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ORIGINAL ARTICLE

Advances in the conservation of dry grasslands: Introduction to contributions from the seventh European Dry Grassland Meeting

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Abstract

Dry grasslands in Europe are mostly of zoo-anthropogenic origin, but nevertheless they are among the most diverse plant communities of the world at small spatial scales, and they support a significant proportion of the biodiversity of the continent. Both agricultural intensification and abandonment of former dry grasslands caused dramatic losses in area and quality of this habitat type during recent decades. Here we report from the 7th European Dry Grassland Meeting, organised by the European Dry Grassland Group (EDGG) in Smolenice, Slovakia, in 2010. Under the motto "Succession, restoration and management of dry grasslands" one hundred researchers from throughout Europe discussed conservation issues of this threatened habitat type. We give a brief introduction to those nine articles that are included in this Special Feature. With contributions from many different countries and various dry grassland types, they address issues of conservation value, succession, management as well as regeneration and restoration. We conclude that the diversity of dry grasslands and their conservation problems require further research to develop adequate management techniques under changing frame conditions. However, also the frame conditions, such as the incentives for certain land use practices provided by the Common Agricultural Policy of the European Union need to be addressed if long-term success in conservation of dry grasslands is intended.

Keywords: *Conference report, European Dry Grassland Group, management, restoration, Special Feature, succession*

Dry grasslands in the Western Palaearctic

Grasslands are herbaceous communities dominated by grasses (*Poaceae*) or other graminoids (*Cyperaceae*, *Juncaceae*). As the climate in most areas of the Western Palaearctic is sufficiently moist and warm to support the growth of forests, we find grasslands as large-scale potential vegetation only in the steppes of Eastern Europe and Central Asia (too dry for forests) and in the mountains above the timberline (vegetation period too short for forests) (units L, M, and B5 in Bohn et al. 2004). Small-scale natural stands of grasslands occur where forest cannot grow due to edaphic factors, e.g. on salty soils, in coastal dunes, on very shallow soils surrounding rocky outcrops, or on instable soils on steep slopes (Ellenberg & Leuschner 2010; Klötzli et al. 2010). While nowadays the natural steppes of Eastern Europe and Central Asia have largely been converted into arable land (e.g. Sudnik-Wójcikowska et al. 2011), millennia of human land use have created various types of grasslands, which cover a significant proportion of the surface of the naturally forested regions of Europe, for example, approximately 16% in Germany (BfN 2004) and even 62% in Wales (Stevens et al. 2010). Accordingly, grasslands constitute a major element of Europe's cultural landscape. Despite not being natural in most places, grasslands make a very substantial contribution to the biodiversity of Europe. Hobohm and Bruchmann (2009) found that among the more than 6000 vascular plants endemic to Europe, grassland species with 18.1% constitute the second largest group after the rock-inhabiting species, but with nearly twice as many endemics as forests (10.7%).

Under "dry grasslands", we summarise several different vegetation classes (see Rodwell et al. 2002). From the submediterranean to the hemiboreal zone, the *Festuco-Brometea* (on base-rich, loamy soils) and the *Koelerio-Corynephoretea* (including *Festucetea*

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vaginatae and *Sedo-Scleranthetea*; on sandy soils) are most widespread both as natural steppe vegetation and as semi-natural communities in more oceanic regions; the *Trifolio-Geranietea sanguinei* form their spatio-temporal transition to forests. The natural dry grasslands above the timberline mostly belong to the classes *Elyno-Seslerietea* (base-rich soils) and *Juncetea trifidi* (acid soils), while among the Mediterranean dry grassland classes, the *Helianthemetea guttati* (dominated by annuals) and the *Thero-Brachypodietea ramosi* (dominated by perennials) are most widespread. While mesic and wet grasslands cover much larger areas in Europe, dry grasslands are the most diverse group, which is mirrored in the much higher number of syntaxa (see Rodwell et al. 2002). For areas below 100 m^2, the world records in plant species richness occur in nutrient-poor grasslands, not in tropical rainforests (Wilson, Peet, Dengler & Pärtel, unpublished), in particular in mown stands of semi-dry basiphilous grasslands (order *Brachypodietalia pinnati* within the *Festuco-Brometea*) (see also Dengler 2005). For example, Dengler et al. (2009) reported 102 plant species on 10 m^2 from such a dry grassland in the Transylvanian Lowland (Romania), but stands of similar extreme richness are known from meadows in the White Carpathians (Czech Republic; e.g. Klimeš et al. 2001) and in Estonia (e.g. Kull & Zobel 1991; see also Dengler 2005). In some other taxa, the relevance of dry grasslands for biodiversity conservation is even higher than in vascular plants; for example, 63% of the butterfly species of Europe are bound to dry calcareous grasslands and steppes (WallisDeVries & Van Swaay 2009).

Conservation of dry grasslands

Most European dry grassland communities are semi-natural habitats, which developed over centuries or even millennia of traditional land use, such as mowing, grazing, temporary abandonment of arable fields, and/or other disturbance regimes (Pott 1995; Poschlod & WallisDeVries 2002; Veen et al. 2009; Ellenberg & Leuschner 2010). However, nowadays humans threaten the biological treasure to whose emergence they contributed much in the past. While in some cases dry grasslands are directly destroyed by building activities or mining, the more serious threats are those affecting vast areas, namely agricultural intensification, land abandonment and atmospheric nitrogen input.

Intensive grazing combined with the use of artificial fertilisers or even breaking up of grassland caused serious losses of both quality and extent of dry grassland habitats (Illyés & Bölöni 2007). While during the last century, agriculture was much intensified on productive soils, grazing or mowing at less productive sites such as those inhabited by dry grasslands became less and less profitable. In some regions, this led to the afforestation of valuable dry grasslands with pines and other, often non-native trees with negative consequences for biodiversity (e.g. Ruprecht et al. 2009; Schrautzer et al. 2009). In many other places, dry grasslands were just abandoned, and – as semi-natural communities – subsequently subjected to secondary succession leading to their degradation (Poschlod & Schumacher 1998; Poschlod & WallisDeVries 2002; WallisDeVries et al. 2002). As a consequence of intensification on the one and abandonment on the other hand, the remaining dry grassland habitats became fragmented, and populations of many xero- and thermophilous species became threatened by extinction or inbreeding depression (Fischer & Stöcklin 1997). The expansion of highly competitive species (both native and non-native ones) into grassland ecosystems represents another threat to diverse grassland vegetation. It is often enhanced by increased atmospheric nitrogen deposition, which changes the proportion of available nutrients in soils and promotes the dominance of tall species and competitive grasses (Willems et al. 1993; Bobbink et al. 1998), especially in the absence of management.

Due to all these negative trends, dry grasslands recently belong to the most endangered European habitats (Willems et al. 1993, Veen et al. 2009). Since they at the same time contain a high proportion of rare and endangered species (Wolkinger & Plank 1981; Korneck et al. 1998), the conservation of dry grasslands and of high nature value grasslands in general became a priority throughout Europe, as reflected, for example, by the fact that most dry grassland types are included in the Habitats Directive of the European Union (European Commission 2007).

Proper management and restoration activities can help to maintain and enhance the diversity of dry grasslands (Groom et al. 2006; Kiehl 2009; Schwabe & Kratochwil 2009; Kiehl et al. 2010). Conservation management identifies several approaches for biodiversity maintenance, including conservation of species, ecosystems and processes. An effective conservation management needs to combine all available approaches and to take into account requirements of various groups of organisms (WallisDeVries et al. 2002; Bakker & van Diggelen 2006; Schwabe & Kratochwil 2009; Veen et al. 2009).

7th European Dry Grassland Meeting in Smolenice, Slovakia

The history of the Dry Grassland Meetings dates back to 2004, when the first conference of the Working Group on Dry Grasslands in Germany (*Arbeitsgruppe Trockenrasen*) took place in Lüneburg (see Dengler & Jandt 2005). Other Dry Grassland

Meetings in Germany with increasing numbers of international participants were organised in Münster in 2005, Freising in 2007, Kiel in 2008 and Halle in 2009. During the meeting in Kiel, the necessity of wider international co-operation became evident, which resulted in the foundation of the *European Dry Grassland Group* (EDGG) (www.edgg.org) as an umbrella organisation for research and conservation activities in Western Palaearctic dry grasslands. Later, EDGG became an official Working Group of the *International Association for Vegetation Science* (IAVS). By now, EDGG has more than 600 members from approximately 50 countries.

Bearing in mind the complexity of dry grassland conservation problems, the 7th European Dry Grassland Meeting focused on succession, restoration and management of dry grasslands. It was held in Smolenice (Slovakia) from 27 May to 1 June 2010. The Congress Centre of the Slovak Academy of Sciences situated in the castle of the village provided a pleasant location for scientific debates and was highly appreciated by all participants. Altogether, 100 participants from 19 European countries (Austria, Belgium, Bulgaria, Croatia, Czech Republic, Germany, Greece, Hungary, Italy, Macedonia, Netherlands, Poland, Romania, Russia, Slovenia, Slovakia, Sweden, Ukraine and UK) plus Australia took part in the meeting (Figure 1). During the conference, 39 oral presentations and 43 posters were presented within six sessions, opened by a keynote lecture of L. Mucina on the origin and evolution of dry grasslands of Central Europe (for detailed conference reports, see Janišová et al. 2010, 2011).

The papers included in this Special Feature mainly derive from the conference in Smolenice, supplemented by some additional contributions from EDGG members. A companion Special Feature with further contributions from the conference is published in the German geobotanical journal *Tuexenia* (Janišová et al. 2011; Petřík et al. 2011; Škodová et al. 2011; Wiezik et al. 2011; Willner 2011). The pdf versions of those talks and poster presentations, whose authors agreed to the online publication, the conference proceedings (Janišová et al. 2010), and a photo gallery from the conference are available at http://www.edgg.org/edgg_meeting.html.

Contributions in this Special Feature

The Special Feature includes nine articles on dry grassland communities of the classes *Festuco-Brometea*, *Koelerio-Corynephoretea* (including *F. vaginatae*), *Trifolio-Geranietea sanguinei*, *Juncetea trifidi*, as well as Mediterranean dry grasslands ranging from

Figure 1. Participants of the 7th European Dry Grassland Meeting in front of the Smolenice castle.

Spain via Slovakia, Hungary, Slovenia, Bulgaria and Ukraine to Israel. We have arranged them according to four main topics: conservation value (Sudnik-Wójcikowska et al. 2011), succession (Vassilev et al. 2011; Hegedüšová & Senko 2011; Kaligarič et al. 2011), management (Házi et al. 2011; Henkin & Seligman 2011), and regeneration and restoration (Csecserits et al. 2011; Deák et al. 2011; Madruga-Andreu et al. 2011).

Conservation value

Habitat destruction and fragmentation belong to the major threats of biodiversity. However, there are cases in which conversely man-made objects, for example ancient burial mounds (kurgans), maintain the natural or semi-natural vegetation. These phenomena are especially important in agricultural landscapes. Sudnik-Wójcikowska et al. (2011) assessed the floristic value of more than 100 kurgans over four climatic-vegetation zones (steppes and forest steppe) in southern Ukraine and confirmed that kurgans could play a role as refuges of the steppe flora, i.e. natural communities of the classes *Festuco-Brometea* and *Koelerio-Corynephoretea*. The authors also indicated several threats to the kurgan flora, including direct destruction of the kurgans by frequent fires, excessive grazing, cultivation practices, archaeological excavations or illegal activities of archaeological looters. The authors proposed a more active conservation of kurgans as archaeological sites as well as areas of high floristic value.

Succession

One block of the presented papers deals with processes following grassland abandonment and the course of succession. In the past, most dry grassland habitats were exposed to low intensity traditional management by grazing and/or mowing. Due to agricultural intensification, traditional husbandry was transformed into factory farming, and many pastures have become fallow. The litter accumulation on abandoned pastures leads to changes in both stand microclimate and nutrient cycling (Willems et al. 1993, Bobbink et al. 1998), generally resulting in the expansion of mesophytic species. High-growing and competitively stronger species out-compete the helophilous and stress-tolerant, xero-thermophilous species, and the vegetation diversity gradually decreases. However, during the period immediately following abandonment (the earliest successional stages), species richness may grow due to the occupation of gaps in the vegetation by species sensitive to grazing and mowing. Generally, dry grasslands at small spatial scales very nicely follow the intermediate-disturbance hypothesis, with highest richness found at light grazing (or shortly after abandonment), while both heavily grazed and long-term abandoned pastures are much less diverse (e.g. Škornik et al. 2010). Vassilev et al. (2011) compared species composition and species richness of traditionally grazed semi-natural grasslands (mostly *Festuco-Brometea*) and abandoned sites in the Western Balkan Mountains, Bulgaria. They found that pasture abandonment led to an increase in vegetation height, species richness of mesophytic species and number of red-listed species. On the contrary, grazed plots showed higher total species richness, more xerophytes, rosette-forming and spring-flowering species. The authors recommend to manage the grasslands in an extensive way with a zonation regime in order to favour both species of open grasslands and those of mid-successional grassland communities.

In the advanced successional stages, woody species gradually enter grassland communities and force profound and fast changes to the vegetation by shading and producing a large amount of litter (Facelli & Pickett 1991). Sometimes, even areas of outstanding natural value are severely damaged by succession and suffer from a dramatic decline in species richness and significant changes in species composition in spite of a strict conservation regime. Modern GIS (Geographic Information System) techniques offer new opportunities for modelling drivers of vegetation changes and, therefore, may provide effective tools for conservation planning (Guisan & Zimmermann 2000; Warren et al. 2002). An interesting example was given by Hegedüšová and Senko (2011) based on a long-term study in the Devínska Kobyla Mts., showing that a complex GIS approach assists the identification of the most endangered areas. The authors also emphasise the need of a close connection between GIS and classical botanical methodology when simulating landscape processes.

It is well known that in the process of secondary succession, some plants may act as succession facilitators (e.g. Yamamoto 1999). In certain areas of the Northern Adriatic Karst Plateau, the secondary succession begins with a colonisation by tall umbellifers (*Apiaceae*). Conversely to facilitation, these plants are supposed to retard succession by self-promotion, based on the strong competition associated with their allelopathic potential. Kaligarič et al. (2011) evaluated the allelopathic potential of the umbellifers *Laserpitium siler* and *Grafia golaka*, which retard successional development in abandoned grasslands in Slovenia. Both studied species tend to form monodominant stands, where colonisation of woody species is restricted except for two pine species. The authors explain the successful germination and survival of *Pinus sylvestris* in the dense stands of *L. siler* by the fact that both species contain the same secondary compounds, making Pinus seedlings self-tolerant to these allelochemicals.

Management

One of the typical plant species spreading successfully in areas where former human management has been abandoned is *Calamagrostis epigejos*, a tall perennial clonal grass with a broad range of distribution in Europe (Prach & Pyšek 1994, 2001). This species is most successful in open, nutrient-rich, mesic habitats, where it forms monodominant patches capable of aggressive expansion (Rebele 2000; Somodi et al. 2008). Házi et al. (2011) provide interesting results of a long-term mowing experiment carried out to suppress the spread of *C. epigejos* to mid-successional grasslands in Hungary. Frequent mowing was confirmed as an effective tool for reducing the cover of *C. epigejos* and increasing the overall community diversity after about 4–5 years. With regard to a parallel decrease of *C. epigejos* in the control plots, the authors suggest that the species can disappear spontaneously in secondary grassland succession after 40–50 years.

Restoration success is often considered on a biological basis. A restoration measure is regarded as successful when the species composition is approaching some target state. However, economic considerations are also important. Henkin and Seligman (2011) evaluated alternative restoration measures connecting ecological aspects with detailed economical analyses. Their paper aims at supporting range management by exploring the effect of phosphate amelioration and herbicide application on reducing the rate of recovery process after fire and by estimating the economic feasibility of the treatments for controlling shrub encroachment in a Mediterranean ‘‘batha’’ community. They conclude that the practical feasibility of this management option depends on the relation between costs and benefits. Using 20-year data of experimental secondary successions, they were able to define conditions under which the control of successional shrub encroachment can be economically feasible.

Regeneration and restoration

One possibility for the conservation of dry grassland species and for improving the connectivity of remaining semi-natural dry grasslands is to develop ‘‘tertiary’’ dry grasslands from arable fields (e.g. Kiehl & Jeschke 2005; Kiehl & Pfadenhauer 2007). In this Special Feature, Csecserits et al. (2011) used an ‘‘unplanned experiment’’ in Hungary, where arable fields have become fallow during the last six decades, to analyse how close their species composition became to (semi-) natural sandy base-rich grasslands of the *Koelerio-Corynephoretea* or natural forests. They could show that approximately one decade after abandonment, the vegetation composition of former arable fields became similar to (semi-) natural grasslands of the region, being inhabited by many dry grassland specialists while showing only little establishment of typical woodland species. Accordingly, in their study region, fallow arable fields could gain considerable value for conservation without any specific management, just by waiting. However, the authors also found that even after nearly 60 years the ‘‘tertiary’’ grasslands still showed significant differences to the (semi-) natural grasslands; in particular, a higher cover of neophytes indicated that the conservation of ancient dry grasslands should always be given the highest priority.

Litter and graminoid biomass play a crucial role in grassland dynamics (Martin & Wilsey 2006). Their negative effects on the surrounding vegetation include changes in microclimatic conditions on the soil surface; inhibition of germination; and reduction of space, water and nutrients available for other species (Facelli & Pickett 1991; Foster & Gross 1998; Eckstein & Donath 2005). Deák et al. (2011) found that the accumulation of litter and graminoid biomass of species (*Festuca pseudovina*, *F. rupicola*, *Poa angustifolia*, *Bromus inermis*) sown during the grassland restoration of an old field in Hungary may have both positive and negative impacts on the recovered grassland community; it suppresses the development of weedy forbs, but at the same time the immigration of target species. Therefore, the reduction of litter and graminoid biomass is necessary to facilitate the development of the target grassland communities. This can be achieved, e.g. by resuming the traditional management with an increased frequency and/or intensity.

Sowing of commercial seed mixtures with ecotypes or even species not native/typical for the region clearly is not a recommended measure in nature conservation. Nevertheless, it is widely applied in landscape management, even in nature reserves, when the primary aim is to (re-)vegetate bare soils, mainly because of easy availability and low costs. In two experiments, Madruga-Andreu et al. (2011) compared different re-vegetation methods (all involving commercial seed mixtures) for disturbed areas in mountain grasslands of the class *Juncetea trifidi* in Spain. While all approaches were successful in re-vegetating the bare patches, none of them led to a vegetation similar to the original grassland. The variant with transplants of *Festuca gautieri* from nearby grasslands in addition to the seed mixture, yielded the best results from a nature conservation point view. The non-native plants that were sown or planted in the plots generally declined over the years, but many of them still had significant cover after seven years, highlighting that commercial seed mixtures might be successful in preventing soil erosion, but are problematic regarding the conservation of native plant diversity.

Conclusions and outlook

We believe that the papers in this Special Feature will contribute to the knowledge on the gradually changing dry grassland ecosystems and will help to establish appropriate conservation measures for their maintenance. Evidently, dry grasslands are so diverse that a single set of measures cannot be sufficient for their conservation, but nevertheless processes and problems are often similar so that conservationists in one region could greatly benefit from the experiences gained elsewhere. Therefore, the European Dry Grassland Meetings, the *Bulletin of the EDGG*, and topical Special Features in international journals such as the one at hand will continue to be important tools for knowledge exchange. However, beyond the scientific dimension of better understanding the processes underlying compositional changes of dry grasslands and finding appropriate means for their restoration, the political dimension will be equally crucial for maintaining this important part of Europe's natural heritage. A significant alteration of the Common Agricultural Policy (CAP) of the European Union is necessary in order to safeguard the diversity of Europe's High Nature Value Grasslands for the next centuries (Veen et al. 2009). Bearing this in mind, EDGG at its conference in Slovakia has adopted the *Smolenice Grassland Declaration*, which can be found and signed at http://www.edgg.org/edgg_meeting.html.

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