Available online at www.sciencedirect.com
ScienceDirect
Forest Ecology and Management 242 (2007) 374–390
Forest Ecology and Management
www.elsevier.com/locate/foreco

Bryophytes and lichens in different types of forest set-asides in boreal Sweden

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Received 8 June 2006; received in revised form 20 November 2006; accepted 21 January 2007

Abstract

Setting aside forest land is practiced globally and is of vital importance to the preservation of forest biodiversity. As detailed species inventories rarely precede the establishment of set-asides, empirical studies on the species content of different set-aside types are needed, in order to evaluate their conservation relevance and to design efficient conservation strategies. Here, we compared the biodiversity value per unit area of three types of set-asides, common in boreal Europe: nature reserves, key habitats and retention groups on clear-cuts, and we also included old managed forests as reference sites. We surveyed bryophytes on all substrates and lichens growing on spruce in spruce-dominated forests in middle boreal Sweden and in total 252 bryophytes and 176 lichens were found. For bryophytes the number of species, as well as the number of red-listed species, per unit area was higher in key habitats than in retention groups and old managed forests, while intermediate in nature reserves. As the complementarity between areas was greatest in key habitats, the total number of bryophyte species found was by far the highest in this set-aside type. For lichens the patterns were similar but the differences much less pronounced. Site selection methods based on linear programming demonstrated that key habitats also played the most important role in representing the surveyed taxa effectively but that the value of nature reserves increased when multiple representations of each species were required. The study shows that the richness and composition of bryophytes and lichens differ between the three set-aside types and consequently, the outcome of large-scale conservation strategies based on anyone type would be different. At present, key habitats stand out as core areas of high diversity in the forest landscape but it is important also to acknowledge the temporal dynamics of the forest landscape and how the capacity of each set-aside type to host species can be expected to change over time.

Keywords: Nature reserve; Woodland key habitat; Retention group; Red-listed species; Indicator species; Conservation strategy

1. Introduction

The establishment of set-asides for conservation purposes is practiced in all parts of the world, with 11% of the global forest area designated for the preservation of biodiversity (FAO, 2006). There has long been a theoretical interest in ecology on how the size and spatial configuration of patches affect communities and populations (e.g. MacArthur and Wilson, 1967; Diamond, 1975; Hanski, 1999), and this has been linked to nature conservation, with substantial practical implications. Further, in the last 20 years there has been an increasing focus on systematic conservation planning, i.e. how to select protected areas in a way that captures biodiversity as efficiently as possible (e.g. Margules and Pressey, 2000). But, there is still a lack of empirical studies in which comparisons regarding biodiversity are made between different types of set-asides. Because large financial resources are spent on biodiversity preservation and protection of forest land, this research topic warrants more attention.

In Scandinavia, intensification of forestry during the last 100 years has led to even-aged, more fragmented forests with shorter rotation periods and a scarcity of dead wood (Esseen et al., 1997; Östlund et al., 1997). This has resulted in small or declining populations of almost 2000 forest-living species (Gärdenfors, 2005) and in recognition of this, increasing amounts of forest land have been set-aside during the last decades and new management techniques are being employed in order to satisfy the needs of the flora and fauna. Today 4% of the productive forest land in Sweden is protected by law, although only 1% of this is outside the mountain forest

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0378-1127/$ – see front matter
doi:10.1016/j.foreco.2007.01.055

(Svedlund and Löfgren, 2003). This is a low proportion compared to other countries where forest is a dominating land class (FAO, 2006). On the other hand, the protection regulations are strictly obeyed and thus the set-aside areas are normally completely allocated to biodiversity conservation.

There are several types of forest set-asides in Sweden as well as in other parts of boreal Europe, differing in establishment form, legal status and size. Nature reserves represent the most common type, with about 2500 established from 1967 to 2003, covering 850,000 ha of productive forest land (Svedlund and Löfgren, 2003). The mean size of forested or partly forested nature reserves is 130 ha, but the size varies from a few hectares up to several thousands of hectares. Most reserves are established to protect biodiversity, although there can also be recreational purposes. A majority of nature reserves have a strong legal protection and timber harvesting is normally prohibited.

Lately, the so-called woodland key habitats (hereafter called ''key habitats'') have come to play an important role in conservation. The Swedish Forest Agency initiated a survey in 1993 on all forest holdings <5000 ha, which mostly belong to private forest owners, in order to find the most valuable forest patches in the landscape. On forest holdings >5000 ha, the forest owner is responsible for carrying out the inventory, supervised by the Swedish Forest Agency. According to the definition, a key habitat is a forest area of great importance to sensitive flora and fauna because of its structural, historical and physical characteristics and should contain or be expected to contain red-listed species (Nitare and Norén, 1992; Norén et al., 2002). The inventory of key habitats is based mainly on structural characteristics and on a set of indicator species of bryophytes, lichens and fungi, supposed to indicate forests with high conservation value. The key habitats are classified into 51 different biotope types, of which coniferous forest, coniferous wetland forest and water-associated habitats are the most common types in middle Sweden (Swedish Forest Agency, 2006). Similar inventories of key habitats have recently been conducted in Denmark, Norway, Finland, Estonia, Latvia and Lithuania. Key habitats are generally small with a mean size of 3.2 ha (Swedish Forest Agency, 2006). Until 2006, about 56,000 key habitats were found on private land, corresponding to an area of 150,000 ha, or slightly more than 1%, of the productive forestland. Key habitats are not protected by law, but the forest owner must consult with the Swedish Forest Agency before logging. According to the forest certification schemes FSC (Forest Stewardship Council) and PEFC (Programme for the Endorsement of Forest Certification schemes), forest owners should voluntarily set aside 5% of their productive forest land, and where key habitats are present they are normally prioritized. Additionally, due to the above mentioned certification schemes and a strong public opinion, timber from key habitats is virtually unsalable. Therefore, here we classify key habitats as set-asides.

Increasingly, small groups of living trees (hereafter called ''retention groups'') are systematically left on clear-cuts as a way to reduce the negative impacts of clear-cutting on biodiversity (Hazell and Gustafsson, 1999). On average 3.1% of the total clear-cut area was left as groups of trees (0.6%), groups of young trees (0.5%), buffer zones (0.9%) and sensitive habitats (1.1%) in Sweden between 1995 and 1997 (Swedish Forest Agency, 2006). Also in e.g. Finland (Vanha-Majamaa and Jalonen, 2001) and the USA (Aubry et al., 1999) retention of trees at final harvest is a common practice. Retention groups are intended as short-term refugia for many organisms over the regeneration phase and can become sources of dispersal into the growing forest (Esseen et al., 1997; Franklin et al., 2000). However, the capacity of retention groups to support biodiversity is poorly known (but see Vanha-Majamaa and Jalonen, 2001; Nelson and Halpern, 2005).

As large-scale species inventories are expensive, forest set-asides are generally identified on the basis of stand characteristics or indicator species. Thus, to a large extent the actual species diversity in the set-asides is normally unknown. Several comparisons have been made between set-aside and non set-aside areas, e.g. for birds in Finland (Virkkala et al., 1994), saproxylic beetles in Norway (Sverdrup-Thygeson, 2002) and vascular plants in South Africa (Shackleton, 2000). But, we know of no study, in Scandinavia or elsewhere, in which extensive field inventory of species has been made in different types of set-asides, for the purpose of comparison and evaluation of their biodiversity quality (here defined as total number of species and presence of species of conservation interest). Further, there is a scarcity of full-range data on less known but species-rich organism groups like bryophytes and lichens. Many of the conservation-oriented studies performed on these groups have focused on red-listed species (e.g. Johansson and Gustafsson, 2001; Gustafsson et al., 2004). Bryophytes and lichens have been given increasing attention within conservation since they are considered sensitive to forestry operations, and in northern Europe they are used as indicators of forest sites valuable to biodiversity (Hallingbäck and Weibull, 1996; Esseen et al., 1997).

The aim of this study, which is part of a research project on cost-effective reserve strategies in boreal Sweden, was to compare the biodiversity quality per unit area in three types of forest set-asides: nature reserves, key habitats and retention groups, as well as in old managed forests. Bryophytes and lichens were used as assessment tools and we focused on total species richness and on two sub-groups of species of conservation interest: red-listed species and indicator species, which are assumed to indicate forests with high conservation value.

2. Methods

2.1. Study area

The inventory was made in the northern part of Gävleborg county (Fig. 1), within the middle boreal vegetation zone (Ahti et al., 1968) in Sweden. The study area is approximately 150 km × 150 km, central position 61°45′N, 16°10′E. The elevation ranges from 80 m above sea level in the eastern parts to 490 m above sea level in the northwestern part. The forests, which cover 80% of Gävleborg county, consist mainly of