



CONSERVATION VALUE, MANAGEMENT AND RESTORATION OF EUROPE'S SEMI-NATURAL OPEN LANDSCAPES

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Abstract

Most semi-natural open habitats in Europe have been traditionally maintained by anthropogenic activities, such as grazing or mowing, preventing the establishment of woody vegetation. These habitats harbour a remarkably rich biodiversity in terms of both plant and animal species, but are also highly threatened, mainly by agricultural intensification and land abandonment. With this Editorial we introduce a Special Issue initiated by the European Dry Grassland Group (EDGG) at the Open Landscapes Conference (Hildesheim, 2013) and the 11th European Dry Grassland Meeting (Kulikovo Pole, 2014). We aim to give a short introduction to the current conservation status, significance and research of semi-natural open habitats in Europe and present the collected articles of the Special Issue. These papers cover a wide range of different semi-natural open habitats, including wood-pastures, heathlands, steppes, semi-dry and dry grasslands across the Palearctic region and address issues related to the assessment methods, threats, management and restoration of these habitats. We conclude that, in order to ensure their conservation and to monitor the changes in open habitats, integrative approaches are needed that take into account not only vegetation records, but also multiple animal taxa, abiotic factors, management practices, ecosystem services and modelling simulations for anticipating possible future scenarios. We also recommend that decision-makers should support actions to conserve open habitats in Europe by addressing such major challenges as the encroachment of woody vegetation. We are convinced that the present Special Issue will contribute to a better understanding of ecosystem functions and support the biodiversity conservation and management of semi-natural open habitats.

Keywords: agri-environmental scheme, biodiversity, ecosystem service, grassland, heathland, land-use change, Palearctic, succession, wood pasture.

Izvilleček

Večino pol naravnih odprtih habitatov v Evropi tradicionalno vzdržuje s svojim delovanjem človek, kot na primer s pašo ali košnjo, in tako preprečuje zaraščanje z lesnato vegetacijo. Ti habitati so biodiverzitetno zelo bogati z rastlinskimi in živalskimi vrstami, vendar tudi močno ogroženi zaradi intenzifikacije kmetijstva in opuščanja obdelave. V uvodu želimo predstaviti posebno številko revije, ki jo je vzpodbudila Evropska sku-

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pina za suha travišča (EDGG) na konferenci Open Landscapes (Hildesheim, 2013) in na 11. srečanju skupine (Kulikovo Pole, 2014). Predstaviti želimo trenutni varstveni status, pomen in raziskave pol naravnih odprtih habitatov v Evropi in zbrane članke v posebni številki. Ti članki obravnavajo širok nabor različnih pol naravnih odprtih habitatov, med njimi gozdne pašnike, resave, stepe, pol suha in suha travišča palearktične regije in obravnavajo metode njihove presoje, njihovo ogroženost, gospodarjenje in obnovo. Zaključimo lahko, da moramo poleg vegetacijskih popisov upoštevati tudi številne živalske vrste, abiotske dejavnike, načine gospodarjenja, ekosistemske usluge in modeliranje predvidenih možnih prihodnjih scenarijev, če želimo zagotoviti njihovo ohranjanje in spremljanje sprememb. Predlagamo tudi, da nosilci odločanja podprejo prizadevanja za ohranjanje odprtih habitatov v Evropi z obravnavanjem tako velikih izzivov kot je zaraščanje z lesnato vegetacijo. Prepričani smo, da bo posebna številka prispevala k boljšemu razumevanju ekosistemskih funkcij in omogočila ohranjanje biodiverzitete in gospodarjenje spol naravnimi odprtimi habitatami.

Gljučne besede: kmetijsko-okoljska shema, biodiverziteta, ekosistemske usluge, travišče, resava, sprememba rabe zemljišč, Palearktika, sukcesija, gozdni pašnik.

1. INTRODUCTION

MOTIVATION

In its broadest context, the definition “open habitats” covers all of those terrestrial habitats that do not have dense tree cover. This includes natural open habitats, in which the environmental conditions are inadequate for the development of forest due to shallow soil, inundation or insufficient precipitation, but also semi-natural habitats, in which anthropogenic activities, such as grazing or mowing, mainly prevent the establishment of woody vegetation. These habitats harbour a rich biodiversity in terms of both plant and animal species, but are also threatened by a high and growing number of factors. With this editorial, we want to give a short introduction to the current conservation status, significance and research of semi-natural open habitats, focusing mostly on Europe, and to provide some background on the initiation and development of the current Special Feature and introduce its contributions.

This Special Issue complements the series of Special Features devoted to Palaearctic grasslands (including Janišová et al. 2011, 2014, Dengler et al. 2013, 2014, Habel et al. 2013, Apostolova et al. 2014) edited on behalf of the European Dry Grassland Group (EDGG; <http://www.edgg.org>). The EDGG was founded in 2008 as a professional network of both botanical and zoological researchers and conservationists, dealing with Palaearctic semi-natural grasslands and pristine steppes. It became an official Working Group of the International Association for Vegetation Science (IAVS; <http://www.iavs.org>) and a member of the European Forum on Nature Conservation and Pastoralism (EFNCP; <http://www.efncp.org>). Currently, the EDGG has 1,050 members from 63

countries (as of 23 June 2015). In addition to editing Special Features in international journals, EDGG activities include the annual organisation of the European Dry Grassland Meetings and the research-oriented field workshops, the publication of the quarterly open-access *Bulletin of the European Dry Grassland Group* (ISSN 1868-2456) as well science-policy activities like the *Smolenice Grassland Declaration* (see Vrahnakis et al. 2013).

The present Special Feature was initiated by members of the EDGG attending the Open Landscapes Conference, held in Hildesheim, Germany (29 September – 3rd October 2013; Figure 1) and the 11th European Dry Grassland Meeting (EDGM), held in Kulikovo Pole, Tula, Russia (6–9 June 2014, Figure 2). The Open Landscapes conference covered a wide range of topics, from local ecological patterns and processes in pristine and disturbed ecosystems, plant-animal relationships to their consequences of global change for



Figure 1: Key-note presentation of Paul Keddy at the Open Landscapes Conference, Hildesheim, Germany (30 September 2013; photo: J. Mantilla-Contreras).

Slika 1: Uvodno predavanje Paula Keddyja na konferenci Open Landscapes Conference, Hildesheim, Nemčija (30. 9. 2013; foto: J. Mantilla-Contreras).



Figure 2: Group photo of the participants of the 11th European Dry Grassland Meeting (EDGM), held at Kulikovo Pole, Tula, Russia (7 June 2014; photo: J. Dengler, JD141357).

Slika 2: Skupinska slika udeležencev 11. srečanja European Dry Grassland (EDGM), ki je bilo v kraju Kulikovo Pole, Tula, Rusija (7. 6. 2014; foto: J. Dengler, JD141357).

biodiversity and ecosystem services. Regarding applied aspects, it also aimed at providing tools and targets for ecosystem restoration and innovative strategies for nature conservation. The main aim of the conference was to collect researchers from all over Europe to discuss the implementation of appropriate strategies in all kinds of open habitats, including wetlands, coastal ecosystems, grasslands, wood-pastures, mountain ecosystems and agricultural landscapes. The conference, with its subtitle *Ecology, Management and Nature Conservation*, was attended by about 250 participants from over 25 countries. One of the main outcomes of the conference was the conclusion that researchers and conservation organizations are not cooperating sufficiently and that there is a big need to incorporate ecological research into conservation activities.

The theme of the EDGM in Tula was *Steppes and Semi-natural Dry Grasslands: Ecology, Transformation and Restoration*. This theme was particularly appropriate after the publication the previous year of a comprehensive volume on the European

steppes (Baumbach & Pfützenreuter 2013), which included contributions from numerous members of the EDGG and other experts on grassland topics. The 11th EDGG was attended by 55 participants from 10 countries and provided a forum for discussion between grassland scientists and conservationists from Europe and Russia, on the diversity of steppe habitats, contemporary challenges to their conservation and restoration strategies.

SEMI-NATURAL OPEN HABITATS IN EUROPE AND THEIR CONSERVATION

Within Europe, natural open habitats have generally developed and been maintained because of climatic and edaphic conditions limiting the establishment and survival of trees (i.e. zonal steppes, alpine grasslands, ombrotrophic bogs, coastal and inland halophytic habitats). Also regular and frequent natural disturbances, such as large herbivores, wildfire, flooding or avalanches) could create natural open habitats. However, most of the open habitats in Europe are caused

by and maintained through human disturbances (regular mowing, livestock grazing, fire) (Ehlenberg & Leuschner 2010, Klötzli et al. 2010). These man-made habitats can be subdivided into semi-natural types, which are managed at low intensity, and anthropogenic habitats, where the humans have a much stronger influence on shaping the habitat conditions than the abiotic conditions. Due to reduced natural disturbances (lack of megaherbivores, flood regulation) also some of the natural open habitats nowadays require the implementation of management regimes to retain their open character and to inhibit ongoing succession towards forest vegetation (Britton et al. 2001).

Semi-natural open habitats harbour high biodiversity and thus are conservation priorities in Europe. Certain unimproved, mostly mown, temperate grassland habitats have a particularly high level of small-scale plant diversity (Wilson et al. 2012), and they are also valuable habitats for birds (e.g. Vickery et al. 2001) and insects (Southwood et al. 1979, Bártary et al. 2007b, Venn et al. 2013). Many of the species assemblages of grassland habitats have evolved over centuries of extensive anthropogenic exploitation and utilization. Over recent decades, dramatic declines have been reported in a number of taxa, such as birds (Bártary et al. 2007a, Vickery et al. 2001) and butterflies (e.g. Dover et al. 2011). Clearly there are a considerable number of factors contributing to the diversity decline in steppe and other grassland habitats, including agricultural intensification, cessation of extensive agricultural husbandry, other forms of land-use change, and fire linked to climate change. Most of these factors combine to threaten semi-natural open habitats in general.

Prior to the 18th and 19th centuries, semi-natural open habitats were widely distributed throughout Europe, as it had been necessary to exploit also less productive areas, such as nutrient poor grasslands or heathlands. Today, changes in land-use (intensification or abandonment) are the main reasons for the deterioration or loss of these habitats. As most open areas are strongly affected by humans, their persistence and quality strongly depend on the continued implementation of traditional land-use practices, such as extensive grazing, mowing and burning. In fact, phosphorous limitation, and especially the absence of grazing, seem to play a crucial role in the disappearance of some of these habitats, such as dry heathlands (Härdtle et al. 2006, Mohamed et al. 2007).

One of the major problems after abandonment, in the absence of grazing or adequate management, is the rapid establishment and spread of competitive graminoids and shrubs (Olsson et al. 2000, Tasser et al. 2007, Prevosto et al. 2011). On the one hand, the encroachment of tall graminoid species, such as *Nardus stricta*, *Molinia caerulea*, *Deschampsia flexuosa*, *Calamagrostis epigejos* and *Carex arenaria*, has become a major problem for several open habitats (Ketner-Oostra & Sýkora 2004). Graminoid encroachment slows down succession, changes species composition by suppressing poor-competitor graminoids and forbs, and alters the local environmental conditions (i.e. causing increased litter accumulation), often resulting in monodominant stands and loss of biodiversity (Veer & Kooijman 1997, Mantilla-Contreras et al. 2012). In most studies, graminoid encroachment has been associated with eutrophication, due to high atmospheric nitrogen deposition or terrestrial nutrient runoff from croplands, for instance (e.g. Carroll et al. 2003, Bobbink et al. 2010). On the other hand, shrub encroachment is considered to be one of the most threatening drivers of degradation of semi-natural open habitats. Not only does this diminish the open character of the habitats, but also results in alterations to soil properties (e.g. increasing soil organic matter, soil carbon and nitrogen) and leads to strong vegetational changes, especially in the presence of nitrogen-fixing shrub species (Caldwell 2006, Isermann et al. 2007).

Besides land abandonment and the absence of grazing, a number of additional threats make the conservation of semi-natural open habitats a challenging task. These include increased atmospheric deposition of nitrogen and sulphur, changes in hydrology, invasive species, anthropogenic disturbance and habitat fragmentation (Piessens et al. 2005, Härdtle et al. 2007, Bobbink et al. 2010). All these factors act in synergy with land abandonment, threatening the persistence of open habitats. For example, the absence of grazing is of particularly high importance under high nitrogen deposition.

Due to the high value of these ecosystems and to the numerous threats they face, we consider that the time is ripe for the implementation of research-driven conservation strategies in Europe's open habitats. This Special Feature represents an attempt to advance this cause and the papers collected here address several of the issues and topics mentioned above.

2. CONTRIBUTIONS OF THE SPECIAL ISSUE

This Special Issue consists of eight contributions, from Italy (Giarrizzo et al. 2015, Labadessa et al. 2015), the United Kingdom (Kirby 2015), Czech Republic (Dostálek & Frantík 2015), Austria (Sengl et al. 2015), Romania (Sutcliffe et al. 2015), Ukraine (Polchaninova 2015) and Russia (Vanteeva & Solodyankina 2015). These papers cover a wide range of semi-natural and sometimes natural open habitats, including wood-pastures, heathlands, steppes, semi-dry and dry grasslands. In the following sections, we briefly introduce them, grouped into three major topics: assessment methods (3 papers), threats and management (3 papers) and restoration (2 papers).

ASSESSMENT METHODS FOR BIODIVERSITY AND CONSERVATION

Given the high biodiversity value of semi-natural open habitats in Europe and the numerous threats they face, the development of appropriate tools and methods for correctly assessing and monitoring their conservation status is imperative in order to prevent further losses of these habitats and the biodiversity they support. Here we present three proposed new approaches to the monitoring of semi-natural open habitats.

The first crucial step for the appropriate monitoring of semi-natural habitats in a context of global change, is to develop methodologies for assessing their changes through time. Giarrizzo et al. (2015 in this issue) address this by focusing on semi-natural dry grasslands. The authors propose a methodology aimed at quantifying temporal changes in vascular plant species composition, based on historical phytosociological data, detailed vegetation maps and a novel plot-revisitation strategy. Furthermore, they propose to rely on auxiliary data for identifying the environmental and management variables that drive the detected patterns of change. In a case study application of their approach, Giarrizzo et al. (2015) re-sampled historical plots of *Bromus erectus* grasslands in Central Italy after more than 30 years. Through this diachronic analysis, they were able to show that a significant change in species composition occurred in these habitats between the two vegetation samplings, and that vegetation modifications were driven by variation in environ-

mental factors and management practices. Their findings offer encouragement for the application of future re-visitation studies aimed at monitoring and understanding the evolution of European semi-natural open habitats in recent decades.

In addition to hosting a very high species richness of vascular plants, bryophytes and lichens, open semi-natural habitats also support a rich biodiversity of higher trophic levels, notably of arthropods. For example, 63% of the butterfly species of Europe are associated with dry calcareous grasslands and steppes (WallisDeVries & van Swaay 2009). Indeed, integrating the requirements of both flora and fauna is a challenge for the conservation of open habitats in Europe (WallisDeVries & van Swaay 2009). Moreover, arthropods are also excellent indicators for monitoring semi-natural ecosystems, as they provide a number of ecosystem services (e.g. pollination, pest control, and dung decomposition) and also respond readily to environmental change (Losey & Vaughan 2006, Thomas et al. 2004). Labadessa et al. (2015 in this issue) propose to use *Orthoptera* to provide insights on the conservation status of the plant communities of open habitats in their study focusing on Mediterranean calcareous grasslands. Orthopterans can constitute the bulk of the overall invertebrate biomass in the grass layer and they respond strongly to habitat modification and management changes (Whiles & Charlton 2006, Weiss et al. 2013). In their case study, Labadessa et al. (2015) found that different orthopteran functional groups were associated with distinct plant communities, particularly in relation with grassland conservation state. They conclude that using orthopteran functional groups as indicators can assist managers in better interpreting biodiversity changes in these habitats. Indeed conservation efforts should strive to integrate multiple trophic levels in the assessment of conservation state in these ecosystems.

Finally, theoretical modelling can greatly complement re-visitation studies and indicator-based fieldwork for identifying management directions for the conservation of open habitat mosaics. Kirby (2015 in this issue) uses such an approach to generate management recommendations for the maintenance of British wood-pastures. Wood-pastures are rich and fragile ecosystems, consisting of varying amounts of tree and woodland cover, with extensive open areas, grazed by livestock or deer (Hartel & Pleininger 2014). The open grassland/heath element of the system requires

that the canopy cover remains relatively low, but the presence of too few young trees represents a threat to the long-term survival of the species associated with old trees. Kirby's (2015) model provides a means of determining the tree population structure that would allow a population of old trees to be maintained in perpetuity in a wood-pasture system, and what this might mean in terms of the balance between tree-cover and openness on a site. Kirby concludes that the openness of current wood-pastures is a consequence of the absence of younger cohorts of the tree population, which is not a sustainable tree population structure. He therefore identifies a conservation dilemma, given that many protected sites may be too small to provide sufficient space for restoring the missing generation of trees and at the same time retaining adequate levels of openness.

The combination of multiple instruments, ranging from more applied to very theoretical, and the integration of vegetation and arthropod indicators, can greatly advance our ability to assess the conservation state of a range of semi-natural open habitats in Europe.

THREATS AND MANAGEMENT OF OPEN LANDSCAPES

Selection of the most suitable management strategy depends strongly on local site conditions (e.g. nutrient and water availability, plant species composition) and the local causes of degradation. A site-adapted management strategy is therefore important for the achievement of the optimal results. As most open habitats were formed by extensive livestock grazing in former times, most studies suggest that grazing (by cattle, sheep, horses or combinations) is the best method to protect open areas from succession and grass encroachment and to maintain their typical species (Dostalek & Frantik 2008). Goats are recommended for areas with high shrub cover, as they reduce shrub distribution by stripping their bark and in addition prevent the establishment of new seedlings (Valderrábano & Torrano 2000). Manual or mechanical removal of shrubs or smaller trees is a fast method to clear areas but often results in a homogenous habitat structure and a smaller number of mosaics than can be achieved by traditional grazing (Pietzsch et al. 2013).

In several cases, the implementation of more intensive management interventions is necessary,

such as mowing, sod-cutting or choppering (Niemeyer et al. 2007). This is especially important when soil nutrients are high, grass and/or shrub encroachment cannot be controlled by grazing or for the purpose of regenerating old heathland. However, sod-cutting and choppering in particular are very cost intensive and can therefore often not be applied to large areas (Zerbe & Wiegleb 2009). Thus, management strategies should try to prevent the degradation of all types of semi-natural open habitats and should adapt or improve management as rapidly as possible after the first signs of degradation have been recognized (see Dostálek & Frantík 2015 and Sengl et al. 2015, both in this issue).

Many studies suggest that optimal conservation strategies for semi-natural open habitats involve the incorporation of agricultural activities (Rühs & Hampicke 2010). This is especially the case for species-rich semi-natural open habitats in the Târnava Mare region in Southern Transylvania, Romania. Sutcliffe et al. (2015 in this issue) recommend the implementation of the concept of High Nature Value (HNV) farmland, in which areas consisting of a large proportion of semi-natural vegetation (type 1), are combined with a mosaic of low intensity agriculture and natural and structural elements (type 2), or with areas supporting rare species or a significant proportion of European populations (type 3) (see also Paracchini et al. 2008). Sutcliffe et al. (2015) investigated three major supporting measures which should help to conserve HNV farmlands in Romania: agri-environment schemes, Natura 2000, and publicly funded conservation projects. The authors conclude that the presence of multiple instruments can have synergistic effects on the conservation of HNV farmland and other semi-natural open habitats, and that this overlap provides a certain amount of resilience: even if one instrument fails, another may suffice to fill the gap. Cross-cutting projects which combine research with activities to tackle the "problem" of the socio-economic undesirability of low-intensity farming, as well as the "symptom" of the loss of HNV farmland, have also been found to be highly important.

Grassland ecosystems are associated with a number of ecosystem services (Tscharntke et al. 2005). For several centuries, the principle service has been the provision of most of our food, through extensive agriculture. In recent decades, much of this food production has primarily taken

place on intensively farmed grasslands, and the amount of extensively managed semi-natural grasslands within the landscape has declined. Much of the grasslands that have not been converted to intensive agriculture have undergone structural changes, due to the cessation of traditional extensive agriculture (Vassilev et al. 2011); moreover, large areas have been lost to other forms of anthropogenic landscape-change (Valkó et al. 2012). The implications of these large-scale ongoing changes to grassland habitats in the Palaearctic for the conservation of biodiversity are reasonably well known, but there is clearly a need to review the situation from the point of view of ecosystem services. The service of pollination has attracted much attention, particularly after reports of collapses of pollinator communities in some parts of the world (Pauw 2007, Potts et al. 2010). However, services related to hydrology and the integrity of the soil layer are also key areas for research (Tongqian et al. 2004). In regions affected by landscape change due to tourism or urbanization, for instance, loss of plant biomass can have a dramatic effect on hydrological functions, with consequential erosion in a whole mosaic of habitats, affecting their soil layer and water quality (Vanteeva & Solodyankina 2015 in this issue).

Vanteeva & Solodyankina (2015) assessed different landscapes' values for the provision of ecosystems functions and services, focusing on the function of plant biomass formation and soil erosion prevention in a steppe area of the western coast of Lake Baikal, in the Asian part of Russia. They used GIS tools to evaluate the changes in land-use cover over a ten year period. These were most intensive around settlements and recreational areas. The amount of plant biomass was estimated from the most degraded sites, and silt transfer was assessed using a rainfall simulator. Their results show that areas with a high level of anthropogenic pressure showed high levels of plant biomass loss, and this resulted in a high level of silt transfer. Their results clearly indicate that some habitat types, such as *Caragana* steppe with sagebrush, were particularly vulnerable, showing a dramatic increase in silt transfer rate under anthropogenic disturbance.

The issue of fire is also one that requires further research. Fire is considered an important element of the management regimes in such grassland ecosystems as the species-rich *Themeda triandra* grasslands of south-eastern Australia (Morgan 1999) and short-grass prairies in the

USA (Brockway et al. 2002). However, climate change has exacerbated the impact of forest and grassland fires, particularly in more arid regions, notably California, Tasmania, Russia, Greece and the Iberian Peninsula, resulting in long-scale fire events. In addition to direct economic losses, such as timber and property, these fires have also led to wide-ranging health impacts (Johnston et al. 2012). Thus whilst controlled fires and prescribed burning on an appropriate scale generally have ecological benefits and enhance heterogeneity, large-scale grassland fires constitute major ecosystem disservices (Valkó et al. 2013). In a study of the effects of a long-scale fire on spiders, Polchaninova (2015 in this issue) concludes that many elements of spider communities recover well from fire, though rare, stenotopic species are highly vulnerable. If the habitat of such species is destroyed by fire and the population lost, then the probability of subsequent re-colonization is extremely small. Thus, whilst there is little change at the alpha and beta diversity levels, there is the potential for losses at the gamma diversity level. From this we can conclude that management should endeavour to ensure that rare habitats and the habitats of threatened species should be adequately protected from the threat of fire. Prescribed fires on a smaller scale could be beneficial for enhancing heterogeneity, though there is currently insufficient knowledge of species that benefit from fire.

RESTORATION OF OPEN HABITATS

The restoration of open habitats has become a hot topic in the field of biodiversity conservation during recent decades. Habitat restoration in its broadest sense refers not only to the recovery of former vegetation and fauna, but also to the recovery and maintenance ecosystem functions and ecosystem services, which the restored habitat types provide (Habel et al 2013). Grassland and heathland restorations can be considered as excellent examples of open habitat restoration, because they can be characterised by high variability both in species composition and diversity, and they represent a high spatial heterogeneity along a wide range of abiotic conditions (Dengler et al. 2014).

We can distinguish two types of habitat restoration. The first type applies to habitats, which are somewhat degraded, but in which a number

of functional and structural elements are still prevalent (i.e. degraded habitats). In this case enhancement of diversity can be achieved by various means, such as re-initiating or altering regimes of mowing or livestock grazing, halting or reversal of shrub and tree encroachment or restoration of a former hydrological state. In the second and more extreme type, former habitats have been completely eliminated by human activities, such as urbanisation or ploughing and the whole habitat may need to be re-created in the restoration process, such as grassland restoration in croplands (Török et al. 2011).

With respect to the intensity of restoration measures that need to be implemented, we can recognize two extreme cases: 1) restoration relies completely on spontaneous regeneration processes (i.e. no active restoration measures are necessary - the habitat recovers by natural processes, e.g. by spontaneous immigration of desirable species through dispersal and/or from the seed bank); or 2) restoration needs to be based on technical and labour-intensive reclamation (Prach & Hobbs 2008). The selection of the best restoration method in any particular case is generally determined by a number of factors, including: (i) habitat type and associated abiotic and biotic conditions (e.g. propagule availability, weed infestation risk, residual soil fertility), (ii) available budget, manpower and technical resources available for restoration, and (iii) available time (Török et al. 2011).

Spontaneous grassland recovery is the most natural and cost-effective means of restoration (Santoro et al. 2012, Prach et al. 2014). Thus, the analysis of the possibilities of grassland recovery is essential in local and landscape-scale conservation planning. Sengl et al. (2015 in this issue) analysed spontaneous semi-dry grassland recovery in SE Austria, and found that the cover of a number of target species expanded very rapidly. The authors therefore concluded that spontaneous succession might be considered as a relatively fast and effective method for partial grassland restoration in similar systems, when target grasslands are present nearby. However, the most successful colonisers were tall-growing species characteristic of Species-poor mesic *Arrhenatherion* communities. In contrast, rare, small and stress-adapted species were found to be poor colonisers. Moreover, the colonisation success of target species was not correlated with the nutrient content of the soil. These results were also supported

by Jírová et al. (2012), Bartha et al. (2014) and Albert et al. (2014). Therefore, passive recovery methods should be complemented by additional measures aimed at supporting the establishment of poor competitors and stress-tolerant species, such as (i) elimination of weedy/graminoid swards that develop rapidly after the cessation of agricultural use, (ii) removal of the upper nutrient-rich soil layers in topsoil removal, and (iii) facilitating the establishment of target species by direct translocation of their propagules, using hay transfer for direct seeding (Verhagen et al. 2001, Török et al. 2011).

A more challenging task is represented by the recovery of habitats characterised by nutrient poor and dry conditions (Prach & Hobbs 2008). Heathlands with a high cover of *Calluna vulgaris*, are an example of such habitats. Prescribed burning is often suggested as a means for heathland restoration and recovery, but in many countries the application of prescribed burning is restricted (Valkó et al. 2013). Thus, alternative methods are needed in order to achieve restoration goals. In this issue, Dostálek & Frantík (2015 in this issue) reported a comparative study where two possible restoration techniques (extensive, low intensity sheep and goat grazing vs. sod-cutting) were compared in *Calluna vulgaris* dominated heathland recovery. Both methods were shown to be effective for the recovery of *Calluna* at sites where it had disappeared. However, the authors also found that grazing suppressed herbaceous vegetation to a greater extent than the sod-cutting treatment, while the latter treatment favoured the expansion of mosses. These results suggest that the most effective method to restore dry *Calluna* heathlands on shallow, nutrient poor soils is the maintenance of a regime of low intensity grazing. Sod-cutting is not only more demanding, but it is also associated with a higher risk of the degradation of recovered *Calluna* heathland stands, given that the increase of unwanted herbs and tree species can be foreseen.

3. CONCLUSIONS AND OUTLOOK

The area covered by forests in Europe has increased at a rate of approximately 0.4% per year since 1990, as a result of governmental and non-governmental afforestation programmes, natural succession and abandonment of farming (European Commission 2013). Inevitably, this increase

has been at the expense of open habitats, mostly of semi-natural open habitats of high conservation value. These trends are surely partially beneficial, especially considering that the forest cover in other parts of the world is decreasing. However, we should note that newly established non-native forest plantations, created for example by planting *Robinia pseudoacacia* or *Pseudotsuga menziesii*, also contribute to this increase of forest cover. Furthermore, the increase in forest cover threatens some very Species-rich open habitats, such as calcareous pastures and meadows, as well as other dry and mesic Species-rich grasslands (Stampfli & Zeiter 1999). We therefore recommend that decision-makers should support actions to conserve open habitats in Europe by addressing such major challenges as the encroachment of woody vegetation, especially in biodiversity hotspot areas.

We conclude that carefully designed monitoring and evaluation approaches are needed, in order to follow changes in the species composition of open habitats caused by abiotic, biotic or anthropogenic factors and in order to ensure their effective conservation and restoration. Such monitoring approaches should be based not only on vegetation records, but also on integrative assessments of multiple other taxa and on the regular monitoring of abiotic parameters. The collection of data on management actions and other factors influencing or initiating changes in these habitats is crucial. Finally, it is also important to have models to generate scenario predictions and to support conservation and restoration actions, particularly in the face of future climate and other global changes.

The papers presented in this Special Issue reveal that open habitats are vulnerable to multiple threats. Their degradation, and consequent loss of their former area and species richness, is especially critical in relation to altered local management and fragmentation. To counteract these negative changes, appropriate and sustainable management at the local and landscape level is necessary. Carefully designed management and conservation actions should be fine-tuned at the habitat level, considering habitat-specific differences. Furthermore, it is essential that local farmers be involved, in order to ensure long-term sustainable management in both the remaining and recovered open habitats.

In conclusion, we are convinced that the present Special Feature on European open landscapes contributes to a better understanding of

ecosystem functions and supports the biodiversity conservation and management of semi-natural open habitats. We also draw attention to the fact that multitaxon studies (e.g. Zulka et al. 2014) and landscape-scale studies in particular, are still very rare. Thus, in the future, more intensive research should be directed at understanding the effects of landscape complexity and configuration on local and landscape scale biodiversity and on ecosystem functioning.

4. ACKNOWLEDGEMENTS

We editors are very grateful to all the reviewers for their voluntary contributions to the improvement of the papers in this Special Issue. P.T. was supported by OTKA PD 100 192 during manuscript preparation and M.C. by a Marie Curie Intra European Fellowship within the European Community's Seventh Framework Program (FP7-PEOPLE-2012-IEF; IASIMOV 327616). Finally, we would like to thank the German Research Foundation (DFG) for financial support of the Open Landscapes Conference and this Special issue.

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Received: 23 June 2015

Accepted: 25 June 2015

Co-ordinating Editor: Urban Šilc