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European Union tree density limits do not reflect bat diversity in wood-pastures

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ABSTRACT

The European Union's Common Agricultural Policy (CAP) recommends subsidies are only granted for wood-pastures with < 100 trees/ha. This guidance exists despite these habitats being among the most biodiverse in boreal Europe and currently under threat due to land conversion. Bats are important bio-indicators of agricultural landscapes, but bat diversity has not explicitly been studied in relation to this policy. We investigate how bat activity, foraging, species richness and functional groups are affected in twenty-six wood-pastures along a gradient of tree density, from open to dense. In parallel, open fields and deciduous forests were sampled and the effect of the surrounding landscape configuration was explored. Our results show a consistent increase in total bat activity, foraging activity and species richness within wood-pastures along the tree density gradient. We find optimal tree densities within wood-pastures are higher than values reported in previous studies, and suggest thresholds might depend on the landscape context. Shrub density was a strong predictor of total bat activity and foraging; whilst structural variation of tree size in wood-pastures was most strongly correlated with species richness. We show that wood-pastures are an important habitat and in comparison to forests they contribute to higher bat species richness and activity levels. Interestingly, higher activity levels of forest feeding specialists were observed in wood-pastures compared to forests. At the landscape level, amount of water in the landscape was the strongest predictor of bat activity whilst deciduous forest mostly influenced foraging activity. This study demonstrates that tree density within wood-pastures is not a limiting factor of bat activity and foraging and that other habitat and landscape parameters are important. Thereby focusing solely on tree density limits will not help to promote the ecological requirements for bats. Instead we suggest that a results based approach to CAP payments would be preferable.

1. Introduction

The European agricultural landscape has undergone dramatic changes over the past few centuries with a marked decrease in habitats associated with traditional agricultural practices like wood-pastures and other semi-natural grasslands (Eriksson et al., 2002). It is estimated that a 12.8% decline in European grasslands has occurred in the last 30 years, with worst affected countries experiencing losses between 80% and 20% (Silva et al., 2008). Wood-pastures are especially threatened as a result of conversion to forestry and, to a lesser extent, arable fields (Cousins et al., 2015). Typically, with low grazing pressure, wood-pastures are semi-open habitats with areas of grassland, shrubs and deciduous trees with hollows and decaying wood. Due to increasing awareness of their biodiversity value, being among the most species rich habitats in boreal Europe, Fennoscandian wood pastures are now conserved via the Natura 2000 network (Eriksson, 2008).

Recently, wood-pastures have come under pressure due to the 2003 reform of the Common Agricultural Policy (CAP), with the recommendation that wood-pastures with over 50 trees/ha should not receive subsidies (EC, 2003). This resulted in widespread declines of European wood-pastures receiving subsidies e.g. with Estonia and Bulgaria, having an estimated 70% and 66% of wood-pasture becoming ineligible for subsidies (Plieninger et al., 2015), whilst Sweden had a 15% decrease of subsidies (Beaufoy, 2014). The CAP was reformed in 2014, increasing the allowable number of trees to 100 per hectare (EC, 2013) and subsequently reinstated eligibility for some of these pastures. Although there are numerous studies of biodiversity in semi-natural grasslands (Eriksson et al., 2002; Söderström et al., 2001), few have specifically targeted the effect of tree density in wood-pastures on biodiversity and assessed if current EU subsidies eligibility criteria will be sufficient to cover the most biodiverse wood-pastures The only known studies that explicitly test the effects of this policy are focusing on plants (Jakobsson and Lindborg, 2015) and birds (Jakobsson and Lindborg, 2017). They found that increasing tree density in wood-

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pastures is a key driver of plant biodiversity by favouring shade specialists without compromising open grassland species. Bird populations showed a similar trend, with continually increasing bird abundance along the tree density gradient.

Mammals have generally been neglected in research into the effects of agricultural change on biodiversity (Macdonald et al., 2007) and specifically few studies have investigated bats despite that they are considered important bio-indicators (Jones et al., 2009). Some European and Australian studies have focused on how landscape configuration affects bat species within agricultural landscapes (de Jong, 1995; de Jong and Ahlén, 1991; Dietz et al., 2013; Frey-Ehrenbold et al., 2013; Fuentes-Montemayor et al., 2013; Kalda et al., 2015a; Kalda et al., 2015b; Lentini et al., 2012; Lumsden and Bennett, 2005) or in relation to agri-environmental schemes (Fuentes-Montemayor et al., 2011) and others have compared effects of organic versus intensive farming (Wickramasinghe et al., 2003).

Bats require heterogeneous habitats with many features associated to various aspects of their lifecycle, making them an ideal study organism for understanding landscape complementation (Dunning et al., 1992). Despite this, knowledge on bat populations' responses to landscape structure and connectivity is considered scarce (Dietz et al., 2013; Kalda et al., 2015a). Forest fragmentation, independent of forest cover, has been found to have a positive effect on bat abundance. This is most likely due to landscape complementation increasing access to foraging and roosting habitat in the landscape (Ethier and Fahrig, 2011). Bats are more active in well-connected landscapes (Frey-Ehrenbold et al., 2013) and therefore complexity in landscape structure is crucial to maintain bat diversity. It has been hypothesised that the foraging behaviours of bats can contribute to their vulnerability to habitat fragmentation. Species that glean prey from vegetation or those that forage in cluttered environments are considered more at risk than open habitat foragers (Jones et al., 2003; Safi and Kerth, 2004), that presumably can adapt better to habitat fragmentation.

Landscape composition and configuration can dictate the species pool of a region, but small scale habitat features can be seen as filters steering diversity at the community level (Zobel et al., 1998). In relation to bats, several studies have explored the effects of habitat level characteristics. Increasing habitat complexity, with more tree hollows, fallen logs and scattered trees, was shown to increase bat species richness and activity in farmed landscapes (Lentini et al., 2012). Tree density studies in agricultural land have mainly focused on the effect of scattered trees and particularly at low densities and found that low tree densities support high populations of bats (Fischer et al., 2010; Lentini et al., 2012; Lumsden and Bennett, 2005). Tree density and

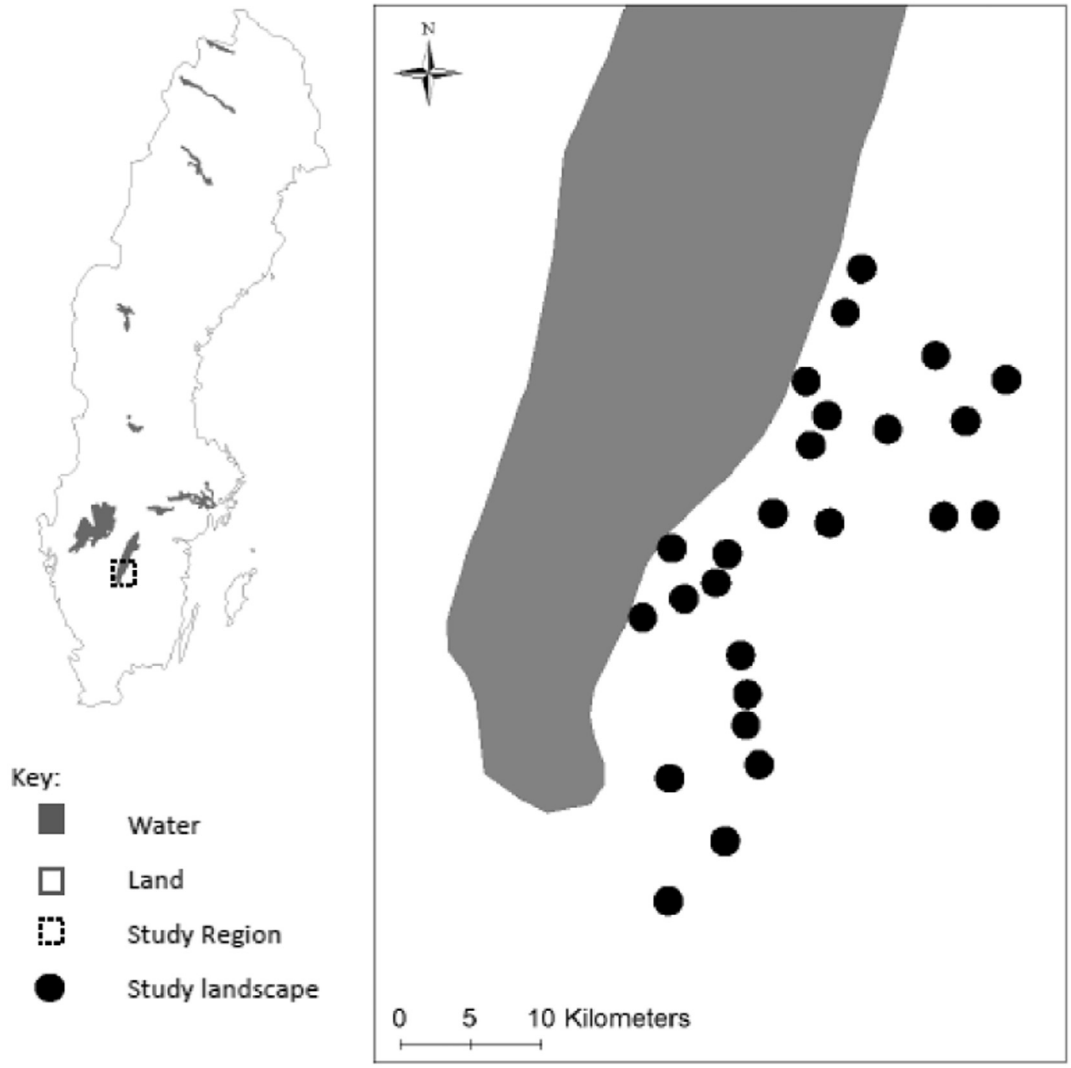

Fig. 1. Site map showing location of study area within Sweden (inset) and the location of the 1.5 km landscapes are denoted by black circles.
Map reproduced from Terrängkartan, Lantmäteriet (2016).