Agriculture, Ecosystems and Environment 247 (2017) 91–97

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

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

Effects of the conversion of intensive grasslands into Christmas tree plantations on bird assemblages

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ARTICLE INFO

Keywords:
Non-food crop
Christmas tree plantation
Grassland
Land use change
Hedge
Bird assemblage

ABSTRACT

Over the last decade, the conversion of annual-rotation based crops or grassland areas into non-food perennial crops has been increasingly prevalent in European farming systems. This shift is associated with major changes in management practices and has created new environmental conditions and resources for wildlife. Impacts on birds have been examined for bioenergy agricultural systems, such as miscanthus plantations and short-rotation willow coppice. However, they remain largely unknown for Christmas tree plantations (CTPs) that have recently increased considerably in some European countries. We examined the extent to which CTPs alter bird species assemblages in the farmland areas of southern Belgium, where they mainly replace intensive grassland. The abundance of birds was recorded during the breeding season in randomly selected sites located in grassland and in CTP. Results show that introduction of CTP into landscapes dominated by grassland with low hedge densities locally increases bird species richness and abundance without leading to biotic homogenization. Differences in species richness and abundance between grassland and CTP decrease with increasing hedge densities. A community analysis indicates that the plantation of Christmas trees enriches the bird assemblage of intensive grassland areas. In intensive grassland with few hedges, small-size CTPs could constitute an option to increase structural heterogeneity and provide new potential breeding conditions for some farmland birds. However, questions remain about the genuine quality of the resources available in CTP and further research is needed to examine the breeding success and survival of birds that settle in this type of habitat.

1. Introduction

Agricultural activities have modified landscapes for millennia at different levels, thus creating ever-changing conditions for wildlife. Over the last 50 years, agricultural intensification and development of new crops have led to rapid modifications in the productive agricultural matrix, while hedgerows and woodlands have changed more slowly (Hinsley and Gillings, 2012). These major changes have caused a global decline of farmland biodiversity (Stoate et al., 2009) that conservation efforts have found difficult to halt (Kleijn et al., 2011). However, results of studies on the impact of agricultural modifications on wildlife are often species- and system-specific and not applicable to new conditions generated by a particular practice or crop.

Non-food perennial crops, such as those used for bioenergy, have recently become more prevalent in European farming systems (Lewandowski, 2016). They were pushed by the willingness of the European Union to increase the renewable sources of energy (Fischer et al., 2010) and, in turn, new habitats with specific vegetation structures and resources were created. Christmas tree plantation (CTP) is another non-food crop which is considerably increasing in some European countries (*e.g.* Østergaard and Christensen, 2008; Schuster, 2008), in farming and/or forest areas depending on local legislations. European annual production is estimated at 75 million Christmas trees on some 115,000 ha (Christensen, 2015). The sector is boosted by the recent demand for high-quality Christmas trees and the profitability of CTP compared to other types of land use (Sirgmets, 2009; Konstantinos et al., 2011).

The way in which new crops affect biodiversity depends on the

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http://dx.doi.org/10.1016/j.agee.2017.06.029
Received 2 March 2017; Received in revised form 19 June 2017; Accepted 20 June 2017
0167-8809/

magnitude of the land use shifts (Pedroli et al., 2013). Further intensification in agricultural practices and landscape homogenization negatively impact farmland birds (Everaars et al., 2014; Jerrentrup et al., 2017) which are already in strong decline (Gamero et al., 2017; Voříšek et al., 2010). In contrast, in the case of intensive cropping systems converted into perennial crops, positive effects on farmland birds are expected (Pedroli et al., 2013). Perennial biomass crops, such as miscanthus and short-rotation willow coppice, are associated with reduced disturbances due to crop management in comparison with traditional annual-rotation based crops. This difference may explain support of higher weed biomass and invertebrate abundance (Haughton et al., 2016). With respect to bird communities, higher bird diversity and abundance were found in miscanthus and short-rotation willow coppice compared to annual intensive crops, both in the breeding and the wintering seasons (Bellamy et al., 2009; Berg, 2002; Sage et al., 2010, 2006). However, part of the species recorded in these crops are habitat generalists and some studies have suggested than these new perennial crops may provide lower habitat suitability for endangered or specialized farmland birds (Schulz et al., 2009; Vepsäläinen, 2010), indicating that the development of these crops can potentially cause biotic homogenization.

In spite of the recent expansion of CTPs over Europe, their impacts on biodiversity have been far less studied compared to those of bioenergy crops. In Belgium, CTPs have significantly expanded in the southern part of the country (Wallonia, mainly the Ardenne Region), where they are largely replacing hay meadows and pastures (hereafter referred to as grassland). CTPs cover about 5000 ha (0.7% and 3.3% of the farmland productive area of Wallonia and Ardenne Region, respectively) and this coverage is predicted to double in the next few years. The main Christmas tree species are Nordmann firs (*Abies nordmanniana*) and Norway spruce (*Picea abies*), with respectively 65% and 20% of the Belgian Christmas tree production.

At the field scale, the conversion of grassland into CTP induces major changes in vegetation structure and crop management. Plants measuring between 30 and 40 cm are planted at an interval of 1 × 1 m after the field was plowed and cleaned with herbicides. Christmas trees are mainly harvested when they are between 1 and 1.75 m high. Growth stage can be divided into two parts: the first is a non-harvesting phase lasting from three to six years depending on the species, and the second is a harvesting phase in which each autumn, generally for three to five years, a proportion of Christmas trees is harvested. There are manifold cultivate practices during these two phases: weeds are controlled by using herbicides or mowing to limit competition and to avoid them growing into the trees; insecticides and fungicides are commonly used for pest control, and nitrogen and potash fertilization is recommended for *Abies* species. Pruning operations are common for improving Christmas tree shape.

Some studies have pointed out the negative impacts of using herbicides and fertilizer in CTP on soil and water ecosystems (i.e. Dousset et al., 2004; Rothstein, 2005), but to the best of our knowledge, there is a lack of research comparing species diversity and density between CTP and the type of habitat it substitutes.

The aim of this study is to quantify the effects of the conversion of grassland into CTP on farmland birds. We assessed this conversion effect at the field-scale by comparing bird assemblages between locations in CTP and in grassland, sampled in an area where Christmas tree production is becoming increasingly prevalent. Because field boundaries are important predictors of bird abundance in farming systems (Batáry et al., 2010; Siriwardena et al., 2012), we also considered in our habitat comparison the presence of hedges in the neighbourhood.

2. Materials and methods

2.1. Study area

The study area was located in southern Belgium (Wallonia) in the western part of the Ardenne region (centre of study area is 49°57′N, 4°58′E). It covers about 215 km^2 and is dominated by forests (54%). Farmland areas cover 37% of the study area and are dominated by grassland, because shallow soils and short growing seasons limit the extension of intensive cereal crops. Grassland in the study area is managed with intensive mowing (hay meadows) and intensive grazing regime (pastures). Meadows are frequently mowed two or three times per year, with the first mowing event usually taking place in the beginning of May. Livestock units are about 2.3 per hectare of grassland. About 4.7% of the farmland areas are now dedicated to CTP. Altitude ranges from 220 to 445 m and the relief consists of plateaus, which support most grassland and CTP, alternating with forested river valleys. The climate is characterized by a mean annual rainfall of 1250 mm and a mean annual temperature of 7.4 °C (Avril, 1975).

2.2. Selection of sampling locations

In order to compare bird assemblages of CTP with those of grassland, 58 locations were sampled in these two habitats. Grassland and CTP areas (size of plantation from 0.5 to 13.7 ha) were mapped from field visits covering the whole study area to update a vector topographic database at a scale of 1:10.000 (Top10Vector v1.1 from the year 2011 provided by the Belgian National Geographic Institute). We randomly selected 31 sampling locations in CTP and 27 in grassland according to three rules: (1) locations were sampled at a minimum distance of 100 m from any forest edge or village to avoid inflating the collected data with records of species that are related only to forest or urban areas and that have no clear link to the two target habitats; (2) locations were separated from each other by more than 500 m to ensure as much as possible the independence between data recorded in the different locations (Bibby et al., 2000) and (3) locations in grassland were separated by at least 500 m from any CTP (see Fig. S1 in Supplementary materials for a map with the sampling locations). In our study system, CTPs mostly consist of non-homogenous blocks formed by small-size adjacent plots of Christmas trees at varying growth stages. Within 100-m buffers around CTP locations, there were on average 2.6 CTP plots (std = 1.41, range: 1–6). Within each of the 100-m buffers, there were at least some Christmas trees reaching at least 80 cm in high. In two third of the buffers, plots representing both harvesting and non-harvesting phases were present. Pictures of sampling locations in grassland and CTP are provided in Supplementary materials (Fig. S2).

2.3. Bird counts

The point count technique was used to sample breeding bird communities in the sampling locations (Bibby et al., 2000). Birds were recorded twice during the breeding season in 2013 by the same observer (R.G.) to maximize chances of recording both early and late breeding birds. First and second surveys respectively occurred between the 13th of April and the 9th of May, and between the 3rd and 17th of June. Counts were conducted within a four-hour period beginning 30 min after sunrise, and the sequence in which locations were visited during the same morning was inverted between the two surveys. Birds were counted under suitable weather conditions (*i.e.* no rain and wind velocity < 20 km/h).

Birds were surveyed over a 5 min period (Bonthoux and Balent, 2012), starting 2 min after the arrival of the observer at the sampling location, in order to reduce possible disturbance caused by the observer displacement. All birds seen or heard during the survey were positioned on an aerial picture printed at a 1/2.500 scale, except when they were clearly over-flying the sampling area.

Only birds recorded within a 100-m buffer around the sampling location were taken into account in the analysis. This distance was chosen to restrict the bird data to the scale of the comparison between grassland and CTP. The unit of abundance used was the "territory" (Bibby et al., 2000). For each species and during each survey at each