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# Large-Scale Restoration of Dry Grasslands on Ex-Arable Land Using a Regional Seed Mixture: Establishment of Target Species

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## Abstract

**Large-scale (circa 500 ha) restoration of species-rich dry grasslands was conducted using a high-diversity regional seed mixture in the White Carpathians Protected Landscape Area and Biosphere Reserve, Czech Republic, Central Europe. After sowing, the restored grasslands were regularly mown. Vegetation was analyzed at sites restored 1–12 years ago and compared with that of ancient, extremely species-rich grasslands nearby. Nearly all (98%) sown target species successfully established and nearly half of unsown target species established spontaneously, partly dependent on distance to the ancient grasslands. Early mowing in the first half of June appeared to support species diversity and broad-leaved forbs at the expense of competitive grasses. Using a regional seed mixture appeared to be an effective way of restoring dry grasslands and is especially recommended in the proximity of still existing ancient grasslands where spontaneous establishment of unsown target species may reinforce the success of restoration more easily.**

**Key words:** **grassland restoration, regional seed mixture, species diversity, target species, vegetation.**

## Introduction

Species-rich semi-natural dry grasslands are endangered habitats across Europe (Pullin et al. 2009) which is one of the reasons why they are included as priority habitats, especially if they harbor orchid species, under the Natura 2000 scheme (Anonymous 2003). Many of these grasslands have suffered declines in biodiversity due to inappropriate management, often being either overexploited (i.e. intensively fertilized, cut more than usual, seeded with productive grasses, etc.) or neglected, if not converted to arable land or afforested. In the past two or three decades, the intensity of agriculture in Europe has been decreasing (Brower & van der Straaten 2002). Thus "regrassing" of former arable land is in progress (Török et al. 2011), however, mostly with the use of various commercial seed mixtures composed of several more or less common grasses and legumes. Ecological restoration of the grasslands can be carried out applying two main approaches: (1) restoration of existing but degraded grasslands, and (2) recreation of grasslands on arable land (Bakker & van Diggelen 2006). In this paper, we deal with the latter case.

Restoration has many constraints, e.g. residual high soil fertility, depletion of the soil seed bank, lack of diaspore sources in the surroundings, and limited opportunities for diaspores to disperse to a restored site. High soil fertility supports expansion of strong competitors, which then limit establishment of other species, which are usually competitively less capable but often of nature conservation value (Marrs 1993). The majority of typical grassland species do not form a permanent soil seed or bud bank (Thompson et al. 1997), thus we cannot expect the species to survive long periods of arable management at sites where species-rich grasslands previously existed. For successful restoration, it is important to have reference sites in the surrounding area—the closer, the better. The adjacent grasslands provide seed sources of target species which may establish spontaneously (Partel et al. 1998; Ozinga et al. 2005).

The majority of studies of grassland restoration on ex-arable land have been conducted as small-scale experiments (Kiehl & Pfadenhauer 2007; Lepš et al. 2007). However, results of such small-scale experiments must be extrapolated or scaled-up to the landscape scale with great caution, especially if practical use is intended. Small-scale experimental plots may differ from an area of large-scale restoration in their natural seed rain, herbivore activity, microclimate, etc., and thus restoration success may differ. Large-scale practical restoration does not always allow strict control of abiotic and biotic conditions and is often technically limited in standardization. We are aware of just a

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few published reports of large-scale (i.e. in an area of at least dozens of hectares) grassland restoration projects on ex-arable land, being at least partly comparable with those in our study (Fagan et al. 2008; Török et al. 2010). Our study relates to grasslands restored in the past 12 years on arable land using a regional seed mixture.

In the White Carpathian Mountains in the eastern part of the Czech Republic, Central Europe, thousands of hectares of dry grasslands have been managed as hay meadows for a long time. Currently, available evidence supports the hypothesis that these grasslands are of prehistoric, rather than medieval, origin (Hájková et al. 2011). We therefore indicate these grasslands as "ancient" in this paper.

Most grasslands were plowed, overfertilized or abandoned in this area in the period 1950–1990. About 4000 ha of the ancient hay meadows have survived and are now protected under national legislation in a network of nature reserves within a Protected Landscape Area. They are also internationally recognized as Natura 2000 habitats (Jongepierová 2008). The White Carpathian grasslands are among the most species-rich grasslands in Europe (Klimeš et al. 2001) and harbor many rare and threatened plant and animal species, especially vascular plants and insects, some of which have their last or only localities in the country and/or are at their distribution limits here (Jongepierová 2008).

Since the 1990s, approximately 7,000 hectares of arable land in the area have been turned back into grasslands ("regrassed") using either spontaneous succession, sowing commercial grass-clover seed mixtures, and since 1999 a locally prepared regional seed mixture (Jongepierová et al. 2007; Jongepierová 2008). This regional seed mixture has been used to restore about 500 ha. The aim of using a regional seed mixture is not only to restore the high biodiversity, but also, in contrast to most commercial seed mixtures, to allow development of sustainable vegetation well adapted to local site conditions. Several small-scale experiments were conducted earlier to test the efficiency of the regional seed mixture (Jongepierová et al. 2007; Mitchley et al. 2012), but no data were available about the development of sites restored with this mixture on a large scale.

We were especially interested in answering the following questions: (1) How fast and how successful is the large-scale restoration? (2) How successfully do the species from the regional seed mixture establish? (3) How well do other target species, i.e. those not being sown, establish?

## Methods

### Studied Sites

The study sites are located in the relatively dry and warm south-western part of the White Carpathian Mountains, latitude 48°50′–49°05′N, longitude 17°19′–17°55′E, altitude 250–610 m a.s.l. The mean annual temperature is between 7 and 9°C, the mean annual precipitation between 500 and 800 mm. The area is formed by tertiary flysch sediments which are mostly calcareous. The main grassland type in the area is a semi-natural, species-rich dry grassland classified in the European system as the Bromion erecti alliance (Ellenberg et al. 1991) and as broad-leaved dry grassland Natura 2000 category 6210 (Chytrý et al. 2011). The study area is described in detail in the study by Jongepierová (2008).

In total, 34 of the grasslands sown with the regional seed mixture 1–12 years ago (Table 1) were selected for surveying in 2009. All regrassed grasslands with known history and composition of the seed mixture were selected. Some of the restored sites were covered by grassland in the past, but converted to arable land in 1970–1990, some of them had existed as arable land for many decades. The size of the particular grasslands ranged from 0.9 to 38.2 ha.

The regional seed mixture sown contained 85–90% grasses, 3–5% legumes, and 7–10% other forbs (weight percentage) representing species typical of the ancient grasslands in the area. The seed application rate was 17–20 kg/ha (pure seeds). This seed mixture consisted of (1) seeds produced in seed beds which included all forbs and some regional grasses, mainly erect brome (*Bromus erectus*) and furrowed fescue (*Festuca rupicola*) as typical dominants of the ancient grasslands, (2) seeds obtained with a combine and a brush harvester in ancient species-rich grasslands nearby, representing nearly all local grasses because of early harvest in June, and (3) commercially produced grasses, namely tall oatgrass (*Arrhenatherum elatius*), meadow fescue (*Festuca pratensis*), red fescue (*F. rubra*), Kentucky bluegrass (*Poa pratensis*), and yellow oatgrass (*Trisetum flavescens*) occurring at the reference sites in the region. The species composition of the seed mixture was determined before it was sown at the different sites, and was used in some calculations. Altogether 26 slightly different variants of the regional seed mixture were used. Due to the above described process, the regional seed mixture also differed slightly over the years. The grasslands were sown either in the autumn or early spring, were annually mown in June–August, and the biomass was removed afterwards. The date of harvest was recorded. The restored grasslands were not fertilized.

### Data Collection and Elaboration

Sampling sites were located in each of the grasslands at a distance of 100 m from the border closest to an ancient grassland. In a few cases, when the grassland was smaller, the central part was selected. At each site, three plots 5 × 5 m were located in a line perpendicular to the slope at 10 m from each other. The plots were measured with a GPS instrument, average accuracy 3 m. Vegetation records were made in the plots at the beginning of June 2009 before cutting. Percent cover of all vascular plants was visually estimated (Kent & Coker 1992). Vegetation records from permanently existing species-rich grasslands in the vicinity of our restored sites were extracted from the Czech National Phytosociological Database (Chytrý & Rafajová 2003). Together 20 records were available and were used as reference sites.

**Table 1.** Summary data for the restored grasslands included in the study: year of sowing, numbers of sown and established species, distance to the nearest ancient grassland, and date of cutting.

| *Site* | *Year of Sowing* | *No. of Sown Target Species* | *No. of Established Sown Target Species* | *No. of Established Unsown Target Species* | *Total No. of Target Species* | *Total No. of Species* | *Distance to the Nearest Permanent Grassland (m)* | *Time of Mowing* |
|---|---|---|---|---|---|---|---|---|
| 1 | 1998 | 14 | 11 | 4 | 15 | 47 | 150 | E |
| 2 | 2000 | 22 | 13 | 4 | 17 | 44 | 280 | L |
| 3 | 2000 | 21 | 16 | 10 | 26 | 69 | 4000 | E |
| 4 | 2000 | 22 | 17 | 3 | 20 | 43 | 190 | L |
| 5 | 2001 | 30 | 13 | 4 | 17 | 38 | 120 | L |
| 6 | 2001 | 19 | 11 | 3 | 14 | 25 | 100 | L |
| 7 | 2001 | 20 | 18 | 9 | 27 | 75 | 475 | E |
| 8 | 2001 | 30 | 15 | 1 | 16 | 34 | 100 | L |
| 9 | 2001 | 24 | 15 | 4 | 19 | 45 | 200 | E |
| 10 | 2001 | 24 | 17 | 5 | 22 | 51 | 150 | E |
| 11 | 2002 | 31 | 13 | 4 | 17 | 43 | 100 | L |
| 12 | 2003 | 31 | 17 | 3 | 20 | 50 | 125 | L |
| 13 | 2003 | 25 | 15 | 6 | 21 | 56 | 175 | E |
| 14 | 2003 | 30 | 24 | 2 | 26 | 54 | 250 | E |
| 15 | 2003 | 29 | 24 | 4 | 28 | 66 | 280 | E |
| 16 | 2004 | 37 | 31 | 11 | 42 | 79 | 150 | E |
| 17 | 2005 | 31 | 26 | 2 | 28 | 53 | 200 | E |
| 18 | 2005 | 31 | 26 | 2 | 28 | 56 | 140 | E |
| 19 | 2006 | 34 | 22 | 1 | 23 | 40 | 150 | E |
| 20 | 2006 | 34 | 28 | 1 | 29 | 52 | 50 | E |
| 21 | 2006 | 36 | 26 | 0 | 26 | 43 | 100 | E |
| 22 | 2006 | 30 | 20 | 3 | 23 | 62 | 550 | E |
| 23 | 2006 | 30 | 19 | 2 | 21 | 69 | 470 | E |
| 24 | 2007 | 33 | 20 | 1 | 21 | 57 | 2850 | E |
| 25 | 2007 | 33 | 18 | 0 | 18 | 62 | 700 | E |
| 26 | 2007 | 24 | 10 | 1 | 11 | 43 | 150 | L |
| 27 | 2007 | 33 | 27 | 1 | 28 | 68 | 1000 | E |
| 28 | 2008 | 24 | 5 | 0 | 5 | 50 | 150 | L |
| 29 | 2008 | 34 | 21 | 2 | 23 | 81 | 250 | E |
| 30 | 2008 | 36 | 21 | 2 | 23 | 65 | 750 | E |
| 31 | 2008 | 30 | 25 | 1 | 26 | 63 | 600 | E |
| 32 | 2009 | 4 | 2 | 0 | 2 | 46 | 725 | E |
| 33 | 2009 | 28 | 19 | 0 | 19 | 69 | 1400 | E |
| 34 | 2009 | 28 | 21 | 0 | 21 | 68 | 1500 | E |
| All sites | — | 44 | 43 | 27 | 70 | 248 | — | — |

E, Early; L, late.

Vegetation data and the relative species composition of the seed mixture were analyzed using Detrended Correspondence Analysis (DCA), an unconstrained ordination technique. Vegetation records from restored sites were analyzed using Canonical Correspondence Analysis (CCA) (Ter Braak & Šmilauer 2002), a constrained ordination technique. Time since sowing (Age) in years and distance of sampling site to the nearest ancient grassland were included as explanatory variables, and time of mowing (early—first half of June; late—later in the season) was included as a categorical explanatory variable. Species data were logarithmically transformed. Using unimodal methods was justified by the length of the gradient in DCA, which was equal to 4.5 SD-units (Lepš & Šmilauer 2003). In the CCA analysis, inter-sample distances and Hill scaling were used. To separate the effect of locality (i.e. restored site), the identifier of vegetation records situated within the same restored site was used as a co-variable in analyses. Ordination diagrams were produced using the CanoDraw program (Ter Braak & Šmilauer 2002). Centroids of the three vegetation records characterized each one restored site.

Target species were defined as those which were present at 8 or more of the 20 reference sites with at least 2% cover at one reference site or more. If the species was less common than this, affiliation to the Festuco-Brometea or Trifolio-Geranietea vegetation groups was used as a criterion according to Ellenberg et al. (1991). The former group represents natural and semi-natural dry grasslands, the latter dry fringe communities, and species belonging to the vegetation are typical of the Bromion erecti grasslands (Jongepierová 2008). Success of the target species in the process of restoration was evaluated using a simple index ($I_S$, Index of success), in which the average cover of a particular species at restored sites was divided by

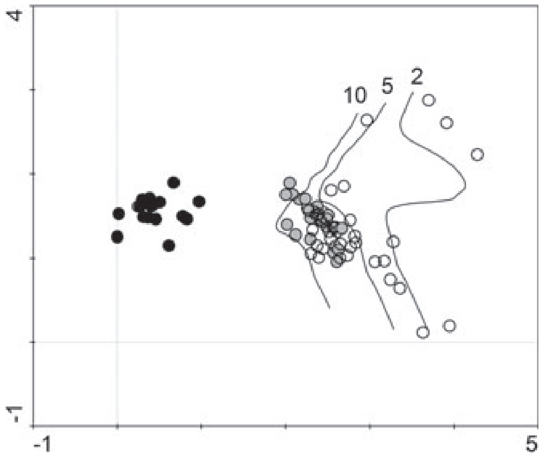


Figure 1. Unconstrained ordination (DCA) of vegetation samples from restored sites (open circles) and reference sites (black dots) and the species composition of seed mixtures used for restoration (gray). Isolines represent the time since sowing the seed mixtures.

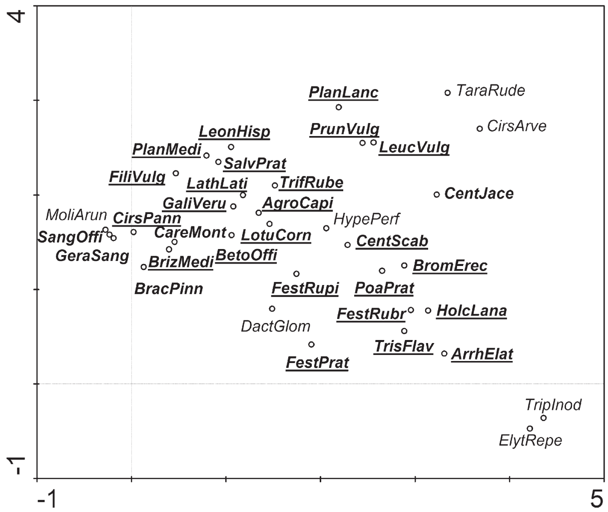


Figure 2. DCA ordination of species. Species best fitted to the model are shown. Target species are in bold. Species underlined were intentionally sown. Abbreviations of species names: AgroCapi, *Agrostis capillaris*; AnthVuln, *Anthyllis vulneraria*; ArrhElat, *Arrhenatherum elatius*; BetoOffi, *Betonica officinalis*; BracPinn, *Brachypodium pinnatum*; BrizMedi, *Briza media*; BromErec, *Bromus erectus*; CareMont, *Carex montana*; CentScab, *Centaurea scabiosa*; CirsArve, *Cirsium arvense*; CirsPann, *Cirsium pannonicum*; CrepBien, *Crepis biennis*; DactGlom, *Dactylis glomerata*; EchiCrus, *Echinochloa crus-galli*; ElytRepe, *Elytrigia repens*; FestPrat, *Festuca pratensis*; FestRubr, *Festuca rubra*; FestRupi, *Festuca rupicola*; FiliVulg, *Filipendula vulgaris*; GaliVeru, *Galium verum*; GeraSang, *Geranium sanguineum*, HolcLana, *Holcus lanatus*; HypePerf, *Hypericum perforatum*; LathLati, *Lathyrus latifolius*; LeonHisp, *Leontodon hispidus*; LeucVulg, *Leucanthemum vulgare*; LoliPere, *Lolium perenne*; LotuCorn, *Lotus corniculatus*; MoliArun, *Molinia arundinacea*; PicrHier, *Picris hieracioides*; PlanLanc, *Plantago lanceolata*; PlanMedi, *Plantago media*; PoaPrat, *Poa pratensis*; PrunVulg, *Prunella vulgaris*; SalvPrat, *Salvia pratensis*; SangOffi, *Sanguisorba officinalis*; TaraRude, *Taraxacum* sect. *Ruderalia*; TrifRube, *Trifolium rubens*; TripIno, *Tripleurospermum inodorum*; TrisFlav, *Trisetum flavescens*.

its average cover at reference sites. Values of the index ranged from 0 for species not yet established, to 1 for species which reached the same or a higher cover at the restored sites than at the reference sites.

## Results

The results of DCA ordination of samples from restored and reference sites combined with species composition of seed mixtures are shown in Figure 1. The first axis explained 61.5% of variability in vegetation data and can easily be interpreted as a gradient of successional age. The second axis explained 27.2% of variability, but was not clearly interpretable. The results show that during 10 years the restored sites converged in their species composition toward the species composition of the seed mixtures. This means that the potential for restoration provided by the seed mixture was fully exploited. The restored sites were still rather far from the reference sites in terms of species composition, however, the trajectory of restoration seems to be heading into the right direction.

The results of DCA species ordination are shown in Figure 2. Among the species which best fitted the model are the weedy species on the right hand side of the ordination biplot, but these were soon succeeded by sown target species. Only four unsown target species appeared in the diagram which established in the restored sites and one (bloody cranesbill, *Geranium sanguineum*) occurred only in the reference sites. Figure 2 shows a clear gradual and convergent pattern from the weedy stages toward the vegetation of the reference sites.

In the direct (constrained) ordination CCA of the restored sites (Fig. 3), time since sowing, distance to the nearest ancient grassland, and time of mowing appeared as significant explanatory variables ($p < 0.05$). Time since sowing explained 34.2% of the vegetation variability, distance to the nearest ancient grassland 11.5% and date of mowing 8.9%. Earlier mowing (first half of June) increased the proportion of broad-leaved herbs and total species richness, while late mowing favors a higher proportion of grasses.

In total, 373 species of vascular plants were recorded at all the study sites combined (i.e. restored sites and reference grasslands), 102 of which were classified as target species, the remaining were either weeds or common grassland species. Forty-four of these were sown at the restored sites, all of which, except one, established at one or more of the restored sites. Twenty-seven species established spontaneously, and 31 target species were not found at the restored sites, but only recorded at the reference sites. Altogether, 248 species occurred at the restored sites (Table 1). Considering the success of establishment of target species at the restored sites, only 1 of 44 species sown did not establish (common rockrose, *Helianthemum grandiflorum* ssp. *obscurum*). However, only four species reached cover values at least equal to that at the reference sites (*Bromus erectus, Festuca rubra,* common

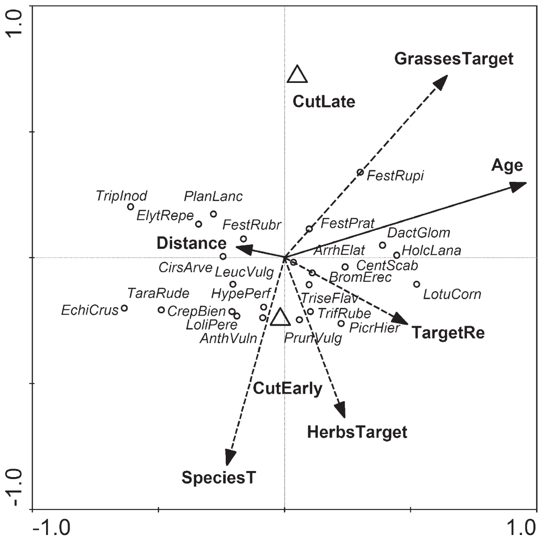


Figure 3. Constrained ordination (CCA) of vegetation samples from the restored sites. Time (Age) since sowing and time of mowing (CutEarly—mown in the first half of June, CutLate—mown later in the season) were employed as explanatory variables. Total species number (SpeciesT), share of target species (TargetRe), relative cover of grasses (GrassesTarget) and that of broad-leaved forbs (HerbsTarget) were plotted as passive variables. For abbreviations of species names, see Figure 2.

**Table 2.** Index of success of target species at the restored sites.

| *Index of success ($I_S$)* | *Target species (102)* | |
|---|---|---|
| | Sown | Unsown |
| 0 (only at reference sites) | 1 | 31 |
| 0.01–0.10 | 25 | 25 |
| 0.11–0.99 | 14 | 2 |
| 1.00 | 4 | 0 |

For calculation of the index, see text.

velvetgrass—*Holcus lanatus*, and *Trisetum flavescens*, all representing sown grasses). The majority of the target species, both sown and spontaneously established, were present at the restored sites only at low cover values (Table 2). According to the index of success ($I_S$), the two most successful spontaneously established target species were carline thistle (*Carlina vulgaris*) and strawberry (*Fragaria viridis*). The total cover of target species in the restored grasslands continuously increased with time ($r^2 = 0.829$, $p < 0.05$). After 12 years, it was nearly equal to that in the reference grasslands.

## Discussion

The results of this study show that after approximately 10 years using regional seed mixtures appeared to be a successful first step in the restoration of the dry grasslands. Despite great variability among the particular sites, 98% of sown target species have established at the restored sites, which was more than in the study of Gibson-Roy et al. (2010) who reported 80%. Moreover, nearly half of the unsown target species present in the ancient grasslands established spontaneously. The restoration also appears to proceed faster than in the case reported by Fagan et al. (2008) from the United Kingdom. The establishment success of sown regional species shows that the seed mixtures were appropriately prepared (technical details on preparation of the regional seed mixture are given in Jongepierová 2008). Also, the previous controlled experiment using the regional seed mixture (Jongepierová et al. 2007) justified its application. In a recent study (Mitchley et al. 2012), evaluating a 10-year field experiment with small-scale plots which had been sown with regional seed mixtures, the trends were essentially similar to this study, i.e. restored plots developed a species composition heading toward the composition of a reference site. However, controlled experiments can provide different results from practical large-scale applications. This field experiment particularly showed cross-contamination of different experimental plots, e.g. by sown grasses which affected some of the results especially those regarding the role and level of spontaneous colonization (Mitchley et al. 2012).

Restoration using regional seed mixtures appeared to be much more effective than transferring grassland blocks (Klimeš et al. 2010), especially at a large scale. Restoration using fresh seed-containing hay has recently started to be tested in a small-scale experiment in the study area. Its application at a larger scale may be considered and in the future its effectiveness may be compared with sowing a regional seed mixture. This is usually an effective method in grassland restoration (Kiehl et al. 2006; Kiehl & Pfadenhauer 2007). However, sowing a seed mixture is generally considered to be the most reliable way to establish desired plant communities (Hutchings & Stewart 2002). Sometimes, low-diversity seed mixtures are recommended for restoration of large areas (Török et al. 2010), but this approach is not suitable for restoration of species-rich grasslands in our study area, where species-rich grasslands are the target.

Annual weeds typically dominate the early succession in abandoned fields either left without intervention or seeded (Cramer & Hobbs 2007). In our study, they largely disappeared during the first 2 years. Perennial competitive weeds (such as Canada thistle—*Cirsium arvense* and couchgrass—*Elytrigia repens*), typical of ex-arable land in the region (Prach et al. 2007), did not attain significant cover at our study sites and occurred only in the initial stages, i.e. 1–3 years after sowing. These species were probably competitively suppressed by the sown dominant grasses, especially by the constituent species *Bromus erectus*. Regular cutting probably also inhibited expansion of some of the weeds (Bakker 1989).

Early cutting, in the first half of June, encouraged broad-leaved forbs at the expense of grasses, although the opposite effect is usually expected, and later cutting is recommended to allow forbs to set seed (Bakker & van Diggelen 2006). In the grasslands of our study, the early cut reduces the biomass of fast growing and early flowering grasses at the time when forbs still have short stems or occur as rosettes. Removing the taller biomass of grasses accelerates the growth of forbs, moreover some forbs easily regenerate after cutting (Klimešová et al. 2010) and until the end of the season they set seed in any case. Whether an early cut should be recommended more generally as a management measure in other restored dry grasslands is difficult to say. It seems that dry grasslands vary in optimal cutting times (Bobbink & Willems 1991; Smith & Jones 1991).

Because most target species in our study do not form a persistent seed or bud bank (Thompson et al. 1997), it is unlikely that they survived the period of arable cultivation which lasted approximately 15–30 years (Jongepierová 2008). All these species were either sown or have probably established spontaneously from seed rain after restoration. The latter is often reported as a crucial constraint in grassland restoration relying on spontaneous establishment of target species in which the distance to reference sites is highly important (Poschlod et al. 1998; Bakker & Berendse 1999; Matsamura & Takeda 2010).

The most promising result for the development of these restored grasslands is the spontaneous establishment of many target species, obviously from the adjacent ancient grasslands. But there is still a case to be made for this spontaneous recovery as seen from Figure 1, where the most advanced restored sites are approximately half the distance in the ordination biplot to the samples from the ancient grasslands. Hence, we can tentatively state that we are approximately half way through the restoration process. However, because of extremely high alpha (up to 75 vascular plant species per 1 $m^2$—Jongepierová 2008) and beta diversity (the average similarity in species composition among the reference sites used in this study was only 44%, Sørensen index used) of the ancient grasslands in the area, we cannot expect all the target species to establish in all study sites even in the long-term. But many target species occurring in the close vicinity to a particular restored grassland certainly have a high chance to establish. In another study of spontaneous restoration of semi-natural grasslands on ex-arable land, we found that it took only about 20 years for the species composition of restored and adjoining ancient grasslands to become nearly identical (Lencová & Prach 2011). Rapid spontaneous succession of ex-arable land into dry grasslands was also reported by Ruprecht (2005) and Csecserits et al. (2007). However, Fagan et al. (2008) wrote that there was little overlap between restored and ancient grassland communities in species composition even after 60 years in the case of calcareous grasslands in the United Kingdom. They concluded that successful restoration of these grasslands is achievable but the process is slow. Proximity of ancient grasslands was also important in this case. Target species which fail to establish spontaneously or do with difficulties can be introduced by hay transfer (Kiehl et al. 2006) or by additional sowing to achieve the same level of complexity observed in the ancient grasslands. The spatial arrangement of restored and reference sites in a landscape is often considered as crucial especially for spontaneous restoration (Walker et al. 2004; Řehounková & Prach 2006; Matsamura & Takeda 2010). The role of the landscape context, i.e. spatial arrangement of restored and ancient grasslands in the area under concern, is currently being studied into more detail.

### Implications for Practice

- A properly designed regional seed mixture is a very effective first step in the restoration of species-rich dry grasslands.
- Early mowing (in the first half of June) appears to be beneficial to species diversity of the restored grasslands and encourages desired broad-leaved forbs.
- Under certain conditions, especially if reference ancient grassland sites still exist in the close vicinity of restored sites, spontaneous establishment can also be expected from unsown target species.
- Restoration is recommended close to ancient grasslands. In addition to facilitating the spontaneous establishment of target species, the restored sites may serve as corridors or buffer zones among or around ancient grasslands.

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