EDGE EFFECTS ON EPIPHYTIC LICHENS IN UNMANAGED BLACK ALDER STANDS IN SOUTHERN LATVIA

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Abstract
The emergence of human–induced edges in forested landscapes has caused major threat for the existence of habitat specialists. Woodland key habitat (WKH) concept has been created in the Baltic and Fennoscandian forests to preserve small forest parcels with a high biodiversity value in the production forests. In this study we investigated the occurrence of epiphytic lichen indicator species in black alder WKHs in Southern Latvia. In total 30 black alder WKHs with age of 84 to 129 years were chosen for analysis including stands adjacent to young, middle–aged and mature stands. Sample plots were placed at three distances from the forest edge. Our results indicate significant differences in number of species per sample plots adjacent to stands of different age. Lichen indicator species were considerably more common in habitats adjacent to mature forest stands and further (40–50 m) from the edge. From four lichen indicator species found in this study, sample plots adjacent to young stands hosted only two species. We argue that the indicator species response to human–induced edges is species specific and some of them are resistant to microclimatic changes near the edges.
Key words: Edge effects, epiphytic lichens, woodland key habitats, indicator species, black alder.

Introduction

During the last centuries European forest landscape has changed from mostly natural conditions of forest growth to the dominance of production forests (Kuuluvainen, 2009; Löfman and Kouki, 2001; Vanbergen et al., 2005). In the 21st century, the majority of forests are affected by intensive silvicultural practices and only few areas of production forest are left intact (Timonen et al., 2010). Intensive silvicultural practices and logging have caused landscape fragmentation and changed the forest structural composition, and reduced the presence of forest–dwelling species in the Baltic and Fennoscandian forests (Hanski, 2005). Landscape fragmentation and habitat depletion has been defined as a major threat for biodiversity in forest ecosystems (Aune et al., 2005). For instance, habitat fragmentation decreases the patch size and core habitat for species, decreases the connectivity and increases the edge effects (Laurance et al., 2008). It is known that large part of forestry practices are negatively influenced by edge effects (Harper et al., 2005) and therefore the effects of human–induced edges in forest landscape have been widely studied during the last decades (Murcia, 1995; Ries et al., 2004; Aune et al., 2005; Laurance et al., 2008; Baker et al., 2013). Most of such studies have focused on the gradient from the edge to forest interior or have dealt with the comparisons of focal species abundance, diversity, growth rate and occurrence between managed and old–growth forest stands (Chen et al., 1993; Hylander 2005). Human–induced edges influence the environment in forest parcels due to changes in biotic and abiotic conditions and many taxonomic groups are responding to these changes (Ries et al., 2004). Some species are adapted to new conditions following the formation of human–induced edges, while others are responding negatively to changes in microclimatic conditions (e.g. increased exposure to sunlight and wind) and altered species interactions (Murcia, 1995). For instance, many studies revealed that epiphytic lichens (Esseen and Renhorn, 1998; Moen and Jonsson, 2003), bryophytes and herbaceous plants (Jules, 1998) are responding negatively to human–induced forest edges and their abundance is considerably lower than in the forest interior. Conversely, only few studies suggest that lichens and bryophytes respond positively to forest edges (e.g. Caruso et al., 2011).

Lichens are key elements of biodiversity in boreal and temperate forest ecosystems (Gilbert, 2000). In hemiboreal forests, south and south–west expositions have been used for the estimation of microclimatic changes in assessing edge effects (Aune et al., 2005). We investigated the influence of edge effects from south and south–west facing edges on indicator species of epiphytic lichens in black alder woodland key habitats. Woodland key habitats (WKHs) are small forest parcels in production forest which are particularly important for maintaining biodiversity at the landscape level (Timonen et al., 2010), but they are strongly influenced by forestry actions in adjacent stands. Indicator species have been used as a component for determination WKHs in the Baltic and Fennoscandian forests (Straupe and Donis, 2008). In addition, the presence of indicator species should be correlated with red–listed species in WKHs. These species in WKHs are vascular plants, epiphytic lichens and bryophytes (Ek et al., 2002).

The human–induced edges reduce the forest interior area and affect species of both mature and young forest stands (Murcia, 1995). It is known that edge effects could be more crucial for species persistence than the isolation or habitat loss (Moen and Jonsson, 2003). For instance, lower colonization rate of epiphytic lichens has been found closer to habitat edges (Hilmo and Holien, 2002).

The aim of this study was to test edge effects on indicator species of epiphytic lichens in black alder WKHs. Further, we hypothesize that the distance from edge to forest interior affects the presence of epiphytic lichens. We also tested the influence of adjacent forest in different age stages on the occurrence of epiphytic lichens in black alder WKHs.

Materials and Methods

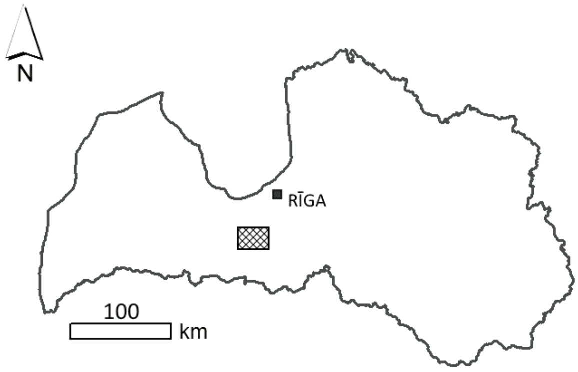

Figure 1. Location of the study sites.

Latvia falls into hemiboreal vegetation zone (Sjörs, 1963). The studied sites were located in Southern Latvia, particularly in Ozolnieki and Jelgava municipalities (Fig. 1) with elevation ranging from 0 to 20 m a.s.l. The average temperature is –5.3 °C in January and 17 °C in July and the mean annual precipitation reaches 667 mm (www.meteo.lv). This region is dominated by agricultural lands, the forest covers approximately 20% of area and it is dominated by mixed coniferous–deciduous tree species. Major tree species are Scots pine *Pinus sylvestris* L., Norway spruce *Picea abies* (L.) H. Karst., birch species *Betula pendula* Roth. and *Betula pubescens* Ehrh., grey alder *Alnus incana* (L.) Moench., black alder *Alnus glutinosa* (L.) Gaertn. (State Forest Service, 2008). Other species occurred sparsely. This forest region is dominated by the production forest and only small forest parcels (WKHs) are excluded from silvicultural practices. The study sites represented black alder WKHs with age of 84–129 years. All studied stands were semi–natural, located in close proximity to each other and had been managed in a similar manner. The evident influence of silvicultural practices of forests within existing WKHs likely consisted of thinning; forest drainage; few of them are located nearby forest roads. In total 30 sites were chosen for analysis. The study sites were established in three forest types: *Dryopterioso–caricosa, Filipendulosa* and *Oxalidosa* turf. mel. were dominated by *Alnus glutinosa*.

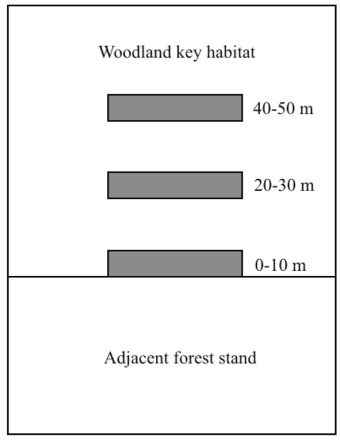

Figure 2. Schematic design of sample plots in relation to habitat edge.

During the vegetation season of 2013 a string of permanent sample plots was established in each WKH from the stand edge into forest interior (from S or SW side) to describe the gradient (Fig. 2). The size of sample plots was 20×50 m and each plot was divided into three zones with distances from edge 0–10 m, 20–30 m and 40–50 m (each zone was area of 200 m^2). Plots representing edges with S or S–W exposition were chosen: 10 with clearcut and young stand, 10 with middle–aged and 10 with mature stands (Fig. 2). We tested in each zone for the occurrence of lichen indicator species on randomly chosen black alder trees at the height of 0.5 m and 1.5 m from the ground.

The number of epiphytic lichen indicator species for the distance from edge and adjacent forest categories were tested for normality with the Shapiro–Wilk test. Non–parametric Kruskal–Wallis rank sum test was used to test the significance between groups and distances from the edge. We carried out pair–wise comparisons between the adjacent forest stands and distances from edge to interior using Wilcoxon signed rank test with Bonferroni adjusted p–values (at confidence level p=0.05). All statistical analyses were performed in R 3.1.1 (R development core team, 2013).

Results and Discussion

Species composition

In total four crustose lichens indicator species were found in the studied black alder WKHs. Three of them were especially protected species in Latvia (*Arthonia leucopellea* (Ach.) Almq, *Arthonia spadicea* Leight. and *Arthonia vinosa* Leight.), and one – common species *Graphis scripta* (L.) Ach. Two species were found in the study sites with adjacent young forests stands and four species were found in sites with adjacent mature forest stands. The richness of lichen indicator species was differed between none of species to two species in sites with adjacent young

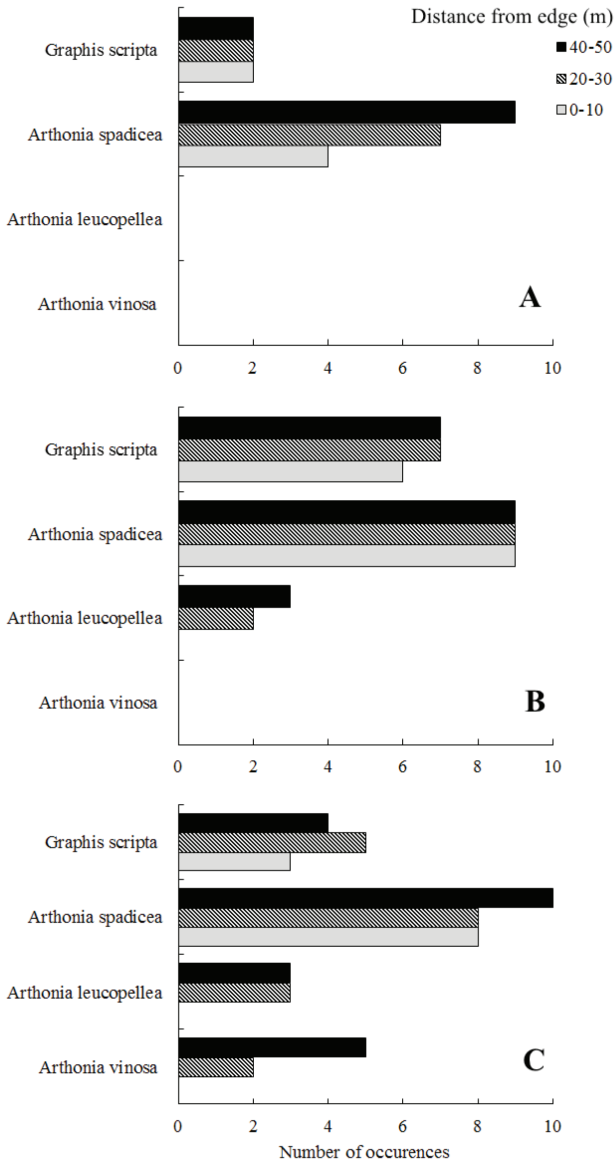

Figure 3. Edge effects on the number of lichen species occurrence in WKHs with adjacent young forest stands (A), middle–aged forest stands (B) or mature forests (C).

stands, and from none to three indicator species in sites with adjacent middle–aged stands and from one to four species in sites with adjacent mature forests.

The epiphytic lichens were affected by the distance from the forest edge and by adjacent young forests. Compared with adjacent mature forests, the number of observed species was lower in sites adjacent to young forest (Fig. 3). At least some epiphytic indicators (*A. spadicea* and *G. scripta*) are able to colonize and survive in habitats near edges (Fig. 3). This is explained by the fact that certain indicator species are more resistant to microclimatic changes and respond positively to edge effects. For instance, Hylander (2009) did not find any edge effects on ground–living bryophytes. This is in contrast with our study, which shows significant influence from adjacent forest. Our study also showed that more species are found with increasing distance from the edge (40–50 m).

Effects of distance from edge and stand age of adjacent forests on species occurrence

Our results show that indicator species occupancy increased with the distance from the edge into the forest interior (Fig. 4). There were significant differences between the number of indicator species in different groups of adjacent forests (p=0.001). Furthermore, we found that the number of epiphytic lichen species differed significantly in habitats adjacent to mature forests between distances 0–10 m and 40–50 m (p=0.03). Lower number of species

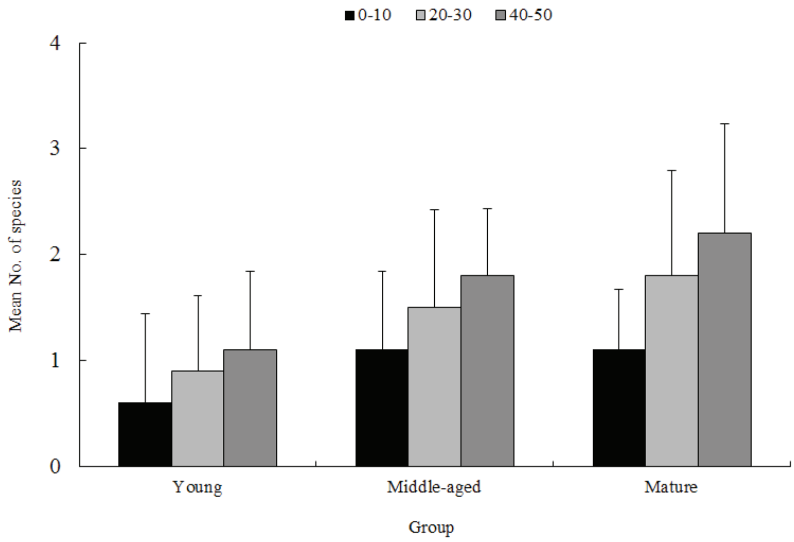

Figure 4. Edge effects on species composition in black alder WKHs with different groups of adjacent forests and the distance from forest edge to interior. Error bars indicate standart deviation (SD).

was found from the edge and highest number (n=4) was found from distance 40–50 m from the habitat edge. Previous studies indicated that edge effects are gradually decreasing with increasing distance from the edge (e.g. Murcia, 1995). It has been reported that WKHs due to their small size (avarage from 0.5–2.5 ha) are strongly influnced by edge effects (Aune et al., 2005). In addition, edge effects are induced by the changes in abiotic and biotic conditions, which may negatively affected lichen abundance (Esseen and Renhorn, 1998). Some studies also argued that WKHs have a lack of core area and entire stand is influenced by the edge effects (e.g. Aune et al., 2005).

The occurrence patterns of indicator species in our study were affected by the age of adjacent forest. Significant differences were found in a number of species in habitats between forest stands adjacent to young and middle–aged (p=0.0004) and young and mature forests (p=0.0006). All four epiphytic indicator species were found in habitats with adjacent mature forests (Fig. 4). One study demonstrated (Mancke and Gavin, 2000) that in fragmented landscape multiple edge effects could be stronger than one side edge influences. In highly fragmented forest areas, the greater tree mortality near clear–cut edges are from windthrow (Harper et al., 2005), which also caused the lack of the substrate for epiphytic lichen species. Edge effects on large forest remnants with adjacent clear-cuts could reach 10–25 m, but in scattered forest parcels up to 60 m (Mascarúa López et al., 2006). To reduce the impact of edge effects and preserve forest–dwelling species, the creation of wider buffer zones are essential. We show that some of indicator lichen species are able to survive near the forest edges with young adjacent forest. As we hypothesized, the adjacent forest age stages and recent forestry practices also influenced indicator species presence in WKHs. Some indicator species could occur near the edges of adjacent forests of clear-cuts and young forests where particular contrasts in microclimate occurred from south–facing edges. Studies investigating the presence of epiphytic lichens and bryphytes have showed an association with old–growth or late successional stage forests (Hedenås and Ericson, 2003). The main results from this study illustrated that the occurrence of indicator lichens could be influenced by the condition of adjacent forest stands.

Conclusions

Our results also show that the preservation of small forest parcels as woodland key habitats could be an efficient conservation tool in production forest landscapes with even–aged stands. In addition, changes in microclimatic conditions could also be crucial for sensitive epiphytic lichen species. The consideration of buffer zones or retention tree line from south–facing edges are also important to considered. In addition, other biological factors also influenced the persistence of indicator species on black alder trees. Further studies are needed to investigate the interactions between the occurrences of other lichens species, for instance, *Lepraria spp*. occurrence on black alder tree stems with the absence of epiphytic indicators. These additional factors have to be taken into account when estimating the colonization of indicator species in black alder WKHs. The persistence of edge effect studies on WKHs is important considering forestry practices planned in adjacent stands.

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