Ecological Engineering 102 (2017) 501–508

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

Filling up the gaps—Passive restoration does work on linear landscape elements

Orsolya Valkó[a], Balázs Deák[a,*], Péter Török[b], András Kelemen[b,c], Tamás Miglécz[a,c], Béla Tóthmérész[a]

[a] MTA-DE Biodiversity and Ecosystem Services Research Group, Egyetem tér 1., Debrecen H-4032, Hungary
[b] University of Debrecen, Department of Ecology, Egyetem tér 1., Debrecen H-4032, Hungary
[c] MTA's Post Doctoral Research Program, MTA TKI, Nádor utca 7, Budapest, 1051 Hungary

ARTICLE INFO

Article history:
Received 23 November 2016
Received in revised form 3 February 2017
Accepted 18 February 2017
Available online 6 March 2017

Keywords:
Alkali grassland
Channel
Grassland restoration
Linear landscape element
Succession
Steppe

ABSTRACT

Open landscapes in many parts of Europe have been negatively affected by large-scale drainage and amelioration to support agricultural production. In continental alkali grasslands, amelioration and establishment of drainage ditch systems were typical in the 1950s and 60s. Drainage ditches caused a considerable fragmentation and degradation of natural grasslands; thus several projects aimed at eliminating these linear landscape elements. In a multi-site study, we explored the drivers of grassland recovery after soil-filling of drainage ditches in landscape-scale restoration projects in Hortobágy National Park, East-Hungary. Ditch embankments, formerly built from the excavated soil, were used to fill the 8-m wide ditches and grazing was applied to facilitate the recovery of grasslands similar to the surrounding matrix. Three age classes were selected for the study: 1-, 6- and 8-year-old filled ditches; with nine sites per age group, surrounded by three grassland types (27 ditches in total). We recorded the percentage cover of vascular plant species in 18 plots per ditch, 486 plots in total. We found that the species pool of the filled ditches became more similar to the reference grasslands with increasing successional age and increasing distance to the central zone of the ditches regardless of grassland type. Species richness of the filled ditches became more similar to that of the reference grasslands with increasing successional age. However, we found that several target species, especially salt-tolerant pioneers, could establish even in the first year. Grassland recovery was most successful in sites adjacent to dry grasslands characterised by soils with high salt content, which favoured specialist species and suppressed non-target species. Cover of non-target species was higher in wet meadows with moist, nutrient-rich soils which favoured generalists and non-target species. Our study revealed that passive restoration after soil filling of disused drainage ditches can effectively support grassland recovery even within less than ten years, when restoration sites are surrounded by natural grasslands.

1. Introduction

Parallel to the increasing level of infrastructural development, the area covered by linear landscape element networks is rapidly increasing worldwide. Roads, railways, electric wires, pipelines, dams, ditches and channels are the main elements of this network. For instance, the total length of the road network is longer than 64 million km in the World and we can expect its marked increase in the near future (van der Ree et al., 2015). A common feature of these linear landscape elements is that their construction and operation is usually associated with intense human disturbance, which results in a serious loss of natural habitats (Fahrig, 2003). In many cases these linear structures facilitate the dispersal of disturbance-tolerant or invasive species (Deák et al., 2016a). Moreover, they reduce habitat connectivity and often act as barriers for the movements of plant and animal populations (Hoenke et al., 2014; Wu et al., 2013). Fragmentation of formerly connected habitats affects landscape traits and ecological processes at multiple scales by altering habitat characteristics, community structure and population dynamics of species which generally leads to the decline of biodiversity (Deák et al., 2016b; Dolt et al., 2005; Ewers and Didham, 2006). These negative effects are well studied for roads (van der Ree et al., 2015), but much less attention has been paid to the effects of drainage ditch systems on biodiversity.

* Corresponding author.
E-mail address: debalazs@gmail.com (B. Deák).

http://dx.doi.org/10.1016/j.ecoleng.2017.02.024
0925-8574/

Strategic conservation planning is essential for mitigating the negative effects of linear landscape elements on natural ecosystems. It is crucial to assess the ecological consequences of the establishment of the existing items as well as to eliminate the disused ones (Bulot et al., 2014; Coiffait-Gombault et al., 2011; Hoenke et al., 2014). The elimination of disused linear landscape elements can be an effective and fast way of landscape-scale restoration if methods are fine-tuned and consider local circumstances. In areas where the ratio of natural habitats (i.e. propagule sources of target species) is high, we can expect a fast recovery of natural habitats after the elimination of linear landscape elements. By this approach, we can improve landscape-scale ecosystem functioning by enlarging existing natural habitats and re-establishing connections between them (Freund et al., 2014; Török et al., 2012; Zulka et al., 2014). The successful restoration of landscape connectivity includes three major steps (i) site preparation by removal of linear structures and landscape scars; (ii) supporting the establishment of target species, and (iii) post-restoration management to sustain and improve the diversity of recovered habitats (Freund et al., 2014; Kelemen et al., 2014).

The quality of the surrounding habitat matrix is a crucial factor of restoration success. When propagules of target species and dispersal vectors are provided in the surrounding matrix, establishment of target species is usually fast in the recovering habitats. In such cases, passive restoration can rely on locally available propagule sources (e.g. seed bank or seed rain; Prach and Řehounková, 2008; Török et al., 2011), offering a cost-effective and natural way of recovery. Thus, spontaneous recovery is expected to be faster in landscapes harbouring natural habitats, where propagule sources and dispersal vectors are present (Albert et al., 2014).

Several open landscapes in Europe have been affected by large-scale drainage and amelioration works in the past centuries to support agricultural production (Blann et al., 2009). For instance, 34% of farmland in Northwest Europe has been modified by drainage (Abbot and Leeds-Harrison, 1998). Worldwide, drainage systems are present on one third of the total land area, where the lack of the natural water supplies constrains agricultural production (Smedema and Ochs, 1997). In many cases drainage activities have not resulted in the desired increase in agricultural productivity, and thus drainage ditches can be removed. In such cases, soil filling of disused ditches can increase landscape aesthetic values and enhance landscape connectivity (Blomqvist et al., 2003). Grassland recovery on these linear landscape structures offers a unique opportunity to study the effects of the surrounding habitat matrix on grassland regeneration potential. Linear structures have a high perimeter/area ratio, which increases the establishment rate of target species via vegetative dispersal or seed rain from the surrounding matrix (Deák et al., 2015). Thus, grassland recovery is expected to be fast on narrow and linear soil surfaces surrounded by target grasslands.

We studied grassland recovery after soil-filling of drainage ditches in landscape-scale restoration projects in Hortobágy National Park, East-Hungary. The study area holds one of the largest open landscapes in Europe covering about 82,000 ha (Deák et al., 2015). The aims of the restoration projects were to restore former landscape connectivity by eliminating disused drainage ditches by soil-filling, to restore grasslands on the ditches, and to sustain the recovered grasslands by grazing. The overall aim of the restoration projects was to recover grasslands similar to their surrounding matrix, i.e. to grasslands adjacent to the filled ditches. Grassland recovery on soil-filled ditches is expected to be fast, since filled ditches are linear and narrow, their surrounding matrix consists of natural grasslands, and dispersal vectors, i.e. grazing livestock are present in the landscape (Deák et al., 2015; Tóth et al., 2016).

2. Aims of the study

Landscape-scale restoration projects provided a unique opportunity for a multi-site study of grassland recovery. We studied spontaneous grassland recovery on newly created open soil surfaces on soil-filled former drainage ditches. Since all the soil-filled ditches were adjacent to reference grasslands, we were able to define the reference state of grassland recovery and to compare vegetation characteristics of the recovering grasslands to those of reference grasslands. For this purpose, we adapted and tested the usefulness of the Relative Response Index (RRI; Armas et al., 2004; Perkins and Hatfield, 2014), which is generally used in ecological studies, but seems a proper tool also for restoration purposes. Our goal was to test the effect of the surrounding matrix (grassland type), spatial position and successional age on the success of grassland recovery on filled ditches. High similarity to reference grasslands in terms of species composition and cover of perennial graminoids, target forbs and non-target species were considered as restoration targets. We hypothesised that with increasing successional age and with increasing distance to the central zone of the ditch (i) the species pool of soil-filled ditches becomes more similar to reference grasslands, (ii) the cover of perennial grasses and target forbs becomes higher, and (iii) the cover of non-target species becomes lower.

3. Materials and methods

3.1. Study area

The study sites are in the Hortobágy Puszta (Hortobágy National Park) in Eastern-Hungary near settlements Balmazújváros, Tiszacsege, Hortobágy, Kunmadaras and Püspökladány (central coordinates: N 47°35′; E 21°09′). The lowland open landscape of the Hortobágy Puszta (elevation between 87 and 110 m a.s.l.) is characterised by alkali grasslands, marshes and loess steppes, forming one of the largest open landscapes in Europe (Török et al., 2014). The typical soil type of the region is meadow solonetz, characterized by moderate or high soluble soil content (Deák et al., 2014a). Alkali habitats are characterised by a dynamically changing water regime, they are wet in springtime and get dry for midsummer. The climate of the region is moderately continental characterised by a mean annual precipitation of 550 mm and a mean temperature of 9.5 °C with high strong variability among years (Lukács et al., 2015).

3.2. Site preparation and restoration

In the 1950s and 60 s several efforts were made to support agricultural intensification in Central-European alkali landscapes, especially in the Hortobágy Puszta. As a part of this attempt an extensive system of drainage and watering ditches was established in the region (Deák et al., 2015). These linear structures had considerable negative effects on the habitats at the landscape scale. They altered the natural water balance regimes by hampering surface water movement and lowering of the groundwater table. The latter caused severe leeching of alkali soils and resulted in a degradation of the alkali grasslands. The dense network of ditches caused serious problems in grassland management: the approximately 8-m wide ditches acted as obstacles during grazing and mowing. During the last decades, these problems motivated several landscape-scale restoration projects, aiming at elimination of disused linear structures.

We selected altogether 27 former ditches which were restored by soil-filling in 2004, 2006 and 2011 (9 ditches per each year respectively). Ditch embankments, formerly built from the excavated soil, were used to fill the ditches. Due to the applied