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Factors and scales potentially important for saproxylic beetles in temperate mixed oak forest

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ABSTRACT

The influence of environmental factors on species richness and species composition may be manifested at different spatial levels. Exploring these relationships is important to understand at which spatial scales certain species and organism groups become sensitive to fragmentation and changes in habitat quality. At different spatial scales we evaluated the potential influence of 45 factors (multiple regression, PCA) on saproxylic oak beetles in 21 smaller broadleaved Swedish forests of conservation importance (woodland key habitats, WKH). Local amount of dead wood in forests is often assumed to be important, but two landscape variables, area of oak dominated woodland key habitats within 1 km of sites and regional amount of dead oak wood, were the main (and strong) predictors of variation in local species richness of oak beetles. The result was similar for red-listed beetles associated with oak. Species composition of the beetles was also best predicted by area of oak woodland key habitat within 1 km, with canopy closure as the second predictor. Despite suitable local quality of the woodland key habitats, the density of such habitat patches may in many areas be too low for long-term protection of saproxylic beetles associated with broadleaved temperate forests. Landscapes with many clustered woodland key habitats rich in oak should have high priority for conservation of saproxylic oak beetles.

1. Introduction

In biogeography, species richness and composition are clearly related to latitude and altitude (Wright, 1983; Stevens, 1989; Cox and Moore, 1999; Gaston, 2000). Species richness and composition are also assumed to depend on spatio-temporal factors such as region, landscape quality and configuration, habitat continuity, and habitat or stand quality (Meffe and Carroll, 1997; Nilsson and Baranowski, 1997; Forman, 1999; Gaston and Blackburn, 2000). Some studies emphasize the importance of the surrounding landscape for local species richness. For instance, the surrounding landscape seems to influence species richness of birds in riparian forests (Saab, 1999); bark beetles in boreal forests (Peltonen et al., 1998); saproxylic beetles in boreal forest (Økland et al., 1996); fungus gnats in temperate forest (Økland, 1996; Økland et al., 2005); herbivorous insects on thistles (Kruess, 2003); plants, insects and birds in semi-natural pastures (Söderström et al., 2001); and insects and plants in farmland (Weibull et al., 2003). Studies of single beetle species (Rukke and Midtgaard, 1998; Kehler and Bondrup-Nielsen, 1999) and of a moth species (Gripenberg and Roslin, 2005), also indicate impact of the surround-

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ing landscape on local abundance. All these studies analysed at least two different spatial scales and two or more variables potentially influencing species richness.

Recently, there has been focus on the local stand and its qualities seem to be important for species richness of insects (Siitonen and Martikainen, 1994; Rosenzweig, 1995; Sverdrup-Thygeson, 2001), but few insect studies have related local diversity to landscape factors and even fewer to several spatial scales (but see Peltonen et al., 1998; Økland et al., 2005). Patches of semi-natural forest of conservation concern are often small and scattered in the landscape, reducing local population sizes of taxa and impeding dispersal. Therefore, besides factors or processes at site or stand level (about 1–3 ha), variation in the surrounding landscape (in this study about 3–1200 km^2), climate, and topography is likely to influence local species richness and species composition. The relative roles of the scales, and temporal factors, have rarely been investigated.

Dead wood in natural forests is a very species-rich substrate (Samuelsson et al., 1994; Speight, 1989), which is scarce in European production forests today (Nilsson et al., 2001; Siitonen, 2001; Nilsson et al., 2002; Nordén et al., 2004a; Christensen et al., 2005). Fungi and insects colonize and decompose dead trees; the saproxylic beetles represent a major part of this biodiversity, including 1257 species in Scandinavia of which several hundred are red-listed in Sweden (Dahlberg and Stokland, 2004; Gärdenfors, 2005). Several factors influencing species richness of saproxylic beetles have been identified: continuity of forest and/or substrate (Siitonen, 1994; Jonsell and Nordlander, 2002; Similä et al., 2003; Bouget and Duelli, 2004), quality/amounts of dead wood in local stands (Nilsson and Baranowski, 1997; Ranius and Jansson, 2000; Schiegg, 2000; Ranius, 2002), and composition of the surrounding landscape (Økland et al., 1996).

In this study a range of local and landscape variables of potential importance for species richness and species composition of beetles in mixed oak-dominated forest are evaluated. The study is explorative and the following general question was posed: What factors predict or are related to variation in local species richness and species composition of saproxylic beetles in oak-dominated temperate mixed forest, and at what spatial scale are the relationships strongest?

For analysis of different scales, we quantified the following major variables: dead wood, species richness of fungi (often used by saproxylic beetles (Gilbertson, 1984)), forest composition, land use, climate, and topography.

2. Methods

2.1. *Study area and stands*

We studied 21 semi-natural forests in the boreonemoral vegetation zone of southern Sweden (Fig. 1), a transition between boreal and nemoral or temperate forest (Ahti et al., 1968; Nilsson and Baranowski, 1997; Nilsson et al., 2001). The study sites were abandoned pasture woodlands situated 5–230 m above sea level, with mature oaks (*Quercus robur* and *Q. petraea*, oldest trees 80–200 years). At each site we used two 100 × 100 m plots about 50 m apart. The canopy in the plots was closed or almost closed with 14.1% (SD = 3.5%, n = 21 sites) of visible sky from ground level. The mean basal area, at breast height (1.3 m) of trees larger than 1 cm in diameter, was 25.1 m^2/ha (SD = 3.8 m^2, n = 21), and the mean basal area of oak was 12.5 m^2/ha (SD = 4.8, n = 21). Other common trees were spruce (*Picea abies*, mean basal area 11.1%), birches (*Betula verrucosa* and *B. pubescens*, 9.5%), aspen (*Populus tremula*, 6.8%), ash (*Fraxinus excelsior*, 6.2%), lime (*Tilia cordata*, 3.1%), pine (*Pinus sylvestris*, 2.5%) and maple

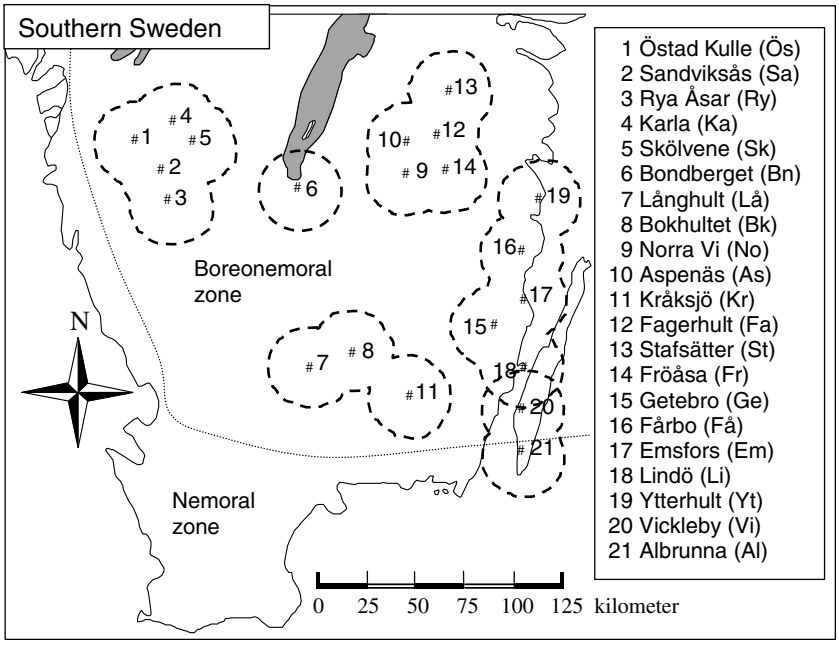

Fig. 1 – Study sites in southern Sweden. The encircled areas are large landscapes or regions, where mean values of dead wood were estimated by the National Forest Survey.