Agriculture, Ecosystems and Environment 268 (2018) 61–69

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

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

Farmland bird responses to land abandonment in Western Siberia

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ARTICLE INFO

Keywords:
Russia
Forest steppe
Cropland
Livestock grazing
Meadow birds
Sustainable intensification

ABSTRACT

Land abandonment is an important driver of biodiversity changes. Nearly 60 million ha of cropland and huge areas of managed grassland were abandoned after the collapse of the Soviet Union in 1991. We compared community structure and abundances of farmland birds on used and abandoned cropland, pastures and hay meadows in a study area situated in the Western Siberian crop belt. Abandoned land hosted distinct communities of farmland birds that were similar to those of abandoned farmland elsewhere in the former Soviet Union. More species profited from abandonment than suffered, but the densities of a distinct group of 'meadow birds', a group of high conservation concern in Eurasia, were lower on abandoned land compared to managed pastures and hay meadows.

Abandoned land had taller, but not denser vegetation and higher plant litter cover than used pastures and hay meadows. The vegetation structure of abandoned land explained differences in bird abundance well, and responses to vegetation parameters were non-linear and species-specific. Future land-use trends are difficult to predict, but cropland recultivation and intensification seem likely. Conservation strategies should entail minimized reclamation of abandoned cropland (perhaps coupled with sustainable intensification on existing farmland), and low-input management of pastures and hay meadows. As a large proportion of the grassland is managed for subsistence farming, measures to slow down further rural human outmigration would also benefit bird biodiversity.

1. Introduction

Land-use change affects biodiversity globally, especially through the conversion, degradation and fragmentation of habitat (Pereira et al., 2010). Grasslands have suffered disproportionally (Hoekstra et al., 2005). Seventy percent of all native grasslands were converted to cropland or are seriously degraded (e.g., Wright and Wimberly, 2013). Cropland expansion continues in large parts of the world, especially in the tropics (Phalan et al., 2013). Traditional agricultural habitats that are managed with low intensity can harbour rich biodiversity (Fischer et al., 2012), but farmland management has been intensified recently across the globe, with largely negative consequences for biodiversity (Stoate et al., 2009; Reif and Vermouzek, 2018).

On the other hand, cropland expansion has been slowed down and even reverted in many temperate regions (Cramer et al., 2008). Agricultural intensification, urbanization, political change and an increasing displacement of land use to less developed countries (Lambin and Meyfroidt, 2011) all result in widespread abandonment of cropland and grazing lands (Cramer et al., 2008; Hatna and Bakker, 2011). The effects of abandonment on biodiversity are still not fully understood, and abandonment is seen as both a threat and an opportunity for biodiversity conservation (Queiroz et al., 2014).

The former Soviet Union is a global hotspot of land abandonment (Lesiv et al., 2018). The break-up of the country into independent republics in 1991 resulted in the abrupt cut of state subsidies and a lack of workforce due to rural outmigration over vast areas. This led to a collapse of the state farming system. As a result, between 42 and 59 million ha cropland were abandoned across the former Soviet countries in the 1990s, of which 31–39 million ha were situated in Russia (Lesiv et al., 2018). Livestock numbers declined dramatically in the 1990s, leading to the abandonment of vast expanses of hay meadows and pastures, the extent of which remains unquantified (Wesche et al., 2016). In Russia, only a small proportion of the abandoned cropland has since been recultivated (Lesiv et al., 2018), whereas in

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https://doi.org/10.1016/j.agee.2018.09.009
Received 31 May 2018; Received in revised form 7 September 2018; Accepted 8 September 2018

neighbouring Kazakhstan, ca. 50% of all abandoned cropland are in use again (Dara et al., 2018; Kamp et al., 2011). Similar processes were observed in Eastern European countries after the end of socialism (Alcantara et al., 2013). The magnitude, drivers and spatial patterns of post-Soviet land-use change are comparatively well established for Eastern Europe (Kuemmerle et al., 2011; Smaliychuk et al., 2016), European Russia (Prishchepov et al., 2013) and Kazakhstan (Kamp et al., 2011; Dara et al., 2018), but information remains scarce and coarse for the Asian part of Russia (Lesiv et al., 2018).

The described, continent-scale changes in agriculture likely had massive effects on biodiversity and ecosystem properties in post-Socialist countries. For example, land abandonment after 1991 has been shown to affect species richness, abundance anddistribution of birds and butterflies in Poland (Skórka et al., 2007), the Czech Republic (Reif et al., 2008), Hungary (Verhulst et al., 2004), Romania (Baur et al., 2006) and European Russia (Bolnykh and Vengerov, 2011; Borisov et al., 2014; Korovin, 2014). However, the published research on farmland biodiversity of the Palearctic is strongly skewed towards Western Europe (Tryjanowski et al., 2011; Sutcliffe et al., 2015). This is unfortunate, as Eastern European and the former Soviet countries are still characterized by a comparatively low land-use intensity and rich wildlife (incl. very large populations of farmland birds) compared to Western Europe (Sutcliffe et al., 2015). They also face different research and conservation priorities (Báldi and Batáry, 2011).

With the exception of Kazakhstan (Kamp et al., 2011), hardly anything is known about land-use change effects on biodiversity for the huge belt of arable and managed grassland east of the Ural mountains, stretching all across Western Siberia east to the Altai mountains (Kühling et al., 2016). This region, largely following the borders of the forest-steppe biome, is characterized by a habitat mosaic of birch groves, pine forests, hay meadows, pastures and large wetlands (fens, raised bogs and reeds). “Pristine” baseline habitat is difficult to define, as the region has a long land-use history (Zakh et al., 2010). The patchy landscape of small forests and open grasslands does not only result from plant growth limitation due to drought, but has been maintained open by livestock bred by local tribes since ca. 7000 years BP (Zhilich et al., 2017). Around 2500 years BP, sedentary and semi-nomadic animal husbandry was the basis of the local economies, and there was little evidence for crop cultivation (Zakh et al., 2010; Zhilich et al., 2017). More recently, agriculture was widespread in the 18th century (Ramankutty and Foley, 1999), but remained patchy and unproductive until Khrushchev’s ‘Virgin Land Campaign’ in the 1950s, when millions of hectares were ploughed (Durgin, 1962). With an estimated 35 million ha cropland (Bartalev et al., 2016) across the seven Russian provinces situated in this steppe and forest-steppe belt, a significant proportion of the area is now used for food production.

We aimed to assess the responses of farmland biodiversity to large-scale, post-Soviet agricultural abandonment in the Western Siberian grain belt during the 1990s. We used birds as a model group, because more is known about their distribution and ecology in Russia than about any other taxonomic group, and they are a prominent focus for conservation efforts.

Specifically, we asked:

1) How did the extent and intensity of land use change since the break-up of the Soviet Union?
2) How did land abandonment affect species richness, abundance and community composition?
3) Which species profited from abandonment, and which suffered?
4) What are the main vegetation features that affect farmland bird abundance on abandoned land?

2. Material and methods

2.1. Study area

Fieldwork was conducted in a 40,000 ha study area situated in the Russian province of Tyumen near the city of Omutinsk (56°27′N/67°35′E) in the year 2013 (Supplementary information, Fig. S1). The climate is continental with a mean annual temperature in Omutinsk of 1.5 °C, and an annual precipitation sum 471 mm (Russian Federal Service For Hydrometeorology and Environmental Monitoring, 2014). The region is largely flat, with high ground water levels and strong seasonal water table fluctuation. Population density is low with 6.93 inhabitants/km^2 in the district of Omutinsk.

Agriculture is characterized by crop and livestock production. Cereals (mostly wheat) prevail, but fodder and oil seed crops are increasingly grown (Kühling et al., 2016). Field size is comparatively large (ca. 30–200 ha), farm sizes range from 70 ha (= 1 field, family business) to typically 3000–10,000 ha (larger enterprises). Crops are nearly exclusively sown in spring, and no irrigation is used except for vegetables. Commercial cattle are partly herded on natural pastures, but dairy cattle largely kept in stables year-round. Private (subsistence) households graze cattle, sheep, goats and horses at varying densities on natural grassland in community herding schemes. Wood pasture in birch forests is commonly practiced. Hay meadows are cut once per year and are not fertilised.

2.2. Analysis of land-use data

In order to characterise extent and intensity of arable agriculture and livestock breeding since the break-up of the Soviet Union, we obtained agricultural census data (time-series) on the level of Tyumen oblast (province) and Omutinsk rayon (region) for the period 1990–2013. We downloaded data on area sown (total crops, and separate per crop) per year, livestock numbers (cattle, sheep/goats, horses), inputs (mineral and organic fertilizer) and yields for all crops and livestock produce from the free statistical portal http://tumstat.gks.ru/ (Territorial Administration of the Federal Statistics Service, Tyumen province). To fill data gaps and request early time-series that were not available online, we visited rayon and province level statistical agencies in May 2014 and copied data from statistical yearbooks with permission of the responsible authorities. The gathered time series allowed (Supplementary information, Fig. S2) us to characterise extent and intensity of arable agriculture and livestock breeding since the break-up of the Soviet Union.

2.3. Sampling design and bird surveys

We recorded all birds on a total of 105 line transects of 500 m length, which were surveyed twice each in May and June 2013. Due to logistical constraints, random sampling was not feasible, but we placed transects in a regular design with at least 1 km distance between each transect centre (Fig. S1). The past and current land use at all transects was established from a supervised classification of remote sensing data from Landsat 5 T M, 7 ETM and Rapid Eye satellite images (Kämpf et al., 2016). Classifications were available for the years 1988 (peak of Soviet cropland extent and management intensity), 1998 (economic low point in the post-Soviet period), and 2012 (current situation). In the classifications, abandoned cropland could not be distinguished from grassland easily. Therefore, cropland was defined as abandoned, when it was classified as worked cropland either in 1988 or 1998, but classified as grassland 2012. We improved the remote sensing classification by recording land-use in the field while walking the bird transects. Abandoned cropfields that showed clear signs of haymaking or grazing were classified as current pastures and hay fields, and abandoned cropland and grassland of different age classes lumped to increase the transect sample size for statistical analyses (Table 1). This resulted in 38