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Semi-natural grassland continuity, long-term land-use change and plant species richness in an agricultural landscape on Öland, Sweden

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Abstract

The study characterizes historical land-use change and the development of semi-natural grassland habitats, over 274 years, within a mosaic agricultural landscape (22 km^2) on the island of Öland (Sweden). We also explore the relationship between previous land-use, habitat continuity and present-day vascular plant species richness in grassland patches. Land-cover maps, based on cadastral maps and aerial photographs, were produced for six time-periods between 1723/1733 and 1994/1997. In 1723/1733, the landscape was dominated by grasslands, with arable land surrounding the villages. The grassland area decreased throughout the study period and grassland patches became progressively more fragmented. Present-day grasslands represent 18% of the grassland area in 1723/1733. The land-use structure of the early 18th century is still evident in the modern landscape. The majority of the present-day grasslands are situated on former common grazing land and have had a continuity of at least 274 years: the remaining grasslands are younger and developed during the 20th century on arable or forested land. The proportion of plant species that depend on grazing and are characteristic of semi-natural grasslands significantly reflects the continuity and previous land-use of grassland sites. The study illustrates the way in which information on historical land-use and habitat continuity can help to explain the structuring of plant assemblages in semi-natural grasslands within the modern landscape.

Keywords: Aerial photographs; Cadastral maps; Habitat continuity; Land-use history; Rural landscape; Vascular plant species

1. Introduction

One of the consequences of the rationalization of agriculture in Europe, over the last half-century, is the loss and fragmentation of traditionally managed habitats, such as semi-natural grasslands (Cousins, 2001; Kiviniemi and Eriksson, 2002). Several studies have shown that the loss and isolation of habitats is, in its turn, accompanied by a reduction in the sizes of populations occupying the remaining habitat fragments, by reduced levels of immigration and by an increased risk of species-extinction (Eriksson et al., 2002; Soons and Heil, 2002; Van der Veken et al., 2004).

Traditionally managed, unfertilized semi-natural grasslands, such as pastures and hay meadows, are known to support a rich flora and are often characterized by high species diversity (Kull and Zobel, 1991; Norderhaug et al., 2000). Approximately 600 species of grasses, herbs and woody plants have been recorded in semi-natural grasslands in Sweden (Svensson, 1988), and Swedish pastures commonly contain at least 30 species of vascular plants per square metre (Eriksson and Eriksson, 1997; Sykes et al., 1994). However, semi-natural grasslands are probably one of the most threatened habitats in Scandinavia. The total area of the remaining fragments of traditionally managed grassland in Sweden is approximately 200,000 ha, representing less than 10% of the grassland area that existed at the beginning of the 20th century (Bernes, 1994).

Many grassland plant species are threatened by modern agricultural practices. The abandonment of grazing or mowing of open grassland habitats is followed by a succession to scrub

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and secondary forest (Rocchini et al., 2006; Rosén and van der Maarel, 2000). And the improvement of semi-natural grasslands by artificial fertilization eliminates species that are unable to compete with the strongly growing grasses that are promoted by high levels of nutrients (Van den Berg et al., 2005).

The extent and distribution of unimproved grassland fragments are expected to influence population sizes and species diversity (e.g. Bruun, 2000; Kiviniemi and Eriksson, 2002; Krauss et al., 2004). While current levels of species diversity may be related to spatial properties of the present landscape, the historical structure of the landscape and the continuity of existing habitat fragments are also predicted (and have been shown) to have had a pronounced effect on species-occurrences and the present-day diversity of species (e.g. Dahlström et al., 2006; Norderhaug et al., 2000; Lindborg and Eriksson, 2004).

Devising management strategies that sustain and promote species rich landscapes requires a better understanding of the historical dynamics of landscape structure and the ways in which land-use changes influence particular habitat types, such as semi-natural grasslands. We also need to understand the ways in which habitat history may have determined present-day diversity—on the level of communities, species and genes.

Despite an increasing awareness of the importance of landscape history as a determinant of present plant species diversity, many studies of biodiversity still focus only on the present-day landscape or include short-term (20–50 years) historical data. One reason for this short-term focus might be the lack of fine-scale historical land-use maps for many areas of Europe. The Nordic countries, as well as the Baltic States still contain relatively extensive regions that have retained a traditional landscape structure (Bernes, 1994). Parts of these countries (which fell within the Swedish Empire during the 17th and 18th centuries) have a fine-scale map coverage that extends back to the 18th century – or even to the first half of the 17th century (Kain and Baigent, 1992; Tollin, 1991). The Baltic island of Öland, in Sweden, is notable for its high proportion of semi-natural grassland habitats, many of which have not been improved by artificial fertilization and which support a high diversity of vascular plants (Bengtsson et al., 1988; Forslund, 2001; van der Maarel and Sykes, 1993). The island is also well covered by detailed cadastral maps dating back to the early 18th century.

The present study focuses on a mosaic agricultural landscape on Öland (Sweden) and makes use of a 274-year-long series of maps and aerial photographs to investigate the dynamics of change in land-use/cover in the overall landscape in relation to the distribution and extent of semi-natural grassland – a habitat that is of central importance for the conservation of species diversity in the modern landscape (cf. WallisDeVries et al., 2002).

The main aims of the study were: (1) to characterize the structure of the historical and present landscape, (2) to describe the long-term development of grassland habitats in relation to land-use changes and habitat fragmentation within a landscape context, (3) to characterize the continuity and previous land-use of present-day grassland fragments, and (4) to investigate the relationships between grassland continuity, previous land-use and vascular plant species richness.

2. Material and methods

2.1. Study site

The study area (centred on 56°40′49″N, 16°33′58″E) is located on the Baltic island of Öland in Sweden (Fig. 1) and covers approximately 22.5 km^2. The area includes the land associated with the village of Jordtorp and four adjacent villages.

The bedrock of the Jordtorp area consists of Cambro-Silurian limestone. The overall topography is flat, but the area is crossed by a number of low ridges and deposits of glaciofluvial material (Forslund, 2001). The mean annual temperature is 7 °C (July mean = 16 °C; January mean = −1 °C) and the mean annual precipitation is 468 mm (Forslund, 2001).

The Jordtorp area lies on the SW margin of an extensive area of deciduous forest (Mittlandskogen) (Forslund, 2001). The landscape is at present characterized by a mosaic of arable cultivation, deciduous forest and grasslands. The forest characteristically contains *Quercus robur*, *Fraxinus excelsior* or *Carpinus betulus*, with *Corylus avellana* forming the shrub layer. While some forest stands on deeper soil have a typical woodland ground flora, other forest areas are dominated by dense *Corylus avellana* stands (Forslund, 2001). However, most of the forest in the area has a semi-open character and a ground-layer containing many grassland species. The grasslands include species rich semi-natural grassland on neutral to weakly basic morainic soils and small patches of "alvar" grassland on lime-

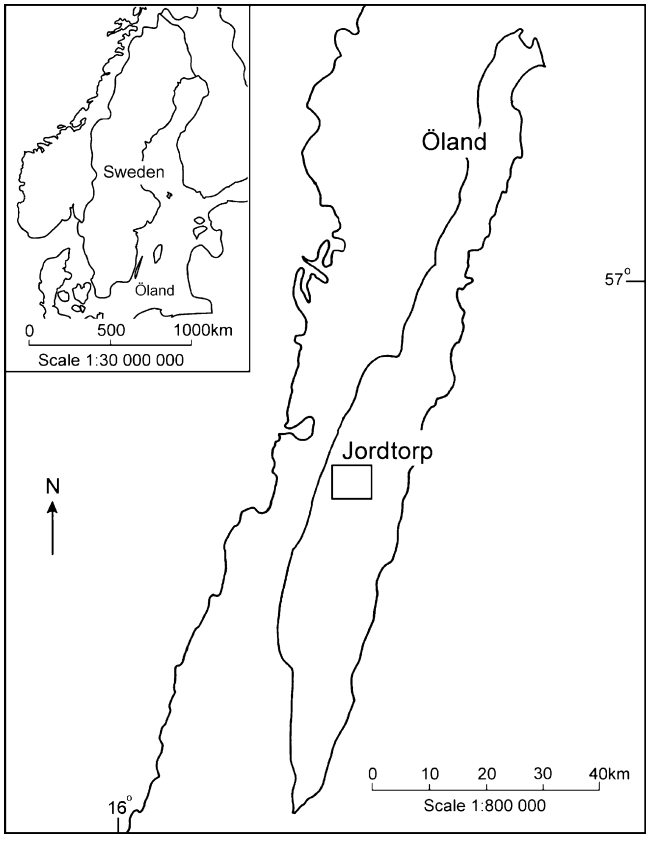

Fig. 1. The study area, (the Jordtorp area) – a local agricultural landscape on the Baltic Island of Öland, Sweden.