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Is the riparian habitat creation an effective measure of plant conservation within the urbanized area?

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ABSTRACT

The study presents results of habitat creation and riparian vegetation recovery in artificial oxbow lakes in urbanized area within the large river valley. The investigation of open water, rush and wet meadows flora and vegetation in three ponds located in the city centre of Opole was conducted in years 2001–2013. Oxbow lakes were constructed as a compensation measure and no vegetation was transplanted into the ponds on purpose. 13-years observation showed that (1) the red-listed species are able to spontaneous reoccurrence after habitat restoration, but they can thrive only in first years of oxbow lakes recolonisation process, (2) there are some restoration constraints, especially in relation to *Phragmites australis* and *Nuphar lutea* expansion, but alien species invasions were insignificant and (3) the species number and vegetation cover was constantly increasing during the recolonisation process in recreated oxbow lakes. The dynamic of vegetation was considerable, especially in first 6 years of experiment when the significant increase in diversity and richness of native plant species was observed. After that time, the increasing expansion of *P. australis* and *N. lutea* was noted causing the decline of several species and vegetation types. So, restoring just the environmental conditions may be sufficient for a limited period of time only. Strong disturbances, much intense that moderate inundations, imitating disastrous flooding within the valley each 10–13 years are need to maintain the ecological niches for river corridor and riparian species.

1. Introduction

Due to the richness of distinct plant and animal species, diversity of plant communities as well as significant decline of the number or quality of the oxbow lakes of large rivers in last centuries, these biotopes are valuable conservation areas in lowland Europe (Ot'ahel'ová et al., 2007; Erwin, 2009). This floodplain ecosystems are also recognized as one of the most susceptible to the climate change and are going to lose their functional capacity (Erwin, 2009). The needs of inland transport and the anti-flooding investments (ditches, dikes, embankments) cause considerable shrinkage of this type of habitats and as a consequence the withdrawal of many wetland species (Tockner and Stanford, 2002). As an example, in the southern Poland three main rivers, namely the Oder, Vistula and San were shortened by the river engineering works in the 19th century by about 20–30% (Tomiałojć, 1993; Jermaczek et al., 1996; Rast et al., 2000). Like in many other countries in Europe, the side lakes of the Oder River are subjected to strong impacts and influences. Among the most significant are enrichment of nutrients and eutrophication of water, often causing hypereutrophication. The stream channelization and flow regulation have also altered significantly the water regime of rivers. Along with this man-made changes of river floodplains, it is also worth considering that the surrounding of oxbow lakes has changed through centuries from forested areas, followed by grasslands to intensively used arable fields nowadays. The strong impact of agriculture combined with anti-flooding constructions make the oxbow lakes the last refuge for many wetland species (Gallardo et al., 2012; Knight et al., 2013). The habitat is protected by the EC Habitat Directive 92/43/EEC. Many endangered or rare species and plant communities have been found here. For example in Poland, the most valuable plants are *Corrigiola litoralis*,*Carex buekii*, *Cnidium dubium*, *Thalictrum flavum*, *Mentha pulegium*, *Leonurus marrubiastrum*, *Euphorbia palustris*, *E. lucida*, *Wolffia arrhiza*. There are also many other typical river valley plants of more frequent distribution like *Alisma lanceolatum*, *Allium angulosum*, *Butomus umbellatus*, *Eryngium planum*, *Melampyrum*

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cristatum, *Scrophularia scopoli*, *Stratiotes aloides*, *Symphytum tuberosum* and others (Burkart, 2001; Nobis and Skórka, 2014). Also several important vegetation types still occur within the valley on the Opole Silesia section.

After the disastrous flood in southern Poland in 1997, the central and regional authorities implemented a modernisation programme of hydrotechnical systems alongside the Oder River (Oder 2006 programme). The rebuilding of "hydrotechnical node Opole" was a part of this project which main goal was to increase the water capacity of the river valley during the inundations. As it was enumerated in the project, the regional authorities build new water embankments and a new bypass channel. As a result two oxbow lakes have to be eliminated. During the environmental impact assessment procedure the creation of three artificial oxbows has been imposed on investor as a compensation measure.

The main goal of this study is to assess the vegetation changes and population dynamics of target species in these artificial oxbows. After habitat recreation, we started observations of the secondary succession to determine the directions of vegetation changes and predict the longevity of that kind of artificial reservoirs. At the beginning of our study it was hypothesised that the secondary succession would start shortly after recreation of oxbow lakes. The fast colonisation by different therophytes and anthropophytes as well as expansive native species and alien invasive species would happen on the lake banks. We expected also that spreading of expansive native plants like *P. australis* and increasing participation of alien invasive plants (common in the Oder valley) would occur after about 5 years further. However, we were not sure what the succession rate and the dynamics of distinct species populations would be.

To assess the vegetation changes and population dynamics of target species in restored three artificial oxbow lakes, we are going to answer the following questions: (a) what is the diversity, composition and dynamics of vegetation in created oxbow lakes? (b) what are the restoration constraints, especially in relation to the *P. australis* expansion and alien species invasion in urbanised areas? and (c) are the red-listed species capable of spontaneous reoccurring after the habitat creation?

2. Methods

2.1. Study area

The Oder river is crossing the Opolskie Province in a valley of different width, approximately 1 km in Morawa Gate and about 12 km in the central part of the regional section (Badora, 2001). The valley area had been intensively changed by humans already in Middle Ages. The river was used for transport, sailing and rafting. During those times many woodlands were changed into agricultural plots and the river was partially regulated (Rast et al., 2000). Today, the Oder valley landscape is a mosaic of forest patches, meadows, pastures, rushes, mud vegetation, arable lands, as well as dry grasslands developed on slopes of the valley margins and anti-flooding embankments. Because of the frequent floods in the city area in the second half of the 19th century in western part of the city the by-pass channel "Ulga" was built within the Odra River valley. The channel is about 6 km long, 200 m wide and is embanked on both sides.

The three artificial oxbow lakes were dug between the Ulga channel embankments within the Oder River valley in central part of Opole in 2000 (Fig. 1). They have a rectangular shape, depth of 1.8 m and different surface area: 740 m^2, 890 m^2 and 2070 m^2 (reservoirs 1, 2 and 3, respectively (Fig. 1)). The artificial oxbows were dig in the wings of the Oder valley in close vicinity of the Ulga Channel (about 30 m). Before the habitat creation works, the area was covered by the anthropogenic grassland with the dominance

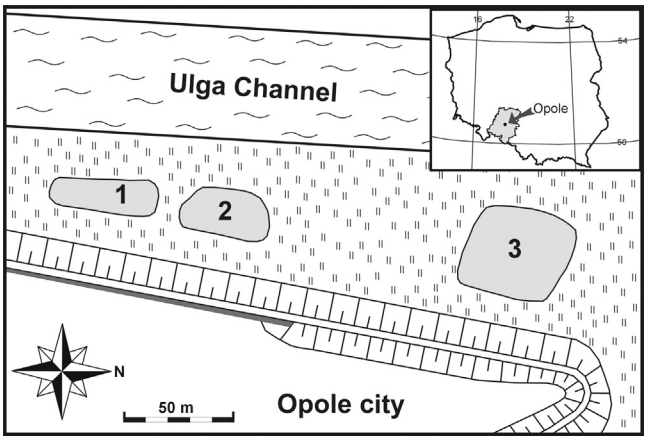

Fig. 1. The location of research area in Poland.

of species typical to fresh meadow *Arrhenatherion elatioris*. The main contributors were *Centaurea jacea*, *Poa trivialis*, *P. pratensis*, *Galium mollugo*, *Lathyrus pratensis*, *Leontodon autumnalis* and *Arrhenatherum elatius*. Only a very narrow margin of the Ulga Channel stream was sparsely overgrown by rush vegetation with *Bolboschoenus maritimus*, *P. australis* and *Scirpus lacustris*. The aim of the lake digging was to create a substitute habitat for two natural oxbows of the Oder River undergoing destruction due to anti-flooding works within floodplain, about 4 km upstream. No plant translocation measures were taken after digging so the vegetation was spontaneously re-established with no conservation support. The area is regularly inundated by flooding waters. During the research, the inundations were observed each year between May and July, however with no destruction of vegetation cover occurred. The last catastrophic inundation took place in 1997.

2.2. Sampling

Monitoring of spontaneous plant colonisation in the restoration site started in 2001 (i.e. the second growing season after habitat creation). Plant species composition and cover were sampled in fourteen 2 m × 2 m plots distributed along 3 transects in each artificial oxbow lake (Fig. 2). The examined plots cover all types of wetland habitats, i.e. open water, rushes, edge vegetation (meadow or tall-herbs) and mud vegetation. Altogether 42 plots were sampled in 2001, 2002, 2003, 2005, 2007, 2009, 2011 and 2013. The

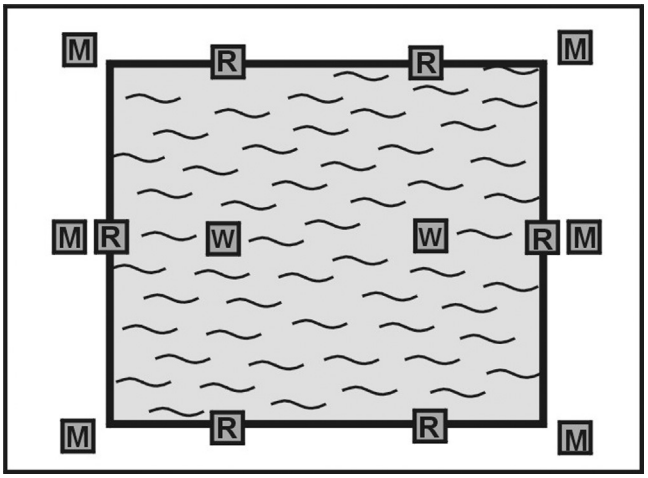

Fig. 2. Sampling design of the research in a one oxbow lake. Explanations: W-aquatic (water) plot, R-riparian plot, M-meadow plot.