# 2

# Palaearctic Grasslands in Transition: Overarching Patterns and Future Prospects

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## Introduction

The Palaearctic biogeographic realm covers about 45 million km² (Table 2.1), which corresponds to 35 per cent of the terrestrial ice-free surface of the Earth and thus it is the largest out of the eight biogeographic realms (Olson et al., 2001). In geographic terms, this means Europe, Africa north of the Sahara and the Mediterranean, temperate, boreal and arctic zones of Asia (Fig. 2.1). The realm currently comprises circa 9.7 million km² grasslands, which correspond to 22 per cent of its total area (Table 2.1) and thus the largest amount and likely also the biggest share of grasslands among all biogeographic realms. These grasslands are partly natural, partly secondary, that is, anthropogenic. In any case, they are of high ecological and economic importance, but at the same time subject to various severe threats.

Here we introduce the Palaearctic section of *Grasslands of the World*. Apart from this introductory and synthesis chapter, the section consists of seven regional treatises, roughly arranged from the west to the east (Fig. 2.1): Western and Northern Europe (Dengler and Tischew, 2018), Eastern Europe (in the socioeconomic sense) (Török et al., 2018), the Mediterranean Basin and the Middle East (Ambarlı et al., 2018), Russia (Reinecke et al., 2018), Kazakhstan and Middle Asia (Bragina et al., 2018), China and Mongolia (Pfeiffer et al., 2018) and, last but not least, Japan (Ushimaru et al., 2018). These chapters have been organised by the *Eurasian Dry Grassland Group* (EDGG), an international scientific network, which deals with ecology, biodiversity, conservation and management of all types of natural and semi-natural grasslands throughout the Palaearctic biogeographic realm (Box 2.1).

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**Box 2.1 The *Eurasian Dry Grassland Group* (EDGG).**

The *Eurasian Dry Grassland Group* (EDGG; http://www.edgg.org; Vrahnakis et al., 2013; Venn et al., 2016) was founded in 2008 under the name *European Dry Grassland Group*, resulting from an internationalization of the German *Arbeitsgruppe Trockenrasen*. Notwithstanding that EDGG deals with both animals and plants, it became an official working group of the *International Association for Vegetation Science* (IAVS; http://www.iavs.org) in 2009, which gave the group access to financial and organizational support of a global scientific organization. EDGG is also a member of the *European Forum on Nature Conservation and Pastoralism* (EFNCP; http://www.efncp.org/). With EDGG's name change from 'European' to 'Eurasian', the group in parallel also widened its scope even beyond what the new name suggests, which had been chosen to be able to retain the well-known acronym. According to its bylaws, EDGG now deals with biodiversity, ecology and conservation of all natural and semi-natural grasslands of the Palaearctic biogeographic realm. This means that instead of the former focus on dry grasslands, EDGG now deals with grasslands, whether they are wet, mesic or dry, base-rich, acidic or saline, and from the coastline to the alpine zone. In autumn 2017, the EDGG had about 1,250 members from nearly 70 countries, including both scientists and conservation practitioners. Membership is free of charge. EDGG is governed by a seven-head Executive Committee, elected by the members for a two-year term.

EDGG coordinates scientific and policy-related actions in grassland research, conservation and restoration. It facilitates international communication between researchers, site managers, policy- and decision-makers, using its mailing list and the quarterly published open-access electronic journal, *Bulletin of the Eurasian Dry Grassland Group* (now: *Palaearctic Grasslands*), available from the EDGG website. The main recurrent activity of the EDGG is its annual scientific conference in varying locations. In summer 2017, the 14th *Eurasian Grassland Conference* (EGC) was jointly organized by Latvian and Lithuanian EDGG members in Riga, with excursions to various grasslands in both the countries, scientific talks and posters as well as practical workshops. Slightly younger are the *EDGG Field Workshops* (formerly known as *EDGG Research Expeditions*, e.g., Aćić et al., 2017) during which interested EDGG members of all levels join for one to 1.5 weeks to collect high-quality grassland diversity data (originally vascular plants, bryophytes and lichens, now increasingly also including animal taxa) in less well-studied regions of the Palaearctic. They use a standardized methodology, involving multi-scale sampling, which allows for many different analyses (Dengler et al., 2016b). The 9th such event in early summer 2017 took place in central Italy, as usual with participants from many different countries and a wide range of academic levels. The data of these sampling events are then used for joint publications on patterns and drivers of grassland biodiversity (Kuzemko et al., 2016; Polyakova et al., 2016) or grassland classification (e.g., Dengler et al., 2013), and contribute to collaborative vegetation-plot databases that allow drawing further academic benefits. EDGG was strongly involved in establishing comprehensive national grassland databases in various regions of Europe (e.g., Vassilev et al., 2012, 2018; Dengler et al., 2017), and has recently (re-) started the *Database of Scale-Dependent Phytodiversity Patterns in Palaearctic Grasslands* (GrassPlot; http://bit.ly/2qKTQt2; Janišová et al., 2017). This database combines all the data from the EDGG field workshops (Dengler et al., 2016a) plus many comparable datasets from other projects and aims at using these for multiple broad-scale vegetation ecological and macroecological studies.

Last but not least, EDGG has organized numerous special features and special issues on grassland-related topics in international journals. Since 2005, it has an annual special feature in *Tuexenia*

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focused on grassland vegetation in Central Europe (e.g., Deák et al., 2017). Reflecting the now taxonomically and geographically wider scope, since 2014 this series has been complemented by EDGG Special Issues in *Hacquetia*, about every 1.5 years (e.g., Valkó et al., 2016). Beyond that, EDGG has also organized special issues in other international journals, focusing on specific topics, namely *Conservation of dry grasslands* (in *Plant Biosystems*; Janišová et al., 2011), *European grassland ecosystems* (in *Biodiversity and Conservation*; Habel et al., 2013), *Biodiversity of Palaearctic grasslands* (in *Agriculture, Ecosystems and Environment*; Dengler et al., 2014) and *Palaearctic steppes* (in *Biodiversity and Conservation*; Török et al., 2016). EDGG also has edited two special issues aimed at advancing the consistent broad-scale classification of Palaearctic grassland vegetation, in *Applied Vegetation Science* (together with the *European Vegetation Survey*, another IAVS working group: Dengler et al., 2013) and in *Phytocoenologia* (Janišová et al., 2016). Some of the contributions in these EDGG special issues/features became much-cited reference works because they reviewed and synthesized the knowledge on certain grassland-related topics, most importantly, perhaps *Biodiversity of Palaearctic grasslands* (focused on secondary grasslands; Dengler et al., 2014) and *The Palaearctic steppe biome* (exclusively dealing with the natural, zonal grasslands; Wesche et al., 2016). The eight chapters in this book go a step further by providing seven consistent regional reviews covering nearly the complete Palaearctic biogeographic realm and both natural and secondary grasslands, complemented by this synthesis of syntheses at hand.

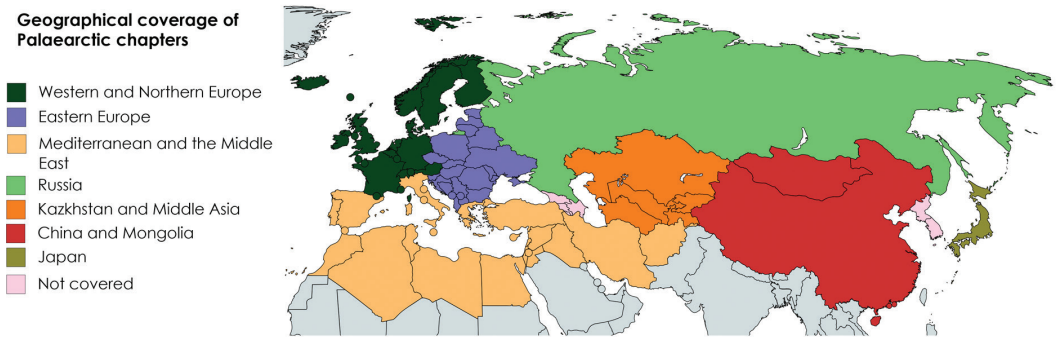


**Fig. 2.1** Chapter division of the Palaearctic realm. There are no chapters dealing with the Caucasus countries (Armenia, Azerbaijan and Georgia) nor with North and South Korea. Note that, deviating from this simplified map, the chapter 'Western and Northern Europe' excludes Mediterranean France (treated in the chapter 'Mediterranean Basin and the Middle East') but includes the Italian Alps (instead of the chapter 'Mediterranean Basin and the Middle East'), and from China only the Palaearctic northern part is considered.

The chapters are arranged according to biogeographic and socioeconomic criteria because both can have a strong impact on the current state of grasslands, their diversity, management and threats. Since many statistics are only available on a per-country basis and socioeconomic drivers usually act on a country level, we normally included complete countries in a chapter even if parts of a country territory show stronger biogeographic relationships to the region of another chapter. The only exceptions are France and Italy, which have been divided between Western and Northern Europe (Dengler and Tischew, 2018) and the Mediterranean Basin and the Middle East (Ambarlı et al., 2018), as well as China, whose subtropical parts (belonging to the Indo-Malayan biogeographic realm) are not considered. Overall, we managed to cover the whole Palaearctic biogeographic realm, with the only exception of two smaller regions, namely the Caucasus countries (Armenia,

Azerbaijan and Georgia) and the Korean Peninsula (North and South Korea). To facilitate comparisons between the regions, the chapters use a similar structure and terminology. They have been written by a team of 28 experts from the EDGG, resident in 17 different countries.

## Grasslands in the Palaearctic

To get a hang of the topic, one first needs to define what grasslands are, which is not easy as there are many different definitions from ecological, physiognomic, agronomic or remote-sensing points-of-view (Gibson, 2009; Dixon et al., 2014; Wesche et al., 2016). Here we adopt the definition of Janišová et al. (2011) modified by Dengler et al. (2014): *Grasslands are herbaceous vegetation types that are mostly dominated by grasses (Poaceae) or other graminoids (Cyperaceae, Juncaceae) and have a relative dense vegetation cover (usually > 25 per cent)*. On top of that, we only need to exclude artificial grasslands that are re-seeded every year, such as cereal fields. Based on this definition, we can find four main types of grasslands in the Palaearctic (Dengler et al., 2014):

(1a) *Steppes* (climatogenic grasslands in climates that are too dry to sustain forests and are affected by frost).

(1b) *Arctic-alpine grasslands* (climatogenic grasslands in climates that are too cold to sustain forests).

(1c) *Azonal and extrazonal grasslands* (pedogenic or topogenic grasslands under special soil or topographic conditions that, at small spatial scales, allow grassland to exist in climates that otherwise would support forests, shrublands or deserts).

(2) *Secondary grasslands* (resulting from other natural vegetation, mainly forests, but also wetlands, through human land use, like mowing, grazing, burning or abandoning arable fields).

Types (1a) to (1c) together form the natural grasslands, and there are many transitions between these, for example alpine steppes, which are both too cold and too dry for forests (Wesche et al., 2016).

With these concepts in mind, we tried to compile overall statistics on the grasslands of the Palaearctic (Table 2.1). Already getting an overall extent of grasslands in the realm was a challenge as there are many statistics that often strongly deviate from each other. The widely recognised 'world grassland types' of Dixon et al. (2014) give a value of 10.1 million km² of 'International Vegetation Classification Divisions with Dominant Grassland Types' for the Palaearctic. Deviating from what the title of this paper suggests, this value is not meant to provide the actual distribution of grasslands and their areas, but the area of ecozones that are assumed to have a natural vegetation dominated by grasslands. Thus on the one hand, all the secondary grasslands, are excluded but on the other, grassland biomes that have been converted to arable fields or other land-cover types are included. In consequence, Dixon et al. (2014) do not even provide a well-founded estimate of the area of grassland biomes because, while including various units dominated by forests and shrublands, they excluded other units that are clearly grassland-dominated (see Wesche et al., 2016). The latter authors therefore re-evaluated the same basic units (ecoregions) from the Terrestrial Ecosystems of the World (Olson et al., 2001) and concluded that the original extent of steppes (including alpine steppes) was circa 8.9 million km². While this number is

**Table 2.1** Grassland areas and fractions in the Palaearctic biogeographic realm and its seven main regions according to the chapter division of this book. (Note that the majority of figures are based on expert estimates by the chapter authors and the authors of this synthesis; this is particularly true for the subordinate grassland categories. NA = not available.)

| Region | Western and Northern Europe[1] | Eastern Europe | Mediterranean Basin and the Middle East[1] | Russia | Kazakhstan and Middle Asia | China and Mongolia[2] | Japan | Total[3] |
|---|---|---|---|---|---|---|---|---|
| **Chapter** | **Dengler and Tischew (2018)** | **Török et al. (2018)** | **Ambarlı et al. (2018)** | **Reinnecke et al. (2018)** | **Bragina et al. (2018)** | **Pfeiffer et al. (2018)** | **Ushimaru et al. (2018)** | |
| **Number of countries included**[1] | 19 | 19 | 21 | 1 | 5 | 2 | 1 | 71 |
| **Total area included [km²]** | 2,714,355 | 2,187,878 | 10,744,442 | 17,125,000 | 4,008,139 | 7,900,000 | 377,972 | 45,057,786 |
| **Total extant grasslands [km²]** | 470,000 | 300,000 | 1,810,000 | 1,790,000 | 1,480,000 | 3,800,000 | 20,000 | 9,710,000 |
| - Fraction of territory | 17% | 14% | 17% | 10% | 37% | 48% | 5% | 22% |
| - Proportion of natural grasslands | 21% | 7% | 60% | 79% | 87% | 95% | 30% | 78% |
| - Proportion of HNV grasslands[4] | 36% | 69% | NA | 91% | 76% | 83% | NA | ca. 80%[7] |
| **(1) Natural grasslands[5] (extant) [km²]** | 100,000 | 20,000 | 1,080,000 | 1,420,000 | 1,290,000[8] | 3,610,000 | 6,000 | 7,550,000 |
| - as fraction of their original extent | 98% | 7% | 80% | 51% | 63%[8] | 95% | 80%[9] | 72% |
| (i) Steppes [km²] | 0 | 11,000 | 830,000 | 500,000 | 1,120,000[8] | 1,900,000 | 0 | 4,380,000 |
| (ii) Arctic-alpine grasslands [km²] | 80,000 | 5,000 | 210,000 | 820,000[0] | 100,000[8] | 1,610,000 | 500 | 2,830,000 |
| (iii) Azonal + extrazonal grasslands [km²] | 20,000 | 4,000 | 40,000 | 100,000 | 70,000[8] | 100,000 | 5,500 | 340,000 |
| (a) In good state [km²] | 95,000 | 13,000 | NA | 1,280,000 | 9,50,000 | 3,040,000 | NA | ca. 84%[7] |
| (b) Degraded [km²] | 5,000 | 7,000 | NA | 140,000 | 340,000 | 570,000 | NA | ca. 16%[7] |
| **(2) Secondary grasslands[6] (extant) [km²]** | 370,000 | 280,000 | 730,000 | 370,000 | 190,000 | 190,000 | 14,000 | 2,160,000 |
| - as fraction of their maximum extent (in the past) | 60% | 50% | 80% | NA | NA | 100% | 30% | ca. 72%[7] |
| (a) Semi-natural grasslands [km²] | 75,000 | 195,000 | NA | 345,000 | 170,000 | 95,000 | 3,500 | ca. 62%[7] |
| (b) Intensified grasslands [km²] | 295,000 | 85,000 | NA | 25,000 | 20,000 | 95,000 | 10,500 | ca. 38%[7] |

[1]France and Italy, partly treated under 'Western and Northern Europe', partly under 'Mediterranean Basin and the Middle East', appear twice. [2]Only the Palaearctic part of China is considered under 'China and Mongolia'. [3]Total also includes the Caucasus countries Armenia, Azerbaijan and Georgia as well as North and South Korea, for which there are no regional chapters. We thus assumed that the situation in the Caucasus is roughly similar to that in Russia and that of the Korean Peninsula to that in Japan. [4]HNV (High Nature Value) grasslands are here defined as those of categories 1a and 2a. [5]Under 'Natural grasslands' we include those secondary grasslands that grow in the place of natural grasslands (e.g., overgrazed natural grasslands or recovering grasslands after temporary use as arable fields). [6]Under 'Secondary grasslands' we include here only those grasslands that grow in places that naturally would be occupied by non-grassland formations, e.g., forests and shrublands. [7]Percentage calculated on the basis of those regions with data. [8]The values of original coverage of natural grasslands in the region are based on the estimates in Wesche et al. (2016: Online Resource 3) for the included ecoregions. We roughly assume that circa 60 per cent of the original steppes (as given by Wesche et al. [2016: Online Resource 7] for Kazakhstan) remained unconverted, but circa 75 per cent of the original azonal/extrazonal grasslands and 90 per cent of the original arctic-alpine grasslands. [9]No published values seem to exist. However, under forest climates as in Japan not much more than the currently 6,000 km² of natural grasslands are to be expected (compare the situation in Western and Northern Europe). [10]This number includes 6,70,000 km² of a total of 3,352,000 km² reindeer pastures, assuming that circa 20 per cent of these can roughly be ascribed to grasslands in the wide sense.

useful, it also does not quantify how much of these steppes are still extant, nor how much area needs to be added for arctic-alpine, azonal or extrazonal and secondary grasslands.

Table 2.1 for the first time attempts to provide such an overview of grassland areas and their types for the Palaearctic biogeographic realm as a whole and its main regions corresponding to our chapters. To compile this table, we used the expertise of the seven regional author teams as well as additional sources. Still in many cases the values are to be considered as rather rough estimates. The total areas of all extant grasslands were mostly derived from statistics of the Food and Agriculture Organisation of the United Nations (FAO), based on land use statistics. Unfortunately, even in Western European countries, there are considerable unexplained discrepancies between grassland areas provided by FAO and two European statistical sources (see Dengler and Tischew, 2018), while in Iran, an estimate based on national sources gave a more than three-fold larger grassland area than the FAO value (907,000 vs. 295,000 km²; A. Naqinezhad, pers. comm.). We also tried to estimate the amount of High Nature Value (HNV) grasslands in the regions because this is a term that becomes more widely applied in discussions on biodiversity conservation (Veen et al., 2009; Oppermann et al., 2012). While originally this term was only applied to grasslands in low-input farming systems that host a high biodiversity or high concentrations of species with particular conservation interest (Paracchini et al., 2009), we extended it here to match its intuitive meaning, that is, to include both natural and secondary grasslands that contribute significantly to biodiversity conservation. Thus, we subdivided natural grasslands (in the sense of all grasslands that grow in places naturally covered by grasslands) into (a) those of good state and (b) degraded ones and secondary grasslands into (a) semi-natural ones and (b) intensified ones (Table 2.1). The natural grasslands in good state and the semi-natural grasslands together would then constitute the HNV grasslands. Evidently, in both cases there is a gradual transition between (a) and (b), and we are not aware of any previous clear definition. Thus, we consider, for the purpose of this synthesis, HNV grasslands roughly as those that still host 50 per cent or more of their 'original' diversity and whose floristic composition and structure are still so similar to the 'original' state that they would conventionally be considered the same vegetation type (phytosociological association or at least alliance), albeit possibly a different subtype. This was the rule of thumb with which the regional author teams were asked to 'classify' their grasslands, acknowledging all imprecisions that come with that.

As a result of our exercise, we can now state with reasonable confidence that currently there are about 9.7 million km² of grasslands in the Palaearctic, of which 78 per cent (7.6 million km²) are natural and 22 per cent (2.2 million km²) are secondary (Table 2.1). The extant natural grasslands are the remains of originally about 10.4 million km² (i.e., 78 per cent). Their biggest share are steppes (58 per cent), followed by arctic-alpine grasslands (37 per cent), while azonal and extrazonal grasslands are of subordinate importance only (5 per cent). Secondary grasslands have also lost about one-fourth of their maximum extent. The HNV fraction among the remaining natural grasslands (84 per cent) is higher than that among the secondary grasslands (62 per cent). Of particular interest are the regional differences revealed by Table 2.1—the fraction of grasslands among the current land cover types ranges from only 5 per cent in Japan to nearly 50 per cent in the Palaearctic parts of China and Mongolia. The extant grasslands are strongly dominated by natural types (more than 75 per cent) in Russia, Kazakhstan and Middle Asia as well as China and Mongolia, while these contribute an intermediate share in the Mediterranean Basin and the Middle East (60 per cent) and a relatively small fraction in Western and Northern Europe as well as Japan (20–30 per cent). A special case is eastern Europe, which once had extensive natural steppes (mainly in Ukraine), which were almost completely

destroyed (Korotchenko and Peregrym, 2012) so that nowadays secondary grasslands are strongly prevailing (only 7 per cent for all three groups of natural grasslands).

## Drivers of Biodiversity Loss in Palaearctic Grasslands

Palaearctic grasslands are in very intense transition; in many regions grassland biodiversity is facing many threats, which are strongly linked to changes in human activities (Dengler et al., 2014; Wesche et al., 2016). We summarized the most important threats and their relative importance by region in Table 2.2. The table was composed based on the information provided in the seven Palaearctic chapters and refined and supplemented by the author teams of these regions. Inspired by the reference works of World Resource Institute (2005), Salafsky et al. (2008) and Janssen et al. (2016), we distinguished 14 threat categories arranged into six main groups. While the drivers of biodiversity loss vary from region to region, some general patterns are obvious nevertheless.

It is evident that overall and in most regions grassland abandonment or underuse can be considered as the most important threat to grassland biodiversity (Table 2.2: relevance score 17). Other generally influential threat factors (relevance scores ≥ 10) are overgrazing and other types of intensification of grassland use and various types of grassland losses due to conversions to arable land, forest or built-up areas. Alterations of site conditions, climate change, invasive species and direct human impacts are considered of lesser impact across the Palaearctic grasslands. Beyond these general patterns, there are also striking regional differences. Most importantly, abandonment/underuse, as one of the prevailing threats in the other five regions, was considered of low importance in Kazakhstan and Middle Asia, as well as China and Mongolia. By contrast, in these two regions as well as in Russia, conversion of grasslands to arable land and overgrazing are still the most important threats. The conversion of grasslands to arable fields also has a long history in Western, Central and Northern Europe, with a peak probably in the early decades of the 20th century, but it hardly accounts for biodiversity losses in recent decades. By contrast, the countries of the former Soviet Union, particularly Ukraine, Russia and Kazakhstan with their large share of the steppe biome, experienced the most intense conversion ('Virgin Land Campaign') during the communist period, but continue on an alarming scale until today. Finally, eutrophication is considered one of the two main threat factors in Western and Northern Europe and of some importance in other parts of Europe, while it is hardly seen as relevant in the Asian regions.

Our new assessment based on expert knowledge from the individual regions reveals some marked differences to previous seminal works on relevance of threat factors to biodiversity. Sala et al. (2000) suggested that for extratropical grassland land use (meaning both land use change and conversion to other land-cover types) is the most important group of threats, while each of their four other factor groups (climate, N deposition, biotic exchange, increase in atmospheric $CO_2$) are on a similar and lower level, approximately at one-third. According to our assessment, 'land use' would be even more influential, while the negative impacts of climate change and biotic exchange for Palaearctic grasslands are probably lower and those of elevated $CO_2$ currently probably negligible. With a slightly different categorization of threats, the Millennium Ecosystem Assessment (World Resources Institute, 2005) considered for temperate grasslands habitat change and eutrophication as the two categories of very high importance for past biodiversity loss, invasive species as moderately relevant while climate change and overexploitation so far had low importance. While our new assessment agrees with the ranking of the last two and of land use, rating

**Table 2.2** Relative importance of recent threats (< past 30 years) for grassland biodiversity reviewed in the regional chapters of the Palaearctic biogeographic realm. (Relative importance of a respective threat: –: absent or very rare, +: rare/local/low impact, ++ moderately widespread/moderate impact, +++: widespread/high impact. The overall relevance score, intended to provide an idea of the relative importance of threat factors, was pragmatically defined as the number of +'s per threat, not taking into account the different sizes of the regions.)

| | Region | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Threats/causes of Biodiversity Loss** | **Western and Northern Europe** | **Eastern Europe** | **Mediterranean Basin and the Middle East** | **Russia** | **Kazakhstan and Middle Asia** | **China and Mongolia** | **Japan** | **Relevance Score** |
| **Habitat loss of grasslands** | | | | | | | | |
| - Conversion to arable land | + | ++[1] | + | +++[2] | +++[3] | ++[4] | – | 12 |
| - Afforestation | + | ++ | + | ++[5] | + | + | ++[6] | 10 |
| - Mining and energy production | + | + | + | + | + | ++ | – | 7 |
| - Urbanisation, transport and touristic infrastructure | + | + | ++ | + | + | ++ | ++ | 10 |
| **Changes in grassland use** | | | | | | | | |
| - Abandonment and/or underuse | +++ | +++ | +++ | +++ | + | +[7] | +++ | 17 |
| - Overgrazing | + | + | ++ | ++[8] | ++[9] | ++[10] | + | 11 |
| - Other types of agricultural intensification | ++ | + | + | + | + | + | +++[11] | 10 |
| **Alteration of site conditions** | | | | | | | | |
| - Eutrophication | +++ | ++[12] | ++ | + | + | – | – | 9 |
| - Altered water regime | ++ | ++ | + | + | ++ | – | – | 9 |
| **Climate change** | + | + | + | + | ++ | + | +[13] | 8 |
| **Invasive species** | + | ++ | ++ | + | + | – | + | 8 |
| **Direct human impact** | | | | | | | | |
| - Military and armed conflicts | –[14] | +[15] | +[16] | – | + | + | – | 4 |
| - Recreational activities | + | + | + | + | + | – | + | 6 |
| - Collecting wild plants/hunting wild animals | – | + | ++ | ++ | ++ | ++ | – | 9 |

[1]Lower rate in mountainous regions and countries are typical. [2]Heterogeneous; main threat in Stavropol and Krasnodar, but low impact in other provinces. [3]Massive re-use of fallows (secondary grasslands), but not primary steppes. [4]Heterogeneous in the region; in China higher rate of conversion is typical. [5]Heterogeneous; important threat in Belgorod and a few other provinces, but minor impact in others; [6]mostly conifer plantations, but no data on extent. [7]Some abandonment in Mongolia. [8]Insignificant in central Russia and the Volga region. [9]Overgrazing is an important issue in Kazakhstan around settlements. [10]Heterogeneous; lower rates are typical in Mongolia. [11]Conversion to sown pastures and paddy consolidation caused rapid biodiversity loss. [12]In the Baltic countries and lowland regions this is a typical threat. [13]Affects mostly alpine grasslands in the region. [14]In Western and Northern Europe military is not only not negative, but in general quite positive for maintaining grassland diversity as many of the most valuable grasslands are located inside military training areas, where they are kept open, while no eutrophication occurs. [15]While in some countries of the region military acts protective, in Ukraine it is an important threat for biodiversity. [16]Armed conflicts in north Africa and Syria became a major driver of land cover changes.

eutrophication as very high in the past across all temperate grasslands seems to be a result of the biased view or researchers resident in highly industrialized regions that clearly suffer from this factor, while large areas in the inner part of Eurasia do not. Lastly, our three European regions show a good correspondence to the recent assessment of threat factors of grasslands in the European Union and in neighboring countries (Janssen et al., 2016).

The impact of military and armed conflicts is difficult to assess, but was pointed out to be important by several author teams. While in Western and Northern Europe, eastern Europe and Japan military help to protect and maintain grasslands (i.e., low accessibility of military training areas to agriculture, tourism, etc.), in some other regions and countries (e.g., Ukraine, North Africa and the Middle East or Kazakhstan and Middle Asia) armed conflicts and regular military training are an emerging threat to grassland biodiversity.

Regardless of region, we can point out that lowlands and mountainous areas generally differ with respect to threats. In mountain areas, the recent historical rate of conversion to arable land, the effects of eutrophication and altered water regime are considered to be much lower.

## Conclusions and Future Prospects

Building on previous syntheses of the EDGG, in particular Wesche et al. (2016) for the Palaearctic steppes, we provided here for the first time a comprehensive and regionalized assessment of grassland areas and types as well as the relative importance of threat factors considering all types of grasslands across the whole Palaearctic biogeographic realm. We based Tables 2.1 and 2.2 on the aggregation of many different sources, mostly at country level, with varying and often low reliability. Assuming that there was no systematic bias, but over- and underestimation were equally frequent, we are confident that the overall picture reflects the reality. Moreover, some of the parameters were more easy to assess than others: Generally the importance of threats in a region can be estimated easily than their overall impact on grassland biodiversity. Moreover, in some regions, such as the Mediterranean Basin and the Middle East (Ambarlı et al., 2018), the separation of natural and secondary grasslands was challenging because landscape-modifying human impact here dates back more than 10,000 years to the onset of the Neolithic Revolution (see Wesche et al., 2016). Therefore in the countries of this region and some others, national statistics do not distinguish natural and secondary grasslands at all or, as in Spain, use the term ‘steppes’ (according to common definitions defined as climatogenic grasslands, see above) for widespread dry grasslands in the Mediterranean forest biome (M. Pulido Fernández, pers. comm.; compare with Bohn et al., 2004).

Biodiversity of Palaearctic grasslands is shaped by a complex of interacting abiotic, biotic and human-mediated socio-economic factors. To halt biodiversity loss, caused mostly by changes in land use type and intensity, it is vital to develop a realm-scale inventory and database of grasslands and to identify and conserve the key areas by establishing ecological networks. The very first step would be to agree on joint definitions of grassland types according to origin, use, conservation value, ecology and biogeography, clear delimitations against other formations, etc. This would establish better and more consistent statistics across the Palaearctic realm. It is necessary to develop and coordinate targeted research for sustainable-management practices fine-tuned to regional and local biodiversity patterns. It is also vital to evaluate the natural capital of grassland habitats and calculate realistic values of their ecosystem services.

We can conclude that for sustainable use and biodiversity conservation in Palaearctic grasslands an integrative view and holistic thinking are inevitable. This implies that effective policy tools acting at a transnational level should be implemented. In particular this means (i) to develop a more effective international-level policy tools and actions for grassland conservation and restoration, (ii) to initiate a transnational knowledge transfer and networking for enhanced food security and sustainable use of grasslands, and (iii) to develop a platform integrating the opinions of key stakeholders and policy-makers in tuning decisions related to sustainable grassland management and conservation.

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## Abbreviations

EDGG = Eurasian Dry Grassland Group; FAO = Food and Agriculture Organisation of the United Nations; HNV = High Nature Value

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