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Species diversity, pollinator resource value and edibility potential of woody networks in the countryside in northern Belgium

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ABSTRACT

Woody networks of hedgerows, tree lines and forest patches can harbour a high biodiversity and may serve as an important species refuge in agricultural landscapes. In order to protect the biodiversity and associated potential ecosystem services of woody networks, we need to understand their drivers. We surveyed the plant diversity and calculated the pollinator resource value and edibility value of 831 woody elements in 47 landscape windows of 1 km^2 in the countryside in northern Belgium. The woody network hosted approximately 45% of the plant diversity in the studied countryside, and forest species, grassland species, tall herbs as well as pioneer species coexisted successfully within the woody elements. The pollination resource value showed the highest correlation with the species richness and abundance of the forest species, whereas for edibility the species richness and abundance of the tall herbs were determinative. The number of forest species mainly depended on the presence of forests in the surrounding landscape and the link was even stronger in historical woody elements. For grassland species, tall herbs and pioneers, we found that structural variables of the woody element itself were the most important driver. We argue that by protecting existing woody elements and thoughtfully designing and locating new ones, intrinsic and functional diversity in the countryside can benefit well.

1. Introduction

Agricultural practices play a central role in the environmental quality of European landscapes (Rounsevell et al., 2003; EEA, 2010; Palmieri et al., 2011). About half of Europe's land surface is agricultural land, of which 94.4% is in conventional agricultural use (Samborski and Van Bellegem, 2013). Conventional practices create intensively managed agroecosystems and have a profound impact on the countryside's biodiversity. Nevertheless, a large share of Europe's biodiversity is intermingled to agricultural landscapes (Poschlod and Bonn, 1998), underlining the importance to counteract biodiversity losses also in these areas. The European 2020 biodiversity strategy (EC, 2015) postulates an increase in the contribution of agriculture to biodiversity, ecosystem functioning and the delivery of ecosystem services in the European Union. One approach may be conserving and managing the permanent or semi-permanent non-crop habitats (Baudry, 1988; Burel, 1996; Tscharntke et al., 2005, 2012; Bianchi et al., 2006) such as woody networks – i.e. the networks formed by small forest patches and linear habitats such as tree lines and hedgerows.

Historically, tree lines and hedgerows were planted and used for many purposes (e.g., livestock barriers, property markings, firewood provisioning). Along with the decline of these traditional functions, the total land surface covered by woody networks declined all over the world (Baudry et al., 2000). However, woody networks function as a semi-natural ecosystem in agricultural landscapes and provide a wide set of associated ecosystem services. Using the concept of ecosystem services is attractive because it helps us to describe how society is linked to nature as well as depends on its services (Haines-Young and Potschin, 2013). Harbouring intrinsic biodiversity, for instance, is an important ecosystem service provided by woody networks. Landscape-level plant species diversity likely increases when woody networks are present in an agricultural landscape (Freemark et al., 2002). With regard to fauna diversity, woody networks may provide nesting, foraging and resting areas for a range of invertebrates, birds, small mammals and their predators, many of which have a high protection status (Dover and Sparks, 2000; Butet and Leroux, 2001; Marshall, 2004; Sullivan and

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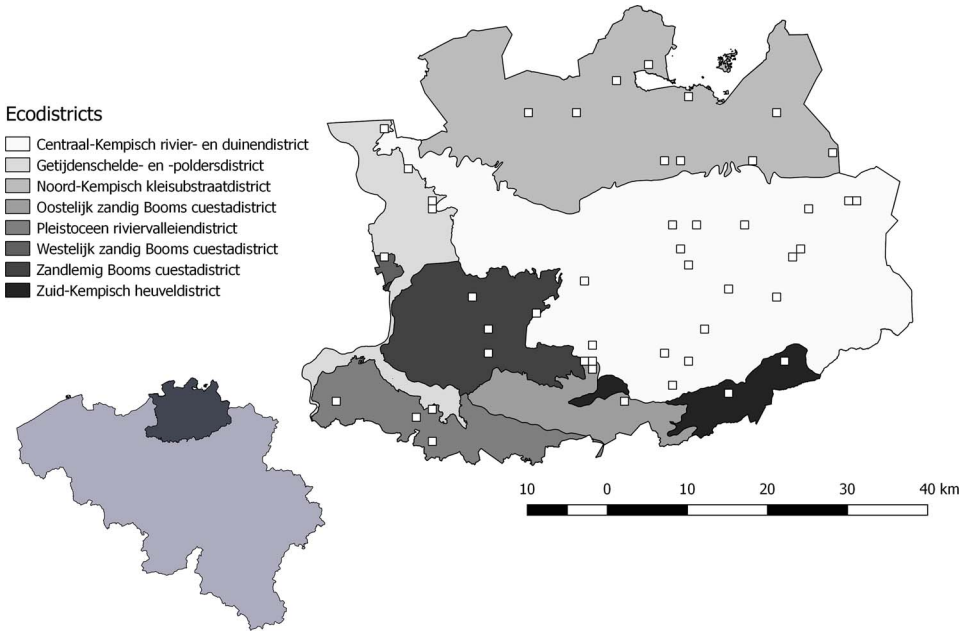

Fig. 1. Study area. The 47 square kilometre landscape windows in the countryside in the eight ecodistricts of the province of Antwerp (northern Belgium).

Sullivan, 2009). Other examples of ecosystem services delivered by woody networks in agricultural lands include their windbreak function through which they enhance crop growth in adjacent fields (Forman and Baudry, 1984), the reduction of soil erosion, floods and pesticide drift (Marshall and Moonen, 2002), the increase in organic matter content in adjacent fields (Wojewoda and Russel, 2003), the shelter they provide for predators useful in pest control (Dainese et al., 2017), and how they harbour pollinators that can provide pollination services (Morandin and Kremen, 2013). Although several studies have looked at ecosystem services of woody networks, little is known about the link between biodiversity and the associated ecosystem services in these woody networks. Plant diversity, for instance, might influence the potential for providing ecosystem services because plants, as primary producers, can have a bottom-up control on higher trophic levels (Siemann et al., 1998). The total species diversity, in turn, will affect the overall ecosystem functioning of the hedgerow seeing that a larger gene pool allows natural processes to be buffered against man-made threats (Barr et al., 2004).

We studied the herb layer of the woody network in the province of Antwerp, northern Belgium, a region with a high degree of urbanization and intensive farming. We focussed on the herb layer because it develops spontaneously, unlike the shrub or tree layer of woody elements that may have been planted. Seeing the lack in studies linking the biodiversity and ecosystem services provided by woody networks, we assessed the intrinsic plant diversity of the woody network and focussed on two characteristics of the vegetation linked to potential ecosystem services: value of the plants as a resource for pollinators (proxy for pollination) and edibility of the plants (proxy for wild food production). Services related to pollination are a highly relevant study topic as wild pollinator populations are threatened, mainly because of land use intensification and the associated loss of nesting places and food resources (Schulp et al., 2014a; Potts et al., 2010; Goulson et al., 2015). Wild food production is an iconic ecosystem service that receives little attention, especially in Europe, but Schulp et al. (2014b) argued to include 'gathering and consuming wild food' in the ecosystem service assessments of the European Union, as a cultural ecosystem service linked to recreation and sense of place. In addition, we tried to gain insight into the drivers of the herb layer diversity of the network elements and their value as providers of resources for pollinators and wild food, in order to provide input for adjusting management decisions aimed at maximising both the diversity and associated ecosystem services of woody networks. Our specific research questions were:

(1) For which plant functional groups do woody networks provide suitable habitats, and what is their importance for plant diversity in the studied countryside?
(2) What historical, landscape-related, structural and abiotic factors drive the plant species diversity (i.e. intrinsic biodiversity) of woody elements?
(3) What historical, landscape-related, structural and abiotic factors drive the pollinator resource value and edibility value (i.e. potential functional biodiversity) of woody elements?

2. Methods

2.1. Study area

The province of Antwerp is located in northern Belgium (2.867 km^2, 51°13′N, 4°24′E) and has a mild temperate climate with a mean annual rainfall of 778 mm and a mean annual temperature of 10.1 °C. The soils are mostly podzolic, from wet to dry and with a sandy to loamy texture. The province can be divided into eight 'ecodistricts', i.e. relatively homogeneous regions in terms of geology, soil, geomorphology and soil water dynamics (Sevenant et al., 2002). Using a 1-km^2 grid overlay, we selected 47 landscape windows through stratified random sampling, with the number of windows per ecodistrict proportional to the total area of the ecodistrict (Fig. 1). We only retained landscape windows in which the land cover of residential zone and industry was smaller than 50% to ensure we were mainly sampling the countryside. The agricultural land cover in the windows ranged between 45.0 and 71.3%, with an average of 56.2 ± 9.2% (see Appendix A for an overview of the land uses).

2.2. Inventory

Within each selected landscape window, we identified all woody elements on aerial photographs (AGIV, 2010) in a GIS environment (ESRI, 2013). A woody element was defined as a hedgerow, forest patch (< 0.1 ha), tree line or pollarded tree line that is homogeneous with regard to its herb, shrub or tree layer (for definitions, see Appendix B).