Forest Ecology and Management 397 (2017) 48–56

Contents lists available at ScienceDirect

Forest Ecology and Management

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

Avian diversity in Norway spruce production forests – How variation in structure and composition reveals pathways for improving habitat quality

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ARTICLE INFO

Article history:
Received 3 February 2017
Accepted 21 April 2017
Available online 3 May 2017

Keywords:
Community composition
Forest birds
Norway spruce
Picea abies
Species richness

ABSTRACT

Forests used for timber production provide essential ecosystem services to society, as well as potential breeding habitat for bird communities. In southern Sweden, 90% of productive forest land is used for timber production and stands dominated by Norway spruce (*Picea abies*) constitute approximately 40% of the forested area. Due to their homogeneous structure, these spruce production forests are often regarded as depauperate. Despite this perception, knowledge about the biodiversity found in these stands is scarce. Here we synthesize the results of four separate bird surveys conducted within 35 spruce production stands of southern Sweden. The results are compared to recent population trends within the general study area. In total 49 bird species were recorded, with a strong difference in species composition between newly planted clear-cuts (forest age <15 years) and forests older than 15 years. The majority of species encountered in the older forest category were common forest birds, with a single red-listed species among the regularly occurring species. In contrast, three red-listed "farmland species" were frequently encountered in the newly planted forests, revealing the capacity of those birds preferring open and recently disturbed habitats to utilize clear-cuts. A higher diversity of tree sizes and the inclusion of even relatively small proportions (<15%) of broadleaved tree species had a positive effect on bird species richness. Several species encountered in spruce production forests are declining in numbers, but it is not clear whether these stands are acting as source or sink environments for their populations. However, our results indicate that relatively small adjustments to spruce forest management should improve the quality of this widespread habitat.

1. Introduction

Forests used for timber production are increasing in extent and now constitute one third of global forest area (FAO, 2010). Besides providing important ecosystem services to society, these forests also provide habitat for plants and animals (Pawson et al., 2013). In Sweden, 90% of productive forest land is used for timber production (Anonymous, 2016), and the primary approach to forest management involves the rotational clear-cutting of even-aged coniferous stands. Over the last 100 years the increased use of this forest management model, as well as changes in agricultural practices, have dramatically altered tree species composition especially in the southern parts of the country (Lindbladh et al., 2014a). Norway spruce (*Picea abies*, hereafter spruce), has benefited most from this alteration in Sweden, to the extent that spruce dominated stands cover approximately 40% of the forested area (Anonymous, 2016). Forest managers have promoted spruce due to its simple management, early returns from thinning, high wood production, short rotation periods, low susceptibility to browsing pressure from ungulates (Månsson et al., 2007) and favorable market demand. A development of a "spruce culture" among forest managers (Felton et al., 2010a) has further strengthened the promotion of spruce.

Due to their homogeneous structure, intensively managed spruce production forests are often regarded as depauperate habitats (Gärdenfors, 2015). Whereas this perception may be warranted, especially in relation to natural forest systems, there is nevertheless a lack of studies of species diversity, including bird communities, in these stands (but see Nilsson, 1979a, b; Felton et al., 2011). This is unfortunate because societies require evidence-based evaluations of the biodiversity contribution of

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http://dx.doi.org/10.1016/j.foreco.2017.04.029
0378-1127/

dominant land-uses. Birds are a particularly advantageous taxonomic group for biodiversity assessments (e.g. Fischer et al., 2007) because they fulfill diverse and important ecological functions, including seed dispersal, pest control, pollination, and ecosystem engineering (Sekercioglu, 2006). Furthermore, birds are also visually and acoustically conspicuous (Whelan et al., 2008), and can thus provide an efficient means of evaluating the importance of habitat structure and change in forest systems (Gardner et al., 2008).

To increase the knowledge regarding the avian diversity found in spruce production forests, we synthesize data from four surveys conducted in 35 spruce production stands of varying age in southern Sweden. As the composition and abundance of bird communities can be affected by the management of the stands (e.g. rotation length, (Jansson and Andrén, 2003), the proportion of conifer versus broadleaved trees (Felton et al., 2010b) and the stand's structural diversity (MacArthur, 1964)), we were particularly interested in the influence of such factors on bird numbers and species diversity. The specific questions addressed in this study are:

- Which bird species dominate this forest habitat during the breeding season?
- How does species number and composition relate to stand age?
- How are bird species composition and abundance affected by different levels of broadleaves in the spruce stands?
- Do stands with a more diverse diameter distribution have a higher diversity and distinct bird species composition?

We then compare our data to the breeding population trends for the same species and region, as recorded in standardized counts of the Swedish Bird Survey (SBS, Green et al., 2016). These trends provide an important context for evaluating the contribution that spruce production stands make to habitat availability in the region. The SBS is designed to capture general trends in bird species occurrence and abundance, but in contrast to this study, do not relate survey outcomes to specific habitats or vegetation types.

In summary, the overall goal of the study is to provide information to forest owners and policy makers about the value of Norway spruce production forests for breeding bird communities, and how management interventions can detract or enhance this value. Our results are of relevance outside of Sweden, as Norway spruce is commonly used in the production forests of other northern and central European countries

2. Methods

We used data from four studies, surveyed during 2010, 2011, 2013 and 2016 respectively, two of which were published (Felton et al., 2011; Lindbladh et al., 2014b). Each study had a different purpose; two investigated the influence of a deciduous component in spruce forests, and one surveyed young stands. The fourth survey (from 2016) was conducted in order to provide a more balanced and representative data set for analysis, with respect to stand age and the relative proportion of deciduous trees.

2.1. Study area

The 35 surveyed stands (Fig. 1) are located in the hemi-boreal and temperate zones of southern Sweden (Ahti et al., 1968).

The mean temperature (1961–1990) in the region ranged between −2 and −3 °C in January, and between 14 °C and 15 °C in July. Precipitation varies widely between the western part (1000–1200 mm/year) and the eastern part (approximately 600 mm/year) of the study area.

Forests cover 63% of the land area in southern Sweden (Götaland). Commercial forestry dominates, and approximately 2% of productive forest land is formally protected (Table 1.5 in Nilsson and Cory, 2016). Norway spruce is the most common tree species, comprising 47% of total volume (SFA, 2014). Norway spruce dominated forests are generally managed using rotationally clear cut even-aged stands which are pre-commercially and commercially thinned two to three times during a rotation, and are harvested after a rotation period of between 45 and 70 years. Scots pine (*Pinus sylvestris*) is the second most common tree (33%) in the region, followed by birch (*Betula pendula/pubescens*; 11%) oak (*Quercus robur/petraea*; 3.3%), aspen (*Populus tremula*; 2.6%), alder (*Alnus glutinosa*; 2.4%) and beech (*Fagus sylvatica*; 1.6%).

2.2. Bird surveys

Stands ranged in size from 4.0 to 23.5 ha, with a mean stand size of 10.0 ha ±5 SD. All four studies used the point count method to survey the breeding bird communities in these stands (Bibby et al., 2000). Point counts are an effective means of surveying bird communities, with the abundance estimates provided acting as indices that are correlated with the true abundance of the bird species present (Felton et al., 2016b). Each study used the same methodology, with the exception that the size of the point count area surveyed varied between studies. In two of the studies the survey radius was 40 m, whereas it was 50 m in the other two. These threshold distances limit the birds assessed to only those located within the stand, and reduce the risk of double counting birds at two survey points. Furthermore, this radius is less than the maximum distance observers are estimated to be able to differentiate the distance to calling birds (i.e. 65 m, see Alldredge et al., 2007). Four survey points were located within each stand (each of the four points were surveyed four times, see below), with the proviso that the distance between two survey points was 80 or 100 m (depending on study, see above), and at least 40 m from the stand edge. Points were concentrated within the centre of each stand, to reduce the influence of birds using the transition zone of vegetation at the edge of the study site. This constraint also helped to ensure that survey points were not displaced over larger areas in larger stands, which could have increased bird community diversity in such stands due to an increased range of environments surveyed. Survey points were located beforehand using aerial photos and the aforementioned decision rules, to avoid onsite selection bias. Whereas modeling approaches can be used to address detectability issues in point count data, these approaches themselves introduce additional concerns and uncertainties (Barry and Welsh, 2001; Johnson, 2008). In this study we adopt an *a priori* approach to minimizing problems of detectability in the field via multiple elements of our sampling design (see below).

We surveyed each of the study sites four times; twice in early spring (April) and twice in late spring (May/June). We chose these survey periods to coincide with annual peaks in singing activity of breeding resident and migrant passerines respectively. Notably, the majority of the tropical migrant passerines surveyed have not arrived in this region at the time of the first survey period. Daily surveys began at dawn, at approximately 6:00 am in April and 4:30 am in May/June, and finished at 9:00 am and 7:30 am respectively. This period overlapped with the daily peak in bird vocal activity. On each survey day, the same person surveyed two stands. The order in which the stand types were visited each day was varied systematically to ensure that no stands types were weighted towards early morning or late morning survey times. Surveys were only conducted in suitable weather for conducting bird surveys (i.e. minimal wind, no rain), to minimize environmental influences on detectability.