Floodplain restoration by dike relocation along the Elbe river and the need to monitor the effects

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1 Moore room for rivers - an introduction

In Europe, floodplain landscapes in the 21st century are characterised by fragmented habitats and depauperate communities. Since the Middle Age, floodplain forests were cleared and replaced by pasture and arable land or have been used for urbanisation. Many anthropogenic alterations to river systems such as the flow regulation for navigation and the building of dikes for land reclamation or flood protection have disrupted the lateral connectivity of river systems, leading to the disappearance of 70 to 90% of active floodplains of large rivers (Brunotte et al. 2009). The loss and degradation of floodplain habitats, as well as organic and chemical pollution and invasive species are major factors responsible for the decline of floodplain biodiversity (Tockner & Stanford 2002). Trade-offs exist between the conservation of floodplain ecosystem biodiversity and the human use of floodplain goods and services (MEA 2005; Dudgeon et al. 2006). Floodplains offer a remarkably diverse array of natural functions and services for humans; more than any other ecosystem type (e.g. Costanza et al. 1997; Maltby et al. 2009). Active floodplains have the ability to act as filters for sediments and dissolved pollutants (sinks), flood retention areas and natural habitats for highly specialised flora and fauna. Floodplain management and restoration measures should take into account the multidimensional structure of riverine ecosystems. Developing more natural riverine systems and improving the connectivity are key issues for floodplain restoration projects. Creating more space for rivers in floodplains by dyke displacement allow combining flood protection and ecological rehabilitation (Buijse et al. 2005; Scholten et al. 2005; Blackwell & Maltby 2006). At the German Elbe, reactivations of former floodplains are planned at 15 locations and will encompass 2,600 ha (ICPE 2003). However so far, implementation only occurred at three sites in UNESCO-Biosphere Reserve Riverine Landscape Elbe and covering a total surface of 580 ha (Scholz et al. 2009b). The involvement of the different stakeholder groups, nature conservation organisations and local people are essential for the acceptance and achievement of such integrated management approaches (Puhlmann & Jährling 2003; Moss & Monstadt 2008). Ecological motivation for floodplain restoration is the re-establishment of the hydrological processes to improve the dynamics and functions of floodplain ecosystems and restore their biodiversity. However, higher connectivity with the river may also increase nutrients and pollutants inputs (Lamers et al. 2006). Thus, a long-term monitoring of the effects of dike relocation or creation of new retention surfaces is a prerequisite for successful restoration of further floodplain areas.

In this paper we present an innovative multidisciplinary research design to study the effects of the first large-scale floodplain restoration project realised at the German River Elbe – the Rosslau dike relocation.

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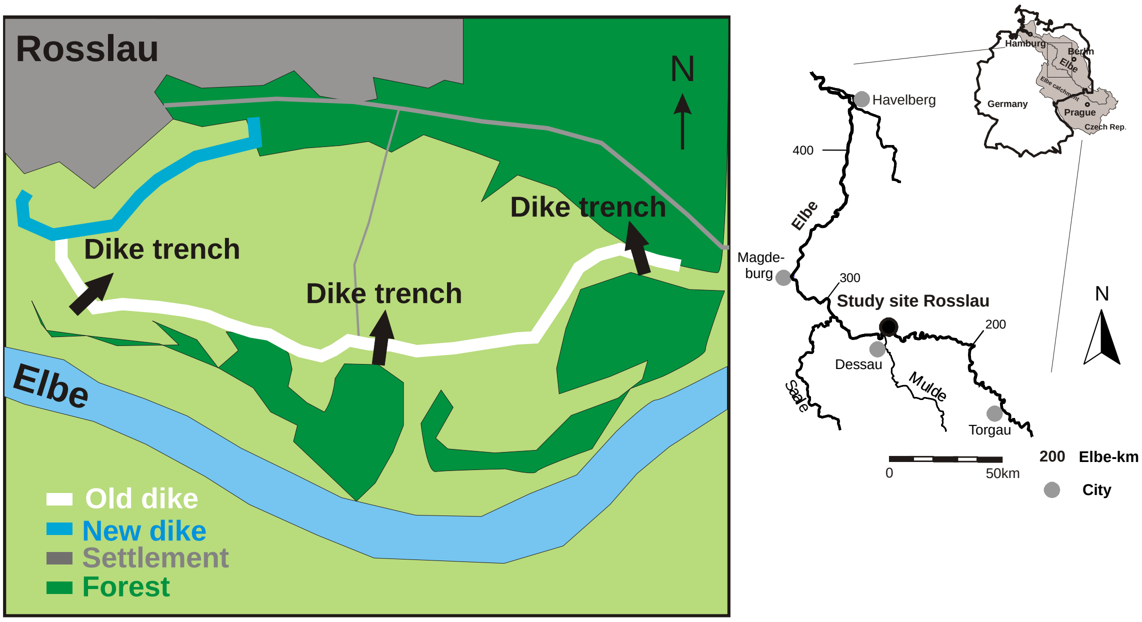

Figure 1. *Dike relocation „Rosslauer Oberluch“ Middle Elbe*

2 Dike relocation in the Rosslauer Oberluch

The first large implemented floodplain restoration project along the German Elbe was realised in 2006 in the city of Dessau-Rosslau after a planning phase of 15 years. In Rosslau, the high restoration costs of the old dike line motivated the stakeholders to build a less expensive smaller dike close to the city, and to reopen the former floodplain at three locations (fig. 1). Today the 140 ha of reconnected floodplain are used for flood retention, agriculture (grassland), forestry, drinking water supply, and as recreation area. Nevertheless, the Rosslau area showed already in the beginning of the project a high restoration potential and hosted diversified floodplain habitats (alluvial grasslands, reeds, riparian forests, and permanent or temporary water bodies). Former arable land has been transformed to extensive riparian grasslands and plantations of floodplain forest already in the beginning of the planning phase during the 1990s (Scholz et al. 2009b).

3 Monitoring approach

Since spring 2006, a multidisciplinary research platform for floodplain ecology is established by the UFZ as a part of the TERENO-Program (=TERrestrial ENviromental Observatoriato) to study short-term and long-term effects of floodplain restoration on floodplain ecosystem services and functions in the Rosslau area. A BARCI approach (Before-After/Reference-Control-Impact design (Lake 2001) with a stratified, randomised study design developed and tested in the RIVA project and HABEX project (Henle et al. 2006; Scholz et al. 2009a, b) sets the scientific basis to all participating disciplines and is to be considered as the core of the research platform. According to the BARCI approach, three different sub-areas have been chosen: restoration area, untouched active floodplain (reference area), and former inactive floodplain (control area). The stratified, randomised study design with interdisciplinary study plots covers flood-channels and depressions; wet grassland; and mesophilous grassland. The rationale behind the stratification was to capture the full range of hydrological conditions and to distribute the plots approximately evenly across this range, despite great differences in the area. The Rosslau project requested that every scientist has to work on the same plot, thus enabling a proper study of the relationships between the different kinds of data. It allows representative monitoring data and repeated surveys of the same plots for biotic (molluscs, insects, vegetation) and abiotic (soil, nutrients, pollutants, hydrology) factors. All the locations for sampling abiotic and biotic data were restricted to fixed locations within the 30m x 15m study plot. The localities for the different botanical, zoological, and soil surveys within plots are shown in figure 2. Since in floodplains the elevation is of paramount ecological importance, we oriented each plot to minimize elevational heterogeneity within plots.

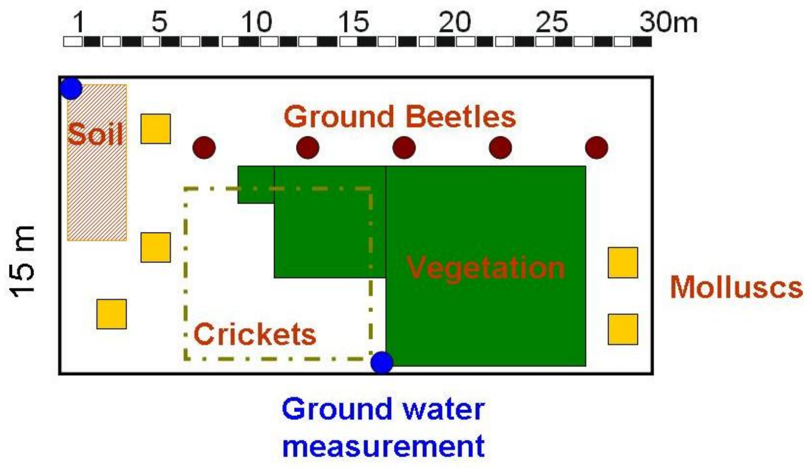

Figure 2. *Standard survey plot (Henle et al. 2006, modified)*

4 Bioindicator species groups

Suitable and effective bioindicators have to fulfil general criteria in two ways: firstly, economic and logistic suitability (time- and cost-efficiency, personnel and knowledge requirements) and secondly, biological efficiency (taxonomic, sensitivity, and variability criteria) (Dziock et al. 2006; Scholz et al. 2009a). In the Rosslau project, four species groups were chosen: vascular plants, molluscs (shelled snails and mussels), carabid beetles, and grasshoppers. Other studies on bioindication in floodplains have also adopted these groups (e.g. Murphy et al. 1994; Henle et al. 2006), indicating their abundance in floodplains and their high indicatory relevance for ecological changes in floodplains. Additionally, these species groups cover a wide gradient of mobility. Plants move only by distributing their diaspores, molluscs are slow and often passively distributed by water, carabides can run quite fast on the ground, some species can fly, and grasshoppers are quiet mobile insects including seasonal migrants. The wide gradient of mobility should be advantageous, because the degree of mobility determines the strategy for how a species copes with flooding (Lytle & Poff 2004). Immobile species need adaptations to withstand seasonal or erratic floods, or their occurrence is restricted to the uppermost parts of the floodplain. Mobile species can more or less avoid longer contact with the water by moving to drier places. The species groups have in common that they are sensitive to changes in flood regime and can tolerate the high nutrient input by the river typical for active floodplains. They contain species that have a strong relationship to hydrological variables on a small scale, which is one of the pre-assumptions to use them for bioindication (Henle et al. 2006). Independently from the plots we are doing a survey of amphibians (highly mobile, sensitive to landscape context) and mosquitoes (possible disease vectors) on temporary and permanent waterlog water pools. These habitats are the key habitats for their reproduction and therefore predominant for the meta-population of these species groups in the study site.

5 Abiotic Data

Additionally to the biotic data we are gaining abiotic data in the field. Soil variables are obtained in the field (e.g. soil type) as well as in the laboratory (e.g. grain size, nutrients or C/N ratio). Grassland management shows considerable differences in cultivation among and within the study sites (depending on their relief). For example, on the uppermost flat parts, grassland use is more intensive compared to the flood-channels, which are not accessible for agricultural machines. Under the assumption of stable conditions of land use, water variables were assumed to be the most important environmental factors determining species occurrence and abundance in floodplains. In most cases, they are also most difficult and time-consuming to measure, making them a most important potential focus for measuring the restoration efforts. Hydrological variables (groundwater and inundation) were measured at least fortnightly using gauges in each of the 36 study plots. Data analysis is applied to obtain inundation, groundwater depth, minima, maxima, amplitudes, means, and standard deviations for biologically relevant time periods.

6 Outlook and conclusions

Until now, for all disciplines a (Status Quo) pre-flood survey was successfully carried out. The soils of all study areas showed typical features of floodplain soils. Mollusc communities differed between the 3 sub-areas, being more diverse in the active floodplain; whereas ground beetles and grasshopper community composition mainly depended on small-scale morphological features. Vegetation is more diverse in the restoration and reference areas than in the active floodplain where nutrient loads from the Elbe may favour nitrophytes (Scholz et al. 2009b). First flooding of the restoration area by the Elbe occurred in spring 2009 and 2010 and the field monitoring is ongoing. However, to assess the effects of the dyke relocation on biodiversity, a long-term monitoring is needed.

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