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Biodiversity on the waves of history: Conservation in a changing social and institutional environment in Hungary, a post-soviet EU member state

Barbara Mihók[a,b,*], Marianna Biró[a,b], Zsolt Molnár[a,b], Eszter Kovács[c], János Bölöni[a,b], Tibor Erős[b,d], Tibor Standovár[e], Péter Török[f], Gábor Csorba[g], Katalin Margóczi[h], András Báldi[a,b]

[a] MTA Centre for Ecological Research, Institute of Ecology and Botany, Lendület Ecosystem Services Research Group, Alkotmány u. 2-4, Vácrátót 2163, Hungary
[b] MTA Centre for Ecological Research, GINOP Sustainable Ecosystems Group, Klebelsberg Kuno u. 3, Tihany 8237, Hungary
[c] Institute of Nature Conservation and Landscape Management, Szent István University, Páter Károly utca 1, Gödöllő 2100, Hungary
[d] MTA Centre for Ecological Research, Balaton Limnological Institute, Klebelsberg K. u. 3, Tihany 8237, Hungary
[e] Department of Plant Systematics, Ecology and Theoretical Biology, Eötvös Loránd University, Pázmány Péter Sétány 1/C, Budapest 1117, Hungary
[f] MTA-DE Biodiversity and Ecosystem Services Research Group, Egyetem sqr. 1, Debrecen 4032, Hungary
[g] Department of Zoology, Hungarian Natural History Museum, Baross u. 13, Budapest 1088, Hungary
[h] Department of Ecology, University of Szeged, Közép-fasor 52, Szeged 6726, Hungary

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ABSTRACT

Changes of the social-political system in the last twenty-five years heavily affected biodiversity conservation in the post-soviet Central and Eastern European (CEE) countries. We used a framework to present the effect of the two fundamental social, political and economic changes on the biodiversity and ecosystems of Hungary from 1989 until recently. First, following the democratic transformation in 1989 social, political, economic and institutional drivers led to the increase in farmland biodiversity, improvement of water quality due to less chemical use and decrease of habitat loss within protected areas. At the same time, land privatisation and uncertain ownership led to habitat degradation, abandonment and fragmentation. These changes were coupled with the spread of alien species and re-ploughing. The second change was joining the European Union in 2004. This resulted in the establishment of the Natura 2000 network, the application of the relevant EU policies, and access to conservation related EU funds, which contributed to successful habitat restorations increasing of some charismatic species' populations. Meanwhile, however, disappearance of extensive farming practices, agricultural intensification and infrastructural developments driven by some increasing EU funds led to a net habitat loss, degradation and decline in biodiversity, with more than half of the species of European importance having unfavourable conservation status. Increased support for conservation institutions, adaptive and extended agri-environment schemes and further research and monitoring to establish, refine and supervise sustainable management practices, including water management, are needed to prevent further biodiversity loss in the coming years.

1. Introduction

Effective conservation of biological diversity can be achieved only if viewed in a coupled socio-ecological system (Berkes and Folke, 1998; Díaz et al., 2015). Understanding the links between society and nature, however, requires specific knowledge, gained particularly from regions where rapid social transformations have high stakes regarding biodiversity conservation. In Central and Eastern European (CEE) countries political, legal and regulatory systems changed dramatically in a relatively short period making a substantial impact on biodiversity conservation (Liira et al., 2008; Berkes, 2016). Despite of forced intensification trends (Peterson, 1993; Jepsen et al., 2015), extensive farming practices and extended semi-natural and natural habitats survived in Hungary during socialism (Báldi and Batáry, 2011), similarly to other CEE countries (Stoate et al., 2009; Tryjanowski et al., 2011). These habitats contributed substantially to the increase of biodiversity-rich areas of the European Union (EU) when these countries joined (Henle et al., 2008; Young et al., 2007; Stoate et al., 2009; Sutcliffe et al., 2015). The deconstruction of the socialist legislation, the establishment of new institutions, new progressive conservation laws and later the EU accession introduced new regulation and management tools for biodiversity conservation in the new member

* Corresponding author at: MTA Centre for Ecological Research, Institute of Ecology and Botany, Alkotmány u. 2-4, Vácrátót 2163, Hungary.
E-mail addresses: mihok.barbara@okologia.mta.hu, barbaramihok@gmail.com (B. Mihók).

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states, including the establishment of the Natura 2000 network and the related agricultural incentives (Hochkirch et al., 2013; Kati et al., 2014). The EU Common Agricultural Policy (CAP) has a much broader and debatable influence on the ecosystems: in addition to resource allocation to the conservation of high nature value areas (HNVA-s) and sustainable agriculture and forestry practices, CAP is driving agricultural intensification accelerating the decrease of farmland biodiversity (Tryjanowski et al., 2011; Pe'er et al., 2014). While impacts of socio-economic changes on species, habitats and land-use are thus manifold (e.g. Kuemmerle et al., 2008; Pullin et al., 2009), biodiversity governance and conservation institutions have also gone through substantial transformation in these countries (Kluvánková-Oravská et al., 2013), resulting in an ever-so changing socio-political landscape of conservation advocacy.

Particular case studies contributed to the overall picture of conservation in the CEE region on e.g. protected areas (Iojă et al., 2010; Knorn et al., 2012; Lepšová and Pouska, 2014), conservation policy (Ioras, 2003), and pollinators (Kovács-Hostyánszki et al., 2016) in Romania, farmland birds population trends in Poland and Hungary (Sanderson et al., 2009; Szép et al., 2012), wood pastures (Hartel et al., 2013; Varga et al., 2015) and steppe habitats (Wesche et al., 2016) in Eastern Europe. Information compiled from the EU Member States' reports and further assessments under the EU Directives provides a review on the status of habitats and species in the European Union (EEA, 2015). There is an increasing need, however, to understand the wider picture of this dynamic era (see e.g. Hanspach et al., 2014), but no report is available at the most important and operative administrative level, the state, to scrutinise the relationship between biodiversity, governance and legislation in a socio-economic context. Thus, information from the CEE region, that applies an integrative approach and provides the wider context are key for a better understanding and documentation of how substantial changes in socio-political context influence biodiversity conservation. Considering the recent rapid political changes, such case study will provide essential information. Hungary has been the subject of these radical changes while substantial knowledge has been also accumulated enabling us to assess the effects of changes on biodiversity. Exploring these changes and their impacts on biodiversity conservation is strongly needed, as it provides further basic insights into the links between society and nature. This is all the more needed, as biodiversity conservation faces particular challenges more than twenty-five years after the transition from communism to democracy and a decade after the EU accession (e.g. Knorn et al., 2012; Baumann et al., 2011; Báldi and Vackar, 2016).

A conceptual framework is needed for this exploration as it can provide a simple view of the key components and relationships in a complex socio-ecological system. Such a framework is particularly useful for interdisciplinary approaches, namely to highlight relationships across disciplines, science and policy (Ostrom, 2009; Díaz et al., 2015). For this paper, we use a conceptual framework (CF) based on the IPBES (Intergovernment Science-Policy Platform on Biodiversity and Ecosystem Services) framework (Díaz et al., 2015). The central tenet of the concept is that society makes an impact on the ecosystems through indirect and direct drivers. These drivers affect nature, biodiversity and ecosystems and lead to different impacts in terms of ecosystem services and human well-being. These impacts lead to various actions in society (e.g. institutional re-structuring) initiating changes in indirect and direct drivers. The IPBES CF furthermore incorporates “anthropogenic assets” in the framework as the accumulation of physical, intellectual or cultural achievements (Díaz et al., 2015).

Our framework follows the above approach in a simplified way by exploring the basic elements of IPBES CFs: *Indirect drivers*, *Direct drivers*, and *Biodiversity and ecosystems* (Fig. 1) from 1989 up until recently. Under *Indirect drivers* (Section 3) we discuss the country-scale institutional, legal and financial changes affecting nature in Hungary in this period. While a comprehensive review of all indirect drivers (e.g. economic, technological and cultural, Díaz et al., 2015) would be much beyond the scope of this paper, we include some substantial aspect of cultural and economic changes in the discussion which we see as fundamental, including ‘anthropogenic assets’ such as knowledge accumulation. *Direct drivers* (Section 4) cover those anthropogenic factors influenced by the indirect drivers, that induce changes in ecosystems directly, including habitat conversions, shifts in land-use, deforestation and afforestations, habitat restoration, exploitation, species introduction and pollution (Díaz et al., 2015). The consequences of these direct effects on the species and habitats in Hungary are reviewed under *Biodiversity and ecosystems* (Section 5).

By applying this framework, we aim to show the biodiversity gains due to the strengthening conservation instruments after the transition and the EU accession, and to highlight the threat of biodiversity losses imposed by recent institutional changes, development and agricultural pressures following the EU enlargement. Finally we discuss a number of responses that are most needed to address these threats in order to maintain biodiversity in Hungary in the longer term.

2. Study area: Hungary in the centre of the Pannonian Biogeographical Region

Hungary is situated in the Carpathian basin, Central Europe, a topographically discrete unit of the European landscape in the temperate zone. Despite the country's relatively small area (93,030 km^2) and low altitudes (highest point is 1015 m) its classified moderately humid continental climate is rather erratic as it is substantially influenced by the Atlantic and the sub-Mediterranean climatic regimes, with alpine influences (Loczy, 2015; Fekete et al., 2014). The diversity of flora and fauna is especially high due to the multiple biogeographic effects and the species dispersal during and after the glacial period (Varga, 1995; Fekete et al., 2014). The uniqueness of the Hungarian flora and fauna contributed to the formation of a particular biogeographical unit within Europe named as the Pannonian Biogeographical Region (or Pannonicum), covering whole of Hungary, and small areas from the neighbouring countries and the Czech Republic (Fekete et al., 2014; Fekete et al., 2016). Unique endemic communities include the Pannonian forest–steppe forest on loess with *Acer tataricum*; oak scrub forests with *Quercus pubescens* and *Fraxinus ornus*; forest–steppe forests and tall-herb meadow steppes on saline soil; forest–steppe forests on sand; vegetation mosaic of dry perennial *Festuca vaginata* grasslands with juniper–poplar forests on sand; fine-scale mosaic of *Artemisia*- and *Achillea* steppes with *Puccinellia* and *Camphorosma* swards and salt lakes; open dolomite grasslands and dolomite rocky beech forests (Fekete et al., 2014).

Concerning the fauna, there are some widely distributed, pan-European or Eurasian species of priority importance within the EU that are present in remarkable population sizes in Hungary (i.e. the Imperial eagle (*Aquila heliaca*), Saker falcon (*Falco cherrug)*, Eurasian otter (*Lutra lutra*)). However, the speciality of the Carpathian Basin is that it is the most Western and unique outpost of the palaearctic steppe zone (Wesche et al., 2016) and holds a diverse mixture of fauna elements from a large number of geographical regions. Originating from the Siberian, the Mediterranean, the Balkan, the Alpine or Atlantic regions, several fauna elements are now the endemics of the Pannonian Biogeographical Region and as such are unique natural assets of Hungarian nature conservation. The proportion of endemisms is high in the following taxa: molluscs, diplopods, orthopterans and trichopterans (Varga and Kordos, 2003). Of the vertebrate species, the Biharian barbel (*Barbus biharicus*), the Hungarian meadow viper (*Vipera ursinii rakosiensis*), the Pannonian birch mouse (*Sicista trizona*) and four Blind mole-rat species (belonging to the genera *Nannospalax* and *Spalax*) can only be found within the Carpathian Basin. Conservation regulations under the EU legislation are putting therefore most of the responsibility to conserve biodiversity in the Pannonian region on Hungary.

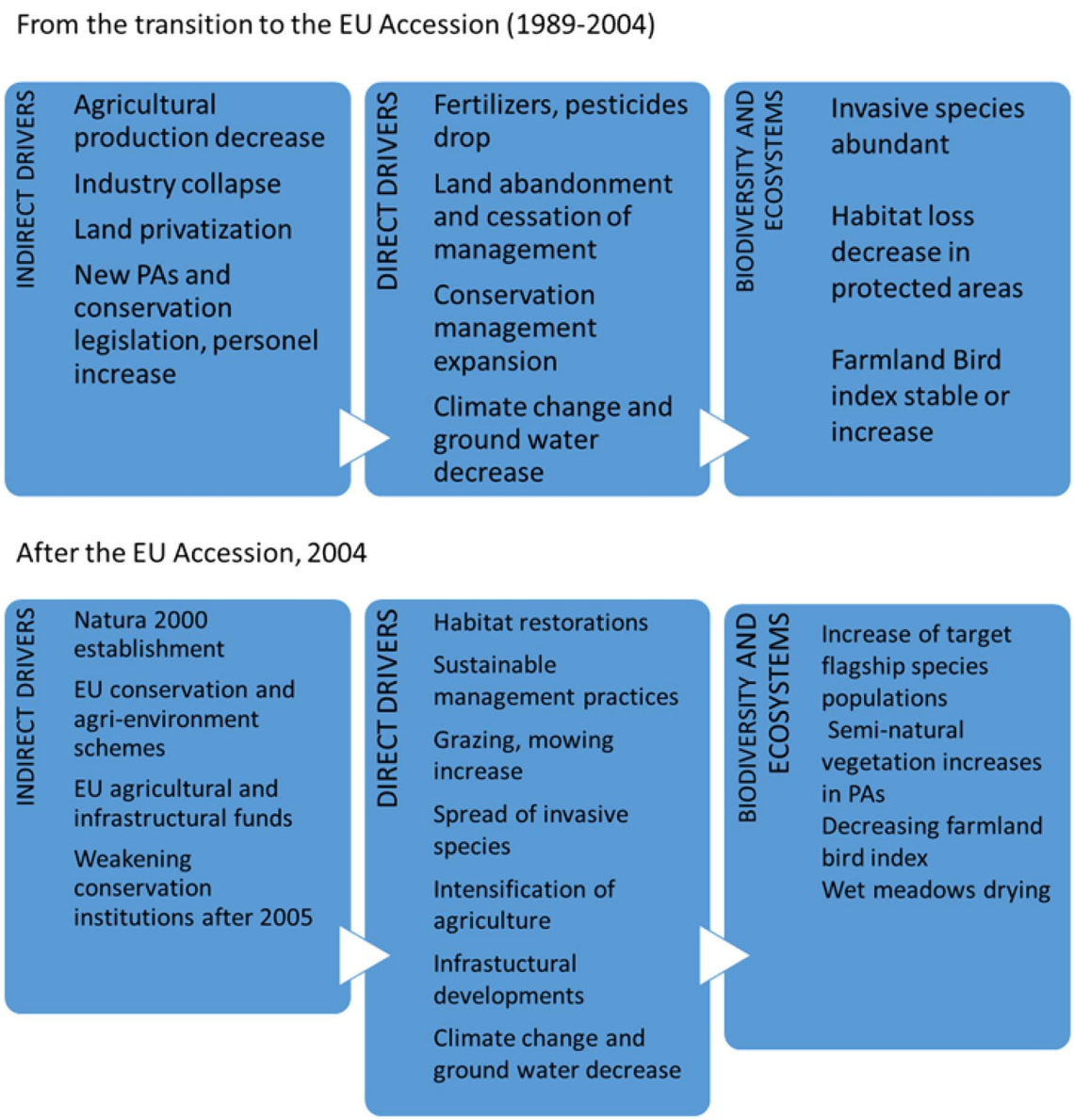

Fig. 1. Major indirect drivers and direct drivers affecting biodiversity in Hungary after the transition from communism to democracy in 1989 and following the EU accession in 2004.

3. Indirect drivers affecting biodiversity and ecosystems

As a major socio-economic driver, a decline in economic performance and agriculture accompanied the transition in the early 1990s in almost all CEE countries (Liira et al., 2008), with a GDP fell by 15% between 1990 and 1993 in Hungary (e.g. Burger, 2001). Agricultural production has declined even more, its contribution to GDP fell from 18% in the late 1980s to 5% by 1997 (e.g. Báldi and Faragó, 2007). Animal husbandry declined substantially as a result of the collapse of the former socialist market and land fragmentation during privatisation after transition (Potori et al., 2013), as in almost every CEE country intensive privatisation increased the share of land owned by private farms (Liira et al., 2008).

The transition in 1990s led to the strengthening of the position of nature conservation within the state, which resulted in the expansion of protected areas (PAs), conservation instruments, measures and actions directly affecting habitats and ecosystems as discussed in Section 4. Six new national parks were established following the transition, and fifty-six new PAs (after 1997, NCP, 2015). Currently PAs under national legislation in Hungary cover 9,1% of the total area (8943 km^2, Fig. 2). Since the 1990s the state has provided financial resources for the purchase and appropriation of protected land, and their management has been assigned to the national park directorates (NPDs). While in 1990 there were only 20,000 ha under the property management of the directorates, at the end of 2012 it was above 290,000 ha, part of which (approx. 50%) has been leased to farmers (Rakonczay, 2009; NCP, 2015). The 1996 law on nature conservation and a new deputy state secretary substantially helped conservation efforts, and “field-level” conservation bodies (NPDs) were also being strengthened. The number of personnel including the rangers in NPDs increased with temporal fluctuations till 2004.

Accession to the European Union in 2004 brought many changes in the legal-institutional setting as well as in financing nature conservation. Following the requirements of the Birds and Habitats Directives of EU, 525 Natura 2000 sites (Sites of Community Importance) were designated in 2004 as an obligatory step (many of which have not been protected previously): 56 Special Protection Areas (SPAs) and 479 Special Areas of Conservation (SACs) (21,39%, 14,77% and 15,51% of the country area, respectively) (CBD Report, 2014). Thus recently 22% of the country's area is under different level of protection with presumably no substantial further increase in the future. Many of these areas are under private ownership due to the land privatisations after

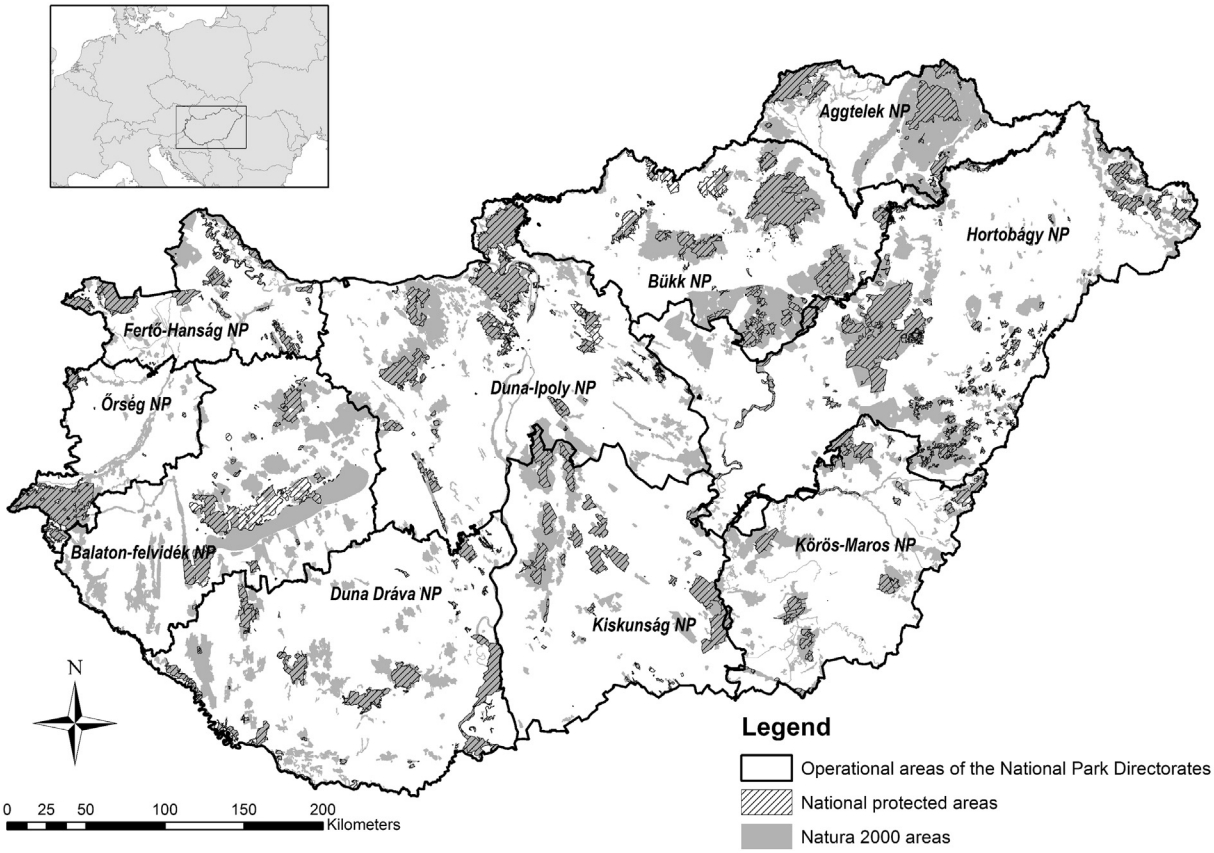

Fig. 2. Protected areas in Hungary.

1989, resulting in the diversification of interest groups in protected areas.

The incoming EU funds (e.g. LIFE, structural and rural development funds) started to play a key role in financing nature conservation activities for the rehabilitation of degraded habitats, species protection projects, nature friendly land management, construction of visitor centres, and development of nature schools (Kovács, 2005; Kovács et al., 2014; Appendix A). With the EU Accession, huge resources became available for infrastructural development projects including e.g. road constructions. Hungary also introduced the Common Agricultural Policy, and gained access to EU payment schemes for supporting agricultural production (Potori et al., 2013). The increase in available resources for both conservation and agricultural led to mixed effects in terms of habitat and species conservation as discussed in the next sections. Several species and habitat conservation programs started and contributed to conservation (for an overview of conservation programs see Appendix D). Conservation management schemes directly influence species and habitats, a comprehensive management guidebook with the contributions of 160 experts, has been recently published providing species and habitat-specific description and management options for nearly all Natura 2000 species and habitats (Haraszthy, 2014). The guidebook emphasizes the need to integrate past management experiences and traditional ecological knowledge into conservation management schemes.

As the EU required the separation of management and authoritative tasks, in 2005 most of the authoritative tasks of the national park directorates were allocated to the regional inspectorates for environment, nature conservation and water (3rd Nature Conservation Plan 2009–2013, 96/2009 Parliamentary decision). This step was also accompanied with a temporary decrease in personnel (which has not been fully recovered since), and presumably resulted in a less effective implementation of conservation regulation. Since 2010 institutional changes have been unfavourable to nature conservation as the Ministry for Environment and Water was ceased and the tasks were inserted into the Ministry for Rural Development (currently Ministry of Agriculture). Since then there has been no separate deputy state secretary position for nature conservation. Currently departments related to nature conservation operate under the environmental affairs deputy state secretariat. These institutional changes supposedly led to the decrease in power and advocacy of conservation issues within the government. In 2015 the regional inspectorates were integrated into the governmental offices as one of their departments (governmental decrees Nos 66/2015. and 71/2015). An investigation by the ombudsman conducted in 2012 highlights that the institutional changes and the substantial decrease in terms of state funding between 2008 and 2011 seriously threatened the professional conservation management and monitoring activities of national park directorates. Moreover, the required increase in capacity and resources were not provided to meet the obligations regarding the implementation of Natura 2000 network. The report draws the conclusion that these changes unfortunately hindered the conservation of biological diversity (Szabó, 2012).

Environmental non-governmental organization gained enhanced influence in the Natura 2000 sites designation and carried out large-scale conservation programs which all increased their resources and expertise. This indicated the increase of NGO's influence in conservation governance as a cultural shift in CEE countries (Cent et al., 2013).

Conservation biology and applied botanical, zoological and ecological research projects and publications multiplied both within academic institutions and within national park directorates (e.g. Báldi and Batáry, 2006). Scientific and pragmatic knowledge – as the element of anthropogenic assets (Díaz et al., 2015) - has expanded enormously in the last 25 years, directly affecting conservation management and supporting sustainable forestry and agricultural practices. Recent increase of ethnobotanical, -zoological and traditional ecological knowledge (TEK) research in Hungary indicates the recognition of TEK's relevance in conservation management and the urge to gather

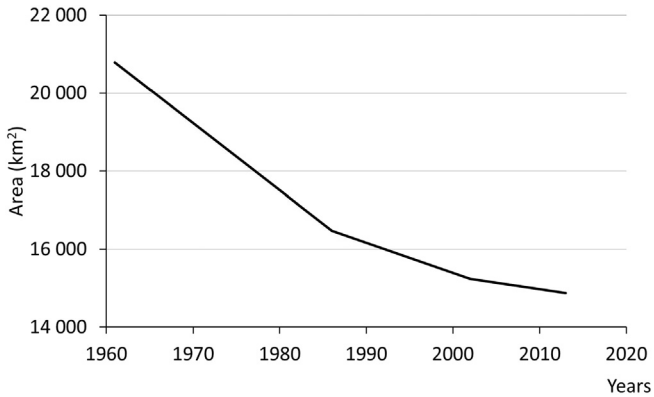

Fig. 3. Total area of semi-natural habitats between 1961 and 2013 in Hungary based on Biró et al., 2016.

this knowledge before it diminishes (e.g. Molnár et al., 2008b; Varga and Molnár, 2014).

4. Direct drivers affecting species, habitats and ecosystems

Following the transition the decrease in agricultural production led to less fertilizer and pesticide use and consequently, an improvement of water quality. Cut down of animal husbandry and the restructuring of land-ownership resulted in substantial changes regarding land-use, e.g. land abandonment and lack of grazing and mowing (Appendix C, Table C.3). Abandonment of extensively used agricultural lands has affected all CEECs as well - for instance in Poland 5.5% of land was abandoned between 1996 and 2000 - and can be considered as the major threat to biodiversity in CEE countries (Liira et al., 2008). In Hungary abandonment of extensive, traditional practices affected and still threatens those habitats that rely on regular extensive management e.g. natural and semi-natural steppes, species-rich hay meadows, marshes and wood-pastures with ancient trees (Molnár et al., 2008a; Babai and Molnár, 2014; Appendix C). Cessation of management also led to, for instance, the acceleration of invasion by non-native species (e.g. goldenrods (*Solidago canadensis*, *S. gigantea*), indigo bush (*Amorpha fruticosa*), black locust (*Robinia pseudo-acacia*), silkweed (*Asclepias syriaca*), maple ash (*Acer negundo*). Invaded areas are most often abandoned former pastures and hay meadows, old fields, open sand grasslands, forest-steppe woodlands and river floodplains including riverine forests (Botta-Dukát, 2008; Biró, 2009). Invasive animal species e.g. spiny-cheek crayfish (*Orconectes limosus*), Amur sleeper (*Perccottus glenii*), harlequin lady beetle (*Harmonia axyridis*) also cause more and more serious problems adversely affecting native populations.

Decrease of ground water levels (up to 8 m of decrease) since the 1980s as a result of landscape-level drainage and serious drought periods threatens lowland wetlands and lowland forest habitats (Kertész and Mika, 1999) and fosters the succession of oxbow lakes in the floodplain of large alluvial rivers. Freshwater habitats are also heavily affected by invasive species, while upstream pollution, fragmentation and physical modification of the riverbed are also among the major threats (Borics et al., 2016; Appendix C). Forests have been and are still exposed to unsustainable forestry management and high game pressure (depending on the type of habitats), while the impacts of climate change should be proactively mitigated by adapting management (Appendix C).

EU agri-payments promote the intensification of agriculture, by which productive grasslands are heavily burdened EU agri-environmental schemes also supported shrub clearance, with many pastures or abandoned arable fields cleared to be eligible for payments (Appendix C). Further EU funds (e.g. Cohesion Funds) also contributed to large infrastructural developments including motorway constructions: 1200 km of new motorway has been built between 2003 and 2014 (KSH, 2017).

After the EU accession, between 2007 and 2013 approx. 5% of the Natura 2000 sites and 10% of the PAs (102,000 ha) have been affected by different habitat conservation programs - including habitat restorations - an increasingly important direct driver inside protected areas - and the development of sustainable forest management practices (NCP, 2015). EU LIFE programs supported the conservation and/or restoration of habitats such as large alluvial riverine islands (Szabadság Island) as well as Euro-siberian steppic woods and Pannonic sand steppes ("Nagykőrösi pusztai tölgyesek" SCI) (EULIFE, 2014). One of the most extended habitat restoration projects financed by EU and co-financed by the state was the restoration of pannonic steppes, marshes, sodic wetlands and grasslands in the Hortobágy National Park. In this program, formerly established 265 km long agricultural drainage system was destructed (totalling by now approx. 1000 km) and a twelve-thousand hectare area was restored. Other LIFE and LIFE + programs addressed the conservation and increase of target species population (e.g. imperial eagle (*Aquila heliaca*), Hungarian meadow viper (*Vipera ursinii rakosiensis*), Pannon endemic plant *Dianthus diutinus* by extended in situ and ex situ conservation actions (Appendix D). Agri-environmental schemes contributed – at a various level - to the maintenance and development of nature friendly agricultural practices in rural areas throughout the country and in specific high value areas as well (Pe'er et al., 2014; Batáry et al., 2015). Forest-environmental payments served as an incentive to promote sustainable forestry practices in private forests and Natura 2000 payment schemes available for grasslands and forests in Natura 2000 areas supported management practices required to maintain conservation status of species and habitats of European importance.

5. Status of biodiversity and ecosystems

The effectiveness of strengthened conservation, and expansion of PAs after the transition can be detected in the changes of the habitat loss rate calculated for the last 50 years (Biró et al., 2016). The rate of loss in semi-natural habitats during the decades of the communism (between 1961 and 1986) had been 0.8%/year. After the communist period the rate decreased approx. to 0.5%/year, and to 0.2% after the EU accession (Biró et al., 2016; Fig. 3). During the transition years (between 1986 and 2002) the rate of habitat loss was significantly lower in protected areas than in non-protected ones (0%/year vs. 0.7%/year, respectively). Since 2002 semi-natural vegetation in protected areas has a net 0.1% / year gain rate (mostly as a result of regeneration of sites on extreme soils abandoned in the second half of the communist era), while in non-protected areas habitat loss decreased to 0.4%/year) (Biró et al., 2016).

Tables 1 and 2 summarize the most important open (non-forested) and forested habitat types in Hungary (Molnár et al., 2007; Appendix B), the current status of forests, grassland and freshwater habitats are discussed in detail in Appendix C. Currently approximately 18% of the country's total area is covered by semi-natural vegetation, while only 0.3% of the country is covered by natural vegetation (Bölöni et al., 2008). Remnants of semi-natural and natural vegetation are under increasing pressure, and habitat quality is relatively low for easily accessible and productive habitats, such as steppe grasslands or mesic meadows (Table 1; Appendix C). More than half of the halophytic grassland types are still in a semi-natural condition, while the proportion of the natural and semi-natural habitats decreases from rocky grasslands towards sand steppes, wet meadows and steppe grasslands – indicating the human land-use pattern (Table 1). Regarding forests, in average a 48,6% value of naturalness (VN) was assessed for all forest stands in Hungary (Table 2., Bartha et al., 2005). Highest VN is characteristic in stands dominated by native tree species, while stands with more frequent locally non-indigenous species, or with prevalently non-indigenous species got lower score, emphasizing the deteriorating effect of invasive species. Calciferous forests have the highest VN

Table 1
Area of semi-natural habitats and percentage of higher quality stands based on naturalness-based habitat quality values in Hungary for non-forested vegetation (based on Bölöni et al., 2008, Molnár et al., 2008a, habitat categories were derived from the General Habitat Classification System (ÁNÉR), Haraszthy, 2014, Bölöni et al., 2007, 2011).

Habitat groups	Area (km^2)	Proportion of semi-natural and natural stands (stands with '4' and '5' habitat quality) (%)
Steppe and rock shrub	6	69
Euhydrophyte habitats	83	68
Fens	148	62
Halophytic habitats	1875	57
Fen and riverine shrub	31	57
Rocky grasslands	57	47
Marshes	761	45
Open sand steppes	110	45
Wet meadows	840	40
Wet tall herb habitats	27	37
Mesic meadows	226	29
Steppe grasslands	745	27
Pioneer shrub	560	17

Table 2
Area and value of naturalness for forested vegetation based on Bartha et al. (2005) and Bölöni et al. (2008).

Habitat groups	Area (km^2)	Value of naturalness, % (0%: canopy, shrub and ground layer missing; 100%: pristine stand)
Calcifrequent oak woods	301	62
Rocky woods	98	59,3
Beech woodlands	1170	59,7
Oak-hornbeam woodlands	2419	58,3
Dry-mesic oak woodlands (*Q. cerris*-forests and acidofrequent oak forests)	1661	56,4 and 57,7
Swamp woods	41	54,7
Riverine woods	630	54,5
Steppe woods	167	50,6
Coniferous woods	13	n.d.

(62%), while the lowest VN was observed in steppe forests (50,6%), which are more affected by ground water decrease, invasive species and decrease in grazing. VN decreases gradually from beech-dominated stands (59,7%), to oak-hornbeam (58,3%) and Turkey oak dominated (57,7%) ones (Table 2).

Regarding freshwater habitat quality, the 1989 transition and the decrease in agricultural production led to the significant improvement of water quality, resulting in the recolonization of many native taxa (Appendix C). However, at present only 9% of the natural surface water bodies are in excellent or good ecological status (Water Management Plan 2015).

Concerning species, although there are detailed species conservation plans elaborated for more than fifty species, it is difficult to show overall trends due to the lack of extended analysed data-series for the majority of species. According to the 2007 Vascular Flora Red List, there is a strong increase (30%) in the number of threatened taxa compared to the end of 80s (Király, 2007). According to the latest EU Country Report (HuRep, 2013) the conservation status of 75 species was considered as Favourable and 127 species as Unfavourable (species listed under the Habitat Directive). Population of particular target species such as the imperial eagle (*Aquila heliaca*), great bustard (*Otis tarda*) increased in the same time due to the success of targeted conservation programs (EULIFE, 2014). According to the results of the Hungarian Common Bird Monitoring – the most extended long-term monitoring dataset -, farmland bird populations have been declining from 2005 following a stable trend beforehand, although the rate of decrease is slower in areas affected by agri-environment schemes (AESs) (Szép et al., 2012).

The knowledge about ecosystem services (ESs) in Hungary is still scarce and represent a research gap as indicated in Mihók et al. (2015) addressed by intensely developing research programs. Many papers use proxy for ecosystem services, others address – national or global – policy aspects (e.g. Kovács et al., 2015). The few studies that directly link biodiversity with ecosystem service support the positive relationship between diversity and services (Földesi et al., 2016; Bereczki et al., 2014). In addition to well-established interdisciplinary research collaborations (e.g. Molnár, 2014), a number of recent EU-funded projects address this issue (e.g. Liberation, http://www.fp7liberation.eu/; Quessa, http://www.quessa.eu/; OpenNESS, http://www.openness-project.eu/). Moreover, Hungarian experts were elected or invited into most of the expert groups of the IPBES, and are also active in the EU's MAES (Mapping and Assessment of Ecosystems and their Services) working group. Ecosystem service policy and research is closely interlinked, which is a historically novel situation for Hungarian biodiversity research, benefiting also from a recent large-scale domestic fund and the launch of the national ecosystem services mapping and assessment in 2016 co-financed by EU's structural funds.

6. Conclusions and recommendations

Decreasing levels of agricultural intensification and strengthening of conservation institutions could be responsible for the decreasing habitat loss rate after the transition in 1989 (see also Biró et al., 2013; Jepsen et al., 2015) similarly to other CEE countries (e.g Iojă et al., 2010). The effect of protection is clearly indicated by the lowered habitat loss rate in protected areas (or even recent net gain) shown above (see also Koleček et al., 2014). Joining the EU resulted also in some positive outcomes: the establishment of the Natura 2000 network ensured that more than 21% of the country is under (some sort of) protection, the incoming conservation EU funds also contributed to successful conservation of particular habitats and species. However, there are also serious challenges and unresolved problems that needs further adaptive social and institutional actions: the recent re-structuring and weakening of conservation institutions, deteriorating effect of CAP payments and agricultural intensification and decreasing farmland biodiversity, climate change and ground water decrease. The following recommendations address these indirect and direct drivers and provide some major intervention points for the long-term conservation goals.

6.1. Increasing infrastructural, financial and legislative support for conservation institutions

is inevitable in order to have enough professional capacity in terms of personnel and expertise. Tasks related to Natura 2000 site management, for example, multiplied the workload of the national park directorates' staff without any added financial resource. Lacking human resources for monitoring of management actions hinders the development of adaptive management practices, bearing huge risks for further conservation efforts. Socio-economic constrains on national park functions particularly calls for increased capacity and resources as indicated in other papers from the region (Křenová and Vrba, 2014; Dickie et al., 2014; Kindlmann and Křenová, 2016).

6.2. Towards more extended and adaptive agri-environment schemes

The reformed Common Agricultural Policy launched in 2013 has been announced as a tool for further strengthening conservation efforts in the EU. However, greening of CAP remains to have a debated outcome: according to Pe'er et al. (2014) "new environmental prescriptions are so diluted that they are unlikely to benefit biodiversity". In order to be able to compensate for the negative effects of the EU agri-incentives, as one of the major indirect drivers, the agri-environment schemes are needed to be extended and become more flexible (Báldi

and Batáry, 2011; Szép et al., 2012; Żmihorski et al., 2016), taking into account the local, regional aspects and management practices, similarly to other CEE countries (Wegener et al., 2011; Báldi et al., 2013; Dahlström et al., 2013; Babai et al., 2015; Sutcliffe et al., 2015).

6.3. Addressing knowledge gaps, increasing research and monitoring capacity

Species and habitat conservation status cannot be properly assessed without a long-term monitoring of management actions, and consistent and freely accessible monitoring datasets are still not available in Hungary (Haraszthy, 2014). Although a long-term monitoring system called National Biodiversity Monitoring System (http1) had been established in 1997–1998, large part of this dataset is still cannot be utilized due to unavailability and a stable functioning GIS system (i.e. the Hungarian Nature Conservation Information System, Takács et al., 2010). Setting up and maintaining an information centre of long-term monitoring system to quantify species and habitat status and management impacts (e.g. AESs impacts) with providing up-to-date freely and easily available data is necessary for designing species and habitat conservation programs and to support land-use decisions (Mihók et al., 2015). As agricultural intensification is a major threat, research providing input on the ecological criteria of sustainable resource management is a crucial demand. Elements of traditional ecological knowledge (TEK) can also contribute to this knowledge-pool and to the adaptive management of ecosystems, e.g. in cases such as knowledge on grazing practices (Haraszthy, 2014). This recommendation is in line with Sutcliffe et al. (2015) opinion paper, which highlights the urgent need for targeted research and monitoring to preserve high biodiversity landscapes in CEE.

6.4. Involving stakeholders: application of participatory methods in conservation

Participatory approaches in conservation and integration of land-users' perspectives in conservation planning and management has been rather limited in most levels of governance in the CEE countries (e.g. Lawrence, 2008; Stringer and Paavola, 2013). Applying participatory methods in adapting EU legislation and agri-environment schemes to local landscapes is a theoretically supported approach with some promising signs (e.g. Kovács et al., 2016).

6.5. Sustainable water management

Fulfilling the requirement of the EU Water Framework Directive (WFD) provides a press on political governance to maintain and restore good ecological status of freshwaters. Sustainable water management should be part of the conservation management concepts in a regional context, particularly as a key strategic element in climate change adaptation and addressing ground water decrease. Aquatic habitats should be incorporated in the protected areas management more effectively through an institutional and operational framework, as current PA network is not able to handle water sheds appropriately (Dolezsai et al., 2015). More intensive cooperation is needed between neighbouring countries to mitigate the effects of cross-borded detrimental impacts on the country's biota embedded in a regional approach.

In sum, Hungary provided a case where socio-economic changes on the waves in history was scrutinised from a conservation perspective, providing insights on how particular indirect drivers influences species, habitats and ecosystems and what challenges lie ahead in a new socio-political setting. Such studies can contribute to a better understanding of the links between society and nature in this rapidly changing word.

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Appendix A. Supplementary data

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