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Tree plantations are hot-spots of plant invasion in a landscape with heterogeneous land-use

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ABSTRACT

Invasion of alien plant species is one of the main reasons for biodiversity loss in terrestrial ecosystems. However, alien plant species are not evenly distributed in the landscape. We studied which factors determine the actual level of neophyte invasion in a landscape with heterogeneous land-use and which habitats are the most infected. Since neophyte species with different life-forms can respond differently to the factors determining the invasion, species groups of annual, herbaceous perennial and woody neophytes were also analyzed separately.

The study was conducted within the field site network of the Kiskun-LTER program (Hungary), in 16 sites of 5 km × 5 km. Fifteen habitat types were distinguished belonging to five major land-use/land cover types (agricultural land, abandoned agricultural land, tree plantation, semi-natural grassland and semi-natural forest). Present and past land-use, landscape composition and environmental variables were included as factors with a potential impact on the level of invasion.

The most important factor determining invasion level was present habitat type, followed by the past habitat type of the location and landscape context. Tree plantations, agricultural habitats and recently abandoned agricultural habitats had the highest level of invasion.

As expected, annual neophytes were most abundant in agricultural habitats, while perennial herbaceous neophytes were most abundant in old-fields and plantations, and woody neophytes in tree plantations. Past agricultural land-use was reflected in the higher levels of invasion of annuals and perennials, and past forestry practice resulted in higher levels of invasion of woody neophytes. In a landscape with a higher proportion of tree plantations, not only the tree plantations, but primary woodland patches also showed higher levels of invasion by woody neophyte species.

Our results indicate the importance of present and past land-use in plant invasion and suggest that tree plantations are hot-spots of plant invasion and threaten the remnants of semi-natural vegetation.

1. Introduction

Land-use change and invasion of alien species are two major drivers responsible for recent biodiversity loss in terrestrial ecosystems (Hobbs, 2000; Sala et al., 2000). The problem caused by alien invasion is often related to changes in land-use (Hobbs, 2000; Vilà et al., 2006, 2009): land-use influences the invasion process by creating and supporting optimal habitats for invaders and by enhancing actual propagule pressure through landscape compositional changes (Vilà and Ibáñez, 2011).

The level of invasion is defined as the number or proportion of alien species in a given habitat (Catford et al., 2012; Richardson and Pyšek, 2006). Comparison of habitats across regions revealed that habitats differ considerably in the level of invasion, and differences are consistent across different regions (Chytrý et al., 2008b). The level of invasion seems to depend more on the inherent properties of habitats (invasibility), than on the actual propagule pressure or the geographic location (Chytrý et al., 2008b). Habitats associated with high invasion levels are generally characterized by a fluctuating availability of resources either as a result of natural fluctuations (e.g. floodplains) or due to anthropogenic disturbance (Chytrý et al., 2008a, 2008b; Davis et al., 2000; Pyšek and Chytrý, 2014). Disturbed and intensively managed habitats support the highest levels of invasion both at the local (Chytrý et al., 2005; González-Moreno et al., 2014; Jauni and Hyvönen, 2010; Vilà et al.

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2007; Walter et al., 2005), and regional scales (Chytrý et al., 2008b, 2009).

Land-use and its change directly influence alien invasion through the alteration of habitat types (Hobbs, 2000). Beside the direct effect of changing habitat type, the indirect effects of land-use, such as landscape configuration and historical land-uses can be important in the invasion process (Vilà and Ibáñez, 2011). Therefore, these factors should also be taken into account when land-use planning and management decisions are made to control alien species (Cole et al., 2007; Thomas and Moloney, 2015). The landscape configuration can be an important factor determining the presence of alien species compared to local scale factors that have greater effect on species abundance (Vilà and Ibáñez, 2011). The main drivers from landscape configuration resulting in increased levels of invasion are: increasing fragmentation and decreasing habitat connectivity; intensification of land-use such as agriculture; urbanization; and the development of transport networks (Hobbs, 2000). The temporal sequence of land-use change can have diverse impact on invasion. For example, the type of land-use at the time of introduction of a given alien species, along with the direction of the land-use change (i.e. increasing or decreasing intensity of human disturbance) can have important effects (Vilà and Ibáñez, 2011).

Different groups of invasive species might respond differently to land-use change. For example species with a longer history of invasion in a given country (e.g. archaeophytes) depend more on the habitat type than recently arrived species (Pyšek and Chytrý, 2014; Vicente et al., 2014). This is probably due to their adaptation to agricultural management (Jauni and Hyvönen, 2010). Neophyte species having a shorter history of adaptation to the new environment and depend more on continuous propagule pressure (Chytrý et al., 2008b; Pyšek and Jarošík, 2005). Alien species belonging to different life forms, trophic levels or functional groups might induce different changes in the ecosystem structure or function. The establishment and expansion of different invasive groups (e.g. annuals, perennial herbs and woody species) might be a good indicator of invasion pathways and processes (Catford et al., 2012; Gassó et al., 2012; Thuiller et al., 2006).

Hungary, situated in a transitional biogeographic zone between deciduous forest and the forest steppe (Magyari et al., 2010; Zólyomi, 1974), has significant biodiversity, but also a high diversity of alien species. The number of recognized neophyte plant species was 715 in 2004 (Balogh et al., 2004). The problem of invasion is coupled with human landscape change (Török et al., 2003). In the Kiskunság region the landscape has been altered significantly: primary or secondary grasslands were transformed to tree plantations or arable lands while arable lands have been transformed to secondary grasslands or tree plantations. By the 21st century, almost fifty percent of 18th century open sand grasslands have been replaced by tree plantations (Biró et al., 2013). The present landscape is dominated by agricultural land, semi-natural grasslands and non-native tree plantations, resulting in a heterogeneous land-use pattern (Biró et al., 2013; Rédei et al., 2008; Rédei et al., 2011). Given the relatively homogeneous climatic conditions in the study area and the presumably uniform regional alien species pool, we hypothesize that the level of invasion would reflect the effect of present and past land-use. Our questions are:

1. What factors determine the level of neophyte invasion in a landscape with heterogeneous land-use?
2. Which habitat types are the hot-spots of plant invasion in this landscape?
3. Is there a difference in the factors that determine the invasion level of annual, perennial herbaceous and woody neophytes?

2. Materials and methods

2.1. Study area and sampling design

The study was conducted in the Kiskunság inland sand dune area, which extends to 7500 km^2, in the centre of the Pannonian biogeographic region. The climate of the region is moderately continental with a sub-Mediterranean influence. The landscape consists of the remnants of the forest steppe vegetation (Fekete et al., 2014; Magyari et al., 2010; Zólyomi, 1974) and cultivated land with changing land-use patterns (Biró et al., 2013; Csatári and Farkas, 2008). For more details on the study area see Csecserits et al. (2011) and Rédei et al. (2014).

Table 1
Overview of habitat types used in this study and their correspondence with the European Nature Information System (EUNIS).

Habitat name	Habitat codes	Number of relevés	EUNIS code
agricultural habitat			
croplands	AC	46	I1
vineyards and orchards	AV	29	G1.D
abandoned agricultural habitat			
old-fields abandoned 1–7 years ago	O1	35	E5.1
old-fields abandoned 8–20 years ago	O2	42	E5.1
old-fields abandoned 21–57 years ago	O3	40	E5.1
tree plantation			
locust (black)	PL	44	G1C3
pine (black and Scot)	PP	47	G3F2
native white and grey poplar	PN	39	G1C1
exotic poplar	PE	19	G1C1
oak	PO	17	G1C4
young plantations	PY	41	G5.7
semi-natural grassland			
open grasslands	GO	37	E1.994
closed grasslands	GC	46	E1.995
semi-natural woodland			
open woodlands	WO	37	G1.7A1
closed woodlands	WC	36	G1.7A1