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Research paper

Detailed study of a river corridor plant distribution pattern provides implications for river valley conservation

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A B S T R A C T

River valleys have been subjected to human-induced changes for centuries, but they are still considered regional hotspots of biodiversity. In central Europe, some vascular plant species demonstrate confinement to the corridors of large rivers. They are termed river corridor plants (RCPs). RCPs are an important component of regional biodiversity and include a high proportion of threatened species, thus they deserve attention. Here we examine: (1) the detailed distribution pattern of RCPs within a river valley, (2) the habitat preferences of RCP species, and (3) the correlation between the richness of RCP species and selected variables. The studied variables include: river bed proximity, distance from the river mouth, floodplain coverage, richness of native, red listed and invasive species, and number of habitats considered to be of Europaean Community importance. Surveys were conducted in 10 transects running perpendicularly to the San River bed (Poland, central Europe). Each transect was divided into 14 plots (1 km × 1 km). In each plot, the site locations of RCPs as well as their habitats were recorded. The occurrence of all vascular plant species in a particular plot was also noted. The richness and abundance of RCP species depended on the distance from the river and the floodplain coverage in a plot. The plots located in the vicinity of the river were the richest in RCP species and usually harbored the largest number of native, red-listed and invasive species. They were also characterized by the largest number of habitats considered to be of importance to the European Community. RCP species differed in the degree of confinement to habitats regarded as typical for them. Some of the RCP species were recorded only within typical habitats while others were found in several different types of habitats, including anthropogenic ones. Knowledge concerning the RCP distribution pattern and its correlates can make restoration initiatives in river valleys more effective. While implementing conservation measures in river valleys, one should keep in mind that: (1) hotspots of RCP and invasive species spatially overlap and (2) anthropogenic linear elements occurring within river valleys constitute important habitats for some RCP species.

1. Introduction

River valleys are very distinctive landscape elements covering a substantial proportion of land. They are the most important natural corridors (Forman, 1983) serving as migration routes for plants (Thébaud and Debussche, 1991; Johansson and Nilsson, 1993; Liu et al., 2006) and animals (Farrell, 2009; Cormier et al., 2013; Romanowski et al., 2013). River valleys are usually very rich in species, thus they are regarded as regional hotspots of biodiversity (Décamps and Tabacchi, 1994; Naiman et al., 1993; Tockner and Ward, 1999; Ward et al., 2001). Unfortunately, they have been subjected to severe human-induced changes for centuries (Décamps et al., 1988; Richardson et al., 2007). These mainly include: river flow regulation, water pollution, expansion of agriculture, building development and recreation. As a consequence, the vegetation typical of riverine floodplains in many European countries has lost a significant part of its original coverage, in some cases even up to 95% (Tockner and Stanford, 2002). Currently, an extensive legislative effort is being implemented in order to improve biodiversity conservation policies and the management of river basins and riverine habitats (e.g. EU Water Framework Directive). Twenty-one habitats typical of river valleys in Europe are considered to be of importance to the European Community (Council Directive 92/43/EEC). In 1992–2015, over 300 restoration or conservation projects in river valleys were co-funded by LIFE, which is the European Union's financial instrument supporting nature conservation (http://ec.europa.eu/environment/life/project/Projects/index.cfm).

In central Europe, 162 vascular plant species grow mainly or exclusively in the valleys of large rivers (Burkart, 2001; Nobis and Skórka, 2016) and are termed by Burkart (2001) as ‘river corridor plants’. River corridor plants (RCPs) include annual, biennial and perennial

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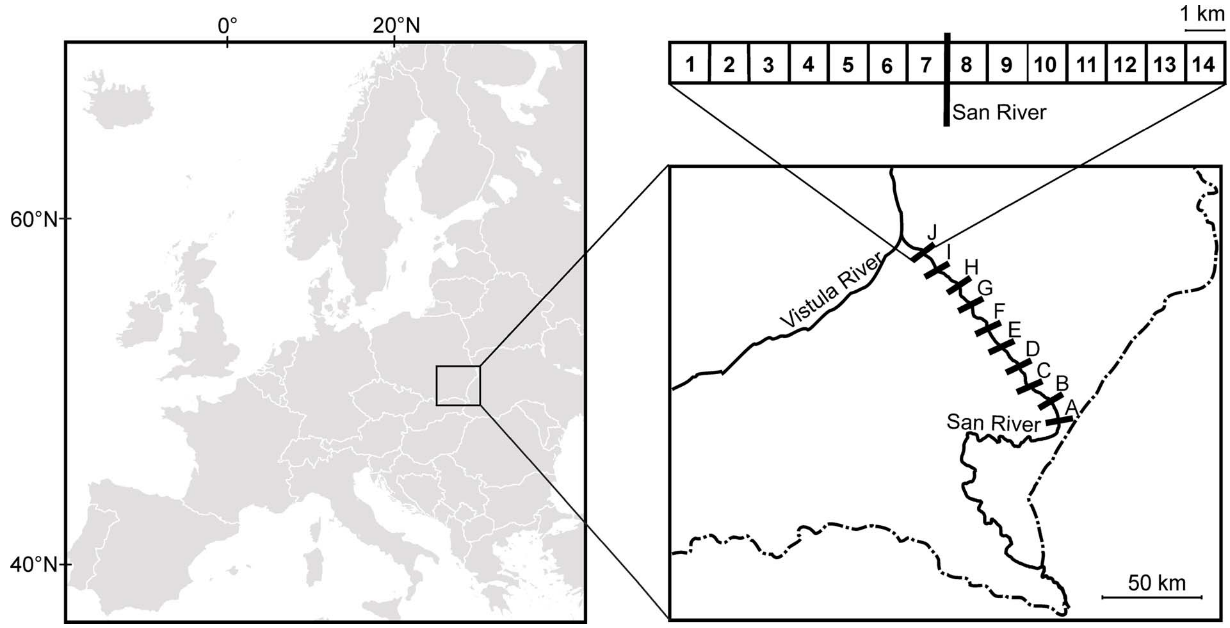

Fig. 1. Location of the study area and 10 investigated transects (A-J), each divided into 14 square plots.

herbaceous species, woody species, as well as hemiparasites and parasites. The group is also diverse in terms of habitat requirements (Burkart, 2001; Nobis and Skórka, 2016). The phenomenon whereby certain plant species display a river corridor distribution pattern has long been recognized by plant geographers (Ascherson, 1859, 1864), and different hypotheses have been proposed to elucidate the confinement of plant species to river corridors. Some researchers believed that hydrochory well explains the linear distribution pattern of RCPs (Ascherson, 1859; Loew, 1879). Others supposed that flood disturbances typical of river valleys are most important for plant distribution in river corridor (Jentsch and Seitz, 1997; Vent and Benkert, 1984). According to the summer warmth hypothesis, temperatures of the warm half-year within river valleys are higher than in neighboring areas, which is a factor determining the confinement of some species to river corridors (Müller-Stoll et al., 1962; Vent and Benkert, 1984). Moreover, differences in the nutrient supply in floodplains and in their surrounding areas imply that RCPs may require high nutrition levels (Fischer, 1996; Vent and Benkert, 1984). Some scientists considered that the feeding preferences of animals affect the distribution of RCPs (Hensgen et al., 2011). Others suggested that species confined to river corridors may differ from widespread species in their ability to form arbuscular mycorrhizae (Nobis et al., 2015). Finally, recent experimental studies provided hypothesis according to which RCP species are not able to benefit from the absence of flooding and the more benign soil conditions outside river valleys to the same extent as widespread species (Fischer et al., 2010).

Plant distribution maps available in national atlases enable us to determine whether a particular species is a RCP or the degree of its confinement to the river corridor (Nobis and Skórka, 2016). However, due to their scale (e.g. Haeupler and Schönfelder, 1988 – the grid cell 11 km × 11 km, Zając and Zając, 2001 – the grid cell 10 km × 10 km), they do not allow us to answer how the distribution pattern of RCPs changes across the valley and what is the main driving force behind the richness and abundance of RCP species within the river valley. Knowledge concerning the distribution pattern of RCPs is valuable because they include a high proportion of threatened species and constitute an important component of regional biodiversity. The detailed recognition of the RCP distribution pattern and its correlates may be very useful in making restoration initiatives in river valleys more effective, especially when we bear in mind that the frameworks for river valley management are still rather scarce (Richardson et al., 2007).

In designing the studies conducted in the San River Valley (SE Poland, central Europe), we addressed the following questions: (1) What is the detailed spatial distribution pattern of RCP species in a river valley? (2) What are the habitat preferences of RCPs in the studied area? (3) Which factors are related to the richness of RCP species in a river valley?

Since many RCP species are confined to riparian vegetation (Nobis and Skórka, 2016), we hypothesized that the richness and abundance of RCP species is positively correlated both with river bed proximity and floodplain coverage within partcular plots. We also supposed that the high richness of river corridor plants in plots adjacent to the river bed is synchronized with the high richness of both native and invasive plant species, because riparian zones harbor extremely high numbers of vascular plant species (Décamps and Tabacchi, 1994; Naiman et al., 1993; Tockner and Ward, 1999) and are simultaneously very sensitive to penetration by alien species (Brown and Peet, 2003; et al., 2008, 2009; et al., 2008, 2009). Owing to habitat type, we expected that the species compositions of plots located next to the river bed differ from those located away from the river. Finally, since a significant proportion of vegetation in central European floodplains has been replaced with croplands and/or urbanized a long time ago (Tockner and Stanford, 2002), we supposed that some of the RCP species (despite being native components of the flora) have become well adapted to anthropogenic habitats.

2. Methods

2.1. Study area

The San River is a tributary of the Vistula River (Fig. 1). It has a length of 457 km and is the 6th longest river in Poland. The mean annual river discharge at the confluence with the Vistula River is $123\ m^3\ s^{-1}$. The drainage area comprises approximately 17,000 km^2 (Czarnecka, 2005). The water-level regime of the river includes low-power spring flooding and subsequent lowering of the water level during summer.

The study was carried out in the lower course of the San River, flowing north-west in this section, from approximately N 49°46′/E 22°45′, elevation 196 m a.s.l., to N 50°44′/E 21°50′, at 137 m a.s.l. The annual growing season (definied as the number of days with temperatures exceeding +5°C) lasts 225 days (Ustrnul and Czekierda, 2003).