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Short-term community-level response of arthropods to group selection with seed-tree retention in a northern hardwood forest

Joshua M. Shields, Christopher R. Webster *, Andrew J. Storer

Ecosystem Science Center, School of Forest Resources and Environmental Science, Michigan Technological University, Houghton, MI 49931-1295, USA

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Abstract

We examined the short-term effects of group-selection harvesting with seed-tree retention on ground-dwelling and bark-dwelling arthropod communities in a northern hardwood forest in the Upper Peninsula of Michigan. Arthropods were sampled in 16 group-selection openings and 8 closed canopy reference plots. Two opening sizes were examined—radii of 0.5 (320 ± 27 m^2, $n = 8$) and 1.0 (1217 ± 62 m^2, $n = 8$) times the mean canopy height (22 m). Each opening and reference plot was centered on a single *Betula alleghaniensis* Britt. (yellow birch). Ground-dwelling arthropods were sampled using pitfall traps that were opened for two 1-week periods (rounds 1 and 2), and bark-dwelling arthropods were sampled with sticky traps attached to the centrally located *B. alleghaniensis* trees. Family-level diversity of ground-dwelling arthropods was lower in reference plots than in the openings, but the only significant difference occurred during round 2, between the matrix and large openings ($P < 0.01$). During both sampling periods, the ground-dwelling community exhibited a distinct clustering of family-level composition along environmental gradients such as opening size. Families such as Staphylinidae (rove beetles) and Trombidiidae (red velvet mites) were not favored by higher canopy openness while families such as Acrididae (grasshoppers) and Lycosidae (wolf spiders) were captured more in openings than in the forest matrix. Landing rates of wood-boring insects such as Buprestidae (metallic wood-boring beetles) and Xiphydriidae (wood wasps) were significantly higher on seed trees in group-selection openings than in reference plots ($P < 0.05$). Our results suggest that integrating group-selection openings within northern hardwood forests can lead to an increase in the family-level diversity of ground-dwelling arthropods, at least in the short term. Furthermore, seed trees left in such openings may be more attractive to bark- and wood-boring insects, which warrants further investigation into the susceptibility of these seed trees to damage by certain insect pests.
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Keywords: *Betula alleghaniensis*; Buprestidae; Diversity; Ground-dwelling arthropods; Red velvet mites; Rove beetles; Uneven-aged management; Xiphydriidae

1. Introduction

Ecosystem functions and dynamics depend on both biotic and abiotic interactions (Price, 1997; Schowalter, 2000; Molles, 2002; Triplehorn and Johnson, 2005). Arthropods play a significant role in these interactions, serving as both consumers (Moore et al., 1988) and food sources (Rodenhouse and Holmes, 2002), and also as regulators of decomposition (Webb, 1977; Paoletti and Hassall, 1999) and successional trajectories (Amman, 1977; Jonkman, 1977). Consequently, arthropods are often used as bio-indicators of ecosystem change (Paoletti, 1999; Paoletti and Hassall, 1999; Paoletti et al., 1999; Mattoni et al., 2000; Longcore, 2003; Rainio and Niemelä, 2003).

In forested ecosystems, canopy disturbance may lead to changes in arthropod abundance and composition due to higher canopy openness (Shure and Philips, 1991; Greenberg and Forrest, 2003; Latty et al., 2006) or fluctuations in the amount of leaf litter (Duguay et al., 2000; Haskell, 2000; Latty et al., 2006) and coarse woody debris (Ulyshen et al., 2004; Latty et al., 2006). For example, Latty et al. (2006) found that opening area, coarse woody debris volume, percent cover of ground-layer vegetation, and forest floor depth were all important variables in structuring Carabidae (ground beetles) assemblages in northern hardwood-hemlock forests in northern Wisconsin and the Upper Peninsula of Michigan. Greenberg and Forrest (2003) found that the abundance and biomass of ground-dwelling arthropods were lower in natural and salvage-logged canopy openings than in the forest matrix in an Appalachian forest in North Carolina. The authors speculated that differences might have occurred because canopy openings did not contain the moist microclimate and litter layer depths

* Corresponding author. Tel.: +1 906 487 3618.
E-mail address: cwebster@mtu.edu (C.R. Webster).

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characteristic of the forest matrix (Greenberg and Forrest, 2003). Conversely, bark-dwelling arthropods such as those in the families Buprestidae (metallic wood-boring beetles) and Cerambycidae (longhorn beetles) may be attracted to the large volume of coarse woody debris found in canopy openings (Ulyshen et al., 2004).

We examined the short-term response of ground-dwelling and bark-dwelling arthropods to the intermediate-scale disturbance induced by group-selection harvesting with seed-tree retention. Sixteen group-selection openings and eight closed canopy reference plots were observed in a northern hardwood forest in the Upper Peninsula of Michigan. Each plot contained a codominant/dominant *Betula alleghaniensis* Britt. (yellow birch) at its center (i.e., a seed tree). Most of the studies on the responses of ground-dwelling arthropods to silvicultural openings have focused on a single family, usually Carabidae (Koivula and Niemelä, 2003; Klimaszewski et al., 2005; Ulyshen et al., 2006). Consequently, the effect of silvicultural openings on arthropod communities is less clear (see Shure and Philips, 1991). Furthermore, while a few studies have examined the effects of green-tree retention in clear cuts upon arthropod communities (see Hyvärinen et al., 2005 and Schowalter et al., 2005), it is unclear how retention within smaller canopy openings influences arthropod communities. The specific objectives of this study were to examine: (1) the short-term response of the diversity and composition of ground-dwelling arthropod communities to the intermediate-scale disturbance created by group-selection harvesting with seed-tree retention and (2) the influence of retaining a single seed tree on the landing rates of bark-dwelling arthropods (e.g., wood-boring insects).

2. Methods

2.1. Study area

Research was conducted at the Ford Forestry Center in a hemlock-northern hardwood forest encompassing section 30, T49N, R33W, 46°37′N, 88°29′W, Baraga County, MI. Tree species composition was typical of hemlock-northern hardwoods, with *Acer saccharum* Marsh. (sugar maple) and red maple *Acer rubrum* L. (red maple) dominating the overstory strata. Canopy layers also contained the following species: *B. alleghaniensis*, *Tsuga canadensis* (L.) Carr. (eastern hemlock), *Prunus serotina* Ehrh. (black cherry), *Abies balsamea* (L.) Mill. (balsam fir), *Pinus strobus* L. (eastern white pine), *Tilia americana* L. (American basswood), *Ostrya virginiana* (P. Mill.) K. Koch (ironwood), *Picea glauca* (Moench) Voss (white spruce), *Thuja occidentalis* L. (northern white cedar), and *Ulmus americana* L. (American elm).

The landscape of this study area was characterized by nearly level to hilly till plains and moraines, with elevations ranging from 411 to 448 m above sea level (Berndt, 1988). Soil series on low knolls and ridges consisted of Champion cobbly silt loams and Kallio cobbly silt loams; depressions and drainage ways were dominated by Net silt loams, Alstad silt loams, and Witbeck mucks (Berndt, 1988). Annual precipitation in the study area is approximately 87 cm, with an average seasonal snowfall of approximately 382 cm (Berndt, 1988). Mean temperatures range from −9.8 °C (winter) to 17.4 °C (summer; Berndt, 1988).

During the winter of 2004, 49 group-selection openings were created in the southern portion of the study area. Group selection is an uneven-aged management technique in which variable sized groups of mature and/or low quality trees are removed periodically to open the canopy and facilitate regeneration (Smith et al., 1997). This technique is often used in conjunction with single-tree selection. Each opening was placed at least 60 m from another opening to minimize edge effects from proximate openings. Each opening contained a single codominant/dominant *B. alleghaniensis* in the center. These openings were created to promote the establishment of *B. alleghaniensis*. With the exception of the seed tree, all woody stems ≥10 cm diameter at breast height (dbh) and rooted within the prescribed radius were felled; merchantable stems were removed and non-merchantable stems were left onsite. From these 49 openings, we randomly selected 16 openings representing two size classes—radii of 0.5 ($n = 8$, hereafter referred to as small openings) and 1.0 ($n = 8$, herafter referred to as large openings) times the mean canopy height (22 m). To facilitate comparisons with the forest matrix, eight reference plots were centered on randomly selected *B. alleghaniensis* trees located at least 60 m from an opening edge.

2.2. Data collection

2.2.1. Environmental variables

Group-selection opening areas were determined by measuring distances from the center of the seed tree to the edge of the opening along the eight cardinal and sub-cardinal directions. We determined opening edges by using a clinometer to vertically project border tree crown edges to the ground. Distances from the center of the opening to the edges were used to calculate the area of each opening as an eight-sided polygon. Resultant mean areas for small and large openings were 320 ± 27 m^2 and 1217 ± 62 m^2, respectively.

During the summer of 2005, we established 288 regeneration sub-plots across the 16 openings and 8 reference plots (12 regeneration sub-plots per opening/reference plot). Each regeneration sub-plot was comprised of a 1 m × 1 m quadrat nested within a 3.14 m^2 circular plot (Fig. 1). Sub-plots were randomly placed within openings and on reference plots (sub-plots within openings were at least 1 m from an opening edge).

Within each 3.14 m^2 circular plot, we recorded the number of saplings (≥50 cm tall, but <10 cm dbh). Within each 1 m × 1 m quadrat, we determined aerial percent covers of ground-layer vegetation (including tree seedlings, woody shrubs, forbs, graminoids, ferns, club mosses, horsetails, mosses, and lichens). We also estimated the aerial percent covers of bare soil, rocks, and woody debris (stumps, logs, slash, and decayed debris). A single observer performed ocular estimates in order to reduce observer bias.

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