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Birds and plants: Comparing biodiversity indicators in eight lowland agricultural mosaic landscapes in Hungary

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ABSTRACT

This study compares biodiversity indicators based on plant and bird communities in eight mosaic landscapes in Hungary, dominated by a mixture of agro-ecosystems and grasslands. The eight landscapes were selected to represent the diversity of the mixed agricultural landscapes of South-East Europe, where a mosaic pattern of intensively managed farmlands and high nature value semi natural grasslands is still relatively prevalent. Bird communities were described using several assemblage-level (species number, total abundance, and Shannon diversity of the assemblage, based on 15 pre-selected key farmland bird species), as well as species-level (presence/absence of the 15 bird species) indicators, which were checked against a synthetic landscape quality indicator describing the degradation of the local plant communities with respect to an ideal baseline (vegetation-based natural capital index, NCI). The authors were interested if and how the assemblage- and species-level bird indicators can describe landscape quality in South-East European agricultural mosaic landscapes.

It was found that assemblage-level bird indicators were poorly associated to the landscape quality measured in terms of NCI: only total abundance correlated significantly with NCI. On the other hand, species-level indicators were much more successful in predicting landscape quality. Six (*Alauda arvensis*, *Emberiza calandra*, *Falco tinnunculus*, *Motacilla flava*, *Limosa limosa*, *Vanellus vanellus*) of the 15 farmland bird species studied showed significant positive correlation with NCI, while three species (*Emberiza citrinella*, *Galerida cristata*, *Sylvia communis*) exhibited negative correlations. We also found that it was possible to draw conclusions about the landscape quality in an agricultural landscape based on the bird communities better, than to predict the bird assemblages from vegetation condition.

The negative correlations for species that indicate good quality habitats in Western Europe, underline the context specificity of biodiversity indicators: whereas the conditions preferred by these species can be considered relatively natural in Western Europe, they correspond to relatively degraded habitats in South-East Europe. The nine farmland bird species which showed a significant connection to NCI can be seen as potential candidates for a regional Farmland Bird Index customized for agricultural landscapes in South-East Europe, in the Pannonian biogeographic region, or in Hungary.

1. Introduction

For centuries, traditional farming practices created and maintained species-rich habitats in Europe and other developed regions of the world (Bignal and McCracken, 1996; Vera, 2000). From the 1950′ onwards agricultural intensification has dramatically degraded these habitats, which led to the decline of many, previously common species and the disappearance of less common ones. This process involved several elements of agricultural intensification and land use change, including increased use of agrochemicals and mechanization (Robinson and Sutherland, 2002), an increase in plot sizes (Aebisher et al., 2000), drastic changes in animal husbandry (Chamberlain et al., 2001), and a general loss in semi-natural habitats in agricultural regions (García-Feced et al., 2014). Several processes, like the disappearance of low intensity grasslands (Aebisher et al., 2000), are particularly evident in Western

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Europe and North America (Herkert, 1994; Pain and Pienkowski, 1997), while in South-East Europe this process is less obvious (Verhulst et al., 2004). In Western Europe, many studies have been made concerning the effect of intensive agriculture on birds and other animal groups (Aebisher et al., 2000; Pain and Pienkowski, 1997; Robinson and Sutherland, 2002). The bird species linked to agrarian landscapes has drastically decreased due to the agriculture becoming more intensive and profit-oriented (Pain and Pienkowski, 1997). Farmland birds suffered the highest losses during these unfavourable processes (Pain and Pienkowski, 1997; Robinson and Sutherland, 2002). On the other hand, due to the relatively milder and delayed intensification in agriculture, extensively managed farmland landscapes in South-East Europe are still a hotspot of biodiversity (Báldi et al., 2005; Verhulst et al., 2004), frequently coupled with outstanding cultural values (Filepné et al., 2012). However, these areas are now increasingly being threatened by intensification (Aebisher et al., 2000; Lefranc, 1997; Verhulst et al., 2004).

In order to stop this unfavourable process it is necessary to explore the different ecosystem processes collecting data on the state of these ecosystems at a broad scale. However, the immense complexity of ecological systems, the lack of time and money, the lack of adequate professional experiences and the incomplete technical conditions cause serious difficulties to biodiversity monitoring (Rodrigues and Brooks, 2007). To overcome these difficulties various types of biodiversity indicators have been proposed that describe the status of ecosystems and their biodiversity in an aggregated form (Eglington et al., 2012; Lindenmayer et al., 2000; van Strien et al., 2009). Such indicators are more than simple metrics to measure the diversity of organisms, they should rather be regarded as general indicators monitoring the state of the ecosystems (ten Brink, 2006; Niemeijer and de Groot, 2008).

One of the most straightforward ways of characterizing the state of an ecosystem is to study its species. According to Juhász-Nagy's (1986) "universal indication principle", any species can be good indicator for its environment, indicating that conditions enabling survival are present in that locality. Thus the occurrence and/or the abundance of a group of well-chosen species can render meaningful and reliable information on the ecological conditions of a certain location. Biodiversity metrics quantified over major taxonomic groups are often used as general-purpose biodiversity indicators for the evaluation and monitoring of ecosystem state and trend (Browder et al., 2002; Canterbury et al., 2000; Mace and Baillie, 2007).

One of the major taxonomical groups used most frequently for creating general purpose biodiversity indicators is that of the birds. Scientists often apply bird species and assemblages as proxies for quantifying the state of ecosystems and biodiversity (Bildstein, 2001; Gregory et al., 2005). The causes of popularity of birds are manifold: their taxonomy is stable, their natural history is well known, they are relatively easily monitored, they appear in all types of habitats up to the top-level of the food-web, they are sensitive to environmental changes, and in several countries there are lots of monitoring programmes and databases dealing with them (Burger, 2006; Gregory et al., 2003; Pearson, 1994). Several studies have shown that there is a close relationship between bird diversity and overall biodiversity (Gregory and van Strien, 2010; Kati et al., 2004; Sauberer et al., 2004). Birds are suitable to characterize the ecological status of a landscape unit at a broader scale, although there are some limitations (e.g. migratory species, or species living in several different habitats inevitably convey signals that are difficult to decipher – Gregory et al., 2003, 2005; Gregory and van Strien, 2010). Nevertheless, birds were taken as the basis of ecosystem health indicators in forests (Canterbury et al., 2000), riparian-wetland areas (Croonquist and Brooks, 1991), grasslands (Browder et al., 2002) and marshes (Smith-Cartwright and Chow-Fraser, 2011). The demise of low intensity farmlands and the degradation/loss of wetlands exert particularly high impact on many bird species. This relationship is made explicit in the Farmland Bird Index developed in the UK and Europe, which describes farmland bird population trends associated with agricultural practices (Gregory et al., 2005), and is one of the most recognised multi-species bird indicators at the landscape level.

Plants are also frequently used as the basis for biodiversity indicators in many contexts including agroecosystems (Matzdorf et al., 2008). The most important characteristics of plants which make them good indicators are the following: they are easy to observe and identify, relatively well-known (with many charismatic species), they reflect their direct physical environment, and they are the primary target of many of the pressures (Landsberg and Crowley, 2004). Furthermore, plants constitute the basis of the food web, thus they are in a key role in ecosystems. Plants and vegetation are especially frequently used for assessing and mapping the naturalness (or hemeroby, which is essentially the opposite of naturalness) of specific habitat types (Battisti and Fanelli 2016; Fanelli and Battisti 2015; Fanelli and De Lillis, 2004; Hill et al., 2002). Spatially aggregated forms of plant-based naturalness indicators (i.e. the "average naturalness" of a larger area) is considered to be a reliable and highly policy relevant metric for landscape quality over large areas (e.g. the vegetation-based NCI is widely used for this purpose in Hungary, and it has been proposed as a key sustainability indicator, KSH, 2008) However, to get a good spatial overview of the naturalness of a large area, vast quantities of plant/vegetation data are needed. Fortunately, in most of the Western countries there are several monitoring programmes and databases for plants available (Gonzales-Alonso et al., 2004; Schaminée et al., 2009).

Birds and plants are undoubtedly the two taxonomic groups most frequently used as biodiversity indicators. The importance of birds and plants as key indicator organisms in South-East European agricultural landscapes has also been confirmed (Sauberer et al., 2004). There are several studies where indicators of birds and plants were compared in various geographic and ecological contexts (Flather et al., 1997; Ricketts et al., 1999; Qian and Ricklefs, 2008), showing that bird- and plant-based indicators diverge at the local scale (<10 ha), but are well-correlated at relatively coarse spatial scales (>100 km^2) (Sauberer et al., 2004). Nevertheless, most of these studies are confined to Western Europe and North America, so there is little knowledge on this relationship in relatively diverse agricultural landscapes typical for Eastern Europe. There are many inherent differences in the application of birds and plants as biodiversity indicators. Birds, like many other large-bodied and vagile animals, require a mosaic of habitats to live, feed and breed, and thus can provide already an aggregated overview on the ecological state of the landscape. Sessile plants, on the other hand, convey information only about their immediate habitat, which offers a significantly higher potential for spatial resolution, but also needs a lot more data. Plants also exhibit a much higher taxonomical diversity with a more intensive spatial variation among local and regional flora. Consequently, instead of using single species or pure "community descriptors"(e.g. species number, Shannon diversity) for this purpose, most of the "useful" plant-based biodiversity indicators (e.g. Czúcz et al., 2012; Hill et al., 2002; Parkes et al., 2003; Winter, 2012) are created in a synthetic way, based on the conservation value and the main functional characteristics of the individual species.

This study compares landscape-level biodiversity indicators based on two popular taxonomic groups (plants and birds) in eight mosaic landscapes dominated by a mixture of agro-ecosystems and grasslands in Hungary, Eastern Europe. Whereas both species groups are elements of the same ecosystem, the inherent differences in how the underlying species use and perceive the landscape may result in highly different responses to processes like degra-