 2000; Lowman and Rinker, 2004). Current questions about the protection of biological diversity and forest health under alternative management scenarios require that quantitative data from replicated plots be available to assess insect responses to modifications in environmental conditions (Schowalter, 1995, 2000; McIntosh et al., 2001).

Taxa from all functional groups have shown significant reactions to silvicultural treatments, especially through an increase in the abundance of some herbivorous arthropods in relatively homogeneous stands or a decline in populations of detritivores and some predators in harvested stands (Progar et al., 1999). Reducing host-tree density should have a strong impact on herbivore populations because of changes in the microclimate, host-plant conditions, and the proximity of new hosts (Lorio, 1980; Schowalter et al., 1986; Amman et al., 1988; McMillin and Wagner, 1993; Muzika and Liebhold, 2000; Harrington et al., 2001). Although many predators and detritivores, as well as some herbivores, are less abundant or absent in disturbed stands (Kruess and Tscharntke, 1994; Schowalter, 1994, 1995) and some defoliators are sensitive to tree spacing and, so, decrease in numbers in thinned stands (Batzer, 1976; Lance, 1983; Schowalter, 1995; Muzika and Liebhold, 2000), it is still critical that researchers know the scientific capacity for utilizing intercept traps, e.g., window traps. Evaluating trends in groups

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of flying insects that are associated with forest species and management regimes is important to our understanding of changes in the diversity and dynamics of populations or communities (Progar et al., 1999; Cronin et al., 2000; McIntosh et al., 2001). For example, the distribution and physical structure of forests can influence the spatial patterns of insect herbivore populations. Enhanced vegetative diversity may encourage predators by providing shelter or increasing the quantity of prey, which then helps maintain a high predator density. The largest role for herbivorous insects is to suppress the productivity of primary producers (Hodkinson and Hughes, 1982; Muzika and Liebhold, 2000).

The purpose of this current project was to assess the responses of flying insects when different thinning treatments were applied within young, managed forest ecosystems in western Oregon. It was hypothesized that, as the level of thinning increased and tree spacings widened, the abundance of plant feeders (i.e., defoliators and bark beetles) and the predacious insects that preyed upon these herbivores would also grow.

MATERIALS AND METHODS

Study Sites

Study sites were located in the Willamette National For-

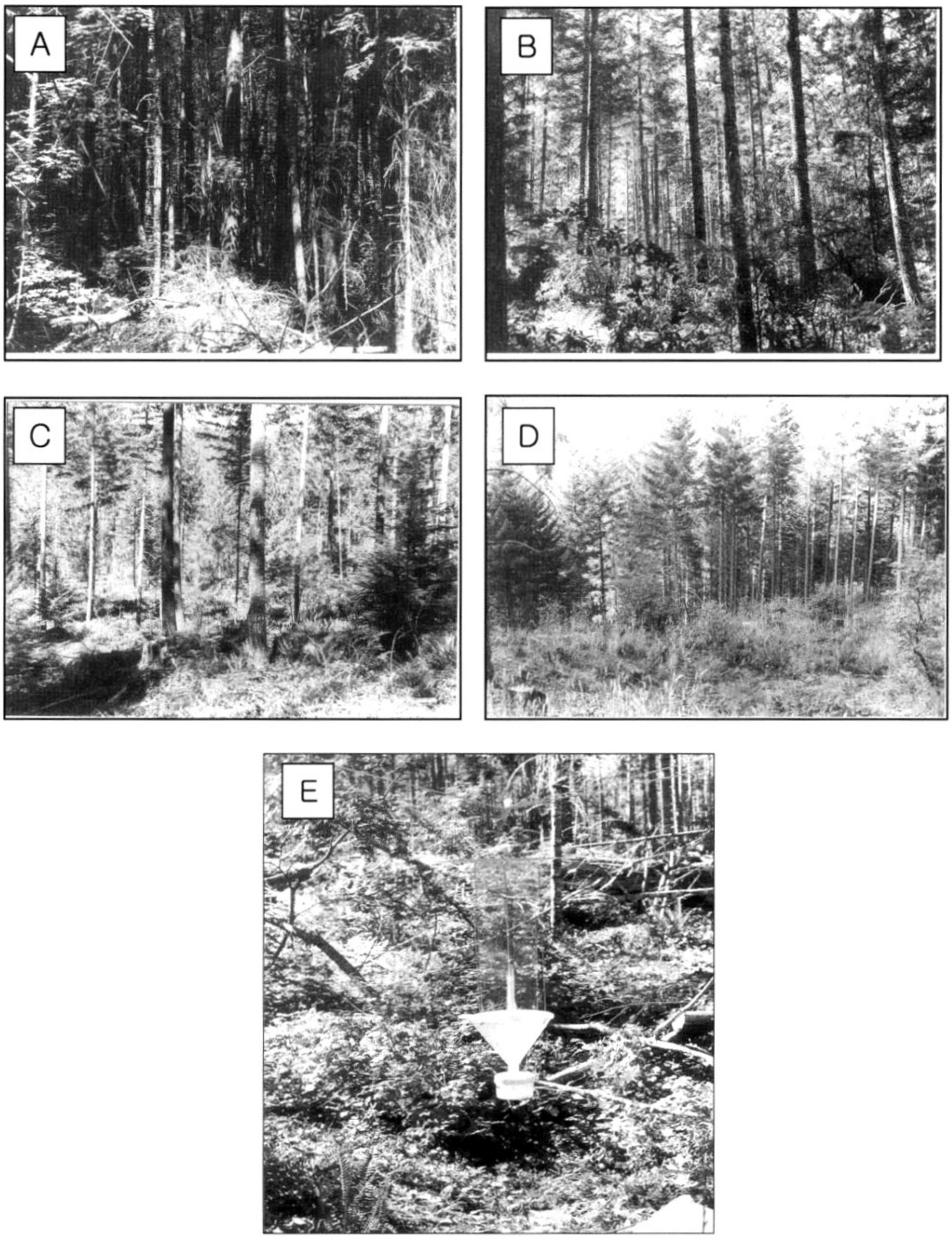

Figure 1. Four thinning treatments and a window trap on FLAT site in study areas within Willamette National Forest, Blue River District, in Oregon. (**A**) Control (CN: no treatment, usually 615 trees per hectare (tph)). (**B**) Light-thin (LT: 270 tph). (**C**) Heavy-thin (HT: 125 tph). (**D**) Light-thin with gaps (L/G: 270 tph). (**E**) A window trap (30 x 100 cm).