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Differing effects of fallow type and landscape structure on the occurrence of plants, pollinators and birds on environmental fallows in Finland

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ABSTRACT

Long-term grassland fallow and short-term meadow fallow represent alternative fallowing strategies for biodiversity conservation on farmland. Conventional grassland mixtures are used to establish long-term grassland fallows, whereas short-term meadow fallows are sown with specific meadow seed mixtures and require regular re-establishment to maintain the abundance of sown species. This study examined the impact of fallow type and landscape structure on the species richness and abundance of four taxa: plants, bumblebees, butterflies and birds. Long-term grassland fallows and short-term meadow fallows were studied in four contrasting landscape types in Finland, differing in the cover of forest and perennial grasslands. The fallow type and landscape structure affected each species group differently, and the value of a particular fallow type was also modified by landscape setting. Bumblebees were most abundant in short-term meadow fallows, whereas butterflies benefited more from long-term grassland fallows. Species richness of plants and butterflies were higher in forested than in open landscapes. Long-term grassland fallows promoted species richness of butterflies as well as the abundance of foraging edge birds in forested landscapes, whereas short-term meadow fallows enhanced the abundance of foraging edge birds in open landscapes. In landscapes with high grassland cover, the breeding density of open farmland birds was higher in meadow fallows than in grassland fallows, while the reverse was true in landscapes with low perennial grassland cover. The fallowing strategy thus can be adapted to the landscape context depending on the specific objectives. For overall biodiversity enhancement, establishing and managing different kinds of fallows is important.

1. Introduction

Agricultural intensification has resulted in a decline in farmland biodiversity across Europe (Stoate et al., 2009). In the European Union, increasing concern over biodiversity loss has led to the introduction of agri-environmental schemes (AES), the cost-efficiency of which has been widely debated (Kleijn et al., 2011). In many European countries, farmers are paid agri-environmental subsidies for managing or creating areas that are not directly used for production, such as fallow fields or wildflower strips (Keenleyside et al., 2011; Scheper et al., 2013). Compared to cultivated farmland, these areas have been shown to support considerably higher species richness and population densities of several species groups (van Buskirk and Willi, 2004; Haaland et al., 2011; Herzon et al., 2011).

For sown perennial fallows, two general fallowing strategies can be distinguished: *long-term grassland fallow* and *short-term meadow fallow*. Long-term grassland fallows are established by sowing with conventional grassland mixtures. After establishment they can be kept in place for years or even decades, only management being regular mowing, and can be gradually colonized by wild plants and animals (van Buskirk and Willi, 2004; Critchley and Fowbert, 2000). Short-term meadow fallows, also known as 'wildflower areas', have vegetation resembling meadows: they are sown with specific meadow seed mixtures containing flowering herbs and low competitive grasses (Frank et al., 2009; Haaland et al., 2011; Toivonen et al., 2013). Contrary to long-term grassland fallows, the meadow fallow schemes require re-establishment at regular intervals to maintain the abundance of sown species. The strategy is currently most commonly used on strips of arable land along field boundaries (Haaland et al., 2011; Haaland and Gyllin, 2011), but it is also applied to create larger fallow areas (Frank et al., 2009; Toivonen et al., 2013). The AES in several European

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countries subsidise variations of the two fallowing strategies (Keenleyside et al., 2011). However, the relative importance of different fallow types for biodiversity conservation across a range of taxa has received little attention (exception in Firbank et al., 2003; Steffan-Dewenter and Tscharntke, 1997).

Species and species groups naturally differ in their responses to AES, including fallow provisioning (Batáry et al., 2011; van Buskirk and Willi, 2004; Tscharntke et al., 2011). The composition of fallow vegetation is strongly influenced by whether the fallow is established through natural regeneration or by sowing with a specific seed mixture, whether it is managed by mowing, and for how long it is kept (Boatman et al., 2011; Toivonen et al., 2013; Tscharntke et al., 2011). Species richness and abundance of butterflies, moths and beneficial arthropods usually increase with the age of fallow (Alanen et al., 2011; Frank et al., 2009; Kuussaari et al., 2011), whereas bumblebees and farmland birds have been observed to benefit also from short-term fallows, assuming that food or nesting sites are available (Firbank et al., 2003; Henderson et al., 2000; Kuussaari et al., 2011; Steffan-Dewenter and Tscharntke, 2001; Tscharntke et al., 2011).

Besides local habitat quality, the surrounding landscape structure also affects the effectiveness of AES in biodiversity conservation (Kleijn et al., 2011; Tscharntke et al., 2005). According to the hypothesis of Tscharntke et al. (2005), the impacts of AES are more pronounced in structurally simple landscapes (1–20% semi-natural habitat) than in cleared (below 1% semi-natural habitat) or complex landscapes (above 20% semi-natural habitat). The hypothesis has been corroborated in meta-analyses (Batáry et al., 2011; Scheper et al., 2013). While complex landscapes harbour larger species pools of wild plants and animals, allowing high local diversity on a fallow, the effect of the fallow may not be recognizable, because biodiversity is at a high level already (Tscharntke et al., 2011). However, the majority of published AES studies, including those on fallows, have focused on intensively cultivated agricultural landscapes of West and Central Europe, while relatively few studies have been performed in fundamentally different kinds of boreal farmland-forest mosaic landscapes of Northern Europe (e.g. Öckinger et al., 2012; Pöyry et al., 2009; Wretenberg et al., 2010). In order to contribute to an understanding of conservation value of fallows in North-European farmland landscapes, we conducted a quasi-experimental study in Finland. Existing fallow fields of two types were selected in landscapes varying in two potentially important landscape characteristics, the amount of forests and amount of perennial grasslands.

This study examined the impact of fallow type, landscape structure and their interactions on species richness and abundance of several taxa on perennial environmental fallows. A total of 40 long-term grassland fallows and short-term meadow fallows were selected for the study in four contrasting landscape types, differing in the cover of forest and perennial grasslands. The focus was on four species groups differing in mobility and resource requirements: vascular plants, bumblebees, butterflies and birds. For birds, utilization of fallow fields for both nesting and foraging was considered. Foraging was considered separately because even though a fallow patch itself may not be used for breeding, it may nonetheless provide a valuable source of food for individuals breeding elsewhere (Douglas et al., 2010). Firstly, it was expected that the two fallow types promote different animal species, which could be attributed to the foraging and nesting resources on fallows. Fallows with vegetation complementary to that already common in landscape were expected to attract birds particularly strongly. Secondly, landscapes with high cover of forest and perennial grasslands were expected to enhance species richness due to a greater connectivity of fallows with perennial habitats and edges. The effect was assumed to be most pronounced for the relatively sedentary taxa of plants and butterflies. For a highly mobile taxon of birds, the landscape effect was expected to depend on response of species to field edges.

2. Material and methods

2.1. Study design

The study was conducted in Southern Finland (60°54′–60°4′N, 23°20′–26°13′) (Fig. 1). In the study region, the landscape is mainly covered by forests (58%) and arable land (19%), with scattered built-up areas. Agriculture is characterized by intensive cereal cultivation on clay soils. Fallows and cultivated grasslands occupy 16% and 14% of the utilized agricultural area respectively (Tike, 2014).

The two fallowing strategies – long-term grassland fallow and short-term meadow fallow – were represented by the two perennial fallow types included in the AES of Environmental Fallow (EF) in Finland (Toivonen et al., 2013): grassland fallow and meadow fallow. Grassland fallows are either established under the EF scheme by sowing with a perennial grass mixture, or they are former obligatory set-asides or production grasslands that have been enrolled as EFs. Meadow fallows are established under the EF scheme by sowing with low competitive meadow plants. In most

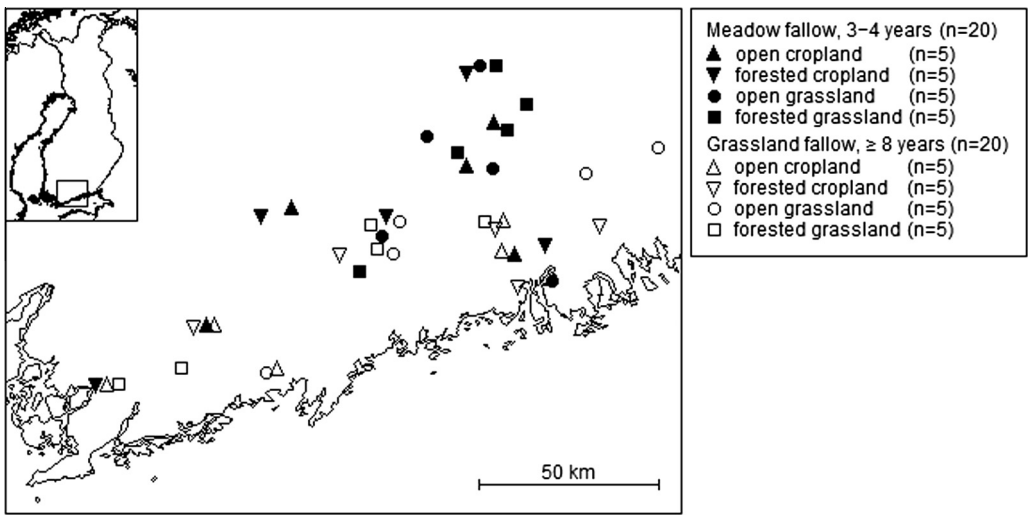

Fig. 1. Locations of the 40 study fallows representing two fallow types and four landscape types (characterized in Table 1) in Southern Finland.