Forest Ecology and Management 359 (2016) 65–73

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Long-term effects of clear-cutting on epigaeic beetle assemblages in boreal forests

Therese Johansson [a,*], Joakim Hjältén [a], Jörgen Olsson [a], Mats Dynesius [b], Jean-Michel Roberge [a]

[a] Department of Wildlife, Fish, and Environmental Studies, Swedish University of Agricultural Sciences, SE-901 83 Umeå, Sweden
[b] Department of Ecology and Environmental Science, Umeå University, SE-901 87 Umeå, Sweden

ARTICLE INFO

Article history:
Received 13 March 2015
Received in revised form 24 September 2015
Accepted 26 September 2015

Keywords:
Species conservation
Trophic interactions
Boreal forest
Biodiversity
Forest management
Staphylinidae
Carabidae
Curculionidae
Leiodidae

ABSTRACT

Management of boreal forests for timber production has caused changes in forest structures and disturbance regimes, which have influenced a wide range of organisms. The aim of this study was to evaluate how composition of epigaeic (ground-living) beetle assemblages is influenced by stand age and management history in a heavily managed boreal forest landscape. We compared the epigaeic assemblages among stands of three ages: (1) young (8–25 years) and (2) middle-aged (40–58 years) stands regrown after clear-cutting, and mature stands (80–130 years) that had been selectively cut historically but never clear felled. We sampled epigaeic beetles in each of 42 stands, using 10 pitfall traps during seven summer weeks. More than 9000 specimens were collected and identified. The assemblages in young stands differed from those in middle-aged and mature stands, both for the Staphylinidae (rove beetles) and all beetle families combined. Carabidae (ground beetles) composition differed between young and middle aged stands only, and assemblages of Curculionidae (weevils, bark beetles and allies) differed between young and mature stands only. Assemblages of Leiodidae (round fungus beetles) had similar composition in all three stand types. Considering all families, young stands generally harbored fewer species and lower abundances compared with middle aged and mature stands. However, the Leiodidae had similar species richness in all three stand types. The lack of differences in assemblage composition, species richness and abundance between middle aged and mature stands suggests that epigaeic beetle assemblages recolonize following clear-felling. However, our collections included large numbers of unique and usually rare species in mature stands, indicating that old forest is important for the conservation of epigaeic beetles. Furthermore, the lower abundance of these beetles in young stands indicates that an increasing proportion of young stands on managed landscapes will reduce the overall abundances of epigaeic beetle species, with potentially negative impacts on recolonization.

1. Introduction

Intensive forest management for timber production has been associated with significant losses in biodiversity as a consequence of reductions in habitat quality for many species (Berg et al., 1994; Siitonen, 2001; Grove, 2002; Niemelä et al., 2007; Paillet et al., 2010). Natural forest characteristics such as predominance of large trees, amount of coarse dead wood, and multilayered stands have been reduced (Linder and Östlund, 1992, 1998; Jönsson and Jonsson, 2007), leading to changes in assemblage composition in many taxa (Thor, 1998; Martikainen et al., 2000; Maeto and Sato, 2004; Dynesius and Hylander, 2007; Josefsson et al., 2010; Stenbacka et al., 2010). In Scandinavia, over 90% of the boreal forest landscape is managed and older semi-natural forests are being replaced with younger even-aged stands, regenerated after clear-felling. These stands are managed to be harvested again within 80–100 years which are relatively short rotation periods compared with natural conditions. Such management regimes began in the 1950s, and the result is the present-day matrix of the forest landscape (Axelsson and Östlund, 2001). Development of assemblages of different organisms over time in these stands will structure the future biodiversity of Scandanavian boreal landscapes.

Many semi-natural boreal forests and old managed forest stands that have never been clear-cut retain large parts of the assemblages found in more natural stands (Gustafsson et al., 2003; Gibb et al., 2006; Johansson et al., 2007), although population sizes of many species are smaller and some species appear to be missing in the absence of old-growth characteristics (Martikainen et al., 1996, 1999; Stenbacka et al., 2010; Hjältén

* Corresponding author.
E-mail address: therese.johansson@slu.se (T. Johansson).

http://dx.doi.org/10.1016/j.foreco.2015.09.041
0378-1127/

et al., 2012). In contrast, boreal stands regenerated after clear-cutting differ widely from semi-natural and old managed forest stands and are often considered a bottleneck for biodiversity (Fridman and Walheim, 2000; Stenbacka et al., 2010; Gibb et al., 2013). Recent studies of different organisms, e.g. bryophytes (Dynesius et al., 2009; Schmalholz and Hylander, 2009; Rudolphi and Gustafsson, 2011), vascular plants (Widenfalk and Weslien, 2009), lichens (Hilmo et al., 2009; Rudolphi and Gustafsson, 2011), beetles (Similä et al., 2002; Stenbacka et al., 2010), and wood-inhabiting fungi (Junninen et al., 2006) in stands regenerating after clear-cutting largely support this view.

Assemblages of epigaeic (i.e. ground-living) arthropods are clearly affected for some time by forest harvest (Niemelä et al., 1993; Koivula, 2002; Koivula et al., 2002; Pohl et al., 2007). Populations of old-forest specialists are reduced with the habitat loss and fragmentation that results from clear-cutting (Wikars, 1995; Abildsnes and Tömmersås, 2000), while populations of other species are favored by natural or anthropogenic disturbances (Muona and Rutanen, 1994; Koivula and Niemelä, 2002).

Environmental factors such as standing tree volume, ground moisture and composition of ground- and field-layer vegetation are important determinants of epigaeic carabid assemblages (Koivula, 2002). Moreover, although most epigaeic arthropods are not defined as saproxylic (i.e. dependent on dead wood), the abundance of several taxa increases with increasing dead wood volumes (Castro and Wise, 2010; Barton et al., 2011) and capture rates in pitfall traps decreases for Carabidae if logging residues are harvested (Nitterus et al., 2007). However, the extent to which assemblages of epigaeic arthropods may recolonize forest over time after clear-cutting remains unclear (but see Buddle et al. (2000) and Buddle et al. (2006)). Indeed, different taxa can be expected to respond differently to disturbance and their ability to establish populations in the new stands may vary. To conserve naturally occurring species in managed landscapes it is important to know how species composition varies among stands differing in age and management history.

The aim of our study was to evaluate how the assemblage composition, species richness and abundance of epigaeic beetles, including the poorly known but abundant and speciose rove beetles (Staphylinidae), differ between three types of boreal forest stands currently common in Scandanavia: young (mean 16 years, range 8–25) and middle aged (mean 47 years, range 40–58) stands that have regenerated after clear felling, and mature managed stands (mean 104 years, range 80–130) that have never been clear felled but that have been selectively cut in the past. We test two hypotheses flowing from assumptions that time for colonization will be directly proportional to stand age, and that continuity of old-growth characteristics and associated microclimates in older stands will maintain populations dependent on these traits. First, we predicted that epigaeic assemblages in young stands will differ markedly in composition from those in older stands. Second, we predicted that assemblages of mature stands would differ strongly from those seen in both young and middle-aged stands.

2. Methods

2.1. Study area and experimental design

We sampled mixed stands of Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*) of the three age classes defined above in a 30 × 40 km forest landscape in the middle boreal zone (Ahti et al., 1968) of northern Sweden (64°05′–64°10′N, 19°05′–19°30′E) (Fig. 1). The two dominant forest site types (Arnborg, 1990) in the stands were mesic and moist dwarf-shrub types with *Vaccinium myrtillus* as the dominant species in the field layer, and the more productive herb dwarf-shrub type with some meadow herbs (e.g. *Geranium silvaticum, Oxalis acetosella, Solidago virgaurea*) and grasses. We sampled 14 stands from each age class for a total of 42 stands. One square study plot of 1 ha was placed in the center of a homogenous part of each stand, with study plots separated by at least 500 m. Stands of different ages were spatially interspersed to minimize potential confounding effects of larger-scale environmental variation.

2.2. Beetle sampling

We sampled beetles using 10 pitfall traps in each of the 42 plots during seven weeks from June 14–18 to August 2–5, 2010. The

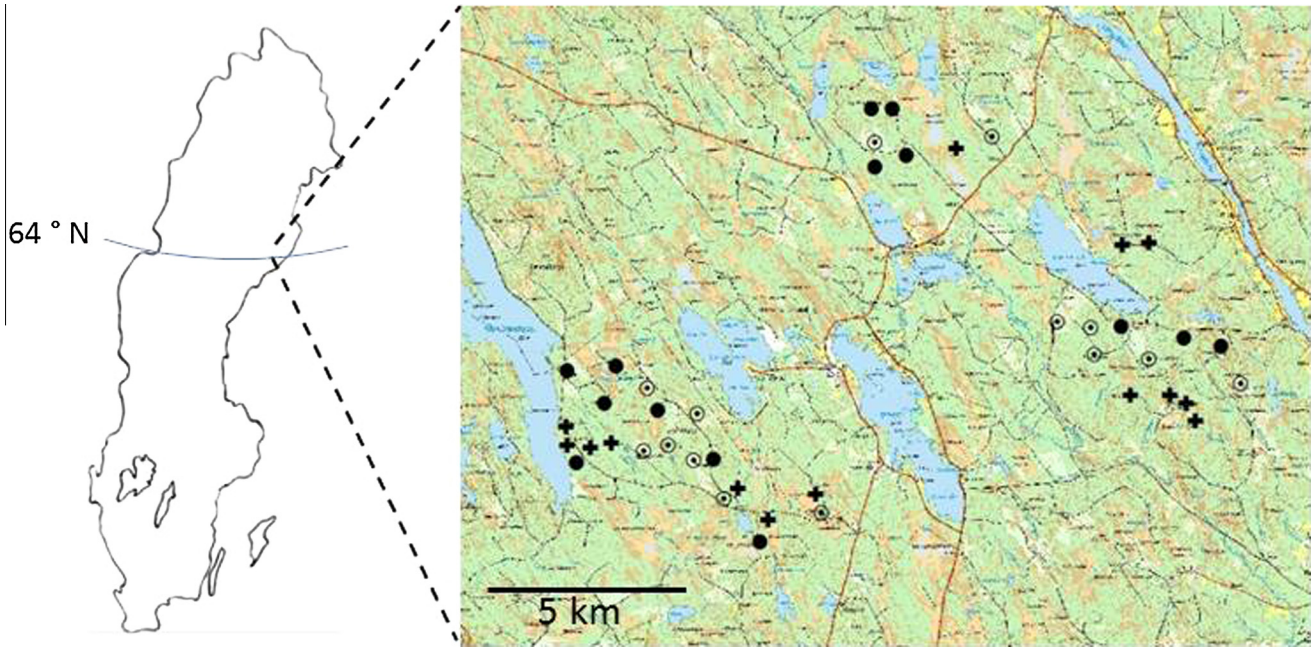

Fig. 1. Map of Sweden showing the location of the study area (left) and the 42 study stands (right). Black dots denote mature stands, crosses denote middle aged stands and circles with dots denote young stands.