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Diversity of saproxylic beetle species in logging residues in Sweden – Comparisons between tree species and diameters

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ABSTRACT

Growing interest in harvesting logging residues for energy production will reduce the amount of fine (small-diameter) wood. This could pose a threat to saproxylic (dead-wood living) organisms. Therefore, we asked firstly if logging residues have a beetle fauna of conservation interest, and secondly which differences there are between different categories of logging residues. Samples of logging-residue wood of aspen, birch, oak and spruce, divided into three diameter classes ranging between 1 and 15 cm were collected from 60 clear cuts in southern Sweden. Saproxylic beetles were then reared out from the samples. In total, we found 50,566 saproxylic beetles representing 160 species. The number of red-listed species, 22, indicated that logging residues hosts many species important for conservation. For all tree species there were more species in 3–5-year-old wood than in one-summer-old wood. However, in spruce species density was low, especially with respect to red-listed species. Amongst the deciduous trees species density varied, but all, and especially aspen and oak, hosted high numbers of red-listed species. Differences in species numbers between diameter classes were minor for all tree species. The species composition was different between the tree species studied (large differences) and between diameter classes. There were species associated both with the thinnest and the coarsest wood. Tree species provides a convenient basis for recommendations at forest fuel harvesting. They are easily recognised and there are conspicuous differences in the conservation value. Diameter classes are less useful because we found that they had little effect.

1. Introduction

Green-house gases emitted from combustion of fossil fuels are identified as the main cause of global warming (Mitchell et al., 2001). Therefore, there is a great demand for new sources of renewable energy. Logging residues, which previously was retained on clear cuts is one such potential source in increasing use. It has not attracted much attention as a substrate for forest organisms because it mainly consists of fine woody debris and has been recognised as a trivial substrate. In parts of the world where forest management is intensive and has a long history they anyway make up a considerable part of the total woody debris. For example in Fennoscandia, where the amount of coarse woody debris is reduced by 90–98% in the managed forest landscape (Siitonen, 2001). Thus, extraction of logging residues on a large scale may strengthen the threat to species depending on woody debris.

Species that depend on dead wood for their development, during some part of their life cycle, are referred to as saproxylic (Speight, 1989). These species constitute a substantial component of the biodiversity in forest ecosystems (Harmon et al., 1986; Siitonen, 2001) and many of them are now considered to be threatened, because forest management has

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reduced the amount of dead wood in forests (Berg et al., 1994; Esseen et al., 1997; Gärdenfors, 2000; Siitonen, 2001). However, research tends to focus on the so-called 'coarse woody debris' (CWD), which usually refers to pieces of wood thicker than 10 cm (Grove, 2002). Logging residues, in contrast, mainly consist of fine woody debris (FWD), i.e. twigs, branches and tops. The flora and fauna in this fraction have been little studied. Nevertheless, it has been concluded that nature conservation issues should not hinder the extensive use of forest fuel (Lundborg, 1998), although the data to support this viewpoint are limited.

From a practical perspective, studies of organisms in logging residues are most relevant for organisms that use clear cuts. First, forest fuels are currently harvested more intensively on clear cuts than in thinnings (Egnell et al., 2001). Second, the reduction in the amount of fine wood due to the extraction of logging residues will be larger on clear cuts than in closed forest, even if logging residues are extracted in the same proportions of the cuttings. Clear cutting is the main creator of sun-exposed wood in the managed forest landscape, whereas shaded wood is also created by natural processes, i.e. self thinning of trees and branches. Therefore amounts of sun-exposed wood may also decrease considerably at the landscape scale if large quantities of residues are extracted. For insects, such reductions could be important since many species are particularly associated with sun-exposed wood (Kouki et al., 2001; Lindhe et al., 2005). These sun-loving species are probably adapted to disturbances caused by fires and major storms.

In addition to sun-exposure, many other factors affect a piece of woods' suitability for different insects (Palm, 1959; Warren and Key, 1991; Jonsell et al., 1998). If certain types of wood are more valuable for biodiversity than others, information on their relative importance could be used to formulate appropriate management recommendations. For this purpose, variables that are both easy to assess during forest operations and correlated with the diversity of the saproxylic fauna are required. Two variables that meet the first criterion are tree species and diameter. The former has also been shown to strongly influence the saproxylic fauna hosted in pieces of wood (Palm, 1959). The effect of diameter in wood of thinner dimensions has been little considered.

There are also differences in the potential effects of extracting logging residues between species associated with early and late stages in the succession of decaying wood. The primary colonisers, which use the wood during the first summer, may, in addition to being affected by the reduction in available substrate, be trapped in the wood and transported with their offspring to the furnaces. Therefore, the Swedish forestry board has recommended that fuel wood stored in the forest during the vegetation period should be retained until the autumn to allow the insects to emerge, at least at sites of "high conservation value". Species later in the succession will be affected solely by substrate reduction. In this study we investigated both of these communities.

The aims of this paper were to determine how many species may be affected by extracting logging residues, and the types of logging residues that are the most valuable for saproxylic fauna. Therefore, we studied the diversity and species composition of beetles in logging residues from clear cuts – categorised into different decay stages, tree species and diameter classes. The ultimate aim was to estimate which fractions contain species with populations sensitive to habitat loss. The number of red-listed species was used as an indicator of this. More specifically we addressed the following questions:

(1) Are there saproxylic beetle species in logging residues that can be considered important for conservation?
(2) Are there differences in diversity between recently dead wood and wood that has decayed for some years?
(3) What are the differences in saproxylic beetle fauna between logging residues of four different tree species?
(4) What are the differences in saproxylic beetle fauna between three different diameter classes of logging residues?

2. Materials and methods

Samples of logging residue wood was collected in 60 clear cuts in southern Sweden (Fig. 1). The clear cuts were chosen by foresters at the Forestry board, Sveaskog, Korsnäs and Stora. They selected them after our requirements on region, age since cutting and tree-species composition. The wood was collected during three different time periods (="sampling series"), and in each there are some differences in which categories of wood that were collected and from which sites (see below).

Three main factors were to be compared, tree species (four species), diameter (three classes), and substrate age (two ages). Rearing method (two types) was an additional factor in some analyses. From each clear cut we thus sampled two or four tree species (depending on the sample series, as described below): aspen (*Populus tremulae* L.), birch (*Betula pubescens* Ehrh. and *B. verrucosa* Ehrh.), oak (*Quercus robur* L.), and spruce (*Picea abies* (L.) Karst.) were investigated. However, it

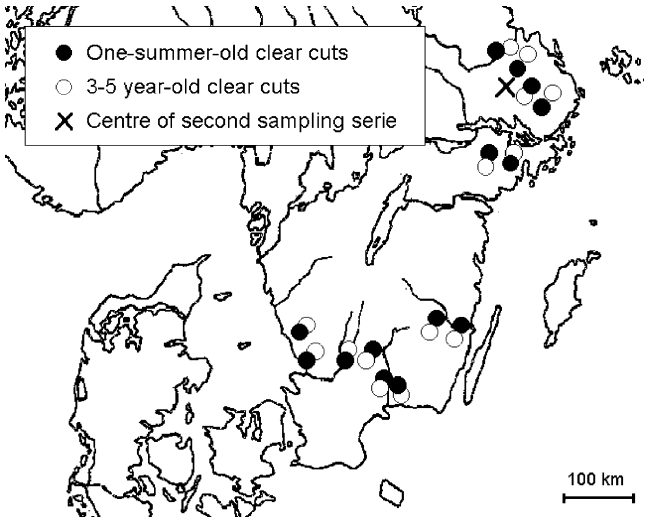

Fig. 1 – Location of the sampling sites in southern Sweden. Second sampling series is defined in materials and methods.