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The biodiversity contribution of wood plantations: Contrasting the bird communities of Sweden's protected and production oak forests

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ABSTRACT

The oak-dominated woodlands and forests of northern Europe have experienced dramatic declines due to agriculture, urbanization, and conifer-dominated production forestry. These losses have had a substantial negative impact on biodiversity due to the large number of forest species which depend on oak and the environments oak-dominated forests provide. Production oak stands may serve as a means of supplementing or complementing the habitat provided by the limited remaining natural oak remnants in this region. Here we evaluate the extent to which oak plantations in temperate southern Sweden provide habitat and resources for bird communities, by surveying and contrasting the bird species composition and diversity found in mature and young production oak stands (5 and 8 replicates respectively) and protected oak-dominated remnant forests (5 replicates). The mature production stands possessed a bird community partially overlapping in bird species composition, and comparable in species richness (34 species) to that found within protected oak forests (39 species). Furthermore, the production oak forests surveyed hosted threatened or near threatened bird species, including black woodpecker (*Dryocopus martius*), goldcrest (*Regulus regulus*), starling (*Sturnus vulgaris*), and yellowhammer (*Emberiza citrinella*). Though production oak forests cannot replace the habitat provided by protected oak forests, these stands do appear to provide conditions consistent with the habitat and resource requirements of a diverse cross-section of bird species in this region, including species of substantial conservation concern. Production oak forests thus have the capacity to make a positive contribution to biodiversity conservation, as well as providing a diverse range of goods and services to society.

1. Introduction

Oak-dominated (*Quercus* spp.) forest ecosystems are found throughout Eurasia and the Americas where they are of high importance to biodiversity, and provide a range of important ecosystem services (Johnson et al., 2009). Throughout many regions of Europe, the oak-dominated woodlands and forests of the past have, or are being, extensively reduced by agriculture, urbanization, and forestry (Wulf and Rujner, 2011; Dorresteijn et al., 2013; Lindbladh et al., 2014a; Plieninger et al., 2015). This is particularly the case in southern Sweden, which was dominated by broadleaf woodlands 1500 years ago, often composed of the native pedunculate (*Quercus robur*) or sessile oak (*Quercus petraea*) (Lindbladh and Foster, 2010). Over subsequent centuries, anthropogenic impacts gradually reduced this forest type, culminating in precipitous oak losses during the 1800s (Lindbladh and Foster, 2010). Declines in oak during this period were driven by the extensive creation of agricultural lands, and the targeted felling of oaks for fuel and construction timbers (Eliasson and Nilsson, 2002). The remaining oak-dominated woodlands experienced yet further losses during the 20th century, when many of these fragmented remnants were cleared for the establishment of production conifer forests (Nilsson et al., 2006; Lindbladh et al., 2014a). The net result is that the forest of southern Sweden has been largely converted to production forest stands of Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*), which together encompass over 75% of the current standing volume in this region (SFA, 2014).

The resultant decline in oak abundance, and the limited number of remaining old, large, and hollow oak individuals, has had a disproportionate negative impact on forest biodiversity (Jansson et al., 2009). This stems from the oak's association with a substantial number of species from a wide range of taxonomic groups (Jonsell et al., 1998; Thor, 1998; Berg et al., 2002; Götmark and

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Thorell, 2003; Widerberg et al., 2012), many of which are now endangered (Gärdenfors, 2015). Whereas oak-related conservation actions are justifiably targeted toward the preservation of remaining stands containing old individuals (Nilsson et al., 2006; Jansson et al., 2009), the re-establishment of new oak forest is also considered integral to biodiversity conservation in this region (Löf et al., 2015). Oak plantations offer one potential means of achieving such increases. Oak plantations have been used in southern Sweden for the production of timber since the 1830s (Carbonnier, 1975; Eliasson and Nilsson, 2002), with a number of plantations established since the 1920s on arable land, pastures, and previously forested land (Brunet et al., 2012). These oak plantations may provide a means of supplementing or complementing protected oak habitats (see Dunning et al., 1992; Tscharntke et al., 2012) in landscapes with fragmented oak-woodland remnants and isolated oaks in pastures (Jansson et al., 2009; Brunet et al., 2011).

The extent to which oak production forests are advocated, incentivized by targeted policies, and ultimately adopted by forest managers and owners in southern Sweden, depends on the perceived and demonstrated benefits associated with this production forest alternative (Hugosson and Ingemarson, 2004; Ní Dhubháin et al., 2007; Kindstrand et al., 2008; Puettmann et al., 2015). In this regard, empirical assessments are needed to determine the biodiversity value of oak production forests. Despite the fact that oak trees are associated with a high percentage of Sweden's flora and fauna (Berg et al., 1994; Jonsell et al., 1998), the biodiversity benefits of production oak stands may nevertheless be limited due to the simplified structure, limited tree species composition, and limited tree ages found in even-aged production stands comprised of this tree species (Bengtsson et al., 2000; Nilsson et al., 2005; Paillet et al., 2010).

When evaluating the biodiversity of alternative land-uses subjected to gradients of human disturbance, birds are a particularly advantageous taxonomic group (e.g. Fischer et al., 2007). First, birds are one of the best known classes of organism (Sekercioglu et al., 2004), and 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 (Bibby et al., 2000; Whelan et al., 2008), and can thus provide an efficient means of evaluating habitat change in forest systems (Gardner et al., 2008). Despite these advantages, few biodiversity assessments involving birds have been conducted in the production forests of southern Sweden. Of those studies which do exist, most have surveyed the bird communities of Norway spruce stands (Nilsson, 1979a, 1979b; Felton et al., 2011), primarily as a response to concerns regarding the environmental impact of conifer-dominated production in the region. In contrast, studies of bird communities in oak-dominated forests, have primarily focused on unmanaged, semi-natural or traditionally managed woodlands and protected areas (Nilsson and Liberg, 1984; Hansson, 1997, 2001; Svensson, 2009). Though these studies are highly relevant to addressing the conservation priorities of this region, there remains a substantial gap in our knowledge regarding the potential contribution of production oak stands to avian biodiversity.

Here we evaluate the extent to which oak plantations in temperate southern Sweden provide habitat and resources for biodiversity by contrasting the bird species composition and diversity found in mature planted production oak stands with oak-dominated protected forest areas. We assessed stand level variation in vegetation variables to identify management-relevant determinants of bird community composition and diversity. Likewise, we divided birds into guilds based on specific functional roles and life history traits to aid in understanding observed responses by species (Didham et al., 1996; Gardner, 2012). We surveyed both mature and young oak plantations to assess the development of avian biodiversity in relation to stand age. We used stands varying in landscape context to assess landscape-level influences, and associated opportunities to improve bird community composition, richness, and abundance when creating production stands.

2. Material and methods

2.1. Study sites

Study sites were all located within the southern-most county of Sweden, Skåne. The region has a temperate sub-oceanic climate, with a mean January temperature that varies across the region between 0 and −2 °C, and a mean July temperature between 15 and 17 °C and a mean annual precipitation of approximately 650 mm. The majority of Skåne's land cover (1.1 million hectare) consists of arable or pasture land (53%), followed by forests (34%), and urban areas (10%) (SFA, 2014). Surveys were conducted in Pedunculate oak (hereafter "oak") dominated protected areas (hereafter "natural stands" or NS, five replicates, 11–22 ha), 50–80 year old mature production stands (hereafter "mature production stands" or "PM", five replicates, 5–31 ha), and 15–20 year old production stands (hereafter "young production stands" or "PY", eight replicates, 5–86 ha) (Fig. 1). We use the term "natural" for protected areas to indicate the relatively dominating influence of ecological rather than anthropogenic influences on growth, senescence, decay and regeneration in these stands, rather than indicating an absence of historical human disturbance. Stands were located at least 800 m from one another to reduce the potential for the same individual birds to be encountered in separate stands during the survey period.

2.2. Bird surveys

We used the point count method when surveying birds (Bibby et al., 2000). Point counts are an effective and efficient means of surveying bird communities, from which the abundance estimates provided are indices correlated with the true abundance of the bird species present. Caution is warranted when interpreting such indices, because variability in bird detectability will influence results (Buckland and Handel, 2006). Whereas modeling approaches can be used to address detectability issues in point count data, these approaches themselves introduce additional concerns and uncertainties (see Barry and Walsh, 2001; Johnson, 2008; Banks-Leite et al., 2014). In this study we adopt an *a priori* approach to minimizing problems of detectability in the field (Johnson, 2008; Banks-Leite et al., 2014), via multiple elements of our sampling design (see below), and more generally via our primary focus on community composition, rather than emphasizing abundance, when interpreting results.

Four survey points were located within each stand, with provisos that the minimum distance between two points was at least 100 m, and at least 50 m from the stand edge. Points were concentrated within the center of each stand, to reduce the influence of birds using the transition zone of vegetation at the edge of the study site. This approach also helped to ensure that survey points were not displaced over larger areas in larger stands, which could have inflated bird community diversity in such stands, due to an increased range of environments surveyed. Survey points were located *a priori* using satellite-based maps and the aforementioned decision rules, to avoid on-site selection bias.

We surveyed each of the study sites four times; twice in early spring and twice in late spring. Surveys were conducted in the first weeks of April (1st to the 15th) and the last weeks of May 2012 (19th to the 3rd of June), an approach considered more reliable than single count surveying of birds (Drapeau et al., 1999). We