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Long-term effects of large-scale grazing on the vegetation of a rewetted river valley

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ABSTRACT

Large-scale, low-density grazing is a standard management concept for conserving or enhancing biodiversity in cultural landscapes of central Europe. Documentation of results concerning effects of this type of grazing on biodiversity and functioning of degraded river valleys, however, is rare. For a period of ten years, we investigated vegetation development of three pastures in a river valley of northern Germany, where rewetting was combined with large-scale cattle grazing for restoration of the valley's biodiversity as well as its water and nutrient regulation. The study yielded ambiguous results concerning achievement of restoration goals. Changes in plant diversity were dependent on site conditions and on previous land-use of the associated pastures. On mineral soils, species richness, total species number and β-diversity increased. On fen soils that formerly were species-poor wet grasslands, an increase in species richness was observed, whereas at sites formerly of species-rich vegetation, species richness decreased. Development of β-diversity showed no clear trend on fen sites. Establishment of woody species as indicator for enhanced structural heterogeneity was successful on mineral soils of abandoned arable fields with an open sward, and also on fen soils close to mature nursery trees. We conclude that a fine-tuning of factors influencing grazing behaviour of cattle is necessary for achieving simultaneous targets of nature conservation and resource protection. Restoration of river valleys in cultural landscapes is however a lengthy process, thus, long-term monitoring is indispensable for avoiding mismanagement.

1. Introduction

In central Europe, structure and functions of nearly all river valleys have been impacted by anthropogenic activities as riverbed straightening, dam and dike construction, floodplain drainage, and land-use intensification (Jensen et al., 2006; Krause et al., 2011; Lamers et al., 2014). Thus, many of these systems have lost completely their functions as water and nutrient regulators, and their characters as exceptionally high biodiversity habitats (Kimmel and Mander, 2010). Only a few river valleys continue to maintain a near-natural character, thanks to moderation in both land-use and artificial drainage. These valleys occur usually in the upper courses of rivers. They harbour many typical species of semi-natural ecosystems, including dry grasslands on the slopes and fen grasslands in the floodplains. Today, because of land-use intensification and/or abandonment, they are counted among the most endangered ecosystems of central Europe (Tockner and Stanford, 2002; Rosenthal, 2010).

In central Europe, restoration of degraded river valleys aims most frequently at two targets: (a) reestablishment of ecosystem services (flood mitigation, nutrient retention, carbon sequestration by peat-forming species); and (b) restoration of species-rich, semi-natural habitats (Van Diggelen et al., 2006). The first requires maintenance of the water table near and above the soil surface by closing ditches, discontinuing pump stations, and/or remeandering of straightened rivers (Hoffmann and Baattrup-Pedersen, 2007; Pedersen et al., 2007; Lorenz et al., 2009). Vegetation developing after these measures usually consists of *Phragmites*-reeds, tall-sedge reeds and, at locations without long flooding periods during growing season, also of alder carrs (Schrautzer et al., 2013). The second target can be achieved only via maintenance or re-establishment of management measures preserving the open

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vegetation structure of the landscape. Applicable measures include mowing 1–2 cuts per year without fertilization, or grazing with low stocking densities (Grootjans et al., 2002; Middleton et al., 2006). Such measures are often combined with moderate re-wetting, topsoil removal for reduction of nutrient availability, and, in highly degraded species-poor systems, the support of plant dispersal via seeding or hay transfer (Klimkowska et al., 2010). Such efforts have been successful in the establishment of early-successional species such as low-productive, light-demanding species of mesotrophic fen grasslands (Rasran et al., 2007; Schrautzer et al., 2007; Lamers et al., 2014) and low-productive dry grassland species on slopes with mineral soils (Lederbogen et al., 2004). Disadvantageous to these management concepts is their costly implementation.

Another nature management practise now commonly accepted in central Europe is large-scale, low-density cattle grazing. In accordance with Rosenthal et al. (2012), we define this concept as a type of land-use which is applied on large pastures (at least 10 ha) with a stocking density that is adjusted to seasonal fodder shortages due, for example, to summer drought or strong winter cold. Its target is the development of a mosaic of successional stages (Olff et al., 1999; WallisDe Vries et al., 2002; Riecken et al., 2004), focusing on improvement of species diversity at landscape scale (β-, γ-diversity). Low-density grazing with domestic herbivores replaces the positive effects of former natural disturbances (fires, floods, grazing by megaherbivores) on biodiversity, and thus contributes to the conservation of light-demanding, low-productive species (Plachter and Hampicke, 2010). Furthermore, a pre-condition for the enhancement of diversity on the landscape scale is the simultaneous development of late successional stages consisting either of tall-growing herbaceous species or of woody species. A key process in this regard is the so-called "thorny shrub succession," which describes the establishment of deciduous trees under the protective shield of thorny shrubs such as *Crataegus* spec. and *Prunus spinosa* (Olff et al., 1999) or *Rubus fruticosus* agg. (Kuiters and Slim, 2003).

A comprehensive survey of existing large pasture landscapes in Europe has been published by Redecker et al. (2002). Effects of large-scale grazing on biodiversity have been reviewed by others (Danell et al., 2006; Bunzel-Drüke et al., 2008; Gordon and Prins, 2008; Plachter and Hampicke, 2010; Rosenthal et al., 2012). However, in river valleys of central Europe, grazing has seldom been applied for the purpose of improving biodiversity (Couvreur et al., 2004; Ausden et al., 2005; Moran et al., 2008), the reason being that in most cases for conservation purposes, mowing was preferred (Bakker et al., 2002; Härdtle et al., 2006; Kolos and Banaszuk, 2013). Particularly on large pastures with high habitat heterogeneity, such as river valleys, grazing behaviour of livestock is affected by complex interactions between biotic (forage quality and supply, plant species composition), abiotic (water supply, soil moisture, topography of the pasture etc.), and animal-related (animal species, breed, animal health) parameters (Schaich et al., 2010a; Rosenthal et al., 2012). Overall, monitoring results for implementation of large-scale cattle grazing in rewetted river valleys in central Europe are rare (Pedersen et al., 2007; Schaich et al., 2010b). In this ten-year study, we investigated vegetation development in the upper Eider valley (northern Germany), where restoration aimed at the parallel optimization of several ecosystem functions. Rewetting of fens in combination with large-scale, low-density cattle grazing was conducted to improve the nutrient retention capacity of the valley and to foster biodiversity. In detail we aim to answer the following questions:

- How does large-scale, low-density cattle grazing affect species richness and development of target species in a rewetted river valley?
- Does β-diversity as an indicator for structural heterogeneity increase after implementation of large-scale grazing?
- Under which conditions can the establishment of woody species be expected?
- Which factors influence grazing intensity?
- How can this information be useful for management of river valleys in central Europe?

2. Project area and study sites

The river Eider originates in the eastern Pleistocene region of the northernmost German regional state of Schleswig-Holstein. The climate of the region is sub-oceanic with a mean yearly temperature of 8.4 °C and a mean yearly accumulated precipitation of 791 mm.

The project area (Fig. 1) is about 400 ha and is located ca. 15 km south west of Kiel in the upper course of the river. It is a typical river valley of northern Germany containing fens of varying hydrology relative to groundwater recharge and discharge in the floodplain, and mesic grasslands on the mineral soils of the slopes. Beginning in the middle of the 19th century, anthropogenic changes to stream course, his deepening of the riverbed and establishment of drainage systems have altered the valley's hydrology. Strong groundwater inflow to the valley, however, has restricted the potential for further land-use intensification,

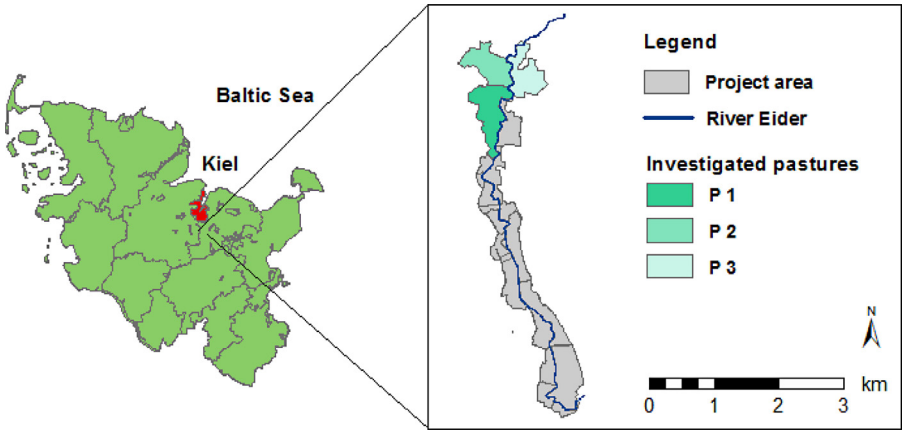

Fig. 1. Location of the project area (Upper Eider Valley, N-Germany) in the regional state of Schleswig-Holstein and the selected three pastures (P1–P3).