



Harnessing the biodiversity value of Central and Eastern European farmland

Laura M. E. Sutcliffe^{1*}, Péter Batáry², Urs Kormann², András Báldi³, Lynn V. Dicks⁴, Irina Herzon⁵, David Kleijn⁶, Piotr Tryjanowski⁷, Iva Apostolova⁸, Raphaël Arlettaz⁹, Ainars Aunins¹⁰, Stéphanie Aviron¹¹, Ligita Baležentienė¹², Christina Fischer¹³, Lubos Halada¹⁴, Tibor Hartel¹⁵, Aveliina Helm¹⁶, Iordan Hristov¹⁷, Sven D. Jelaska¹⁸, Mitja Kaligaric¹⁹, Johannes Kamp²⁰, Sebastian Klimek²¹, Pille Koorberg²², Jarmila Kostiuková²³, Anikó Kovács-Hostyánszki³, Tobias Kuemmerle²⁴, Christoph Leuschner¹, Regina Lindborg²⁵, Jacqueline Loos²⁶, Simona Maccherini²⁷, Riho Marja¹⁶, Orsolya Máthé²⁸, Inge Paulini²⁹, Vânia Proença³⁰, José Rey-Benayas³¹, F. Xavier Sans³², Charlotte Seifert¹, Jarosław Stalenga³³, Johannes Timaeus³⁴, Péter Török³⁵, Chris van Swaay³⁶, Eneli Viik²² and Teja Tscharntke²

ABSTRACT

A large proportion of European biodiversity today depends on habitat provided by low-intensity farming practices, yet this resource is declining as European agriculture intensifies. Within the European Union, particularly the central and eastern new member states have retained relatively large areas of species-rich farmland, but despite increased investment in nature conservation here in recent years, farmland biodiversity trends appear to be worsening. Although the high biodiversity value of Central and Eastern European farmland has long been reported, the amount of research in the international literature focused on farmland biodiversity in this region remains comparatively tiny, and measures within the EU Common Agricultural Policy are relatively poorly adapted to support it. In this opinion study, we argue that, 10 years after the accession of the first eastern EU new member states, the continued under-representation of the low-intensity farmland in Central and Eastern Europe in the international literature and EU policy is impeding the development of sound, evidence-based conservation interventions. The biodiversity benefits for Europe of existing low-intensity farmland, particularly in the central and eastern states, should be harnessed before they are lost. Instead of waiting for species-rich farmland to further decline, targeted research and monitoring to create locally appropriate conservation strategies for these habitats is needed now.

Keywords

Agricultural intensification, agri-environment schemes, common agricultural policy, European Union, high nature value farmland.

¹Plant Ecology and Ecosystem Research, Georg-August University of Göttingen, Göttingen, Germany, ²Agroecology, Georg-August University of Göttingen, Göttingen, Germany, ³MTA Centre for Ecological Research, Vácrátót, Hungary, ⁴Department of Zoology, University of Cambridge, Cambridge, UK, ⁵Department of Agricultural Sciences, University of Helsinki, Helsinki, Finland, ⁶Alterra, Centre for Ecosystem Studies, Wageningen, The Netherlands, ⁷Institute of Zoology, Poznań University of Life Sciences, Poznań, Poland, ⁸Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, Sofia, Bulgaria, ⁹Division of Conservation Biology, University of Bern, Bern, Switzerland, ¹⁰Faculty of Biology, University of Latvia, Riga, Latvia, ¹¹INRA SAD-Paysage, Rennes, France, ¹²Aleksandras Stulginskis University, Akademija, Lithuania, ¹³Restoration Ecology, Technical University of Munich, Munich, Germany, ¹⁴SAS, Bratislava, Slovakia, ¹⁵Department of Environmental Sciences, Sapientia Hungarian University of Transylvania, Cluj Napoca, Romania, ¹⁶Institute of Ecology and Earth Sciences, University of Tartu, Tartu, Estonia, ¹⁷Bulgarian Society for the Protection of Birds, Sofia, Bulgaria, ¹⁸Faculty of Science, University of Zagreb, Zagreb, Croatia, ¹⁹Faculty of Agriculture and Life Sciences and Faculty of Natural Sciences and

*Mathematics, University of Maribor,
Slovenia,* ²⁰*Institute of Landscape Ecology,
University of Münster, Münster, Germany,*
²¹*Thünen Institute of Biodiversity,
Braunschweig, Germany,* ²²*Agricultural
Research Centre, Tartu, Estonia,* ²³*Nature
Conservation Agency of the Czech Republic,
Praha, Czech Republic,* ²⁴*Geography
Department, Humboldt University of Berlin,
Berlin, Germany,* ²⁵*Department of Physical
Geography and Quaternary Geology,
Stockholm University, Stockholm, Sweden,*
²⁶*Faculty of Sustainability, Leuphana
University of Lüneburg, Lüneburg,
Germany,* ²⁷*Department of Life Sciences,
University of Siena, Siena, Italy,* ²⁸*Department
of Ecology & Genetics, Babeş-Bolyai
University, Cluj Napoca, Romania,*
²⁹*Geobotany and Nature Conservation,
University of Bonn, Bonn, Germany,*
³⁰*Instituto Superior Técnico, University of
Lisbon, Lisbon, Portugal,* ³¹*Department of
Life Sciences, University of Alcalá, Alcalá,
Spain,* ³²*Department of Plant Biology,
University of Barcelona, Barcelona, Spain,*
³³*Institute of Soil Science and Plant
Cultivation-State Research Institute, Puławy,
Poland,* ³⁴*Helmholtz Centre for
Environmental Research, Leipzig, Germany,*
³⁵*MTA-DE Biodiversity and Ecosystem
Services Research Group, Debrecen, Hungary,*
³⁶*Dutch Butterfly Conservation, Wageningen,
The Netherlands*

*Correspondence: Laura M. E. Sutcliffe,
Untere Karspüle 2, 37073 Göttingen,
Germany.
E-mail: sutcliffe.laura@gmail.com

INTRODUCTION

The long history of low-intensity agricultural land use in Europe has created many unique and species-rich assemblages, and a large proportion of European species are now dependent over much of their ranges on this form of human disturbance (Bignal, 1998). However, the industrialization of agriculture has, directly and indirectly, caused a dramatic impoverishment of the fauna and flora compared to the situation a century ago (Gregory *et al.*, 2005; Tscharntke *et al.*, 2005; Storkey *et al.*, 2012). This has contributed not only to the current biodiversity crisis in Europe as a whole, but also to the decline in ecosystem services such as crop pollination and biological pest control (Tscharntke *et al.*, 2005). As a result, the protection of farmland biodiversity has become a key issue in EU and national agricultural and environmental

policies, and large amounts of research and funding are devoted to biodiversity conservation approaches such as agri-environment schemes (Farmer *et al.*, 2008).

Whilst many conservation schemes play an important role in mitigating the impacts of intensive farming, the support of low-intensity practices on existing high nature value (HNV) farmland is, in the short and medium term, the most (cost-)effective way to stop the decline of many specialist species and species-rich communities (Bignal & McCracken, 1996; Kleijn *et al.*, 2009). HNV farmland is present throughout Europe, although it is often restricted to upland or other areas difficult to farm, particularly in Northern and Western Europe (EEA, 2004). Eastern and Southern Europe, in contrast, generally have lower average levels of land use intensity, and healthy populations of many species declining or endangered in the north-west persist here (Liira *et al.*, 2008; Stoate

et al., 2009; Báldi & Batáry, 2011; Tryjanowski *et al.*, 2011; Overmars *et al.*, 2014). Whilst several decades of EU membership have already contributed to the large-scale loss of semi-natural farmland habitats in lowland Northern, Western and, to a lesser extent, Southern Europe (e.g. Donald *et al.*, 2001; Henle *et al.*, 2008; Stoate *et al.*, 2009), the central and eastern new member states (NMS) have only relatively recently started implementing EU biodiversity-related and agricultural policies. In this opinion study, we highlight the contrast between the importance of the central and eastern NMS for farmland biodiversity in Europe on the one hand, and their poor fit with EU agricultural policy and lack of published ecological data in the international literature on the other. Addressing these problems now could help prevent a further decline in European biodiversity and ecosystem quality.

THE LEGACY OF COMMUNIST AGRICULTURE IN CENTRAL AND EASTERN EUROPE AND ITS IMPLICATIONS FOR FARMLAND BIODIVERSITY

Between 2004 and 2013, 11 countries from post-communist Central and Eastern Europe joined the EU in a phased enlargement process that brought it to 28 member states, sharing common policies and goals (see Fig. 1a). Despite heterogeneous in many respects, a shared characteristic of the central and eastern NMS is the legacy of communist agricultural policy during the mid and late 20th century, affecting not only on the structure and use of farmland, but also farmland biodiversity (Báldi & Faragó, 2007; Liira *et al.*, 2008; Cousins *et al.*, 2014). In the western EU-15, and particularly countries such as the UK, France, Germany and the Netherlands, the intensification of lowland farmland was relatively effective, carried out mainly by family farms and driven by production-linked agricultural subsidies. In contrast, although the state-imposed homogenization and intensification of farmland in Central and Eastern Europe also had severe negative impacts on biodiversity in places, this process was relatively inefficient, leaving many remaining patches of semi-natural land (Young *et al.*, 2007). Collectivization of land in most Central and Eastern European countries also merged many private smallholdings into industrial farms of up to several thousand hectares in size. After the fall of the communist regimes around 1990, much of this land was returned to private ownership by individuals, but this had a lasting effect of creating a predominance of small semi-subsistence holdings (generally < 5 ha in size), contrasted with few but very large industrial farms (Fig. 2a; Davidova *et al.*, 2012).

Production dropped dramatically in the east, and large areas of both cropland and grassland were abandoned in the 1990s and early 2000s, both of which allowed at least short-term population recoveries of many species (Donald *et al.*, 2001; Keijs, 2003; Stoate *et al.*, 2009; Kamp *et al.*, 2011; but see e.g. some negative effects of farmland abandonment in Hungary documented by Verhulst *et al.*, 2004). In the EU-15 during the same period, farming intensity was maintained but with increasing regulation of environmental impacts,

most notably through successive reforms of the EU Common Agricultural Policy (CAP) (see Fig. 2b,c; Stoate *et al.*, 2009).

Through the funding structures of the EU CAP, as well as the influence of the EU market, the central and eastern NMS have experienced both large-scale reactivation and intensification of farmland since accession and continuing abandonment of marginal areas (Stoate *et al.*, 2009; Tryjanowski *et al.*, 2011; Sanderson *et al.*, 2013). Nevertheless, fragmentation of land ownership is still a major hindrance in many NMS to the consolidation of farmland and agricultural intensification (Hartvigsen, 2014), and convergence of the agricultural sectors of old and new member states is limited (Csáki & Jámbor, 2013). Thus, compared to Northern and Western Europe, the NMS can be said to have (1) lower levels of agrochemical inputs, mechanization and productivity, with per hectare yields less than half of those of the EU-15 (Csáki & Jámbor, 2013; see also Fig. 2b,c); (2) farm structures polarised between a small number of very large industrial units and a large number of very small units (Fig. 2a); and (3) a predominance of subsistence and semi-subsistence farming, which is linked with positive effects on biodiversity via its promotion of mixed farming and mosaic structures (Tryjanowski *et al.*, 2011; Davidova *et al.*, 2013).

These are all major reasons why comparative studies show greater ecosystem quality for biodiversity (Reidsma *et al.*, 2006), as well as higher levels of rare species occurrence and species richness in lowland farmland (Batáry *et al.*, 2010a) in the NMS than in Northern and Western Europe. However, this also means that nutrient-limited yield gaps are currently larger in Eastern than in Western Europe (Mueller *et al.*, 2012) so that the potential to intensify in the NMS is high. Whilst farmland biodiversity declines now appear to be slowing for some taxa in Northern and Western Europe, as they have already experienced their strongest losses in the mid to late twentieth century (Carvalheiro *et al.*, 2013), the picture may be different in the NMS. For example, long-term monitoring trends in farmland birds suggest that their decline has been accelerating in the NMS in recent years. The farmland bird indices in Hungary (Szép *et al.*, 2012), Latvia (Aunins & Priednieks, 2009) and Poland (Sanderson *et al.*, 2013) all decreased following their accession to the EU in 2004, which the authors link to the changes in agricultural practices provoked by the CAP. General trends are difficult to measure due to the lack of standardised monitoring data from this region (notable exceptions being the Pan-European Common Bird Monitoring Scheme; Voríšek *et al.*, 2010; and in some countries the European Butterfly Monitoring Scheme; Van Swaay & Warren, 2012), as well as time-lags in species responses (Kuussaari *et al.*, 2009; Dullinger *et al.*, 2013). The little evidence that is available from bird monitoring suggests that the current measures in place to protect farmland biodiversity in Central and Eastern Europe seem to be insufficient, but the lack of baseline and comparative data in these regions means that we have very little idea of what is currently being lost.

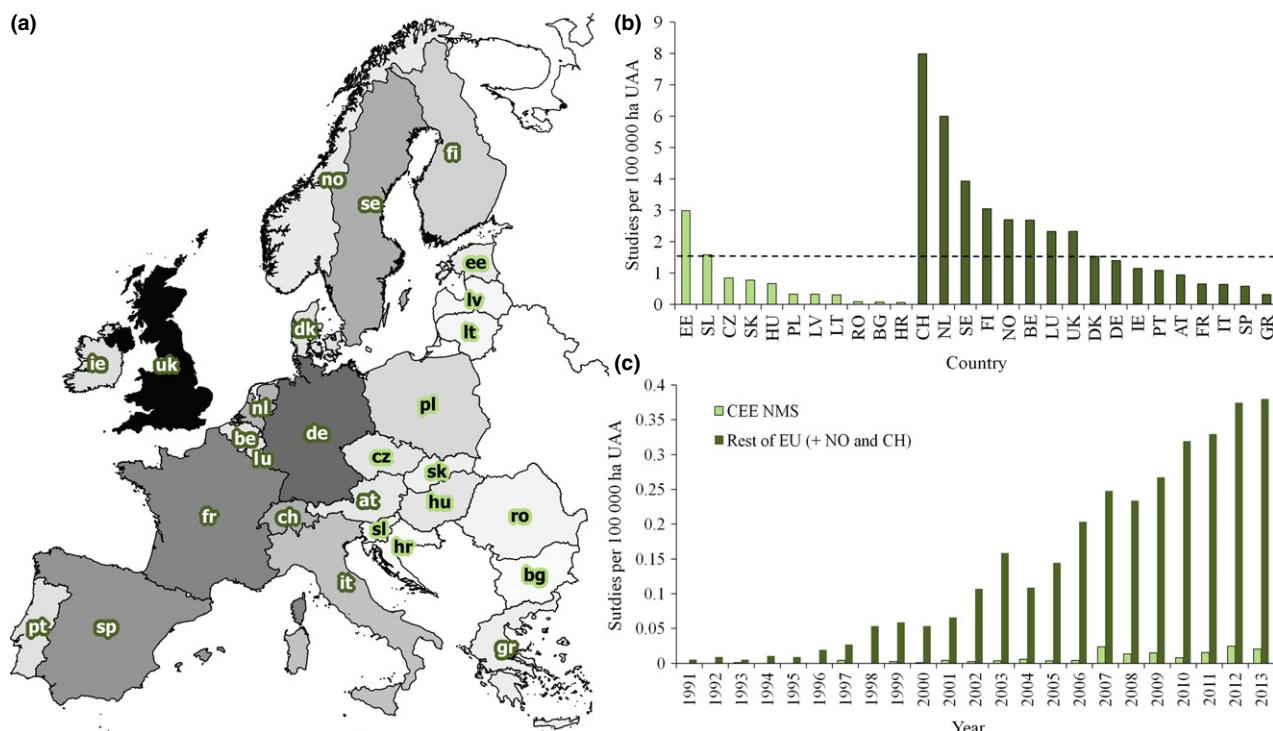


Figure 1 (a) Map of Europe depicting the total number of studies on farmland biodiversity carried out in each EU country found in a search of the Web of Science database. A larger number of studies are indicated by a darker shade of grey (numbers given in Table S1). Black label text = Central and Eastern European new EU member states (CEE NMS), white label text =rest of EU + Norway and Switzerland. We have included the results for Norway and Switzerland, here grouped with the ‘old’ member states due to the similarities of their agricultural systems. Details of the search are given in Appendix S1 and results and country codes in Table S1. (b) Number of studies per 100,000 ha utilised agricultural area (UAA) carried out in each EU country (+ Norway and Switzerland) between 1991 and 2013. The dotted line depicts the average number of studies per country. (c) Number of studies per 100 000 ha UAA carried out in CEE new member states compared to the rest of the EU (+ Norway and Switzerland) in each year since 1991.

AGRICULTURAL BIODIVERSITY IN CENTRAL AND EASTERN EUROPE IS UNDER-REPRESENTED IN THE INTERNATIONAL LITERATURE

The ecological literature on European farmland biodiversity has grown steadily in the last two decades. It plays an important role not only in providing locally relevant evidence to feed into conservation management, but also for large-scale international reviews and meta-analyses to synthesise current knowledge on a topic of interest (Dicks *et al.*, 2013). Searching the online database Web of Science for peer-reviewed publications produced to date on farmland biodiversity in EU countries yielded 1952 studies published since 1991 (see Appendix S1 in Supporting Information). However, Northern and Western Europe dominates the literature both in terms of absolute number of studies (Fig. 1a; the UK, for example, is the focus of twice as many publications as the central and eastern EU NMS together) and proportional to the agricultural area (Fig. 1b).

Whilst the number of studies from central and eastern NMS is increasing, even when adjusted for the agricultural area in the region, they are still only the focus of a tenth of the number of studies focussed on the rest of Europe

(Fig. 1c). This confirms the results of a recent literature review on European AES, in which only 3% focussed on the NMS (Uthes & Matzdorf, 2013), despite the fact that AES have been in place in most NMS for at least 4 years by the end of the analysed time period. There are many possible reasons for the disparity in the numbers of publications on farmland biodiversity. Greater perceived urgency of farmland biodiversity loss and amount of research funding available in the west is likely to play a role, although the acceptance rate by journals of submissions from Eastern Europe has also been criticised (e.g. Rotter & Gostincar, 2014). Whilst it can be assumed that ecological research from the NMS is also published in non-English language or regional journals, these are usually not detected by the international community, for example when creating large-scale reviews. This limits the accuracy of conclusions drawn from the literature, both for the general understanding of agricultural ecosystems and for the local design of conservation measures, because the responses of many species to management changes are moderated by the landscape context (Tscharntke *et al.*, 2012a; Gonthier *et al.*, 2014). For example, moderate intensification was found to positively affect corn bunting (*Emberiza calandra*) populations in a study in Poland (Szymkowiak *et al.*, 2014), compared to strong evidence for the negative effects

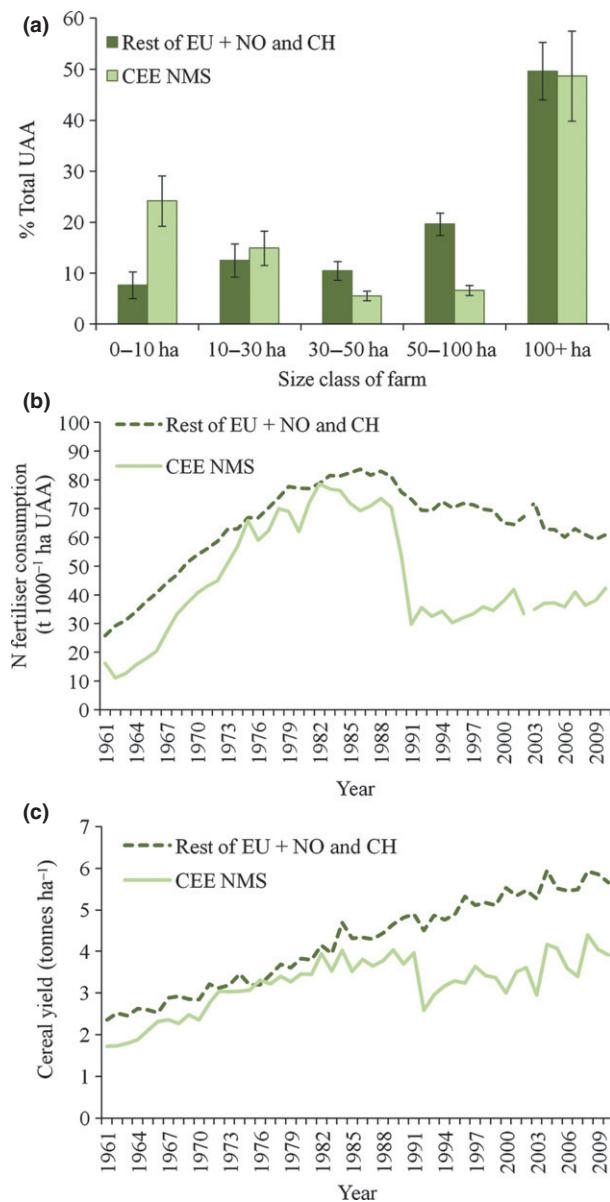


Figure 2 Indices of agricultural intensity in the Central and Eastern EU new member states (CEE NMS) and the rest of the EU (+ Norway and Switzerland). (a) Distribution of farmland area (UAA) according to size classes of farms in 2010 (data from Eurostat, <http://epp.eurostat.ec.europa.eu>) showing standard error bars. (b) Consumption of N fertiliser in tonnes per 1000 ha utilised agricultural area (UAA) between 1961 and 2010 for CEE NMS and the rest of the EU (+ NO and CH) (data from FAOSTAT, <http://faostat3.fao.org>). The categorization N fertiliser changes slightly in 2002; therefore, difference between the years 2002 and 2003 is not comparable. (c) Cereal yield in tonnes per ha (data from FAOSTAT, <http://faostat3.fao.org>). For FAOSTAT data, countries included in each category vary according to data availability, and excluding countries with incomplete data did not affect trends.

in the UK (Brickle *et al.*, 2000; Brickle & Harper, 2002), probably due to the generally low level of intensification in the surrounding Polish landscape. For similar reasons, red-

backed shrikes (*Lanius collurio*) were found to have generally low breeding site fidelity in Polish landscapes, in contrast to their high site fidelity in ‘islands’ of habitat in Western Europe (Tryjanowski *et al.*, 2007).

HARNESSING THE BIODIVERSITY VALUE OF CENTRAL AND EASTERN EUROPEAN FARMLAND

Of the support measures available for farmland biodiversity in the EU, the CAP has by far the greatest influence. With an average payment of 237 € ha⁻¹ of farmland in the last programming period (Farmer *et al.*, 2008), the direct payments of the CAP play an important role in supporting the viability of farming in the EU. However, it is particularly the subsistence and semi-subsistence farms making up such a large proportion of holdings in the NMS that benefit the least from this subsidy and therefore are most likely to be forced towards abandonment or intensification. Whilst it was known prior to accession that many of the smallest holdings in the NMS would have to be excluded from direct payments due to the administrative costs, this system was nonetheless adopted unaltered, exacerbating the competitive disadvantage of semi-subsistence farms (Swain, 2013). Furthermore, only few of the rural development measures so far offered by the CAP are accessible by semi-subsistence farms as they are either too small or lack the financial capital required (Davidova *et al.*, 2012). There is, however, a planned single payment in the 2014–2020 CAP for ‘small farms’, which may improve the financial situation of these holdings (Hennessy, 2014). Nevertheless, it seems to have generally been the fate of NMS thus far to have ‘imported’ EU policies that have been designed according to the priorities of the EU-15, without being able to ‘upload’ those with a better fit to their own structures and institutions (Gorton *et al.*, 2009; Davidova *et al.*, 2012; Swain, 2013).

This situation is also found in other rural development measures, such as agri-environment schemes (AES). AES are the only instrument in the CAP directly targeting farmland biodiversity conservation, and in 2009, 20.9% of farmland in the EU was enrolled in AES (Eurostat, 2012), which received approximately €33.2 billion in AES support over the period 2007–2013 (ENRD, 2014). Although member states have a high degree of flexibility in the design and implementation of AES (EC, 2005), several schemes in the NMS are based on well-supported data from Northern and Western Europe that may not fit to the local or regional circumstances. For example, postponing mowing from spring to summer is a popular agri-environment measure found in a review of several Western European studies to be generally beneficial for plant and invertebrate diversity (Humbert *et al.*, 2012; Buri *et al.*, 2013, 2014). However, when applied to already extensively managed patches of meadow such as exist in many regions of Romania, any postponement of mowing mainly results in a synchronization of management and a loss of the mosaic of sward heights (Dahlström *et al.*, 2013; see also Konvička

et al., 2007 and Cizek *et al.*, 2011). Even within Northern and Western Europe, the effects of AES are largely dependent on the type of landscape in which they are applied (Batáry *et al.*, 2010b; Schepers *et al.*, 2013), suggesting that schemes are likely to be ineffective unless they are adapted to the local context.

In contrast to much of lowland EU, the main challenge – and opportunity – for farmland biodiversity conservation in the NMS is that a large number of species of conservation concern often still coexist (e.g. in Polish field margins: Wuczyński *et al.*, 2014). These target species may have different requirements, creating conflicts when prescribing management measures. Simple but rigid measures applied over large areas can therefore be worse than existing management (e.g. Nikolov *et al.*, 2011; Elts & Löhmus, 2012). Another side effect of rigid prescriptions is the disruption and eventual loss of local traditional ecological knowledge related to adaptive management (Babai & Molnár, 2014).

Many areas of HNV farmland in Central and Eastern Europe are also not eligible for AES support. As with the direct payments, a large proportion of holdings fall below the size threshold, or the vegetation does not fall into one of the categories of agricultural land defined by the EU (Kazakova & Stefanova, 2011). Actively harnessing the biodiversity value of this farmland will therefore require measures adapted to regional circumstances and allowing for variable or even idiosyncratic small-scale management using a more flexible definition of agricultural land. For this to happen, interdisciplinary research is needed on the impact of different policy options on ecology and economy of the regions. Whilst the recent reform of the CAP has failed to meet expectations regarding provisions for biodiversity conservation, the increased devolution of responsibility to member states may provide the greater flexibility needed to develop local strategies to promote farmland biodiversity (Pe'er *et al.*, 2014).

CONCLUSION

The maintenance of HNV farmland is a policy priority for the EU, not only for the ecological, cultural and economic benefits it provides, but also for the conservation of many ‘wild’ species that over millennia of human disturbance have come to rely on these habitats. Thus, whilst there are many areas in which the promotion of low-intensity agriculture is now clearly inappropriate, the continuation of these practices should be made viable for local land managers in places where it still exists. Following Chappell & LaValle (2011), we believe that the future of food security and sustainable agriculture lies less in focussing on yield gaps, and more in increasing socio-economic access to produce, in which low-intensity and small-scale agriculture plays an important role (Tscharntke *et al.*, 2012b). Promoting sustainable development of rural regions goes hand in hand with this, most importantly by creating a direct link between the ecological state of a landscape and the well-being of its human population (see e.g. the discussion in Fischer *et al.*, 2012). In HNV

landscapes, yields are usually limited by adverse physical conditions (altitude, substrate, climate), and biodiversity promotion as well as other functions of agriculture, such as social coherence or cultural dimensions, should be the priority rather than intensification. Although approaches to valorise HNV landscapes through high-end products and tourism are starting to make an impact in some areas, the current viability of low-intensity farmland is largely supported by payments through the EU CAP.

In this study, we have argued that the widespread low-intensity farmland and associated biodiversity in Central and Eastern European countries makes them of special conservation significance in the EU, especially given the generally poor conservation status of farmland relative to other habitat types in Europe (Halada *et al.*, 2011). Yet these habitats are disadvantaged by the EU CAP, which is poorly adapted to their needs. This is aggravated by a lack of relevant research from the east in the international literature, leading to a bias in ecological observations in Europe towards the north-west. This not only limits the scalability and transferability of information found in the literature, but also the ability to design locally appropriate conservation measures. Whilst these problems are not unique to Central and Eastern Europe, the scale and the depth of the problem here mean that focussing more on improving the fit and evidence base of agricultural policies in the central and eastern NMS would play a disproportionately large role in sustaining European biodiversity. Promoting pan-European research and monitoring networks, as well as more research targeted on the farmland of Central and Eastern Europe, both within and outside of the EU, would help to formulate better conservation approaches to counteract the increasing pressure on farmland species in Europe.

ACKNOWLEDGEMENTS

The authors would like to thank the Volkswagen Foundation for funding the workshop ‘East meets West – transferring conservation approaches between Eastern and Western European landscapes’ (<http://eastwest2013.wordpress.com/>). Many thanks also to Oliver Schweiger and one anonymous referee for their help in improving this manuscript. We are very grateful to Gwyn Jones, Miroslava Čierna-Plassmann and Ana Štrbenac for helpful discussion. For further acknowledgements please see Appendix S2.

REFERENCES

- Aunins, A. & Priednieks, J. (2009) Recent changes in agricultural landscape and bird populations in Latvia: impacts and prospects of EU agricultural policy. *Avocetta*, **33**, 93–98.
- Babai, D. & Molnár, Z. (2014) Small-scale traditional management of highly species-rich grasslands in the Carpathians. *Agriculture, Ecosystems and Environment*, **182**, 123–130.
- Báldi, A. & Batáry, P. (2011) Spatial heterogeneity and farmland birds: different perspectives in Western and Eastern Europe. *Ibis*, **153**, 875–876.

- Báldi, A. & Faragó, S. (2007) Long-term changes of farmland game populations in a post-socialist country (Hungary). *Agriculture, Ecosystems and Environment*, **118**, 307–311.
- Batáry, P., Báldi, A., Sárospataki, M., Kohler, F., Verhulst, J., Knop, E., Herzog, F. & Kleijn, D. (2010a) Effect of conservation management on bees and insect-pollinated grassland plant communities in three European countries. *Agriculture, Ecosystems and Environment*, **136**, 35–39.
- Batáry, P., Báldi, A., Kleijn, D. & Tscharntke, T. (2010b) Landscape-moderated biodiversity effects of agri-environmental management: a meta-analysis. *Proceedings of the Royal Society B: Biological Sciences*, **278**, 1894–1902.
- Bignal, E.M. (1998) *Low-intensity livestock systems - defining ecological attributes*. Paper presented at The European Policy Evaluation Network (ELPEN), Institute of Mountain and Rural Economics, Greece.
- Bignal, E.M. & McCracken, D.I. (1996) Low-intensity farming systems in the conservation of the countryside. *Journal of Applied Ecology*, **33**, 413–424.
- Brickle, N.W. & Harper, D.G.C. (2002) Agricultural intensification and the timing of breeding of Corn Buntings *Miliaria calandra*. *Bird Study*, **49**, 219–228.
- Brickle, N.W., Harper, D.G.C., Aebsicher, N.J. & Cockayne, S.H. (2000) Effects of agricultural intensification on the breeding success of corn buntings *Miliaria calandra*. *Journal of Applied Ecology*, **37**, 742–755.
- Buri, P., Arlettaz, R. & Humbert, J. (2013) Delaying mowing and leaving uncut refuges boosts orthopterans in extensively managed meadows: evidence drawn from field-scale experimentation. *Agriculture, Ecosystems and Environment*, **181**, 22–30.
- Buri, P., Humbert, J.-Y. & Arlettaz, R. (2014) Promoting pollinating insects in intensive agricultural matrices: field-scale experimental manipulation of hay-meadow mowing regimes and its effects on bees. *PLoS ONE*, **9**, e85635.
- Carvalheiro, L.G., Kunin, W.E., Keil, P., Aguirre-Gutiérrez, J., Ellis, W.N., Fox, R., Groom, Q., Hennekens, S., Van Landuyt, W., Maes, D., Van de Meutter, F., Michez, D., Rasmont, P., Ode, B., Potts, S.G., Reemer, M., Roberts, S.P.M., Schaminée, J., Wallis De Vries, M.F. & Biesmeijer, J.C. (2013) Species richness declines and biotic homogenisation have slowed down for NW-European pollinators and plants. *Ecology Letters*, **16**, 870–878.
- Chappell, M.J. & LaValle, L.A. (2011) Food security and biodiversity: can we have both? An agroecological analysis. *Agriculture and Human Values*, **28**, 3–26.
- Cizek, O., Zamecnik, J., Tropek, R., Kocarek, P. & Konvicka, M. (2011) Diversification of mowing regime increases arthropods diversity in species-poor cultural hay meadows. *Journal of Insect Conservation*, **16**, 215–226.
- Cousins, S.A.O., Kaligarić, M., Bakan, B. & Lindborg, R. (2014) Political systems affect mobile and sessile species diversity – a legacy from the post-WWII period. *PLoS ONE*, **9**, e103367.
- Csáki, C. & Jámbor, A. (2013) The impact of EU accession: lessons from the agriculture of the new member states. *Post-Communist Economies*, **25**, 325–342.
- Dahlström, A., Iuga, A.-M. & Lennartsson, T. (2013) Managing biodiversity rich hay meadows in the EU: a comparison of Swedish and Romanian grasslands. *Environmental Conservation*, **40**, 194–205.
- Davidova, S., Fredriksson, L., Gorton, M., Mishev, P. & Petrovici, D. (2012) Subsistence farming, incomes, and agricultural livelihoods in the new member states of the European Union. *Environment and Planning C: Government and Policy*, **30**, 209–227.
- Davidova, S., Bailey, A., Dwyer, J., Erjavec, E., Gorton, M. & Thomson, K. (2013) Semi-subsistence farming: value and directions of development. Directorate General for Internal Policies. Policy Department B: Structural and Cohesion Policies, Brussels.
- Dicks, L.V., Hodge, I., Randall, N.P., Scharlemann, J.P.W., Siriwardena, G.M., Smith, H.G., Smith, R.K. & Sutherland, W.J. (2013) A transparent process for “evidence-informed” policy making. *Conservation Letters*, **7**, 119–125.
- Donald, P.F., Green, R.E. & Heath, M.F. (2001) Agricultural intensification and the collapse of Europe’s farmland bird populations. *Proceedings of the Royal Society B: Biological Sciences*, **268**, 25–29.
- Dullinger, S., Essl, F., Rabitsch, W., Erb, K.-H., Gingrich, S., Haberl, H., Hülber, K., Jarosík, V., Krausmann, F., Kühn, I., Pergl, J., Pysek, P. & Hulme, P.E. (2013) Europe’s other debt crisis caused by the long legacy of future extinctions. *Proceedings of the National Academy of Sciences of the United States of America*, **110**, 7342–7347.
- EC (2005) *Agri-environment Measures: Overview on General Principles, Types of Measures, and Application*. European Commission, Directorate General for Agriculture and Rural Development, Brussels.
- EEA (2004) *High nature value farmland*. Characteristics, trends and policy challenges. European Environment Agency, Luxembourg.
- Elts, J. & Lõhmus, A. (2012) What do we lack in agri-environment schemes? The case of farmland birds in Estonia. *Agriculture, Ecosystems and Environment*, **156**, 89–93.
- ENRD (2014) Rural Development Programme Financial and Physical Indicators. European Network for Rural Development. Data source: DG AGRI and Annual Progress Reports from Managing Authorities. Available at: http://enrd.ec.europa.eu/enrd-static/policy-in-action/rural-development-policy-in-figures/rdp-monitoring-indicator-tables/financial-and-physical-indicators/en/financial-and-physical-indicators_en.html. (accessed 3 October 2014).
- Eurostat (2012) Agri-environmental indicator - commitments. Available at: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Agri-environmental_indicator--commitments (accessed 3 October 2014).
- Farmer, M., Cooper, T., Swales, V. & Silcock, P. (2008) *Funding for Farmland Biodiversity in the EU: Gaining*

- Evidence for the EU Budget Review.* A report for the RSPB by Institute for European Environmental Policy and Cumulus Consultants.
- Fischer, J., Hartel, T. & Kuemmerle, T. (2012) Conservation policy in traditional farming landscapes. *Conservation Letters*, **5**, 167–175.
- Gonthier, D.J., Ennis, K.K., Farinas, S., Hsieh, H.-Y., Iverson, A.L., Batáry, P., Rudolphi, J., Tscharntke, T., Cardinale, B.J. & Perfecto, I. (2014) Biodiversity conservation in agriculture requires a multi-scale approach. *Proceedings of the Royal Society B: Biological Sciences*, **281**, 20141358.
- Gorton, M., Hubbard, C. & Hubbard, L. (2009) The folly of European Union policy transfer: why the Common Agricultural Policy (CAP) does not fit Central and Eastern Europe. *Regional Studies*, **43**, 1305–1317.
- Gregory, R.D., van Strien, A., Vorišek, P., Meyling, A.W.G., Noble, D.G., Foppen, R.P.B. & Gibbons, D.W. (2005) Developing indicators for European birds. *Philosophical Transactions of the Royal Society B: Biological Sciences*, **360**, 269–288.
- Halada, L., Evans, D., Romão, C. & Petersen, J.-E. (2011) Which habitats of European importance depend on agricultural practices? *Biodiversity and Conservation*, **20**, 2365–2378.
- Hartvigsen, M. (2014) Land use policy land reform and land fragmentation in Central and Eastern Europe. *Land Use Policy*, **36**, 330–341.
- Henle, K., Alard, D., Clitheroe, J., Cobb, P., Firbank, L.G., Kull, T., McCracken, D., Moritz, R., Niemela, J. & Rebane, M. (2008) Identifying and managing the conflicts between agriculture and biodiversity conservation in Europe—A review. *Agriculture, Ecosystems and Environment*, **124**, 60–71.
- Hennessy, T. (2014) CAP 2014–2020 Tools to enhance family farming: opportunities and limits. Directorate-General for Internal Policies. Policy Department B: Structural and Cohesion Policies – Agriculture, Brussels.
- Humbert, J.-Y., Pellet, J., Buri, P. & Arlettaz, R. (2012) Does delaying the first mowing date benefit biodiversity in meadowland? *Environmental Evidence*, **1**, 9.
- Kamp, J., Urazaliev, R., Donald, P.F. & Hözel, N. (2011) Post-Soviet agricultural change predicts future declines after recent recovery in Eurasian steppe bird populations. *Biological Conservation*, **144**, 2607–2614.
- Kazakova, Y. & Stefanova, V. (2011) *High Nature Value Farming in South-Eastern Europe: Policy Opportunities and Challenges in the EU Accession*. European Forum on Nature Conservation and Pastoralism.
- Keišs, O. (2003) Recent increases in numbers and the future of Corncrake *Crex crex* in Latvia. *Ornis Hungarica*, **12–13**, 151–156.
- Kleijn, D., Kohler, F., Báldi, A., Batáry, P., Concepción, E.D., Clough, Y., Díaz, M., Gabriel, D., Holzschuh, A., Knop, E., Kovács, A., Marshall, E.J.P., Tscharntke, T. & Verhulst, J. (2009) On the relationship between farmland biodiversity and land-use intensity in Europe. *Proceedings of the Royal Society B: Biological Sciences*, **276**, 903–909.
- Konvička, M., Benes, J., Cizek, O., Kopecek, F., Konvička, O. & Vitaz, L. (2007) How too much care kills species: grassland reserves, agri-environmental schemes and extinction of *Colias myrmidone* (Lepidoptera: Pieridae) from its former stronghold. *Journal of Insect Conservation*, **12**, 519–525.
- Kuussaari, M., Bommarco, R., Heikkinen, R.K., Helm, A., Krauss, J., Lindborg, R., Ockinger, E., Pärtel, M., Pino, J., Rodà, F., Stefanescu, C., Teder, T., Zobel, M. & Steffan-Dewenter, I. (2009) Extinction debt: a challenge for biodiversity conservation. *Trends in Ecology and Evolution*, **24**, 564–571.
- Liira, J., Aavik, T., Parrest, O. & Zobel, M. (2008) Agricultural sector, rural environment and biodiversity in the Central and Eastern European EU member states. *AGD Landscape and Environment*, **2**, 46–64.
- Mueller, N.D., Gerber, J.S., Johnston, M., Ray, D.K., Ramanukutty, N. & Foley, J. (2012) Closing yield gaps through nutrient and water management. *Nature*, **490**, 254–257.
- Nikolov, S.C., Demerdzhiev, D.A., Popgeorgiev, G.S. & Plachiyski, D.G. (2011) Bird community patterns in sub-Mediterranean pastures: the effects of shrub cover and grazing intensity. *Animal Biodiversity and Conservation*, **34**, 11–21.
- Overmars, K.P., Schulp, C.J.E., Alkemade, R., Verburg, P.H., Temme, A.J.A.M., Omtzigt, N. & Schaminée, J.H.J. (2014) Developing a methodology for a species-based and spatially explicit indicator for biodiversity on agricultural land in the EU. *Ecological Indicators*, **37**, 186–198.
- Pe'er, G., Dicks, L.V., Visconti, P. et al. (2014) EU agricultural reform fails on biodiversity. *Science*, **344**, 1090–1092.
- Reidsma, P., Tekelenburg, T., Vandenberg, M. & Alkemade, R. (2006) Impacts of land-use change on biodiversity: an assessment of agricultural biodiversity in the European Union. *Agriculture, Ecosystems and Environment*, **114**, 86–102.
- Rotter, A. & Gostincar, C. (2014) A defense of Eastern European science. *Science*, **343**, 839.
- Sanderson, F.J., Kucharz, M., Jobda, M. & Donald, P.F. (2013) Impacts of agricultural intensification and abandonment on farmland birds in Poland following EU accession. *Agriculture, Ecosystems and Environment*, **168**, 16–24.
- Scheper, J., Holzschuh, A., Kuussaari, M., Potts, S.G., Rundlöf, M., Smith, H.G. & Kleijn, D. (2013) Environmental factors driving the effectiveness of European agri-environmental measures in mitigating pollinator loss - a meta-analysis. *Ecology Letters*, **16**, 912–920.
- Stoate, C., Báldi, A., Beja, P., Boatman, N.D., Herzon, I., van Doorn, A., de Snoo, G.R., Rakosy, L. & Ramwell, C. (2009) Ecological impacts of early 21st century agricultural change in Europe – A review. *Journal of Environmental Management*, **91**, 22–46.
- Storkey, J., Meyer, S., Still, K.S. & Leuschner, C. (2012) The impact of agricultural intensification and land-use change on the European arable flora. *Proceedings of the Royal Society B: Biological Sciences*, **279**, 1421–1429.

- Swain, N. (2013) Agriculture "East of the Elbe" and the common agricultural policy. *Sociologia Ruralis*, **53**, 369–389.
- Szép, T., Nagy, K., Nagy, Z. & Halmo, G. (2012) Population trends of common breeding and wintering birds in Hungary, decline of long-distance migrant and farmland birds during 1999–2012. *Ornis Hungarica*, **20**, 13–63.
- Szymkowiak, J., Skierczyński, M. & Kuczyński, L. (2014) Are buntings good indicators of agricultural intensity? *Agriculture, Ecosystems and Environment*, **188**, 192–197.
- Tryjanowski, P., Goławski, A., Kuźniak, S., Mokwa, T. & Antczak, M. (2007) Disperse or stay? Exceptionally high breeding-site infidelity in the Red-backed Shrike *Lanius collurio*. *Ardea*, **95**, 316–320.
- Tryjanowski, P., Hartel, T., Báládi, A., Szymański, P., Tobolka, M., Herzon, I., Goławski, A., Konvička, M., Hromada, M., Jerzak, L., Kujawa, K., Lenda, M., Orlowski, G., Panek, M., Skórka, P., Sparks, T.H., Tworek, S., Wuczyński, A. & Żmihorski, M. (2011) Conservation of farmland birds faces different challenges in Western and Central-Eastern Europe. *Acta Ornithologica*, **46**, 1–12.
- Tscharntke, T., Klein, A.M., Kruess, A., Steffan-Dewenter, I. & Thies, C. (2005) Landscape perspectives on agricultural intensification and biodiversity - ecosystem service management. *Ecology Letters*, **8**, 857–874.
- Tscharntke, T., Tylianakis, J.M., Rand, T.A. et al. (2012a) Landscape moderation of biodiversity patterns and processes - eight hypotheses. *Biological Reviews*, **87**, 661–685.
- Tscharntke, T., Clough, Y., Wanger, T.C., Jackson, L., Motzke, I., Perfecto, I., Vandermeer, J. & Whitbread, A. (2012b) Global food security, biodiversity conservation and the future of agricultural intensification. *Biological Conservation*, **151**, 53–59.
- Uthes, S. & Matzdorf, B. (2013) Studies on agri-environmental measures: a survey of the literature. *Environmental Management*, **51**, 251–266.
- Van Swaay, C. & Warren, M. (2012) *Developing butterflies as indicators in Europe: current situation and future options*. De Vlinderstichting/Dutch Butterfly Conservation, Butterfly Conservation UK, Butterfly Conservation Europe, Wageningen, reportnr. VS2012.012.
- Verhulst, J., Báládi, A. & Kleijn, D. (2004) Relationship between land-use intensity and species richness and abundance of birds in Hungary. *Agriculture, Ecosystems and Environment*, **104**, 465–473.
- Voríšek, P., Jiguet, F., van Strien, A.J., Škorpilová, J., Klvanová, A. & Gregory, R.D. (2010) Trends in abundance and biomass of widespread European farmland birds: how much have we lost? *BOU Proceedings - Lowland Farmland Birds III*.
- Wuczyński, A., Dajdok, Z., Wierzycholska, S. & Kujawa, K. (2014) Applying red lists to the evaluation of agricultural habitat: regular occurrence of threatened birds, vascular plants, and bryophytes in field margins of Poland. *Biodiversity and Conservation*, **23**, 999–1017.
- Young, J., Richards, C., Fischer, A., Halada, L., Kull, T., Kuzniar, A., Tartes, U., Uzunov, Y. & Watt, A. (2007) Conflicts between biodiversity conservation and human activities in the Central and Eastern European countries. *Ambio*, **36**, 545–550.

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Appendix S1 Web of Science search protocol and results

Appendix S2 Author acknowledgments

Table S1 Results of a Web of Science search on 10.01.2014

BIOSKETCH

Laura Sutcliffe is a post doc at the University of Göttingen, Germany. Her research focuses on grassland biodiversity in Romania. The authors all took part in the workshop 'East meets West – transferring conservation approaches between Eastern and Western European landscapes' in 2013, funded by the Volkswagen Foundation, which forms the basis for this article.

The workshop behind this article was conceived by L.M.E.S, P.B., U.K. and T.T. All authors contributed to the discussions that form the basis of this article. Writing and analysis were led by L.M.E.S, with major contributions from P.B., U.K., A.B., L.V.D., I.H., D.K., P.T. and T.T., and feedback from all authors.

Editor: Ingolf Kühn